Peninsula Drainage District No. 1

Levee Engineering Assessment
Portland, Oregon

CORNFORTH CONSULTANTS

Report to

Multnomah County Drainage District
1880 NE Elrod Drive
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PENINSULA DRAINAGE DISTRICT NO. 1
LEVEE ENGINEERING ASSESSMENT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

PENINSULA DRAINAGE DISTRICT NO. 1
LEVEE ENGINEERING ASSESSMENT

1. INTRODUCTION

1.1 General

A large portion of North and Northeast Portland are natural floodplains. Beginning in 1917, a system of levees and pump stations has been constructed to provide critical flood protection and stormwater management functions for the Columbia Corridor. This levee system is broken into four distinct subsystems. These are Peninsula Drainage District No. 1 (PEN 1), Peninsula Drainage District No. 2 (PEN 2), Multnomah County Drainage District (MCDD), and the Sandy Drainage Improvement Company (SDIC). This system is a valuable asset that is the product of local, state, and federal investment. It reduces the risk of flooding for an area that is home to thousands of people, 10 percent of the jobs in Multnomah County, and billions of dollars in investment.

In 2013, MCDD, the agency responsible for managing the Columbia Corridor levee system, received notification that the system was no longer meeting federal standards. In particular, PEN 1's United States Army Corps of Engineers (USACE) certification expired in August 2013. The loss of this certification creates the potential for the loss of levee accreditation under the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP).

Beginning in June 2013, MCDD retained Cornforth Consultants to assist with the levee certification studies and accreditation application submittal for PEN 1. In October 2013 more than twenty jurisdictions and other regional partners came together to work on the levee improvement project through a Governor-designated Oregon Solutions process convened by Portland Mayor Charlie Hales and Multnomah County Commissioner Jules Bailey. The Oregon Solutions Project Team is working to ensure that the Columbia Corridor levee system meets federal standards and reduces the risk of damage to lives and property that can result from flooding. The first step in this process, and the purpose of this Levee Engineering Assessment, is to deliver a collaboratively-sponsored evaluation of the current condition of the levee system in PEN 1.

The Oregon Solutions Project Team will use these findings as a starting point to determine the community's flood risk tolerance and identify flood risk reduction strategies. The assessment does not identify strategies for improving levee performance or reducing flood risk. Nor does this report provide cost estimates for remediating the areas of concern. Identifying and selecting strategies to address identified concerns, and estimating the associated costs, is part of what the Oregon Solutions Project Team will address next. The Oregon Solutions Project Team will work to engage all communities with current or historical ties to the levee system in a collaborative discussion about how to address the technical and community based implications of levee maintenance and improvements.

1.2 Focus of Current Study

A levee system must be certified in order to apply for accreditation from FEMA. The criteria for certification are described in the Code of Federal Regulations (CFR) 44 CFR 65.10. The FEMA standard for flood protection is known as the "base flood" or "1-percent-annual-chance flood," which is described in more detail below. The certification of a levee consists of documentation that is signed and sealed by a registered Professional Engineer and must demonstrate how the system meets 44 CFR 65.10. The CFR references USACE engineering analysis procedures and guidelines that may be used to assess the levee system's capacity for meeting the safety requirements. Once the levee meets the requirements of 44 CFR 65.10, FEMA can accredit the levee system. FEMA accredits a levee system as providing adequate risk reduction on the Flood Insurance Rate Map (FIRM) if the certification and adopted operation and maintenance plan provided by the levee owner are confirmed to be adequate. Once accreditation is achieved, FEMA can show the areas behind the levee as a moderate-risk area on a FIRM. An accredited levee system has other implied advantages, including:

- Property owners are not required to buy flood insurance
- If desired, property owners can acquire low cost insurance through the National Flood Insurance Program (NFIP)
- City of Portland Floodplain Development Code standards do not apply to developments in the leveed area.

The field investigations and engineering analyses performed for this assignment are focused on the requirements for certification of the PEN 1 levee network and must meet 44 CFR 65.10. Specifically, the engineering analyses discussed herein include: (i) freeboard; (ii) embankment erosion and scour protection; (iii) embankment and foundation stability and potential seepage; and (iv) interior drainage. The intent of this report is to identify the segments of the levee system that currently do not or may not meet 44 CFR 65.10. It is understood that the results of this report will assist the Oregon Solutions Project Team in developing action plans and budgeting cycles for upgrading the identified levee segments to meet 44 CFR 65.10. Please note that the analyses of other potential hazards such as seismic stability and flooding related to climate change are outside the current scope of work. In addition, this Levee Engineering Assessment does not address technical issues related to the USACE Rehabilitation and Inspection Program (RIP). The Oregon Solutions Project Team may retain a consultant to evaluate the RIP criteria under a separate authorization.

1.3 FEMA 1-Percent-Annual-Chance Flood Standard

The analyses and supporting information for certification requires documentation that the levee system will provide protection under a "base flood" event on the Columbia River. The base flood is defined in regulation as a flood event with a 1-percent-annual-chance exceedance probability. This flood has a one in 100 chance of occurring in any year, and an average recurrence interval of 100 years. It is often referred to as the "1-percent-annual-chance flood". In addition, levee certification studies must analyze the interior drainage of the area within the levee system. This

analysis identifies the scale of flooding that may occur within PEN 1 during simultaneous 1-percent rainfall and river flood events.

1.4 Phase 1 and Phase 2 Studies

The engineering assessment described in this report was performed in two phases. The first phase included a review of the PEN 1 and USACE Portland District archives to determine if any studies and documentation required for certification have already been completed. The Phase 1 investigation uncovered information on the history of levee construction, construction plans, site investigations, and some limited engineering analyses. The results of the Phase 1 study were presented in a memorandum to MCDD dated August 21, 2013. Following this work, MCDD and Cornforth Consultants developed a Phase 2 investigation plan to help fill the gaps in information required to complete an analysis for certification. This investigation plan included subsurface field explorations throughout the levee system. Subsequently, MCDD and Cornforth Consultants met with representatives of the USACE Portland District in September 2013 to discuss the proposed Phase 2 field and laboratory investigation plans and engineering analyses of the levee system. The formal Phase 2 Site Investigation Work Plan was submitted to MCDD on December 23, 2013, and the plan was reviewed by the USACE in January 2014. The Phase 2 Site Investigation Work Plan moved forward as proposed. Field drilling work occurred between the months of February and May 2014, and the laboratory testing and office analyses continued through August and September 2014.

The information provided in this initial report is a supplemental engineering assessment that was not part of the original Phase 2 scope of work. Through the course of periodic stakeholder meetings in the spring and summer months of 2014, it became evident that an interim engineering assessment would be beneficial to provide the Oregon Solutions Project Team with timely information on the likely repairs that will be needed for certification to assist with their planning and budgeting efforts. As such, this assessment focuses on the most critical elements of the Phase 2 tasks with regard to potential impacts to planning efforts and construction costs, namely: (i) embankment erosion and scour protection; (ii) embankment and foundation stability and potential seepage; (iii) potential settlement and loss of levee freeboard; (iv) interior drainage modeling review; and (v) review as-built plans. These same tasks and the remaining tasks will be covered in greater detail under the Phase 2 summary report (Task 9) described in Section 2 that will be developed to include with the accreditation submittal to FEMA.

1.5 Consultant Team

The investigation team for the studies summarized in this report includes: Cornforth Consultants as the prime consultant and geotechnical engineer; WEST Consultants of Salem, Oregon to assist with hydrology/hydraulic issues; and Western States Soil Conservation of Hubbard, Oregon to provide subsurface explorations. Outside of this consultant team, MCDD separately retained Gibbs and Olson of Longview, Washington to provide a topographic survey of the PEN 1 District; and Group Mackenzie of Portland, Oregon to develop As-Built maps and cross-sections. MCDD internally handled select portions of the levee certification studies, including the interior

drainage studies and development of the Operations, Maintenance and Emergency Response manuals.

2. BACKGROUND INFORMATION AND SCOPE OF WORK

2.1 Project Description and Background

PEN 1 is located in North Portland and within Multnomah County. According to USACE reports, the district protects an area of about 901 acres. Approximately 116 acres are improved and utilized for commercial and industrial purposes. Other significant property uses include the Expo Center, Portland International Raceway, Heron Lake Golf Course, Delta Park West, and Port of Portland's Vanport Wetlands. There are no residential properties within the district.

The PEN 1 system is approximately 4.95 miles in length, and includes levees as well as highway and railroad embankments. A Vicinity Map of the PEN 1 district is shown on Figure 1. The Site Plans, Figures 2A through 2C, include aerial photographs with associated levee station information for orientation purposes. The PEN 1 levee system is bordered by Interstate 5 to the east, embankments of the Union Pacific Railroad and Burlington Northern Santa Fe Railroad to the west, and the Columbia Slough to the south. The Oregon Slough along the Columbia River comprises the northern boundary of the district from river mile 105.6 to 106.5. The levee crest is approximately at elevation 38.7 ft (NAVD88). The width of the levee is approximately 12 feet for the reaches along the Oregon Slough and Columbia Slough. The embankments supporting the railroad and Interstate 5 are in excess of 80 feet.

The interior drainage system consists of a series of ponds on the Heron Lake Golf Course, sloughs in the Portland International Raceway, Vanport Wetlands, Force Lake, and smaller ditches, pipes, and channels that drain to a pump station. A portion of the levee along the Oregon Slough includes a concrete flood wall. From Station 36+42 to 50+75 (see Fig. 2A), the exposed height of the flood wall is approximately 6 feet. There is an additional section of flood wall near the northeast end of the drainage district (Station 2+89 to 6+92, see Fig. 2A) that is approximately 5 feet in height.

The PEN 1 levee system features four closure structures that are located along the northern and western boundary. Two of these structures are located in the existing concrete floodwall between the Oregon Slough and N Marine Drive. These have the potential to provide small gaps in the wall to provide access between N Marine Drive and a recreational path on the north side: however only one is kept open (near Station 26+00, see Fig. 2A). The third structure provides a closure across N Marine Drive (west of Station 55+00, see Fig. 2A). The fourth closure structure is located in the northwest corner of the district at an opening in the railroad embankment (Station 64+00, see Fig. 2A). All of these closures consist of concrete slide panels that can be inserted between steel posts. MCDD is currently working on renewing an Intergovernmental Agreement with the City of Portland as the City's Bureau of Transportation typically operates and installs these closure structures prior to a high water event. City staff periodically run practice drills on operating and installing the closures.

2.2 Design and Construction History

The levee system protecting PEN 1 makes use of the Interstate 5 embankment to the east of the district (which is a shared boundary with Peninsula Drainage District No. 2 (PEN 2) to the east), and the railroad embankments of the Union Pacific and the Burlington Northern Santa Fe railroads to the west. All of these embankments pre-date the levees. The majority of the railroad embankment was constructed in three sections that were built between 1907 and 1911 using fill from a cut that was made for the construction of the railroad track near St. Johns in north Portland. Fill was dumped within the existing wood trestles to construct the embankments, and the timber piling supporting the trestles were incorporated into the fill along with, apparently, other debris, including telegraph poles, railroad ties, and rails. The wooden trestle timbers were never removed from the embankment. The final stretch of the embankment was completed in 1918 using two different fill materials: dredge material (presumably obtained from Smith Lake or the Columbia River) was placed to an elevation of 31.4 feet NAVD88; and fill from the St. Johns Railroad cut was placed over the dredge material to an elevation of 49.8 feet NAVD88.

The levees along the Oregon Slough to the north and the Columbia Slough to the south were originally constructed by local interests beginning in 1918. Following the passage of the Flood Control Act of 1936 by Congress, the USACE improved the levee reaches bordering the Oregon Slough and the Columbia Slough. Between 1940 and 1942, 6,100 linear feet of new levee, concrete flood wall, and stop log closures were constructed along the Oregon Slough on the northern edge of the district. The USACE also relocated and raised a significant portion of the 7,400 feet of levee along the Columbia Slough to the south and reinforced the remainder of this reach. The construction documents suggest that the embankment fill for this effort was obtained from borrow sites located within the district interior. This phase of work also saw the construction of a pump station near the southern boundary of the district, with 2,500 ft of drainage canal and two 20-inch pumps emptying into the Columbia Slough.

In late May 1948, a major flood event (now known as the Vanport flood) occurred along the Columbia and Willamette Rivers and their tributaries. After a sustained period of nearly two weeks of flood stage (38.1 ft NAVD88), flood waters breached the railroad embankment at the western boundary of the district. Subsequently, flood waters from PEN 1 breached the Interstate 5 embankment, also inundating PEN 2. A temporary trestle was constructed across the railroad embankment breach to restore rail operations, and the embankment was subsequently reconstructed with material dredged from Smith Lake, leaving the timber piling for the temporary trestle embedded within the reconstructed embankment.

Significant improvements to the system were proposed by the USACE in 1957. These proposed improvements included adding levee buttresses to the railway embankment, constructing thousands of feet of toe drains around the inside of the levee, and protecting the shoreline along the Oregon Slough with riprap. The USACE also proposed flattening the slope of the Interstate 5 embankment, providing improvements near the interchange with N Marine Drive, and constructing a new stop log closure along N Marine Drive. However, these improvements were heavily scaled back due to the PEN 1's difficulty in procuring funds for adequate capital. The proposed levee improvements were de-authorized by the USACE in November 1977.

In 1960, a new pump station was installed along the Columbia Slough to replace the old one that was burned during a fire in November 1959. The new station included two pumps, with a combined capacity of 19,700 gallons per minute. The pump station has discharge pipes of 18 inch and 24 inch diameter.

In 1964, riprap revetment was placed along approximately 4,178 feet of the Oregon Slough shoreline to prevent further encroachment of the river on the foundation of the levee. In 1972, as part of "Operation Foresight," the USACE authorized emergency improvements for an expected high water event which included the installation of toe drains in some locations and placement of fill to reinforce the railroad embankment, although it was not reinforced to the levels proposed in 1957. However, the anticipated high water level never materialized.

In 1998, an additional 2,000 feet of the railroad embankment was reinforced by placing additional fill along the inward toe of the embankment to bring the levee system to a higher reliability against the 1-percent-annual-chance flood. The outlet pipes of the pump station along the Columbia Slough were also raised above the level of the 1-percent-annual-chance flood, and maintenance was performed to repair minor damage from the 1996 flood event.

2.3 Engineering Assessment Background

As mentioned in Section 1, a second phase of work was employed to complete the additional engineering analyses and site investigations to address information gaps identified by the Phase 1 documentation review. The specifics of the engineering analysis are listed below, along with a brief description of what each task entails. Task 9 describes a Summary Report that will be prepared at the completion of the Phase 2 studies and subsequent system improvement, which ultimately will be provided to FEMA along with the PEN 1 application for levee accreditation. The Summary Report is separate from this Levee Engineering Assessment and will be finalized after all of the deficiencies in the PEN 1 District have been addressed. The ultimate purpose of the Summary Report and accreditation application is to provide FEMA with a single, comprehensive document that indicates that all conditions for accreditation are met.

The Phase 2 studies include the following tasks:

Task 1 – Embankment Erosion and Scour Protection Analyses. WEST Consultants performed this task with some assistance from Cornforth Consultants. Their work tasks included site reconnaissance visits to observe and document existing levee slope conditions, levee closures, and existing interior drainage facilities. Their analyses include an evaluation of existing bank erosion protection, estimation of toe scour potential, impacts due to wind and wave action, and the potential impacts from ice, debris and debris flows. A brief discussion of the major results is presented in Section 6 of this assessment.

Task 2 – Embankment and Foundation Stability and Potential Seepage Analysis. Cornforth Consultants took the lead on evaluating the stability of the embankment and foundation materials using information developed from a comprehensive field investigation and laboratory testing program (presented below under Task 4) to characterize existing subsurface conditions. FEMA requires analyses that demonstrate levee stability during the base flood loading conditions. These analyses must include potential shear failure surfaces within both the embankment and

foundation soils, as well as an assessment of the potential seepage through and underneath the levee. The key results from these analyses are presented in Section 6 of this assessment.

Task 3 – Analysis of Potential Settlement and Loss of Levee Freeboard. The 44 CFR 65.10 requires engineering analyses that assess the potential and magnitude of future losses of freeboard as a result of levee settlement. The analyses must address embankment loads, compressibility of embankment and foundation soils, age of the levee, and construction compaction methods. The CFR also specifies that settlement analyses shall be performed using procedures such as those described in the USACE manual EM 1110-1-1904, Soil Mechanics Design – Settlement Analysis. Cornforth Consultants completed these analyses using information obtained from the field exploration and laboratory testing programs. Results are presented in Section 6 of this assessment.

Task 4 – Additional Subsurface Explorations and Laboratory Testing. Cornforth Consultants has completed subsurface and laboratory testing programs to obtain data needed to perform the required engineering analyses. These programs are briefly described below.

Subsurface Explorations. The exploration program for PEN 1 included 57 borings overall, with 44 performed on land and 13 performed overwater from a barge. Out of the 57 borings, 18 were completed through the levee crest, 18 at the waterward toe (some were accessed from land), and 21 at the landward toe. Details on the subsurface investigation program are presented in Section 3 of this assessment.

Laboratory Testing. A laboratory testing program was performed on representative samples obtained from the drilling program to develop soil parameters that were used in the engineering analyses. The laboratory testing consisted of: (i) natural moisture contents on all samples; (ii) index tests that include grain size, plasticity and unit weights; (iii) consolidation testing (settlement parameters); and (iv) shear strength testing. Details on the laboratory program are included in Section 5 of this assessment.

Task 5 – Interior Drainage Modeling Review. MCDD's engineering staff performed interior drainage studies for the PEN 1 system. WEST Consultants completed a peer review of MCDD's models and analyses to check for conformance with the 44 CFR 65.10 requirements. WEST's review comments were communicated directly to MCDD during the study, along with recommendations, as needed, to help MCDD develop base flood inundation zone maps for inclusion in the FEMA accreditation submittal. WEST's review comments are summarized in Section 6 of this assessment.

Task 6 – Review and Assessment of Operation Plan. MCDD will be preparing an updated operation plan for the PEN 1 levee system in accordance with the requirements of 44 CFR 65.10. Cornforth Consultants will provide review comments and assessments of a draft version of the MCDD's plan. This review will be based on Cornforth Consultants understanding of the CFR criteria and their recent experience with other levee certification projects.

Task 7 – Review and Assessment of Maintenance Plan. As with the operation plan discussed above, MCDD will also prepare a maintenance plan for the PEN 1 levee system in accordance with the requirements outlined in 44 CFR 65.10. Cornforth Consultants will provide review

comments and assessments of a draft version of the MCDD's maintenance plan. As stated earlier, the assessments would be based on Cornforth Consultants understanding of the CFR criteria and their recent involvement with other levee systems. The final version of the maintenance plan would also be incorporated into the FEMA accreditation submittal.

Task 8 – Review As-Builts. MCDD retained Gibbs & Olson to provide a set of topographic maps to show the current levee geometry to meet CFR certification requirements. MCDD also retained the Group Mackenzie consultants to use the new topographic maps and add-on utilities and buildings along the levee alignment to assess the current conditions of any potential encroachments into the original levee design geometry. Cornforth Consultants assisted MCDD with the reviews of both map sets to provide editorial comments and recommendations for revisions to the Gibbs & Olson topographic map and the As-Built maps and cross-sections prepared by Mackenzie. Further details on the As-Built drawings are presented in Section 7 of this assessment.

Task 9 – Phase 2 Summary Report. The results of all field investigations, laboratory testing and engineering analyses will be summarized in a report that the participating community could submit to FEMA in addition to the accreditation application. The report will ultimately include: (i) summary logs of all exploratory borings; (ii) plots and tabulations of laboratory test results; (iii) summaries and key results of engineering analyses; (iv) conclusions on the interior drainage analyses and Operations, Maintenance, and Emergency Response manuals prepared by MCDD; and (v) conclusions on the overall compliance of the levee system with the requirements for FEMA accreditation. The summary report preparation is on-going at this time.

Task 10 – Levee Certification Application Package. Following completion of the Phase 2 Summary Report, Cornforth Consultants will assist in the preparation of an application package to FEMA Region X for levee accreditation.

Task 11 - Regulatory Review Period Assistance. Cornforth Consultants will assist as necessary during the review period by responding to technical questions from the regulatory agencies and help with drafting response letters or documents.

3. SUBSURFACE EXPLORATIONS

3.1 Field Explorations

In order to obtain additional information on the condition of the levee, a field exploration program of the PEN 1 system was completed between February 11 and May 16, 2014. Western States Soil Conservation, Inc. performed the borehole drilling. Western States' drilling equipment included a truck-mounted CME 55 mud-rotary drill rig and a track-mounted CME 850 mud-rotary drill rig for borings performed on land; and a skid-mounted CME 45 mud-rotary drill rig that was loaded onto a barge for the over-water borings.

The program consisted of 57 exploratory borings. The borings were grouped into rows of two to three borings per location at intervals varying from approximately 580 to 1,375 feet along the levee alignment, with an average spacing of about 1,030 feet (with the exception of the railroad embankment segments – see Section 3.2 below). The program included 18 crest borings, 21 landward side toe borings, and 18 waterward side toe borings. Of the waterward toe borings, 13 were over water and required the use of a barge. All boring locations are shown on the Site Plans, Figures 2A through 2C. The borings are designated as P1-CC-1 through P1-CC-62, beginning at N. Marine Drive and Interstate 5 and continuing counter-clockwise around PEN 1 along N. Marine Drive, N. Portland Road, the Columbia Slough, and Denver Avenue/Interstate 5.

Representative samples of the soils were taken vertically at approximately 5-foot intervals using Standard Penetration Tests (SPT). In addition, 3-inch diameter thin-wall Shelby tube samples were obtained at select locations to acquire relatively undisturbed soil samples. The exploratory boring depths ranged from 21.5 to 101.5 feet. The total drilling footage was approximately 2,130 feet.

A field representative from Cornforth Consultants was present throughout the field explorations to collect and log the recovered soil samples, prepare a descriptive field log of the subsurface conditions encountered by the drilling, and to collect digital data during field falling head permeability testing. The Cornforth Consultants field representative also coordinated and assisted the driller during the backfilling and clean-up efforts for each boring.

A summary log of the subsurface conditions encountered in each boring is shown on Summary Boring Logs, Figures A1 through A57 in Appendix A. The Summary Boring Logs describe the drilling methods, materials encountered, depths and types of samples, SPT blowcounts, interpretive layer thicknesses, and natural water contents of collected samples. The ground surface elevations noted in the Summary Boring Logs are approximate and based on the topography provided by MCDD contractors (Gibbs & Olson) and the GPS locations of the borings collected by the Cornforth Consultants field representative.

3.2 Railroad Embankment Explorations

The original site exploration plan included proposed borings and test pits located on the Union Pacific and Burlington Northern Santa Fe railroad embankments that form the west side of the PEN 1 levee district. MCDD entered negotiations with both of these railroad companies to

acquire access for the investigations, but they were unable to reach an agreement on terms. As a result, the PEN 1 investigation has not included any subsurface investigations through the railroad embankments to-date. However, the planned borings on both the landward and riverward sides of the railroad embankments were completed at locations outside of the railroads' right-of-way.

The railroad borings that were not performed include P1-CC-18, P1-CC-19, P1-CC-24, P1-CC-27, and P1-CC-29 (see Figs. 2A and 2B for locations). The original work scope also included three exploratory test pits to be excavated into the railroad embankment at Station 83+00, 102+00, and 114+00 (see Fig. 2B), which were not performed either. Based on the foregoing, the vulnerability assessments of the railroad embankment levee segments discussed in this report had to be developed without actual subsurface information and laboratory test data.

3.3 Previous Field Explorations by Others

Unrelated to the current levee evaluation, several other geotechnical studies have been performed by various firms and agencies in the project area, particularly on the cross-levee segment along the Interstate 5 embankment. Drawing from these earlier investigations by others, an additional thirteen boring logs were acquired and used as substitutes for some of the planned borings. These boring logs came from a total of six previous geotechnical reports, with the borings themselves completed between 1986 and 2013. The summary logs from these previous explorations are shown in Appendix B, Figures B1 through B13. The locations of these older borings are also shown on the Site Plans, Figs. 2A through 2C.

3.4 Field Permeability Testing

A total of eighteen falling head field permeability tests were performed in fourteen borings to evaluate the permeability of the soil layers at selected depths. The borings on which falling head tests were conducted are generally those used in the seepage and stability analysis cross sections (see Section 6 of this report). In general, testing was performed with the hollow-stem auger cutting bit resting on the base of the drilled hole, making the seepage area equal to the base area within the interior diameter of the casing. Occasionally the rate of seepage was slow and the casing was raised above the base of the drillhole a short length, making the seepage area equal to the base area and the exposed sidewall surface area of the hole.

The results of the field permeability testing are summarized in the following table:

Table 1 – Falling Head Field Permeability Test Results

Boring	Drilled Depth (ft)	"k" value (cm/sec)	"k" value (ft/min)	Summary Log Classification
P1-CC-02	40	3.44E-03	6.78E-03	slightly sandy SILT; trace clay
P1-CC-04	20	7.19E-04	1.42E-03	slightly sandy, slightly clayey SILT
P1-CC-05	25	1.81E-03	3.57E-03	slightly sandy SILT
P1-CC-13	20	1.51E-03	2.97E-03	slightly sandy, slightly clayey SILT
P1-CC-14*	10	7.42E-03	1.46E-02	silty fine SAND
P1-CC-14	25	6.10E-04	1.20E-03	slightly silty fine SAND; trace clay
P1-CC-23	25	4.67E-03	2.64E-02	slightly sandy, slightly clayey SILT
P1-CC-36	15	4.53E-03	2.21E-02	sandy SILT; trace clay
P1-CC-37	10	3.80E-03	9.20E-03	slightly clayey SILT; trace sand
P1-CC-37	35	8.76E-04	3.12E-03	silty fine SAND, trace clay
P1-CC-48	20	1.27E-01	1.91E-04	clayey SILT
P1-CC-49	15	1.60E-01	8.91E-03	sandy SILT
P1-CC-49	50	3.71E-02	7.48E-03	sandy SILT; trace clay
P1-CC-57	15	1.57E-02	1.72E-03	slightly sandy SILT; trace clay
P1-CC-57	20	3.44E-03	2.50E-01	silty fine SAND
P1-CC-58*	20	7.19E-04	3.16E-01	fine SAND
P1-CC-61	15	1.81E-03	7.30E-02	slightly sandy, slightly clayey SILT
P1-CC-62	30	1.51E-03	3.10E-02	clayey SILT; trace fine SAND

**test performed above groundwater table*

4. SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Site Geology

The PEN 1 Levee District is located along the south shoreline of the Oregon Slough, from River Mile 105.6 to 106.5. The levee is approximately 5 miles north of the downtown Portland, Oregon. Published geologic reports and mapping of this area show the native soils in the upper approximately 100 to 130 feet beneath the levee embankments generally consist of non-glacial Quaternary Alluvium Sediments of the Columbia River; comprised of silt, sand, organic-rich clay and minor gravel deposits. The overall surface of the alluvial deposits is relatively undissected, except for small interior drainage channels and ponds. The Summary Boring Logs, Figures A1 to A57 in Appendix A, identify all native alluvial sediments beneath the levee embankments as "Alluvium".

4.2 General Stratigraphy

Subsurface conditions along the levee generally consist of man-made embankment fills placed over geologically-recent river alluvium. There are also some localized fills overlying natural alluvium along North Portland Road, which runs parallel to the railroad embankment on the west edge of PEN 1, and the developed areas along N. Marine Drive. The levee embankment fills tend to vary between fine sandy, slightly clayey silt, and sandy silt to silty fine sand. The underlying river alluvium is mostly inter-layered deposits of sandy and clayey silt, silty sand, and silty clay. The alluvium typically becomes slightly denser and more-sandy with depth. One of the borings at the southeast corner of the district (P1-CC-49) encountered a layer of dense, sandy gravel (Troutdale Formation) at depth beneath the alluvium. It is anticipated that this dense gravel layer would likely be encountered beneath the alluvium at greater depths across the entire district.

4.3 Levee Embankment Fill

As mentioned above, the levee embankment fill materials were typically classified as slightly sandy, slightly clayey silt to sandy silt/silty fine sand. The consistency of the embankment soil is generally very soft to soft in areas where it is comprised of clayey silt, and loose to medium dense where it consists of the more-granular sandy silt/silty sand. Embankment samples of the clayey silt material were found to have relatively low plasticity.

USACE archives suggest that the levee fill material was obtained from three primary sources: nearby railroad alignment excavations, dredge material, and borrow sites located within the district interior. The fill material used to plug the levee breach from the 1948 Vanport Flood was reportedly dredged from Smith Lake. The levee fill thickness noted in the crest borings, ranges from as low as 13 feet along N. Marine Drive (at Boring P1-CC-5) up to 31 feet along the Columbia Slough (at Boring P1-CC-31). Along the Interstate 5 cross-levee segment the embankment fill was observed to be up to 37.5 feet in thickness (at Boring P1-CC-58).

4.4 River Alluvium

The river alluvium soils typically consist of inter-layered clay, silt and sand with varying amounts of minor constituents that include some gravel, cobbles and organics. In general, the alluvium soils were observed to be slightly softer and more clayey in the upper portion of the layer, and somewhat denser and sandier with depth. The alluvium materials are typically soft to medium stiff where clay is present, and loose to medium dense where it is more granular (i.e. predominantly fine sand). All of the alluvial materials are randomly inter-layered across the site, and are typically either non-plastic or have relatively low plasticity.

Five crest borings at select locations along the levee were drilled to greater depths to check the subsurface conditions at lower elevations. The five select borings included: P1-CC-2 (drilled depth – 61.5 feet); P1-CC-16 (drilled depth – 61.5 feet); P1-CC-37 (drilled depth – 81.5 feet); P1-CC-49 (drilled depth – 88 feet); and P1-CC-58 (drilled depth – 101.5 feet). The deeper borings generally encountered similar conditions in the river alluvium, with slightly denser soils at depth as compared to the upper alluvial soils. Boring P1-CC-49, located along the Columbia Slough, encountered refusal (the condition reached when the drill bit could not penetrate further) in a dense sandy gravel layer (Troutdale Formation) at a depth of 88 feet.

The heterogeneous mixture of silt, sand, clay and gravel layers is typical of many Pacific Northwest river alluvial deposits. In general, the borings did not encounter any unusual conditions that would not be expected in this geologic setting.

4.5 Groundwater Conditions

Groundwater conditions within and near the levee are anticipated to be heavily influenced by the water levels in the adjacent Oregon Slough (Columbia River), and to a lesser extent by the Columbia Slough (slack water slough along the southern boundary). The flow volumes and water levels in the Columbia River are closely controlled by the dams that have been constructed along the lower reaches of the river (Bonneville Dam, The Dalles Dam, John Day Dam, etc.).

5. LABORATORY TESTING

Laboratory testing was performed to determine soil index and engineering properties on selected samples. All testing was performed at Cornforth Consultants' soil testing laboratory in Portland, Oregon in general accordance with American Society for Testing and Materials (ASTM) standards, and with the USACE's EM 1110-2-1906, Laboratory Testing Procedures (USACE, 1986). Tests were conducted on samples selected from the field explorations to verify field classifications and to determine the following properties:

- natural moisture content
- grain-size distribution (gradations)
- Atterberg limits
- unit weights
- consolidation properties
- shear strength parameters: angle of internal friction and cohesion intercept (consolidated-undrained triaxial shear strength testing and direct shear testing).

All of the laboratory test plots except for natural moisture contents (see below) are included in Appendix C.

Soil Classification. All soil samples obtained from the field explorations were visually re-examined in the laboratory to confirm the field classifications, using ASTM guidelines. Final soil descriptions were prepared based on a combination of the visual examination and additional laboratory testing of index properties. The final classifications, layer descriptions, and interpretive layer contacts are presented on the Summary Boring Logs, Figures A1 to A57 in Appendix A.

Natural Moisture Content. All soil samples collected from the borings were tested to determine their natural moisture contents in general accordance with ASTM D-2216-10. The results of these tests are plotted graphically on the Summary Boring Logs, Figures A1 to A57 in Appendix A.

Grain-Size Distribution (Gradations). Grain-size distribution analyses (gradation analyses) by both mechanical-only and combined mechanical/hydrometer test methods were performed on select samples in general accordance with ASTM D-422-63R07. Mechanical-only tests were performed on three levee embankment fill samples. Combined mechanical/hydrometer tests were performed on three embankment samples. The results of the embankment gradation tests are plotted on Figures C1 and C2. Gradation analyses by mechanical-only were completed on eight foundation samples and by combined mechanical/hydrometer tests on four foundation samples. The results of the gradation tests on foundation soils are plotted on Figures C3 through C5 in Appendix C.

Atterberg Limits. Liquid and plastic limits (Atterberg limits) were determined for selected embankment and foundation soil samples collected during the field investigations. Of the eighteen soil samples tested, nine were found to be non-plastic. Eight of the nine non-plastic

samples came from the foundation soil samples. Test procedures were in general accordance with ASTM D-4318-10. Results of this testing are shown in Tables 2 and 3 below and plotted graphically on the appropriate Plasticity Charts, Figures C6 and C7 in Appendix C.

Table 2 - Atterberg Limits and Natural Moisture Contents of Select Embankment Soils

Boring No.	Sample No.	Depth (ft)	Natural Moisture (%)	LL (%)	PL (%)	PI (%)	Atterberg Limit Classification
P1-CC-05	S-2	10	29	34	26	8	Silt (ML)
P1-CC-08	S-2	10	35	44	27	17	Silt (ML)
P1-CC-11	S-3	15	12	-	-	-	Non-plastic
P1-CC-34	S-3	15	38	43	28	15	Silt (ML)
P1-CC-37	S-2	10	35	53	32	21	Silt (MH)
P1-CC-49	S-2	10	31	41	29	12	Silt (ML)

Table 3 - Atterberg Limits and Natural Moisture Contents of Select Foundation Soils

Boring No.	Sample No.	Depth (ft)	Natural Moisture (%)	LL (%)	PL (%)	PI (%)	Atterberg Limit Classification
P1-CC-02	S-5	25	43	34	26	8	Silt (ML)
P1-CC-14	S-5	27	46	-	-	-	Non-plastic
P1-CC-17	S-4	20	26	-	-	-	Non-plastic
P1-CC-21	S-4	20	90	44	32	12	Silt (ML)
P1-CC-28	S-5	27	48	49	36	13	Silt (ML)
P1-CC-43	S-5	25	35	-	-	-	Non-plastic
P1-CC-45	S-5	20	76	-	-	-	Non-plastic
P1-CC-46	S-9	40	42	-	-	-	Non-plastic
P1-CC-54	S-6	30	63	-	-	-	Non-plastic
P1-CC-56	S-3	15	45	-	-	-	Non-plastic
P1-CC-58	S-13	65	36	-	-	-	Non-plastic
P1-CC-62	S-8	40	42	46	32	14	Silt (ML)

Unit Weights. Unit weight determinations were performed on numerous test samples, including: three samples used for the consolidation tests; nine samples used in the consolidated-undrained triaxial shear tests; three samples used in direct shear test (discussed further below); and sixteen tests performed only to obtain unit weights. Unit weight was determined for twelve samples from the embankment soils and nineteen samples from the foundation soils. These analyses were performed in general accordance with ASTM D7263-09. The results of these tests are summarized in Tables 4 and 5 below.

Table 4 – Moist and Dry Unit Weights of Select Embankment Samples

Boring No.	Sample No.	Depth (ft)	Moist Unit Weight (pcf)	Dry Unit Weight (pcf)	Summary Log Classification
P1-CC-05	S-2	8.4-8.9	119.1	94.4	sl. clayey SILT
P1-CC-05	S-2	8.9-9.4	112.7	85.8	sl. clayey SILT
P1-CC-05	S-2	9.4-9.8	112.6	85.8	sl. clayey SILT
P1-CC-08	S-2	9.4-9.8	112.0	87.7	sandy SILT
P1-CC-11	S-3	14-14.1	107.8	89.8	silty SAND
P1-CC-11	S-3	14.1-14.2	108.1	82.1	silty SAND
P1-CC-11	S-3	14.2-14.3	100.7	75.9	silty SAND
P1-CC-11	S-3	14.3-14.7	102.5	85.0	silty SAND
P1-CC-11	S-3	14.7-14.8	118.0	92.0	silty SAND
P1-CC-34	S-3	14.4-14.8	114.1	82.4	clayey SILT
P1-CC-37	S-2	9.4-9.8	110.5	78.2	sl. clayey SILT
P1-CC-49	S-2	9.4-9.8	105.3	79.6	clayey SILT

Table 5 – Moist and Dry Unit Weights of Select Foundation Samples

Boring No.	Sample No.	Depth (ft)	Moist Unit Weight (pcf)	Dry Unit Weight (pcf)	Summary Log Classification
P1-CC-02	S-5	24.4-24.8	112.7	79.6	clayey SILT
P1-CC-14	S-5	26.4-26.8	113.1	81.3	silty SAND
P1-CC-17	S-4	19.4-19.8	113.1	86.1	SAND
P1-CC-21	S-4	18.0-18.5	102.8	63.3	sl. clayey SILT
P1-CC-21	S-4	18.5-19.0	96.4	53.5	sl. clayey SILT
P1-CC-21	S-4	19.0-19.5	94.1	49.4	sl. clayey SILT
P1-CC-21	S-4	19.5-19.8	97.8	57.4	sl. clayey SILT
P1-CC-21	S-4	19.8-19.9	118.0	82.0	sl. clayey SILT
P1-CC-28	S-5	26.4-26.8	107.0	71.9	sl. clayey SILT
P1-CC-43	S-5	24.4-24.8	118.0	88.8	sl. clayey SILT
P1-CC-45	S-5	18.3-18.8	96.8	55.3	sl. clayey SILT
P1-CC-45	S-5	18.8-19.3	98.5	57.7	sl. clayey SILT
P1-CC-45	S-5	19.3-19.8	96.6	54.9	sl. clayey SILT
P1-CC-46	S-9	39.5-39.8	110.5	78.9	sandy SILT
P1-CC-46	S-9	39.8-39.9	121.0	87.0	sandy SILT
P1-CC-54	S-6	29.4-29.8	103	65.4	sl. sandy SILT
P1-CC-56	S-3	14.4-14.8	112.0	77.9	sandy SILT
P1-CC-58	S-13	64.4-64.8	116.0	85.5	very sandy SILT
P1-CC-62	S-8	39.4-39.8	111.8	78.3	clayey SILT

Consolidation Tests. Consolidation tests were performed on one levee embankment sample and two foundation soil samples in general accordance with ASTM D-2435-04.

One sample was obtained from the silty sand fill in the levee embankment. One sample was obtained from soft silt foundation soils under the levee embankment. One sample was obtained from soft silt foundation soils on the landward toe of the levee, to model the settlement characteristics of foundation materials that had not been previously overlain by fill. All samples were collected in the field using a 3-inch diameter thin-walled Shelby tube sampler, and extruded in the laboratory prior to testing. The samples were tested under an incrementally-applied controlled stress load. Representative calculated consolidation parameters: coefficient of consolidation, c_v, secondary compression index, C_α, and permeability values, k, at a loading of 1 ton per square foot (tsf) are shown in Table 6 below. Graphical plots of the consolidation test results are shown on Consolidation Test plots, Figures C8 through C10 in Appendix C.

Table 6 – Summary of Consolidation Test Parameters/Results (at 1tsf loading)

Boring No.	Sample No.	Depth (ft)	c_v (ft^2/yr)	c_α	k (cm/s)	k (ft/min)	Summary Log Classification
P1-CC-11	S-3	14.8	2578	7.2E-4	2.5E-06	7.2E-04	silty SAND
P1-CC-21	S-4	19.8	2431	7.7E-4	5.8E-06	1.6E-03	sl. clayey SILT
P1-CC-46	S-9	39.8	2438	5.8E-4	4.1E-06	1.2E-03	sandy SILT

Consolidated-Undrained Triaxial Shear Tests. Nine consolidated-undrained triaxial compression shear tests were performed at incremental confining pressures to evaluate typical shear strength parameters of the levee embankment and levee foundation soils. Each soil sample was collected in the field using a 3-inch diameter thin-walled Shelby tube sampler, and extruded in the laboratory prior to testing. The consolidated-undrained tests were divided between three samples with three tests each. The samples were tested under the same series of confining pressures, consisting of 1,000 pounds per square foot (psf), 2,000 psf, and 4,000 psf. Testing was performed in general accordance with ASTM D-4767-04. The key results from the triaxial shear testing are summarized in terms of the internal angle of friction (ϕ') and the cohesion intercept (c') as determined from a Mohr Diagram plot. These results from the testing are presented below in Table 7, and the Mohr Diagram plots, raw test data, and supporting stress-strain diagrams for the three samples are shown on Figures C11 through C19 in Appendix C.

Table 7 – Summary of Consolidated-Undrained Triaxial Shear Test Results

Boring No.	Sample No.	Depth (ft)	Internal Angle of Friction ϕ' (degrees)	Cohesion Intercept c' (psf)	Summary Log Classification
P1-CC-05	S-2	7-10	32	130	sl. clayey SILT
P1-CC-21	S-4	18-19.5	32	86	sl. clayey SILT
P1-CC-45	S-5	18.5-20	32	0	sl. clayey SILT

Direct Shear Tests. Three direct shear tests were performed at incremental confining pressures to evaluate typical shear strength parameters of the silty fine sand embankment material. The soil sample was collected in the field using a 3-inch diameter thin-walled Shelby tube sampler, and extruded in the laboratory prior to testing. The direct shear test consisted of one sample with three tests. The sample was tested under a series of confining pressures, consisting of 970 psf, 1,940 psf, and 3,880 psf. Testing was performed in general accordance with ASTM D-4767-04. The key results of the direct shear testing are summarized in terms of the internal angle of friction (ϕ') and the cohesion intercept (c') as determined from a Mohr Diagram plot. These results from the testing are presented below in Table 8 and the Mohr Diagram plot for the sample is shown on Figure C20 in Appendix C.

Table 8 – Summary of Direct Shear Test Results

Boring No.	Sample No.	Depth (ft)	Internal Angle of Friction ϕ' (degrees)	Cohesion Intercept c' (psf)	Summary Log Classification
P1-CC-11	S-3	14.3	36	0	silty Sand (SM)

6. ENGINEERING ANALYSES

6.1 General

The analyses summarized in this section of the report are associated with a 1-percent-annual-chance flood in accordance with 44 CFR 65.10. Specifically, the engineering analyses discussed herein include: (i) freeboard; (ii) embankment erosion and scour protection; (iii) embankment and foundation stability and potential seepage; and (iv) interior drainage. Details on each are provided below.

6.2 Freeboard

6.2.1 General Freeboard Analysis

For a levee system to receive FEMA accreditation, information must be provided to show that the existing levee is certified and therefore, meets the requirements established by 44 CFR 65.10 (b)(1) for minimum freeboard during a 1-percent-annual-chance flood. The requirements for minimum freeboard from 44 CFR 65.10 states:

> "Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the 1-percent-annual-chance flood. An additional one foot above the minimum is required within 100 feet on either side of structures (such as bridges) riverward of the levee or whenever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required."

To evaluate the current freeboard conditions along the PEN 1 levee network, two tasks were completed. The first was to develop updated information on the existing crest elevations along the levee alignment. This was accomplished by a new topographic survey completed by Gibbs & Olson, Inc., which was finalized in October 2013.

The second task was to identify the anticipated 1-percent-annual-chance water surface elevations from published reports and compare those elevations with the existing levee crest elevations. WEST Consultants, Inc. completed a review of freeboard conditions and other issues related to levee certification as part of the ongoing engineering assessments for PEN 1. Their freeboard analysis utilizes the Gibbs & Olson updated survey data and published 1-percent-annual-chance water surface elevations along the Columbia River published by FEMA (FEMA, 2010) and by the USACE (USACE, 2007).

This comparison included three primary geographic locations based on their flooding sources: Along the Oregon Slough (Columbia River) to the north and west, along the Columbia Slough to the south, and along the adjacent Peninsula Drainage District # 2 (PEN 2) to the east. Stationing along the levee alignment begins at 0+00 in the northeast corner of PEN 1 and encircles the district in a counterclockwise direction (see Fig. 2A). For the analysis of the cross-levee between PEN 1 and PEN 2, the 1-percent-annual-chance flood elevation within PEN 2 was assumed to be the maximum possible elevation achieved should the PEN 2 levee along the Oregon Slough fail, fully inundating PEN 2 to the elevation of the Oregon Slough 1-percent-annual-chance flood.

Plots illustrating the top-of-levee elevation versus the 1-percent-annual-chance flood profile and required freeboard are presented in Figures 3 through 6 from the WEST analysis. As Figures 3 and 4 indicate, the vast majority of the levee system along the Oregon Slough and Columbia Sloughs has six or more feet of freeboard above the 1-percent-annual-chance water surface and meets the requirements of 44 CRF 65.10. As seen in Figures 5 and 6, however, portions of the embankment that makes up the border between PEN 1 and PEN 2 do not reach the minimum required freeboard. This occurs in the vicinity of the traffic interchange between Interstate 5 and Oregon 99E / Marine Drive. In this area, the actual high ground is not aligned with the levee station line. The elevations used for computation of freeboard in this area are taken from the actual high ground, with the stationing projected to the levee station line. Between approximate levee stations 245+80 and 251+00 (see Fig. 2B) the freeboard only reaches 1.7 feet. This is the segment of Interstate 5 entering the clover leaf interchange from the south as it dips under the overpass for Oregon 99E. Between approximate levee stations 262+50 and 263+55 (see Fig. 2B) the freeboard falls to 2.7 feet. This is the segment that crosses N Pier 99 Street. Both of these sections are not in compliance with the required freeboard called for in 44 CFR 65.10.

6.2.2 Potential Freeboard Loss Due to Settlement

General. Levee certification requires an analysis to check for the potential and magnitude of future settlement that could lead to a loss of levee freeboard. The settlement analyses must consider the embankment loading conditions, compressibility of the embankment and foundation soils, the age of the levee, and the methods of levee construction.

Settlement Potential. The site investigations of the PEN 1 levee embankment and foundation soils indicate that although the soils are relatively soft/loose, they have low plasticity. This suggests that the soils can exhibit a significant amount of settlement under the fill loads, but the settlement is likely to occur relatively quickly. As discussed in Section 2 of this report, the bulk of the PEN 1 levee network was built in the late 1910's, with some major modifications in the 1940's and lesser modifications in the 1970's and 1990's. On that basis, the majority of the levee embankment fill has been in-place for over 60 years. The levee crest elevation is currently close to the original as-built elevation (typically within about 12 to 18 inches), and it is Cornforth Consultants' understanding that the MCDD has not noticed any settlement problems, nor have they placed any additional fills on top of the levee to the knowledge of the current and past employees. This apparent lack of on-going settlement confirms the statement above that the soils probably settled over a short time period after the fill placement occurred.

