Final Report

Geotechnical Investigation and Levee Analysis

City of Burlington and Dike District 12 Levee Certification Project
Burlington, Washington

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Edmonds, Washington

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REPORT

FINAL REPORT

GEOTECHNICAL INVESTIGATION AND LEVEE ANALYSIS CITY OF BURLINGTON AND DIKE DISTRICT 12 LEVEE CERTIFICATION PROJECT

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EXECUTIVE SUMMARY

This report presents the results of our geotechnical investigation and levee analysis for the City of Burlington and Dike District 12 Levee Certification Project located in Burlington, Washington. The purpose of this geotechnical investigation was to evaluate the existing levees and provide geotechnical engineering recommendations regarding improvements to the existing levees and constructing new levees. The levee is to provide flood protection to the city of Burlington and nearby areas from a 100-year flood event of the Skagit River. A further purpose of the improvements will be to receive accreditation by the Federal Emergency Management Agency (FEMA).

The proposed flood protection project originates north of the intersection of Lafayette Road and Peter Anderson Road and terminates just west of the intersection of Bouslog Road and Bennett Road (Figure 1). The project covers a distance of approximately 4.6 miles.

We advanced a total of 28 exploratory borings, GB-1 through GB-28, and 11 cone penetration tests (CPTs), CPT-1 through CPT-11. The explorations encountered fill materials up to 24 feet, underlain by native alluvial deposits to the depths explored. The alluvial deposits consisted of quiet-water deposits, overbank deposits, and channel deposits. In general terms, the quiet-water deposits consisted of very loose silt with organics. The overbank deposits consisted of loose, interbedded silt and sand. The channel deposits consisted of compact to dense sands and occasional gravels. Using the results of the field investigation, a geological profile of the project alignment was created.

The static and seismic slope stability of the existing and proposed levees was evaluated at selected sections along the alignment using geologic information from Golder and others and the top of levee and 100-year flood levels provided by Pacific International Engineering (PIE). The levees were generally evaluated for both the reported U.S. Army Corps of Engineers (USACE) flood level and PIE's flood level. An approximately 1 in 500 year earthquake event was used for the seismic assessment. Seepage analyses, including underseepage and rapid drawdown, and settlement analyses for the different levee raise types were performed at select sections along the project alignment. In addition, design and construction recommendations for levees and, as an alternative to levees, cantilever sheet pile flood walls were provided. The USACE guidelines (EM 1110-2-1913) were utilized for assessing the levees and providing construction recommendations.

The existing and proposed levee configurations generally meet USACE static stability factors of safety, with the exception of the existing stability of the Skagit River bank and the BNSF railway embankment. The existing river bank is steep in many areas, but we understand it has been stable for a number of years including following several flood events. Stability analysis indicates a surficial stability may exist along the steep sections of the river bank; however, the stability cannot be accurately assessed because the thickness of the existing rip-rap is unknown.

Seepage analyses were carried out for three representative sections along the project alignment. The rise and fall of the flood water was simulated using data from past major floods. A conservative combination of slow river rise followed by a rapid decrease was used. A function was developed to simulate a flood event up to the USACE flood level. The results of the analyses indicate that the sections analyzed have acceptable performance under the steady-state and rapid drawdown design cases.

The riverside of the Northern Santa Fe (BNSF) railroad embankment does not meet static stability requirements and therefore we recommend that the proposed levee should be entirely separate and constructed west of the BNSF railroad embankment. The levee should cross perpendicular to the BNSF railroad embankment and a flood gate would be required across the existing tracks. As an alternative, a cantilever sheet pile flood wall could be installed on top of the railroad embankment crest. This alternative would require that the riverside of the BNSF embankment be regraded to at least 3H:1V, widening of the crest and Whitmarsh Road would require realignment.

The native soils are susceptible to liquefaction at several locations along the project alignment. Towards the west end of the alignment, the seismic factors of safety are below USACE design values due to the shallow and low strength liquefiable layer underlying the proposed new levee. We recommend flattening the levee sideslopes to create a larger levee footprint area. However, maintenance and repair to the levee should be anticipated following the design seismic event.

Settlement analyses were performed on select sections along the project alignment in order to approximate the total settlement that will be caused by levee construction. Between 1 and 6 inches of total settlement should be anticipated along the centerline of the proposed levee alignment. The design heights of the levees should be increased to account for the anticipated settlements. Where the proposed levee intersects the existing Interstate 5 the total settlement induced by the levee on the I-5 embankment decreases from about 4.5 inches at the toe of the I-5 embankment to 1 inch at the termination of the levee. The settlement induced is not likely to impact the shoulder or travelling lanes of the I-5. However, for the I-5 embankment, we recommend that settlement is monitored during construction.

Another tie in levee occurs where the proposed levee connects to the BNSF embankment. We recommend, when the configuration is agreed upon, that Golder review the arrangement in order to assess the settlement impact on the BNSF embankment. It is likely that settlement monitoring of the rail tracks will be required during construction.

1.0 INTRODUCTION

The following report describes the geotechnical site investigation and engineering analyses for the proposed City of Burlington and Dike District 12 Levee Certification Project in Burlington, Washington. The work described herein was performed by Golder Associates Inc. (Golder) of Redmond, Washington in accordance with Golder's March 5, 2009 proposal (083-93509) to Pacific International Engineering (PIE) accepted and signed March 9, 2009.

The proposed flood protection project originates north of the intersection of Lafayette Road and Peter Anderson Road and terminates just west of the intersection of Bouslog Road and Bennett Road (Figure 1). The project covers a distance of approximately 4.6 miles. Flood protection measures considered for the project consist of levees and cantilever sheet pile flood walls.

This City of Burlington and Dike District 12 project consists of evaluating existing levees, performing improvements to the existing levees, and constructing new levees. These flood protection improvements are being performed in order to protect Burlington and nearby areas from a 100-year flood event of the Skagit River. A further purpose of the improvements is to receive accreditation by the Federal Emergency Management Agency (FEMA). To receive FEMA accreditation, it is our understanding that the condition of existing levees and any improvements made must be shown to conform to standards established by the U.S. Army Corps of Engineers (COE).

Golder previously prepared a report titled, *Preliminary Geotechnical Evaluation, City of Burlington and Dike District 12 Levee Certification Project, Burlington, Washington* dated March 5, 2009. This report should be used in conjunction with this report. The Golder 2009 report summarizes our preliminary interpretations of the foundation conditions underlying existing and proposed levees, summarizes potential geologic hazards to the levees, provides the basis for the assessment of the existing levees, summarizes potential sources of borrow material, and provides recommendations for the exploration program summarized in this report.

1.1 Purpose

The purpose of the geotechnical site investigation and engineering analyses was to provide subsurface geotechnical information and geotechnical engineering site recommendations to PIE, the City of Burlington, and the Dike District 12 for the proposed Levee Certification Project. The primary geotechnical issues addressed by our site investigation and analyses, and discussed in this report, include:

- Condition and thickness of fill underlying the project alignment;
- Type and condition of native soil units underlying the project;
- Stability of the proposed levees, including liquefaction analysis, seismic stability and static stability;

- Recommended locations for proposed levees and cantilever sheet pile flood walls, so as to avoid impacting the stability of the existing banks of the Skagit River;
- Potential for underseepage during flood events; and
- Geotechnical recommendations for construction and design of levees and cantilever sheet pile flood walls.

To address these issues, our site investigation and analyses was performed under the scope of work items outlined in Section 1.2.

1.2 Scope

The scope of work completed for the geotechnical site investigation and engineering analyses was performed in substantial accordance with our March 5, 2009 proposal to PIE, except where modified based on subsequent discussions with PIE. Our scope of work included the following tasks:

- A field investigation consisting of advancing and logging 28 hollow-stem auger borings and 11 cone penetration tests (CPT). Eight of the borings were completed as piezometers. The field work was completed in April 2009. The methods used to complete the field investigation are described in more detail in Section 3.0;
- Laboratory analysis of samples collected during the field investigation;
- Geologic analysis and preparation of geologic profiles, based on the results of the field investigation and supplemented with the results of previous investigations by others;
- Engineering analysis of the proposed flood protection project, including analysis of seismic and static slope stability, liquefaction potential, and analysis of flood wall suitability (where appropriate);
- Preparation of engineering recommendations, including recommended setbacks to maintain bank stability, geotechnical design and construction recommendations for levees, materials recommendations for levees, geotechnical design and construction recommendations for cantilever sheet pile flood walls, and other recommendations, as appropriate; and
- Preparation of this report.

1.3 Report Outline

The report presented herein documents the methods, results, conclusions, and recommendations of our geotechnical site investigation and engineering analyses of the City of Burlington and Dike 12 Levee Certification Project. The report is organized as follows:

- **Section 1 (Introduction)** this section.
- **Section 2 (Physical Setting and Project Understanding)** outlines the physical setting of the project and provides a brief summary of our understanding of the proposed flood protection measures.
- **Section 3 (Methods)** describes the methods used to complete the field investigation and laboratory analyses.
- **Section 4 (Geologic Setting)** discusses the general geologic setting of the project.
- **Section 5 (Subsurface Conditions)** summarizes the subsurface soil and groundwater conditions underlying the project area.

- **Section 6 (Laboratory Analyses)** summarizes the results of the laboratory analyses.
- **Section 7 (Engineering Analyses)** describes the results of our engineering analyses.
- **Section 8 (Recommendations)** presents our geotechnical recommendations for design and construction of the flood protection measures.
- **Section 9 (Summary)** summarizes the results of our investigation and analyses.
- **Section 10 (Closing)** describes our intention of the use of this report.
- **Section 11 (References)** documents the outside resources referred to in performing our investigation and analyses.

Six appendices are also included with this report, including:

- **Appendix A (Exploration Logs)** presents a summary of the various explorations completed for this project.
- **Appendix B (Laboratory Testing and Analysis)** presents the complete results of the laboratory testing and associated analyses.
- **Appendix C (Engineering Analyses – Static Stability)** presents the calculations and outputs used in our static slope stability analyses.
- **Appendix D (Engineering Analyses – Seismic Stability)** presents the calculations and outputs used in our seismic slope stability analyses.
- **Appendix E (Engineering Analyses – Liquefaction Analysis)** presents the calculations and outputs used in our liquefaction analyses.
- **Appendix F (Engineering Analyses – Seepage Assessment)** presents the calculations and outputs used in our seepage assessment.

2.0 PHYSICAL SETTING AND PROJECT UNDERSTANDING

The proposed flood protection project is located along the right (west/north) bank of the Skagit River in and near the downtown area of Burlington, Washington (Figure 1). While the final alignment of the proposed flood protection project has not yet been determined, in general the project will originate at the north near the intersection of Lafayette Road and Peter Anderson Road, traverse to the south along the existing levee on the right river bank, turning to the west continuing along the river bank and terminating near the west end of Bennett Road just west of the intersection with Bouslog Road (Figure 2). The length of the project is approximately 4.6 miles.

Flood protection measures will likely consist of a combination of levees and cantilever sheet pile flood walls, but may consist entirely of one type, based upon the options selected by the City of Burlington and the Dike District 12. The flood protection project will be designed to protect downtown Burlington from a 100-year flood event on the Skagit River.

For the purposes of this report, and ease of discussion, we have divided the project into two areas based on our understanding of the project and the physical characteristics of each area. These areas are: the Northeastern Area and the Western Area (Figure 2). The location of the proposed alignment at the time this report was prepared, as provided by PIE, is shown on Figure 3. This alignment corresponds to the location of the main geologic profile (Figures 4 through 10). The stationing begins at the west end of the project and is used to describe locations of particular interest. Stationing used for the final project design will not necessarily correspond to the stationing used in this report.

2.1 Northeastern Area

The Northeastern Area of the project extends from the area that the alignment crosses East Whitmarsh Road to the northern end of the project, Station 78+50 to Station 241+50. This section of the alignment is underlain by an existing earthen levee adjacent to the Skagit River to provide flood protection. Several residences, a few businesses, several city parks, and the Section Street Wastewater Treatment Plant are located behind the levee.

The existing levee is typically set back from the river, with the amount of setback varying from 50 feet to more than 1,000 feet. The existing crest in this section varies from about 15 feet wide to about 50 feet wide. The levee in this area has a relatively flat backslope of between 4H:1V (horizontal: vertical) up to 8H:1V. The existing levee crown has a gravel driving surface used by Dike District 12 for maintaining the levees. Access to the driving surface along the levees is limited by locking gates along the alignment. There are soil stockpiles located adjacent to the levees along the northern end of the alignment. The existing levee sideslopes are lightly vegetated (grass).

Flood protection measures considered for this area consist of raising the existing levees.

2.2 Western Area

The Western Area of the project corresponds to the beginning of the project alignment, Station 0+00, and extends to Station 78+50. The start of the alignment is approximately 500 feet west of the intersection of Bennett Road and Bouslog Road. The end of the Western Area (Station 78+50) is in the area where the alignment crosses East Whitmarsh Road. This is the area that the project alignment corresponds to the existing levee alignment. Several businesses are located behind the levee in the Western Area, including car dealerships, supermarkets, home improvement stores, banks, and retail stores.

The majority of the proposed project alignment in the Western Area does not follow the path of the existing earthen levee. The existing earthen levee in this area is located south of Whitmarsh Road and crosses under both South Burlington Boulevard and Interstate 5. The majority of the planned alignment is offset approximately 200 to 800 feet north of the existing earthen levee. An approximately 1,000 foot section of the alignment (starting at Station 0+00) runs parallel to Bouslog Road, which is perpendicular to the existing levee alignment. The proposed project alignment crosses several agricultural fields and local paved roads; intersects the lightly vegetated, earthen embankments for Interstate 5 and the ramps for South Burlington Boulevard; and follows the Northern Santa Fe (BNSF) railroad embankment, which is overlain with railroad ballast and has lightly vegetated sideslopes.

Near the eastern end of the Western Area, the levee turns to the north and can follow one of two possible alignments. The main alignment is adjacent to approximately 0.4 miles of the BNSF railroad. The alternate setback levee alignment is located approximately 150 feet west of and parallel to the BNSF railroad and rejoins the main alignment at Station 78+77. The levee section in this area is relatively steep with slopes of about 2.5H:1V. At the end of the Western Area, approximately Station 78+50, the levee turns to the east.

Flood protection measures considered for this area primarily consist of a levee.

2.3 Previous Reports

As mentioned in our Preliminary Geotechnical Evaluation (March 6, 2009), we reviewed several reports prepared by others, including the Dike District 12, Army Corps of Engineers, Shannon and Wilson, and Landau Associates. The items reviewed include the following list of reports.

- A Dike District 12 Background Report (February 2008) discusses the history and current conditions of the existing levee project. This report includes aerial photos from the Dike District showing the areas of historical underseepage, widened areas of levees, approximate keyway locations, and areas where the Skagit River banks have had rip-rap repaired.
- The U.S. Army Corps of Engineers produced two reports (1979 and 2000) containing numerous boring logs drilled for comprehensive flood protection project for Skagit County, including Burlington. Nine borings were drilled near the current project centerline.

- The Shannon & Wilson (2000) Geotechnical Report discusses the ten borings drilled for the Riverside Bridge with the north end of the bridge intersecting the project centerline. One boring, B-8, was drilled on the planned levee alignment.
- The Landau Associates (2003) Report of Geotechnical Engineering Services was for the Proposed Home Depot Store. This report provides 21 boring logs and 25 test pit logs on the Home Depot store site located north of the alignment between Golder borings GB-23 and GB-24.

3.0 FIELD INVESTIGATION

Fieldwork for the geotechnical investigation consisted of advancing and logging twenty-eight hollow-stem auger borings (GB-1 through GB-28) and conducting eleven cone penetration tests (CPT-1 through CPT-11). The locations of the borings and CPTs were selected based on the preliminary project alignment at the time of our proposal. After the field investigation was completed, the project alignment was changed. In the Western Area (between approximate Stations 40+00 to 70+00), the alignment shifted to the north and several of our borings (GB-17 through GB-21 and GB-27) and a CPT (CPT-8) are offset from the revised alignment by approximately 15 to 70 feet.

The hollow-stem auger borings and CPTs were performed to evaluate the soil and groundwater conditions underlying the proposed alignment. Exploration locations, including select previous explorations by others, are shown on Figure 3. The methods used to conduct the hollow-stem auger borings and CPTs are discussed in Sections 3.1 and 3.2., respectively. Summary exploration logs of the borings and CPTs are provided in Appendix A.

Laboratory tests were performed at our Redmond, Washington laboratory on selected samples collected during the drilling of the hollow-stem auger borings. Results of the laboratory testing are provided in Appendix B and summarized in Section 6.0.

3.1 Hollow Stem Auger Borings

Twenty-eight hollow-stem auger borings were advanced and logged between April 13, 2009 and April 27, 2009 to evaluate the soil and groundwater conditions underlying the project (GB-1 through GB-28). The borings were advanced to depths ranging between 26.5 to 80.5 feet below ground surface (bgs). Eight of the borings were completed as piezometers. Right-of-entry for all of the locations drilled was secured by the City of Burlington or the Dike District 12.

The boring locations and depths are listed below in Table 3-1. The stationing locations given below are based on the stationing shown on Figures 4 through 10. Latitudes, longitudes, and stationing locations should be considered approximate, as the boring locations were not surveyed. A handheld GPS unit was used to determine the latitude and longitude of the boring locations.

TABLE 3-1

Geotechnical Boring Depths and Locations

Exploration Number	Depth of Boring (feet)	Latitude	Longitude	Approximate Stationing
GB-1	61.5	48° 29' 7.74" N	122° 17' 47.81" W	239+28, 50 ft Left
GB-2	46.5	48° 28' 57.66" N	122° 17' 52.70" W	228+47
GB-3 (i)	41.5	48° 28' 55.41" N	122° 17' 41.97" W	219+42
GB-4	51.4	48° 28' 48.56" N	122° 17' 48.82" W	211+07
GB-5	31.3	48° 28' 41.61" N	122° 17' 55.91" W	202+55
GB-6 (i)	36.5	48° 28' 31.10" N	122° 17' 56.96" W	191+77
GB-7	36.5	48° 28' 21.37" N	122° 18' 1.60" W	180+87
GB-8	35.9	48° 28' 17.69" N	122° 18' 12.79" W	172+45
GB-9	31	48° 28' 10.90" N	122° 18' 28.96" W	159+53
GB-10 (i)	41.5	48° 28' 3.36" N	122° 18' 39.28" W	148+85
GB-11	36	48° 27' 53.78" N	122° 18' 46.05" W	138+05
GB-12	61.5	48° 27' 42.27" N	122° 18' 51.02" W	125+85
GB-13	56.5	48° 27' 33.34" N	122° 19' 3.72" W	113+38
GB-14 (i)	80.5	48° 27' 22.94" N	122° 19' 15.24" W	100+16
GB-15	36.5	48° 27' 10.48" N	122° 19' 21.34" W	86+66
GB-16	51.5	48° 27' 5.79" N	122° 19' 29.03" W	78+11, 75 ft Left
GB-17	41.5	48° 26' 54.55" N	122° 19' 27.63" W	67+00, 125 ft Right
GB-18 (i)	71	48° 26' 50.95" N	122° 19' 28.65" W	65+25, 492 ft Right
GB-19	61.5	48° 26' 49.39" N	122° 19' 35.87" W	61+47, 509 ft Right
GB-20	56.5	48° 26' 48.13" N	122° 19' 48.11" W	50+47, 402 ft Right
GB-21 (i)	66.5	48° 26' 48.16" N	122° 19' 57.63" W	45+20, 105 ft Left
GB-22	51.5	48° 26' 49.09" N	122° 20' 3.98" W	41+28, 14 ft Left
GB-23	46.4	48° 26' 49.80" N	122° 20' 11.74" W	36+06, 90 ft Left
GB-24 (i)	56.5	48° 26' 49.31" N	122° 20' 24.70" W	27+30, 26 ft Left
GB-25	36.5	48° 26' 51.12" N	122° 20' 36.68" W	19+00, 50 ft Left
GB-26	36.5	48° 26' 50.88" N	122° 20' 40.56" W	16+41
GB-27	26.5	48° 26' 52.99" N	122° 20' 47.91" W	8+61, 149 ft Left
GB-28 (i)	31.5	48° 27' 1.29" N	122° 20' 50.02" W	0+50, 51 ft Left

Notes:
(i) Piezometer installed.

The drilling and sampling were performed in general accordance with Golder Technical Procedures. Soil cuttings from most of the borings were removed and stockpiled, at a location specified by the Dike District 12. Upon the completion of the drilling, borings not completed as piezometers were backfilled with bentonite chips, in accordance with Washington State Department of Ecology regulations. Eight of the borings, GB-3, GB-6, GB-10, GB-14, GB-18, GB-21, GB-24, and GB-28 were completed as piezometers. The methods used to complete the borings as piezometers are described below.

All of the soil borings were drilled and sampled using a CME 75 truck-mounted drill rig operated by Cascade Drilling, Inc. of Woodinville, Washington under the full-time observation of Golder project geologist, Alison Dennison. Standard penetration tests (SPTs) were conducted at 2.5-foot intervals until approximately 20 feet bgs and then at 5-foot intervals to the depths explored. SPTs were conducted using a standard 2-inch inner diameter split barrel sampler advanced with a 140-pound autohammer falling a distance of 30-inches for each strike, in accordance with ASTM D-1586. The number of hammer blows for each six inches of penetration was recorded. The standard penetration resistance (N) of the soil is calculated as the sum of the number of blows required for the final 12-inches of sampler penetration. The N-value is an indication of the relative density of cohesionless soils and the consistency of cohesive soils. If a total of 50 blows are recorded for a single 6 inch interval, the test is terminated and the blow count is recorded as 50 blows for the total inches of penetration. Field judgment is required when assigning density descriptions to soils with a high percentage of gravel or cobbles since the driving resistance is often increased by the presence of such materials. All samples were collected and placed in plastic jars to reduce moisture loss and returned to our Redmond, Washington laboratory for further classification and laboratory testing.

If soft, cohesive soils were encountered, thin-walled Shelby tubes were pushed to collect “undisturbed” samples. These samples were capped and taped to prevent moisture loss and transported to Soil Technology, Inc in Bainbridge Island, Washington. The samples were extruded from the Shelby tubes and geotechnical laboratory testing was completed.

The soils were examined and logged by the project geologist. The soil samples were classified in accordance with Golder Technical Procedures and the USCS classification system. Pertinent information was recorded, including soil sample depths, stratigraphy, groundwater occurrence (if any), and soil engineering characteristics.

Summary boring logs are presented in Appendix A-1. The stratigraphic contacts shown on the boring log represents the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific dates and locations reported and, therefore, are not necessarily representative of other locations and times.

As mentioned, eight of the borings (GB-3, GB-6, GB-10, GB-14, GB-18, GB-21, GB-24, and GB-28) were completed as piezometers. All of the piezometers were constructed using 2-inch diameter PVC casing, with 10-feet of 0.010-inch slotted screen. Clean silica sand was used for the filter pack around the screen and extended approximately two feet above the top of the screen. Bentonite chips were used to provide a surface seal. All of the piezometers were completed as flush-mounted monuments set in concrete extending approximately 3 feet below ground surface. The piezometers have lockable caps and locks. Details of the piezometer completions are provided on the respective boring logs in Appendix A-1.

3.2 Cone Penetration Tests (CPTs)

Eleven cone penetration tests (CPT-1 through CPT-11) were conducted on May 18 through May 21, 2009 to evaluate the soil and groundwater conditions underlying the alignment as a supplement to the hollow-stem auger borings. The CPTs were advanced to depths between 32.32 feet bgs and 81.0 feet bgs. The City of Mount Vernon and the Dike District 12 secured right-of-entry for all of the locations where the CPTs were performed.

The CPT locations and depths are listed below in Table 3-2. The stationing locations given below are based on the stationing shown on Figures 4 through 10. Latitudes, longitudes, and stationing locations should be considered approximate, as the CPT locations were not surveyed. A handheld GPS unit was used to determine the latitude and longitude of the CPT locations.

TABLE 3-2

CPT Depths and Locations

Exploration Number	Depth of CPT (feet)	Latitude	Longitude	Approximate Stationing
CPT-1	60.20	48° 28.953'57.18"N	122° 17'53.76"W	228+38
CPT-2	63.32	48° 28.803'48.18"N	122° 17'48.84"W	210+76
CPT-3	81.00	48° 28.428'25.68"N	122° 17'57"W	186+29
CPT-4	72.83	48° 28.292'17.52"N	122° 18'13.14"W	172+14
CPT-5	62.01	48° 28.05'3"N	122° 18'39.42"W	148+49
CPT-6	79.72	48° 27.377'22.62"N	122° 19'15.48"W	99+80
CPT-7	60.20	48° 26.992'59.52"N	122° 19'27.9"W	71+74, 75 ft Left
CPT-8	74.64	48° 26.806'48.36"N	122° 19'40.8"W	54+86, 674 ft Right
CPT-9	66.17	48° 26.826'49.56"N	122° 19'59.46"W	44+41, 20 ft Left
CPT-10	32.32	48° 26.817'49.02"N	122° 20'24.84"W	27+21
CPT-11	70.54	48° 27.022'1.31"N	122° 20'49.62"W	0+15

The CPTs were completed by In Situ Engineering of Snohomish, Washington using truck-mounted CPT equipment. The CPT testing consisted of pushing an approximately 1.4-inch diameter cone attached to steel rods and continuously recording information on the subsurface conditions provided by electronic transducers located in the cone and rods. Collected data included tip resistance, friction ratio, and pore pressure. At selected locations, pore pressure dissipation testing was also performed. The dissipation testing was generally used to determine the static groundwater levels which are shown on the CPT records. Summary records of the CPT testing are provided in Appendix A-2.

4.0 GEOLOGIC SETTING

4.1 General Geologic Setting

The recent geologic history of the Puget Sound Lowland region has been dominated by several glacial episodes. The most recent, the Vashon Stade of the Fraser Glaciation (about 12,000 to 20,000 years ago), is responsible for most of the present day geologic and topographic conditions. As worldwide sea levels lowered and the Puget lobe of the Vashon Stade advanced southward from British Columbia into the Puget Sound Lowland, sediments composed of proglacial lacustrine silt and clay, advance outwash, lodgment till, and recessional outwash were deposited upon either bedrock or older Pre-Vashon sediments. The older Pre-Vashon deposits include predominantly glacial and nonglacial sediments deposited during repeated glacial and interglacial periods during the past 2 million years. As the Puget Lobe of the Vashon Stade glacier retreated northward, it deposited a discontinuous veneer of recessional outwash and local deposits of ablation till upon the glacial landscape. The sculpted landscape was characterized by elongated north-south oriented uplands, and intervening valleys. Post glacial deposits include: alluvium deposited within active stream channels, modern lacustrine deposits, organic silt and local peat deposits within depressions, drainages, and outwash channels; volcanic lahar, and landslide deposits.

The geologic map prepared by D.P. Dethier and J.T. Whetten (1981) indicates that the site is underlain by artificial fill or alluvium. The artificial fill consists of man-placed soils. The alluvium is described as fluvial sand, silt, and gravel with minor lacustrine deposits along the Skagit River.

The project area lies in the broad alluvial valley of the Skagit River. The Holocene alluvial sediments have been filling the valley since the retreat of Vashon Stade glaciers from the area. The alluvial sediments consist of interbedded channel, overbank and quiet-water deposits. Channel deposits consist primarily of sand and gravel that were deposited in a relatively high-energy environment, typically on the bed or pointbar of a channel of the Skagit River. Overbank deposits consist of silt and silty fine sand that were deposited during floods of the Skagit River. Overbank deposits may also contain trace amounts of woody debris and other organic material. Quiet-water deposits primarily consist of silt, clay and fine sand that were deposited in low-energy environments, such as lakes, marshes, estuary type environments, oxbow lakes, or small side channels associated with the Skagit River. Quiet-water deposits tend to contain more organic material than the overbank deposits.

From boreholes and well logs reviewed, these alluvial sediments can be in excess of 150 feet thick. According to the geologic map by Dethier and Whetten (1981), isolated bedrock outcrops are present within the valley, although it does not appear that any are located within the project area.

The most recent agent of change in the project area has been human activity. In the course of modern settlement in the Burlington area, humans have greatly modified the area of the project through the construction of bridges, placement of fill, placement of rip-rap along the river banks, and the construction of buildings, structures, roads, and utilities. Specific conditions underlying the project are discussed in the following section (Section 5.0).

5.0 SUBSURFACE CONDITIONS

The following sections summarize the soil and groundwater conditions encountered during the hollow-stem auger and CPT explorations. Section 5.1 outlines previous reports referenced for this project. Section 5.2 discusses the general soil conditions encountered along the project alignment, and discuss soil conditions underlying specific areas of the project. Section 5.3 discusses the general groundwater conditions underlying the alignment, including a discussion of hydraulic conductivity, and the elevation of the groundwater at the time of drilling. Summary boring and CPT logs are provided in Appendix A. The subsurface soil conditions interpreted from the explorations along and adjacent to the alignment are visually depicted on Figures 4 through 10.

5.1 Previous Investigations

To supplement the borings drilled for this project, we have reviewed the results from borings and test pit logs from previous investigations by others. Although the conclusions and interpretations summarized in this report are primarily drawn from the exploration work Golder conducted in April 2009, previous reports provide additional information about conditions underlying the proposed flood protection project and the nearby vicinity. Select boring logs from these reports are discussed in the following list. Their locations are shown on Figure 3 and supplemented the exploration work by Golder. The complete versions of these reports are presented in our Preliminary Geotechnical Evaluation (March 5, 2009).

- Fifty borings were advanced by the Army Corps of Engineers between 1964 and 1978. Nine of these borings were drilled along or near the current levee alignment to depths between 6.5 feet and 51.5 feet.
- Ten borings (B-1 through B-10) were drilled by Shannon and Wilson in 1997, 1998, and 1999 for the Riverside Bridge Replacement project. Boring B-8 was drilled on the current levee alignment and was included in our analysis of the project
- Twenty-one borings were drilled and twenty-five test pits were excavated by Landau Associates in 2003 for the construction of a Home Depot store (since constructed). Similar soil conditions were reported in all of the explorations. We selected borings B-1 through B-6 as representative explorations to include in our analysis of the project.

5.2 Site Subsurface Soil Conditions

5.2.1 General Soil Conditions

Geologic units encountered in the various borings included fill and alluvial deposits consisting of: Quiet-water deposits, overbank deposits, and channel deposits. General descriptions of these units are presented below. However; for specific soil descriptions, the exploration logs should be reviewed as provided in Appendix A.

Fill – The uppermost unit encountered across the entire project alignment was interpreted to be human-placed fill. The soil making up the fill was most likely derived from a mixture of local sources of imported material. The density of the fill material ranged from very loose to very dense. The fill thickness in the Western Area of the project ranged from 1.5 to 4 feet with the exception of borings GB-18, GB-19, GB-22, and GB-23 which ranged from 12 to 24 feet. Borings GB-18 and GB-19 were located at the top of the existing levee. Borings GB-22 and GB-23 are located in areas of major roadways supported by fill. The fill contained asphalt underlain by crushed rock base course and dark brown to gray sand with varying amounts of silt, gravel, and organics to gray-brown, silty gravel with some sand.

The fill thickness in the Northeastern Area of the project ranged from 9.5 to 19.5 feet with the average thickness 14 feet. All of the borings in the Northern Area are located on top of the existing levee. In general, the fill material was heterogeneous ranging from gray brown, silty sand to gray brown sand with trace silt to sandy silt with varying amounts of organic fragments, rootlets, straw, and sand pockets.

Quiet-Water Deposits – Quiet-water deposits primarily consist of silt, clay, and fine sand that were deposited in low-energy environments, such as lakes, marshes, oxbow lakes, or small side channels associated with the Skagit River. Quiet-water deposits tend to contain more organic material than the overbank deposits. Quiet-water deposits were encountered underlying the fill or as lenses within the other deposits. This deposit was not encountered in all explorations and varied in thickness between 1.1 to 10 feet. In general the deposit consisted of very soft to soft, gray to brown, non-stratified to stratified, silt with sand to clay to plastic silt with organic fragments up to 8 inches in thickness, and trace iron-oxide staining.

Overbank Deposits – Overbank deposits are deposited during floods of the Skagit River. Overbank deposits are generally finer grained than the channel deposits and may also contain trace organic materials. Overbank deposits were encountered in all borings underlying the fill or quite-water deposits. The overbank deposits generally overlay and were occasionally interbedded with the channel deposits. In general the overbank deposits consisted of loose, light gray to blue gray, stratified, fine sandy silt with trace organic fragments and trace gravel to compact, light gray, non-stratified, silt with some fine sand, sand seams, and iron-oxide stained layers and pockets of loose, brown to light gray, stratified, sand with little silt and trace iron-oxide stained layers. Boring GB-19 was terminated in this unit.

Channel Deposits – Channel deposits were deposited in a relatively high-energy environment, typically on the bed or pointbar of a channel of the Skagit River. This unit generally underlies the overbank deposits and occasionally interbedded with quite-water deposits. The channel deposits generally consisted of compact to very dense, brown gray, non-stratified to slightly stratified, fine to coarse sand with little to trace silt and trace gravel to very loose to loose, gray, non-stratified sand with little silt. All borings, except for GB-19, was terminated in this unit.

Subangular scoria and mica grains were observed in the channel deposit samples. These minerals typically mechanically alter during transport. The shape and size of the minerals observed in the samples indicates that the material did not travel far and in fact might be a lahar deposit. However, we did not distinguish between a river channel deposit and a possible lahar deposit.

TABLE 5-1

Depths of Soil Units Encountered

Exploration Number	Fill (ft bgs)	Quiet-Water Deposit (ft bgs)	Overbank Deposit (ft bgs)	Channel Deposit (ft bgs)	Exploration Depth (ft bgs)
GB-1	0 - 9.5	17 - 19.5	9.5 - 17 19.5 - 58	58 - 61.5	61.5
GB-2	0 - 9.5	17 - 19.5	9.5 - 17 19.5 - 44	44 - 46.5	46.5
GB-3 (i)	0 - 14.5	20.3 - 24	14.5 - 20.3	24 - 41.5	41.5
GB-4	0 - 15.9	15.9 - 17	17 - 38	38 - 51.4	51.4
GB-5	0 - 17	-	17 - 21.5	21.5 - 31.3	31.3
GB-6 (i)	0 - 16.5	-	16.5 - 22	22 - 36.5	36.5
GB-7	0-14.5	-	14.5 - 28	28 - 36.5	36.5
GB-8	0 - 13.3	-	13.3 - 18.1	18.1 - 35.9	35.9
GB-9	0 - 9.5	-	9.5 - 12	12 - 31	31
GB-10 (i)	0 - 9.5	-	9.5 - 24	24 - 41.5	41.5
GB-11	0 - 12	-	12 - 17	17 - 36	36
GB-12	0 - 17	-	17 - 29 39 - 49	29 - 39 49 - 61.5	61.5
GB-13	0 - 14.5	-	14.5 - 24	24 - 56.5	56.5
GB-14 (i)	0 - 19.5	59 - 69	19.5 - 59	69 - 80.5	80.5
GB-15	0 - 19.5	19.5 - 25.5	25.5 - 29	29 - 36.5	36.5
GB-16	0 - 4.5	29 - 37.5	4.5 - 17	17 - 29 41.5 - 51.5	51.5
GB-17	0 – 3.1	12 - 15.6	3.1 - 12	15.6 - 41.5	41.5
GB-18 (i)	0 - 19.5	-	19.5 - 64	64 - 71	71
GB-19	0 – 13.5	-	13.5 – 61.5	-	61.5
GB-20	0 - 7	-	7 - 21.5 39 - 44	21.5 - 39 44 - 56.5	56.5
GB-21 (i)	0 - 4.5	-	4.5 - 24 39 - 49	24 - 39 49 - 66.5	66.5
GB-22	0 - 24	-	24 - 39	39 - 51.5	51.5
GB-23	0 - 12	-	12 - 28	28 - 46.4	46.4
GB-24 (i)	0 - 4.5	4.5 - 13.3	13.3 - 24	24 - 56.5	56.5
GB-25	0 - 2	-	2 - 24	24 - 36.5	36.5
GB-26	0 - 2	-	2 - 12	12 - 36.5	36.5
GB-27	0 - 2	-	2 - 14.5	14.5 - 26.5	26.5
GB-28 (i)	0 - 1.5	-	1.5 - 9.5 25.7 - 29	9.5 - 25.7 29 - 31.5	31.5

Notes:
(i) Piezometer installed.

5.2.2 Geological Interpretation

The subsurface soil conditions encountered in our explorations varied across the project alignment. Figures 4 through 10 depict our interpretations of subsurface conditions underlying the proposed project alignment, as provided by PIE. The subsurface conditions depicted on Figures 4 through 10 are generally based on the exploration work completed for this project, supplemented with results from borings and test pits from previous investigations by others, as described in Section 5.1. The geologic profile was selected to match the project alignment current as of this report.

Figures 11 and 12 depicts our interpretation of the soil conditions at thirteen sections located across the profile, sections A-A’ through M-M’. The stability sections were used for analysis of slope stability for the project, as described in Sections 7.1 and 7.4. These stability sections are not meant to represent geologic cross-sections and may differ slightly from the alignment profile geology presented on Figures 4 through 10. Additional interpretation was made on the stability sections using engineering judgment supplemented by borings from the U.S. Army Corps of Engineers (1964, 1978).

As previously discussed in Section 3.0, several of our borings (GB-17 through GB-21 and GB-27) and a CPT (CPT-8) are offset from the project alignment current as of this report. The profile and analysis sections in the vicinity of these explorations required geological interpretation over a longer distance. Subsurface conditions between the actual boring locations and the project alignment may differ than what was encountered during the field investigation.

5.2.3 Heaving Sand Conditions

Heaving sand conditions were encountered in several of the borings at varying depths within the channel deposits (as noted on the boring logs, Appendix A). Heaving sands occur when the hollow stem auger is below the water table and the head difference between the groundwater and the inside of the augers pushes clean sands up into the inside of the auger. The driller can reduce the sample disturbance by adding potable water to the inside of the auger to help equalize the water pressure on both sides of the auger. When the driller lowers the sample rods into the auger to begin sampling, the heaving sands can already be flowing up into the auger and causes the blow counts for the standard penetration test to be low as the sands have been disturbed. Other times, heaving sands can cause the blow counts for the standard penetration test to be high. This occurs when the sands continue to heave into the auger as the sample is being driven, this causes the sample and auger to be locked together and advance together. During the advancement of the boring for this project, we encountered heaving conditions with elevated blow counts. These conditions are noted on the boring logs. In the general areas that the borings encountered the heaving sands, cone penetration tests (CPTs) were advanced. The estimated blow count values calculated by the CPTs are not affected by heaving sands. During the engineering analysis of these areas, the blow count data collected from the CPTs were used. The CPT data confirmed the artificial elevated blow counts in the zones of heaving sands.

5.3 Groundwater Conditions

5.3.1 Groundwater Depth and Elevation

Groundwater was encountered in all of the borings drilled for this project (GB-1 through GB-28). The measured elevation of the groundwater table at the time of drilling ranged from 11 feet above mean sea level (amsl) to 27.9 feet amsl, with a trend of the water increasing in elevation to the northwest. The top of the borings, including the eight borings completed as piezometers, had not been surveyed at the time of this report, and thus the measured elevations of the water table should be considered to be approximate. Typically, the water table underlying the project should be expected to be at an elevation similar to the water level of the Skagit River, except during flood event. The approximate groundwater elevations measured at the time of drilling for all borings and in the piezometers after installation are presented in Table 5-2.

The nearest continuously operating water level gage on the Skagit River is the United States Geological Survey gage number 12200500, located on the right bank approximately 150 feet downstream from South Burlington Boulevard bridge. This is approximately 430 feet south of GB-23. The USGS notes that the gage is located at latitude 48°26'42" and longitude 122°20'03" (NAD27). Water levels and discharge amounts have been recorded between 1941 through 2007. Based on this gage, the maximum water level elevation of the Skagit River was 37.37 feet amsl on November 25, 1990; the minimum water level elevation of the Skagit River was 7.37 feet amsl on October 26, 1942; and the mean water level of the Skagit River from 1990 to 2008 was about 14.64 feet amsl.

TABLE 5-2

Groundwater Depths

Exploration Number	Elevation of Groundwater (feet)						
	During Drilling	After Piezometer Installation					
		4/14/09	4/17/09	4/24/09	4/27/09	5/19/09	7/24/09
GB-1	28	-	-	-	-	-	-
GB-2	25	-	-	-	-	-	-
GB-3 (i)	23	23	23	24	23	25	22
GB-4	22	-	-	-	-	-	-
GB-5	21	-	-	-	-	-	-
GB-6 (i)	20	-	21	22	21	23	20
GB-7	15	-	-	-	-	-	-
GB-8	18	-	-	-	-	-	-
GB-9	19	-	-	-	-	-	-
GB-10 (i)	16	-	-	20	19	21	19
GB-11	18	-	-	-	-	-	-
GB-12	17	-	-	-	-	-	-
GB-13	20	-	-	-	-	-	-
GB-14 (i)	18	-	-	-	18	20	18
GB-15	18	-	-	-	-	-	-
GB-16	15	-	-	-	-	-	-
GB-17	16	-	-	-	-	-	-
GB-18 (i)	17	-	-	19	19	20	18
GB-19	16	-	-	-	-	-	-
GB-20	15	-	-	-	-	-	-
GB-21 (i)	14	-	-	18	17	19	17
GB-22	17	-	-	-	-	-	-
GB-23	14	-	-	-	-	-	-
GB-24 (i)	12	-	-	-	15	18	15
GB-25	11	-	-	-	-	-	-
GB-26	12	-	-	-	-	-	-
GB-27	15	-	-	-	-	-	-
GB-28 (i)	16	-	-	17	17	17	17

Notes:
(i) Piezometer installed.

5.3.2 Hydraulic Conductivity

As summarized in Section 3.3, five soil samples were submitted for grain size analysis. Based on the results of grain size analysis, we have estimated saturated hydraulic conductivity for four of these samples, using the Hazen and Massmann methods, as summarized in Table 5-3 (Freeze and Cherry, 1979; Massmann, 2003). The results of the laboratory soil testing are described in Section 6.0. The equations and values used to estimate hydraulic conductivity are provided in Appendix B-5.

TABLE 5-3

Estimated Saturated Hydraulic Conductivity

Exploration Number	Depth (feet)	Hazen		Massmann		Geologic Unit	USCS
		K^1 (cm/s)	K^1 (ft/day)	K^1 (cm/s)	K^1 (ft/day)		
GB-8	2.5	0.00014	0.41	0.0022	6.21	Fill	ML
GB-4	25	0.00029	0.82	0.0012	3.39	Overbank Deposits	ML
GB-23	17.5	0.00212	6.0	0.0068	19.37	Overbank Deposits	SM
GB-27	7.5	0.00084	2.38	0.0026	7.49	Overbank Deposits	ML
GB-1	60	0.062	176.4	0.029	81.19	Channel Deposit	SP-SM
GB-3	30	0.00032	0.92	0.0013	3.34	Channel Deposit	SP
GB-5	30	0.023	65.3	0.044	123.93	Channel Deposit	SP
GB-9	30	0.091	257.9	0.091	256.76	Channel Deposit	SP
GB-13	50	0.062	176.4	0.051	145.66	Channel Deposit	SW
GB-21	65	0.022	62.8	0.034	97.75	Channel Deposit	SW

The results of the hydraulic conductivity analysis are consistent with our geologic interpretations. That is, the coarser-grained channel deposits generally have a higher hydraulic conductivity than the finer grained overbank and fill deposits. Based on this analysis, the average of the calculated saturated hydraulic conductivity of the primary geologic units encountered in our borings is as follows:

Undocumented Fill

- Hazen Method: 1.4 x 10^{-4} centimeters/second; 2.4 feet/day
- Massmann Method: 2.2 x 10^{-3} centimeters/second; 6.21 feet/day

Overbank Deposits

- Hazen Method: 1.2 x 10^{-3} centimeters/second; 3.1 feet/day
- Massmann Method: 3.6 x 10^{-3} centimeters/second; 10.1 feet/day

Channel Deposits

- Hazen Method: 5.8 x 10^{-2} centimeters/second; 166 feet/day
- Massmann Method: 5.9 x 10^{-2} centimeters/second; 166 feet/day

6.0 LABORATORY TESTING

Selected samples collected from the hollow-stem auger borings were submitted for geotechnical testing. The samples collected using the split spoon were submitted to our Redmond, Washington laboratory. The five Shelby tubes were submitted to Soil Technology, Inc in Bainbridge Island, Washington. Geotechnical laboratory tests were conducted to characterize engineering and index properties of the site soils. While performing the tests discussed below, the natural moisture content of the soil samples was determined in accordance with American Society for Testing and Materials (ASTM) D2216-90. The results of all of the laboratory testing are presented in Appendix B.

The Atterberg Limits test was used to determine the Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) for ten samples in accordance with ASTM D-4318. The table below summarizes the results of the Atterberg Limits analyses and the soil type based on the United Soil Classification System (USCS). The results of the Atterberg Limits testing are presented in Appendix B-1.

TABLE 6-1

Atterberg Limits Analyses Summary

Exploration Number	Sample Depth (feet)	Liquid Limit	Plastic Limit	Plasticity Index	USCS
GB-6	20	35	31	4	ML
GB-13	17.5	46	32	14	ML
GB-14	20	28	29	1	ML
GB-14	62	29	25	4	ML
GB-15	20	32	33	0	ML
GB-17	15	45	36	9	ML
GB-20	7.5	43	40	3	ML
GB-24	13.5	NV	NP	NP	ML
GB-28	25	82	49	33	MH
GB-28	27.5	46	31	15	ML

The grain size distributions of eleven soil samples were determined in accordance with ASTM D-422. The table below summarizes the results of the grain size analyses and the soil type based on the USCS. The results of the grain size distribution testing are presented in Appendix B-2.

TABLE 6-2

Grain Size Analyses Summary

Exploration Number	Sample Depth (feet)	Percent of Gravel	Percent of Sand	Percent Passing No. 200 Sieve	USCS
GB-1	60	0	93	7	SP-SM
GB-3	30	0	33	67	ML
GB-4	25	0	33	67	ML
GB-5	30	0	97	3	SP
GB-7	17.5	0	6	94	ML
GB-8	2.5	5	43	52	ML
GB-9	30	5	94	1	SP
GB-13	50	20	75	5	SW
GB-21	65	27	68	5	SW
GB-23	17.5	0	67	33	SM
GB-27	7.5	0	49	51	ML

The percent passing the number 200 sieve test was used to determine fines content for nine samples in accordance with ASTM D-1140. The table below summarizes the results of the percent passing the number 200 sieve analyses and the soil type based on the USCS. The results of the number 200 sieve analyses testing are presented in Appendix B-3.

TABLE 6-3

Grain Size Analyses of 200 Sieve Wash Only Summary

Exploration Number	Sample Depth (feet)	Percent Retained on No. 200 Sieve	Percent Passing No. 200 Sieve	USCS
GB-1	61.2	12	88	ML
GB-2	20	42	58	ML
GB-4	7.5	52	48	SM
GB-7	25	31	69	ML
GB-10	10	95	5	SP
GB-12	17.5	7	93	ML
GB-16	7.5	16	84	ML
GB-18	40	48	52	ML
GB-25	10	14	86	ML

Moisture content tests were completed on a total of 36 samples in accordance with ASTM D-2216. The table below summarizes the results of all moisture contents and the soil type based on the USCS.

TABLE 6-4

Moisture Content Summary

Exploration Number	Sample Depth (feet)	Moisture Content	USCS
GB-1	60	21.9	SP-SM
GB-1	61.2	37.7	ML
GB-2	20	41.7	ML
GB-3	30	34.6	ML
GB-4	7.5	21.8	ML
GB-4	25	29.4	ML
GB-5	30	24.7	SP
GB-6	20	38.2	ML
GB-7	17.5	34.0	ML
GB-7	25	57.9	ML
GB-8	2.5	23.8	ML
GB-9	30	22.3	SP
GB-10	10	8.6	ML
GB-12	17.5	34.8	ML
GB-13	17.5	44.2	ML
GB-13	50	17.0	SW
GB-14	20	40.7	ML
GB-14	62	36.0	ML
GB-14	63	35.0	ML
GB-14	63.5	36.0	ML
GB-15	20	24.2	ML
GB-16	7.5	37.7	ML
GB-17	15	50.0	ML
GB-17	15.5	92.0	ML
GB-18	40	35.1	SP
GB-20	7.5	51.6	ML
GB-21	65	12.4	SW
GB-23	17.5	16.8	SM
GB-24	13.5	31.0	ML
GB-24	14	39.0	ML
GB-24	14.5	36.0	ML
GB-25	10	40.1	ML
GB-27	7.5	23.9	ML
GB-28	25	69.2	MH
GB-28	27.5	39.8	ML
GB-28	28.2	28.0	ML

7.0 ENGINEERING ANALYSIS

This section of the report summarizes the geotechnical engineering analyses performed, based on the subsurface conditions encountered in our explorations conducted for this project and previous borings conducted for other projects. Appendices C, D, E, and F present the calculations and outputs used for our engineering analysis.

7.1 General

The purpose of these analyses was to evaluate the existing and proposed levees based on slope stability, seepage, and settlement analyses and provide comments on the locations of the proposed levees and raises. We used the USACE guidelines (EM 1110-2-1913) for assessing the levees.

The minimum design height of the flood protection measures used in our analysis was based on the 100-year flood event. PIE provided Golder with USACE and PIE elevations for the top of the levee and 100-year flood event along the project alignment. The flood protection measure elevations as proposed by USACE were between approximately 1.9 to 3.3-feet higher in elevation than the PIE elevations. For our analysis, we generally reviewed both cases. Both cases included between 3 and 3.5-feet of freeboard.

As discussed in Section 5.2.2, a total of 13 analysis sections (A-A’ through M-M’) along the project alignment, created from the topographic survey data, were used for our analysis (Figures 11 and 12). For seven of these sections (B-B’, C-C’, D-D’, F-F’, G-G’, H-H’, I-I’), bathymetric survey data was also provided. The locations of each section are shown on Figures 3 though 10. The sections analyzed are representative of the existing conditions along the project alignment.

For analysis sections B-B’, C-C’, D-D’, E-E’, F-F’, G-G’, H-H’, and I-I’; raising the existing levees is proposed. For analysis sections K-K’, L-L’, and M-M’; new levees setback from the existing levees are proposed. For these sections, the minimum levee crest width was 20 feet. For analysis sections A-A’ and J-J’, a new levee is proposed adjacent to the existing levee with a minimum levee crest width of 10 and 20 feet respectively. 3H:1V sideslopes were used for the new levee slopes and fill sections placed on existing levees. It should be noted that the new levee configurations were selected to generally reduce the impact footprint of the levee or volume of additional fill required while maintaining stability. A wider crest or flatter sideslopes can generally be utilized, if space permits. Figure 13 shows the proposed levee plan including the locations and schematic cross-sections for raise alternatives.

Based on the subsurface conditions encountered in the field investigation and laboratory test results, the main geotechnical issues at the site are liquefiable soils towards the west end of the Western Area and the existing stability of the Skagit River bank and the BNSF railway embankment. A summary of the geotechnical engineering analyses performed are provided in the following sections.

7.2 Soil Strength Parameters

Soil strength parameters were assigned to the major soil types encountered in our investigation (existing fill, quiet-water deposits, overbank deposits, and channel deposits) and the proposed levee fill material.

Based on the results of our field investigation and laboratory testing, our engineering experience with similar soils in the Puget Sound region, and published typical soil properties (NAVFAC, 1986; Terzaghi et al., 1996; and USACE EM 1110-2-2502), the drained strength parameters for the existing fill, quiet-water deposits, overbank deposits, and channel deposits were selected for the analysis. The soil conditions encountered within each of the units were not constant over the project alignment; therefore, differing strength parameters were used for our analysis depending upon location. The range of strength parameters used is shown in Table 7-1.

The strength parameters for the proposed levee fill material, which we have assumed would consist of compacted silty sand borrow, were selected based on engineering experience.

TABLE 7-1

Soil Strength Parameters

Material Type	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Existing Fill	115 - 125	28 - 33	0
Proposed Levee Fill	120	32	0
Quiet-Water Deposits	115 - 120	26 - 28	0
Overbank Deposits	115 - 120	26 - 30	0
Channel Deposits	120 - 125	30 - 35	0

7.2.1 Groundwater

The groundwater conditions encountered during the field investigations were not constant over the project alignment. Based on the approximate groundwater elevations measured at the time of drilling for all borings and in the piezometers after installation (Table 5-2), a mean water level was chosen for each analysis section.

7.3 Seismic Design Criteria

Based on USACE draft engineering technical letter (ETL) 1110-2-570 dated September 12, 2007 and USACE engineer circular (EC) 1110-2-6067 dated September 20, 2008, we understand that the design earthquake for levees is based on the 10% in 500 years event. Both of the aforementioned documents make reference to USACE EC 1110-2-6001 entitled Seismic Analysis of Dams and Levees, which had a target release date of 2008. We have not been able to obtain a copy of EC 1110-2-6001. Additionally, we understand that ETL 1110-2-570 and EC 1110-2-6067 are draft documents to be used for interim guidance until a final manual, pamphlet or regulation is issued. Therefore, some revision of the seismic analysis may be required at a later date.

7.3.1 Liquefaction Assessment

7.3.1.1 Assumptions

The peak ground acceleration (PGA) values on bedrock for seismic design were estimated using U.S. Geological Survey Earthquake Ground Motion Parameters program v5.0.9. Assuming a risk level of 10 percent probability of exceedance (PE) in 50 years (approximately a 475-year recurrence interval) at a site located at latitude of N48.48.0499, longitude W122.318001. Based on the USGS program a PGA of 0.25g can be used for seismic stability assessment. An earthquake of Magnitude 7.0 was assumed for analysis purposes.

7.3.1.2 Methodology

The liquefaction potential of the soil was evaluated using commercially available computer program LiquefyPro version 5.8a, a proprietary software code produced by CivilTech Software of Seattle-Bellevue area, Washington State, U.S.A.

LiquefyPro uses the procedure presented by Youd and Idriss (2001) to assess the liquefaction hazard of the soil. In this procedure, the cyclic shear stress induced by the earthquake is compared with the cyclic resistance of the soil. If the induced shear stress is greater than the resistance of the soil, liquefaction is likely to occur.

The earthquake-induced cyclic shear stress was calculated using the simplified procedure of Seed and Idriss (1971) using the estimated peak horizontal ground acceleration. The cyclic stress ratio (CSR) is a function of the total vertical overburden stress, the effective vertical overburden stress, the peak horizontal ground acceleration, and a stress reduction coefficient.

The liquefaction or cyclic resistance of the soil was calculated using the procedure in Youd and Idriss (2001) for insitu test data from the SPT tests and Modified Robertson Method (1997) for insitu test data from the CPT tests. For the SPT test data, the SPT blow counts (N) are corrected for the vertical effective stress (N_1), hammer efficiency $(N_1)_{60}$, rod lengths, and fines content of the soil. The corrected value is the $(N_1)_{60cs}$, which is correlated to the cyclic resistance ratio of the soil (CRR). The CRR is adjusted for the earthquake magnitude. For the CPT test data, the measured tip resistance is corrected for the soil behavior type index (I_c), vertical overburden pressure, a reference stress (one atmosphere), and fines content of the soil. The corrected value is the $(q_{C1N})_f$, which is correlated to the CRR of the soil and adjusted for the earthquake magnitude.

For the SPT data, the hammer efficiency is determined by a hammer energy test performed on the equipment used during the field investigation. A summary of the hammer energy test results, as performed by Dynmark Engineering Inc. for Cascade Drilling, Inc., is provided in Appendix E-1.

7.3.1.3 Results

The results of the liquefaction assessment indicate that liquefaction induced by the 500-year design event is likely to occur in the very loose to compact granular deposits. The depth and elevation of soils which would likely liquefy under the design seismic event were computed based on elevation of the borings and CPT's located nearest to the analysis sections. The potentially liquefiable soil zones are summarized in Table 7-2.

TABLE 7-2

Liquefiable Soil Zones

Analysis Section	Liquefied Zone – Depth (ft bgs)	Liquefied Zone – Elevation (ft AMSL)
A-A’	28.5 - 31 38.5 – 43 51 - 56	16 – 13.5 6 – 1.5 (-6.5) – (-11.5)
B-B’	26.5 – 36 40.5 – 41.5 49 – 52.5	18.5 – 9 4.5 – 3.5 (-4) – (-7.5)
C-C’	26.5 - 36 40.5 – 41.5 49 – 52.5	18.5 – 9 4.5 – 3.5 (-4) – (-7.5)
D-D’	28.5 – 32 43 – 46 52 – 56	14.5 – 11 0 – (-3) (-9) – (-13)
E-E’	60 - 73	(-15) – (-28)
F-F’	23 – 27.5	20.5 – 16
G-G’	28.5 – 32 42 – 46 52.5 – 55.5	14.5 – 11 1 – (-3) (-9.5) – (-12.5)
H-H’	28.5 – 32 42 – 46 52.5 – 55.5	14.5 – 11 1 – (-3) (-9.5) – (-12.5)
I-I’	29 - 32	14 - 11
J-J’	17 – 19 38 – 43 48 – 53 57 - 59	14.5 – 12.5 (-7) – (-12) (-16.5) – (-21.5) (-25.5) – (-28)
K-K’	10 – 17 37 – 40 43 – 46 49 – 54 62 - 64	20 – 13.5 (-6.5) – (-10) (-12.5) – (-16) (-19) – (-23.5) (-31.5) – (-33.5)
L-L’	4 – 10.5 10.5 - 17	18 – 11.5 11.5 - 5
M-M’	13.5 – 24 45.5 – 53 61.5 – 69	12.5 – 2 (-19.5) – (-27) (-35.5) – (-43)

The liquefied zones are based primarily on the results of the CPT's. The CPT data is generally considered more reliable for assessing soil density and discriminating between soil types.

The seismic slope stability analysis provided in Section 7.4.3.3 utilizes the results of the liquefaction assessment to determine zones of residual (liquefied) strength for the different analysis sections.

Select results from the liquefaction assessment for the SPT and CPT data are provided in Appendix E-2 and E-3, respectively.

7.4 Slope Stability

7.4.1 Assumptions

- The Dike District 12 Background Report (February 2008) included aerial photos from the Dike District showing the areas along the Skagit River that had rip-rap repairs. However, the thickness of rip-rap is unknown. Additionally, the upper bank of the Skagit River along the project alignment is vegetated. Therefore, we assumed the bank was not susceptible to localized shallow surface sloughing and that the effects of scour and erosion on the river bank would be mitigated as part of on-going maintenance.
- We generally assumed the critical failure circle extended from the toe to the crest of the levee slope.
- Stability analysis of the Skagit River bank were performed only on the seven analysis sections (B-B', C-C', D-D', F-F', G-G', H-H', I-I') where bathymetric survey data was available.
- Pseudo-static stability analyses were not required for the analysis sections as liquefaction was indicated to occur at each location and therefore analyses using reduced (residual) strengths were carried out.

The following table summarizes the target factors of safety that we have assumed for this report. It combines recommendations from Table 6-1b of USACE EM 1110-2-1913 and ETL 1110-2-570 for levees.

TABLE 7-3

Design Factors of Safety

Design Case	Factor of Safety
End-of-Construction (levee)	1.3
Long term (levee)	1.4
Seismic (levee)	1.2
Rapid Drawdown (levee)	1.0

7.4.2 Methodology

An analysis of the stability of the existing and proposed conditions was carried out using the commercially available computer slope stability program Slide version 5.042, a proprietary software code produced by RocScience, Inc. of Toronto, Ontario, Canada. Limit equilibrium analyses were performed using the Morgenstern-Price methods. Select outputs from the Slide analyses are provided in Appendix C and D.

The slope stability analysis was performed to determine the likely static and seismic stability factors of safety for various locations along the project alignment. The slope stability analyses were carried out for a two-dimensional condition.

7.4.3 Static Slope Stability Results

The slope stability of the existing and proposed conditions were analyzed in order to provide recommendations for the proposed levees to maintain the minimum USACE factor of safety requirements.

As described in Section 7.4.1 and Table 7-3, a factor of safety of at least 1.4 is considered acceptable for the static, long-term condition for levees. At each analysis section, the proposed levee crown centerline was generally near the alignment originally provided by PIE. The results of the initial analyses are summarized in Table 7-4 for the original existing condition and for the levee system constructed to the USACE 100-year flood level design crest level. The USACE crest level is always a more critical design condition than the crest designed to the PIE flood level.

TABLE 7-4

Calculated Factors of Safety

Levee Static Stability

Analysis Section	Levee Side	Existing	USACE Design Crest Level
A-A’	River	2.13	1.98
	Land	1.66	1.66
B-B’	River	1.77	1.73
	Land	4.44	3.39
C-C’	River	1.71	1.75
	Land	5.55	5.14
D-D’	River	2.46	2.25
	Land	1.46	1.95
E-E’	River	1.39	1.46
	Land	1.27	1.98
F-F’	River	2.46	2.45
	Land	4.35	3.71
G-G’	River	1.76	1.72
	Land	2.24	2.13
H-H’	River	1.42	1.47
	Land	2.29	1.99
I-I’	River	1.60	1.54
	Land	3.71	3.53
J-J’	River	0.97	1.03
	Land	1.85	1.96
J-J’ Alternate	River	N/A	1.94
	Land	N/A	1.96
K-K’	River	N/A	1.94
	Land	N/A	1.85
L-L’	River	N/A	1.91
	Land	N/A	1.92
M-M’	River	N/A	1.89
	Land	N/A	1.91

In general the existing levees all meet static stability requirement except for the BNSF railway embankment. Raising the levees generally decreases the factor of safety but to levels that are still acceptable according to USACE requirements. River bank stability cannot be accurately assessed because the thickness of the existing rip-rap is unknown. If normal stability analyses are carried out for the river banks, then a surficial stability problem would be indicated. Although the existing bank is steep in many areas, we understand it has been stable for a number of years including following several flood events. The basic assumption relating to scour during flood events is that it has been controlled by proper maintenance after flood events and would continue to be for the project life. However, if required, Golder could carry out an assessment of rip-rap placement records to estimate rip-rap type and thickness. If the records are unclear or not available, a field study may be required.

The following discusses the static slope stability results for the analysis sections. The flood protection measure elevations as proposed by USACE are referenced below. As discussed in Section 7.1, USACE elevations are between approximately 1.9 to 3.3-feet higher in elevation than the PIE elevations.

Section A-A’ – The proposed levee is about 12.5 feet in height (USACE) at this section. The proposed levee centerline is setback from the riverside crest of the existing levee by about 31 feet and overlies approximately 32 feet of the existing levee riverside slope. The proposed levee has minimal impact on existing stability. This section is located north of the river and has no impact on the stability of the river bank. Section A-A’ is shown on Figure 11.

Section B-B’ - The riverside crest of the proposed levee at this section is located approximately 95 feet from the crest of the river bank. A crest raise of about 3.9 feet (USACE) would be required for the existing levee to be at an acceptable crest level. Raising the existing levee has a minimal impact on the existing river bank stability. A static stability analysis of the crest raise on the existing levee indicates that the overall crest to toe stability of the riverside and landside slopes are slightly lower than the static existing conditions. Section B-B’ is shown on Figure 11.

Section C-C’ - The riverside crest of the proposed levee at this section is located approximately 142 feet from the crest of the river bank. A crest raise of about 4.4 feet (USACE) would be required for the existing levee to be at an acceptable crest level. Raising the existing levee has no impact on the existing river bank stability. A static stability analysis of the crest raise on the existing levee indicates that the overall crest to toe stability of the riverside slopes is slightly greater than the static existing condition and the overall stability of the landside slopes are slightly lower than the static existing conditions. Section C-C’ is shown on Figure 11.

Section D-D’ - The riverside crest of the proposed levee at this section is located approximately 200 feet from the crest of the river bank. A crest and landside raise of about 4.4 feet (USACE) at the crest would be required for the existing levee to be at an acceptable crest level. Raising the existing levee has a minimal impact on the existing river bank stability. A static stability analysis of the crest and landside raise on the existing levee indicates that the overall crest to toe stability of the riverside slope is slightly lower than the static existing condition and the overall stability of the landside slope is slightly greater than the static existing condition. Section D-D' is shown on Figure 11.

Section E-E' - A land and riverside raise of about 3.4 feet (USACE) at the crest would be required for the existing levee to be at an acceptable crest level. A static stability analysis of the crest and landside raise on the existing levee indicates that the overall crest to toe stability of the riverside and landside slopes are slightly greater than the static existing conditions. This proposed levee section is located more than 1,000 feet from the Skagit River and has no impact on the stability of the river bank. Section E-E' is shown on Figure 11.

Section F-F' - The riverside crest of the proposed levee at this section is located approximately 161 feet from the crest of the river bank. A crest raise of about 4.3 feet (USACE) would be required for the existing levee to be at an acceptable crest level. Raising the existing levee has no impact on the existing river bank stability. A static stability analysis of the crest raise on the existing levee indicates that the overall crest to toe stability of the riverside and landside slopes is lower than the static existing conditions. Section F-F' is shown on Figure 11.

Section G-G' - The riverside crest of the proposed levee at this section is located approximately 81 feet from the crest of the river bank. A crest raise of about 3.9 feet (USACE) would be required for the existing levee to be at an acceptable crest level. Raising the existing levee has no impact on the existing river bank stability. A static stability analysis of the crest raise on the existing levee indicates that the overall crest to toe stability of the riverside and landside slopes is slightly lower than the static existing conditions. Section G-G' is shown on Figure 12.

Section H-H' - The riverside crest of the proposed levee at this section is located approximately 80 feet from the crest of the river bank. A crest raise of about 4.0 feet (USACE) would be required for the existing levee to be at an acceptable crest level. Raising the existing levee has no impact on the existing river bank stability. A static stability analysis of the crest raise on the existing levee indicates that the overall crest to toe stability of the riverside slope is slightly greater than the static existing condition and the overall stability of the landside slope is lower than the static existing condition. Section H-H' is shown on Figure 12.

Section I-I' - The riverside crest of the proposed levee at this section is located approximately 92 feet from the crest of the river bank. A crest raise of about 3.5 feet (USACE) would be required for the existing levee to be at an acceptable crest level. Raising the existing levee has a minimal impact on the existing river bank stability. A static stability analysis of the crest raise on the existing levee indicates that the overall crest to toe stability of the riverside and landside slopes is slightly lower than the static existing conditions. Section I-I’ is shown on Figure 12.

Section J-J’ – Two levee configurations were analyzed at this section. Both configurations are shown on Figure 12.

- The first proposed levee configuration is a landside raise of the existing BNSF railway embankment. The crest of the proposed levee is about 5.2 feet higher (USACE) than the crest of the existing railway embankment. The proposed levee centerline is setback from the landside crest of the existing railway embankment by about 33 feet and overlies approximately 51 feet of the existing landside railway embankment sideslope. A static stability analysis indicates that the factor of safety for the riverside slope of the existing embankment is unacceptable due to surficial instability. This proposed levee section is located more than 600 feet from the Skagit River and has no impact on the stability of the river bank.
- The alternate levee configuration is a new setback levee west of the existing BNSF railway embankment. The proposed levee is about 17.4 feet in height (USACE) above the existing ground surface. The proposed levee centerline is setback from the landside crest of the existing railway embankment by about 115 feet. This is a new levee configuration that follows USACE EM 1110-2-1913 minimum dimension recommendations. A static stability analysis of the new setback levee indicates that the overall crest to toe stability of the riverside and landside slopes have a factor of safety greater than 1.9. This proposed levee section is located more than 700 feet from the Skagit River and has no impact on the stability of the river bank.

Section K-K’ - The centerline of the proposed new levee is setback from the landside crest of the existing levee by about 260 feet. The proposed new levee is about 18.5 feet in height (USACE) above the existing ground surface. This is a new levee configuration that follows USACE EM 1110-2-1913 minimum dimension recommendations and has a stable configuration. A static stability analysis of the new setback levee indicates that the overall crest to toe stability of the riverside slope has a factor of safety greater than 1.9 and the landside slope has a factor of safety greater than 1.8. This proposed levee section is located more than 400 feet from the Skagit River and has no impact on the stability of the river bank. Section K-K’ is shown on Figure 12.

Section L-L’ - The centerline of the proposed new levee is setback from the landside crest of the existing levee by about 345 feet. The proposed new levee is about 23 feet in height (USACE) above the existing ground surface. This is a new levee configuration that follows USACE EM 1110-2-1913 minimum dimension recommendations and has a stable configuration. A static stability analysis of the new setback levee indicates that the overall crest to toe stability of the riverside and landside slopes have a factor of safety greater than 1.9. This proposed levee section is located more than 450 feet from the Skagit River and has no impact on the stability of the river bank. Section L-L’ is shown on Figure 12.

Section M-M’ - The landside crest of the proposed new levee is setback from the landside crest of the existing levee at its closest location by about 200 feet. The proposed new levee is about 17.4 feet in height (USACE) above the existing ground surface and parallels Bouslog Road. This is a new levee configuration that follows USACE EM 1110-2-1913 minimum dimension recommendations and has a stable configuration. A static stability analysis of the new setback levee indicates that the overall crest to toe stability of the riverside slope (west slope) has a factor of safety greater than 1.8 and the landside slope (east slope) has a factor of safety greater than 1.9. This proposed levee is located at least 200 feet from the Skagit River and has no impact on the stability of the river bank. Section M-M' is shown on Figure 12.

Select results of the static stability analyses for each section are provided in Appendix C.

7.4.4 Seismic Slope Stability Results

The strengths of the liquefiable deposits were estimated using the plot provided by the Federal Energy Regulatory Commission (FERC) and provided for reference in Appendix E-4. The plot is based on work by I.M. Idriss (2002). This method correlates a corrected SPT N-value (corrected for hammer energy and depth below ground surface, converted to an equivalent blow count in clean sand, and designated as $(N_1)_{60CS}$ to a mobilized, undrained residual strength (S_r). Table 7-5 summarizes S_r values for selected $(N_1)_{60CS}$ values and liquefied zones for each section.

TABLE 7-5

Liquefied Strength Zones

Analysis Section	Liquefied Zone – Elevation (ft AMSL)	Residual Strength, S_r (psf)
A-A’	16 – 13.5 6 – 4 4 – 1.5 (-6.5) – (-11.5)	780- 630 680 – 390 390 – 700 820
B-B’	18.5 – 13 13 – 9 4.5 – 3.5 (-4) – (-7.5)	1080 – 410 410 – 230 860 – 1230 510 - 590
C-C’	18.5 – 13 13 – 9 4.5 – 3.5 (-4) – (-7.5)	1080 – 410 410 – 230 860 – 1230 510 - 590
D-D’	14.5 – 11 0 – (-3) (-9) – (-12) (-12) – (-13)	700 – 930 1050 – 730 600 – 570 570 - 620
E-E’	(-15) – (-20) (-20) – (-28)	270 – 340 340 - 550
F-F’	20.5 – 18.5 18.5 - 16	490 – 220 220 - 420
G-G’	14.5 – 11 1 – (-3) (-9.5) – (-12.5)	700 – 930 1050 – 730 570
H-H’	14.5 – 11 1 – (-3) (-9.5) – (-12.5)	700 – 930 1050 – 730 570
I-I’	14 - 11	150 - 430
J-J’	14.5 – 12.5 (-7) – (-12) (-16.5) – (-21.5) (-25.5) – (-28)	680 – 470 410 – 490 730 790 - 590
K-K’	20 – 18 18 – 13.5 (-6.5) – (-8) (-8) – (-10) (-12.5) – (-14) (-14) – (-16)	380 380 – 650 650 – 330 330 – 1620 510 – 410 410 – 640

Analysis Section	Liquefied Zone – Elevation (ft AMSL)	Residual Strength, S_r (psf)
	(-19) – (-23.5) (-31.5) – (-33.5)	540 460
L-L’	18 – 11.5 11.5 - 5	300 300 - 630
M-M’	12.5 – 11 11 – 2 (-19.5) – (-20.5) (-20.5) – (-23.5) (-23.5) – (-27) (-35.5) – (-39.5) (-39.5) – (-43)	650 – 320 320 – 360 670 – 350 350 350 – 960 600 600 - 760

As discussed in Section 7.3.1.3, the liquefied zones and strengths are based primarily on the results of the CPT’s.

As described in Section 7.4.1 and Table 7-3, a factor of safety of at least 1.2 is considered acceptable for the seismic condition for levees. The results of the seismic slope stability analyses are summarized in Table 7-6.

TABLE 7-6

Calculated Factors of Safety

Seismic Slope Stability Using Residual Strengths

Analysis Section	USACE Crest Level Riverside Factor of Safety
A-A’	1.98
B-B’	1.59
C-C’	1.55
D-D’	2.53
E-E’	1.46
F-F’	2.18
G-G’	1.46
H-H’	1.2
I-I’	1.47
J-J’	>1.2 (i)
J-J’ Alternate	1.96
K-K’	1.74
L-L’	1.08
M-M’	1.63

Notes:
(i) Crest to toe failure surface – surficial movement likely.

The following discusses the seismic slope stability results for select analysis sections. The flood elevations, as proposed by USACE, and locations are discussed in Section 7.4.3. The analysis sections all have an acceptable seismic factor of safety except for section L-L’.

Section L-L’ – This section did not meet the recommended factor of safety for the seismic condition due to the shallow and low strength liquefiable layer underlying the proposed new levee. It may be possible to meet the recommended factor of safety by flattening the levee sideslopes to form a larger levee footprint area. Based on the extent of the damage, maintenance and repair to the levee should be anticipated following the design seismic event. Section L-L’ is shown on Figure 12.

Select results of the seismic stability analyses for each section are provided in Appendix D. Seismically induced settlement of up to 6 inches could occur. Based on the liquefaction assessment results, this will primarily occur in the southern section and three bridges area.

It should also be noted that it is likely that sections of the Skagit River bank are likely to experience sloughing and movement towards the river during a seismic event. Based on our analyses, these surficial bank failures would not impact the integrity of the proposed and existing levee. However, inspection and maintenance should be carried out following a seismic event and any sloughed areas should be repaired as these areas would be susceptible to retrogressive failure and exposed to scour from future flood events. An Operation and Maintenance (O & M) plan, which includes responses to seismic events including emergency repair procedures, can be developed and would enable rapid assessment and repair of damage following a major seismic event.

7.5 Levee Settlement Analysis

7.5.1 Parameters

One-dimensional consolidation tests were carried out on two samples collected during the field investigation from borings GB-17 and GB-24. The tests were completed by Soil Technology, Inc. The results of the consolidation tests (provided in Appendix B-4) were used to obtain compressibility parameters for the quiet-water and overbank deposits.

Compressibility parameters for the channel deposits were estimated by Golder based on blow count data and available correlations. The soil strength parameters in Table 7-1 and compressibility parameters in Table 7-7 were used for the settlement analyses.

TABLE 7-7

Compressibility Parameters

Material Type	Compressibility Parameters
Quiet-Water Deposits	c_c = 0.33, c_r = 0.03 σ_p' = 4.28 ksf, e_o =1.36
Overbank Deposits	c_c = 0.15, c_r = 0.03 σ_p' = 7.28 ksf, e_o =0.85
Channel Deposits	E_s = 500 ksf

7.5.2 Methodology

Settlement analyses were carried out using the commercially available program *Settle3D* version 1.012, a proprietary software code produced by RocScience, Inc. of Toronto, Ontario, Canada. *Settle3D* is a 3-dimensional program for the analysis of vertical settlement and consolidation under surface loads.

Settlement analyses were performed for the following cases:

- Levee crest raise
- Levee crest and landside raise
- Riverside levee raise
- New levee
- New levee tie into existing embankment

The levees were assumed to have a crown width of 20 feet and sideslopes of 3H:1V.

7.5.3 Results

Table 7-8 below summarizes the anticipated total settlement that will be caused by levee construction. Estimated settlements are given for a range of levee heights based on the specific proposed raise alternative. The anticipated settlement pattern where the proposed levee alignment crosses under the existing earthen embankments for Interstate 5 is discussed in Section 7.5.3.1.

The design heights of the levees should be increased to account for the anticipated settlements given in the below table.

TABLE 7-8

Settlement Estimates

Case	Location	Levee Height or Height Increase of Existing Levee (USACE) (ft)	Estimated Settlement (in)	
			Centerline	Toe
Levee Crest Raise	78+77 - 141+25 202+00 - 228+38	3.3 – 5.2	1.0 – 1.5	0 - 0.5
Levee Crest and Landside Raise	141+25 - 202+00	3.4 – 4.4	1.0 – 3.0	0 – 1.0
Riverside Levee Raise	228+38 - 241+50	7.3 – 16.6	2.0 - 4.0	0.5 – 1.0
New Levee	0+00 - 67+12 65+34 - 78+77 (i)	13.7 – 26.6	4.0 – 6.0	0.5 – 1.0

7.5.3.1 Alternate Setback Levee Alignment Parallel To The BNSF Railroad New Levee Tie Into Existing Embankment

The proposed levee alignment crosses the earthen embankments for Interstate 5 and the ramps for South Burlington Boulevard. A settlement analysis was performed where the proposed levee alignment will tie into the existing Interstate 5 embankment from the east. This location was chosen for analysis since it has the maximum proposed fill height at a levee tie in location and an underlying very soft to soft quiet-water deposit.

At the east toe of the existing Interstate 5 embankment, the proposed levee has a fill height of approximately 27 feet. The proposed levee overlies the existing Interstate 5 embankment sideslope. The fill height for the proposed levee decreases to zero as the Interstate 5 embankment height reaches the USACE crest level elevation. As presented in Table 7-8 above, the total maximum settlement that is likely to occur along the centerline of the proposed full height levee is approximately 6 inches. The total settlement induced by the levee on the I-5 embankment decreases from about 4.5 inches at the toe of the I-5 embankment to 1 inch at the termination of the levee. The settlement induced is not likely to impact the shoulder or travelling lanes of the I-5. However, for the I-5 embankment, we recommend that settlement is monitored during construction.

Most of the settlement will occur during construction (approximately 3 inches at the centerline). The remaining portion should occur within the first 60 days after construction.

Another tie in levee occurs where the proposed levee connects to the BNSF embankment. We recommend that when the configuration is agreed upon that Golder review the arrangement in order to assess the settlement impact on the BNSF embankment. It is likely that settlement monitoring of the rail tracks will be required during construction.

7.6 Seepage Assessment

7.6.1 Assumptions

Seepage analyses were carried out for analysis sections E-E’, H-H’, and K-K’. Analysis section E-E’ was selected to represent northern areas where the overbank deposit thins to about 5 feet. Analysis section H-H’ was selected as having the lowest riverside factor of safety for sections close to the river. Analysis section K-K’ was selected to represent a new segment of setback levee and in general any levee section with a river and landside slope of at least 3H:1V.

As noted in our report entitled *Preliminary Geotechnical Evaluation, City of Burlington and Dike District 12 Levee Certification Project, Burlington, Washington* dated March 5, 2009; many sections of the levee have a seepage cut-off trench. The geometry of the cut-off trench has not been fully documented or their locations surveyed. The presence of the cut-offs have undoubtedly reduced underseepage and improved levee performance; however, for the purposes of this report, we have assumed that they are not present.

In addition many of the levees have been widened in response to seepage problem areas identified in the past and many sections have landside slopes at angles flatter than about 4H:1V. The flattening of these slopes helps to improve stability against seepage under and/or through the levees.

7.6.2 Methodology

The commercially available programs *SEEP/W* and *SLOPE/W* version 7.13 produced by Geo-Slope International of Calgary, Alberta, Canada were used. The steady-state (at maximum flood) and transient flow conditions were analyzed using *SEEP/W* and then *SLOPE/W* was used for a conventional slope stability analysis using the pore pressures at a selected time step from *SEEP/W*.

The rise and fall of the flood water was simulated with a hydraulic boundary function. Data from past major floods was assessed in order to develop the function. This data is summarized in Appendix F-1. The floods reviewed included November 1990, November 1995 and October 2003. A conservative combination of slow rise followed by a rapid fall in water level was used. A function was developed to simulate a flood event up to the USACE flood level, as shown in Appendix F-1. The characteristics of this function were that two peaks were simulated in a thirty day period and a maximum rapid drawdown rate of 7 feet per day was used.

The following table provides the hydraulic conductivity for the seepage analysis sections. The strength parameters were as per the static slope stability analysis, as shown in Table 7-1. The conductivities were selected based on the grain size test results and estimates based on material type and in line with Section 5.3.2. However, a range of conductivities were used to assess seepage effects. Hydraulic conductivity and water content functions were selected based on general material type.

TABLE 7-9

Soil Strength Parameters for Seepage Assessment

Material Type	Hydraulic Conductivity Range (ft/day)
Existing Fill	0.3 to 6.2
Overbank Deposits	0.04 to 6.2
Channel Deposits	40 to 166

7.6.3 Results

After the seepage analyses were completed, the pore pressure data was used to carry out slope stability analyses. Stability analyses were carried for the landside slopes under steady-state seepage and for the riverside slopes under rapid drawdown conditions. See Appendix F for summary plots for typical seepage analysis and slope stability analysis results. Each analysis section is discussed as follows:

Section E-E’ – For the transient condition, the riverside slope stability is generally critical at about 2 to 3 days after peak. As described in Section 7.4.1 and Table 7-3, a factor of safety of at least 1.0 is considered acceptable for the rapid drawdown condition for levees. However, the factor of safety for the slope is greater than 1.3, see Appendix F-2. This is because the rate of flood decrease is too low to generate internal pore pressures within the levee and cause slope instability. A parametric study was carried out to check the effect of the fill permeability on the performance of the levee and in general there was no significant effect on drawdown stability. Increased permeability led to greater saturation but also the embankment drained more rapidly. Decreased permeability led to lower levels of saturation and the seepage did not penetrate the embankment to a sufficient depth to cause any instability as the flood level dropped.

For steady-state seepage, the factor of safety for a localized condition at the slope toe is about 1.1 and for an overall crest to toe trial surface the factor of safety is greater than 1.4, see Appendix F-2. As described in Section 7.4.1 and Table 7-3, a factor of safety of at least 1.4 is considered acceptable for the static, long-term condition for levees. However, we consider that this section is acceptable because the flood, based on the transient analysis results, does not stay at the peak level long enough to be able to develop steady-state flow conditions within the levee embankment and the exit seepage gradients are low enough (0.1 to 0.2) to indicate that piping through the embankment does not occur.

Section H-H’ - For the transient condition, the riverside slope stability is generally critical about 2 to 3 days after peak. The factor of safety for the riverside slope is greater than 1.5, see Appendix F-3. For steady-state seepage, the factor of safety is also greater than 1.5.

Section K-K’ - For the transient condition, the riverside slope stability is generally critical about 2 to 3 days after peak. The factor of safety for the riverside slope is greater than 1.5, see Appendix F-4. For steady-state seepage, the factor of safety for a localized condition at the slope toe is about 1.4 and for an overall crest to toe trial surface the factor of safety is greater than 1.5.

We consider that all the sections analyzed have acceptable performance under flood seepage conditions.

Note that surficial failure surfaces potentially occur on the river bank face during the rapid drawdown. However, we have no record of such failures having occurred during the flood events that the drawdown rates are based on. We also note that seepage areas have been recorded behind levees in isolated areas. These seepage areas are probably due to localized ground conditions such as high permeability zones within the channel deposits combining with a thinning of the less permeable overbank deposits. These subsurface conditions are more likely to exist on the northern half of the levee alignment. Also, these seepage areas do not induce slope stability problems and therefore may be treated as an operating and maintenance problem by the dike district.

8.0 RECOMMENDATIONS

This section of the report provides our geotechnical engineering and construction recommendations based on the subsurface conditions encountered in our explorations conducted for this project and borings previously drilled for other projects. The recommendations provided in this report are based on our understanding of the project and are applicable for this site only.

8.1 Recommendations by Project Area

The following sections provide flood protection measure recommendations by area of the project (Figures 2, 4 through 10, and 13).

8.1.1 Northeastern Area (Station 78+50 to 241+50)

The proposed flood protection alignment for the Northeastern Area is shown on Figures 4 through 7 and 13. Either levees or cantilever sheet pile flood walls can be used throughout this area. The cantilever sheet pile wall option is installation of a flood wall on top of the existing crest of the levee. However, given the lengths of levee involved, use of a cantilever sheet pile flood wall is not likely to be cost effective.

8.1.2 Western Area (Station 0+00 to 78+50)

The proposed flood protection alignment for the Western Area is shown on Figures 8 through 10 and 13. Levees should be used between Stations 0+00 and the BNSF railroad embankment. Construction of new levees setback from the existing levees are proposed throughout this area. The use of cantilever sheet pile flood walls is not cost effective in this area considering the height of wall that would be required.

As discussed in Section 2.2, the main project alignment underlies a portion of the BNSF railroad between approximate Stations 68+00 to 78+50. An alternate new setback levee alignment is located approximately 150 feet west of and parallel to the BNSF railroad, between approximate Stations 65+34 and 78+77. If a levee alternative is chosen along the main project alignment, a landside raise of the existing BNSF railway embankment would be required for the existing embankment to be at an acceptable crest level (USACE). The alternate setback levee configuration includes construction of an entirely new setback levee. Based on the results of the stability analyses, the existing riverside slope of the BNSF railroad embankment does not meet static or seismic stability requirements. The addition of levee fill on either side of the BNSF railroad embankment could comprise the stability of the existing railroad embankment. We recommend that the proposed levee should be built entirely separate (a new levee) and constructed west of the BNSF railroad embankment.

An additional alternative to a landside raise to the BNSF railroad embankment is the installation of a cantilever sheet pile flood wall on top of the railroad embankment crest. The cantilever sheet pile would extend approximately from Station 68+00 to 78+50 and would be installed near the riverside edge of the BNSF railroad embankment. However, the riverside slope of the BNSF embankment would require regrading for this alternative to be acceptable. In addition there is likely to be insufficient clearance between the flood wall and the rail tracks and the crest of the embankment would therefore require widening. The riverside slope would have to be regraded to at least 3H:1V and would necessitate realignment of Whitmarsh Road.

Where the alignment crosses under South Burlington Boulevard and Interstate 5, the selected flood protection measure should tie into the existing embankment. A series of closures will be required where the proposed alignment crosses existing local roads. Regardless of the selected configuration, the flood protection measure should tie into the existing BNSF railroad embankment. A railroad flood gate closure will be required where the proposed alignment crosses the railroad tracks.

8.2 Levee Recommendations

A typical levee will consist of an embankment with a composition similar to the underlying foundation materials. The levee should be composed of a uniform, low to moderate permeability material. We recommend silty sand. Potential borrow areas were discussed in our March 2009 report (Golder, 2009).

According to USACE EM 1110-2-1913, the minimum recommended levee crest width is between 10 and 12 feet. Our design included a crest width of 10 to 20 feet; however, a larger width may be required. Operationally, crest widths of 16 to 20 feet are generally preferred. The riverside levee slope can be designed at 3H:1V or flatter and the landside or backslope can be 3H:1V or flatter. A steeper backslope is acceptable provided drainage provisions (toe drains) are incorporated into the design; however, from an operation and maintenance standpoint, it is generally considered that a side slope of 3H:1V is the maximum practical slope. Figure 14 shows a typical levee design.

In most areas, the existing levees can be raised. For a crest raise, levee fill should be placed on the existing levees crest to the desired height and crest width. The levee raise should have sideslopes of 3H:1V and tie into the existing levee sideslopes without enlarging the existing levee foundation area. If one or both of the existing levee sideslopes will receive levee fill, the proposed levee sideslopes should be constructed with 3H:1V sideslopes. Figure 15 illustrates the recommendations for raising the height of existing levees. In general the levees adjacent to the Skagit River should utilize a crest or landside raise in order to avoid reduction of the distance between the levee toe and the river bank.

As discussed in Section 7.5.3, the design heights of the levees should be increased to account for the anticipated settlements given in Table 7-8.

Construction recommendations for levee fill material, placement, and compaction are discussed in Section 8.3.

8.3 Cantilever Sheet Pile Flood Wall Recommendations

Cantilever sheet pile walls consist of corrugated steel sheet piling driven into the existing soil. The sheet pile sections join together and the exposed portions of the sheet piles can be capped with concrete.

Figure 16 shows a typical cantilever sheet pile flood wall design. Cantilever sheet pile walls should be designed to satisfy force and moment equilibrium, while also satisfying global stability. USACE EM 1110-2-2504 can be used in conjunction with the recommendations in this report to determine the minimum embedment depths of cantilever sheet pile walls.

The following should be used for the calculation of the earth pressures for the hydrostatic condition:

Coefficient of Active Earth Pressure (K_a) = 0.3
Coefficient of Passive Earth Pressure (K_p)= 5 (ultimate/unfactored)

The factored/allowable coefficient of passive earth pressure, K_p, varies depending on the design case as per Table 5-1 from USACE EM 1110-2-2504. Allowable K_p values are presented in Figure 17 for the design cases.

Soil Unit Weight, γ = 120 pcf
Buoyant Unit Weight, γ_b = 57.6 pcf

The active and passive earth pressure coefficients assume flat ground behind and in front of the flood wall. If sloping ground is present, the earth pressure coefficients should be modified accordingly. Figure 17 provides the methodology for cantilever sheet pile wall pressure calculations including reduction of passive side pressures due to upward seepage effects in accordance with the USACE manual. We also recommend an H/D ratio of less than 0.5, where H is the height of the water and D is the embedment depth of the sheet pile. In other words the sheet pile embedment depth should be assumed to be two times the flood level: for example if 4 ft of water is present on the river side of the wall then the embedment should be at least 8 ft. The minimum recommended depth of embedment is 6 feet.

8.4 Construction Recommendations

8.4.1 Levee Construction Recommendations

8.4.1.1 General

Based on the subsurface conditions encountered in our investigation, the proposed levee construction is considered feasible. Levee construction will consist of clearing, grubbing, and stripping the foundation area and placing properly compacted levee fill material in stages to achieve new final design alignment and grade.

Fill placement, grading, and compaction can be done using conventional earthwork equipment and will require careful site preparation, surface drainage control, soil handling procedures and sequencing on the part of the earthworks contractor. These issues are discussed in the following sections.

8.4.1.2 Construction Staging

Earth surfaces should not be left open for any length of time, particularly during wet weather. They should be covered with polyethylene to maintain the stability and minimize erosion.

8.4.1.3 Foundation Preparation

Foundation preparation for levees should consist of removal of all obstacles at the ground surface and within the levee foundation area. These may include vegetation, loose stone or gravel, structures, fencing and debris at the ground surface and stumps, large roots (diameter greater than 1.5 inches), buried logs, old piling or other debris within the levee foundation area to a depth of at least 3 feet below the natural ground surface. The levee foundation area will also require stripping, or removal of low growing vegetation and organic topsoil.

Along the majority of the project alignment, the proposed flood protection measure is to raise the crest of the existing levees. The gravel driving surfaces, gates, soil stockpiles, and other debris along the existing levee crown and vegetated sideslopes within the levee foundation area will have to be cleared and removed.

The agricultural fields in the Western Area are vegetated and will require removal of the existing topsoil. Topsoil depths typically range from 6 to 12 inches. Where the alignment abuts an existing levee (north end of the alignment and BNSF railway) or intersects an embankment (South Burlington Boulevard and Interstate 5), the levee foundation area will also require preparation as previously described.

If excavation is required to remove obstacles below the natural ground surface, the subgrade should be flattened and then backfilled with a material similar to the surrounding soils. The backfill should be placed in lifts to the final foundation grade and compacted to a density equal to the adjoining undisturbed soils. Fill placement and compaction is discussed in the next section.

8.4.1.4 Fill Materials and Placement

New levee fill material will be imported to construct the proposed levees. The levee fill material should be uniformly graded silty sand, be near the optimum moisture content and capable of being compacted to the required specifications listed below. The maximum lift thickness for on-site native soils or imported granular materials is 8 inches loose. The fill should be compacted to at least 90% of the ASTM D1557 maximum dry density value for the material.

Samples of proposed fill materials should be tested in a soil laboratory to develop a compaction curve prior to placement. The levee fill material should be compacted with equipment suitable to achieve proper compaction. If density tests taken in the fill indicate that compaction is not being achieved, the fill should be scarified, moisture-conditioned, and re-compacted. If the required densities cannot be met then the material should be excavated and replaced.

8.4.1.5 Use of On-site Soils

We consider that selected areas of native soils in the vicinity of the levees may be suitable for use as fill. In general channel deposits can be reused and some areas of overbank deposits. The quiet-water deposits are generally not suitable for reuse.

8.4.1.6 Construction Monitoring

Critical aspects of the earthwork should be monitored and tested by a qualified geotechnical engineer. These may include but are not be limited to foundation preparation and placement and compaction of levee fill materials.

8.4.2 Cantilever Sheet Pile Flood Wall Construction Recommendations

8.4.2.1 Cantilever Sheet Pile Installation

Based on the geotechnical explorations, the contractor should generally not expect to encounter difficult driving conditions. However, our geological interpretation is based on the observations made at the time of drilling and at the specific boring locations. Actual conditions encountered during construction may be different from those observed in the borings. Variations in subsurface conditions outside the boring locations are common, especially in uncontrolled fill and alluvial environments. The sheet piling contractor should be prepared to deal with driving obstructions in particular woody debris may be present.

8.4.2.2 Levee – Cantilever Sheet Pile Flood Wall Transitions

At locations where the flood protection transitions between levees and cantilever sheet pile flood walls, the levee portion should be completed prior to beginning sheet pile installation.

The sheet pile and levee should overlap a minimum distance equal to the height of the flood protection at that point. Additionally, the heights of the sheet pile and levee should be the same and should be equal to the height of the flood protection at that point. Following this overlap distance, the levee should be tapered off using side slopes no greater than 3H:1V.

9.0 CLOSING

This report has been prepared exclusively for the use of PIE, the City of Burlington, the Dike District 12, and their consultants for specific application for the Burlington Levee Certification Project in Burlington, Washington. We encourage review of this report by bidders and/or contractors as it relates to factual data only (logs of borings, conclusions, etc.). The conclusions and recommendations presented in this report are based on the explorations and observations completed for this study and conversations regarding the proposed levee and are not intended, nor should they be construed to represent, a warranty regarding the proposed levee, but are forwarded to assist in the planning and design process.

Judgment has been applied in interpreting and presenting the results. Variations in subsurface conditions outside the boring locations are common in alluvial environments such as those encountered in Burlington and the site area. Actual conditions encountered during construction may be different from those observed in the borings. When the site project plans are finalized, we recommend that we be given the opportunity to review the plans and specifications to verify that they are in accordance with the conditions described in this report.

The explorations were performed in general accordance with locally accepted geotechnical engineering practice, subject to the time limits and financial and physical constraints applicable to the services for this project, to provide information for the areas explored. There are possible variations in the subsurface conditions between the test locations and variations over time.

The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous site activities or uses of the site and/or resulting from the introduction onto the site of materials from offsite sources are outside the terms of reference for this report and have not been investigated or addressed.

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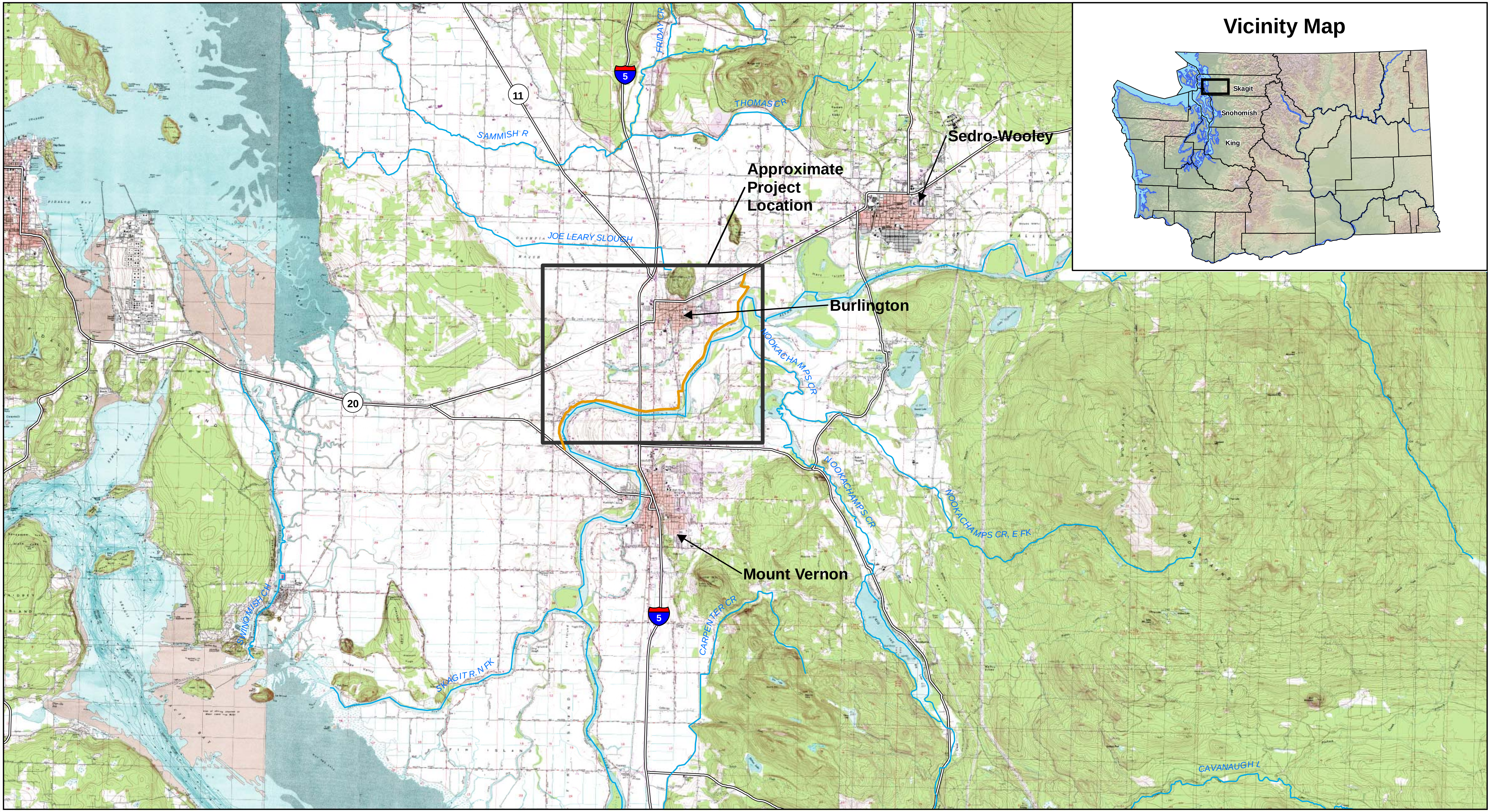
FIGURES



LEGEND

- Existing Dike District 12 Levee
- River
- Highway

0 10000

Scale in Feet

Map Projection:
Washington State Plane
North Zone NAD 1983

Source: USGS, WSDOE, WSDOT,
Skagit County Dike District 12 (2009)

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **1**

PROJECT LOCATION

PIE/BURLINGTON LEVEES/WA

Golder Associates

08393509F05R03.mxd | 10/29/2009 | THAMMOND

This figure was originally produced in color. Reproduction
in black and white may result in a loss of information.

LEGEND

Existing Dike District 12 Levee

Study Area

0 3000

Scale in Feet

N

Map Projection:
Washington State Plane
North Zone NAD 1983

Source: USDA/FSA Aerial Photography Office
(2006), Skagit County Dike District 12 (2009)

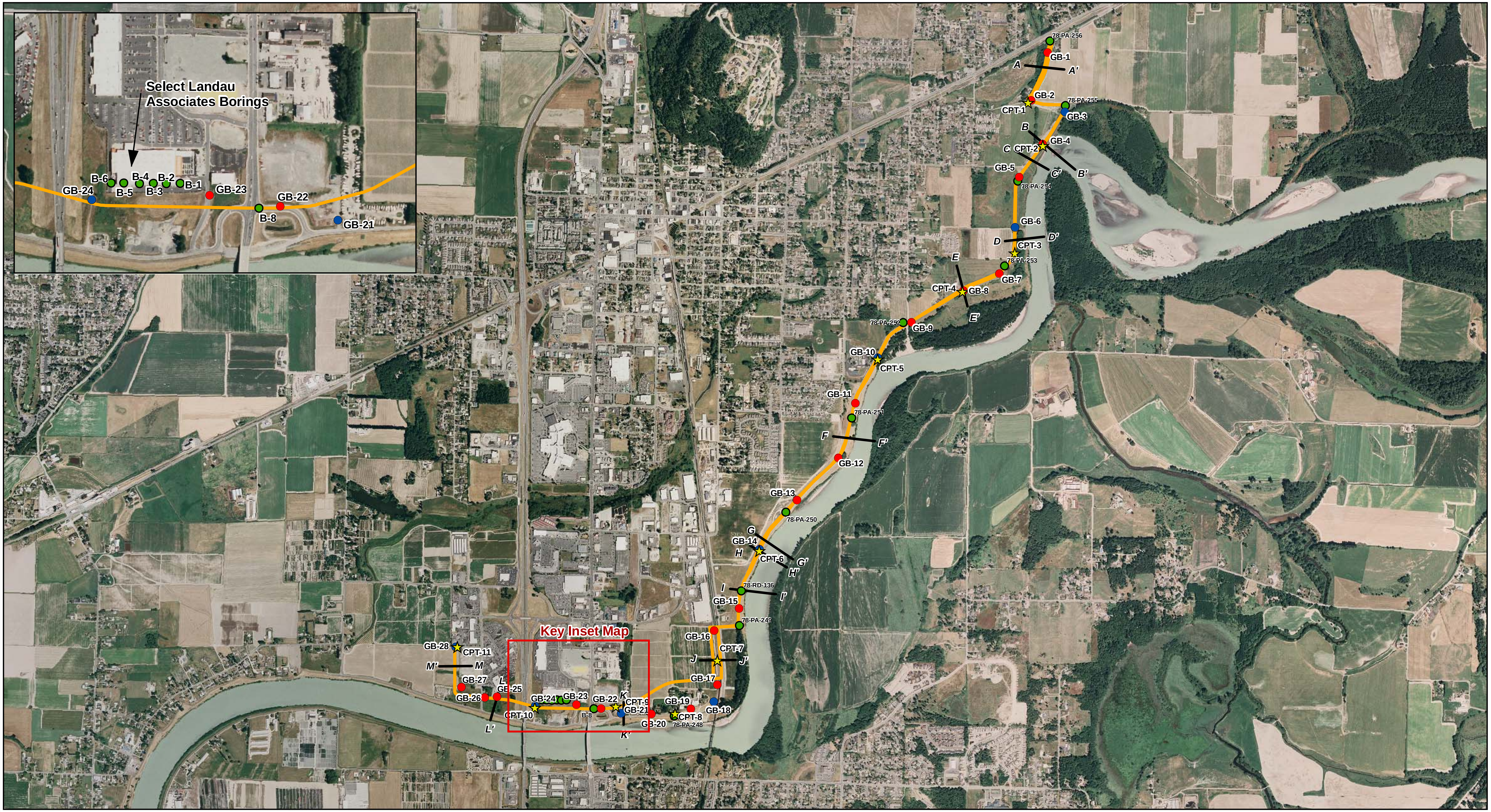
FIGURE 2

BURLINGTON LEVEE
PROJECT AREAS

PIE/BURLINGTON GEOTECH AND LEVEES/WA

Golder Associates

09393153F03.mxd | 10/22/2009 | BVANG-JOHNSON



LEGEND

— Project Centerline and Main Cross Section Line

● Golder Boring Location and Number

● Golder Boring Location and Number with a Monitoring Well Installed

☆ Cone Penetration Test (CPT) Location and Number

Previous Exploration Locations

● Shannon & Wilson Report

● US Army Corps of Engineers Report

● Landau Associates Report

— Cross Section

0 700

Scale in Feet

Map Projection:
Washington State Plane
North Zone NAD 1983

Source: USDA/FSA - Aerial Photography Field Office (2006), US Army Corps of Engineers, Shannon and Wilson

N

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FIGURE **3**

BURLINGTON LEVEE PROJECT EXPLORATION PLAN

PIE/BURLINGTON LEVEES/WA

Golder Associates

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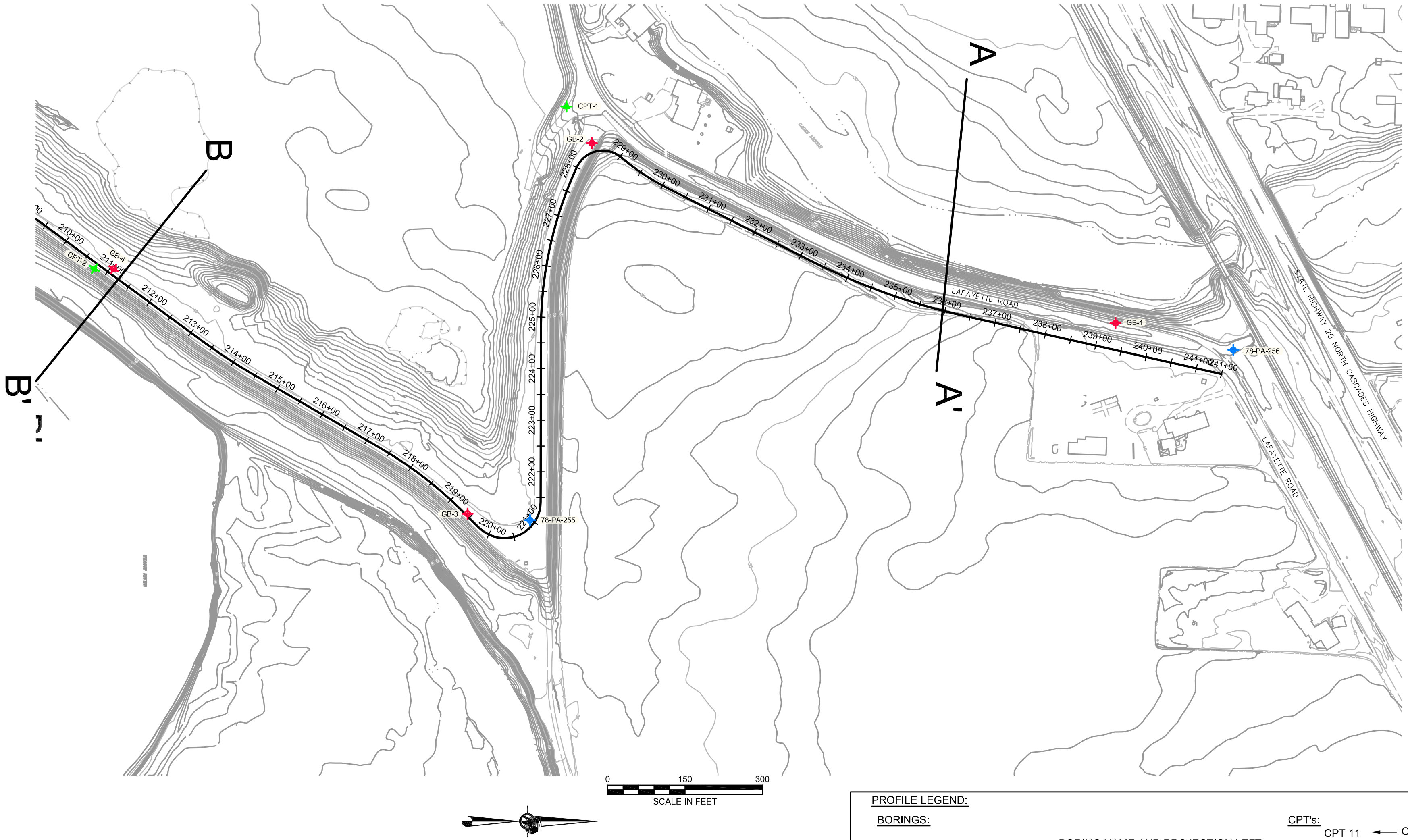


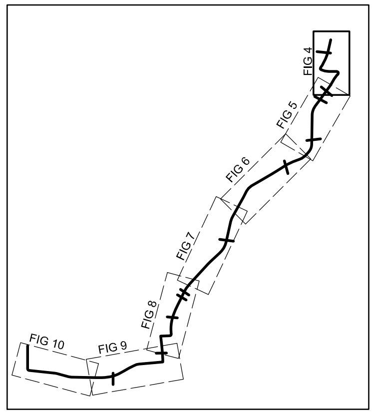
NOTES:

1. INTERPRETED SUBSURFACE CONDITIONS FROM BORINGS DRILLED. DEPICTED SUBSURFACE CONDITIONS USED FOR ENGINEERING ANALYSIS ONLY AND MAY NOT REPRESENT ACTUAL GROUND CONDITIONS.
2. BASEMAP, ALIGNMENT GEOMETRY, AND STATIONING PROVIDED BY PACIFIC INTERNATIONAL ENGINEERING, MAY 2009.

PLAN LEGEND:

⌖ GB-28	APPROXIMATE LOCATION OF BORING BY GOLDER (2009)
⌖ CPT-11	APPROXIMATE LOCATION OF CONE PENETRATION TEST BY GOLDER (2009)
⌖ B-1	APPROXIMATE LOCATION OF BORINGS BY OTHERS

KEY MAP



PROFILE LEGEND:

BORINGS:

GB-1 (78.FT RT) ← BORING NAME AND PROJECTION LEFT OR RIGHT OF PROJECT ALIGNMENT
5
USCS SYMBOL → GW (11-26-07 / 16.5') ← DATE OBSERVED AND WATER LEVEL (FEET BELOW GROUND SURFACE)
16 ← N-VALUE
TD=41.5' ← TOTAL DEPTH
— —?— — ← INFERRED GEOLOGIC CONTACT

CPT's:

CPT 11 ← CPT NAME
← N = 0
← N = 50
← EQUIVALENT N-VALUES (N60)
TD = 70.5' ← CPT TOTAL DEPTH

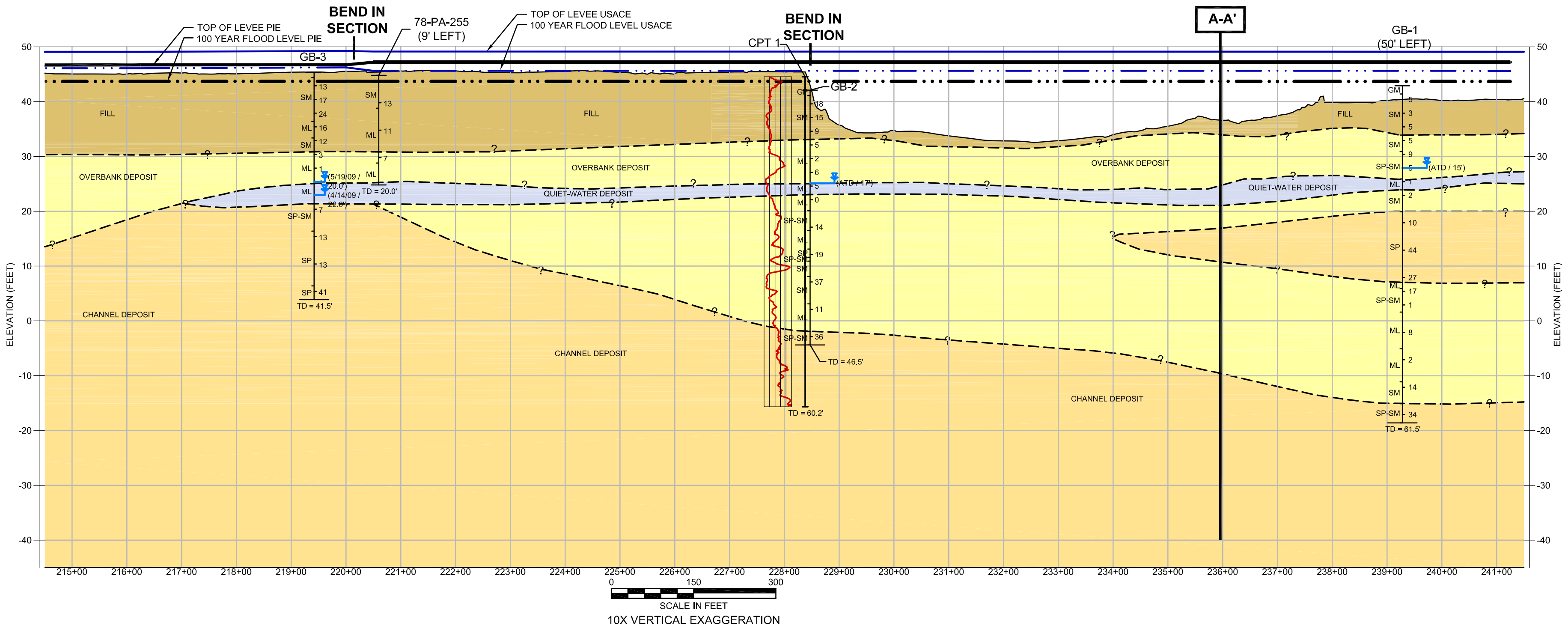
GEOLOGIC UNITS:

▨	FILL
▨	QUIET-WATER DEPOSITS
▨	OVERBANK DEPOSITS
▨	CHANNEL DEPOSITS

USCS SYMBOL:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
GM	GRAVEL AND SILT MIXTURE
SW	WELL-GRADED SAND
SP	POORLY-GRADED SAND
SM	SAND AND SILT MIXTURE
ML	NON-PLASTIC AND LOW-PLASTICITY SILT
CL	LOW-PLASTICITY CLAY
CH	HIGH-PLASTICITY CLAY
MH	HIGH-PLASTICITY SILT

L-L' SLOPE STABILITY SECTION



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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
△	–	–	–	–	–	–

PROJECT

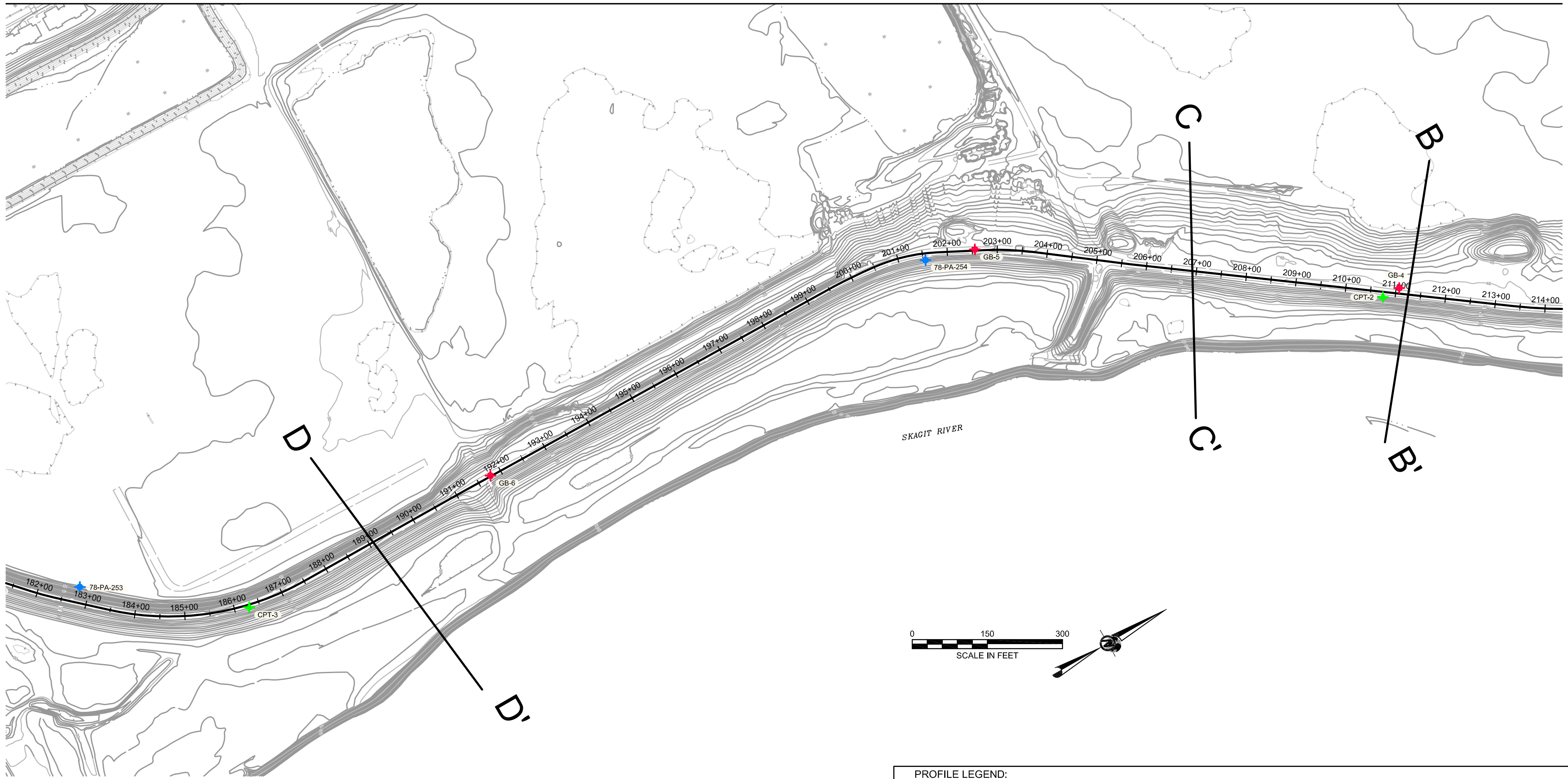
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE

ALIGNMENT PLAN AND PROFILE
(STA 214+50 TO 241+50)

PROJECT No. 093–93153.400		
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SM	08/09
CADD	ACF	08/09
CHECK	SM	08/09
REVIEW	AJW	08/09

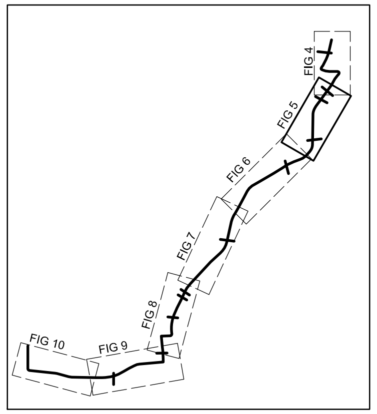
FIGURE 4



PLAN LEGEND:

⌖	GB-28	APPROXIMATE LOCATION OF BORING BY GOLDER (2009)
⌖	CPT-11	APPROXIMATE LOCATION OF CONE PENETRATION TEST BY GOLDER (2009)
⌖	B-1	APPROXIMATE LOCATION OF BORINGS BY OTHERS

KEY MAP



NOTES:
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PROFILE LEGEND:

BORINGS:

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USCS SYMBOL → GW (11-26-07 / 16.5') ← DATE OBSERVED AND WATER LEVEL (FEET BELOW GROUND SURFACE)
16 ← N-VALUE
TD=41.5' ← TOTAL DEPTH
— –?– — ← INFERRED GEOLOGIC CONTACT

CPT's:

CPT 11 ← CPT NAME
← N = 0
← N = 50
← EQUIVALENT N-VALUES (N60)
TD = 70.5' ← CPT TOTAL DEPTH

GEOLOGIC UNITS:

🟫	FILL
🟦	QUIET-WATER DEPOSITS
🟨	OVERBANK DEPOSITS
🟧	CHANNEL DEPOSITS

USCS SYMBOL:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
GM	GRAVEL AND SILT MIXTURE
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SP	POORLY-GRADED SAND
SM	SAND AND SILT MIXTURE
ML	NON-PLASTIC AND LOW-PLASTICITY SILT
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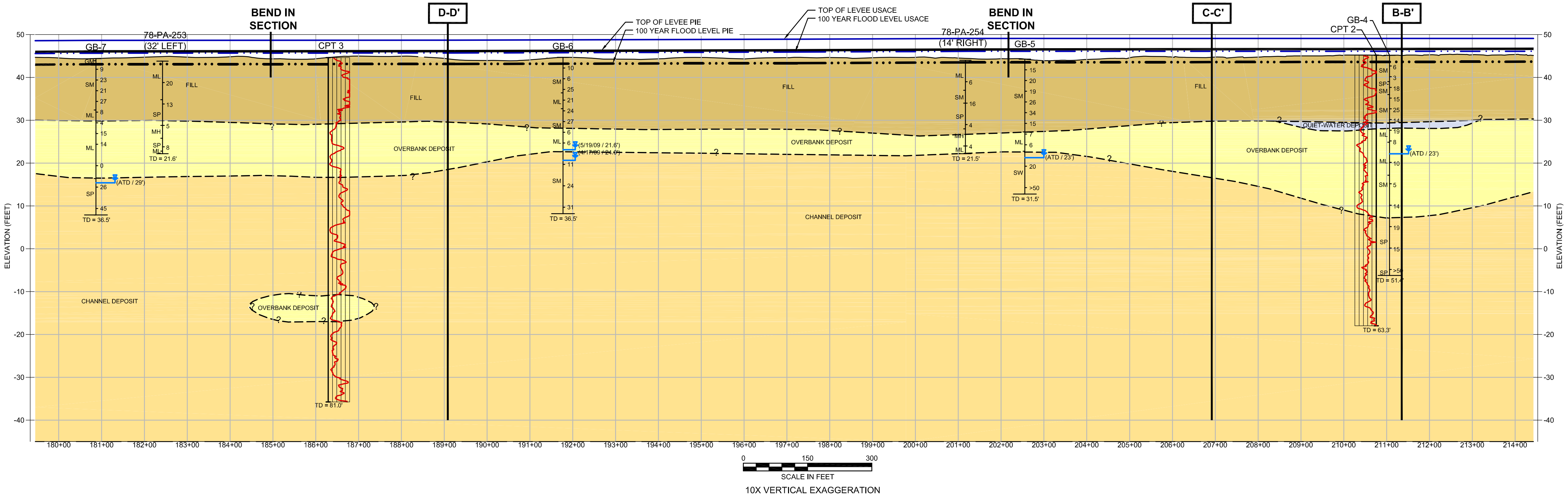
CH	HIGH-PLASTICITY CLAY
MH	HIGH-PLASTICITY SILT

L-L' SLOPE STABILITY SECTION



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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
–	–	–	–	–	–	–

PROJECT
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE
ALIGNMENT PLAN AND PROFILE
(STA 179+50 TO 214+50)

PROJECT No. 093–93153.400		
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SM	08/09
CADD	ACF	08/09
CHECK	SM	08/09
REVIEW	AJW	08/09

FIGURE 5

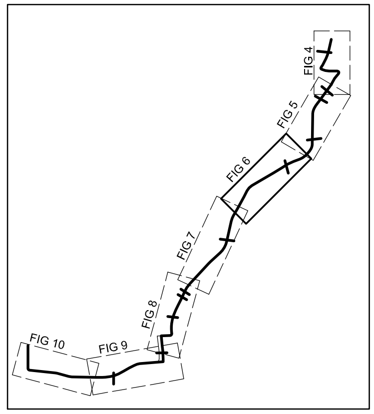
K:\CAD\Projects\2009\0939315\3400\093_93153_400_F01 New Scale r2.dwg | 5 | Mod: 11/17/2009, 19:15 | Plotted: 11/20/2009, 11:54 | SMorgan

0 150 300
SCALE IN FEET

PLAN LEGEND:

GB-28	APPROXIMATE LOCATION OF BORING BY GOLDER (2009)
CPT-11	APPROXIMATE LOCATION OF CONE PENETRATION TEST BY GOLDER (2009)
B-1	APPROXIMATE LOCATION OF BORINGS BY OTHERS

KEY MAP



NOTES:
1. INTERPRETED SUBSURFACE CONDITIONS FROM BORINGS DRILLED. DEPICTED SUBSURFACE CONDITIONS USED FOR ENGINEERING ANALYSIS ONLY AND MAY NOT REPRESENT ACTUAL GROUND CONDITIONS.
2. BASEMAP, ALIGNMENT GEOMETRY, AND STATIONING PROVIDED BY PACIFIC INTERNATIONAL ENGINEERING, MAY 2009.