Estimate of Total Settlement. Settlement analyses of the PEN 1 levee system were performed at a representative levee section at Station 174+00 (see Fig. 2C). The levee fill thickness at that location is approximately 23.5 feet. The analyses were performed using the consolidation test data presented in Appendix C (see Figs. C8 and C9). The settlement calculation was made using a conservative assumption that the entire embankment fill was placed instantaneously (versus the periodic placement that actually occurred). The total estimated settlement is 24 inches, which is reasonably close to the observed settlement of 12 to 18 inches described above.

Time Rate of Settlement. Consolidation tests performed on samples of the alluvium soils indicate that they have a relatively high coefficient of consolidation, c_v of approximately 2,400

square feet per year (see Section 5 of this report). This suggests that for an alluvium layer measuring 60 to 70 feet in thickness, it should only take 2 to 3 years for 95 percent of the primary consolidation to occur under the levee embankment load (assuming the alluvium layer is singly drained). Since over 60 years have passed, it is evident that the primary consolidation was completed long ago, and the compressible foundation should now be experiencing only minor secondary creep. Based on the foregoing, the potential for loss of freeboard due to settlement of the levee embankment is estimated to be very small or negligible.

6.3 Embankment Erosion and Scour Protection

The embankment erosion protection of the PEN 1 levee was evaluated per requirements of 44 CFR 65.10(b)(3). The following potential influences on embankment erosion protection were evaluated: (i) the base flood (1-percent-annual-chance flood); (ii) expected wind and wave action; (iii) ice loading; (iv) impact of debris; and (v) duration of flooding.

6.3.1 Observed Embankment Erosion Protection

Various documents regarding erosion protection along the PEN 1 levee were examined. USACE drawings dated 1953 and 1957 indicate that the levee along the north edge of PEN 1 was lined with 4,178 linear feet of "Riprap Class II" (USACE 1953 and 1957). As-constructed drawings indicate that the revetment construction consisted of an 18-inch layer of rock placed over 12 inches of bedding material installed on a 2H:1V slope. The toe of the revetment is consistently shown in these drawings at an elevation of -3.0 feet and extending to elevation 26 feet NGVD29 – approximately 0.5, and 29.5 feet NAVD88, respectively (USACE 1962). Spatially, the riprap extends from approximate levee Station 14+65 (see Fig. 2A) east along the entire north-facing portion of the levee adjacent to the Oregon Slough.

Field verification of embankment erosion protection was conducted during site reconnaissance in April 2014. In areas where the as-built drawings indicate the presence of "Riprap Class II," the observed median (D_{50}) and maximum (D_{100}) were approximately 16 inches and 26 inches, respectively. Comparing these sizes with modern riprap gradations by Federal Highway Administration (FHWA), the majority existing riprap along the northern PEN 1 levee is more similar to Class IV. The average size of riprap varied along the length of the revetment, from smaller gradations near the upstream end to slightly larger gradations toward the downstream end. Table 9 indicates the observed riprap size, estimated class, and approximate vertical extent at four sites along the northern portion of the levee.

Table 9 – Observed Riprap Characteristics

Approximate Levee Station	D_{50} (in)	D_{100} (in)	Estimated Top of Riprap (ft, NAVD88)	Estimated Riprap Class[1]	As-Constructed USACE Revetment Plans[2]
17+00	15	24	27	Class IV	Class II
27+00	16	30	28	Class IV	Class II
36+00	18	32	26	Class V	Class II
54+00	18	32	25	Class V	Class II

Notes:

[1] Class based solely on observed D50 and D100. Estimate does not consider characteristics such as uniformity ratio

[2] USACE Portland District; Lower Columbia River Basin Bank Protection Works – Swift Location; CLW-106- 15/4; Feb. 1967

There is no indication in as-built drawings or other documentation that erosion protection was installed along the south portion of the levee. Field verification during site reconnaissance in April 2014 did not find any.

6.3.2 1-Percent-Annual-Chance Flood Event

In order to evaluate the adequacy of the PEN 1 levee embankment protection for the 1-percent-annual-chance flood, riprap sizing calculations were performed and compared to the observed characteristics of the existing riprap protection. CHANLPRO software (USACE, 1999) was used to determine the minimum required riprap size at representative locations along the levee alignment. Hydraulic parameters at the river cross section locations for the 1-percent-annual-chance flood were determined using an existing HEC-RAS model of the lower Columbia River (USACE, 2011). The calculations were only carried out along the portion of the PEN 1 levee system along the Oregon Slough. During the 1-percent-annual-chance flood, the Columbia Slough is a backwater area inundated by floodwater from the main channel of the Columbia River. This area has no significant current and is therefore not subject to potential erosive forces associated with the 1-percent-annual-chance flood. Similarly, the scenario of a PEN 2 levee breach and flooding within PEN 2 against the cross-levee would also not result in erosive forces adequate to threaten the integrity of the cross-levee.

A comparison of observed riprap characteristics and the minimum computed riprap size is shown in Table 10. The results in Table 10 utilize a design factor of safety of 1.1.

Table 10 – Observed and Minimum Required Riprap Size

Approximate Levee Station (ft)	Average Riprap Size (in)		Minimum Required Riprap – Equivalent Spherical Diameter (in)			
	D_{100}	D_{50}	D_{100}	D_{50}	D_{15}	Adequate?
00+25	--- [1]	--- [1]	6.6	5.3	3.6	--- [1]
13+33	--- [1]	--- [1]	6.6	5.3	3.6	--- [1]
25+18	30	16	6.6	5.3	3.6	Yes
34+50	30	16	6.6	5.3	3.6	Yes
61+26	--- [2]	--- [2]	6.6	5.3	3.6	--- [2]

Notes:

[1] This portion of the levee was not readily accessible as it is private property

[2] This portion of the levee is set back from the bank of the Columbia River

As indicated in Table 10, the portions of the levee lined with riprap are more than adequately protected from erosion for the 1-percent-annual-chance flood. In the areas where access to the embankment was limited or unavailable (approximate levee stations 0+00 to 14+45, see Fig. 2A), the presence of substantial permanent docks and moorings immediately adjacent to the levee adds a level of protection from high flow velocities associated with potential embankment erosion.

6.3.3 Wind and Wave Action

The existing embankment protection for the PEN 1 levee was evaluated for potential erosion by wind and wave action. Wind data was obtained and used to carry out calculations of erosion potential at four locations along the northern PEN 1 levee to determine the minimum riprap size for an expected range of wind velocities. An average fetch distance at each location was estimated from a wave fetch analysis based on aerial photography.

Wave height was calculated by the restricted fetch limited equation documented in Automated Coastal Engineering System Technical Reference (USACE, 1992). The minimum required stone size of the embankment protection was computed using the Hudson equation documented in EM-1110-2-1100, Coastal Engineering Manual (USACE, 2002). A factor of safety of 1.5 was used in the riprap sizing calculations. Wind speed, wave height, and corresponding minimum riprap size estimated from the Hudson equation are shown in Table 11.

Table 11 - Wind Speed, Wave Height, and Minimum Riprap Size

Location	Levee Station	Fetch (ft)	Estimated wave height (ft)		Minimum D_{50} riprap size for wind speed (in)		Minimum W_{50} riprap weight for wind speed (lbs)	
			45 mph	50 mph	45 mph	50 mph	45 mph	50 mph
1	43+50	15,740	2.2	2.4	13.9	15.5	135	185
2	20+25	15,250	2.2	2.4	13.4	14.9	119	164

The highest sustained wind speed recorded at the Portland Jetport RAWS station is approximately 46 miles per hour. At this speed, the calculated minimum D_{50} stone sizes are 15.5 and 14.9 inches at Locations 1 and 2, respectively. The observed D_{50} riprap is approximately 16

inches in diameter and is sufficient to resist predicted erosion potential from wind and wave action.

As mentioned previously, it should be noted that the presence of the permanent docks and moorings along portions of the riverward bank of the north PEN 1 levee provide an additional measure of protection from erosion caused by wind-generated wave action. The maximum fetch distances calculated for Location 2 in Table 11 does not account for the interference to wave propagation that would result with these features. While this additional protection is not readily quantifiable, it is noteworthy when considering the levee's vulnerability to erosion caused by wind-generated wave action.

6.3.4 Ice Loading

The existing embankment erosion protection for the PEN 1 levee was evaluated for potential of erosion by ice loading. Anecdotal historical records, primarily from newspaper headlines, indicate that while stable ice cover has occurred along the Columbia in the past, most recently in 1949 near the confluence with the Willamette River, there have been no such formations in the last 62 years. Little if any specific historical information is available regarding stable ice forming in the immediate vicinity of PEN 1.

The likelihood of the formation of a stable ice cover on the Columbia River in the vicinity of PEN 1 was evaluated. In order for a stable ice cover to form on the Columbia River, the water must be supercooled to below 32°F. Usually, an air temperature of 18°F or lower for an extended period is required for the supercooling of turbulent water (USACE, 2002). Typical climatic conditions of this region do not support the conditions necessary for the formation of a stable ice cover on the Columbia River.

A climate station located at the Portland International Airport provides typical climate conditions of the area. The examined period of record extends from 1941 to 2010 (WRCC, 2011). The lowest monthly average minimum air temperature of 34^{o}F occurs in January, which is above an air temperature of 18^{o}F. This supports the conclusion that climatic conditions in the vicinity are unlikely to promote the formation of a stable ice cover on the Columbia River.

In the unlikely event of the formation of a stable ice cover, the existing riprap was evaluated for ice generated erosion problems. Where ice flows have historically caused problems, a safety factor of 1.6 – 2.0 should be used to increase the design rock size (FHWA, 1989). To account for ice generated erosion, a safety factor of 1.6 was applied to the calculations of the minimum riprap size and then compared to existing riprap protection. CHANLPRO software (USACE, 1999) was used to determine minimum riprap sizing. Increasing the factor of safety to 1.6 in the calculations yielded identical results for minimum riprap sizing as with a factor of safety set to 1.1 (see Table 10). This indicates that the PEN 1 levee provides adequate embankment erosion protection against erosion caused by ice loading.

6.3.5 Impact of Debris

The existing embankment erosion protection for the PEN 1 levee was evaluated for potential erosion from the impact of debris. The Columbia River does have potential for transporting

floating debris. As noted in section 6.3.2, there are many permanent docks and moorings along the Oregon Slough which could also serve as possible sources for floating debris capable of causing damage to the revetment protecting the PEN 1 levee.

A safety factor of 1.6 should be applied when sizing riprap to account for the impact potential from floating debris (FHWA, 1989). As discussed in the previous sub-section, a safety factor of 1.6 was applied to the calculations of minimum riprap size. The existing riprap is adequately sized to account for the impact potential from floating debris.

6.3.6 Duration of Flooding

A flow duration analysis will be completed during the Phase 2 studies for this project. Historical stream flow data for the Columbia River have been collected and will be evaluated for the United States Geological Survey (USGS) Gage 14128870, "Columbia River Below Bonneville Dam, OR" (USGS, 2011). The gage has 30 years of daily stage data which encompasses several significant flooding events.

The analysis will determine a stage correlation using the 1-percent-annual-chance flood profile for the prediction of the stage near the PEN 1 levee based on the stage observed below Bonneville Dam. This will allow the calculation of durations for which the toe of the PEN 1 levee has been inundated by more than five feet.

6.4 Embankment and Foundation Stability and Potential Seepage

6.4.1 Levee Reaches

The criteria listed in 44 CFR 65.10 require that the overall stability and potential seepage through and under a levee be evaluated under the 1-percent-annual-chance flood loading conditions. When performing seepage and stability evaluations of levees, the analyses are performed by separating the levee into segments with similar features and conditions. These segments with similar properties are generally referred to as "reaches." This method allows several miles of levee alignment to be analyzed in manageable pieces. For the purposes of this investigation, the PEN 1 District was partitioned into 15 reaches. These reaches have been grouped based on: (i) levee embankment configuration; (ii) subsurface conditions; (iii) levee height; and (iv) prior performance history. The approximate limits of the reaches are shown on Figures 2A through 2C. Please note that Reach 1-5 includes a section of levee that features a concrete flood wall (i.e. no levee embankment).

6.4.2 Analysis Cross-Section Models

The stability and seepage analyses were performed on geologic cross-sections through the levee embankment, which were developed using: (i) the topographic information of the site collected by Gibbs & Olson; (ii) bathymetry data acquired by MCDD for the adjacent waterways (Oregon Slough and Columbia Slough); and (iii) the subsurface information obtained from Cornforth Consultants' field investigation program. Analyses were performed on representative cross-sections for 14 out of the 15 reaches, and the results are discussed below. Reach 1-5 is comprised

of a flood wall that is situated above the 1-percent flood elevation; therefore, no analyses were necessary. Cross-sections for the 14 reaches analyzed are presented on Figures 7 through 20.

Railroad Embankment Soils. As noted previously, it was not possible to complete the planned borings and test pits through the railroad embankments. On that basis, it was necessary to estimate both the subsurface conditions and material properties using current and historic available information. The subsurface conditions were modeled primarily using: (i) borehole information from the landward and riverward toe borings that were performed outside of the railroad right-of-way; and (ii) historical information from trial documents resulting from litigation that followed the Vanport Flood of 1948 (Clark et. al. vs. United States of America, December 29, 1954).

6.4.3 1-Percent-Annual-Chance Flood Elevations

The 1-percent-annual-chance flood water surface elevations were determined by WEST Consultants from the Digital Flood Insurance Rate Map (DFIRM) Database for the City of Portland, Oregon. The water surface elevations are based on the combined stage-frequency curves developed from seven gage locations along the Columbia River between River Miles 60 and 123, and one location on the Willamette River.

6.4.4 Analysis Methods / Material Properties

The analysis cross-sections were used as the basis for developing analytical models in the seepage and slope stability software programs SEEP/W-2007 and SLOPE/W-2007; both are modules of the GEO-STUDIO 2007 suite of programs. Based on the data collected from the field investigations, laboratory testing program, and Cornforth Consultants' experience with similar soils, generalized soil properties were developed for the materials encountered by the borings. The material properties used in the seepage and stability analyses are summarized below in Table 12.

As discussed above, the engineering properties of the railroad embankments had to be estimated using existing information. Archive reports describe the embankment fill as being constructed by dumping loose soil through a wooden trestle structure. On that basis, the embankment is likely to be quite loose and heterogeneous. Considering the age of the trestle (built around 1908), the wooden timber structure has probably also decomposed significantly. On that basis, we analyzed the stability of the railroad embankment using a relatively low soil strength (i.e. angle of shearing resistance, ϕ') of 26 degrees. In order to meet the formal certification criteria of 44 CFR 65.10, it will be necessary to thoroughly investigate the subsurface conditions of the railroad embankments at a later date to determine the actual soil parameters.

6.4.5 Seepage Analyses

SEEP/W uses a finite element analysis to model seepage passing through the foundation and embankment soils as a result of higher water levels acting on the riverward side of the levee. Although the finite element mesh is generated by SEEP/W using an internal algorithm, the finite element size can be adjusted by the user. For this project, the approximate element size for all analyses was 2 feet x 2 feet. Using the 1-percent-annual-chance flood level recommended by

WEST Consultants, seepage through the foundation and embankment soils was calculated under saturated, steady-state conditions. As recommended by the SEEP/W manual, the exit gradient at the landward toe of the levee was averaged over 2 mesh units (4 feet). The exit gradients from these analyses were then compared to the recommended maximum exit gradient (i.e. exit gradients should be no higher than 0.5 at the toe of the landward embankment slope) suggested by the USACE in EM 1110-2-1913 (USACE, 2000).

Table 12 – Summary of Estimated Soil Properties for Stability and Seepage Analyses

Material Descriptions	Unit Weight γ (pcf)	Friction Angle ϕ′ (degrees)	Cohesion Intercept c' (psf)	Permeability k (ft/sec)	Permeability Ratio, k_h/k_v
Levee Fill: Silty Sand to Sandy Silt	108	33	0	$2.8x10^{-5}$	4
Levee Fill: Clayey Silt	112	31	0	$2.4x10^{-5}$	4
Railroad Embankments: Mixed Sand, Silt and Timber	110	26*	0	$2.8x10^{-5*}$	10*
Foundation: Clayey Silt; (River Alluvium)	104	32	0	$2.8x10^{-5}$	4
Foundation: Silty Sand; (River Alluvium)	113	33	0	$4.5x10^{-4}$	4

Note* Value estimated based on available information

Results of Seepage Analyses. For most of the analysis sections on the PEN 1 levee, the calculated exit gradient was significantly lower than the maximum value of 0.5 recommended by the USACE. The exit gradients varied from 0 to 0.5. The results of the seepage analyses (i.e. exit gradients) are shown below in Table 13 for each of the reaches analyzed, and also on Figures 7 through 20. The key reason for the low exit gradient values calculated is that the 1-percent-annual-chance flood elevation generally only rises a few feet above the riverward toe. On that basis, there is very little seepage force acting across the embankment.

6.4.6 Embankment Stability Analyses

The slope stability program SLOPE/W performs analyses to calculate the factor of safety (FS) for potential unstable slope conditions using conventional limit equilibrium theory. The analysis method selected from the software suite for this project was Spencer's Method. The steady-state seepage data generated in the SEEP/W model were imported directly into the SLOPE/W model to account for the pore water pressure conditions. The critical slip surface with the lowest FS for specific embankment conditions was determined using a grid and radius search routine with

factors of safety calculated for multiple circular-slip surfaces. A minimum failure surface depth of 10 feet was set as a limiting parameter in the model to ensure that minor, surficial failures would be excluded from the analysis results. These types of shallow failure surfaces may show lower calculated factors of safety; however, they are considered to be far less significant to deeper failures that pose an actual threat to the integrity of the levee. It is assumed that MCDD would be able to treat any shallow failure areas with good maintenance practices as they occur to prevent them from developing into much larger failures that could endanger the levee.

Results of Stability Analyses. The results of the slope stability analyses are summarized on Table 13 below and also on Figures 7 through 20. The calculated FS from each levee reach was compared against the minimum value recommended by the USACE in EM 1110-2-1913 (USACE, 2000); which requires FS greater than 1.4 for static, steady-state seepage conditions. This threshold FS value was met for all the levee reaches except those along the railroad embankment (i.e. Reaches 1-6, 1-7, and 1-8 – See Figures 11 through 13, respectively).

Table 13 – Results of Seepage and Stability Analyses

Levee Reach	Station	100 yr Flood Elevation	Max Exit Gradient	Landward FS	Waterward FS	Meets USACE Standard?
1-1	4+96	31.7	0	*	2.37	Yes
1-2	11+56	31.6	0	*	1.83	Yes
1-3	33+08	31.5	0.1	2.13	1.55	Yes
1-4	41+53	31.5	0.0	*	1.69	Yes
1-5	59+22	31.4	0	*	*	Yes
1-6	82+35	31.3	0	1.29	1.26	No
1-7	89+62	31.3	0.2	1.15	2.04	No
1-8	113+88	31.0	0	1.71	1.28	No
1-9	135+77	31.0	0	1.82	2.30	Yes
1-10	146+13	31.0	0.2	1.75	2.51	Yes
1-11	174+08	31.0	0.3	1.40	2.12	Yes
1-12	204+95	31.7	0.2	1.72	3.00	Yes
1-13	214+81	31.7	0.2	1.83	*	Yes
1-14	227+27	31.7	0.0	1.87	1.93	Yes
1-15	252+34	31.7	0.5	1.41	*	Yes

Note* Flat ground – no slope to analyze

***Flood Wall Stability*.** Detailed structural analyses of flood walls are required under 44 CFR 65.10 for FEMA certification. Upon inspection of the As-Built drawings and cross-section information,

it appears that the existing flood walls in PEN 1 would not experience water loading under the 1-percent-annual-chance flood conditions (i.e. the bases of the walls are above the 1-percent-annual-chance flood elevation). On that basis, detailed analyses were not deemed necessary.

6.5 Interior Drainage Modeling Review

Interior drainage modeling has been completed by MCDD. WEST conducted an independent review of that modeling in November of 2013. Few technical issues were identified with the interior drainage modeling, and those had little effect on the overall results of the analysis. Comments provided to MCDD were applied and the modeling finalized. The independent review was finalized in April of 2014 and ultimately concluded that interior drainage modeling of the PEN 1 levee system was conducted according to standard engineering practice.

7. AS-BUILT DOCUMENTS

The provisions for levee certification under 44 CFR 65.10 require levee districts to provide "certified as-built plans". These are as-built plans of the levee network in its current condition, and not actual as-built documents from the original construction. To develop the as-built maps and cross-sections, MCDD retained Gibbs and Olson to develop a current topographic map of the district. Gibbs and Olson completed their survey in October 2013. Subsequently, MCDD retained Group Mackenzie to develop detailed As-Built maps of the district using the Gibbs and Olson topographic data as well as additional information from LIDAR and utility companies. The Group Mackenzie documents include both topographic maps of PEN 1 and representative cross-sections through the levee embankment. The Group Mackenzie As-Built maps are presented in Appendix D and the As-Built cross-sections are presented in Appendix E of this report.

8. ENCROACHMENTS

8.1 FEMA Certification Focus

The FEMA criterion for levee accreditation focuses on the structural integrity of the levee and its ability to maintain protection of the district interior area under 1-percent-annual-chance flood conditions (i.e. embankment stability, seepage and settlement or freeboard loss). The guidelines do not address the issue of flood fighting concerns caused by encroachments or potential issues related to trees/vegetation, beyond their potential impacts to stability, seepage and freeboard. However, FEMA guidelines do require that the district adopt formal operations and maintenance manuals that outline the operation standards for routine and emergency conditions, and maintenance requirements for equipment upkeep and vegetation control. As described previously, this study was performed to assess whether the district meets FEMA accreditation requirements; therefore, the embankment encroachments were evaluated primarily for their potential to impair the structural integrity of the levee. For the purposes of this levee engineering assessment, encroachments were classified using typical USACE definitions, which includes unauthorized excavations, structures and other obstructions within the levee project easement. Accordingly, engineering evaluations were completed to identify any major encroachments on or adjacent to the PEN 1 levee embankment that could threaten levee stability.

8.2 Encroachment Assessment for FEMA Accreditation

Original Design Section and Levee Overbuild. At many locations throughout PEN 1, the present ground configuration is significantly different from how it was depicted in the original USACE construction documents. Aside from the railroad embankment segments (discussed below), the PEN 1 levee embankments frequently exhibit more fill than the original design sections indicate. This excess fill is referred to as “overbuild”. The excess fill is most prominent on the landward and waterward sides of the levee (i.e. making for a wider embankment), and at some locations on the levee crest. As discussed in Section 7, the cross-sections developed by Group Mackenzie contrast the existing ground surface versus the original design levee sections. These cross-sections are included in Appendix E. Representative cross-sections demonstrating overbuild include Stations 11+50, 23+00 and 174+10. In general, encroachments such as buildings and utilities situated within the levee overbuild areas were considered not to be a significant risk to the levee with regard to the criteria in 44 CFR 65.10, because they do not affect the structural integrity of the original levee section.

Buildings, Utility Lines and Outfalls. Consideration was given to the buildings, multiple utility lines and outfalls identified in the levee sections, particularly those levee segments along N Marine Drive. In general, the buildings appear to be situated on relatively thick overbuild on the waterward side of the levee and flood wall, which does not present stability or seepage issues. Minor feeder utility lines to these buildings (such as gas and water) are not considered seepage hazards either, because they are typically very small diameter and are situated at higher elevations in the embankment. As shown on the as-built cross-sections, there are multiple duct banks and larger utility lines that extend longitudinally along the levee alignment. These longitudinal lines do not pose a significant risk to embankment stability, or to the potential for

excessive seepage within the embankment. Many of these utilities are shown to be at or above the 1-percent-annual-chance flood water level, which would produce very small to no head differential seepage across the section. Also, many of the utilities are shown to be located in wide embankment sections with relatively flat landward slopes or flat ground surfaces with no slopes. Again, the risk of potential slope instability associated with these utility lines specific to the 1-percent-annual-chance flood is considered to be very small to non-existent.

Railroad Embankments. The western edge of PEN 1 is a railroad embankment that extends from approximately Station 61+00 through Station 125+00 (see Figs. 2A and 2B). The northern half of this segment exhibits some overbuild, similar to the rest of the district (see cross-sections in Appendix E at Station 72+05 and 89+60). However, the embankment along the southern extent of the railroad alignment is smaller than expected based on the USACE archive documents. As shown in the cross-sections in Appendix E, the existing embankments at Stations 100+35 and 113+90 do not meet the expected widths, and have steeper side slopes than the design sections. In addition, there is a 36-inch diameter cherry tree growing into the waterward side slope of the railroad embankment at Station 113+90, which possesses a root mass that is expected to comprise nearly half the width of the embankment. As described below, there is a sanitary sewer line in the railroad embankment foundation at Station 124+31 that presents a seepage concern also.

Reviewed Encroachments in Levee Design Section. Table 14 below summarizes the encroachments within the levee sections. The table also includes comments on the expected severity of the encroachments.

Table 14 – Design Section Encroachments on the PEN 1 Levee

Levee Alignment Stationing	Assessment or Comments
11+50	Fiber optic conduit bank extending longitudinally beneath the levee crest. The crest is nearly 70 feet in width at this location, and the conduit is higher than the 1-percent-annual-chance flood elevation. No apparent impacts from encroachment with regard to seepage or stability during 1-percent-annual-chance flood.
33+15	PGE conduit bank and 4-inch gas extending longitudinally beneath landward side toe. Ground surface elevation on landward side is at or near 1-percent-annual-chance flood elevation. No apparent impacts from encroachments with regard to seepage or stability during 1-percent-annual-chance flood.
59+00	Several longitudinal utility lines in close proximity to flood wall. None penetrate through the wall, and the 1-percent-annual-chance flood elevation is too low to exert a hydrostatic load on the wall face. No apparent impacts from encroachments with regard to seepage or stability during a 1-percent-annual-chance flood.

Table 14 – Design Section Encroachments on the PEN 1 Levee Embankments (cont.)

Levee Alignment Stationing	Assessment or Comments
113+90	A 36-inch diameter cherry tree growing from the waterward side slope of the railroad embankment. It is expected that the root penetration could significantly shorten the seepage path across the embankment, and toppling of the tree in a storm could impair the stability.
124+31	A 20-inch diameter sanitary line extends transverse across the railroad embankment through the foundation. The conduit presents a potential seepage path beneath the levee into the landward side. A boil occurred in close proximity to this sewer line during the 1996 high water event.
205+00	A fiber optic conduit bank extends beneath the crest of the cross levee. The levee crest is nearly 110 feet in width at this location, and the conduit is higher than the 1-percent-annual-chance flood elevation. No apparent impacts from encroachment with regard to seepage or stability during the 1-percent-annual-chance flood.
232+39	A 16-inch diameter water line extends transverse across the cross levee embankment through the foundation. The levee is more than 150 feet wide at this location, and there would be very little head acting across the embankment during a 1-percent-annual-chance flood. No apparent impacts from encroachment with regard to seepage or stability during a 1-percent-annual-chance flood.

8.3 USACE Encroachment Standards

The information below provides a preliminary overview of encroachments under the purview of the USACE Rehabilitation and Inspection Program (RIP). While this Levee Engineering Assessment was not scoped to address technical issues related to the USACE RIP, the information below provides a basic overview on how the RIP evaluates encroachments. The Oregon Solutions Project Team may retain a consultant to evaluate encroachments in regards to RIP criteria under a separate authorization.

Authorized Encroachments. The USACE has historically reviewed applications from the general public for encroachments into the levee right-of-way to help ensure that they do not adversely affect the system. Since the early 1980's, the USACE has approved 15 separate construction projects within PEN 1. Authorized encroachments have varied from utility lines, retaining walls, parking spaces, light rail tracks, and structures constructed on overbuilt portions of the levee (i.e. sections where fill has been placed on top of the original levee design section).

RIP Inspections and Unauthorized Encroachments. PEN 1 participates in the USACE's RIP review. On that basis, the USACE performs routine inspections every one to two years, and more-detailed 5-year periodic inspections of the district to identify deficiencies relating to levee conditions and operations. These inspections provide assurance that the levee districts are

maintaining the levee systems to USACE standards, and are also intended to help the levee districts recognize areas of concern, and to assist them in prioritizing levee maintenance and repairs. From a general standpoint, encroachments receive close scrutiny during the USACE inspections because they may negatively impact proper operation and maintenance, or possibly impair the structural integrity of the levee embankment and its ability to prevent flooding of the protected areas. Another critical concern is the potential for encroachments to impede flood fighting capabilities during a flood-related emergency. Trees and other large vegetation growing within the levee footprint have traditionally been considered unauthorized encroachments due to their potential for: (i) seepage issues caused by root penetration; (ii) the capacity to interfere with flood fighting; and (iii) concealment of the ground surface conditions that could prevent the detection of problems.

The most recent 5-year periodic inspection report from the USACE for PEN 1 was completed in January 2011, and subsequent routine inspections have followed. The periodic inspection report identified a limited number of unauthorized encroachments within 15 feet of the levee footprint in PEN 1. The encroachments were typically identified as utilities, trailers and crane booms, and other metal debris. The unauthorized encroachments were rated as “unacceptable” in the inspection reports, presumably for their potential to interfere with maintenance activities and flood fighting. As mentioned above, unauthorized encroachments will need to be addressed in coordination with the USACE Portland District in the future.

9. CONCLUSIONS

In general, the engineering analyses indicate that several long segments of the PEN 1 levee system meet the requirements of 44 CFR 65.10 for certification. However, there are some reaches that do not meet these standards. The primary area of concern is the railroad embankment that comprises the western boundary of PEN 1. As described previously, Cornforth Consultants were not able to perform a subsurface investigation through the railroad segment due to access limitations. On that basis, the engineering analyses were performed using assumptions for the subsurface conditions and soil parameters. As described in Section 6.4.6 of this report, the calculated factor of safety for stability along the railroad embankment is below the acceptable level specified under 44 CFR 65.10 (d). The embankment's status as a heavily-used rail line also suggests that it cannot be maintained and operated as a levee. In addition, the engineering analyses noted encroachments into the railroad embankment that included tree roots and a pipeline penetration, both of which present potential seepage and stability concerns. Lastly, the freeboard analyses noted a small segment at the northern end of the cross levee between PEN 1 and PEN 2 that does not provide the required freeboard under a modeled scenario where the PEN 2 levee system failed and flooded under a 1-percent-annual-chance flood

A summary of the engineering evaluations is presented in Table 15 below:

Table 15 – Summary of Engineering Evaluations per 44 CFR 65.10

Levee Alignment Stationing	Levee Reaches	Assessment or Comments
0+00 through 61+00	Reach 1-1 through Reach 1-5	Meets engineering requirements for certification under 44 CFR 65.10.
61+00 through 125+50	Reach 1-6 through Reach 1-8	Unable to perform site investigations. Analyses suggest levee embankment does not meet requirements of 44 CFR 65.10 for stability. Noted two potential encroachment problems.
125+50 through 245+00	Reach 1-9 through Reach 1-14	Meets engineering requirements for certification under 44CFR 65.10
245+00 through 263+55	Reach 1-15	Minor freeboard deficiencies. Otherwise, the embankment meets the requirements of 44 CFR 65.10 for seepage and stability.

The findings of the Levee Engineering Assessment represent a significant first step in understanding the safety and resiliency of the communities protected by the levee system. After vetting the findings presented in this report, the Oregon Solutions Project Team will engage in a discussion to determine what level of flood protection the community desires. Then, the team will identify the proper design, construction, and financing options that will achieve these community goals and keep the levee system in compliance with FEMA and USACE standards.

10. PHOTOGRAPH LOG

PENINSULA DRAINAGE DISTRICT NO. 1

Photo No. 1 Photo Date: 9/16/2014 Orientation: North Description: Interstate 5 functions as the cross-levee between PEN 1 and 2. The structure is large and wide, at times spanning a distance of 100 feet. The flood wall stops underneath the Interstate 5 bridge in the northeast corner of PEN 1.	

Photo No. 2 Photo Date: 9/18/2014 Orientation: South Description: Interstate 5 functions as the cross-levee between PEN 1 and 2. There is a flood wall on the landward side of the levee adjacent to the Oregon Slough at this location.	

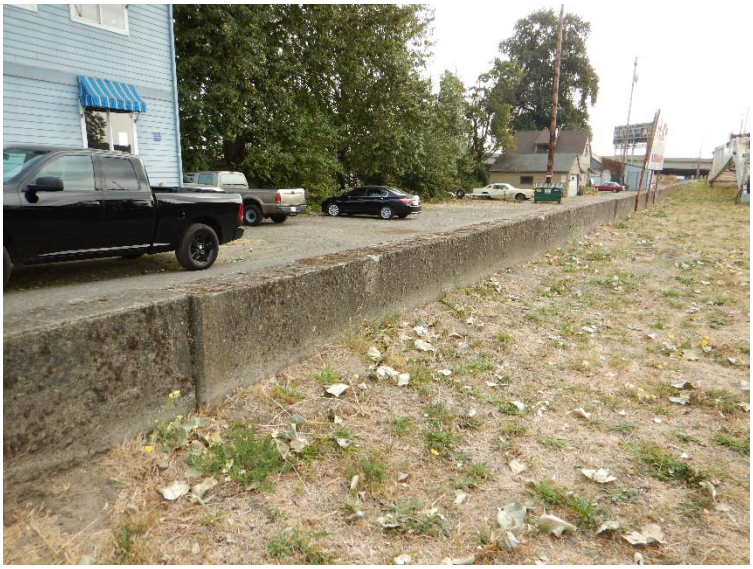
Photo No. 3 Photo Date: 9/16/2014 Orientation: Northeast Description: The flood wall is smaller in height in the northeast corner of PEN 1. At this location, the flood wall is going through private property and is 2 feet tall.	

Photo No. 4 Photo Date: 9/16/2014 Orientation: Northwest Description: The flood wall is smaller in height in the northeast corner of PEN 1. At this location, the flood wall is going through private property and is 1 foot tall. It ends where the ground becomes equal in height.	

Photo No. 5 Photo Date: 9/16/2014 Orientation: West Description: A Portland Parks and Recreation multi-use path runs on top of the levee on the north end of PEN 1. Marine Drive is to the south of the levee and the Oregon Slough is to the north.	

Photo No. 6 Photo Date: 9/18/2014 Orientation: Southwest Description: The eastern corner of the north side of PEN 1 has minimal development as well as a few floating homes on the Oregon Slough. The encroachments in this section are constructed on the overbuild.	

Photo No. 7 Photo Date: 9/16/2014 Orientation: Southwest Description: Flood wall along the north section of PEN 1. A Portland Parks and Recreation multi-use path is located in front of the flood wall.	

Photo No. 8 Photo Date: 9/16/2014 Orientation: South Description: The flood wall has concrete panels to allow access to the north side of the levee, providing recreational access to the multi-use path. The missing panel is attached to the north side of the wall (as shown in image) and can be installed when necessary.	

Photo No. 9 Photo Date: 9/16/2014 Orientation: Southeast Description: Flood wall along the north section of PEN 1. A Portland Parks and Recreation multi-use path is located in front of the flood wall. The Columbia slough is north of the levee.	

Photo No. 10 Photo Date: 9/18/2014 Orientation: South Description: The floodwall can be seen on top of the levee. An outfall with an operating flap gate can be seen daylighting above the toe of the levee.	

Photo No. 11 Photo Date: 9/18/2014 Orientation: South Description: The rip rap along the waterward side of the levee is large in size. The waterward toe of the levee is visible.	

Photo No. 12 Photo Date: 9/18/2014 Orientation: Southeast Description: The levee on the north side of PEN 1 protects the district from high water in the Oregon Slough along the Columbia River. The flood wall is visible on top of the levee.	

Photo No.13 Photo Date: 9/16/2014 Orientation: West Description: Multiple outfalls traverse the levee, south to north, from the Graphic Packaging property in the northwest corner of PEN 1. The outfalls convey stormwater as well as process water. Each outfall has a properly operating flap gate and closure valve.	

Photo No.14 Photo Date: 9/16/2014 Orientation: West Description: South side of the flood wall. Marine Drive lies to the south of the flood wall.	

Photo No. 15 Photo Date: 9/16/2014 Orientation: South Description: The flood wall on the north side ties into the flood wall on the south side with a closure structure that goes across Marine Drive. The closure structure is installed by the City of Portland Bureau of Transportation, as MCDD has an IGA with the bureau. The closure structure closes Marine Dr.	

Photo No. 16 Photo Date: 9/18/2014 Orientation: Southwest Description: The railroad bridge connects to the railroad embankment that forms the northwest corner of PEN 1. The north side of PEN 1 is protected by the levee from the Oregon Slough on the Columbia River. The rip rap is visible along the toe of the levee.	

Photo No. 17 Photo Date: 9/16/2014 Orientation: Southeast Description: A railroad embankment runs along the western edge of PEN 1. The waterward side of the railroad embankment can be seen in the photo. The embankment was built on top of a wooden trestle in the early 1900s. An active rail line is located on top of the embankment.	

Photo No. 18 Photo Date: 9/16/2014 Orientation: Southwest Description: On the northern end of the railroad embankment there is a closure structure that goes across the Peninsula Terminal Co.'s rail line and connects the embankment. This closure structure is also installed by the City of Portland's Bureau of Transportation.	

Photo No.19 Photo Date: 9/16/2014 Orientation: South Description: On the landward side of the railroad embankment there are various private businesses. The middle to south landward toe of the railroad embankment is adjacent to the Heron Lakes Golf Club, a public course owned by Portland Parks and Recreation.	

Photo No. 20 Photo Date: 9/16/2014 Orientation: South Description: This image is of the south end of the railroad embankment. This image shows the waterward side of the embankment. A Portland Parks and Recreation multi-use path runs along the waterward toe of the entire alignment. North Portland road lies to the west.	

Photo No. 21 Photo Date: 9/16/2014 Orientation: East Description: The south end of PEN 1 has a levee that protects the district from the upper Columbia Slough. A Portland Parks and Recreation multi-use path runs on top of the levee that borders the upper Columbia Slough. The Portland International Raceway is located to the north of the levee.	

Photo No. 22 Photo Date: 9/16/2014 Orientation: West Description: The levee at the south end of PEN 1 protects the district from the upper Columbia Slough. There is a pump station to the south of the levee at this location.	

Photo No. 23 Photo Date: 9/16/2014 Orientation: East Description: The landward toe of the levee that runs along the upper Columbia Slough. The Portland International Raceway is located to the north of this levee section.	

Photo No. 24 Photo Date: 9/16/2014 Orientation: Northeast Description: The height and width of Interstate 5, the cross-levee between PEN 1 and 2, can be seen in this image.	

Photo No. 25	
Photo Date: 9/16/2014	
Orientation: South	
Description: Interstate 5 functions as the cross-levee between PEN 1 and 2. The structure is large and wide at both the base and top.	

11. REFERENCES

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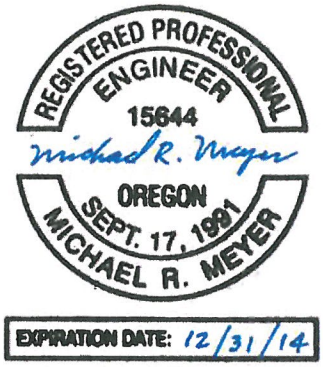
Michael R. Meyer, P.E.
Senior Associate Engineer



By Randall J. Hill
Randall J. Hill, P.E.
Senior Associate Engineer

WEST CONSULTANTS, INC.

By
James Heyen, P.E.
Senior Hydraulic Engineer

Limitations in the Use and Interpretation of this Geotechnical Report

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

BASE MAP CREATED BY MCDD.

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VICINITY MAP

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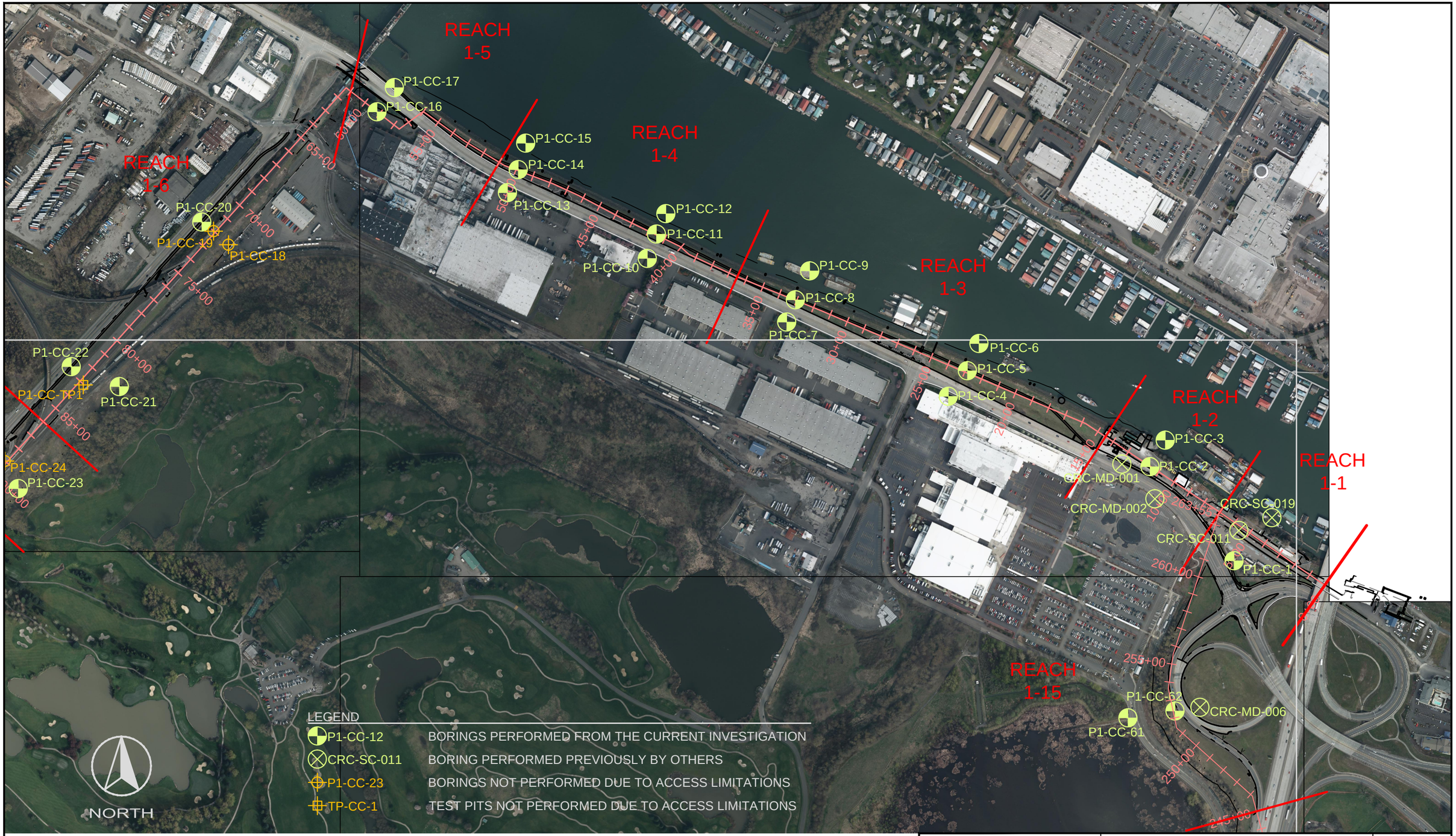
FIG. 1

2319/01.AI NAU



0 500 1,000

SCALE IN FEET

BASE MAP CREATED BY MCDD, DATED 8/14/2014.

PEN 1-Cornforth 8.14.2014.DWG NAU

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SITE PLAN

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FIG. 2A

0 500 1,000

SCALE IN FEET

BASE MAP CREATED BY MCDD, DATED 8/14/2014.

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FIG. 2B

LEGEND

P1-CC-12	BORINGS PERFORMED FROM THE CURRENT INVESTIGATION
CRC-SC-011	BORING PERFORMED PREVIOUSLY BY OTHERS
P1-CC-23	BORINGS NOT PERFORMED DUE TO ACCESS LIMITATIONS
TP-CC-1	TEST PITS NOT PERFORMED DUE TO ACCESS LIMITATIONS

REACH 1-9
REACH 1-10
REACH 1-11
REACH 1-12
REACH 1-13
REACH 1-14

C-30
C-31
130+00
135+00
140+00
145+00
150+00
155+00
160+00
165+00
170+00
175+00
180+00
185+00
190+00
195+00
200+00
199+26
205+00
210+00
215+00
225+00
230+00
235+00

P1-CC-33
P1-CC-34
P1-CC-35
P1-CC-36
P1-CC-37
P1-CC-38
P1-CC-39
P1-CC-40
P1-CC-41
P1-CC-42
P1-CC-43
P1-CC-44
P1-CC-45
P1-CC-46
P1-CC-47
P1-CC-48
P1-CC-49
P1-CC-50
P1-CC-51
P1-CC-52
P1-CC-53
P1-CC-54
P1-CC-55
P1-CC-56
P1-CC-57
P1-CC-58
B-6
C-23
DH-106
DH-111

NORTH

0 500 1,000
SCALE IN FEET

BASE MAP CREATED BY MCDD, DATED 8/14/2014.

PEN 1-Cornforth 8.14.2014.DWG NAU

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FIG. 2C

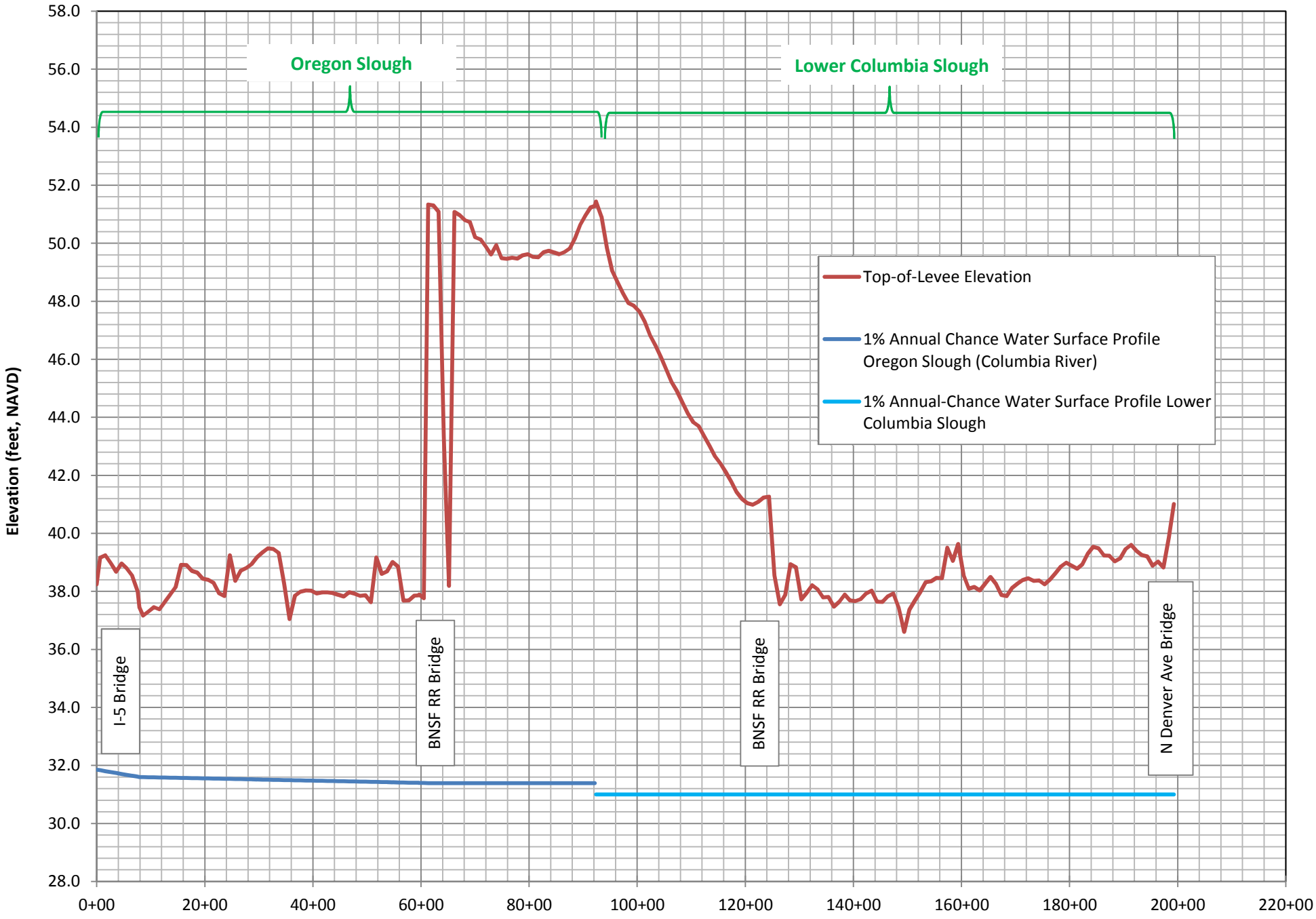


Figure 3 - PEN 1 Levee Crest Elevation and 1% Annual-Chance Water Surface Profiles

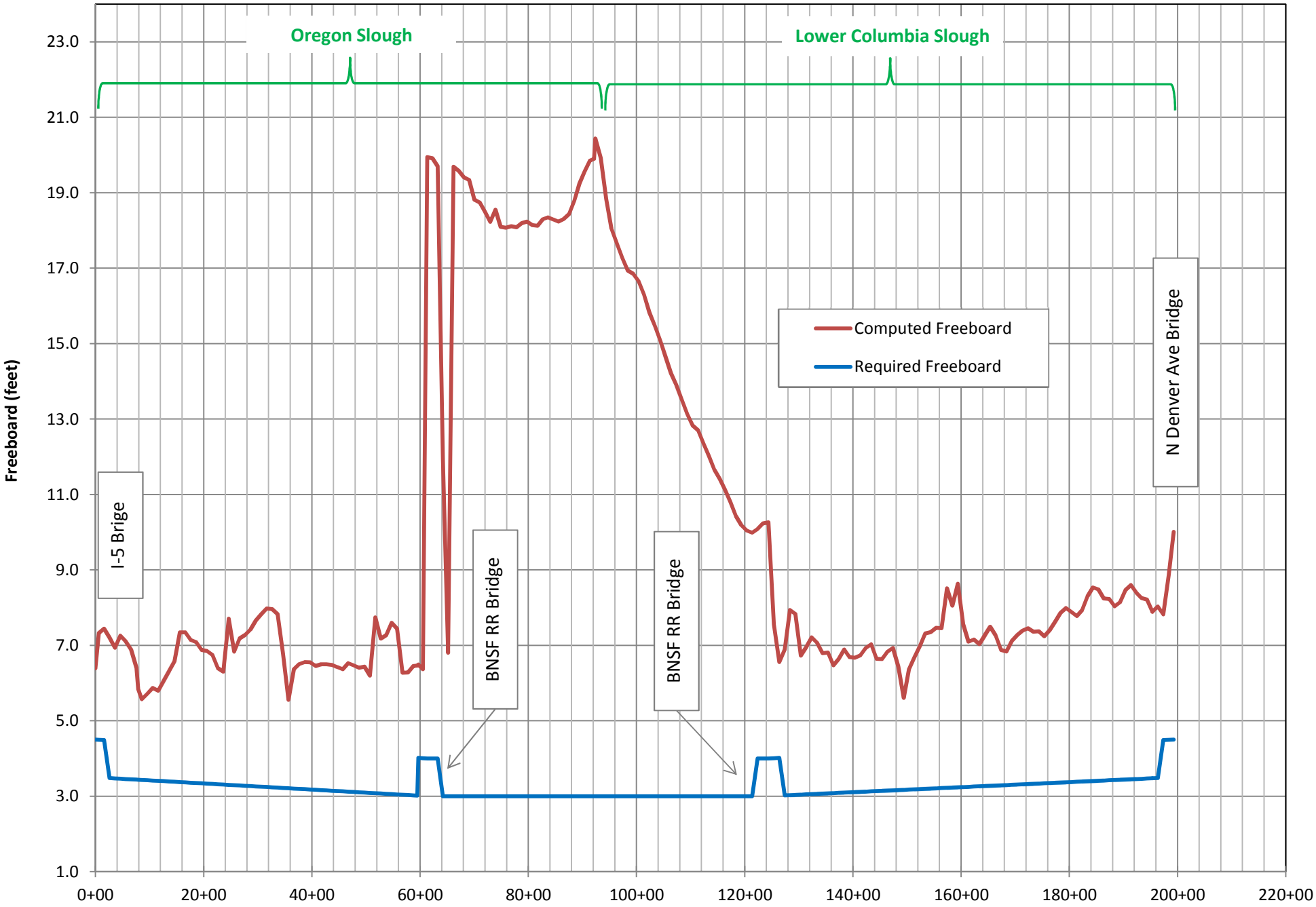


Figure 4 - PEN 1 Computed Versus Required Freeboard

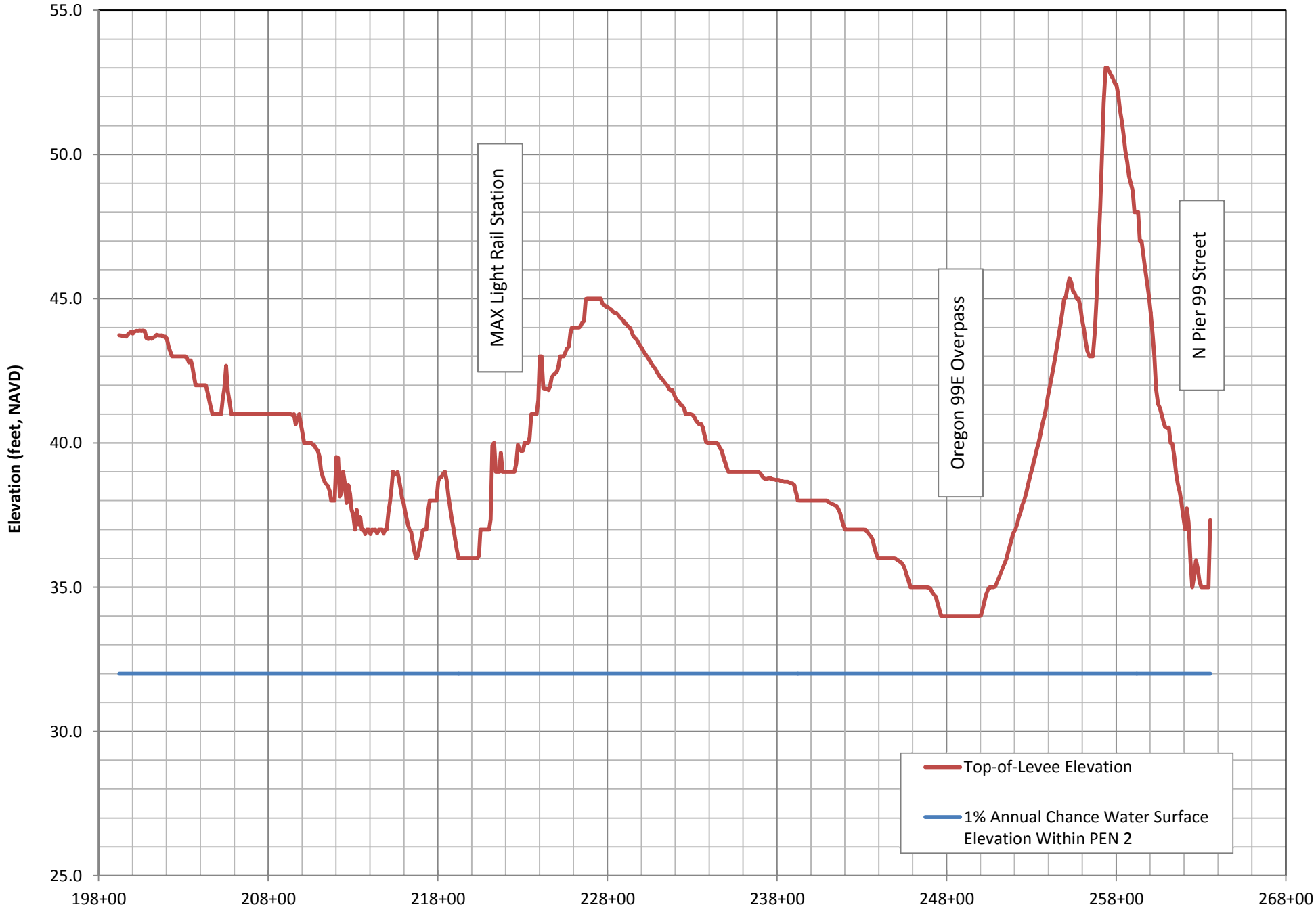


Figure 5 - PEN 1 "Cross Levee" Crest Elevation and 1% Annual-Chance Water Surface Elevation

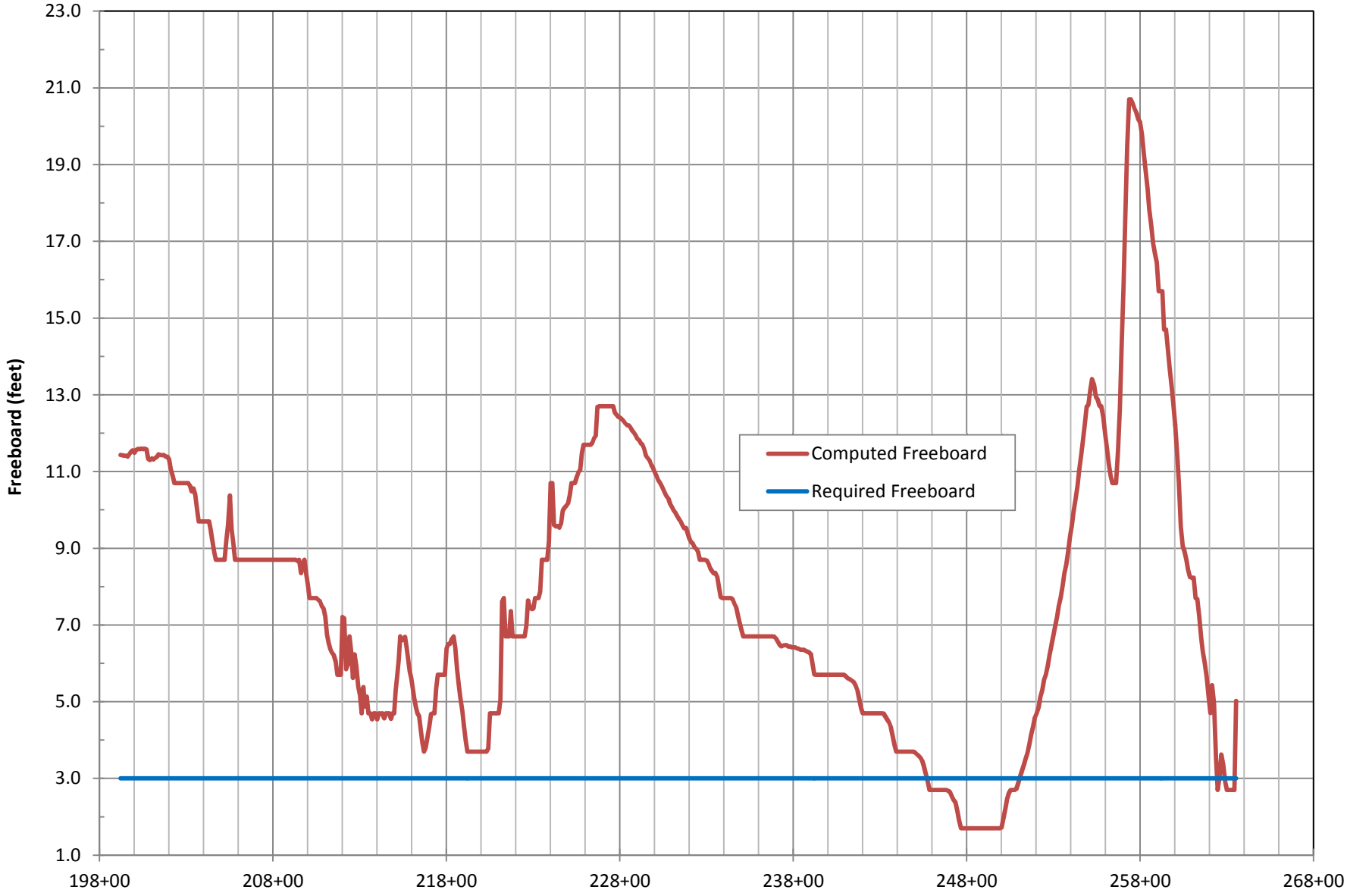


Figure 6 - PEN 1 "Cross Levee"
Computed Versus Required Freeboard

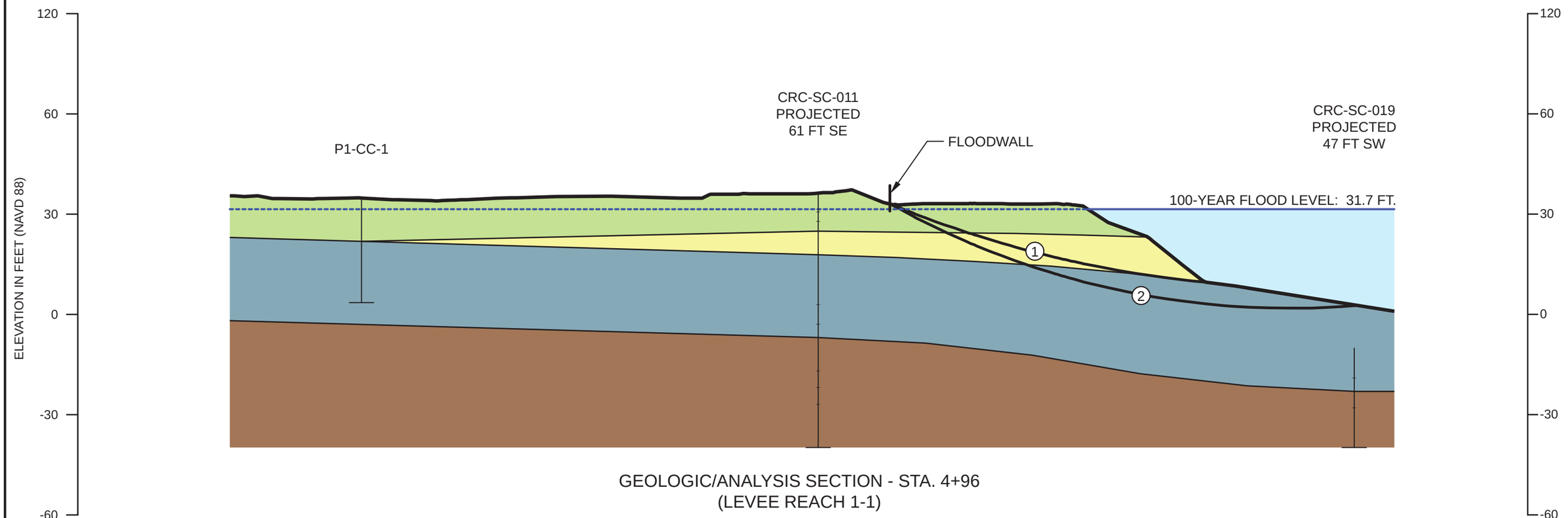
	Railroad Embankment	Mixed sand and silt with timber remnants
	Fill	Soft, slightly clayey to clayey SILT
	Fill	Loose, silty SAND to sandy SILT
	Foundation	Soft, clayey SILT (Alluvium)
	Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	2.54	YES
2	2.37	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 4+96
(LEVEE REACH 1-1)

2319/Sec-4+95.74.AI NAU

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FIG. 7

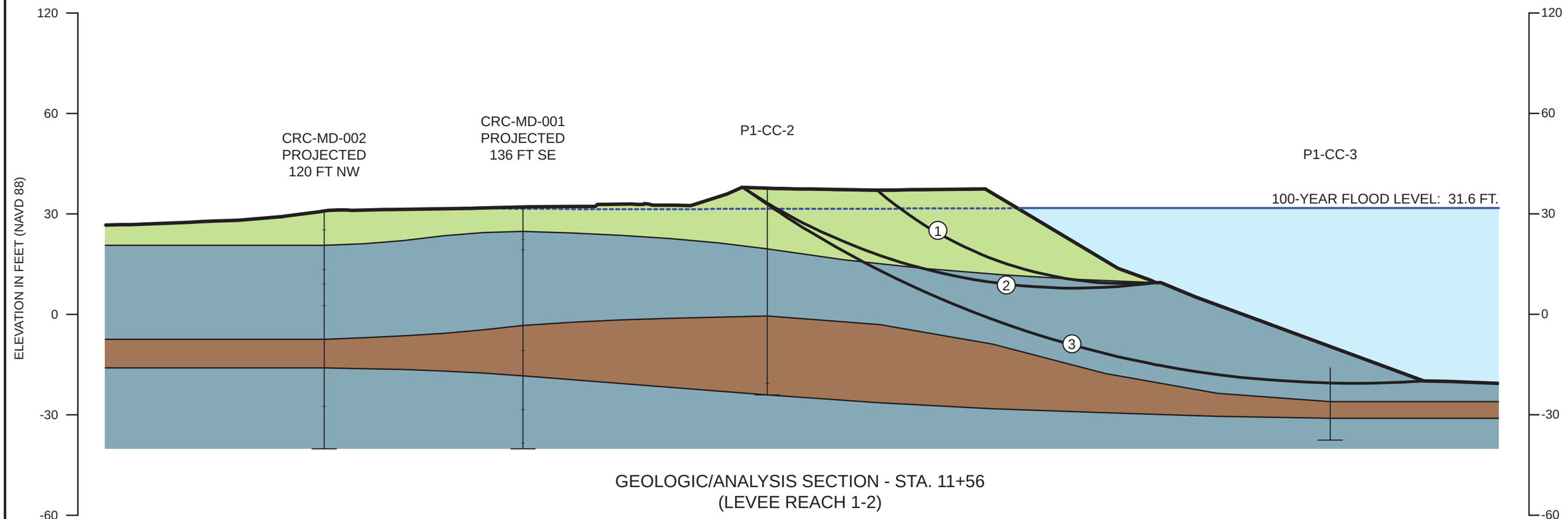
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.83	YES
2	2.83	YES
3	2.09	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 11+56
(LEVEE REACH 1-2)

2319/Sec-11+56.43.AI NAU

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FIG. 8

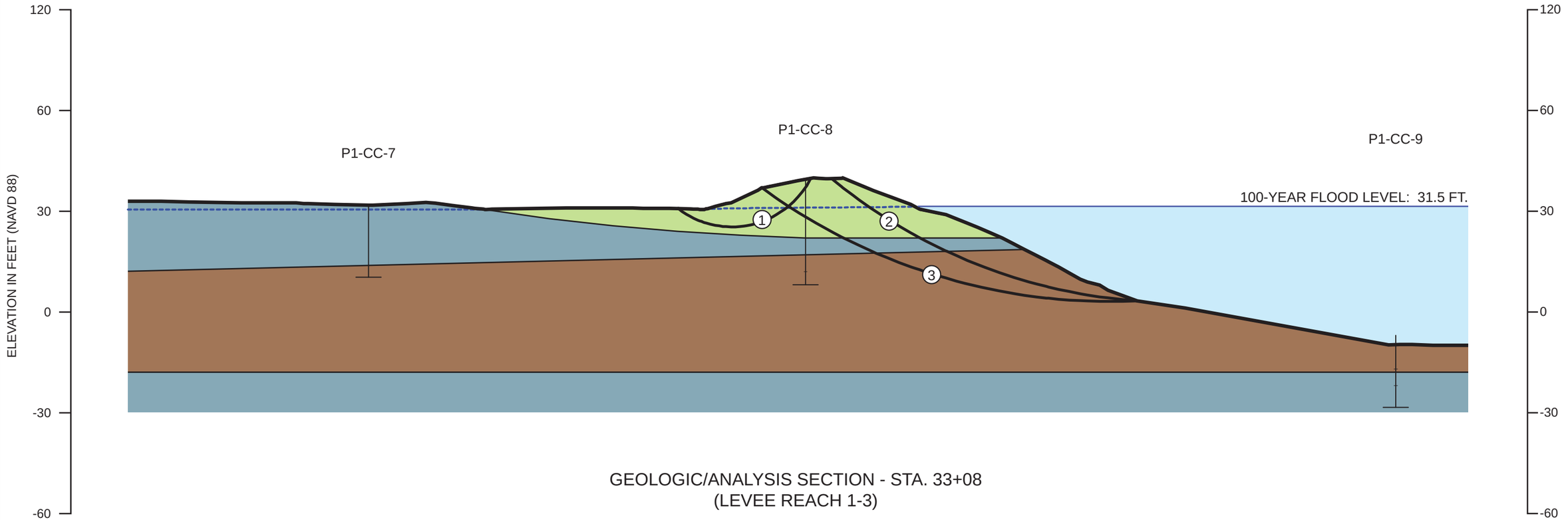
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	2.13	YES
2	1.55	YES
3	1.91	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.1**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 33+08
(LEVEE REACH 1-3)

2319/Sec-33+07.66.AI NAU

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FIG. 9

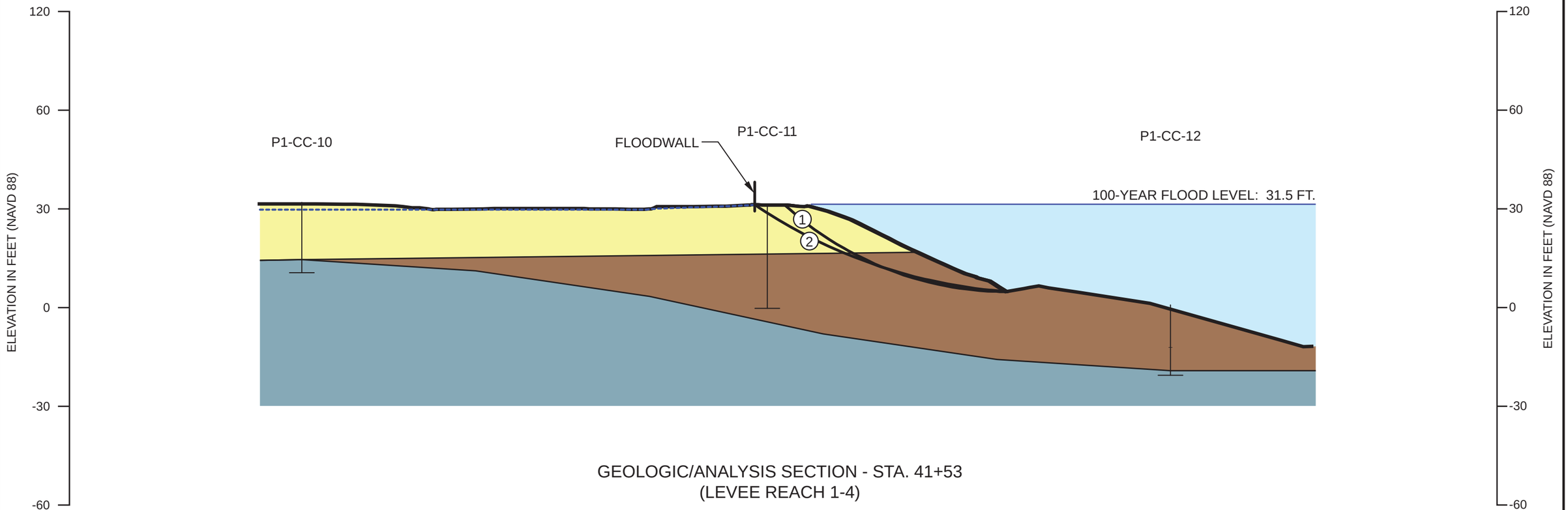
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.69	YES
2	1.84	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 41+53
(LEVEE REACH 1-4)

2319/Sec-41+52.71.AI NAU

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FIG. 10

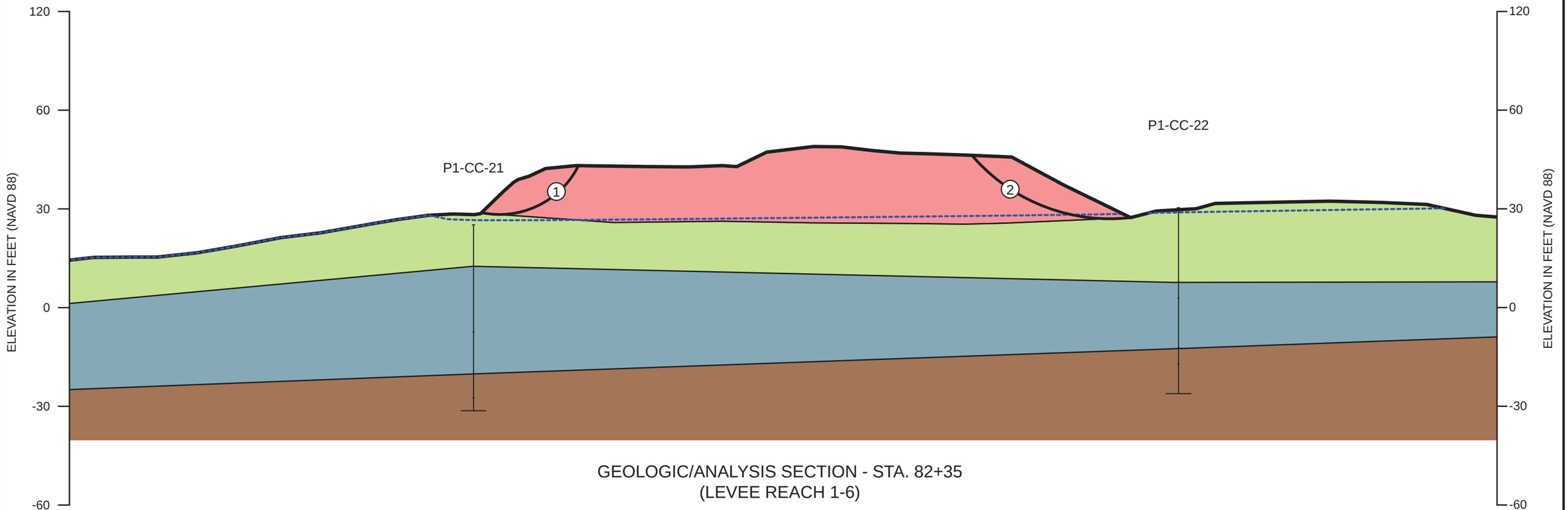
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.29	NO
2	1.26	NO

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 82+35
(LEVEE REACH 1-6)

2319/Sec-83+34.71.AI NAU

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FIG. 11

Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.15	NO
2	2.04	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.2**

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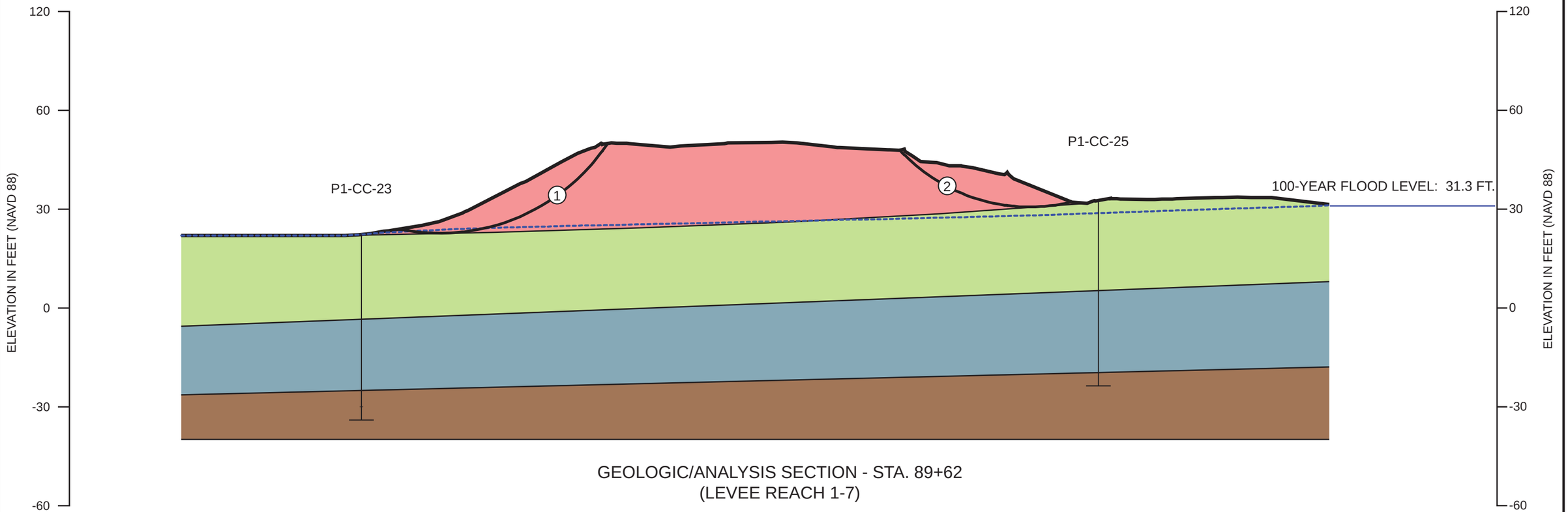

GEOLOGIC/ANALYSIS SECTION - STA. 89+62
(LEVEE REACH 1-7)

2319/ Sec-89+61.AI NAU

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FIG. 12

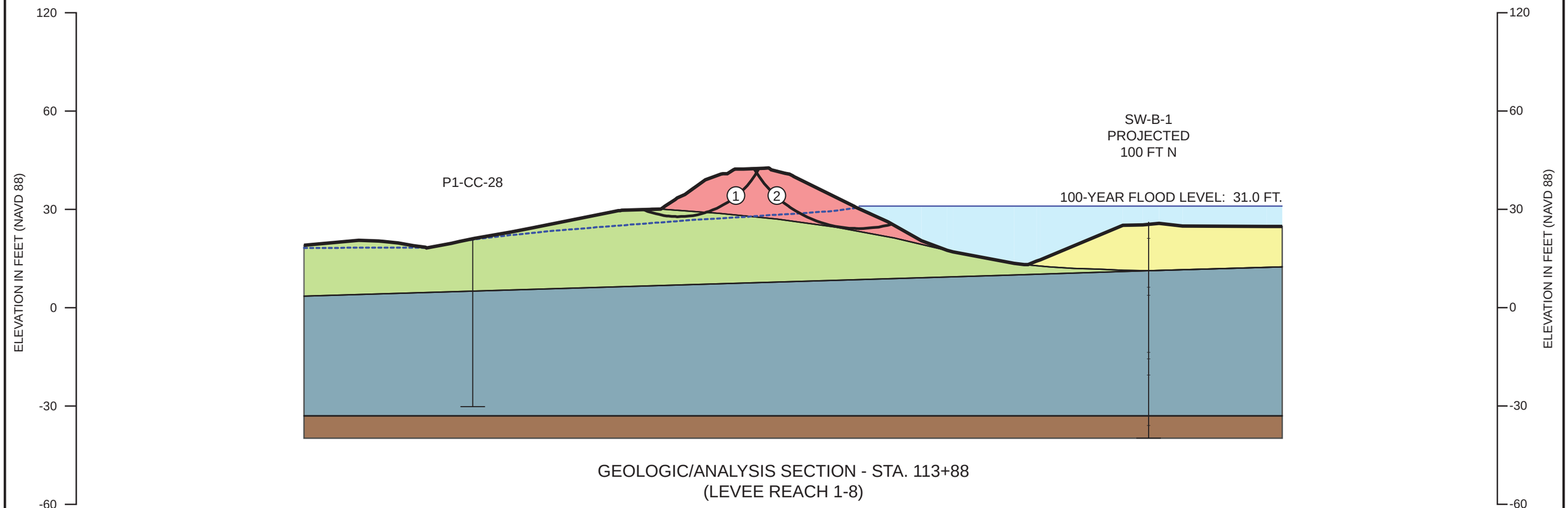
	Railroad Embankment	Mixed sand and silt with timber remnants
	Fill	Soft, slightly clayey to clayey SILT
	Fill	Loose, silty SAND to sandy SILT
	Foundation	Soft, clayey SILT (Alluvium)
	Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.71	YES
2	1.28	NO

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 113+88
(LEVEE REACH 1-8)

2319/ Sec-113+88.35.AI NAU

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GEOLOGIC/ANALYSIS CROSS SECTION

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FIG. 13

	Railroad Embankment	Mixed sand and silt with timber remnants
	Fill	Soft, slightly clayey to clayey SILT
	Fill	Loose, silty SAND to sandy SILT
	Foundation	Soft, clayey SILT (Alluvium)
	Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.82	YES
2	2.31	YES
3	2.30	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

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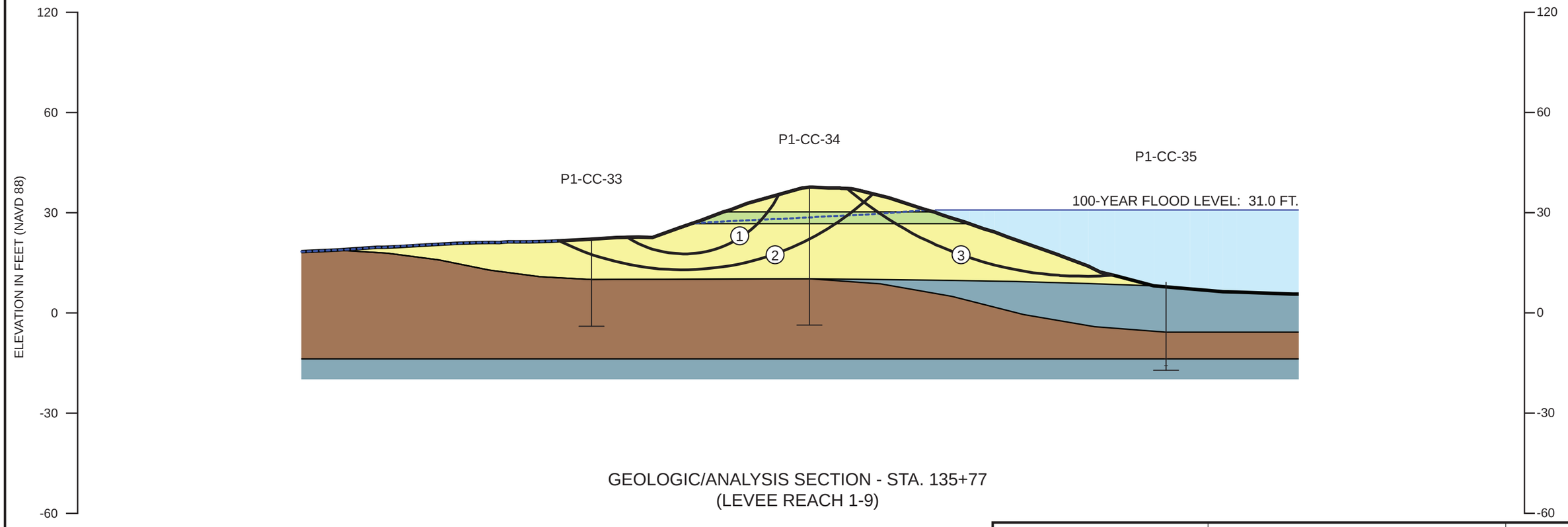

GEOLOGIC/ANALYSIS SECTION - STA. 135+77
(LEVEE REACH 1-9)

2319/Sec-135+77.18.AI NAU

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FIG. 14

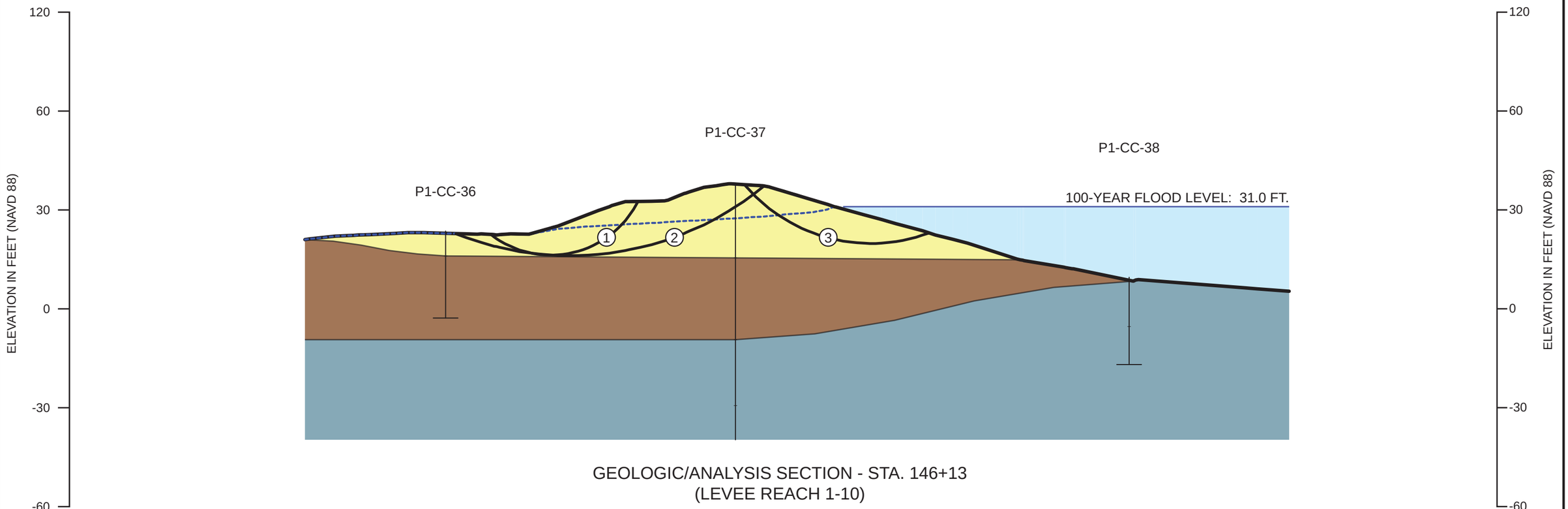
	Railroad Embankment	Mixed sand and silt with timber remnants
	Fill	Soft, slightly clayey to clayey SILT
	Fill	Loose, silty SAND to sandy SILT
	Foundation	Soft, clayey SILT (Alluvium)
	Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.75	YES
2	2.29	YES
3	2.51	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.2**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 146+13
(LEVEE REACH 1-10)

2319/Sec-146+12.94.AI NAU

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GEOLOGIC/ANALYSIS CROSS SECTION

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FIG. 15

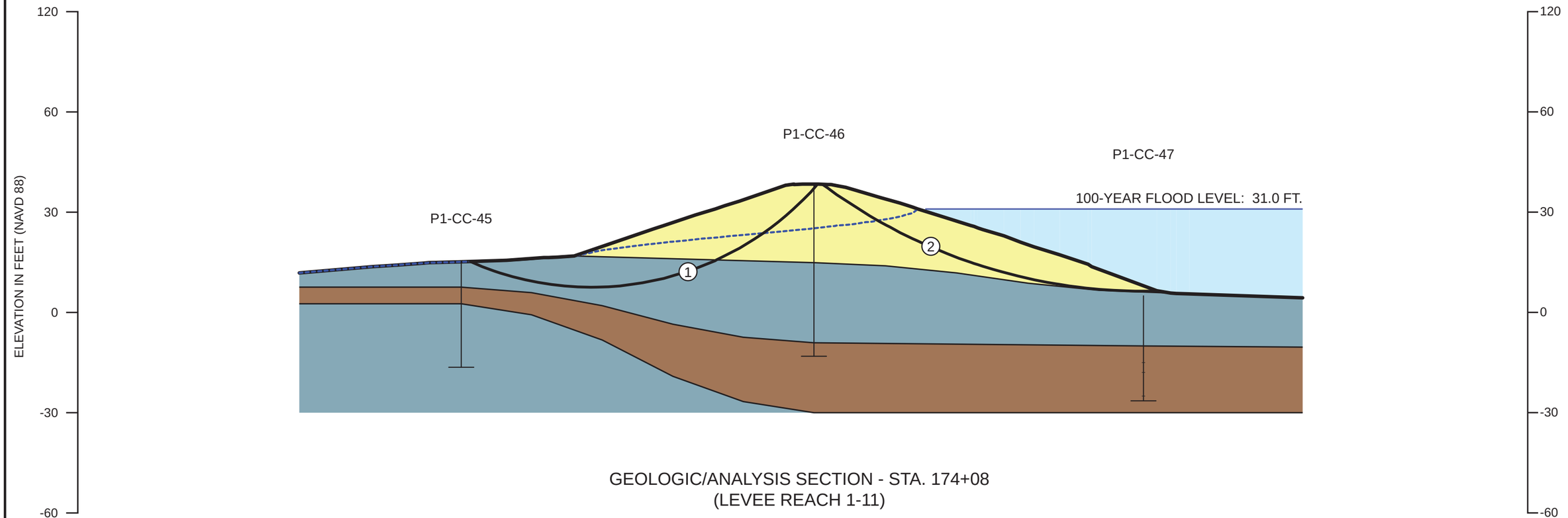
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.40	YES
2	2.12	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.3**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 174+08
(LEVEE REACH 1-11)

2319/Sec-174+08.11.AI NAU

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GEOLOGIC/ANALYSIS CROSS SECTION

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PORTLAND, OREGON

OCT 2014
PROJ. 2319
FIG. 16

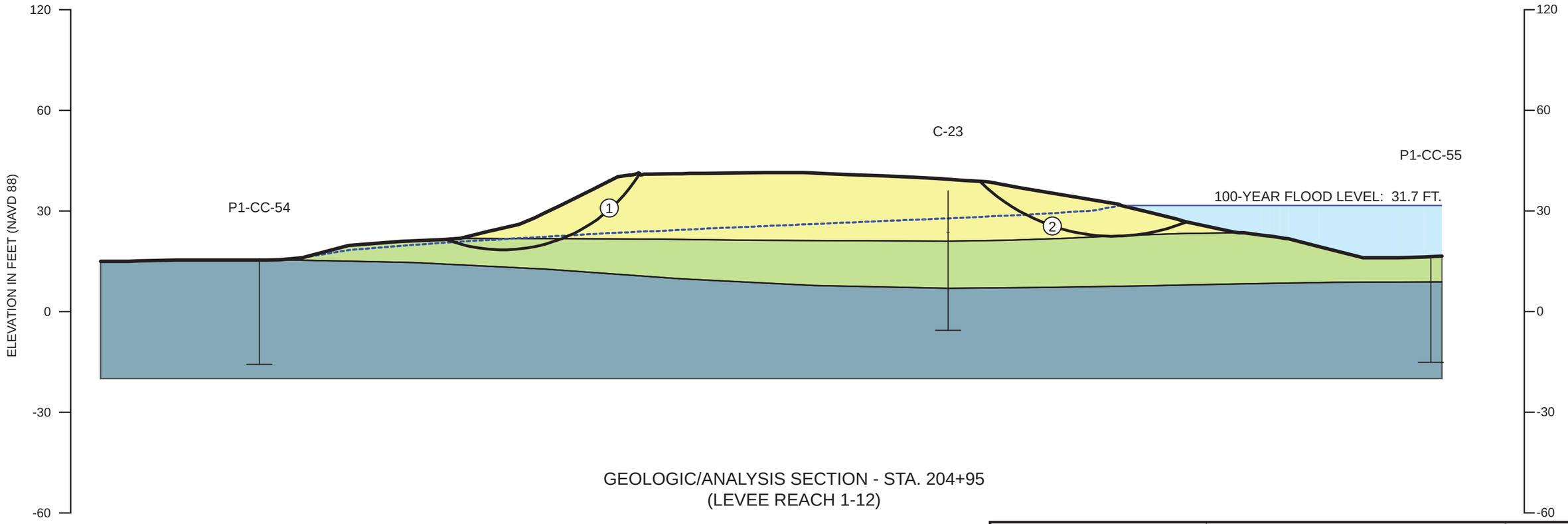
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.72	YES
2	3.00	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.2**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 204+95
(LEVEE REACH 1-12)

2319/Sec-204+94.84.AI NAU

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FIG. 17

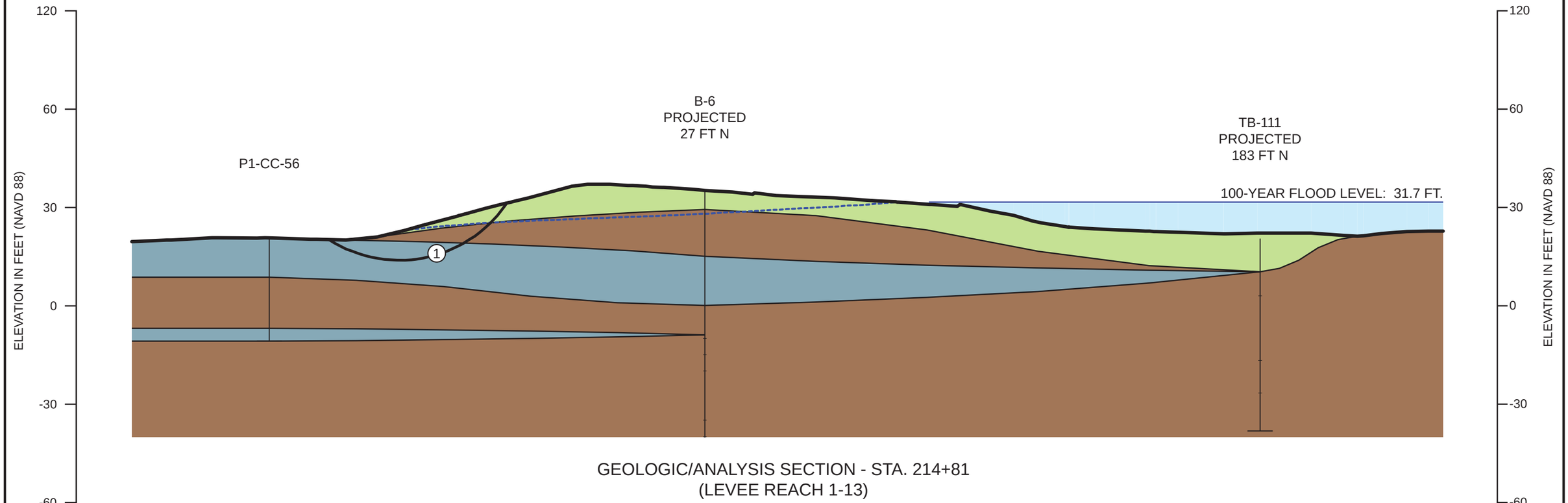
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.83	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.2**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 214+81
(LEVEE REACH 1-13)