PROFILE LEGEND:

BORINGS:

GB-1 (78.FT RT) ← BORING NAME AND PROJECTION LEFT OR RIGHT OF PROJECT ALIGNMENT
USCS SYMBOL → GW (11-26-07 / 16.5') ← DATE OBSERVED AND WATER LEVEL (FEET BELOW GROUND SURFACE)
16 ← N-VALUE
TD=41.5' ← TOTAL DEPTH
— —?— — ← INFERRED GEOLOGIC CONTACT

CPT's:

CPT 11 ← CPT NAME
← N = 0
← N = 50
← EQUIVALENT N-VALUES (N60)
TD = 70.5' ← CPT TOTAL DEPTH

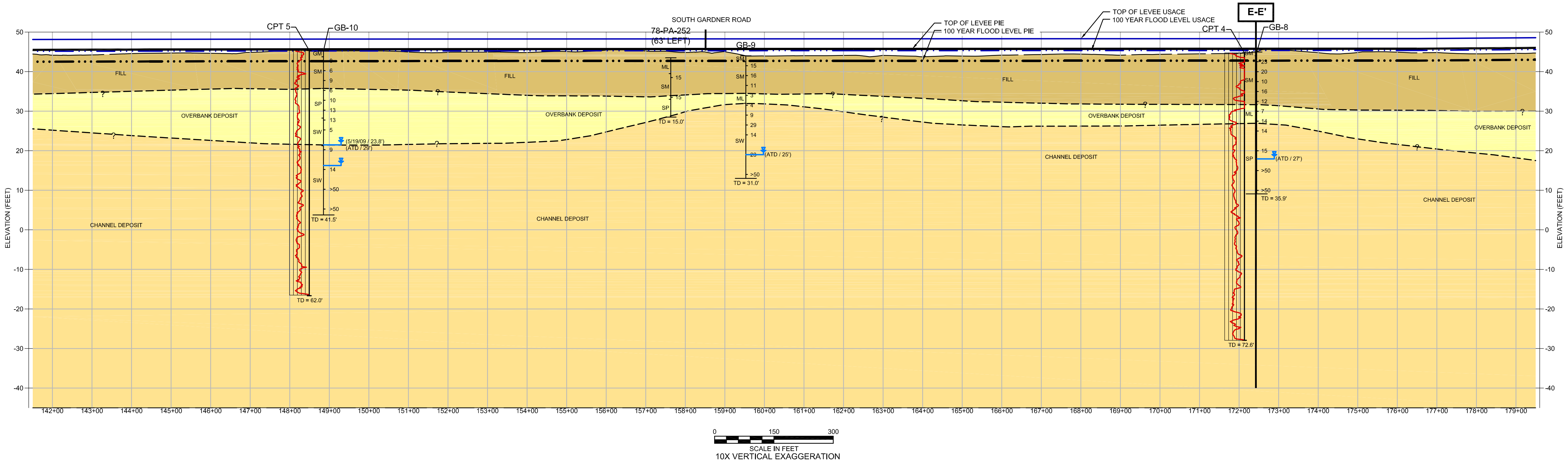
GEOLOGIC UNITS:

▨	FILL
▨	QUIET-WATER DEPOSITS
▨	OVERBANK DEPOSITS
▨	CHANNEL DEPOSITS

USCS SYMBOL:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
GM	GRAVEL AND SILT MIXTURE
SW	WELL-GRADED SAND
SP	POORLY-GRADED SAND
SM	SAND AND SILT MIXTURE
ML	NON-PLASTIC AND LOW-PLASTICITY SILT
CL	LOW-PLASTICITY CLAY
CH	HIGH-PLASTICITY CLAY
MH	HIGH-PLASTICITY SILT

L-L' SLOPE STABILITY SECTION



GOLDER ASSOCIATES INC.
18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
△	-	-	-	-	-	-

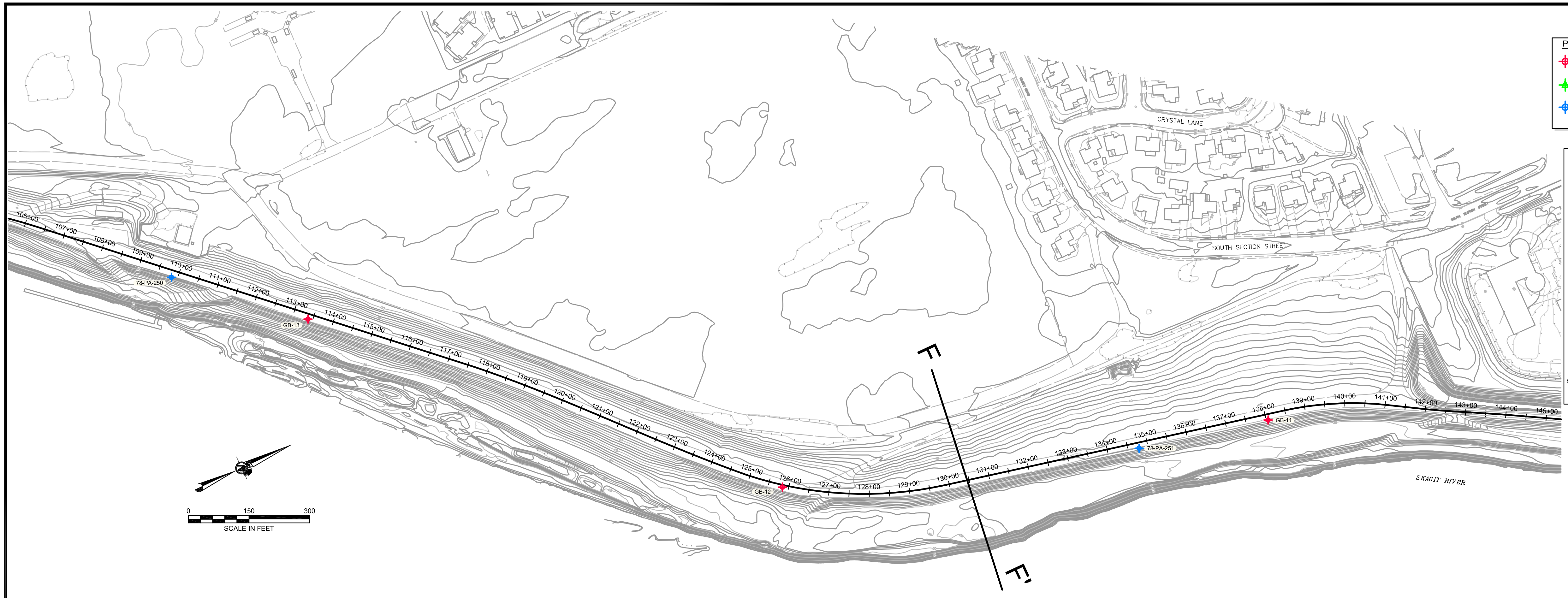
PROJECT
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE
ALIGNMENT PLAN AND PROFILE
(STA 141+50 TO 179+50)

PROJECT No.093–93153.400		
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SM	08/09
CADD	ACF	08/09
CHECK	SM	08/09
REVIEW	AJW	08/09

FIGURE 6

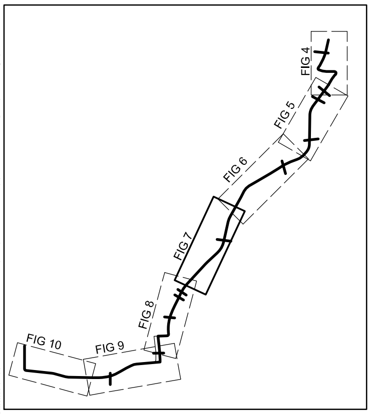
K:\CAD\Projects\2009\09393153\400\093_93153_400_F01 New Scale r2.dwg | 6 | Mod: 11/17/2009, 19:15 | Plotted: 11/20/2009, 11:52 | SMorgan



PLAN LEGEND:

⌖ GB-28	APPROXIMATE LOCATION OF BORING BY GOLDER (2009)
⌖ CPT-11	APPROXIMATE LOCATION OF CONE PENETRATION TEST BY GOLDER (2009)
⌖ B-1	APPROXIMATE LOCATION OF BORINGS BY OTHERS

KEY MAP



NOTES:
1. INTERPRETED SUBSURFACE CONDITIONS FROM BORINGS DRILLED. DEPICTED SUBSURFACE CONDITIONS USED FOR ENGINEERING ANALYSIS ONLY AND MAY NOT REPRESENT ACTUAL GROUND CONDITIONS.
2. BASEMAP, ALIGNMENT GEOMETRY, AND STATIONING PROVIDED BY PACIFIC INTERNATIONAL ENGINEERING, MAY 2009.

PROFILE LEGEND:

BORINGS:

GB-1 (78.FT RT) ← BORING NAME AND PROJECTION LEFT OR RIGHT OF PROJECT ALIGNMENT

5

USCS SYMBOL → GW (11-26-07 / 16.5') ← DATE OBSERVED AND WATER LEVEL (FEET BELOW GROUND SURFACE)

16 ← N-VALUE

TD=41.5' ← TOTAL DEPTH

— —?— — ← INFERRED GEOLOGIC CONTACT

CPT's:

CPT 11 ← CPT NAME

← N = 0

← N = 50

← EQUIVALENT N-VALUES (N60)

TD = 70.5' ← CPT TOTAL DEPTH

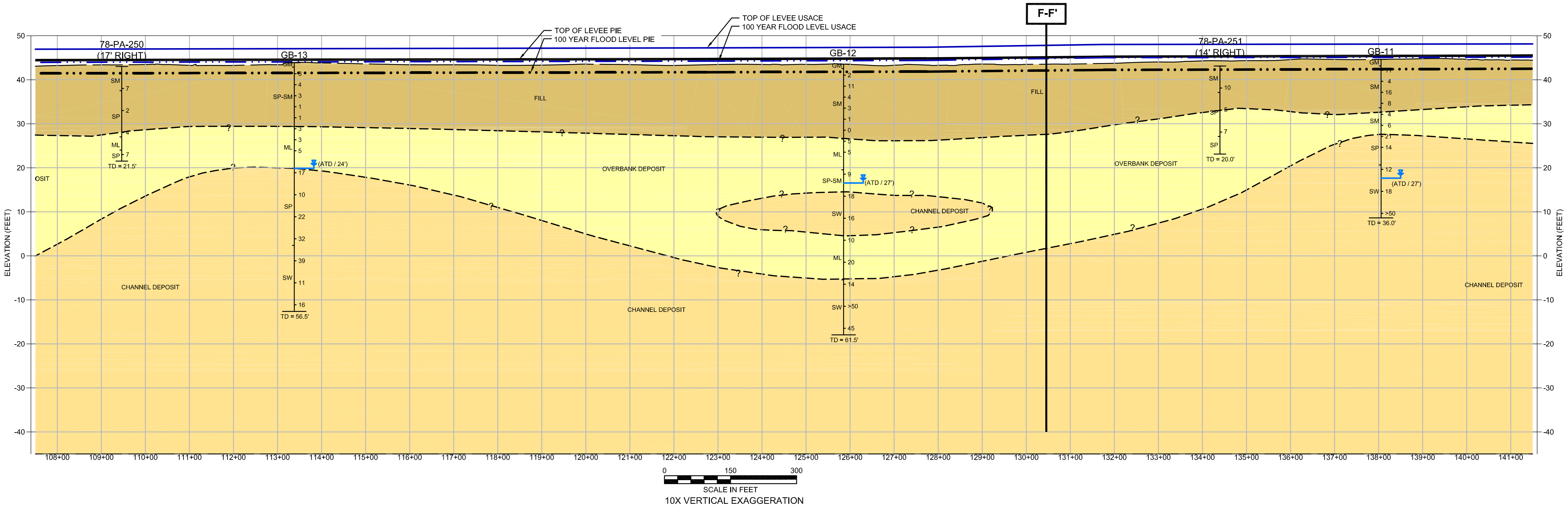
GEOLOGIC UNITS:

🟫	FILL
🟦	QUIET-WATER DEPOSITS
🟨	OVERBANK DEPOSITS
🟧	CHANNEL DEPOSITS

USCS SYMBOL:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
GM	GRAVEL AND SILT MIXTURE
SW	WELL-GRADED SAND
SP	POORLY-GRADED SAND
SM	SAND AND SILT MIXTURE
ML	NON-PLASTIC AND LOW-PLASTICITY SILT
CL	LOW-PLASTICITY CLAY
CH	HIGH-PLASTICITY CLAY
MH	HIGH-PLASTICITY SILT

L-L' SLOPE STABILITY SECTION



Golder Associates

GOLDER ASSOCIATES INC.
18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
△	-	-	-	-	-	-

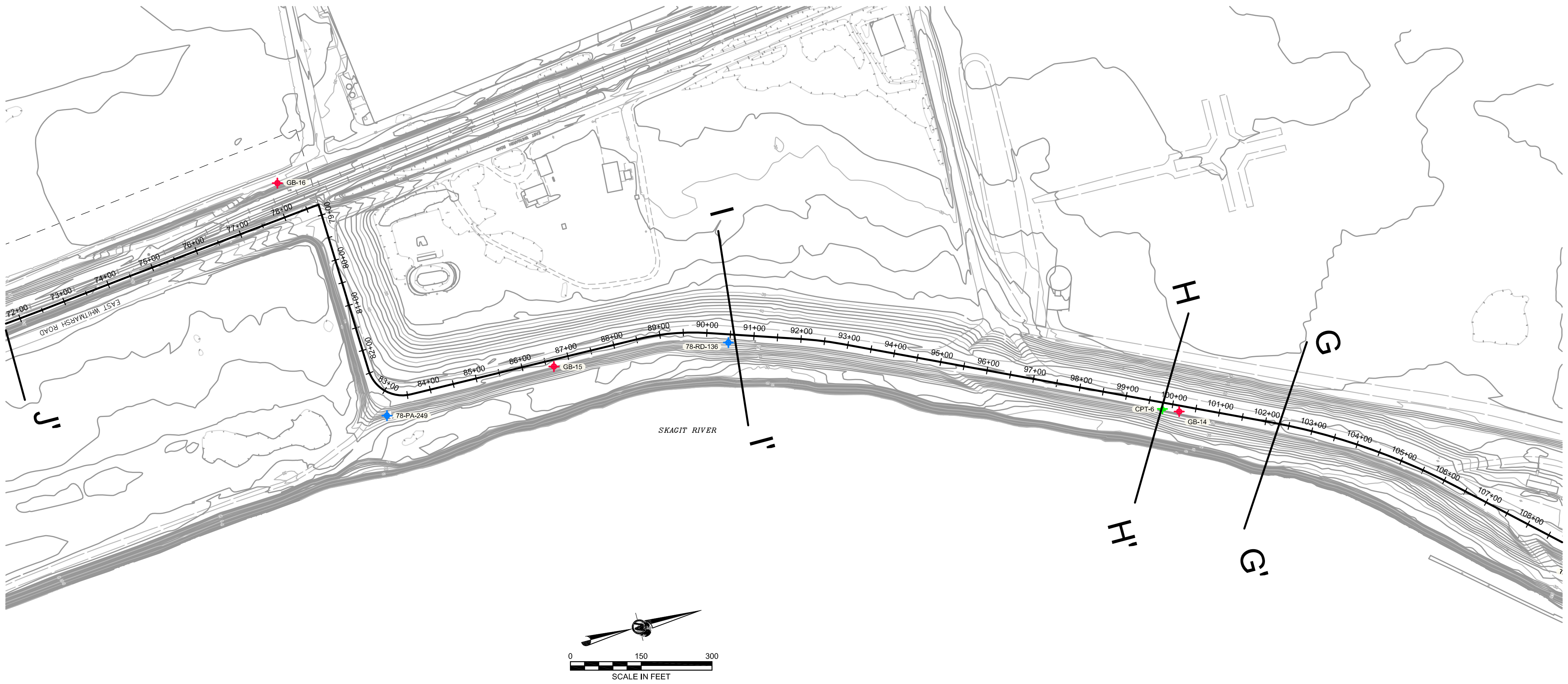
PROJECT
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE
ALIGNMENT PLAN AND PROFILE
(STA 107+50 TO 141+50)

PROJECT No. 093–93153.400		
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SM	08/09
CADD	ACF	08/09
CHECK	SM	08/09
REVIEW	AJW	08/09

FIGURE 7

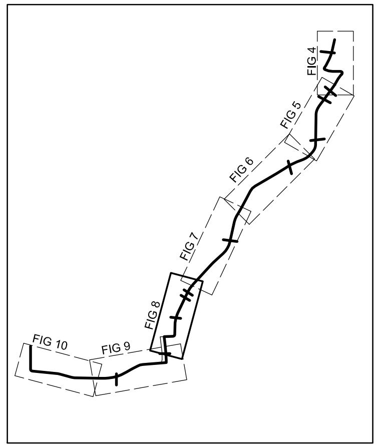
K:\CAD\Projects\2009\0939315З\400\093_93153_400_F01 New Scale r2.dwg | 7 | Mod: 11/17/2009, 19:15 | Plotted: 11/20/2009, 11:50 | SMorgan



PLAN LEGEND:

GB-28	APPROXIMATE LOCATION OF BORING BY GOLDER (2009)
CPT-11	APPROXIMATE LOCATION OF CONE PENETRATION TEST BY GOLDER (2009)
B-1	APPROXIMATE LOCATION OF BORINGS BY OTHERS

KEY MAP



NOTES:
1. INTERPRETED SUBSURFACE CONDITIONS FROM BORINGS DRILLED. DEPICTED SUBSURFACE CONDITIONS USED FOR ENGINEERING ANALYSIS ONLY AND MAY NOT REPRESENT ACTUAL GROUND CONDITIONS.
2. BASEMAP, ALIGNMENT GEOMETRY, AND STATIONING PROVIDED BY PACIFIC INTERNATIONAL ENGINEERING, MAY 2009.

PROFILE LEGEND:

BORINGS:

GB-1 (78.FT RT) ← BORING NAME AND PROJECTION LEFT OR RIGHT OF PROJECT ALIGNMENT
5
USCS SYMBOL → GW (11-26-07 / 16.5') ← DATE OBSERVED AND WATER LEVEL (FEET BELOW GROUND SURFACE)
16 ← N-VALUE
TD=41.5' ← TOTAL DEPTH
— –?– — ← INFERRED GEOLOGIC CONTACT

CPT's:

CPT 11 ← CPT NAME
← N = 0
← N = 50
← EQUIVALENT N-VALUES (N60)
TD = 70.5' ← CPT TOTAL DEPTH

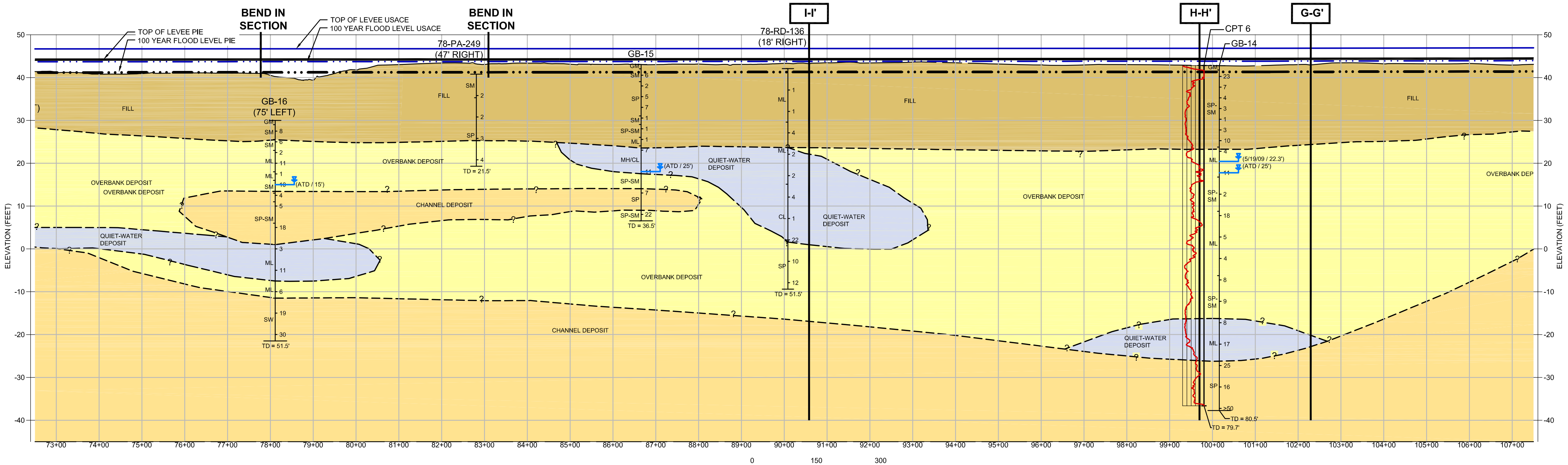
GEOLOGIC UNITS:

▨	FILL
▨	QUIET-WATER DEPOSITS
▨	OVERBANK DEPOSITS
▨	CHANNEL DEPOSITS

USCS SYMBOL:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
GM	GRAVEL AND SILT MIXTURE
SW	WELL-GRADED SAND
SP	POORLY-GRADED SAND
SM	SAND AND SILT MIXTURE
ML	NON-PLASTIC AND LOW-PLASTICITY SILT
CL	LOW-PLASTICITY CLAY
CH	HIGH-PLASTICITY CLAY
MH	HIGH-PLASTICITY SILT

L-L' SLOPE STABILITY SECTION



0 150 300
SCALE IN FEET
10X VERTICAL EXAGGERATION

GOLDER ASSOCIATES INC.
18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
△	-	-	-	-	-	-

PROJECT
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE
ALIGNMENT PLAN AND PROFILE
(STA 72+50 TO 107+50)

PROJECT No. 093–93153.400		
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SM	08/09
CADD	ACF	08/09
CHECK	SM	08/09
REVIEW	AJW	08/09

FIGURE 8

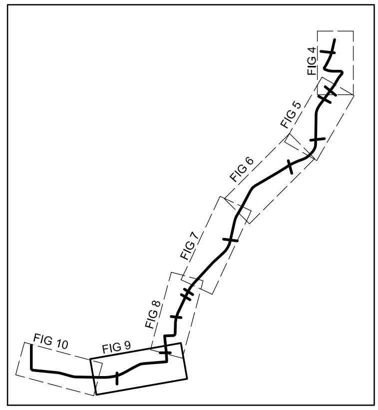
K:\CAD\Projects\2009\093\93153\400\093_93153_400_F01 New Scale r2.dwg | 8 | Mod: 11/17/2009, 19:15 | Plotted: 11/20/2009, 11:49 | SMorgan

0 150 300
SCALE IN FEET

PLAN LEGEND:

⌖	GB-28	APPROXIMATE LOCATION OF BORING BY GOLDER (2009)
⌖	CPT-11	APPROXIMATE LOCATION OF CONE PENETRATION TEST BY GOLDER (2009)
⌖	B-1	APPROXIMATE LOCATION OF BORINGS BY OTHERS

KEY MAP



NOTES:
1. INTERPRETED SUBSURFACE CONDITIONS FROM BORINGS DRILLED. DEPICTED SUBSURFACE CONDITIONS USED FOR ENGINEERING ANALYSIS ONLY AND MAY NOT REPRESENT ACTUAL GROUND CONDITIONS.
2. BASEMAP, ALIGNMENT GEOMETRY, AND STATIONING PROVIDED BY PACIFIC INTERNATIONAL ENGINEERING, MAY 2009.

PROFILE LEGEND:

BORINGS:

GB-1 (78.FT RT) ← BORING NAME AND PROJECTION LEFT OR RIGHT OF PROJECT ALIGNMENT
USCS SYMBOL → GW
(11-26-07 / 16.5') ← DATE OBSERVED AND WATER LEVEL (FEET BELOW GROUND SURFACE)
5
16 ← N-VALUE
TD=41.5' ← TOTAL DEPTH
— —?— — ← INFERRED GEOLOGIC CONTACT

CPT's:

CPT 11 ← CPT NAME
← N = 0
← N = 50
← EQUIVALENT N-VALUES (N60)
TD = 70.5' ← CPT TOTAL DEPTH

GEOLOGIC UNITS:

▨	FILL
▨	QUIET-WATER DEPOSITS
▨	OVERBANK DEPOSITS
▨	CHANNEL DEPOSITS

USCS SYMBOL:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
GM	GRAVEL AND SILT MIXTURE
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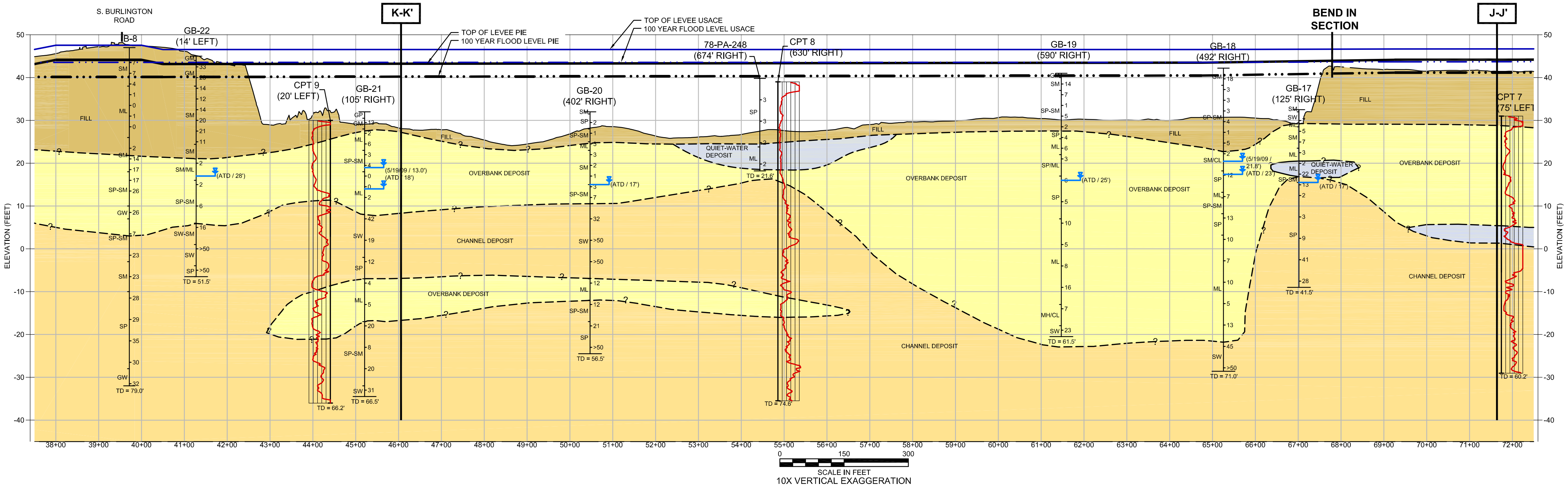
SM	SAND AND SILT MIXTURE
ML	NON-PLASTIC AND LOW-PLASTICITY SILT
CL	LOW-PLASTICITY CLAY
CH	HIGH-PLASTICITY CLAY
MH	HIGH-PLASTICITY SILT

L-L' SLOPE STABILITY SECTION



K:\CAD\Projects\2009\09393153\400\093_93153_400_F01 New Scale r2.dwg | 9 | Mod: 11/17/2009, 19:15 | Plotted: 11/20/2009, 11:47 | SMorgan

GOLDER ASSOCIATES INC.
18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
0	–	–	–	–	–	–

PROJECT

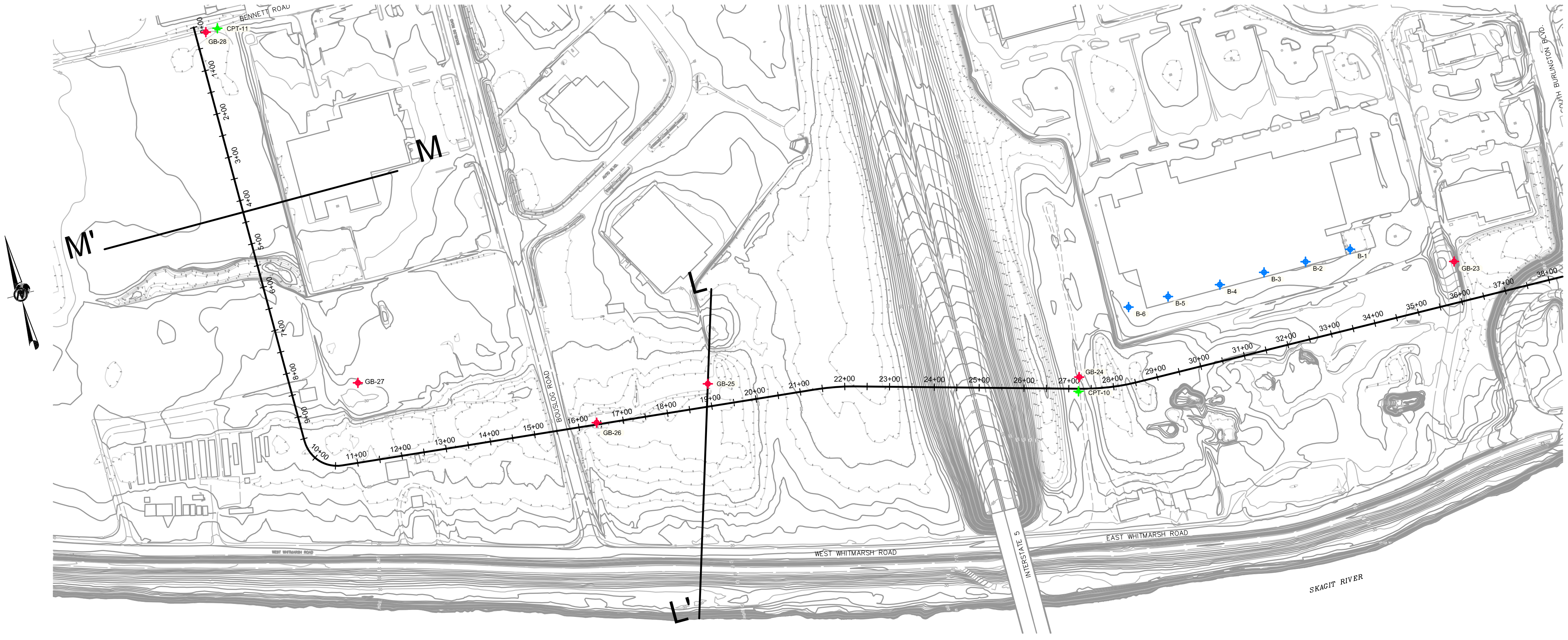
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE

ALIGNMENT PLAN AND PROFILE
(STA 37+50 TO 72+50)

PROJECT No. 093–93153.400		
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SM	08/09
CADD	ACF	08/09
CHECK	SM	08/09
REVIEW	AJW	08/09

FIGURE 9



0 150 300
SCALE IN FEET

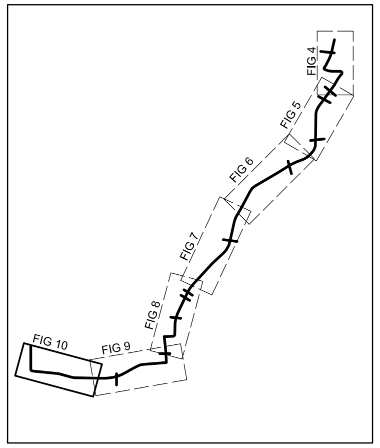
NOTES:

1. INTERPRETED SUBSURFACE CONDITIONS FROM BORINGS DRILLED. DEPICTED SUBSURFACE CONDITIONS USED FOR ENGINEERING ANALYSIS ONLY AND MAY NOT REPRESENT ACTUAL GROUND CONDITIONS.
2. BASEMAP, ALIGNMENT GEOMETRY, AND STATIONING PROVIDED BY PACIFIC INTERNATIONAL ENGINEERING, MAY 2009.

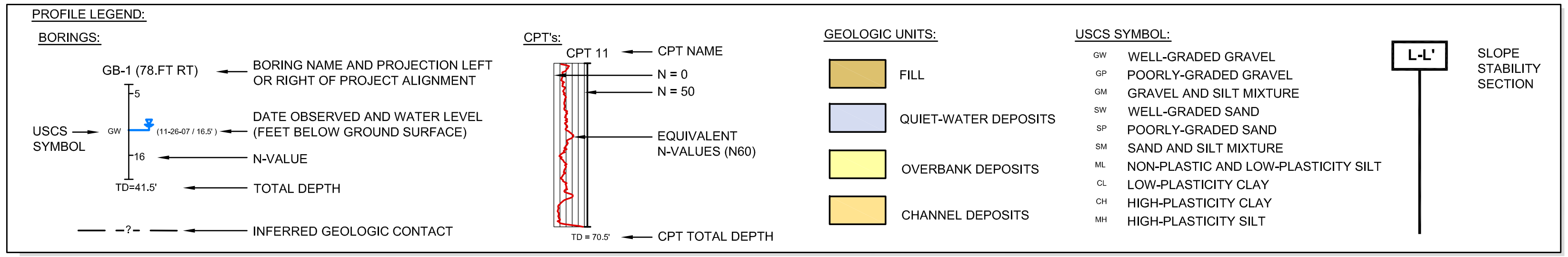
PLAN LEGEND:

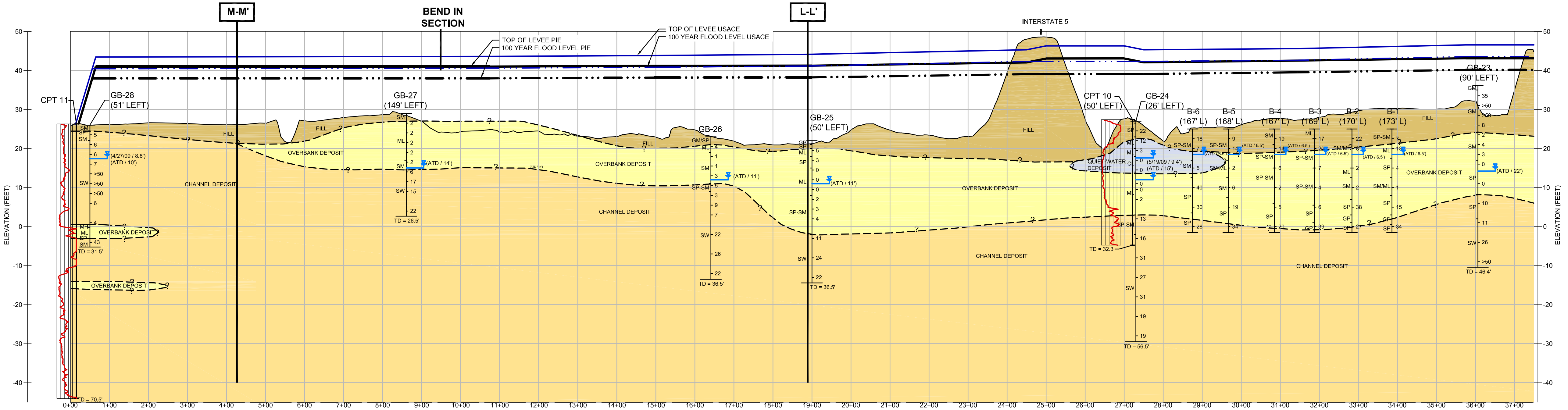
GB-28	APPROXIMATE LOCATION OF BORING BY GOLDER (2009)
CPT-11	APPROXIMATE LOCATION OF CONE PENETRATION TEST BY GOLDER (2009)
B-1	APPROXIMATE LOCATION OF BORINGS BY OTHERS

KEY MAP



PROFILE LEGEND:





0 150 300
SCALE IN FEET
10X VERTICAL EXAGGERATION

GOLDER ASSOCIATES INC.
18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
△	–	–	–	–	–	–

PROJECT

PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE

ALIGNMENT PLAN AND PROFILE
(STA 0+00 TO 37+50)

PROJECT No. 093–93153.400		
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SM	08/09
CADD	ACF	08/09
CHECK	SM	08/09
REVIEW	AJW	08/09

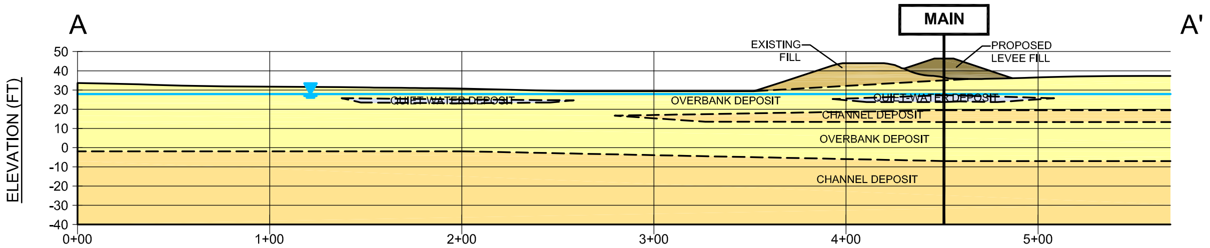
FIGURE 10

K:\CAD\Projects\2009\0939315\3400\093_93153_400_F01 New Scale r2.dwg | 10 | Mod: 11/17/2009, 19:15 | Plotted: 11/20/2009, 11:46 | SMorgan

0 500 1000
SCALE IN FEET

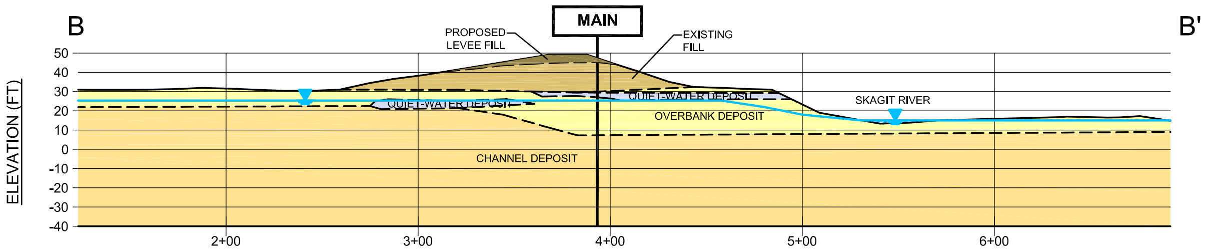
SOURCE: BASE MAP PROVIDED BY PIE, MAY 2009

NOTE:
THE SECTIONS FOR STABILITY ANALYSES WERE DEVELOPED USING GEOLOGIC INFORMATION FROM GOLDER AND OTHERS AND REPRESENT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTIONS. ACTUAL GEOLOGIC CONDITIONS MAY VARY. THE SECTIONS USED FOR STABILITY ANALYSES SHOULD NOT BE USED FOR GEOLOGIC INTERPRETATION, CONTRACT BIDDING, OR CONSTRUCTION.



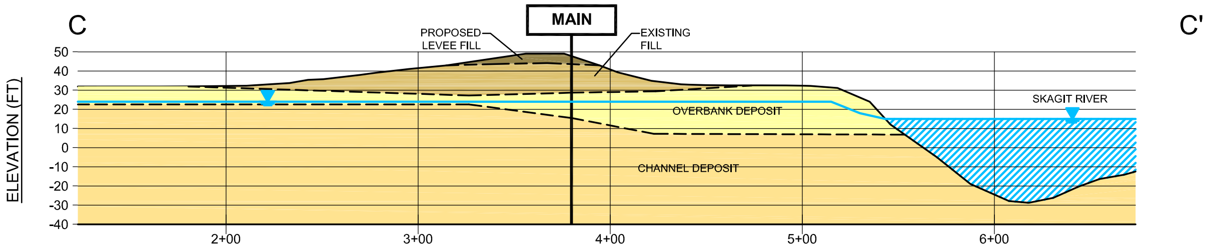
SECTION A-A'

0 50 100
SCALE IN FEET



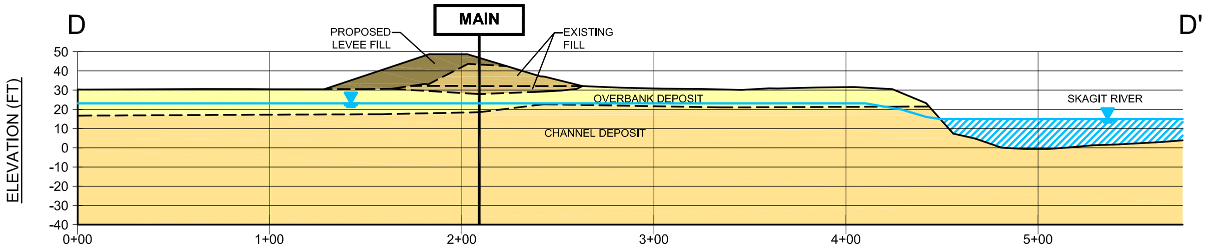
SECTION B-B'

0 50 100
SCALE IN FEET



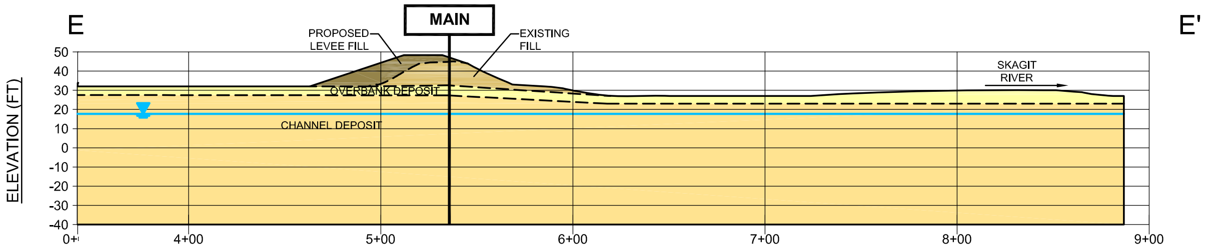
SECTION C-C'

0 50 100
SCALE IN FEET



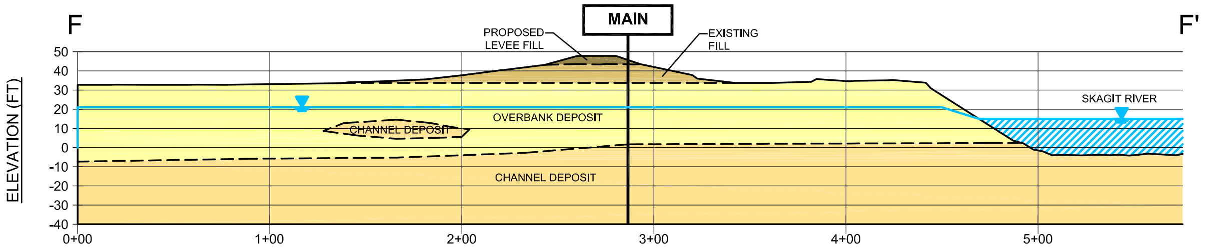
SECTION D-D'

0 50 100
SCALE IN FEET



SECTION E-E'

0 50 100
SCALE IN FEET



SECTION F-F'

0 50 100
SCALE IN FEET

GOLDER ASSOCIATES INC.
18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

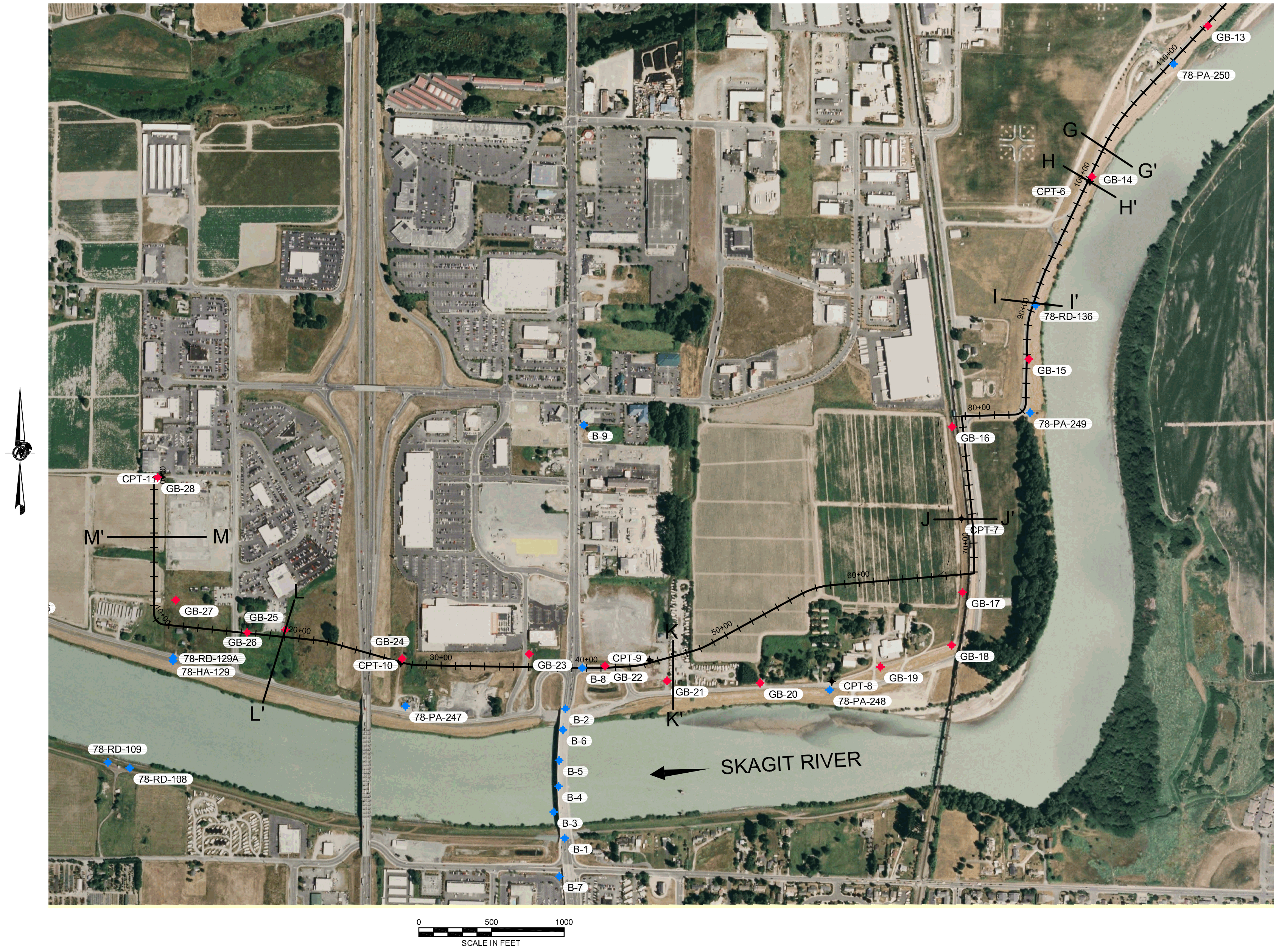
REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
1	10/15/09	SJM	REVISE SECTIONS D-D', E-E'	SJM	AJW	AJW

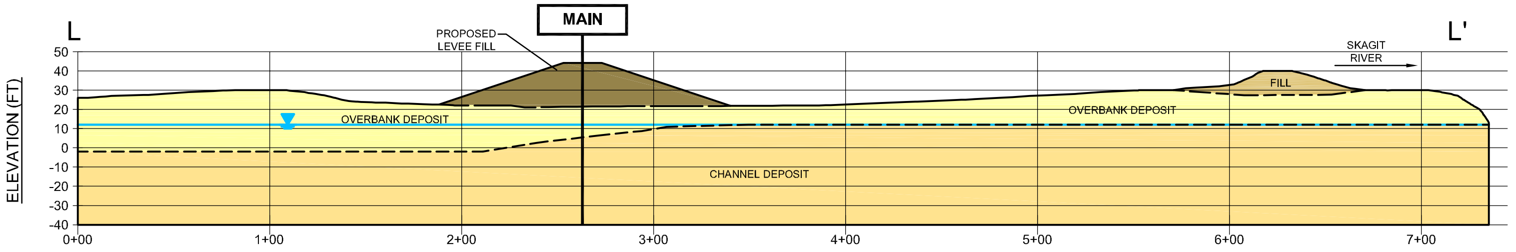
PROJECT
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE
SLOPE STABILITY SECTIONS (1 of 2)

PROJECT No. 093-93153.400		
FILE No. 093_93153_400_F01.dwg		
REV. 0	SCALE AS SHOWN	
DESIGN	SM	8/21/09
CADD	ACF	8/21/09
CHECK	SM	8/21/09
REVIEW	AJW	8/21/09

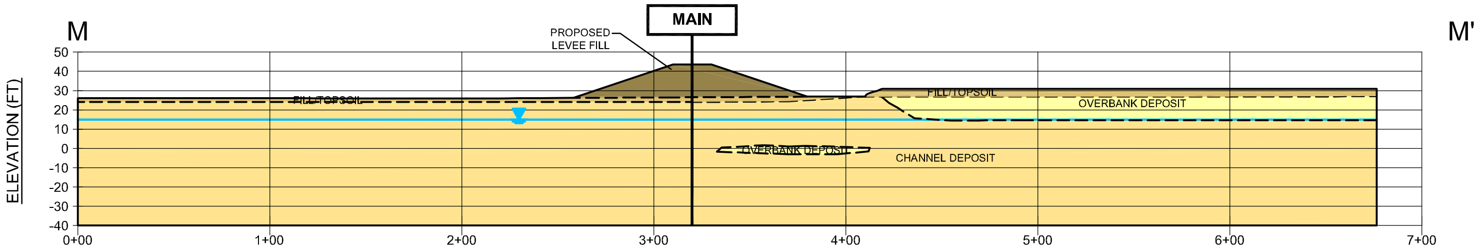
FIGURE 11





SECTION L-L'

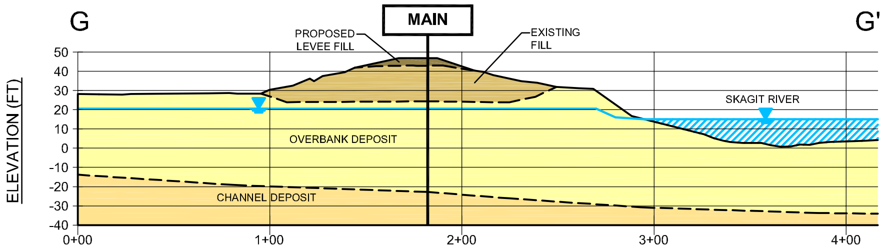
0 50 100
SCALE IN FEET



SECTION M-M'

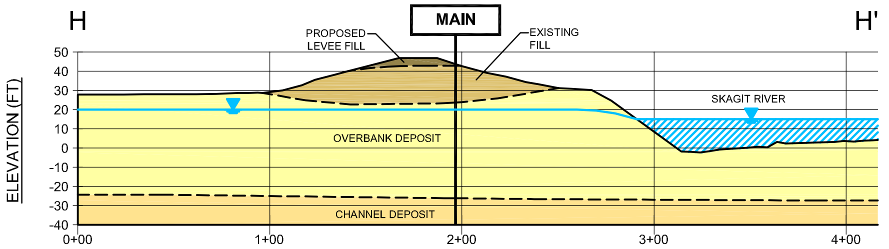
0 50 100
SCALE IN FEET

SOURCE: BASE MAP PROVIDED BY PIE, MAY 2009
REFERENCE AERIAL PHOTO



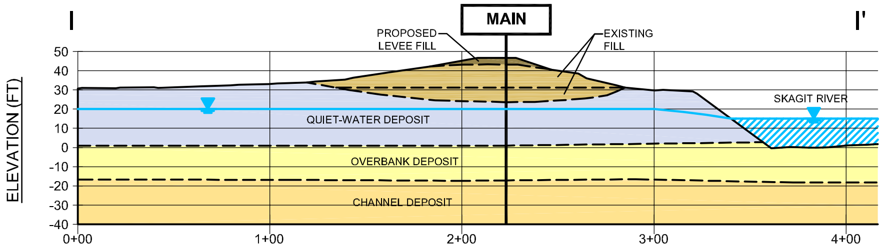
SECTION G-G'

0 50 100
SCALE IN FEET



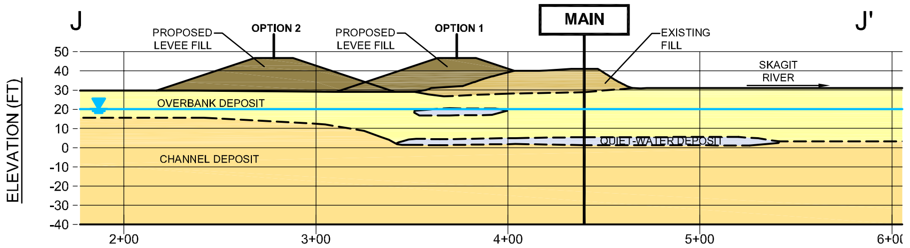
SECTION H-H'

0 50 100
SCALE IN FEET



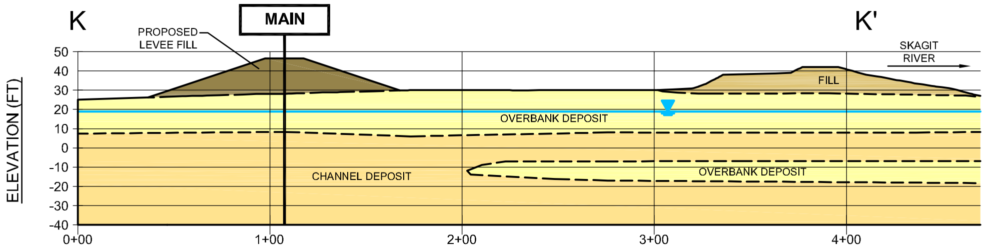
SECTION I-I'

0 50 100
SCALE IN FEET



SECTION J-J'

0 50 100
SCALE IN FEET



SECTION K-K'

0 50 100
SCALE IN FEET

NOTE:
THE SECTIONS FOR STABILITY ANALYSES WERE DEVELOPED USING GEOLOGIC INFORMATION FROM GOLDER AND OTHERS AND REPRESENT TYPICAL CONDITIONS IN THE VICINITY OF THE SECTIONS. ACTUAL GEOLOGIC CONDITIONS MAY VARY. THE SECTIONS USED FOR STABILITY ANALYSES SHOULD NOT BE USED FOR GEOLOGIC INTERPRETATION, CONTRACT BIDDING, OR CONSTRUCTION.

Golder Associates
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18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
–	–	–	–	–	–	–

PROJECT
PIE/BURLINGTON
GEOTECH & LEVEES/WA

TITLE
SLOPE STABILITY SECTIONS (2 of 2)

PROJECT No. 093–93153.400		
FILE No. 093_93153_400_F01.dwg		
REV. 0	SCALE AS SHOWN	
DESIGN	SM	8/21/09
CADD	ACF	8/21/09
CHECK	SM	8/21/09
REVIEW	AJW	8/21/09

FIGURE 12

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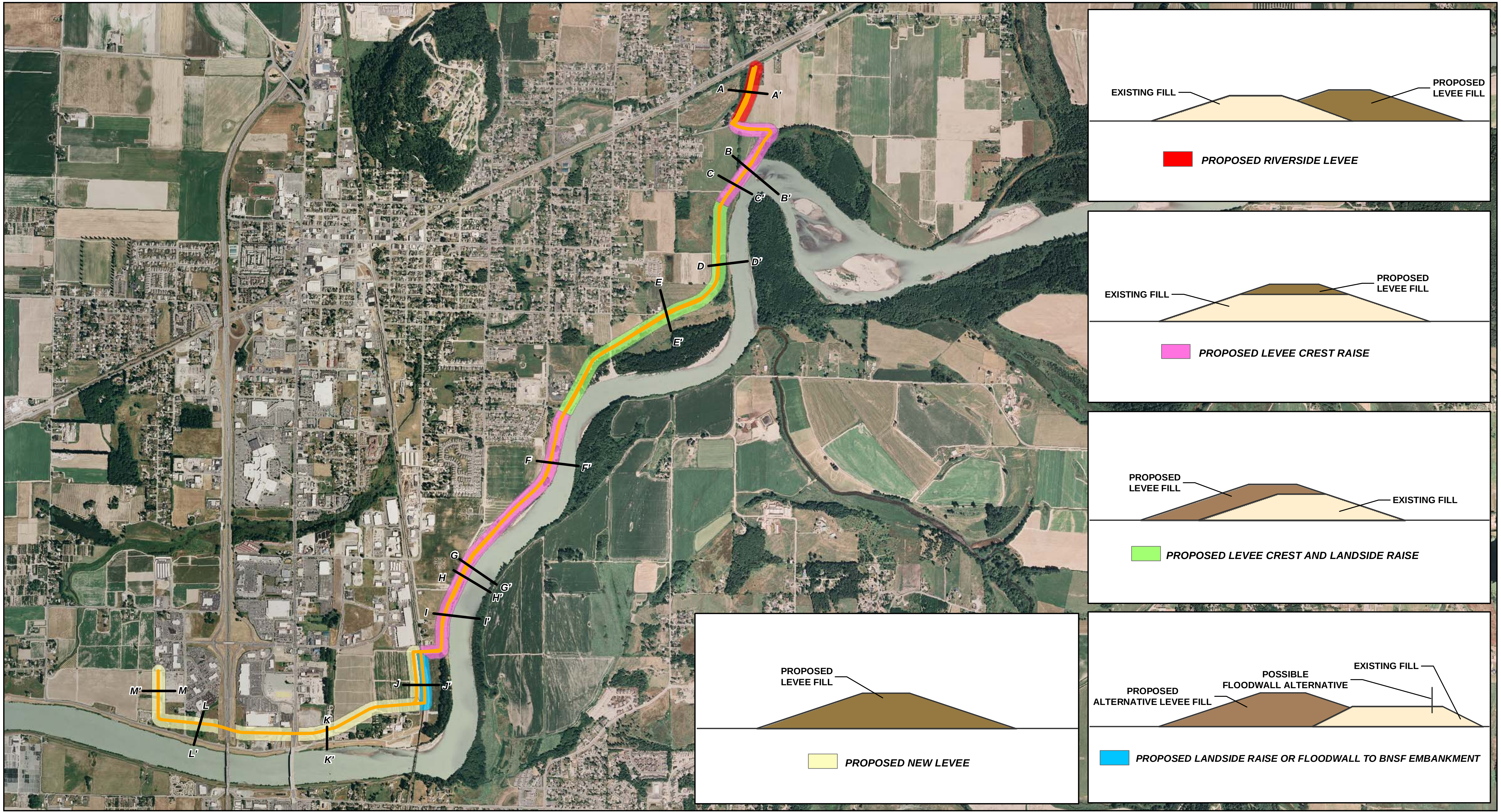

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

LEGEND

Project Centerline and Main Cross Section Line	🟥 Proposed Riverside Levee
Cross Section	🟪 Proposed Levee Crest Raise
	🟩 Proposed Levee Crest and Landside Raise
	🟦 Proposed Landside Raise or Floodwall to BNSF Embankment
	🟨 Proposed New Levee

0 2000
Scale in Feet

Map Projection:
Washington State Plane
North Zone NAD 1983

Source: USDA/FSA - Aerial Photography Field Office (2006), US Army Corps of Engineers, Shannon and Wilson

N

FIGURE **13**

BURLINGTON LEVEE PROJECT
PROPOSED LEVEE PLAN
PIE/BURLINGTON LEVEES/WA

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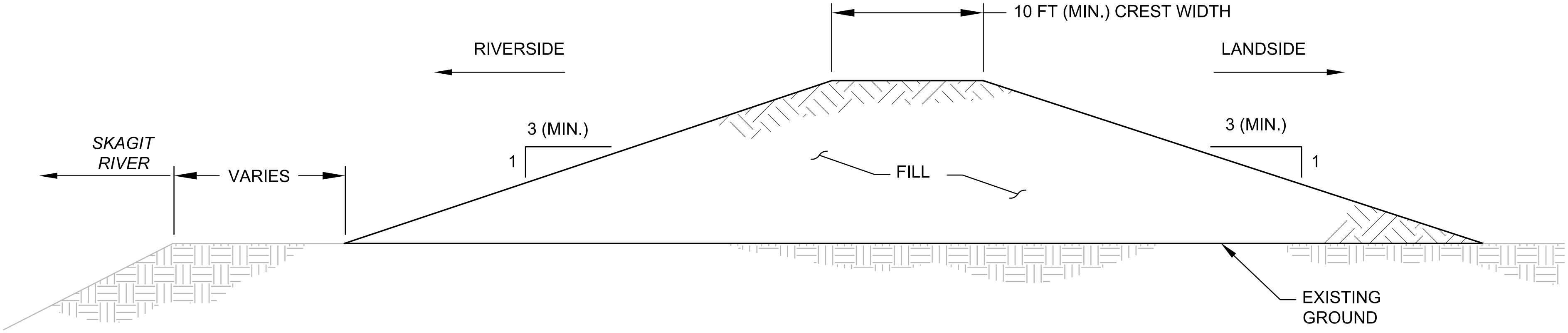

FIGURE **14**

TYPICAL LEVEE DESIGN

PIE/BURLINGTON LEVEES/WA

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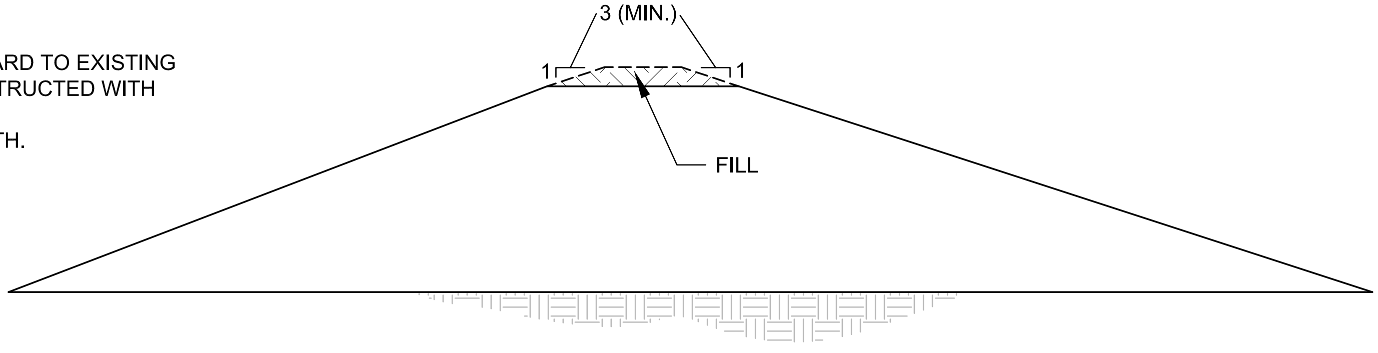
CREST RAISE OF EXISTING LEVEE

- WHEN RAISE IS TO ADD FREEBOARD TO EXISTING LEVEE, THE RAISE CAN BE CONSTRUCTED WITH 3H:1V SIDE SLOPES.
- NOTE REDUCTION IN CREST WIDTH.



CREST AND LANDSIDE RAISE OF EXISTING LEVEE

- THE RAISE CAN BE CONSTRUCTED WITH 3H:1V SIDESLOPES.
- CREST WIDTH CAN BE INCREASED, DECREASED, OR MAINTAINED AS REQUIRED.

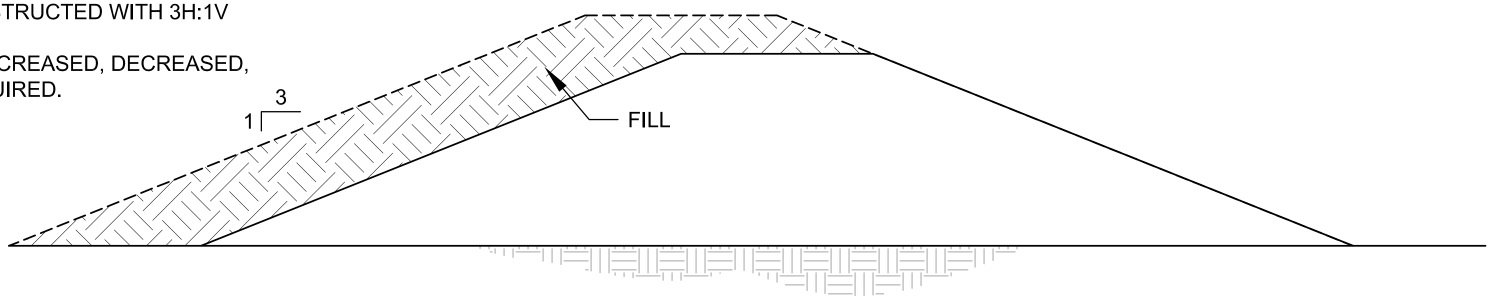


FIGURE **15**

LEVEE RAISE OPTIONS

PIE/BURLINGTON LEVEES/WA

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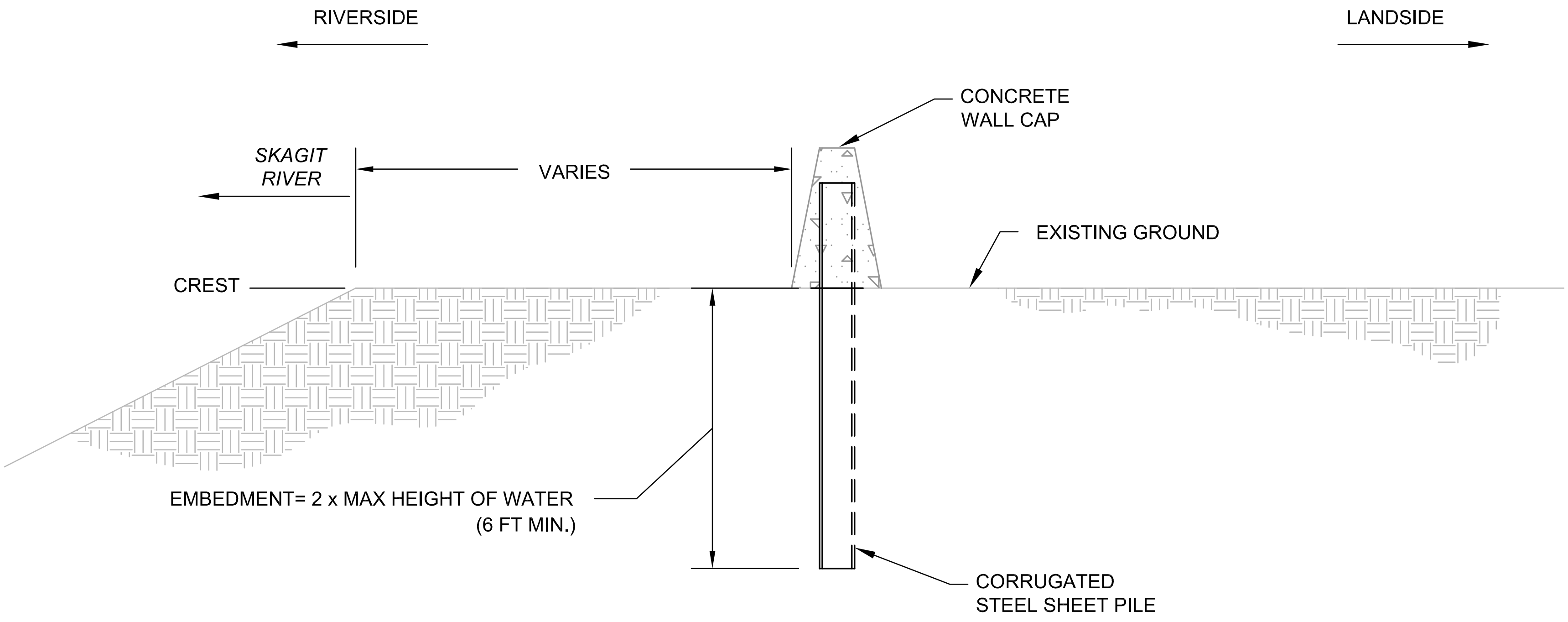

FIGURE 16

TYPICAL CANTILEVER SHEET PILE FLOOD WALL DESIGN

PIE/BURLINGTON LEVEES/WA

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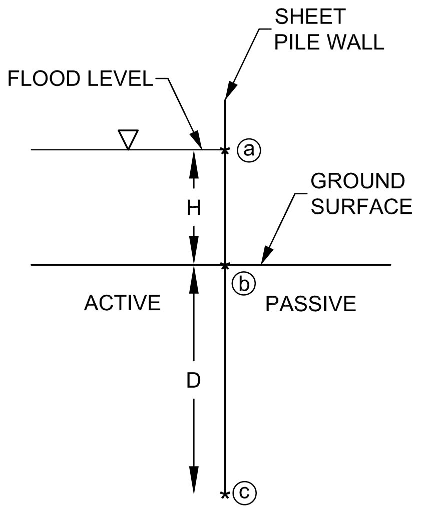
DESIGN PRESSURES ON SHEET PILES

- PER U.S. ARMY CORPS OF ENGINEERS MANUAL EM 1110-2-2504 (31 MARCH 1994)



H = HEIGHT OF WATER AGAINST SHEET PILE (FT)
D = EMBEDMENT DEPTH (FT)
γ_w = UNIT WEIGHT OF WATER (PCF)
γ_b = BUOYANT UNIT WEIGHT OF SOIL
γ_s = UNIT WEIGHT OF SOIL
K_a= COEFFICIENT OF ACTIVE EARTH PRESSURE
K_p= COEFFICIENT OF PASSIVE EARTH PRESSURE

ACTIVE

ⓐ $\sigma_h = 0$
ⓑ $\sigma_h = H\gamma_w$
ⓒ $\sigma_h = \underbrace{K_a D\gamma_b}_{\text{SOIL}} + \underbrace{\gamma_w (H+D)}_{\text{WATER}}$

PASSIVE

ⓐ $\sigma_h = 0$
ⓑ $\sigma_h = 0$
ⓒ $\sigma_h = \underbrace{K_p D\gamma_b}_{\text{SOIL}} + \underbrace{\gamma_w (H+D)}_{\text{WATER}} - \underbrace{K_p \gamma_w H}_{\text{CORRECTION FOR UNDERSEEPAGE}}$

NOTES:

- ASSUME LINEAR VARIATION BETWEEN POINTS ⓐ, ⓑ, & ⓒ.
- K_p FACTORED PER EM 1110-2-2504.

SOIL PARAMETERS

SOIL TYPE SM - LOOSE TO COMPACT
S-TYPE SOIL
γ_w = 62.4 PCF
γ_b = 57.6 PCF ϕ'_p = 32° c' = 0 PSF
K_a = 0.29 K = 5.3 UNFACTORED

K_p VARIES DEPENDING ON DESIGN CASE PER TABLE 5-1 (EM 1110-2-2504).

DESIGN CASE - FLOODWALL

LOADING CASE	FSP	FACTORED K_p FOR FREE-DRAINING SOILS
USUAL	1.5	K_p = 3.1
UNUSUAL	1.25	K_p = 3.9
EXTREME	1.1	K_p = 4.4

FSP = FACTOR OF SAFETY ON PASSIVE RESISTANCE

EXAMPLE

H = 4 FT - EXTREME DESIGN CASE
D = 8 FT

ACTIVE

ⓐ σ_h = 0
ⓑ σ_h = 4 FT x 62.4 PCF = 250 PSF
ⓒ σ_h = 0.29 x 8 FT x 57.6 PCF + 62.4 PCF x (4 FT + 8 FT)
= 134 PSF + 749 PSF = 883 PSF

PASSIVE

ⓐ σ_h = 0
ⓑ σ_h = 0
ⓒ σ_h = 4.4 x 8 FT x 57.6 PCF + 62.4 PCF x (4 FT + 8 FT) - 4.4 x 62.4 PCF x 4 FT
= 2028 PSF + 749 PSF - 1098 PSF = 1679 PSF

FIGURE 17

SHEET PILE WALL PRESSURES SUMMARY AND EXAMPLE

PIE/BURLINGTON LEVEES/WA

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APPENDIX A
EXPLORATION LOGS

A-1: HOLLOW-STEM AUGER BORING LOGS

A-2: CPT LOGS

APPENDIX A-1

HOLLOW-STEM AUGER BORING LOGS

Unified Soil Classification System (USCS)

Criteria for Assigning Group Symbols and Names			Soil Classification Generalized Group Descriptions	
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 Sieve	CLEAN GRAVELS Less than 5% fines	GW	Well-graded Gravels
			GP	Poorly-graded gravels
		GRAVELS WITH FINES More than 12% fines	GM	Gravel and Silt Mixtures
			GC	Gravel and Clay Mixtures
	SANDS 50% or more of coarse fraction passes No. 4 Sieve	CLEAN SANDS Less than 5% fines	SW	Well-graded Sands
			SP	Non-plastic and Low-Poorly-graded Sands
		SANDS WITH FINES More than 12% fines	SM	Sand and Silt Mixtures
			SC	Sand and Clay Mixtures
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	SILTS AND CLAYS Liquid limit less than 50	INORGANIC	CL	Low-plasticity Clays
			ML	Non-plastic and Low-Plasticity Silts
		ORGANIC	OL	Non-plastic and Low-Plasticity Organic Clays Non-plastic and Low-Plasticity Organic Silts
	SILTS AND CLAYS Liquid limit greater than 50	INORGANIC	CH	High-plasticity Clays
			MH	High-plasticity Silts
		ORGANIC	OH	High-plasticity Organic Clays High-plasticity Organic Silts
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat

Based on: ASTM D2487-00

Component Definitions by Gradation

Component	Size Range
Boulders	Above 12 in.
Cobbles	3 in. to 12 in.
Gravel	3 in. to No. 4 (4.76mm)
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 (4.76mm)
Sand	No. 4 (4.76mm) to No. 200 (0.074mm)
Coarse sand	No. 4 (4.76mm) to No. 10 (2.0mm)
Medium sand	No. 10 (2.0mm) to No. 40 (0.42mm)
Fine sand	No. 40 (0.42mm) to No. 200 (0.074mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

Sample Types

Symbol	Description
SS	SPT Sampler (2.0" OD)
HD	Heavy Duty Split Spoon
SH	Shelby Tube
CA	California Sampler
B	Bulk
C	Cored
G	Grab
P	Pitcher Sampler

Cohesionless Soils (a)		
Density	N, blows/ft.[c]	Relative Density (%)
Very loose	0 to 4	0 - 15
Loose	4 to 10	15 - 35
Compact	10 to 30	35 - 65
Dense	30 to 50	65 - 85
Very Dense	over 50	>85

Cohesive Soils(b)		
Consistency	N, blows/ft.[c]	Undrained Shear Strength (psf) [d]
Very soft	0 to 2	<250
Soft	2 to 4	250-500
Firm	4 to 8	500-1000
Stiff	8 to 15	1000-2000
Very Stiff	15 to 30	2000-4000
Hard	over 30	>4000

(a) Soils consisting of gravel, sand, and silt, either separately or in combination, possessing no characteristics of plasticity, and exhibiting drained behavior.
(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.
(c) Refer to text of ASTM D 1586-84 for a definition of N; in normally consolidated cohesionless soils. Relative Density terms are based on N values corrected for overburden pressures.
(d) Undrained shear strength = 1/2 unconfined compression strength.

Laboratory Tests

Test	Designation
Moisture	(1)
Density	D
Grain Size	G
Hydrometer	H
Atterberg Limits	(1)
Consolidation	C
Unconfined	U
UU Triax	UU
CU Triax	CU
CD Triax	CD
Permeability	P

(1) Moisture and Atterberg Limits plotted on log.

Silt and Clay Descriptions

Description	Typical Unified Designation
Silt	ML (non-plastic)
Clayey Silt	CL-ML (low plasticity)
Silty Clay	CL
Clay	CH
Plastic Silt	MH
Organic Soils	OL, OH, Pt

Qualitative Descriptive Terminology for Moisture Content

Dry	No discernible moisture present
Damp	Enough moisture present to darken the appearance but no moisture on materials adheres to the hand
Moist	Will moisten the hand
Wet	Visible water present on materials

Descriptive Terminology Denoting Component Proportions

Descriptive Terms	Range of Proportion
Trace	0-5%
Little	5-12%
Some or Adjective (a)	12-30%
And	30-50%

(a) Use Gravelly, Sandy or Silty as appropriate.

SOIL CLASSIFICATION LEGEND

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RECORD OF BOREHOLE GB-1

SHEET 1 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Lafayette Road

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/13/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.30

ELEVATION: 43
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	0.0 - 0.3 Asphalt.		42.7 0.3						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
	0.3 - 1.5 1 1/2-inch minus crushed rock base rock, damp (GM) (FILL).	GM	41.5 1.5						
	1.5 - 9.5 Very loose to loose, gray brown, heterogeneous, silty fine to coarse SAND, trace fine gravel, damp. (SM) (FILL)	SM		1	SS	4-3-2	5	0.8/1.5	
5				2	SS	1-2-1	3	0.3/1.5	
			33.5 9.5	3	SS	1-2-3	5	1.3/1.5	
10	9.5 - 12.0 Very loose to loose, light gray, non-stratified, fine sandy SILT, trace fine gravel, little roots, little organic fragments, iron-oxide stained layers, damp. (SM) (OVERBANK DEPOSIT)	SM	31.0 12.0	4	SS	2-2-3	5	1.5/1.5	
	12.0 - 17.0 Loose, brown to light gray, stratified, fine to medium SAND, little silt, trace iron-oxide stained layers, dilatant, moist to wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM		5	SS	1-3-6	9	1.3/1.5	
15			26.0 17.0	6	SS	3-3-2	5	1.1/1.5	Groundwater was encounted 15 feet bgs ATD.
	17.0 - 19.5 Very loose, light gray to brown, stratified, SILT, some fine SAND, clay and silt layers, some organic material up to 4-inches thick, dilatant, wet. (ML) (QUIET-WATER DEPOSIT)	ML	23.5 19.5	7	SS	0-0-1	1	1.5/1.5	
20		SM							

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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-1

SHEET 2 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Lafayette Road
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/13/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.30
ELEVATION: 43
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	DESCRIPTION	USCS	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	19.5 - 23.0 Very loose, light gray brown, non-stratified, silty fine to medium SAND, 2-inch thick silt layer, trace iron-oxide staining, trace rootlets, moist. (SM) (OVERBANK DEPOSIT) *(Continued)*	SM		8	SS	0-1-1	2	1.1/1.5	
23	23.0 - 35.9 Compact to dense, gray to dark gray, non-stratified, fine to medium SAND, trace silt, scoria and mica angular grains, wet. (SP) (CHANNEL DEPOSIT)	SP	20.0 23.0						
25				9	SS	2-3-7	10	0.9/1.5	
30				10	SS	6-20-24	44	1.5/1.5	
35				11	SS	7-10-17	27	1.5/1.5	Driller noted heaving sands at 35 feet.
	35.9 - 37.0 Dense, light gray, stratified, SILT, some organics, trace fine sand, moist. (ML) (OVERBANK DEPOSIT)	ML	7.1 35.9						
	37.0 - 41.3 Very loose to compact, dark gray, non-stratified, fine to medium SAND, little silt, angular to subangular grains, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM	6.0 37.0	12	SS	6-7-10	17	1.5/1.5	
40									

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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer
LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

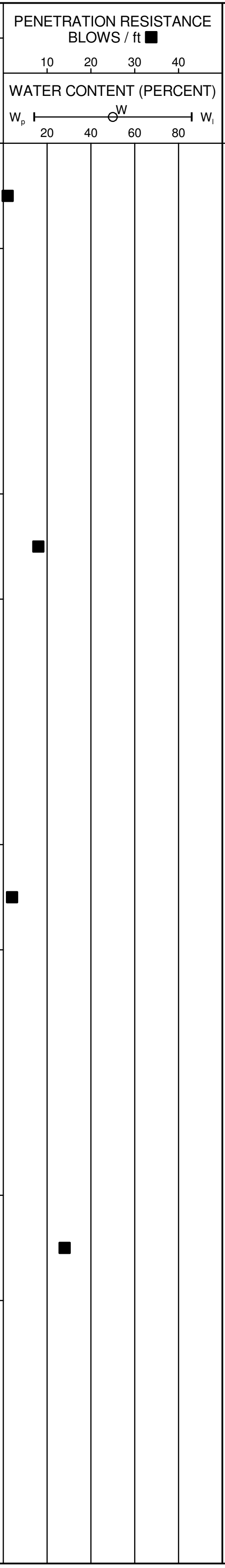
Golder Associates

RECORD OF BOREHOLE GB-1

SHEET 3 of 4

PROJECT: Burlington Levee	DRILLING METHOD: Hollow Stem Auger	DATUM: Geodetic	ELEVATION: 43
PROJECT NUMBER: 093-93153.100	DRILLING DATE: 4/13/2009	AZIMUTH: N/A	INCLINATION: -90
LOCATION: Lafayette Road	DRILL RIG: CME 75 Truck-Mounted	COORDINATES: N: 48.29 E: 122.30	

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	37.0 - 41.3 Very loose to compact, dark gray, non-stratified, fine to medium SAND, little silt, angular to subangular grains, wet. (SP-SM) (OVERBANK DEPOSIT) *(Continued)*	SP-SM		13	SS	1-0-1	1	1.5/1.5	
		41.3 - 48.0 Very loose to loose, medium gray, non-stratified, SILT, trace fine sand, moist. (ML) (OVERBANK DEPOSIT)	ML	1.7 41.3						
45					14	SS	5-5-3	8	1.5/1.5	
		48.0 - 54.0 Very loose to loose, dark gray, non-stratified, SILT, little fine to medium angular to subangular sand, possible ash fragments up to 1/4-inch, moist. (ML) (OVERBANK DEPOSIT)	ML	-5.0 48.0						
50					15	SS	4-1-1	2	1.5/1.5	
		54.0 - 58.0 Compact, dark gray, stratified, silty fine SAND, trace organics, silt seams, angular to subangular grains, wet. (SM) (OVERBANK DEPOSIT)	SM	-11.0 54.0						
55					16	SS	5-7-7	14	1.5/1.5	
		58.0 - 61.5 Dense, dark gray, slightly stratified, fine to coarse SAND, trace to little silt, trace rootlet lenses, dilatant, scoria and mica angular grains, wet. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	-15.0 58.0						
60										



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1 in to 3 ft

DRILLING CONTRACTOR: Cascade Drilling, Inc.

DRILLER: Jaymen Lauer

LOGGED: A. Dennison

CHECKED: A. McKenzie-Johnson

DATE: 7/2/2009

RECORD OF BOREHOLE GB-1

SHEET 4 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Lafayette Road

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/13/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.30

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p —○W— W_l (20 40 60 80)	NOTES WATER LEVELS
60		58.0 - 61.5 Dense, dark gray, slightly stratified, fine to coarse SAND, trace to little silt, trace rootlet lenses, dilatant, scoria and mica angular grains, wet. (SP-SM) (CHANNEL DEPOSIT) *(Continued)*	SP-SM		-18.5 61.5	17	SS	7-13-21	34	1.5 / 1.5	○ ■	G .
		Boring completed at 61.5 ft.										
65												
70												
75												
80												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

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RECORD OF BOREHOLE GB-2

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: 50 ft South of Ecology Blocks

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/13/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 43
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE

DEPTH (ft)	DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 1.0	2-inch crushed rock, damp. (GP) (FILL)	GP	42.0 1.0
1.0 - 9.5	Loose to compact, iron-oxide stained light gray to light brownish gray, heterogeneous, silty fine to medium SAND, trace organic fragments, damp. (SM) (FILL)	SM	33.5 9.5
9.5 - 17.0	Loose, light gray, stratified, SILT, some fine sand, iron-oxide layers, damp. (ML) (OVERBANK DEPOSIT)	ML	26.0 17.0
17.0 - 19.5	Loose, light gray to medium gray, stratified, fine sandy SILT, dark gray organic lenses up to 3-8-inch thick, iron-oxide staining layers, damp. (ML) (QUIET-WATER DEPOSIT)	ML	23.5 19.5
		ML	

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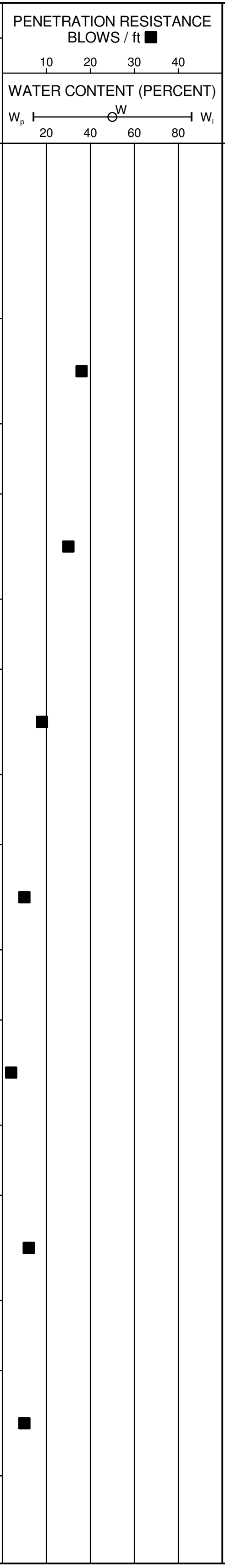
SAMPLES (BLOWS per 6 in; 140 lb hammer, 30 inch drop)

NUMBER	TYPE	BLOWS per 6 in	N	REC / ATT
1	SS	7-8-10	18	1.5/1.5
2	SS	5-7-8	15	1.5/1.5
3	SS	4-4-5	9	1.5/1.5
4	SS	3-3-2	5	1.5/1.5
5	SS	1-1-1	2	1.5/1.5
6	SS	2-2-4	6	1.4/1.5
7	SS	4-4-1	5	1.5/1.5



NOTES / WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

Possible groundwater was encountered at 17 feet bgs during drilling.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-2

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: 50 ft South of Ecology Blocks

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/13/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) Wp —O W— Wl (20 40 60 80)	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	19.5 - 22.0 Very loose, light gray to gray, stratified, SILT and fine SAND, iron-oxide staining, dilatant, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		21.0 22.0	8	SS	0-0-0	0	1.5/1.5	■	G .
		22.0 - 25.6 Compact, gray, stratified, fine to medium SAND, little silt, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM		17.4 25.6							
25		25.6 - 26.0 Compact, light gray to gray, stratified, SILT and fine SAND, iron-oxide staining, dilatant, wet. (ML) (OVERBANK DEPOSIT)	ML		17.0 26.0	9	SS	3-5-9	14	1.5/1.5	■	
		26.0 - 29.0 Compact, light gray, stratified, SILT, some fine sand, iron-oxide layers, damp. (ML) (OVERBANK DEPOSIT)	ML		14.0 29.0							
30		29.0 - 30.5 Compact, yellow brown, slightly stratified, fine to medium SAND, trace silt, angular grains, wet. (SP) (OVERBANK DEPOSIT)	SP		12.5 30.5	10	SS	3-8-11	19	1.5/1.5	■	
		30.5 - 31.2 Compact, dark green gray, stratified, fine SAND, little silt, angular grains, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM		11.8 31.2							
		31.2 - 34.0 Compact, gray, non-stratified, silty fine SAND, wet. (SM) (OVERBANK DEPOSIT)	SM		9.0 34.0							
35		34.0 - 39.0 Dense, light gray, stratified, silty fine SAND, trace rootlets, wet. (SM) (OVERBANK DEPOSIT)	SM		4.0 39.0	11	SS	10-16-21	37	1.5/1.5	■	
40			ML									

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

RECORD OF BOREHOLE GB-2

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: 50 ft South of Ecology Blocks

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/13/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p ⊢—○W—⊣ W_l (20 40 60 80)	NOTES WATER LEVELS
40		39.0 - 44.0 Compact, medium gray to pink gray, stratified, SILT and fine SAND, trace organics, dilatant, moist. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML			12	SS	10-7-4	11	1.5/1.5	■	
		44.0 - 46.5 Dense, medium gray, non-stratified, fine to medium SAND, little silt, trace white pumice fragments, scoria and mica angular grains, wet. (SP-SM) (CHANNEL DEPOSIT)	SP-SM		-1.0 44.0							
45						13	SS	2-20-16	36	1.5/1.5	■	
		Boring completed at 46.5 ft.			-3.5 46.5							
50												
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-3

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Existing Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/14/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE

DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)
0.0 - 1.0 1.5-inch minus crushed rock, damp (GM) (FILL).	GM		44.0 1.0
1.0 - 9.5 Compact, medium brown to light gray, heterogeneous, silty fine SAND, trace iron-oxide stained pockets, damp. (SM) (FILL)	SM		35.5 9.5
9.5 - 12.0 Compact, medium gray, heterogeneous, fine sandy SILT, little organics (roots, straw), damp. (ML) (FILL)	ML		33.0 12.0
12.0 - 14.5 Compact, medium to dark gray, heterogeneous, silty fine to medium SAND, trace fine gravel, little rootlets and straw, damp. (SM) (FILL)	SM		30.5 14.5
14.5 - 20.3 Compact, light gray, slightly stratified, SILT, some fine sand, fine to medium sand seams, iron-oxide stained layers, damp. (ML) (OVERBANK DEPOSIT)	ML		

Log continued on next page

SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	5-6-7	13	1.5/1.5
2	SS	6-8-9	17	1.5/1.5
3	SS	7-11-13	24	1.5/1.5
4	SS	8-7-9	16	1.5/1.5
5	SS	10-6-6	12	1.5/1.5
6	SS	1-0-3	3	1.5/1.5
7	SS	2-0-1	1	1.5/1.5

PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40)
WATER CONTENT (PERCENT) W_p — W — W_l (20, 40, 60, 80)

NOTES WATER LEVELS GRAPHIC

Flush-mount monument set in 2 feet concrete with locked well cap.

2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.

Groundwater

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

RECORD OF BOREHOLE GB-3

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Existing Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/14/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29
ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
20		ML	24.7					
	20.3 - 24.0 Very loose, light gray to yellow brown, slightly stratified, SILT, fine to medium sand pockets, plastic silt pockets with organic fragments, iron-oxide stained lenses, moist. (ML) (QUIET-WATER DEPOSIT)	ML	20.3	8	SS	1-0-1	1	1.5/1.5
	24.0 - 34.0 Loose to compact, iron-oxide stained medium to dark gray, non-stratified, SILT and fine SAND, trace organic fragments, wet. (ML) (CHANNEL DEPOSIT)	ML	21.0 24.0					
25				9	SS	2-4-3	7	1.5/1.5
30		ML		10	SS	2-6-7	13	1.5/1.5
	34.0 - 39.0 Compact, medium gray to gray, non-stratified, fine to medium SAND, trace silt, scoria and mica angular grains, wet. (SP) (CHANNEL DEPOSIT)	SP	11.0 34.0					
35				11	SS	6-6-7	13	1.5/1.5
		SP	6.0 39.0					
40								

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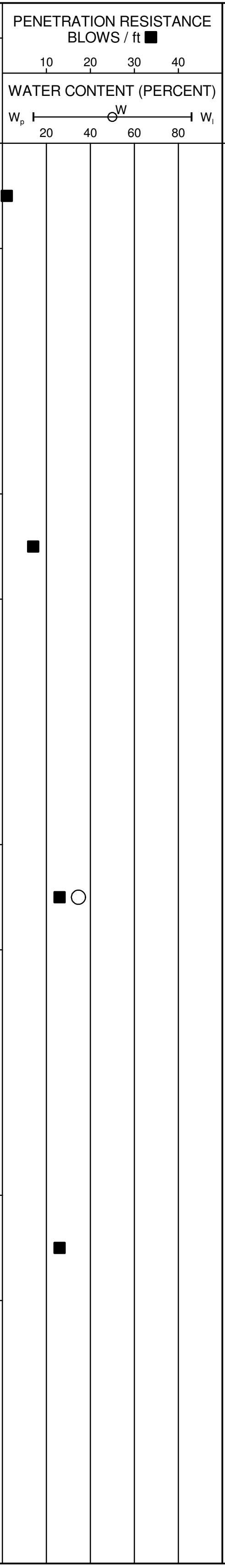

NOTES WATER LEVELS

measured 20.04 ft btc on 5/19/09.

Groundwater measured 21.77 ft btc on 4/24/09.

Groundwater measured 21.96 ft btc on 4/14/09.

Groundwater measured 22.33 ft btc on 4/27/09

Groundwater measured 22.45 ft btc on 4/17/09.

2-inch diameter solid schedule 40 PVC with o-ring joints set in sand backfill.

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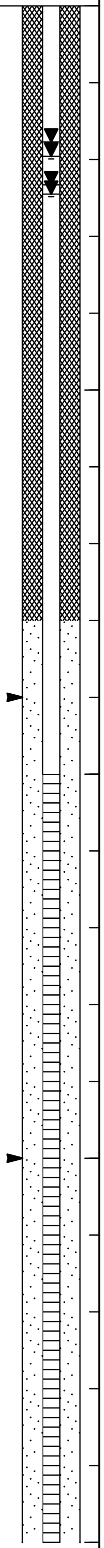
2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill.



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-3

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Existing Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/14/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	SOIL PROFILE USCS	SOIL PROFILE GRAPHIC LOG	SOIL PROFILE ELEV. / DEPTH (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS per 6 in (140 lb hammer 30 inch drop)	SAMPLES N	SAMPLES REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40); WATER CONTENT (PERCENT) Wp —○W— Wl (20 40 60 80)	NOTES WATER LEVELS GRAPHIC
40		39.0 - 41.5 Dense, medium gray to gray, non-stratified, fine to coarse SAND, trace silt, scoria and mica angular grains, wet. (SP) (CHANNEL DEPOSIT) *(Continued)*	SP		3.5	12	SS	12-13-28	41	1.5/1.5	■	Sand backfill. ►
		Boring completed at 41.5 ft.			41.5							
45												
50												
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-4

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/14/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

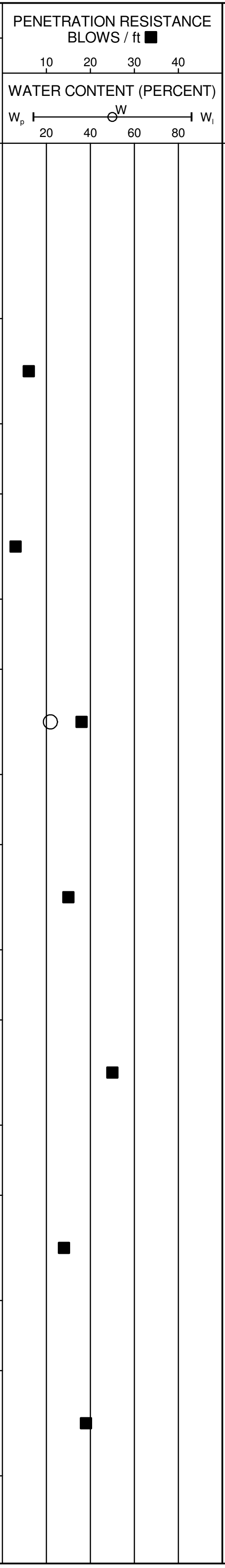
SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 1.0 1.5-inch minus crushed rock, damp (GM) (FILL).	GM	44.0 1.0
1.0 - 7.0 Loose, brown gray, heterogeneous, silty fine to coarse SAND, some fine to coarse gravel, angular fragments, damp. (SM) (FILL)	SM	38.0 7.0
7.0 - 9.5 Compact, light gray, heterogeneous, fine SAND and SILT, iron-oxide staining, damp. (SM) (FILL)	SM	35.5 9.5
9.5 - 15.9 Compact, brown gray, heterogeneous, silty fine to coarse SAND, some fine to coarse gravel, trace organics, silt pockets, angular fragments, damp. (SM) (FILL)	SM	29.1 15.9
15.9 - 17.0 Compact, light gray, non-stratified, SILT, little organics (rootlets), iron-oxide staining, damp. (ML) (QUIET-WATER DEPOSIT)	ML	28.0 17.0
17.0 - 20.3 Compact, light gray, non-stratified, SILT, some fine sand, fine to medium sand seams, iron-oxide stained layers, damp. (ML) (OVERBANK DEPOSIT)	ML	

Log continued on next page

SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	6-4-2	6	0.6 / 1.5
2	SS	2-2-1	3	0.8 / 1.5
3	SS	8-9-9	18	1.5 / 1.5
4	SS	8-7-8	15	1.5 / 1.5
5	SS	7-15-10	25	1.5 / 1.5
6	SS	7-8-6	14	1.5 / 1.5
7	SS	4-9-10	19	1.5 / 1.5



NOTES WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-4

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/14/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	DESCRIPTION	USCS	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20		ML	24.7						
	20.3 - 28.0 Loose, iron-oxide stained, light gray, non-stratified, SILT and fine SAND, damp. (ML) (OVERBANK DEPOSIT)	ML	20.3	8	SS	3-4-4	8	1.5/1.5	
									Possible groundwater was encountered at 23 feet bgs during drilling.
25	-Sample becomes wet.			9	SS	4-5-5	10	1.5/1.5	G .
	28.0 - 38.0 Loose to compact, light to medium gray, stratified, silty fine to medium SAND, leaves, silt layers up to 3 inches thick, organics (leaves), dilatant, wet. (SM) (OVERBANK DEPOSIT)	SM	17.0 28.0						
30				10	SS	1-2-3	5	1.5/1.5	
35				11	SS	0-2-12	14	1.5/1.5	
	38.0 - 51.4 Compact, medium to dark gray, non-stratified, fine to medium SAND, trace silt, angular scoria and mica grains, wet. (SP) (CHANNEL DEPOSIT)	SP	7.0 38.0						
40									

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40
WATER CONTENT (PERCENT) W_p —○W— W_l 20 40 60 80

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-4

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/14/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE				SAMPLES					PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40) WATER CONTENT (PERCENT) W_p —○W— W_l (20, 40, 60, 80)	NOTES WATER LEVELS
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT		
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	38.0 - 51.4 Compact, medium to dark gray, non-stratified, fine to medium SAND, trace silt, angular scoria and mica grains, wet. (SP) (CHANNEL DEPOSIT) *(Continued)*	SP			12	SS	4-6-13	19	1.5/1.5	■	
45						13	SS	4-6-9	15	1.5/1.5	■	
50					-6.4 51.4	14	SS	13-18-55/4"	>50	1.3/1.3	>>■	
		Boring completed at 51.4 ft.										
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-5

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/15/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.30

ELEVATION: 44
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	0.0 - 0.3 1.5-inch minus crushed rock, damp. (GM) (FILL).	GM	43.7 0.3						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
	0.3 - 17.0 Compact, light to medium gray, heterogeneous, silty fine to medium SAND, trace to little pockets of silt, trace organics (fragments and rootlets), iron-oxide stained pockets, damp. (SM) (FILL)	SM							
				1	SS	5-6-9	15	1.5/1.5	
5				2	SS	12-9-11	20	1.5/1.5	
				3	SS	6-9-10	19	1.5/1.5	
10				4	SS	6-12-14	26	1.5/1.5	
	-Grass and straw observed in sample.			5	SS	6-16-18	34	1.5/1.5	
15				6	SS	6-8-7	15	1.5/1.5	
	17.0 - 19.5 Loose, light gray and blue gray, stratified, fine sandy SILT, wet. (ML) (OVERBANK DEPOSIT)	ML	27.0 17.0	7	SS	6-4-3	7	1.5/1.5	G .
20		ML	24.5 19.5						

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-5

SHEET 2 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/15/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.30
ELEVATION: 44
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer, 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40); WATER CONTENT (PERCENT) Wp ⊢○W⊣ Wl (20 40 60 80)	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	19.5 - 21.5 Loose, blue gray, slightly stratified, fine sandy SILT, some organic fragments and rootlets, fine to medium sand seams, damp. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		22.5	8	SS	1-2-4	6	1.5/1.5	■	
		21.5 - 31.3 Compact to very dense, light brown to gray, non-stratified, fine to coarse SAND, trace to little silt, damp to wet. (SW) (CHANNEL DEPOSIT)	SW		21.5							▼ Possible groundwater was encountered at 23 feet bgs during drilling.
25						9	SS	4-10-10	20	1.5/1.5	■	
30					12.7	10	SS	7-40-50/4"	>50	1.3/1.3	>>■	
		Boring completed at 31.3 ft.			31.3							
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-6

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/15/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.30
ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

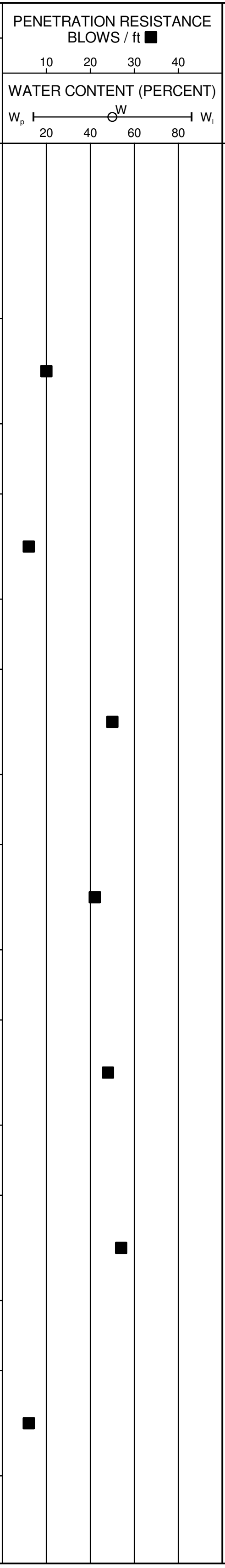
SOIL PROFILE

DEPTH (ft)	DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0	0.0 - 0.5 2-inch minus crushed rock, damp. (GM) (FILL)	GM	44.5 0.5
	0.5 - 9.0 Loose to compact, scattered iron-oxide stained yellow brown to gray, heterogeneous, silty fine to medium SAND, trace to some organic fragments, trace silt pockets, damp. (SM) (FILL)	SM	36.0 9.0
5			
	9.0 - 12.0 Compact, medium gray, heterogeneous, fine sandy SILT, some organic (fragments), damp. (ML) (FILL)	ML	33.0 12.0
10			
	12.0 - 16.5 Compact, medium gray to dark gray, heterogeneous, silty fine to medium SAND, trace to some organics (fragments), damp. (SM) (FILL) -Straw observed in sample.	SM	28.5 16.5
15			
	16.5 - 22.0 Loose, light gray to blue gray, slightly stratified, SILT, trace organic (rootlets), damp to moist. (ML) (OVERBANK DEPOSIT)	ML	
20			

Log continued on next page

SAMPLES

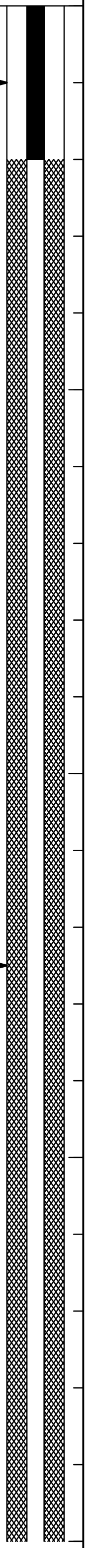
NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	4-6-4	10	$\frac{1.5}{1.5}$
2	SS	1-2-4	6	$\frac{1.5}{1.5}$
3	SS	3-9-16	25	$\frac{1.5}{1.5}$
4	SS	5-9-12	21	$\frac{1.5}{1.5}$
5	SS	9-11-13	24	$\frac{1.5}{1.5}$
6	SS	7-12-15	27	$\frac{1.5}{1.5}$
7	SS	1-3-3	6	$\frac{1.5}{1.5}$



NOTES
WATER LEVELS
GRAPHIC

Flush-mount monument set in 2 feet concrete with locked well cap.

2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-6

SHEET 2 of 2

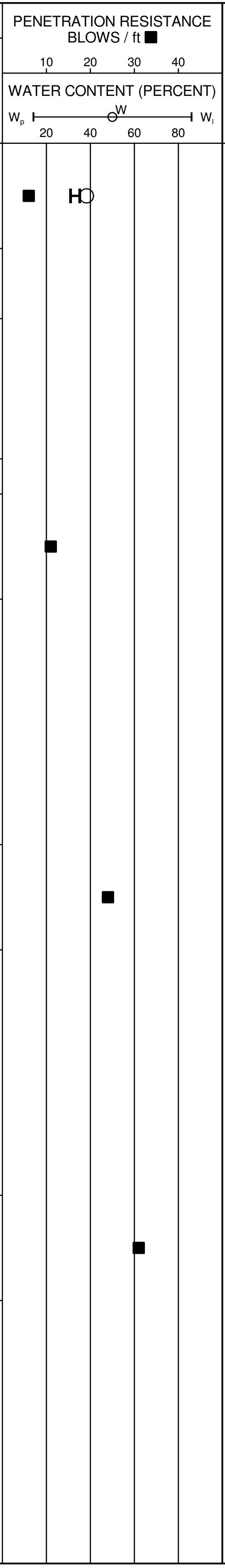
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

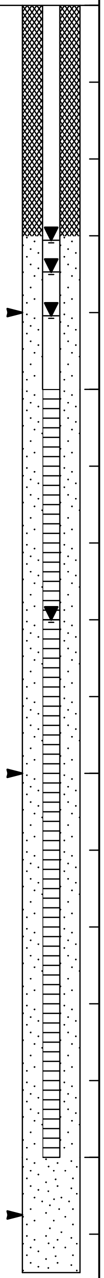
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/15/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.30

ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	16.5 - 22.0 Loose, light gray to blue gray, slightly stratified, SILT, trace organic (rootlets), damp to moist. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		23.0 22.0	8	SS	0-2-4	6	1.5/1.5	2-inch diameter vane shear pushed in 6 inches, max reading 24. Material on vane appeared sandy. Groundwater measured 21.58 ft btc on 5/19/09. Groundwater measured 23.06 ft btc on 4/24/09. Groundwater measured 23.47 ft btc on 4/27/09. 2-inch diameter solid schedule 40 PVC with o-ring joints set in sand backfill. Groundwater measured 24.04 ft btc on 4/17/09.
		22.0 - 36.5 Compact to dense, light to dark gray, non-stratified, silty fine to medium SAND, angular scoria and mica grains, dilatant, wet. (SM) (CHANNEL DEPOSIT)	SM				SH			2.0/2.0	
25						9	SS	2-6-5	11	0.9/1.5	Groundwater encountered at 28 feet ATD. 2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill.
30						10	SS	4-10-14	24	1.5/1.5	
35					8.5 36.5	11	SS	5-14-17	31	1.5/1.5	Sand backfill.
		Boring completed at 36.5 ft.									
40											





1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-7

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.28

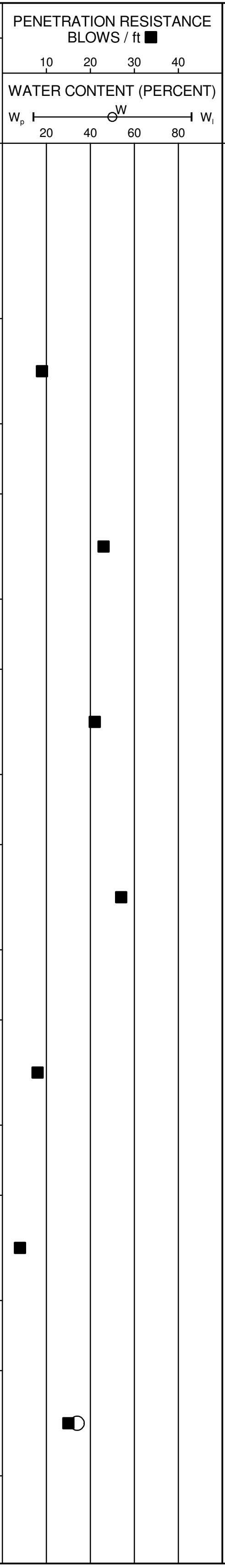
ELEVATION: 44
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE – DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 0.5	2-inch minus crushed rock, damp (GM) (FILL).	GM	43.5 0.5
0.5 - 12.0	Loose to compact, light gray, heterogeneous, silty fine to medium SAND, trace organics, trace silt pockets, trace iron-oxide staining, damp. (SM) (FILL)	SM	32.0 12.0
12.0 - 14.5	Loose, scattered iron-oxide stained light gray, non-stratified, SILT and fine SAND, trace organics, damp. (ML) (FILL)	ML	29.5 14.5
14.5 - 17.0	Loose, iron-oxide stained olive gray to medium gray, non-stratified, SILT, trace organics (rootlets and fragments), damp. (ML) (OVERBANK DEPOSIT)	ML	27.0 17.0
17.0 - 24.0	Compact, light gray, stratified, SILT, little to trace fine to medium sand, fine sandy silt seams (up to 1 inch thick), trace iron-oxide staining seams, moist to wet. (ML) (OVERBANK DEPOSIT)	ML	

Log continued on next page

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	4-3-6	9	1.5/1.5
2	SS	7-12-11	23	1.5/1.5
3	SS	6-7-14	21	1.5/1.5
4	SS	13-14-13	27	1.5/1.5
5	SS	5-5-3	8	1.2/1.5
6	SS	0-2-2	4	1.5/1.5
7	SS	5-6-9	15	1.5/1.5



NOTES / WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

Pocket penetrometer 0.5 to 1.25 TSF, Torvane 1.0 TSF

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-7

SHEET 2 of 2

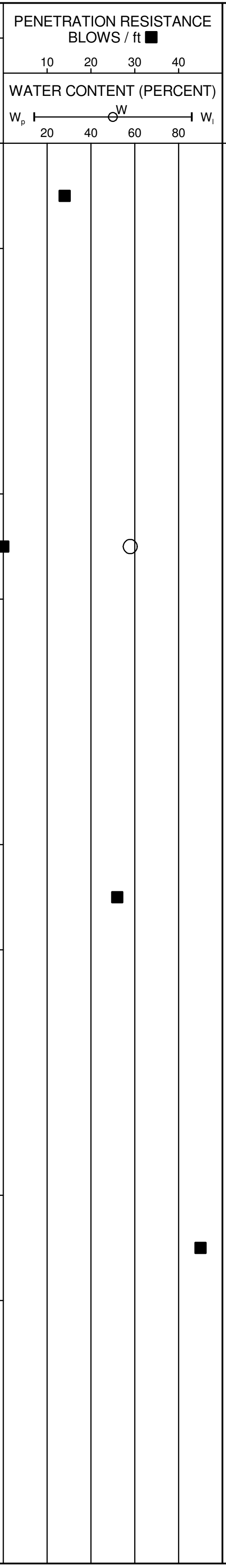
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.28

ELEVATION: 44
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	17.0 - 24.0 Compact, light gray, stratified, SILT, little to trace fine to medium sand, fine sandy silt seams (up to 1 inch thick), trace iron-oxide staining seams, moist to wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		20.0 24.0	8	SS	5-7-7	14	1.2/1.5	
25		24.0 - 28.0 Very loose, dark gray, non-stratified, SILT, some fine sand, some organic fragments up to 0.5 inches thick, moist. (ML) (OVERBANK DEPOSIT)	ML		16.0 28.0	9	SS	0-0-0	0	1.5/1.5	G .
30		28.0 - 36.5 Compact to dense, dark gray, non-stratified, fine to medium SAND, trace silt, scoria and mica subangular to angular grains, wet. (SP) (CHANNEL DEPOSIT)	SP			10	SS	8-14-12	26	1.5/1.5	Groundwater was encountered 29 feet bgs ATD.
35					7.5 36.5	11	SS	8-17-28	45	1.5/1.5	
40		Boring completed at 36.5 ft.									



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-8

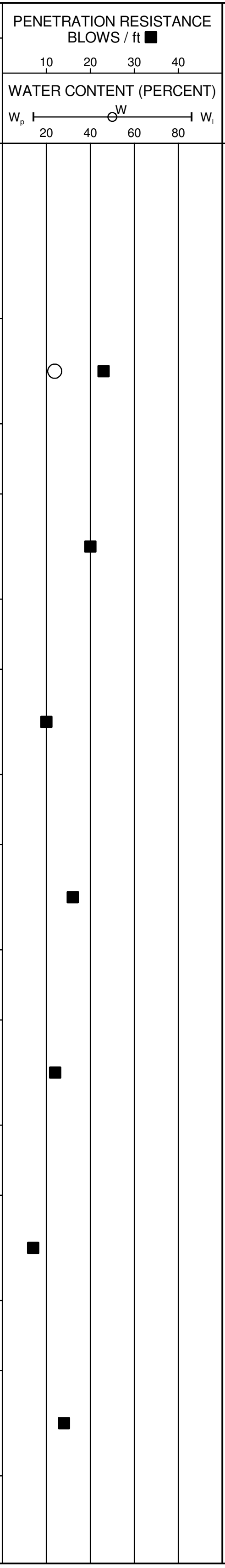
SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29
ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE			
DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)
0.0 - 1.0 1.5-inch minus crushed rock, damp. (GM) (FILL)	GM	▩	44.0 1.0
1.0 - 13.3 Compact, brown gray to olive gray, heterogeneous, SILT and fine to coarse SAND, trace fine gravel, trace organics, trace silt and sand pockets, damp. (ML) (FILL)	ML	▩	31.7 13.3
13.3 - 14.5 Compact, orange brown, non-stratified, fine sandy SILT, little to some organics (rootlets), damp. (ML) (OVERBANK DEPOSIT)	ML	‖	30.5 14.5
14.5 - 18.1 Loose, light gray, non-stratified, fine sandy SILT, little organics (rootlets), damp. (ML) (OVERBANK DEPOSIT)	ML	‖	26.9 18.1
18.1 - 28.0 Compact, gray brown to brown, non-stratified, fine to medium SAND, trace silt, red and mica angular grains, damp. (SP) (CHANNEL DEPOSIT)	SP	⁘	

SAMPLES				
NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT
1	SS	8-11-12	23	1.5/1.5
2	SS	9-10-10	20	1.5/1.5
3	SS	5-5-5	10	1.5/1.5
4	SS	3-4-12	16	1.5/1.5
5	SS	9-5-7	12	1.5/1.5
6	SS	1-3-4	7	1.2/1.5
7	SS	3-6-8	14	1.5/1.5



NOTES
WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

G .

DEPTH (ft): 0, 5, 10, 15, 20

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-8

SHEET 2 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29
ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) Wp ⊢ W ○ ⊣ Wl (20 40 60 80)	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	18.1 - 28.0 Compact, gray brown to brown, non-stratified, fine to medium SAND, trace silt, red and mica angular grains, damp. (SP) (CHANNEL DEPOSIT) *(Continued)*	SP			8	SS	4-6-8	14	1.5/1.5	■	
25						9	SS	5-7-8	15	1.4/1.5	■	
												▼ Groundwater was encountered 27 feet bgs ATD.
		28.0 - 35.9 Very dense, dark gray, non-stratified, fine to coarse SAND, trace silt, scoria and mica subangular to angular grains, wet. (SP) (CHANNEL DEPOSIT)	SP		17.0 28.0							
30		-Blow counts appear overstated, possibly to heaving sand conditions.				10	SS	6-24-50/4"	>50	1.2/1.3	>>■	
												Driller noted 1 foot of heaving sands at 32 feet.
35		-Blow counts appear overstated, possibly to heaving sand conditions.			9.1 35.9	11	SS	11-50/5.5"	>50	0.9/0.9	>>■	
		Boring completed at 35.9 ft.										
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-9

SHEET 1 of 2

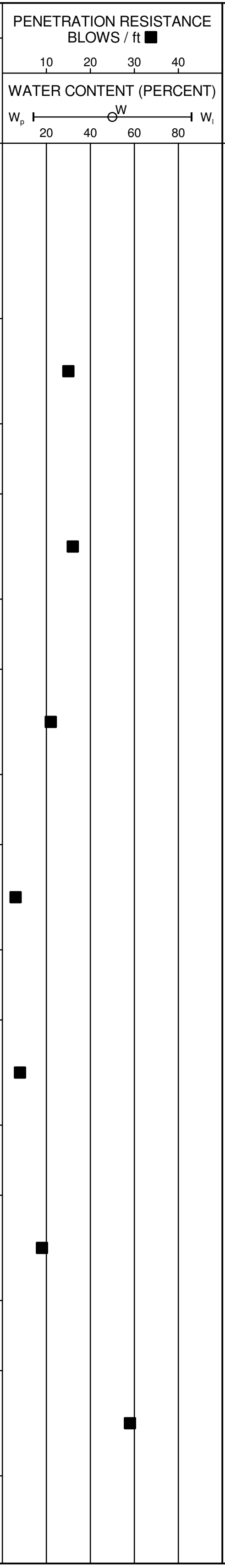
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

ELEVATION: 44
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	0.0 - 1.5 Compact, brown, silty fine to coarse SAND, some organics, some 1.5-inch crushed rock, damp. (SM) (FILL)	SM	42.5 1.5						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
		1.5 - 9.5 Compact, light yellow-brown to brown-gray, heterogeneous, silty fine to medium SAND, pockets of silt, trace to little organics, iron-oxide staining, damp. (SM) (FILL)	SM	34.5 9.5	1	SS	6-7-8	15	1.5/1.5	
5					2	SS	6-7-9	16	1.5/1.5	
					3	SS	7-5-6	11	1.2/1.5	
10		9.5 - 12.0 Very loose, light yellow to orange-brown, non-stratified, fine sandy SILT, trace organics, iron-oxide staining, damp. (ML) (OVERBANK DEPOSIT)	ML	32.0 12.0	4	SS	1-1-2	3	0.8/1.5	
		12.0 - 19.5 Loose to compact, brown-gray, non-stratified, fine to coarse SAND, trace silt, scoria and mica subangular to angular grains, damp. (SW) (CHANNEL DEPOSIT)	SW	24.5 19.5	5	SS	2-1-3	4	1.5/1.5	
15					6	SS	2-4-5	9	1.2/1.5	
					7	SS	8-14-15	29	1.5/1.5	
20		Log continued on next page	SW							



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-9

SHEET 2 of 2

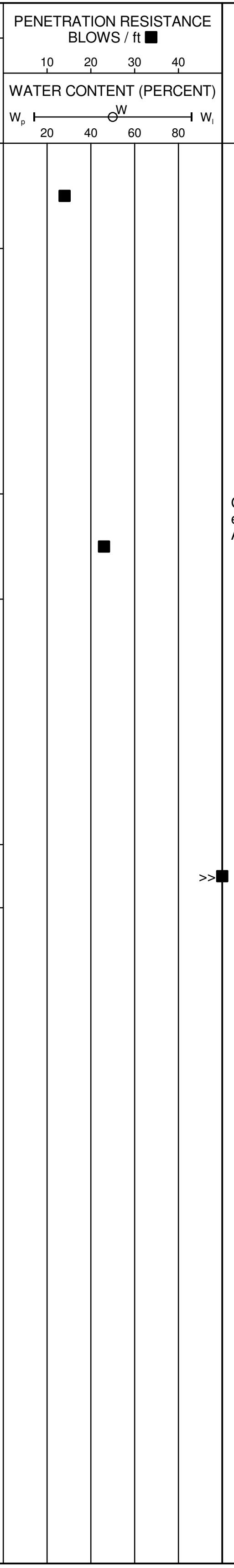
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

ELEVATION: 44
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	19.5 - 31.0 Loose to compact, brown-gray, non-stratified, fine to coarse SAND, little fine to coarse gravel, trace silt, scoria and mica subangular to angular grains, damp to wet. (SW) (CHANNEL DEPOSIT) *(Continued)*	SW			8	SS	8-7-7	14	1.1/1.5	
25						9	SS	10-12-11	23	1.5/1.5	Groundwater was encountered 25 feet bgs ATD.
30					13.0 31.0	10	SS	20-50/5"	>50	0.9/0.9	
31.0		Boring completed at 31.0 ft.									
35											
40											



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-10

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/17/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.29

ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
0.0 - 1.5 1-inch minus crushed rock, damp (GM) (FILL).	GM	43.5 1.5					
1.5 - 9.5 Loose, light brown to light gray, heterogeneous, silty fine to medium SAND, silt pockets, trace organics (fragments and rootlets), damp. (SM) (FILL)	SM		1	SS	2-3-5	8	1.5/1.5
			2	SS	2-3-3	6	1.5/1.5
		35.5 9.5	3	SS	1-5-4	9	1.5/1.5
9.5 - 17.0 Loose to compact, light brown to light gray, slightly stratified, fine SAND, trace silt, trace iron-oxide staining seams, damp. (SP) (OVERBANK DEPOSIT)	SP		4	SS	2-3-3	6	1.2/1.5
			5	SS	2-4-6	10	1.2/1.5
		28.0 17.0	6	SS	3-5-8	13	1.2/1.5
17.0 - 24.0 Loose to compact, light gray, slightly stratified, fine to coarse SAND, trace silt, trace fine gravel, trace iron-oxide stained layers, damp. (SW) (OVERBANK DEPOSIT)	SW		7	SS	8-6-7	13	1.2/1.5

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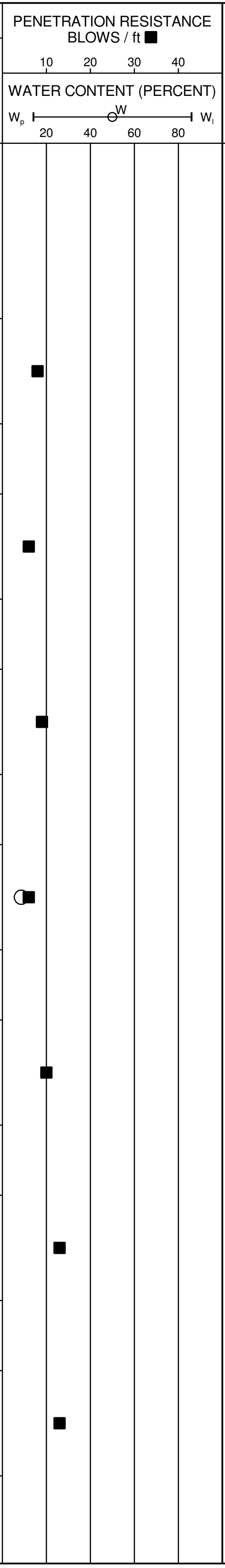
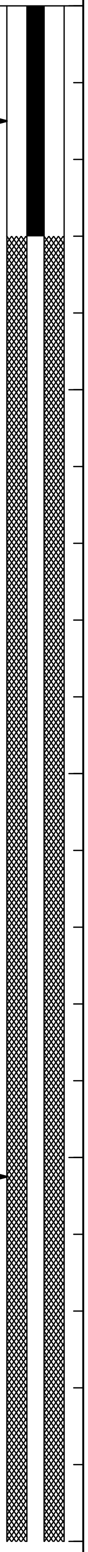


NOTES
WATER LEVELS
GRAPHIC



Flush-mount monument set in 2 feet concrete with locked well cap.

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2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-10

SHEET 2 of 3

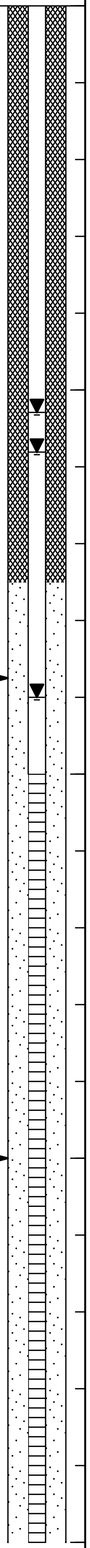
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/17/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.29

ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40); WATER CONTENT (PERCENT) Wp ⊢—○W—⊣ Wl (20 40 60 80)	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	17.0 - 24.0 Loose to compact, light gray, slightly stratified, fine to coarse SAND, trace silt, trace fine gravel, trace iron-oxide stained layers, damp. (SW) (OVERBANK DEPOSIT) *(Continued)*	SW	21.0 24.0	8	SS	3-2-3	5	1.1/1.5	■	Groundwater measured 23.78 ft btc on 5/19/09.
25		24.0 - 41.5 Loose, light gray, non-stratified, fine to coarse SAND, trace silt, trace fine gravel, scoria, mica, quartz, and plagioclase angular grains, damp. (SW) (CHANNEL DEPOSIT)	SW		9	SS	8-5-4	9	1.5/1.5	■	Groundwater measured 25.29 ft btc on 4/24/09. Groundwater measured 25.81 ft btc on 4/27/09. 2-inch diameter solid schedule 40 PVC with o-ring joints set in sand backfill. Groundwater encountered at 29 feet ATD.
30					10	SS	3-6-8	14	1.3/1.5	■	
35		-Blow counts appear over-stated, possibly to heaving sand conditions.			11	SS	8-42-50/4.5"	>50	1.4/1.4	>>■	2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill. Driller noted 2 feet of heaving sands at 35 feet.
40		Log continued on next page									



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-10

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/17/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.29

ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE				SAMPLES					PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40 WATER CONTENT (PERCENT) Wp ⊢—○W—⊣ Wl 20 40 60 80	NOTES WATER LEVELS GRAPHIC
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT		
40		24.0 - 41.5 Loose, light gray, non-stratified, fine to coarse SAND, trace silt, trace fine gravel, scoria, mica, quartz, and plagioclase angular grains, damp. (SW) (CHANNEL DEPOSIT) *(Continued)*	SW		3.5 41.5	12	SS	7-25-43	>50	1.8/1.5	>>■	Driller noted 1 foot of heaving sands at 35 feet. Sand backfill.
		-Blow counts appear overstated, possibly to heaving sand conditions. Boring completed at 41.5 ft.										
45												
50												
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-11

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

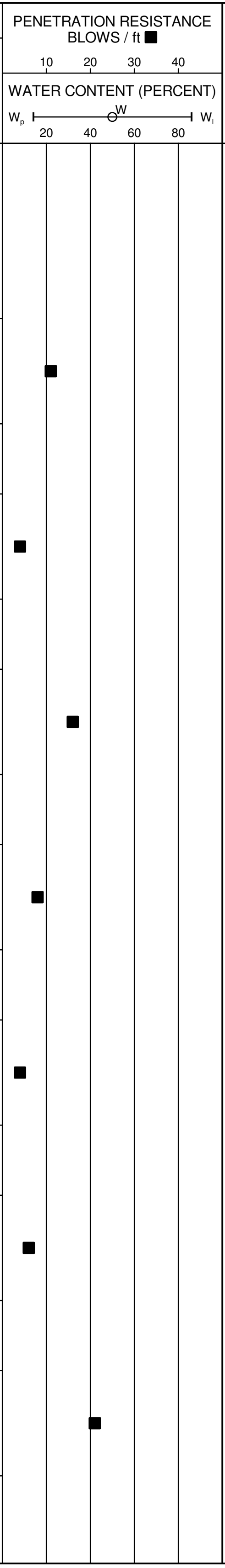
ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0	0.0 - 0.5 1-inch minus crushed rock, damp (GM) (FILL).	GP	44.5 0.5
	0.5 - 12.0 Very loose to compact, brown, heterogeneous, silty fine to medium SAND, trace organics (fragments and rootlets), iron-oxide stained pockets/seams, damp to moist. (SM) (FILL)	SM	33.0 12.0
	12.0 - 17.0 Loose, light yellow to yellow-brown, non-stratified to slightly stratified, silty fine to medium SAND, trace silt pockets, trace organic fragments, iron-oxide staining, damp. (SM) (OVERBANK DEPOSIT)	SM	28.0 17.0
	17.0 - 24.0 Compact, brown-gray to gray, non-stratified, fine to medium SAND, trace silt, scoria and mica angular to subangular grains, damp. (SP) (CHANNEL DEPOSIT)	SP	
20	Log continued on next page		

SAMPLES (BLOWS per 6 in: 140 lb hammer, 30 inch drop)

NUMBER	TYPE	BLOWS per 6 in	N	REC / ATT
1	SS	3-5-6	11	1.5/1.5
2	SS	2-2-2	4	1.0/1.5
3	SS	5-5-11	16	1.0/1.5
4	SS	4-4-4	8	1.2/1.5
5	SS	2-2-2	4	1.5/1.5
6	SS	3-3-3	6	1.1/1.5
7	SS	5-9-12	21	1.5/1.5



NOTES
WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-11

SHEET 2 of 2

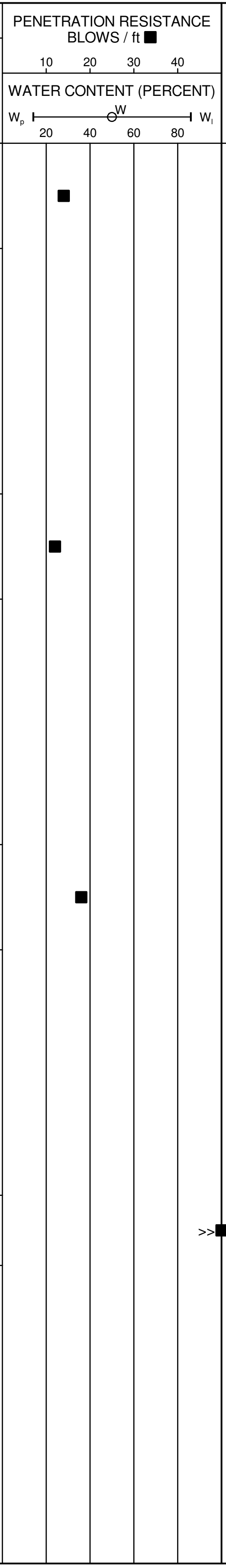
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/16/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	17.0 - 24.0 Compact, brown-gray to gray, non-stratified, fine to medium SAND, trace silt, scoria and mica angular to subangular grains, damp. (SP) (CHANNEL DEPOSIT) *(Continued)*	SP		21.0 24.0	8	SS	7-6-8	14	1.3/1.5	
25		24.0 - 36.0 Compact to very dense, gray, non-stratified, fine to coarse SAND, trace silt, scoria and mica angular to subangular grains, wet. (SW) (CHANNEL DEPOSIT)	SW			9	SS	7-5-7	12	1.1/1.5	Groundwater was encountered 27 feet bgs ATD.
30						10	SS	3-4-14	18	1.5/1.5	
35					9.0 36.0	11	SS	6-50/6"	>50	0.9/1.0	
40		Boring completed at 36.0 ft.									



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-12

SHEET 1 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/17/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

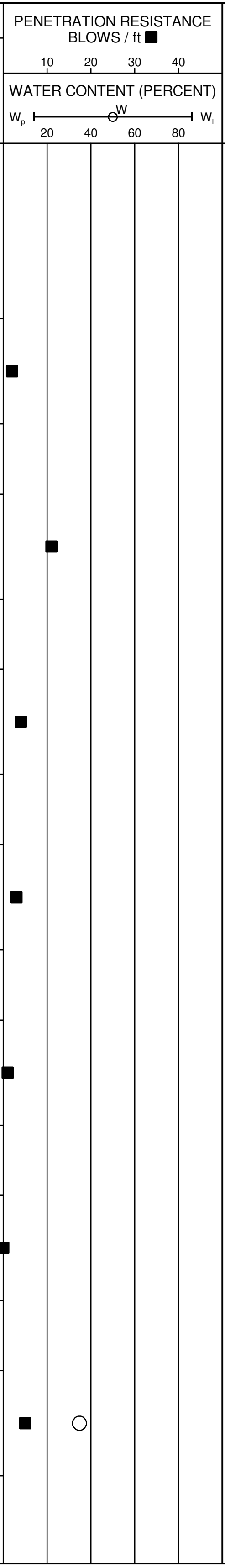
ELEVATION: 44
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)
0.0 - 1.5	2-inch minus crushed rock, damp (GM) (FILL).	GM	▨	42.5 1.5
1.5 - 9.0	Very loose to loose, light brown to gray, heterogeneous, SILT some fine SAND, trace silt, trace organics, damp. (ML) (FILL)	ML	▨	35.0 9.0
9.0 - 14.0	Very loose, light brown, non-stratified to slightly stratified, silty fine to medium SAND, trace organics (rootlets), damp. (SM) (FILL)	SM	▨	30.0 14.0
14.0 - 17.0	Very loose, light brown, heterogenous, SILT, trace fine SAND, trace organics (rootlets), damp. (ML) (FILL)	ML	▨	27.0 17.0
17.0 - 24.0	Loose, light gray to white gray, stratified, SILT, little fine sand, trace organics, iron-oxide stained layers and pockets, wet. (ML) (OVERBANK DEPOSIT)	ML	‖	

Log continued on next page

SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	1-1-1	2	1.5 / 1.5
2	SS	4-5-6	11	1.3 / 1.5
3	SS	1-2-2	4	1.3 / 1.5
4	SS	1-2-1	3	1.5 / 1.5
5	SS	1-0-1	1	1.5 / 1.5
6	SS	1-0-0	0	1.5 / 1.5
7	SS	1-2-3	5	1.5 / 1.5



NOTES WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

RECORD OF BOREHOLE GB-12

SHEET 2 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/17/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 44
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	17.0 - 24.0 Loose, light gray to white gray, stratified, SILT, little fine sand, trace organics, iron-oxide stained layers and pockets, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML	20.0 24.0	8	SS	2-3-2	5	1.5/1.5	
25	24.0 - 29.0 Loose, gray, stratified, fine to medium SAND, little silt, trace iron-oxide stained layers, silty fine sand seams up to 1 inch thick, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM	15.0 29.0	9	SS	9-7-2	9	0.9/1.5	▼ Groundwater was encountered 27 feet bgs ATD.
30	29.0 - 39.0 Compact, brown-gray, non-stratified, fine to coarse SAND, trace silt, trace fine to coarse gravel, subrounded grains, wet. (SW) (CHANNEL DEPOSIT)	SW	5.0 39.0	10	SS	3-7-11	18	1.5/1.5	
35				11	SS	5-6-10	16	1.5/1.5	
40	39.0 - 49.0 Compact, blue-gray, stratified, SILT, trace organic fragments, silty fine to medium sand layers, wet. (ML) (OVERBANK DEPOSIT)	ML							

PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40)
WATER CONTENT (PERCENT) W_p —○W— W_l (20, 40, 60, 80)

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-12

SHEET 3 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/17/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 44
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■	NOTES WATER LEVELS
40	39.0 - 49.0 Compact, blue-gray, stratified, SILT, trace organic fragments, silty fine to medium sand layers, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		12	SS	1-4-6	10	1.1/1.5	■	
45				13	SS	2-8-12	20	2.0/1.5	■	
	49.0 - 61.5 Compact to dense, dark gray, non-stratified, fine to coarse SAND, trace silt, white sand seams, red and mica angular grains, wet. (SW) (CHANNEL DEPOSIT)	SW	-5.0 49.0							
50				14	SS	4-6-8	14	2.0/1.5	■	
55	-Blow counts appear overstated, possibly to heaving sand conditions.			15	SS	9-29-46	>50	2.0/1.5	>>■	Driller noted 6 feet of heaving sands at 55 feet.
										Driller noted 1 foot of heaving sands at 58 feet.
										Driller noted heaving sands at 59 feet. False high blow counts, buldging sampler, heave.
60	Log continued on next page									

PENETRATION RESISTANCE BLOWS / ft ■: 10 20 30 40
WATER CONTENT (PERCENT): W_p — W — W_l: 20 40 60 80

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-12

SHEET 4 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/17/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 44
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE				SAMPLES					PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40) WATER CONTENT (PERCENT) W_p ⊢ W ⊣ W_l (20, 40, 60, 80)	NOTES WATER LEVELS
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT		
60		49.0 - 61.5 Compact to dense, dark gray, non-stratified, fine to coarse SAND, trace silt, white sand seams, red and mica angular grains, wet. (SW) (CHANNEL DEPOSIT) *(Continued)* -Blow counts appear overstated, possibly to heaving sand conditions.	SW		-17.5 61.5	16	SS	6-10-35	45	1.1/1.5	■	
		Boring completed at 61.5 ft.										
65												
70												
75												
80												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Jaymen Lauer

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-13

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.28

ELEVATION: 44
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 1.5 2-inch minus crushed rock, damp. (GM) (FILL).	GM	42.5 1.5
1.5 - 14.5 Very loose, brown, heterogeneous, fine to medium SAND, little silt, trace organics, damp. (SP-SM) (FILL)	SP-SM	29.5 14.5
14.5 - 24.0 Loose, light yellow brown, stratified, SILT, little fine sand, fine to medium sand layers, iron-oxide staining lenses and pockets, damp. (ML) (OVERBANK DEPOSIT)	ML	

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SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	2-1-2	3	1.5 / 1.5
2	SS	3-2-2	4	1.5 / 1.5
3	SS	2-1-2	3	1.5 / 1.5
4	SS	2-1-0	1	1.3 / 1.5
5	SS	1-0-1	1	1.5 / 1.5
6	SS	0-1-2	3	1.5 / 1.5
7	SS	1-1-2	3	1.5 / 1.5

PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40)

WATER CONTENT (PERCENT) W_p —○W— W_l (20 40 60 80)

NOTES WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-13

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.28

ELEVATION: 44
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer, 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	14.5 - 24.0 Loose, light yellow brown, stratified, SILT, little fine sand, fine to medium sand layers, iron-oxide staining lenses and pockets, damp. (ML) (OVERBANK DEPOSIT) *(Continued)* -Sample from 20 feet becomes moist and dilatant.	ML		8	SS	1-2-3	5	1.5/1.5	
		24.0 - 29.0 Compact, dark gray, non-stratified, fine to medium SAND, trace silt, trace organics, wet. (SP) (CHANNEL DEPOSIT)	SP	20.0 24.0						▼ Groundwater was encountered 24 feet bgs ATD.
25					9	SS	6-7-10	17	1.1/1.5	
		29.0 - 34.0 Compact, dark gray, non-stratified, fine to coarse SAND, trace silt, trace fine to coarse gravel, subangular to subrounded sand and gravel fragments, wet. (SW) (CHANNEL DEPOSIT)	SW	15.0 29.0						
30					10	SS	2-4-6	10	1.0/1.5	
		34.0 - 49.0 Compact, dark gray, non-stratified, fine to coarse SAND, trace silt, wet. (SW) (CHANNEL DEPOSIT)	SW	10.0 34.0						
35					11	SS	6-14-8	22	1.5/1.5	
40										

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40
WATER CONTENT (PERCENT) W_p — W — W_l 20 40 60 80

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-13

SHEET 3 of 3

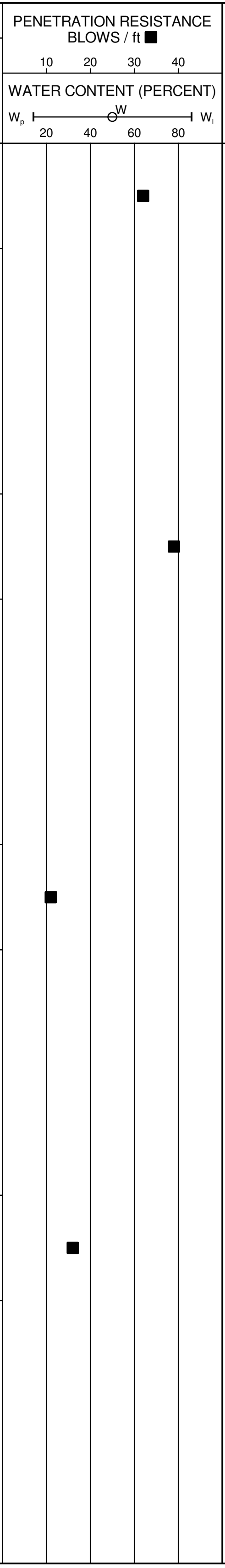
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.28

ELEVATION: 44
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT	NOTES WATER LEVELS
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	34.0 - 49.0 Compact, dark gray, non-stratified, fine to coarse SAND, trace silt, wet. (SW) (CHANNEL DEPOSIT) *(Continued)*	SW			12	SS	3-14-18	32	2.0/1.5	
45						13	SS	4-12-27	39	2.0/1.5	Driller noted 6 feet of heaving sands at 45 feet.
		49.0 - 56.5 Compact, dark gray, non-stratified, fine to coarse SAND, trace silt, trace fine to coarse gravel, subangular to subrounded sand and gravel fragments, wet. (SW) (CHANNEL DEPOSIT)	SW		-5.0 49.0						
50						14	SS	2-3-8	11	2.0/1.5	Driller noted 2 feet of heaving sands at 50 feet.
55						15	SS	2-4-12	16	2.0/1.5	Driller noted 4 feet of heaving sands at 55 feet.
		Boring completed at 56.5 ft.			-12.5 56.5						
60											



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-14

SHEET 1 of 5

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

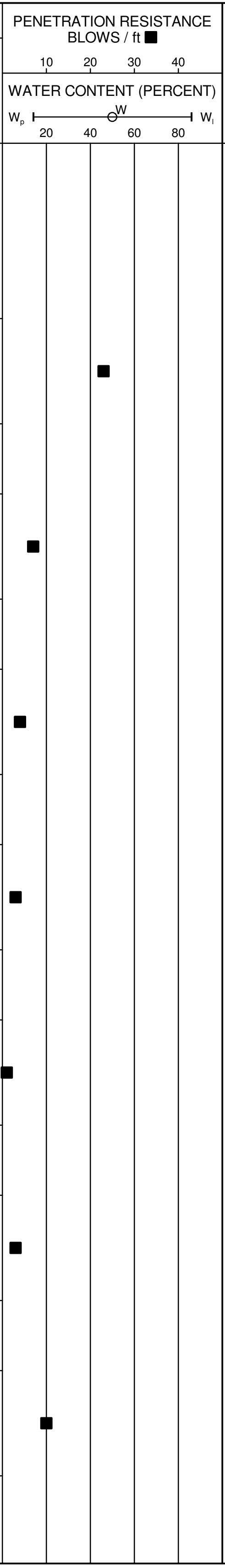
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

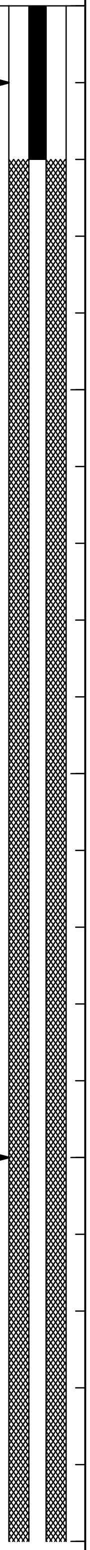
ELEVATION: 43
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	DESCRIPTION	USCS	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	0.0 - 1.0 2-inch minus crushed rock, damp (GM) (FILL).	GM	42.0 1.0						Flush-mount monument set in 2 feet concrete with locked well cap.
1	1.0 - 19.5 Very loose to compact, brown, heterogeneous, fine to medium SAND, little silt, trace organics, damp. (SP-SM) (FILL)	SP-SM							
				1	SS	6-11-12	23	$\frac{1.1}{1.5}$	
5				2	SS	3-4-3	7	$\frac{0.8}{1.5}$	
				3	SS	2-2-2	4	$\frac{1.5}{1.5}$	
10				4	SS	2-2-1	3	$\frac{1.2}{1.5}$	
				5	SS	0-0-1	1	$\frac{1.3}{1.5}$	
15				6	SS	1-1-2	3	$\frac{1.5}{1.5}$	2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.
				7	SS	2-4-6	10	$\frac{1.5}{1.5}$	
19.5		ML	23.5 19.5						
20	Log continued on next page								



NOTES WATER LEVELS GRAPHIC



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-14

SHEET 2 of 5

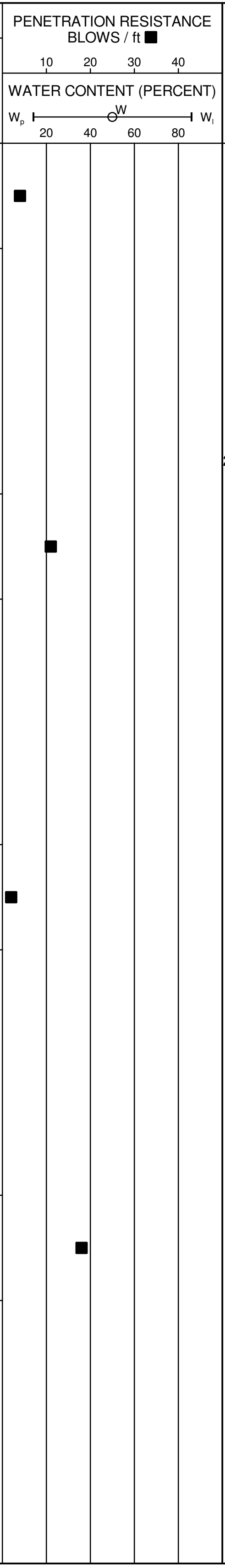
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

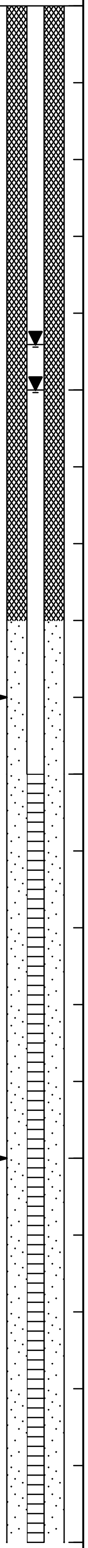
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	19.5 - 26.0 Loose, light gray, stratified, SILT, little fine sand seams, iron-oxide stained pockets and lenses, dilatant, damp. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		8	SS	1-0-4	4	1.5/1.5	Groundwater measured 22.34 ft btc on 5/19/09. Groundwater measured 24.41 feet btc on 4/27/09. Groundwater encountered at 25 feet ATD.
25				17.0 26.0	9	SS	2-3-8	11	1.5/1.5	
30		26.0 - 34.0 Compact, medium gray, stratified, fine to medium SAND, little silt, iron-oxide staining pockets and layers, fine sand partings, wet (SP-SM) (OVERBANK DEPOSIT)	SP-SM	9.0 34.0	10	SS	2-0-2	2	1.5/1.5	2-inch diameter solid schedule 40 PVC with o-ring joints set in sand backfill.
35		34.0 - 49.0 Loose to compact, medium gray, stratified, fine sandy SILT, trace silt and sand layers, trace organics, dilatant, wet. (ML) (OVERBANK DEPOSIT)	ML		11	SS	8-5-13	18	1.5/1.5	2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill.
40										





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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-14

SHEET 3 of 5

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	34.0 - 49.0 Loose to compact, medium gray, stratified, fine sandy SILT, trace silt and sand layers, trace organics, dilatant, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		12	SS	2-2-3	5	1.5/1.5	Sand backfill.
45					13	SS	2-2-2	4	1.5/1.5	
		49.0 - 59.0 Loose, medium gray, non-stratified, silty fine to medium SAND, little fine sand layers up to 1-inch thick, dilatant, wet. (SM) (OVERBANK DEPOSIT)	SM	-6.0 49.0						Bentonite chips backfill.
50					14	SS	1-2-6	8	2.0/1.5	
55					15	SS	3-6-3	9	1.5/1.5	
		59.0 - 64.5 Firm, medium gray, stratified, SILT, little organics (fibrous pieces), wet. (ML) (QUIET-WATER DEPOSIT)	ML	-16.0 59.0						
60										

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40
WATER CONTENT (PERCENT) W_p — W — W_l 20 40 60 80

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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

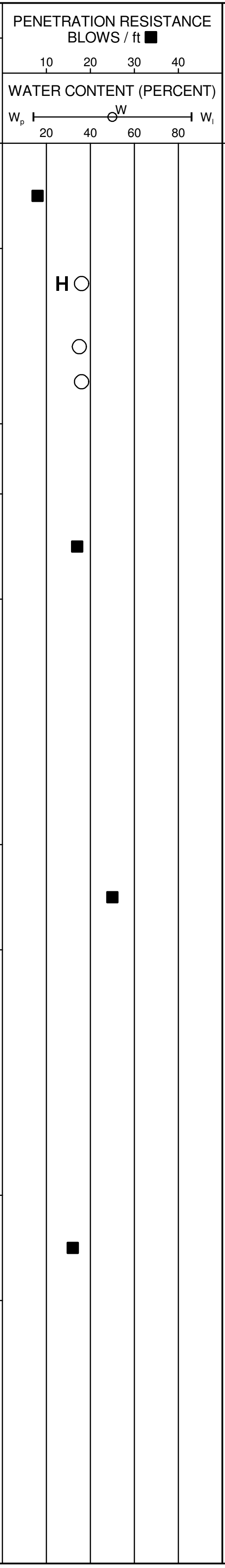
RECORD OF BOREHOLE GB-14

SHEET 4 of 5

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29
ELEVATION: 43
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
60	59.0 - 64.5 Firm, medium gray, stratified, SILT, little organics (fibrous pieces), wet. (ML) (QUIET-WATER DEPOSIT) *(Continued)*	ML		16	SS	0-3-5	8	1.5/1.5	Bentonite chips backfill.
					SH			2.5/2.5	
65	64.5 - 69.0 Compact, gray, stratified, SILT, some fine sand, little organics (fibrous pieces), dilatant, wet. (ML) (QUIET-WATER DEPOSIT)	ML	-21.5 64.5	17	SS	3-9-8	17	1.5/1.5	
70	69.0 - 80.5 Compact to very dense, dark gray, non-stratified, fine to medium SAND, trace silt, trace organics, mica grains, wet. (SP) (CHANNEL DEPOSIT)	SP	-26.0 69.0	18	SS	4-9-16	25	2.0/1.5	
75				19	SS	3-7-9	16	1.5/1.5	Driller noted no heave until 75 feet and had augers charged the whole time.
80									Drill bouncing,



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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott
LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

RECORD OF BOREHOLE GB-14

SHEET 5 of 5

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/24/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE				SAMPLES					PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40 WATER CONTENT (PERCENT) W_p ⊢—○W—⊣ W_l 20 40 60 80	NOTES WATER LEVELS GRAPHIC
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT		
80			SP	⁙	-37.5	20	SS	50/6"	>50	2.0 0.5	>>■	drilled like gravel. ▩
		Boring completed at 80.5 ft.			80.5							
85												
90												
95												
100												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-15

SHEET 1 of 2

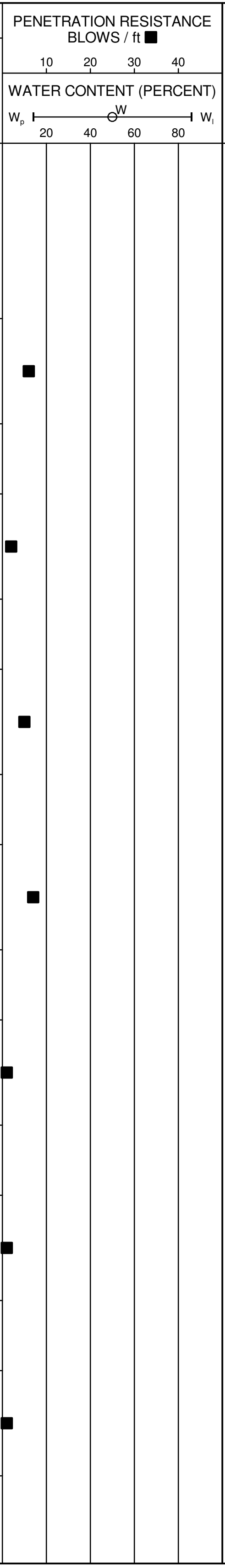
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/27/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	0.0 - 1.0 2-inch minus crushed rock, damp (GM) (FILL).	GM	42.0 1.0						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
		1.0 - 4.0 Loose, iron-oxide stained dark brown, heterogeneous, silty fine to medium SAND, trace fine to coarse gravel, trace organics, trace silt pockets, damp. (SM) (FILL)	SM	39.0 4.0	1	SS	3-3-3	6	1.2/1.5	
5		4.0 - 12.0 Very loose to loose, gray-brown, heterogeneous, fine to medium SAND, trace silt, damp. (SP) (FILL)	SP	31.0 12.0	2	SS	1-1-1	2	1.5/1.5	
					3	SS	2-2-3	5	1.5/1.5	
10					4	SS	2-4-3	7	1.5/1.5	
		12.0 - 14.5 Very loose, brown, heterogeneous, silty fine to medium SAND, sand and silt pockets, damp. (SM) (FILL)	SM	28.5 14.5	5	SS	1-0-1	1	1.5/1.5	
15		14.5 - 17.0 Very loose, brown, heterogeneous, fine to medium SAND, little silt, silt and sand pockets, damp. (SP-SM) (FILL)	SP-SM	26.0 17.0	6	SS	1-1-0	1	1.5/1.5	
		17.0 - 19.5 Very loose, light brown, heterogeneous, fine sandy SILT, iron-oxide staining, damp. (ML) (FILL)	ML	23.5 19.5	7	SS	1-0-1	1	1.5/1.5	
20		Log continued on next page	MH							



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-15

SHEET 2 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/27/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.29 E: 122.29

ELEVATION: 43
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	19.5 - 25.5 Firm, light gray, stratified, plastic SILT, trace organics (partings), iron-oxide staining, damp. (MH) (QUIET-WATER DEPOSIT) *(Continued)*	MH		8	SS	1-3-4	7	1.5/1.5	
25		25.5 - 29.0 Compact, gray, stratified, fine to medium SAND, little silt, iron-oxide stained layers, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM	17.5 25.5	9	SS	2-5-6	11	1.5/1.5	Groundwater was encountered 25 feet bgs ATD. ▼
30		29.0 - 34.0 Loose, medium gray, non-stratified, fine to medium SAND, trace silt, trace iron-oxide staining layers, trace organics, wet. (SP) (CHANNEL DEPOSIT)	SP	14.0 29.0	10	SS	1-2-5	7	1.5/1.5	
35		34.0 - 36.5 Compact, medium gray, stratified, fine to medium SAND to greenish gray SILT, trace silt, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM	9.0 34.0	11	SS	4-7-15	22	1.5/1.5	Driller noted no heave.
		Boring completed at 36.5 ft.		6.5 36.5						
40										

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40
WATER CONTENT (PERCENT) W_p — W — W_l 20 40 60 80

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-16

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.29

ELEVATION: 30
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE

DEPTH (ft)	DESCRIPTION	USCS	ELEV. DEPTH (ft)
0	0.0 - 1.5 2- to 4-inch minus crushed rock, damp (GM) (FILL).	GM	28.5 1.5
	1.5 - 4.5 Loose, dark brown, heterogeneous, silty fine to medium SAND, trace fine to coarse gravel, trace organics, angular grains, damp. (SM) (FILL)	SM	25.5 4.5
5	4.5 - 7.0 Loose, brown, non-stratified, silty fine SAND, little organics (rootlets), silt pockets, iron-oxide staining pockets, damp. (SM) (OVERBANK DEPOSIT)	SM	23.0 7.0
10	7.0 - 12.0 Very loose to compact, light brown to gray, stratified, fine sandy SILT, little organics (rootlets), iron-oxide staining, dilatant, moist to wet. (ML) (OVERBANK DEPOSIT)	ML	18.0 12.0
	12.0 - 14.5 Very loose, dark gray to blue gray, non-stratified, SILT, some organics (fibrous, roots), damp to moist. (ML) (OVERBANK DEPOSIT)	ML	15.5 14.5
15	14.5 - 17.0 Compact, gray to dark gray, slightly stratified, silty fine SAND, silt seams with organics, moist to wet. (SM) (OVERBANK DEPOSIT)	SM	13.0 17.0
20	17.0 - 29.0 Very loose, dark gray, non-stratified, fine to medium SAND, little silt, wet. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	

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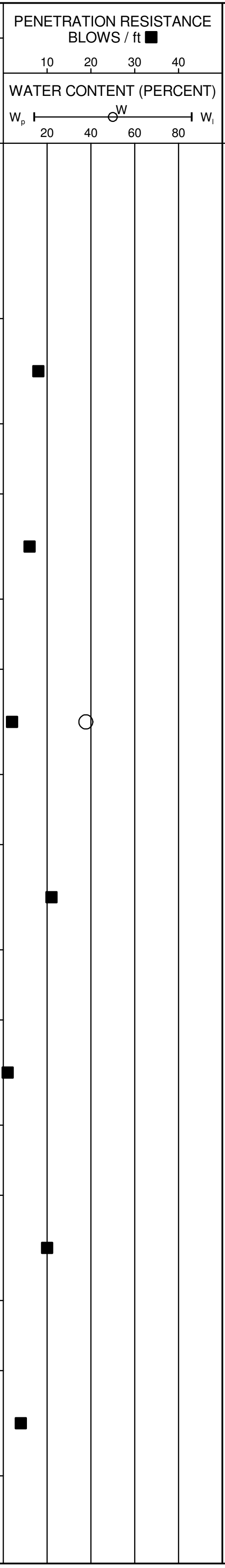
SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	1-3-5	8	1.5/1.5
2	SS	1-2-4	6	1.5/1.5
3	SS	1-1-1	2	1.5/1.5
4	SS	1-5-6	11	1.5/1.5
5	SS	0-0-1	1	1.5/1.5
6	SS	0-2-8	10	1.5/1.5
7	SS	1-3-1	4	0.9/1.5

PENETRATION RESISTANCE



NOTES WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

G

Groundwater was encountered 15 feet bgs ATD. ▼

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-16

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.29

ELEVATION: 30
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	17.0 - 29.0 Very loose, dark gray, non-stratified, fine to medium SAND, little silt, wet. (SP-SM) (CHANNEL DEPOSIT) *(Continued)* -Observed a fibrous organic, up to 2 inches thick, wet.	SP-SM		8	SS	5-2-3	5	0.6/1.5	
25					9	SS	2-7-11	18	1.0/1.5	Driller noted 2 feet of heaving sands at 25 feet.
		29.0 - 37.5 Very loose, gray, non-stratified, SILT, trace fine to medium sand, some organics (fibrous pieces up to 2-inch diameter, fragments), wet. (ML) (QUIET-WATER DEPOSIT)	ML	1.0 29.0						
30					10	SS	0-1-2	3	1.0/1.5	Driller noted 2 feet of heaving sands at 30 feet.
35					11	SS	4-5-6	11	1.1/1.5	Driller noted 2 feet of heaving sands at 35 feet.
		37.5 - 41.5 Loose, gray, non-stratified, SILT, trace organics (small fragments). (ML) (OVERBANK DEPOSITS)	ML	-7.5 37.5						
40										

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40
WATER CONTENT (PERCENT) W_p W W_l 20 40 60 80

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-16

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.29

ELEVATION: 30
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40); WATER CONTENT (PERCENT) Wp ⊢—○W—⊣ Wl (20 40 60 80)	NOTES WATER LEVELS
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	37.5 - 41.5 Loose, gray, non-stratified, SILT, trace organics (small fragments). (ML) (OVERBANK DEPOSITS) *(Continued)*	ML		-11.5 41.5	12	SS	0-0-6	6	$\frac{1.5}{1.5}$	■	
45		41.5 - 51.5 Compact, gray to dark gray, non-stratified, fine to coarse SAND, trace to little silt, scoria and mica subangular grains, wet. (SW) (CHANNEL DEPOSIT)	SW			13	SS	3-7-12	19	$\frac{1.5}{1.5}$	■	
50					-21.5 51.5	14	SS	6-11-19	30	$\frac{1.5}{1.5}$	■	
55		Boring completed at 51.5 ft.										
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-17

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: S end of Road Next to RR

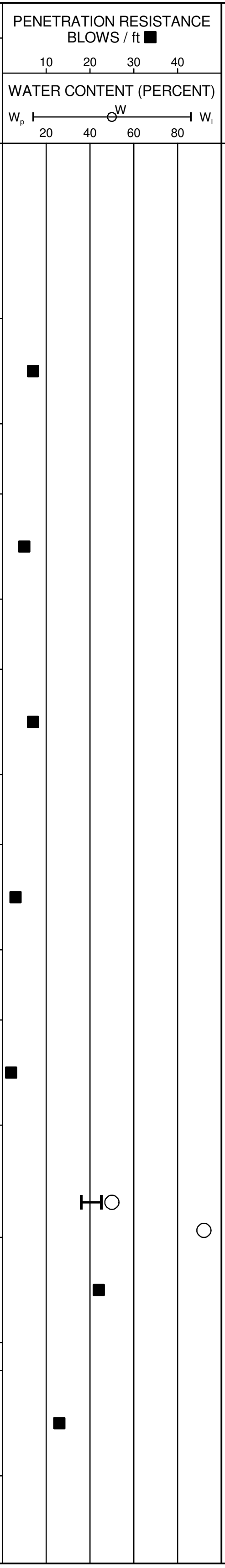
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 33
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	0.0 - 0.5 Loose, dark brown, heterogeneous, silty fine to coarse SAND, some organics, damp (SM) (TOPSOIL)	SM	32.5 0.5						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
	0.5 - 3.1 Loose, gray-brown, non-stratified, fine to coarse SAND, some fine to coarse gravel, trace silt, little organics (roots), damp. (SW) (FILL)	SW	29.9 3.1						
	3.1 - 4.5 Loose, brown, non-stratified, fine sandy SILT, trace organics (rootlets and fragments), damp. (ML) (OVERBANK DEPOSIT)	ML	28.5 4.5	1	SS	7-4-3	7	0.7/1.5	
5	4.5 - 9.5 Loose, light brown, stratified, silty fine SAND, damp. (SM) (OVERBANK DEPOSIT)	SM	23.5 9.5	2	SS	1-2-3	5	1.1/1.5	
				3	SS	3-3-4	7	1.1/1.5	
10	9.5 - 12.0 Loose, iron-oxide stained gray, stratified, fine sandy SILT, wet. (ML) (OVERBANK DEPOSIT)	ML	21.0 12.0	4	SS	1-1-2	3	1.5/1.5	
	12.0 - 15.6 Very loose, gray, non-stratified, SILT, trace organic (fragments), wet. (ML) (QUIET-WATER DEPOSIT)	ML	17.4 15.6	5	SS	1-1-1	2	1.5/1.5	
15					SH			1.6/1.6	
	15.6 - 17.3 Compact, light gray with iron-oxide staining, slightly stratified, fine to medium SAND, little silt, trace organics (fragments), damp. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	15.7 17.3	6	SS	6-10-12	22	1.1/1.5	▼ Groundwater was encountered 17 feet bgs ATD.
	17.3 - 19.5 Compact, light gray, fine to medium SAND, trace silt, trace organic (fragments), wet. (SP) (CHANNEL DEPOSIT)	SP	13.5 19.5	7	SS	2-6-7	13	1.5/1.5	
20	Log continued on next page	SP							



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-17

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: S end of Road Next to RR

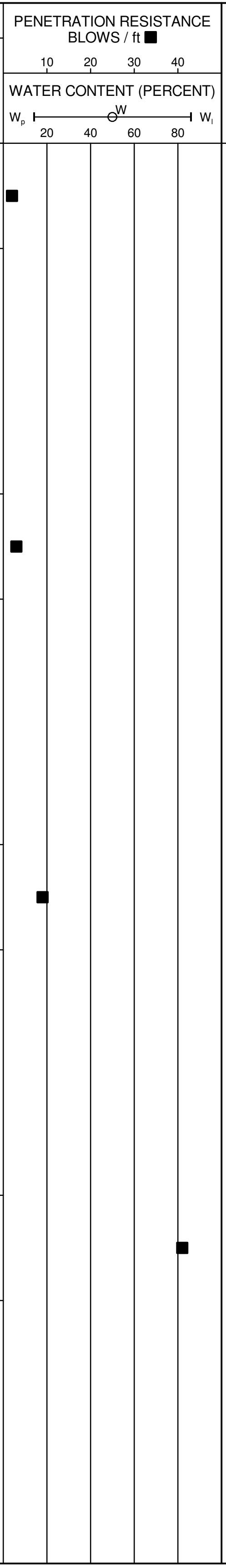
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 33
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	19.5 - 34.0 Very loose to loose, medium gray, slightly stratified, fine to medium SAND, trace silt, trace organics (fragments), wet. (SP) (CHANNEL DEPOSIT) *(Continued)*	SP		8	SS	2-1-1	2	1.5/1.5	
25				9	SS	1-2-1	3	1.5/1.5	
30				10	SS	3-4-5	9	1.5/1.5	
34	34.0 - 41.5 Compact to dense, dark gray, non-stratified, fine to medium SAND, trace silt, scoria and mica angular grains, wet. (SP) (CHANNEL DEPOSIT)	SP	-1.0 34.0						
35				11	SS	6-15-26	41	1.5/1.5	
40	Log continued on next page								



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-17

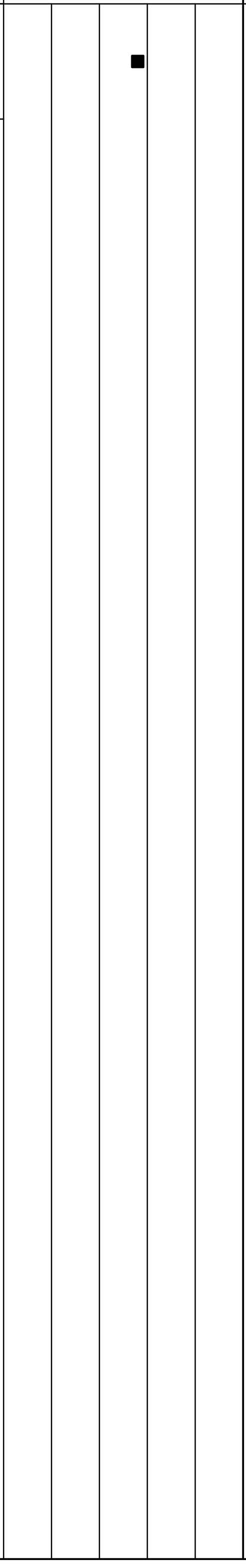
SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: S end of Road Next to RR

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 33
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE				SAMPLES					PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40 WATER CONTENT (PERCENT) Wp W Wl 20 40 60 80	NOTES WATER LEVELS
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT		
40		34.0 - 41.5 Compact to dense, dark gray, non-stratified, fine to medium SAND, trace silt, scoria and mica angular grains, wet. (SP) (CHANNEL DEPOSIT) *(Continued)*	SP		-8.5 41.5	12	SS	9-12-16	28	$\frac{1.5}{1.5}$		
		Boring completed at 41.5 ft.										
45												
50												
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-18

SHEET 1 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29
ELEVATION: 42
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 1.0 2-inch minus crushed rock, damp (GM) (FILL).	GM	41.0 1.0
1.0 - 4.5 Compact, gray, heterogeneous, silty fine to coarse GRAVEL, some fine to coarse SAND, socketed, damp. (GM) (FILL)	GM	37.5 4.5
4.5 - 19.5 Very loose, light brown to light gray, heterogeneous, fine to medium SAND, little silt, iron-oxide stained pockets, damp. (SP-SM) (FILL)	SP-SM	22.5 19.5
Log continued on next page	SM/CL	

SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	8-10-8	18	1.5/1.5
2	SS	2-2-1	3	1.5/1.5
3	SS	1-1-2	3	1.5/1.5
4	SS	0-1-2	3	1.5/1.5
5	SS	3-3-1	4	1.5/1.5
	SH			0.0/1.0
6	SS	1-0-1	1	1.5/1.5
	SH			2.0/2.0
7	SS	1-3-2	5	1.5/1.5

PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40)
WATER CONTENT (PERCENT) W_p — W — W_l (20, 40, 60, 80)

NOTES WATER LEVELS GRAPHIC

Flush-mount monument set in 2 feet concrete with locked well cap.

2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.

14 ft: Pocket Pen:1.5 tsf, Torvane 2.25 tsf

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott
LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-18

SHEET 2 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 42
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	19.5 - 24.0 Very loose, light gray, stratified, silty fine SAND and SILTY CLAY (up to 3" thick), iron-oxide stained layers, wet. (SM/CL) (OVERBANK DEPOSIT) *(Continued)*	SM/CL		8	SS	1-1-1	2	1.5/1.5
25		24.0 - 29.0 Compact, light gray, stratified, fine to medium SAND, trace silt, trace silt seams, wet. (SP) (OVERBANK DEPOSIT)	SP	18.0 24.0	9	SS	8-6-6	12	1.0/1.5
		29.0 - 30.3 Loose, light gray, stratified, fine sandy SILT, little organics (roots), wet. (ML) (OVERBANK DEPOSIT)	ML	13.0 29.0					
30		30.3 - 34.0 Loose, brown-gray, non-stratified, fine to medium SAND, little silt, little organics (rootlets), wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM	11.7 30.3	10	SS	1-0-7	7	1.5/1.5
35		34.0 - 39.0 Compact, medium gray, stratified, fine to medium SAND, trace silt, wet. (SP) (OVERBANK DEPOSIT)	SP	8.0 34.0	11	SS	4-6-7	13	1.5/1.5
40		Log continued on next page	ML	3.0 39.0					

PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40)
WATER CONTENT (PERCENT) W_p — W — W_l (20 40 60 80)

NOTES WATER LEVELS GRAPHIC

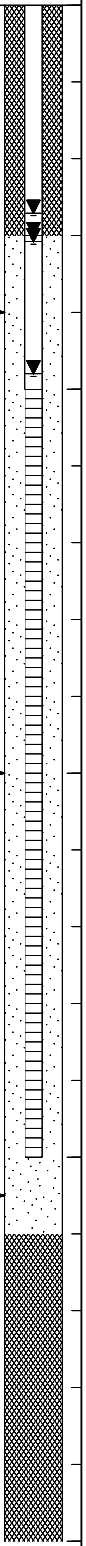
Groundwater measured 21.76 ft btc on 5/19/09. Driller noted stiffer drilling at 22 feet.

Groundwater measured 22.71 feet btc on 4/24/09. Groundwater encountered at 23 feet ATD. Groundwater measured 23.08 feet on 4/27/09. 2-inch diameter solid schedule 40 PVC with o-ring joints set in sand backfill. Groundwater measured 24.8 feet bgs inside auger at time of well installation.

2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill.

Sand backfill.

Bentonite chips backfill.



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

RECORD OF BOREHOLE GB-18

SHEET 3 of 4

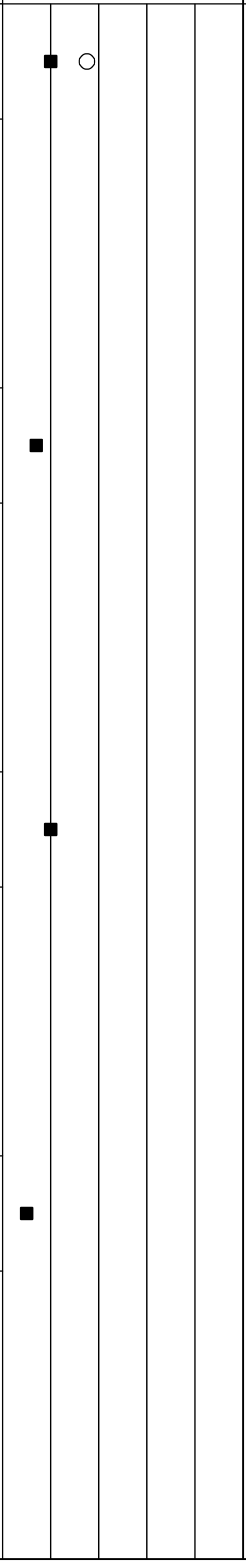
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 42
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT	NOTES WATER LEVELS GRAPHIC
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	39.0 - 64.0 Loose to compact, medium gray, stratified to slightly stratified, SILT and fine SAND, trace silt seams, trace organics (rootlets), dilatant, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML			12	SS	1-5-5	10	1.5/1.5	G .
45						13	SS	2-3-4	7	1.5/1.5	
50						14	SS	5-6-4	10	1.5/1.5	
											Bentonite chips backfill.
55						15	SS	5-2-3	5	1.5/1.5	
60		Log continued on next page									



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-18

SHEET 4 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/21/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 42
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■	NOTES WATER LEVELS GRAPHIC
60	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	39.0 - 64.0 Loose to compact, medium gray, stratified to slightly stratified, SILT and fine SAND, trace silt seams, trace organics (rootlets), dilatant, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		16	SS	3-4-9	13	1.5/1.5	■	
		64.0 - 70.8 Dense, olive gray, non-stratified, fine to coarse SAND, trace fine to coarse gravel, trace silt, subrounded to subangular grains, wet. (SW) (CHANNEL DEPOSIT)	SW	-22.0 64.0							
65					17	SS	7-15-30	45	1.5/1.5	■	Bentonite chips backfill.
70					18	SS	29-62/3"	>50	0.7/0.7	>>■	
		Boring completed at 70.8 ft.		-28.8 70.8							
75											
80											

PENETRATION RESISTANCE scale: 10 20 30 40
WATER CONTENT (PERCENT): W_p ⊢—○W—⊣ W_l 20 40 60 80

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-19

SHEET 1 of 4

PROJECT: Burlington Levee	DRILLING METHOD: Hollow Stem Auger	DATUM: Geodetic	ELEVATION: 41
PROJECT NUMBER: 093-93153.100	DRILLING DATE: 4/27/2009	AZIMUTH: N/A	INCLINATION: -90
LOCATION: Burlington Levee	DRILL RIG: CME 75 Truck-Mounted	COORDINATES: N: 48.30 E: 122.29	

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

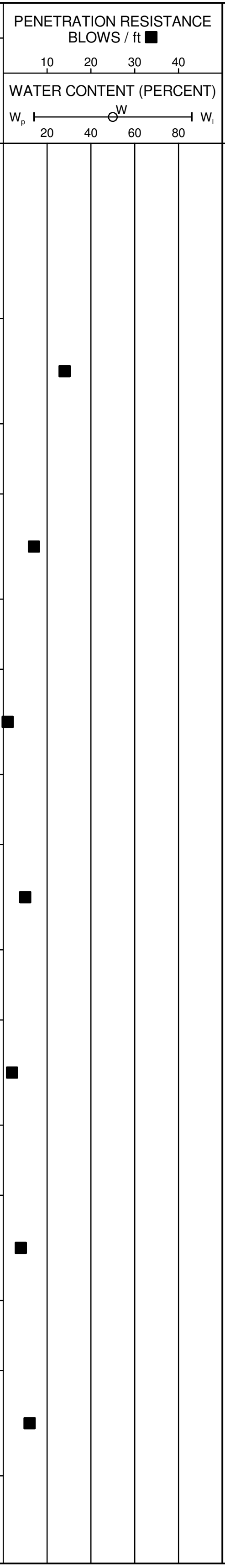
SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 1.0 1.5-inch minus crushed rock, damp. (GM) (FILL)	GM	40.0 1.0
1.0 - 4.5 Compact, light gray, heterogeneous, silty fine to coarse SAND, some fine to coarse gravel, damp. (SM) (FILL)	SM	36.5 4.5
4.5 - 13.5 Very loose to loose, brown with iron-oxide staining, heterogeneous, fine to medium SAND, little silt, trace organics (fragments), damp. (SP-SM) (FILL)	SP-SM	27.5 13.5
13.5 - 15.3 Very loose, gray-brown, non-stratified, fine to medium SAND, trace silt, damp. (SP) (OVERBANK DEPOSIT)	SP	25.7 15.3
15.3 - 19.5 Very loose to loose, light brown, slightly stratified, fine sandy SILT, trace organics, damp. (ML) (OVERBANK DEPOSIT)	ML	21.5 19.5
	SP/ML	

Log continued on next page

SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	6-7-7	14	0.8 / 1.5
2	SS	1-3-4	7	1.5 / 1.5
3	SS	1-0-1	1	1.5 / 1.5
4	SS	1-2-3	5	1.5 / 1.5
5	SS	1-1-1	2	1.5 / 1.5
6	SS	1-2-2	4	1.5 / 1.5
7	SS	2-3-3	6	1.5 / 1.5



NOTES
WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

1 in to 3 ft

DRILLING CONTRACTOR: Cascade Drilling, Inc.

DRILLER: Scott

LOGGED: A. Dennison

CHECKED: A. McKenzie-Johnson

DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-19

SHEET 2 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/27/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 41
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
19.5 - 24.0 Very loose, medium gray, stratified, fine to medium SAND and SILT, trace organics, iron-oxide staining, moist. (SP/ML) (OVERBANK DEPOSIT) *(Continued)*	SP/ML	17.0 24.0
24.0 - 34.0 Loose, medium gray to gray brown, slightly stratified, fine to medium SAND, trace silt, iron-oxide stained layers, wet. (SP) (OVERBANK DEPOSIT)	SP	7.0 34.0
34.0 - 54.0 Loose to compact, medium gray, non-stratified, fine sandy SILT, trace organics, dilatant, wet. (ML) (OVERBANK DEPOSIT)	ML	

Log continued on next page

SAMPLES

DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■
20.0 - 21.5	8	SS	2-2-1	3	1.5/1.5	■ 3
25.0 - 26.5	9	SS	2-2-4	6	0.9/1.5	■ 6
30.0 - 31.5	10	SS	0-2-3	5	1.0/1.5	■ 5
35.0 - 36.5	11	SS	2-5-5	10	1.5/1.5	■ 10

WATER CONTENT (PERCENT): W_p ⊢—W—⊣ W_l (20, 40, 60, 80)

NOTES / WATER LEVELS

▼ (25 ft) Groundwater was encountered 25 feet bgs ATD.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-19

SHEET 3 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/27/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 41
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) Wp ⊢—○W—⊣ Wl (20 40 60 80)	NOTES WATER LEVELS
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	34.0 - 54.0 Loose to compact, medium gray, non-stratified, fine sandy SILT, trace organics, dilatant, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML			12	SS	3-4-1	5	1.5/1.5	■	Driller noted 0.5 feet of heaving sands at 40 feet.
45						13	SS	2-2-6	8	1.5/1.5	■	
50						14	SS	2-4-12	16	2.0/1.5	■	
		54.0 - 59.0 Loose to compact, medium gray, non-stratified, plastic SILT, trace organics (rootlets), dilatant, wet. (MH) (OVERBANK DEPOSIT)	MH		-13.0 54.0							
55						15	SS	2-3-4	7	2.0/1.5	■	Driller noted 1.5 feet of heaving sands at 56 feet. Pocket Pen 0.5 to 1.0 tsf
					-18.0							
60		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-19

SHEET 4 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/27/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 41
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE				SAMPLES					PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40 WATER CONTENT (PERCENT) Wp ⊢ W ○ ⊣ Wl 20 40 60 80	NOTES WATER LEVELS
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT		
60		60.0 - 61.5 Compact, medium gray, slightly stratified, silty fine SAND, trace organics (rootlets), dilatant, wet. (SM) (OVERBANK DEPOSIT)	SM		-20.5 61.5	16	SS	6-9-14	23	2.0/1.5	■	Driller noted 1 foot of heaving sands at 60 feet.
		Boring completed at 61.5 ft.										
65												
70												
75												
80												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-20

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

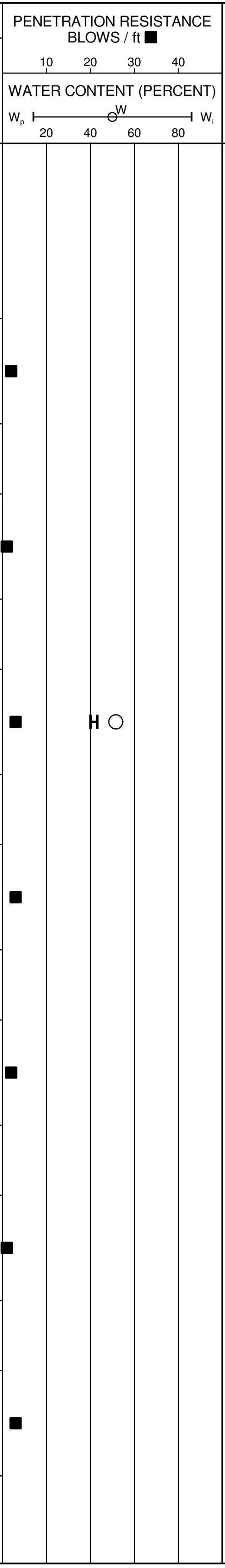
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/22/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 32
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	DESCRIPTION	USCS	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	0.0 - 0.5 Topsoil, dark brown, non-stratified, silty fine to medium SAND, some organics. (TOPSOIL)	SM	31.5 0.5						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
	0.5 - 4.0 Very loose, light gray-brown, heterogeneous, fine to medium SAND, trace silt, trace organics (rootlets), damp. (SP) (FILL)	SP	28.0 4.0	1	SS	1-1-1	2	1.5/1.5	
5	4.0 - 7.0 Very loose, light brown-gray with iron-oxide staining, heterogeneous, fine to medium SAND, little silt, moist. (SP-SM) (FILL)	SP-SM	25.0 7.0	2	SS	1-0-1	1	1.5/1.5	
	7.0 - 9.0 Very loose, light brown, non-stratified, SILT, damp. (ML) (OVERBANK DEPOSIT)	ML	23.0 9.0	3	SS	0-1-2	3	1.5/1.5	Pocket pen 1-1.25
10	9.0 - 17.0 Very loose, light brown with iron-oxide staining, non-stratified, silty fine to medium SAND, damp to wet. (SM) (OVERBANK DEPOSIT)	SM	15.0 17.0	4	SS	1-1-2	3	1.5/1.5	
				5	SS	1-1-1	2	1.5/1.5	
15				6	SS	1-1-0	1	1.3/1.5	
	17.0 - 21.5 Very loose to loose, light brown with iron-oxide staining, slightly stratified, fine to medium SAND, little silt, dilatant, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM		7	SS	1-1-2	3	1.0/1.5	▼ Groundwater was encountered 17 feet bgs ATD.
20	Log continued on next page								



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-20

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/22/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 32
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	17.0 - 21.5 Very loose to loose, light brown with iron-oxide staining, slightly stratified, fine to medium SAND, little silt, dilatant, wet. (SP-SM) (OVERBANK DEPOSIT) *(Continued)*	SP-SM	10.5 21.5	8	SS	1-3-4	7	1.5/1.5	
	21.5 - 39.0 Dense to very dense, orange-light brown to dark brown, non-stratified, fine to coarse SAND, trace silt, scoria and mica subangular sand grains, wet. (SW) (CHANNEL DEPOSIT)	SW							
25				9	SS	4-9-23	32	0.8/1.5	Driller noted slight heaving sands at 25 feet.
30				10	SS	13-34-25	>50	1.5/1.5	Driller noted 0.5 feet of heaving sands at 30 feet.
35				11	SS	-28-59	>50	2.0/1.5	Driller noted 4 feet of heaving sands at 35 feet.
			-7.0 39.0						
40	39.0 - 44.0 Compact, medium gray, stratified, SILT, trace fine sand, dilatant, wet. (ML) (OVERBANK DEPOSIT)	ML							

PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40); WATER CONTENT (PERCENT) W_p ⊢—○W—⊣ W_l (20, 40, 60, 80)

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

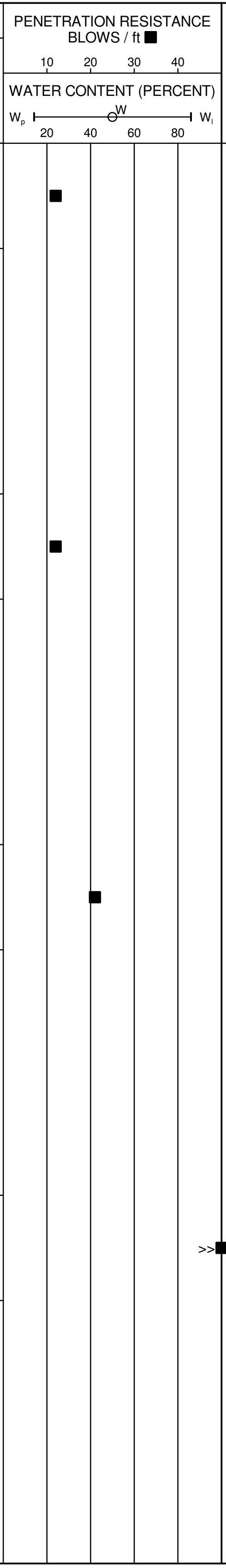
Golder Associates

RECORD OF BOREHOLE GB-20

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/22/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30
ELEVATION: 32
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	39.0 - 44.0 Compact, medium gray, stratified, SILT, trace fine sand, dilatant, wet. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML		12	SS	1-6-6	12	0.7/1.5	Driller noted 0.5 feet of heaving sands at 40 feet.
		44.0 - 49.0 Compact, medium gray, stratified, fine SAND, little to some silt, wet. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	-12.0 44.0						
45					13	SS	5-6-6	12	0.8/1.5	
		49.0 - 56.5 Compact, medium gray, non-stratified, fine SAND, trace silt, trace organics, wet. (SP) (CHANNEL DEPOSIT)	SP	-17.0 49.0						
50					14	SS	2-9-12	21	2.0/1.5	
55					15	SS	8-18-40	>50	1.5/1.5	Driller noted heaving sands at 55 feet.
		Boring completed at 56.5 ft.		-24.5 56.5						
60										



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-21

SHEET 1 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Dyke District Yard
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30
ELEVATION: 32
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE

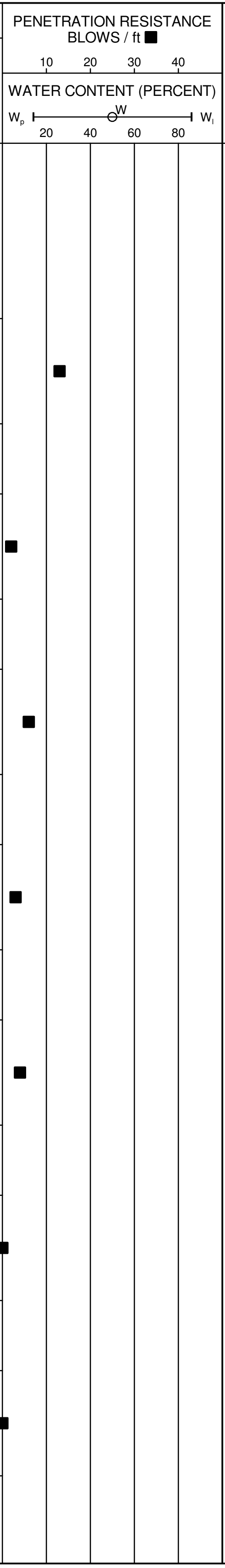
DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 1.5 2-inch minus crushed rock, damp (GP) (FILL).	GP	30.5 1.5
1.5 - 4.5 Compact, gray-brown, non-stratified, silty fine to coarse angular GRAVEL, some fine to coarse sand, damp. (GM) (FILL)	GM	27.5 4.5
4.5 - 9.5 Very loose to loose, light brown, stratified, fine sandy SILT, little sand and silt partings/pockets, iron-oxide stained pockets and layers, damp. (ML) (OVERBANK DEPOSIT)	ML	22.5 9.5
9.5 - 14.5 Very loose, light brown, slightly stratified, fine to medium SAND, little silt, damp. (SP-/SM) (OVERBANK DEPOSIT)	SP-SM	17.5 14.5
14.5 - 24.0 Very loose to loose, light brown, stratified, fine sandy SILT, little sand and silt partings/pockets, iron-oxide stained pockets and layers, damp. (ML) (OVERBANK DEPOSIT) -Sample appears wet.	ML	

SAMPLES

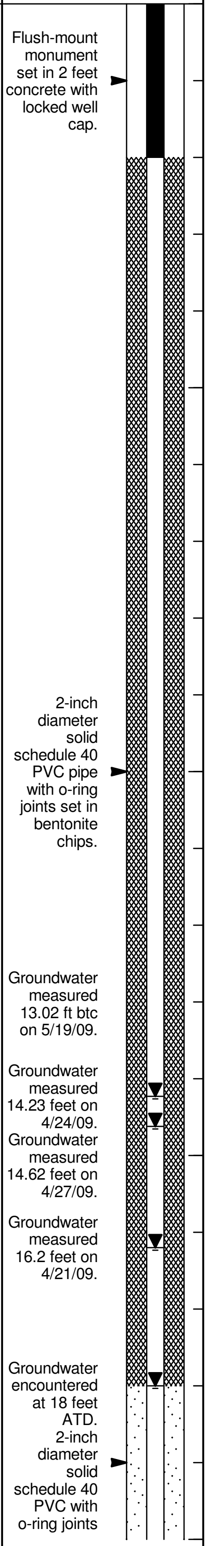
NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	7-8-5	13	1.5/1.5
2	SS	1-1-1	2	1.5/1.5
3	SS	1-2-4	6	1.5/1.5
4	SS	1-2-1	3	0.9/1.5
5	SS	1-2-2	4	1.5/1.5
6	SS	1-0-0	0	1.5/1.5
7	SS	0-0-0	0	1.5/1.5

PENETRATION RESISTANCE BLOWS / ft ■

WATER CONTENT (PERCENT)



NOTES WATER LEVELS GRAPHIC



Flush-mount monument set in 2 feet concrete with locked well cap.

2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.

Groundwater measured 13.02 ft btc on 5/19/09.

Groundwater measured 14.23 feet on 4/24/09.

Groundwater measured 14.62 feet on 4/27/09.

Groundwater measured 16.2 feet on 4/21/09.

Groundwater encountered at 18 feet ATD.

2-inch diameter solid schedule 40 PVC with o-ring joints

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-21

SHEET 2 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Dyke District Yard
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30
ELEVATION: 32
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft): 20 – 40

SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
14.5 - 24.0 Very loose to loose, light brown, stratified, fine sandy SILT, little sand and silt partings/pockets, iron-oxide stained pockets and layers, damp. (ML) (OVERBANK DEPOSIT) *(Continued)*	ML	
24.0 - 34.0 Compact to dense, gray, non-stratified fine to coarse SAND, trace fine to coarse gravel, trace silt, wet. (SW) (CHANNEL DEPOSIT)	SW	8.0 24.0
34.0 - 39.0 Compact, gray, non-stratified, fine to medium SAND, trace silt, wet. (SP) (CHANNEL DEPOSIT)	SP	-2.0 34.0
39.0 - 49.0 Loose, gray, stratified, SILT, silty fine sand layers, trace organics, wet. (ML/SM) (OVERBANK DEPOSIT)	ML	-7.0 39.0

Log continued on next page

SAMPLES

NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT
8	SS	0-1-1	2	1.5/1.5
9	SS	9-16-26	42	1.5/1.5
10	SS	3-7-12	19	2.0/1.5
11	SS	1-4-8	12	1.2/1.5

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40
WATER CONTENT (PERCENT) W_p W W_l 20 40 60 80

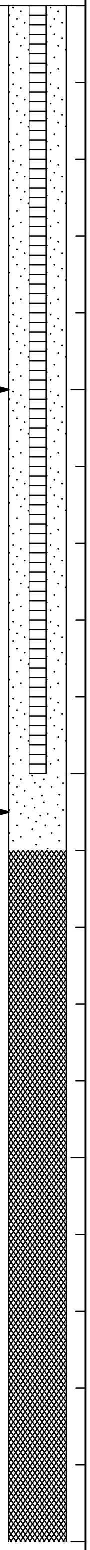
NOTES WATER LEVELS GRAPHIC

set in sand backfill.

2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill.

Sand backfill. Driller noted 0.5 feet of heaving sands at 30 feet.

Bentonite chips backfill.



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott
LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-21

SHEET 3 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Dyke District Yard

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 32
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS GRAPHIC
40	39.0 - 49.0 Loose, gray, stratified, SILT, silty fine sand layers, trace organics, wet. (ML/SM) (OVERBANK DEPOSIT) *(Continued)*	ML		12	SS	1-0-4	4	1.5/1.5	
45				13	SS	0-1-4	5	1.5/1.5	
									Bentonite chips backfill.
	49.0 - 64.0 Compact, medium gray to gray, non-stratified, fine to medium SAND, little silt, dilatant, wet. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	-17.0 49.0						
50				14	SS	4-7-13	20	2.0/1.5	
55				15	SS	1-3-5	8	1.5/1.5	
60									

PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40)
WATER CONTENT (PERCENT) W_p —○W— W_l (20, 40, 60, 80)

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-21

SHEET 4 of 4

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Dyke District Yard

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 32
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS GRAPHIC
60		49.0 - 64.0 Compact, medium gray to gray, non-stratified, fine to medium SAND, little silt, dilatant, wet. (SP-SM) (CHANNEL DEPOSIT) *(Continued)*	SP-SM		16	SS	4-6-14	20	1.5/1.5	Bentonite chips backfill.
		64.0 - 66.5 Dense, medium gray, non-stratified, fine to coarse SAND, some fine to coarse gravel, scoria and mica subangular grains, wet. (SW) (CHANNEL DEPOSIT)	SW	-32.0 64.0						
65					17	SS	7-15-16	31	0.7/1.5	
		Boring completed at 66.5 ft.		-34.5 66.5						
70										
75										
80										

PENETRATION RESISTANCE BLOWS / ft ■ (10, 20, 30, 40)
WATER CONTENT (PERCENT) W_p —○W— W_l (20, 40, 60, 80)

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-22

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: South Burlington Road

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.28

ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

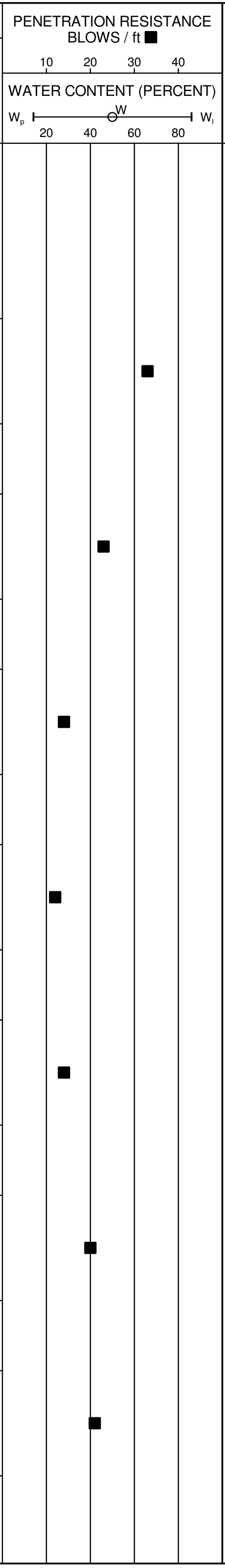
SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 0.5 Asphalt.		44.5 0.5
0.5 - 1.0 2-inch minus crushed rock, damp (GM) (FILL).	GM	44.0 1.0
1.0 - 7.0 Compact to dense, gray-brown, heterogeneous, silty fine to coarse GRAVEL, some fine to coarse sand, subrounded to angular grains, damp. (GM) (FILL)	GM	38.0 7.0
7.0 - 20.6 Compact to dense, gray to gray brown, heterogeneous, silty fine to coarse SAND, some fine to coarse gravel, subrounded to angular grains, damp to moist. (SM) (FILL)	SM	

Log continued on next page

SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	12-17-16	33	1.5/1.5
2	SS	14-13-10	23	1.2/1.5
3	SS	7-7-7	14	–/1.5
4	SS	9-6-6	12	1.2/1.5
5	SS	5-6-8	14	1.0/1.5
6	SS	6-9-11	20	1.5/1.5
7	SS	9-11-10	21	1.2/1.5



NOTES
WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

DEPTH (ft): 0, 5, 10, 15, 20

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-22

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: South Burlington Road

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.28

ELEVATION: 45
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer, 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■	NOTES WATER LEVELS
20		SM	24.4	8A						
	20.6 - 24.0 Compact, blue-gray, heterogeneous, silty fine SAND, trace organics (fragments and rootlets), trace fine sand pockets, damp. (SM) (FILL)	SM	20.6	8B	SS	7-5-6	11	1.3/1.5	■	
	24.0 - 29.0 Very loose, light brown, non-stratified, SILT and fine SAND, trace organics (rootlets), iron-oxide stained layers and pockets, damp. (SM/ML) (OVERBANK DEPOSIT)	SM/ML	21.0 24.0							
25				9	SS	1-0-2	2	1.5/1.5	■	
										Groundwater was encountered at 28 feet bgs ATD.
	29.0 - 39.0 Very loose to loose, light brown, non-stratified, fine to medium SAND, little silt, dilatant, wet. (SP-SM) (OVERBANK DEPOSIT)	SP-SM	16.0 29.0							
30				10	SS	0-1-1	2	1.5/1.5	■	
35				11	SS	1-2-4	6	1.5/1.5	■	
	39.0 - 44.0 Compact, brown-gray, non-stratified, fine to coarse SAND, little silt, dilatant, wet. (SW-SM) (CHANNEL DEPOSIT)	SW-SM	6.0 39.0							
40										

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-22

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: South Burlington Road

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.28

ELEVATION: 45
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40); WATER CONTENT (PERCENT) Wp W Wl (20 40 60 80)	NOTES WATER LEVELS
40	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	39.0 - 44.0 Compact, brown-gray, non-stratified, fine to coarse SAND, little silt, dilatant, wet. (SW-SM) (CHANNEL DEPOSIT) *(Continued)*	SW-SM		12	SS	2-6-10	16	1.5/1.5	■	
											Driller noted gravel.
		44.0 - 49.0 Very dense, gray, slightly stratified, fine to coarse SAND, trace silt, scoria and mica subangular grains, wet. (SW) (CHANNEL DEPOSIT) -Blow counts appear overstated, possibly to heaving sand conditions.	SW	1.0 44.0							
45					13	SS	9-32-51/3"	>50	1.2/1.3	>>■	Driller noted 2 feet of heaving sands at 45 feet.
		49.0 - 51.5 Very dense, gray, non-stratified, fine to coarse SAND, trace fine to coarse gravel, trace silt, scoria and mica subangular grains, wet. (SP) (CHANNEL DEPOSIT) -Blow counts appear overstated, possibly to heaving sand conditions.	SP	-4.0 49.0							
50					14	SS	11-19-60	>50	0.9/1.5	>>■	Driller noted 0.5 feet of heaving sands at 50 feet.
		Boring completed at 51.5 ft.		-6.5 51.5							
55											
60											

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-23

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Market Place

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

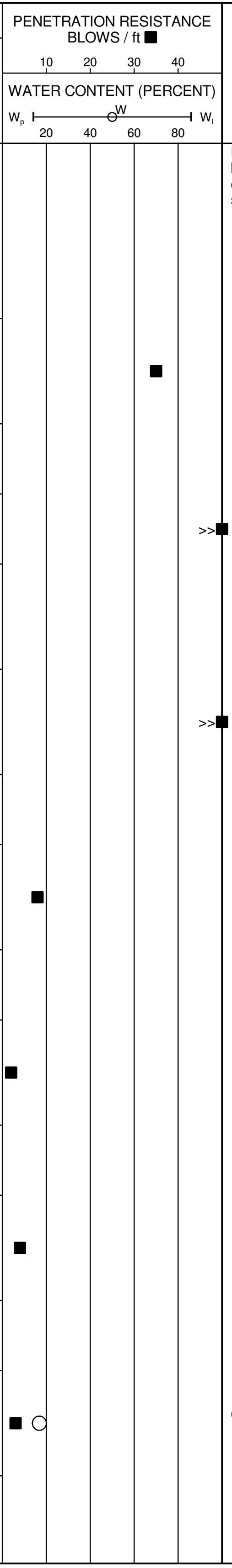
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 36
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE				SAMPLES					NOTES WATER LEVELS
DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT	
0.0 - 1.0 5/8-inch minus crushed rock, damp (GM) (FILL).	GM		35.0 1.0						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
1.0 - 12.0 Dense to very dense, gray-brown to purple-gray, heterogenous, silty fine to coarse angular GRAVEL, some fine to coarse sand, damp. (GM) (FILL)	GM		24.0 12.0	1	SS	9-10-25	35	0.5/1.5	
				2	SS	-15-64	>50	0.3/1.0	
				3	SS	34-37-42	>50	1.5/1.5	
				4	SS	6-4-4	8	0.2/1.5	
12.0 - 19.5 Very loose, light brown, non-stratified, silty fine to medium SAND, trace organics, damp. (SM) (OVERBANK DEPOSIT)	SM		16.5 19.5	5	SS	2-1-1	2	1.2/1.5	
				6	SS	1-2-2	4	1.5/1.5	
				7	SS	2-1-2	3	1.5/1.5	G .
	SP								

DEPTH (ft): 0, 5, 10, 15, 20



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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-23

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Market Place

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 36
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) Wp ⊢ W ⊣ Wl (20 40 60 80)	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	19.5 - 28.0 Very loose, light brown, non-stratified, fine to medium SAND, trace silt, trace organics (rootlets), iron-oxide staining, dilatant, wet. (SP) (OVERBANK DEPOSIT) *(Continued)*	SP		8	SS	2-0-0	0	1.5/1.5	■	Groundwater encountered at 22 feet ATD.
25					9	SS	1-0-0	0	1.5/1.5	■	
		28.0 - 34.0 Loose to compact, light gray, non-stratified, fine to medium SAND, some fibrous organics, dilatant, wet. (SP) (CHANNEL DEPOSIT) -Observed a 2-inch thick layer of wood.	SP	8.0 28.0							Driller noted stiffer drilling conditions at 28 feet.
30					10	SS	1-4-6	10	1.5/1.5	■	
		34.0 - 46.4 Compact, gray, non-stratified, fine to coarse SAND, trace fine gravel, trace silt, some organics (fragments), angular to subangular red and mica grains, wet. (SW) (CHANNEL DEPOSIT) -Observed a 4-inch thick layer of an organic, wood.	SW	2.0 34.0							
35					11	SS	3-4-7	11	1.5/1.5	■	Driller noted stiffer drilling conditions at 38 feet.
40		Log continued on next page									

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-23

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Market Place

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/20/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 36
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p ⊢ W ⊣ W_l (20 40 60 80)	NOTES WATER LEVELS
40		34.0 - 46.4 Compact, gray, non-stratified, fine to coarse SAND, trace fine gravel, trace silt, some organics (fragments), angular to subangular red and mica grains, wet. (SW) (CHANNEL DEPOSIT) *(Continued)*	SW			12	SS	6-10-16	26	0.9/1.5	■	
45						13	SS	11-25-58/4"	>50	1.0/1.4	>>■	
					-10.4 46.4							
		Boring completed at 46.4 ft.										
50												
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-24

SHEET 1 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee East Side of I-5
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29
ELEVATION: 27
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

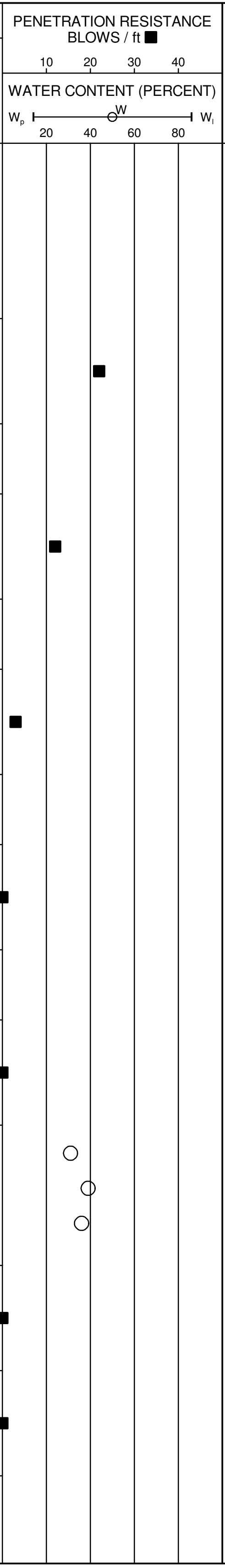
SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 0.5 Loose, dark brown, heterogeneous, silty fine to medium SAND, some organics, damp (SM) (TOPSOIL)	SM	26.5 0.5
0.5 - 4.5 Compact, gray-brown, heterogeneous, fine to medium SAND, trace silt, with iron-oxide staining, damp. (SP) (FILL)	SP	22.5 4.5
4.5 - 7.0 Compact, gray-brown, stratified, fine sandy SILT, fine sand layers, iron-oxide stained layers 2 to 3 inches thick, damp. (ML) (QUIET-WATER DEPOSIT)	ML	20.0 7.0
7.0 - 9.5 Very loose, blue gray, stratified, SILT, trace fine sand, trace organics. (ML) (QUIET-WATER DEPOSIT)	ML	17.5 9.5
9.5 - 13.3 Very loose, greenish gray, non-stratified, CLAY, trace organics (rootlets). (CL) (QUIET-WATER DEPOSIT)	CL	13.7 13.3
13.3 - 24.0 Very loose, blue-gray, slightly stratified, fine sandy SILT, dilatant, wet. (ML) (OVERBANK DEPOSIT)	ML	

Log continued on next page

SAMPLES

NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	6-10-12	22	1.1/1.5
2	SS	6-5-7	12	1.5/1.5
3	SS	2-1-2	3	1.5/1.5
4	SS	0-0-0	0	1.5/1.5
5	SS	0-0-0	0	1.5/1.5
	SH			2.0/2.0
6	SS	1-0-0	0	1.5/1.5
7	SS	1-0-0	0	1.5/1.5



NOTES WATER LEVELS GRAPHIC

Flush-mount monument set in 2 feet concrete with locked well cap.

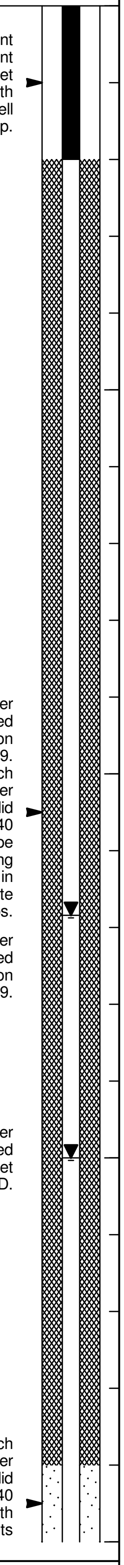
Groundwater measured 9.42 ft btc on 5/19/09.

2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.

Groundwater measured 11.84 feet on 4/27/09.

Groundwater encountered at 15 feet ATD.

2-inch diameter solid schedule 40 PVC with o-ring joints



DEPTH (ft): 0, 5, 10, 15, 20

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

RECORD OF BOREHOLE GB-24

SHEET 2 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee East Side of I-5

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

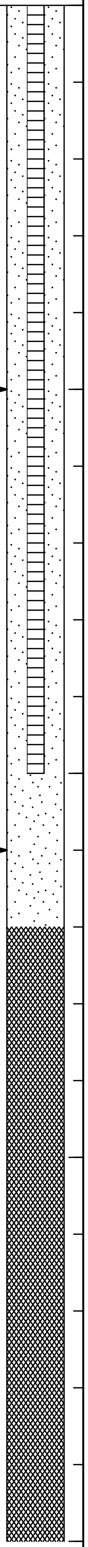
ELEVATION: 27
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	13.3 - 24.0 Very loose, blue-gray, slightly stratified, fine sandy SILT, dilatant, wet. (ML) (OVERBANK DEPOSIT) *(Continued)* -Observed iron-oxide stained partings.	ML		8	SS	0-1-1	2	1.0/1.5	set in sand backfill.
25		24.0 - 29.0 Compact, gray, non-stratified, fine to medium SAND, little silt, scoria and mica grains, wet. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	3.0 24.0	9	SS	2-5-8	13	1.5/1.5	2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill.
30		29.0 - 56.5 Compact to dense, gray to light gray, non-stratified, fine to coarse SAND, trace silt, trace wood fragments, scoria and mica grains, wet. (SW) (CHANNEL DEPOSIT)	SW	-2.0 29.0	10	SS	4-9-7	16	1.3/1.5	Sand backfill.
35					11a,b	SS	2-5-26	31	1.5/1.5	Bentonite chips backfill.
40		-Observed 1-ft thick log.								

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40

WATER CONTENT (PERCENT) W_p W W_l 20 40 60 80

GRAPHIC



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1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

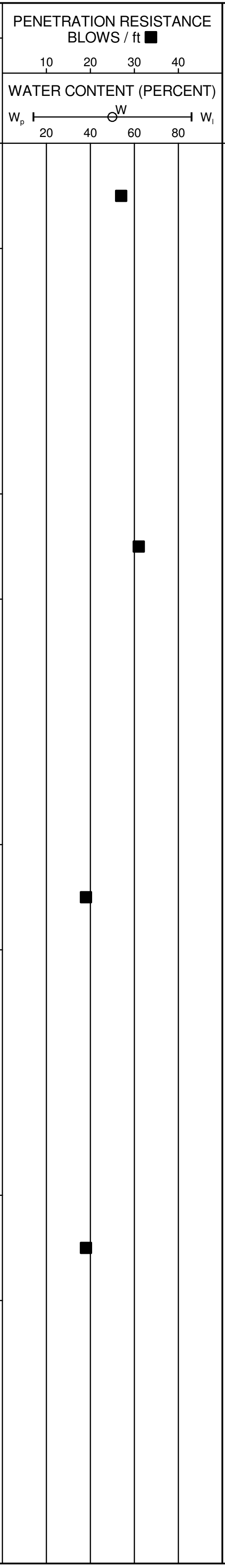
RECORD OF BOREHOLE GB-24

SHEET 3 of 3

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee East Side of I-5
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29
ELEVATION: 27
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
40	29.0 - 56.5 Compact to dense, gray to light gray, non-stratified, fine to coarse SAND, trace silt, trace wood fragments, scoria and mica grains, wet. (SW) (CHANNEL DEPOSIT) *(Continued)*	SW		12	SS	1-12-15	27	1.5 / 1.5	
									Bentonite chips backfill.
45				13	SS	7-13-18	31	2.0 / 1.5	Driller noted 2 feet of heaving sands at 45 feet.
50				14	SS	6-7-12	19	2.0 / 1.5	Driller noted 2 feet of heaving sands at 50 feet.
55				15	SS	3-7-12	19	1.5 / 1.5	Driller noted 1 feet of heaving sands at 55 feet.
	Boring completed at 56.5 ft.		-29.5 56.5						
60									



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

RECORD OF BOREHOLE GB-25

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

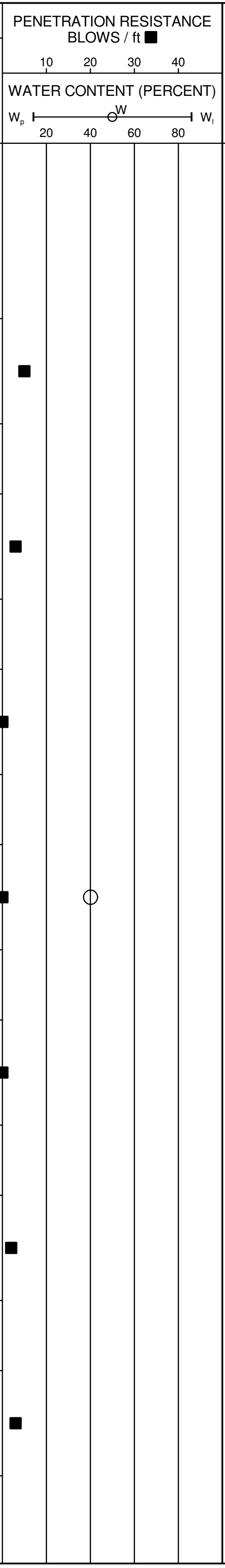
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 22
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	DEPTH (ft)	ELEV.	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	0.0 - 1.0 Loose, gray, heterogeneous, fine GRAVEL, damp (GW) (FILL).	GP		21.0						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
	1.0 - 2.0 Brown, heterogeneous, silty fine to coarse SAND, trace fine to coarse gravel, damp. (SP) (FILL)	SP	1.0	20.0						
	2.0 - 4.5 Loose, light gray-brown, non-stratified, fine sandy SILT, void/air pockets, trace organics (rootlets), iron-oxide staining, damp. (ML) (OVERBANK DEPOSIT)	ML	2.0	17.5	1	SS	1-2-3	5	1.5/1.5	
5	4.5 - 7.0 Very loose, brown-gray, non-stratified, fine to medium SAND, trace silt, iron-oxide staining, damp. (SP) (OVERBANK DEPOSIT)	SP	4.5	15.0	2	SS	1-2-1	3	1.0/1.5	
	7.0 - 14.5 Very loose, brown-gray, non-stratified, SILT, little fine to medium sand, iron-oxide staining, dilatant, wet. (ML) (OVERBANK DEPOSIT)	ML	7.0	7.5	3	SS	1-0-0	0	1.5/1.5	
10					4	SS	1-0-0	0	1.5/1.5	G ▼ Groundwater encountered at 11 feet ATD.
					5	SS	0-0-0	0	1.5/1.5	
15	14.5 - 24.0 Very loose, light gray, slightly stratified, fine SAND, little to some silt, dilatant, wet. (SP-SM/SM) (OVERBANK DEPOSIT)	SP-SM/SM	14.5		6	SS	0-0-2	2	1.5/1.5	
					7	SS	0-1-2	3	1.5/1.5	
20	Log continued on next page									



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-25

SHEET 2 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.29

ELEVATION: 22
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40); WATER CONTENT (PERCENT) Wp ⊢ W ○ ⊣ Wl (20 40 60 80)	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	14.5 - 24.0 Very loose, light gray, slightly stratified, fine SAND, little to some silt, dilatant, wet. (SP-SM/SM) (OVERBANK DEPOSIT) *(Continued)*	SP-SM/SM			8	SS	1-2-2	4	1.5 / 1.5	■	
		24.0 - 36.5 Compact, light gray, non-stratified, fine to coarse SAND, trace silt, trace fine gravel, scoria and mica grains, wet. (SW) (CHANNEL DEPOSIT)	SW		-2.0 24.0							
25						9	SS	1-3-8	11	0.9 / 1.5	■	
30						10	SS	6-11-13	24	0.7 / 1.5	■	Driller noted 1 foot of heaving sands at 30 feet.
35					-14.5 36.5	11	SS	4-8-14	22	0.3 / 1.5	■	
		Boring completed at 36.5 ft.										
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-26

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 23
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
0	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	0.0 - 0.5 2.25-inch crushed rock, damp. (GM) (FILL)	GM	22.5						Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.
		0.5 - 2.0 Compact, dark brown, heterogeneous, silty fine to coarse SAND, some fine to coarse gravel, damp. (SP) (FILL)	SP	0.5 21.0						
		2.0 - 4.5 Very loose, light gray-brown, slightly stratified, SILT, some fine sand, iron-oxide stained layers, damp. (ML) (OVERBANK DEPOSIT)	ML	2.0 18.5	1	SS	1-1-3	4	1.2/1.5	
5		4.5 - 12.0 Very loose, light brown, slightly stratified, silty fine SAND, trace silt and clean sand pockets, trace iron-oxide stained pockets, damp. (SM) (OVERBANK DEPOSIT)	SM	4.5	2	SS	1-0-1	1	1.5/1.5	
					3	SS	1-0-1	1	1.5/1.5	
10				11.0	4	SS	0-1-2	3	1.5/1.5	Groundwater was encountered 11 feet bgs ATD. ▼
		12.0 - 14.5 Loose, brown-gray, non-stratified, fine to medium SAND, little silt, scoria and mica grains, wet. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	12.0 8.5	5	SS	0-2-3	5	1.5/1.5	
15		14.5 - 24.0 Very loose to loose, gray, non-stratified, fine to medium SAND, trace silt, scoria and mica grains, wet. (SP) (CHANNEL DEPOSIT)	SP	14.5	6	SS	1-1-2	3	1.5/1.5	
					7	SS	3-3-6	9	1.5/1.5	
20										

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-26

SHEET 2 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 23
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	14.5 - 24.0 Very loose to loose, gray, non-stratified, fine to medium SAND, trace silt, scoria and mica grains, wet. (SP) (CHANNEL DEPOSIT) *(Continued)*	SP	-1.0 24.0	8	SS	2-2-5	7	2.0 / 1.5	
		24.0 - 36.5 Compact, gray, non-stratified, fine to coarse SAND, little fine to coarse gravel, trace silt, scoria and mica grains, wet. (SW) (CHANNEL DEPOSIT)	SW							
25					9	SS	4-6-16	22	2.0 / 1.5	Driller noted 1 foot of heaving sands at 25 feet.
30					10	SS	5-11-15	26	1.5 / 1.5	Driller noted 1.5 feet of heaving sands at 30 feet.
35				-13.5 36.5	11	SS	4-10-12	22	0.7 / 1.5	Driller noted 2 feet of heaving sands at 35 feet.
		Boring completed at 36.5 ft.								
40										

PENETRATION RESISTANCE BLOWS / ft ■ 10 20 30 40
WATER CONTENT (PERCENT) W_p — W — W_l 20 40 60 80

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-27

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Construction Lot

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted

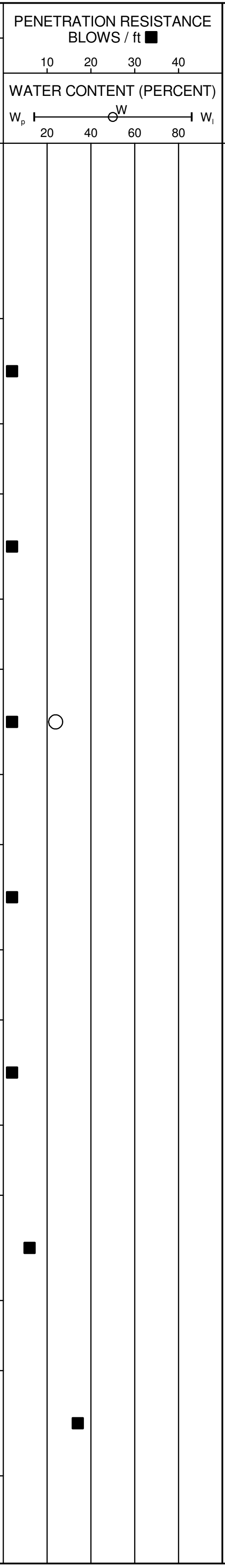
DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 29
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0	0.0 - 2.0 Compact, brown, heterogeneous, silty fine to coarse angular SAND, some fine to coarse gravel, damp. (SM) (FILL)	SM	
	2.0 - 9.5 Very loose, light brown to brown, non-stratified, SILT and fine SAND, damp. (ML) (OVERBANK DEPOSITS)	ML	27.0 2.0
5			
10	9.5 - 12.0 Very loose, light brown, slightly stratified, SILT, some fine sand, fine sand pockets, iron-oxide staining, damp. (ML) (OVERBANK DEPOSIT)	ML	19.5 9.5
	12.0 - 14.5 Very loose, light brown, slightly stratified, silty fine SAND, pockets of silt and clean sand, iron-oxide staining, wet. (SM) (OVERBANK DEPOSIT)	SM	17.0 12.0
15	14.5 - 26.5 Loose to compact, brown-gray, non-stratified, fine to coarse SAND, trace silt, subangular to subrounded scoria and mica sand grains, wet. (SW) (CHANNEL DEPOSIT)	SW	14.5 14.5
20	Log continued on next page		

SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT
1	SS	1-1-1	2	$\frac{1.0}{1.5}$
2	SS	1-1-1	2	$\frac{1.5}{1.5}$
3	SS	1-1-1	2	$\frac{1.5}{1.5}$
4	SS	1-1-1	2	$\frac{1.1}{1.5}$
5	SS	1-1-1	2	$\frac{1.5}{1.5}$
6	SS	1-2-4	6	$\frac{1.5}{1.5}$
7	SS	3-5-12	17	$\frac{1.5}{1.5}$



NOTES
WATER LEVELS

Boring backfilled with bentonite chips with 3 feet of jet-set concrete at surface.

G .

▼ Groundwater was encountered 14 feet bgs ATD.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-27

SHEET 2 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Construction Lot

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/23/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.30 E: 122.30

ELEVATION: 29
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p —O^W— W_l (20 40 60 80)	NOTES WATER LEVELS
20		14.5 - 26.5 Loose to compact, brown-gray, non-stratified, fine to coarse SAND, trace silt, subangular to subrounded scoria and mica sand grains, wet. (SW) (CHANNEL DEPOSIT) *(Continued)*	SW			8	SS	1-3-12	15	1.5/1.5	■	
25					2.5 26.5	9	SS	2-12-10	22	1.5/1.5	■	
		Boring completed at 26.5 ft.										
30												
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-28

SHEET 1 of 2

PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/22/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.30

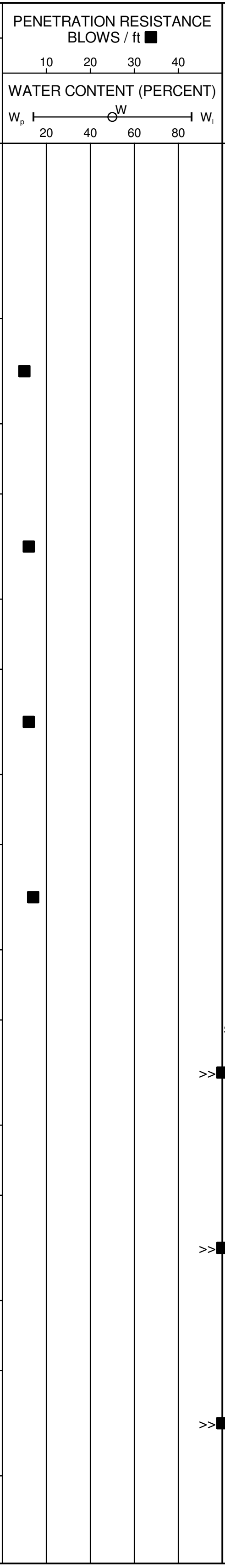
ELEVATION: 26
INCLINATION: -90

BORING METHOD: 4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer

SOIL PROFILE			
DESCRIPTION	USCS	ELEV.	DEPTH (ft)
0.0 - 1.5 Loose, dark brown, non-stratified, silty fine to coarse SAND, some organics, damp. (SM) (TOPSOIL)	SM	24.5	1.5
1.5 - 4.5 Loose, orange-brown to light brown, non-stratified, fine to medium SAND grading to medium SAND, little silt, damp. (SP-SM) (CHANNEL DEPOSIT)	SP-SM	21.5	4.5
4.5 - 9.5 Loose, brown to gray, non-stratified, fine to medium SAND, trace silt, damp (SP) (CHANNEL DEPOSIT)	SP	16.5	9.5
9.5 - 25.7 Loose to very dense, brown-gray, non-stratified, fine to coarse SAND, trace silt, trace fine to coarse gravel, subangular to subrounded scoria and mica grains, wet (SW) (CHANNEL DEPOSIT) -Blow counts appear overstated, possibly to heaving sand conditions. -Blow counts appear overstated, possibly to heaving sand conditions. -Blow counts appear overstated, possibly to heaving sand conditions.	SW		

Log continued on next page

SAMPLES				
NUMBER	TYPE	BLOWS per 6 in 140 lb hammer 30 inch drop	N	REC / ATT
1	SS	2-2-3	5	1.5/1.5
2	SS	3-3-3	6	1.5/1.5
3	SS	1-2-4	6	1.5/1.5
4	SS	3-3-4	7	1.5/1.5
5	SS	4-6-57	>50	2.0/1.5
6	SS	4-6-50	>50	1.0/1.5
7	SS	-6-57	>50	1.5/1.5



NOTES
WATER LEVELS
GRAPHIC

Flush-mount monument set in 2 feet of concrete with locked well cap.

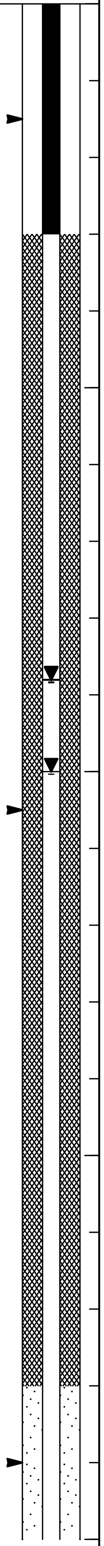
Groundwater measured 8.60 ft btc on 5/19/09. Groundwater measured 8.81 feet on 4/24/09. Groundwater measured 16.2 feet on 4/27/09. Groundwater encountered 10 feet ATD.

2-inch diameter solid schedule 40 PVC pipe with o-ring joints set in bentonite chips.

Driller noted heaving sands at 12.5 feet.

Driller noted hard sands. Driller noted 0.5 feet of heaving sands at 16 feet.

2-inch diameter solid schedule 40 PVC with o-ring joints set in sand backfill.



1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

RECORD OF BOREHOLE GB-28

SHEET 2 of 2

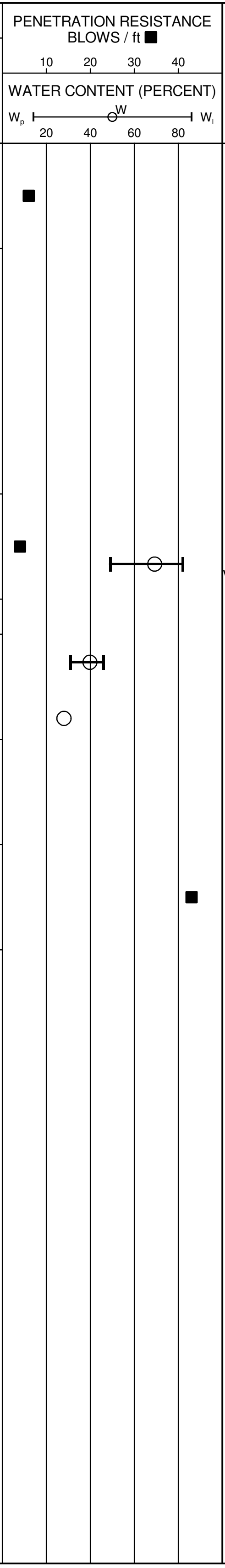
PROJECT: Burlington Levee
PROJECT NUMBER: 093-93153.100
LOCATION: Burlington Levee

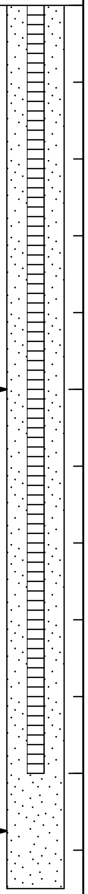
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 4/22/2009
DRILL RIG: CME 75 Truck-Mounted

DATUM: Geodetic
AZIMUTH: N/A
COORDINATES: N: 48.28 E: 122.30

ELEVATION: 26
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	NOTES WATER LEVELS
20	4 1/2-inch inner diameter, 8 1/4-inch outer diameter hollow stem auger with 140 lb autohammer	9.5 - 25.7 Loose to very dense, brown-gray, non-stratified, fine to coarse SAND, trace silt, trace fine to coarse gravel, subangular to subrounded scoria and mica grains, wet (SW) (CHANNEL DEPOSIT) *(Continued)*	SW	0.3 25.7	8	SS	1-2-4	6	1.5/1.5	
25					9A 9B	SS	0-2-2	4	1.5/1.5	2-inch diameter slotted schedule 40 PVC with o-ring joints set in sand backfill.
		25.7 - 26.5 Very soft, light gray, plastic SILT, trace organics, moist (MH) (OVERBANK DEPOSIT)	MH	-0.5 26.5						Vane Shear 2 inch diameter 6 inch max 12 lb
		26.5 - 29.0 Stiff, medium gray, non-stratified, SILT, moist. (ML) (OVERBANK DEPOSIT)	ML	-3.0 29.0		SH			1.5/1.5	
30		29.0 - 31.5 Very loose, gray, non-stratified, fine to medium SAND, little silt, scoria and mica grains, wet (SP-SM) (CHANNEL DEPOSIT)	SP-SM	-5.5 31.5	10	SS	12-17-26	43	1.5/1.5	Sand backfill.
		Boring completed at 31.5 ft.								
35										
40										





1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc.
DRILLER: Scott

LOGGED: A. Dennison
CHECKED: A. McKenzie-Johnson
DATE: 7/2/2009

Golder Associates

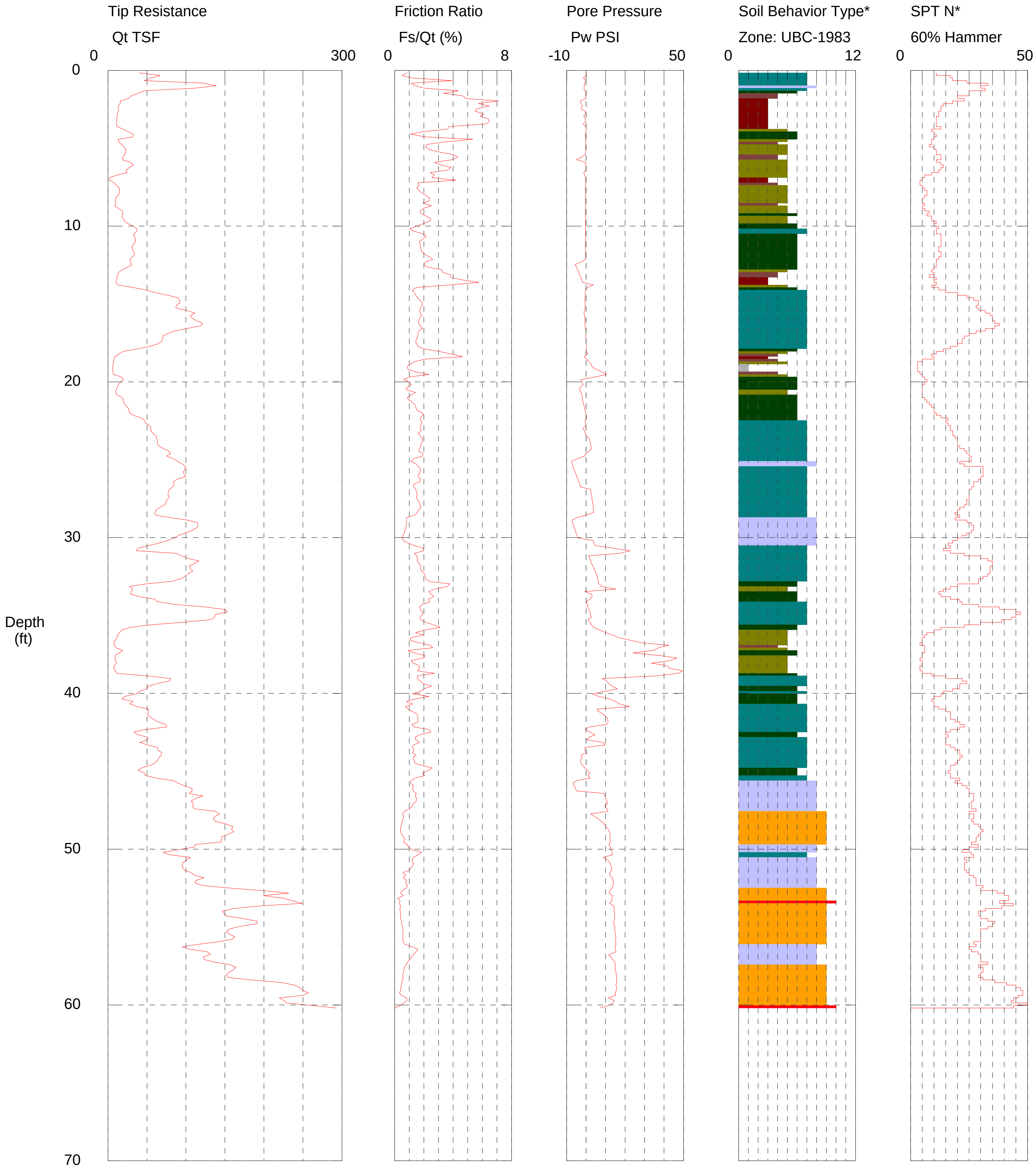
APPENDIX A-2

CPT LOGS

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-01
Cone Used: DSG1079

CPT Date/Time: 5/20/2009 2:15:14 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 60.20 feet

Depth Increment = 0.164 feet

■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

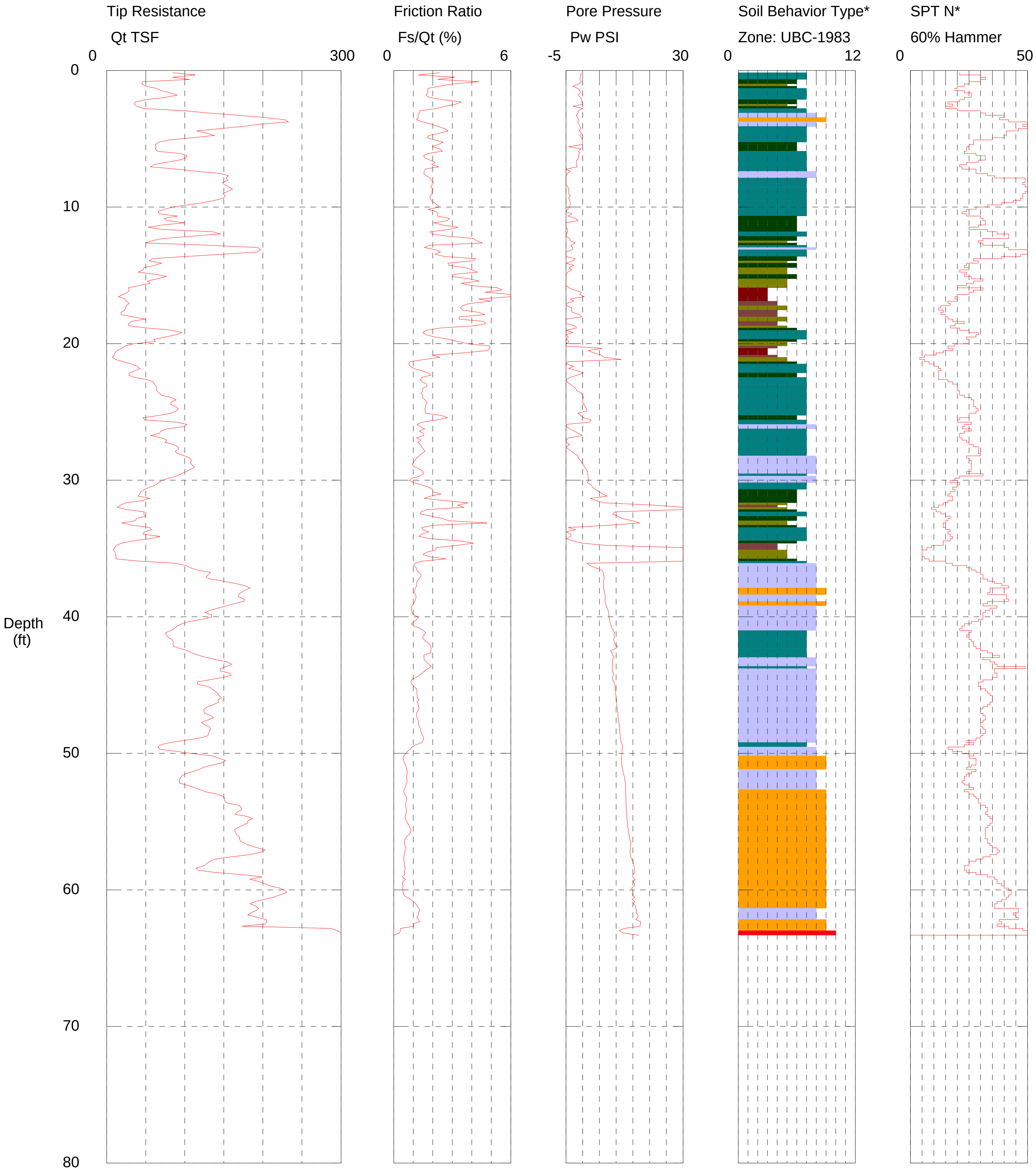
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-02
Cone Used: DSG1079

CPT Date/Time: 5/20/2009 12:48:27 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 63.32 feet

Depth Increment = 0.164 feet

- ▨ 1 sensitive fine grained
- ▨ 2 organic material
- 🟥 3 clay
- 🟫 4 silty clay to clay
- 🟩 5 clayey silt to silty clay
- 🟩 6 sandy silt to clayey silt
- 🟦 7 silty sand to sandy silt
- 🟪 8 sand to silty sand
- 🟧 9 sand
- 🟥 10 gravelly sand to sand
- 🟪 11 very stiff fine grained (*)
- 🟦 12 sand to clayey sand (*)

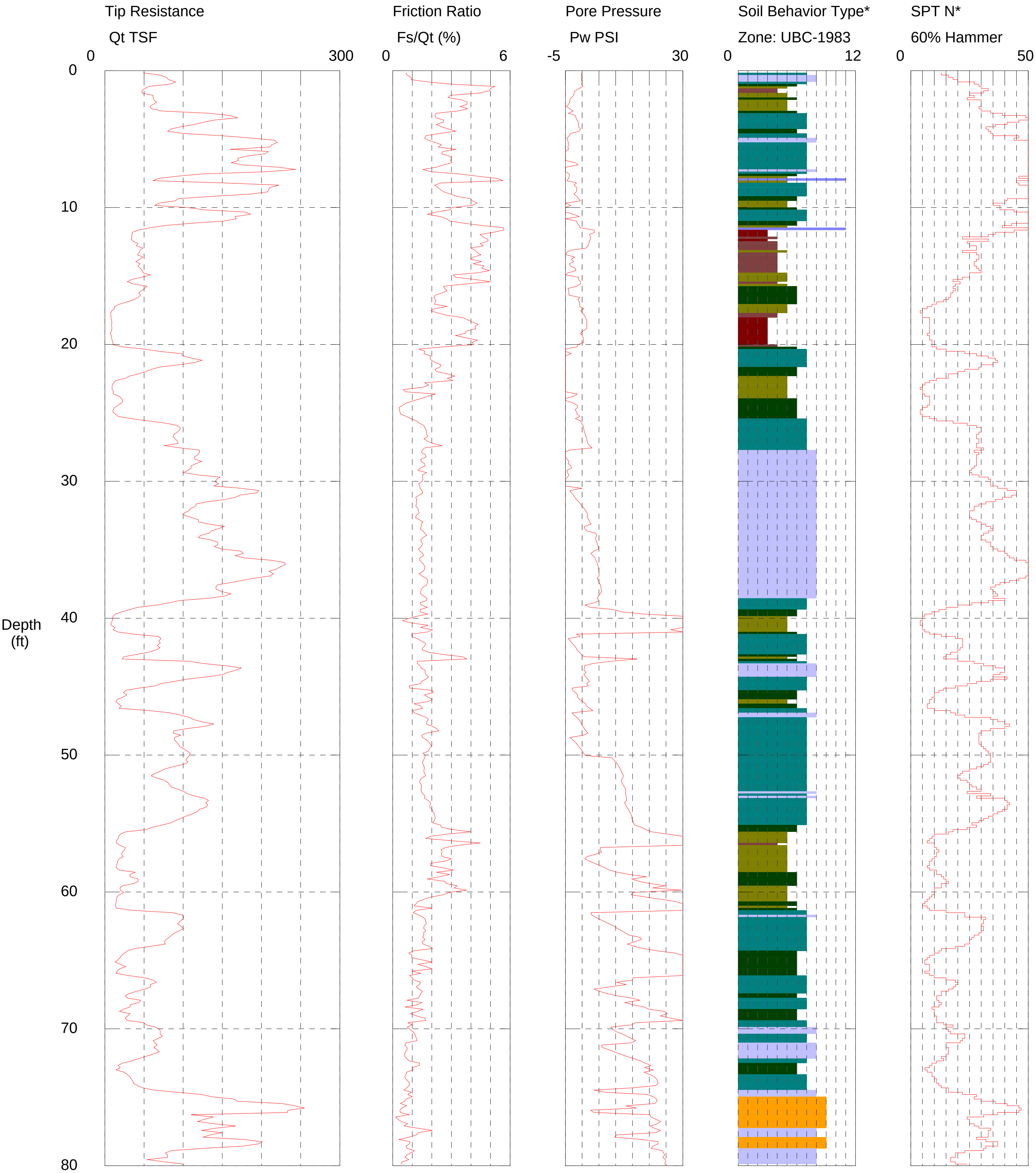
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-03
Cone Used: DSG1079

CPT Date/Time: 5/21/2009 12:03:21 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 81.00 feet

Depth Increment = 0.164 feet

- ⬜ 1 sensitive fine grained
- ⬛ 2 organic material
- 🟥 3 clay
- 🟫 4 silty clay to clay
- 🟨 5 clayey silt to silty clay
- 🟩 6 sandy silt to clayey silt
- 🟦 7 silty sand to sandy silt
- 🟪 8 sand to silty sand
- 🟧 9 sand
- 🟥 10 gravelly sand to sand
- 🟪 11 very stiff fine grained (*)
- 🟦 12 sand to clayey sand (*)

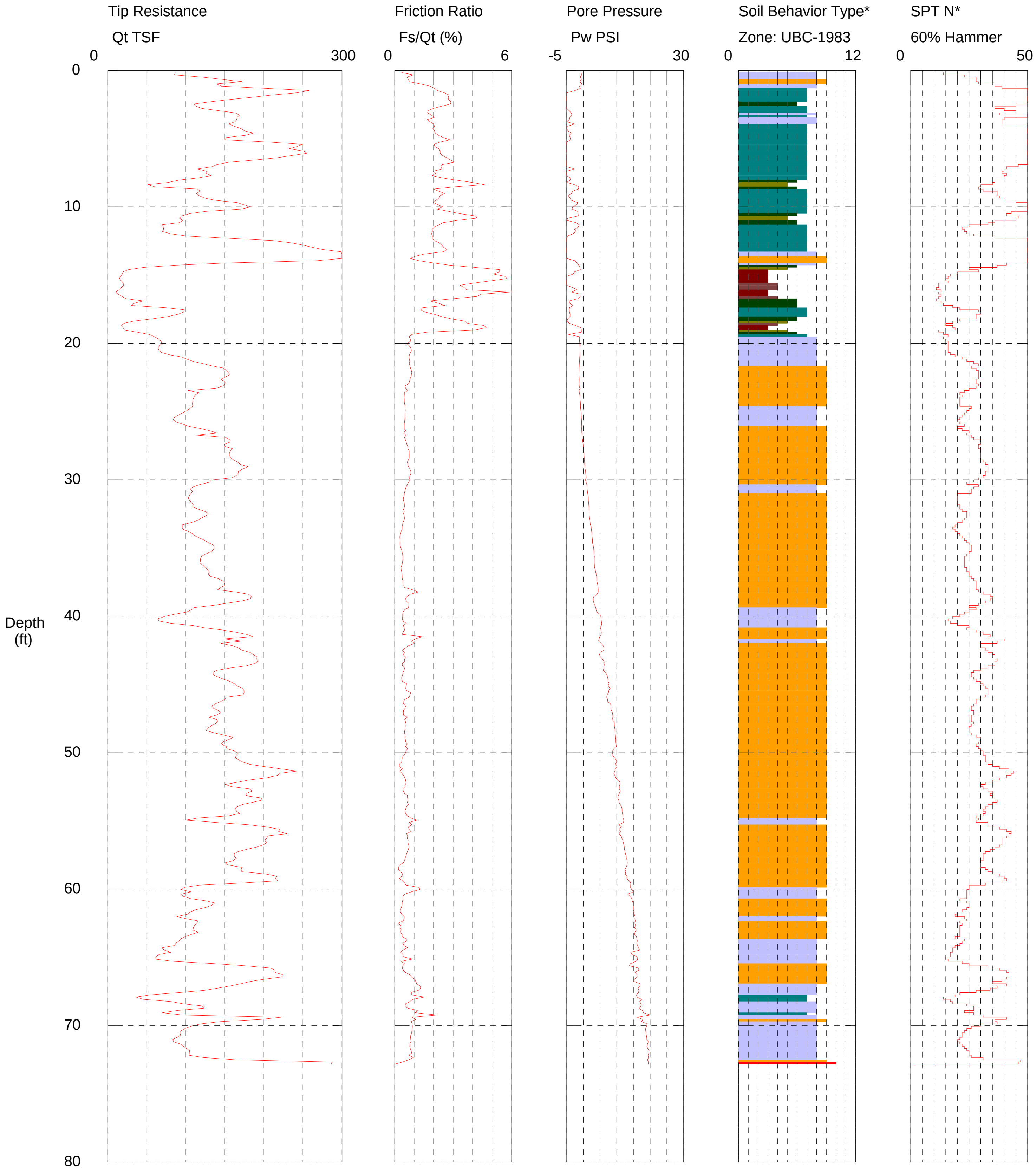
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-04
Cone Used: DSG1079

CPT Date/Time: 5/21/2009 2:01:13 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 72.83 feet

Depth Increment = 0.164 feet

■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

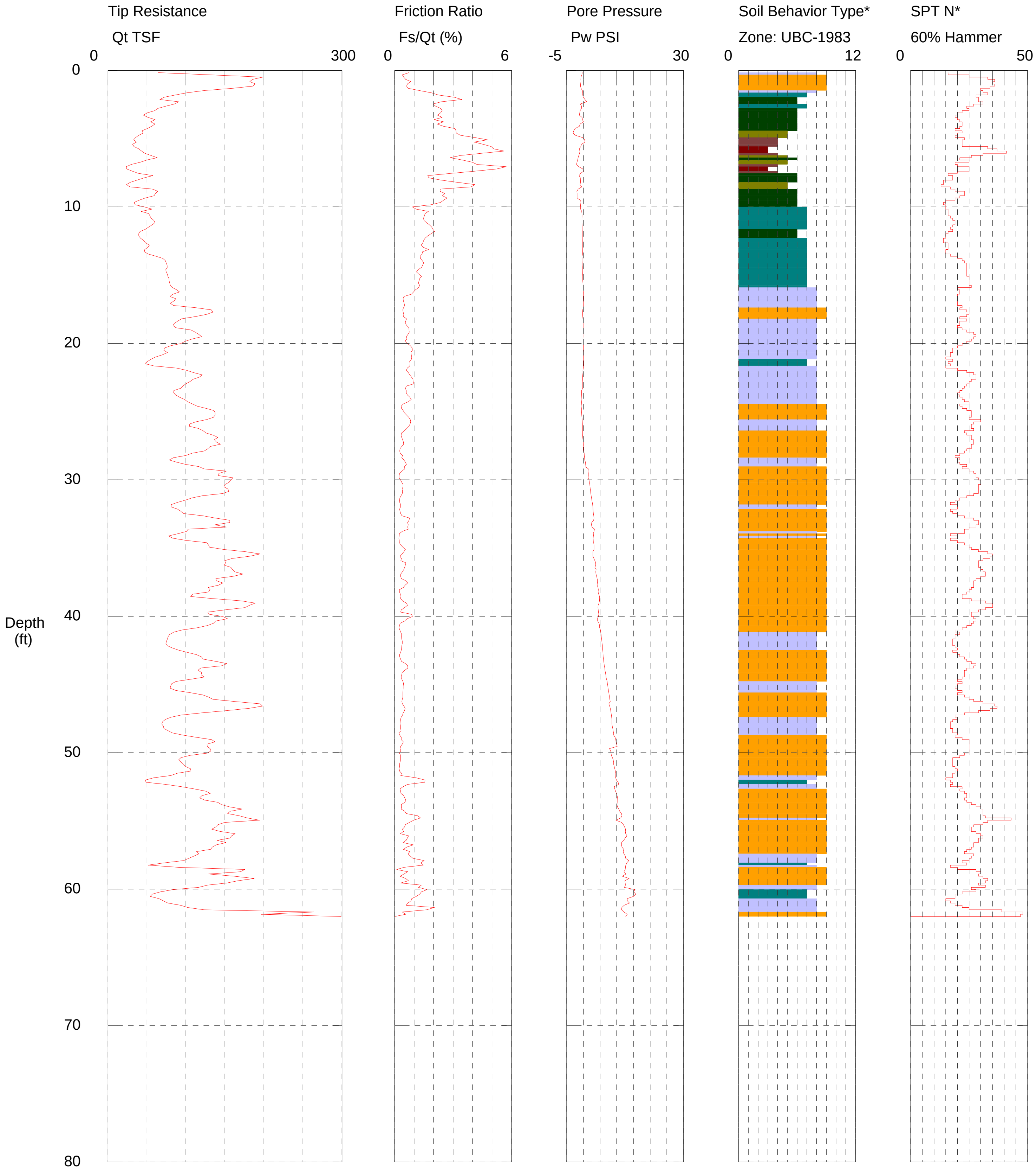
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-05
Cone Used: DSG1079