2319/Sec-214+80.88.AI NAU

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GEOLOGIC/ANALYSIS CROSS SECTION

PENINSULA 1 LEVEE ASSESSMENT
PORTLAND, OREGON

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PROJ. 2319
FIG. 18

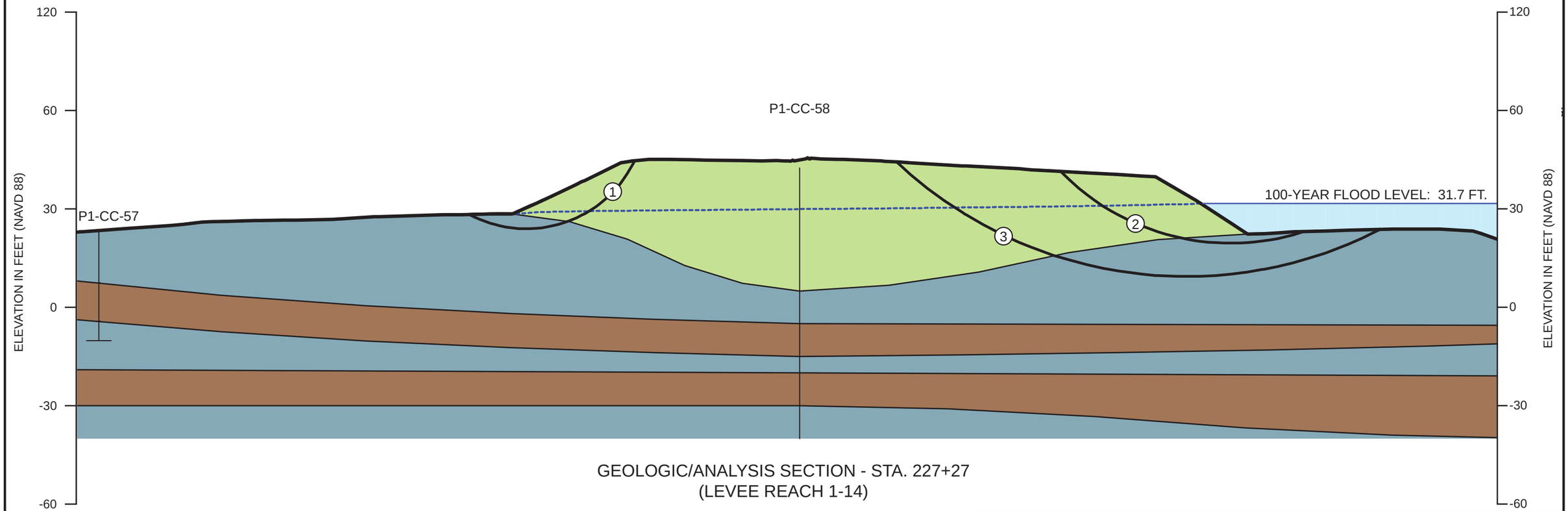
	Railroad Embankment	Mixed sand and silt with timber remnants
	Fill	Soft, slightly clayey to clayey SILT
	Fill	Loose, silty SAND to sandy SILT
	Foundation	Soft, clayey SILT (Alluvium)
	Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.87	YES
2	1.93	YES
3	3.11	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 227+27
(LEVEE REACH 1-14)

2319/Sec-227+26.89.AI NAU

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GEOLOGIC/ANALYSIS CROSS SECTION

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PORTLAND, OREGON

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PROJ. 2319

FIG. 19

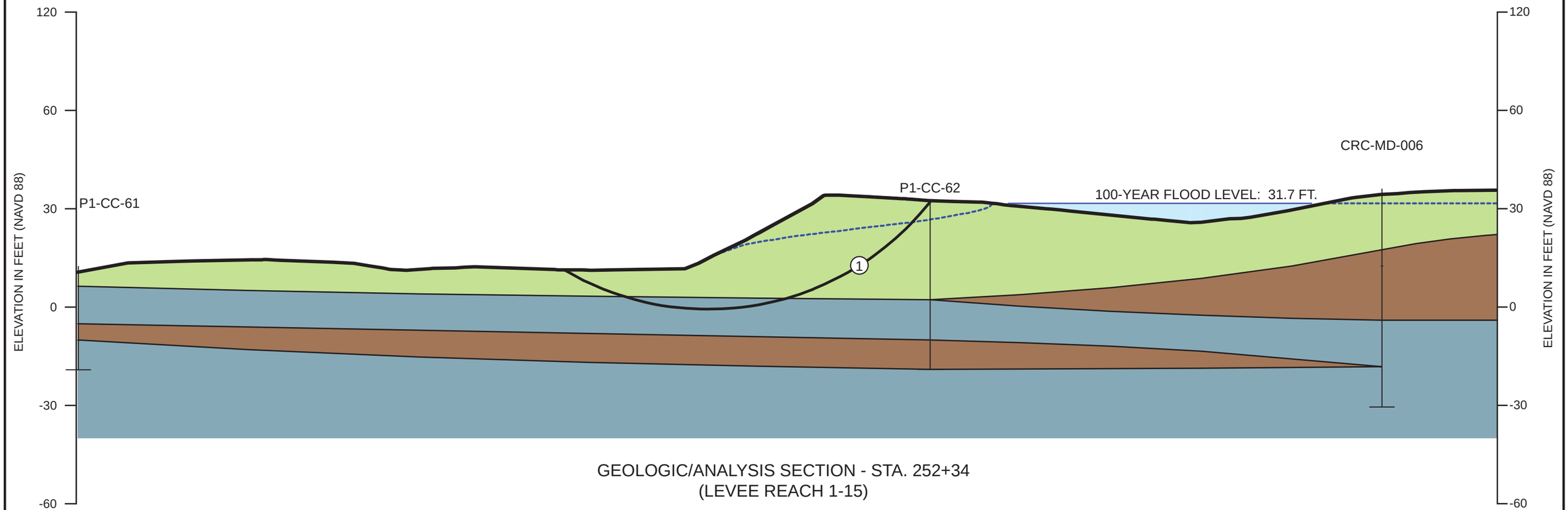
Railroad Embankment	Mixed sand and silt with timber remnants
Fill	Soft, slightly clayey to clayey SILT
Fill	Loose, silty SAND to sandy SILT
Foundation	Soft, clayey SILT (Alluvium)
Foundation	Loose, silty SAND (Alluvium)

LI U ACE	CALCULA E	MEE E UI E
1	1.41	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.5**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 252+34
(LEVEE REACH 1-15)

2319/Sec-252+33.76.AI NAU

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GEOLOGIC/ANALYSIS CROSS SECTION

PENINSULA 1 LEVEE ASSESSMENT
PORTLAND, OREGON

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PROJ. 2319
FIG. 20

APPENDIX A

SUMMARY BORING LOGS
(Current Study)

Appendix A – Table of Contents

Appendix A – Table of Contents (Cont.)

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 35.0 FT.		
		VERY LOOSE to LOOSE, brown, silty fine to medium SAND; trace gravel, trace organics, numerous mica, moist (FILL)	S-1	1 2 2
		… woody debris at approximately 7 to 8 ft below ground surface (inferred based on cuttings and drilling action)	S-2	2 3 2
22.0	13	VERY SOFT to SOFT, gray, slightly sandy, slightly clayey to clayey SILT; trace beds silty fine sand up to 6" thick, occasional organics, numerous orange-brown staining, scattered mica (ALLUVIUM)	S-3	0 2 2
			S-4	
			S-5	0 2 1
		… becomes gray-brown at approximately 25 feet	S-6	1 1 1
			S-7	0 1 3
3.5	31.5	Bottom of Boring: 31.5 FT		

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

5 10 15 20 25 30 35 40

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP

SPT SAMPLER: NO LINER - RECESSED ID

DRILL ROD USED: NWJ

BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES

DATE START: 4/16/2014 FINISH: 4/16/2014

DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-1

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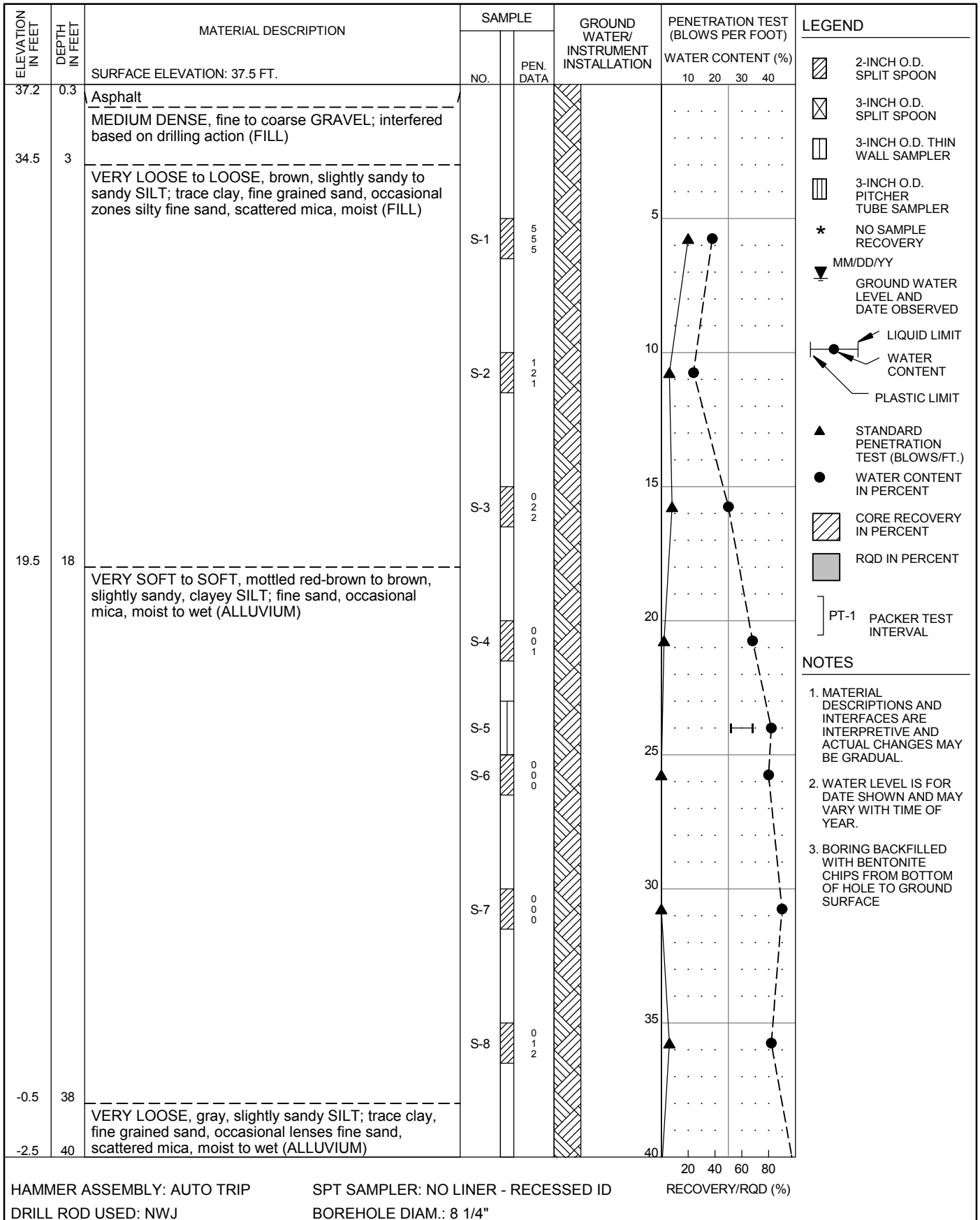
FIG. A1



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/26/2014 FINISH: 2/26/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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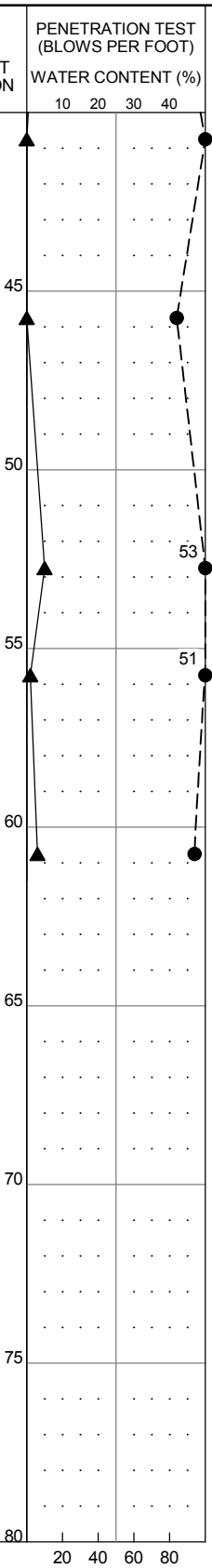
SUMMARY BORING LOG P1-CC-2 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A2

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 37.5 FT.			
		(continued from previous page)	S-9	0 0 0	
			S-10	0 0 0	
			S-11		
			S-12	0 1 4	
			S-13	0 0 1	
-20.5	58	VERY LOOSE, gray, slightly silty, fine SAND; occasional organics, scattered mica, wet (ALLUVIUM)			
			S-14	0 1 2	
-24.0	61.5	Bottom of Boring: 61.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. BORING BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/26/2014 FINISH: 2/26/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-2 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
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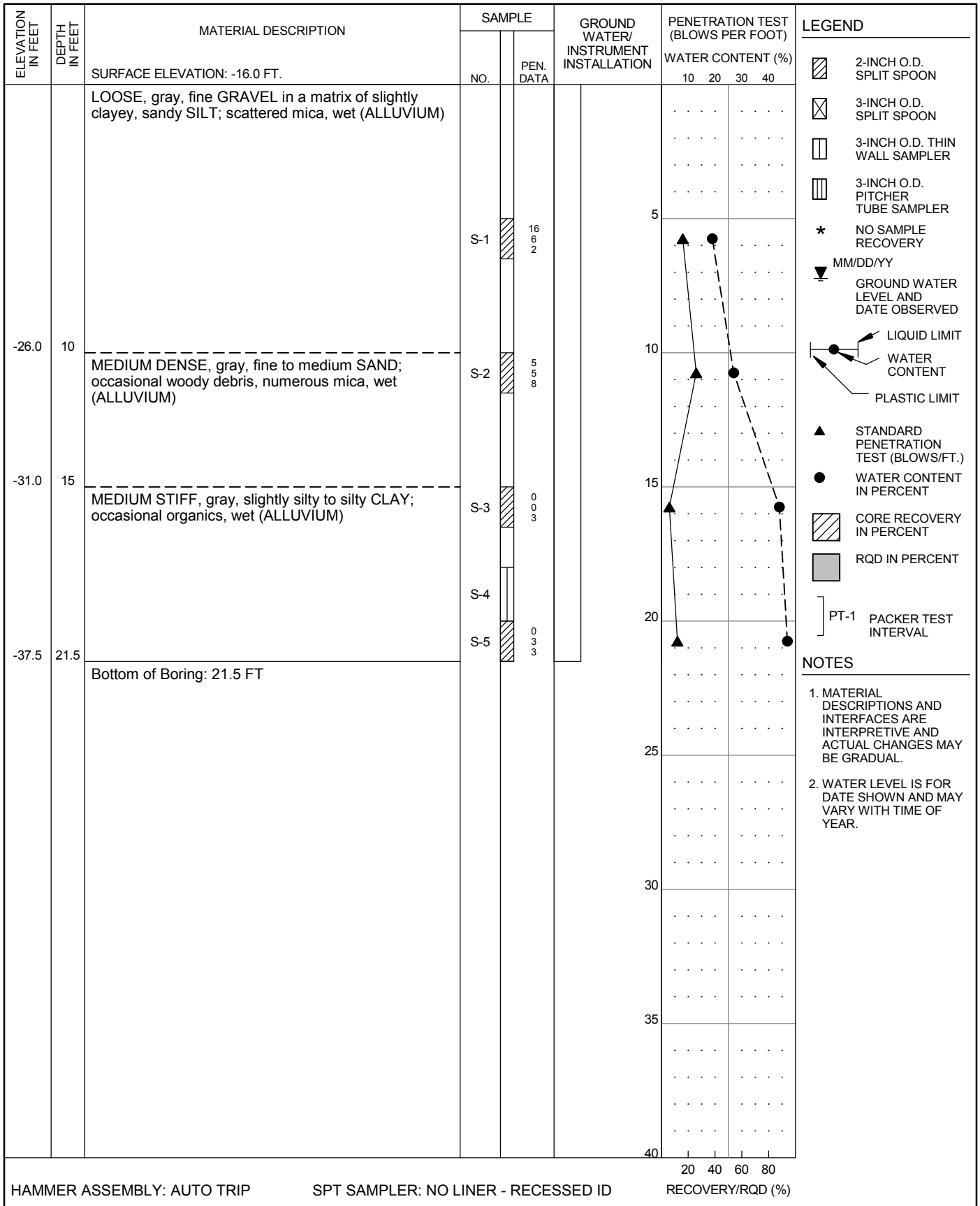
SEP 2014

PROJ 2319

FIG. A2



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/16/2014 FINISH: 5/16/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-3

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A3

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 30.7 FT.		
		LOOSE, brown, fine to medium SAND; trace mica, moist (FILL)	S-1	2 3 3
			S-2	3 3 4
18.2	12.5	SOFT, blue-gray to gray-brown, slightly clayey SILT; trace fine sand, trace mica (ALLUVIUM)	S-3	1 1 2
			S-4	
9.2	21.5	… becomes slightly sandy at 20 feet, with scattered lenses of sandy silt, trace clay	S-5	1 2 3
		Bottom of Boring: 21.5 FT		

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

5 10 15 20 25 30 35 40

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP

DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID

BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES

DATE START: 2/13/2014 FINISH: 2/13/2014

DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-4

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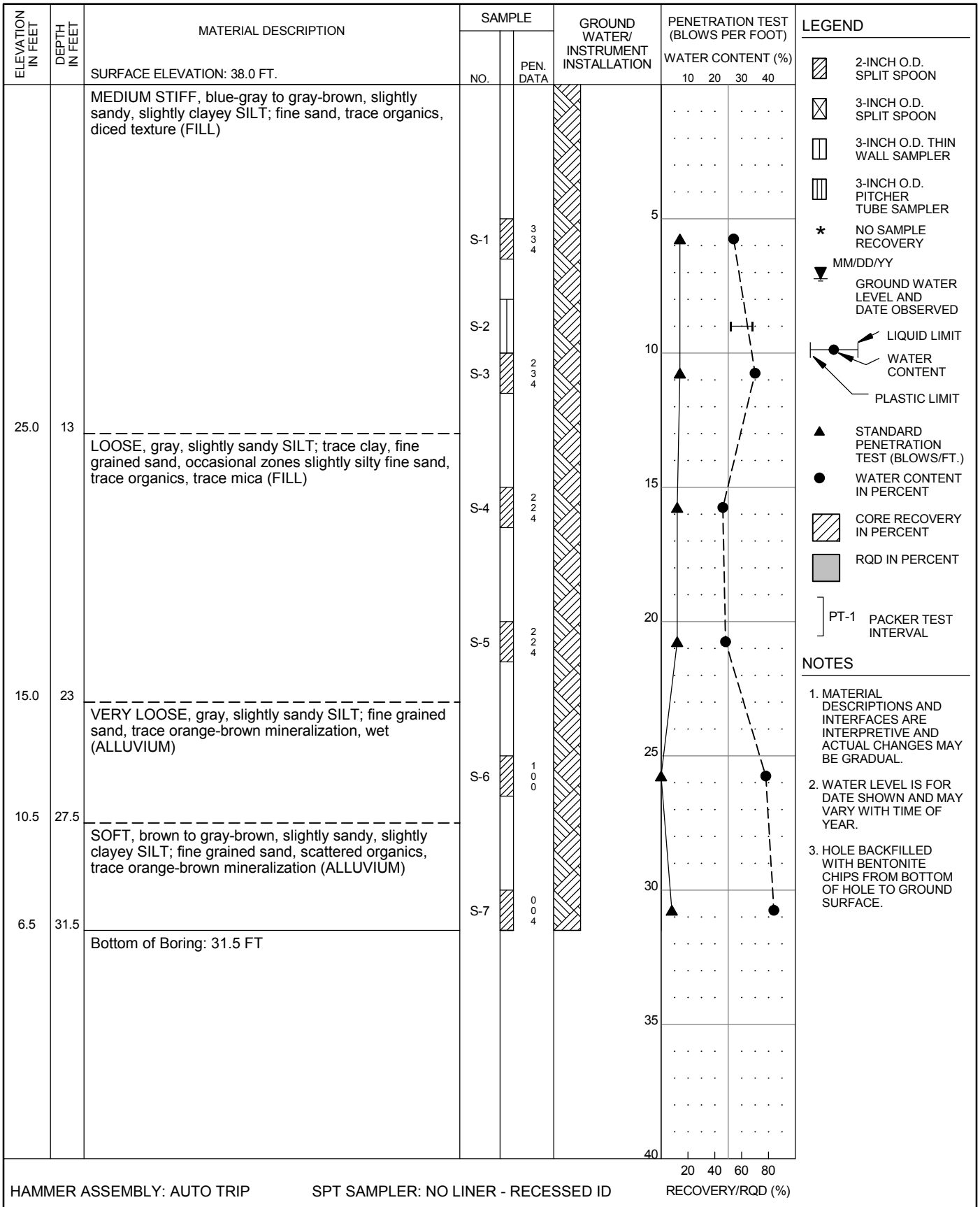
FIG. A4



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/14/2014 FINISH: 2/14/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-5

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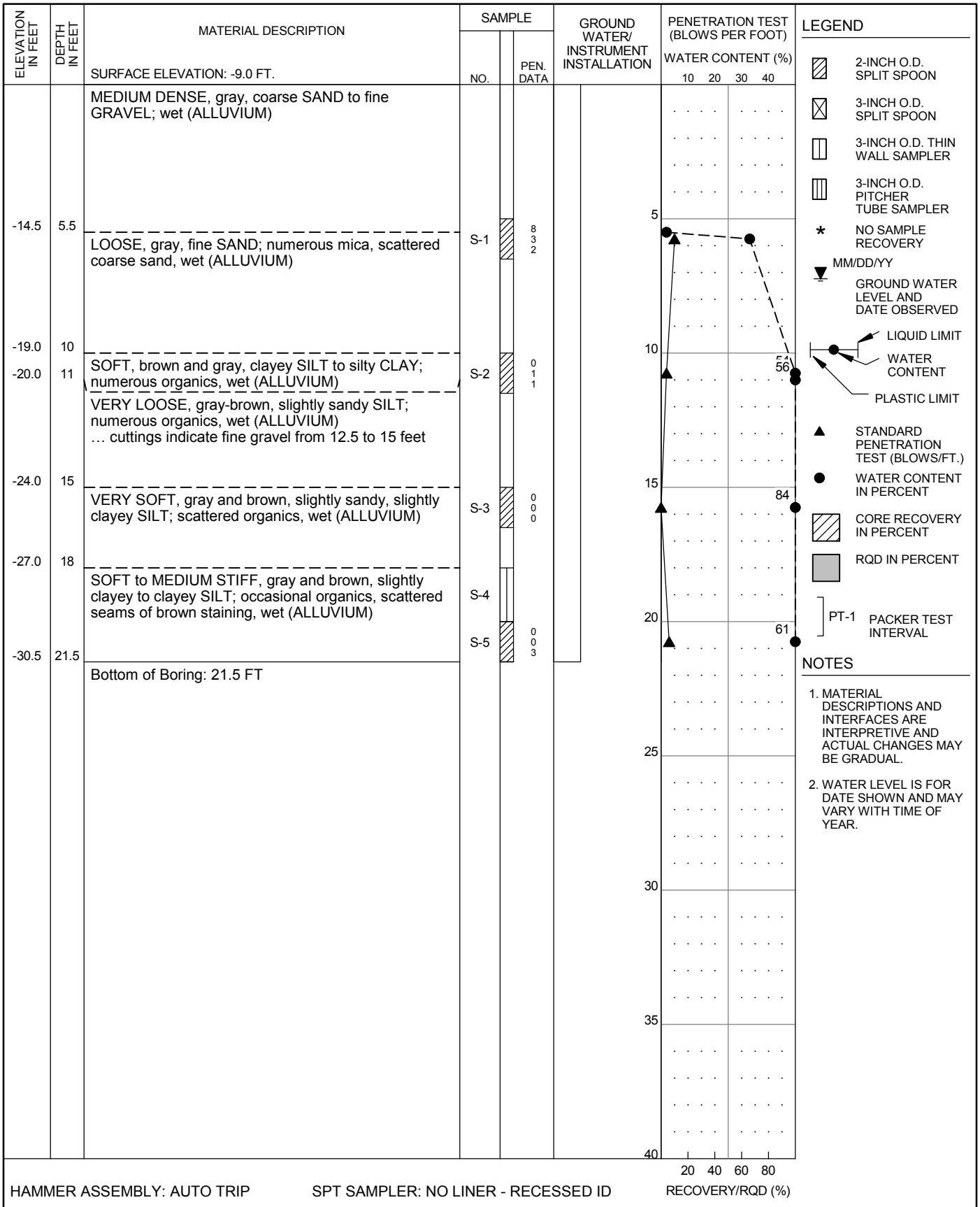
PROJ 2319
FIG. A5



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/15/2014 FINISH: 5/15/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-6

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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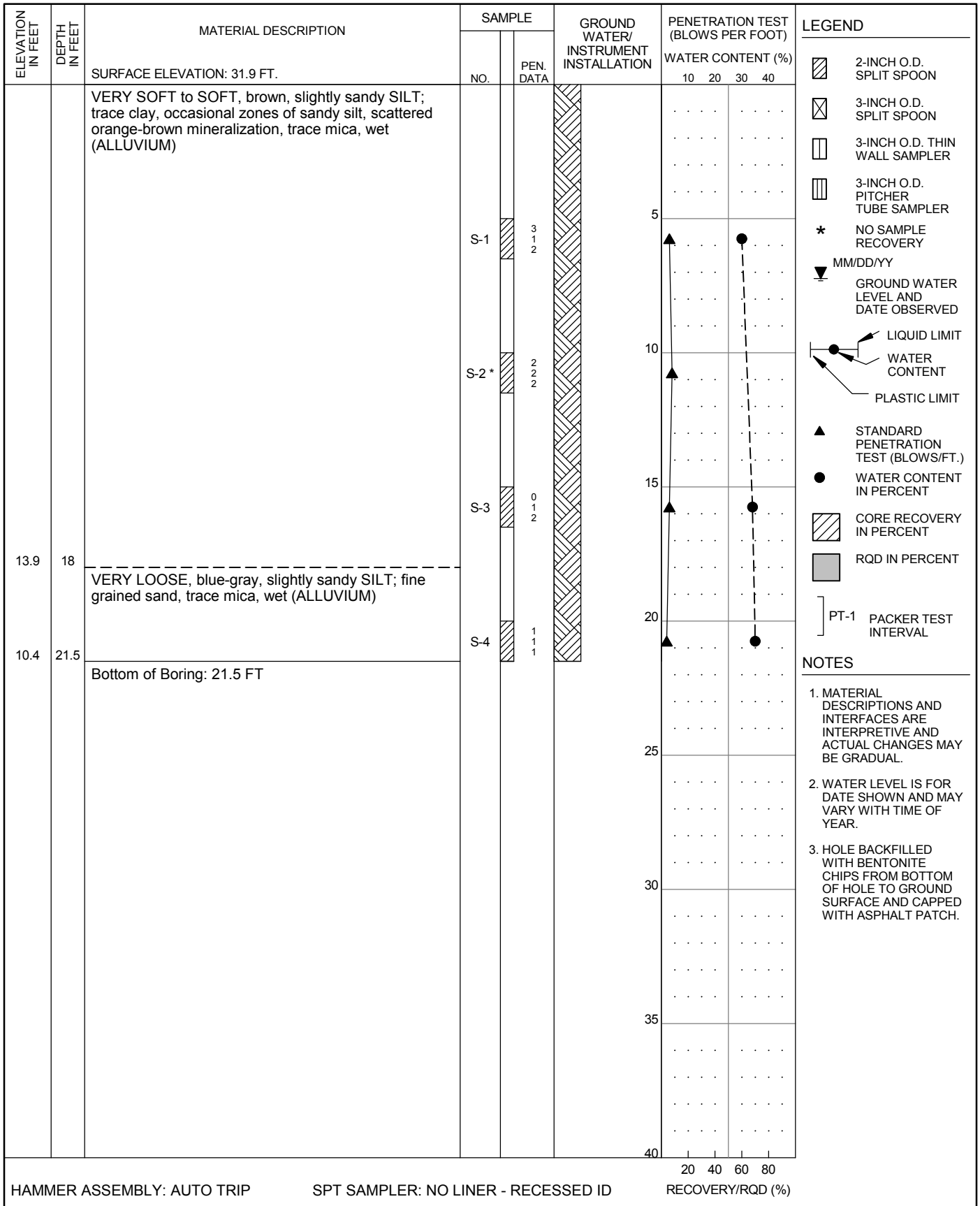
PROJ 2319
FIG. A6



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 2/26/2014 FINISH: 2/26/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-7

PENINSULA DISTRICT 1 LEVEE
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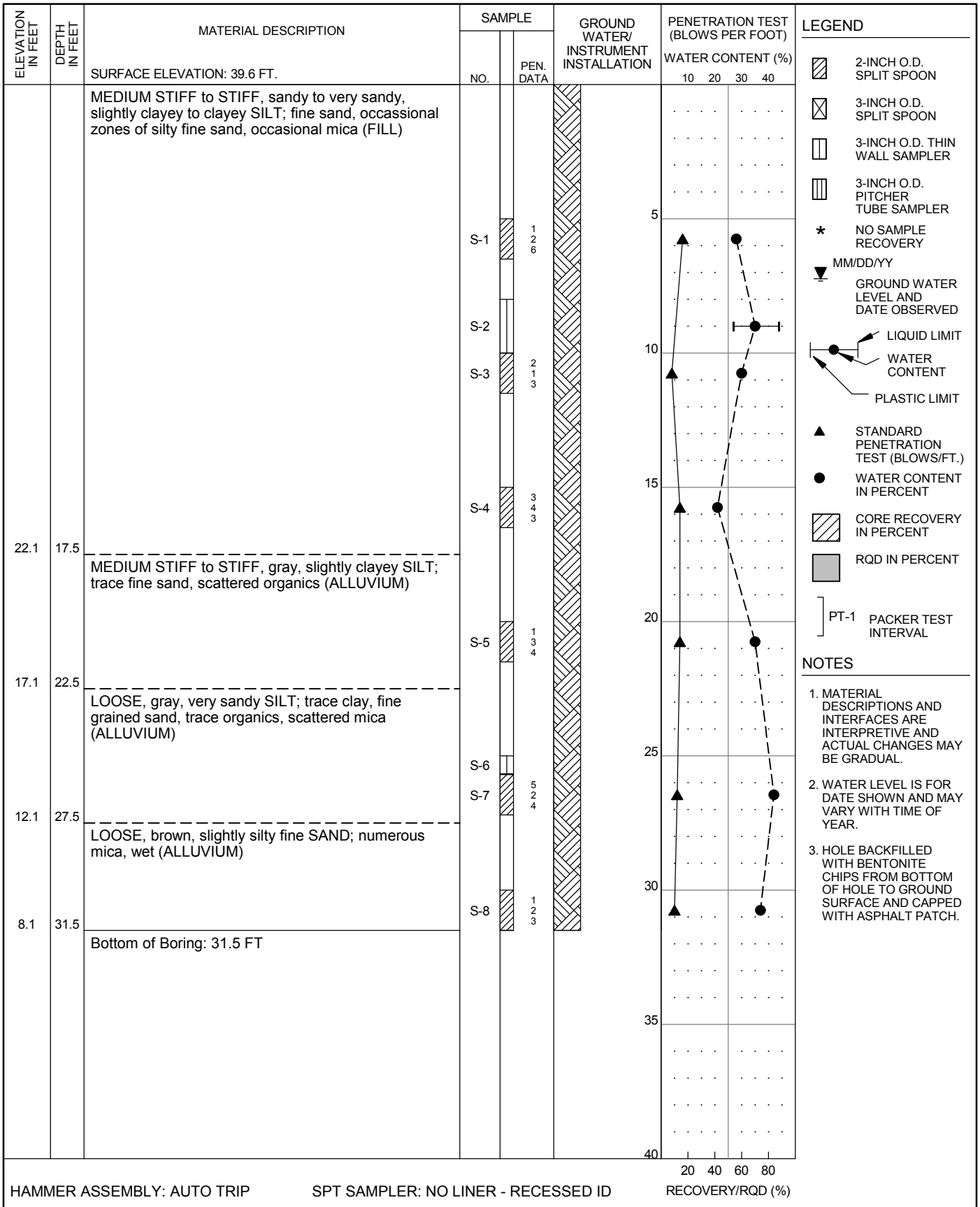
FIG. A7



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/25/2014 FINISH: 2/25/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-8

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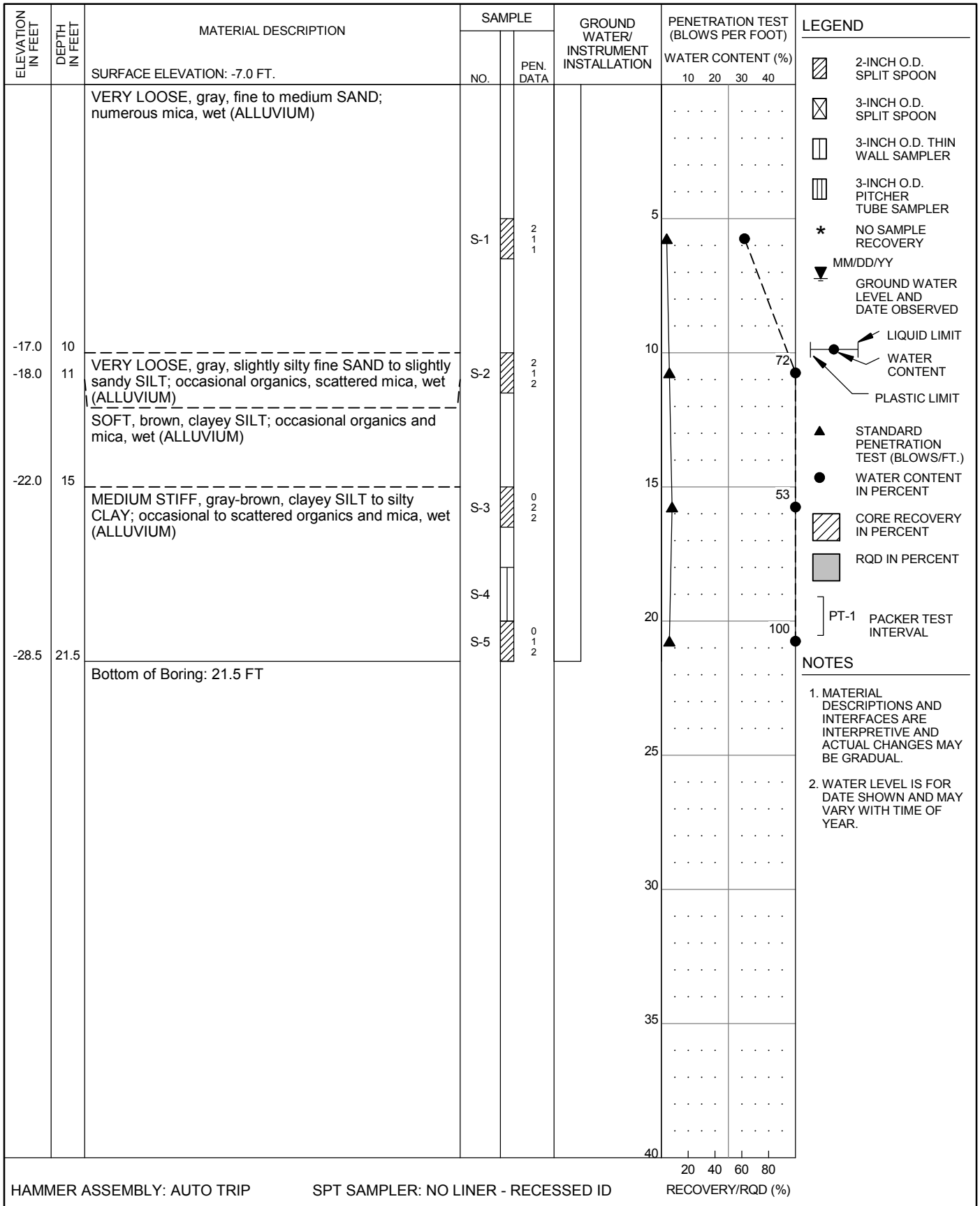
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A8



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/8/2014 FINISH: 5/8/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-9

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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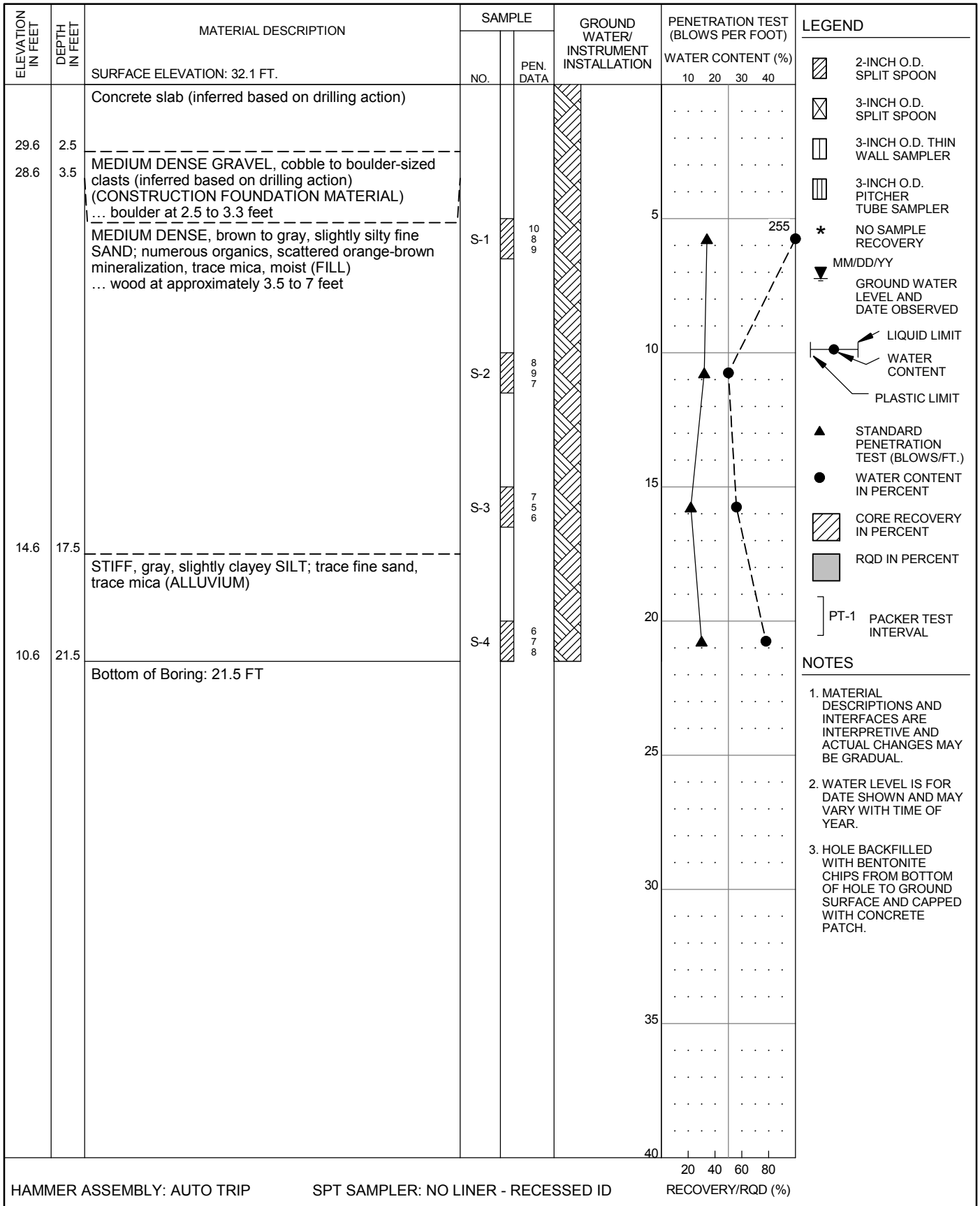
FIG. A9



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/24/2014 FINISH: 2/24/2014
DRILLING TECHNIQUE: MUD ROTARY

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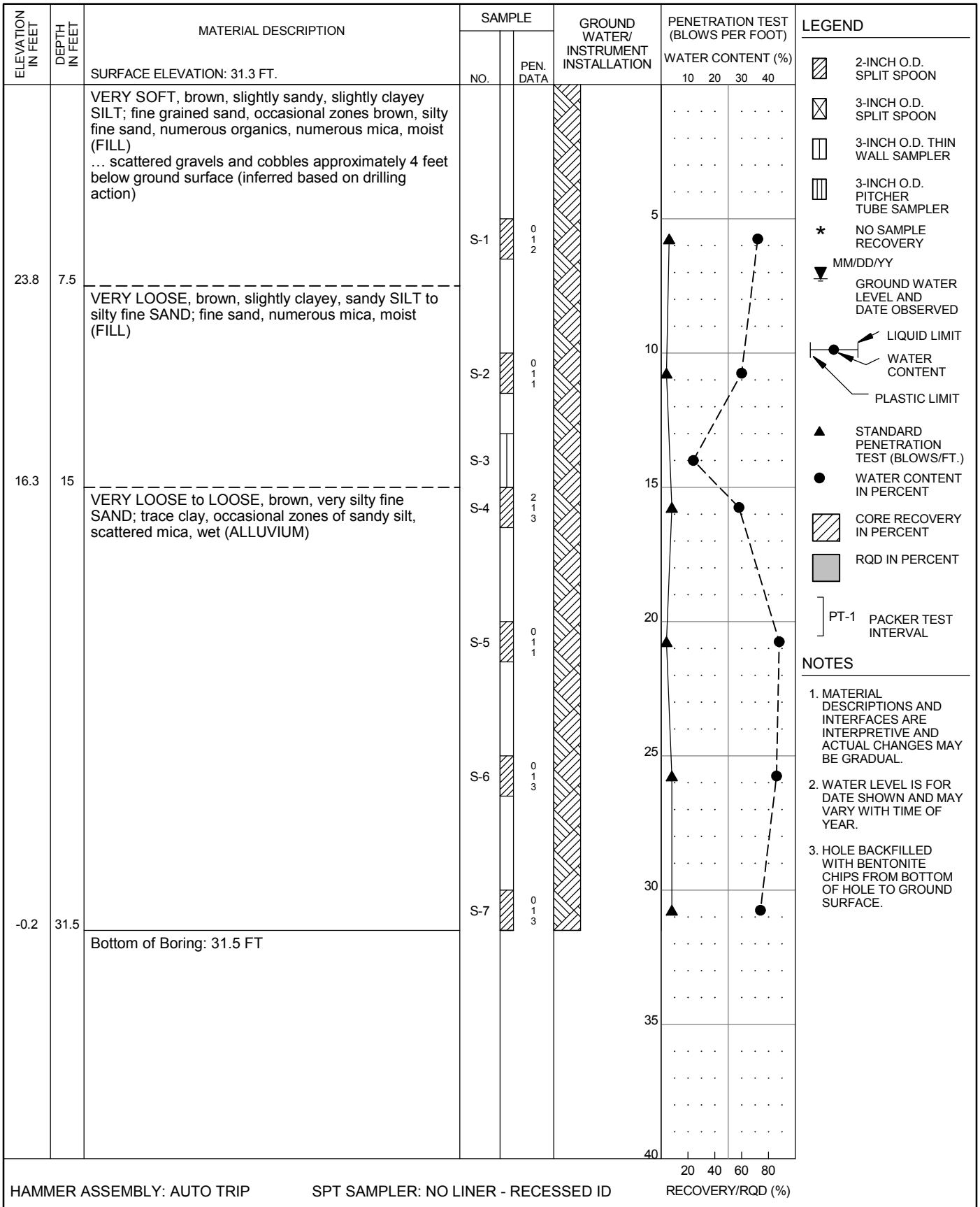
SUMMARY BORING LOG P1-CC-10

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A10



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4

DRILLER: WESTERN STATES
DATE START: 2/25/2014 FINISH: 2/25/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-11

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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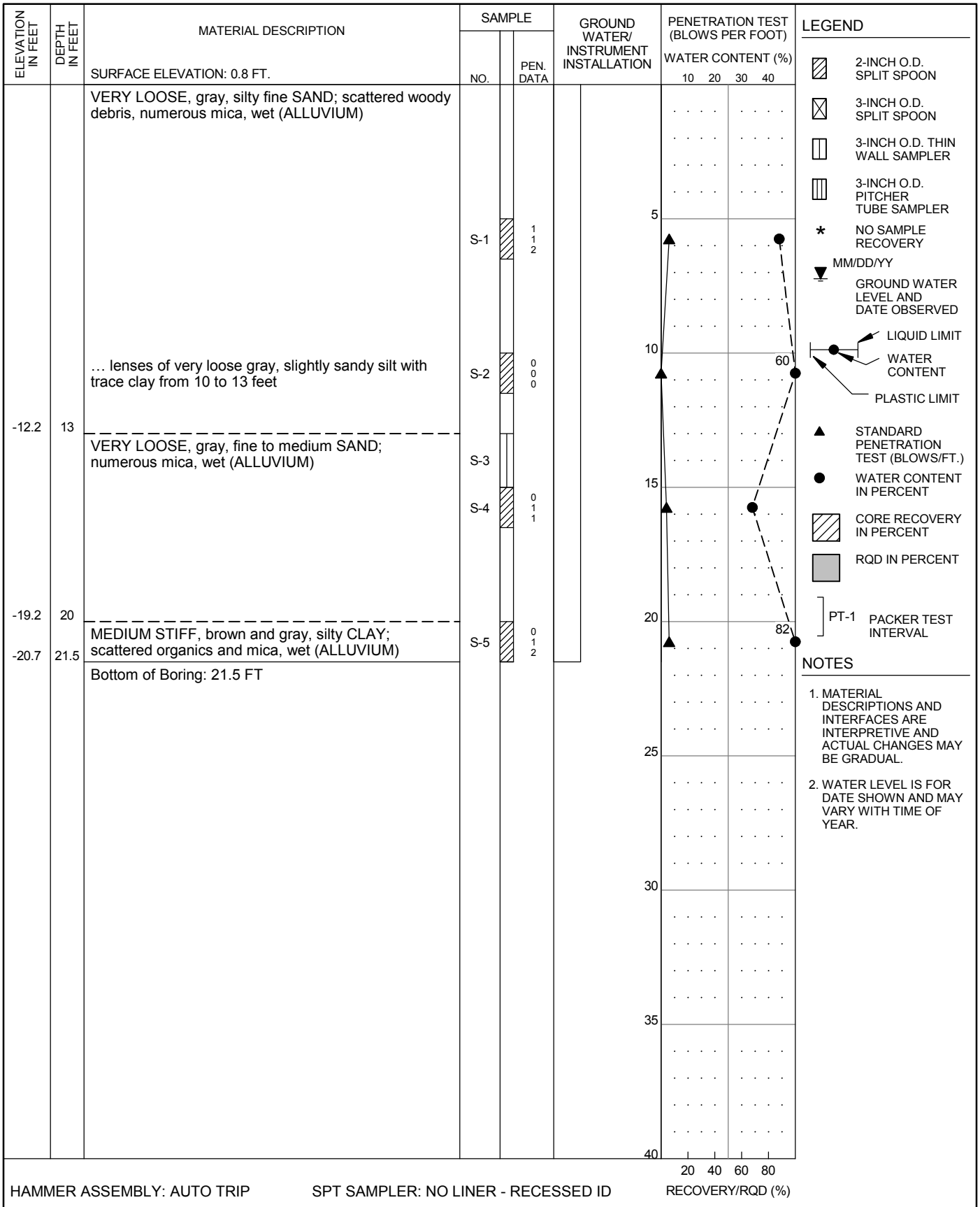
FIG. A11



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/8/2014 FINISH: 5/8/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-12

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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FIG. A12

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 30.9 FT.		
30.2	0.7	2 inches asphalt, 6 inches sub-angular, fine gravel (FILL)		
		VERY LOOSE, brown, sandy SILT; trace clay, fine grained sand, trace mica, moist (FILL)	S-1	2 1 2
			S-2	2 1 3
14.9	16		S-3	1 1 1
		VERY SOFT, brown, slightly sandy, slightly clayey SILT; fine grained sand, scattered orange-brown mineralization (ALLUVIUM)	S-4 *	
			S-5	0 1 1
9.4	21.5	Bottom of Boring: 21.5 FT		

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

5 10 15 20 25 30 35 40

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE AND CAPPED WITH ASPHALT PATCH.

HAMMER ASSEMBLY: AUTO TRIP

SPT SAMPLER: NO LINER - RECESSED ID

DRILL ROD USED: NWJ

BOREHOLE DIAM.: 8 1/4

DRILLER: WESTERN STATES

DATE START: 2/26/2014 FINISH: 2/26/2014

DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-13

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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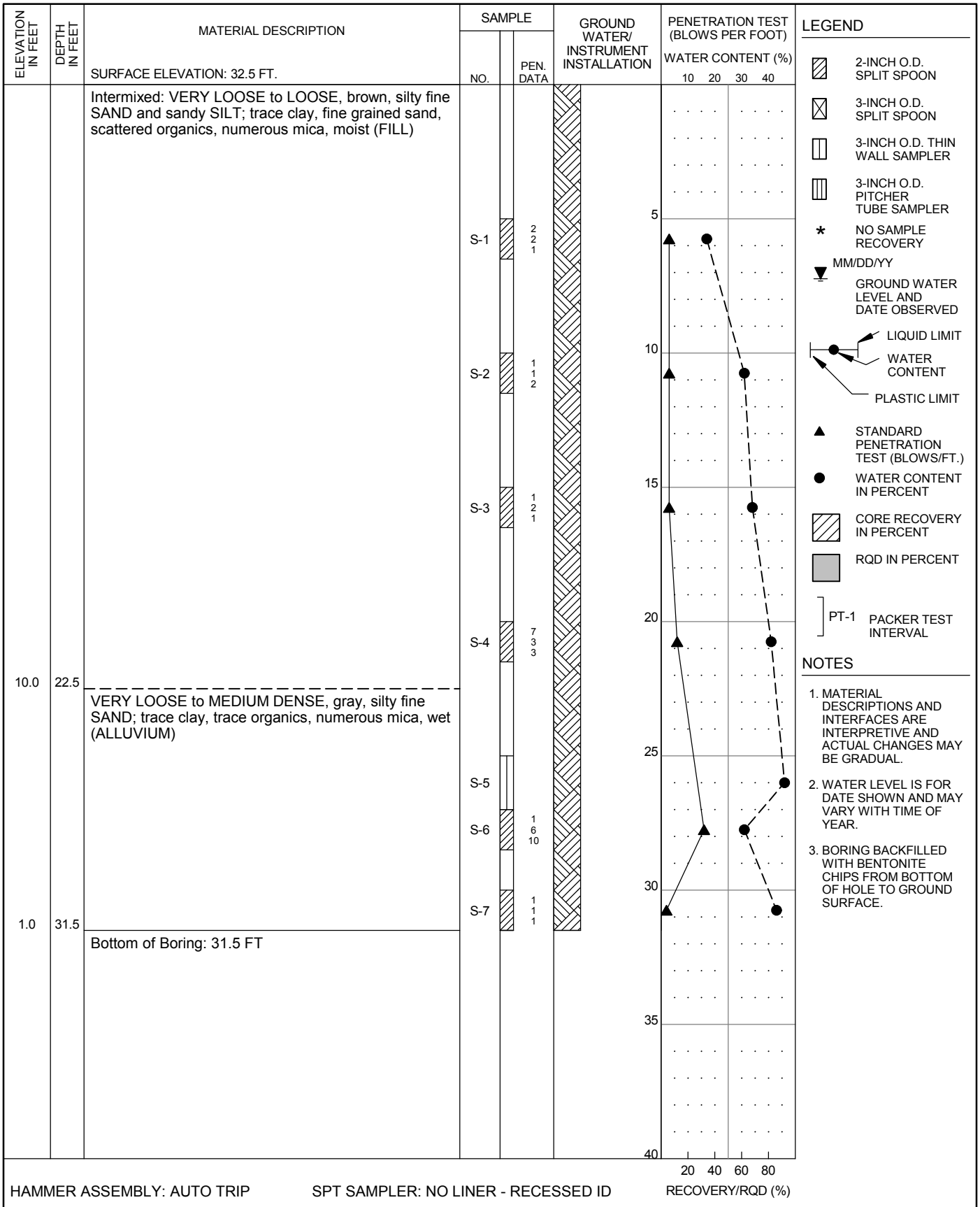
PROJ 2319

FIG. A13



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/24/2014 FINISH: 2/24/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-14

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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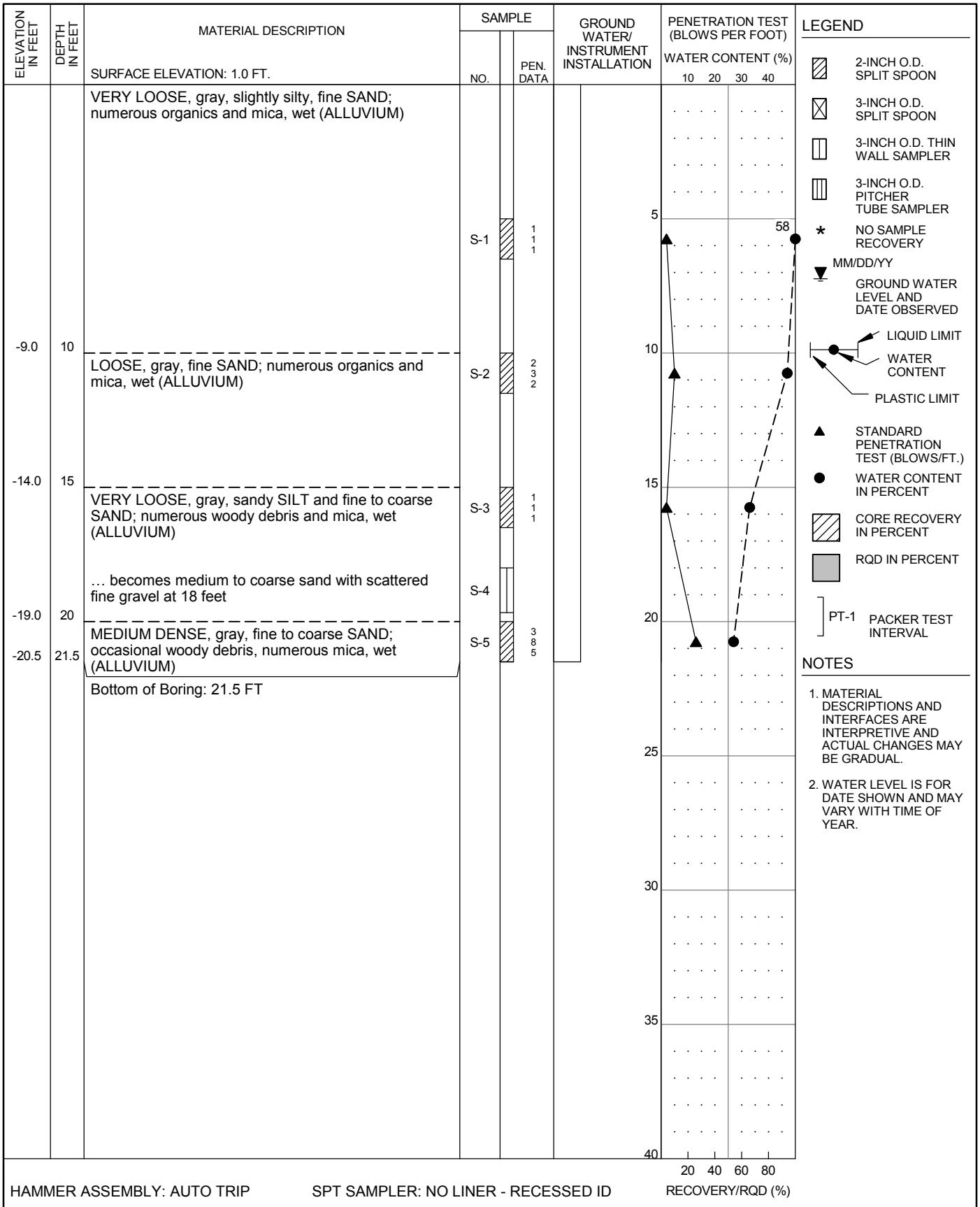
FIG. A14



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/8/2014 FINISH: 5/8/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-15

PENINSULA DISTRICT 1 LEVEE
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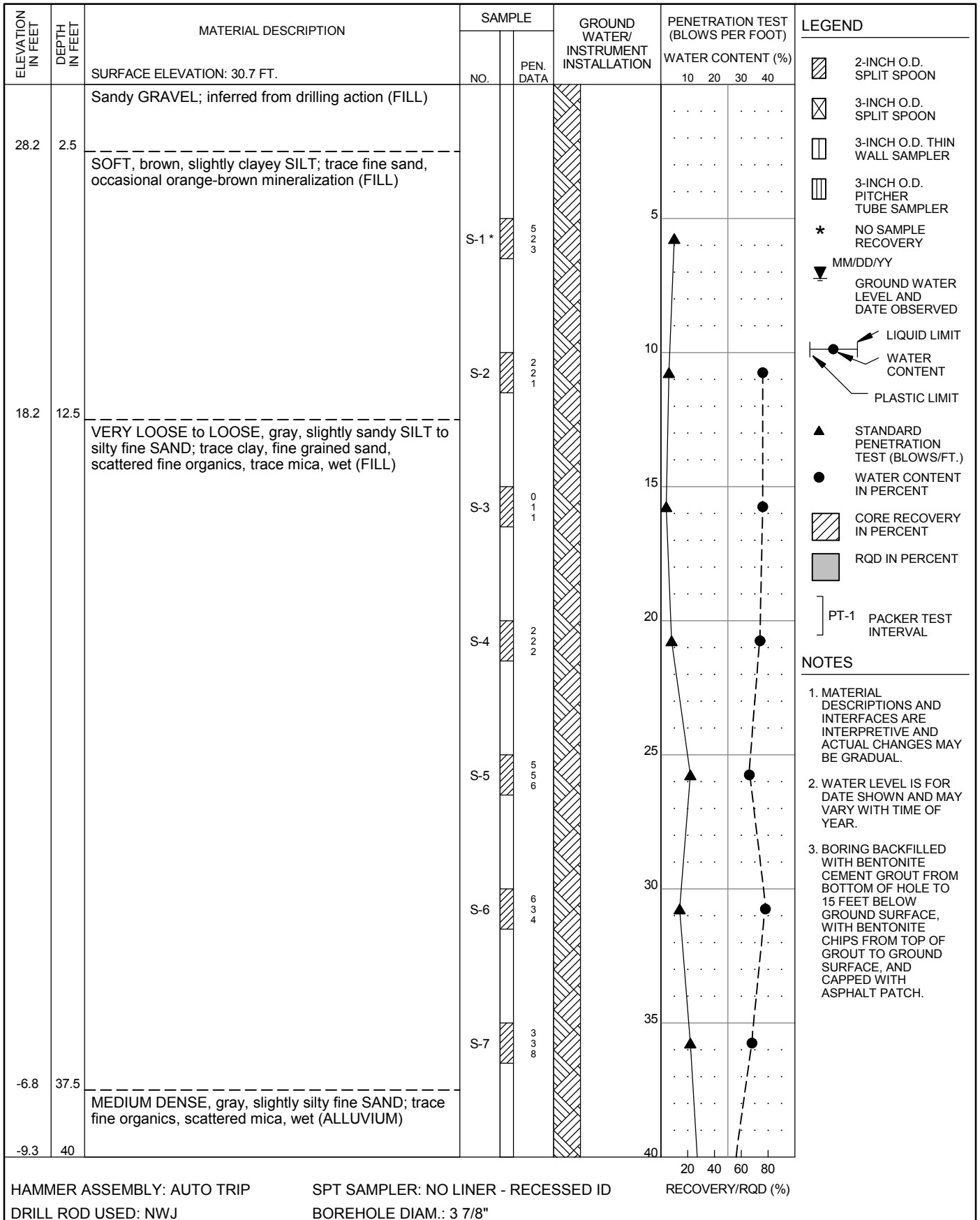
FIG. A15



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/25/2014 FINISH: 2/25/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-16 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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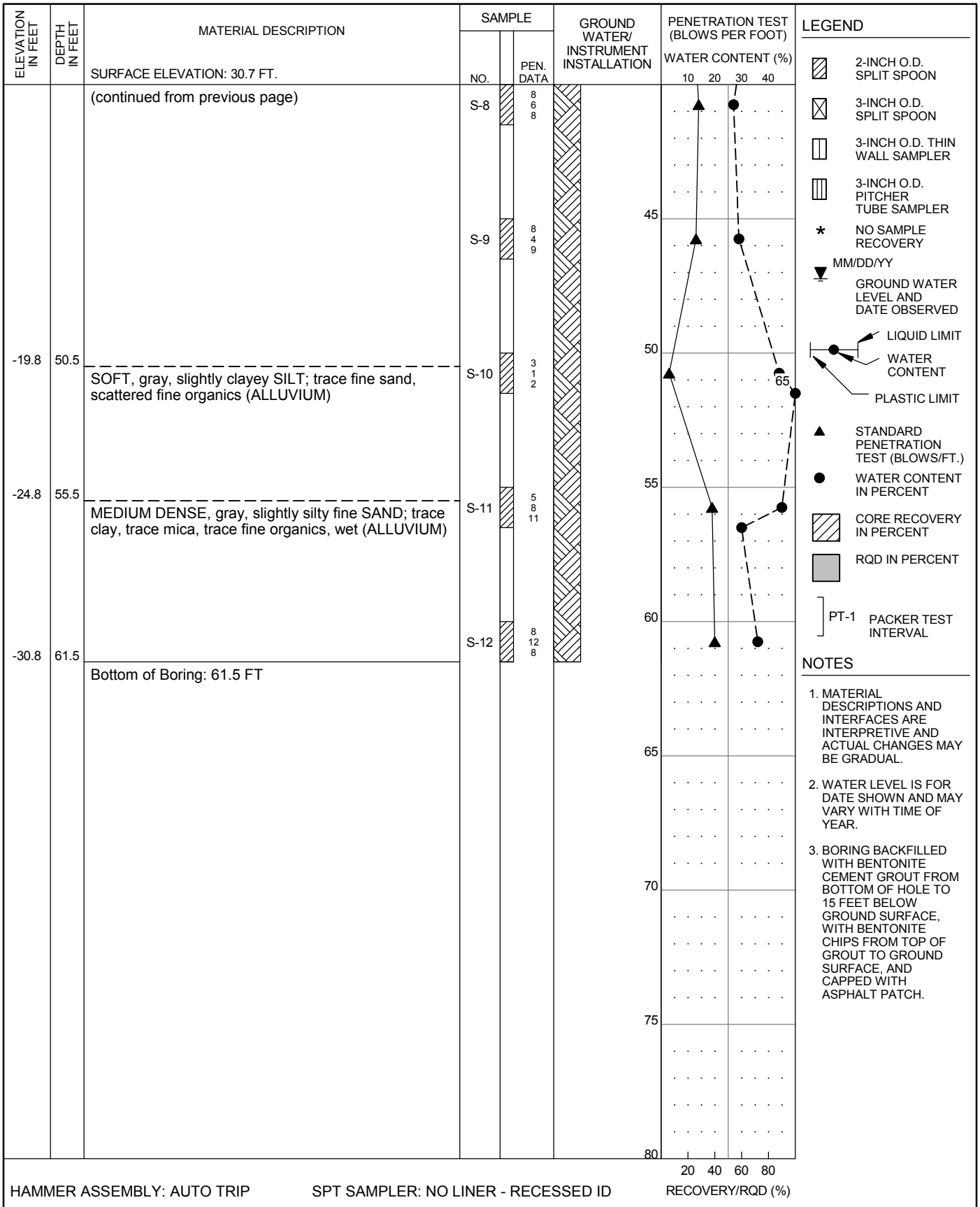
PROJ 2319
FIG. A16



NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. BORING BACKFILLED WITH BENTONITE CEMENT GROUT FROM BOTTOM OF HOLE TO 15 FEET BELOW GROUND SURFACE, WITH BENTONITE CHIPS FROM TOP OF GROUT TO GROUND SURFACE, AND CAPPED WITH ASPHALT PATCH.

HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/25/2014 FINISH: 2/25/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-16 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
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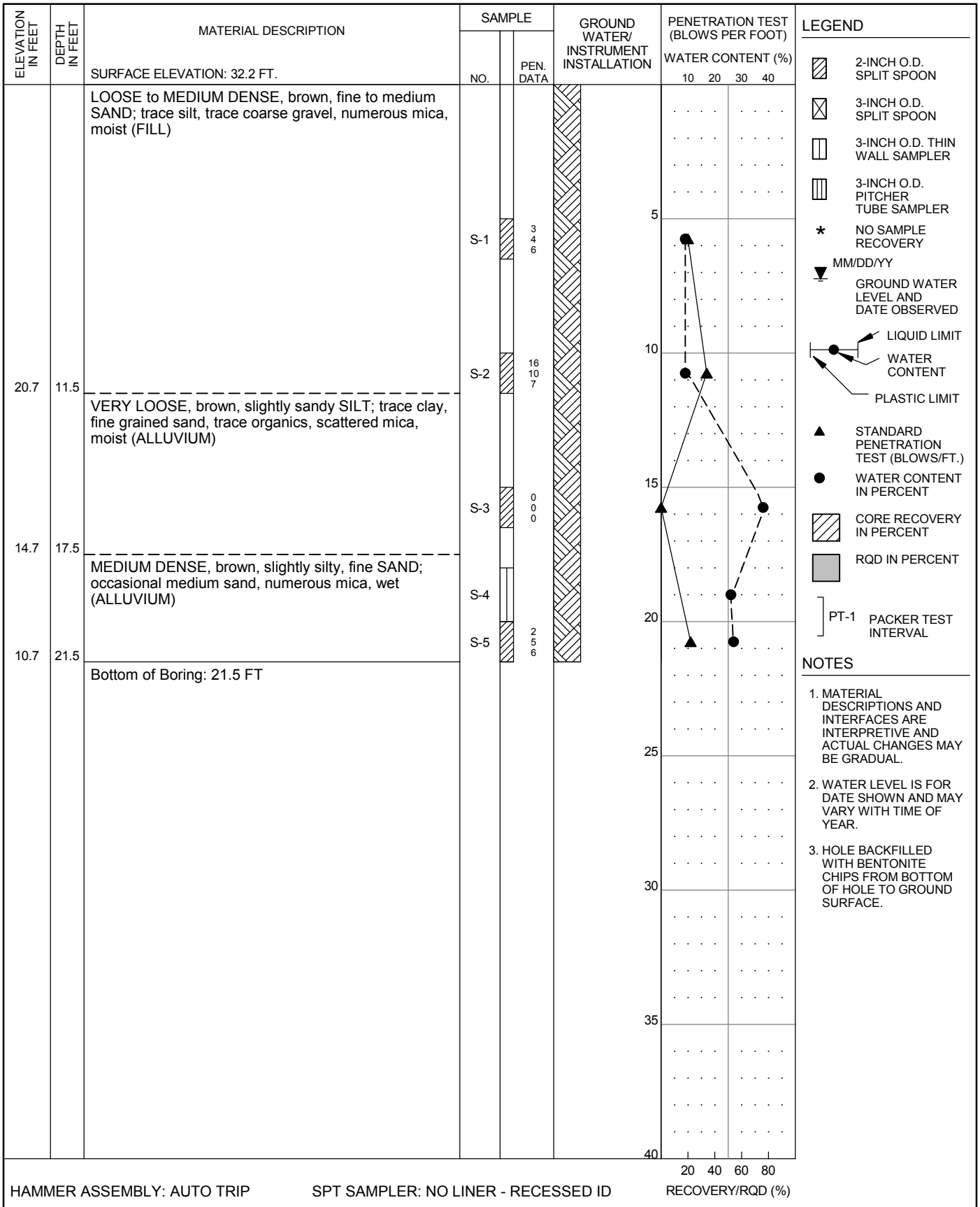
PROJ 2319
FIG. A16



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4

DRILLER: WESTERN STATES
DATE START: 2/24/2014 FINISH: 2/24/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-17

PENINSULA DISTRICT 1 LEVEE
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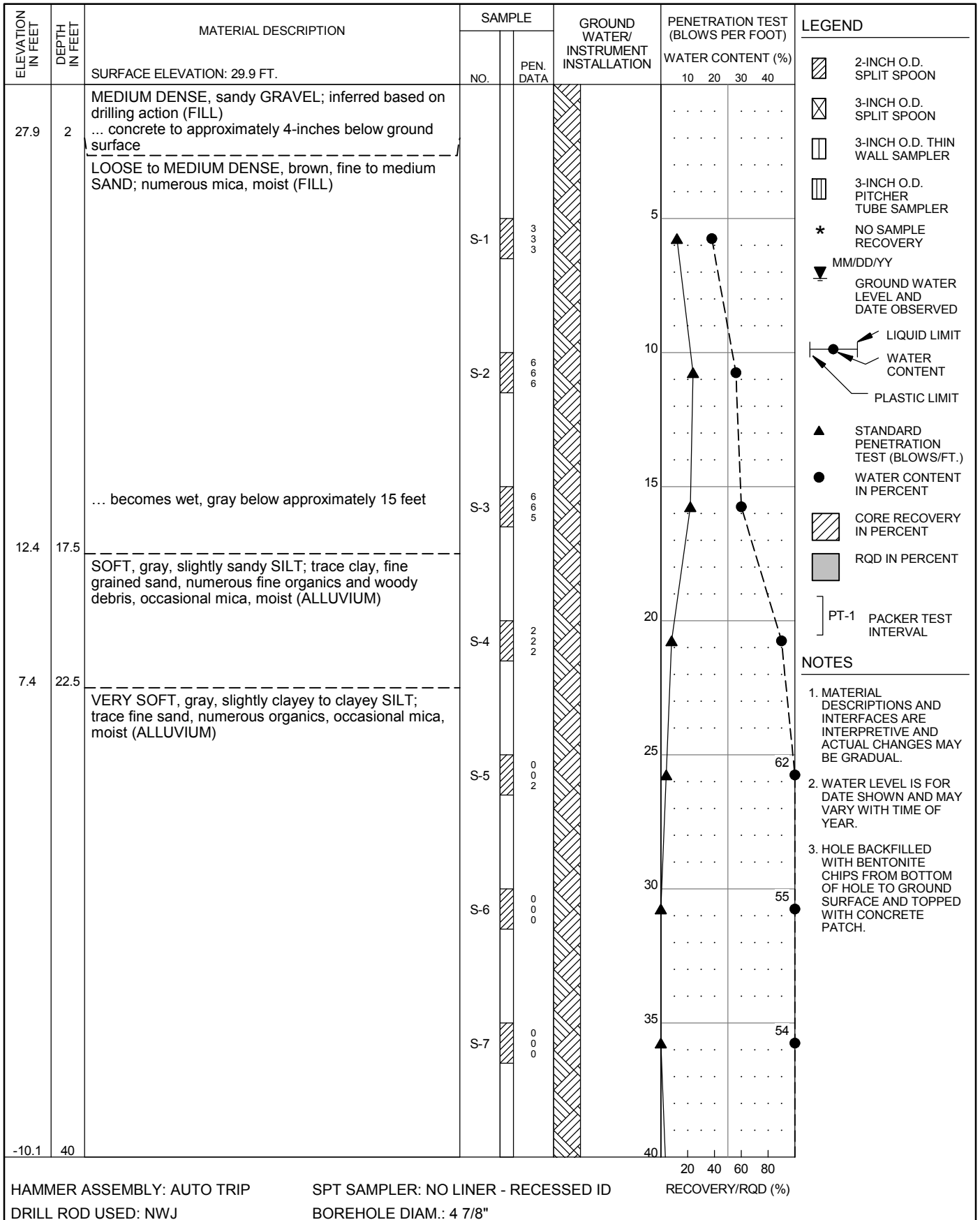
PROJ 2319

FIG. A17



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 3/4/2014 FINISH: 3/4/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-20 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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PROJ 2319
FIG. A18

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 29.9 FT.			
		(continued from previous page)	S-8	0 0 2	
			S-9 *		
			S-10	0 0 4	
			S-11		
		… white shells, less than 1/8" maximum dimension, below approximately 50 feet	S-12	0 0 2	
-22.6	52.5	LOOSE, gray, silty fine SAND; trace clay, numerous organics, numerous mica, wet (ALLUVIUM)			
			S-13	2 2 4	
-26.6	56.5	Bottom of Boring: 56.5 FT			

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

45 50 55 60 65 70 75 80

69 66 56

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE AND TOPPED WITH CONCRETE PATCH.

HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 3/4/2014 FINISH: 3/4/2014
DRILLING TECHNIQUE: MUD ROTARY

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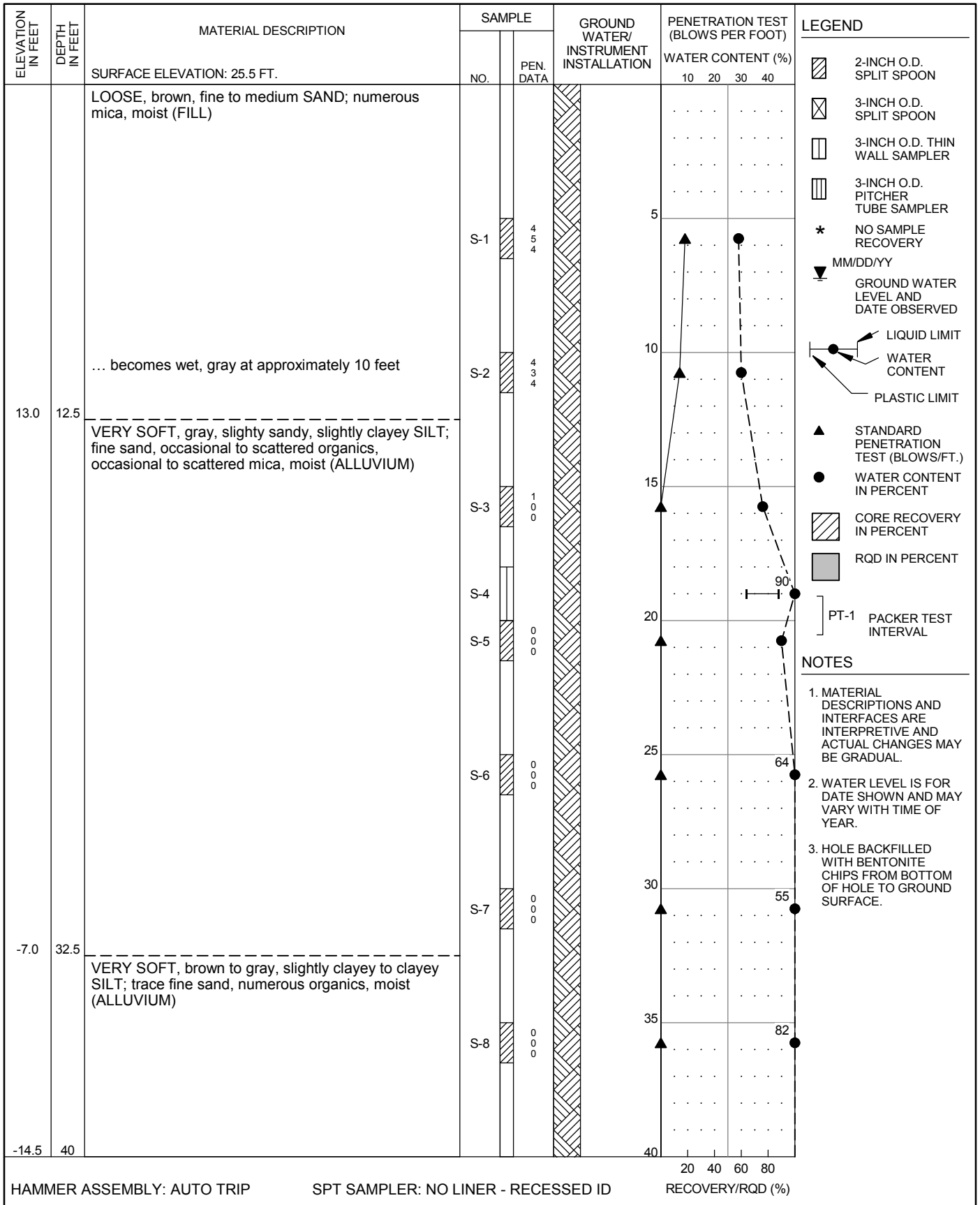
SUMMARY BORING LOG P1-CC-20 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A18



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/17/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-21 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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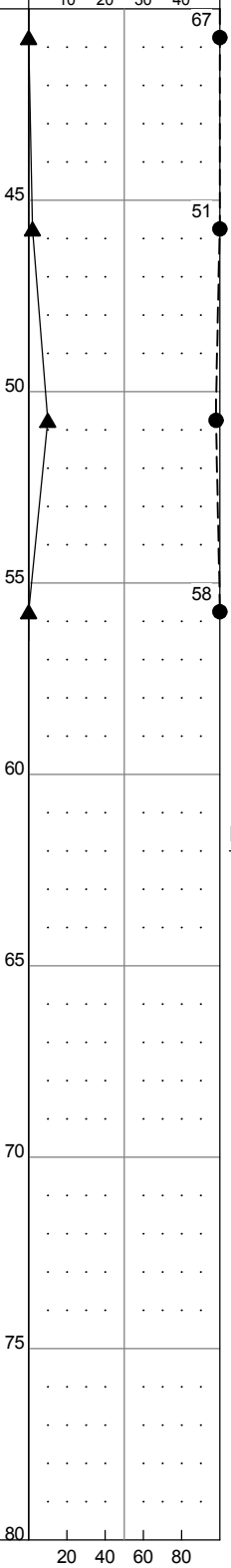
PROJ 2319
FIG. A19

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 25.5 FT.			
		(continued from previous page)	S-9	0 0 0	
-19.7	45.2	Intermixed: VERY LOOSE, gray, silty fine SAND; and slightly sandy SILT; trace clay, fine sand, occasional organics, scattered mica (ALLUVIUM)	S-10	0 0 1	
			S-11	0 1 4	
-27.0	52.5	VERY SOFT, gray, slightly clayey to clayey SILT, trace fine sand, numerous organics, trace mica (ALLUVIUM)			
			S-12	0 0 0	
-31.0	56.5	Bottom of Boring: 56.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/17/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-21 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
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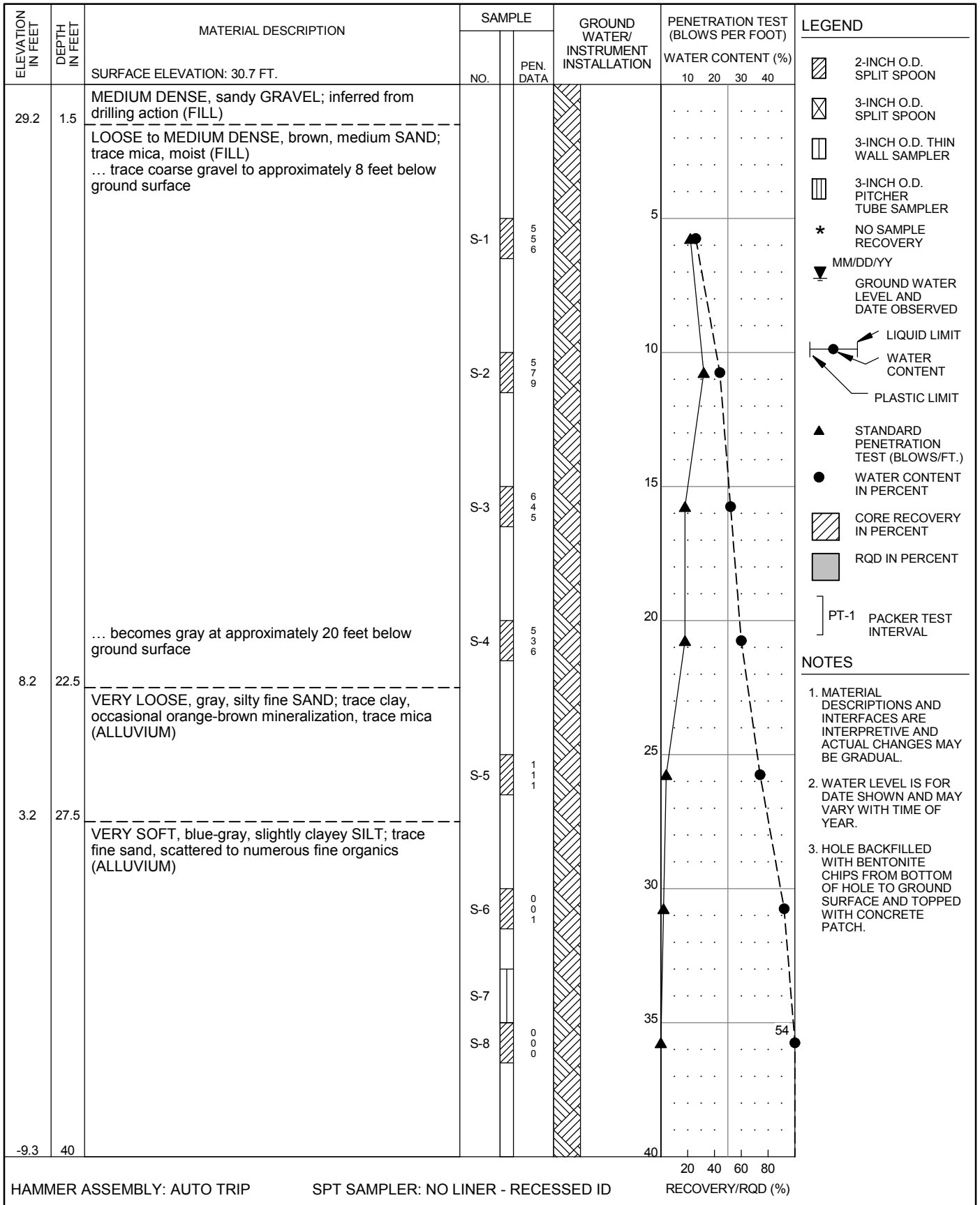
FIG. A19



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 3/4/2014 FINISH: 3/4/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-22 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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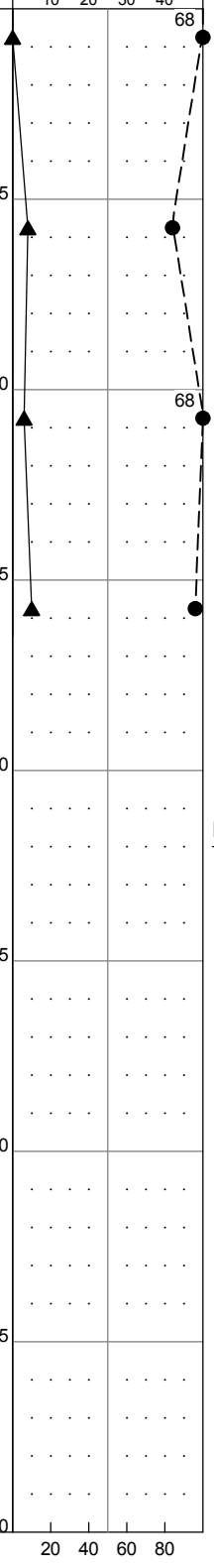
FIG. A20

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 30.7 FT.			
		(continued from previous page)	S-9	0 0 0	
-11.8	42.5	VERY LOOSE, dark gray, silty fine SAND; trace clay, scattered mica, wet (ALLUVIUM)	S-10	2 2 2	
-16.8	47.5	VERY SOFT to SOFT, gray-brown, slightly clayey SILT, trace fine sand, scattered organics, occasional blue-green mineralization (ALLUVIUM)	S-11	0 1 2	
-25.8	56.5	Bottom of Boring: 56.5 FT	S-12	0 1 4	



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE AND TOPPED WITH CONCRETE PATCH.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 3/4/2014 FINISH: 3/4/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-22 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
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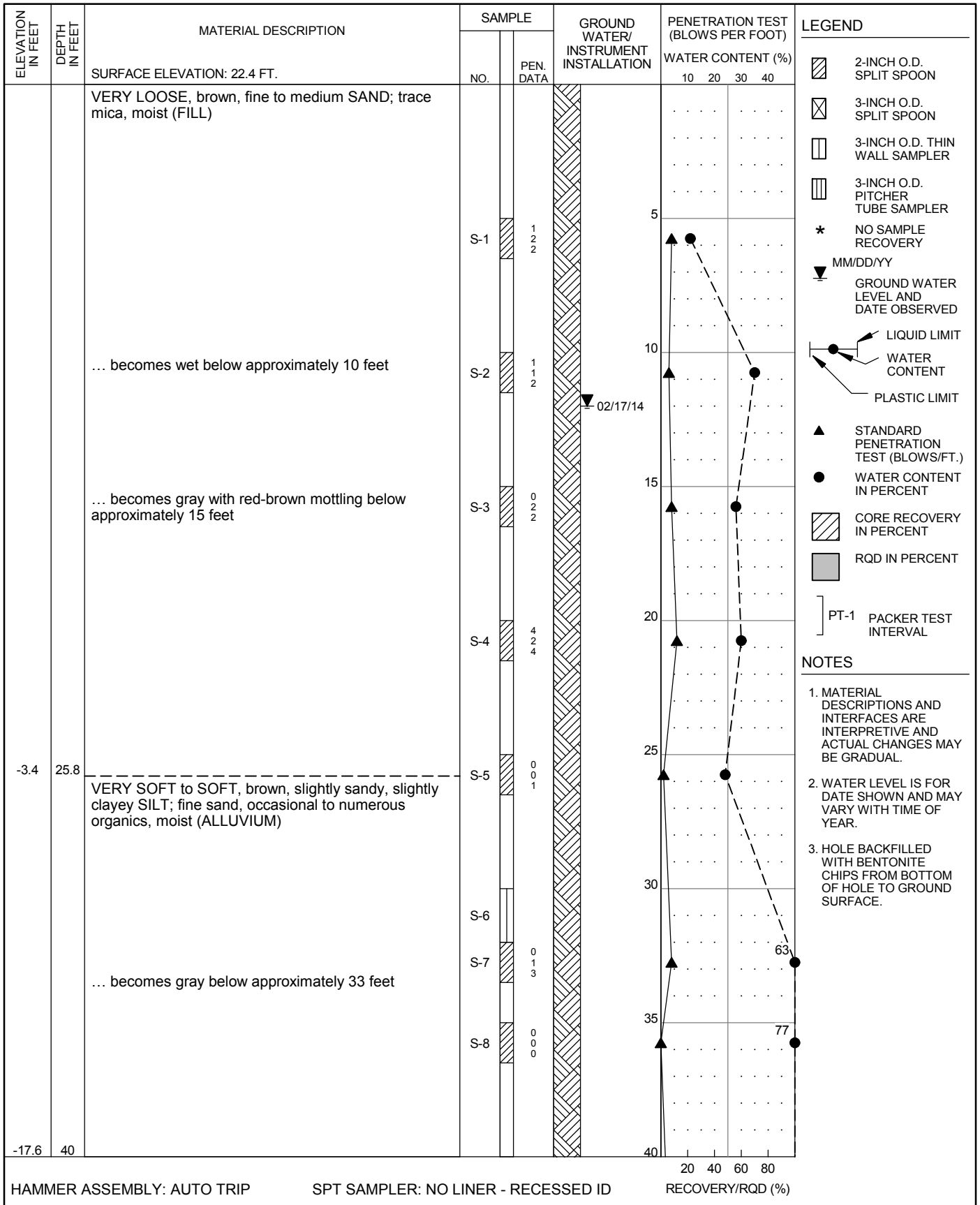
FIG. A20



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/18/2014
DRILLING TECHNIQUE: MUD ROTARY

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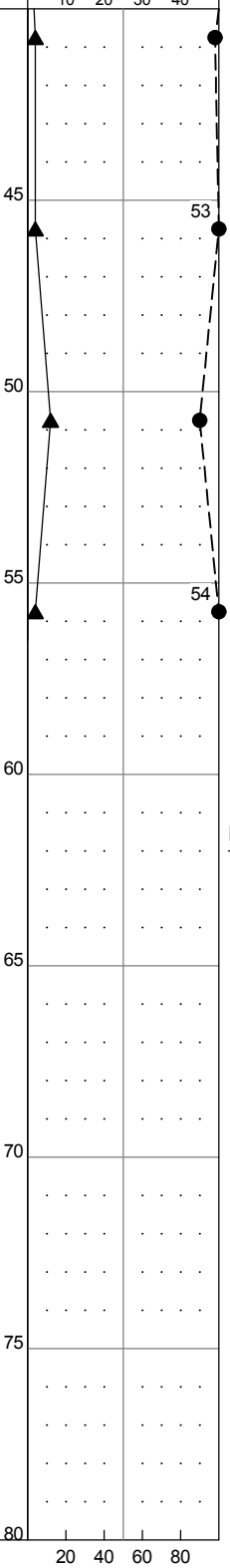
SUMMARY BORING LOG P1-CC-23 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A21

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 22.4 FT.			
		(continued from previous page)	S-9	0 0 2	
			S-10	0 0 2	
-25.1	47.5	LOOSE, gray, silty to very silty fine SAND; trace clay, scattered mica, moist (ALLUVIUM)			
			S-11	0 2 4	
-30.1	52.5	VERY SOFT to SOFT, slightly sandy SILT; trace clay, fine sand, moist (ALLUVIUM)			
			S-12	0 0 2	
-34.1	56.5	Bottom of Boring: 56.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT, WATER CONTENT, PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/18/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-23 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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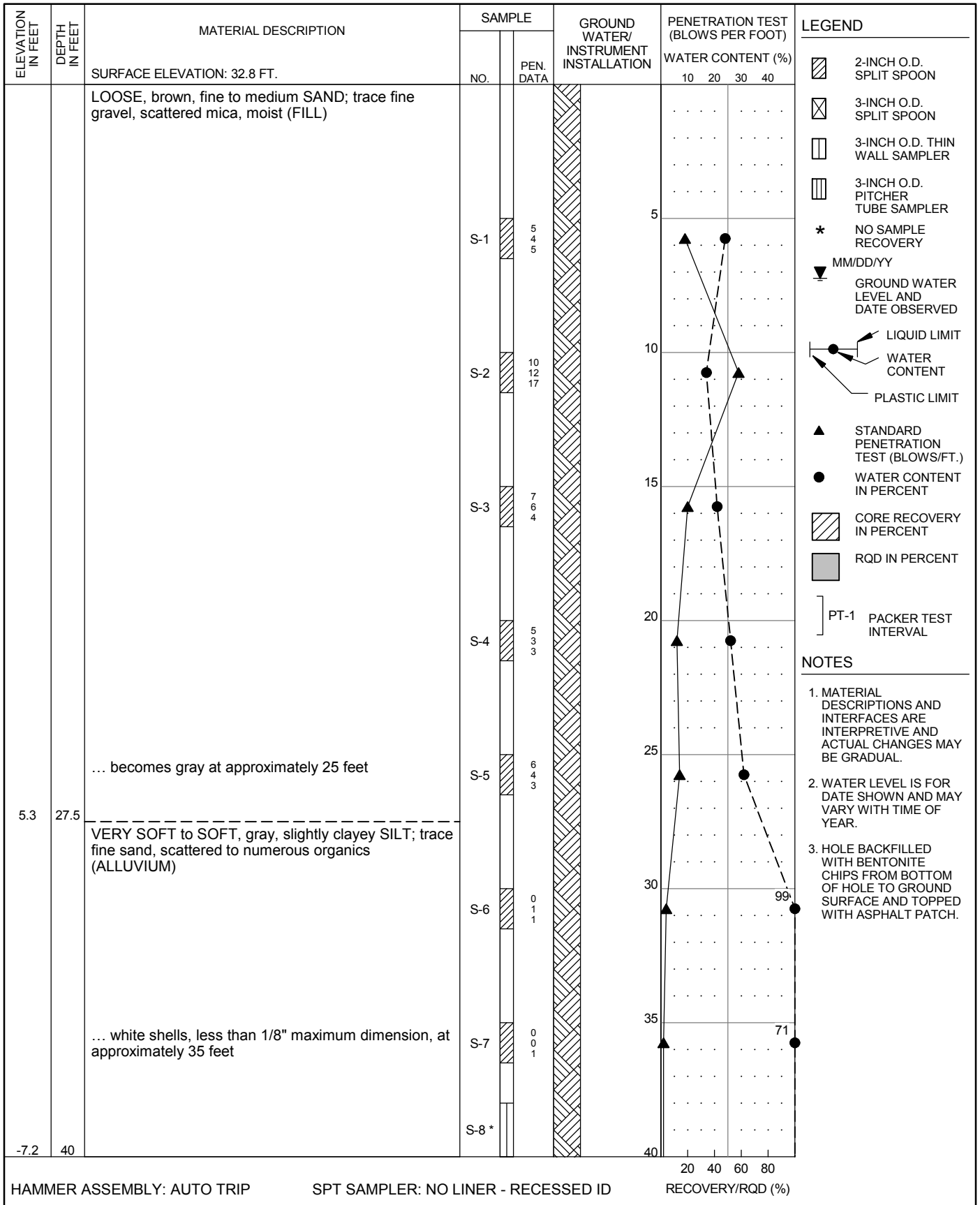
FIG. A21