CPT Date/Time: 5/19/2009 5:32:59 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 62.01 feet

Depth Increment = 0.164 feet

■ 1 sensitive fine grained	■ 4 silty clay to clay	■ 7 silty sand to sandy silt	■ 10 gravelly sand to sand
■ 2 organic material	■ 5 clayey silt to silty clay	■ 8 sand to silty sand	■ 11 very stiff fine grained (*)
■ 3 clay	■ 6 sandy silt to clayey silt	■ 9 sand	■ 12 sand to clayey sand (*)

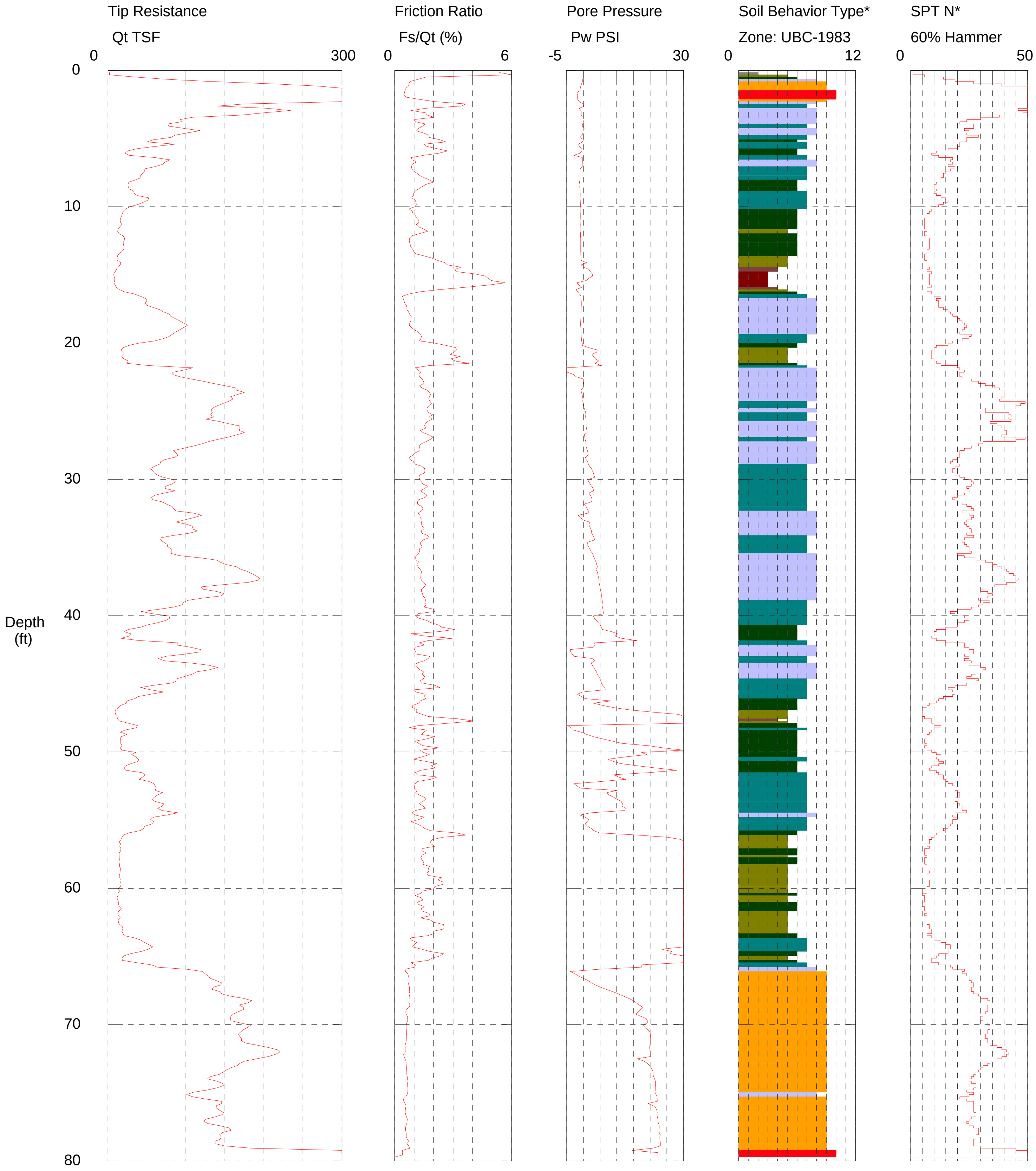
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-06
Cone Used: DSG1079

CPT Date/Time: 5/19/2009 1:35:07 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 79.72 feet

Depth Increment = 0.164 feet

- 1 sensitive fine grained
- 2 organic material
- 3 clay
- 4 silty clay to clay
- 5 clayey silt to silty clay
- 6 sandy silt to clayey silt
- 7 silty sand to sandy silt
- 8 sand to silty sand
- 9 sand
- 10 gravelly sand to sand
- 11 very stiff fine grained (*)
- 12 sand to clayey sand (*)

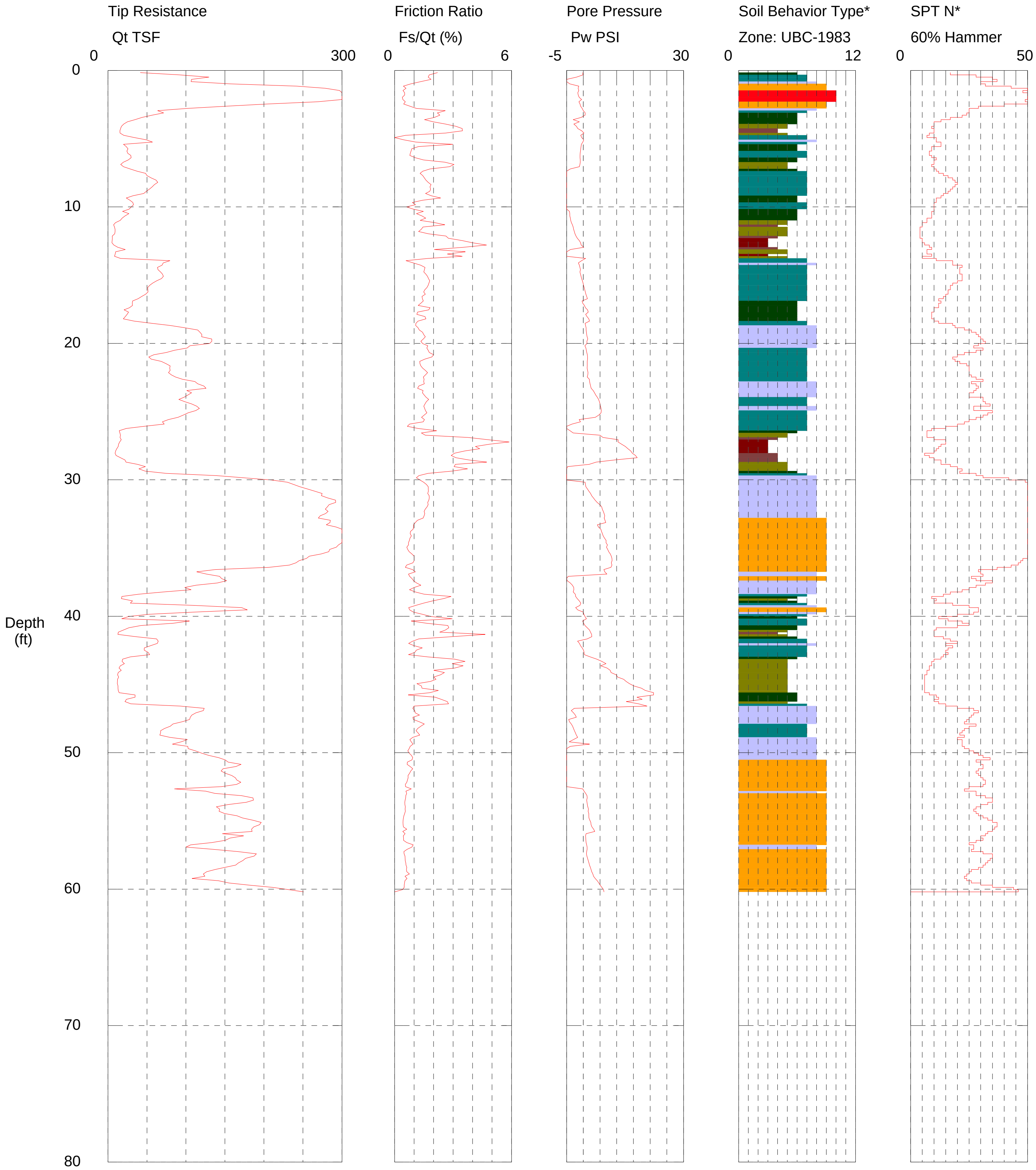
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-07
Cone Used: DSG1079

CPT Date/Time: 5/19/2009 3:49:15 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 60.20 feet

Depth Increment = 0.164 feet

- ⬜ 1 sensitive fine grained
- ⬛ 2 organic material
- 🟥 3 clay
- 🟫 4 silty clay to clay
- 🟫 5 clayey silt to silty clay
- 🟩 6 sandy silt to clayey silt
- 🟦 7 silty sand to sandy silt
- 🟪 8 sand to silty sand
- 🟧 9 sand
- 🟥 10 gravelly sand to sand
- 🟦 11 very stiff fine grained (*)
- 🟦 12 sand to clayey sand (*)

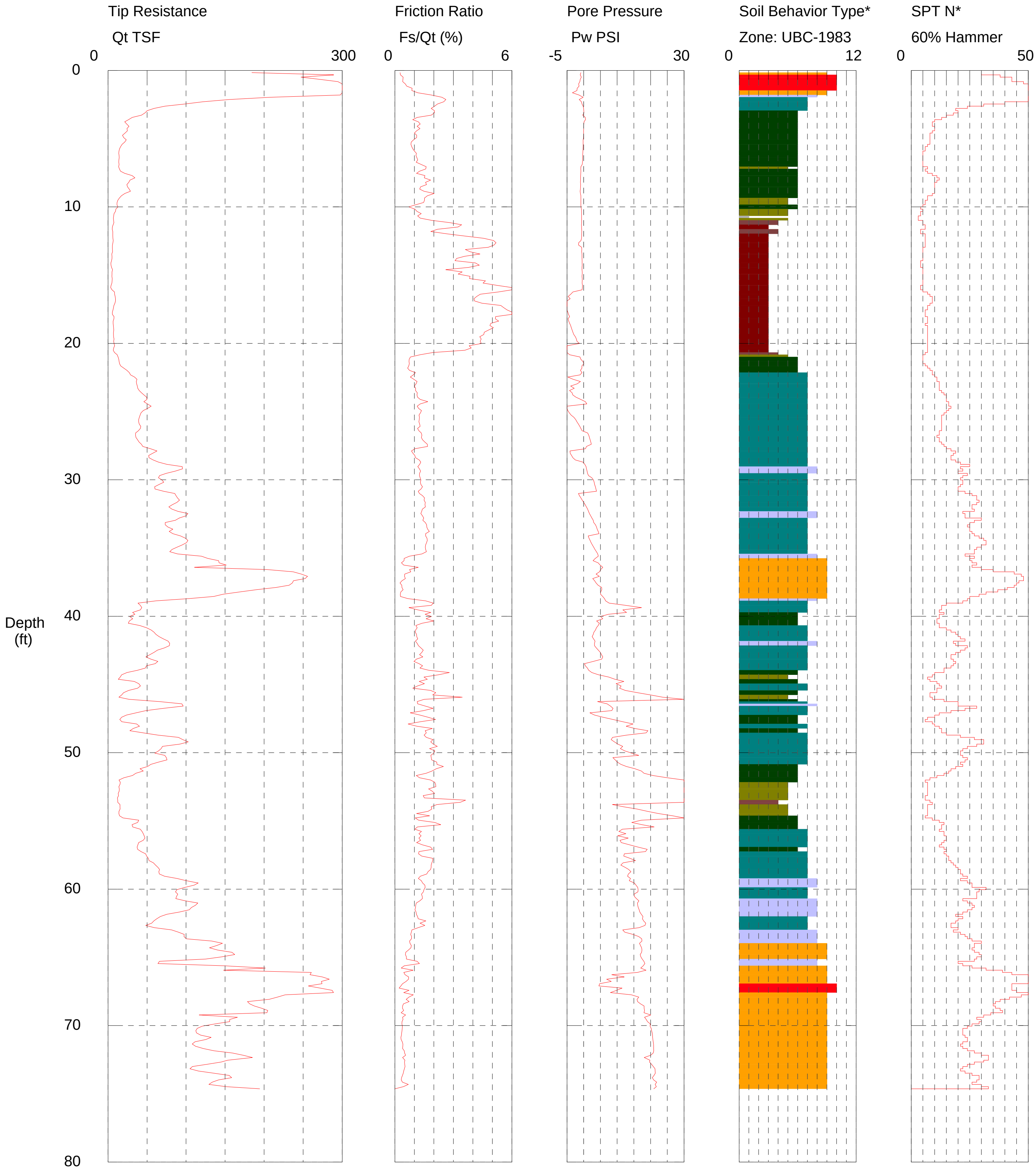
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-08
Cone Used: DSG1079

CPT Date/Time: 5/21/2009 3:55:04 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 74.64 feet

Depth Increment = 0.164 feet

■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

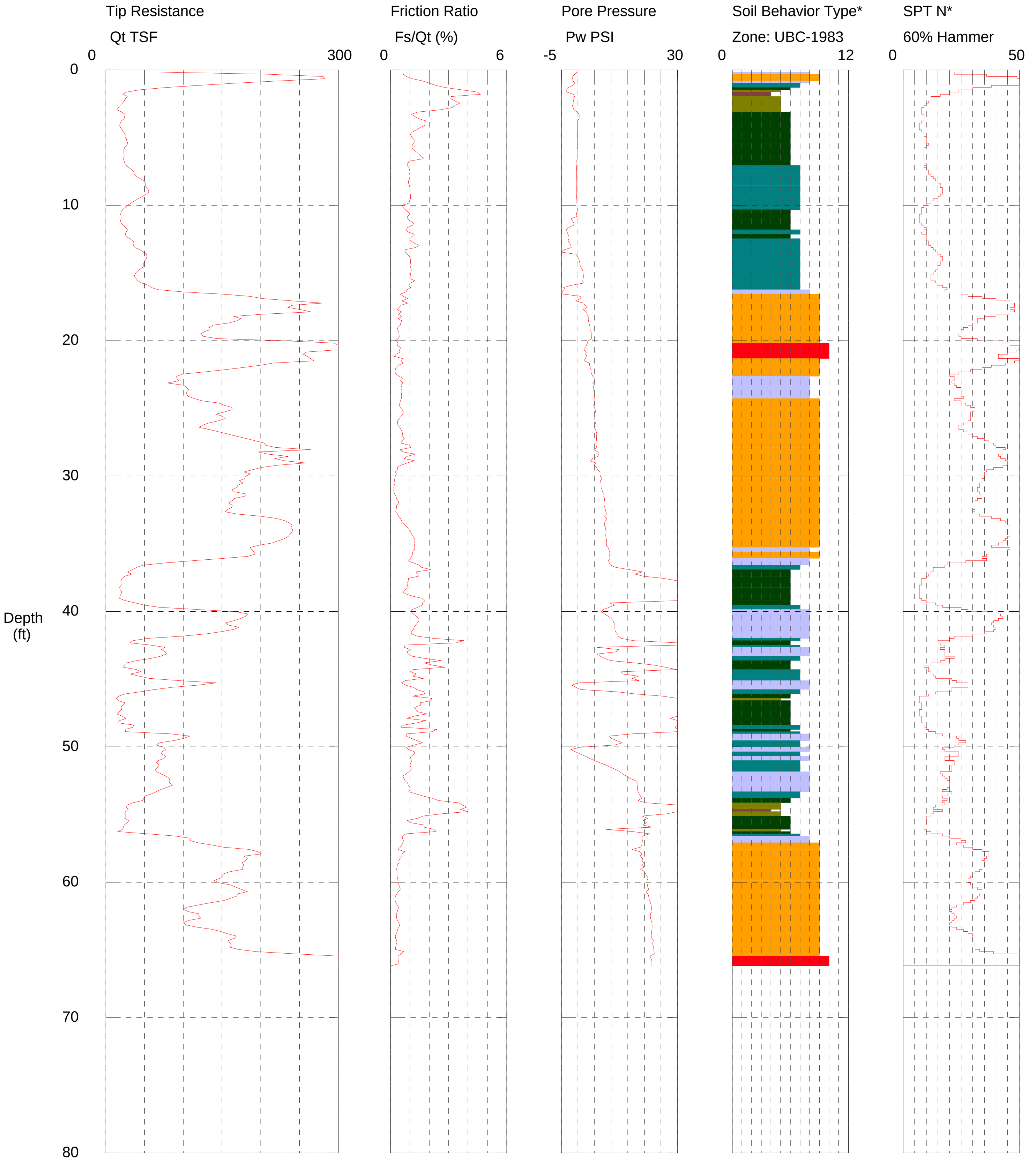
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-09
Cone Used: DSG1079

CPT Date/Time: 5/20/2009 5:05:33 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 66.17 feet

Depth Increment = 0.164 feet

■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

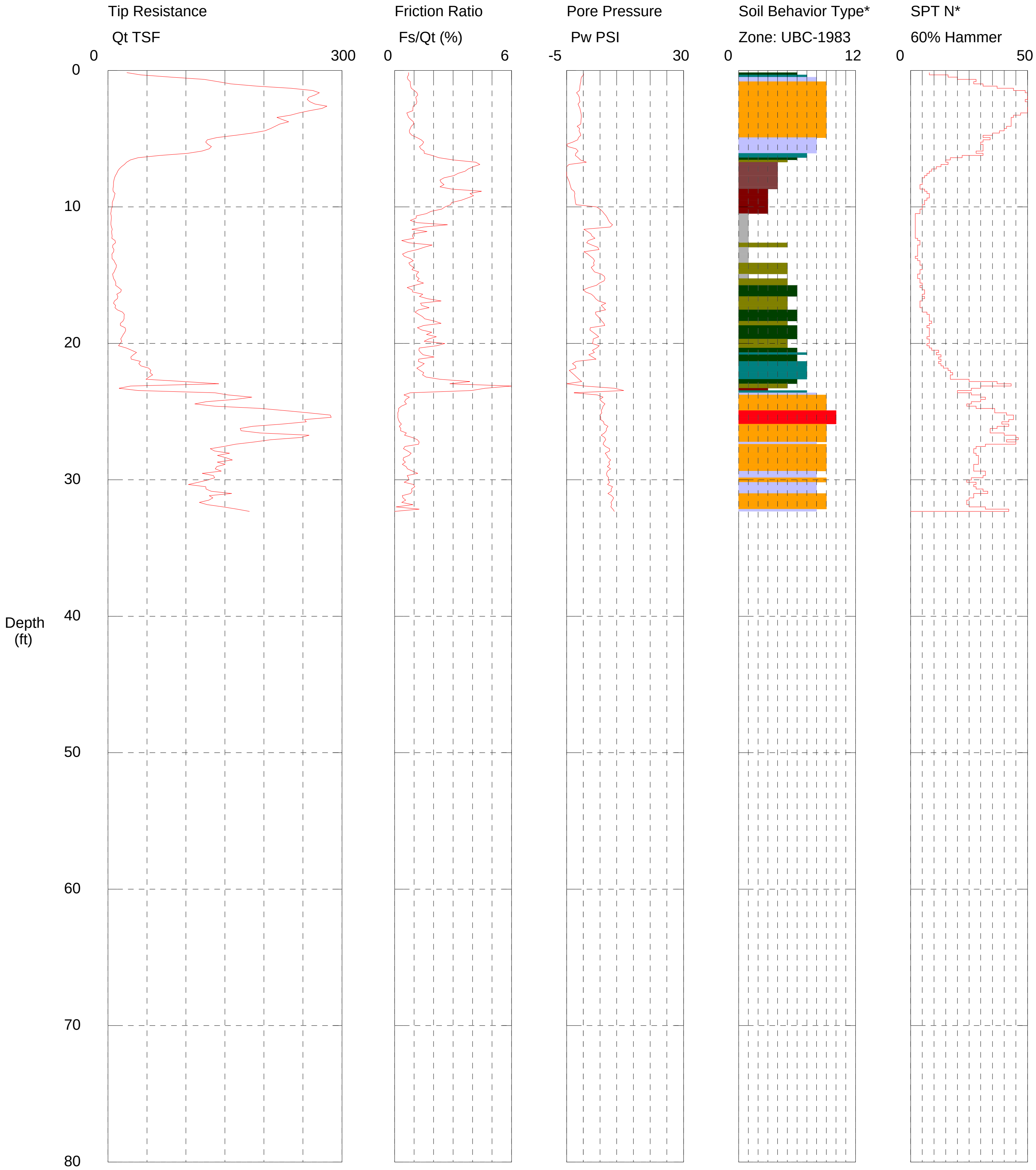
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-10
Cone Used: DSG1079

CPT Date/Time: 5/20/2009 3:58:56 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 32.32 feet

Depth Increment = 0.164 feet

■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

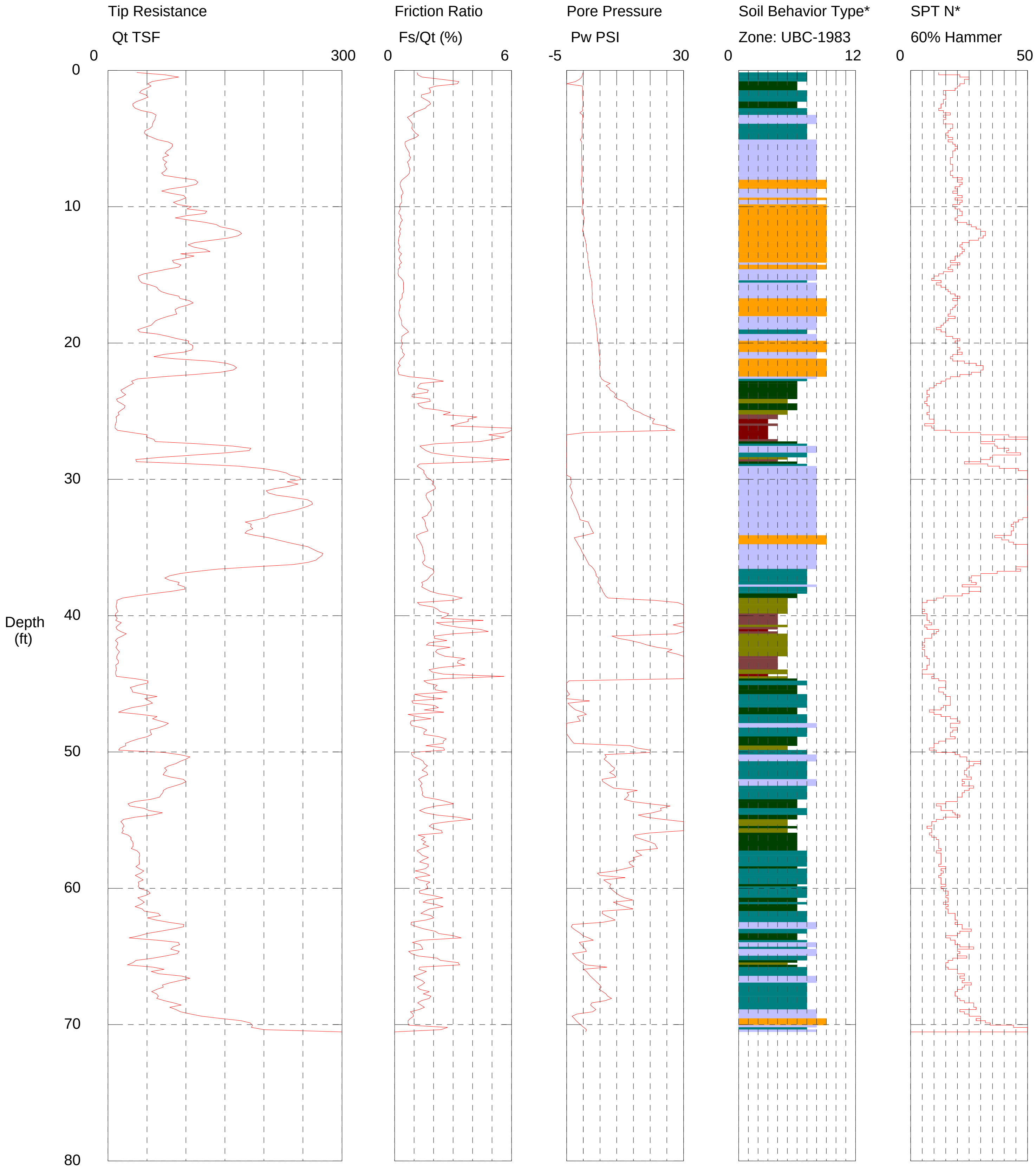
In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Golder Associates Inc.

Operator: Nowak
Sounding: CPT-11
Cone Used: DSG1079

CPT Date/Time: 5/21/2009 6:16:07 PM
Location: Burlington Levee
Job Number: 093-93153



Maximum Depth = 70.54 feet

Depth Increment = 0.164 feet

■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

APPENDIX B
LABORATORY TESTING AND ANALYSIS

B-1: ATTERBERG LIMITS ANALYSIS

B-2: GRAIN SIZE ANALYSIS

B-3: GRAIN SIZE ANALYSES OF 200 SIEVE WASH ONLY

B-4: SHELBY TUBE ANALYSIS OF TESTING RESULTS

B-5: HYDRAULIC CONDUCTIVITY ASSESSMENT

APPENDIX B-1

ATTERBERG LIMITS ANALYSIS

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME: PIE / Burlington Geotech and Levees / WA
PROJECT NUMBER: 093-93153.100
SAMPLE ID: GB-6 S-8 **SAMPLE DEPTH:** 20ft
SAMPLE TYPE: SPT

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION			NATURAL MOISTURE
Number of Blows				16	27	30	
Weight of Wet Soil & Tare (gm)	23.90	23.10	25.20	45.50	46.10	42.20	31.00
Weight of Dry Soil & Tare (gm)	23.20	22.60	24.20	39.00	39.80	36.90	28.40
Weight of Tare (gm)	21.10	20.80	21.10	21.00	21.70	21.30	21.60
Weight of Water (gm)	0.70	0.50	1.00	6.50	6.30	5.30	2.60
Weight of Dry Soil (gm)	2.10	1.80	3.10	18.00	18.10	15.60	6.80
Water Content %	33.33	27.78	32.26	36.11	34.81	33.97	38.24

PLASTIC LIMIT (PL) 31

LIQUID LIMIT (LL) 35

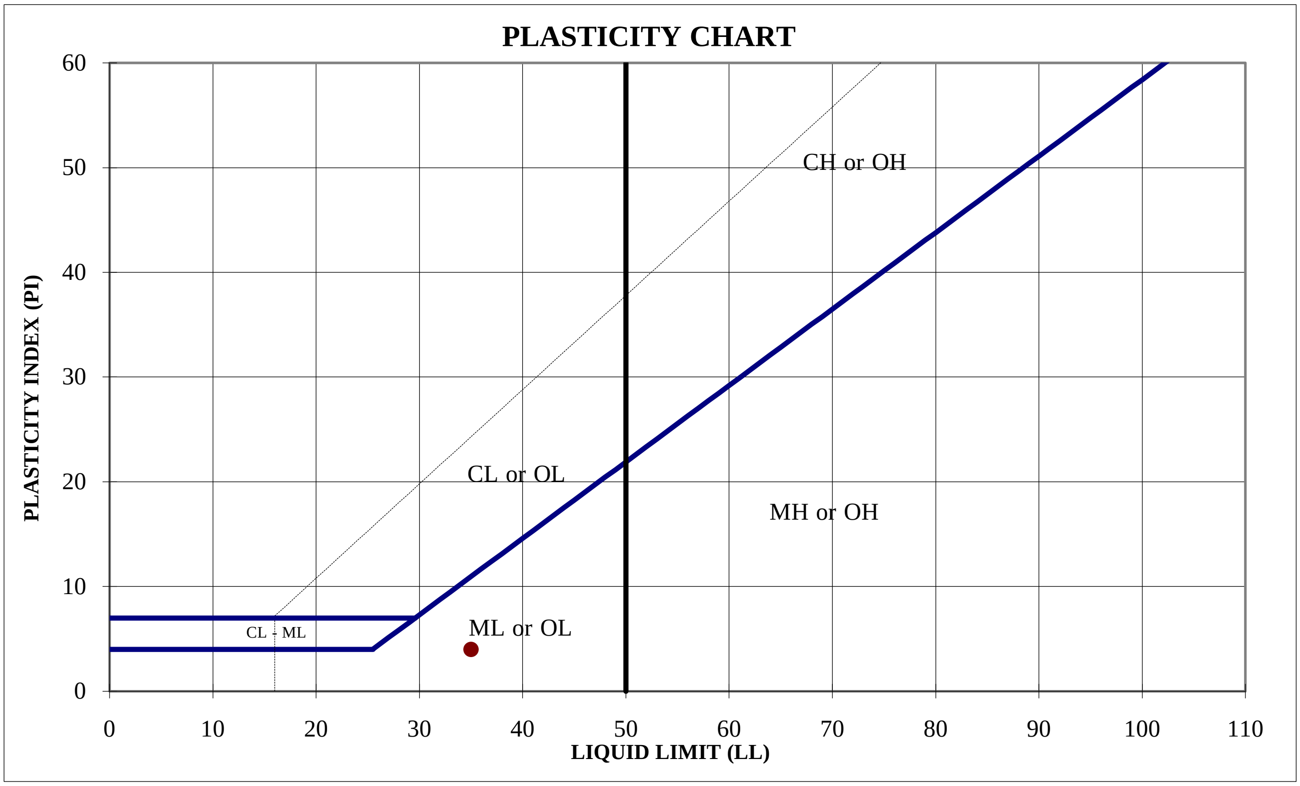
PLASTICITY INDEX (PI) 4

LIQUIDITY INDEX (LI) 1.78

NOTE:

DESCRIPTION SILT

USCS ML



TECH	TCM
DATE	5/20/2009
CHECK	TCM
REVIEW	AJD

Golder Associates Inc.

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME: **PIE / Burlington Geotech and Levees / WA**
PROJECT NUMBER: **093-93153.100**
SAMPLE ID: **GB-13** **S-7** **SAMPLE DEPTH:** **17.5ft**
SAMPLE TYPE: **SPT**

SAMPLE PREPARATION

Wet or Dry: Dry
Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION			NATURAL MOISTURE
Number of Blows				20	28	48	
Weight of Wet Soil & Tare (gm)	28.40	27.70	28.20	46.30	48.40	50.90	35.90
Weight of Dry Soil & Tare (gm)	27.60	27.00	27.40	39.50	40.90	44.90	32.50
Weight of Tare (gm)	24.90	24.90	25.00	25.10	24.70	31.00	24.80
Weight of Water (gm)	0.80	0.70	0.80	6.80	7.50	6.00	3.40
Weight of Dry Soil (gm)	2.70	2.10	2.40	14.40	16.20	13.90	7.70
Water Content %	29.63	33.33	33.33	47.22	46.30	43.17	44.16

PLASTIC LIMIT (PL): 32

LIQUID LIMIT (LL): 46

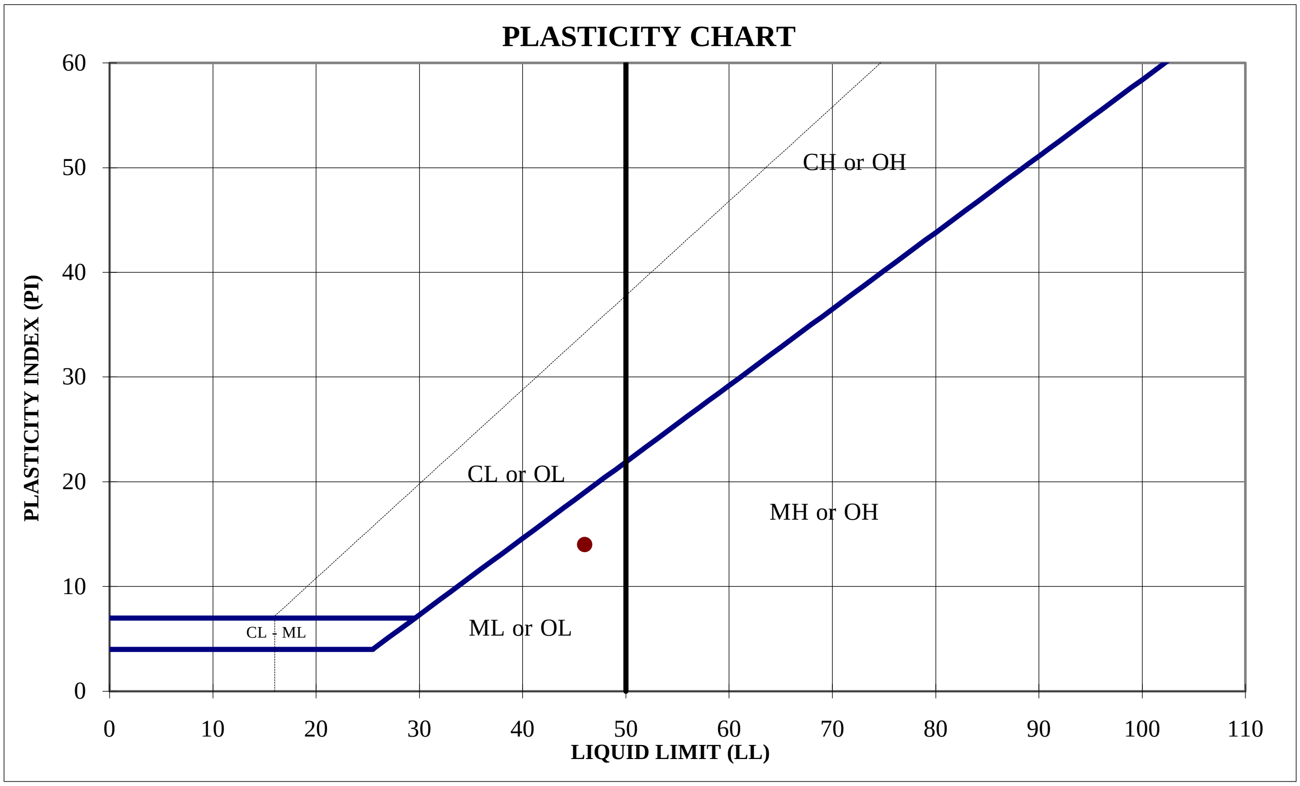
PLASTICITY INDEX (PI): 14

LIQUIDITY INDEX (LI): 0.86

NOTE:

DESCRIPTION SILT

USCS ML



TECH	TCM
DATE	5/20/2009
CHECK	TCM
REVIEW	AJD

Golder Associates Inc.

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME: PIE / Burlington Geotech and Levees / WA
PROJECT NUMBER: 093-93153.100
SAMPLE ID: GB-14 S-8 **SAMPLE DEPTH:** 20ft
SAMPLE TYPE: SPT

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION			NATURAL MOISTURE
Number of Blows				24	28	41	
Weight of Wet Soil & Tare (gm)	23.10	22.60	23.00	49.60	48.00	49.70	33.00
Weight of Dry Soil & Tare (gm)	22.60	22.20	22.60	43.40	42.40	44.30	29.70
Weight of Tare (gm)	21.00	20.80	21.10	21.60	21.30	21.20	21.60
Weight of Water (gm)	0.50	0.40	0.40	6.20	5.60	5.40	3.30
Weight of Dry Soil (gm)	1.60	1.40	1.50	21.80	21.10	23.10	8.10
Water Content %	31.25	28.57	26.67	28.44	26.54	23.38	40.74

PLASTIC LIMIT (PL): 29

LIQUID LIMIT (LL): 28

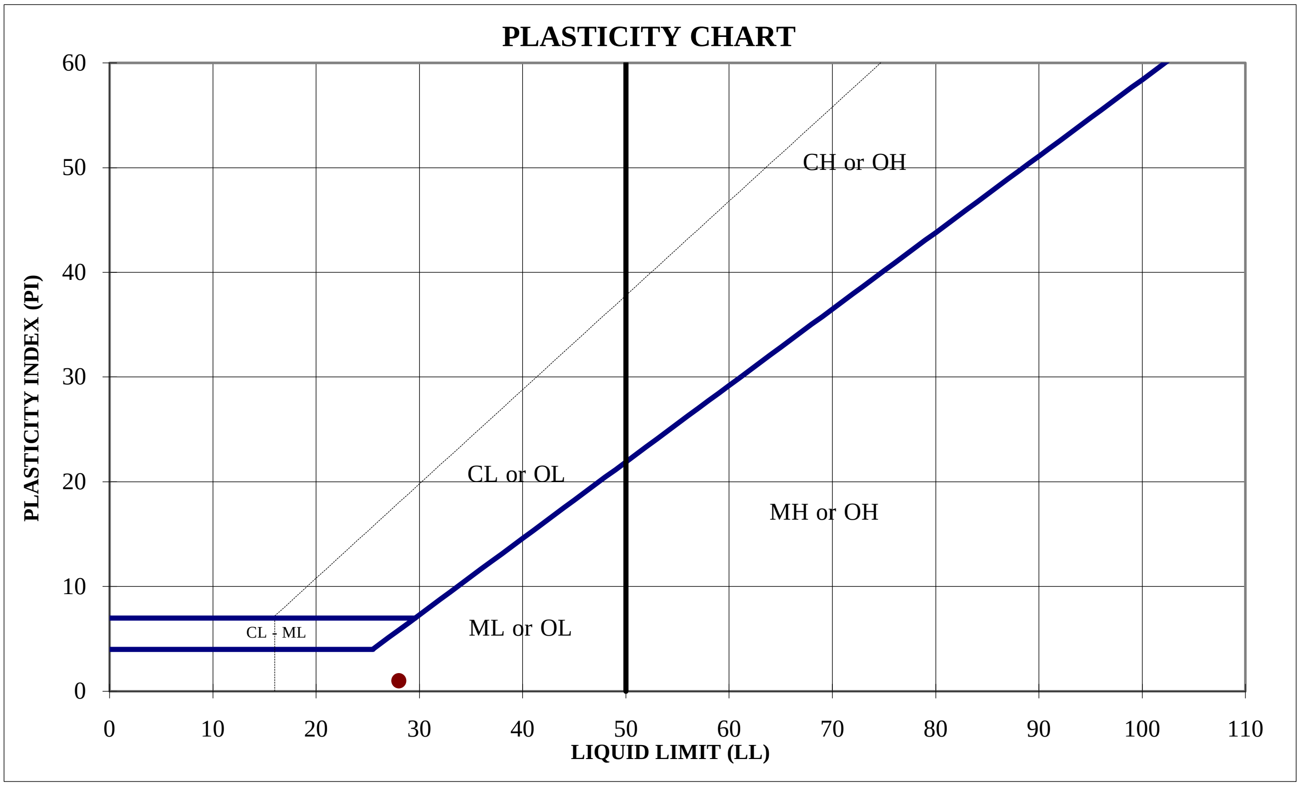
PLASTICITY INDEX (PI): 1

LIQUIDITY INDEX (LI): 11.91

NOTE:

DESCRIPTION Non Plastic

USCS ML



TECH	TCM
DATE	5/20/2009
CHECK	TCM
REVIEW	AJD

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME:	**PIE / Burlington Geotech and Levees / WA**		
PROJECT NUMBER:	**093-93153.100**		
SAMPLE ID:	**GB-15**	**S-8**	**SAMPLE DEPTH:** **20ft**
SAMPLE TYPE:	**SPT**		

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION			NATURAL MOISTURE
Number of Blows				14	23	33	
Weight of Wet Soil & Tare (gm)	29.40	28.70	29.20	56.30	56.10	48.10	44.30
Weight of Dry Soil & Tare (gm)	28.30	27.80	28.10	48.70	48.50	42.60	40.50
Weight of Tare (gm)	24.90	25.00	24.90	24.90	24.60	25.00	24.80
Weight of Water (gm)	1.10	0.90	1.10	7.60	7.60	5.50	3.80
Weight of Dry Soil (gm)	3.40	2.80	3.20	23.80	23.90	17.60	15.70
Water Content %	32.35	32.14	34.37	31.93	31.80	31.25	24.20

PLASTIC LIMIT (PL): 33

LIQUID LIMIT (LL): 32

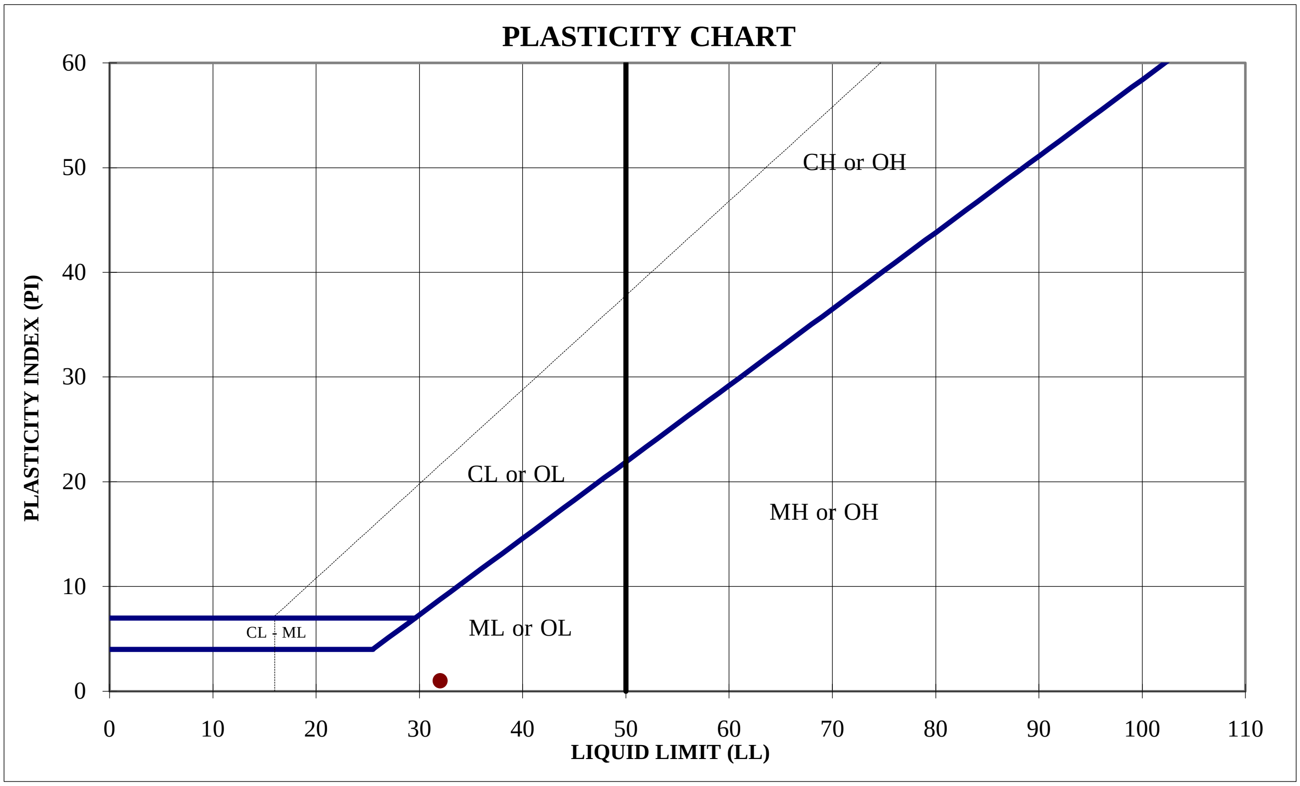
PLASTICITY INDEX (PI): 1

LIQUIDITY INDEX (LI): -8.75

NOTE:

DESCRIPTION Non Plastic

USCS ML



TECH	TCM
DATE	5/20/2009
CHECK	TCM
REVIEW	AJD

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME: PIE / Burlington Geotech and Levees / WA
PROJECT NUMBER: 093-93153.100
SAMPLE ID: GB-20 S-3 **SAMPLE DEPTH:** 7.5ft
SAMPLE TYPE: SPT

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION			NATURAL MOISTURE
Number of Blows				19	27	41	
Weight of Wet Soil & Tare (gm)	23.80	23.20	23.50	40.80	47.20	45.40	36.30
Weight of Dry Soil & Tare (gm)	23.00	22.50	22.80	34.80	39.50	38.20	31.30
Weight of Tare (gm)	21.00	20.70	21.10	21.00	21.70	21.30	21.60
Weight of Water (gm)	0.80	0.70	0.70	6.00	7.70	7.20	5.00
Weight of Dry Soil (gm)	2.00	1.80	1.70	13.80	17.80	16.90	9.70
Water Content %	40.00	38.89	41.18	43.48	43.26	42.60	51.55

PLASTIC LIMIT (PL): 40

LIQUID LIMIT (LL): 43

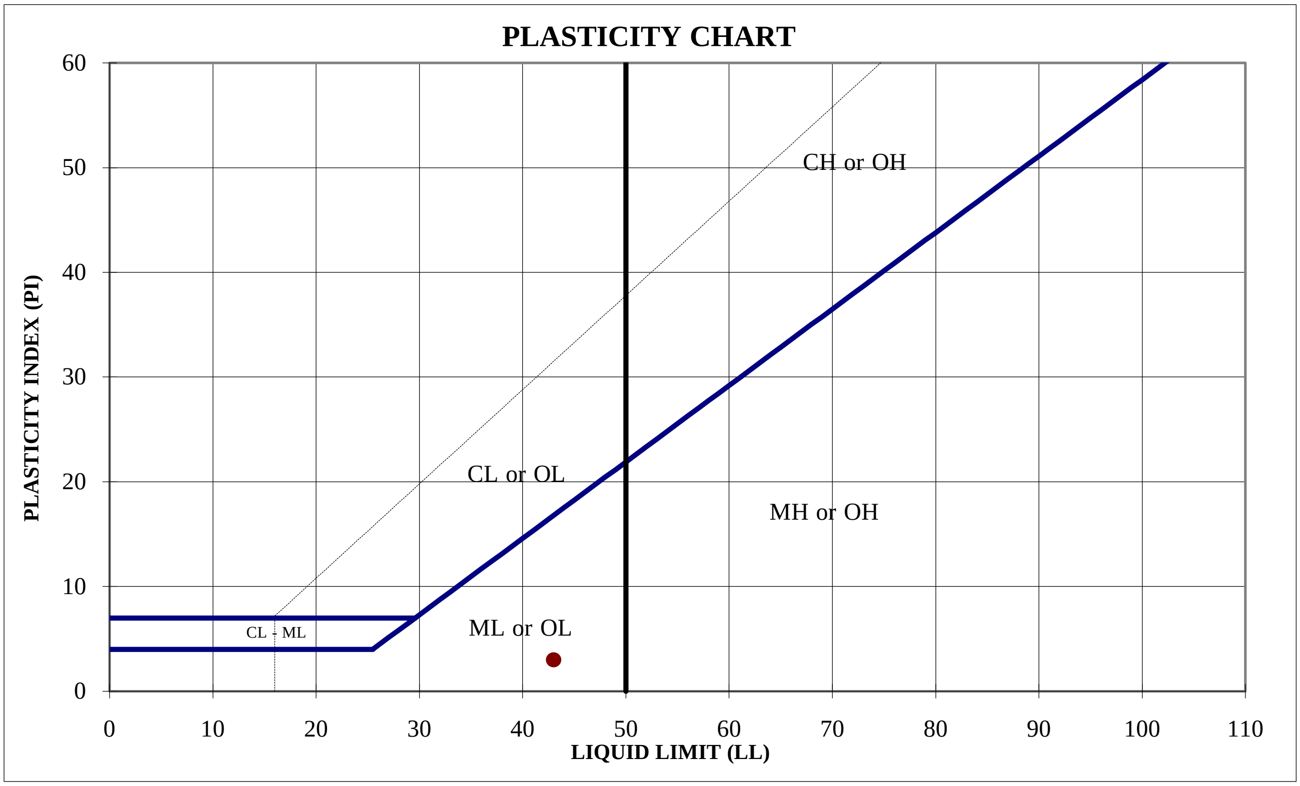
PLASTICITY INDEX (PI): 3

LIQUIDITY INDEX (LI): 3.84

NOTE:

DESCRIPTION: SILT

USCS: ML



TECH	TCM
DATE	5/20/2009
CHECK	TCM
REVIEW	AJD

Golder Associates Inc.

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME: **PIE / Burlington Geotech and Levees / WA**
PROJECT NUMBER: **093-93153.100**
SAMPLE ID: **GB-28** **S-9B** **SAMPLE DEPTH:** **25ft**
SAMPLE TYPE: **SPT**

SAMPLE PREPARATION

Wet or Dry	Dry	Minus #40 Sieve	Yes

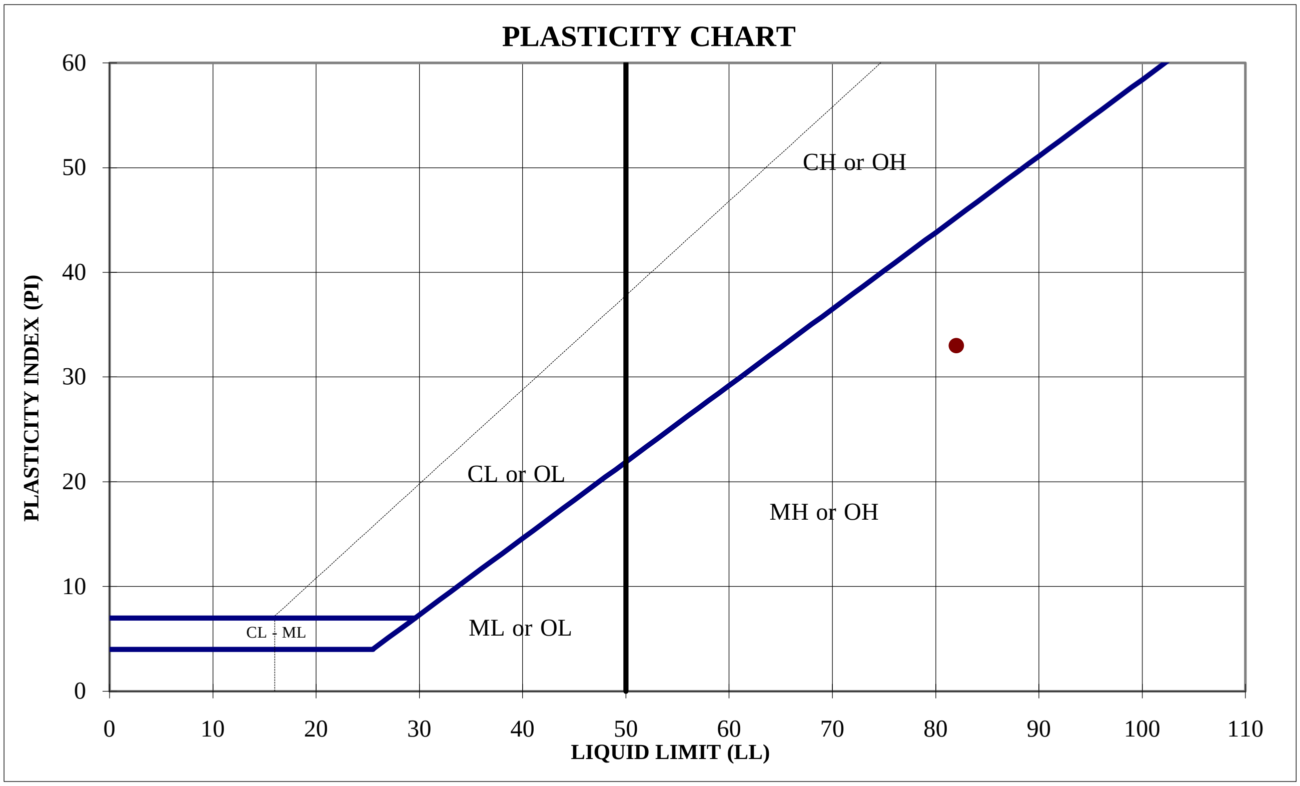
	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION			NATURAL MOISTURE
Number of Blows				18	23	33	
Weight of Wet Soil & Tare (gm)	28.10	27.60	27.70	45.30	53.00	44.90	38.00
Weight of Dry Soil & Tare (gm)	27.10	26.70	26.80	36.00	40.20	36.00	32.60
Weight of Tare (gm)	25.00	24.90	25.00	25.10	24.70	24.90	24.80
Weight of Water (gm)	1.00	0.90	0.90	9.30	12.80	8.90	5.40
Weight of Dry Soil (gm)	2.10	1.80	1.80	10.90	15.50	11.10	7.80
Water Content %	47.62	50.00	50.00	85.32	82.58	80.18	69.23

PLASTIC LIMIT (PL)	**LIQUID LIMIT (LL)**
49	82
PLASTICITY INDEX (PI)	**LIQUIDITY INDEX (LI)**
33	0.61

NOTE:

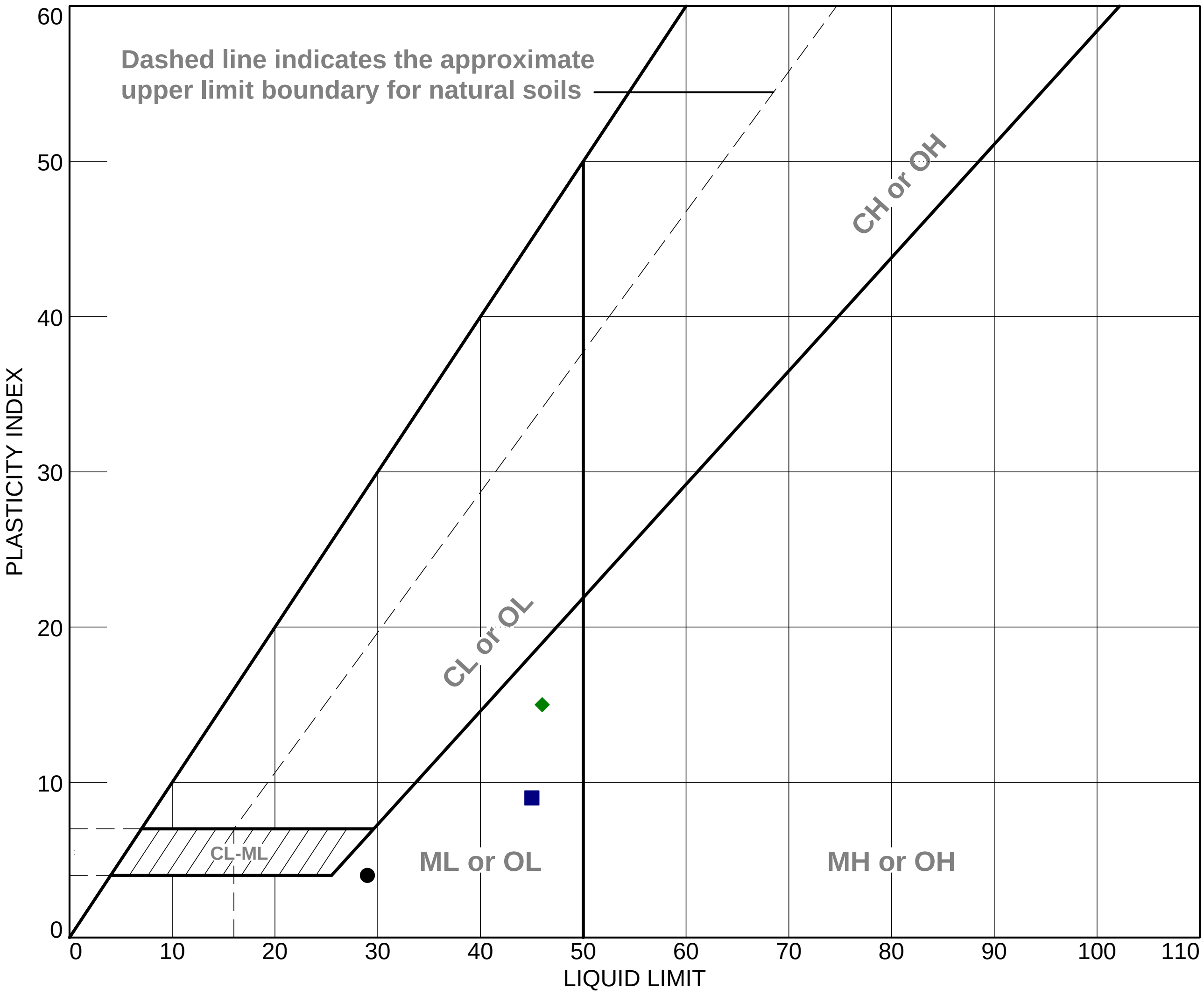
DESCRIPTION plastic SILT

USCS MH



TECH	TCM
DATE	5/20/2009
CHECK	TCM
REVIEW	AJD

Atterberg Limits Test Report ASTM D-4318



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	GB-14		62.0-62.2	36	25	29	4	ML
■	GB-17		15.0-15.1 ft.	50	36	45	9	ML
▲	GB-24		13.3-13.4 ft.	31	NP	NV	NP	ML
◆	GB-28		27.3-27.5	39.8	31	46	15	ML

SOIL TECHNOLOGY

Bainbridge Island, WA

Client: Golder Associates, Inc

Project: Burlington Levee
Project No. 093-93153

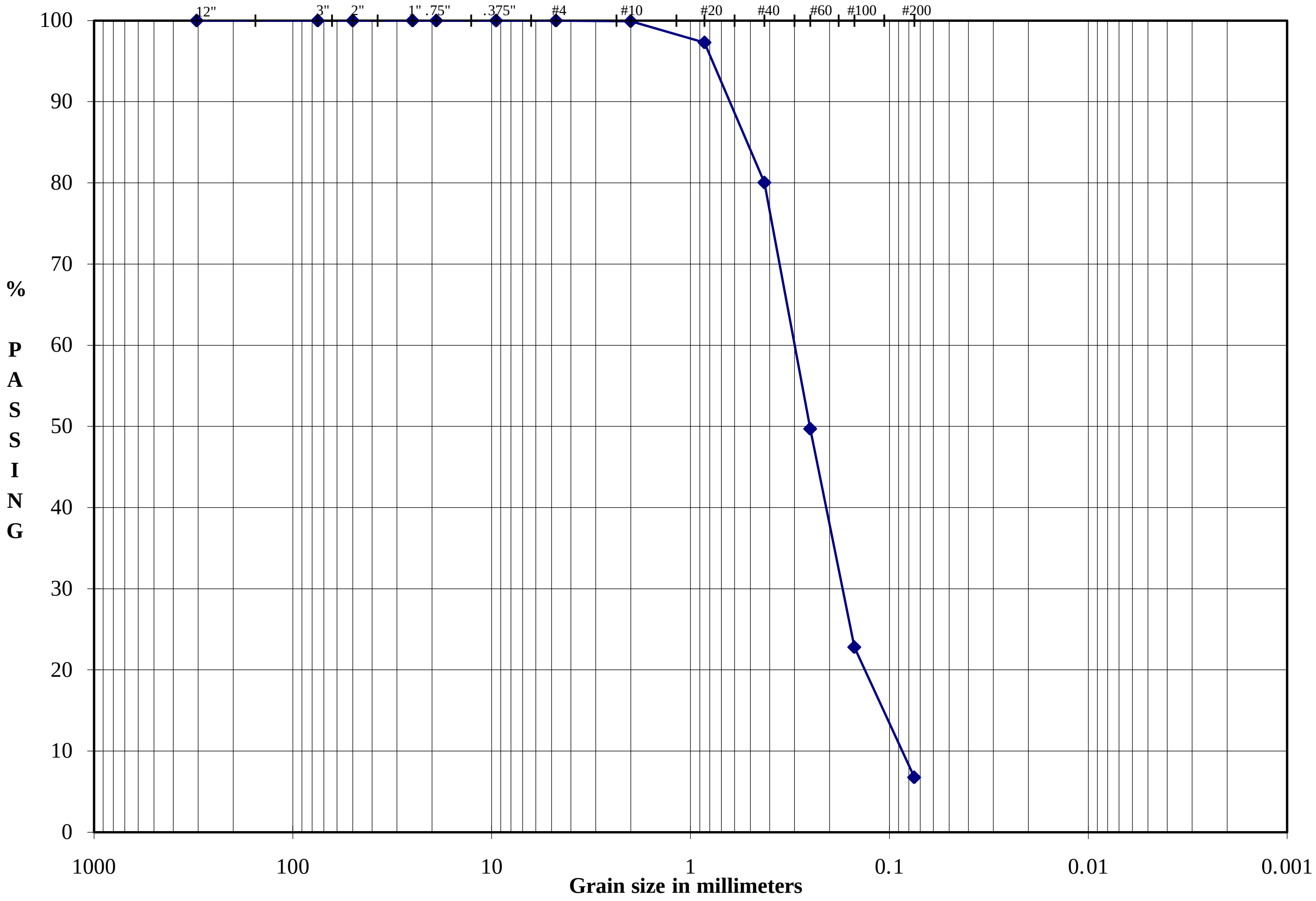
Project No.: J-09-2310 **Figure** 1

Tested By: MR **Checked By:** AJA

APPENDIX B-2

GRAIN SIZE ANALYSIS

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-1	S-17a
SAMPLE TYPE	SPT	
SAMPLE DEPTH	60ft	

LL	-
PL	-
PI	-

DESCRIPTION fine to medium SAND
little silt

USCS SP-SM

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	PIE/Burlington Geotech and Levees/WA	**SAMPLE ID**	GB-1 S-17a
PROJECT NO.	093-93153.100	**SAMPLE TYPE**	SPT
REMARKS		**SAMPLE DEPTH**	60ft

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	1101.60
Wt Dry Soil & Tare (gm)	(w2)	963.00
Weight of Tare (gm)	(w3)	328.60
Weight of Water (gm)	(w4= w1-w2)	138.60
Weight of Dry Soil (gm)	(w5= w2-w3)	634.40
Moisture Content (%)	(w4/w5)*100	21.85

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	963.00
	Tare Weight (gm)	328.60
(W6)	Total Dry Weight (gm)	634.40

SIEVE ANALYSIS

Tare Weight
328.60

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	328.60	0.00	0.00	100.00	12.0"	cobbles
3.0"	328.60	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	328.60	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	328.60	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	328.60	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	328.60	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	328.60	0.00	0.00	100.00	0.75"	fine gravel
0.50"	328.60	0.00	0.00	100.00	0.50"	fine gravel
0.375"	328.60	0.00	0.00	100.00	0.375"	fine gravel
#4	328.60	0.00	0.00	100.00	#4	coarse sand
#10	329.10	0.50	0.08	99.92	#10	medium sand
#20	345.70	17.10	2.70	97.30	#20	medium sand
#40	455.20	126.60	19.96	80.04	#40	fine sand
#60	647.70	319.10	50.30	49.70	#60	fine sand
#100	818.40	489.80	77.21	22.79	#100	fine sand
#200	920.20	591.60	93.25	6.75	#200	fines
PAN	17512.80	17184.20			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.08
% M SAND	19.88
% F SAND	73.30
% FINES	6.75
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

\> 10% mostly coarse (c)
\> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
\> 10% equal amounts each (c-f)

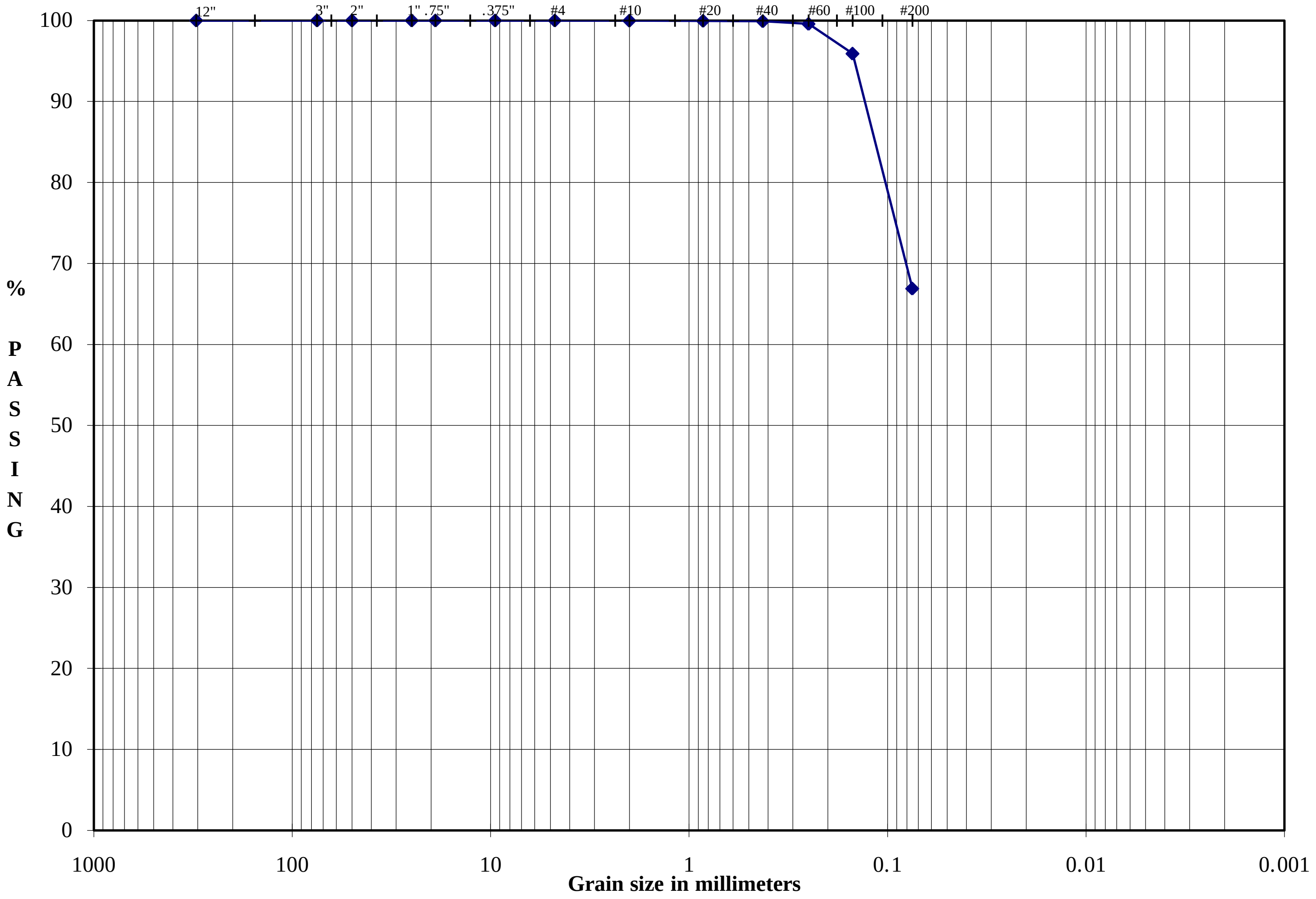
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.09
D30 (mm)	0.18
D60 (mm)	0.31
Cu	3.4
Cc	1.1

DESCRIPTION fine to medium SAND
little silt

USCS SP-SM

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-3 S-10
SAMPLE TYPE	SPT
SAMPLE DEPTH	30ft

LL	-
PL	-
PI	-

DESCRIPTION SILT and fine SAND

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-3**	**S-10**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**30ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	891.20
Wt Dry Soil & Tare (gm)	(w2)	742.50
Weight of Tare (gm)	(w3)	312.20
Weight of Water (gm)	(w4= w1-w2)	148.70
Weight of Dry Soil (gm)	(w5= w2-w3)	430.30
Moisture Content (%)	(w4/w5)*100	34.56

Hygroscopic Moisture For Sieve Sample

	Wet Soil & Tare (gm)	
	Dry Soil & Tare (gm)	
	Tare Weight (gm)	
	Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	742.50
	Tare Weight (gm)	312.20
(W6)	Total Dry Weight (gm)	430.30

SIEVE ANALYSIS

Tare Weight

312.20

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	312.20	0.00	0.00	100.00	12.0"	cobbles
3.0"	312.20	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	312.20	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	312.20	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	312.20	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	312.20	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	312.20	0.00	0.00	100.00	0.75"	fine gravel
0.50"	312.20	0.00	0.00	100.00	0.50"	fine gravel
0.375"	312.20	0.00	0.00	100.00	0.375"	fine gravel
#4	312.20	0.00	0.00	100.00	#4	coarse sand
#10	312.30	0.10	0.02	99.98	#10	medium sand
#20	312.40	0.20	0.05	99.95	#20	medium sand
#40	312.60	0.40	0.09	99.91	#40	fine sand
#60	314.00	1.80	0.42	99.58	#60	fine sand
#100	329.80	17.60	4.09	95.91	#100	fine sand
#200	454.60	142.40	33.09	66.91	#200	fines
PAN	17512.80	17200.60			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.02
% M SAND	0.07
% F SAND	33.00
% FINES	66.91
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

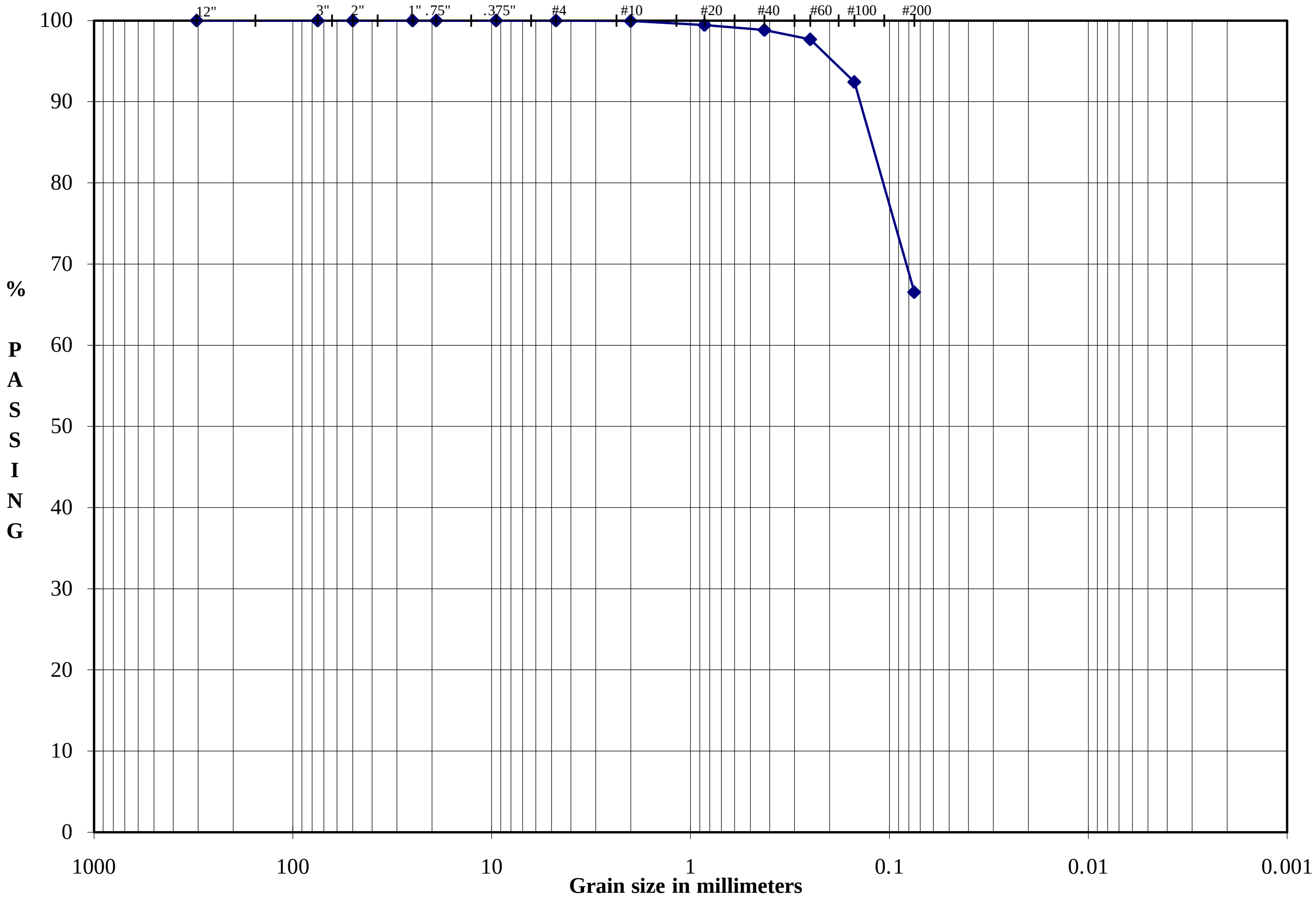
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.02
D30 (mm)	0.03
D60 (mm)	0.06
Cu	3.4
Cc	0.8

DESCRIPTION SILT and fine SAND

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-4	S-9
SAMPLE TYPE	SPT	
SAMPLE DEPTH	25ft	

LL	-
PL	-
PI	-

DESCRIPTION SILT and fine SAND

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	PIE/Burlington Geotech and Levees/WA	**SAMPLE ID**	GB-4	S-9
PROJECT NO.	093-93153.100	**SAMPLE TYPE**	SPT	
REMARKS		**SAMPLE DEPTH**	25ft	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	939.60
Wt Dry Soil & Tare (gm)	(w2)	796.20
Weight of Tare (gm)	(w3)	309.00
Weight of Water (gm)	(w4= w1-w2)	143.40
Weight of Dry Soil (gm)	(w5= w2-w3)	487.20
Moisture Content (%)	(w4/w5)*100	29.43

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	796.20
	Tare Weight (gm)	309.00
(W6)	Total Dry Weight (gm)	487.20

SIEVE ANALYSIS

Tare Weight: 309.00

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	309.00	0.00	0.00	100.00	12.0"	cobbles
3.0"	309.00	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	309.00	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	309.00	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	309.00	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	309.00	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	309.00	0.00	0.00	100.00	0.75"	fine gravel
0.50"	309.00	0.00	0.00	100.00	0.50"	fine gravel
0.375"	309.00	0.00	0.00	100.00	0.375"	fine gravel
#4	309.00	0.00	0.00	100.00	#4	coarse sand
#10	309.30	0.30	0.06	99.94	#10	medium sand
#20	311.70	2.70	0.55	99.45	#20	medium sand
#40	314.70	5.70	1.17	98.83	#40	fine sand
#60	320.30	11.30	2.32	97.68	#60	fine sand
#100	345.90	36.90	7.57	92.43	#100	fine sand
#200	472.10	163.10	33.48	66.52	#200	fines
PAN	17512.80	17203.80			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.06
% M SAND	1.11
% F SAND	32.31
% FINES	66.52
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

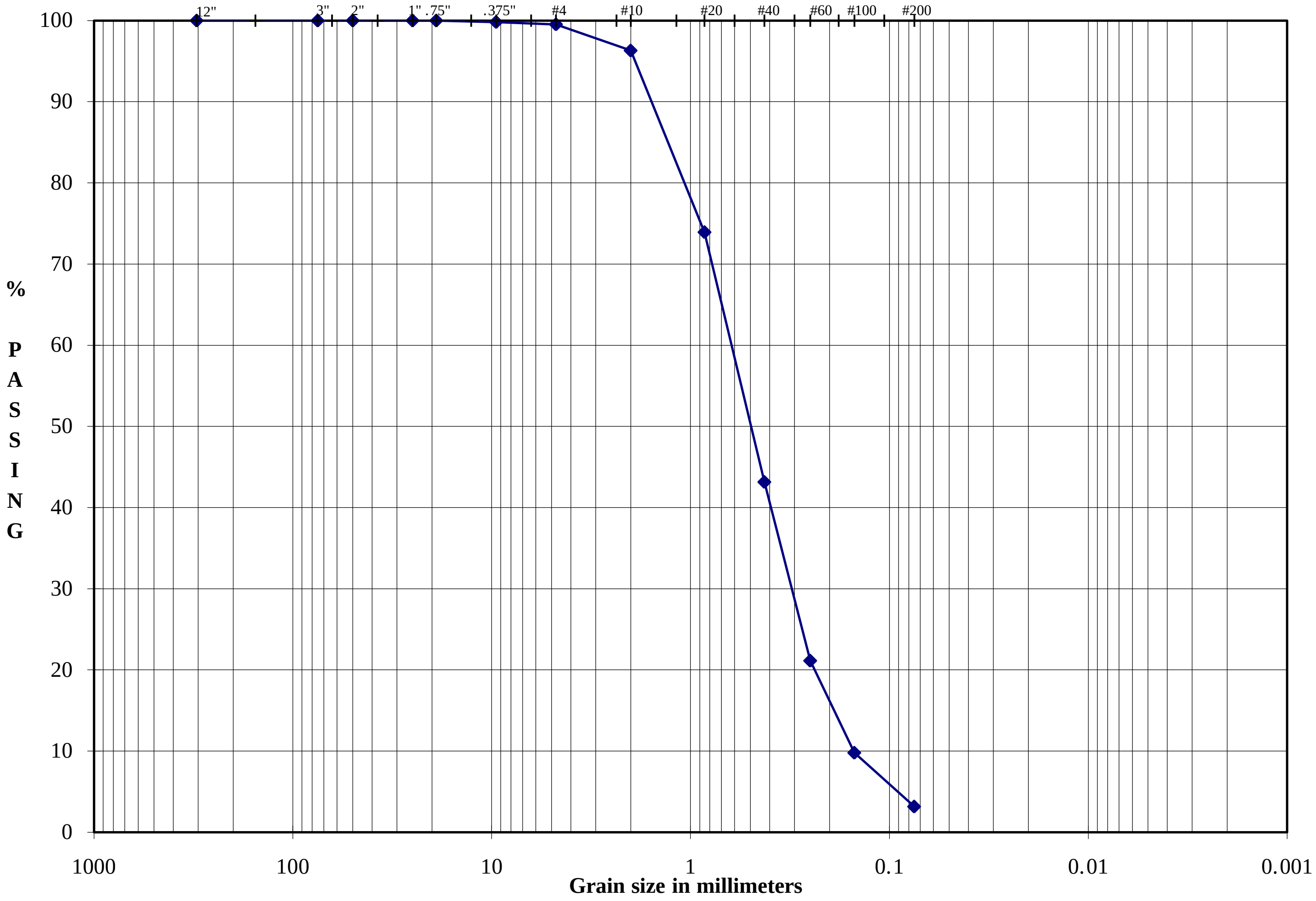
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.02
D30 (mm)	0.03
D60 (mm)	0.06
Cu	3.8
Cc	0.7

DESCRIPTION SILT and fine SAND

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB-5	S-10
SAMPLE TYPE	SPT	
SAMPLE DEPTH	30ft	

LL	-
PL	-
PI	-

DESCRIPTION fine to medium SAND
trace silt

USCS SP

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-5**	**S-10**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**30ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	1146.10
Wt Dry Soil & Tare (gm)	(w2)	981.20
Weight of Tare (gm)	(w3)	314.50
Weight of Water (gm)	(w4= w1-w2)	164.90
Weight of Dry Soil (gm)	(w5= w2-w3)	666.70
Moisture Content (%)	(w4/w5)*100	24.73

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	981.20
	Tare Weight (gm)	314.50
(W6)	Total Dry Weight (gm)	666.70

SIEVE ANALYSIS

Tare Weight

314.50

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	314.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	314.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	314.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	314.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	314.50	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	314.50	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	314.50	0.00	0.00	100.00	0.75"	fine gravel
0.50"	314.50	0.00	0.00	100.00	0.50"	fine gravel
0.375"	315.70	1.20	0.18	99.82	0.375"	fine gravel
#4	317.60	3.10	0.46	99.54	#4	coarse sand
#10	339.10	24.60	3.69	96.31	#10	medium sand
#20	488.30	173.80	26.07	73.93	#20	medium sand
#40	693.50	379.00	56.85	43.15	#40	fine sand
#60	840.30	525.80	78.87	21.13	#60	fine sand
#100	915.90	601.40	90.21	9.79	#100	fine sand
#200	960.10	645.60	96.84	3.16	#200	fines
PAN	17512.80	17198.30			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.46
% C SAND	3.22
% M SAND	53.16
% F SAND	39.99
% FINES	3.16
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

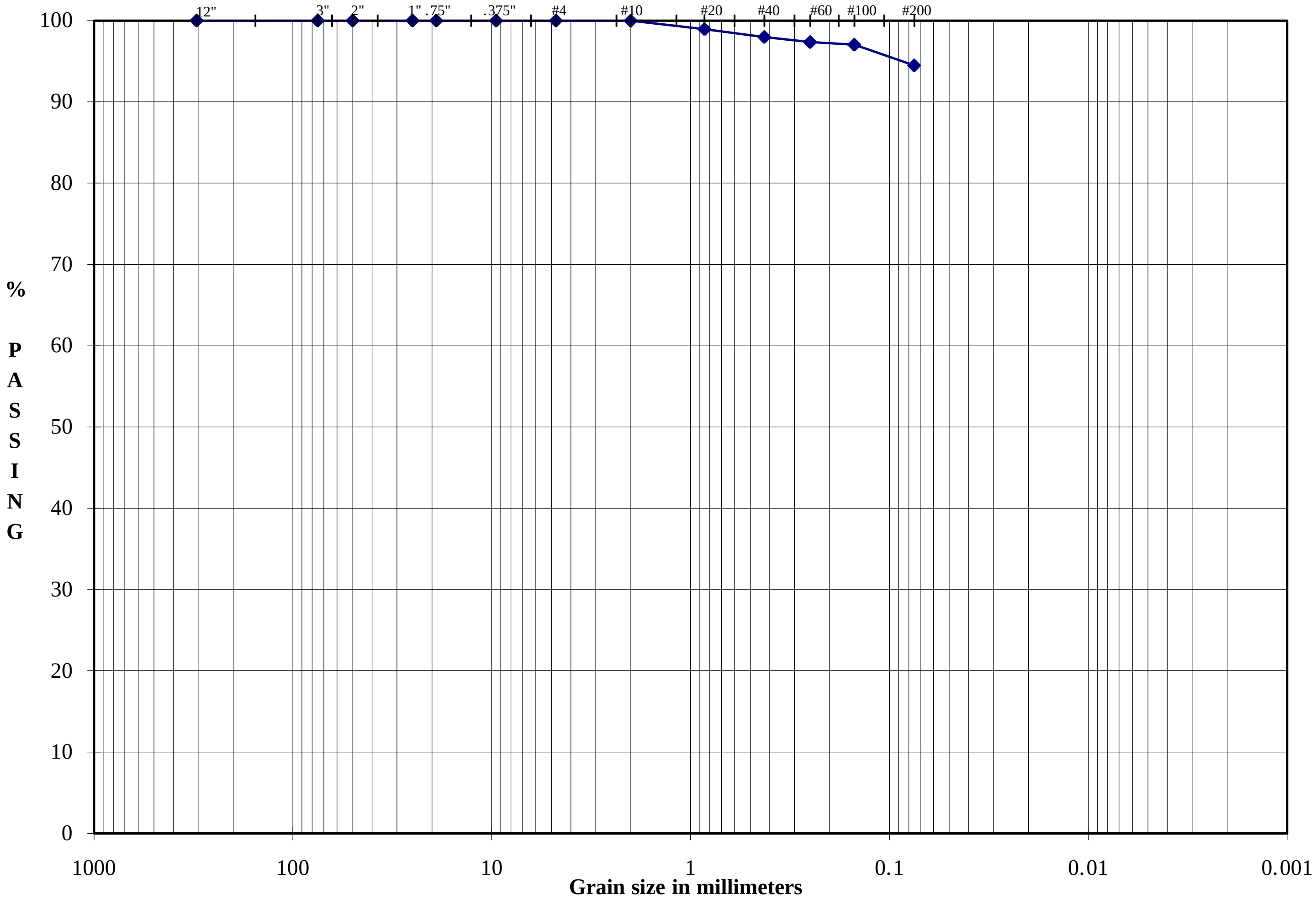
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.15
D30 (mm)	0.32
D60 (mm)	0.66
Cu	4.3
Cc	1.0

DESCRIPTION fine to medium SAND
trace silt

USCS SP

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-7	S-7
SAMPLE TYPE	SPT	
SAMPLE DEPTH	17.5ft	

LL	-
PL	-
PI	-

DESCRIPTION SILT
little fine to medium sand

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	PIE/Burlington Geotech and Levees/WA	**SAMPLE ID**	GB-7	S-7
PROJECT NO.	093-93153.100	**SAMPLE TYPE**	SPT	
REMARKS		**SAMPLE DEPTH**	17.5ft	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	866.30
Wt Dry Soil & Tare (gm)	(w2)	729.90
Weight of Tare (gm)	(w3)	328.80
Weight of Water (gm)	(w4= w1-w2)	136.40
Weight of Dry Soil (gm)	(w5= w2-w3)	401.10
Moisture Content (%)	(w4/w5)*100	34.01

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	729.90
	Tare Weight (gm)	328.80
(W6)	Total Dry Weight (gm)	401.10

SIEVE ANALYSIS

Tare Weight

328.80

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	328.80	0.00	0.00	100.00	12.0"	cobbles
3.0"	328.80	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	328.80	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	328.80	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	328.80	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	328.80	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	328.80	0.00	0.00	100.00	0.75"	fine gravel
0.50"	328.80	0.00	0.00	100.00	0.50"	fine gravel
0.375"	328.80	0.00	0.00	100.00	0.375"	fine gravel
#4	328.80	0.00	0.00	100.00	#4	coarse sand
#10	328.90	0.10	0.02	99.98	#10	medium sand
#20	333.00	4.20	1.05	98.95	#20	medium sand
#40	336.90	8.10	2.02	97.98	#40	fine sand
#60	339.40	10.60	2.64	97.36	#60	fine sand
#100	340.70	11.90	2.97	97.03	#100	fine sand
#200	350.90	22.10	5.51	94.49	#200	fines
PAN	17512.80	17184.00			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.02
% M SAND	1.99
% F SAND	3.49
% FINES	94.49
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

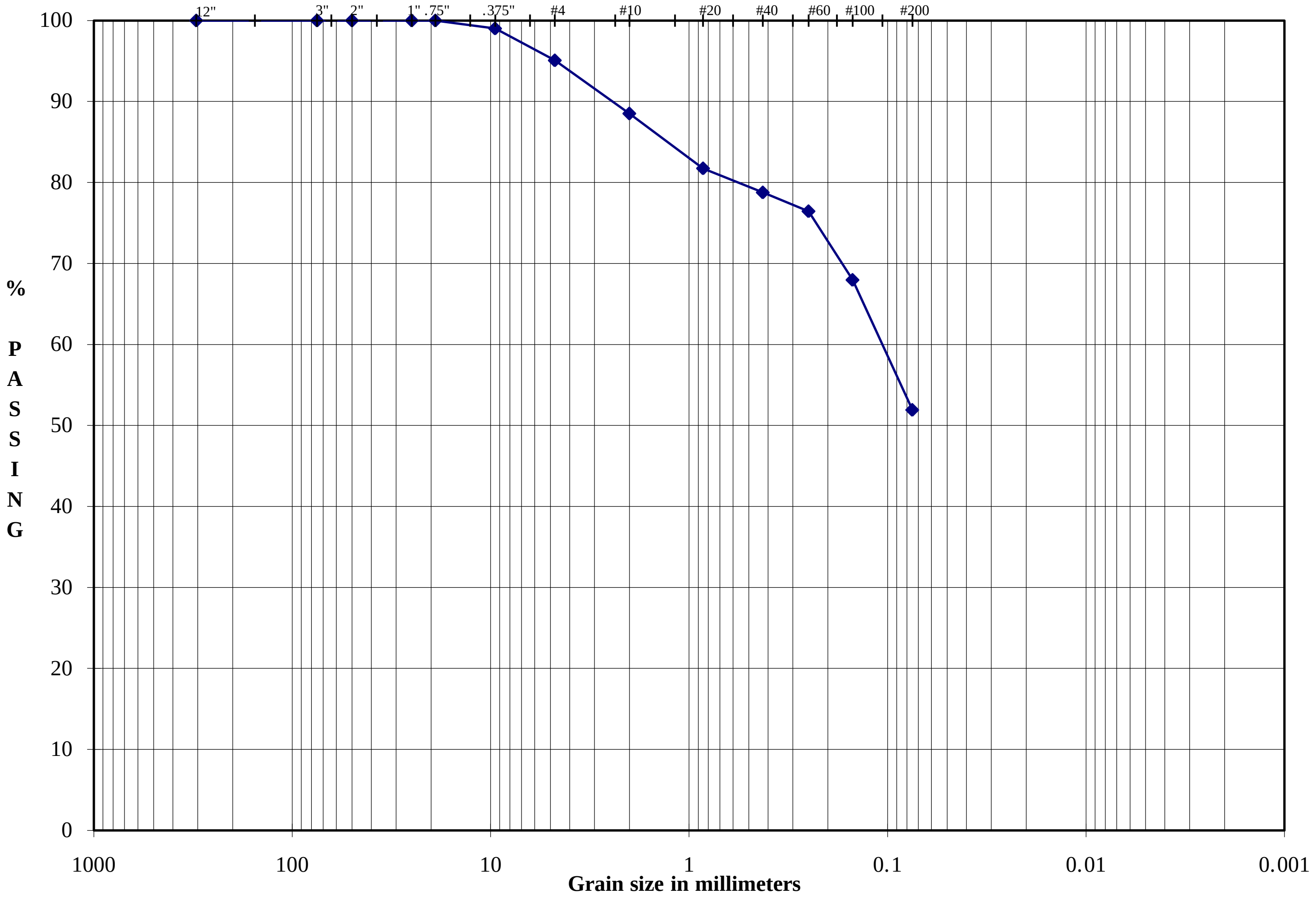
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION SILT
little fine to medium sand

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-8	S-1
SAMPLE TYPE	SPT	
SAMPLE DEPTH	2.5ft	

LL	-
PL	-
PI	-

DESCRIPTION	SILT and fine to coarse SAND trace fine gravel
USCS	ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	PIE/Burlington Geotech and Levees/WA	**SAMPLE ID**	GB-8	S-1
PROJECT NO.	093-93153.100	**SAMPLE TYPE**	SPT	
REMARKS		**SAMPLE DEPTH**	2.5ft	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	953.80
Wt Dry Soil & Tare (gm)	(w2)	852.30
Weight of Tare (gm)	(w3)	425.50
Weight of Water (gm)	(w4= w1-w2)	101.50
Weight of Dry Soil (gm)	(w5= w2-w3)	426.80
Moisture Content (%)	(w4/w5)*100	23.78

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	852.30
	Tare Weight (gm)	425.50
(W6)	Total Dry Weight (gm)	426.80

SIEVE ANALYSIS

Tare Weight
425.50

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	425.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	425.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	425.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	425.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	425.50	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	425.50	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	425.50	0.00	0.00	100.00	0.75"	fine gravel
0.50"	425.50	0.00	0.00	100.00	0.50"	fine gravel
0.375"	429.70	4.20	0.98	99.02	0.375"	fine gravel
#4	446.50	21.00	4.92	95.08	#4	coarse sand
#10	474.50	49.00	11.48	88.52	#10	medium sand
#20	503.40	77.90	18.25	81.75	#20	medium sand
#40	516.10	90.60	21.23	78.77	#40	fine sand
#60	526.00	100.50	23.55	76.45	#60	fine sand
#100	562.20	136.70	32.03	67.97	#100	fine sand
#200	630.70	205.20	48.08	51.92	#200	fines
PAN	17512.80	17087.30			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	4.92
% C SAND	6.56
% M SAND	9.75
% F SAND	26.85
% FINES	51.92
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

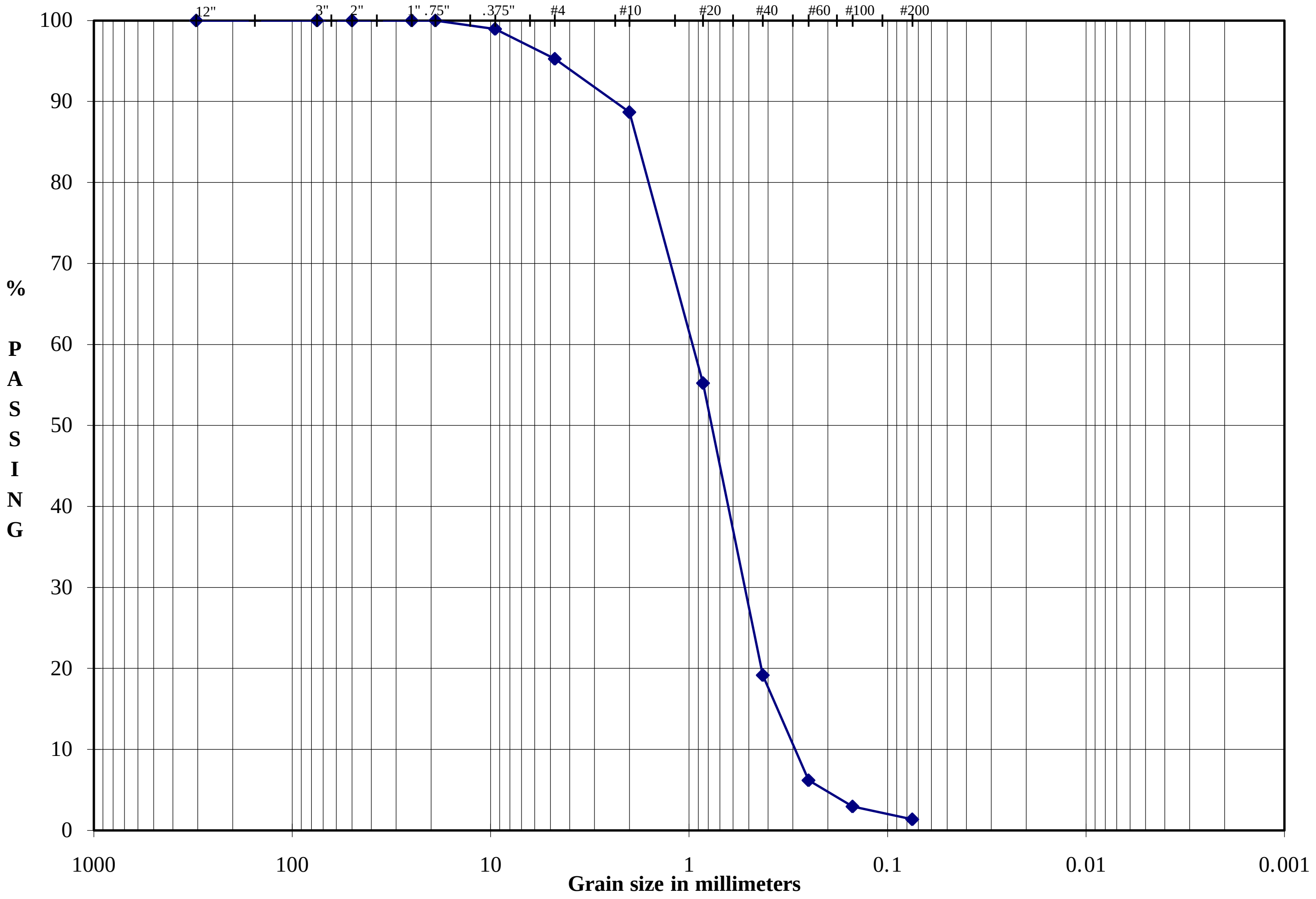
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.01
D30 (mm)	0.03
D60 (mm)	0.11
Cu	9.4
Cc	0.6

DESCRIPTION
SILT and fine to coarse SAND
trace fine gravel

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-9	S-10
SAMPLE TYPE	SPT	
SAMPLE DEPTH	30ft	

LL	-
PL	-
PI	-

DESCRIPTION fine to medium SAND
trace fine gravel, trace silt

USCS SP

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	PIE/Burlington Geotech and Levees/WA	**SAMPLE ID**	GB-9	S-10
PROJECT NO.	093-93153.100	**SAMPLE TYPE**	SPT	
REMARKS		**SAMPLE DEPTH**	30ft	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	1141.60
Wt Dry Soil & Tare (gm)	(w2)	989.70
Weight of Tare (gm)	(w3)	309.00
Weight of Water (gm)	(w4= w1-w2)	151.90
Weight of Dry Soil (gm)	(w5= w2-w3)	680.70
Moisture Content (%)	(w4/w5)*100	22.32

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	989.70
	Tare Weight (gm)	309.00
(W6)	Total Dry Weight (gm)	680.70

SIEVE ANALYSIS

Tare Weight

309.00

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	309.00	0.00	0.00	100.00	12.0"	cobbles
3.0"	309.00	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	309.00	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	309.00	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	309.00	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	309.00	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	309.00	0.00	0.00	100.00	0.75"	fine gravel
0.50"	309.00	0.00	0.00	100.00	0.50"	fine gravel
0.375"	316.10	7.10	1.04	98.96	0.375"	fine gravel
#4	341.20	32.20	4.73	95.27	#4	coarse sand
#10	386.00	77.00	11.31	88.69	#10	medium sand
#20	613.80	304.80	44.78	55.22	#20	medium sand
#40	859.30	550.30	80.84	19.16	#40	fine sand
#60	947.70	638.70	93.83	6.17	#60	fine sand
#100	969.70	660.70	97.06	2.94	#100	fine sand
#200	980.50	671.50	98.65	1.35	#200	fines
PAN	17512.80	17203.80			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	4.73
% C SAND	6.58
% M SAND	69.53
% F SAND	17.81
% FINES	1.35
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

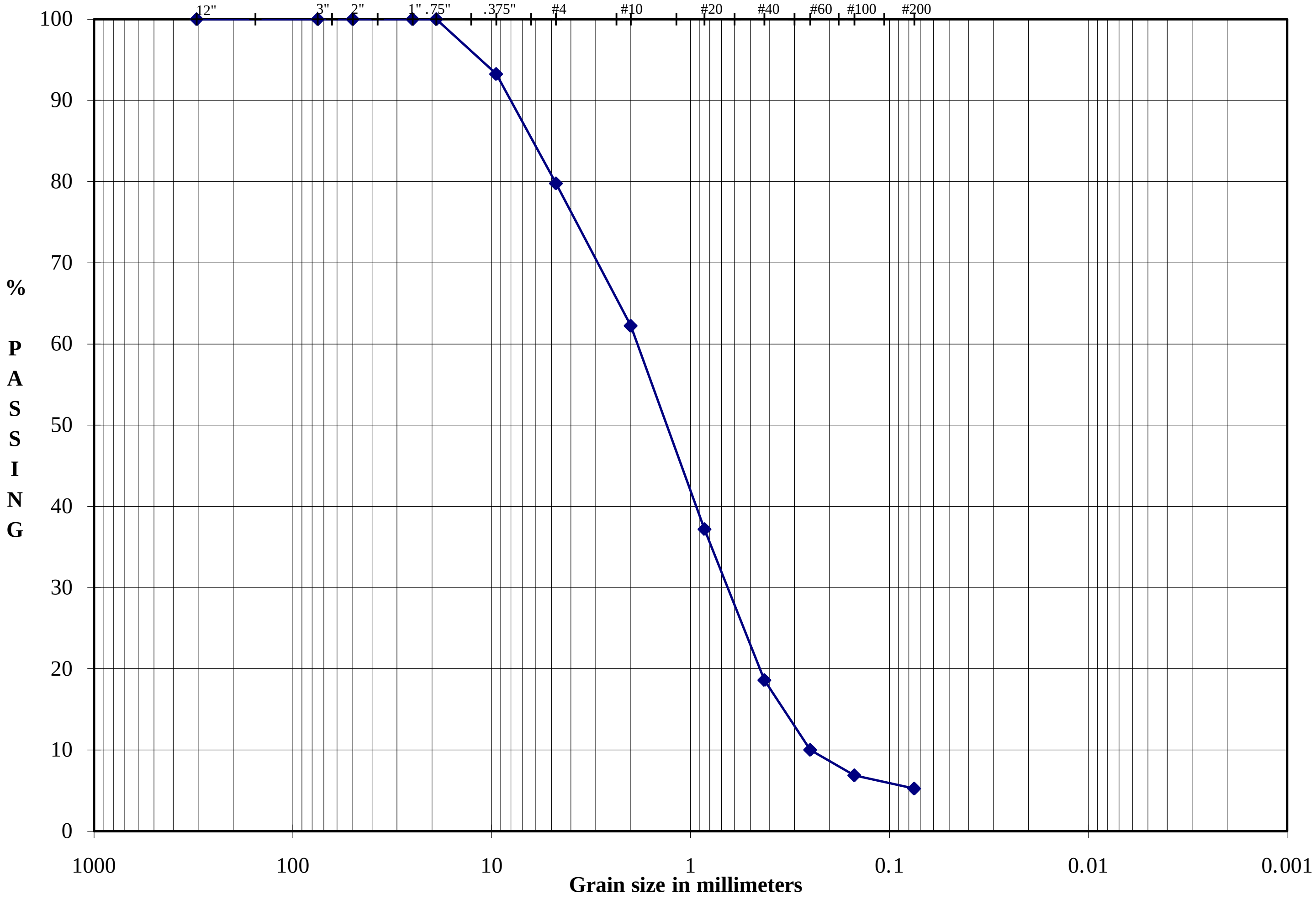
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.30
D30 (mm)	0.55
D60 (mm)	1.01
Cu	3.4
Cc	1.0

DESCRIPTION fine to medium SAND
trace fine gravel, trace silt

USCS SP

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-13	S-14
SAMPLE TYPE	SPT	
SAMPLE DEPTH	50ft	

LL	-
PL	-
PI	-

DESCRIPTION fine to coarse SAND
some fine gravel, trace silt

USCS SW

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-13**	**S-14**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**50ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	935.70
Wt Dry Soil & Tare (gm)	(w2)	845.10
Weight of Tare (gm)	(w3)	312.00
Weight of Water (gm)	(w4= w1-w2)	90.60
Weight of Dry Soil (gm)	(w5= w2-w3)	533.10
Moisture Content (%)	(w4/w5)*100	16.99

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	845.10
	Tare Weight (gm)	312.00
(W6)	Total Dry Weight (gm)	533.10

SIEVE ANALYSIS

Tare Weight

312.00

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	312.00	0.00	0.00	100.00	12.0"	cobbles
3.0"	312.00	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	312.00	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	312.00	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	312.00	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	312.00	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	312.00	0.00	0.00	100.00	0.75"	fine gravel
0.50"	312.00	0.00	0.00	100.00	0.50"	fine gravel
0.375"	348.00	36.00	6.75	93.25	0.375"	fine gravel
#4	419.80	107.80	20.22	79.78	#4	coarse sand
#10	513.30	201.30	37.76	62.24	#10	medium sand
#20	646.80	334.80	62.80	37.20	#20	medium sand
#40	745.90	433.90	81.39	18.61	#40	fine sand
#60	791.70	479.70	89.98	10.02	#60	fine sand
#100	808.40	496.40	93.12	6.88	#100	fine sand
#200	817.10	505.10	94.75	5.25	#200	fines
PAN	17512.80	17200.80			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	20.22
% C SAND	17.54
% M SAND	43.63
% F SAND	13.36
% FINES	5.25
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

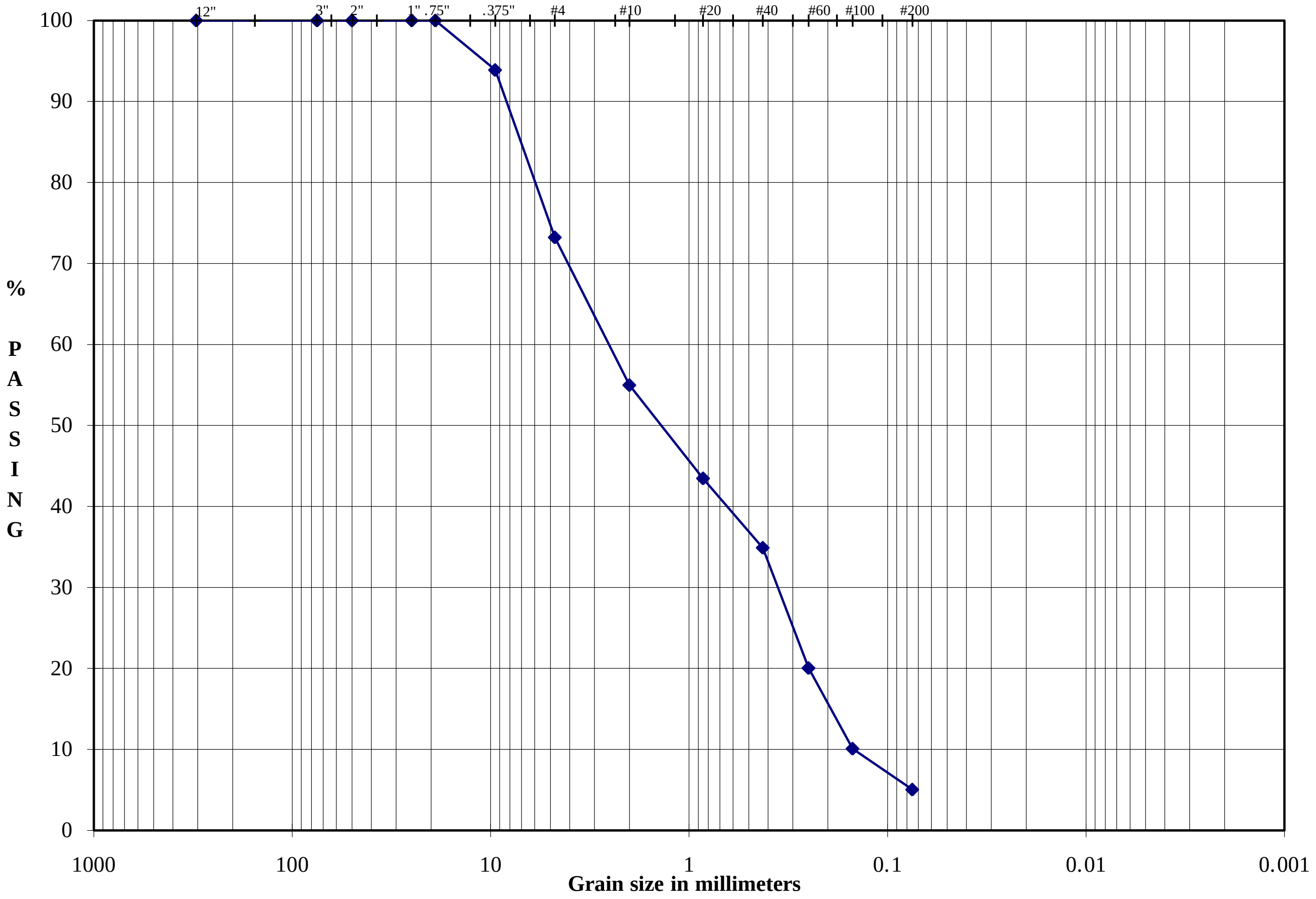
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.25
D30 (mm)	0.69
D60 (mm)	1.65
Cu	6.6
Cc	1.1

DESCRIPTION fine to coarse SAND
some fine gravel, trace silt

USCS SW

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB-21	S-17
SAMPLE TYPE	SPT	
SAMPLE DEPTH	65ft	

LL	-
PL	-
PI	-

DESCRIPTION fine to coarse SAND
some fine gravel, trace silt

USCS SW

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-21**	**S-17**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**65ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	768.70
Wt Dry Soil & Tare (gm)	(w2)	719.50
Weight of Tare (gm)	(w3)	323.70
Weight of Water (gm)	(w4= w1-w2)	49.20
Weight of Dry Soil (gm)	(w5= w2-w3)	395.80
Moisture Content (%)	(w4/w5)*100	12.43

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	719.50
	Tare Weight (gm)	323.70
(W6)	Total Dry Weight (gm)	395.80

SIEVE ANALYSIS

Tare Weight

323.70

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	323.70	0.00	0.00	100.00	12.0"	cobbles
3.0"	323.70	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	323.70	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	323.70	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	323.70	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	323.70	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	323.70	0.00	0.00	100.00	0.75"	fine gravel
0.50"	323.70	0.00	0.00	100.00	0.50"	fine gravel
0.375"	347.90	24.20	6.11	93.89	0.375"	fine gravel
#4	429.70	106.00	26.78	73.22	#4	coarse sand
#10	501.90	178.20	45.02	54.98	#10	medium sand
#20	547.50	223.80	56.54	43.46	#20	medium sand
#40	581.40	257.70	65.11	34.89	#40	fine sand
#60	640.20	316.50	79.96	20.04	#60	fine sand
#100	679.60	355.90	89.92	10.08	#100	fine sand
#200	699.60	375.90	94.97	5.03	#200	fines
PAN	17512.80	17189.10			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	26.78
% C SAND	18.24
% M SAND	20.09
% F SAND	29.86
% FINES	5.03
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

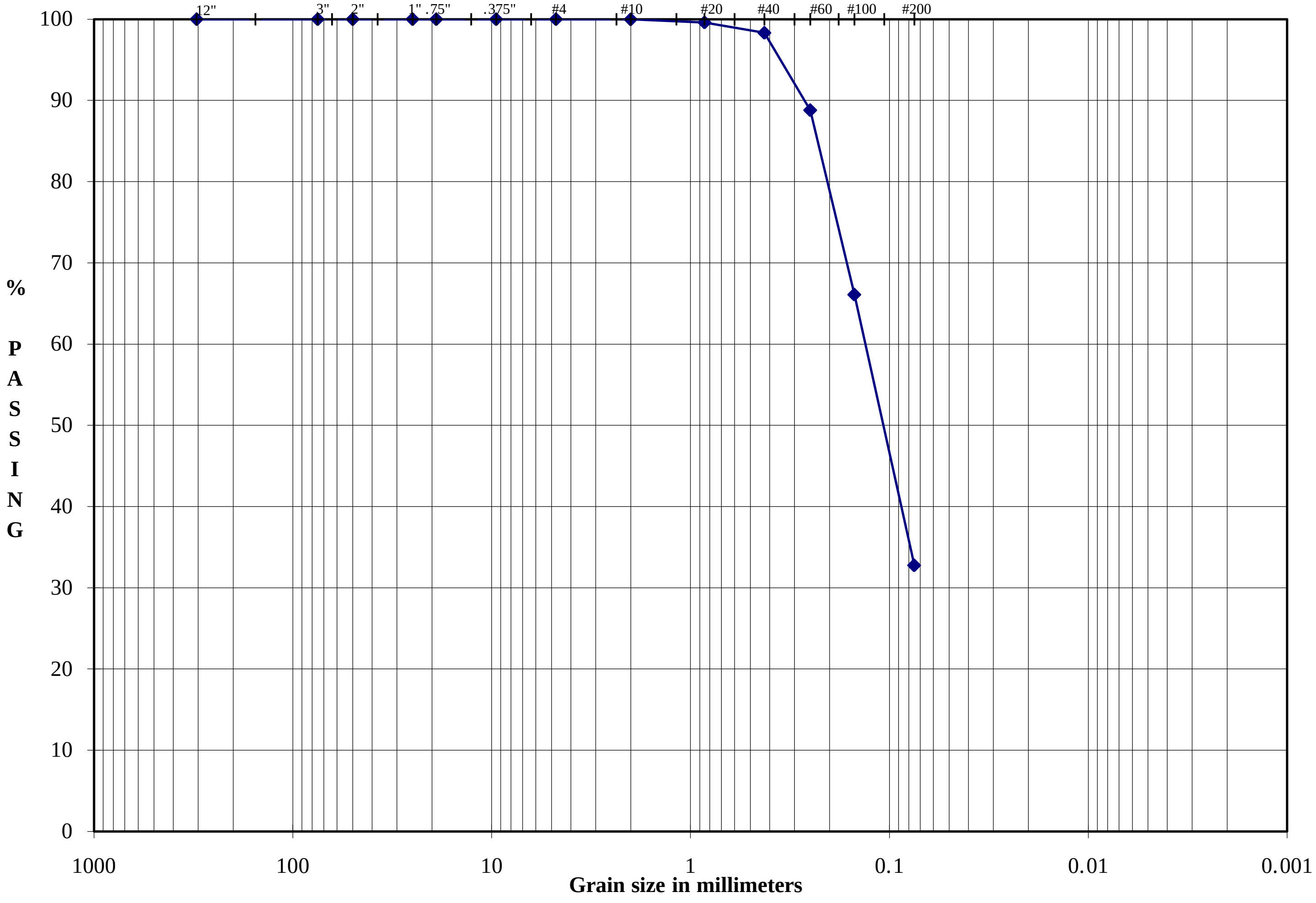
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.15
D30 (mm)	0.37
D60 (mm)	2.76
Cu	18.5
Cc	0.3

DESCRIPTION fine to coarse SAND
some fine gravel, trace silt

USCS SW

TECH	TCM
DATE	8/6/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-23	S-7
SAMPLE TYPE	SPT	
SAMPLE DEPTH	17.5ft	

LL	-
PL	-
PI	-

DESCRIPTION silty fine SAND

USCS SM

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-23**	**S-7**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**17.5ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	946.00
Wt Dry Soil & Tare (gm)	(w2)	869.70
Weight of Tare (gm)	(w3)	416.10
Weight of Water (gm)	(w4= w1-w2)	76.30
Weight of Dry Soil (gm)	(w5= w2-w3)	453.60
Moisture Content (%)	(w4/w5)*100	16.82

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	869.70
	Tare Weight (gm)	416.10
(W6)	Total Dry Weight (gm)	453.60

SIEVE ANALYSIS

Tare Weight

416.10

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	416.10	0.00	0.00	100.00	12.0"	cobbles
3.0"	416.10	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	416.10	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	416.10	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	416.10	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	416.10	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	416.10	0.00	0.00	100.00	0.75"	fine gravel
0.50"	416.10	0.00	0.00	100.00	0.50"	fine gravel
0.375"	416.10	0.00	0.00	100.00	0.375"	fine gravel
#4	416.10	0.00	0.00	100.00	#4	coarse sand
#10	416.20	0.10	0.02	99.98	#10	medium sand
#20	417.90	1.80	0.40	99.60	#20	medium sand
#40	423.70	7.60	1.68	98.32	#40	fine sand
#60	466.90	50.80	11.20	88.80	#60	fine sand
#100	569.90	153.80	33.91	66.09	#100	fine sand
#200	721.10	305.00	67.24	32.76	#200	fines
PAN	17512.80	17096.70			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.02
% M SAND	1.65
% F SAND	65.56
% FINES	32.76
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

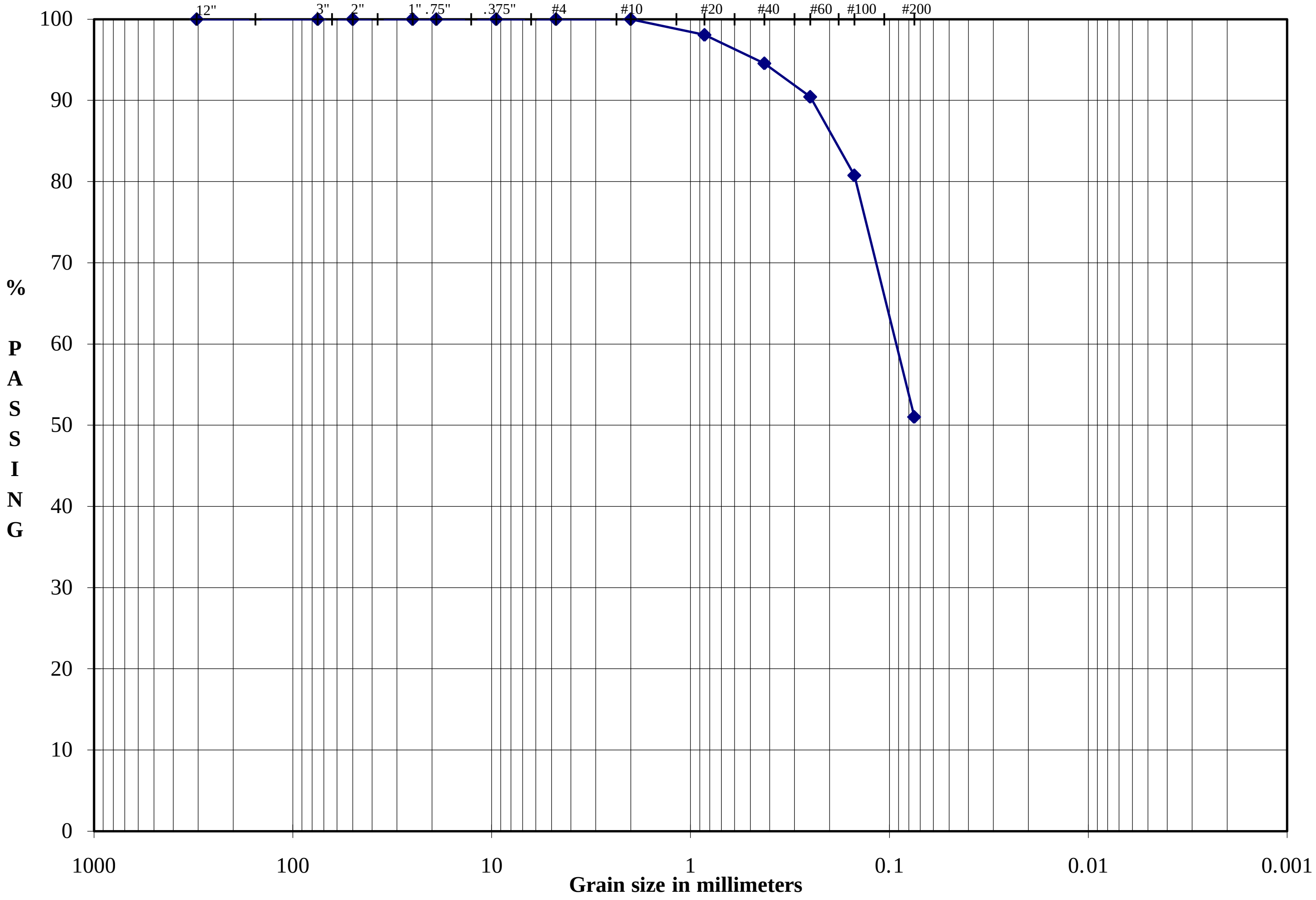
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.05
D30 (mm)	0.07
D60 (mm)	0.12
Cu	2.7
Cc	0.8

DESCRIPTION silty fine SAND

USCS SM

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-27	S-3	**LL**	-
SAMPLE TYPE	SPT		**PL**	-
SAMPLE DEPTH	7.5ft		**PI**	-

DESCRIPTION SILT and fine to medium SAND

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-27**	**S-3**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**7.5ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	866.60
Wt Dry Soil & Tare (gm)	(w2)	781.40
Weight of Tare (gm)	(w3)	424.80
Weight of Water (gm)	(w4= w1-w2)	85.20
Weight of Dry Soil (gm)	(w5= w2-w3)	356.60
Moisture Content (%)	(w4/w5)*100	23.89

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	781.40
	Tare Weight (gm)	424.80
(W6)	Total Dry Weight (gm)	356.60

SIEVE ANALYSIS

Tare Weight

424.80

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	424.80	0.00	0.00	100.00	12.0"	cobbles
3.0"	424.80	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	424.80	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	424.80	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	424.80	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	424.80	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	424.80	0.00	0.00	100.00	0.75"	fine gravel
0.50"	424.80	0.00	0.00	100.00	0.50"	fine gravel
0.375"	424.80	0.00	0.00	100.00	0.375"	fine gravel
#4	424.80	0.00	0.00	100.00	#4	coarse sand
#10	424.80	0.00	0.00	100.00	#10	medium sand
#20	431.70	6.90	1.93	98.07	#20	medium sand
#40	444.20	19.40	5.44	94.56	#40	fine sand
#60	458.90	34.10	9.56	90.44	#60	fine sand
#100	493.40	68.60	19.24	80.76	#100	fine sand
#200	599.50	174.70	48.99	51.01	#200	fines
PAN	17512.80	17088.00			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	5.44
% F SAND	43.55
% FINES	51.01
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.03
D30 (mm)	0.05
D60 (mm)	0.10
Cu	3.4
Cc	0.7

DESCRIPTION SILT and fine to medium SAND

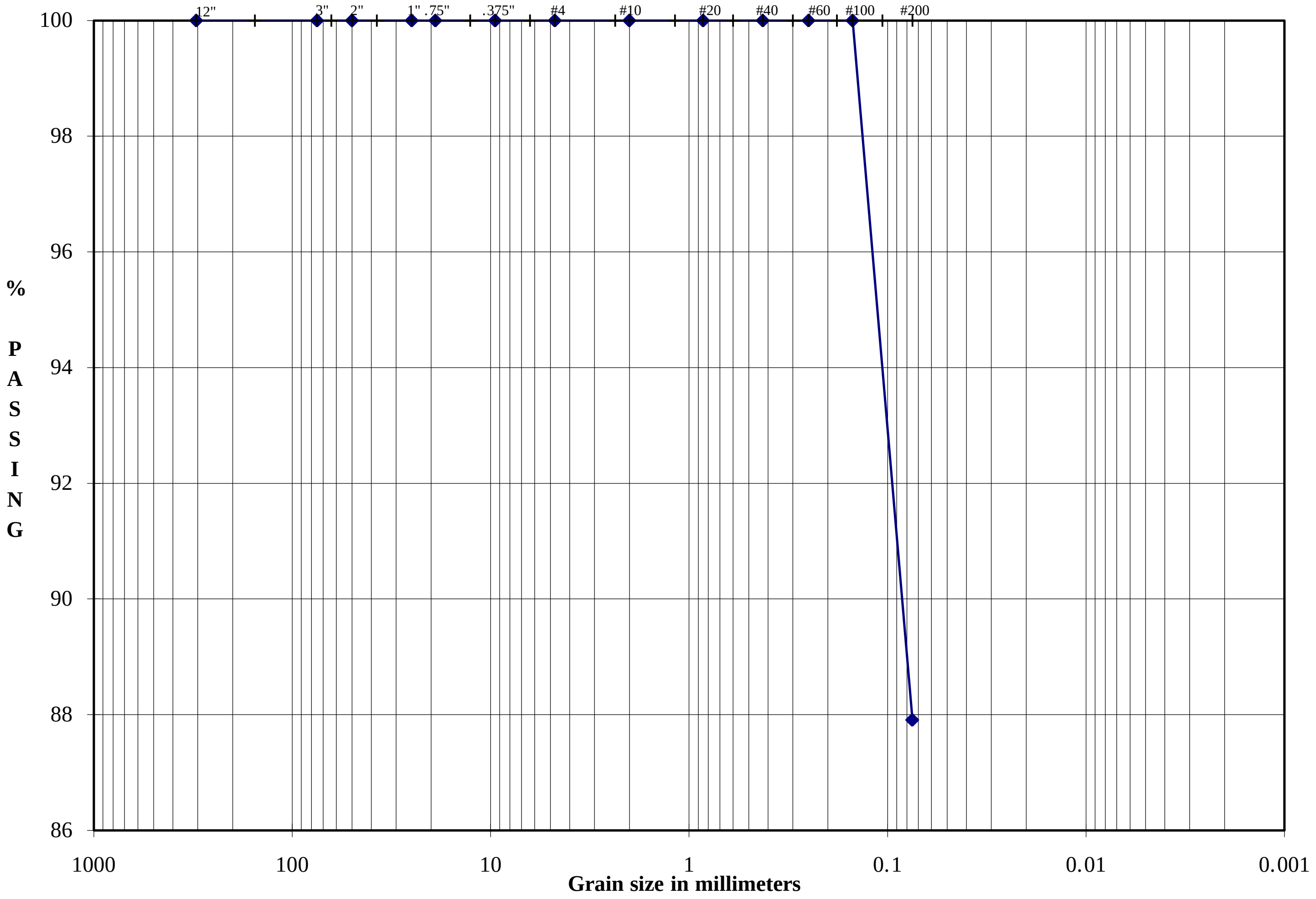
USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

APPENDIX B-3

GRAIN SIZE ANALYSES OF 200 SIEVE WASH ONLY

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-1	S-17
SAMPLE TYPE	SPT	
SAMPLE DEPTH	61.2ft	

LL	-
PL	-
PI	-

DESCRIPTION #200 WASH ONLY
SILT
little sand

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-1**	**S-17**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**61.2ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	566.80
Wt Dry Soil & Tare (gm)	(w2)	500.40
Weight of Tare (gm)	(w3)	324.20
Weight of Water (gm)	(w4= w1-w2)	66.40
Weight of Dry Soil (gm)	(w5= w2-w3)	176.20
Moisture Content (%)	(w4/w5)*100	37.68

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	500.40
	Tare Weight (gm)	324.20
(W6)	Total Dry Weight (gm)	176.20

SIEVE ANALYSIS

Tare Weight

324.20

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	324.20	0.00	0.00	100.00	12.0"	cobbles
3.0"	324.20	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	324.20	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	324.20	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	324.20	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	324.20	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	324.20	0.00	0.00	100.00	0.75"	fine gravel
0.50"	324.20	0.00	0.00	100.00	0.50"	fine gravel
0.375"	324.20	0.00	0.00	100.00	0.375"	fine gravel
#4	324.20	0.00	0.00	100.00	#4	coarse sand
#10	324.20	0.00	0.00	100.00	#10	medium sand
#20	324.20	0.00	0.00	100.00	#20	medium sand
#40	324.20	0.00	0.00	100.00	#40	fine sand
#60	324.20	0.00	0.00	100.00	#60	fine sand
#100	324.20	0.00	0.00	100.00	#100	fine sand
#200	345.50	21.30	12.09	87.91	#200	fines
PAN	17512.80	17188.60			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	12.09
% FINES	87.91
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

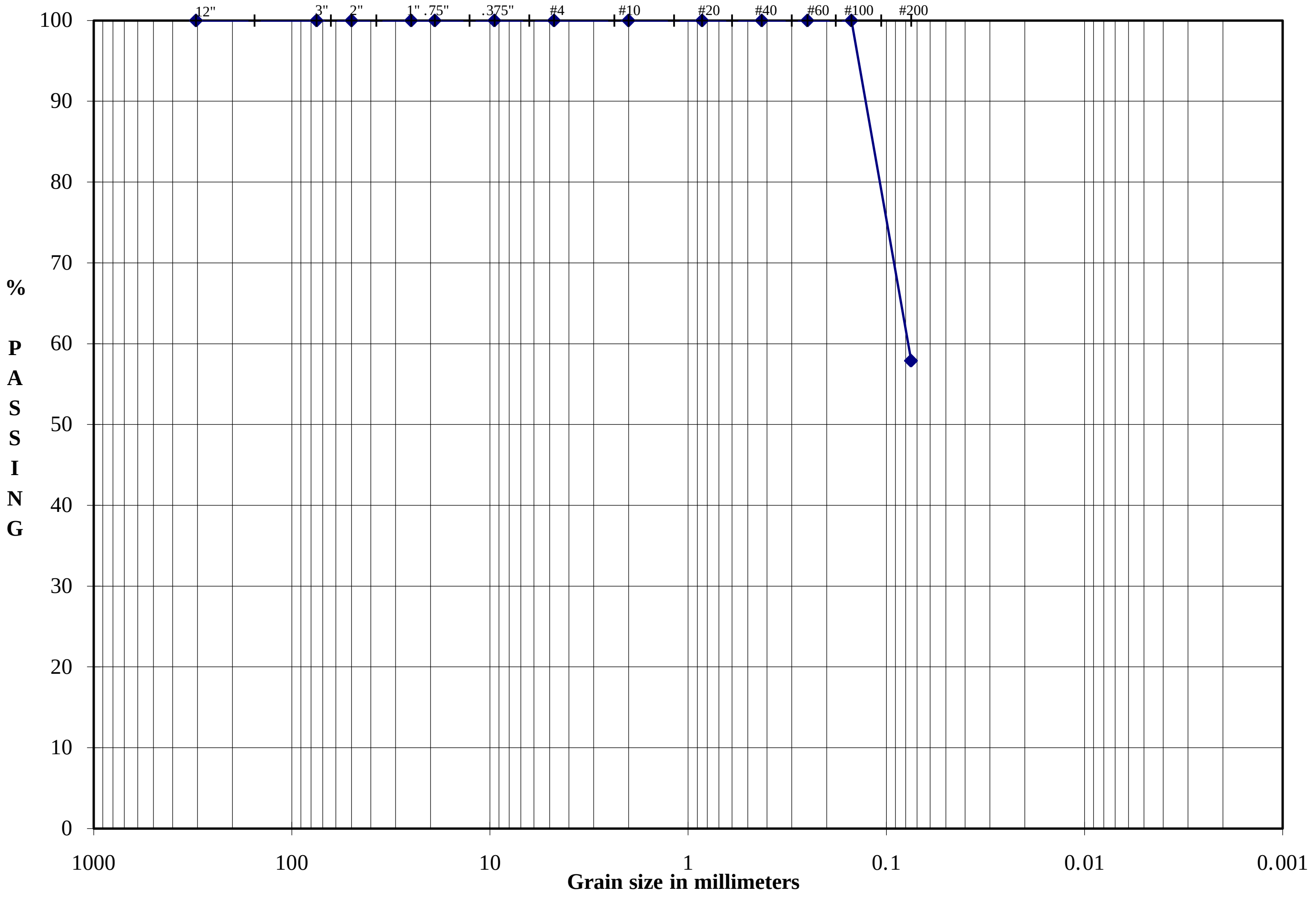
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION #200 WASH ONLY
SILT
little sand

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-2	S-8
SAMPLE TYPE	SPT	
SAMPLE DEPTH	20ft	

LL	-
PL	-
PI	-

DESCRIPTION #200 WASH ONLY
SILT and SAND

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-2**	**S-8**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**20ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	870.06
Wt Dry Soil & Tare (gm)	(w2)	709.40
Weight of Tare (gm)	(w3)	324.00
Weight of Water (gm)	(w4= w1-w2)	160.66
Weight of Dry Soil (gm)	(w5= w2-w3)	385.40
Moisture Content (%)	(w4/w5)*100	41.69

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	709.40
	Tare Weight (gm)	324.00
(W6)	Total Dry Weight (gm)	385.40

SIEVE ANALYSIS

Tare Weight

324.00

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	324.00	0.00	0.00	100.00	12.0"	cobbles
3.0"	324.00	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	324.00	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	324.00	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	324.00	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	324.00	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	324.00	0.00	0.00	100.00	0.75"	fine gravel
0.50"	324.00	0.00	0.00	100.00	0.50"	fine gravel
0.375"	324.00	0.00	0.00	100.00	0.375"	fine gravel
#4	324.00	0.00	0.00	100.00	#4	coarse sand
#10	324.00	0.00	0.00	100.00	#10	medium sand
#20	324.00	0.00	0.00	100.00	#20	medium sand
#40	324.00	0.00	0.00	100.00	#40	fine sand
#60	324.00	0.00	0.00	100.00	#60	fine sand
#100	324.00	0.00	0.00	100.00	#100	fine sand
#200	486.30	162.30	42.11	57.89	#200	fines
PAN	17512.80	17188.80			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	42.11
% FINES	57.89
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

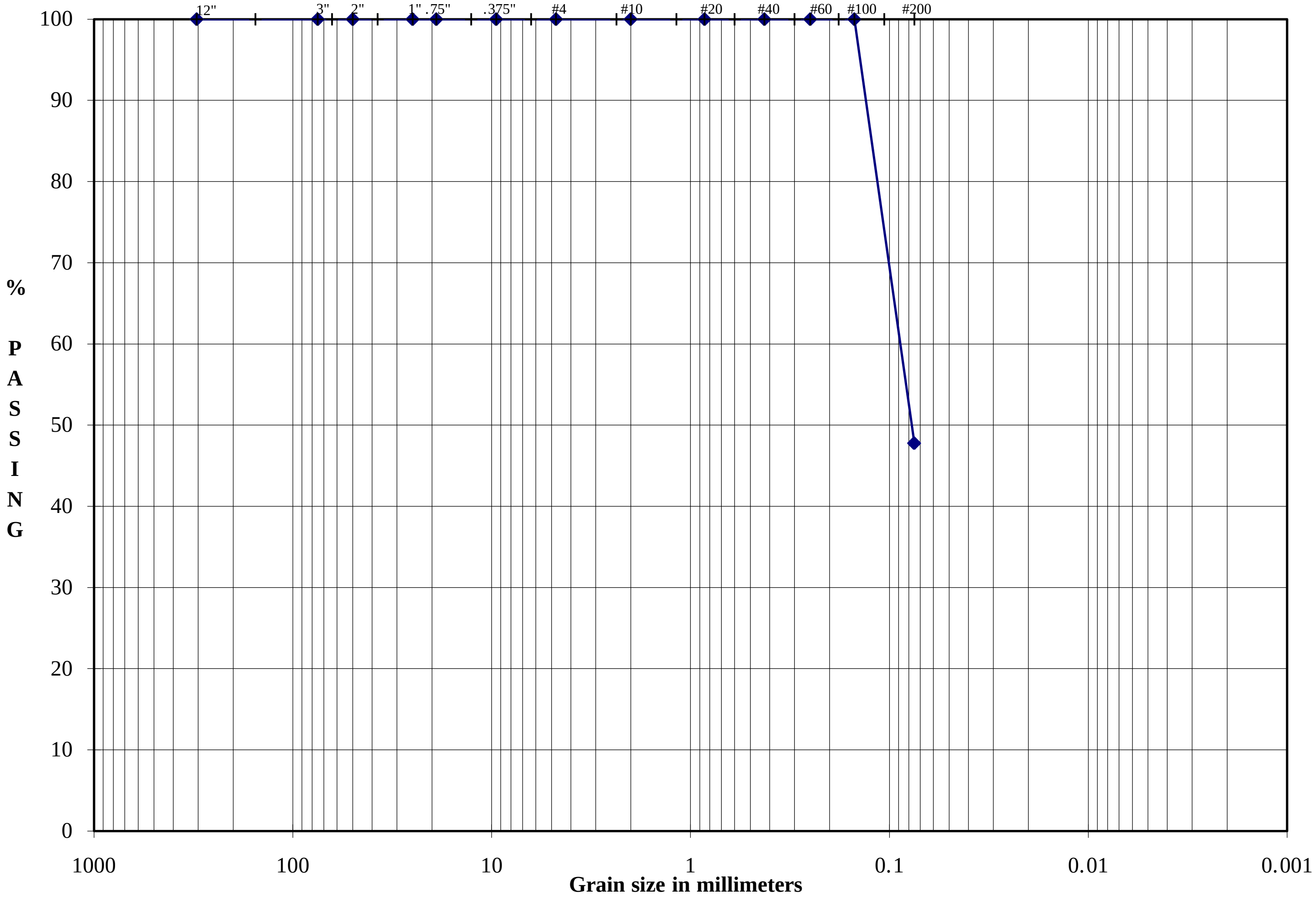
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION
#200 WASH ONLY
SILT and SAND

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB-4	S-3
SAMPLE TYPE	SPT	
SAMPLE DEPTH	7.5ft	

LL	-
PL	-
PI	-

DESCRIPTION #200 WASH ONLY
SAND and SILT

USCS SM

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	PIE/Burlington Geotech and Levees/WA	**SAMPLE ID**	GB-4 S-3
PROJECT NO.	093-93153.100	**SAMPLE TYPE**	SPT
REMARKS		**SAMPLE DEPTH**	7.5ft

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	960.10
Wt Dry Soil & Tare (gm)	(w2)	843.90
Weight of Tare (gm)	(w3)	311.50
Weight of Water (gm)	(w4= w1-w2)	116.20
Weight of Dry Soil (gm)	(w5= w2-w3)	532.40
Moisture Content (%)	(w4/w5)*100	21.83

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	843.90
	Tare Weight (gm)	311.50
(W6)	Total Dry Weight (gm)	532.40

SIEVE ANALYSIS

Tare Weight

311.50

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	311.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	311.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	311.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	311.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	311.50	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	311.50	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	311.50	0.00	0.00	100.00	0.75"	fine gravel
0.50"	311.50	0.00	0.00	100.00	0.50"	fine gravel
0.375"	311.50	0.00	0.00	100.00	0.375"	fine gravel
#4	311.50	0.00	0.00	100.00	#4	coarse sand
#10	311.50	0.00	0.00	100.00	#10	medium sand
#20	311.50	0.00	0.00	100.00	#20	medium sand
#40	311.50	0.00	0.00	100.00	#40	fine sand
#60	311.50	0.00	0.00	100.00	#60	fine sand
#100	311.50	0.00	0.00	100.00	#100	fine sand
#200	589.60	278.10	52.24	47.76	#200	fines
PAN	17512.80	17201.30			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	52.24
% FINES	47.76
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

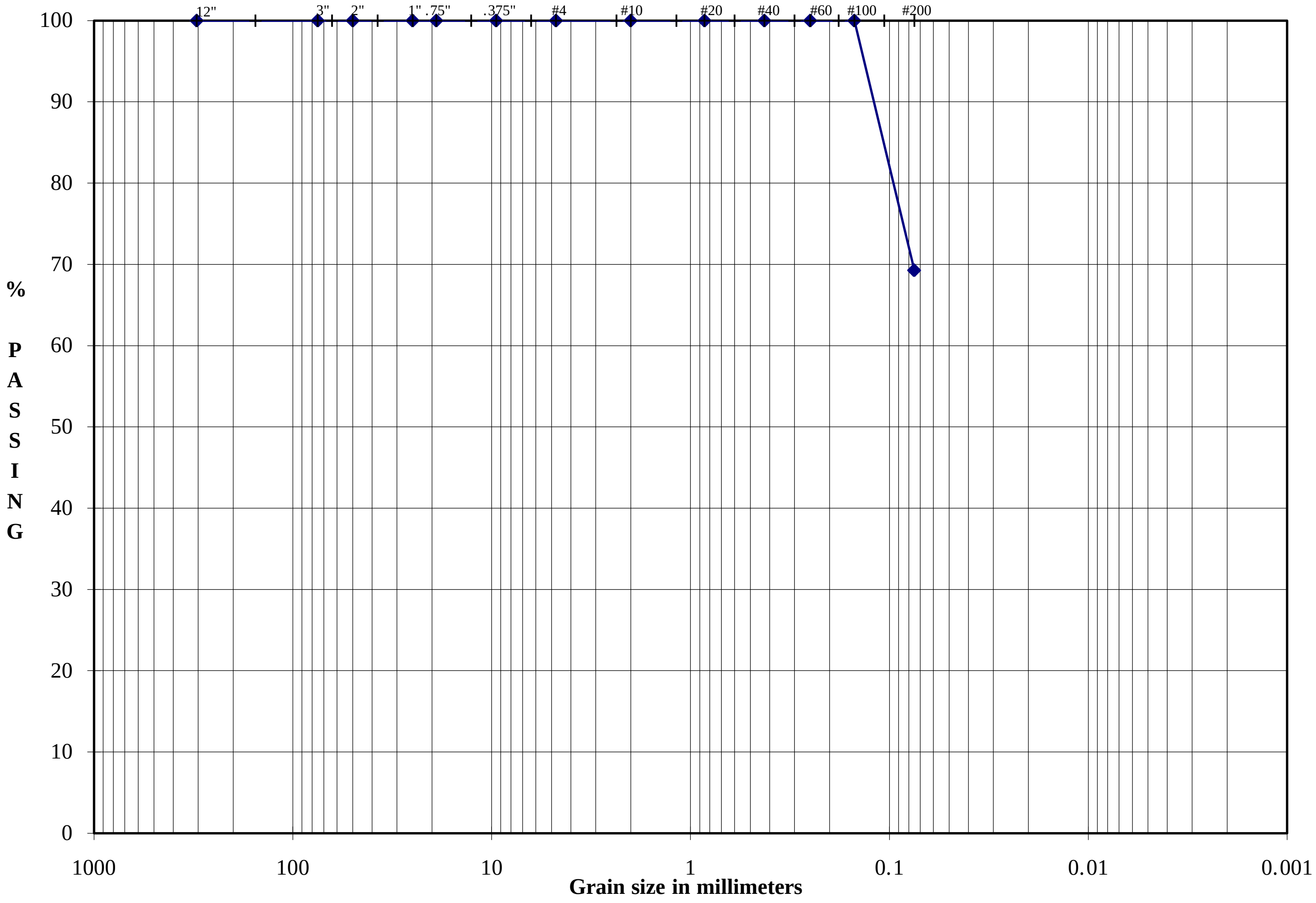
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION #200 WASH ONLY
SAND and SILT

USCS SM

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB-7	S-9
SAMPLE TYPE	SPT	
SAMPLE DEPTH	25ft	

LL	-
PL	-
PI	-

DESCRIPTION #200 WASH ONLY
SILT
some SAND

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

Golder Associates Inc.