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 3/5/2014 FINISH: 3/5/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-25 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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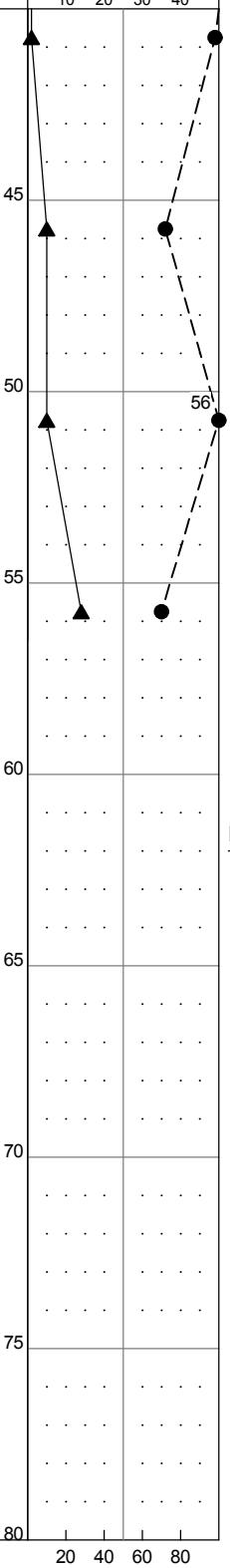
PROJ 2319
FIG. A22

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 32.8 FT.			
		(continued from previous page)	S-9	0 0 1	
		... becomes slightly sandy below 40 feet, with occasional beds of slightly sandy silt with trace clay, up to 1.5 inches thick	S-10	0 1 4	
			S-11		
			S-12	1 2 3	
-19.7	52.5	MEDIUM DENSE, gray, sandy SILT; trace clay, fine to medium sand, scattered organics, scattered mica, wet (ALLUVIUM)	S-13	4 6 8	
-23.7	56.5	Bottom of Boring: 56.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE AND TOPPED WITH ASPHALT PATCH.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 3/5/2014 FINISH: 3/5/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-25 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
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PROJ 2319
FIG. A22

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 10.9 FT.		
		VERY LOOSE to LOOSE, brown, fine to medium SAND; scattered mica, wet (FILL)	S-1	3 3 4
			S-2	1 2 1
-1.6	12.5	VERY SOFT, brown to gray, slightly sandy to sandy SILT; trace clay, fine sand, scattered organics, moist (ALLUVIUM)	S-3	0 0 0
			S-4	0 0 2
			S-5	0 0 0
		... becomes gray below approximately 26 feet	S-6	1 2 2
			S-7	0 0 1
-29.1	40			

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

5 10 15 20 25 30 35 40

53 68 115

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP

DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID

BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES

DATE START: 2/18/2014 FINISH: 2/18/2014

DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-26 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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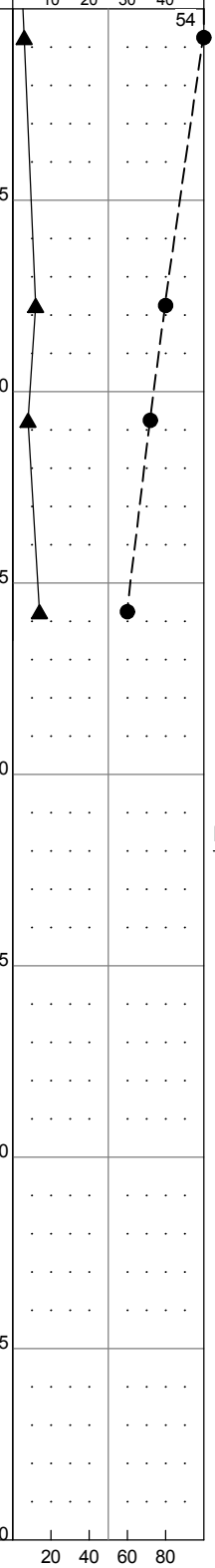
PROJ 2319

FIG. A23

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 10.9 FT.			
		(continued from previous page)	S-8	0 1 2	
			S-9		
			S-10	2 2 4	
-38.1	49	VERY LOOSE to LOOSE, silty fine SAND; scattered zones of slightly clayey silt up to 3" thick, occasional organics, scattered mica, moist (ALLUVIUM)	S-11	2 2 2	
			S-12	5 2 5	
-45.6	56.5	Bottom of Boring: 56.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/18/2014 FINISH: 2/18/2014
DRILLING TECHNIQUE: MUD ROTARY

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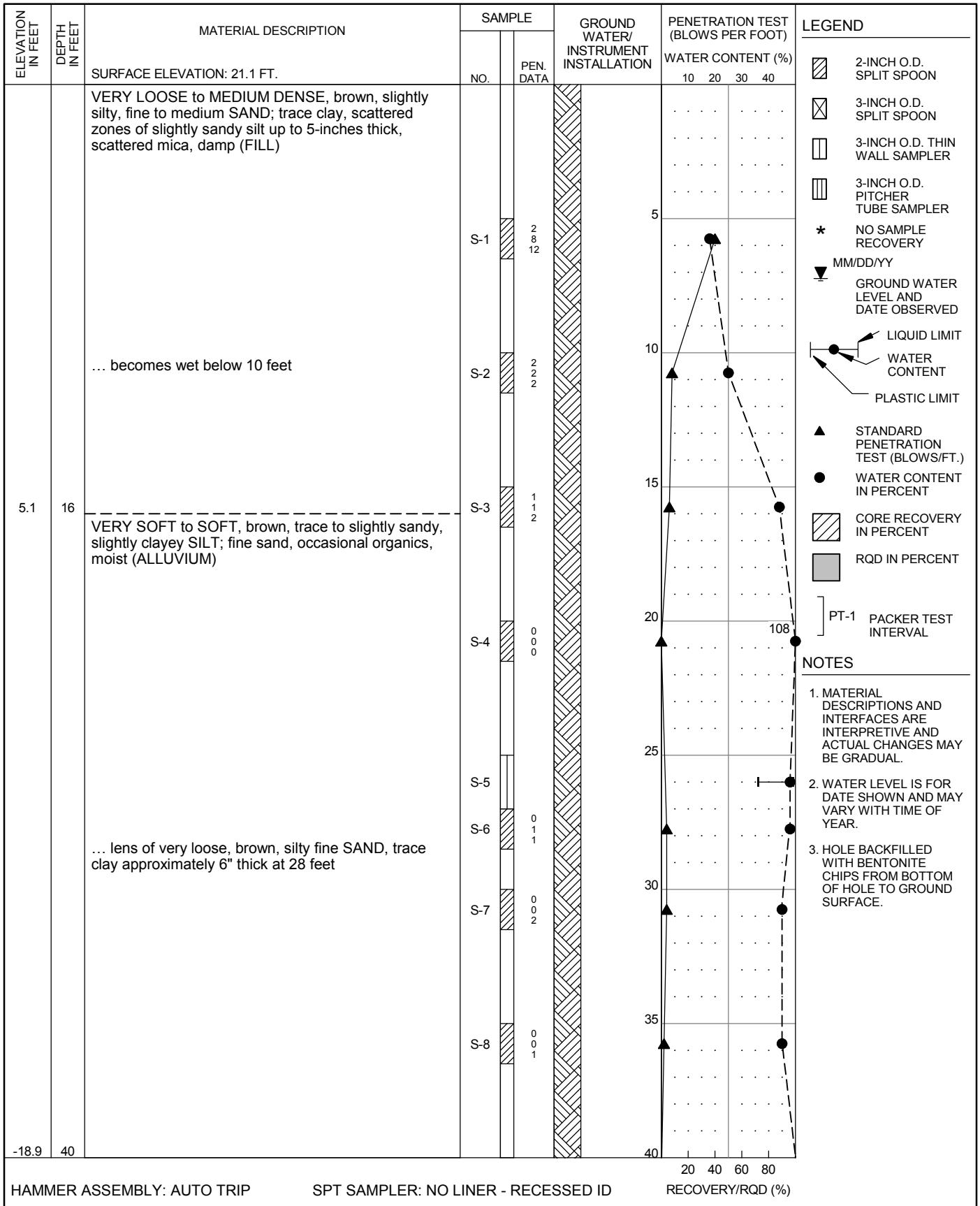
SUMMARY BORING LOG P1-CC-26 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A23



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/19/2014 FINISH: 2/19/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-28 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
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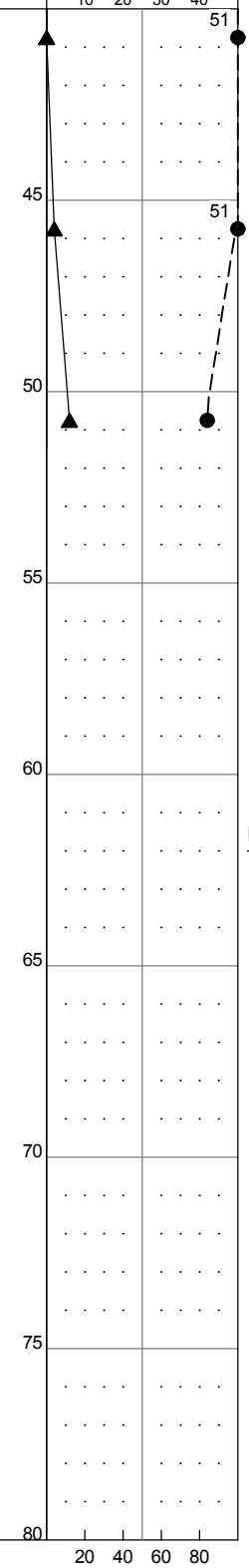
PROJ 2319
FIG. A24

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 21.1 FT.			
		(continued from previous page)	S-9	0 0 0	
			S-10	0 0 2	
			S-11	1 2 4	
-30.4	51.5	Bottom of Boring: 51.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/19/2014 FINISH: 2/19/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-28 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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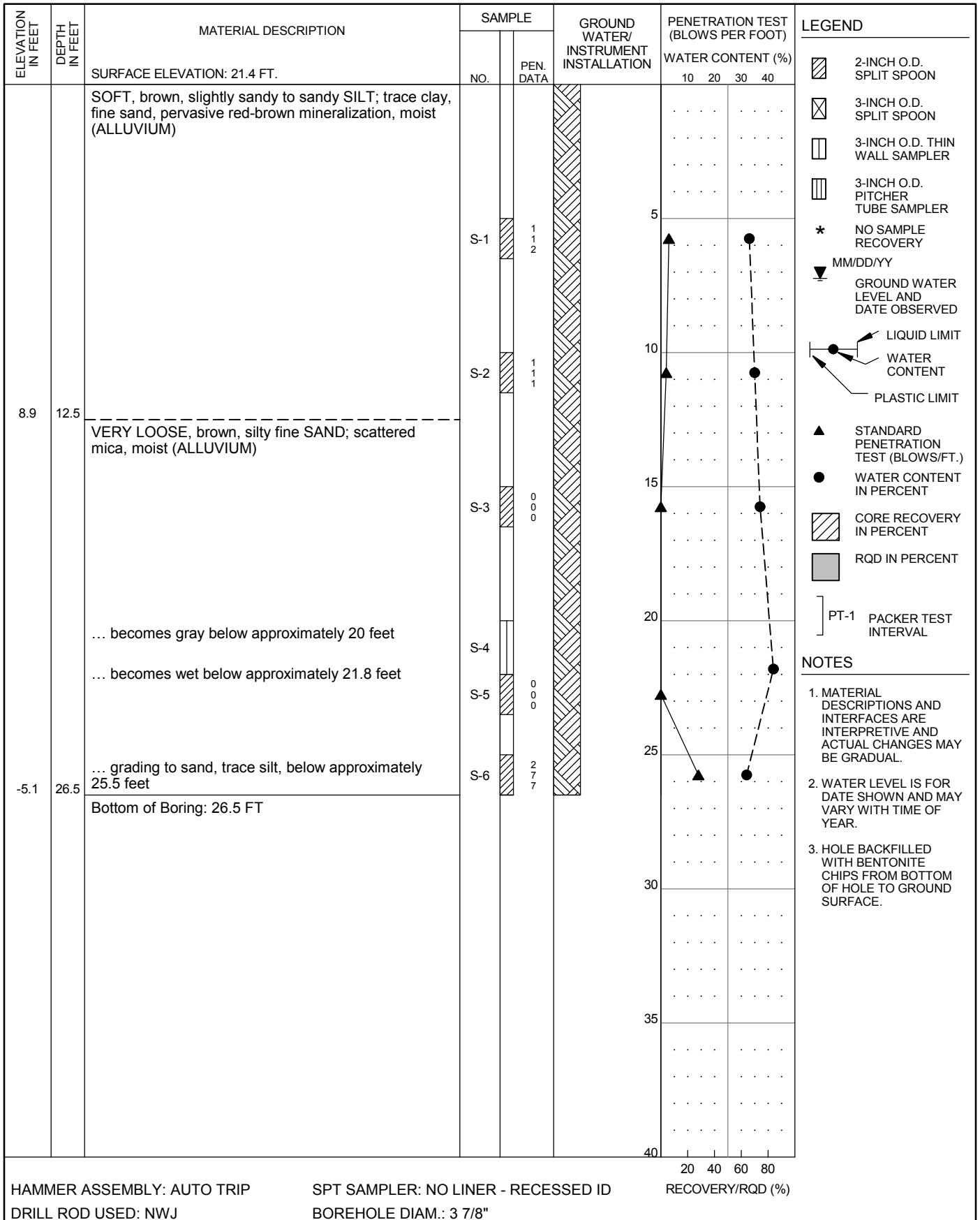
PROJ 2319
FIG. A24



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/19/2014 FINISH: 2/19/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-30

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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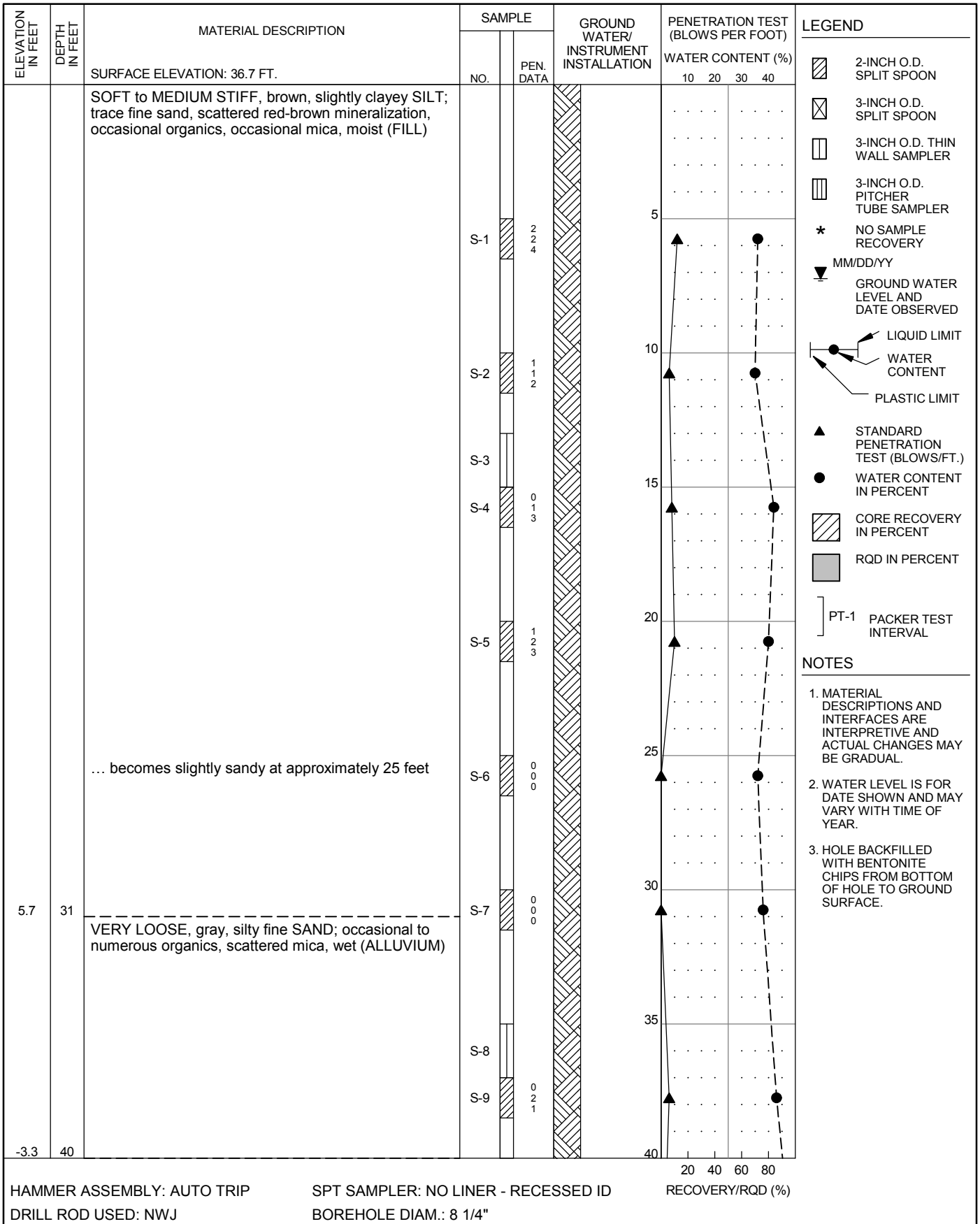
FIG. A25



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/20/2014 FINISH: 2/20/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-31 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A26

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) WATER CONTENT (%) 10 20 30 40
		SURFACE ELEVATION: 36.7 FT.				
-4.8	41.5	(continued from previous page)	S-10	0 0 2		
		Bottom of Boring: 41.5 FT				

45 50 55 60 65 70 75 80

20 40 60 80
RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT, WATER CONTENT, PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/20/2014 FINISH: 2/20/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-31 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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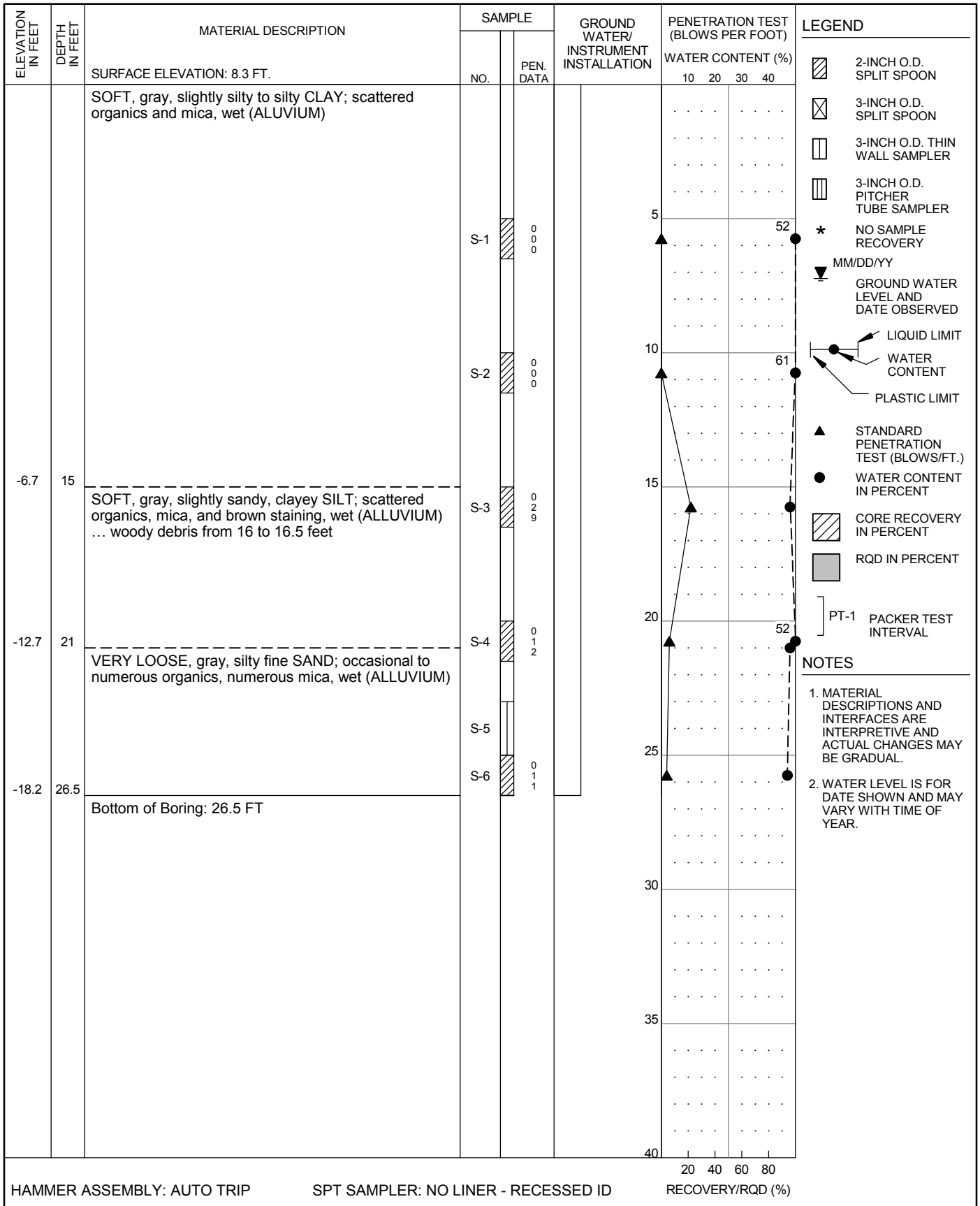
PROJ 2319

FIG. A26



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/6/2014 FINISH: 5/6/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-32

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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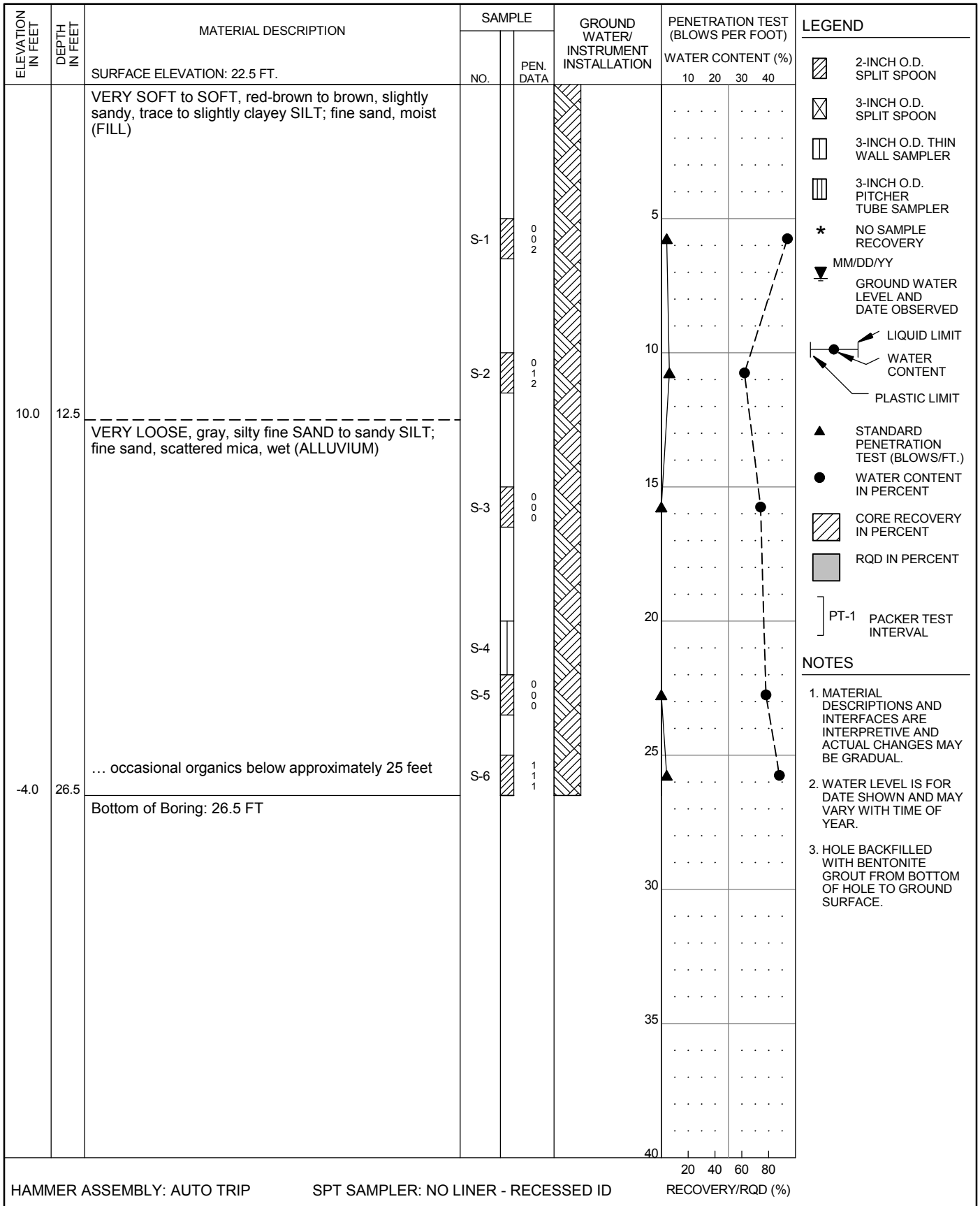
FIG. A27



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/20/2014 FINISH: 2/20/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-33

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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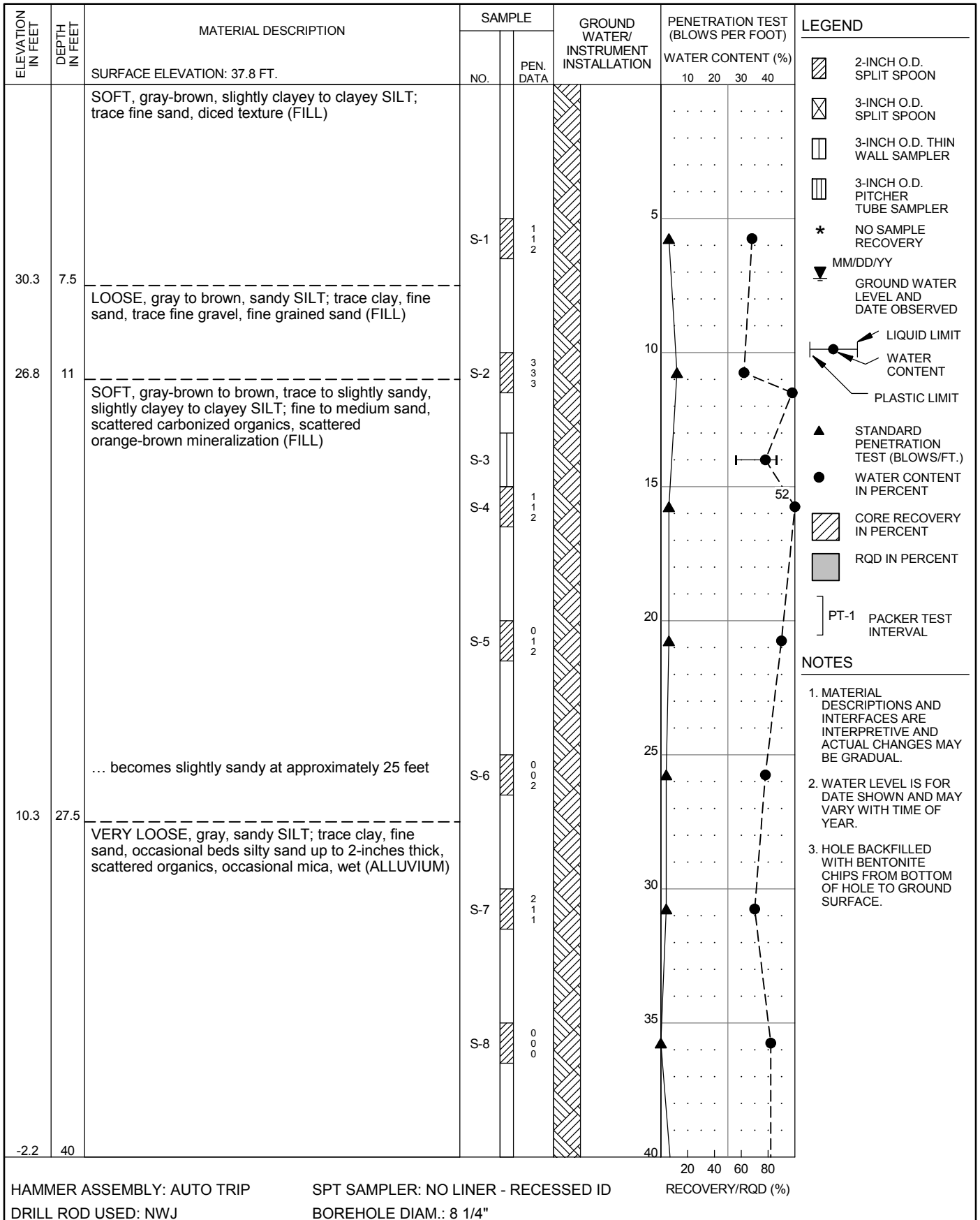
FIG. A28



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/17/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-34 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A29

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 37.8 FT.				
-3.7	41.5	(continued from previous page)	S-9		1 2 2	
		Bottom of Boring: 41.5 FT				

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

45 50 55 60 65 70 75 80

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/17/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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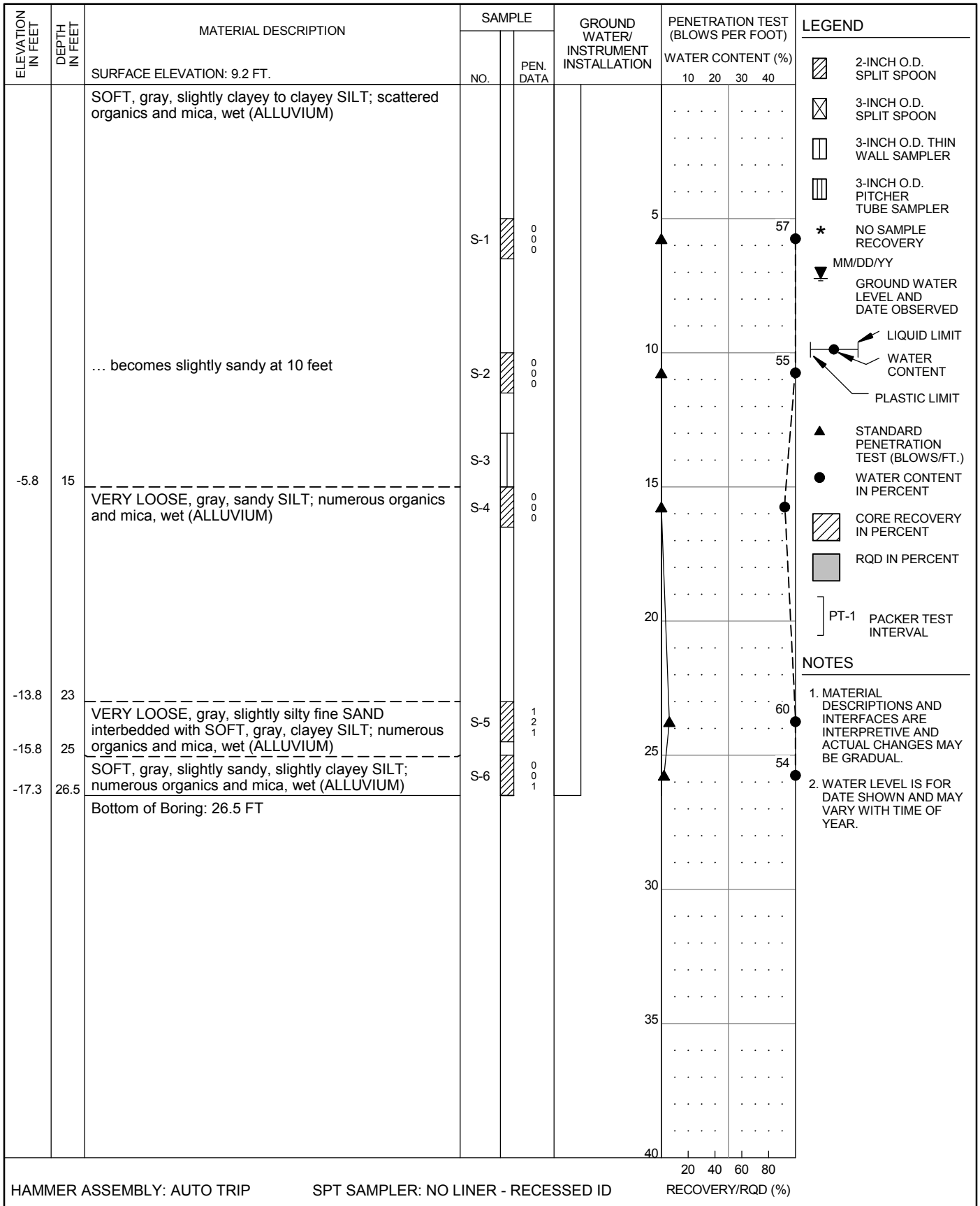
SUMMARY BORING LOG P1-CC-34 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A29



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/6/2014 FINISH: 5/6/2014
DRILLING TECHNIQUE: MUD ROTARY

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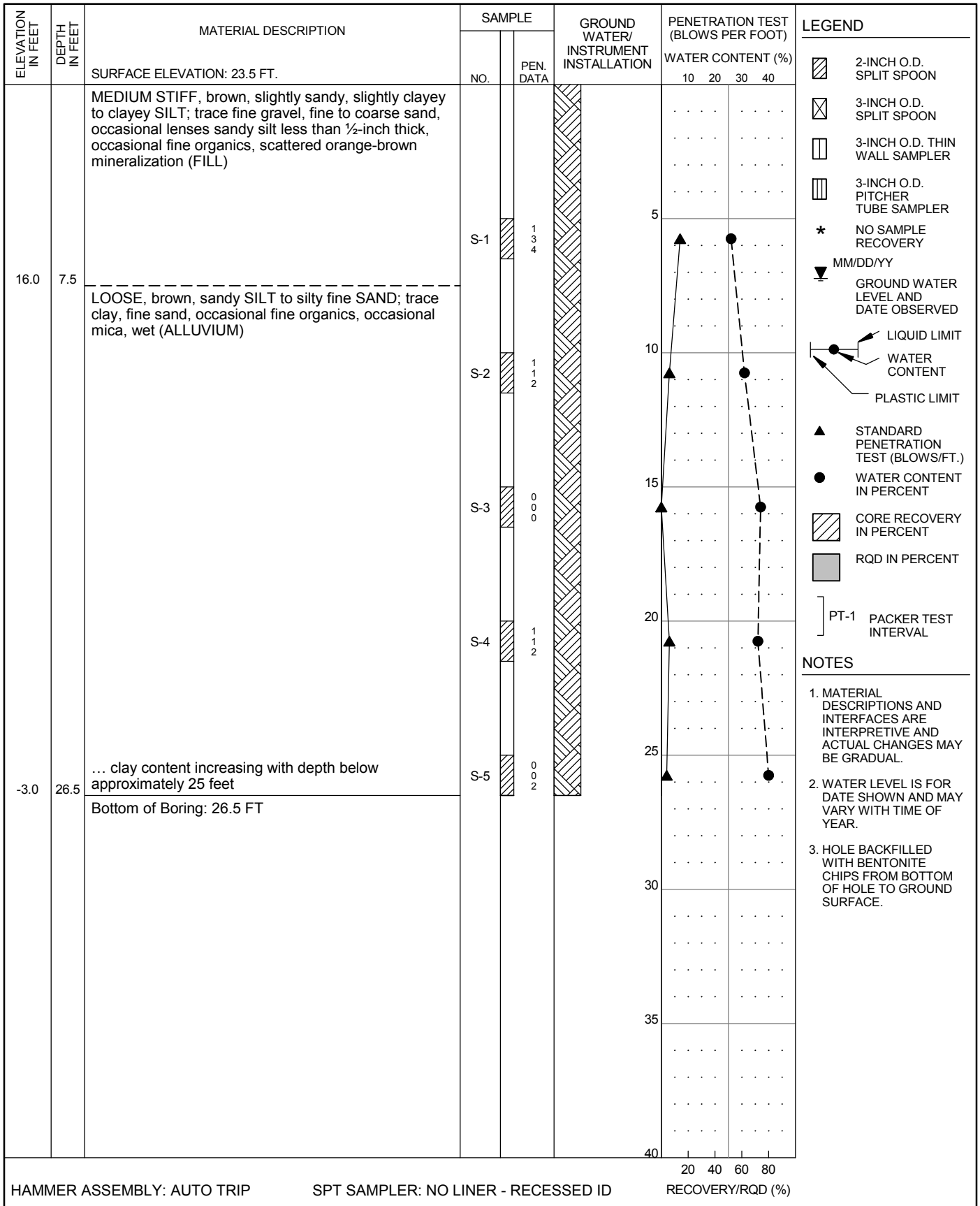
SUMMARY BORING LOG P1-CC-35

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A30



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/14/2014 FINISH: 2/14/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-36

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

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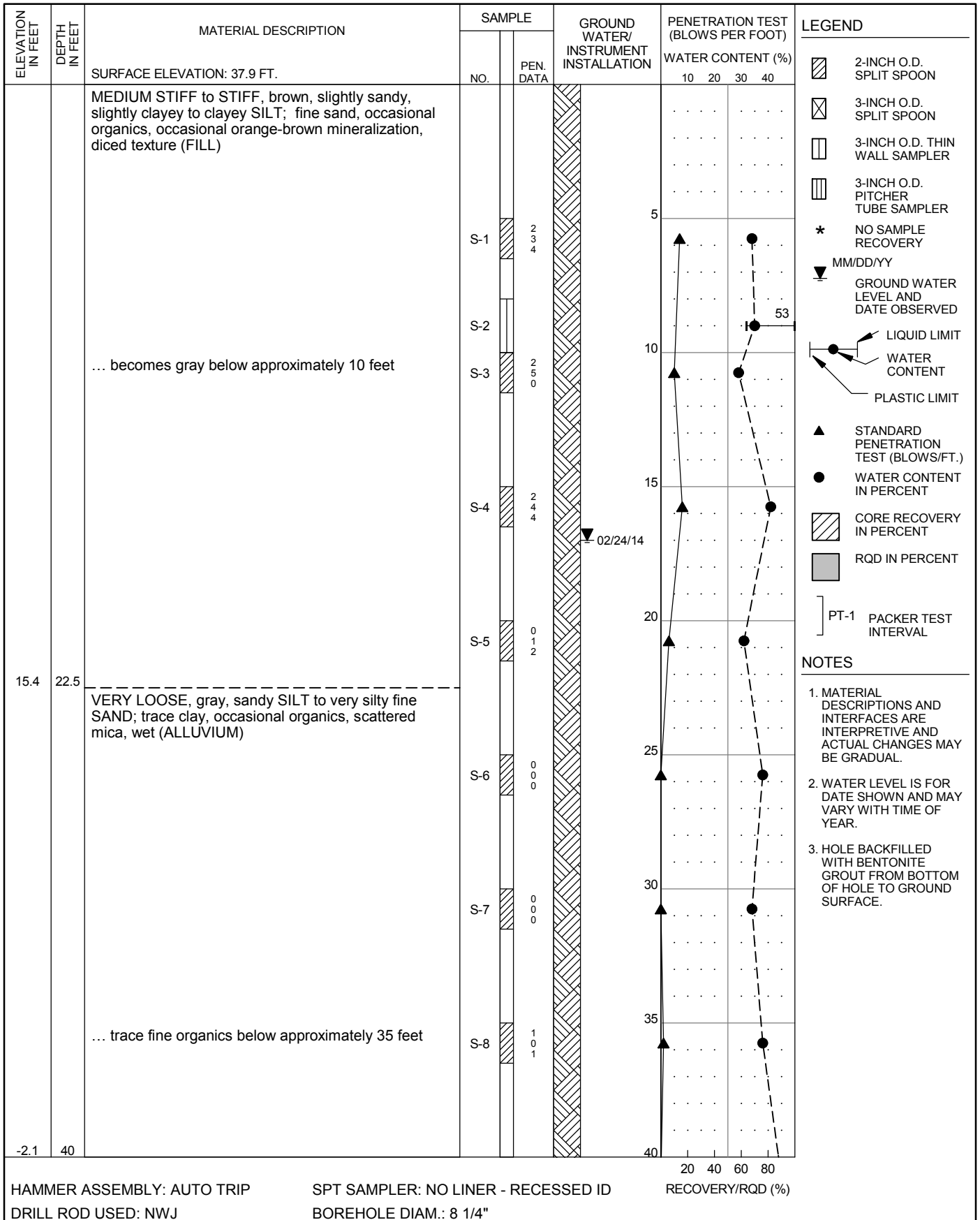
FIG. A31



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/21/2014 FINISH: 2/24/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-37 (1 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

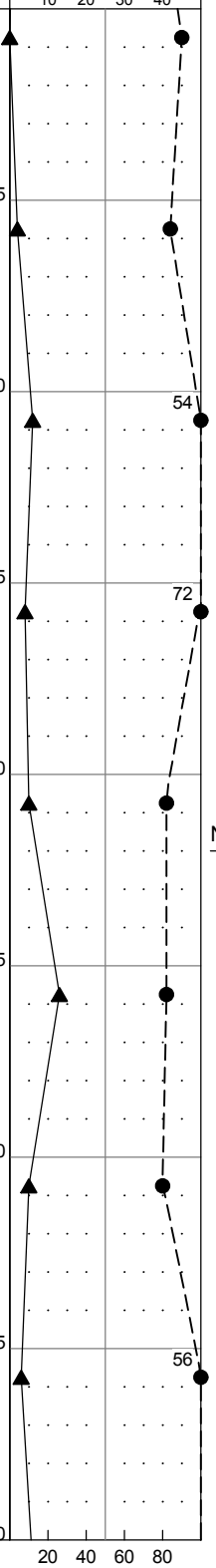
FIG. A32

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 37.9 FT.		
		(continued from previous page)	S-9	0 0 0
			S-10	0 0 2
-9.6	47.5	MEDIUM STIFF, gray, slightly sandy, slightly clayey SILT; fine sand, scattered organics, trace mica (ALLUVIUM)		
			S-11	2 3 3
			S-12	0 2 2
			S-13	
			S-14	0 3 2
		... becomes blue-gray below approximately 65 feet	S-15	2 5 8
-29.6	67.5	Interbedded: LOOSE, gray, silty fine SAND; and SOFT, gray, slightly sandy, slightly clayey SILT; occasional to scattered organics, scattered mica, wet (ALLUVIUM)		
			S-16	1 2 3
			S-17	0 0 3
-42.1	80			

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT, WATER CONTENT, PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE GROUT FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/21/2014 FINISH: 2/24/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-37 (2 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A32

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) WATER CONTENT (%)
		SURFACE ELEVATION: 37.9 FT.				10 20 30 40
-43.6	81.5	(continued from previous page)	S-18	0 2 4		69
		Bottom of Boring: 81.5 FT				

85
90
95
100
105
110
115
120

20 40 60 80
RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE GROUT FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/21/2014 FINISH: 2/24/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-37 (3 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

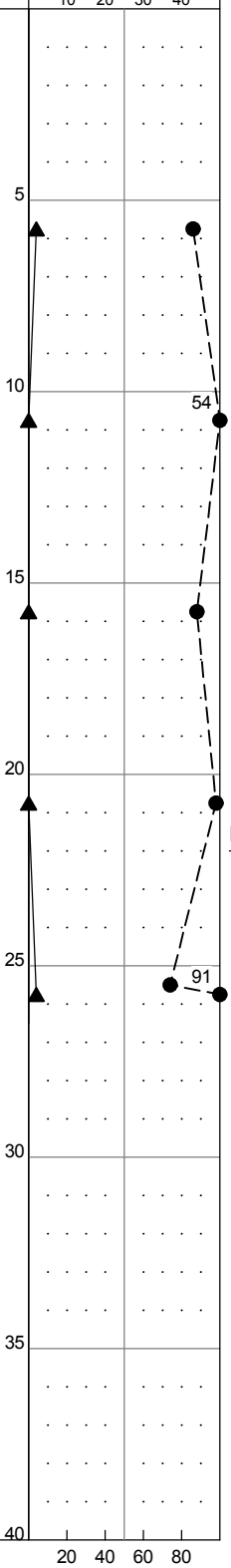
FIG. A32

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 9.4 FT.		
		SOFT, gray, silty CLAY to clayey SILT; occasional organics, scattered mica, wet (ALLUVIUM)	S-1	0 1 1
			S-2	
		… becomes slightly sandy at 10 feet	S-3	0 0 0
-5.6	15	SOFT, gray, slightly sandy, slightly clayey SILT interbedded with VERY LOOSE, gray, sandy SILT to silty fine SAND; scattered to numerous organics, numerous mica, wet (ALLUVIUM)	S-4	0 0 0
			S-5	0 0 0
-17.1	26.5	… becomes clayey at 25.5 feet	S-6	2 1 1
		Bottom of Boring: 26.5 FT		

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/6/2014 FINISH: 5/6/2014
DRILLING TECHNIQUE: MUD ROTARY