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-7**	**S-9**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**25ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	758.10
Wt Dry Soil & Tare (gm)	(w2)	593.70
Weight of Tare (gm)	(w3)	309.90
Weight of Water (gm)	(w4= w1-w2)	164.40
Weight of Dry Soil (gm)	(w5= w2-w3)	283.80
Moisture Content (%)	(w4/w5)*100	57.93

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	593.70
	Tare Weight (gm)	309.90
(W6)	Total Dry Weight (gm)	283.80

SIEVE ANALYSIS

Tare Weight

309.90

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	309.90	0.00	0.00	100.00	12.0"	cobbles
3.0"	309.90	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	309.90	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	309.90	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	309.90	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	309.90	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	309.90	0.00	0.00	100.00	0.75"	fine gravel
0.50"	309.90	0.00	0.00	100.00	0.50"	fine gravel
0.375"	309.90	0.00	0.00	100.00	0.375"	fine gravel
#4	309.90	0.00	0.00	100.00	#4	coarse sand
#10	309.90	0.00	0.00	100.00	#10	medium sand
#20	309.90	0.00	0.00	100.00	#20	medium sand
#40	309.90	0.00	0.00	100.00	#40	fine sand
#60	309.90	0.00	0.00	100.00	#60	fine sand
#100	309.90	0.00	0.00	100.00	#100	fine sand
#200	397.10	87.20	30.73	69.27	#200	fines
PAN	17512.80	17202.90			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	30.73
% FINES	69.27
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

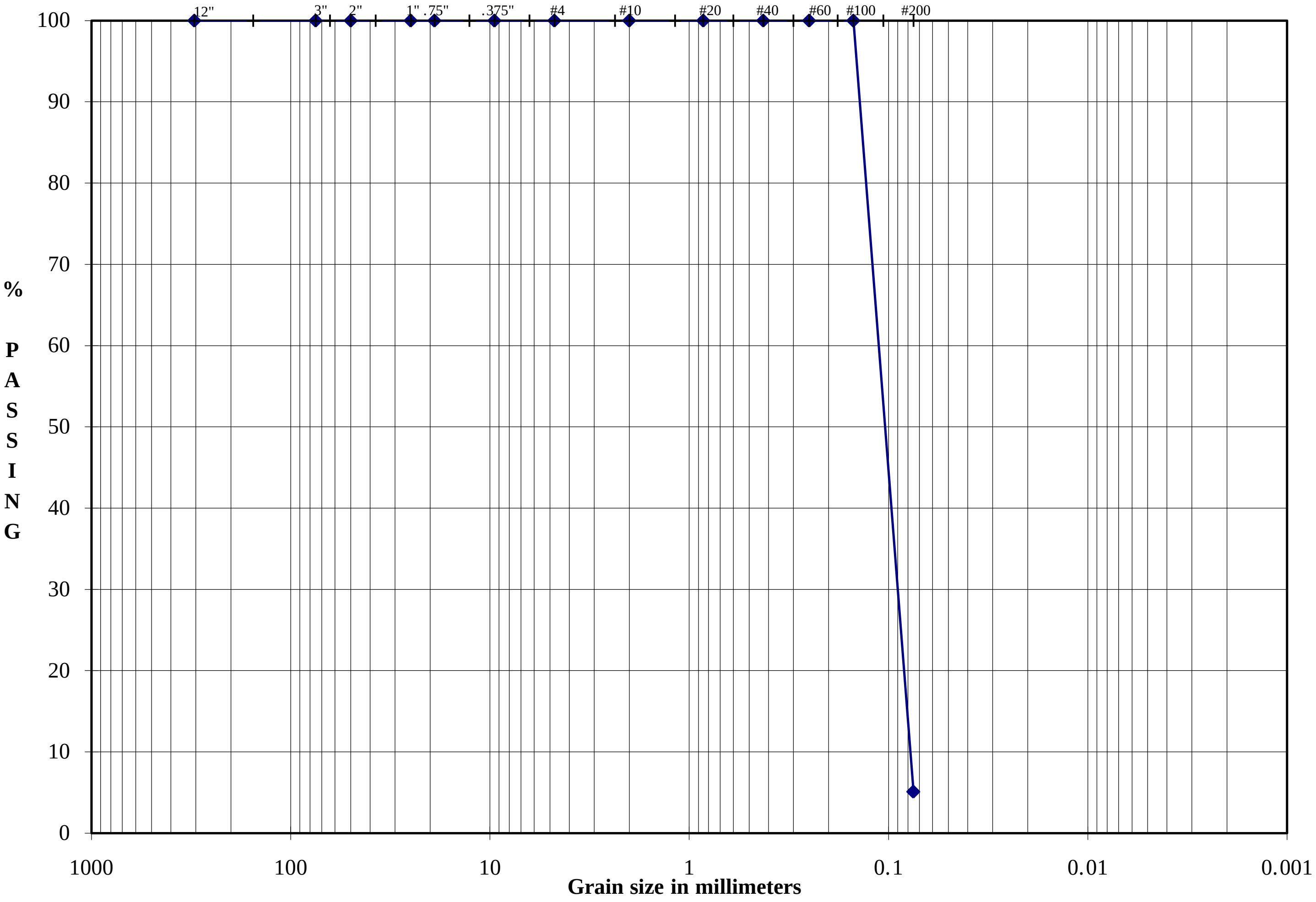
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION
#200 WASH ONLY
SILT
some SAND

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-10	S-4
SAMPLE TYPE	SPT	
SAMPLE DEPTH	10ft	

LL	-
PL	-
PI	-

DESCRIPTION
#200 WASH ONLY
SAND
trace silt

USCS SP

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-10**	**S-4**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**10ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	751.50
Wt Dry Soil & Tare (gm)	(w2)	716.40
Weight of Tare (gm)	(w3)	307.30
Weight of Water (gm)	(w4= w1-w2)	35.10
Weight of Dry Soil (gm)	(w5= w2-w3)	409.10
Moisture Content (%)	(w4/w5)*100	8.58

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	716.40
	Tare Weight (gm)	307.30
(W6)	Total Dry Weight (gm)	409.10

SIEVE ANALYSIS

Tare Weight

307.30

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	307.30	0.00	0.00	100.00	12.0"	cobbles
3.0"	307.30	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	307.30	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	307.30	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	307.30	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	307.30	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	307.30	0.00	0.00	100.00	0.75"	fine gravel
0.50"	307.30	0.00	0.00	100.00	0.50"	fine gravel
0.375"	307.30	0.00	0.00	100.00	0.375"	fine gravel
#4	307.30	0.00	0.00	100.00	#4	coarse sand
#10	307.30	0.00	0.00	100.00	#10	medium sand
#20	307.30	0.00	0.00	100.00	#20	medium sand
#40	307.30	0.00	0.00	100.00	#40	fine sand
#60	307.30	0.00	0.00	100.00	#60	fine sand
#100	307.30	0.00	0.00	100.00	#100	fine sand
#200	695.50	388.20	94.89	5.11	#200	fines
PAN	17512.80	17205.50			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	94.89
% FINES	5.11
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

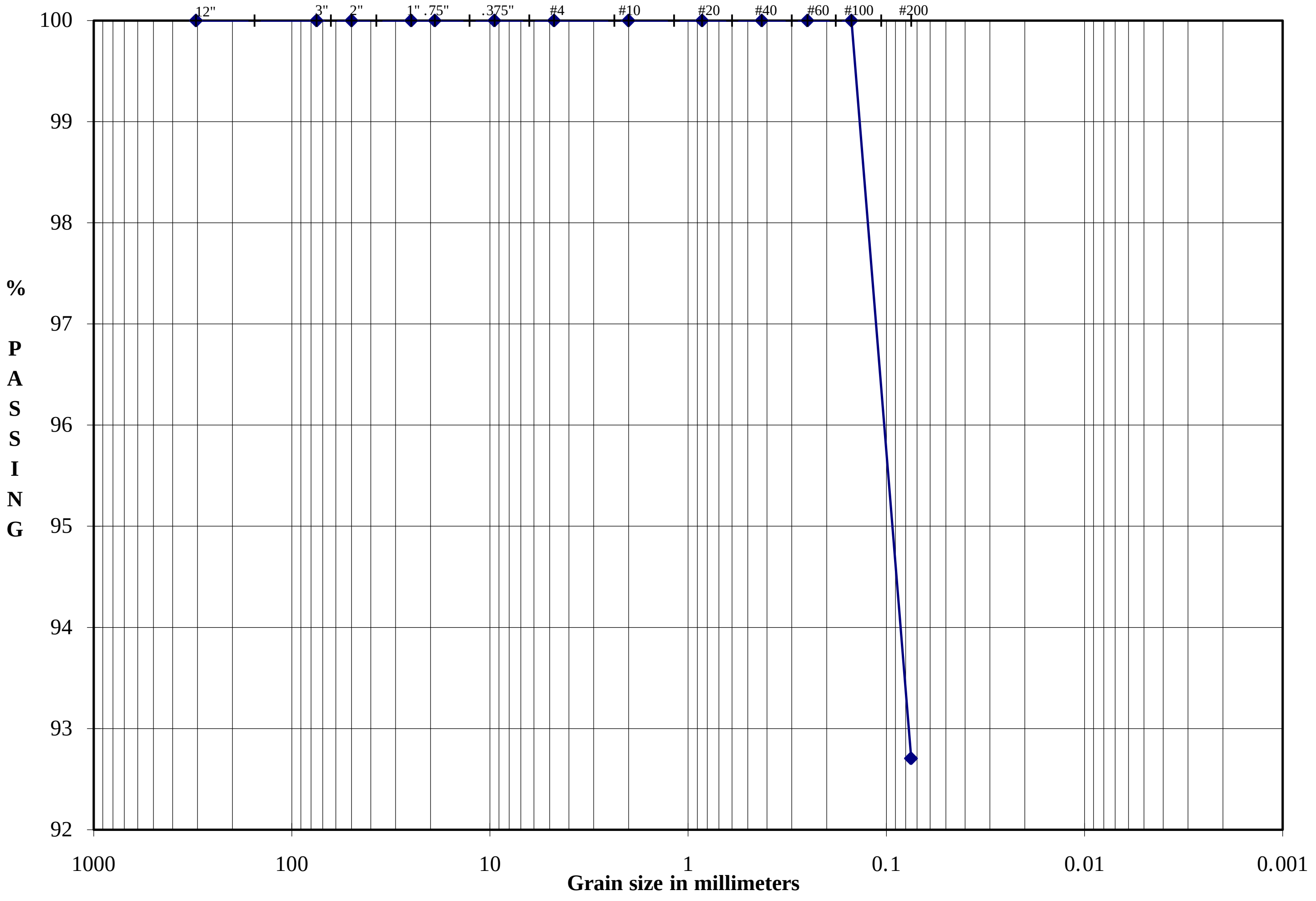
DESCRIPTION #200 WASH ONLY
SAND
trace silt

USCS SP

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

Golder Associates Inc.

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB-12 S-7
SAMPLE TYPE	SPT
SAMPLE DEPTH	17.5ft

LL	-
PL	-
PI	-

DESCRIPTION	#200 WASH ONLY SILT little sand
USCS	ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-12**	**S-7**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**17.5ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	823.30
Wt Dry Soil & Tare (gm)	(w2)	691.20
Weight of Tare (gm)	(w3)	311.50
Weight of Water (gm)	(w4= w1-w2)	132.10
Weight of Dry Soil (gm)	(w5= w2-w3)	379.70
Moisture Content (%)	(w4/w5)*100	34.79

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	691.20
	Tare Weight (gm)	311.50
(W6)	Total Dry Weight (gm)	379.70

SIEVE ANALYSIS

Tare Weight
311.50

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	311.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	311.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	311.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	311.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	311.50	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	311.50	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	311.50	0.00	0.00	100.00	0.75"	fine gravel
0.50"	311.50	0.00	0.00	100.00	0.50"	fine gravel
0.375"	311.50	0.00	0.00	100.00	0.375"	fine gravel
#4	311.50	0.00	0.00	100.00	#4	coarse sand
#10	311.50	0.00	0.00	100.00	#10	medium sand
#20	311.50	0.00	0.00	100.00	#20	medium sand
#40	311.50	0.00	0.00	100.00	#40	fine sand
#60	311.50	0.00	0.00	100.00	#60	fine sand
#100	311.50	0.00	0.00	100.00	#100	fine sand
#200	339.20	27.70	7.30	92.70	#200	fines
PAN	17512.80	17201.30			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	7.30
% FINES	92.70
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

>	10% mostly coarse (c)
>	10% mostly medium (m)
<	10% fine (c-m)
<	10% coarse (m-f)
<	10% coarse and fine (m)
<	10% coarse and medium (f)
>	10% equal amounts each (c-f)

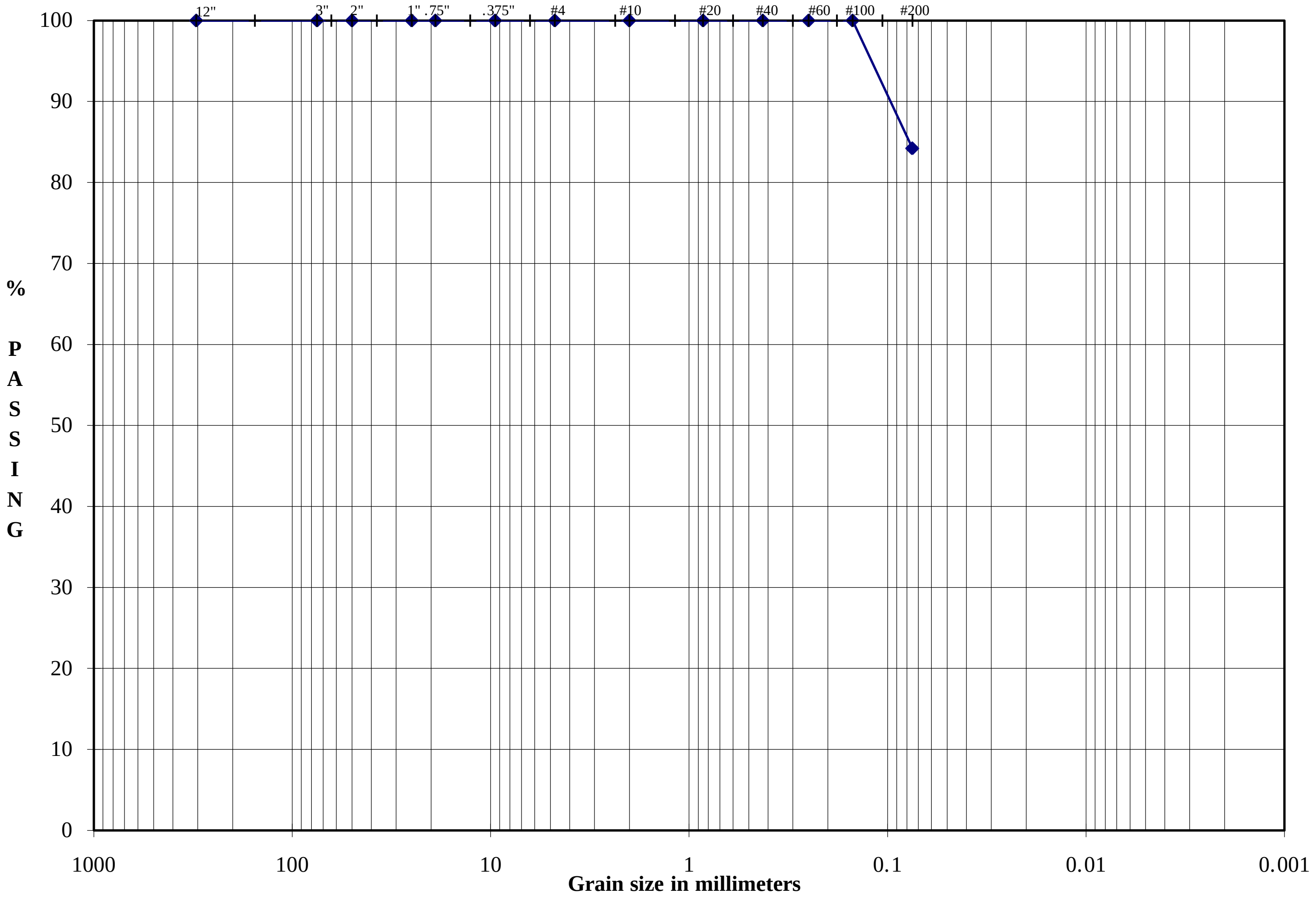
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION
#200 WASH ONLY
SILT
little sand

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-16	S-3
SAMPLE TYPE	SPT	
SAMPLE DEPTH	7.5ft	

LL	-
PL	-
PI	-

DESCRIPTION	#200 WASH ONLY SILT some sand
USCS	ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	PIE/Burlington Geotech and Levees/WA	**SAMPLE ID**	GB-16	S-3
PROJECT NO.	093-93153.100	**SAMPLE TYPE**	SPT	
REMARKS		**SAMPLE DEPTH**	7.5ft	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	839.00
Wt Dry Soil & Tare (gm)	(w2)	695.50
Weight of Tare (gm)	(w3)	314.60
Weight of Water (gm)	(w4= w1-w2)	143.50
Weight of Dry Soil (gm)	(w5= w2-w3)	380.90
Moisture Content (%)	(w4/w5)*100	37.67

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	695.50
	Tare Weight (gm)	314.60
(W6)	Total Dry Weight (gm)	380.90

SIEVE ANALYSIS

Tare Weight: 314.60

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	314.60	0.00	0.00	100.00	12.0"	cobbles
3.0"	314.60	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	314.60	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	314.60	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	314.60	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	314.60	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	314.60	0.00	0.00	100.00	0.75"	fine gravel
0.50"	314.60	0.00	0.00	100.00	0.50"	fine gravel
0.375"	314.60	0.00	0.00	100.00	0.375"	fine gravel
#4	314.60	0.00	0.00	100.00	#4	coarse sand
#10	314.60	0.00	0.00	100.00	#10	medium sand
#20	314.60	0.00	0.00	100.00	#20	medium sand
#40	314.60	0.00	0.00	100.00	#40	fine sand
#60	314.60	0.00	0.00	100.00	#60	fine sand
#100	314.60	0.00	0.00	100.00	#100	fine sand
#200	374.70	60.10	15.78	84.22	#200	fines
PAN	17512.80	17198.20			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	15.78
% FINES	84.22
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

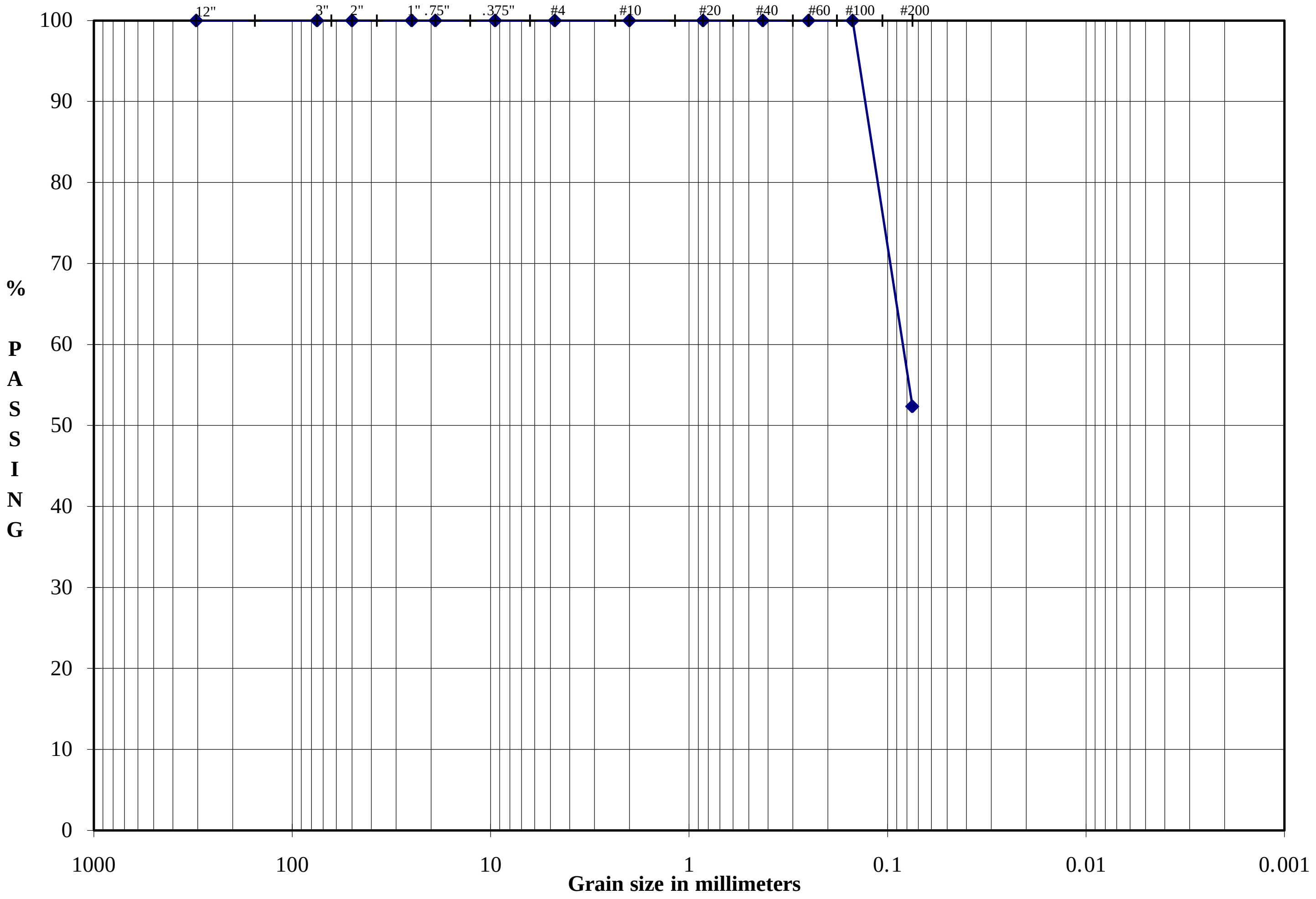
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION
#200 WASH ONLY
SILT
some sand

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB-18	S-12
SAMPLE TYPE	SPT	
SAMPLE DEPTH	40ft	

LL	-
PL	-
PI	-

DESCRIPTION #200 WASH ONLY
SILT and SAND

USCS ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

Golder Associates Inc.

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-18**	**S-12**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**	
REMARKS		**SAMPLE DEPTH**	**40ft**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	984.60
Wt Dry Soil & Tare (gm)	(w2)	812.40
Weight of Tare (gm)	(w3)	321.20
Weight of Water (gm)	(w4= w1-w2)	172.20
Weight of Dry Soil (gm)	(w5= w2-w3)	491.20
Moisture Content (%)	(w4/w5)*100	35.06

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	812.40
	Tare Weight (gm)	321.20
(W6)	Total Dry Weight (gm)	491.20

SIEVE ANALYSIS

Tare Weight

321.20

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	321.20	0.00	0.00	100.00	12.0"	cobbles
3.0"	321.20	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	321.20	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	321.20	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	321.20	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	321.20	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	321.20	0.00	0.00	100.00	0.75"	fine gravel
0.50"	321.20	0.00	0.00	100.00	0.50"	fine gravel
0.375"	321.20	0.00	0.00	100.00	0.375"	fine gravel
#4	321.20	0.00	0.00	100.00	#4	coarse sand
#10	321.20	0.00	0.00	100.00	#10	medium sand
#20	321.20	0.00	0.00	100.00	#20	medium sand
#40	321.20	0.00	0.00	100.00	#40	fine sand
#60	321.20	0.00	0.00	100.00	#60	fine sand
#100	321.20	0.00	0.00	100.00	#100	fine sand
#200	555.30	234.10	47.66	52.34	#200	fines
PAN	17512.80	17191.60			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	47.66
% FINES	52.34
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

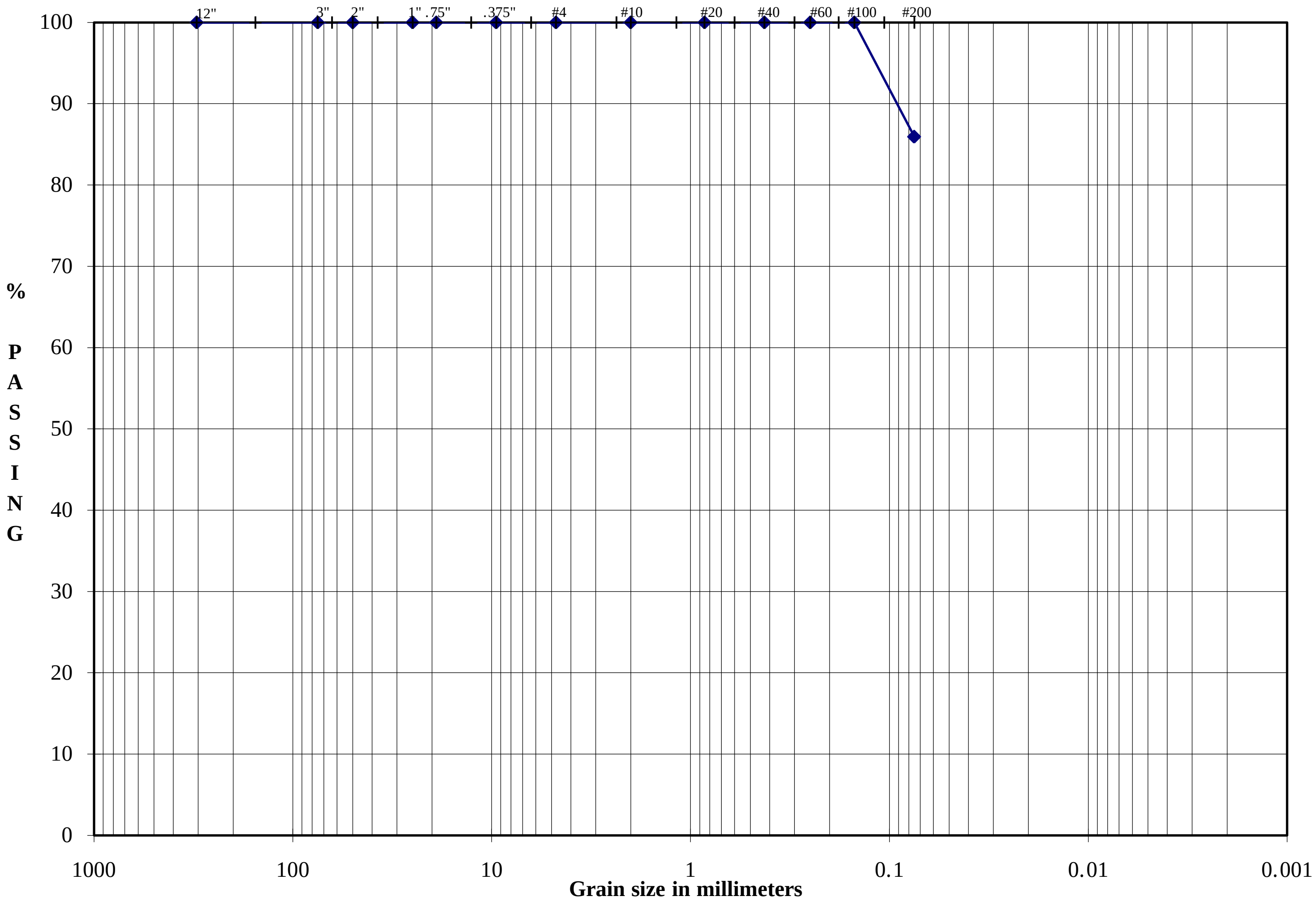
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION #200 WASH ONLY
SILT and SAND

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB-25	S-4
SAMPLE TYPE	SPT	
SAMPLE DEPTH	10ft	

LL	-
PL	-
PI	-

DESCRIPTION	#200 WASH ONLY SILT some sand
USCS	ML

PIE/Burlington Geotech and Levees/WA
093-93153.100

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**PIE/Burlington Geotech and Levees/WA**	**SAMPLE ID**	**GB-25** | **S-4**
PROJECT NO.	**093-93153.100**	**SAMPLE TYPE**	**SPT**
REMARKS		**SAMPLE DEPTH**	**10ft**

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	957.00
Wt Dry Soil & Tare (gm)	(w2)	776.70
Weight of Tare (gm)	(w3)	326.80
Weight of Water (gm)	(w4= w1-w2)	180.30
Weight of Dry Soil (gm)	(w5= w2-w3)	449.90
Moisture Content (%)	(w4/w5)*100	40.08

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	776.70
	Tare Weight (gm)	326.80
(W6)	Total Dry Weight (gm)	449.90

SIEVE ANALYSIS

Tare Weight

326.80

	Wt Ret + Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	326.80	0.00	0.00	100.00	12.0"	cobbles
3.0"	326.80	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	326.80	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	326.80	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	326.80	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	326.80	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	326.80	0.00	0.00	100.00	0.75"	fine gravel
0.50"	326.80	0.00	0.00	100.00	0.50"	fine gravel
0.375"	326.80	0.00	0.00	100.00	0.375"	fine gravel
#4	326.80	0.00	0.00	100.00	#4	coarse sand
#10	326.80	0.00	0.00	100.00	#10	medium sand
#20	326.80	0.00	0.00	100.00	#20	medium sand
#40	326.80	0.00	0.00	100.00	#40	fine sand
#60	326.80	0.00	0.00	100.00	#60	fine sand
#100	326.80	0.00	0.00	100.00	#100	fine sand
#200	390.10	63.30	14.07	85.93	#200	fines
PAN	17512.80	17186.00			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.00
% F SAND	14.07
% FINES	85.93
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.00
D30 (mm)	0.00
D60 (mm)	0.00
Cu	#DIV/0!
Cc	#DIV/0!

DESCRIPTION
#200 WASH ONLY
SILT
some sand

USCS ML

TECH	TCM
DATE	5/20/09
CHECK	TCM
REVIEW	AJD

APPENDIX B-4

SHELBY TUBE ANALYSIS AND CONSOLIDATION TEST RESULTS

Shelby Tube Visual Classification

Job Burlington Levee
Job No. 09-2310
Exploration No GB-14
Sample No. NA
Depth of Sample 61.5-63.5
Sampled Length (from log) 2.0 (feet)
Sample Recovery 2.3 (feet)

Date 5/11/09
Sample Pushed by AJA
Sample Logged by AJA
Type of Sample X shelby ___ other
Diameter of Sample 2.85 (inches)
Sample Quality X Good __Fair __Poor __ Disturbed

Specimen saved	Water content %	Test type	Strength Index		Consistency	Color	Depth (ft)	Classification and Description
			TV TSF	PP TSF				
							61.5	Top of recovery
								61.7- 61.9 Cracked
							62.0	
	36	ATTB	0.25	0.75		Grey		LL=29, PL=25, PI=4
X								
X							62.5	
X								
X								Soft- medium stiff, moist, grey, Silt (ML)
X								
	35	WC	0.35	0.75		Grey	63.0	
	36	WC	0.35				63.5	
								Bottom of recovery
							64.0	

Soil Technology
J-09-2310

Shelby Tube Visual Classification

Job Burlington Levee
Job No. 09-2310
Exploration No GB-17
Sample No. NA
Depth of Sample 14.0-15.6
Sampled Length (from log)1.5 (feet)
Sample Recovery 1.6(feet)

Date 5/8/09
Sample Pushed by AJA
Sample Logged by AJA
Type of Sample X shelby ___ other
Diameter of Sample 2.85 (inches)
Sample Quality __Good X Fair __Poor __ Disturbed

Specimen saved	Water content %	Test type	Strength Index		Consistency	Color	Depth (ft)	Classification and Description
			TV TSF	PP TSF				
							13.5	
							14.0	Top of recovery
								14.0-14.2- Disturbed
							14.5	
X X								Soft, moist, brown, Silt (ML)
			.125	.50			15.0	
ATTB	50	CON				Brown		LL=45, PL=36, PI=9
							15.5	Medium- stiff, moist, brown, numerous organics, Silt
	92	WC						
								Bottom of recovery
							16.0	

Shelby Tube Visual Classification

Job Burlington Levee
Job No. 09-2310
Exploration No GB-18
Sample No. NA
Depth of Sample 16.5-18.5
Sampled Length (from log) 2.0 (feet)
Sample Recovery 2.0 (feet)

Date 5/14/09
Sample Pushed by AJA
Sample Logged by AJA
Type of Sample X shelby ___ other
Diameter of Sample 2.85 (inches)
Sample Quality __Good __Fair __Poor X Disturbed

Specimen saved	Water content %	Test type	Strength Index		Consistency	Color	Depth (ft)	Classification and Description
			TV TSF	PP TSF				
							16.0	
							16.5	Top of recovery
						Tan		16.5-16.8- Loose sand
							17.0	
						Tan		17.0-17.3- Broken- disturbed
							17.5	
							18.0	
						Tan		17.7-18.5- Soft, fractured, dry, tan, Sand (NP)
							18.5	
								Bottom of recovery

Shelby Tube Visual Classification

Job Burlington Levee
Job No. 09-2310
Exploration No GB-24
Sample No. NA
Depth of Sample 13.0-15.0
Sampled Length (from log) 2.0 (feet)
Sample Recovery 2.0 (feet)

Date 5/6/09
Sample Pushed by AJA
Sample Logged by AJA
Type of Sample X shelby ___ other
Diameter of Sample 2.85 (inches)
Sample Quality _Good X Fair _Poor _ Disturbed

Specimen saved	Water content %	Test type	Strength Index TV TSF	Strength Index PP TSF	Consistency	Color	Depth (ft)	Classification and Description
							12.5	
							13.0	Top of recovery
X								
X								13.0-13.3 Disturbed
X								Clay
		CON						
	31	ATTB		.50			13.5	LL=NV, PL=NP, PI=NP
								Soft, moist, olive grey, Silts (ML)
39		WC					14.0	
X								
X								
X								
X								Very soft- soft, moist, olive grey, Sand
	36	WC	.05				14.5	
							15.0	
								Bottom of recovery

Shelby Tube Visual Classification

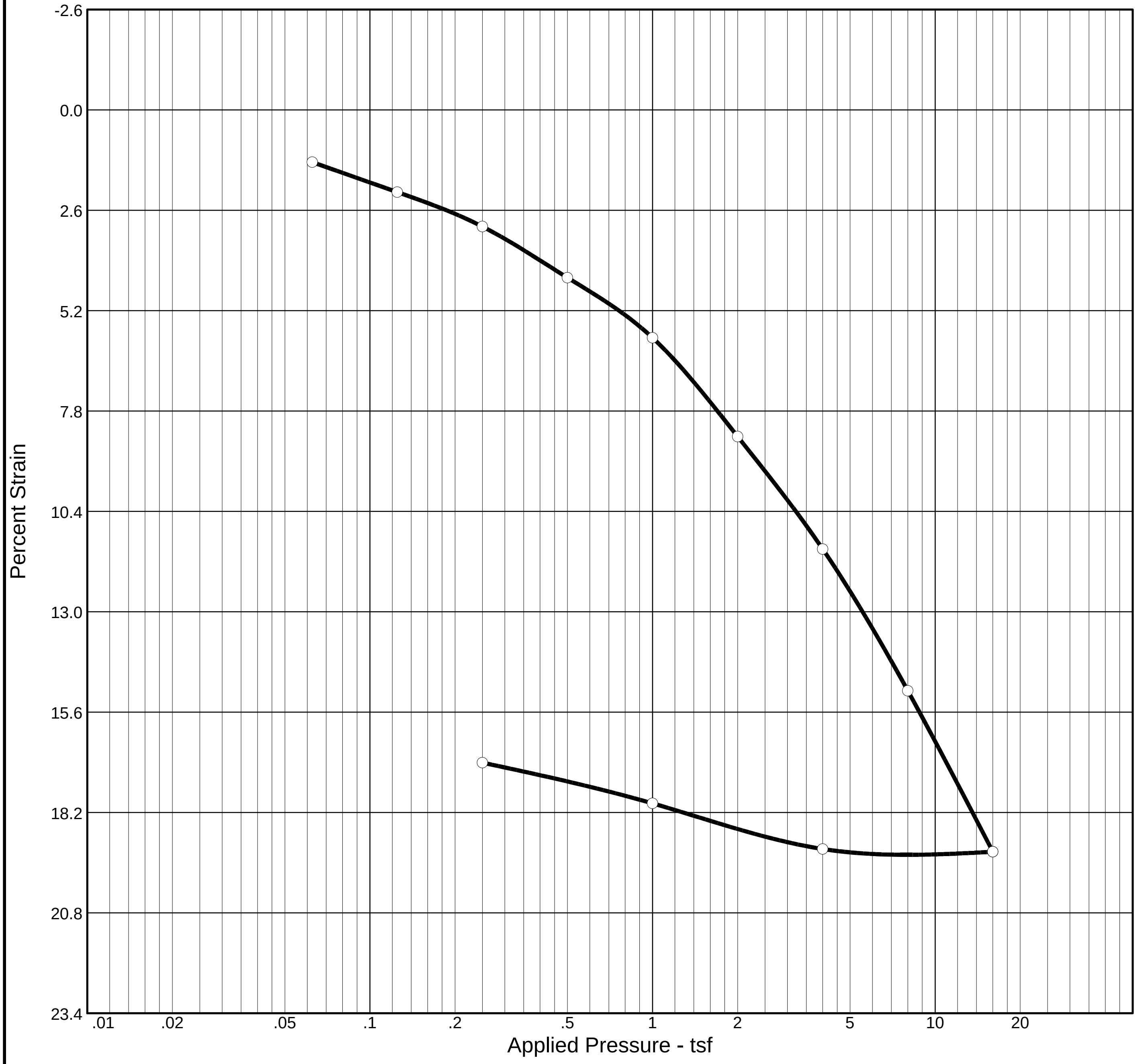
Job Burlington Levee
Job No. 09-2310
Exploration No GB-28
Sample No. NA
Depth of Sample 27.0-28.5
Sampled Length (from log) 1.5 (feet)
Sample Recovery 1.5 (feet)

Date 5/11/09
Sample Pushed by AJA
Sample Logged by AJA
Type of Sample X shelby ___ other
Diameter of Sample 2.85 (inches)
Sample Quality X Good __Fair __Poor __ Disturbed

Specimen saved	Water content %	Test type	Strength Index		Consistency	Color	Depth (ft)	Classification and Description
			TV TSF	PP TSF				
							26.5	
							27.0	Top of recovery
		ATTB						LL=46, PL=31, PI=15
							27.5	
X			.60	2.5		Blue-Grey		
X								
X								Stiff- very stiff, moist, blue- grey, Silt (ML)
X								
X							28.0	
	28	WC	.10			Brown-Grey		Very soft, moist, brown- grey, fine Sandy Silt
							28.5	
								Bottom of recovery
							29.0	

Soil Technology
J-09-2310

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
97.6 %	49.9 %	70.2	45	9	2.65		2.14	0.33	0.03			1.356

MATERIAL DESCRIPTION	USCS	AASHTO
Soft, wet, brown, Silt	ML	-----

Project No. J-09-2310 **Client:** Golder Associates, Inc

Project: Burlington Levee
Project No. 093-93153

Source: GB-17 **Elev./Depth:** 15.0-15.1 ft.

SOIL TECHNOLOGY

Bainbridge Island, WA

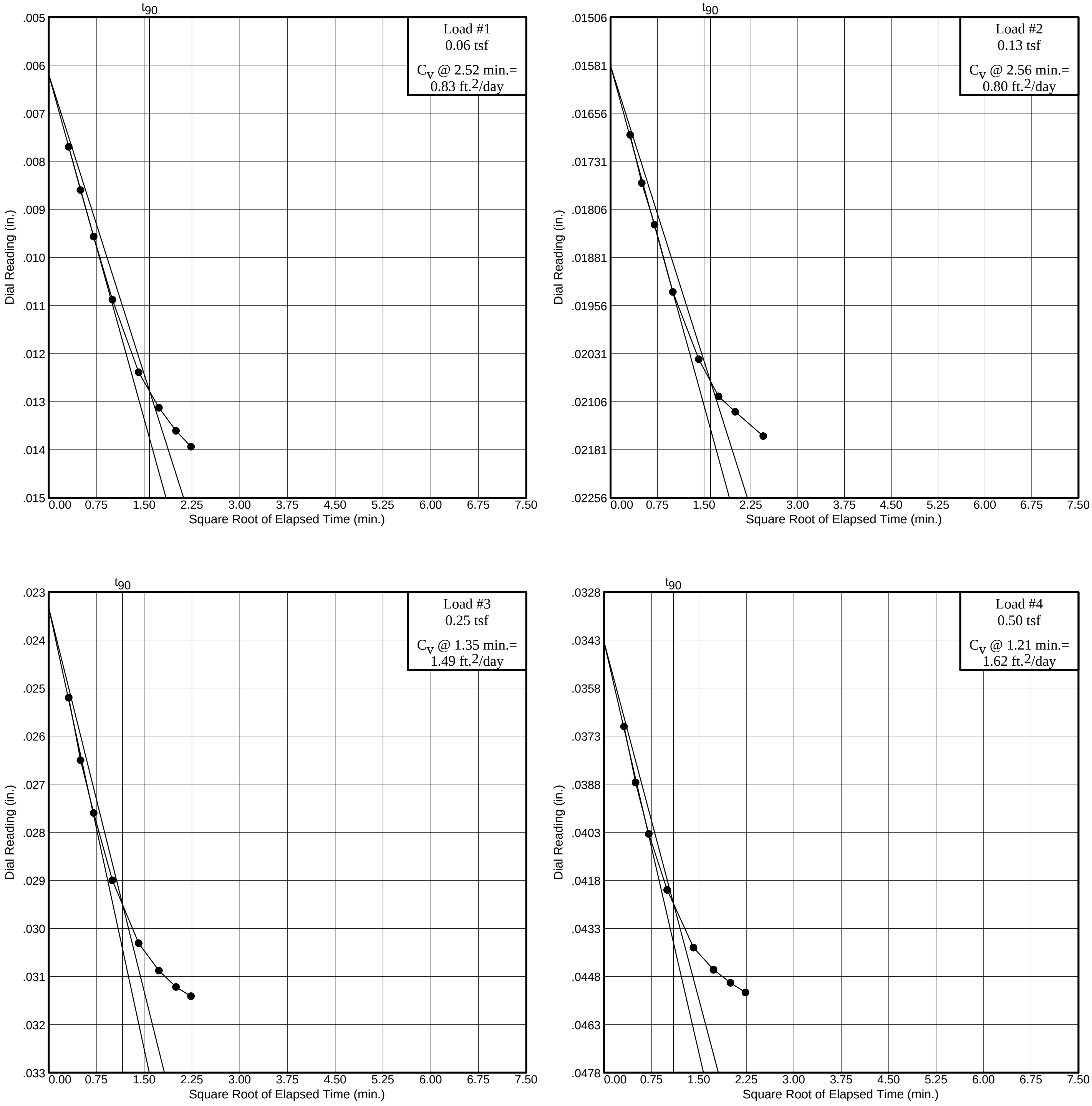
Remarks:

Sample not uniform in density and top platen tilted slightly testing

Figure 1

Dial Reading vs. Time

Project No.: J-09-2310
Project: Burlington Levee
Project No. 093-93153
Source: GB-17 Elev./Depth: 15.0-15.1 ft.



SOIL TECHNOLOGY

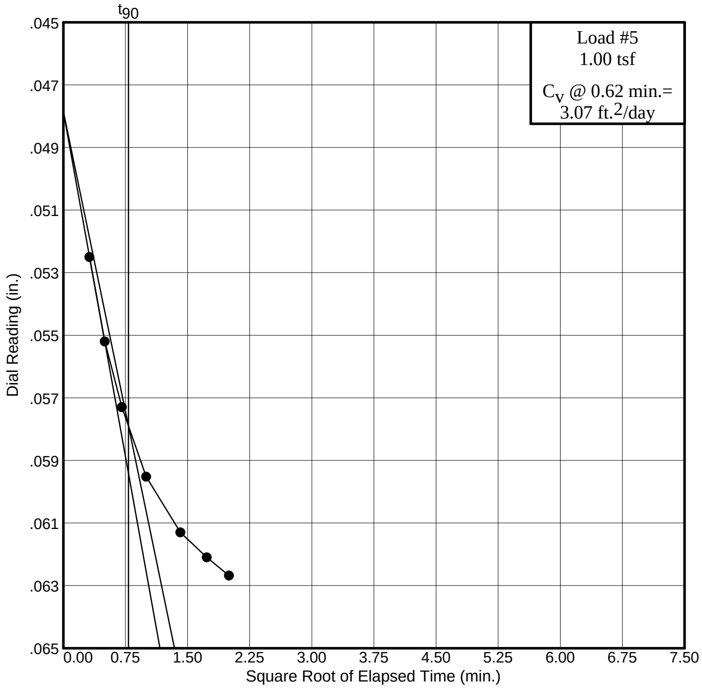
Bainbridge Island, WA

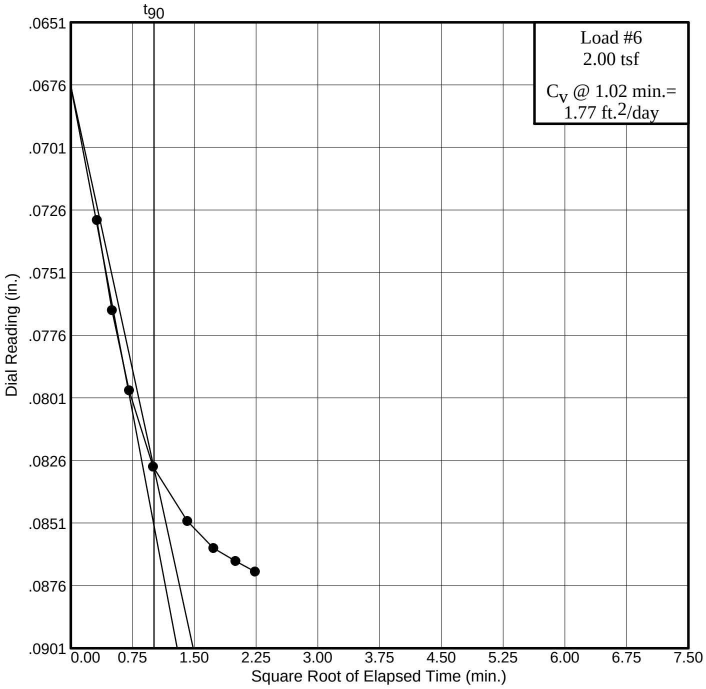
Figure 2

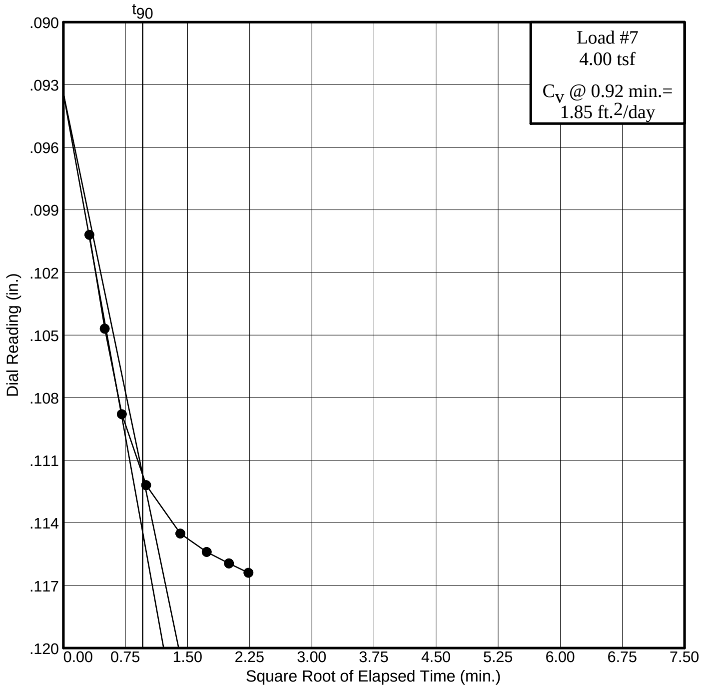
Dial Reading vs. Time

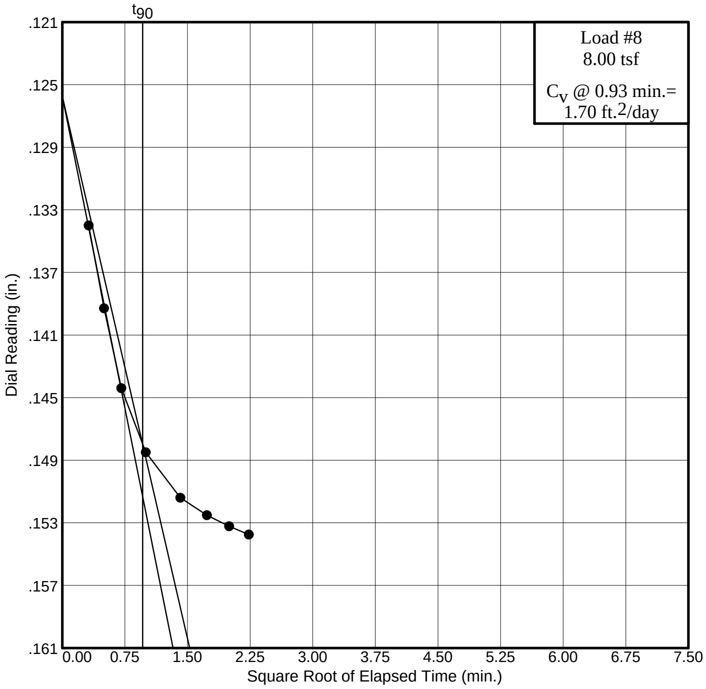
Project No.: J-09-2310
Project: Burlington Levee
Project No. 093-93153
Source: GB-17

Elev./Depth: 15.0-15.1 ft.









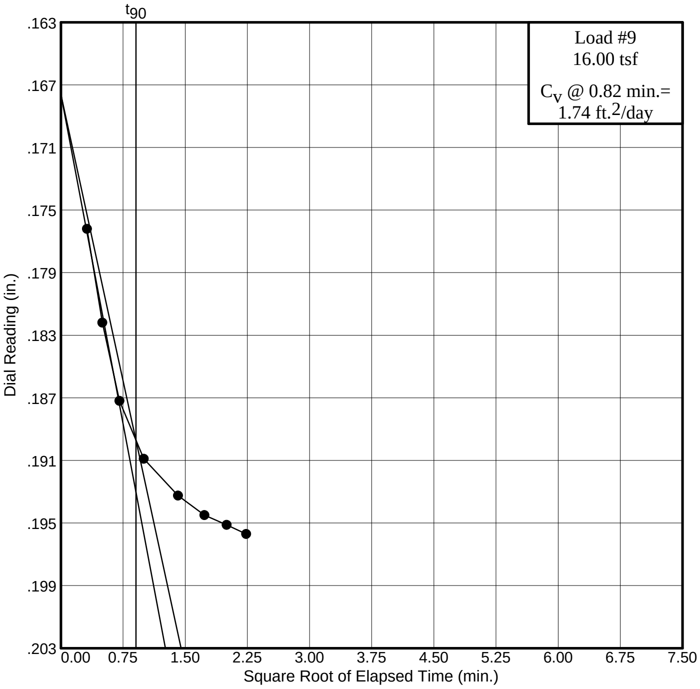
SOIL TECHNOLOGY
Bainbridge Island, WA

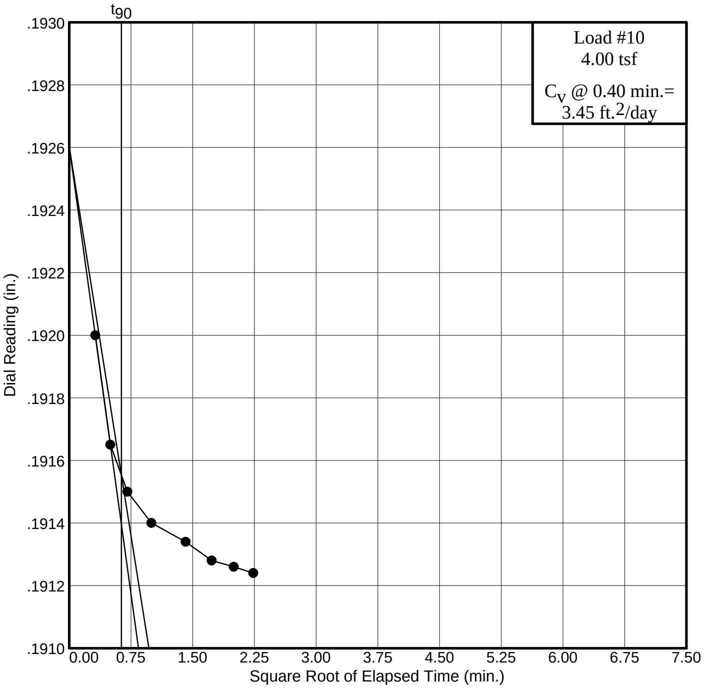
Figure 3

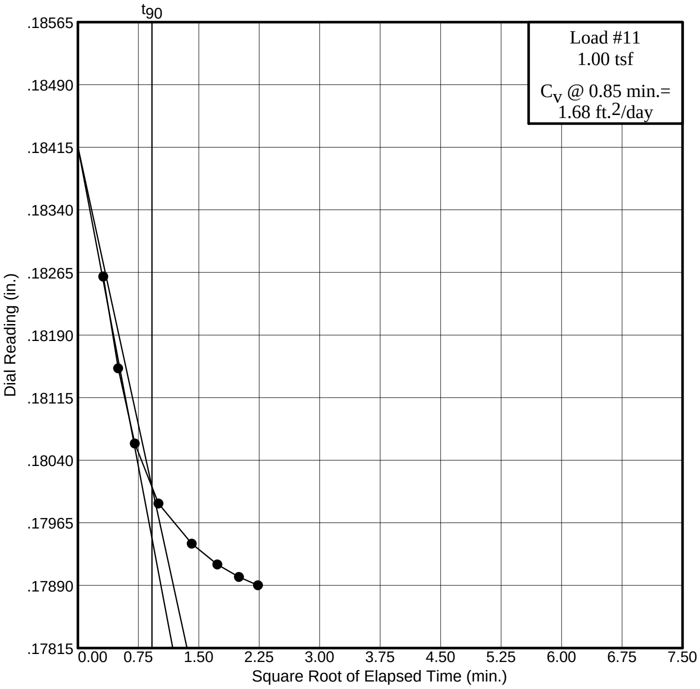
Dial Reading vs. Time

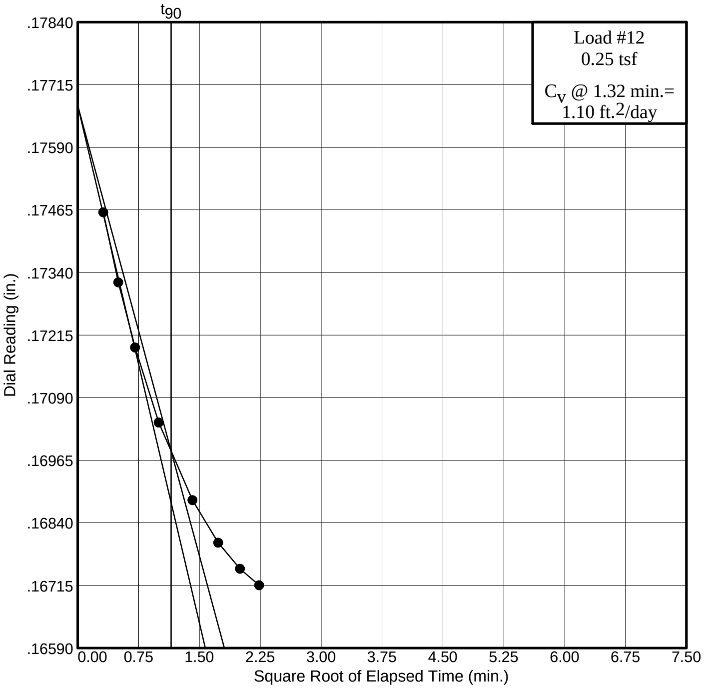
Project No.: J-09-2310
Project: Burlington Levee
Project No. 093-93153
Source: GB-17

Elev./Depth: 15.0-15.1 ft.







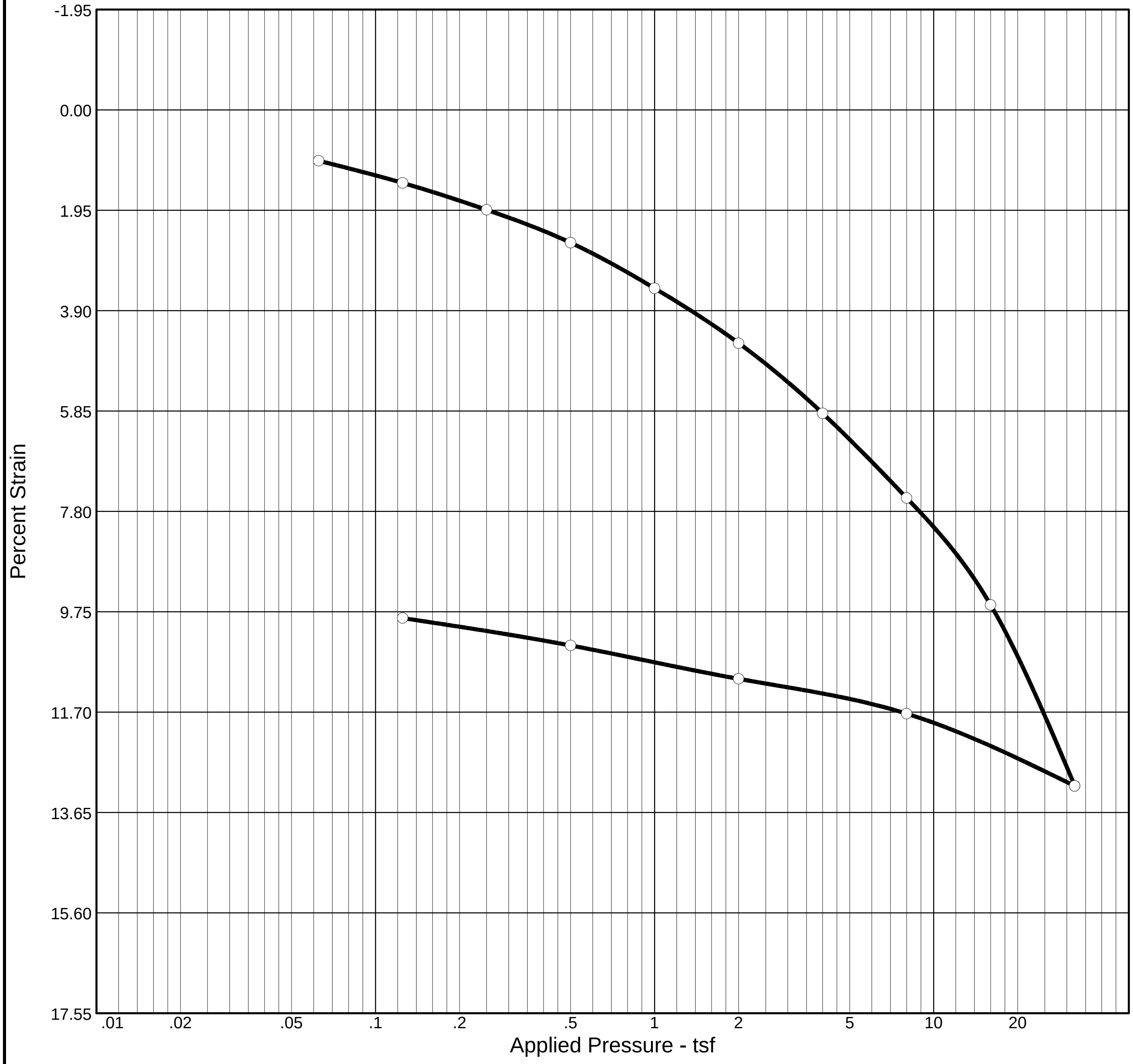


SOIL TECHNOLOGY

Bainbridge Island, WA

Figure 4

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
99.7 %	30.7 %	93.1	NV	NP	2.75		16.93	0.22	0.03			0.848

MATERIAL DESCRIPTION	USCS	AASHTO
Soft, wet, fine sandy Silt	ML	----

Project No. J-09-2310 **Client:** Golder Associates, Inc

Project: Burlington Levee
Project No. 093-93153

Source: GB-24 **Elev./Depth:** 13.3-13.4 ft.

SOIL TECHNOLOGY

Bainbridge Island, WA

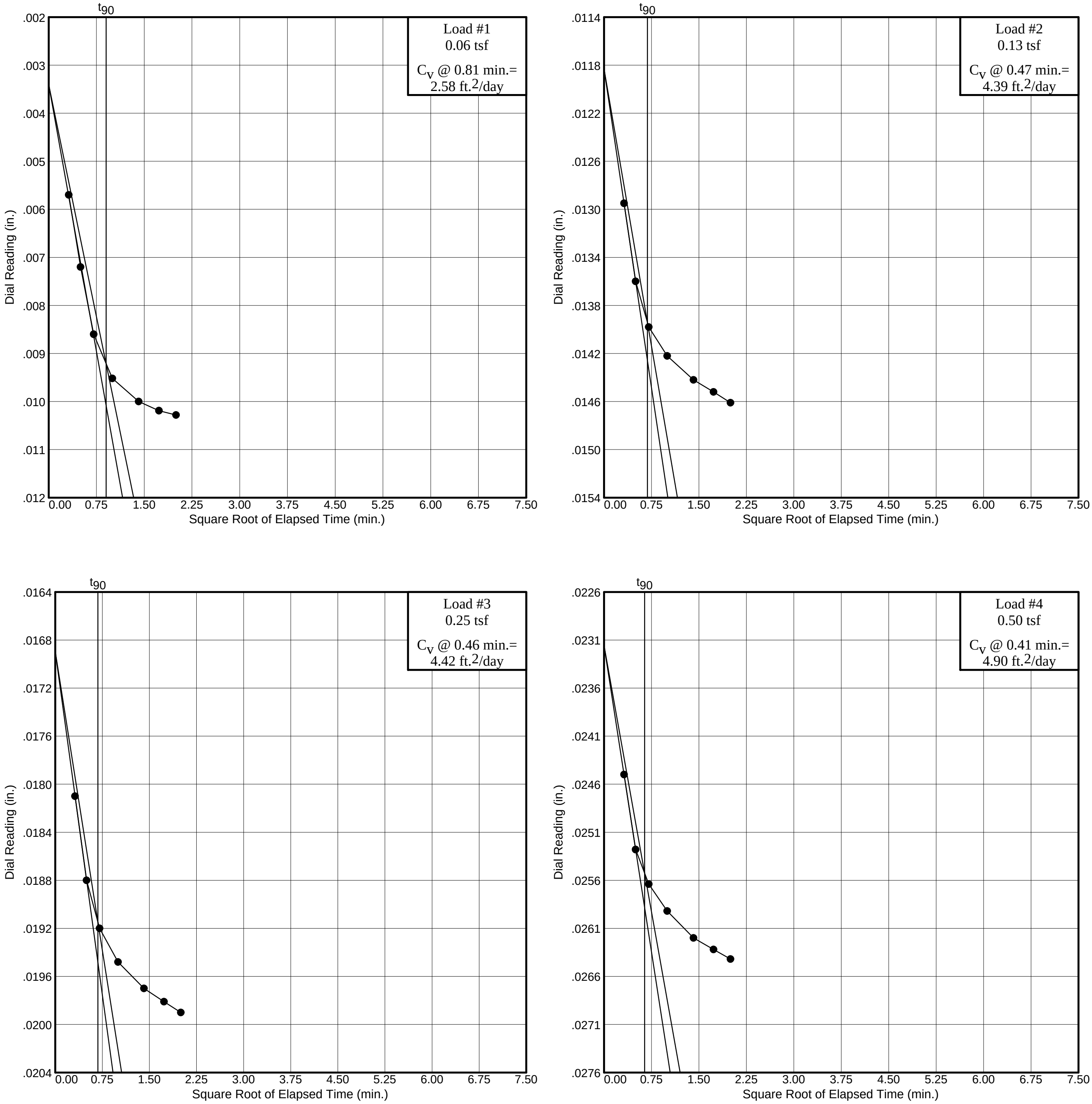
Remarks:

Trimmed past sand pocket in plastic material w/ consol sample in dilatant silt (Poor quality)

Figure 2

Dial Reading vs. Time

Project No.: J-09-2310
Project: Burlington Levee
Project No. 093-93153
Source: GB-24
Elev./Depth: 13.3-13.4 ft.



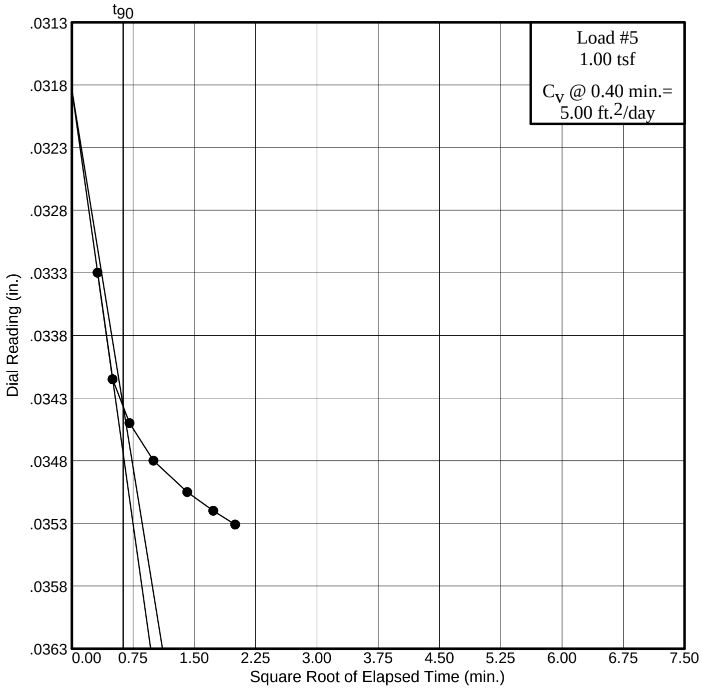
SOIL TECHNOLOGY

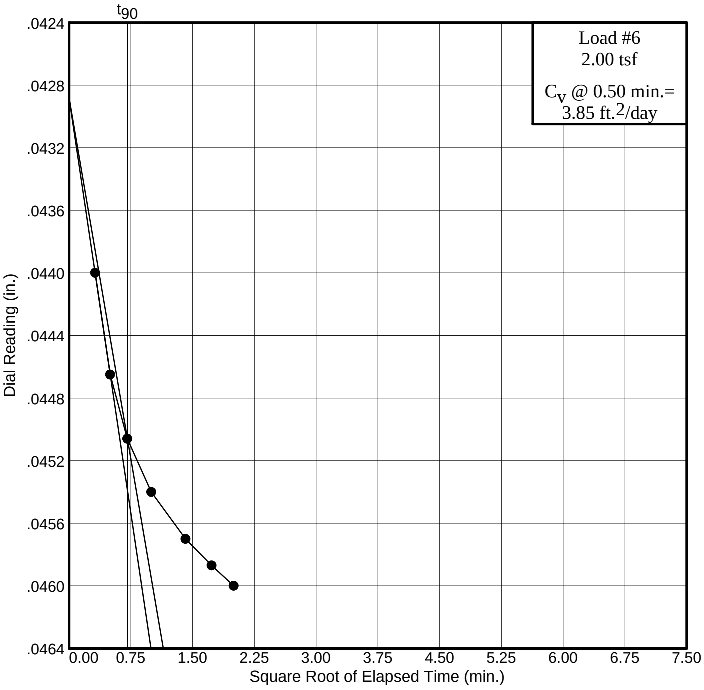
Bainbridge Island, WA

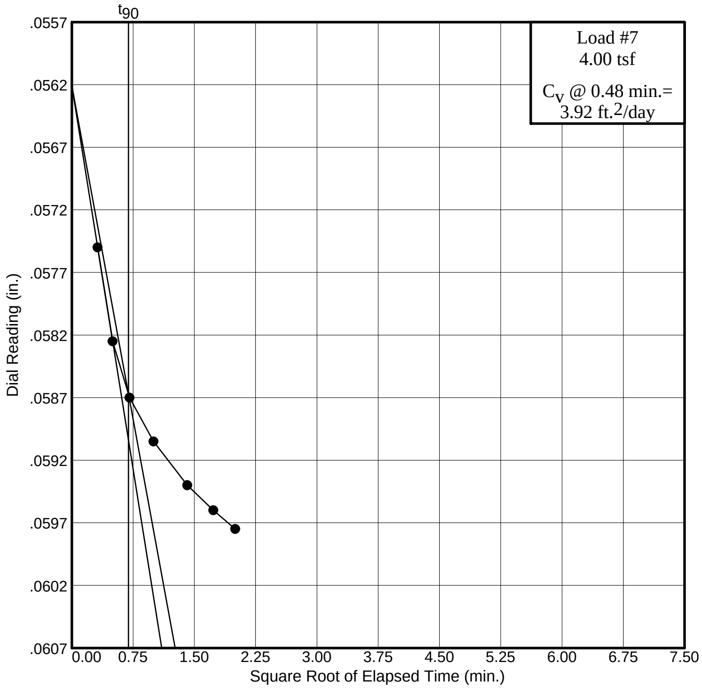
Figure 3

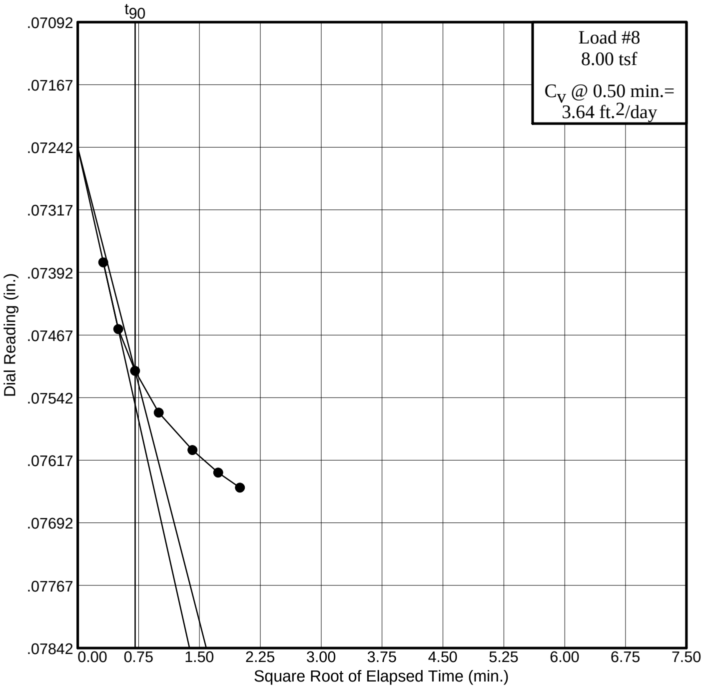
Dial Reading vs. Time

Project No.: J-09-2310
Project: Burlington Levee
Project No. 093-93153
Source: GB-24 Elev./Depth: 13.3-13.4 ft.









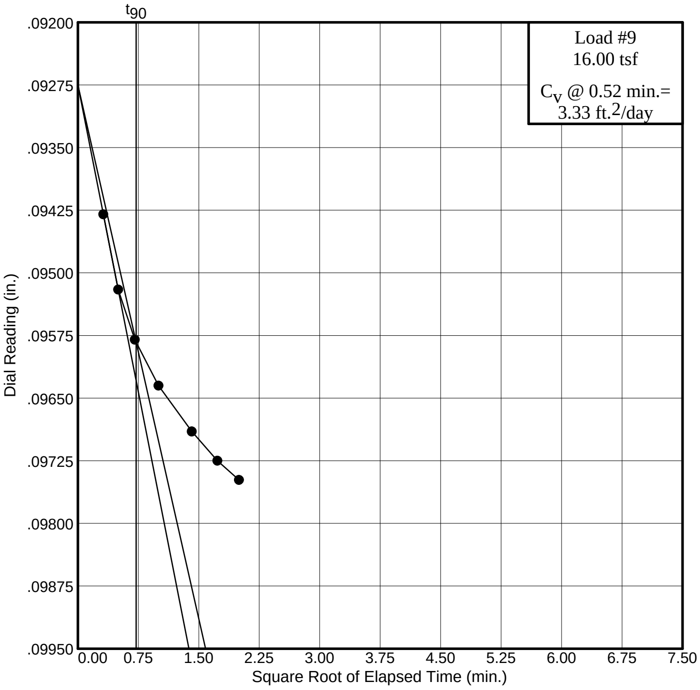
SOIL TECHNOLOGY

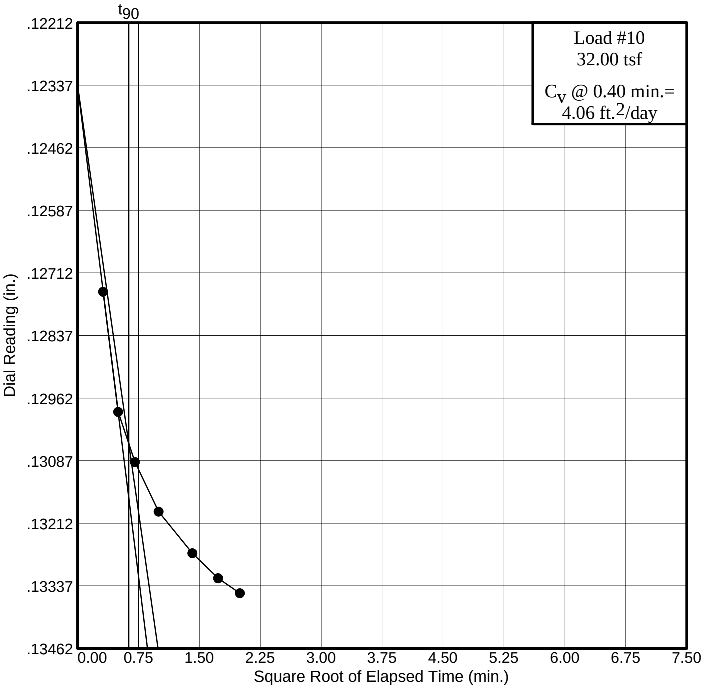
Bainbridge Island, WA

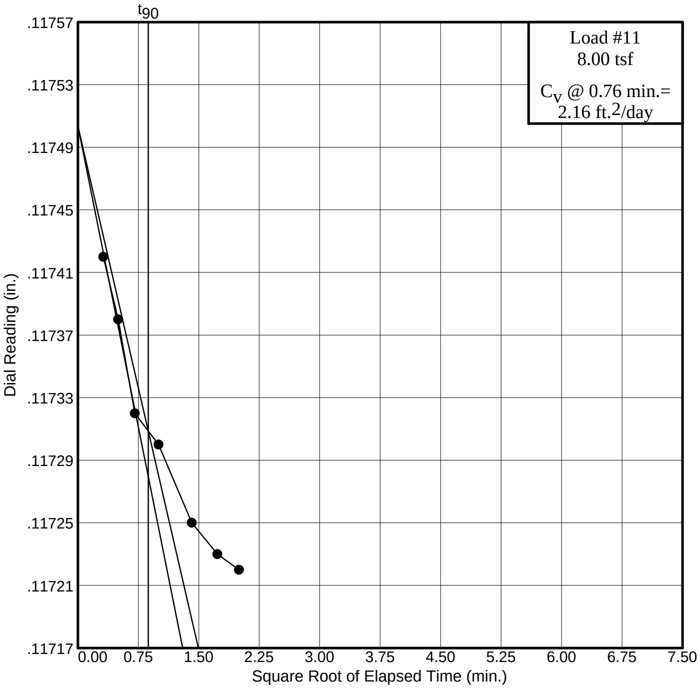
Figure 4

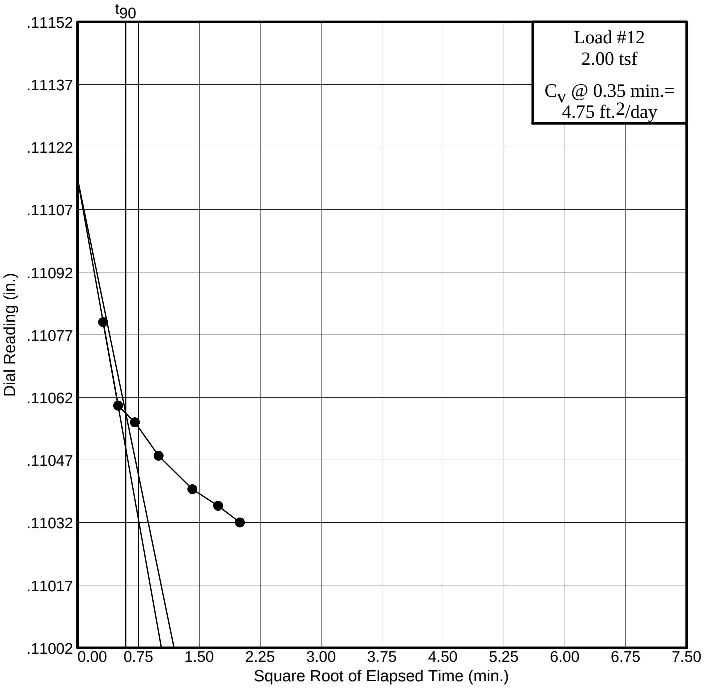
Dial Reading vs. Time

Project No.: J-09-2310
Project: Burlington Levee
Project No. 093-93153
Source: GB-24 Elev./Depth: 13.3-13.4 ft.









SOIL TECHNOLOGY

Bainbridge Island, WA

Figure 5

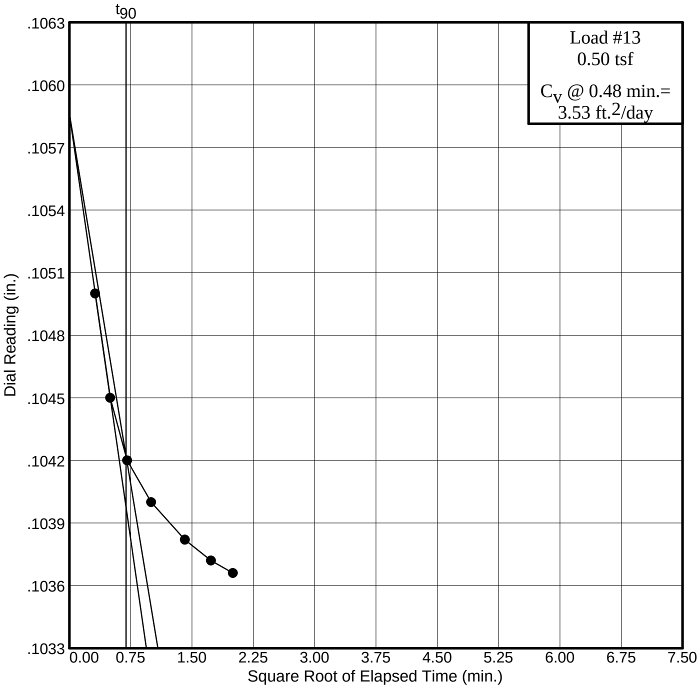
Dial Reading vs. Time

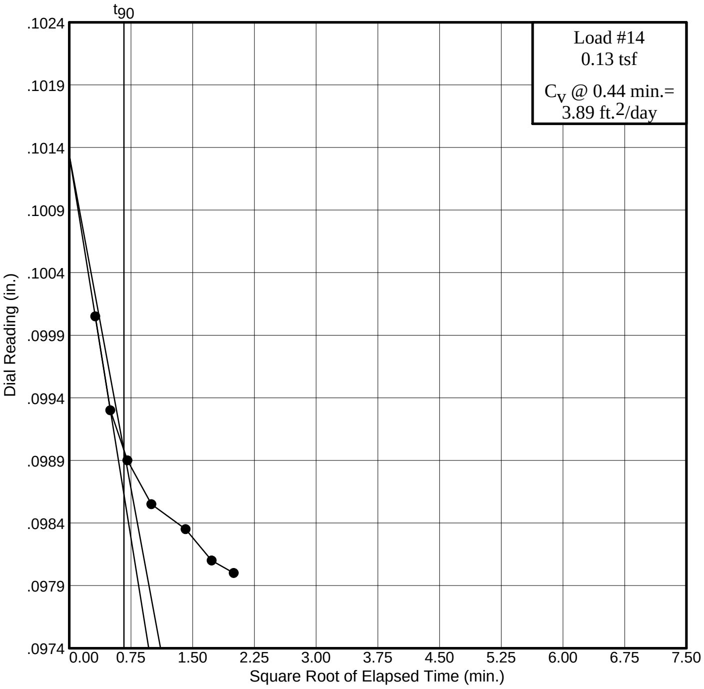
Project No.: J-09-2310

Project: Burlington Levee
Project No. 093-93153

Source: GB-24

Elev./Depth: 13.3-13.4 ft.





SOIL TECHNOLOGY

Bainbridge Island, WA

Figure 6

APPENDIX B-5

HYDRAULIC CONDUCTIVITY ASSESSMENT

Hydraulic Conductivity Analysis Using the Hazen Method

Exploration Number	Depth (feet)	d_{10}	Hazen	
			K^1 (cm/s)	K^1 (ft/day)
GB-1	60	0.09	0.062	176.4
GB-3	30	0.02	0.00032	0.91843
GB-4	25	0.02	0.00029	0.81921
GB-5	30	0.15	0.023	65.3
GB-8	2.5	0.01	0.00014	0.40819
GB-9	30	0.30	0.091	257.9
GB-13	50	0.25	0.062	176.4
GB-21	65	0.15	0.022	62.8
GB-23	17.5	0.05	0.00212	5.99811
GB-27	7.5	0.03	0.00084	2.38394

$K = d_{10}^2$

Hydraulic Conductivity Analysis Using the Massmann Method

Exploration Number	Depth (feet)	d_{10}	d_{60}	d_{90}	f_{fines}	Massmann	
						K^1 (cm/s)	K^1 (ft/day)
GB-1	60	0.09	0.31	0.67	6.75	0.0286	81.19
GB-3	30	0.02	0.06	0.13	66.91	0.0012	3.34
GB-4	25	0.02	0.06	0.14	66.52	0.0012	3.39
GB-5	30	0.15	0.66	1.68	3.16	0.0437	123.93
GB-8	2.5	0.01	0.11	2.62	51.92	0.0022	6.21
GB-9	30	0.30	1.01	2.55	1.35	0.0906	256.76
GB-13	50	0.25	1.65	8.35	5.25	0.0514	145.66
GB-21	65	0.15	2.76	8.61	5.03	0.0345	97.75
GB-23	17.5	0.05	0.12	0.27	32.76	0.0068	19.37
GB-27	7.5	0.03	0.10	0.25	51.01	0.0026	7.50

$\log_{10}(K) = -1.57 + 1.90(d_{10}) + 0.015(d_{60}) - 0.013(d_{90}) - 2.08(f_{fines})$

APPENDIX C

ENGINEERING ANALYSIS – STATIC STABILITY

APPENDIX C-1

SECTION A-A’ ANALYSIS

Golder Associates

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.: 093-93153		Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

<u>Parameter selection summary sheet for design cross-section:</u> A-A'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

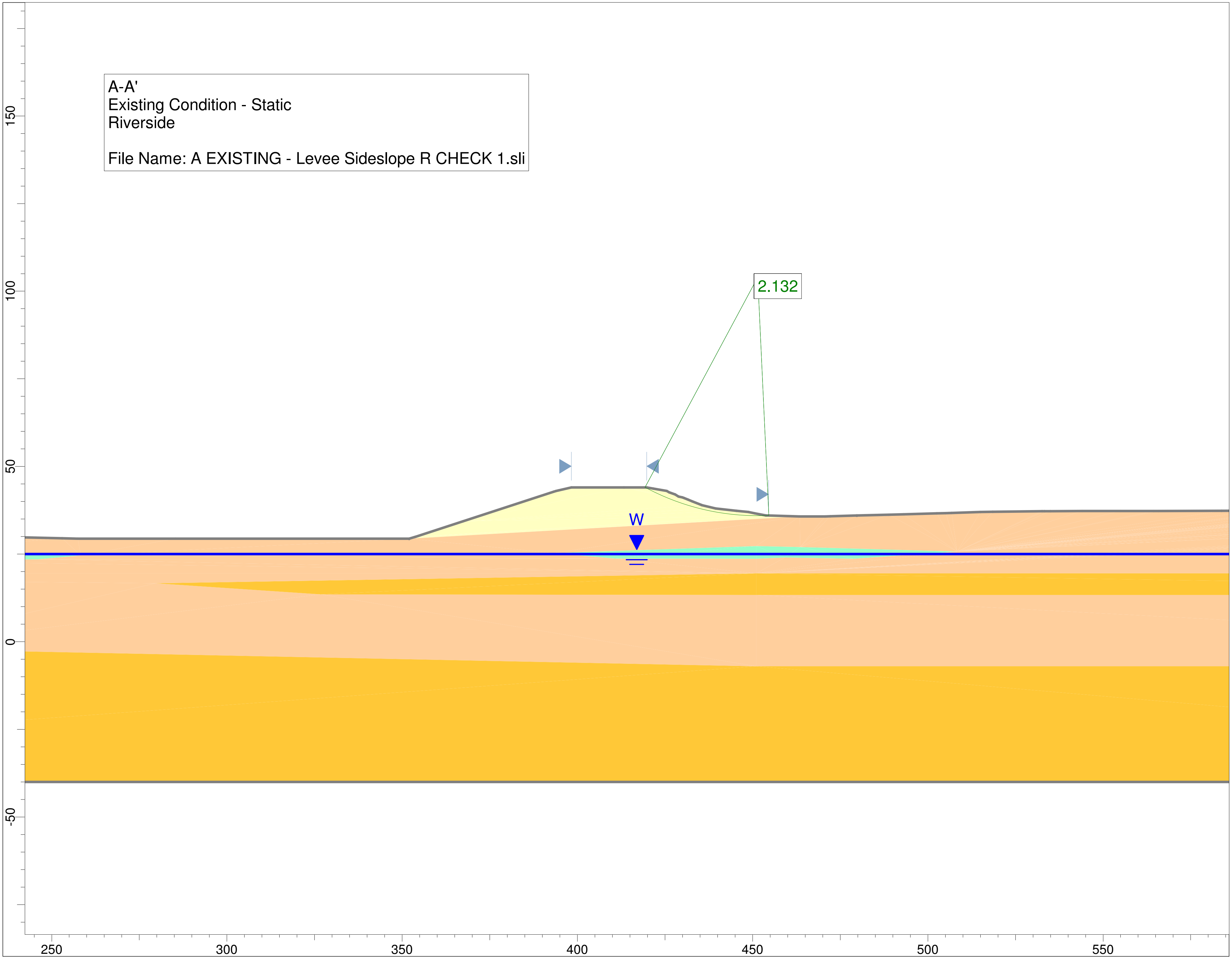
Cross-section ID: A-A'
Alignment Stationing: 235+96
SPT/CPT IDs: GB-1, GB-2, CPT-1
Elevation of GWT[1]: 25 ft

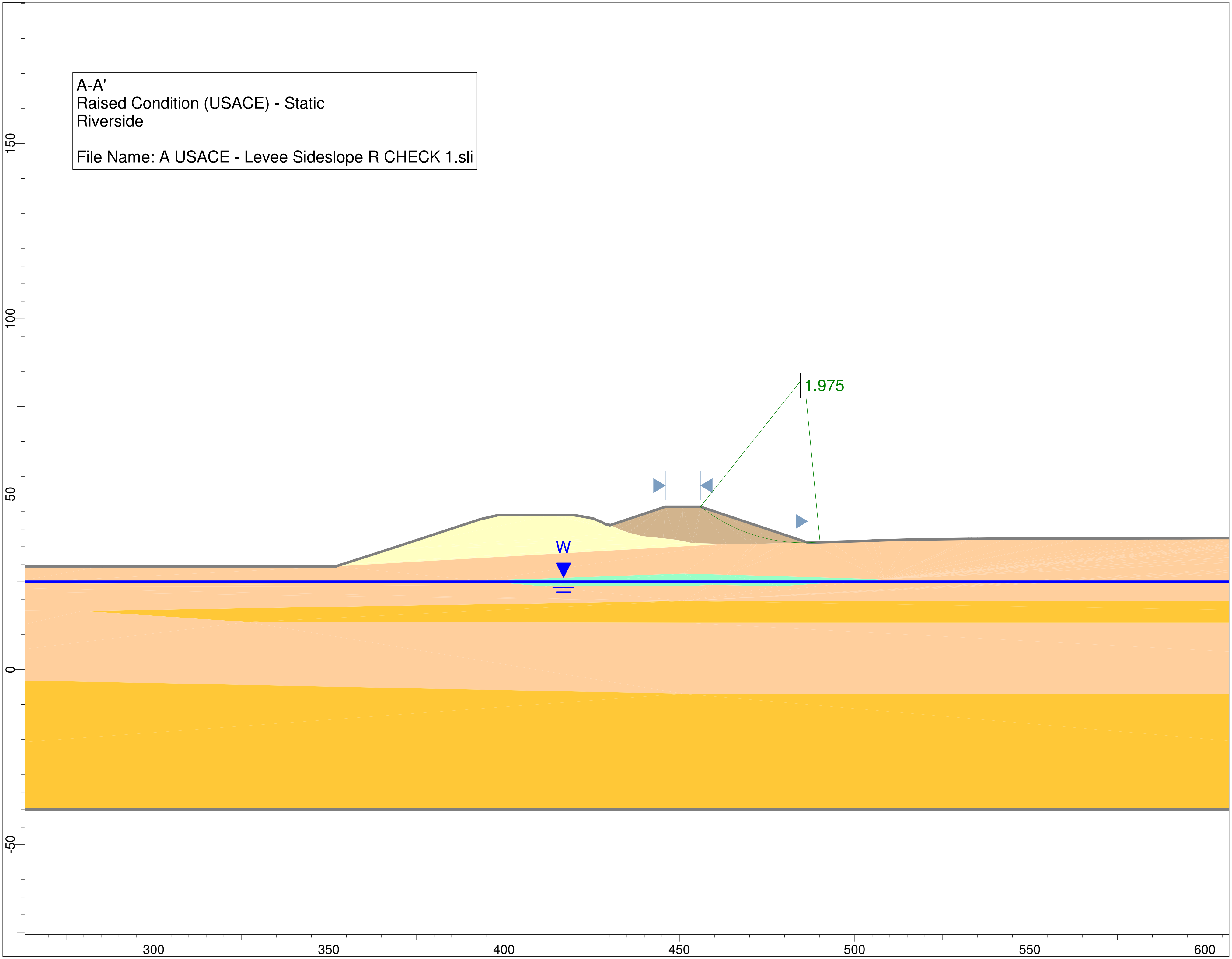
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GM, SM	120	28	0
Overbank Deposits	SM, SP-SM, ML	120	28	0
Quiet-Water Deposits	ML	115	26	0
Channel Deposits	SP, SP-SM	125	35	0

1 Depth to groundwater interpolated from groundwater reading in GB-3 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39

A-A'
Existing Condition - Static
Riverside

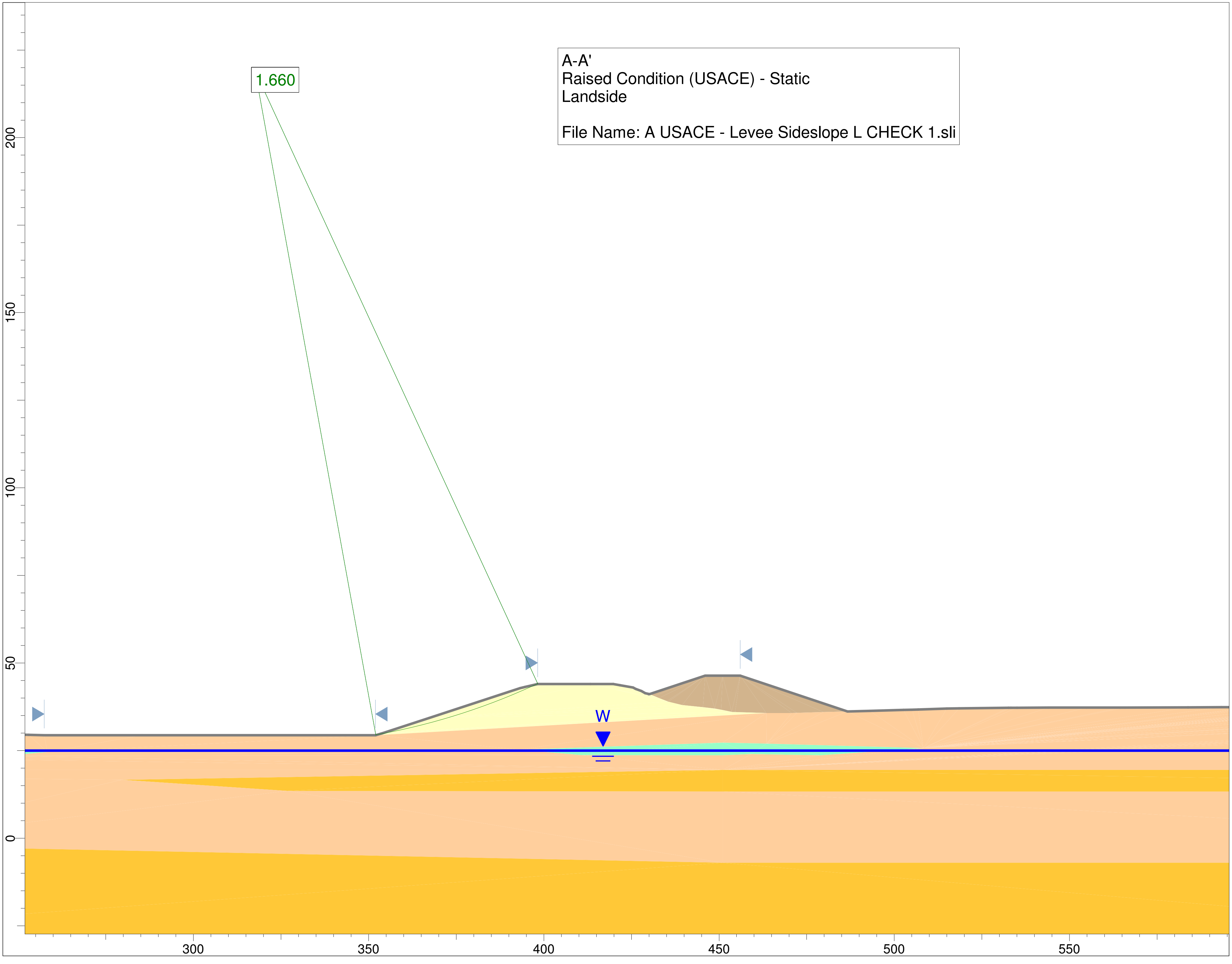
File Name: A EXISTING - Levee Sideslope R CHECK 1.sli





A-A'
Raised Condition (USACE) - Static
Riverside

File Name: A USACE - Levee Sideslope R CHECK 1.sli


1.660
A-A'
Raised Condition (USACE) - Static
Landside
File Name: A USACE - Levee Sideslope L CHECK 1.sli
W
200
150
100
50
0
300
350
400
450
500
550

APPENDIX C-2

SECTION B-B’ ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.: 093-93153	Made by:	SJM	Date:	6/8/2009	
Extender:	Checked by:		Sheet:	as marked	
Phase:	Reviewed by:				

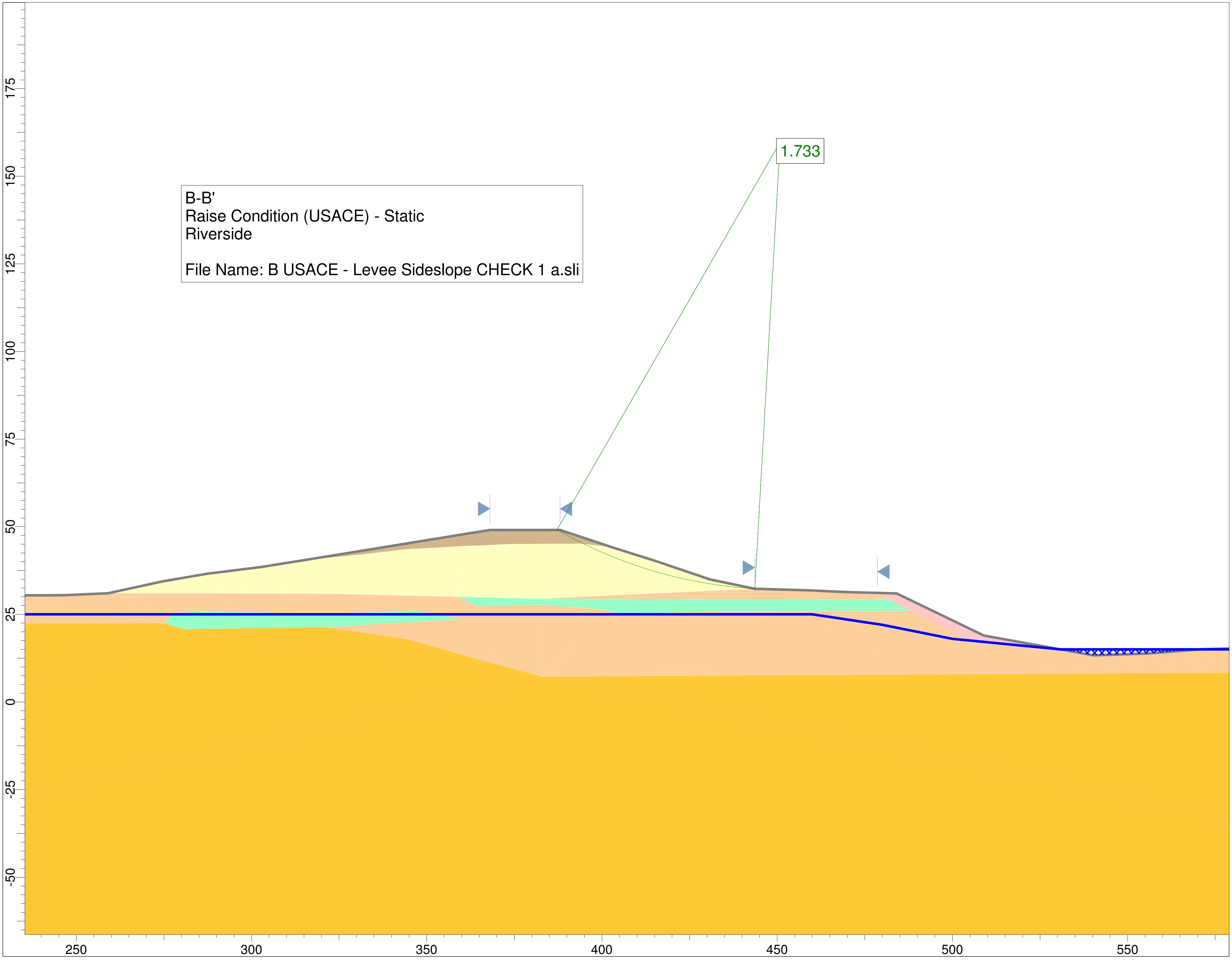
Parameter selection summary sheet for design cross-section: B-B'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: B-B'
Alignment Stationing: 211+25
SPT/CPT IDs: GB-4, CPT-2
Elevation of GWT[1]: 25 ft

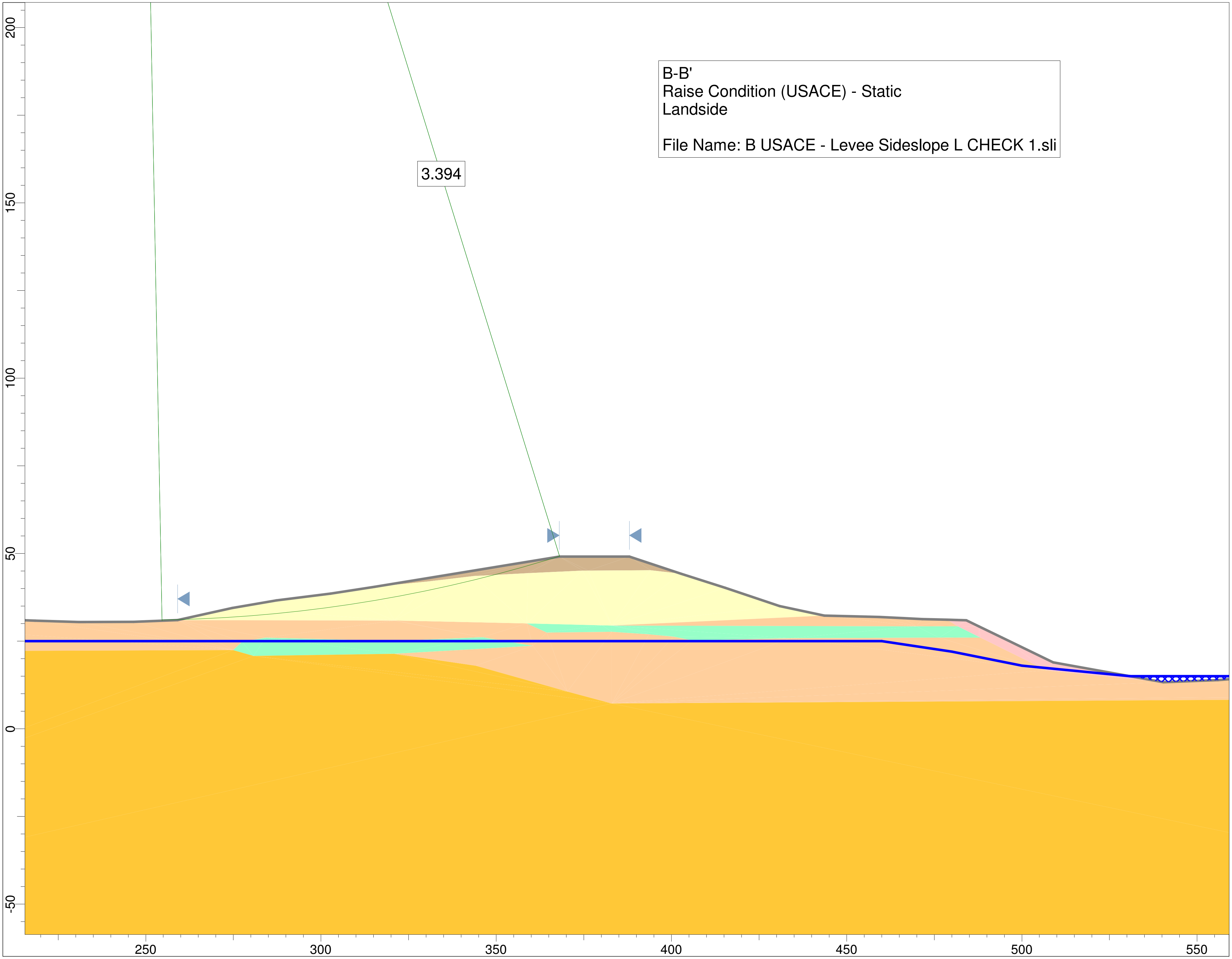
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GM, SM, SP-SM	120	28	0
Quiet-Water Deposits	ML	120	28	0
Overbank Deposits	SM, ML	120	30	0
Channel Deposits	SP	125	35	0

1 Depth to groundwater interpolated from groundwater readings in GB-3 and GB-6 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39



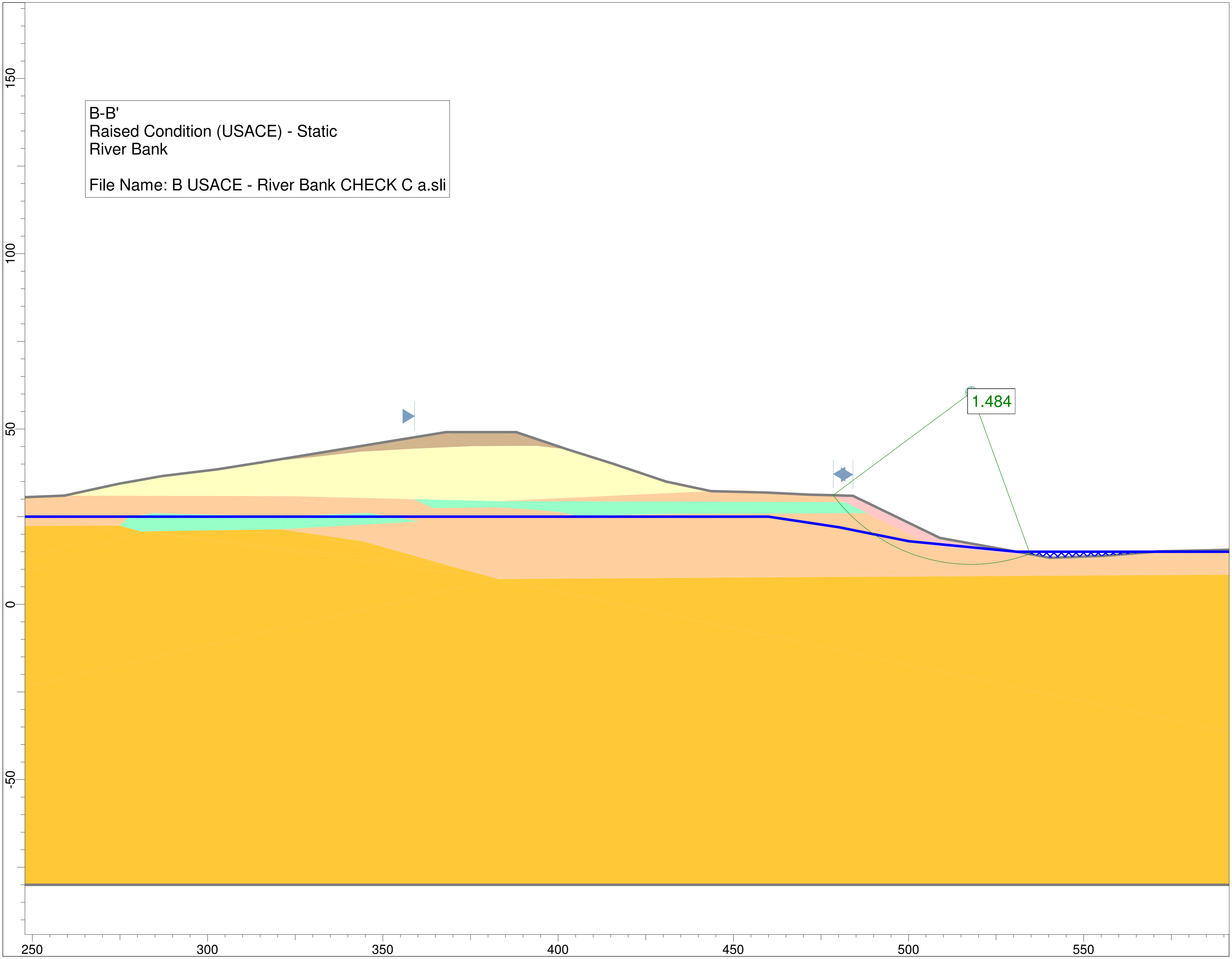
B-B'
Raise Condition (USACE) - Static
Riverside