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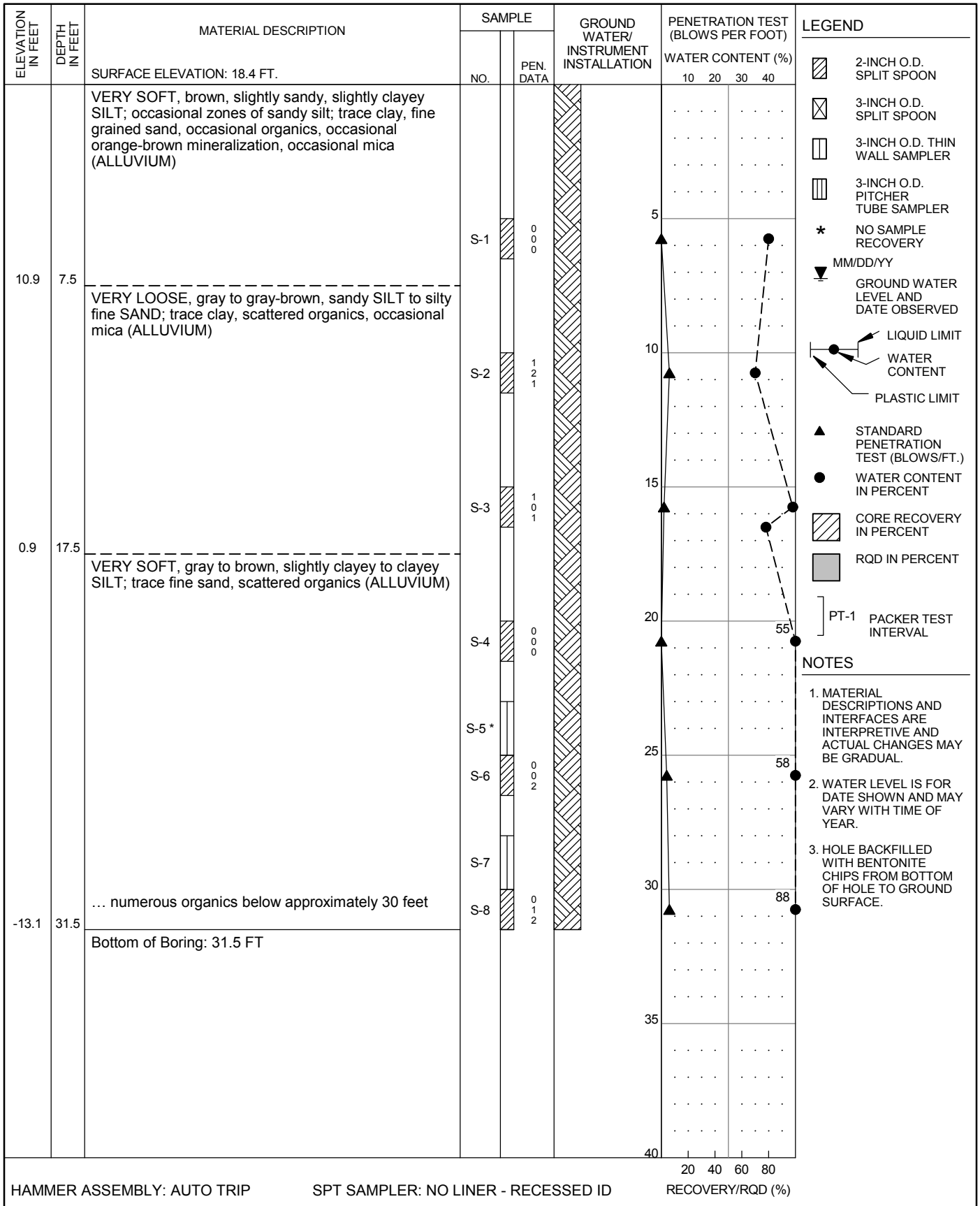
SUMMARY BORING LOG P1-CC-38

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A33



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 2/12/2014 FINISH: 2/12/2014
DRILLING TECHNIQUE: MUD ROTARY

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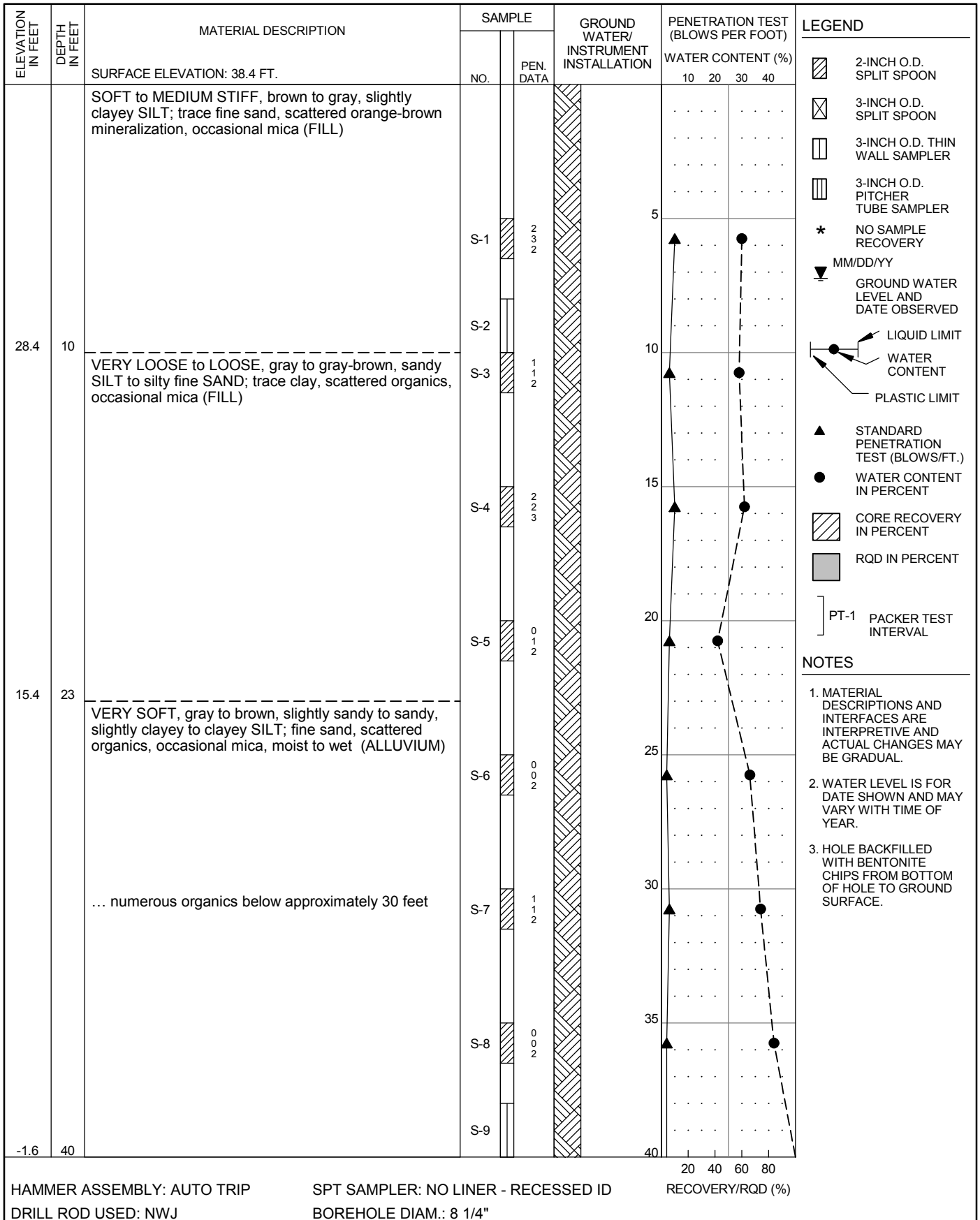
SUMMARY BORING LOG P1-CC-39

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A34



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/17/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-40 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

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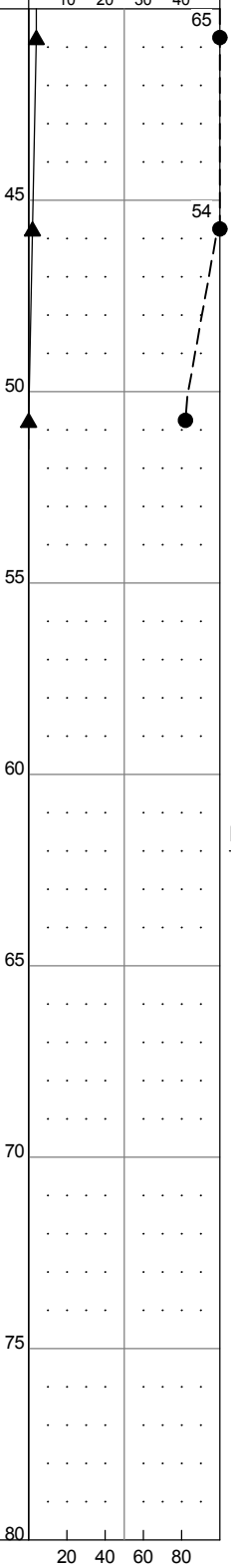
PROJ 2319
FIG. A35

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 38.4 FT.			
		(continued from previous page)	S-10	0 0 2	
			S-11	0 0 1	
			S.12	0 0 0	
-13.1	51.5	Bottom of Boring: 51.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/17/2014 FINISH: 2/17/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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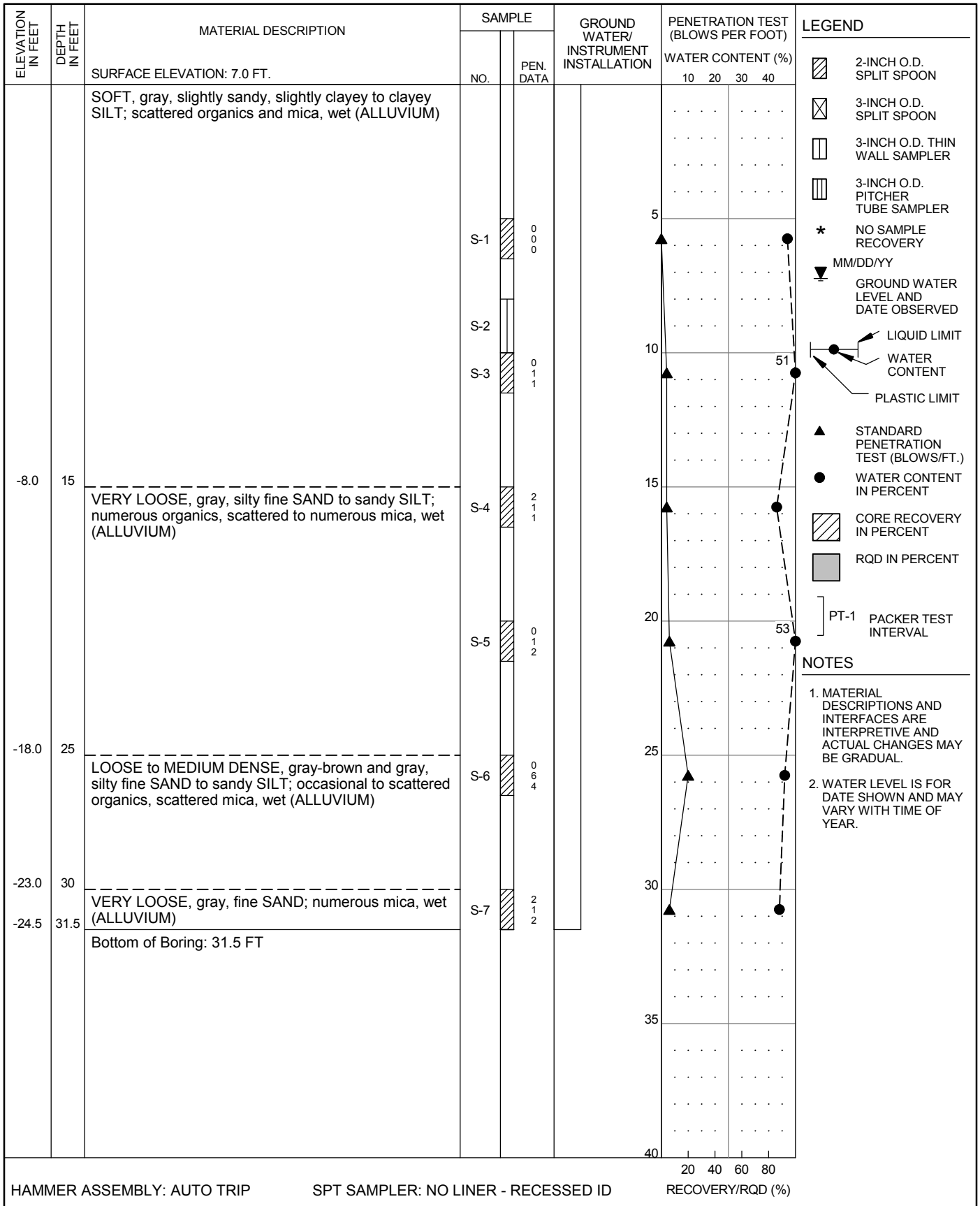
SUMMARY BORING LOG P1-CC-40 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A35



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/7/2014 FINISH: 5/7/2014
DRILLING TECHNIQUE: MUD ROTARY

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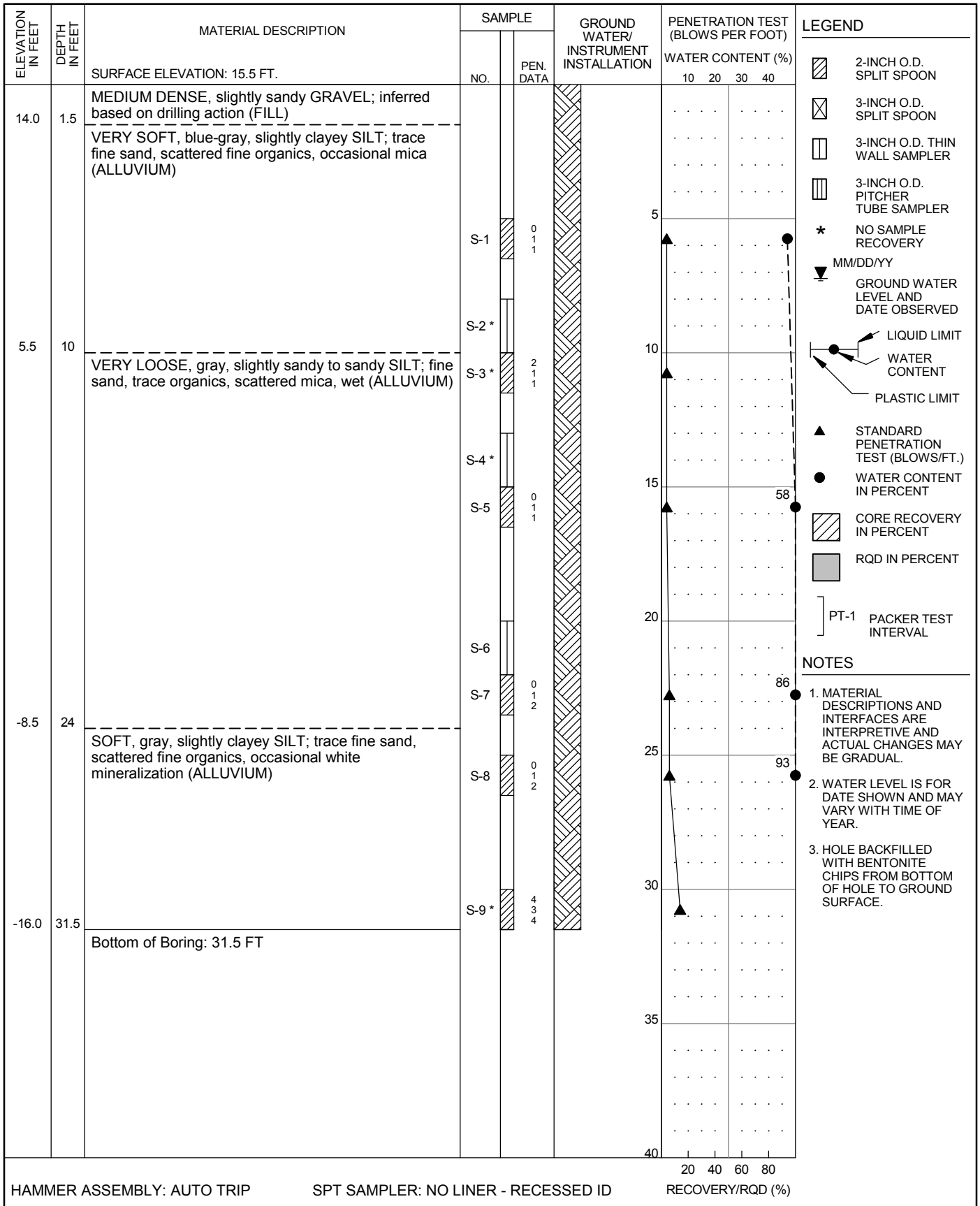
SUMMARY BORING LOG P1-CC-41

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A36



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 2/12/2014 FINISH: 2/12/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-42

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

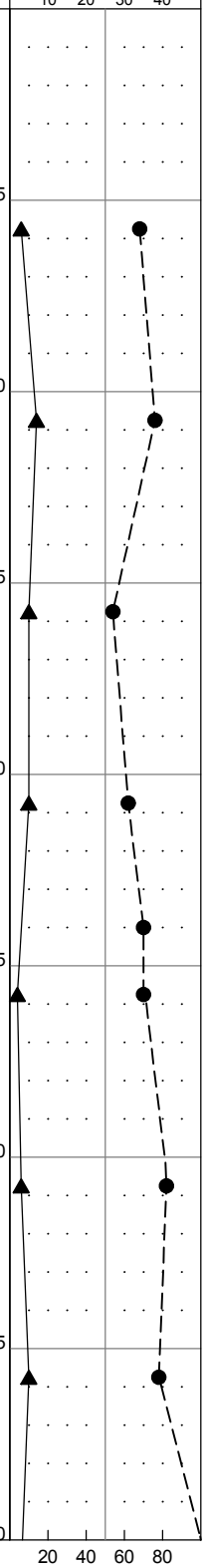
SEP 2014
PROJ 2319
FIG. A37

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 37.9 FT.		
		SOFT to MEDIUM STIFF, brown to gray-brown, slightly sandy, slightly clayey to clayey SILT; fine sand, scattered organics, orange-brown mineralization, diced texture (FILL)	S-1	2 1 2
			S-2	2 3 4
25.4	12.5	LOOSE, gray, sandy SILT; trace clay, fine sand, occasional lenses slightly clayey silt up to ¼-inch thick, scattered organics, occasional blue-green mineralization, occasional mica (FILL)	S-3	1 2 3
20.4	17.5	MEDIUM STIFF, gray, slightly sandy, slightly clayey to clayey SILT; fine sand, scattered organics (FILL)	S-4	1 2 3
15.4	22.5	SOFT to MEDIUM STIFF, gray-brown to gray, sandy, slightly clayey to clayey SILT; fine sand, occasional lenses slightly sandy silt, scattered to numerous organics, occasional mica (ALLUVIUM)	S-5	
			S-6	0 0 2
			S-7	0 0 3
			S-8	0 3 2
-2.1	40			

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/18/2014 FINISH: 2/18/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-43 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

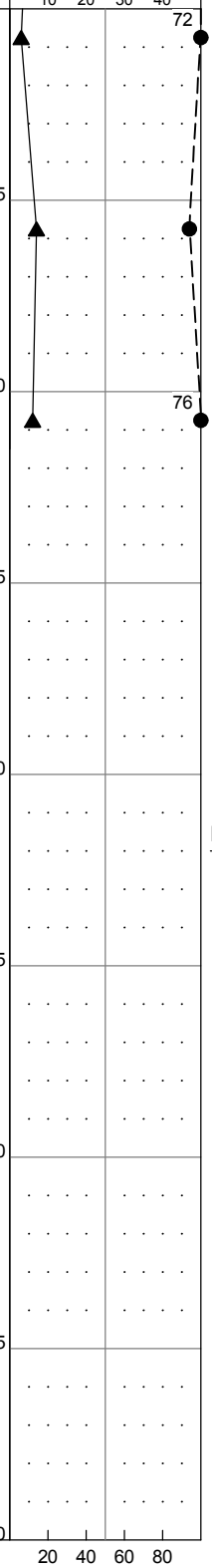
PROJ 2319

FIG. A38

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 37.9 FT.			
		(continued from previous page)	S-9	0 0 3	
		… becomes MEDIUM STIFF below approximately 43 feet	S-10		
			S-11	1 3 4	
			S-12	0 2 4	
-13.6	51.5	Bottom of Boring: 51.5 FT			

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/18/2014 FINISH: 2/18/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-43 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

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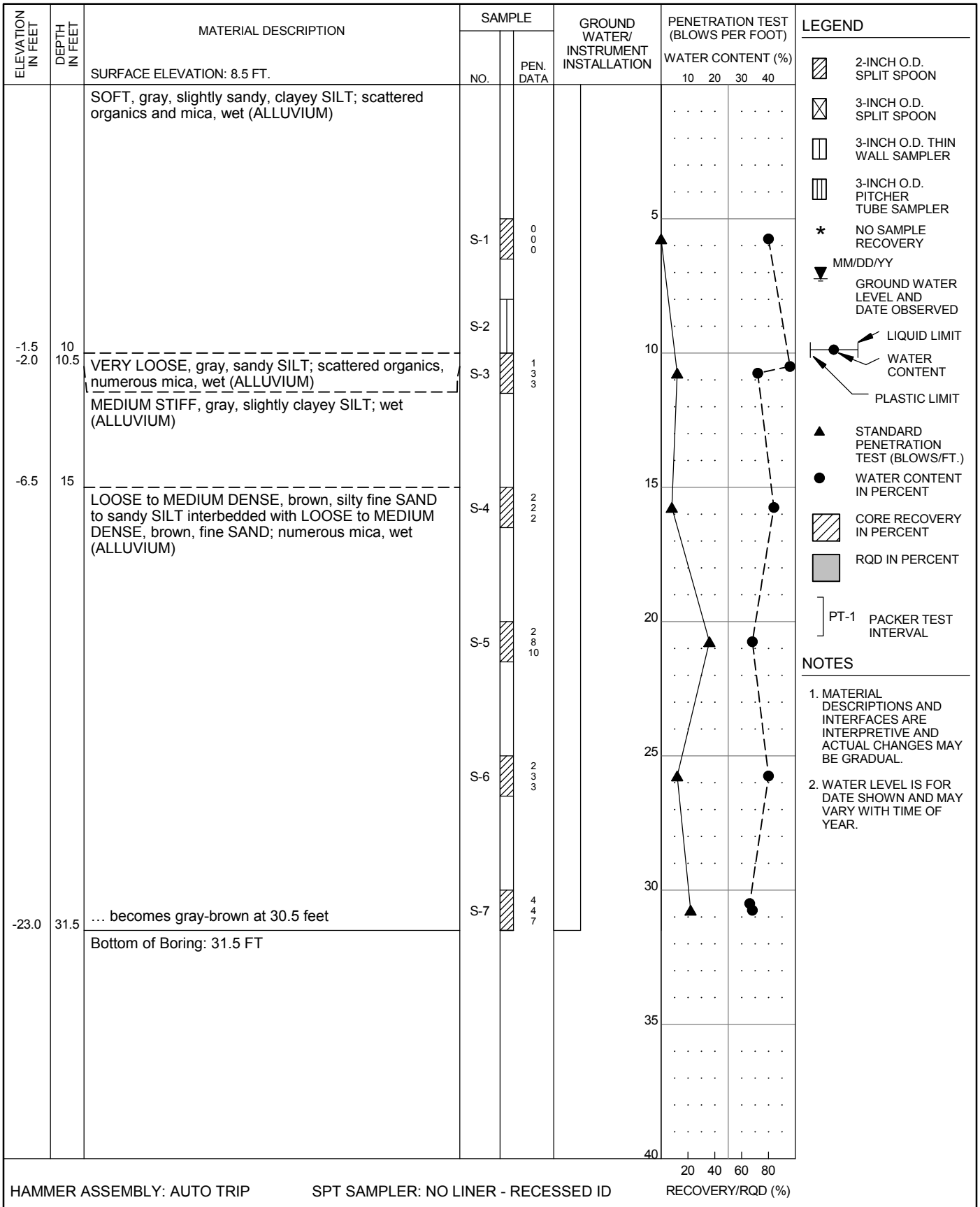
FIG. A38



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/5/2014 FINISH: 5/5/2014
DRILLING TECHNIQUE: MUD ROTARY

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10250 S.W. Greenburg Road, Suite 111
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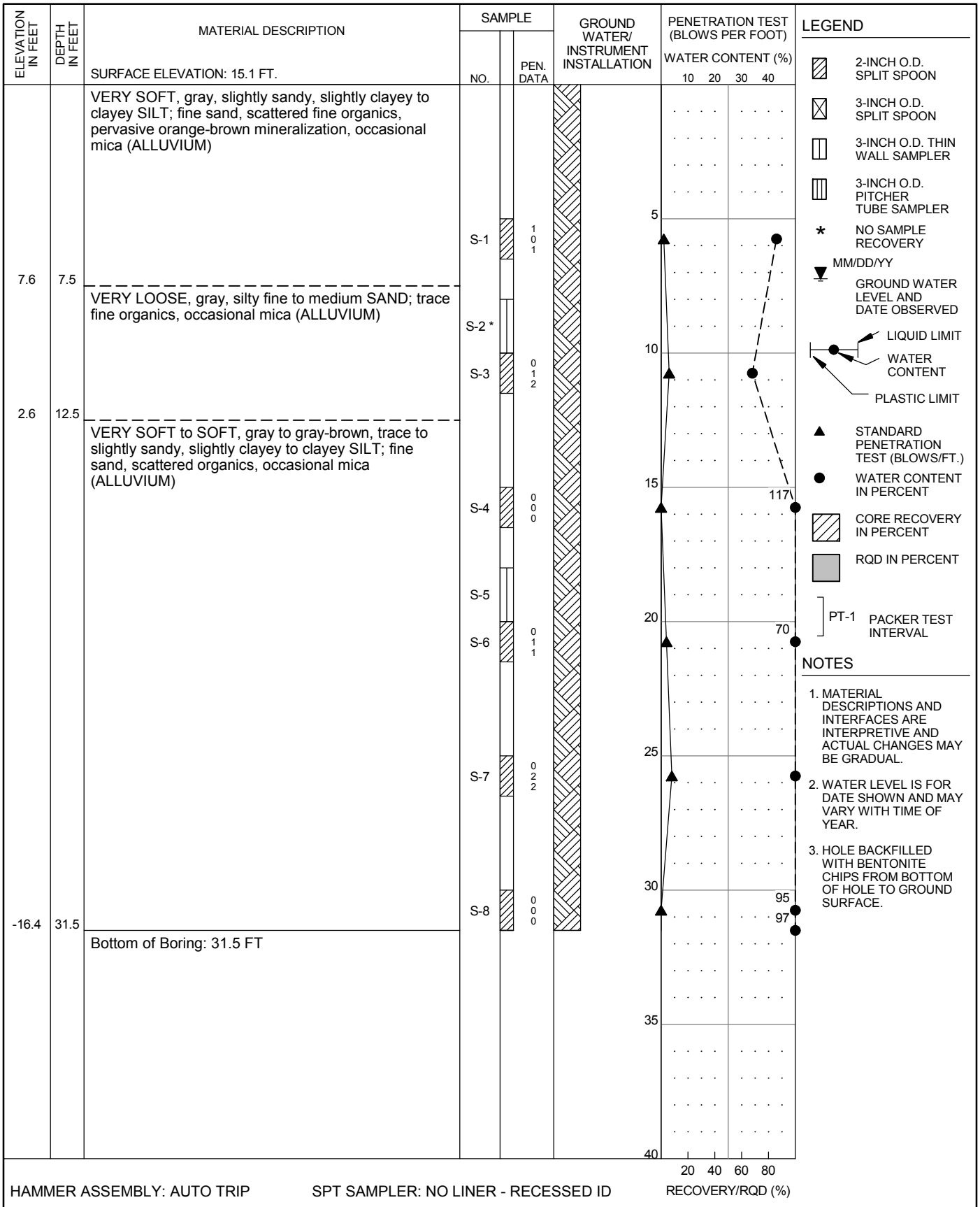
SUMMARY BORING LOG P1-CC-44

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A39



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 2/11/2014 FINISH: 2/11/2014
DRILLING TECHNIQUE: MUD ROTARY

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SUMMARY BORING LOG P1-CC-45

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A40

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 38.4 FT.			
		Interbedded: LOOSE, brown, sandy SILT; trace clay, and VERY SOFT to SOFT, brown to gray, slightly sandy, slightly clayey to clayey SILT; fine sand, occasional organics, occasional mica (FILL)	S-1	0 0 0	
			S-2	1 3 3	
			S-3	1 2 3	
			S-4		
			S-5	0 2 2	
14.9	23.5	VERY SOFT to SOFT, brown, sandy to very sandy, slightly clayey to clayey SILT; fine sand, lenses of sandy silt up to 6-inches thick, scattered organics, occasional mica (ALLUVIUM)	S-6	0 0 1	
		… becomes gray below 31 feet	S-7	0 0 0	
			S-8	0 1 2	
-1.6	40		S-9		

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

5 10 15 20 25 30 35 40

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP

DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID

BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES

DATE START: 2/18/2014 FINISH: 2/18/2014

DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-46 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A41

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 38.4 FT.			
		(continued from previous page)	S-10	1 2 2	
		… becomes MEDIUM STIFF below approximately 40 feet			
			S-11	2 2 3	
-9.1	47.5	LOOSE, gray, sandy SILT; fine sand, scattered organics, scattered mica (ALLUVIUM)			
			S-12	0 2 2	
-13.1	51.5	Bottom of Boring: 51.5 FT			

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

63

45 50 55 60 65 70 75 80

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/18/2014 FINISH: 2/18/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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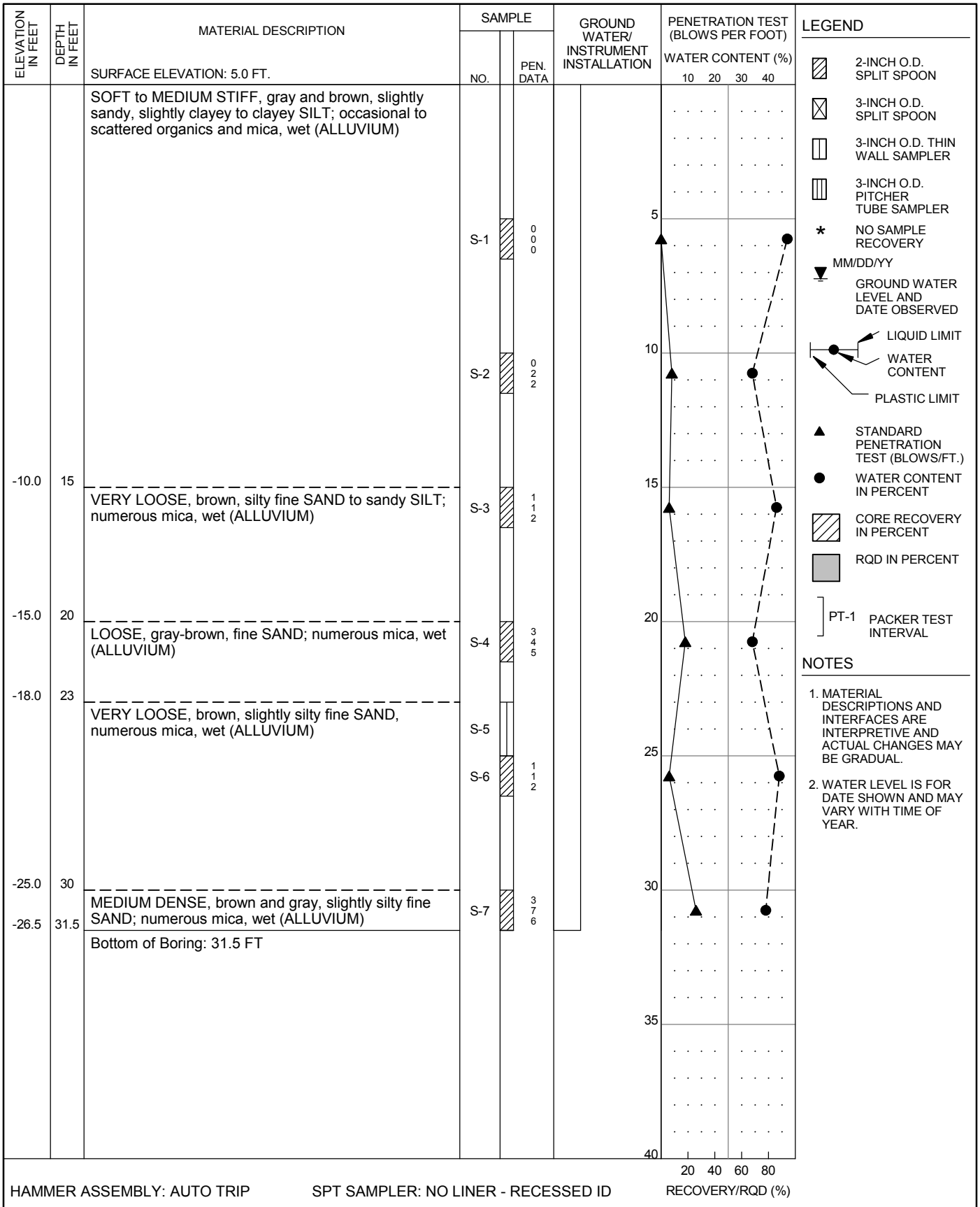
SUMMARY BORING LOG P1-CC-46 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A41



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/5/2014 FINISH: 5/5/2014
DRILLING TECHNIQUE: MUD ROTARY

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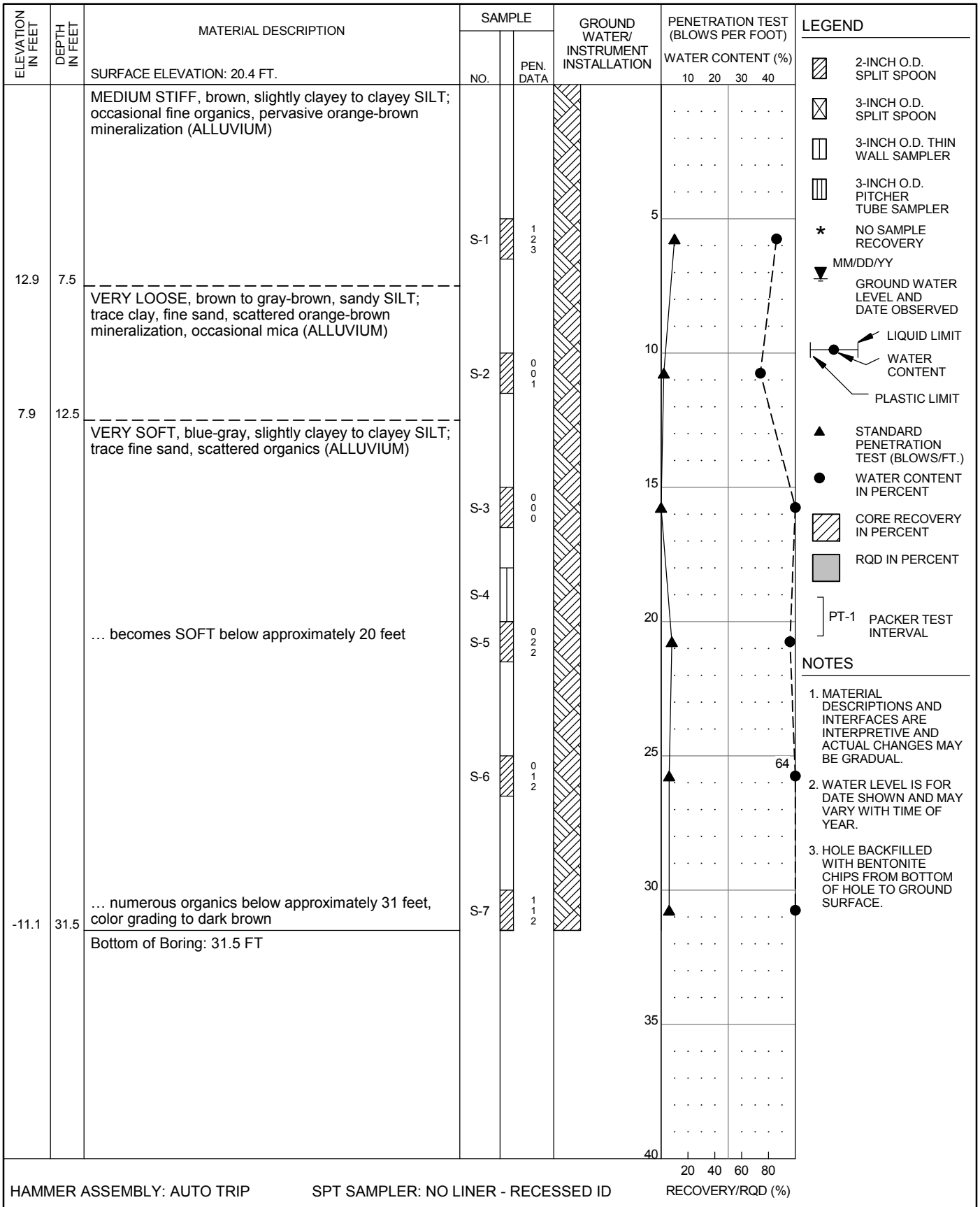
SUMMARY BORING LOG P1-CC-47

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A42



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/12/2014 FINISH: 2/12/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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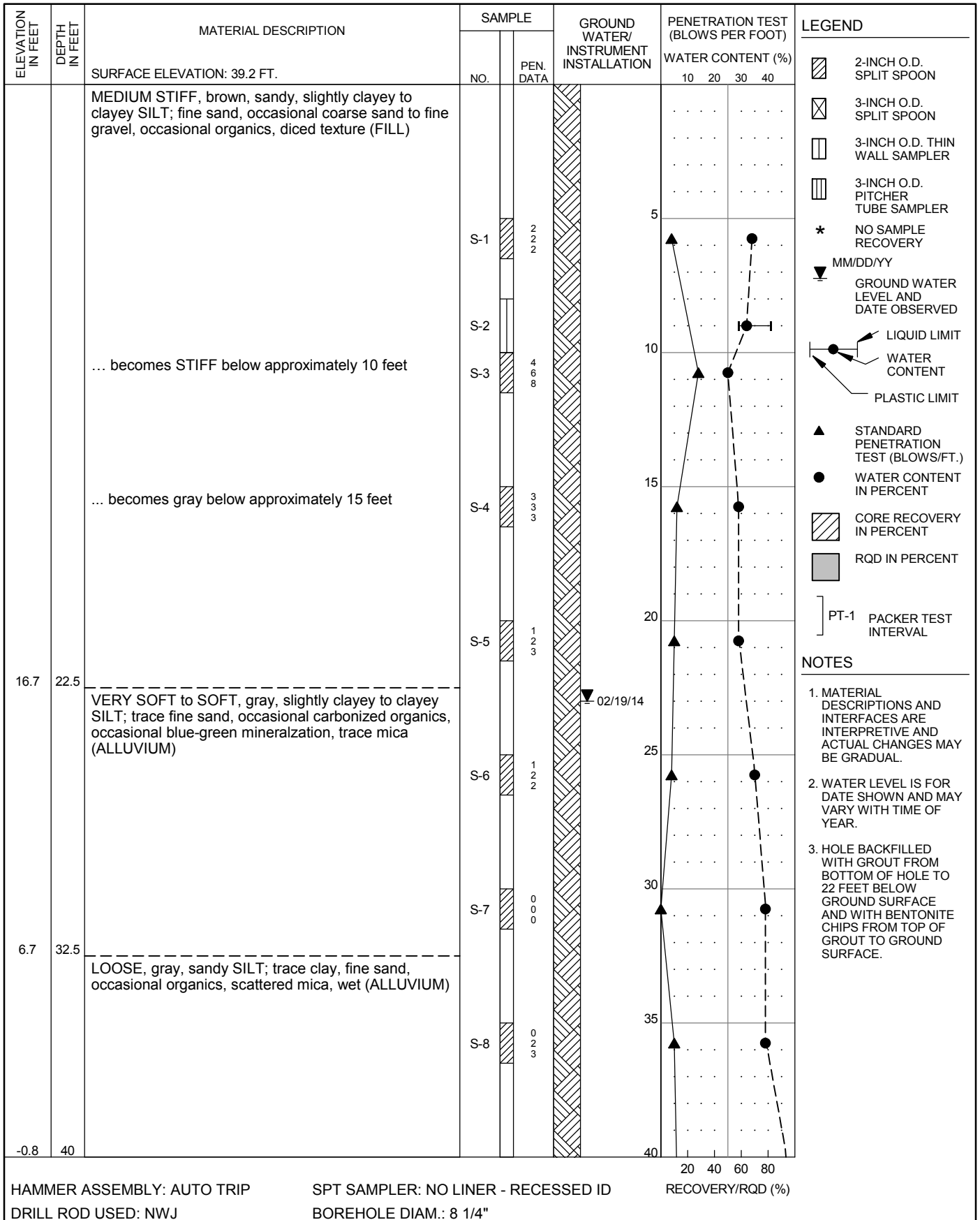
SUMMARY BORING LOG P1-CC-48

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A43



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/19/2014 FINISH: 2/20/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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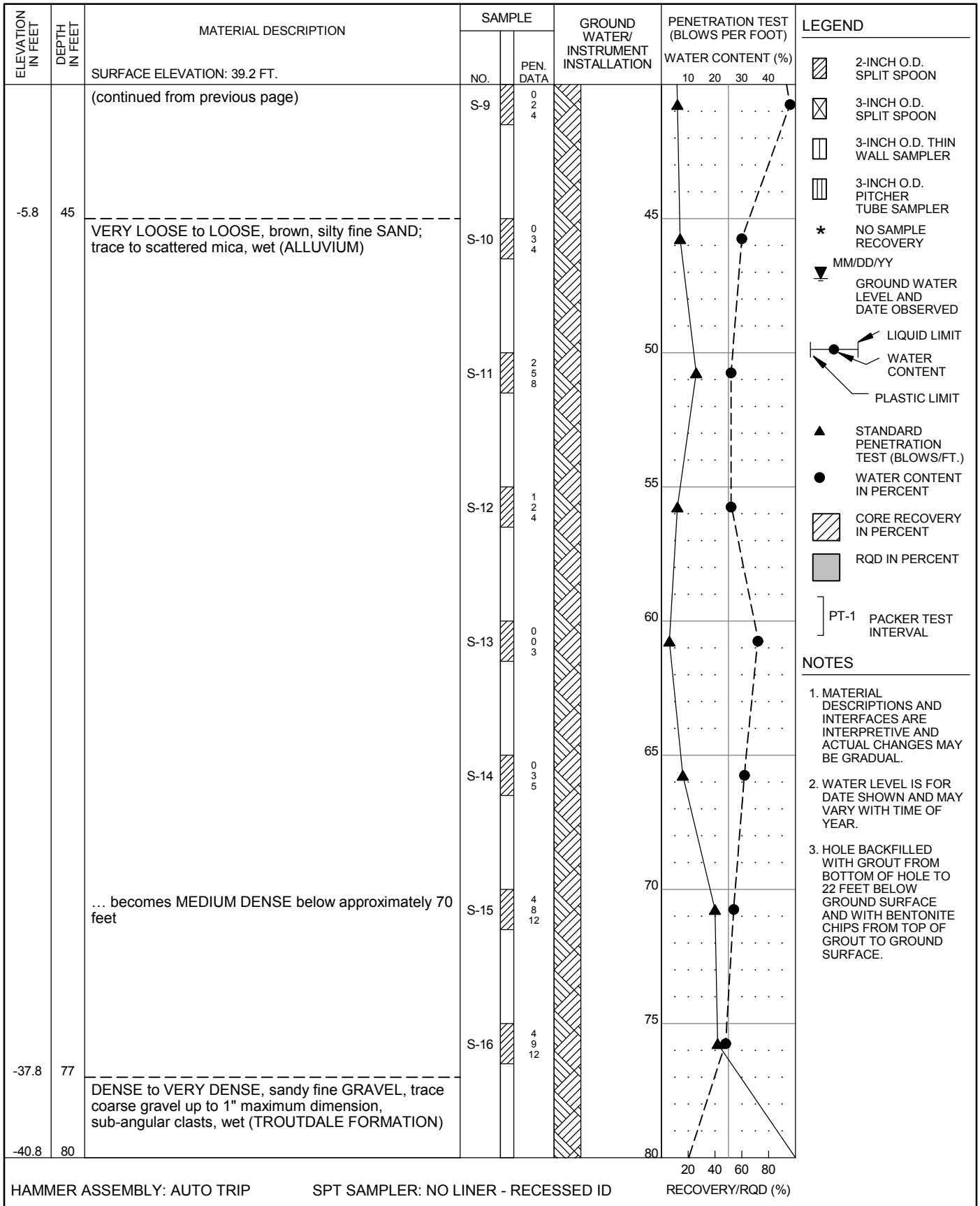
SUMMARY BORING LOG P1-CC-49 (1 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A44



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/19/2014 FINISH: 2/20/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-49 (2 of 3)

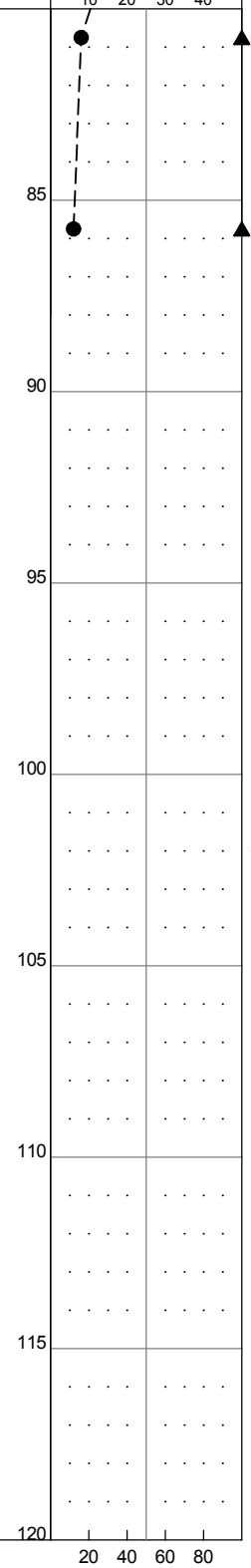
PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A44

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 39.2 FT.			
		(continued from previous page)	S-17	9 30 30	
			S-18	22 21 37	
-48.8	88	… boring terminated after refusal at 87.8 feet			
		Bottom of Boring: 88 FT			