File Name: B USACE - Levee Sideslope CHECK 1 a.sli



B-B'
Raise Condition (USACE) - Static
Landside

File Name: B USACE - Levee Sideslope L CHECK 1.sli



B-B'
Raised Condition (USACE) - Static
River Bank

File Name: B USACE - River Bank CHECK C a.sli

APPENDIX C-3

SECTION C-C’ ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.: 093-93153	Made by:	SJM	Date:	6/8/2009	
Extender:	Checked by:		Sheet:	as marked	
Phase:	Reviewed by:				

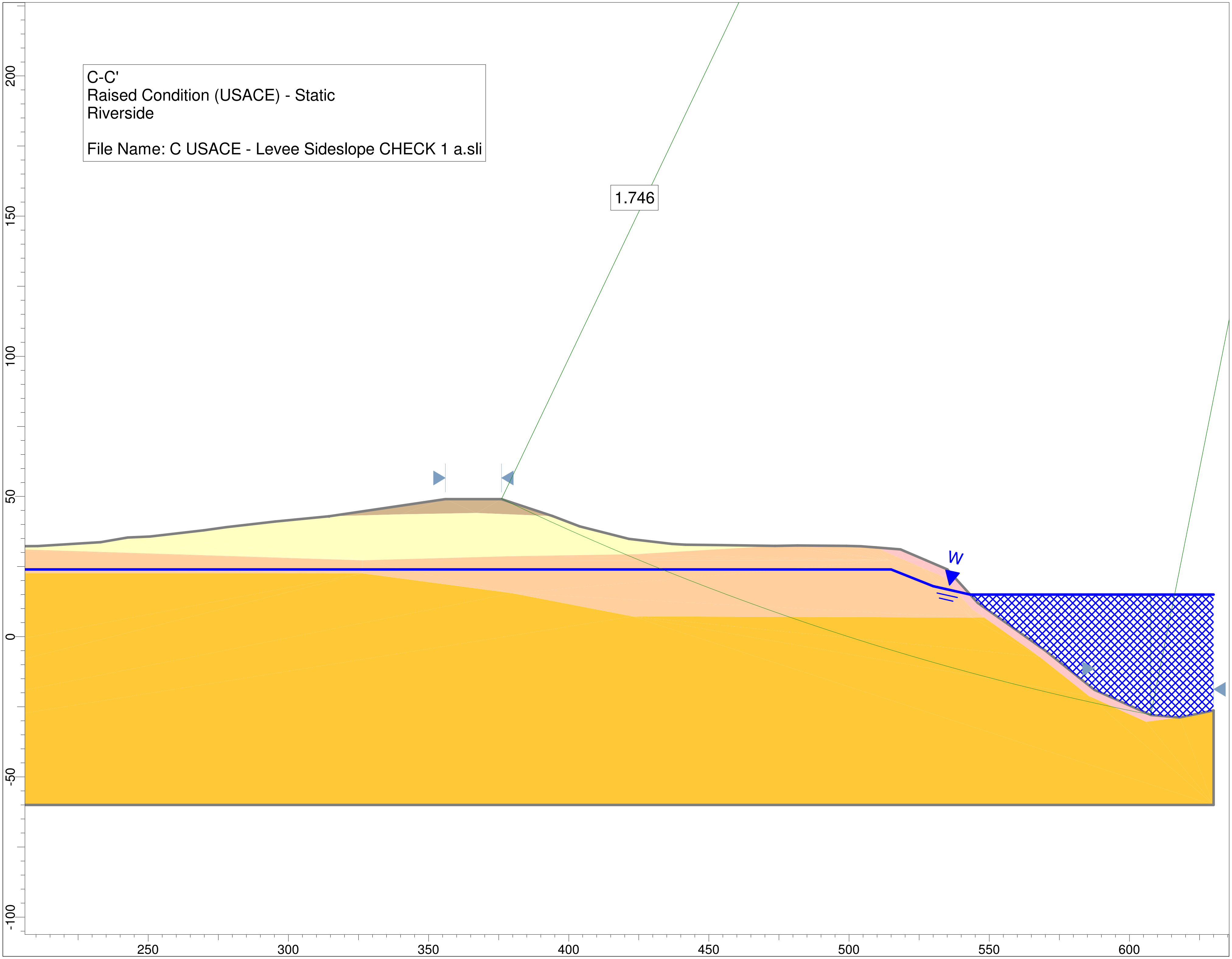
Parameter selection summary sheet for design cross-section: C-C'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: C-C'
Alignment Stationing: 206+92
SPT/CPT IDs: CPT-2, GB-5, GB-4
Elevation of GWT[1]**:** 24 ft

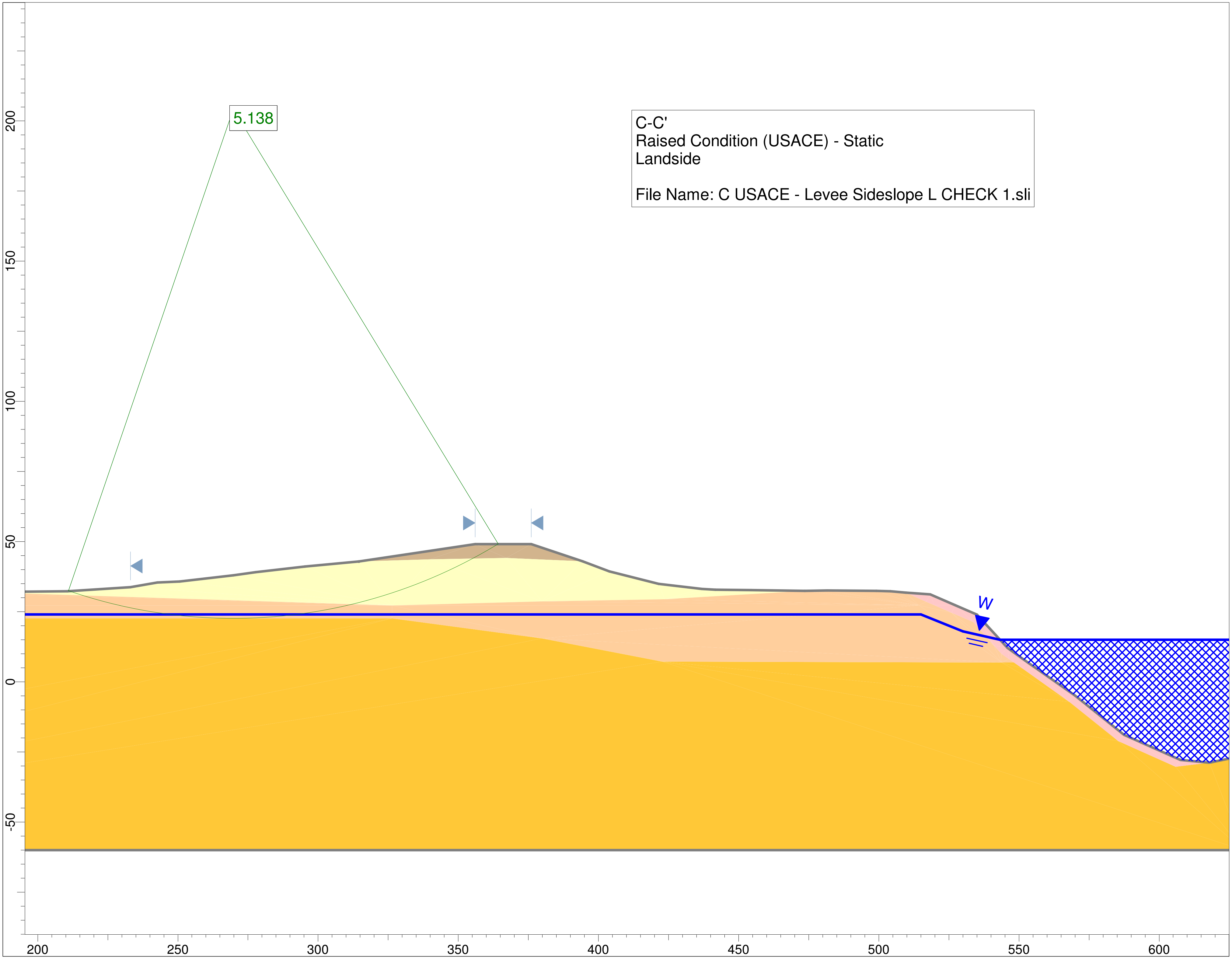
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GM, SM, SP-SM	120	33	0
Overbank Deposits	SM, ML	120	28	0
Channel Deposits	SW, SP	125	35	0

1 Depth to groundwater interpolated from groundwater readings in GB-3 and GB-6 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39



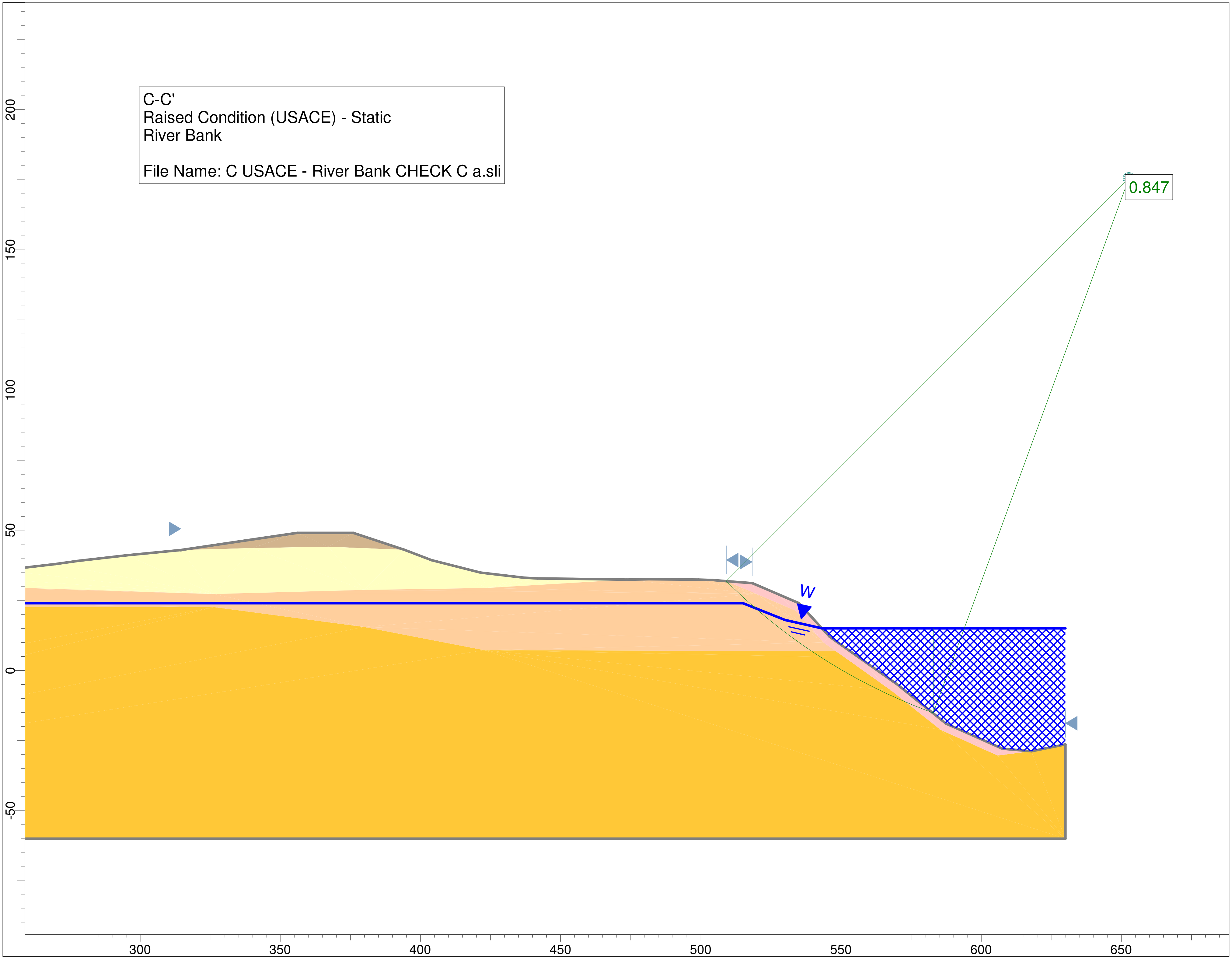
C-C'
Raised Condition (USACE) - Static
Riverside

File Name: C USACE - Levee Sideslope CHECK 1 a.sli



C-C'
Raised Condition (USACE) - Static
Landside

File Name: C USACE - Levee Sideslope L CHECK 1.sli


C-C'
Raised Condition (USACE) - Static
River Bank

File Name: C USACE - River Bank CHECK C a.sli
0.847
W
200
150
100
50
0
-50
300
350
400
450
500
550
600
650

APPENDIX C-4

SECTION D-D’ ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.: 093-93153	Made by:	SJM	Date:	6/8/2009	
Extender:	Checked by:		Sheet:	as marked	
Phase:	Reviewed by:				

Parameter selection summary sheet for design cross-section: D-D'

Description:

This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: D-D'

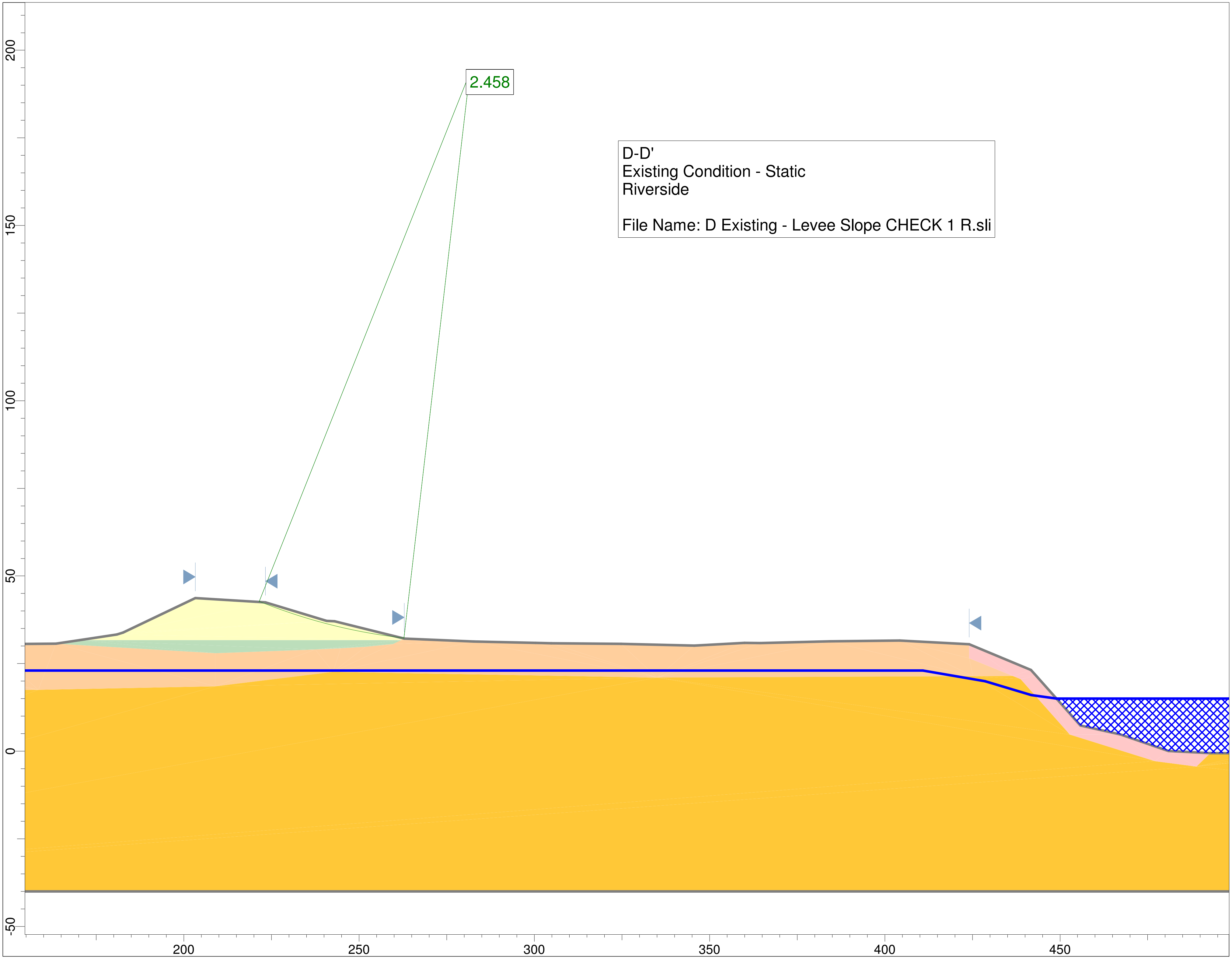
Alignment Stationing: 189+08

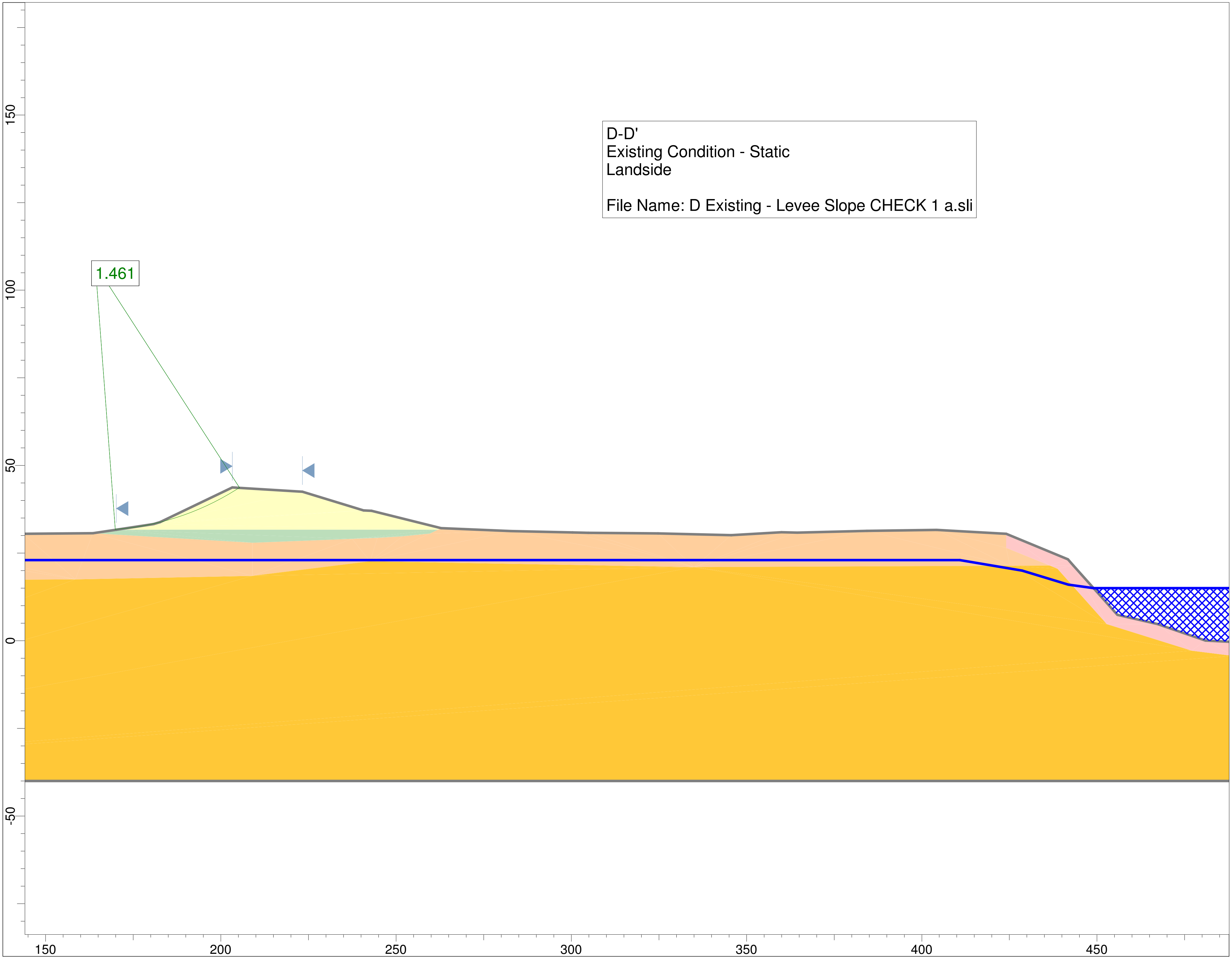
SPT/CPT IDs: GB-6, CPT-3

Elevation of GWT[1]: 23 ft

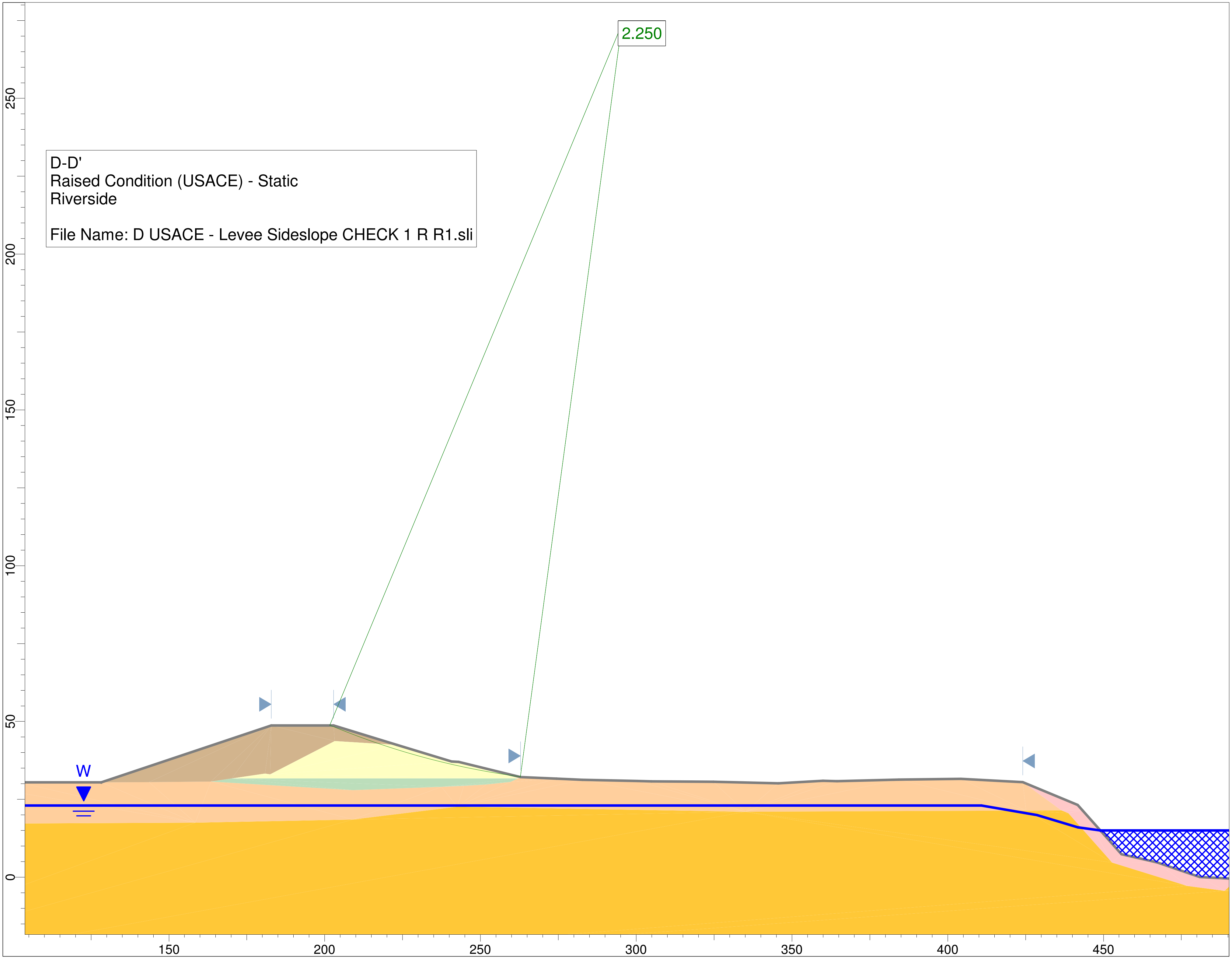
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill 1	GM, SM	120	32	0
Existing Fill 2	SM, ML	120	30	0
Overbank Deposits	ML	115	28	0
Channel Deposits	SM	125	34	0

1 Depth to groundwater interpolated from groundwater readings in GB-6 and GB-10 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39

2.458
D-D'
Existing Condition - Static
Riverside
File Name: D Existing - Levee Slope CHECK 1 R.sli
200
150
100
50
0
-50
200
250
300
350
400
450

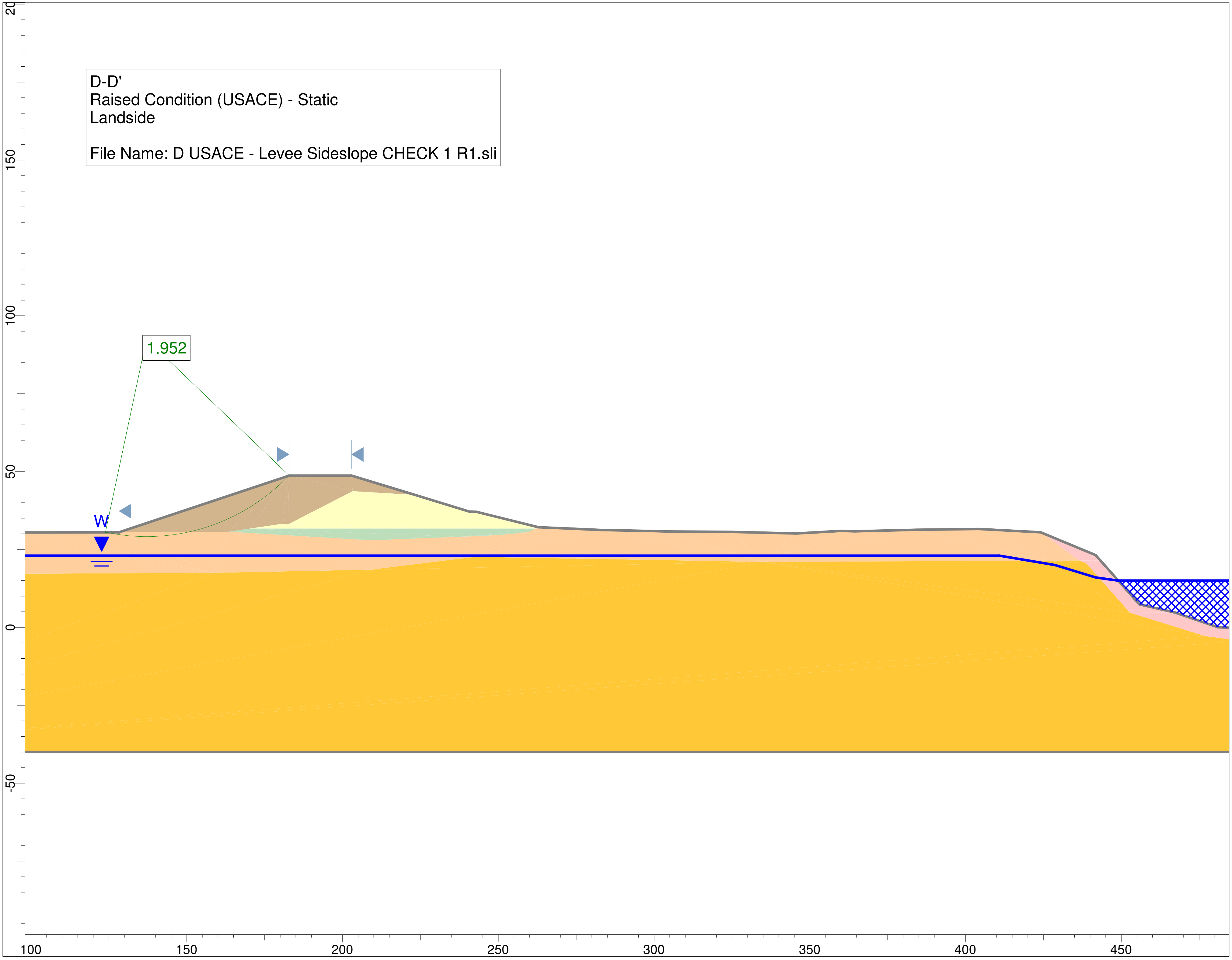

D-D'
Existing Condition - Static
Landside

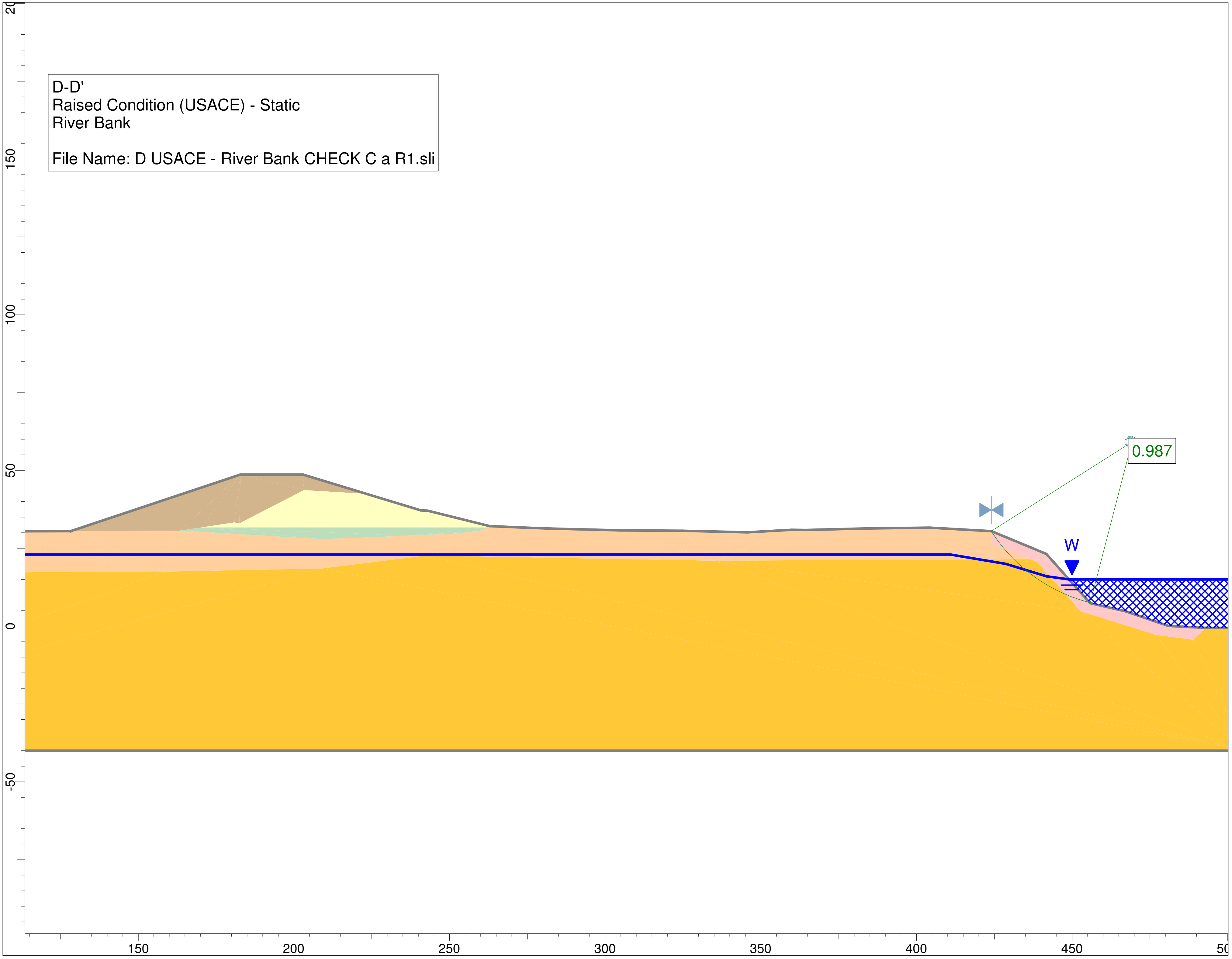
File Name: D Existing - Levee Slope CHECK 1 a.sli
1.461
150
100
50
0
-50
150
200
250
300
350
400
450



D-D'
Raised Condition (USACE) - Static
Riverside

File Name: D USACE - Levee Sideslope CHECK 1 R R1.sli


D-D'
Raised Condition (USACE) - Static
Landside
File Name: D USACE - Levee Sideslope CHECK 1 R1.sli
1.952
W
20
150
100
50
0
-50
100
150
200
250
300
350
400
450


D-D'
Raised Condition (USACE) - Static
River Bank
File Name: D USACE - River Bank CHECK C a R1.sli
0.987
W
150
100
50
0
-50
150
200
250
300
350
400
450

APPENDIX C-5

SECTION E-E' ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.: 093-93153	Made by:	SJM	Date:	6/8/2009	
Extender:	Checked by:		Sheet:	as marked	
Phase:	Reviewed by:				

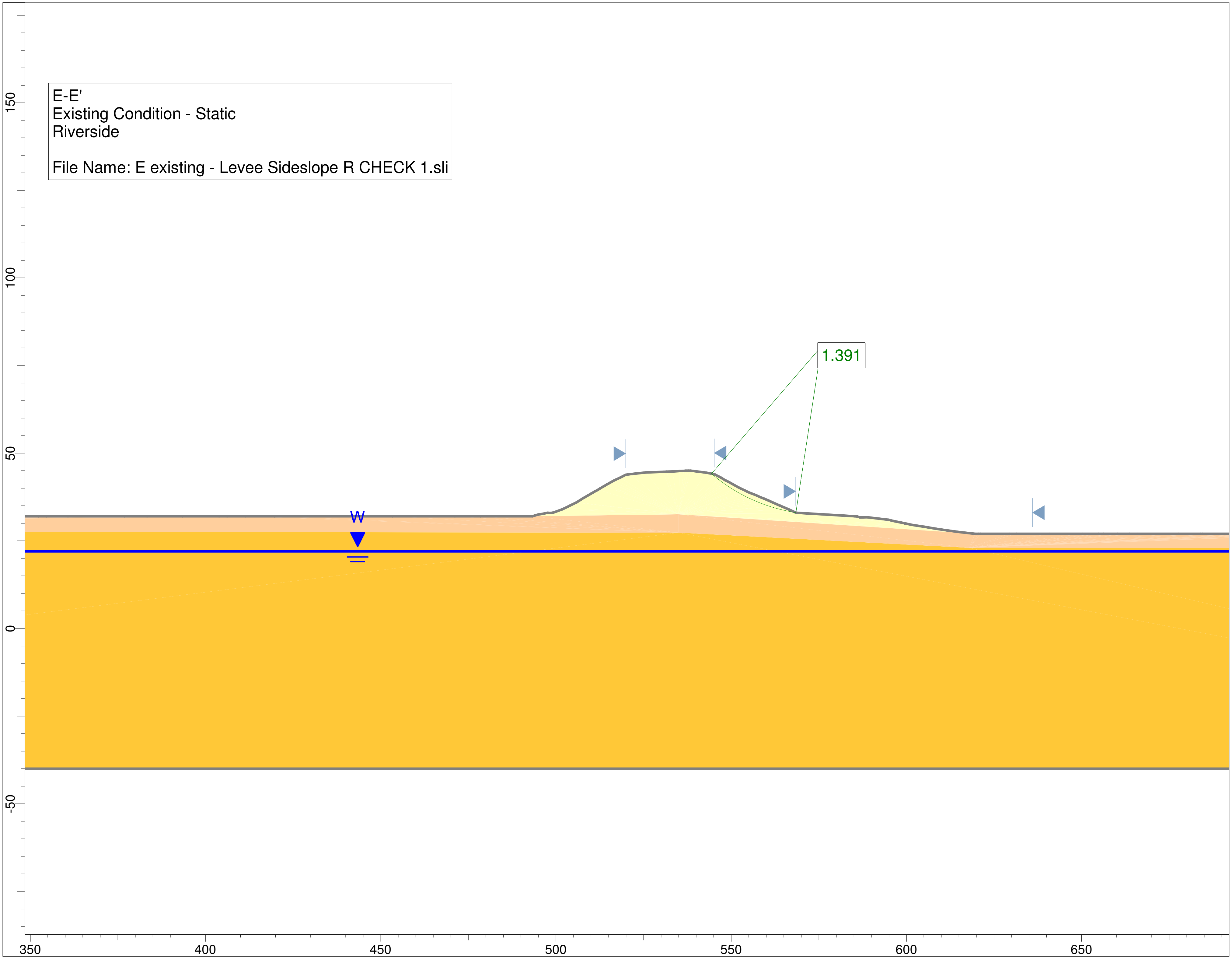
Parameter selection summary sheet for design cross-section: E-E'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: E-E'
Alignment Stationing: 172+42
SPT/CPT IDs: GB-8, CPT-4
Elevation of GWT[1]: 22 ft

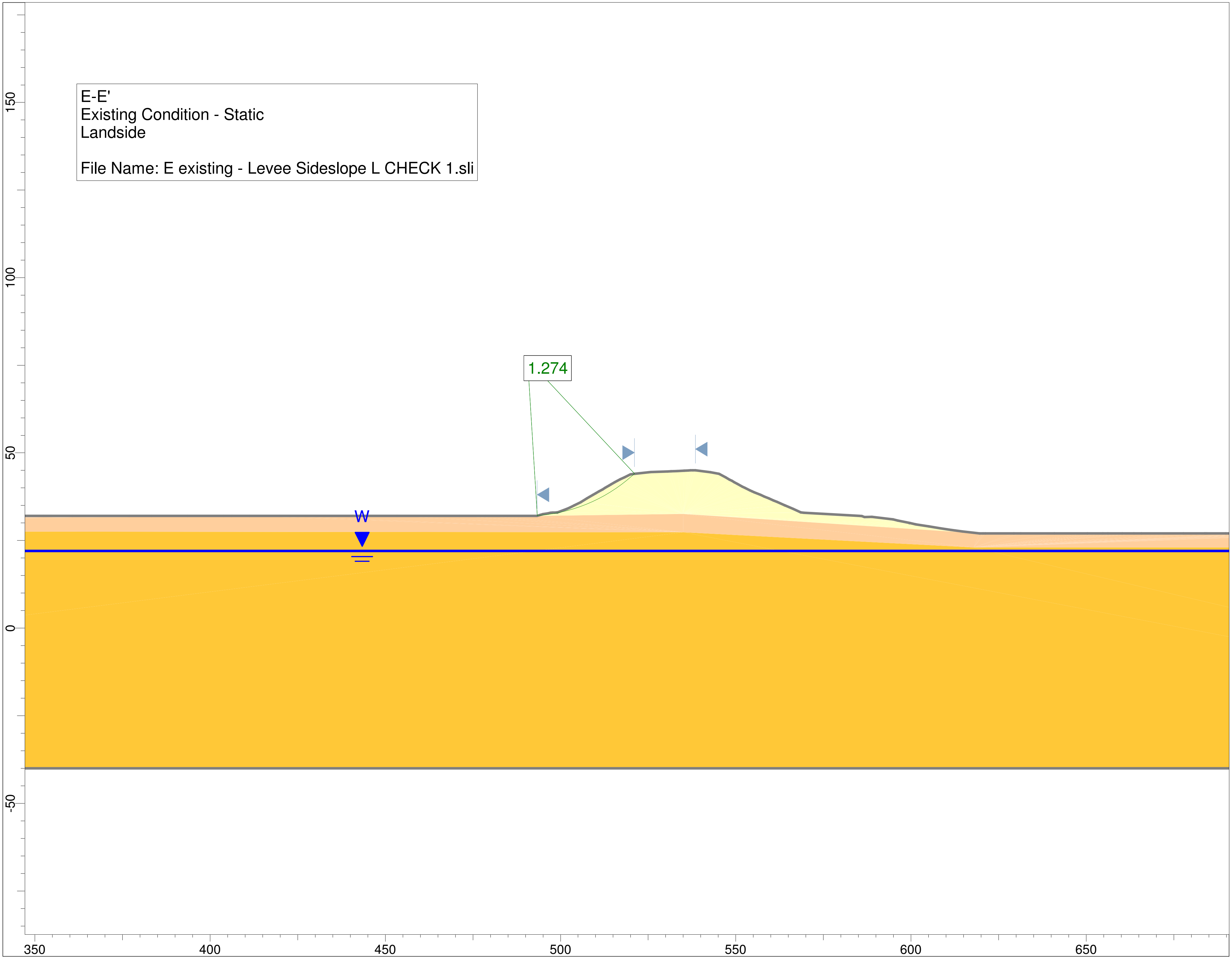
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GM, SM	125	32	0
Overbank Deposits	ML	120	30	0
Channel Deposits	SP	125	32	0

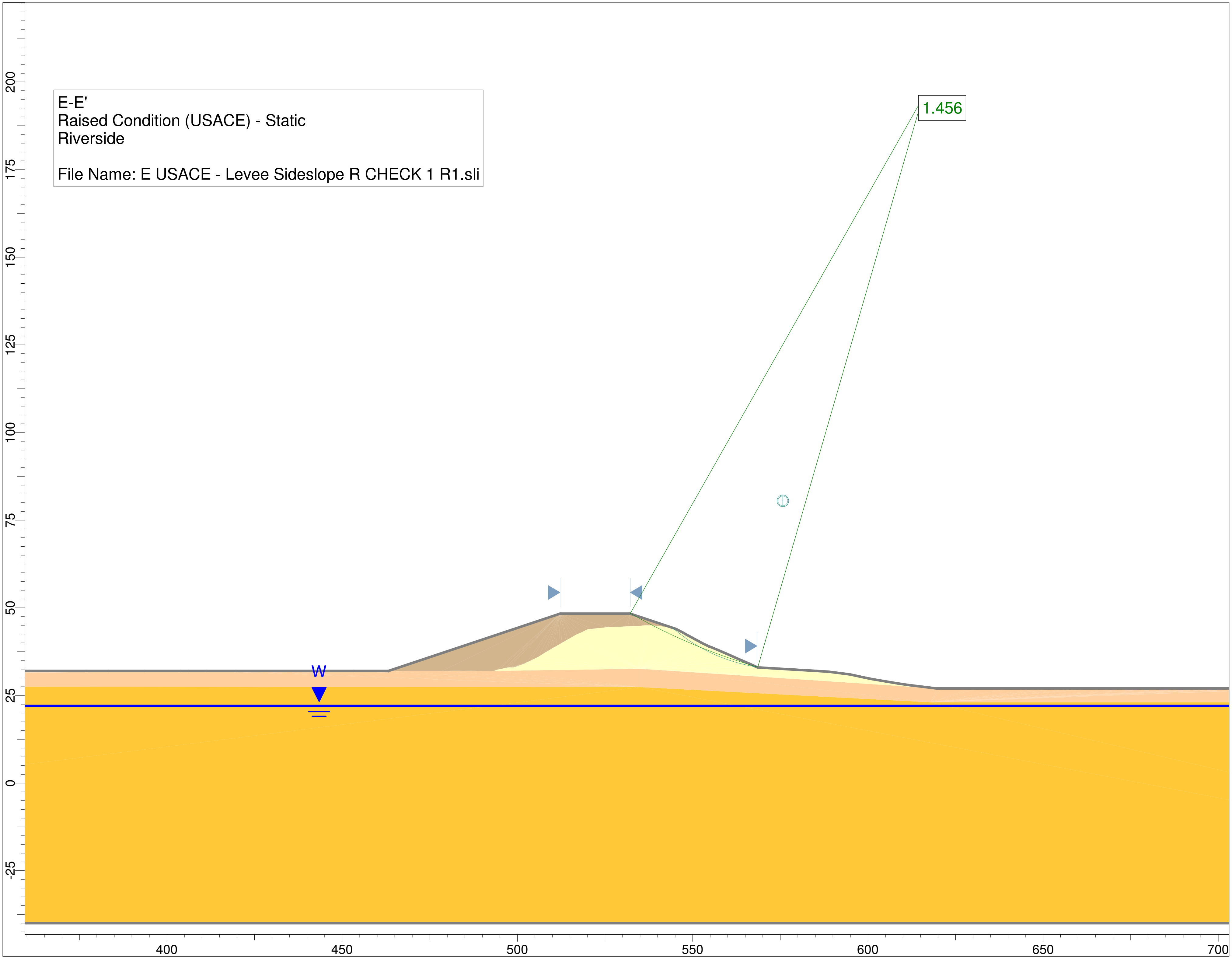
1 Depth to groundwater interpolated from groundwater readings in GB-6 and GB-10 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39


E-E'
Existing Condition - Static
Riverside
File Name: E existing - Levee Sideslope R CHECK 1.sli
1.391
W
150
100
50
0
-50
350
400
450
500
550
600
650

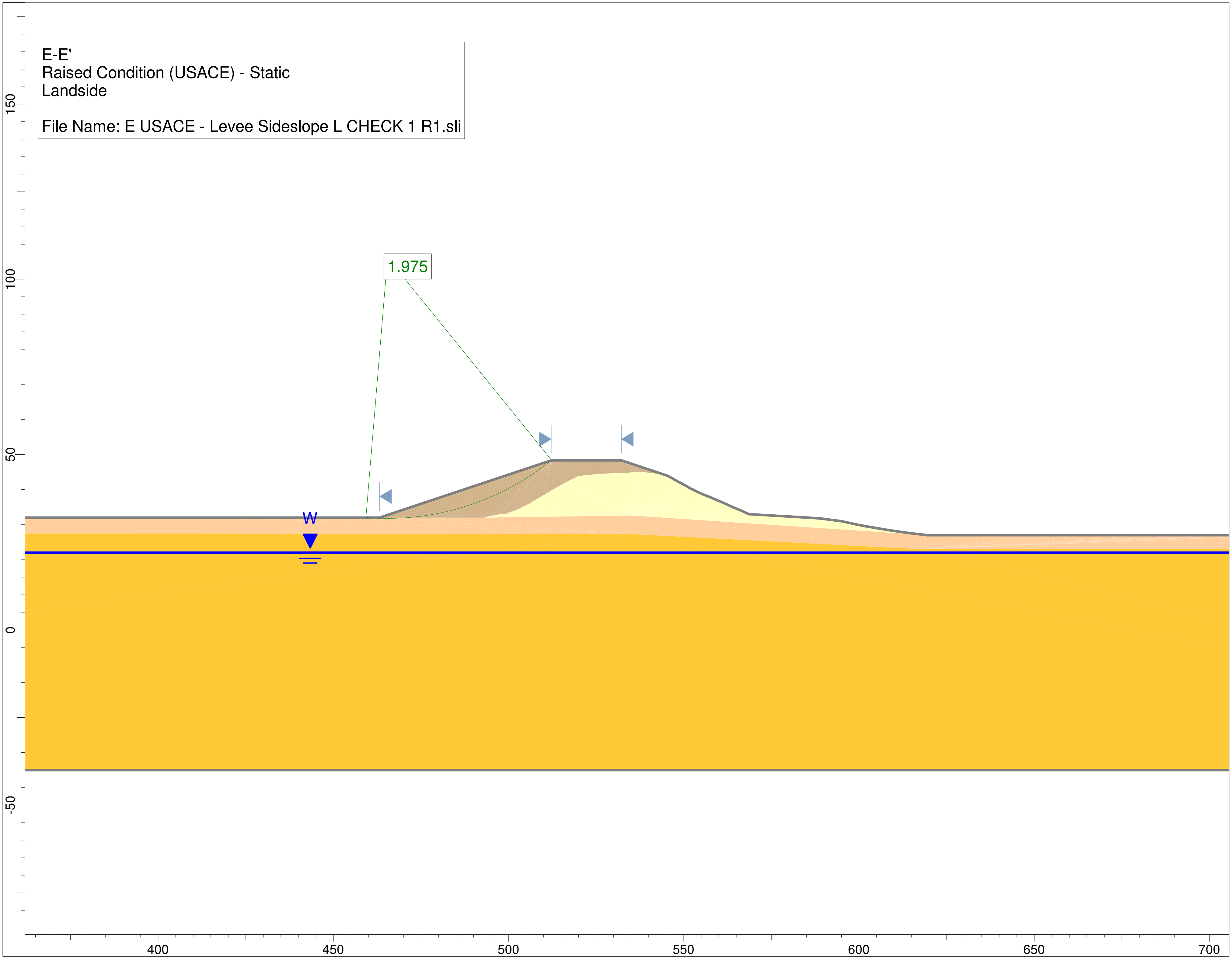
E-E'
Existing Condition - Static
Landside

File Name: E existing - Levee Sideslope L CHECK 1.sli





E-E'
Raised Condition (USACE) - Static
Riverside
File Name: E USACE - Levee Sideslope R CHECK 1 R1.sli
1.456
W
200
175
150
125
100
75
50
25
0
-25
400
450
500
550
600
650
700


E-E'
Raised Condition (USACE) - Static
Landside
File Name: E USACE - Levee Sideslope L CHECK 1 R1.sli
1.975
W
150
100
50
0
-50
400
450
500
550
600
650
700

APPENDIX C-6

SECTION F-F' ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.:	093-93153	Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

Parameter selection summary sheet for design cross-section: F-F'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

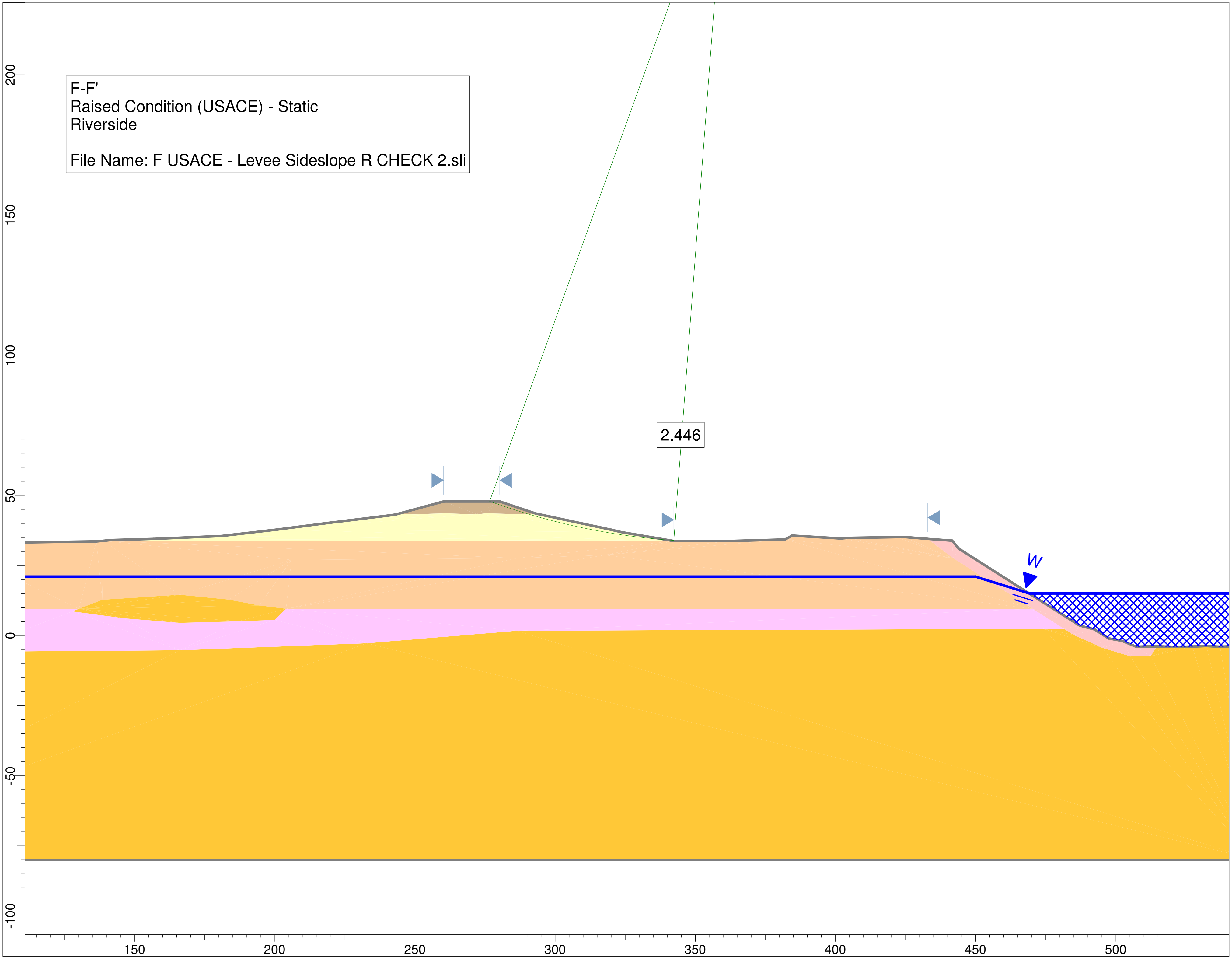
Cross-section ID: F-F'
Alignment Stationing: 130+45
SPT/CPT IDs: GB-12
Elevation of GWT[1]**:** 21 ft

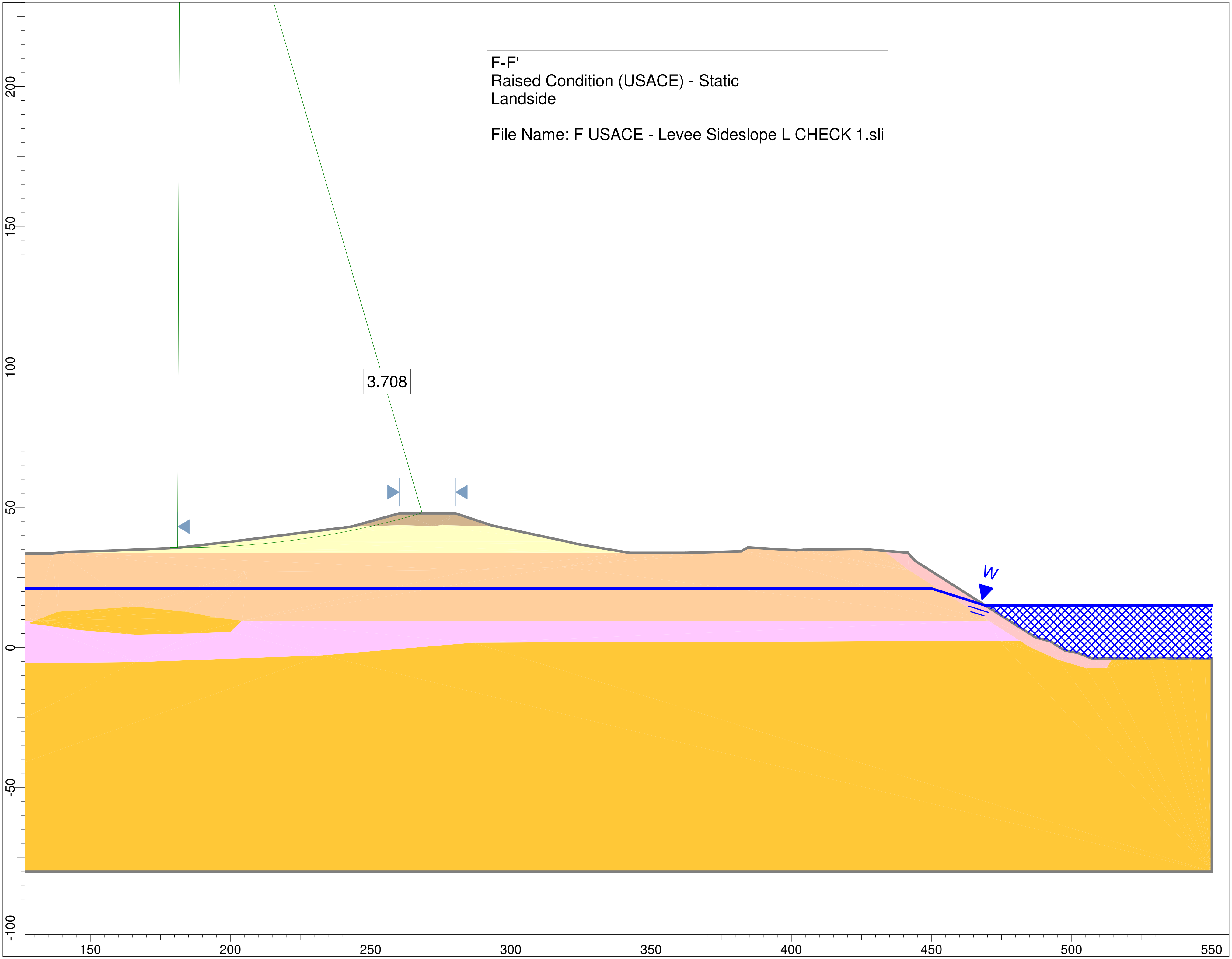
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GM, SM	120	28	0
Overbank Deposits 1	ML, SP-SM	115	28	0
Overbank Deposits 2	ML	120	30	0
Channel Deposits	SW	125	35	0

1 Depth to groundwater interpolated from groundwater readings in GB-10 and GB-14 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39

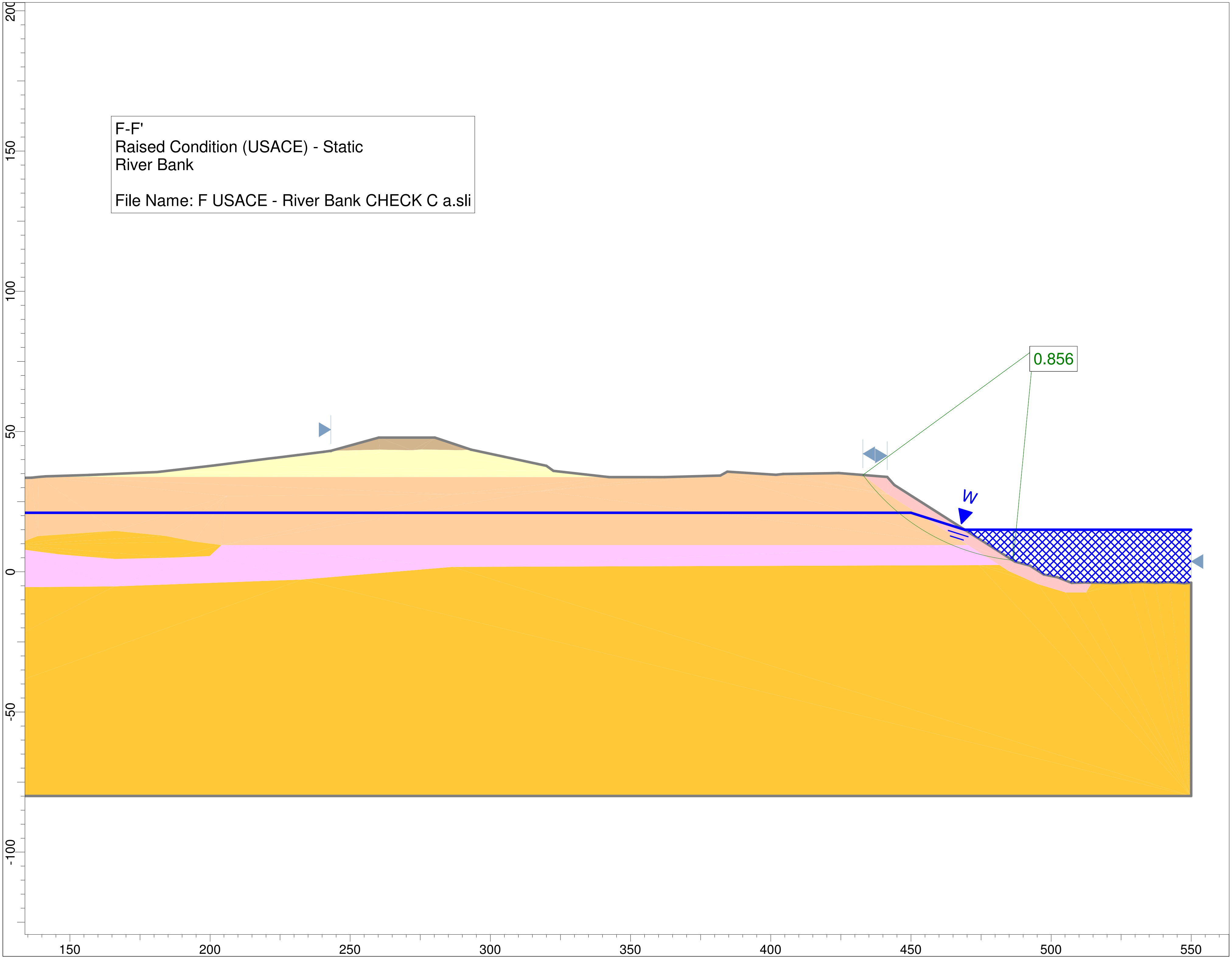
F-F'
Raised Condition (USACE) - Static
Riverside

File Name: F USACE - Levee Sideslope R CHECK 2.sli




F-F'
Raised Condition (USACE) - Static
Landside

File Name: F USACE - Levee Sideslope L CHECK 1.sli
3.708
W
200
150
100
50
0
-50
-100
150
200
250
300
350
400
450
500
550



F-F'
Raised Condition (USACE) - Static
River Bank

File Name: F USACE - River Bank CHECK C a.sli

APPENDIX C-7

SECTION G-G’ ANALYSIS

Subject:		PIE / Burlington Geotech & Levees / WA			
Job No.:	093-93153	Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

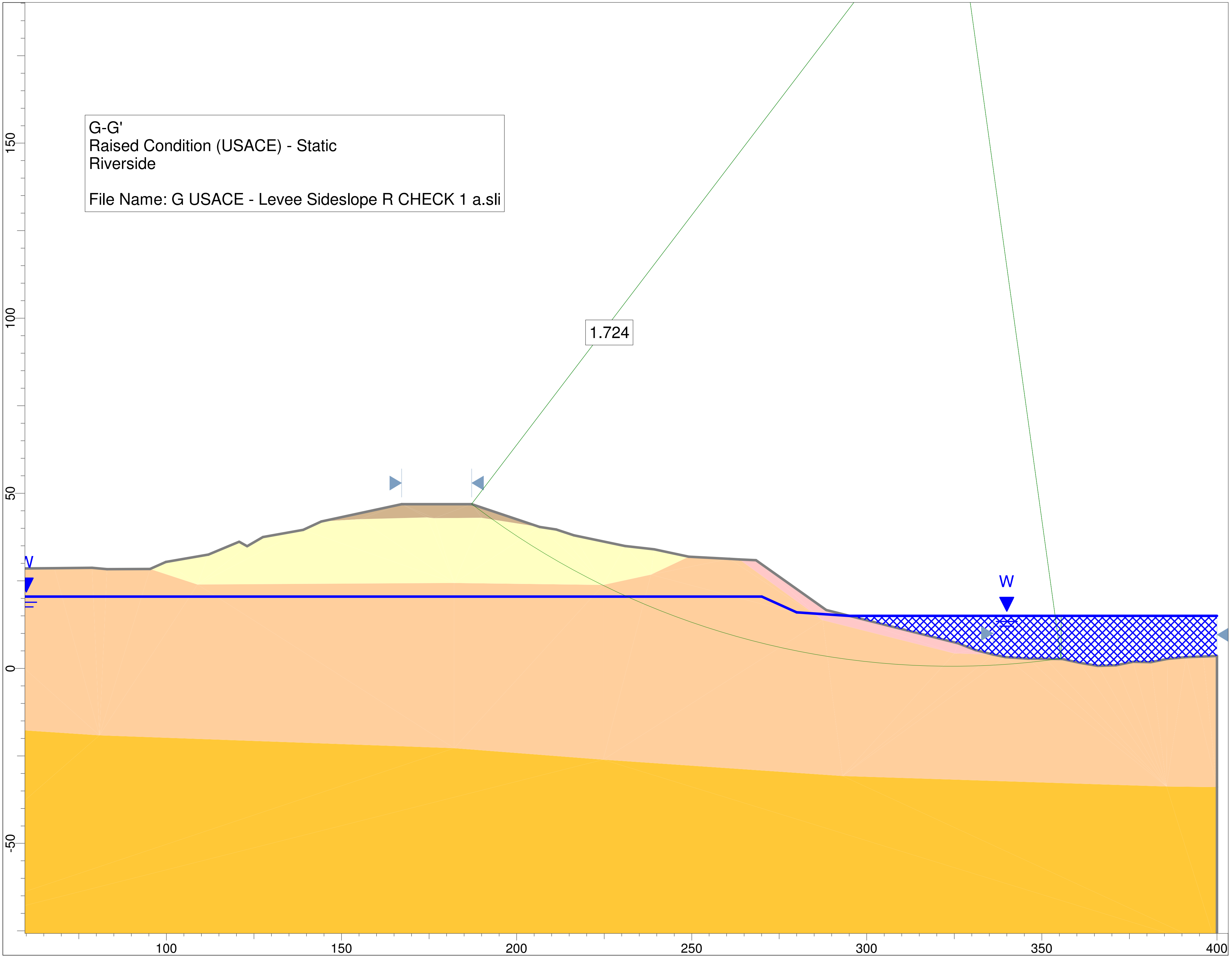
Parameter selection summary sheet for design cross-section: G-G'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: G-G'
Alignment Stationing: 102+30
SPT/CPT IDs: GB-14, CPT 6
Elevation of GWT[1]: 21 ft

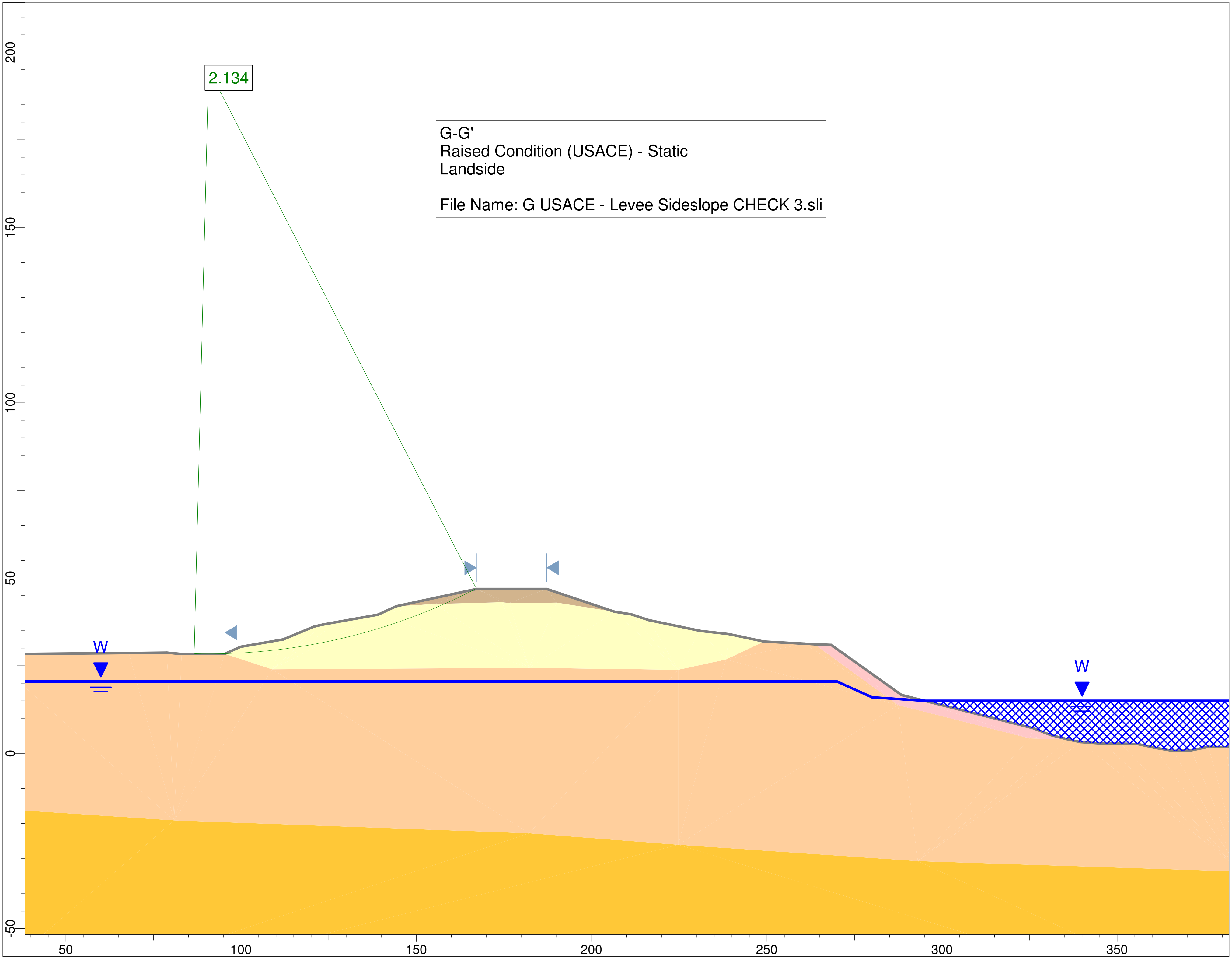
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GM, SP-SM	115	28	0
Overbank Deposits	ML, SP-SM	120	30	0
Channel Deposits	SP	125	35	0

1 Depth to groundwater interpolated from groundwater readings in GB-10 and GB-14 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39



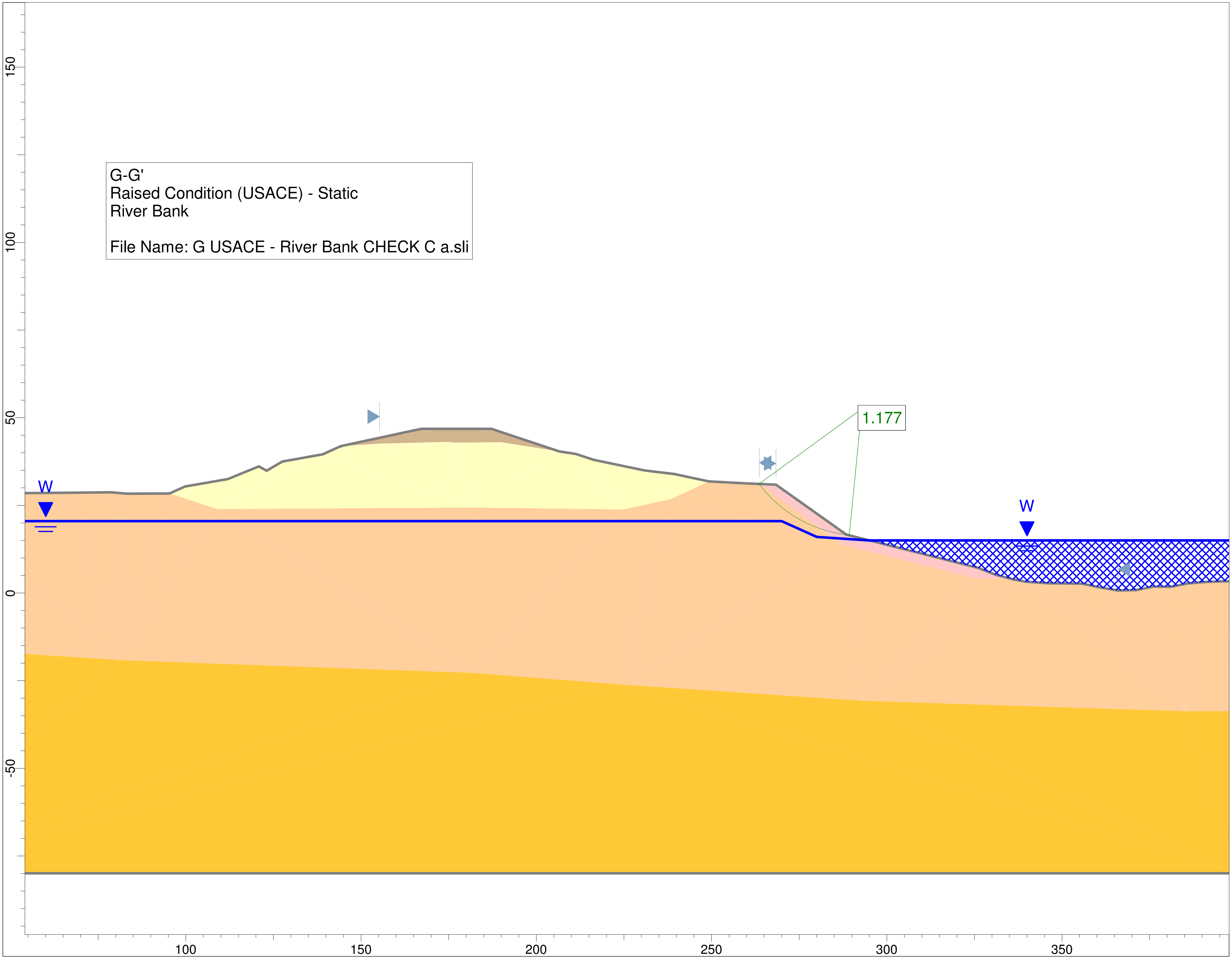
G-G'
Raised Condition (USACE) - Static
Riverside

File Name: G USACE - Levee Sideslope R CHECK 1 a.sli



G-G'
Raised Condition (USACE) - Static
Landside

File Name: G USACE - Levee Sideslope CHECK 3.sli



APPENDIX C-8

SECTION H-H’ ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.:	093-93153	Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

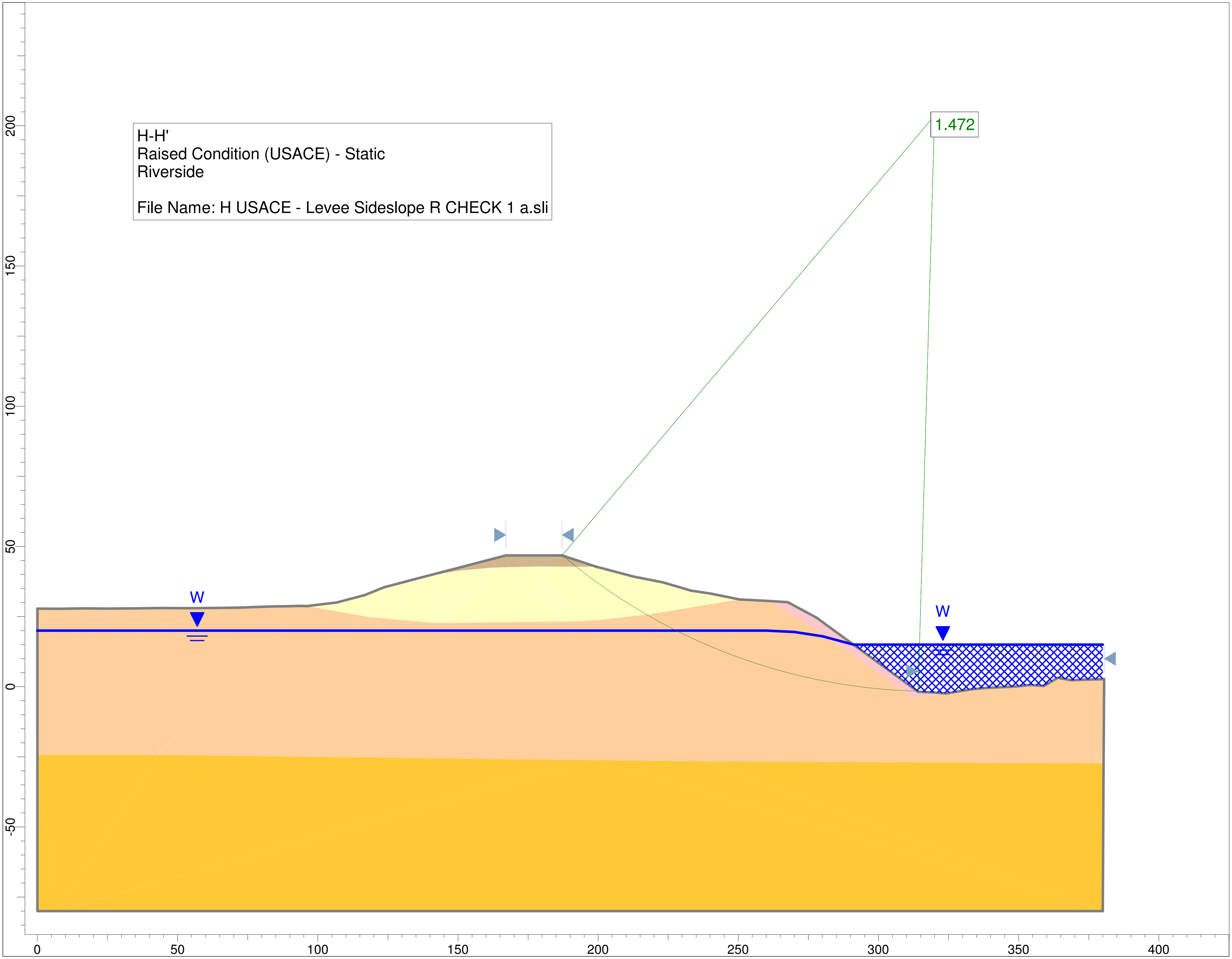
Parameter selection summary sheet for design cross-section: H-H'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: H-H'
Alignment Stationing: 99+79
SPT/CPT IDs: CPT-6, GB-14
Elevation of GWT[1]: 20 ft

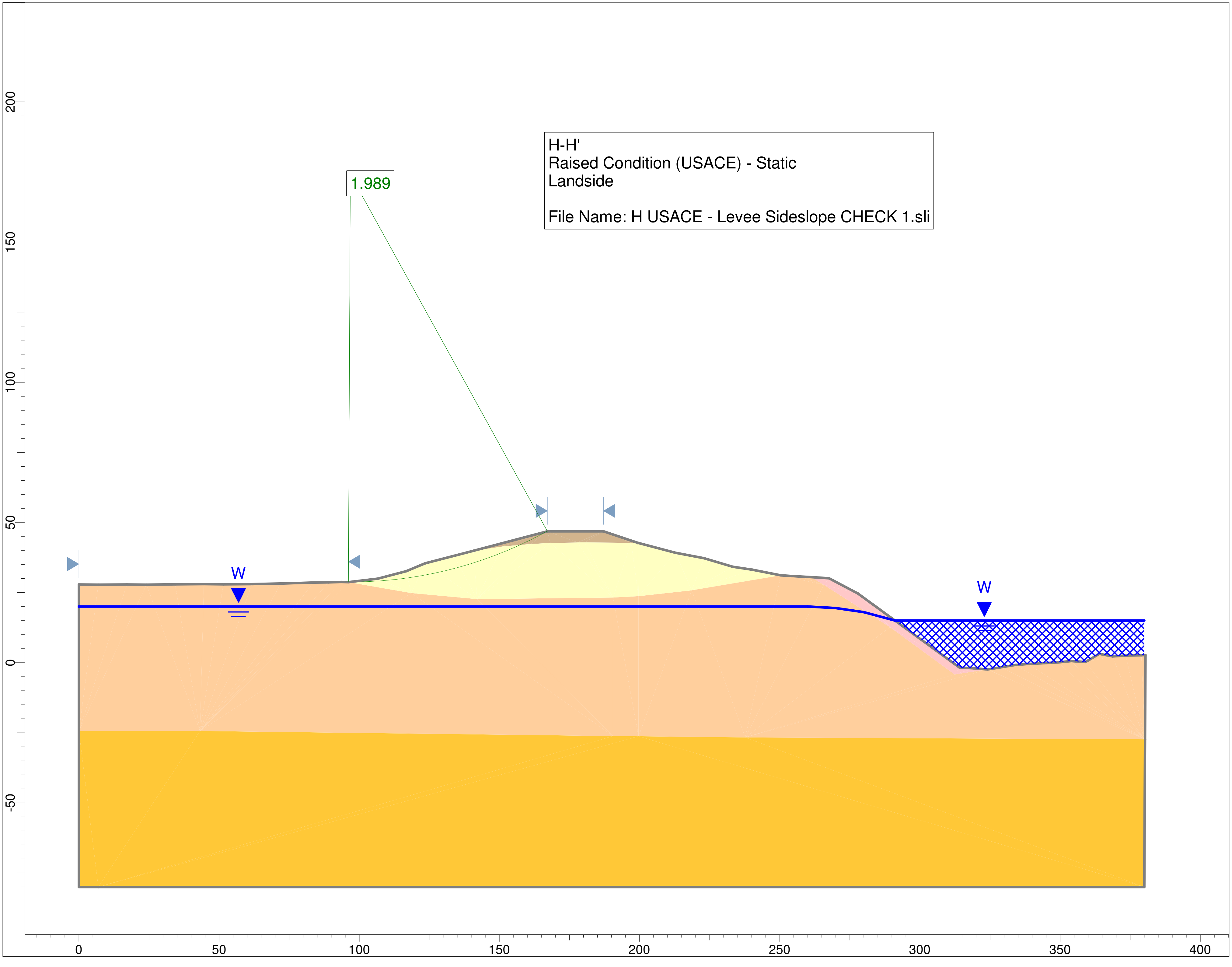
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GM, SP-SM	115	28	0
Overbank Deposits	ML, SP-SM	120	30	0
Channel Deposits	SP	125	35	0

1 Depth to groundwater interpolated from groundwater readings in GB-14 and GB-18 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39



H-H'
Raised Condition (USACE) - Static
Riverside

File Name: H USACE - Levee Sideslope R CHECK 1 a.sli

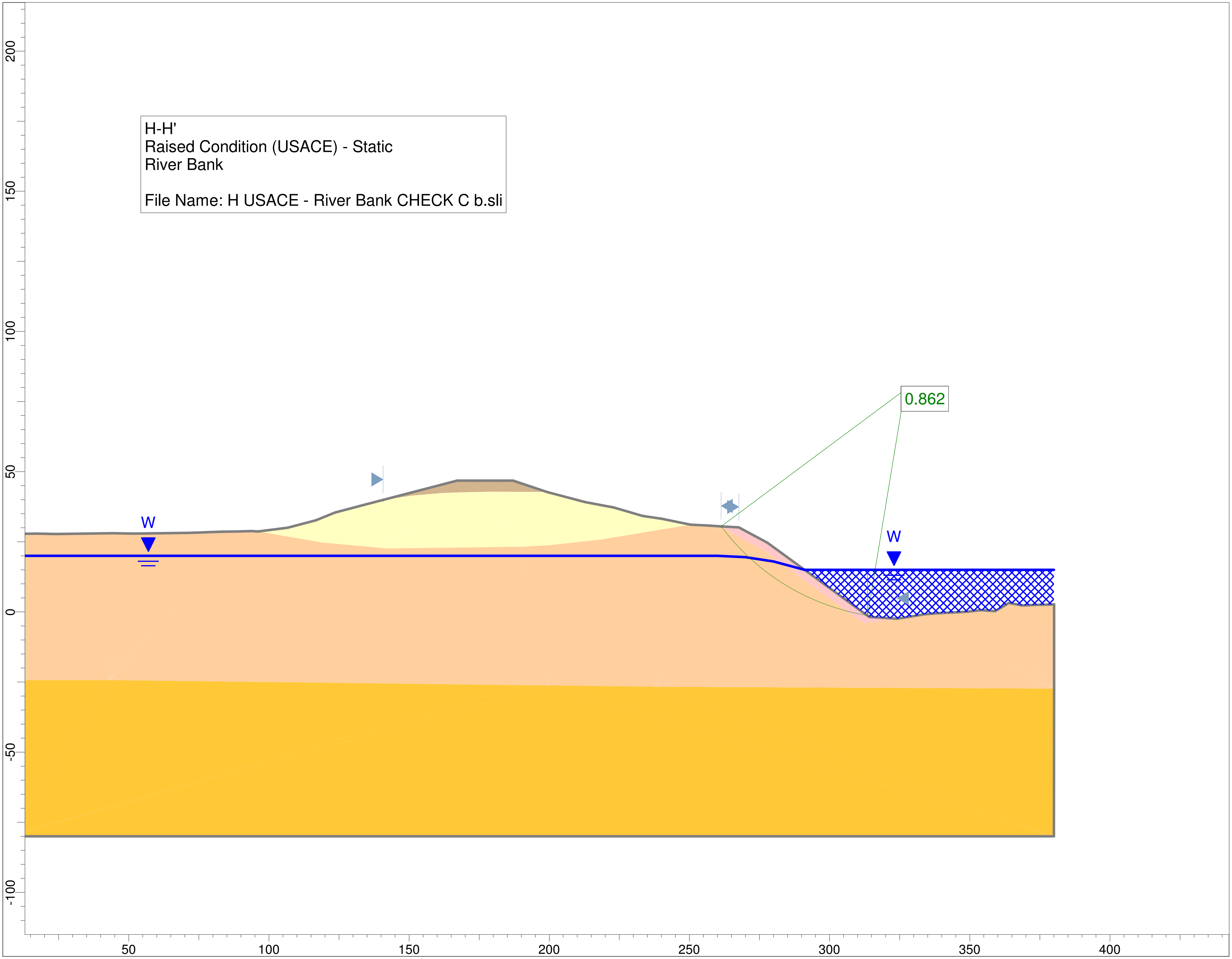


H-H'
Raised Condition (USACE) - Static
Landside

File Name: H USACE - Levee Sideslope CHECK 1.sli

H-H'
Raised Condition (USACE) - Static
River Bank

File Name: H USACE - River Bank CHECK C b.sli



APPENDIX C-9

SECTION I-I’ ANALYSIS

Subject:		PIE / Burlington Geotech & Levees / WA			
Job No.:	093-93153	Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

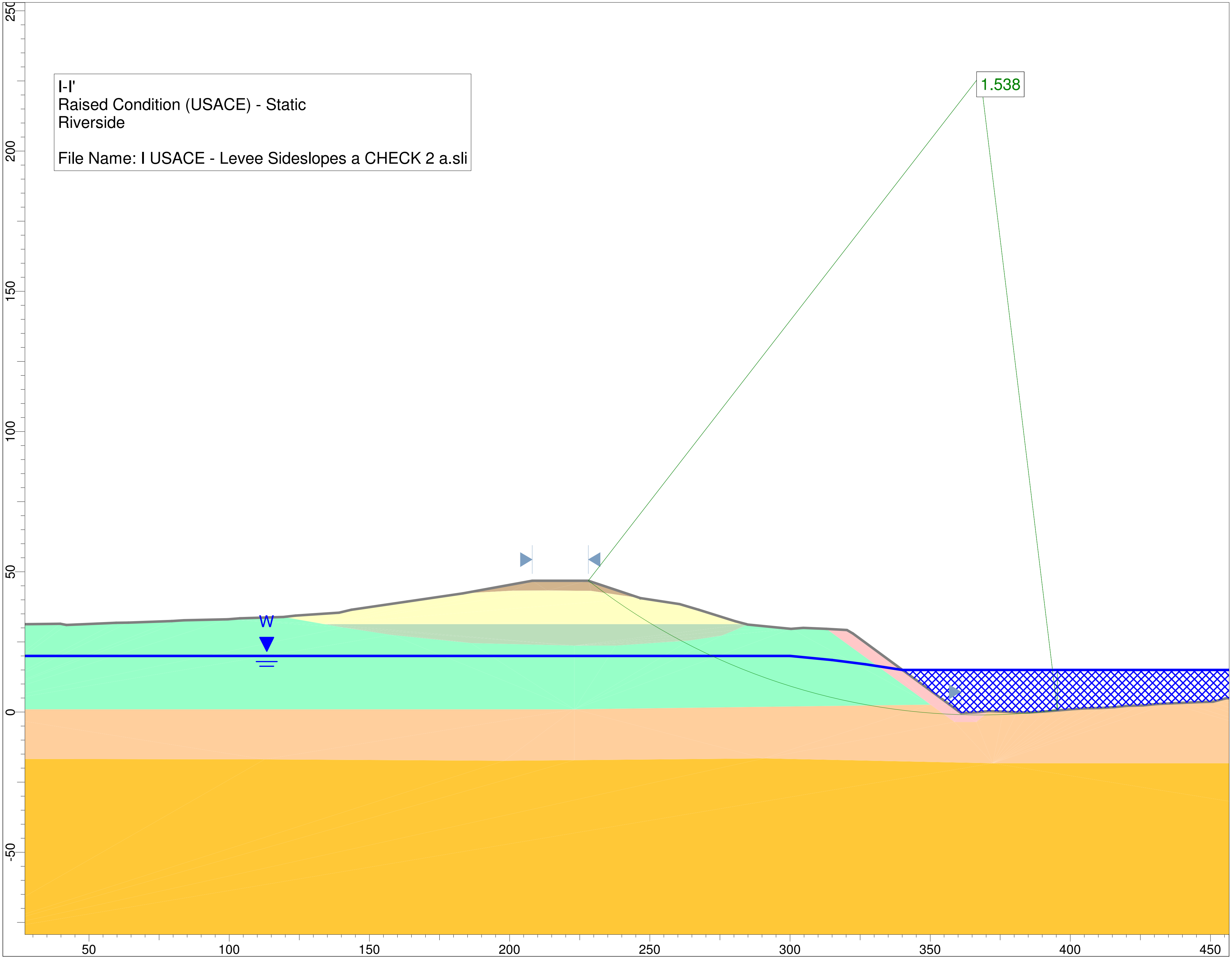
Parameter selection summary sheet for design cross-section: I-I'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID:	I-I'	
Alignment Stationing:	90+58	
SPT/CPT IDs:	GB-15	
Elevation of GWT[1]:	20	ft

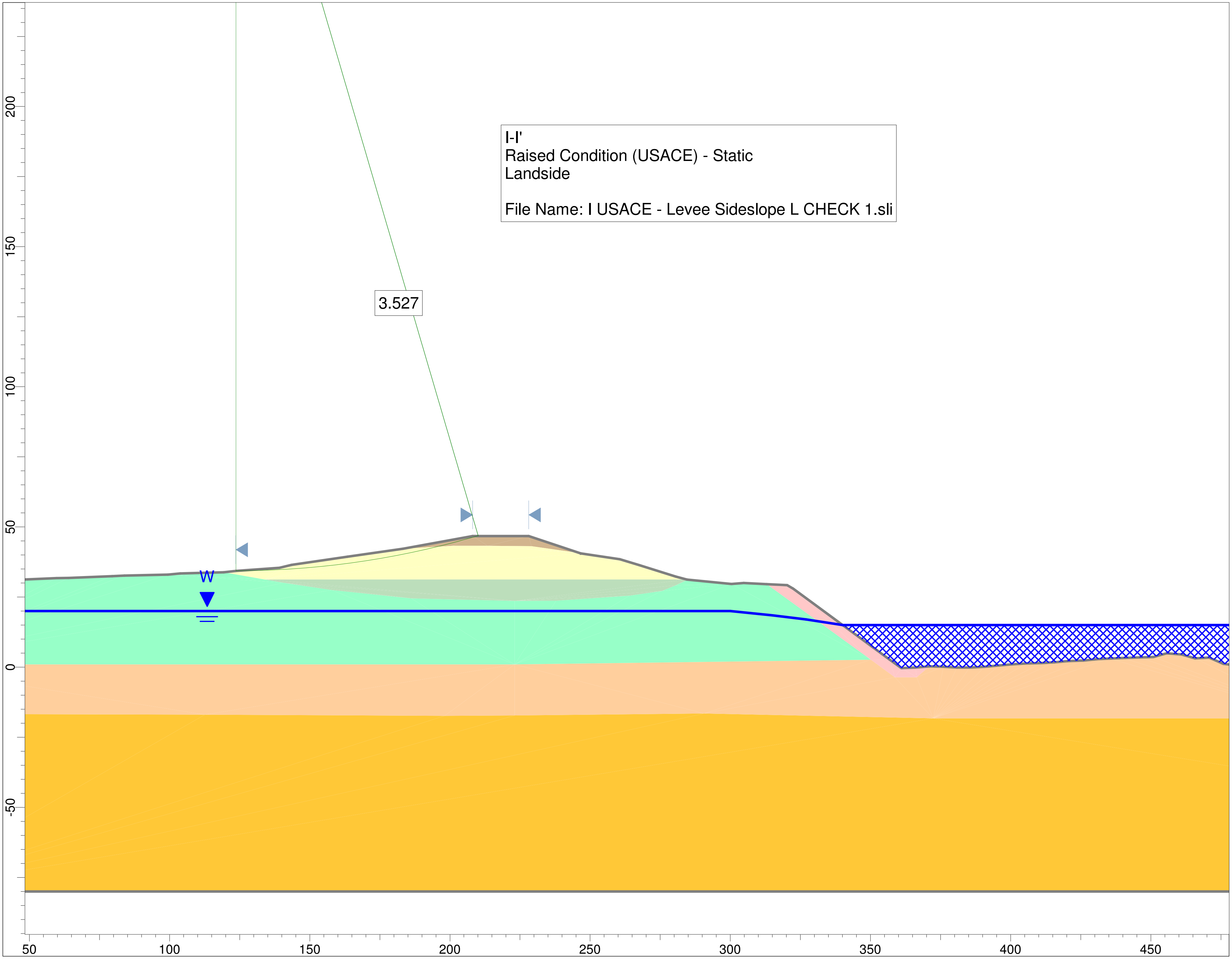
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill 1	GM, SM, SP	120	28	0
Quiet-Water Deposits 1	SM, SP-SM, ML	115	26	0
Quiet-Water Deposits 2	MH/CL, ML	115	28	0
Overbank Deposits	SP-SM	120	30	0
Channel Deposits	SP, SP-SM	120	33	0

1 Depth to groundwater interpolated from groundwater readings in GB-14 and GB-18 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39



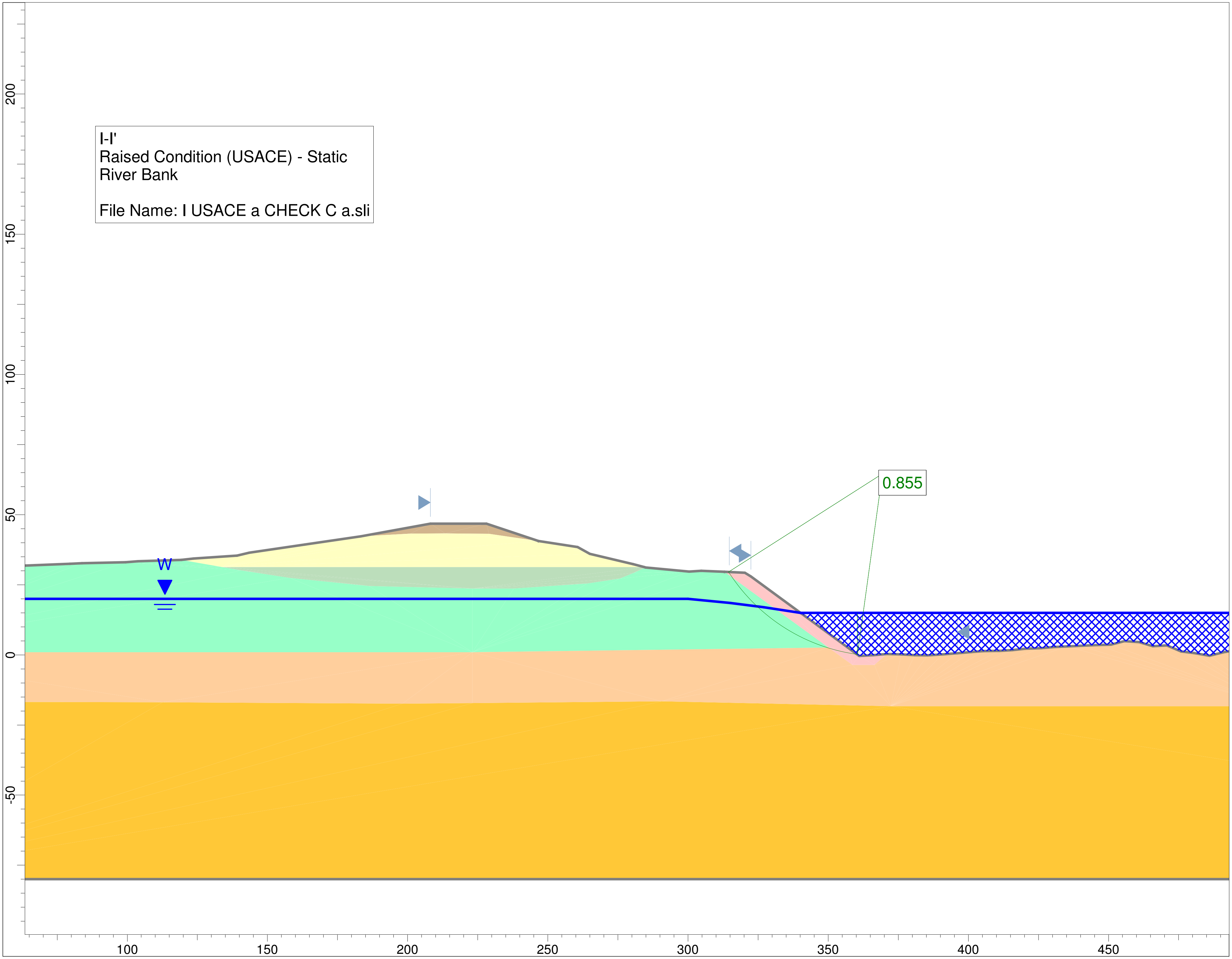
I-I'
Raised Condition (USACE) - Static
Riverside

File Name: I USACE - Levee Sideslopes a CHECK 2 a.sli



I-I'
Raised Condition (USACE) - Static
Landside

File Name: I USACE - Levee Sideslope L CHECK 1.sli


I-I'
Raised Condition (USACE) - Static
River Bank

File Name: I USACE a CHECK C a.sli
0.855
W
200
150
100
50
0
-50
100
150
200
250
300
350
400
450

APPENDIX C-10

SECTION J-J’ ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.:	093-93153	Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

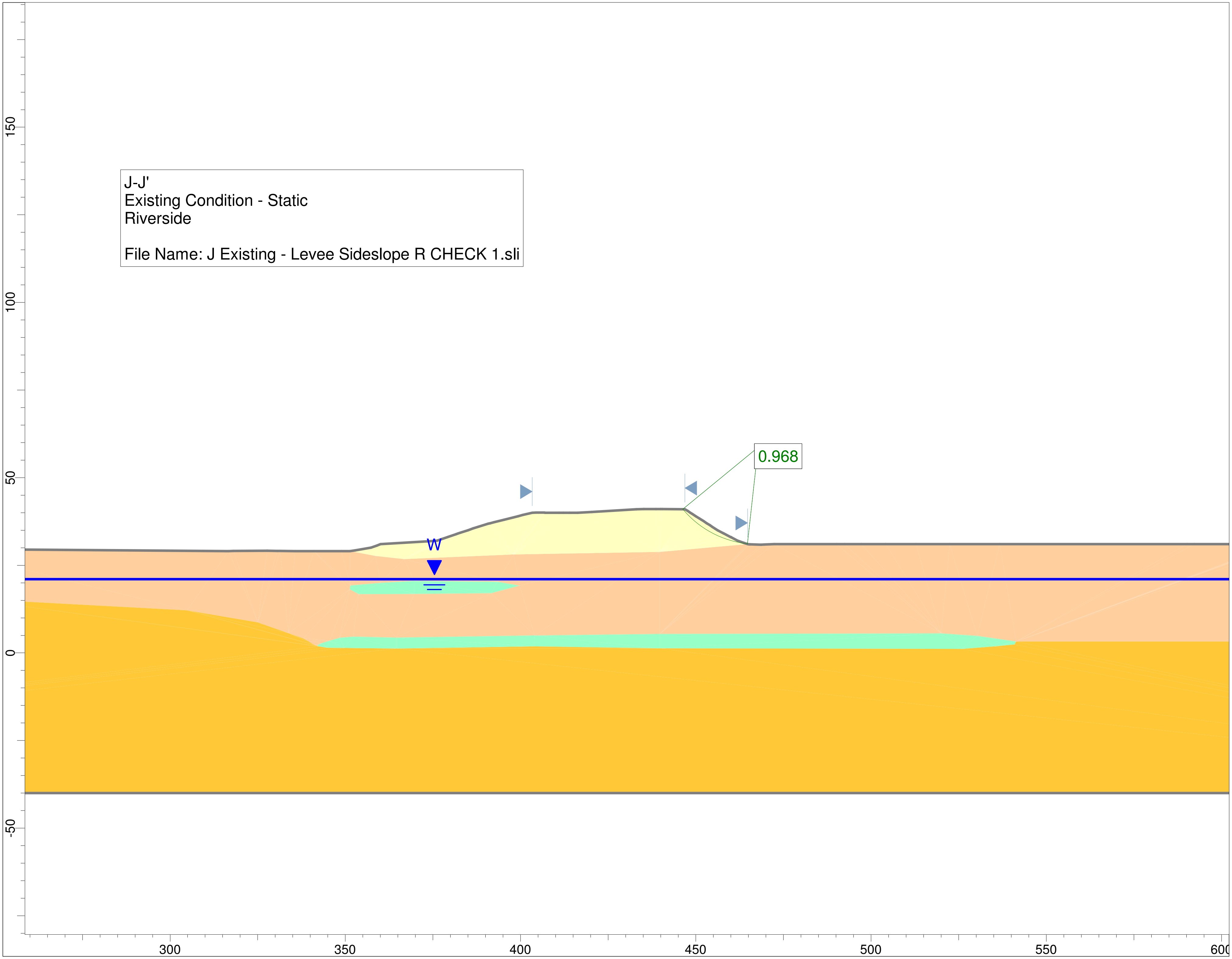
Parameter selection summary sheet for design cross-section: J-J'

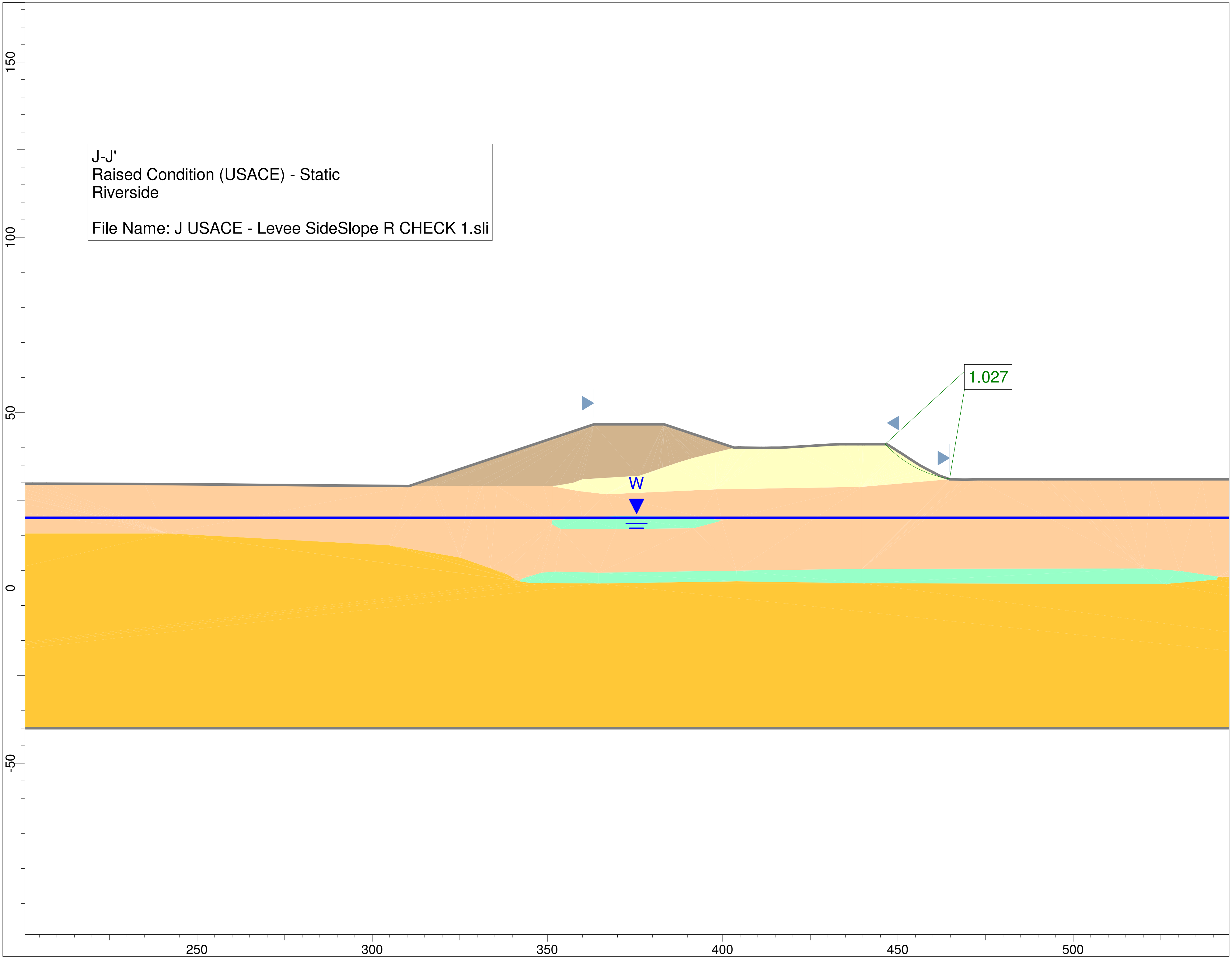
Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: J-J'
Alignment Stationing: 71+64
SPT/CPT IDs: CPT-7, GB-17, GB-16
Elevation of GWT[1]: 20 ft

Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	SM, SW	120	30	0
Overbank Deposits	ML, SM	120	28	0
Quiet-Water Deposits	ML	115	26	0
Channel Deposits	SP-SM, SP	120	33	0

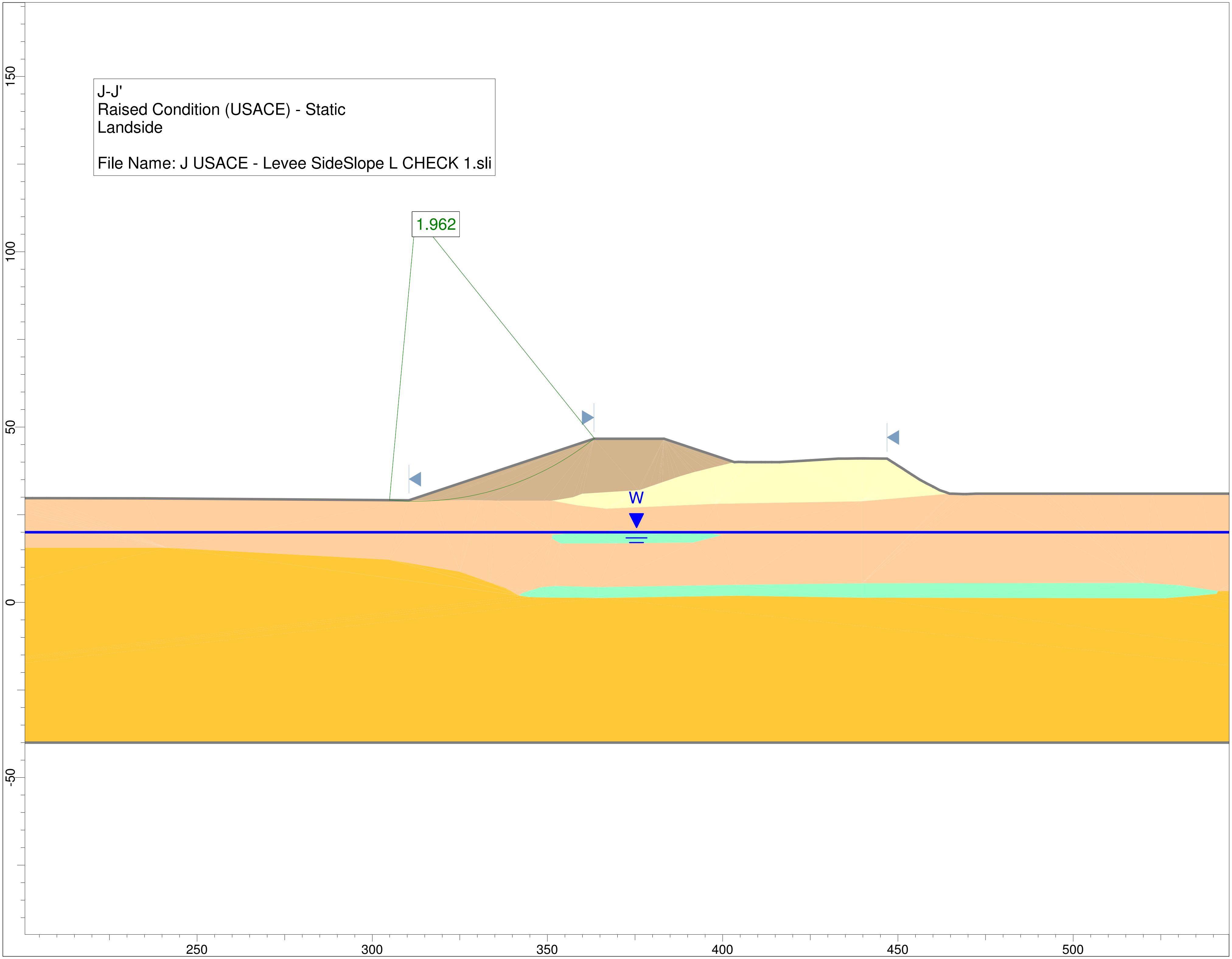
1 Depth to groundwater interpolated from groundwater readings in GB-14 and GB-18 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39


J-J'
Existing Condition - Static
Riverside
File Name: J Existing - Levee Sideslope R CHECK 1.sli
0.968
W
150
100
50
0
-50
300
350
400
450
500
550
600



J-J'
Raised Condition (USACE) - Static
Riverside

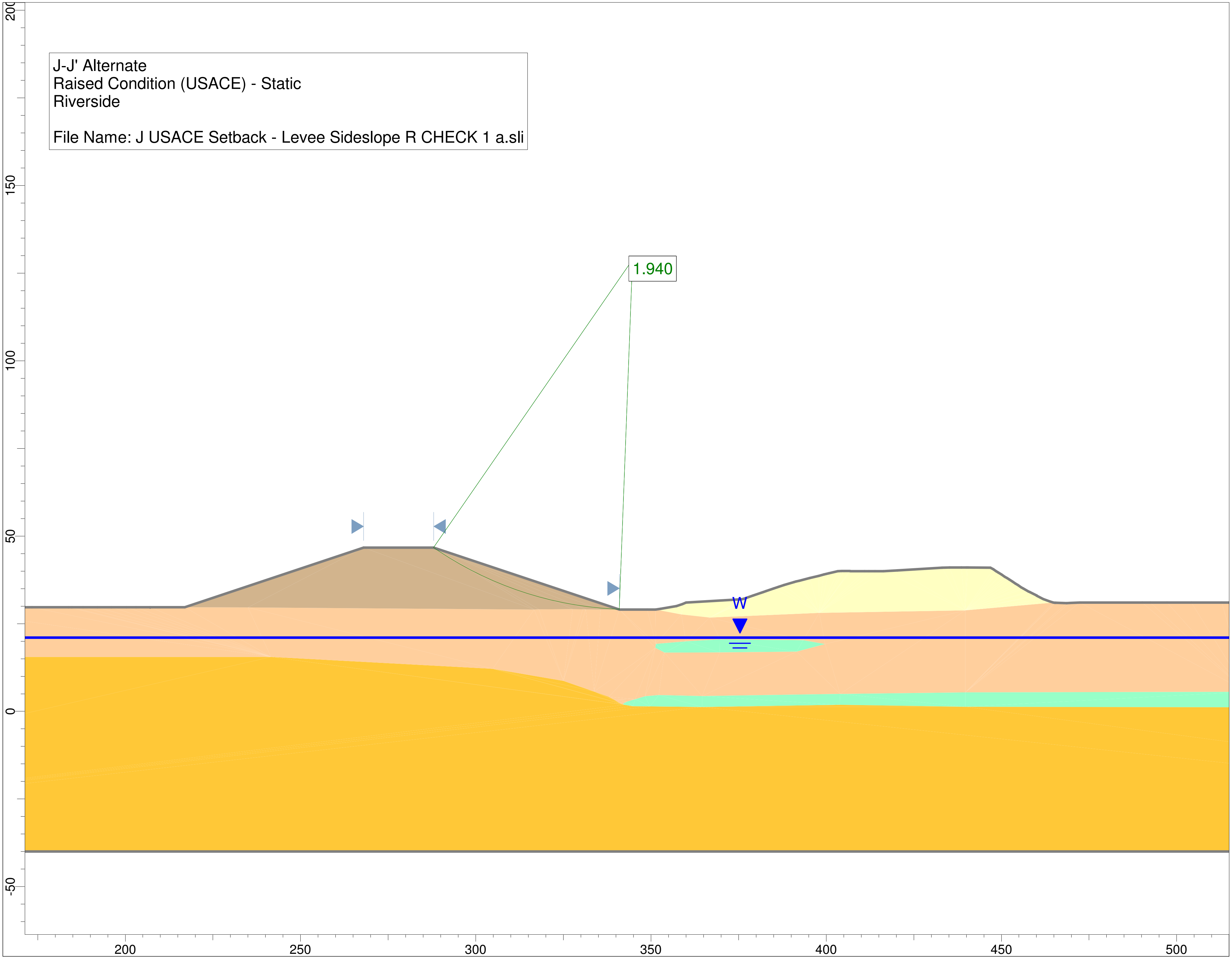
File Name: J USACE - Levee SideSlope R CHECK 1.sli


J-J'
Raised Condition (USACE) - Static
Landside

File Name: J USACE - Levee SideSlope L CHECK 1.sli
1.962
W
150
100
50
0
-50
250
300
350
400
450
500

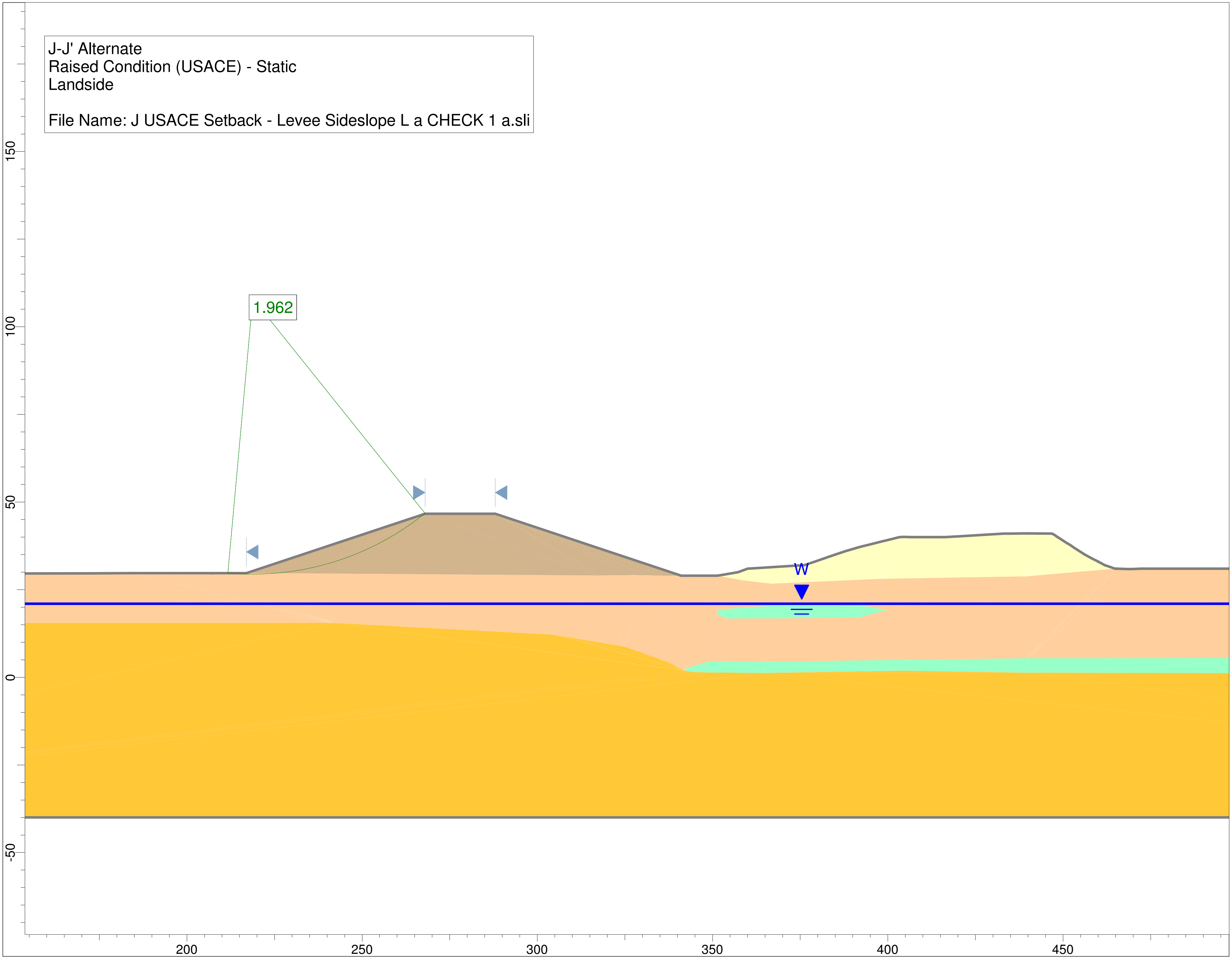
J-J' Alternate
Raised Condition (USACE) - Static
Riverside

File Name: J USACE Setback - Levee Sideslope R CHECK 1 a.sli



J-J' Alternate
Raised Condition (USACE) - Static
Landside

File Name: J USACE Setback - Levee Sideslope L a CHECK 1 a.sli



APPENDIX C-11

SECTION K-K’ ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.: 093-93153		Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

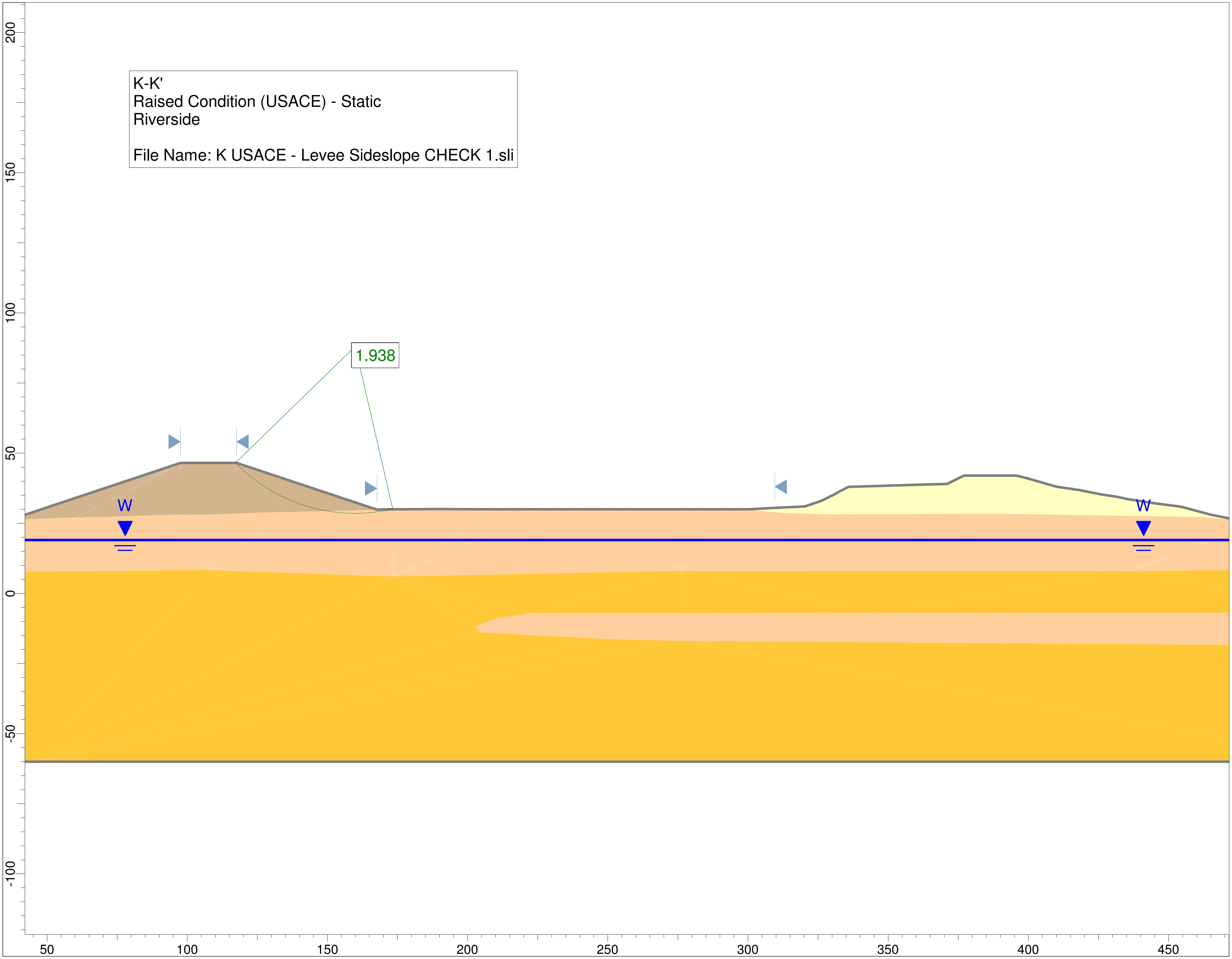
Parameter selection summary sheet for design cross-section: K-K'

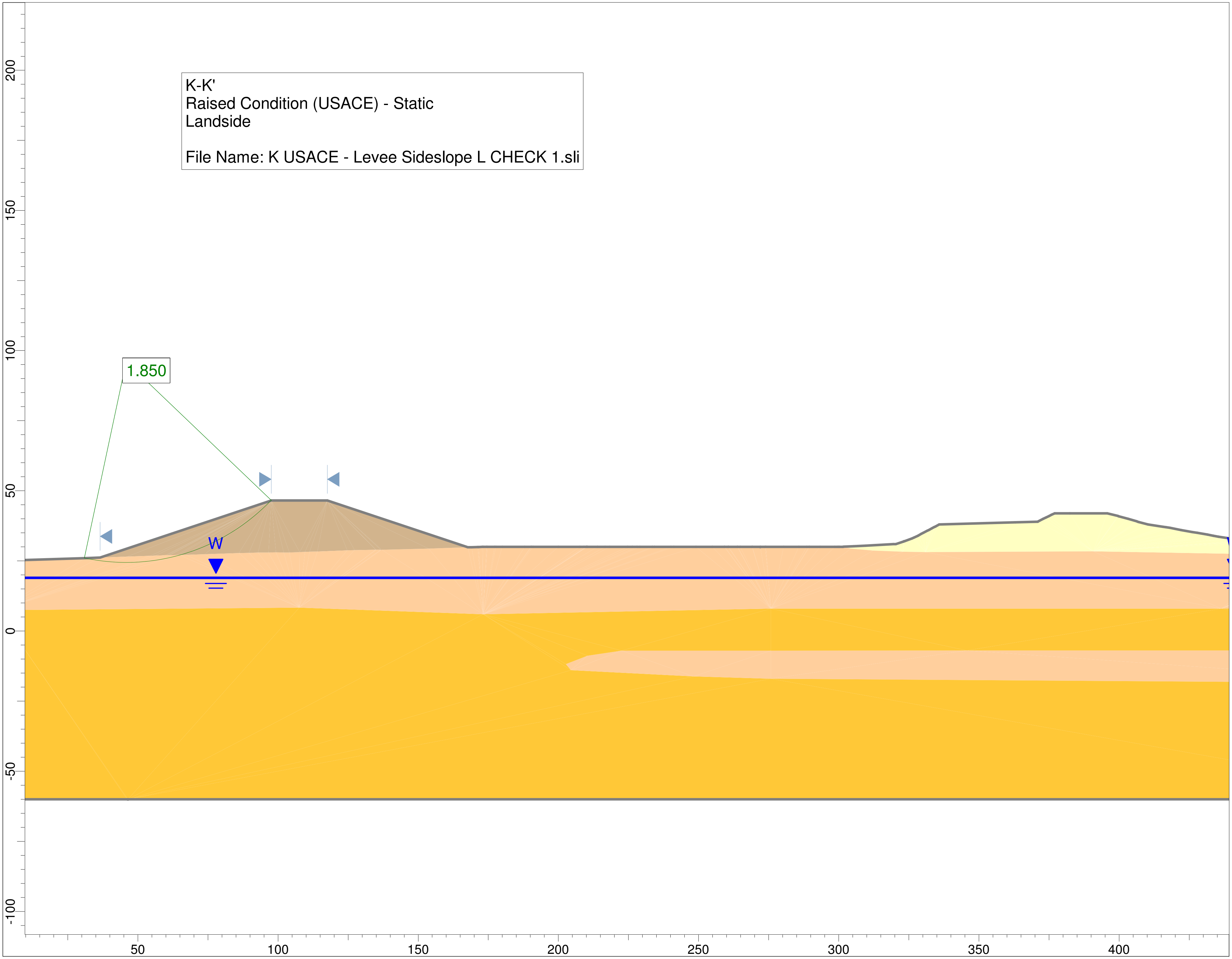
Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: K-K'
Alignment Stationing: 46+06
SPT/CPT IDs: GB-21, CPT-9, GB-22, GB-20
Elevation of GWT[1]: 19 ft

Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GP, GM	120	28	0
Overbank Deposits	ML, SP-SM	115	26	0
Channel Deposits	SP-SM, SW, SM	125	33	0

1 Depth to groundwater interpolated from groundwater readings in GB-18 and GB-21 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39


K-K'
Raised Condition (USACE) - Static
Riverside
File Name: K USACE - Levee Sideslope CHECK 1.sli
1.938
W
W
200
150
100
50
0
-50
-100
50
100
150
200
250
300
350
400
450


K-K'
Raised Condition (USACE) - Static
Landside
File Name: K USACE - Levee Sideslope L CHECK 1.sli
1.850
W
200
150
100
50
0
-50
-100
50
100
150
200
250
300
350
400

APPENDIX C-12

SECTION L-L’ ANALYSIS

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.: 093-93153		Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

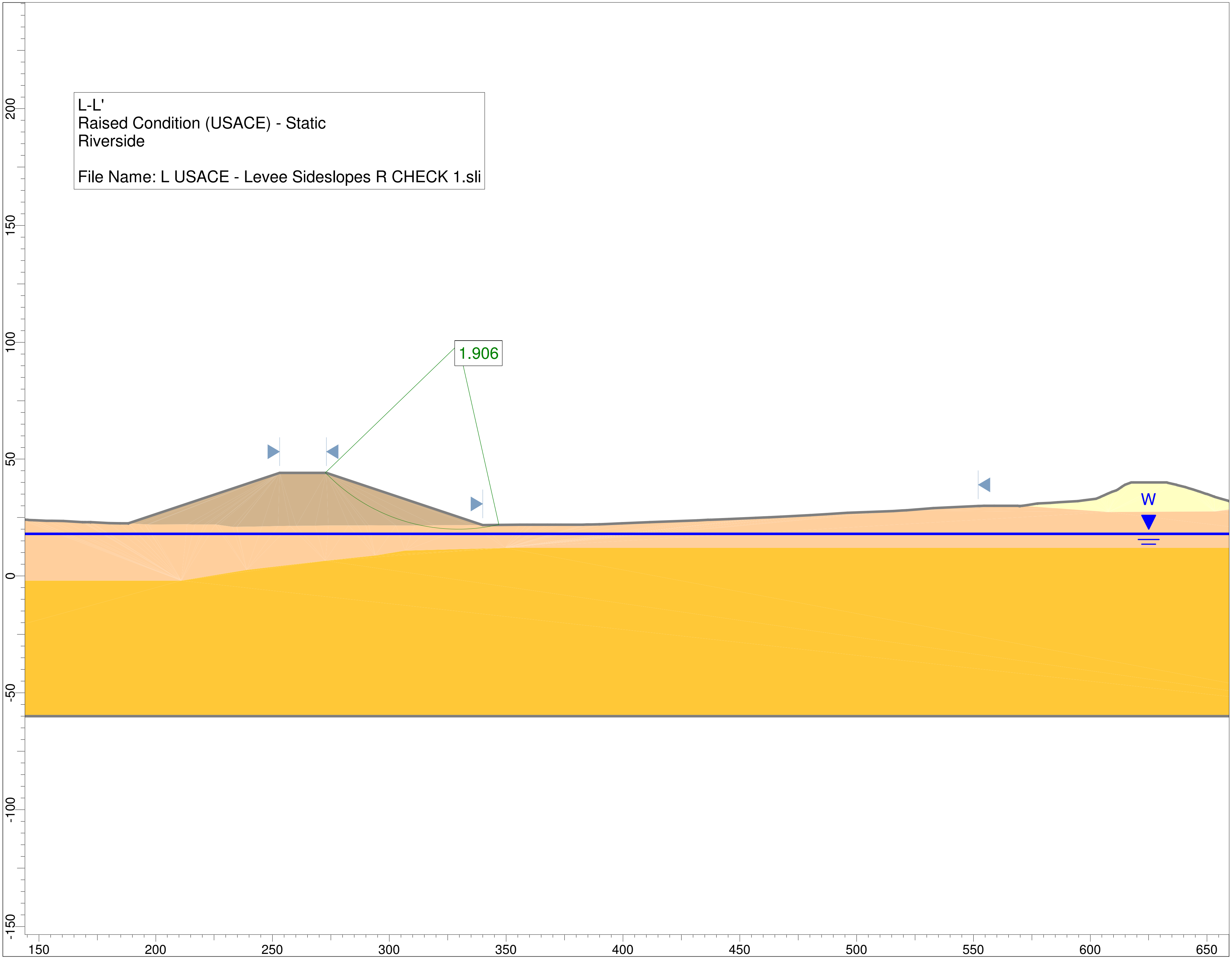
Parameter selection summary sheet for design cross-section: L-L'

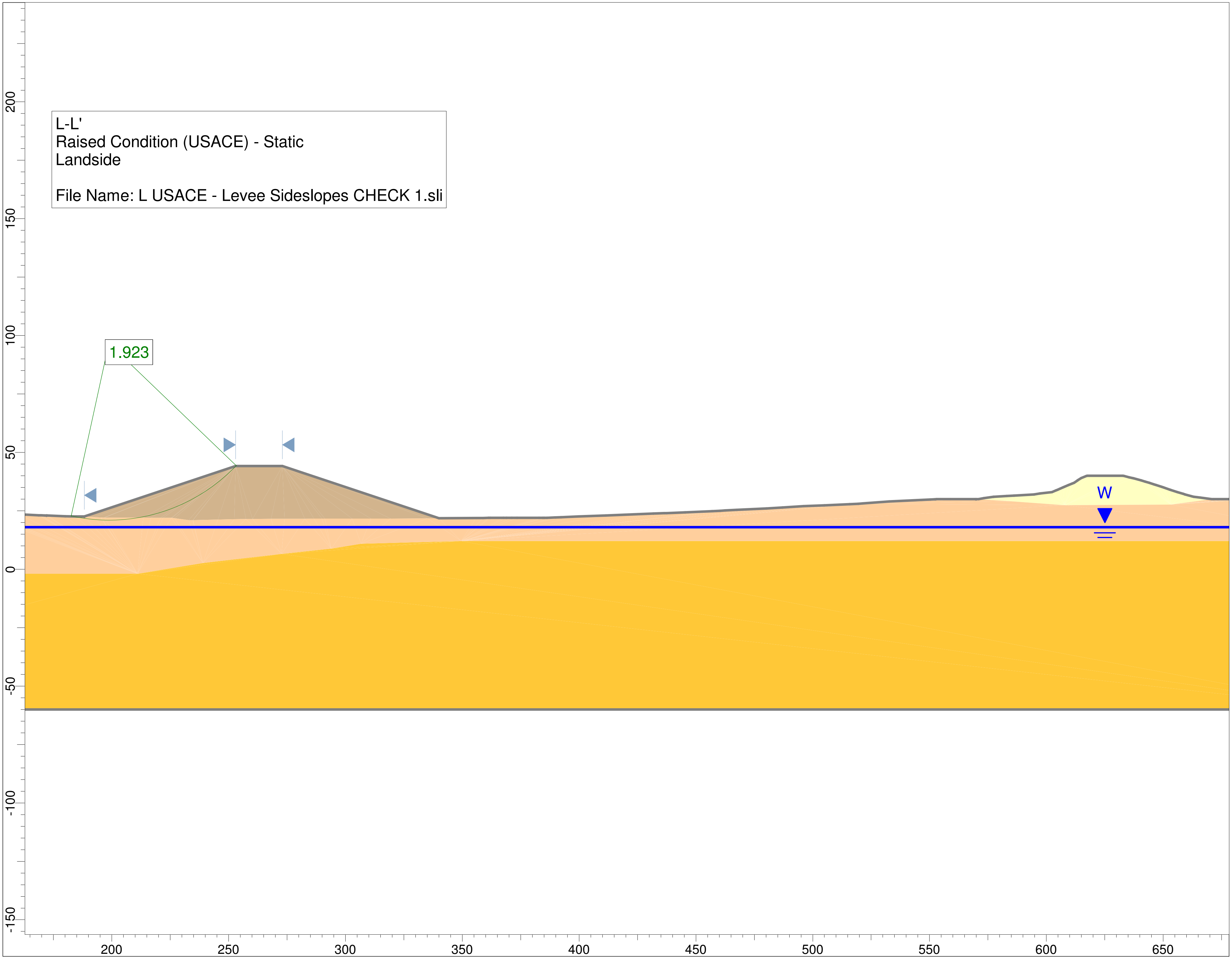
Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

Cross-section ID: L-L'
Alignment Stationing: 18+89
SPT/CPT IDs: GB-25, GB-26
Elevation of GWT[1]**:** 18 ft

Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill	GW, GM, SP	120	28	0
Overbank Deposits	ML, SP, SM, SP-SM/SM	115	26	0
Channel Deposits	SW, SP-SM, SP	120	30	0

1 Depth to groundwater interpolated from groundwater readings in GB-24 and GB-28 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39


L-L'
Raised Condition (USACE) - Static
Riverside
File Name: L USACE - Levee Sideslopes R CHECK 1.sli
1.906
W
200
150
100
50
0
-50
-100
-150
150
200
250
300
350
400
450
500
550
600
650


L-L'
Raised Condition (USACE) - Static
Landside
File Name: L USACE - Levee Sideslopes CHECK 1.sli
1.923
W
200
150
100
50
0
-50
-100
-150
200
250
300
350
400
450
500
550
600
650

APPENDIX C-13

SECTION M-M’ ANALYSIS

Golder Associates

Subject:	PIE / Burlington Geotech & Levees / WA				
Job No.:	093-93153	Made by:	SJM	Date:	6/8/2009
Extender:		Checked by:		Sheet:	as marked
Phase:		Reviewed by:			

Parameter selection summary sheet for design cross-section: M-M'

Description:
This spreadsheet provides a summary of data from SPT/CPT logs along with parameter selection and references.
Layer depths listed are approximate and based on interpretation of data.
Some parameters used may not be listed here. Those parameters will be explained where they are used in calculations.

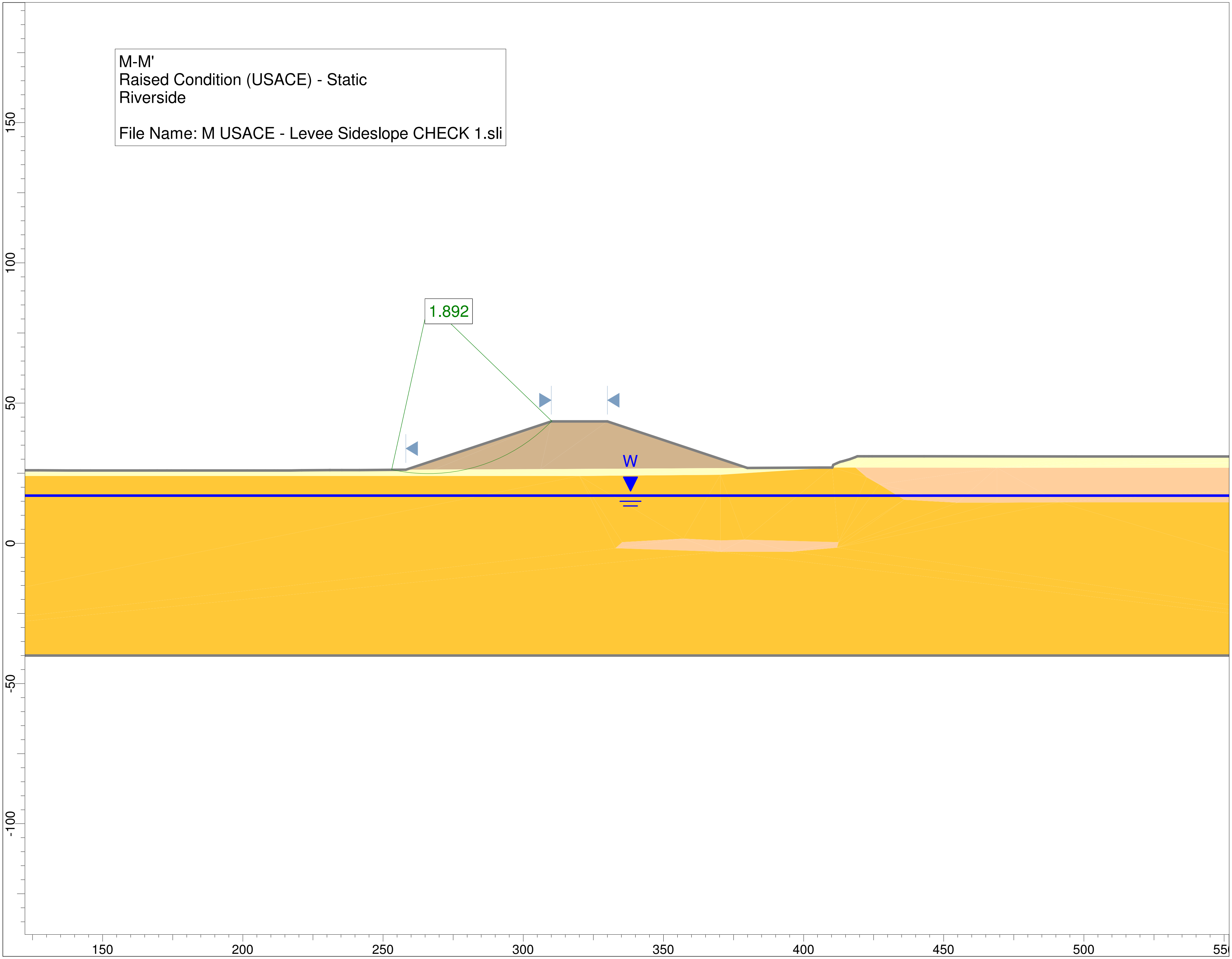
Cross-section ID: M-M'
Alignment Stationing: 4+27
SPT/CPT IDs: GB-27, GB-28, CPT-11
Elevation of GWT[1]**:** 17 ft

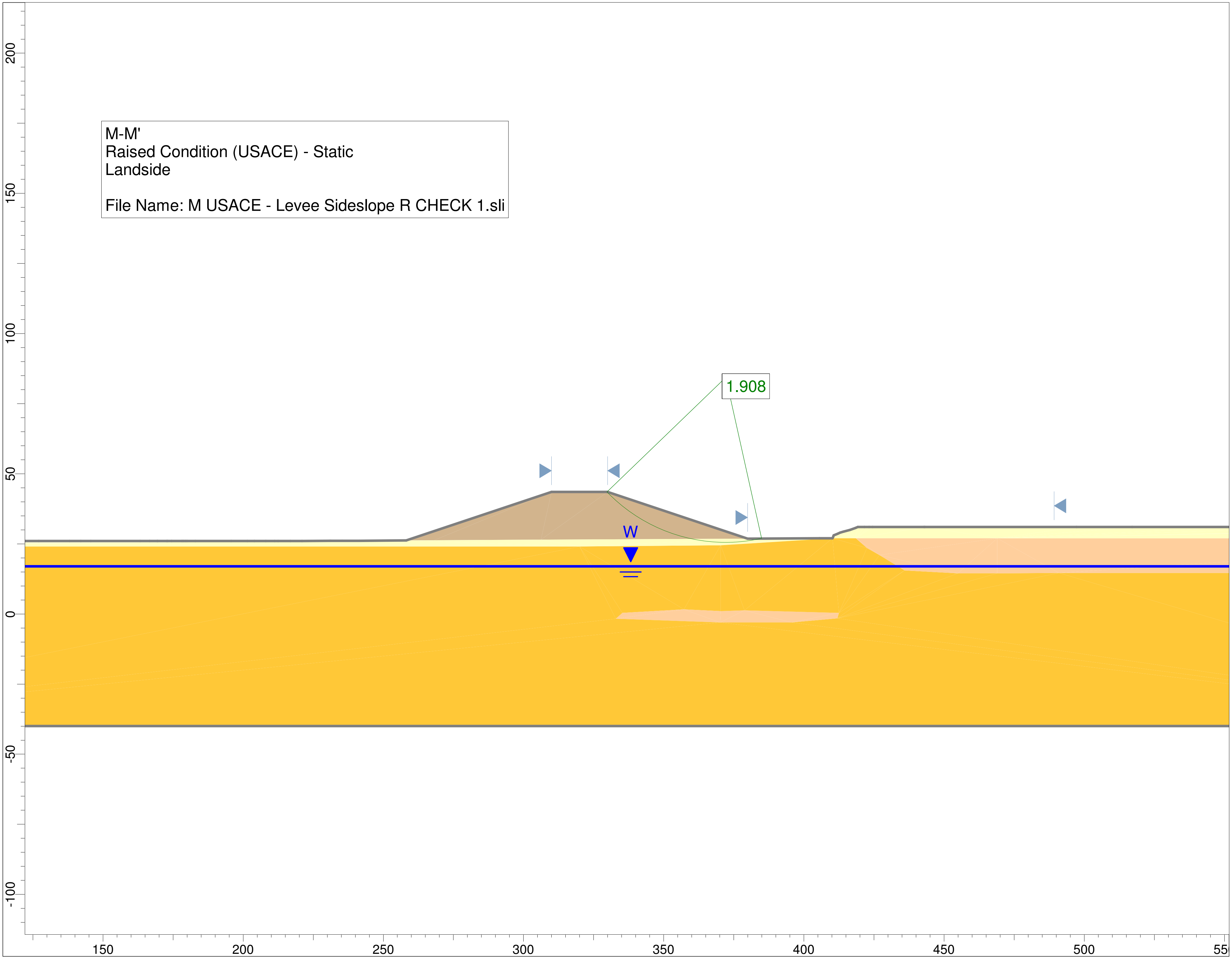
Geologic Unit[2]	USCS[2]	γ_T[3] (pcf)	ϕ[4,5] (degrees)	c[6] (psf)
Existing Fill/Topsoil	SM	120	26	0
Overbank Deposits	ML, SM, MH	115	26	0
Channel Deposits	SP-SM, SW, SP	120	30	0

1 Depth to groundwater interpolated from groundwater readings in GB-24 and GB-28 on 05/19/2009
2 Unit thickness and classification generalized based on available data and soil samples (see project SPT and CPT logs)
3 Unit weight estimated using NAVFAC DM7.2, Page 7.2-39
4 Friction angle of granular soils estimated from USACE EM 1110-2-2502, Figure 2-6, Page 2-13.
5 Friction angle of cohesive soils estimated from TPM, Figure 19.7, Page 152
6 Cohesion estimated using NAVFAC DM7.2, Page 7.2-39

M-M'
Raised Condition (USACE) - Static
Riverside

File Name: M USACE - Levee Sideslope CHECK 1.sli




M-M'
Raised Condition (USACE) - Static
Landside

File Name: M USACE - Levee Sideslope R CHECK 1.sli
1.908
W
200
150
100
50
0
-50
-100
150
200
250
300
350
400
450
500

APPENDIX D

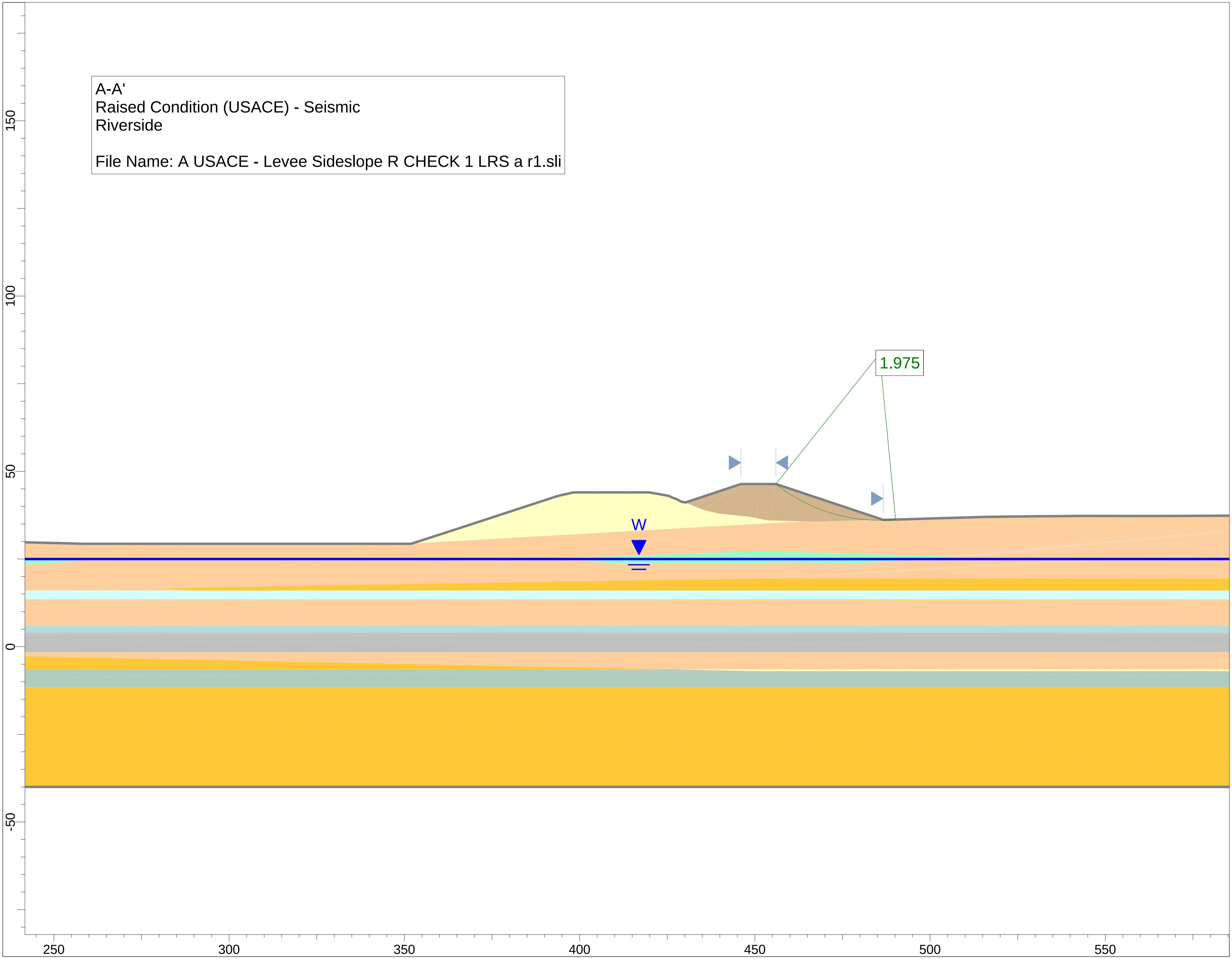
ENGINEERING ANALYSIS – SEISMIC STABILITY

APPENDIX D-1

SECTION A-A’ ANALYSIS

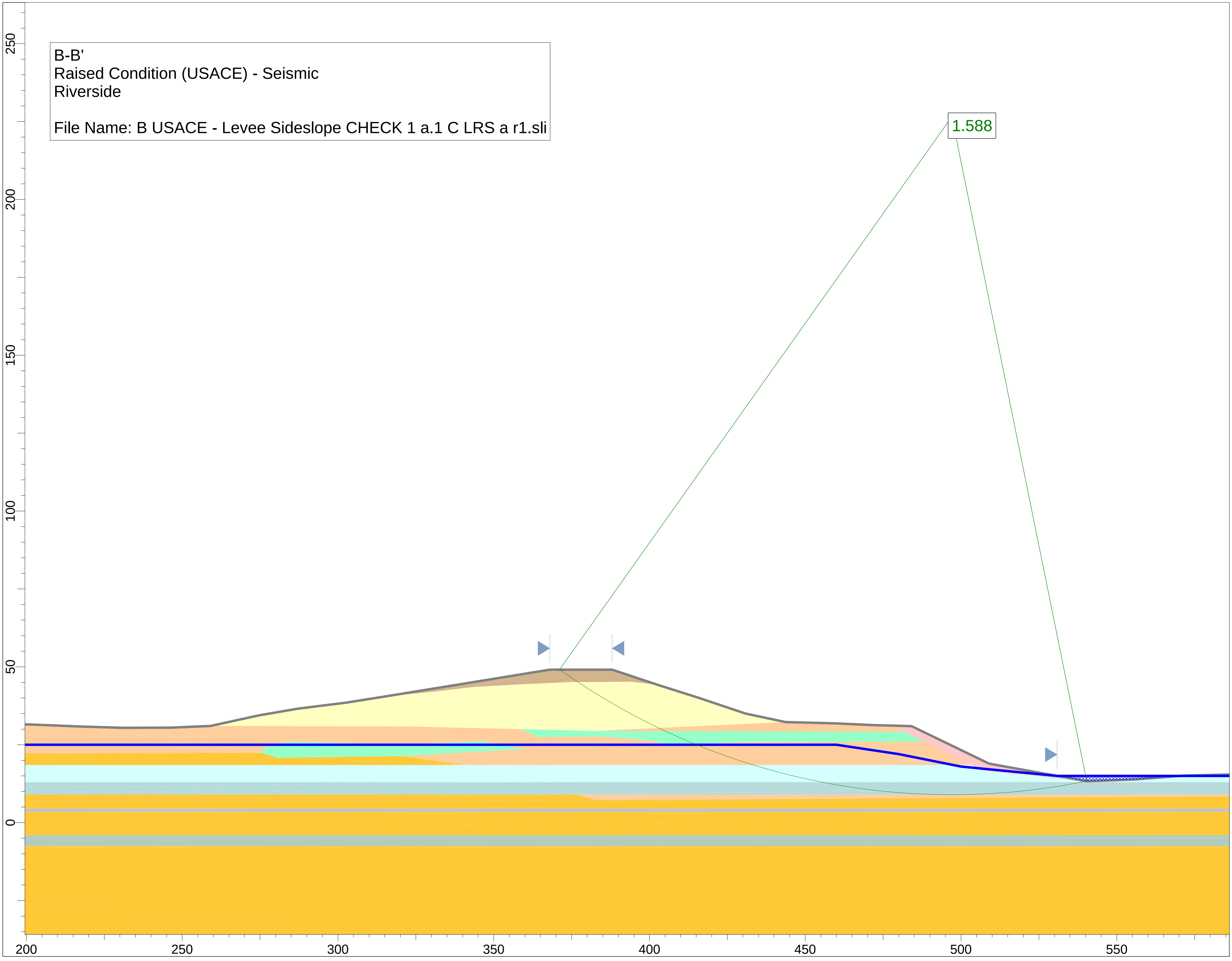
A-A'
Raised Condition (USACE) - Seismic
Riverside

File Name: A USACE - Levee Sideslope R CHECK 1 LRS a r1.sli



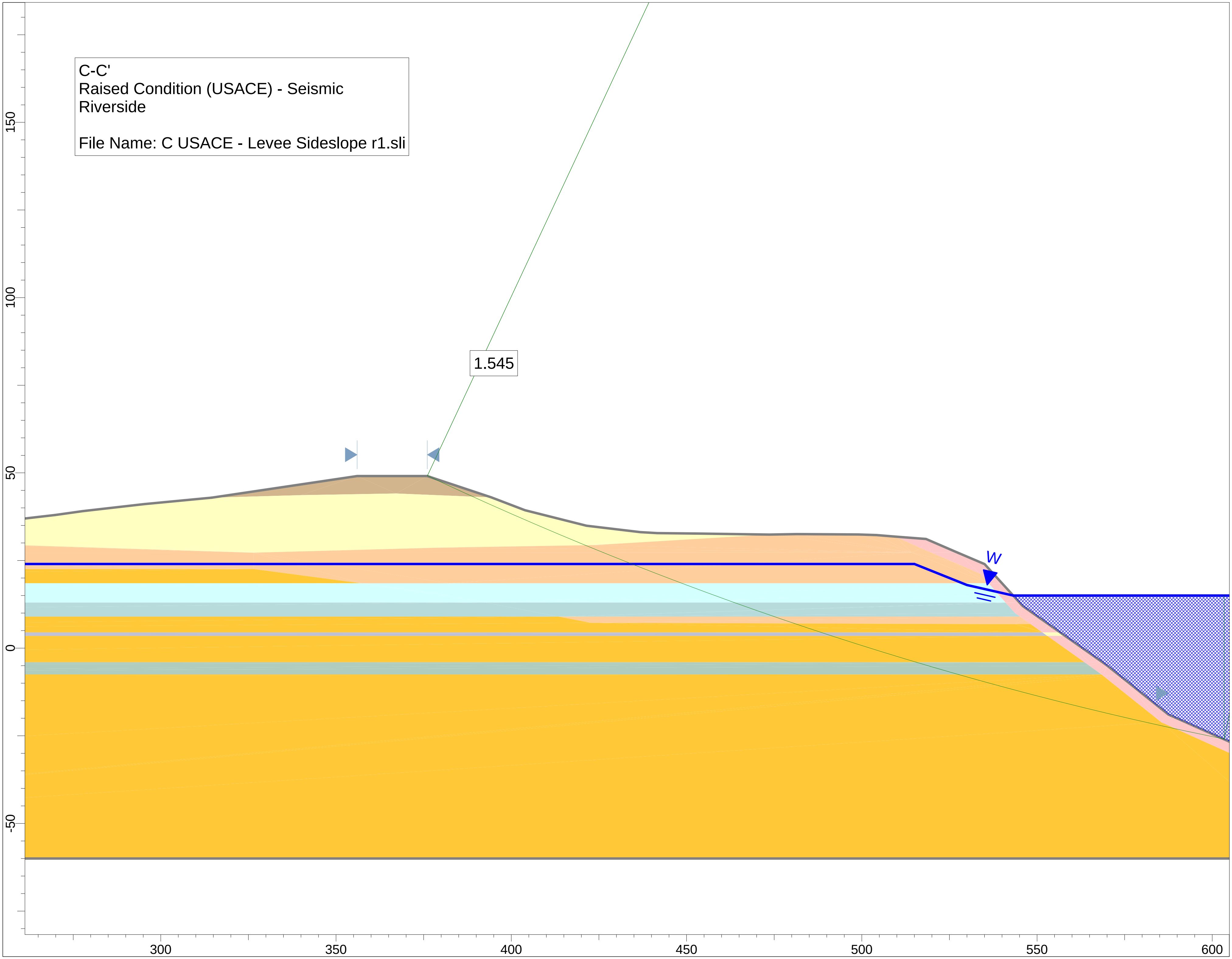
APPENDIX D-2

SECTION B-B’ ANALYSIS


B-B'
Raised Condition (USACE) - Seismic
Riverside
File Name: B USACE - Levee Sideslope CHECK 1 a.1 C LRS a r1.sli
1.588
250
200
150
100
50
0
200
250
300
350
400
450
500
550

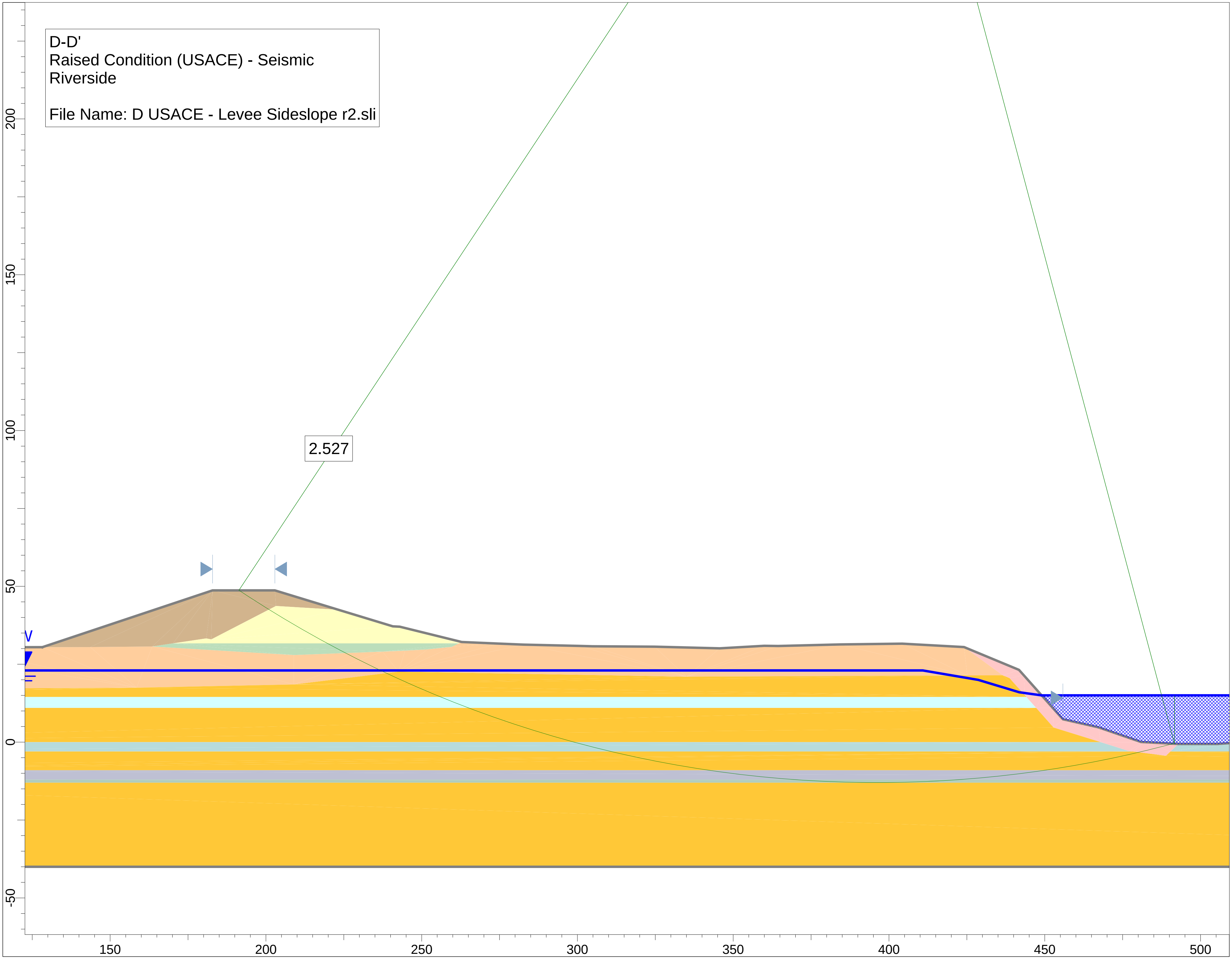
APPENDIX D-3

SECTION C-C’ ANALYSIS


C-C'
Raised Condition (USACE) - Seismic
Riverside
File Name: C USACE - Levee Sideslope r1.sli
1.545
W
150
100
50
0
-50
300
350
400
450
500
550
600

APPENDIX D-4

SECTION D-D’ ANALYSIS


D-D'
Raised Condition (USACE) - Seismic
Riverside

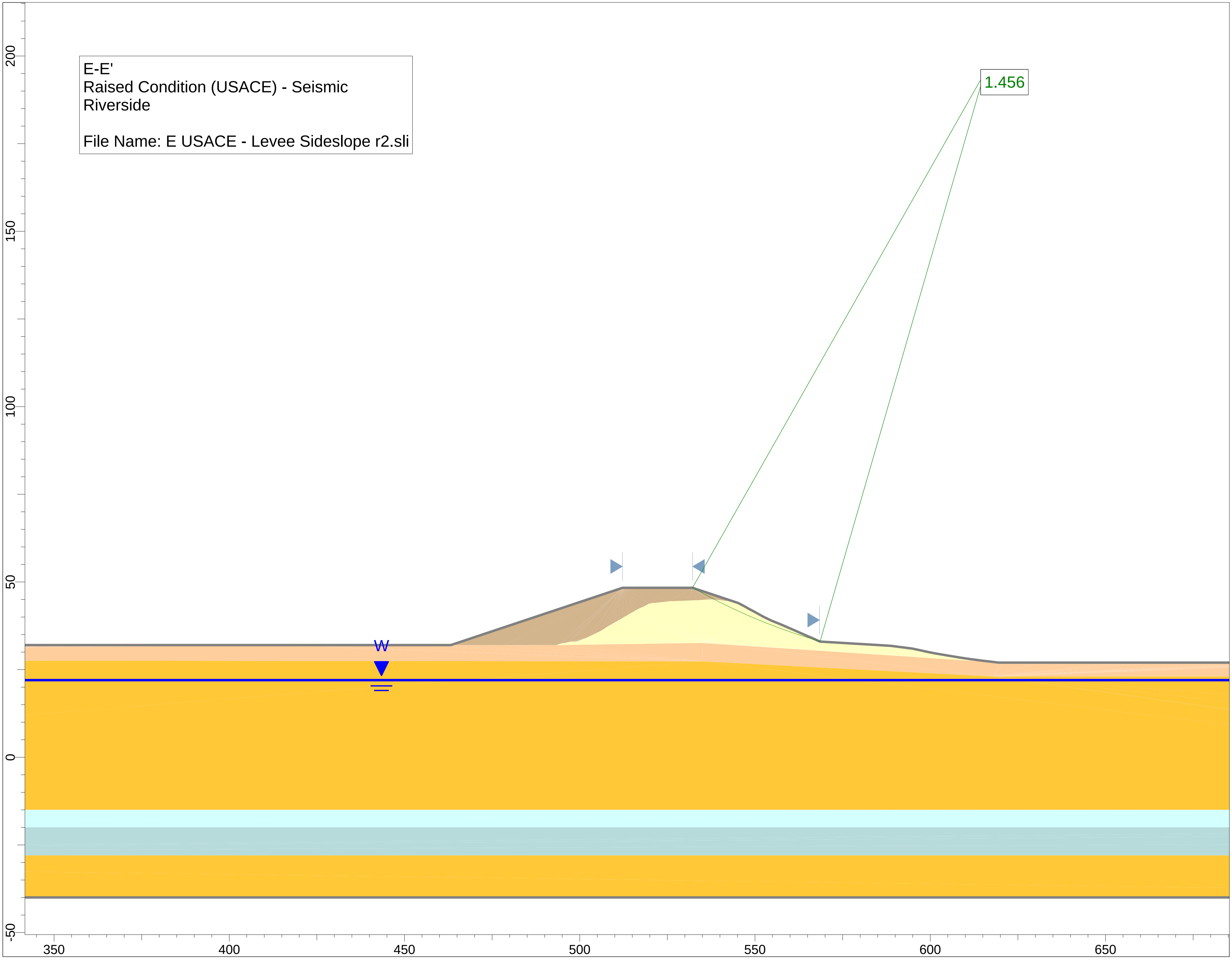
File Name: D USACE - Levee Sideslope r2.sli
2.527
200
150
100
50
0
-50
150
200
250
300
350
400
450
500

APPENDIX D-5

SECTION E-E’ ANALYSIS

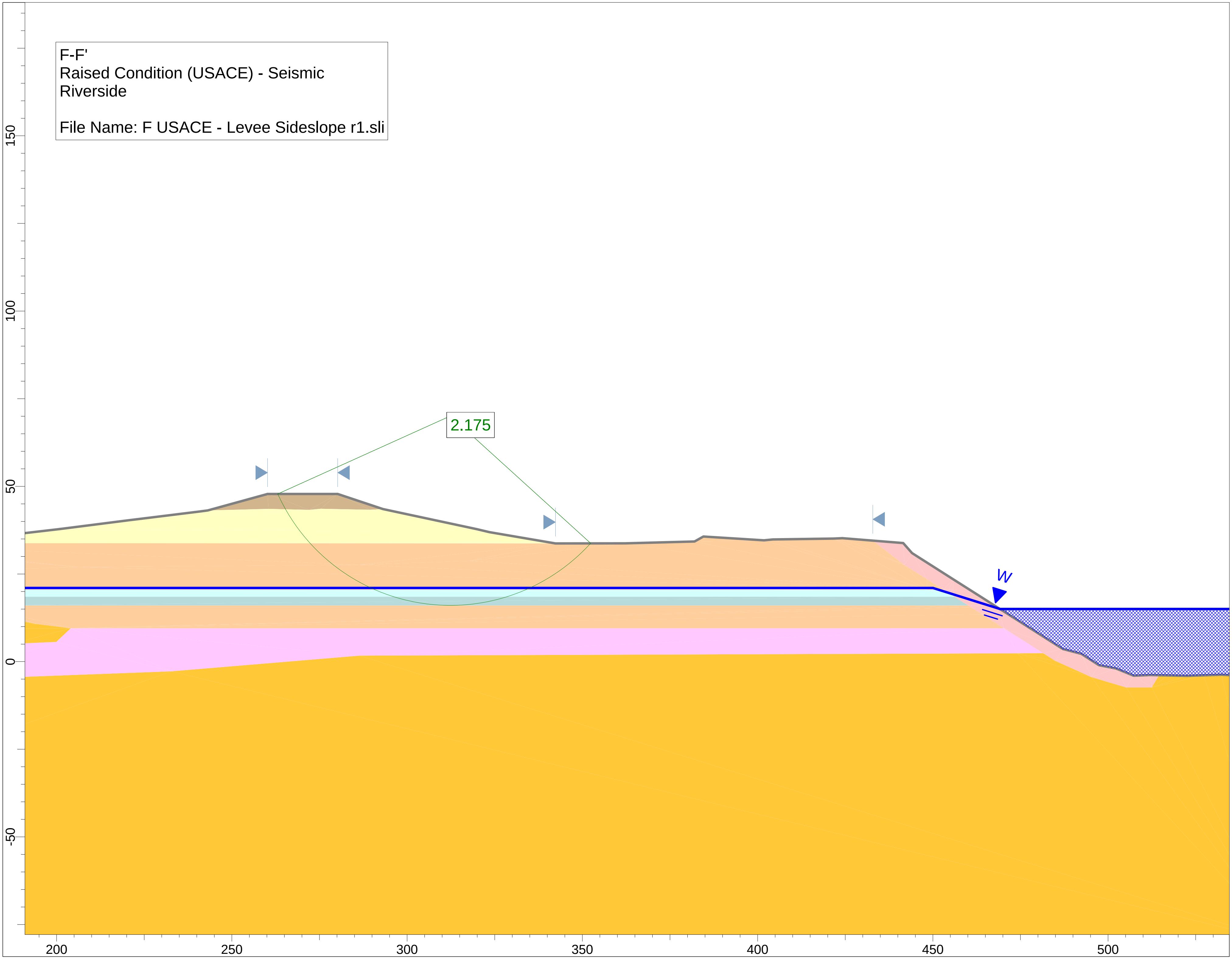
E-E'
Raised Condition (USACE) - Seismic
Riverside

File Name: E USACE - Levee Sideslope r2.sli



APPENDIX D-6

SECTION F-F' ANALYSIS

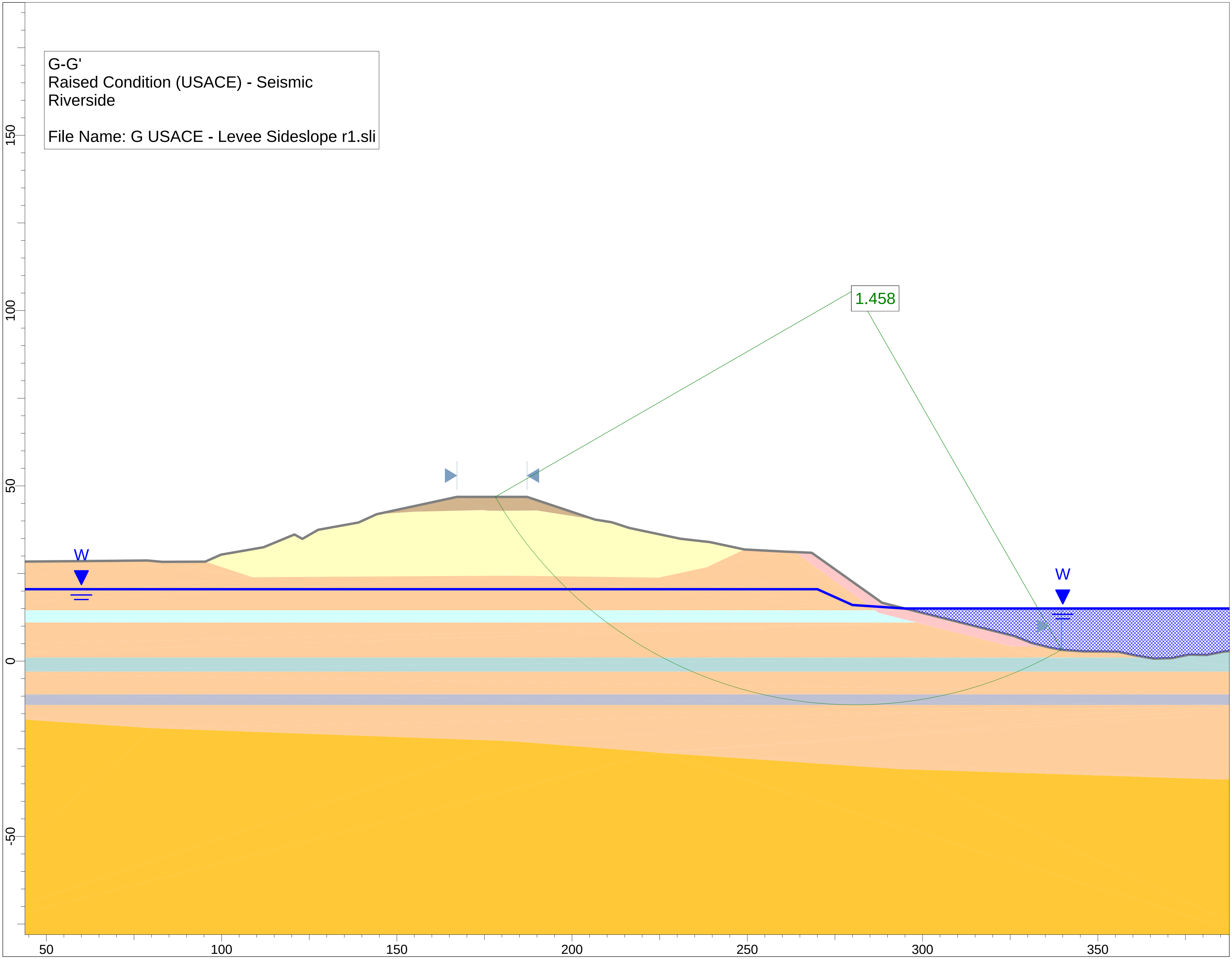


F-F'
Raised Condition (USACE) - Seismic
Riverside

File Name: F USACE - Levee Sideslope r1.sli

APPENDIX D-7

SECTION G-G’ ANALYSIS

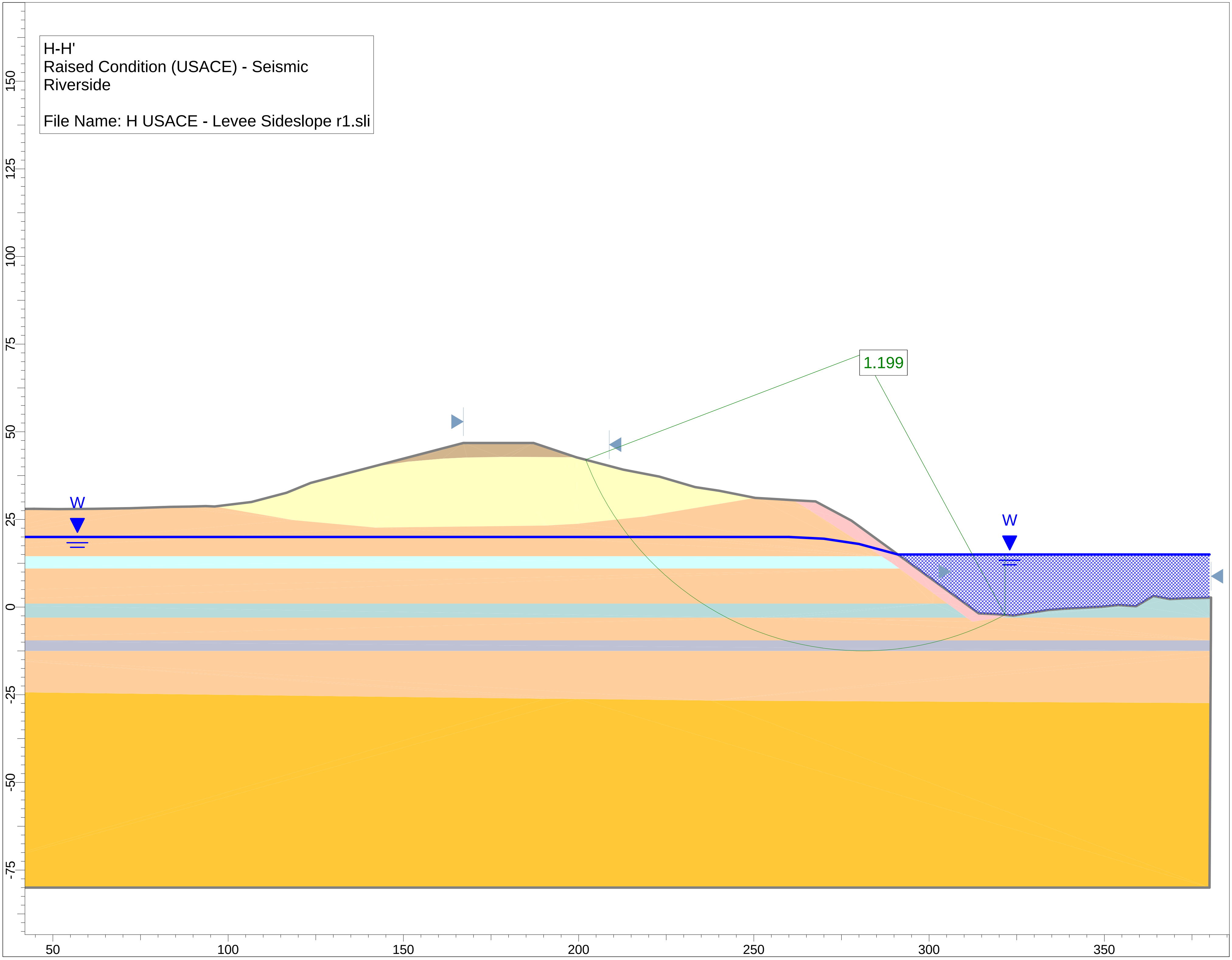


G-G'
Raised Condition (USACE) - Seismic
Riverside

File Name: G USACE - Levee Sideslope r1.sli

APPENDIX D-8

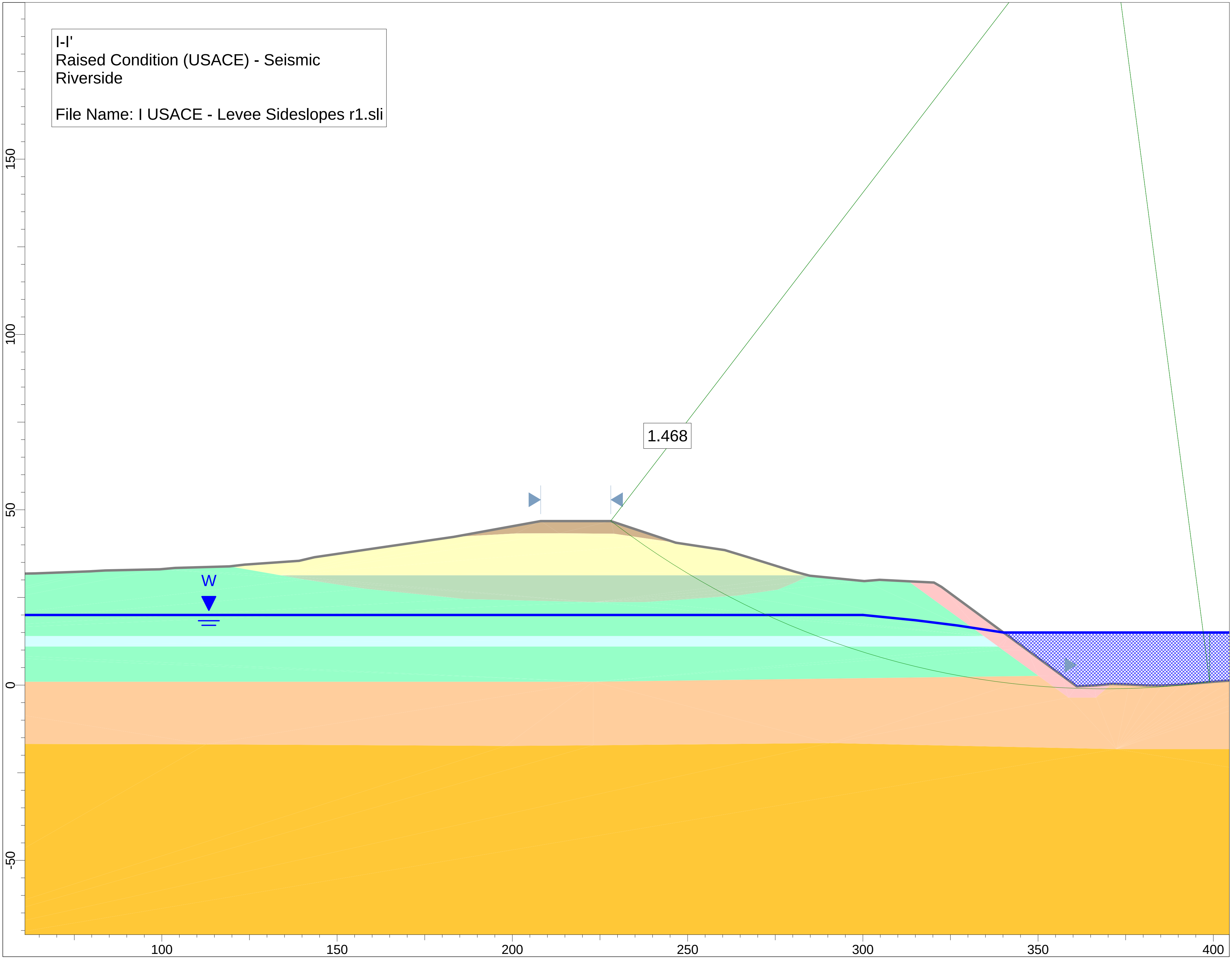
SECTION H-H’ ANALYSIS


H-H'
Raised Condition (USACE) - Seismic
Riverside

File Name: H USACE - Levee Sideslope r1.sli
1.199
W
W
150
125
100
75
50
25
0
-25
-50
-75
50
100
150
200
250
300
350

APPENDIX D-9

SECTION I-I’ ANALYSIS



I-I'
Raised Condition (USACE) - Seismic
Riverside

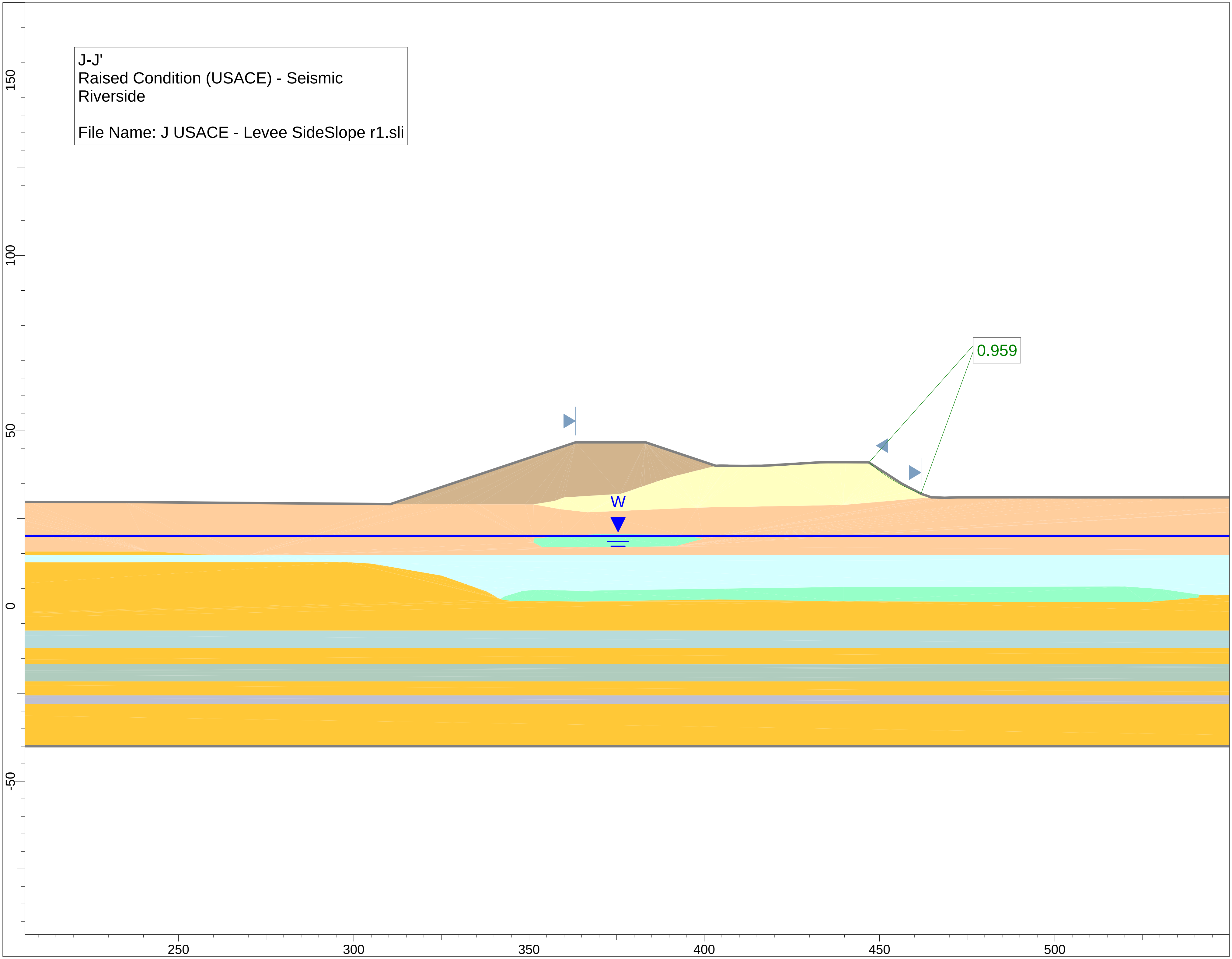
File Name: I USACE - Levee Sideslopes r1.sli

APPENDIX D-10

SECTION J-J’ ANALYSIS

J-J'
Raised Condition (USACE) - Seismic
Riverside

File Name: J USACE - Levee SideSlope r1.sli

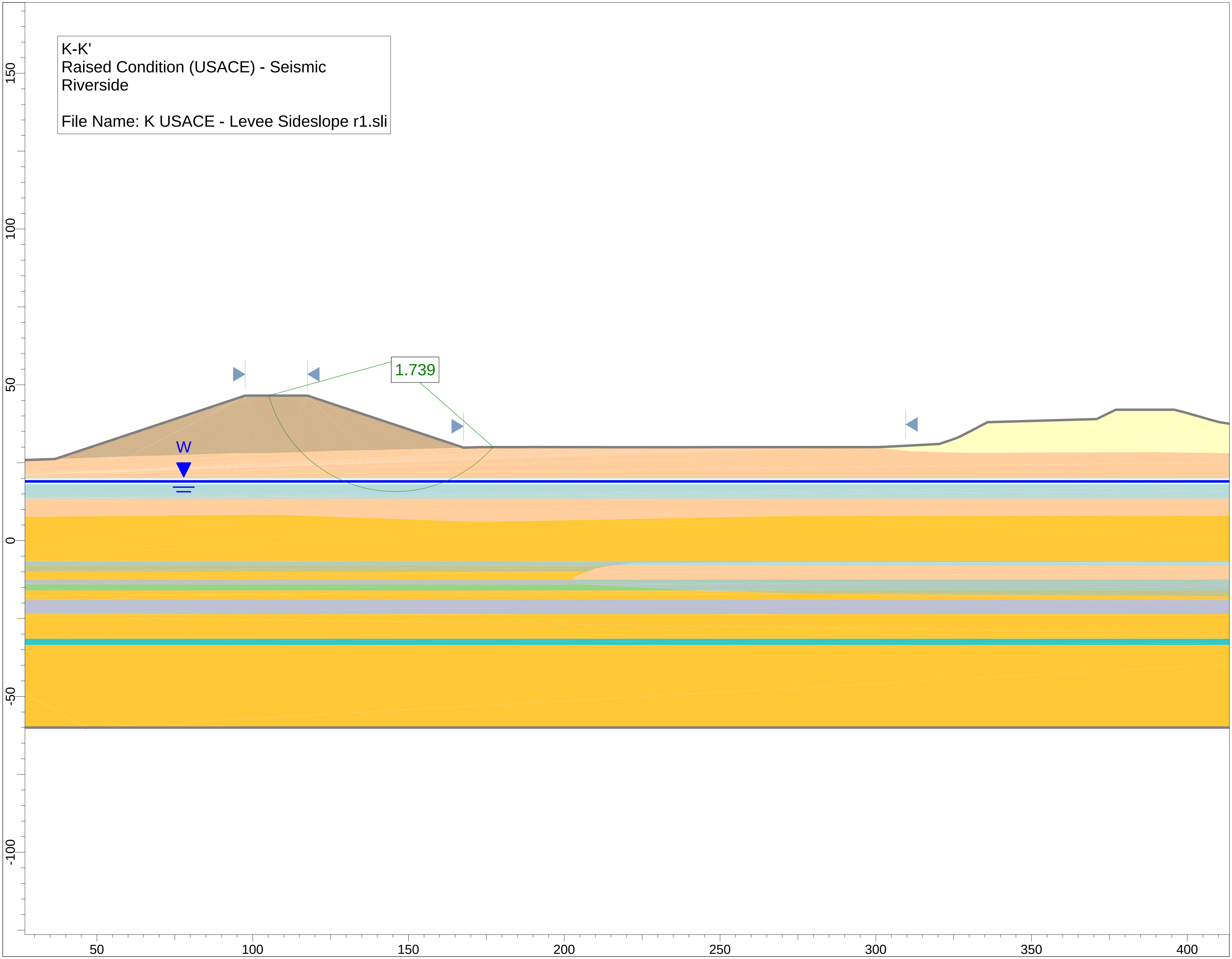


APPENDIX D-11

SECTION K-K’ ANALYSIS

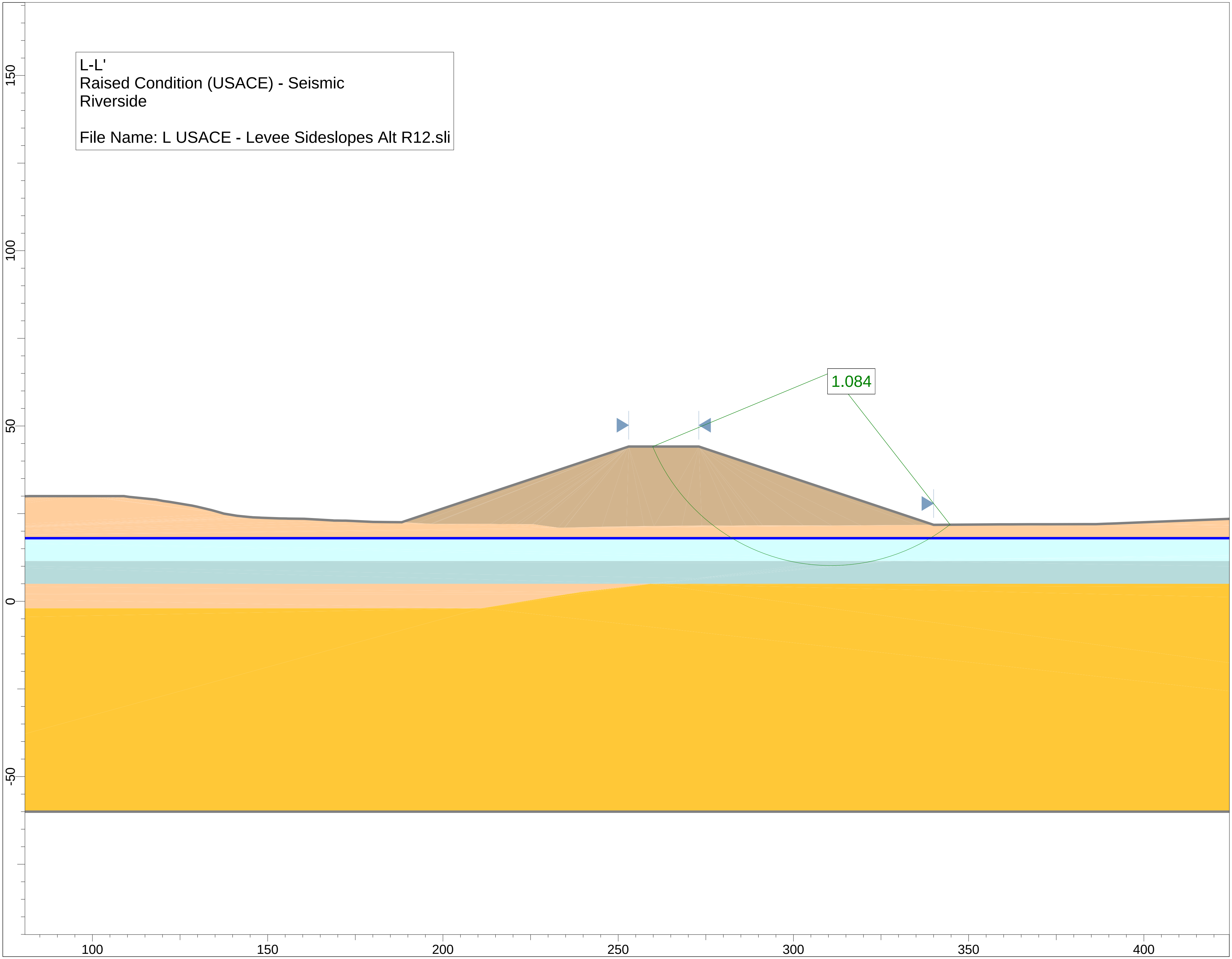
K-K'
Raised Condition (USACE) - Seismic
Riverside

File Name: K USACE - Levee Sideslope r1.sli



APPENDIX D-12

SECTION L-L’ ANALYSIS



L-L'
Raised Condition (USACE) - Seismic
Riverside

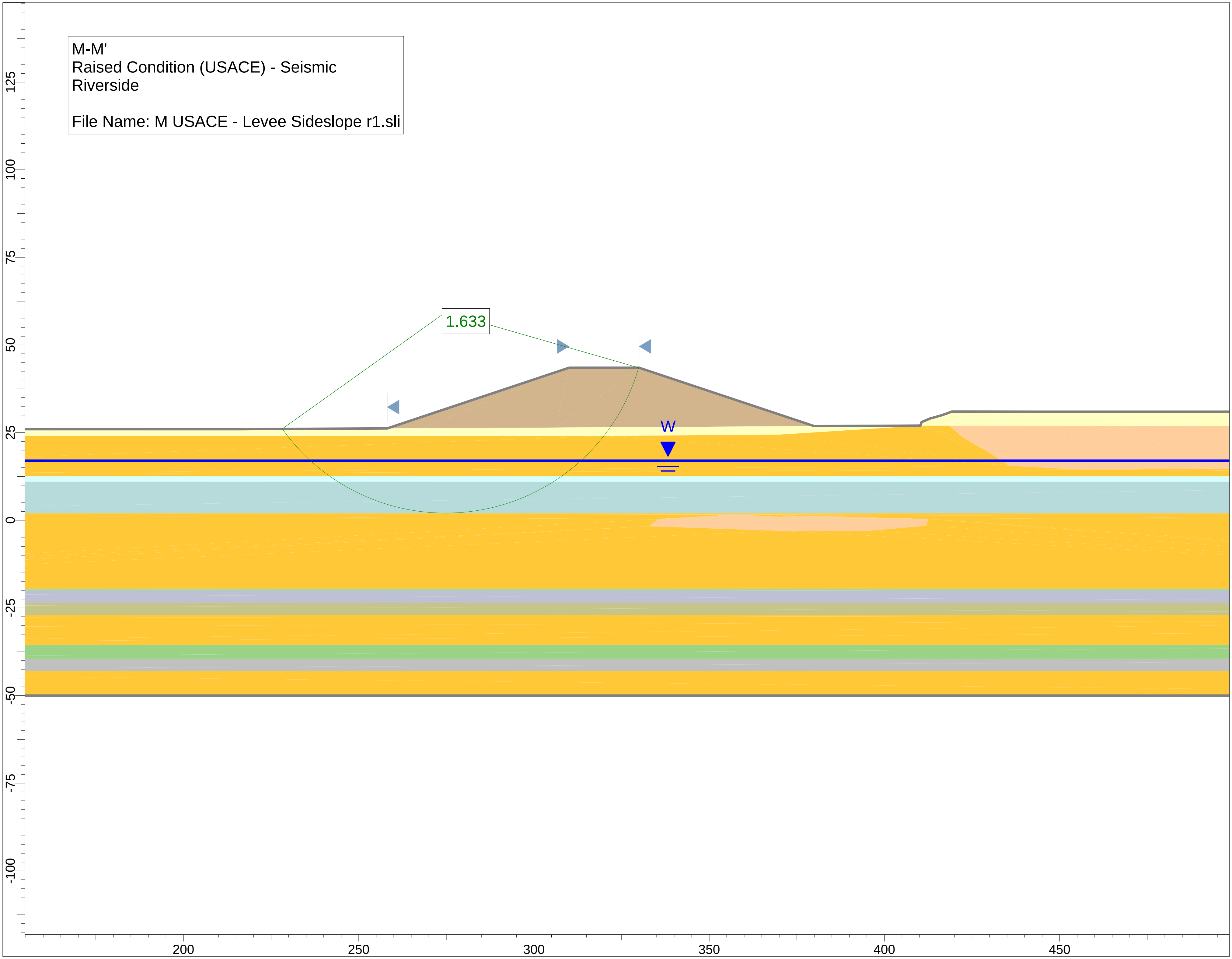
File Name: L USACE - Levee Sideslopes Alt R12.sli

APPENDIX D-13

SECTION M-M’ ANALYSIS

M-M'
Raised Condition (USACE) - Seismic
Riverside

File Name: M USACE - Levee Sideslope r1.sli



APPENDIX E

ENGINEERING ANALYSIS - LIQUEFACTION ANALYSIS

E-1: HAMMER ENERGY TEST RESULTS
E-2: LIQUEFYPRO OUTPUTS – BORING LOGS
E-3: LIQUEFYPRO OUTPUTS – CPT LOGS
E-4: FERC RECOMMENDED RESIDUAL STRENGTH RELATIONSHIP

APPENDIX E-1

HAMMER ENERGY TEST RESULTS

DYNAMARK
DE
ENGINEERING INC.

DEI Cert No. 0904-1003F
July 20, 2009

Mr. Jaymen Lauer
Cascade Drilling, Inc.
PO box 1184 Woodinville, WA 98072

Subject: **Certification of energy transfer between strike hammers and rods on three drilling rigs**
Drill rigs instrumented:
#1 (WA Sate license no. A50711F)
#W121 (WA State license no. B1266A)
#W138 (WA State license no. B96773C)

Reference: Our previous reports dated April 4, 2009

Dear Mr. Lauer:

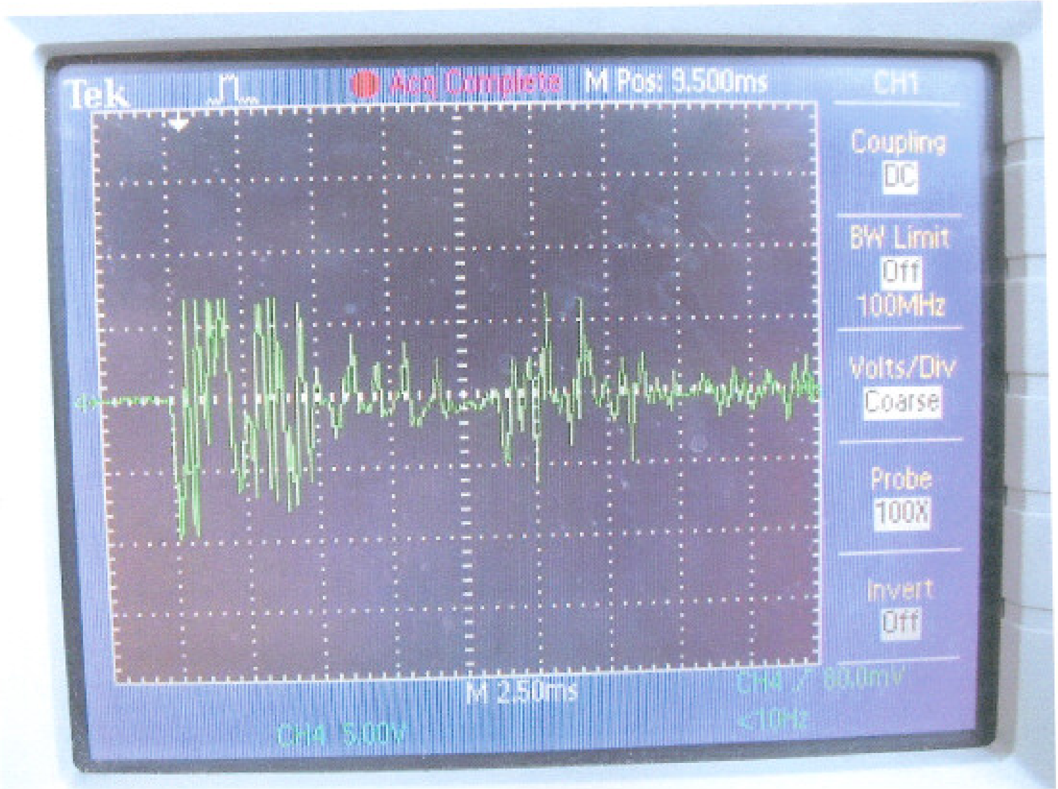
Per your request, we have completed certification of the magnitude of energy transfer between the hammers and rods on three drill rigs. This report contains a summary of our testing approach and results.

The weights of these hammers and their respective drop heights were previously verified in the referenced reports. The approach of this work was to instrument a modified rod with a calibrated, NIST-traceable accelerometer, then read the impulse trace on an oscilloscope during actual hammer blows. The impulse trace was then mathematically integrated to produce an initial momentum of the rod. The rod's initial momentum was then mathematically converted to kinetic energy. This kinetic energy of the rod was compared with the initial kinetic energy of the falling hammer to determine the fraction of the hammer's initial energy that was delivered to the earth via the rod.

Figure 1 on the following page shows the instrumentation setup used for this determination. The sensor is a calibrated, NIST-traceable accelerometer that sends a signal to a digital storage oscilloscope.

Figure 2 shows the typical impulse trace from a hammer blow. The area beneath the initial spike in the trace represents the momentum transferred to the rod. This momentum is then multiplied by the rod's terminal velocity and divided in half to obtain the kinetic energy transferred to the rod.

Figure 1. Accelerometer installation on the modified rod for determination of energy transfer.



M Pos: 9.500ms

Coupling
DC

BW Limit
Off
100MHz

Volts/Div
Coarse

Probe
100X

Invert
Off

M 2.50ms

CH4 5.00V

CH4 ∕ 80.0mV
<10Hz

Figure 2. Typical impulse trace for a typical hammer blow.

Table 1 shows the quantity of energy delivered to each rod by the hammer for the respective drill rig, the energy received by each rod, and the resulting fractional energy transfer, expressed as a percentage of the original hammer energy.

Table 1. Energy Transfer for Each Drill Rig Hammer

Drill Rig ID	Hammer Weight [lbm]	Hammer Energy [ft-lb]	Rod Energy [ft-lb]	Energy Transfer [%]
#1	140	350	265	**75.7**
#W121	300	750	671	**89.4**
#W138	140	350	266	**75.9**

Thank you for using Dynamark Engineering, Inc. Please give me a call if you have any questions regarding this information, or when we can again be of service.

Reviewed by: Leesa Johansen LJ

Sincerely,

Mark J. Suryan, PE

APPENDIX E-2

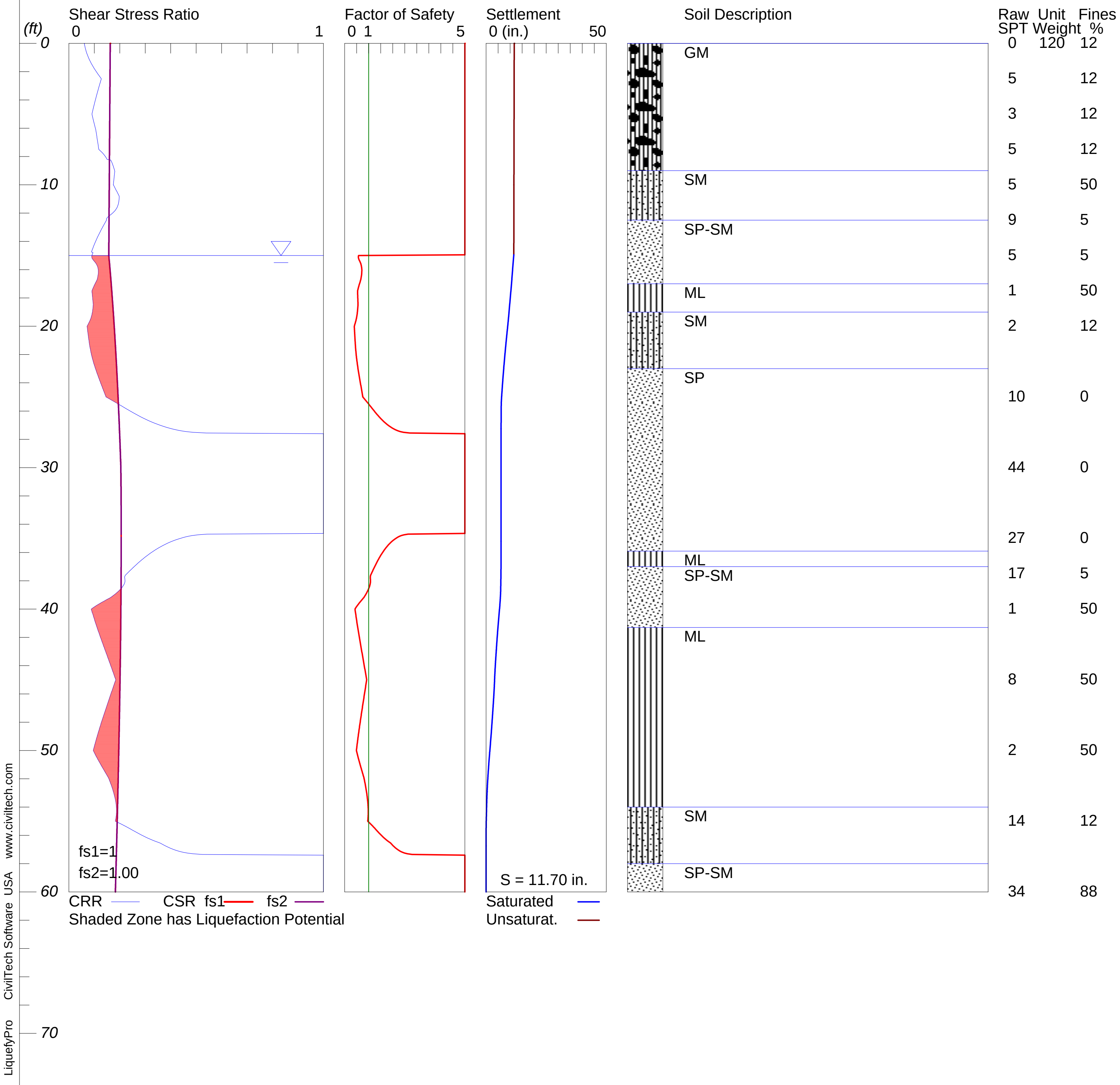
LIQUEFYPRO OUTPUTS – BORING LOGS

LIQUEFACTION ANALYSIS

Boring GB-1

Hole No.=GB-1   Water Depth=15 ft   Surface Elev.=43

Magnitude=7
Acceleration=0.25g

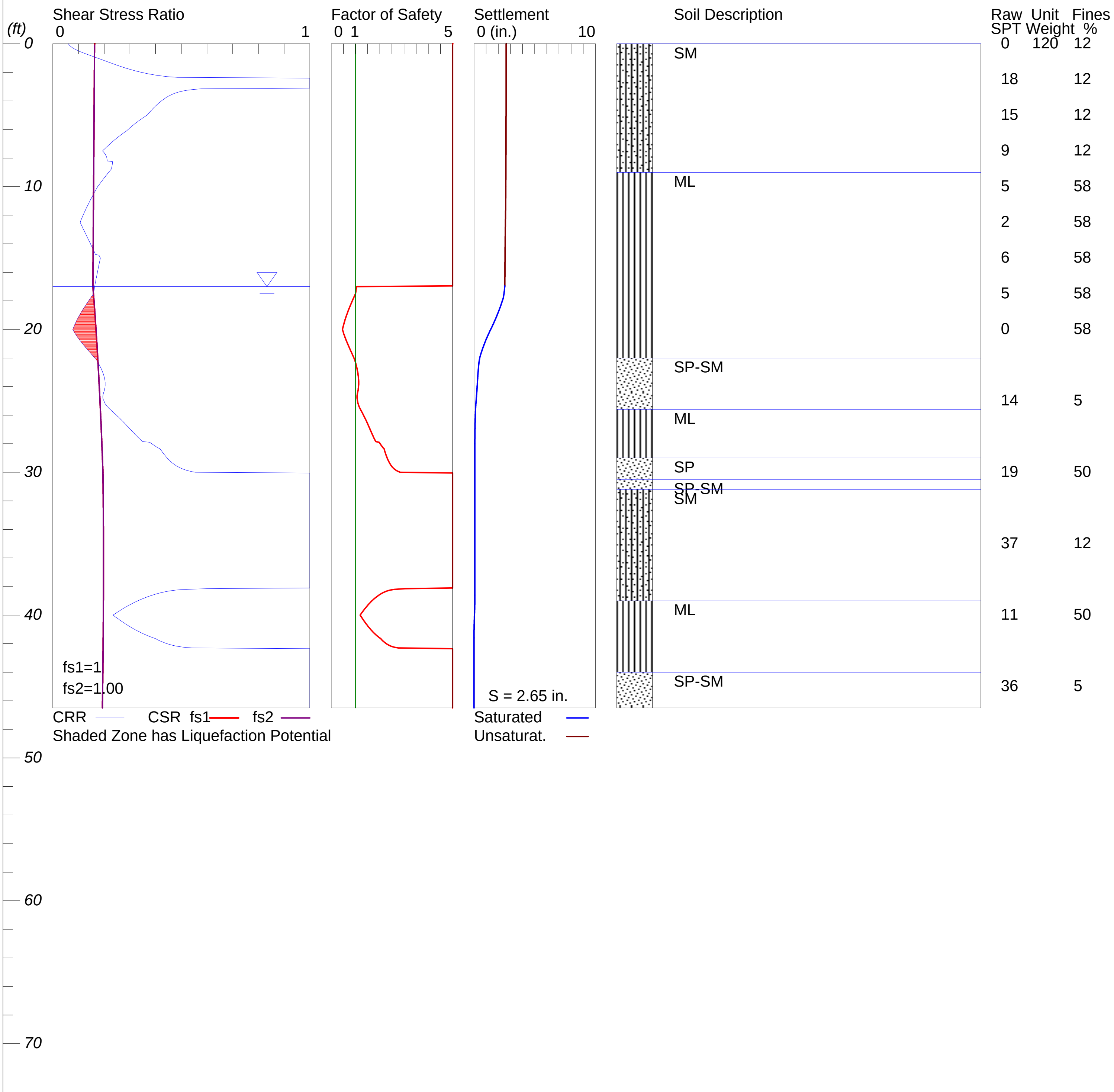


LIQUEFACTION ANALYSIS

Boring GB-2

Hole No.=GB-2 Water Depth=17 ft Surface Elev.=42

Magnitude=7
Acceleration=0.25g



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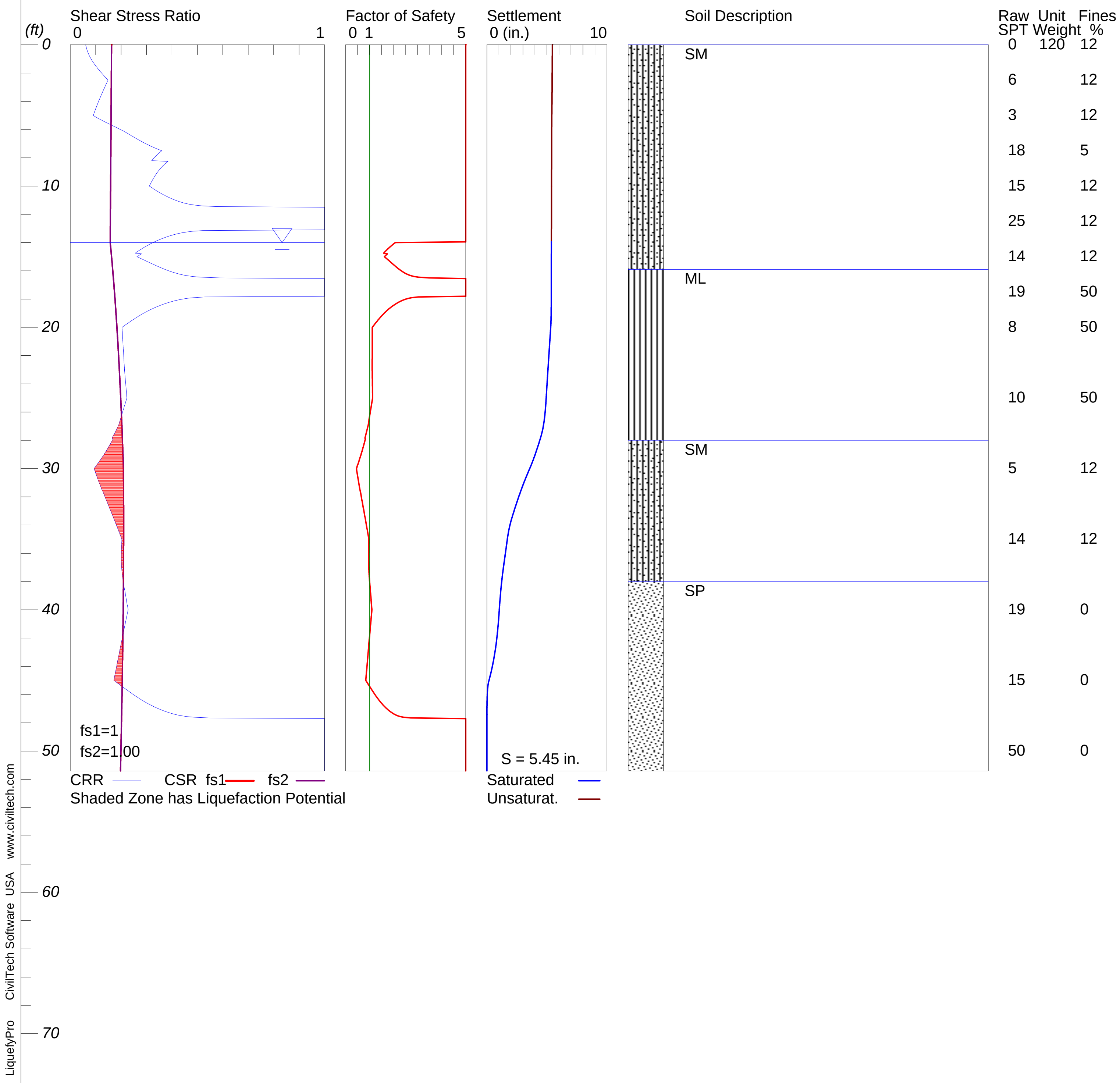
LIQUEFACTION ANALYSIS

Boring GB-4

Hole No.=GB-4 Water Depth=14 ft Surface Elev.=45

Magnitude=7.0
Acceleration=0.25g



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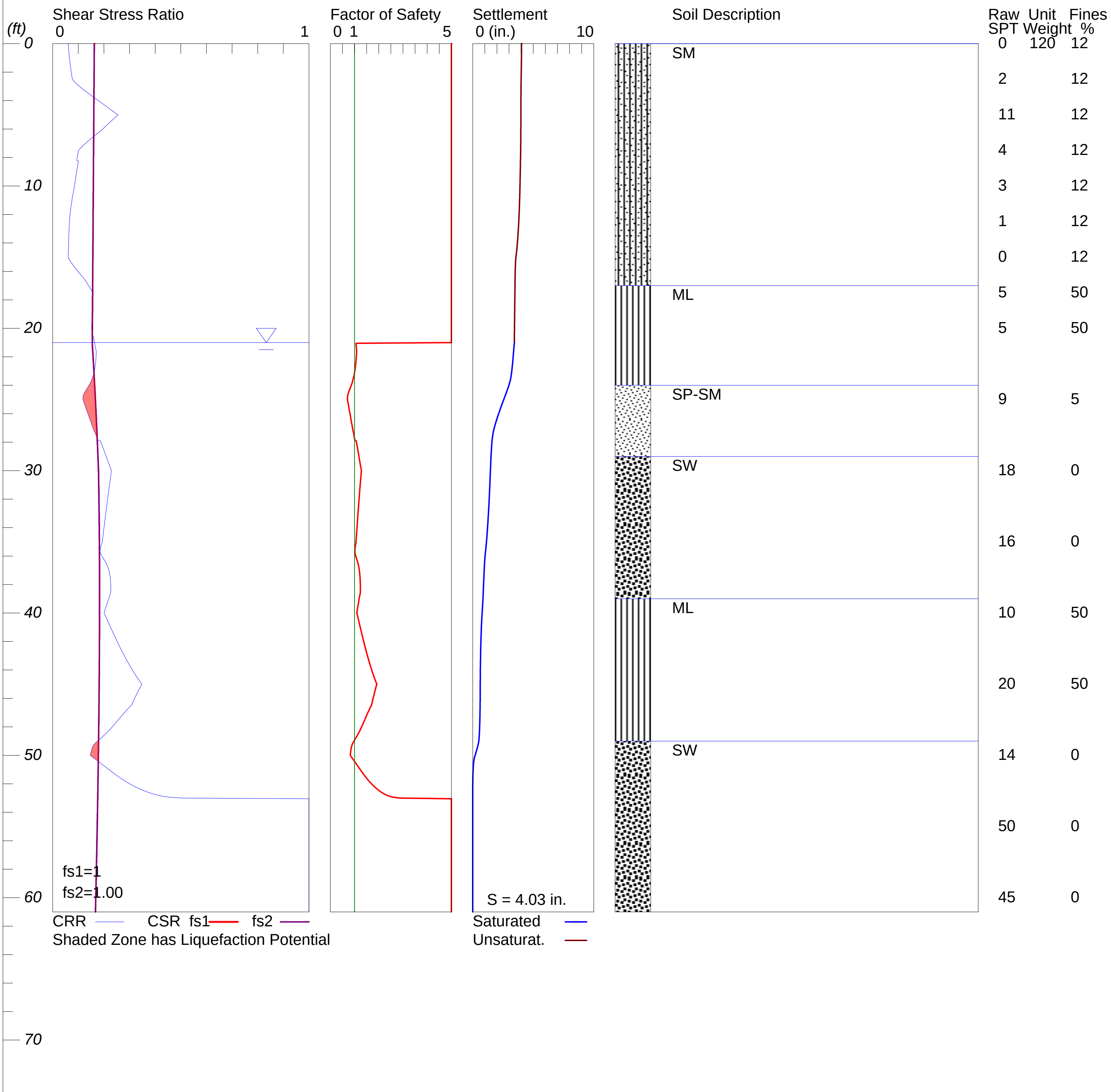
LIQUEFACTION ANALYSIS

Boring GB-12

Hole No.=GB-12 Water Depth=21 ft Surface Elev.=44

Magnitude=7
Acceleration=0.25g



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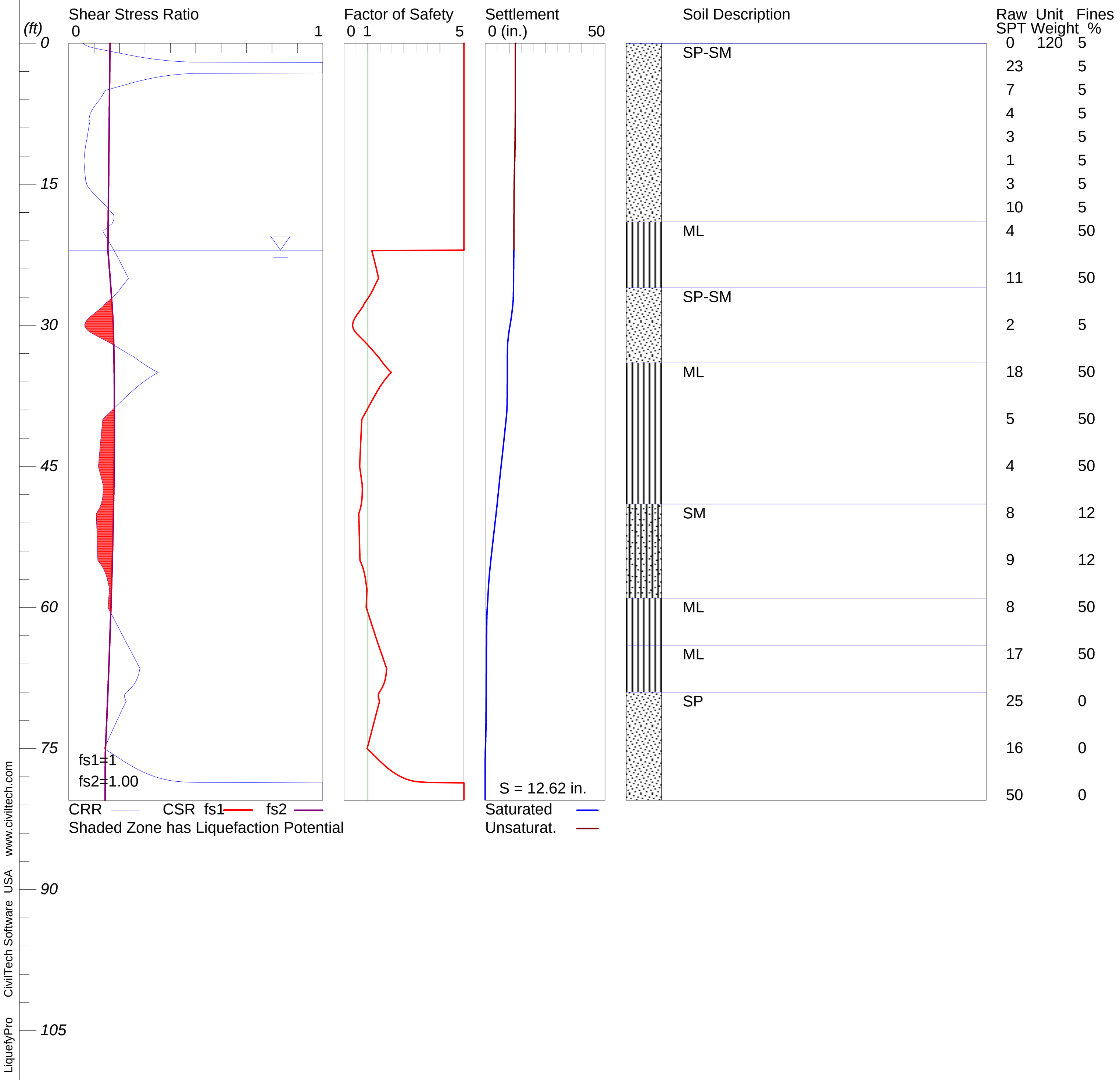
LIQUEFACTION ANALYSIS

Boring GB-14

Hole No.=GB-14 Water Depth=22 ft Surface Elev.=43 ***Magnitude=7.0***
Acceleration=0.25g

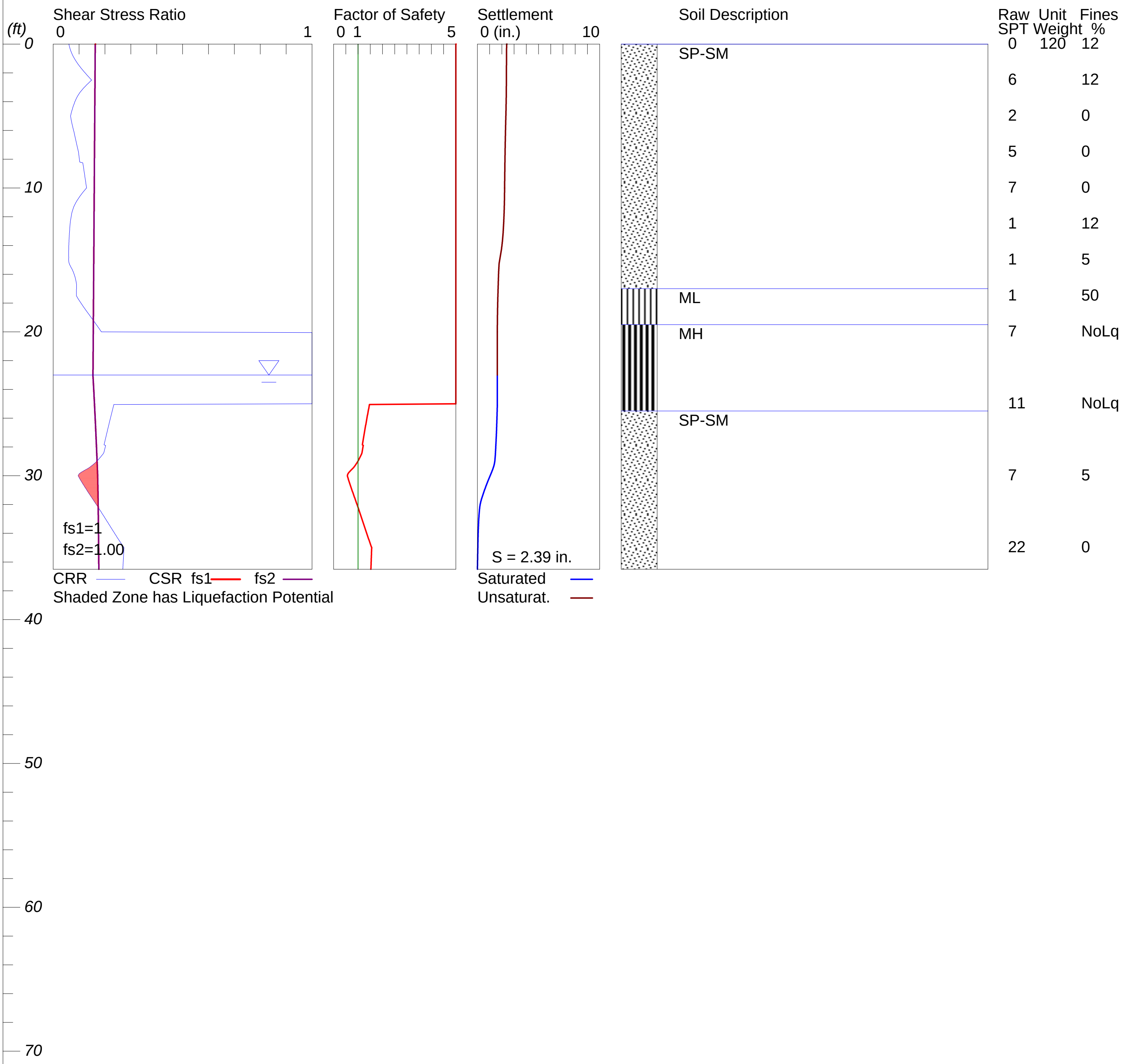


LIQUEFACTION ANALYSIS

Boring GB-15

Hole No.=GB-15   Water Depth=23 ft   Surface Elev.=43

Magnitude=7
Acceleration=0.25g

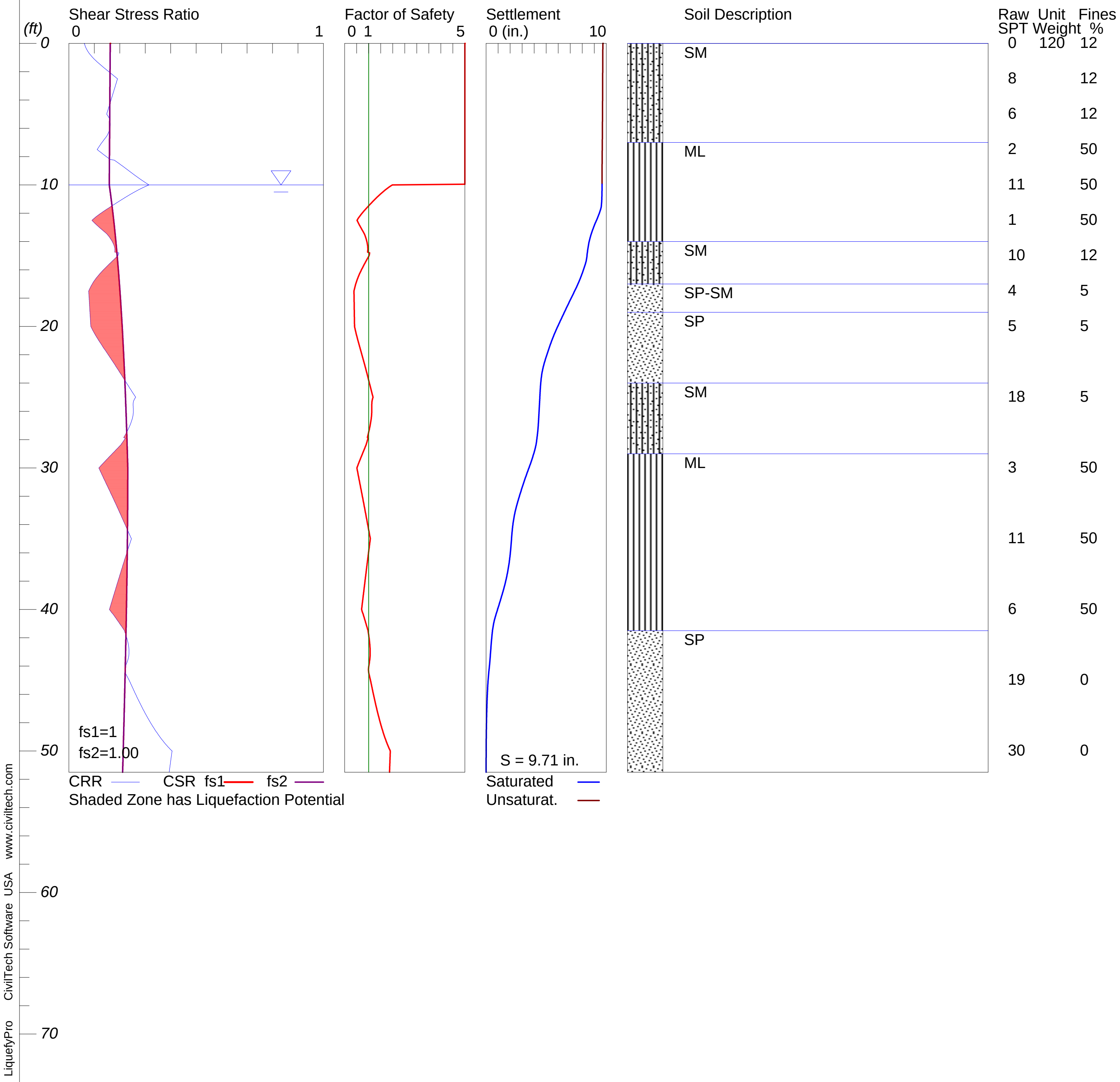


LIQUEFACTION ANALYSIS

Boring GB-16

Hole No.=GB-16 Water Depth=10 ft Surface Elev.=30

Magnitude=7
Acceleration=0.25g



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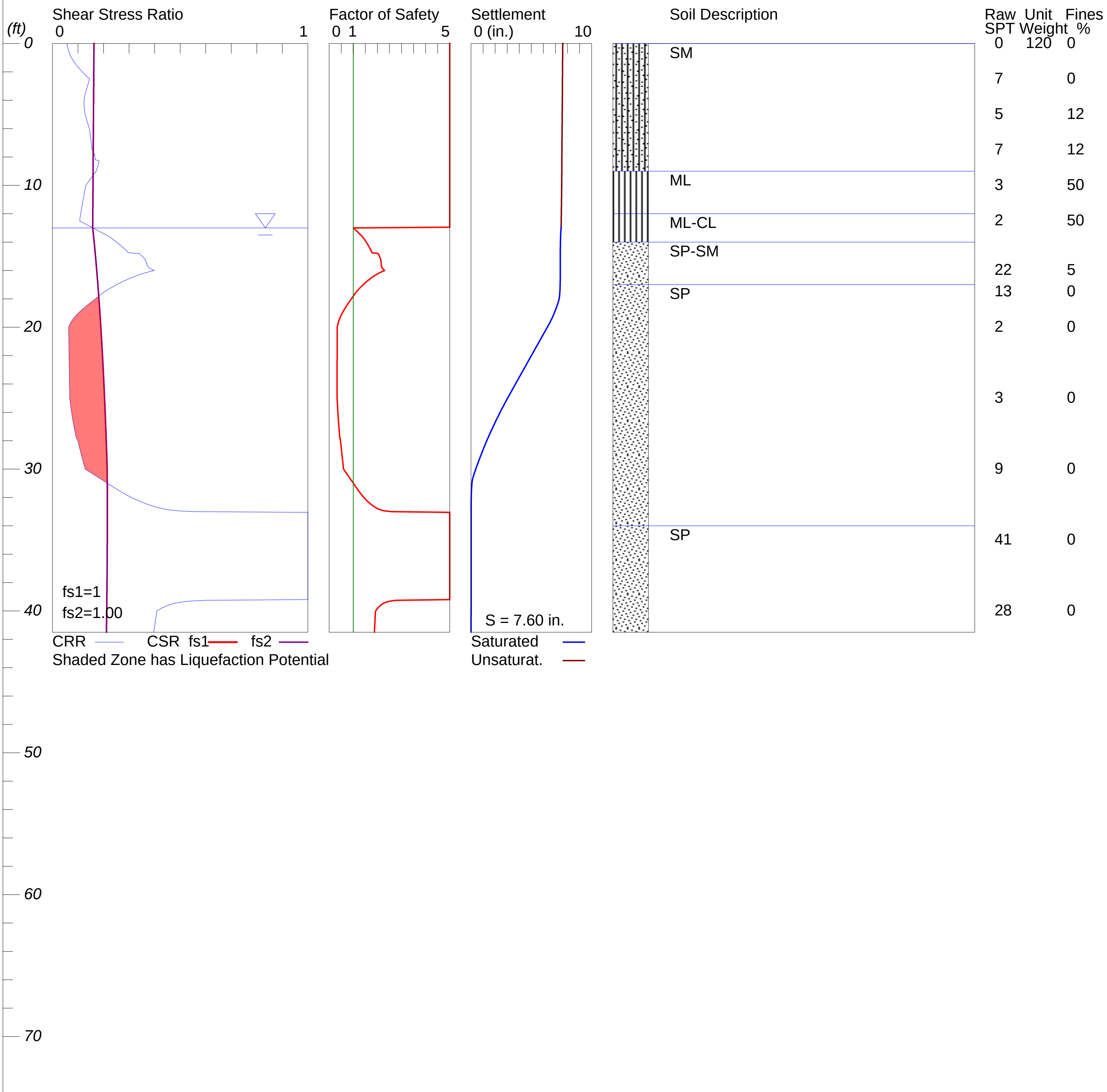
LIQUEFACTION ANALYSIS

Boring GB-17

Hole No.=GB-17 Water Depth=13 ft Surface Elev.=33

Magnitude=7
Acceleration=0.25g



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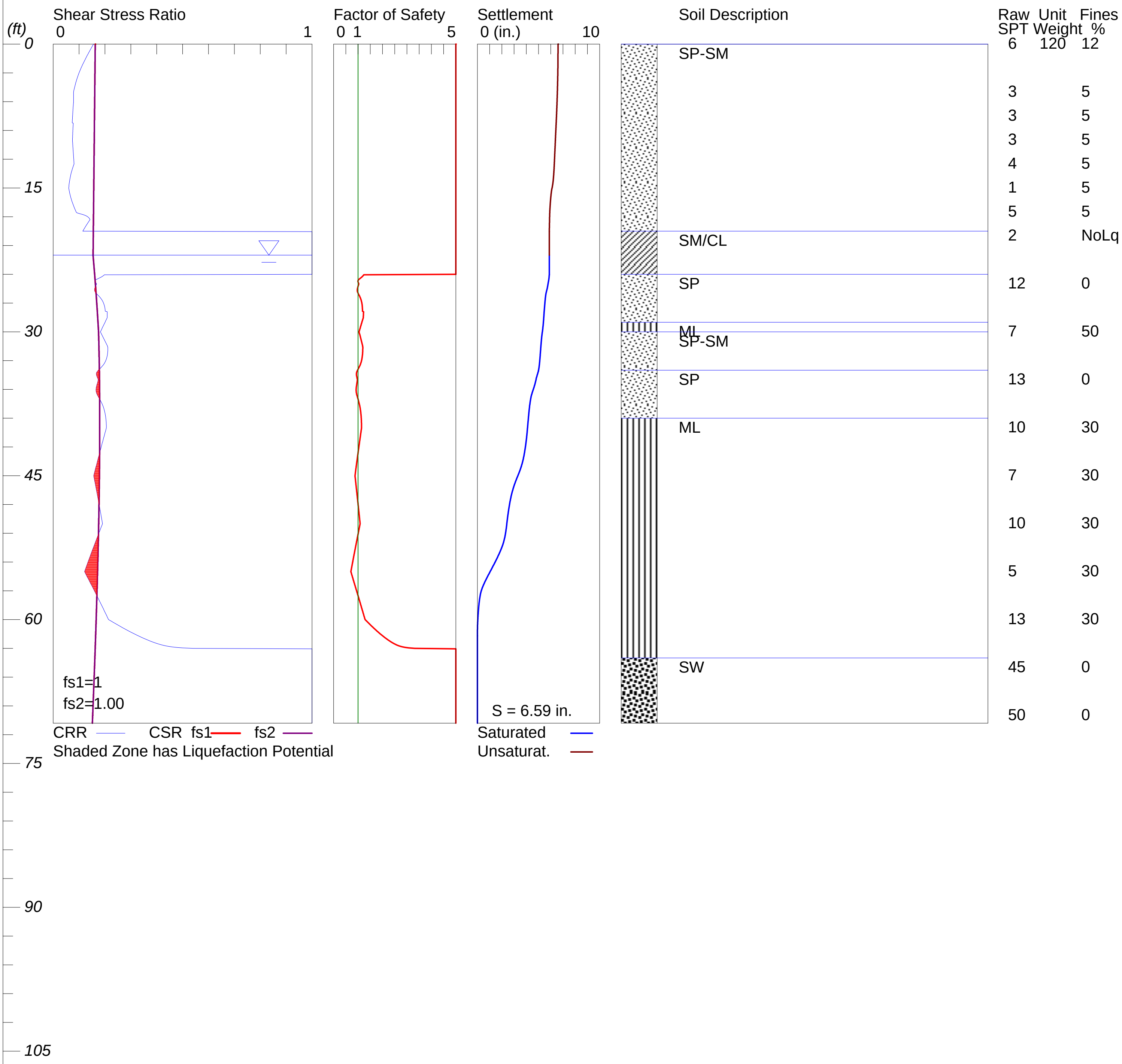
LIQUEFACTION ANALYSIS

Boring GB-18

Hole No.=GB-18 Water Depth=22 ft Surface Elev.=42

Magnitude=7
Acceleration=0.25g



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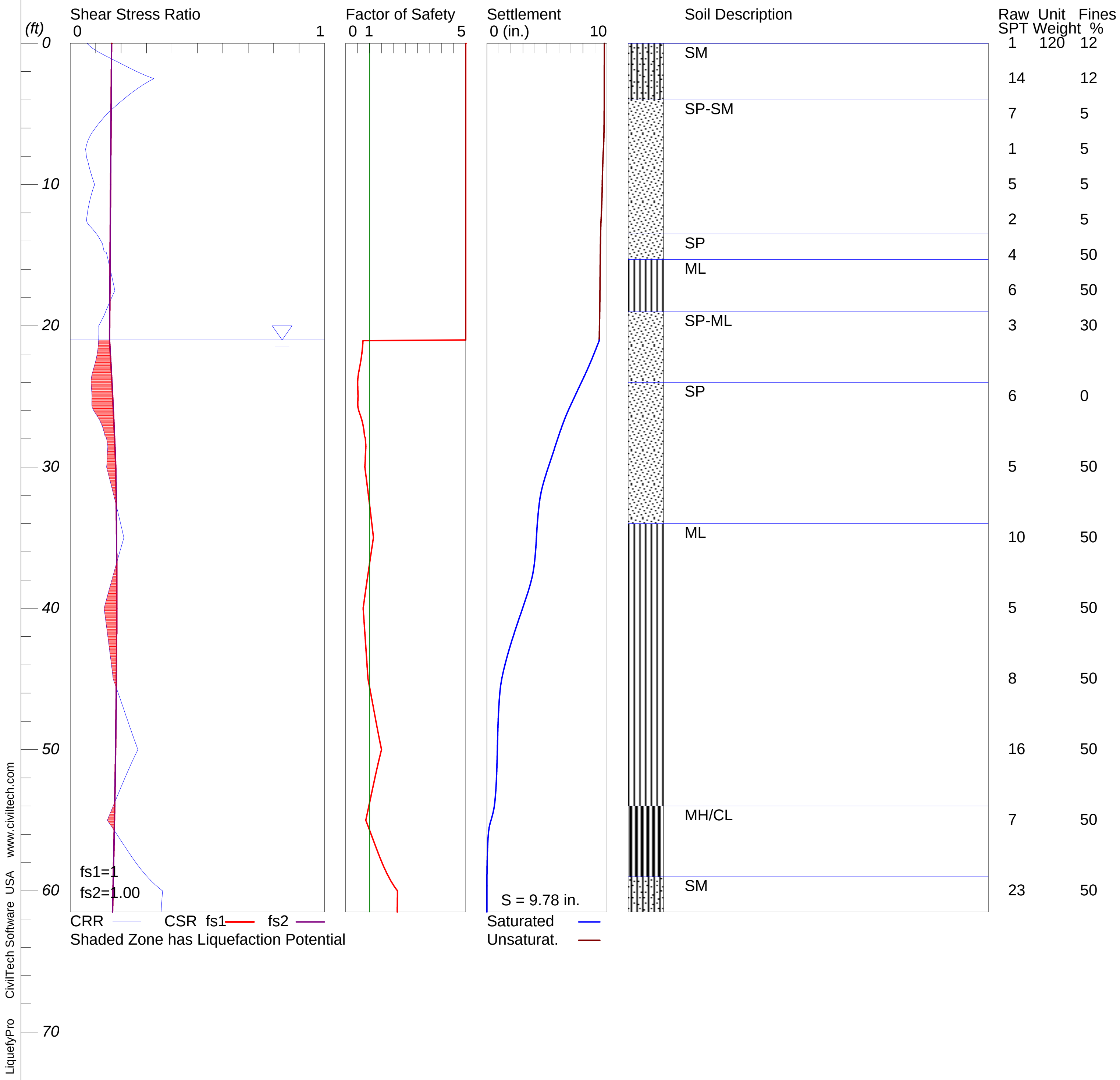
LIQUEFACTION ANALYSIS

Boring GB-19

Hole No.=GB-19 Water Depth=21 ft Surface Elev.=41

Magnitude=7
Acceleration=0.25g

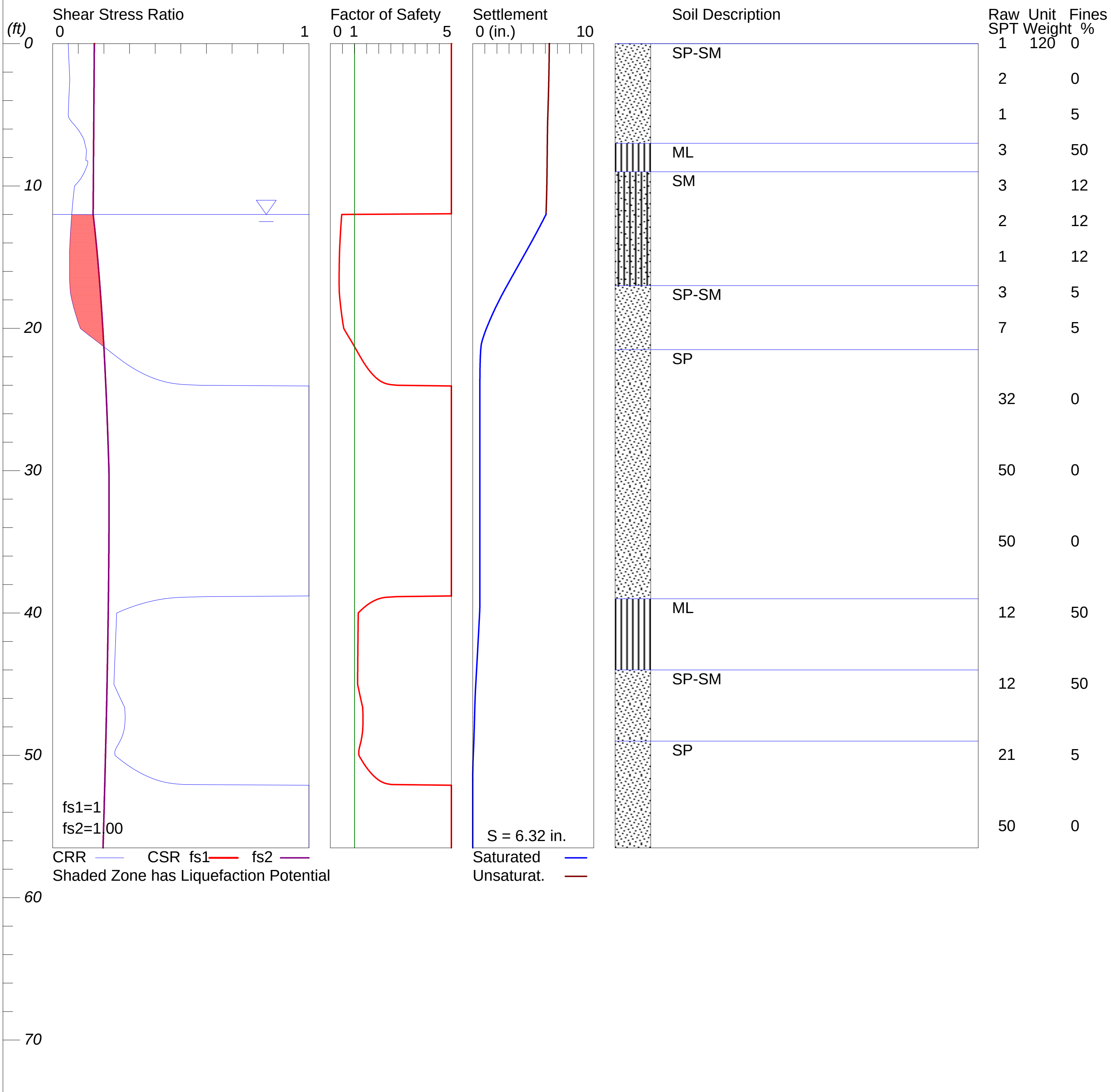


LIQUEFACTION ANALYSIS

Boring GB-20

Hole No.=GB-20 Water Depth=12 ft Surface Elev.=32

Magnitude=7.0
Acceleration=0.25g



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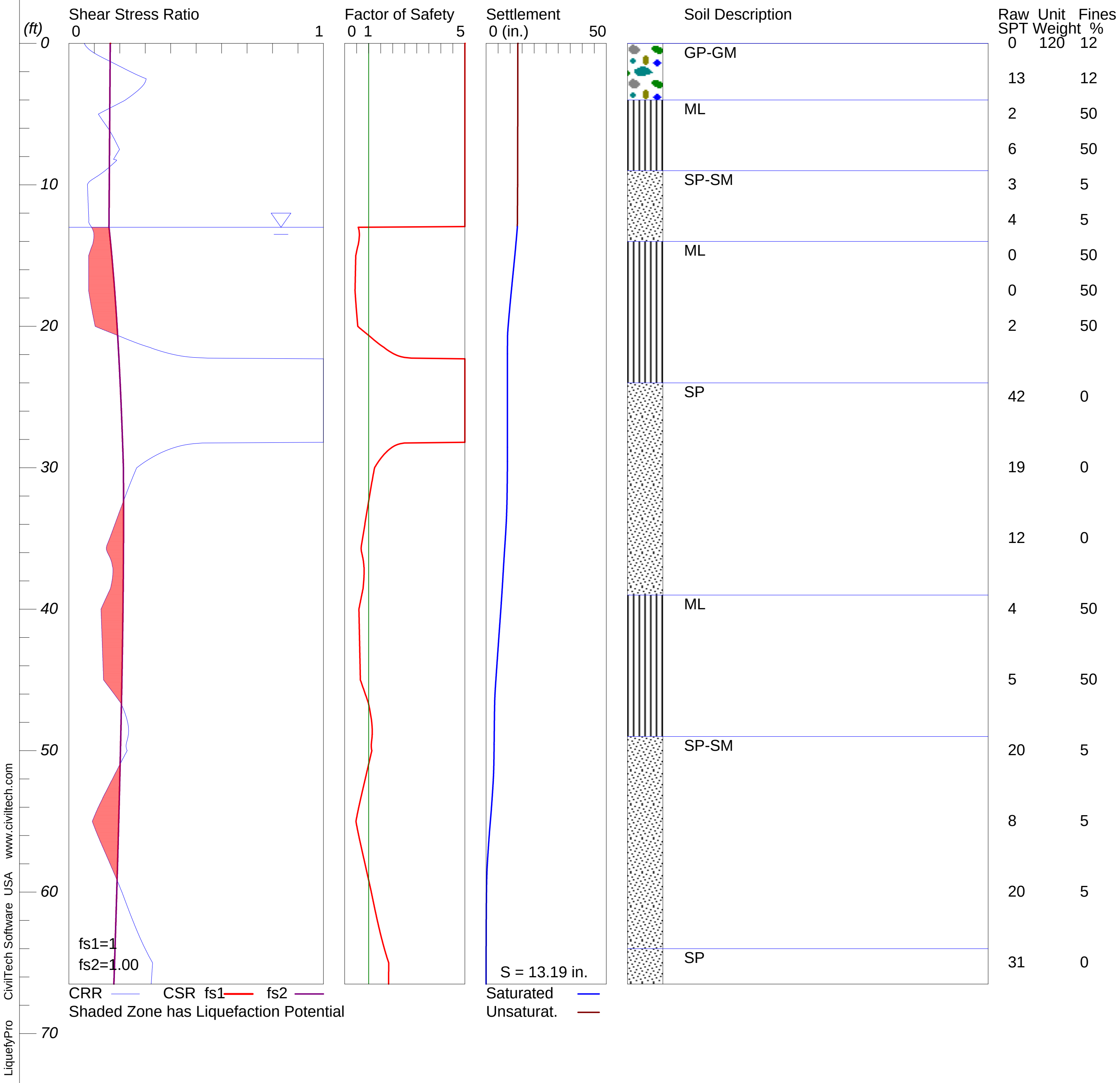
LIQUEFACTION ANALYSIS