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH GROUT FROM BOTTOM OF HOLE TO 22 FEET BELOW GROUND SURFACE AND WITH BENTONITE CHIPS FROM TOP OF GROUT TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/19/2014 FINISH: 2/20/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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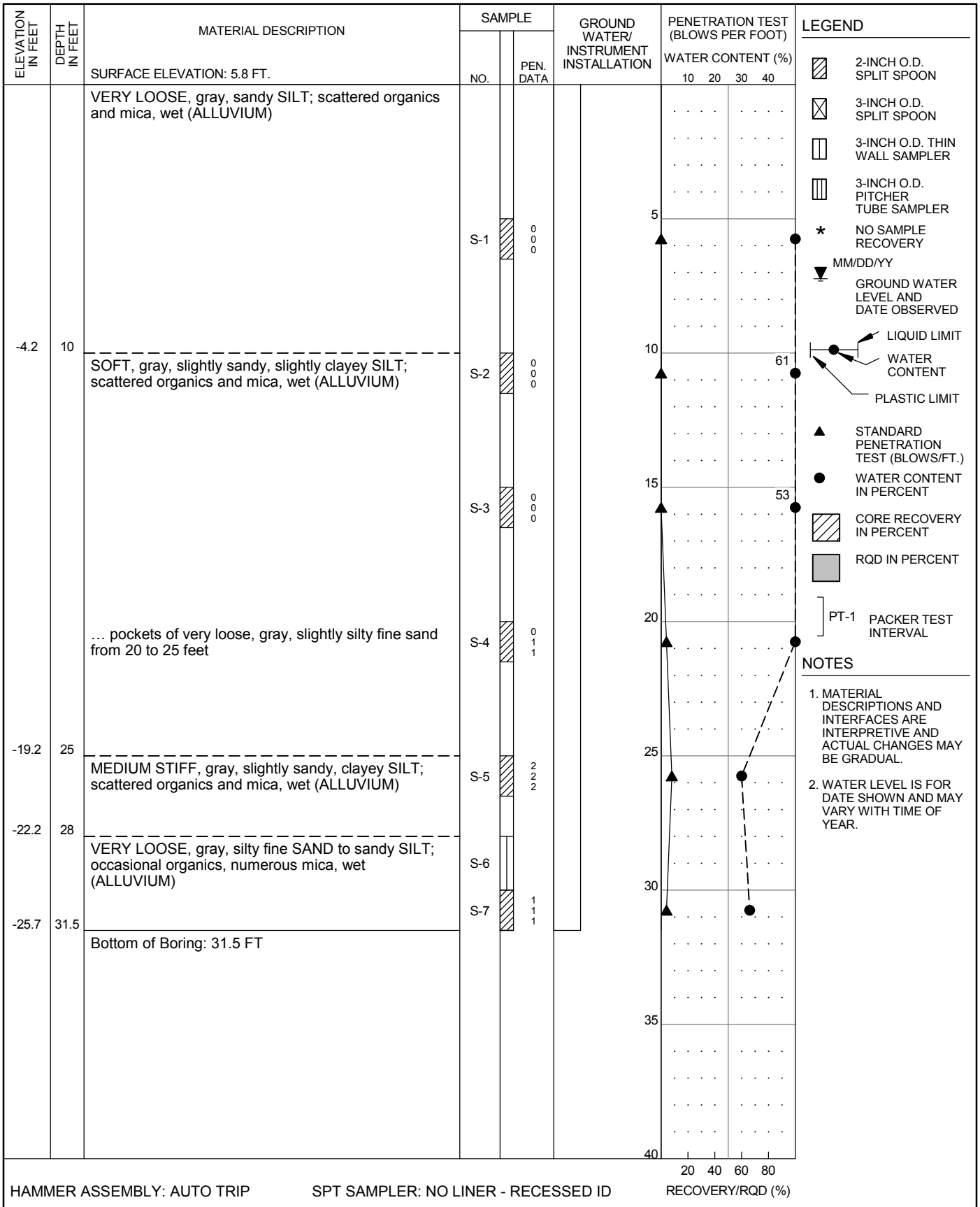
SUMMARY BORING LOG P1-CC-49 (3 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A44



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/5/2014 FINISH: 5/5/2014
DRILLING TECHNIQUE: MUD ROTARY

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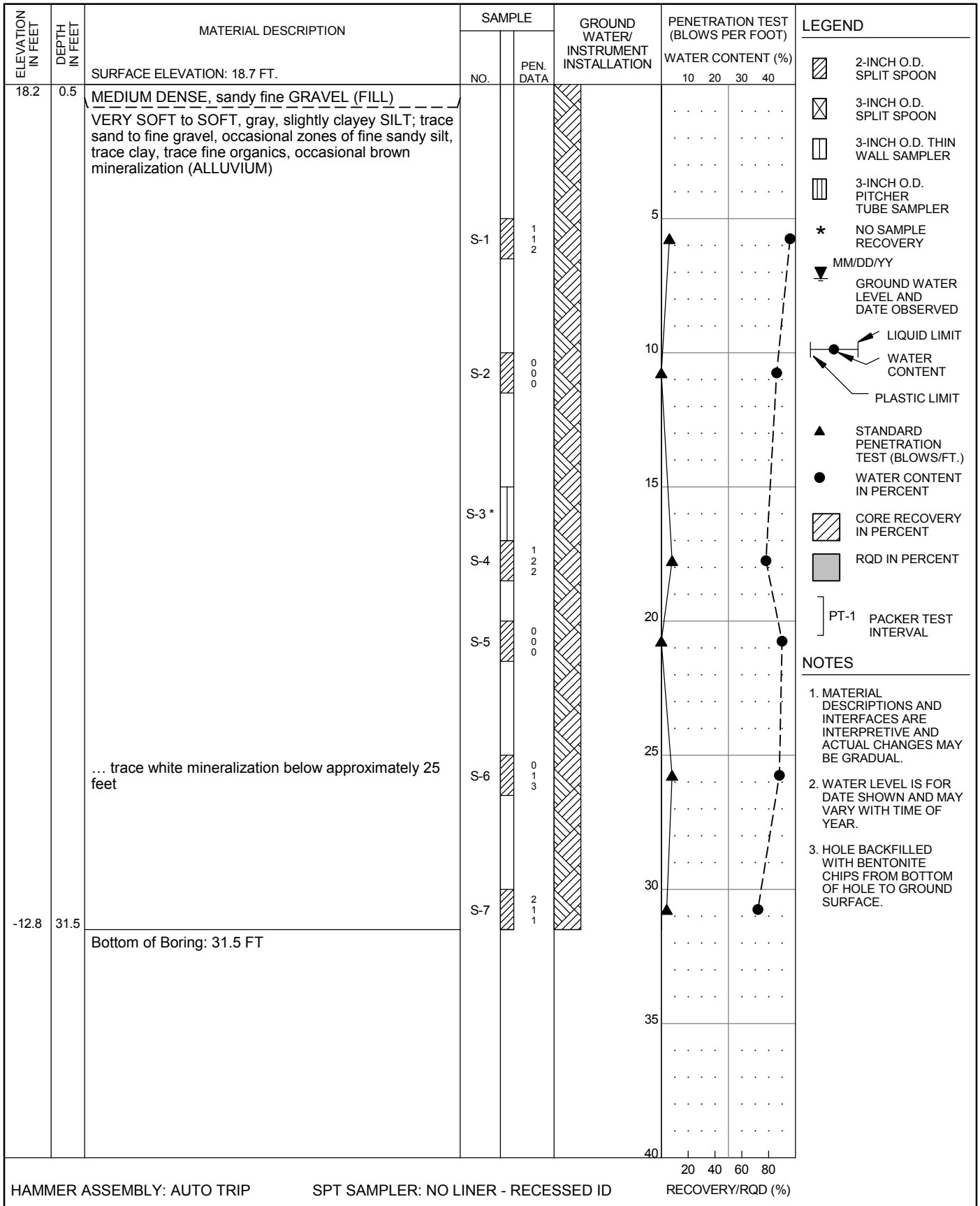
SUMMARY BORING LOG P1-CC-50

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A45



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 2/11/2014 FINISH: 2/11/2014
DRILLING TECHNIQUE: MUD ROTARY

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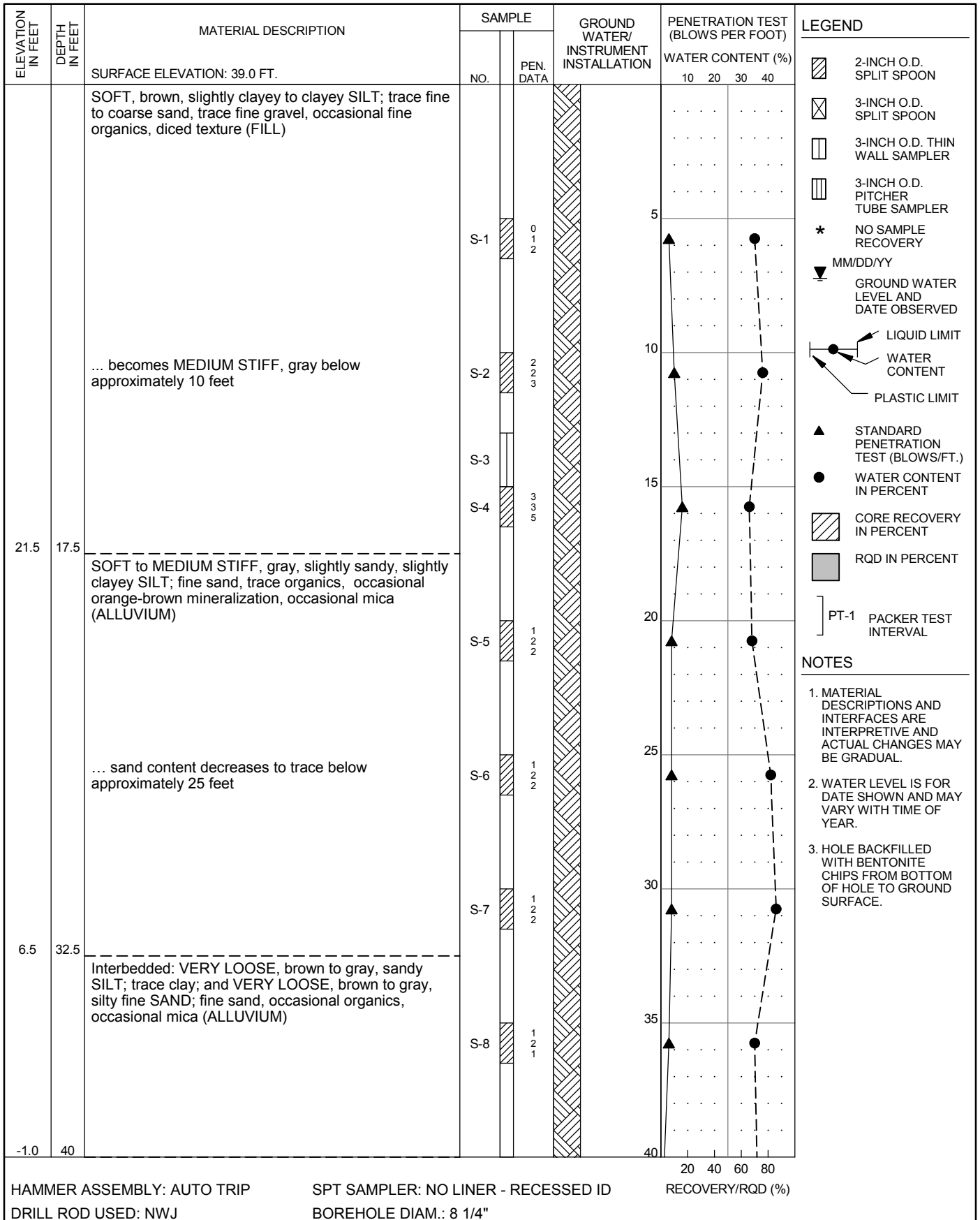
SUMMARY BORING LOG P1-CC-51

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A46



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/18/2014 FINISH: 2/19/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-52 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A47

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 39.0 FT.			
		(continued from previous page)	S-9	0 0 1	
-3.5	42.5	SOFT, gray, slightly sandy, slightly clayey SILT; occasional lenses sandy silt up to 1-inch thick, occasional organics (ALLUVIUM)	S-10	0 1 2	
			S-11		
-12.5	51.5	… clay content decreases below approximately 50 feet	S-12	1 2 2	
		Bottom of Boring: 51.5 FT			

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

45 50 55 60 65 70 75 80

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/18/2014 FINISH: 2/19/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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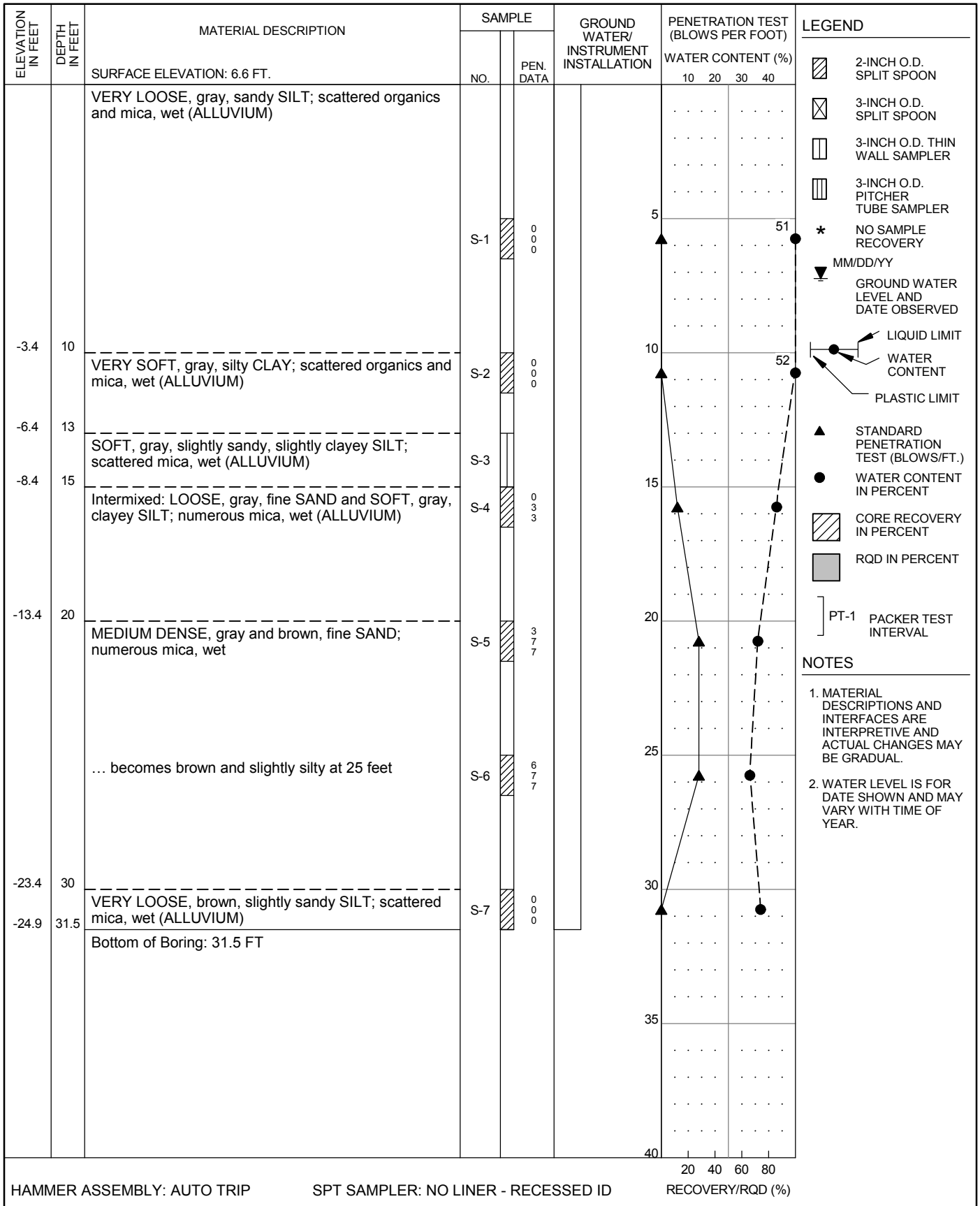
SUMMARY BORING LOG P1-CC-52 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A47



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 5/2/2014 FINISH: 5/2/2014
DRILLING TECHNIQUE: MUD ROTARY

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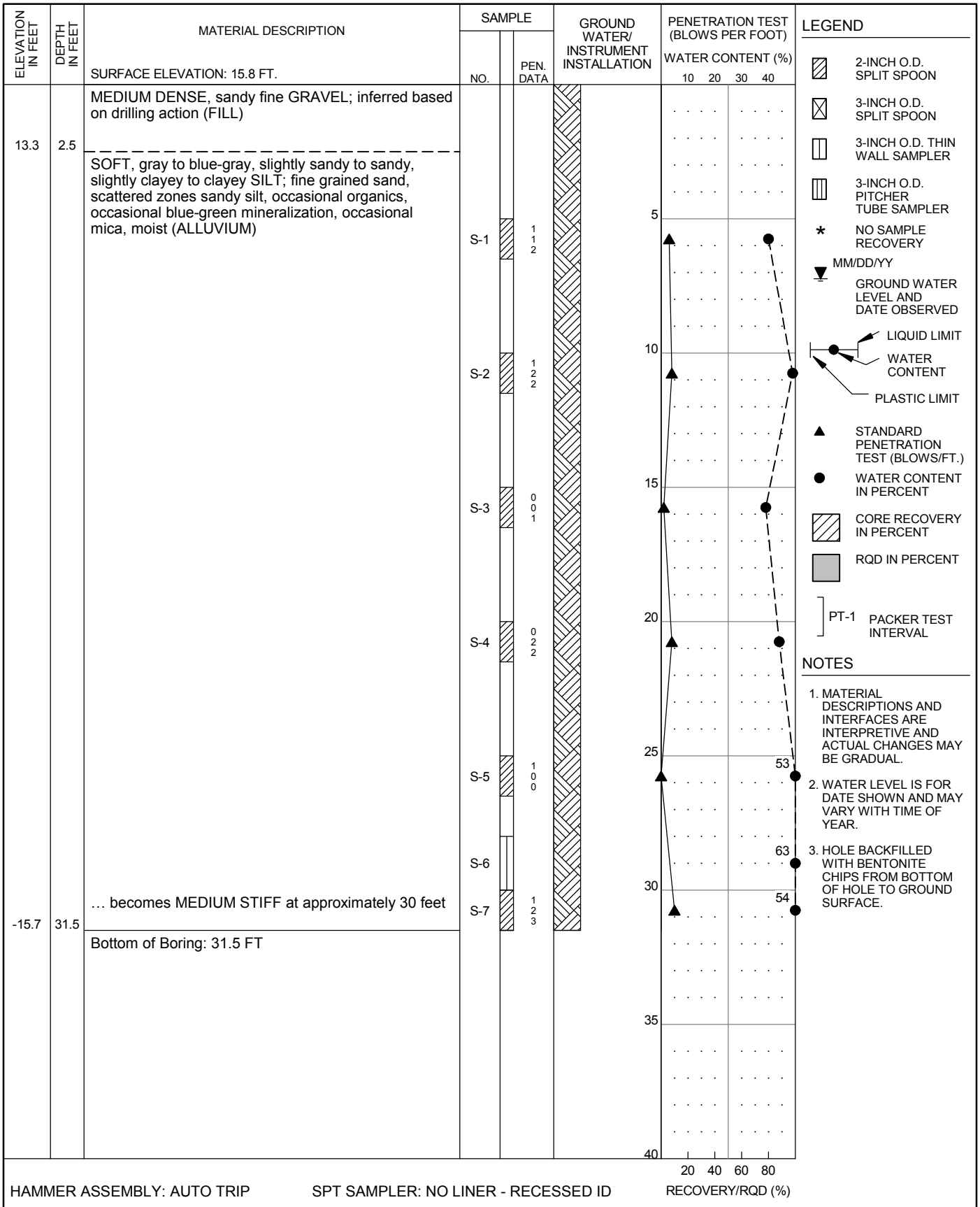
SUMMARY BORING LOG P1-CC-53

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A48



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/14/2014 FINISH: 2/14/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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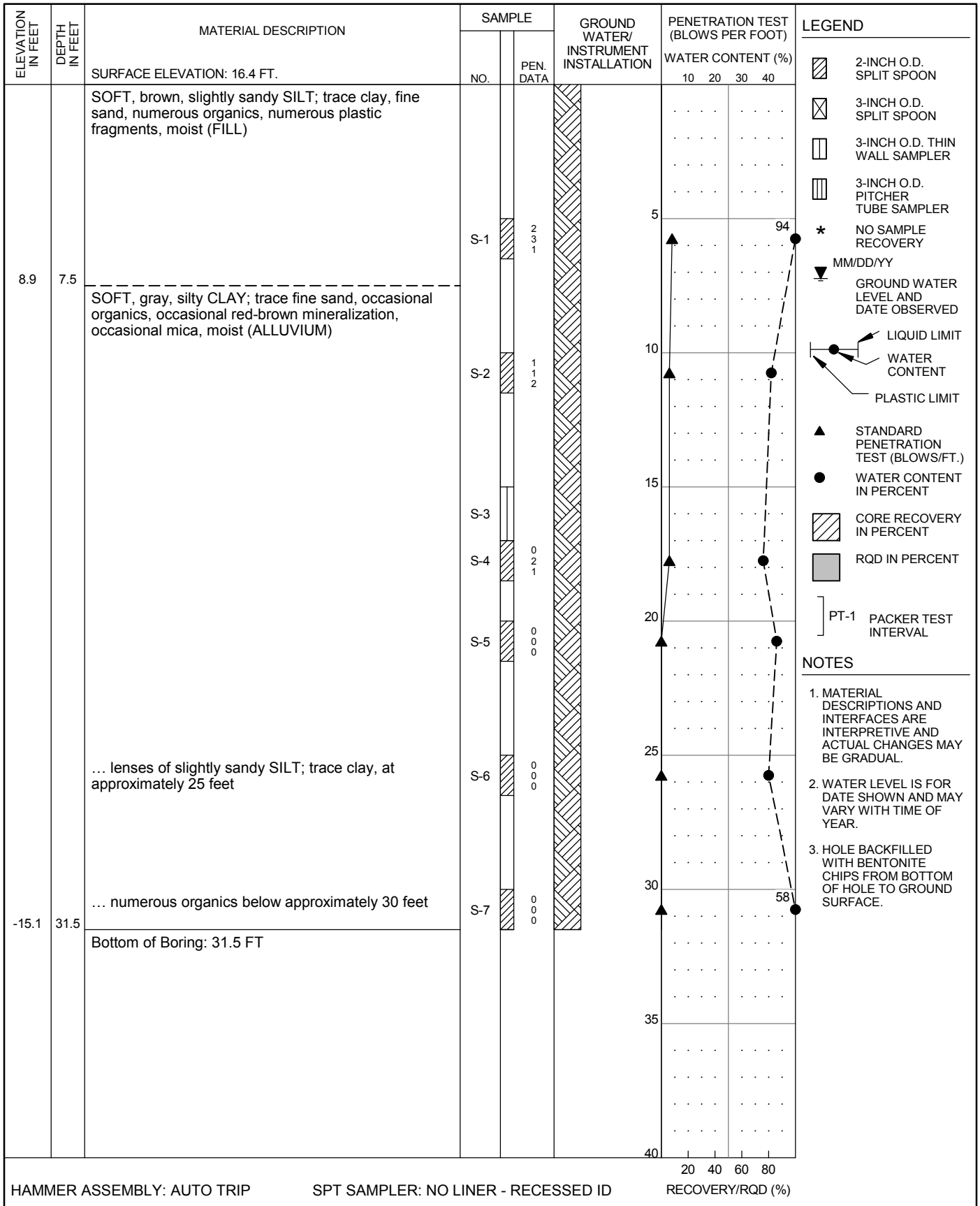
SUMMARY BORING LOG P1-CC-54

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A49



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 3 7/8"

DRILLER: WESTERN STATES
DATE START: 2/21/2014 FINISH: 2/21/2014
DRILLING TECHNIQUE: MUD ROTARY

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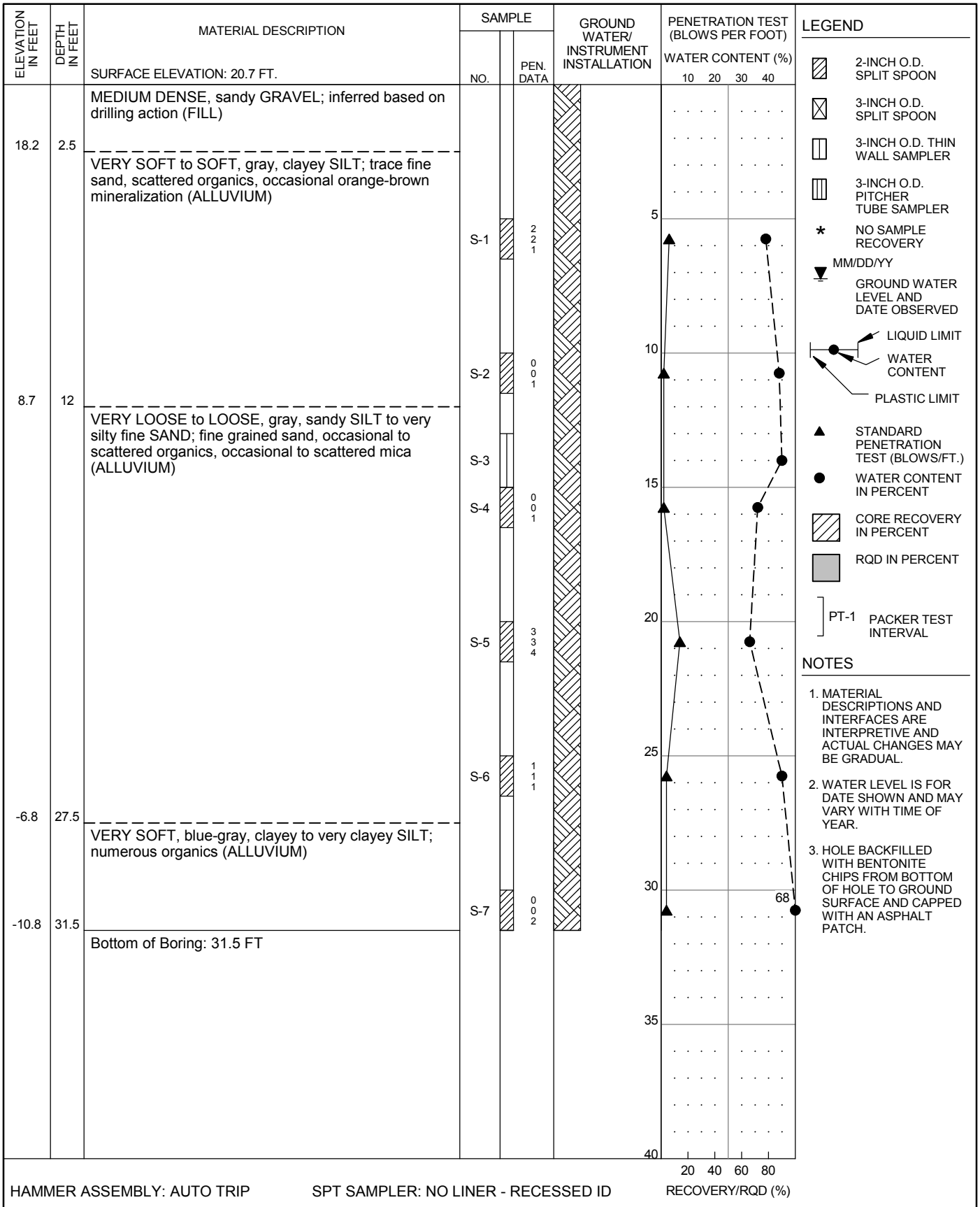
SUMMARY BORING LOG P1-CC-55

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A50



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 2/11/2014 FINISH: 2/11/2014
DRILLING TECHNIQUE: MUD ROTARY

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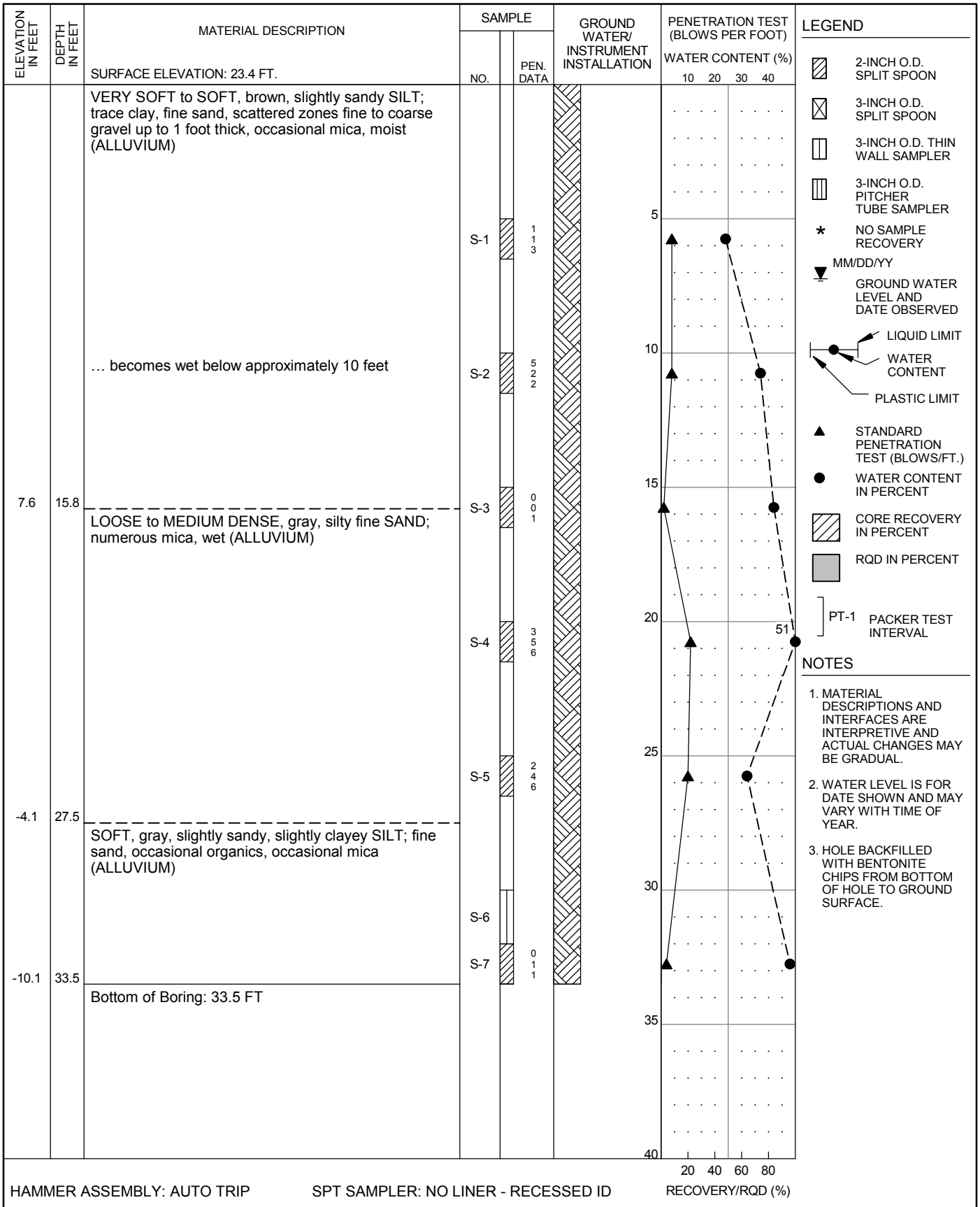
SUMMARY BORING LOG P1-CC-56

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A51



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 2/21/2014 FINISH: 2/21/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-57

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A52

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 42.5 FT.		
		LOOSE, brown, fine to medium SAND; occasional fine organics, occasional mica, moist (FILL)		
		... trace cobbles to approximately 5 feet below ground surface	S-1	3 3 3
			S-2	2 2 2
			S-3	2 3 2
			S-4	3 3 4
			S-5	4 4 4
		… ½-inch lens brown clayey silt at approximately 26 feet		
		… becomes wet below approximately 28 feet		
			S-6	5 3 6
		… becomes gray below approximately 35 feet, fine sand content increasing with depth	S-7	3 3 4
5.0	37.5			
		SOFT, gray, slightly sandy to sandy, slightly clayey SILT; numerous organics, scattered mica (ALLUVIUM)		
2.5	40			

GROUND WATER/ INSTRUMENT INSTALLATION

03/07/14

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

5 10 15 20 25 30 35 40

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH GROUT FROM BOTTOM OF HOLE TO APPROXIMATELY 40 FEET AND WITH BENTONITE CHIPS FROM TOP OF GROUT TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP

DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID

BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES

DATE START: 3/6/2014 FINISH: 3/7/2014

DRILLING TECHNIQUE: HOLLOW STEM AUGER

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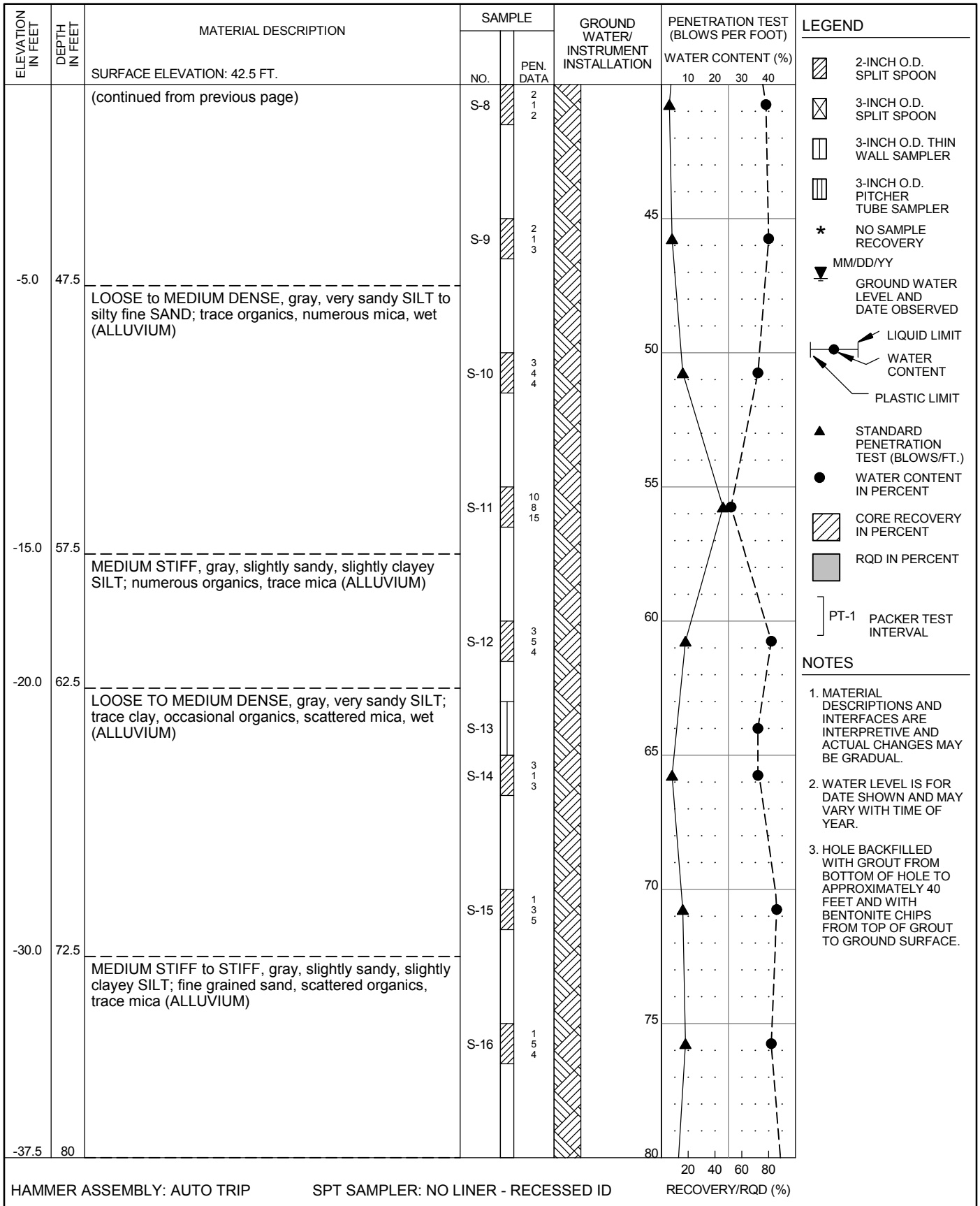
SUMMARY BORING LOG P1-CC-58 (1 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A53



NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH GROUT FROM BOTTOM OF HOLE TO APPROXIMATELY 40 FEET AND WITH BENTONITE CHIPS FROM TOP OF GROUT TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 3/6/2014 FINISH: 3/7/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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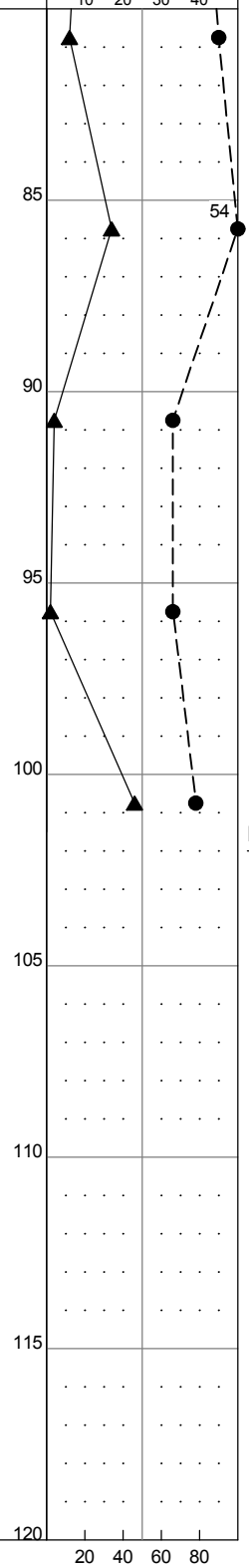
SUMMARY BORING LOG P1-CC-58 (2 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A53

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 42.5 FT.			
		(continued from previous page)	S-17	0 0 6	
			S-18	0 10 7	
			S-19	0 1 1	
-50.0	92.5	LOOSE, gray, very sandy SILT to silty fine SAND: trace organics, trace mica, wet (ALLUVIUM)			
			S-20	1 0 1	
-59.0	101.5	… becomes MEDIUM DENSE at approximately 100 feet	S-21	8 8 15	
		Bottom of Boring: 101.5 FT			



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH GROUT FROM BOTTOM OF HOLE TO APPROXIMATELY 40 FEET AND WITH BENTONITE CHIPS FROM TOP OF GROUT TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 3/6/2014 FINISH: 3/7/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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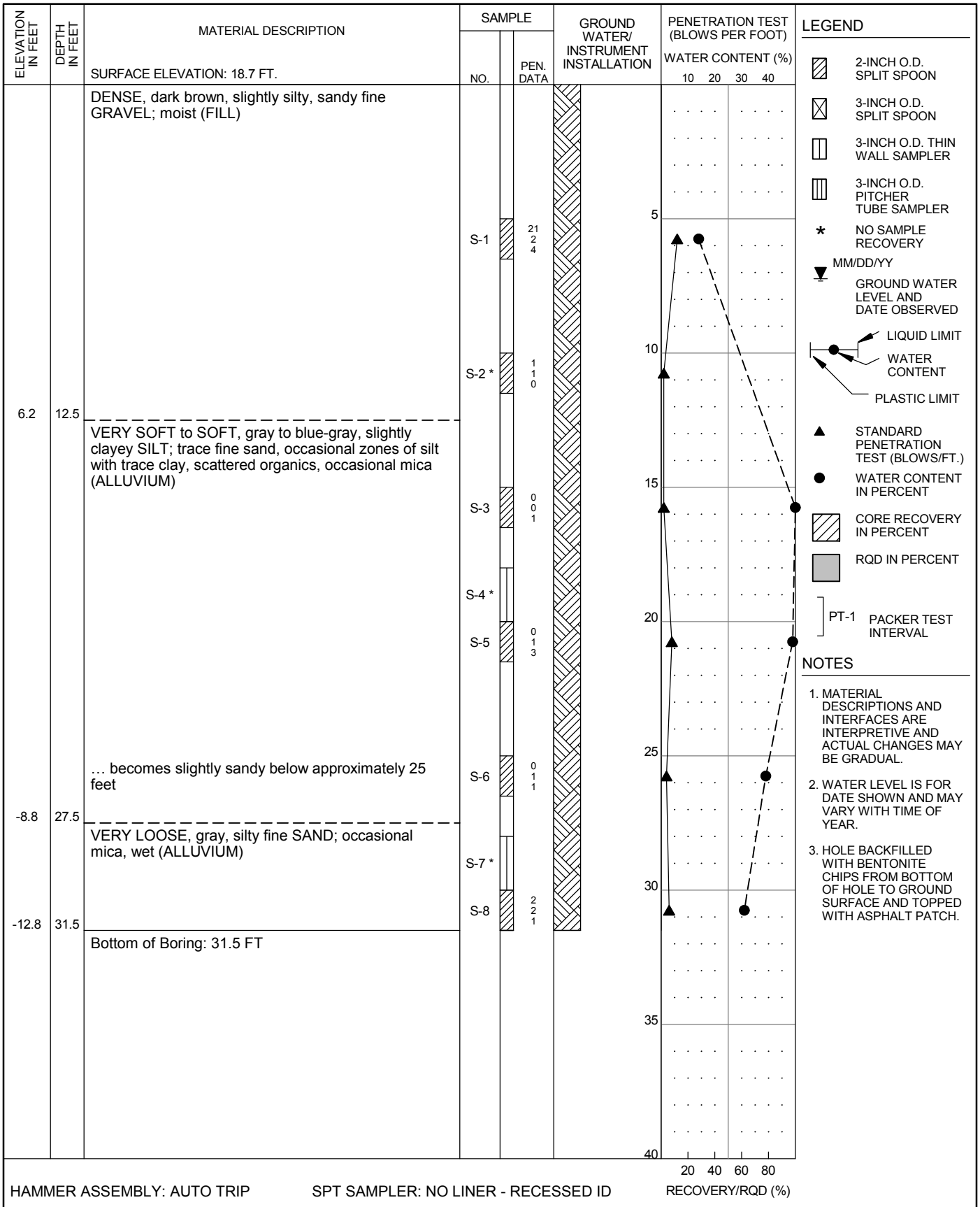
SUMMARY BORING LOG P1-CC-58 (3 of 3)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A53



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 4 7/8"

DRILLER: WESTERN STATES
DATE START: 3/6/2014 FINISH: 3/6/2014
DRILLING TECHNIQUE: MUD ROTARY

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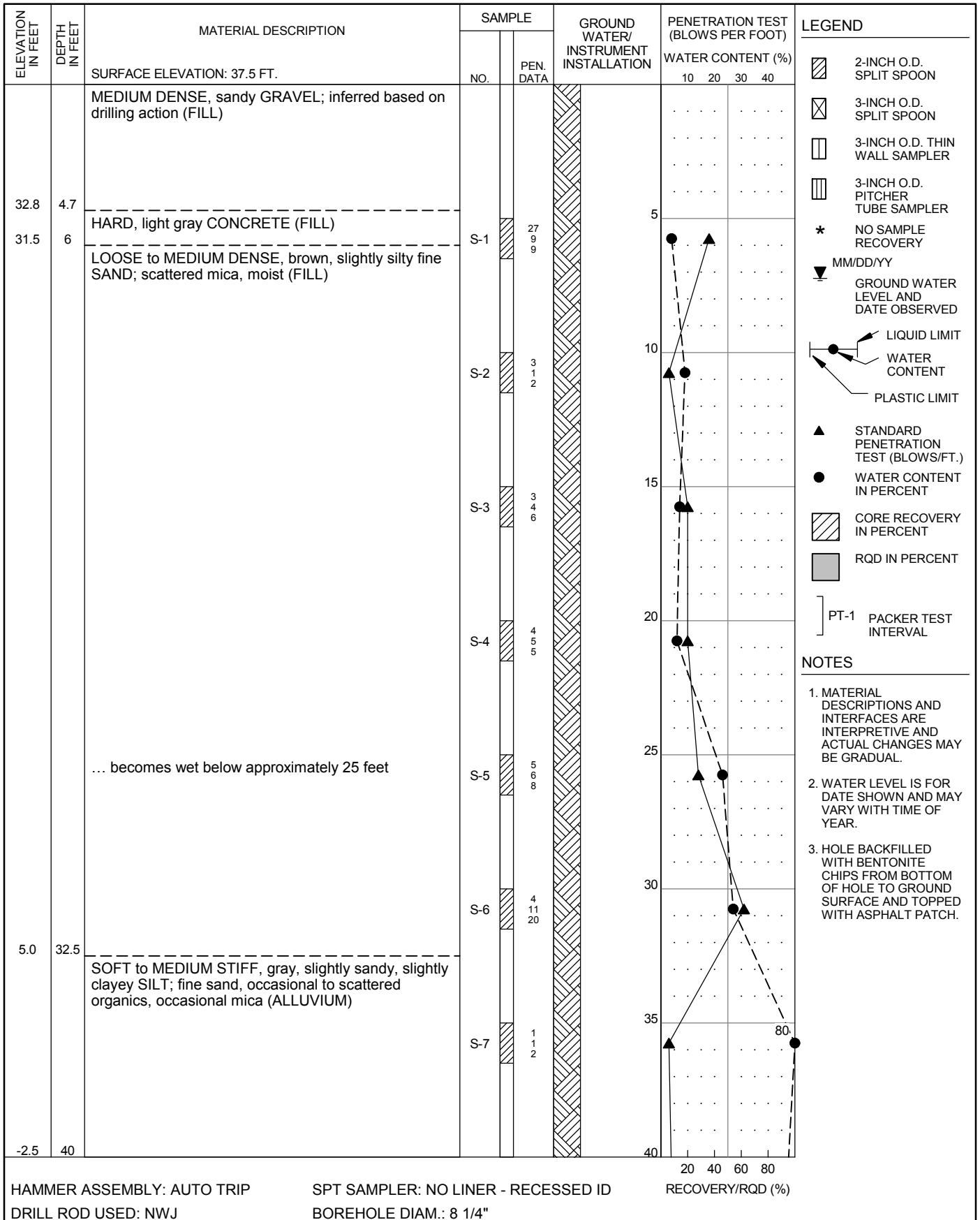
SUMMARY BORING LOG P1-CC-59

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A54



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 3/13/2014 FINISH: 3/13/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-60 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A55

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION
		SURFACE ELEVATION: 37.5 FT.			
		(continued from previous page)	S-8	0 2 2	
			S-9	0 2 2	
			S-10	0 0 3	
-14.0	51.5	Bottom of Boring: 51.5 FT			

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)

10 20 30 40

45 50 55 60 65 70 75 80

20 40 60 80

RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE AND TOPPED WITH ASPHALT PATCH.

HAMMER ASSEMBLY: AUTO TRIP

DRILL ROD USED: NWJ

SPT SAMPLER: NO LINER - RECESSED ID

BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES

DATE START: 3/13/2014 FINISH: 3/13/2014

DRILLING TECHNIQUE: HOLLOW STEM AUGER

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