Boring GB-21

Hole No.=GB-21 Water Depth=13 ft Surface Elev.=32

Magnitude=7.0
Acceleration=0.25g

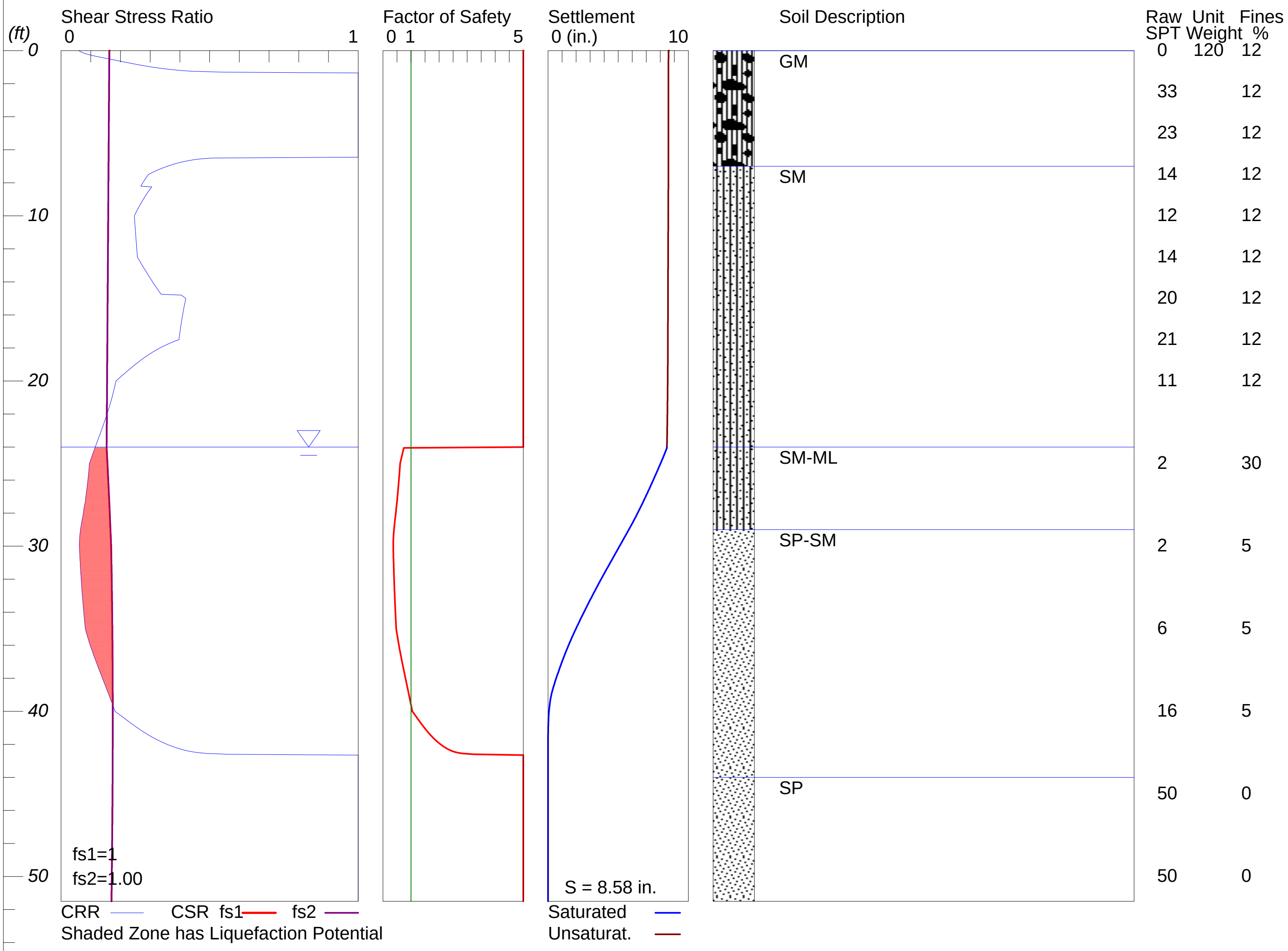


LIQUEFACTION ANALYSIS

Boring GB-22

Hole No.=GB-22 Water Depth=24 ft Surface Elev.=45

Magnitude=7.0
Acceleration=0.25g



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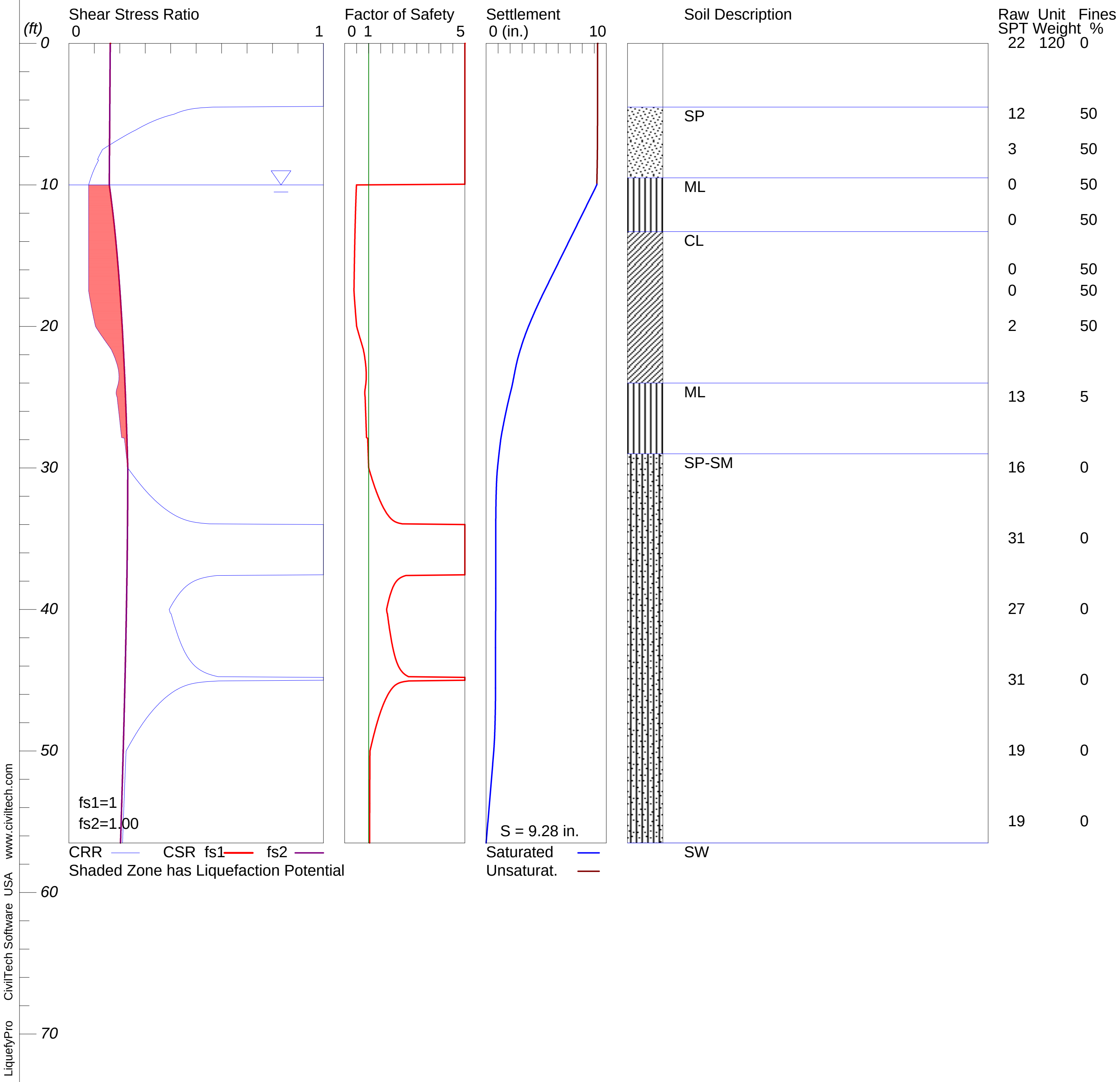
LIQUEFACTION ANALYSIS

Boring GB-24

Hole No.=GB-24 Water Depth=10 ft Surface Elev.=27

Magnitude=7.0
Acceleration=0.25g



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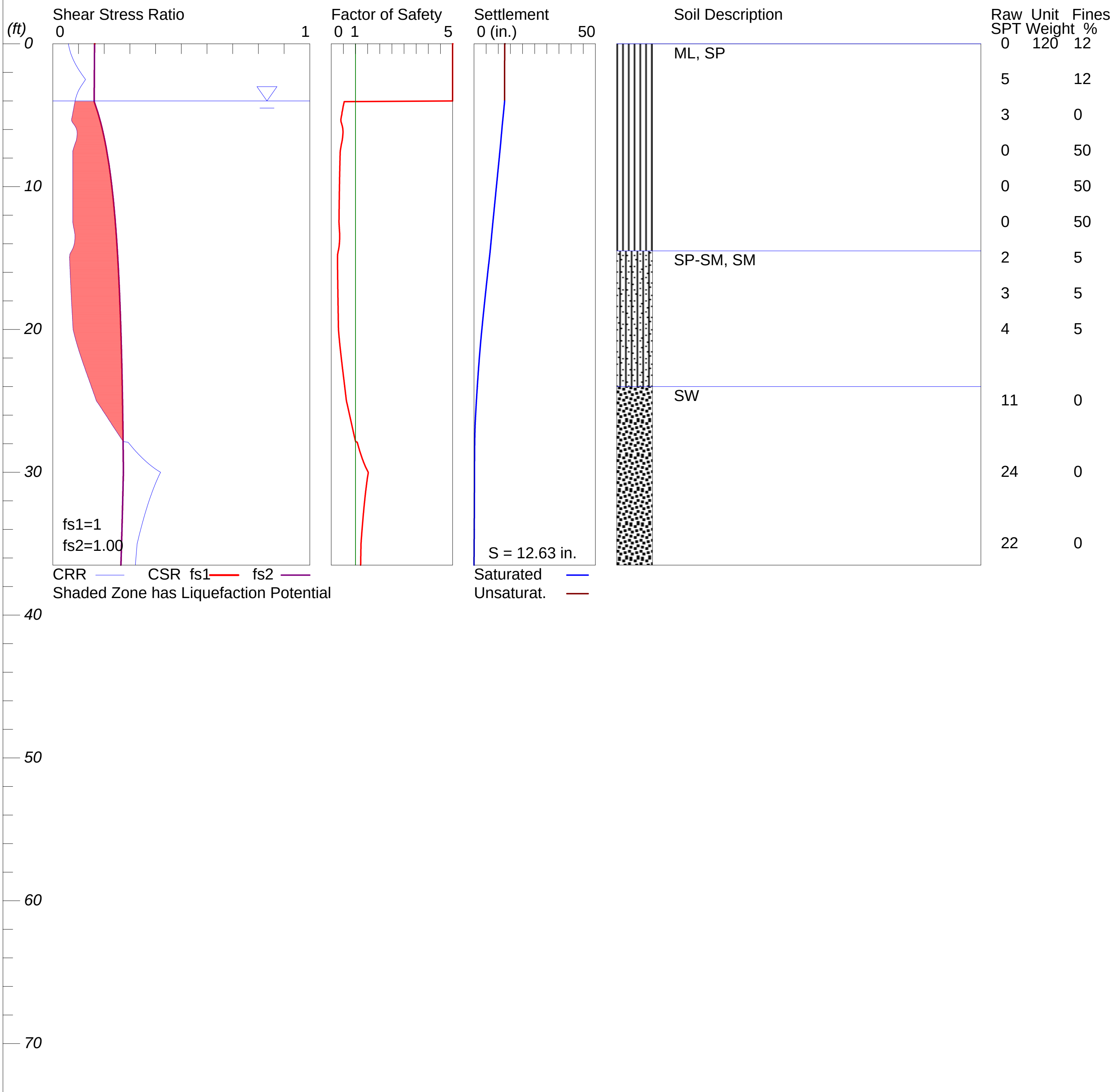
LIQUEFACTION ANALYSIS

Boring GB-25

Hole No.=GB-25 Water Depth=4 ft Surface Elev.=22

Magnitude=7.0
Acceleration=0.25g

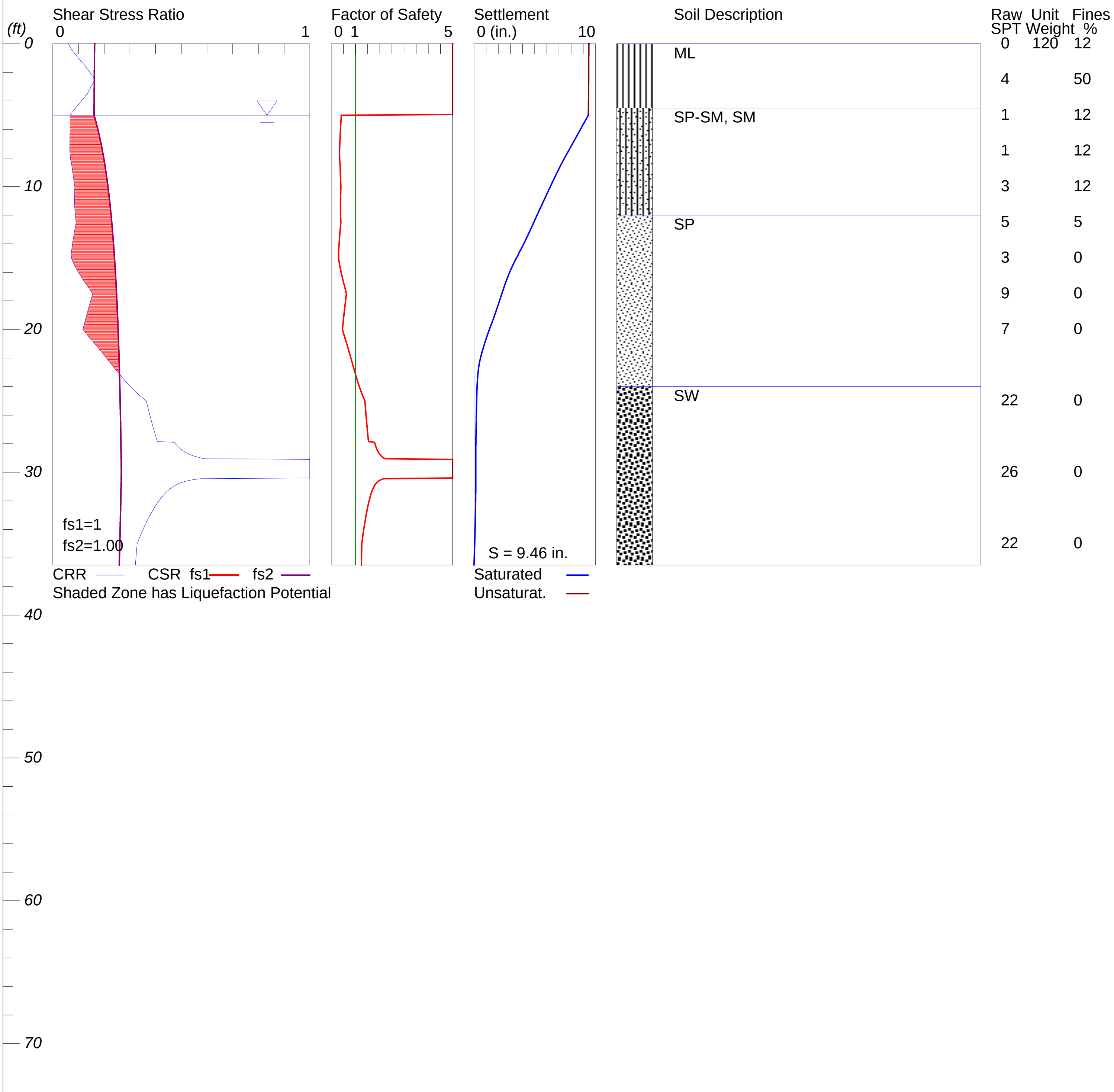


LIQUEFACTION ANALYSIS

Boring GB-26

Hole No.=GB-26 Water Depth=5 ft Surface Elev.=23

Magnitude=7.0
Acceleration=0.25g

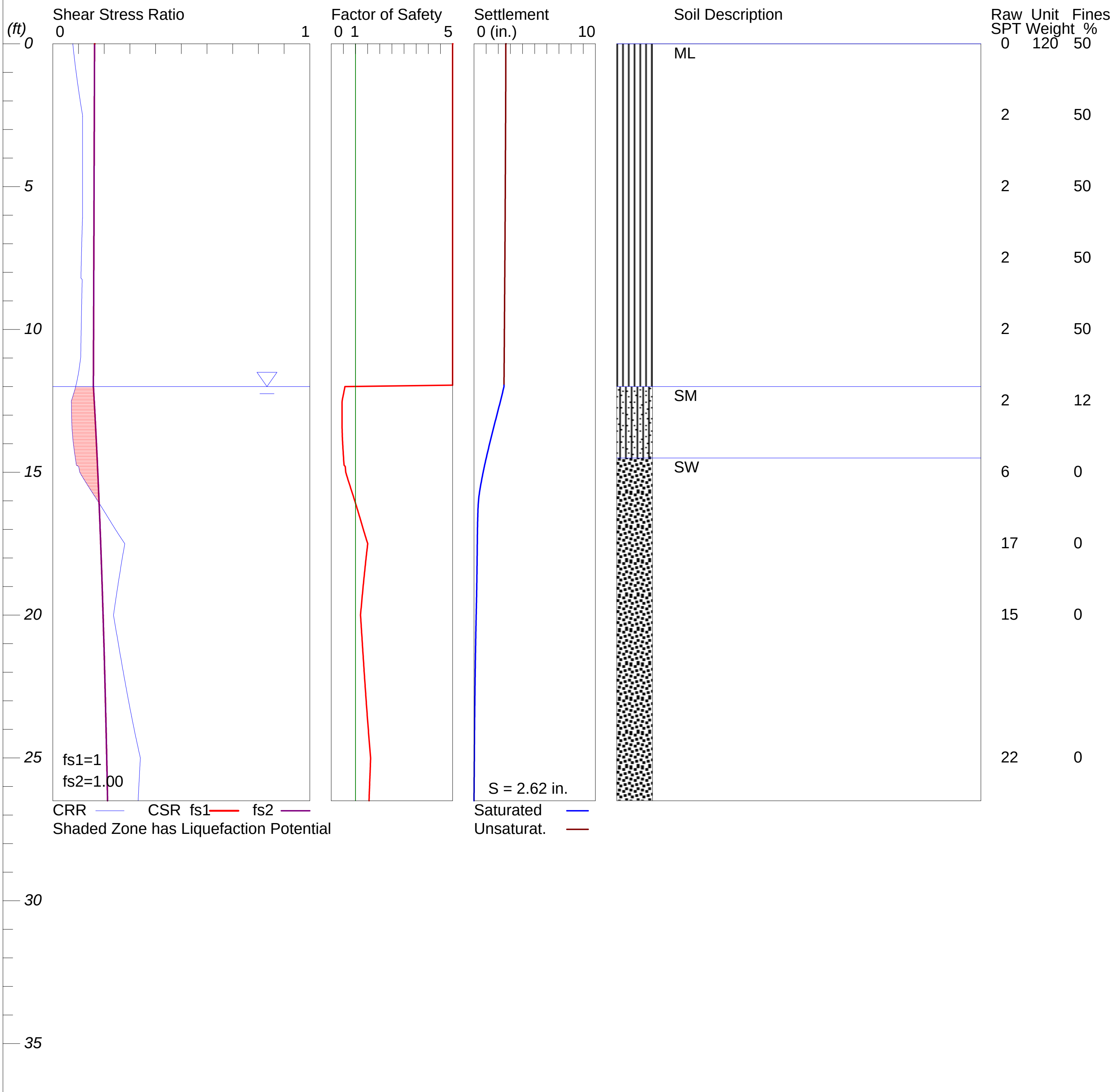


LIQUEFACTION ANALYSIS

Boring GB-27

Hole No.=GB-27 Water Depth=12 ft Surface Elev.=29

Magnitude=7.0
Acceleration=0.25g



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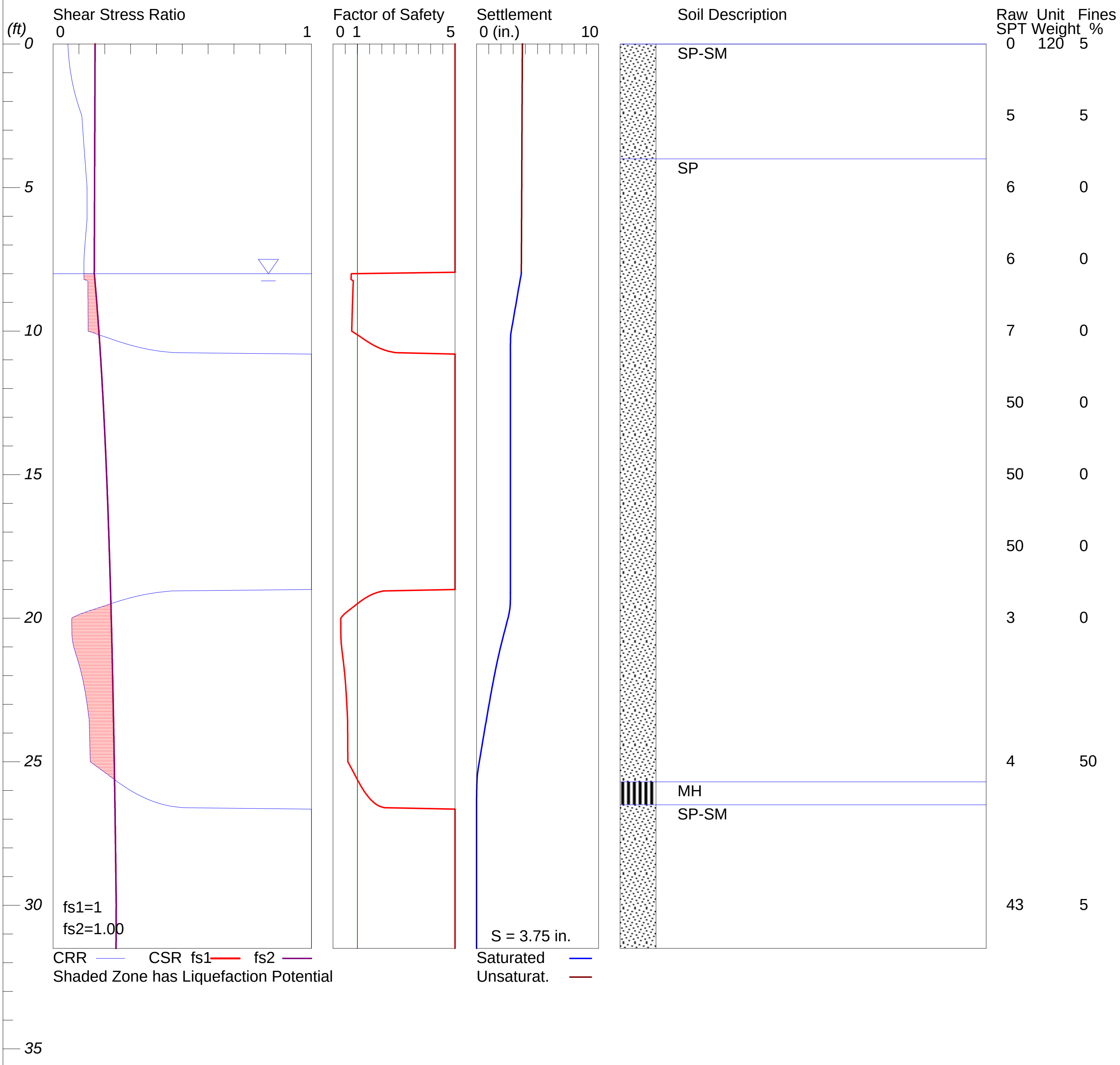
LIQUEFACTION ANALYSIS

Boring GB-28

Hole No.=GB-28   Water Depth=8 ft   Surface Elev.=26

Magnitude=7.0
Acceleration=0.25g



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APPENDIX E-3

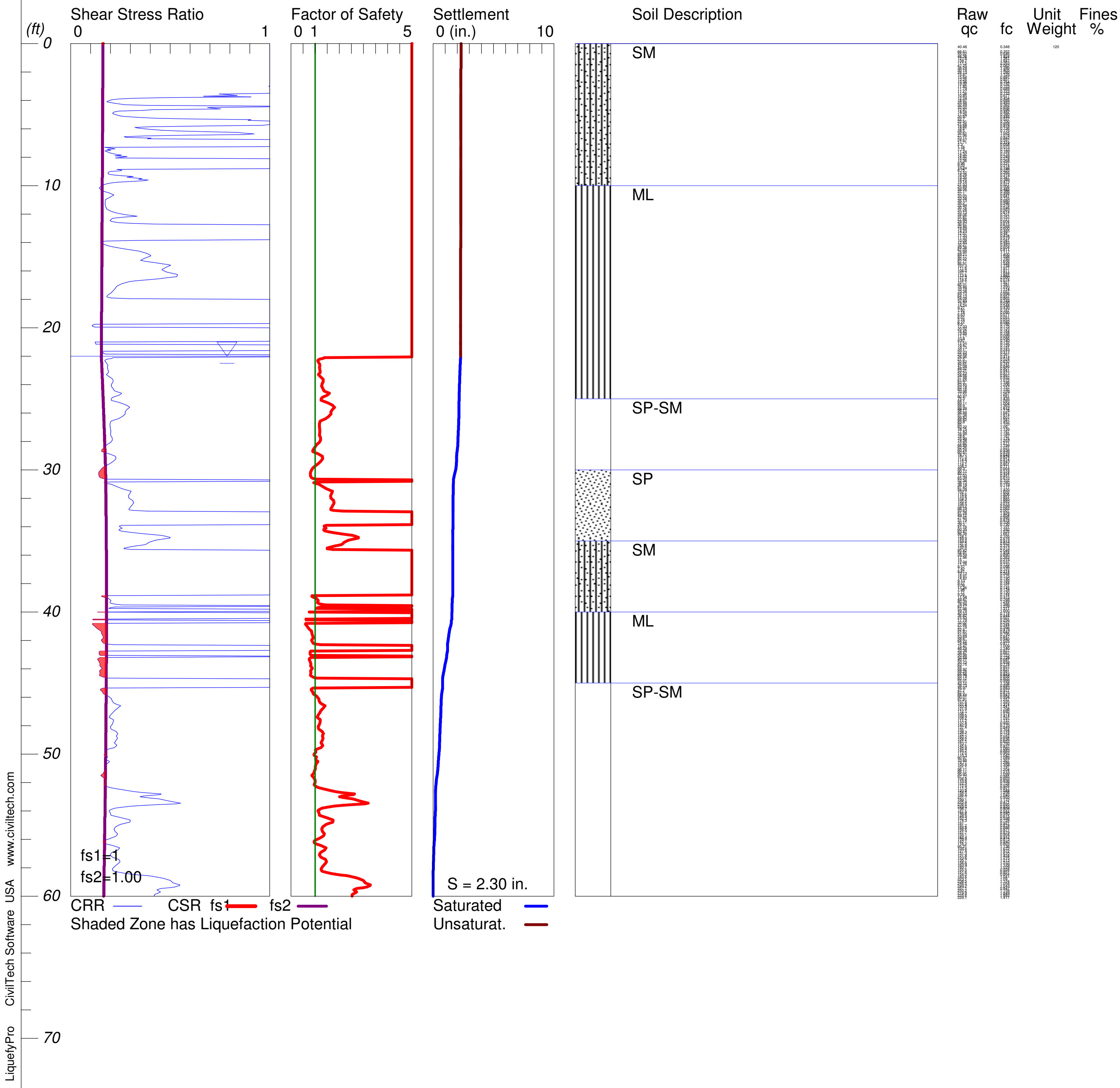
LIQUEFYPRO OUTPUTS – CPT LOGS

LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-1 Water Depth=22 ft Surface Elev.=45

Magnitude=7
Acceleration=0.25g



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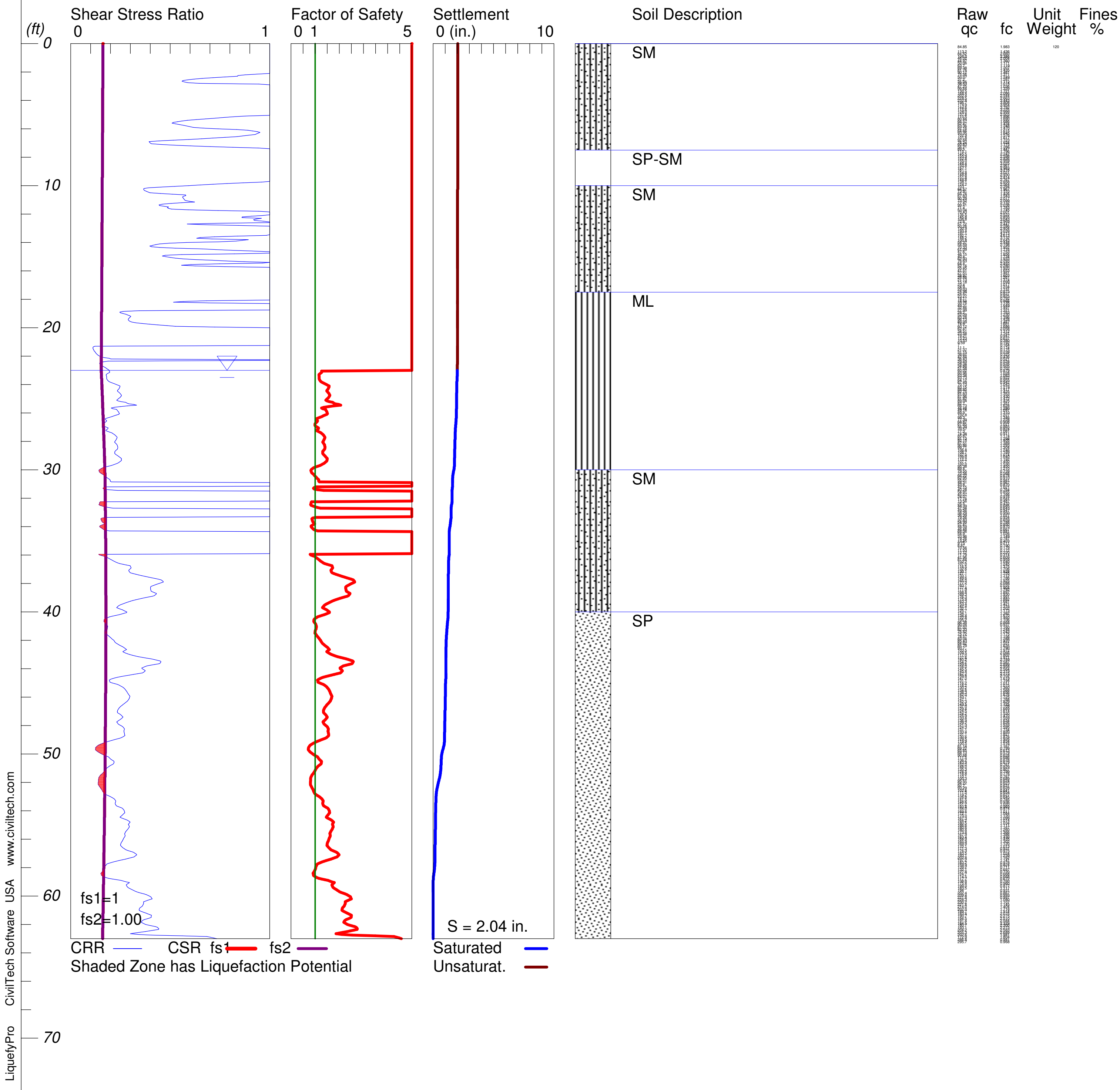
LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-2 Water Depth=23 ft Surface Elev.=45

Magnitude=7
Acceleration=0.25g



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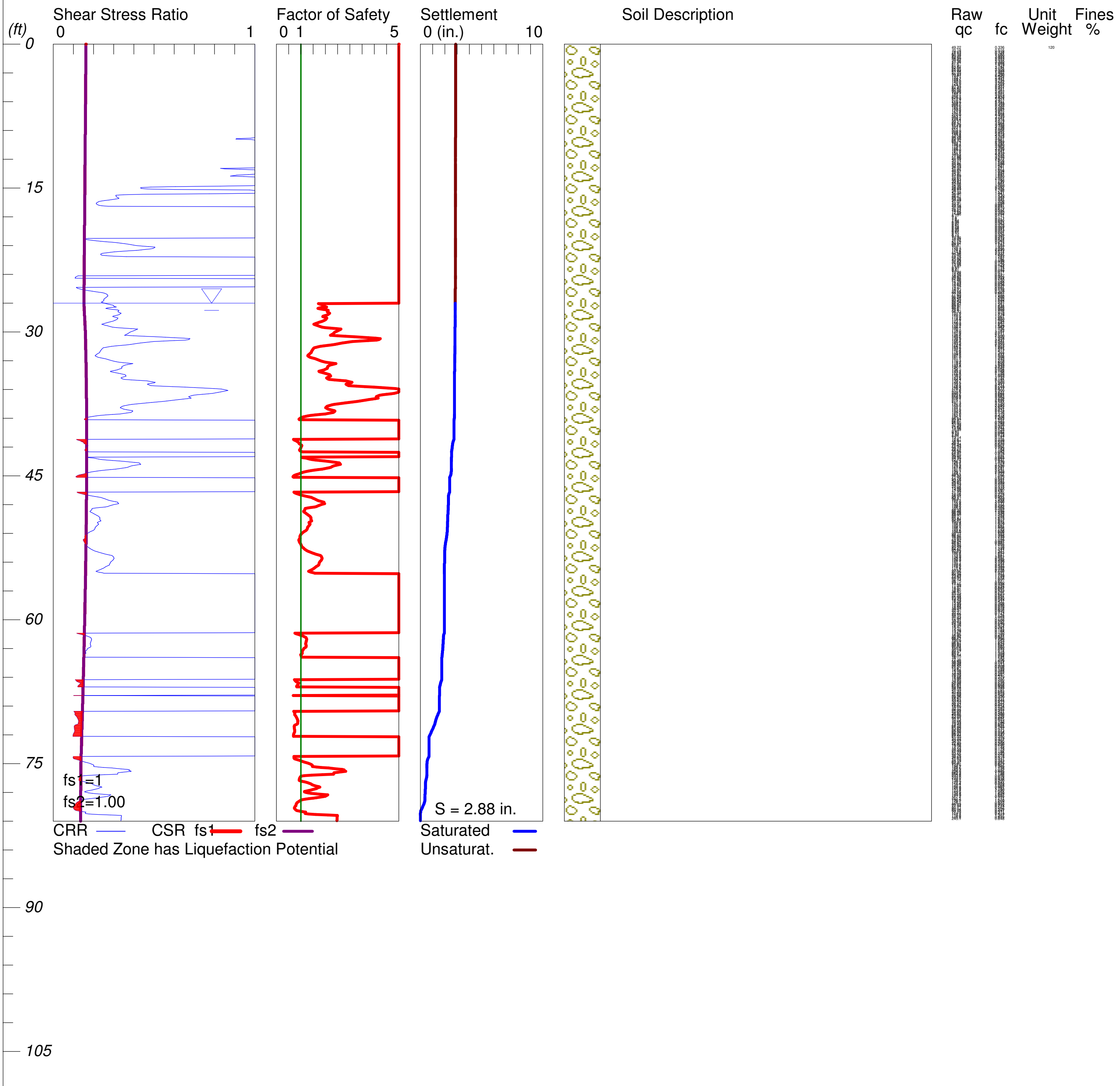
LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-3 Water Depth=27 ft Surface Elev.=45

Magnitude=7
Acceleration=0.25g



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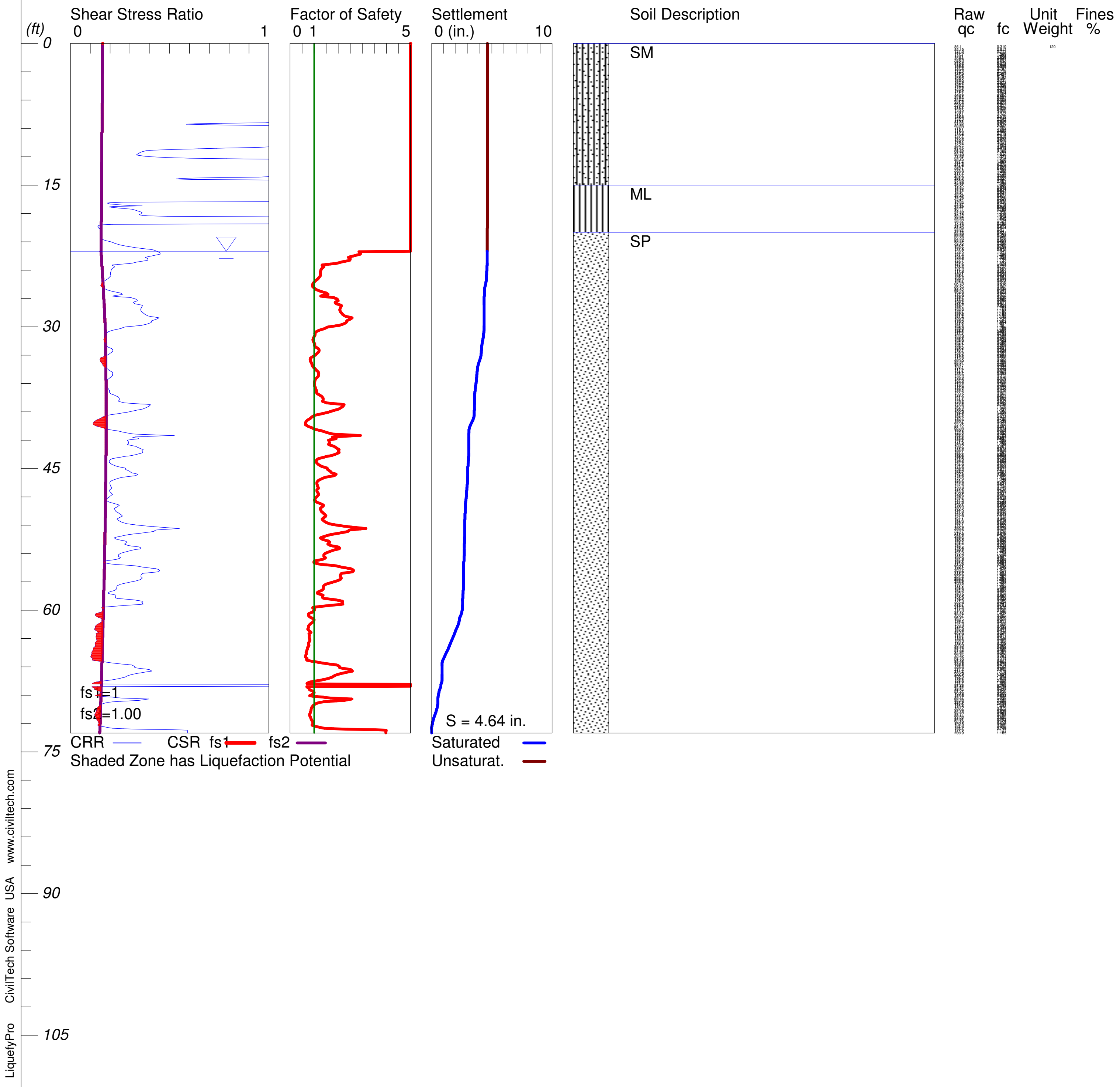
LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-4 Water Depth=22 ft Surface Elev.=45

Magnitude=7
Acceleration=0.25g



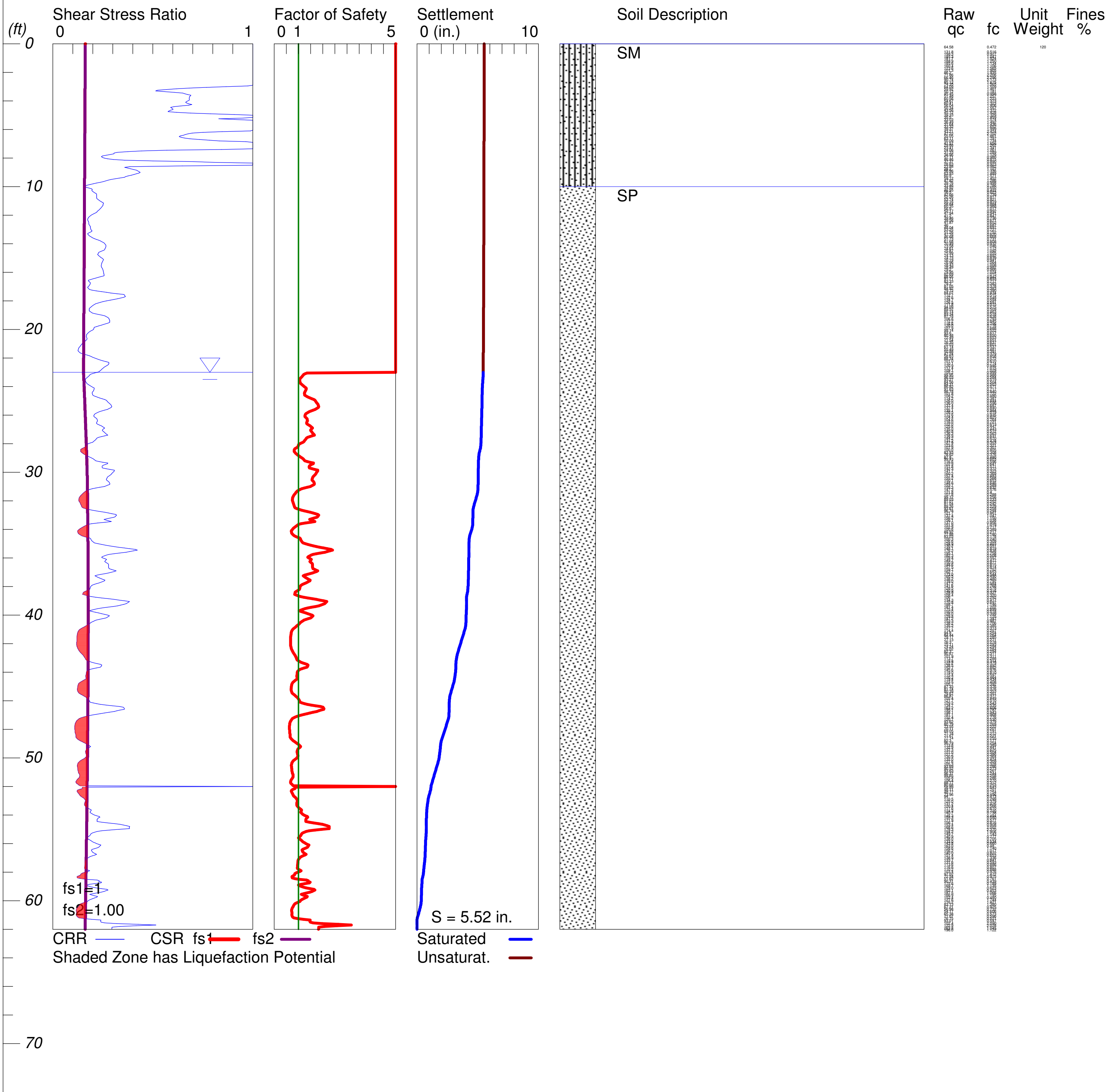
CivilTech Corporation

LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-5 Water Depth=23 ft Surface Elev.=45

Magnitude=7
Acceleration=0.25g



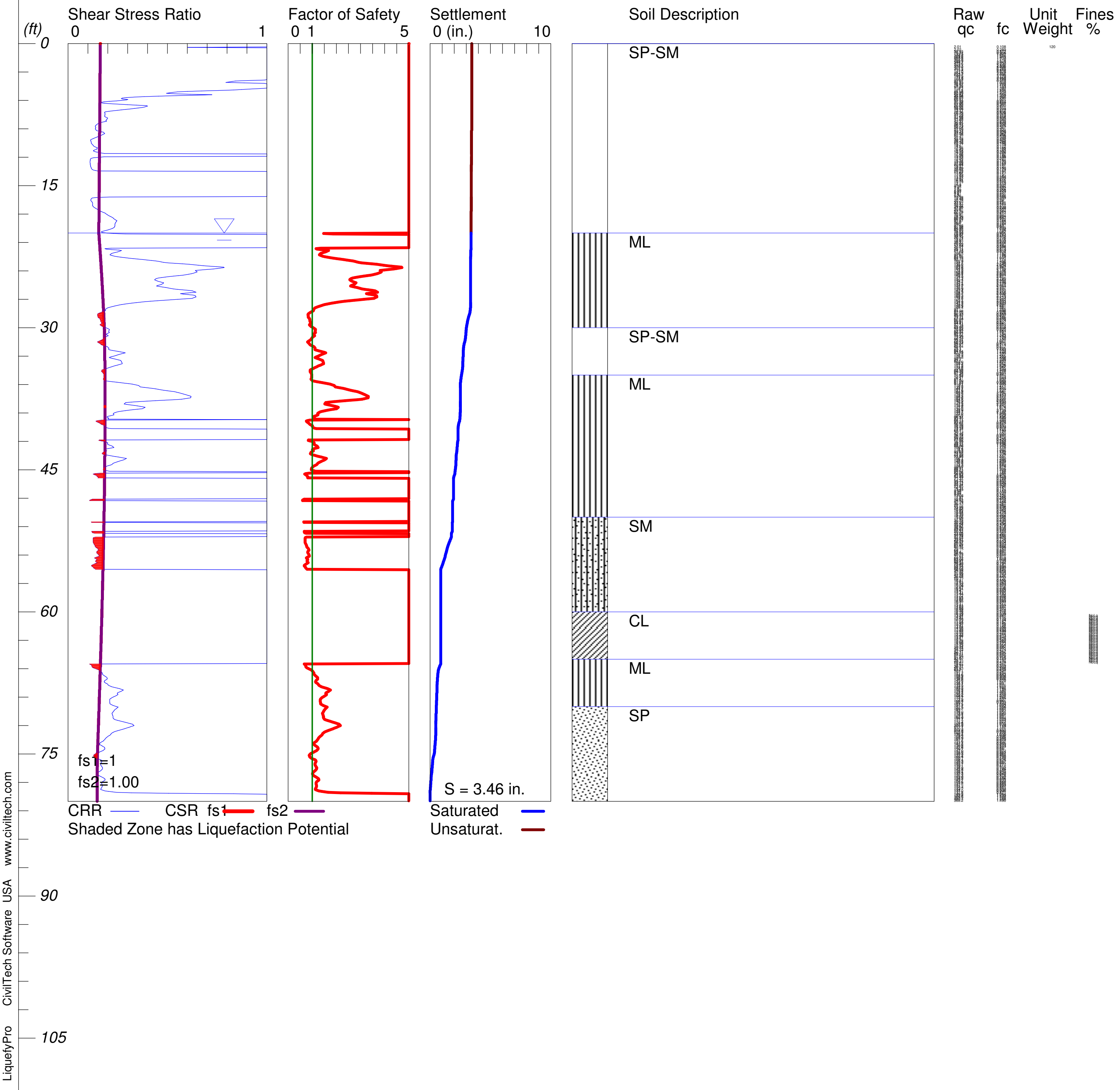
CivilTech Corporation

LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-6 Water Depth=20 ft Surface Elev.=43

Magnitude=7
Acceleration=0.25g



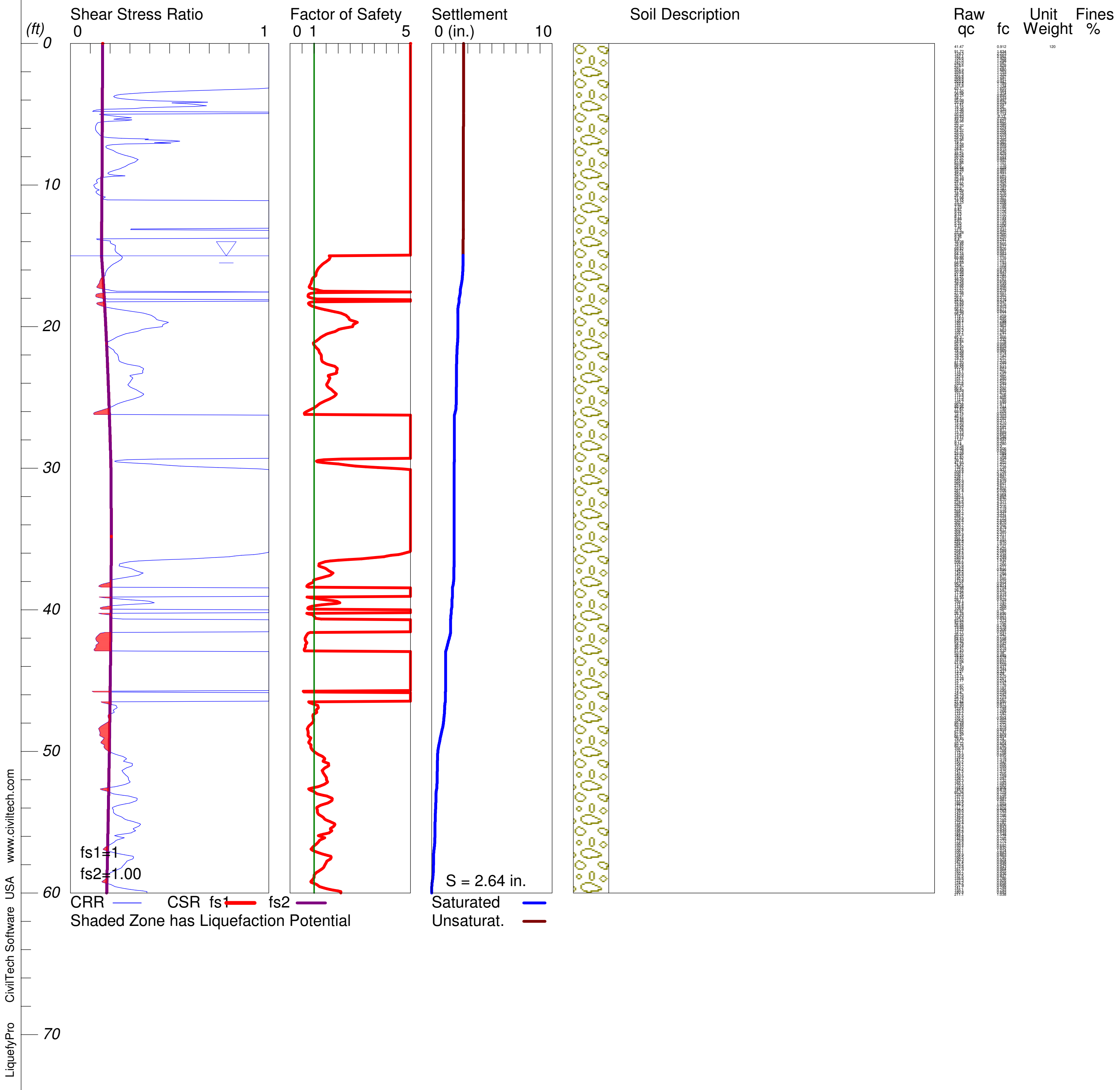
CivilTech Corporation

LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-7   Water Depth=15 ft   Surface Elev.=31

Magnitude=7
Acceleration=0.25g



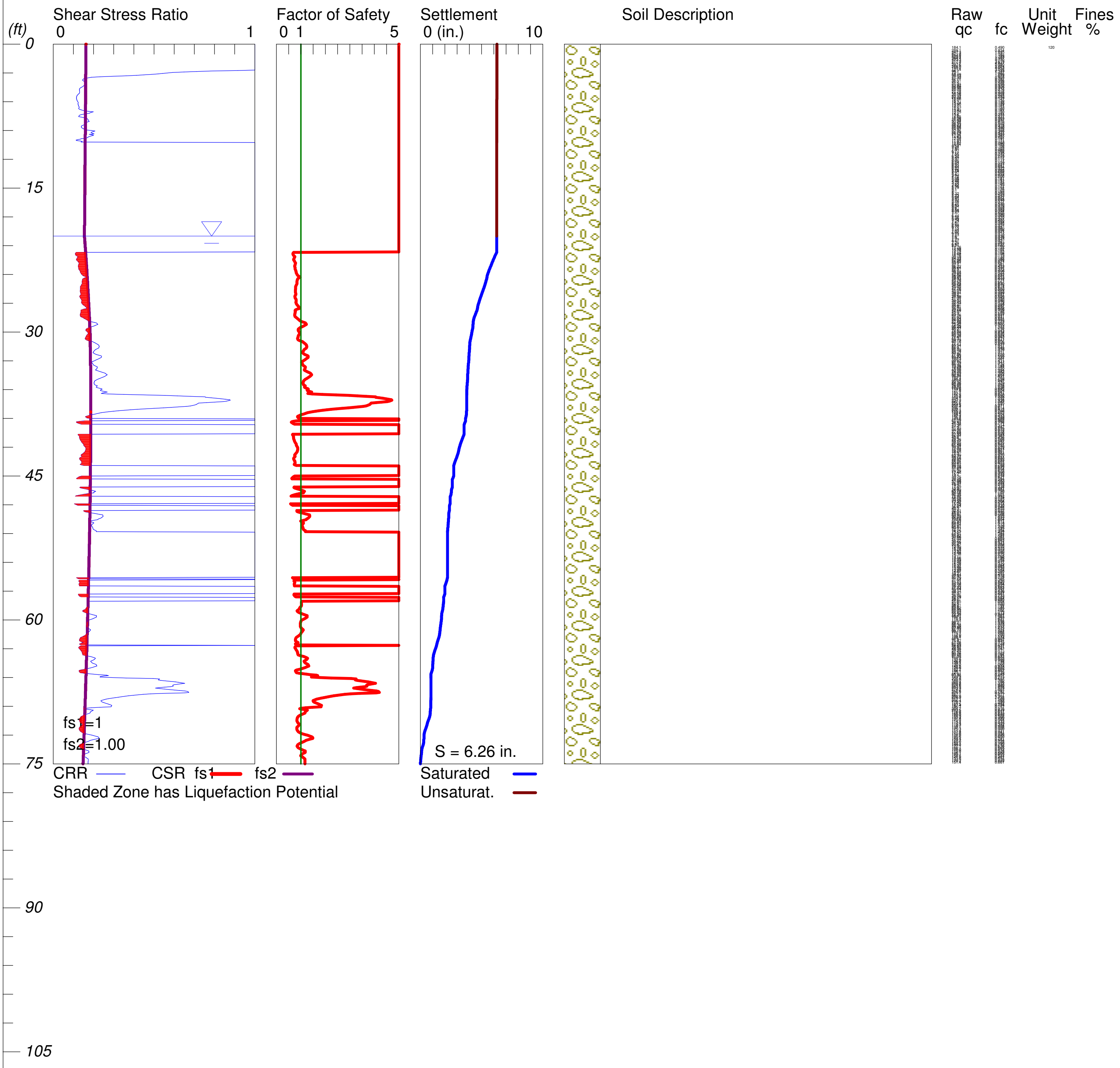
CivilTech Corporation

LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-8 Water Depth=20 ft Surface Elev.=39

Magnitude=7
Acceleration=0.25g

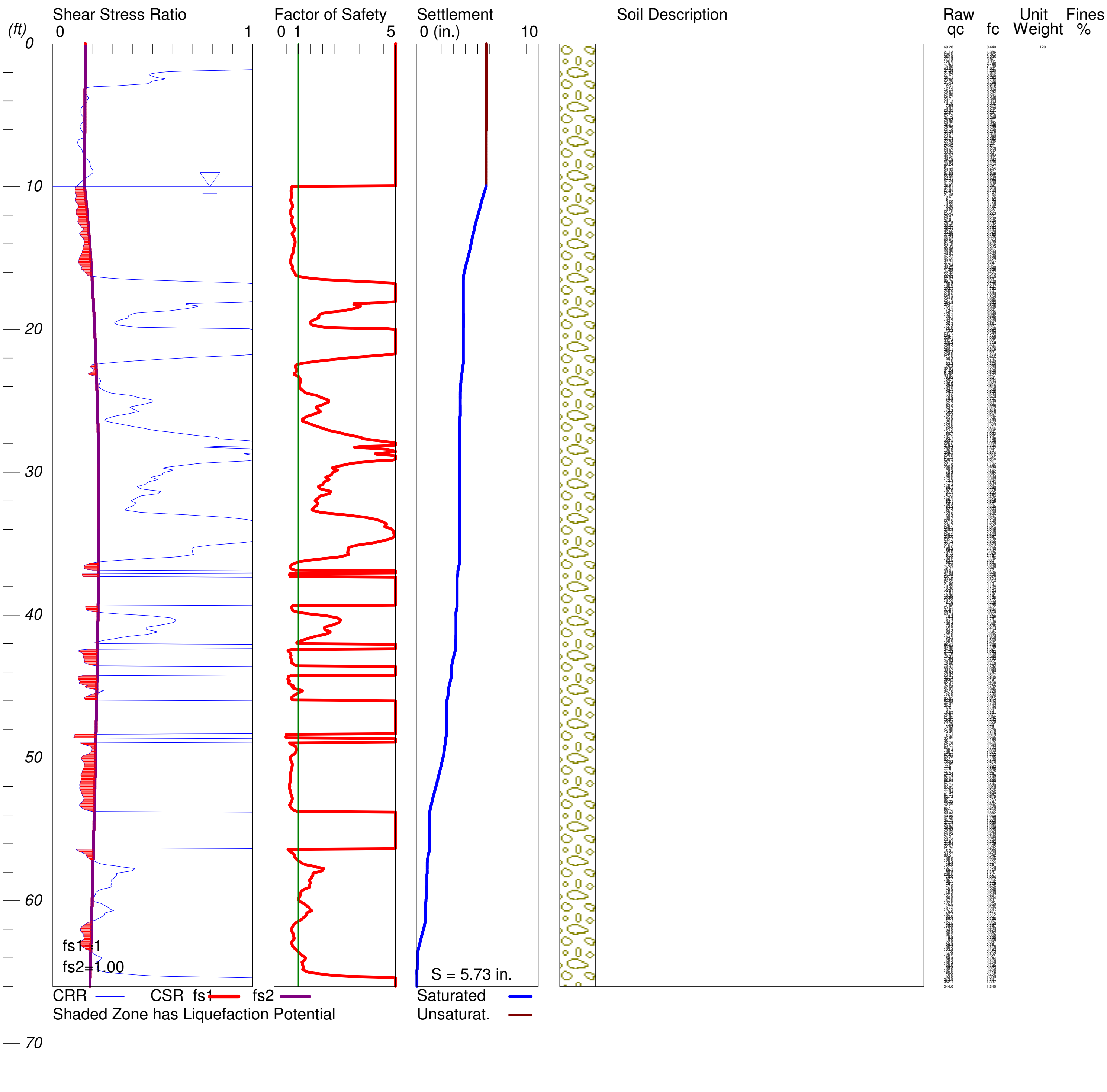


LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-9 Water Depth=10 ft Surface Elev.=30

Magnitude=7
Acceleration=0.25g



LiquefyPro CivilTech Software USA www.civiltech.com

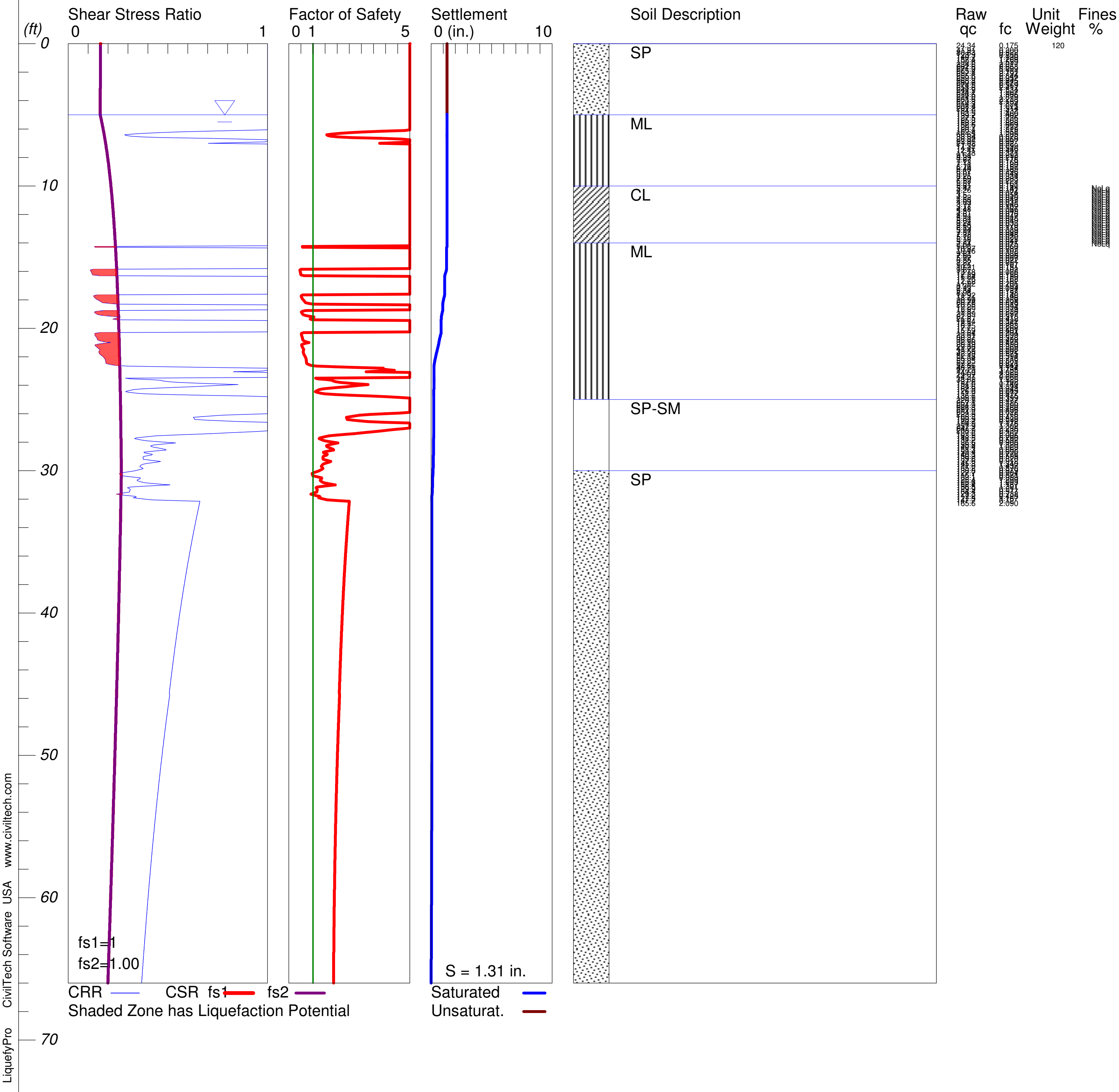
CivilTech Corporation

LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-10   Water Depth=5 ft   Surface Elev.=27

Magnitude=7
Acceleration=0.25g



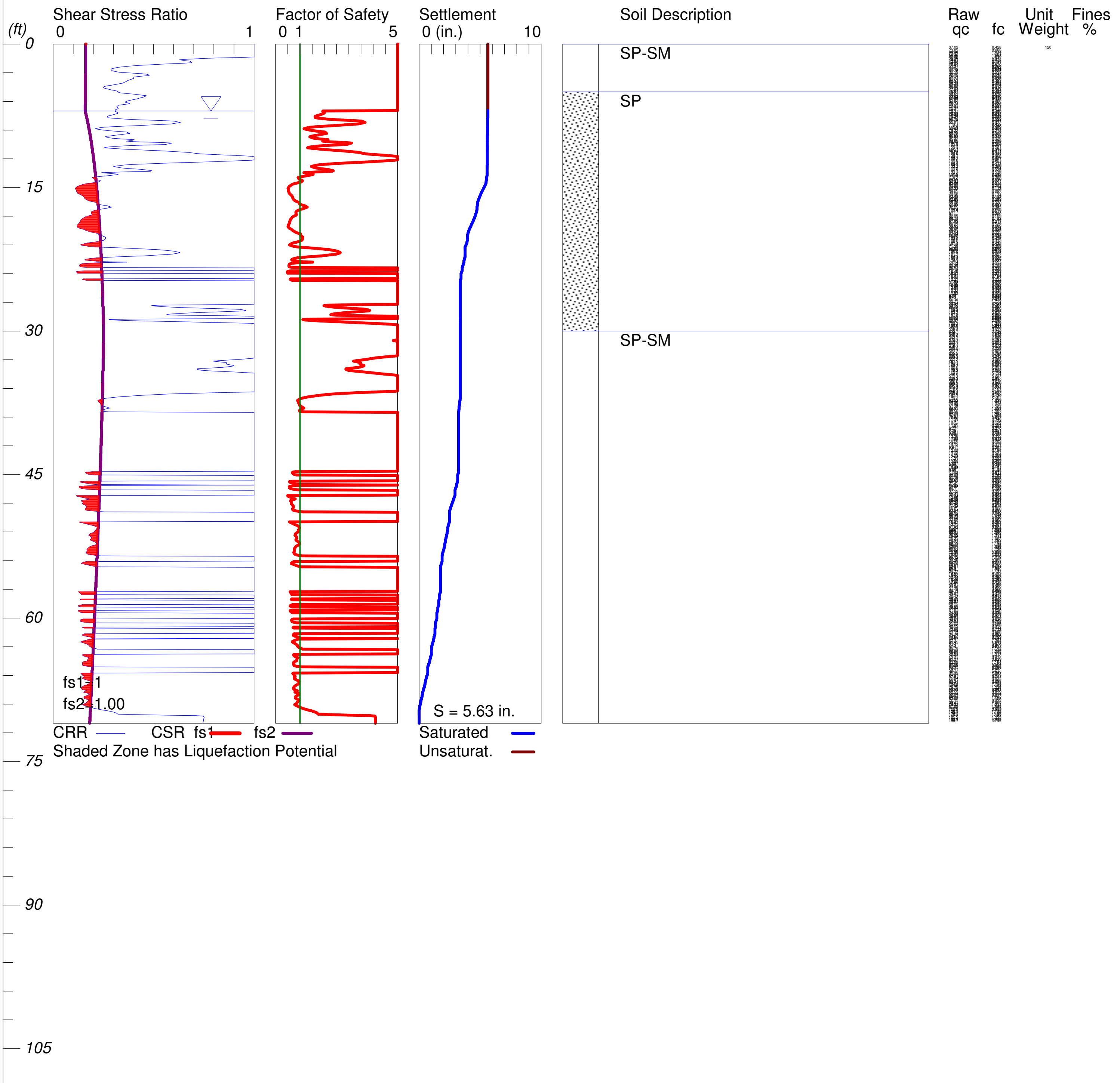
CivilTech Corporation

LIQUEFACTION ANALYSIS

Burlington Levees

Hole No.=CPT-11   Water Depth=7 ft   Surface Elev.=26

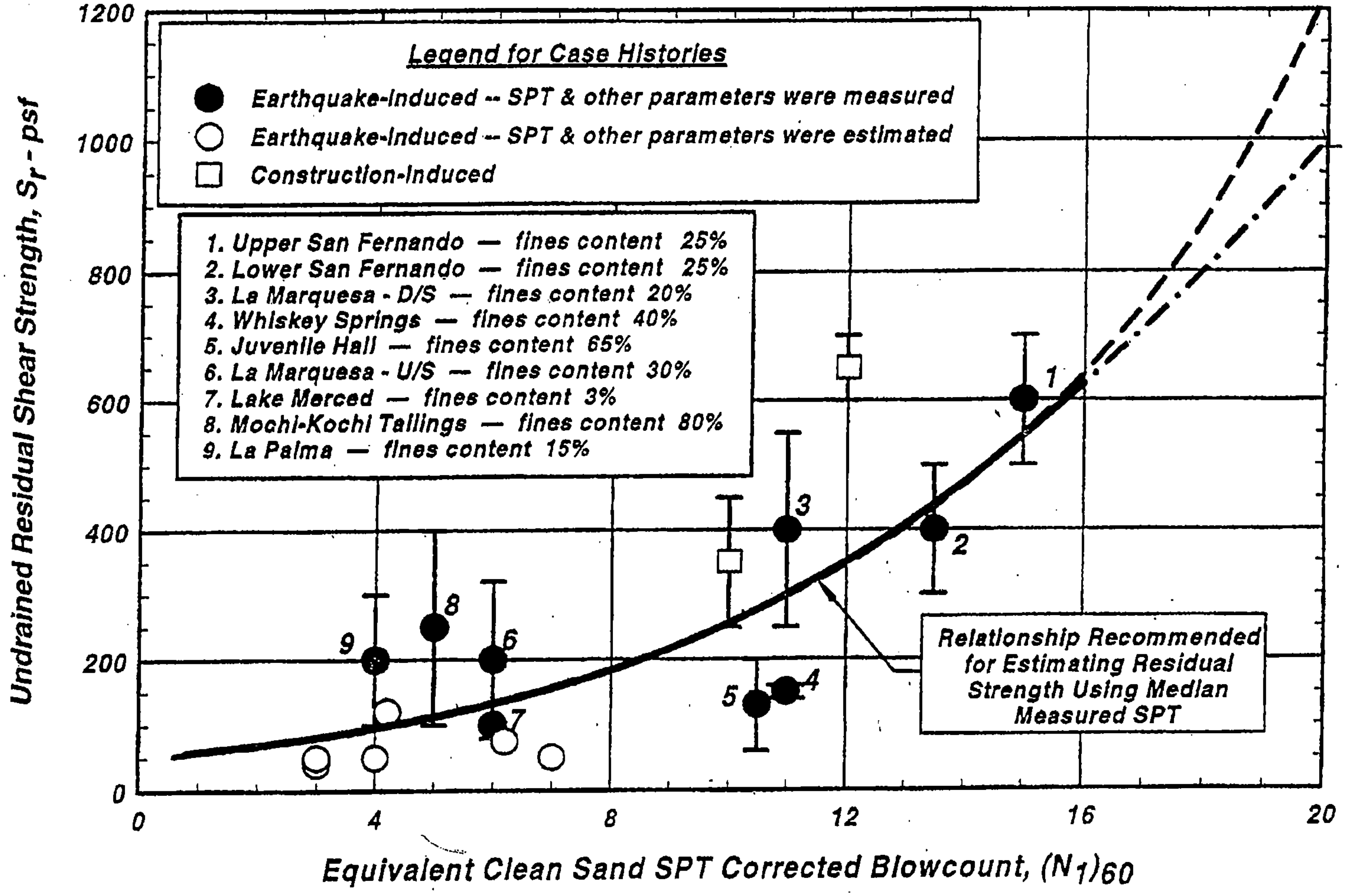
Magnitude=7
Acceleration=0.25g



CivilTech Corporation

APPENDIX E-4

FERC RECOMMENDED RESIDUAL STRENGTH RELATIONSHIP



Dashed Curve:	Curve Recommended by Hendron & Idriss in 1997
Solid & Dash-Dot Curve:	Curve Modified by Idriss in 2002

Contains Critical Energy Infrastructure Information
- Do Not Release -

APPENDIX F

ENGINEERING ANALYSIS - SEEPAGE ASSESSMENT

F-1: FLOOD HISTORY SUMMARY

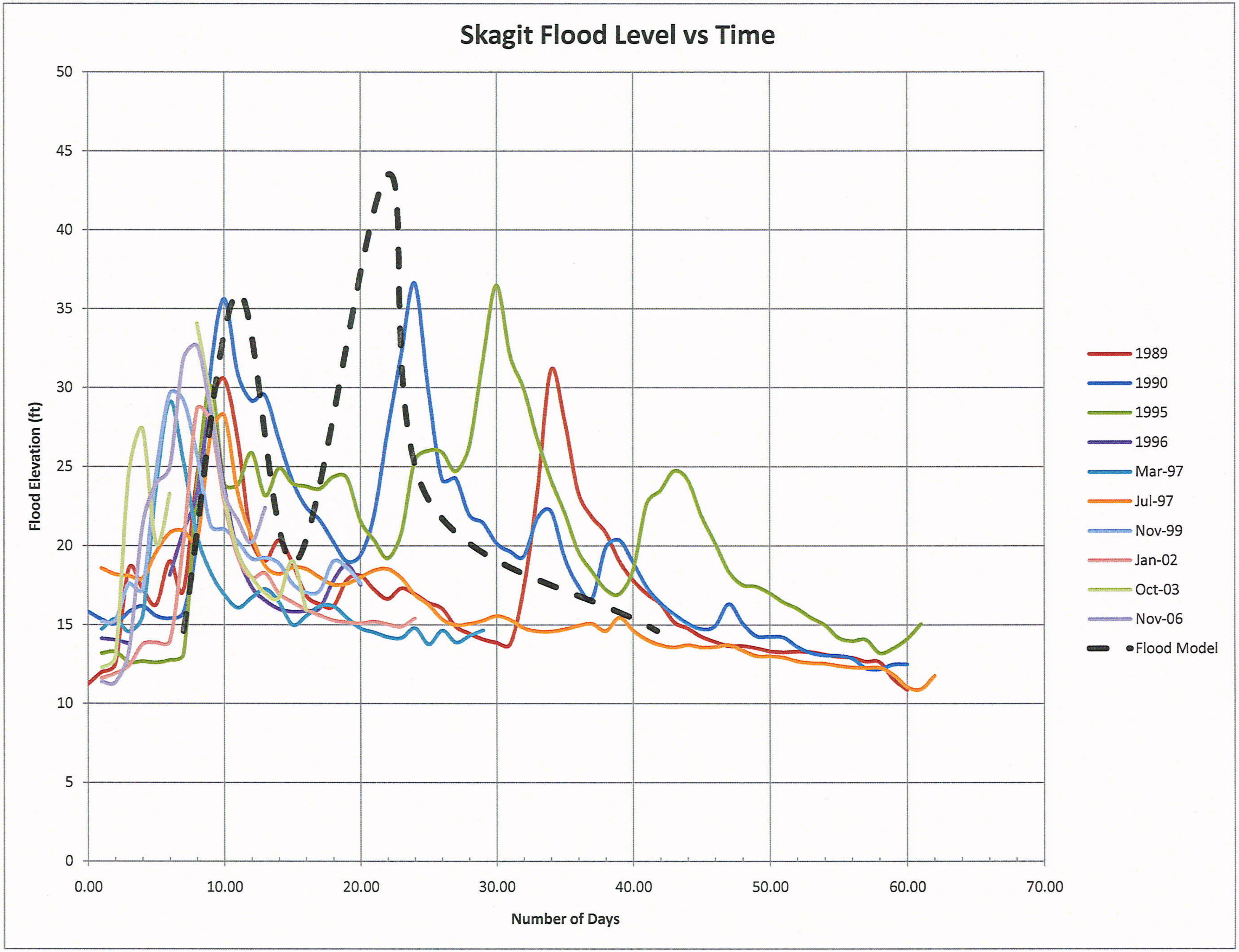
F-2: SECTION E-E’ ANALYSIS (STEADY-STATE AND RAPID DRAWDOWN)

F-3: SECTION H-H’ ANALYSIS (STEADY-STATE AND RAPID DRAWDOWN)

F-4: SECTION K-K’ ANALYSIS (STEADY-STATE AND RAPID DRAWDOWN)

APPENDIX F-1

FLOOD HISTORY SUMMARY AND BOUNDARY FUNCTION


Skagit Flood Level vs Time
Flood Elevation (ft)
0
5
10
15
20
25
30
35
40
45
50
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Number of Days
1989
1990
1995
1996
Mar-97
Jul-97
Nov-99
Jan-02
Oct-03
Nov-06
Flood Model

APPENDIX F-2

SECTION E-E’ ANALYSIS (STEADY-STATE AND RAPID DRAWDOWN)

Model: Saturated / Unsaturated
K-Function: Sand, Ksat = 1.77e-04 ft/s
Vol. WC. Function: Sand

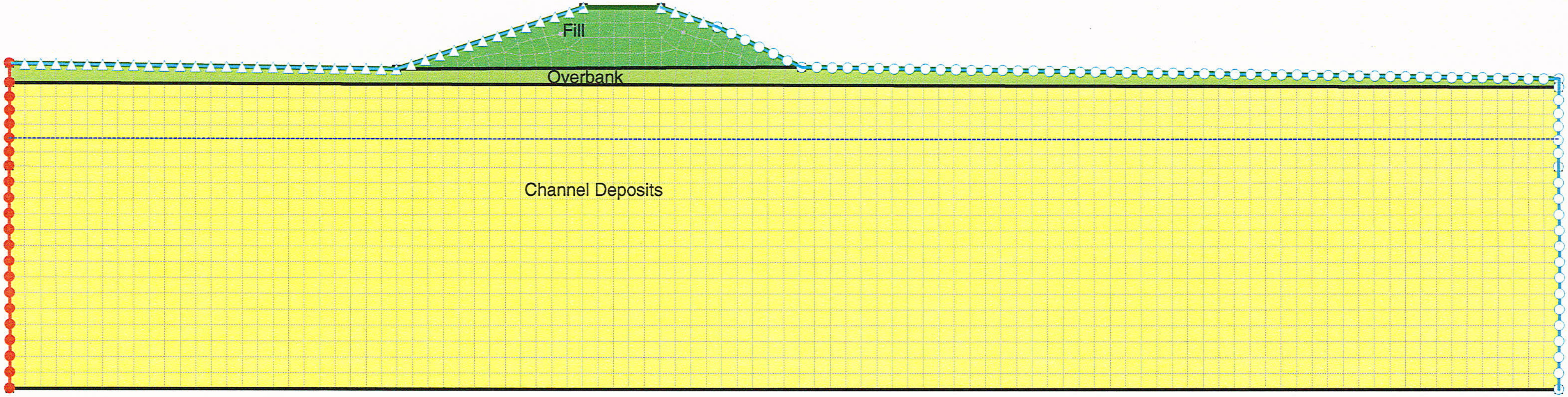
Name: Overbank Deposits
Model: Saturated / Unsaturated
K-Function: Fine sand, Ksat = 1.41e-5 ft/s
Vol. WC. Function: Fine sand

Name: Fill
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s (2)
Vol. WC. Function: Uniform Fine Sand #1

Section E COE Flood-transient -2

Transient analysis

2 days after peak flood level
Pore Pressure



Section E COE Flood-transient -2

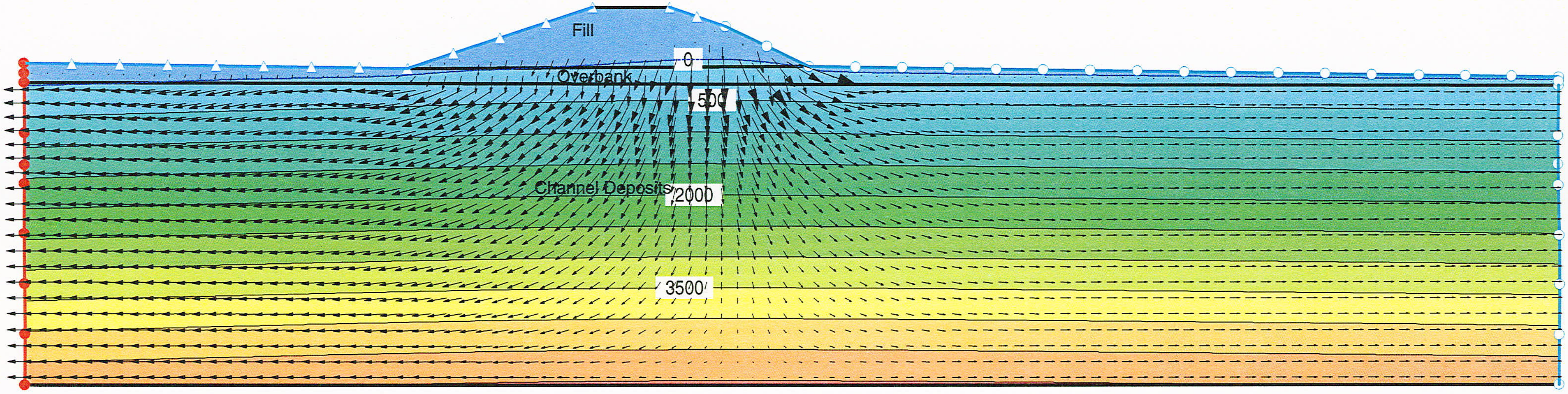
Transient analysis

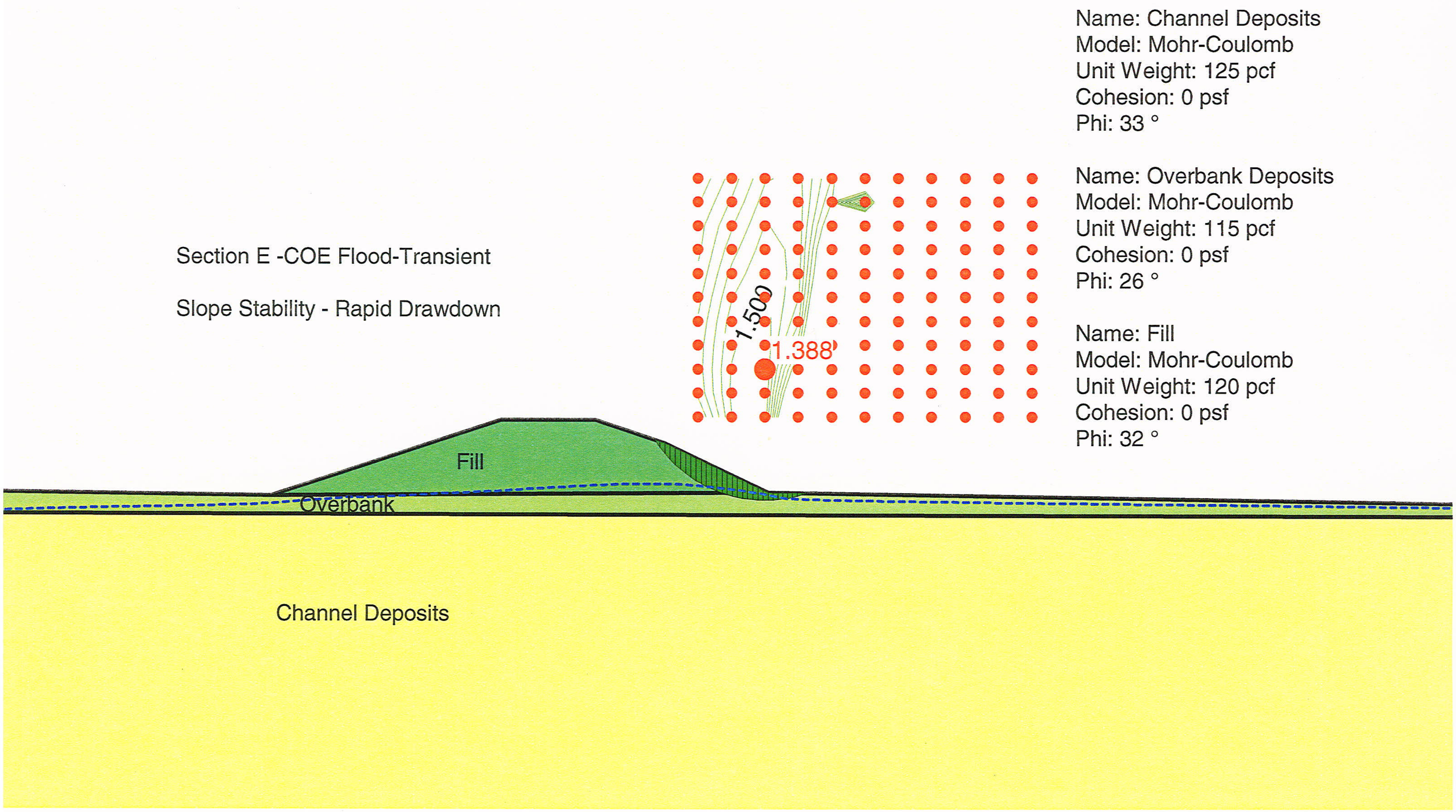
2 days after peak flood level
Pore Pressure

Model: Saturated / Unsaturated
K-Function: Sand, Ksat = 1.77e-04 ft/s
Vol. WC. Function: Sand

Name: Overbank Deposits
Model: Saturated / Unsaturated
K-Function: Fine sand, Ksat = 1.41e-5 ft/s
Vol. WC. Function: Fine sand

Name: Fill
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s (2)
Vol. WC. Function: Uniform Fine Sand #1





Section E -COE Flood-Transient

Slope Stability - Rapid Drawdown

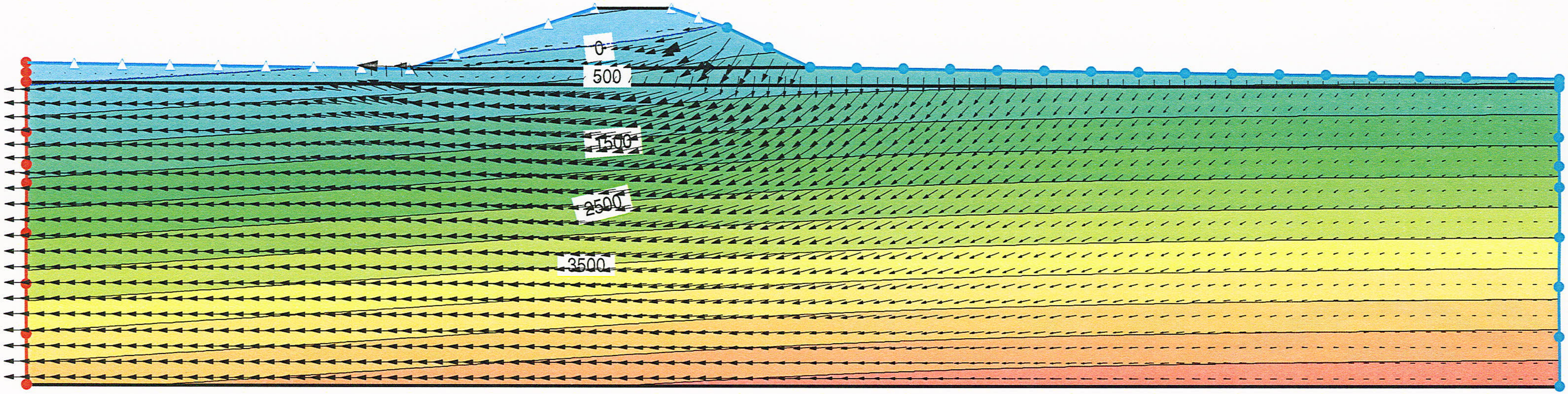
Name: Channel Deposits
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 33 °

Name: Overbank Deposits
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °

Section E COE Flood

Steady-state analysis



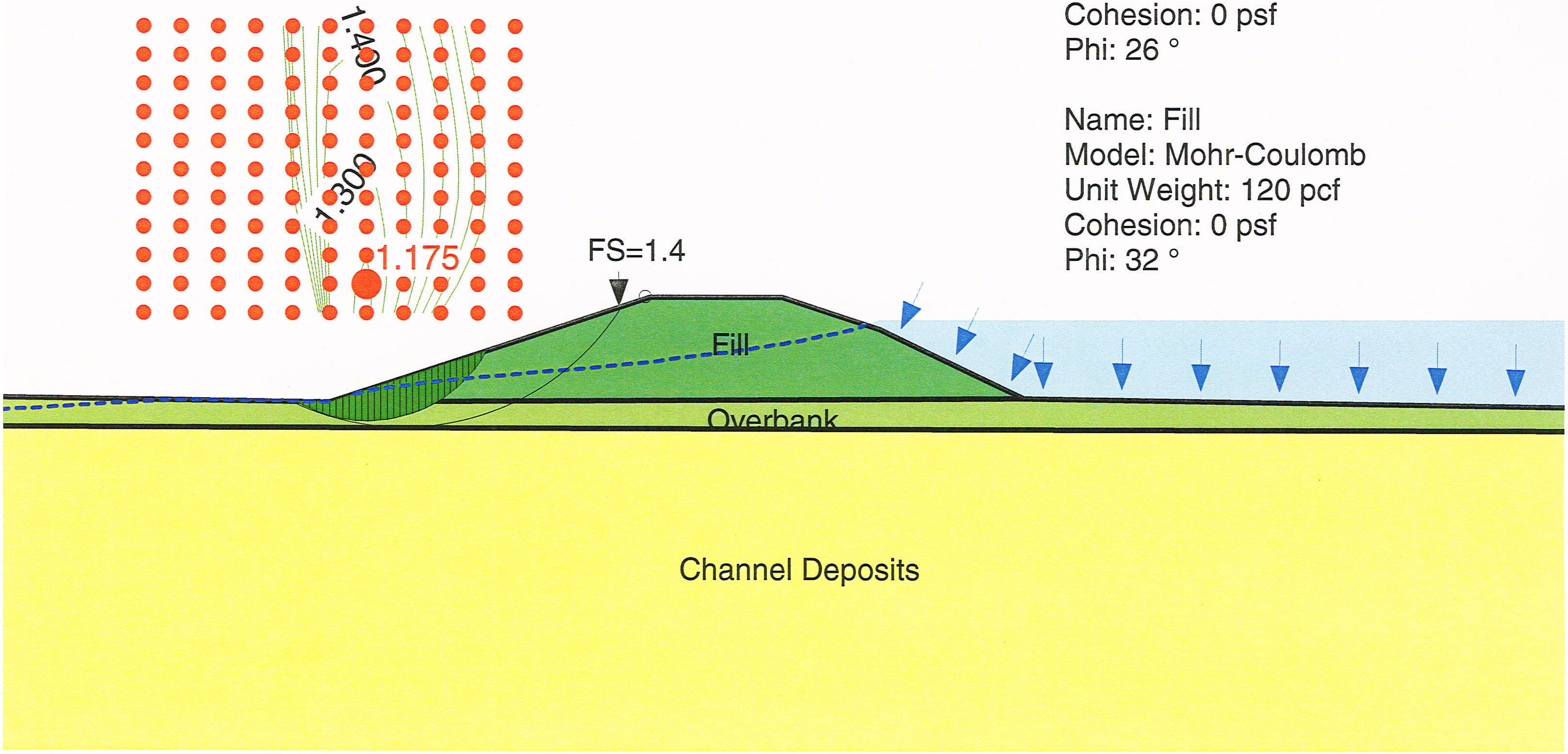
Section E COE Flood

Steady-state analysis - Slope Stability

Name: Channel Deposits
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 33 °

Name: Overbank Deposits
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °



APPENDIX F-3

SECTION H-H’ ANALYSIS (STEADY-STATE AND RAPID DRAWDOWN)

Section H COE Flood

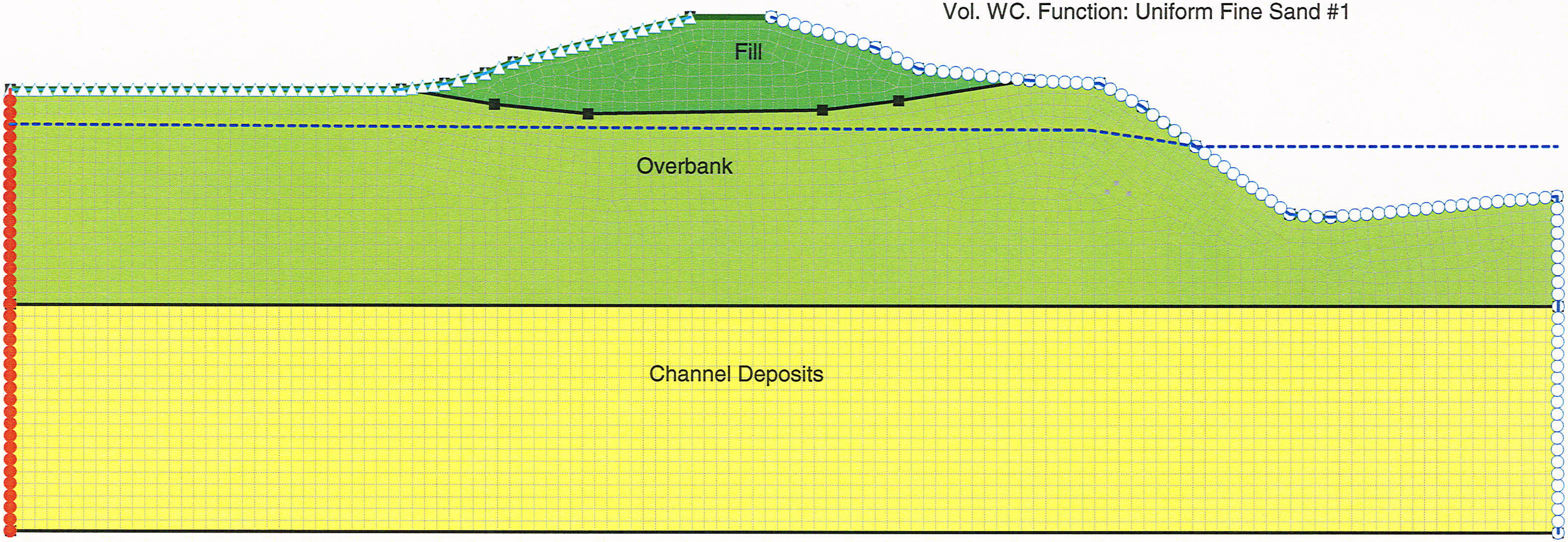
Transient Analysis

2 days after peak flood level
Pore Pressure

Name: Channel Deposits
Model: Saturated Only
K-Sat: 0.0019 ft/sec
Volumetric Water Content: 0 ft³/ft³

Name: Overbank
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s
Vol. WC. Function: Uniform Fine Sand #1

Name: Fill
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s (2)
Vol. WC. Function: Uniform Fine Sand #1



Section H COE Flood

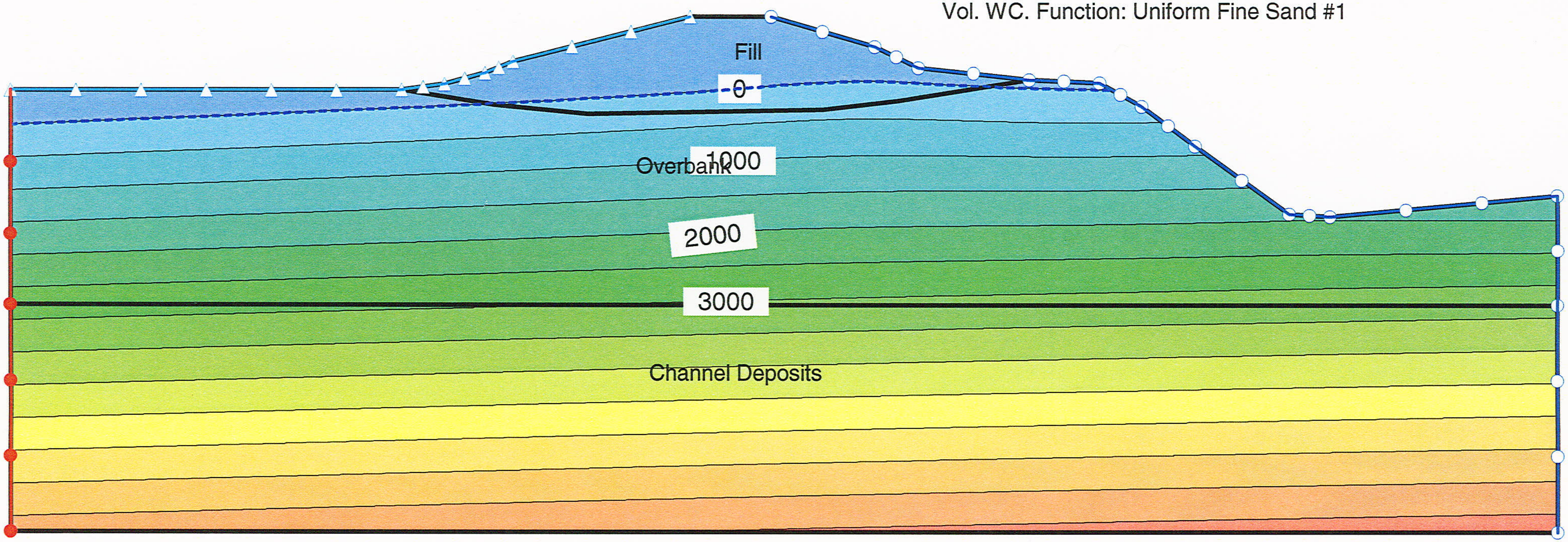
Transient Analysis

2 days after peak flood level
Pore Pressure

Name: Channel Deposits
Model: Saturated Only
K-Sat: 0.0019 ft/sec
Volumetric Water Content: 0 ft^3/ft^3

Name: Overbank
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s
Vol. WC. Function: Uniform Fine Sand #1

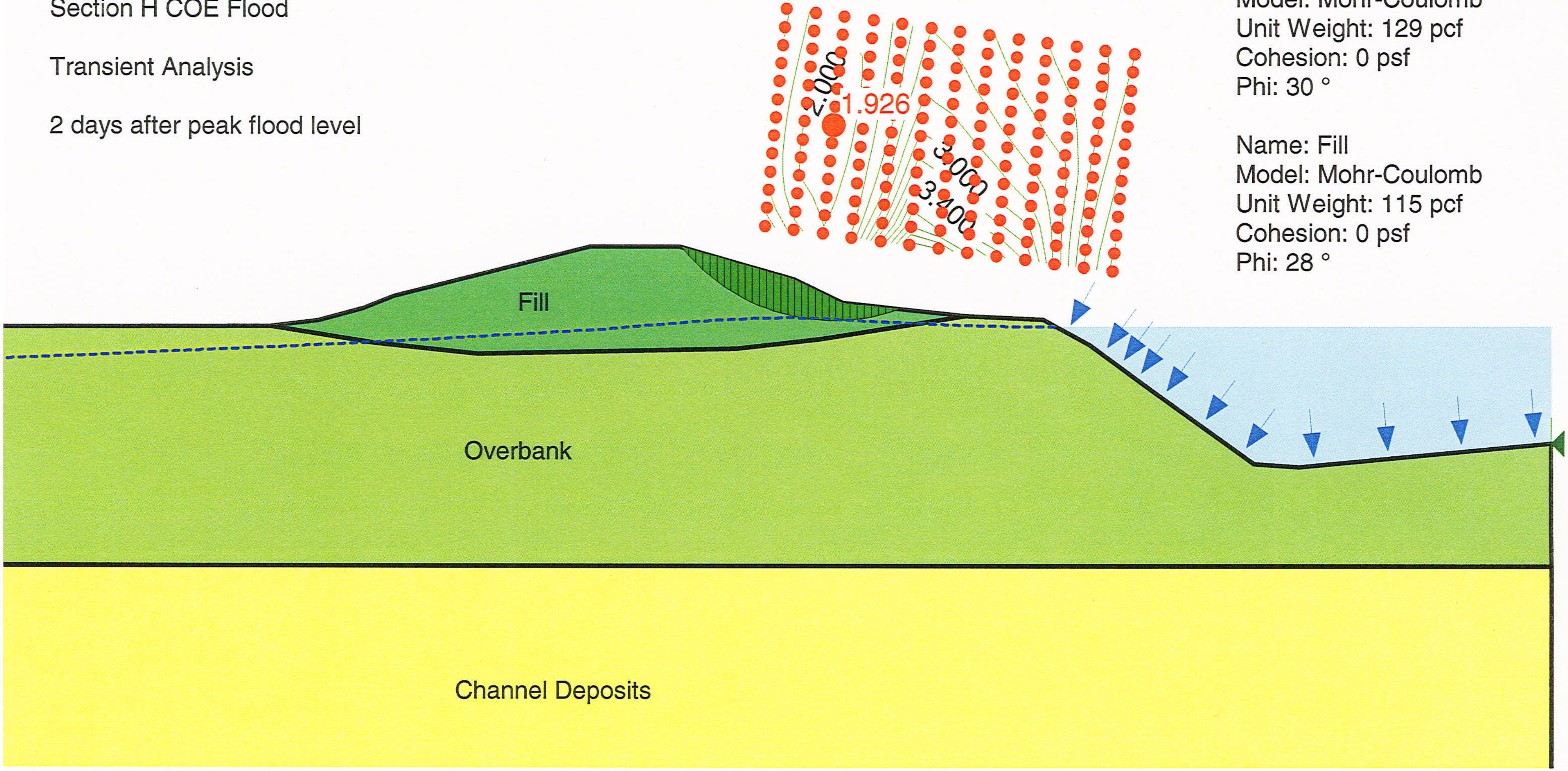
Name: Fill
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s (2)
Vol. WC. Function: Uniform Fine Sand #1



Section H COE Flood

Transient Analysis

2 days after peak flood level



Name: Channel Deposits
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °

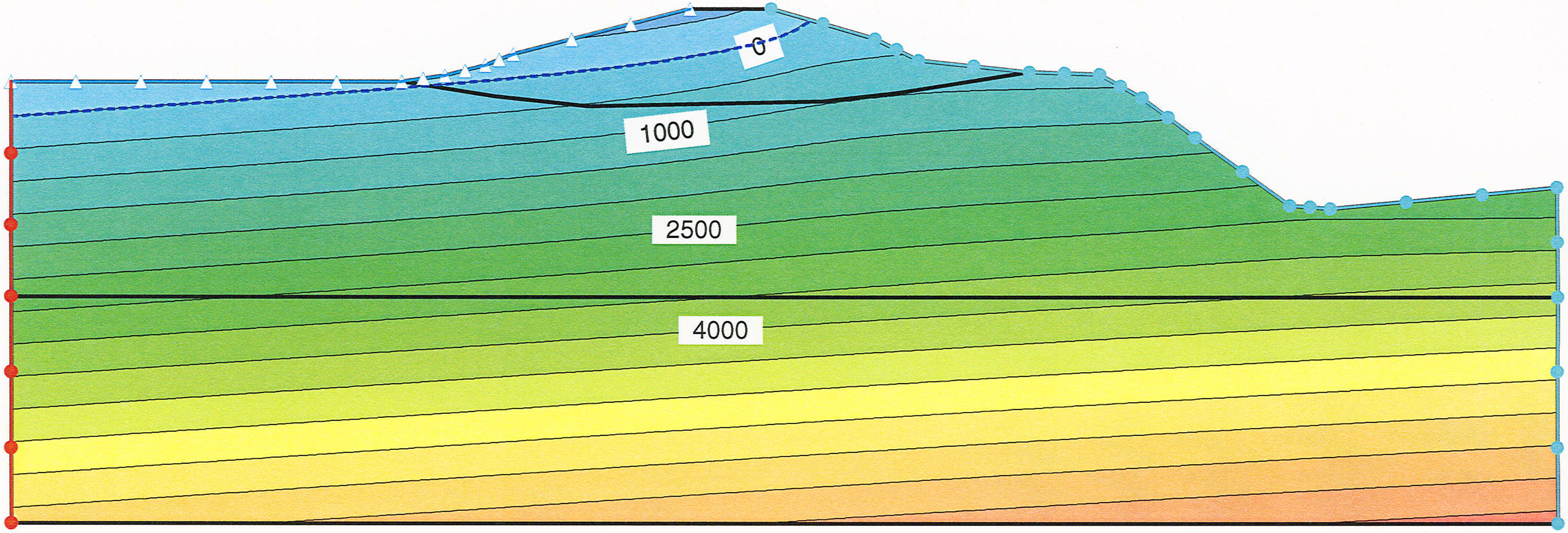
Name: Overbank
Model: Mohr-Coulomb
Unit Weight: 129 pcf
Cohesion: 0 psf
Phi: 30 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °

Section H COE Flood

Steady-state Analysis

Pore Pressure



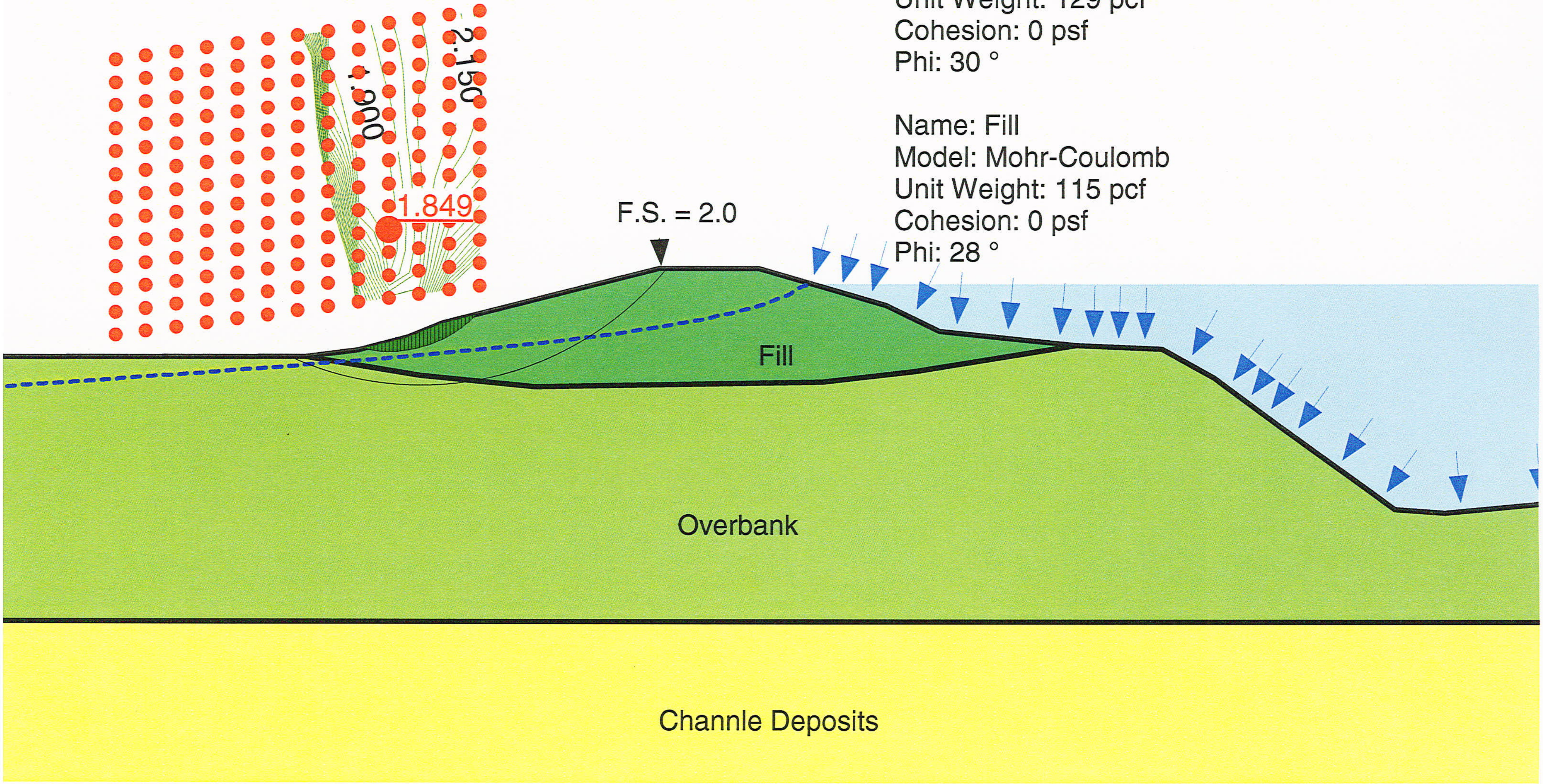
Section H COE Flood

Steady-state Analysis - Slope Stability

Name: Channel Deposits
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °

Name: Overbank
Model: Mohr-Coulomb
Unit Weight: 129 pcf
Cohesion: 0 psf
Phi: 30 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °



APPENDIX F-4

SECTION K-K’ ANALYSIS (STEADY-STATE AND RAPID DRAWDOWN)

Section K COE Flood transient-2

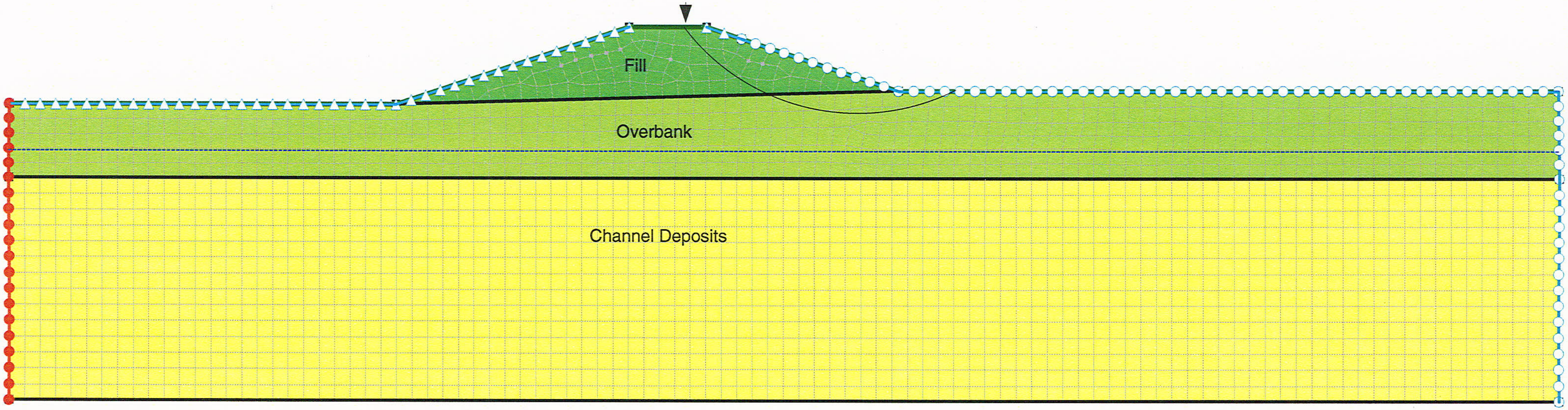
Transient Analysis

2 days after peak flood
Pore Pressure

Name: Channel Deposits
Model: Saturated / Unsaturated
K-Function: Sand, Ksat = 1.77e-04 ft/s
Vol. WC. Function: Sand

Name: Overbank Deposits
Model: Saturated / Unsaturated
K-Function: Fine sand, Ksat = 1.41e-5 ft/s
Vol. WC. Function: Fine sand

Name: Fill
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s
Vol. WC. Function: Uniform Fine Sand #1



Section K COE Flood transient-2

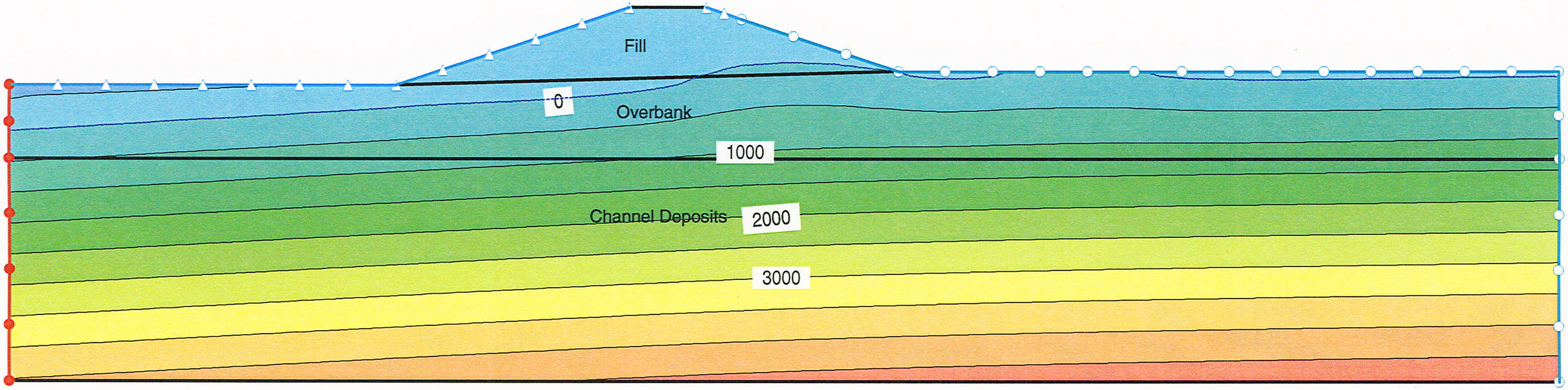
Transient Analysis

2 days after peak flood
Pore Pressure

Name: Channel Deposits
Model: Saturated / Unsaturated
K-Function: Sand, Ksat = 1.77e-04 ft/s
Vol. WC. Function: Sand

Name: Overbank Deposits
Model: Saturated / Unsaturated
K-Function: Fine sand, Ksat = 1.41e-5 ft/s
Vol. WC. Function: Fine sand

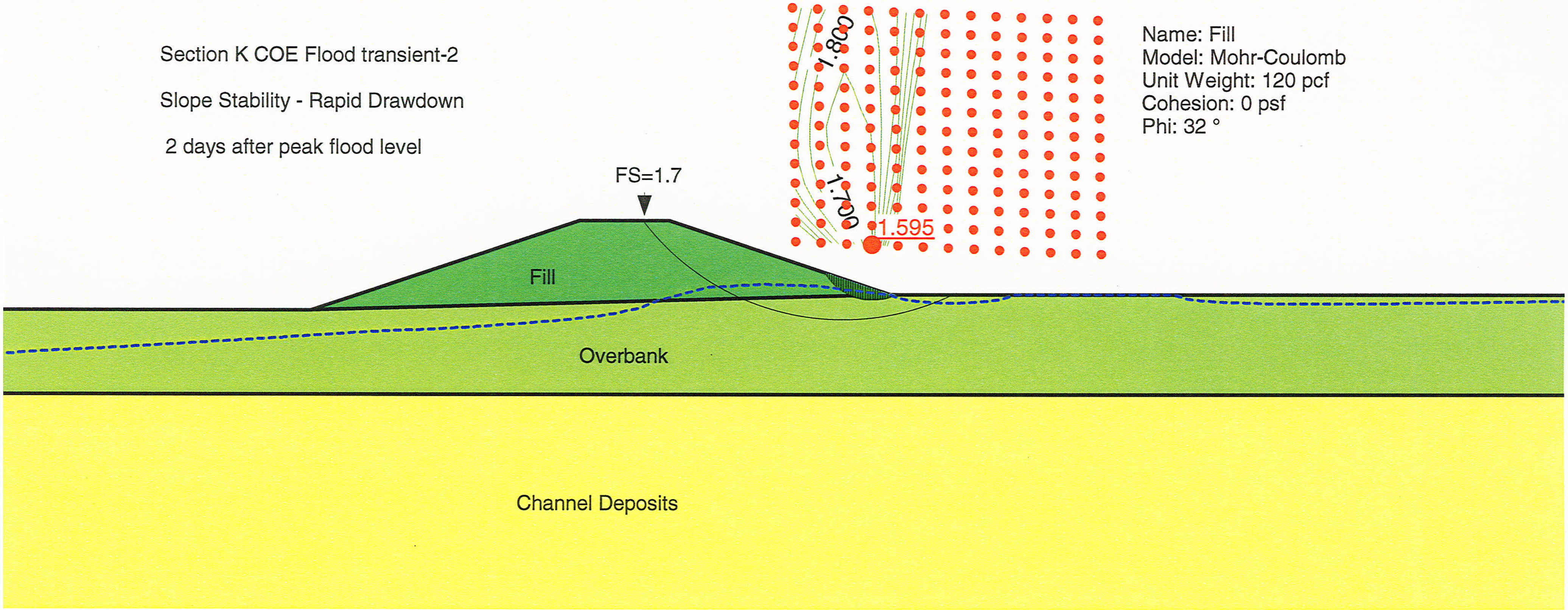
Name: Fill
Model: Saturated / Unsaturated
K-Function: Uniform Fine Sand #1, Ksat = 7.05e-05 ft/s
Vol. WC. Function: Uniform Fine Sand #1



Section K COE Flood transient-2

Slope Stability - Rapid Drawdown

2 days after peak flood level



Name: Channel Deposits
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 33 °

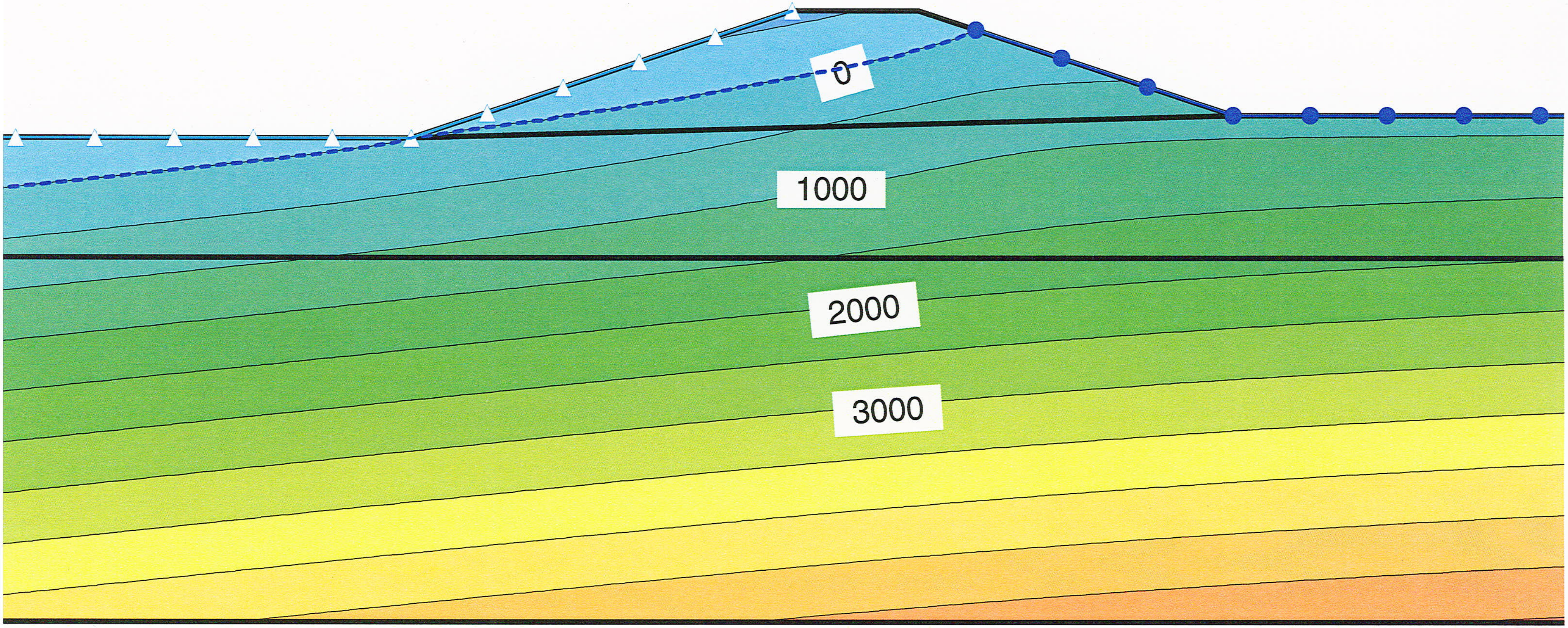
Name: Overbank Deposits
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °

Section K COE Steady-State-2

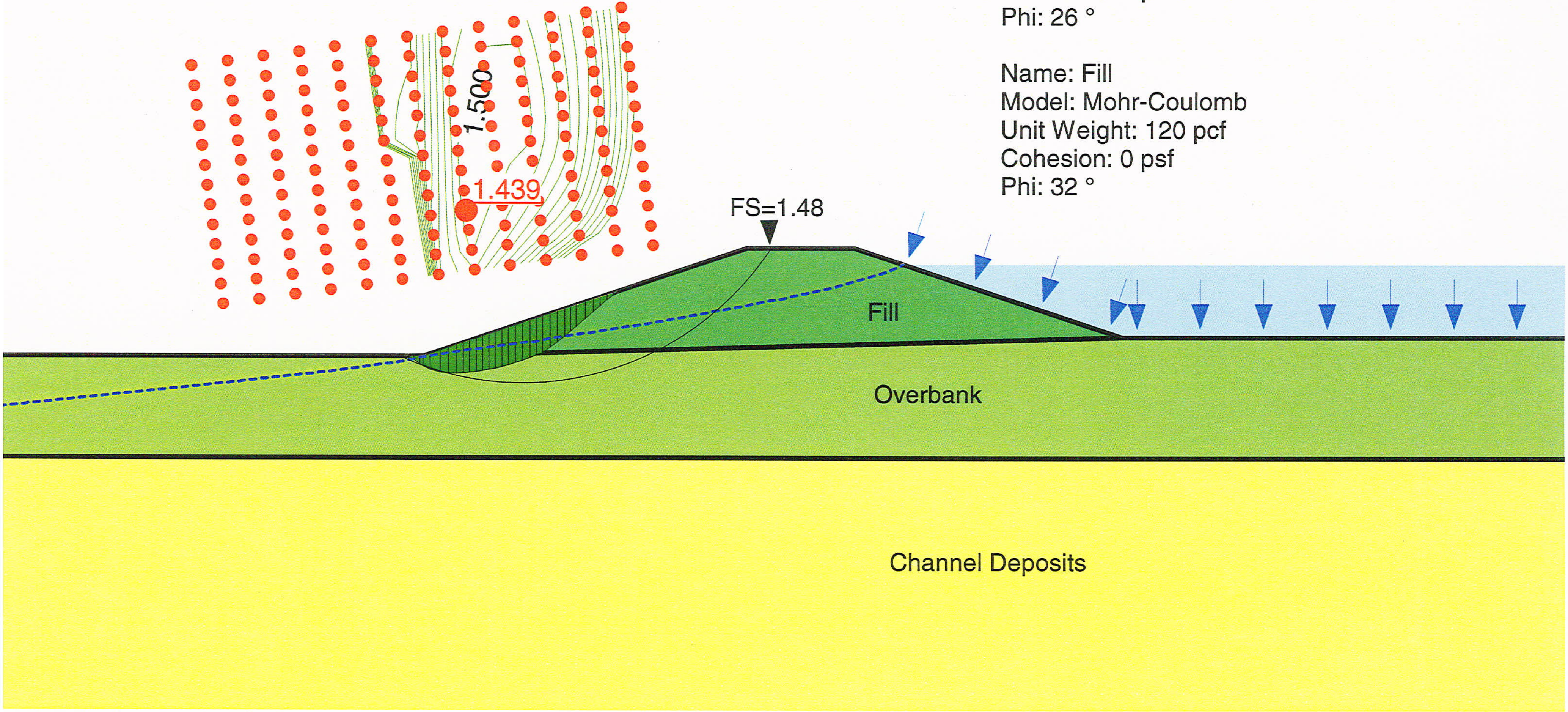
Steady State

Pore Pressure



Section K COE Steady-State-2

Steady State - Slope Stability



Name: Channel Deposits
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 33 °

Name: Overbank Deposits
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °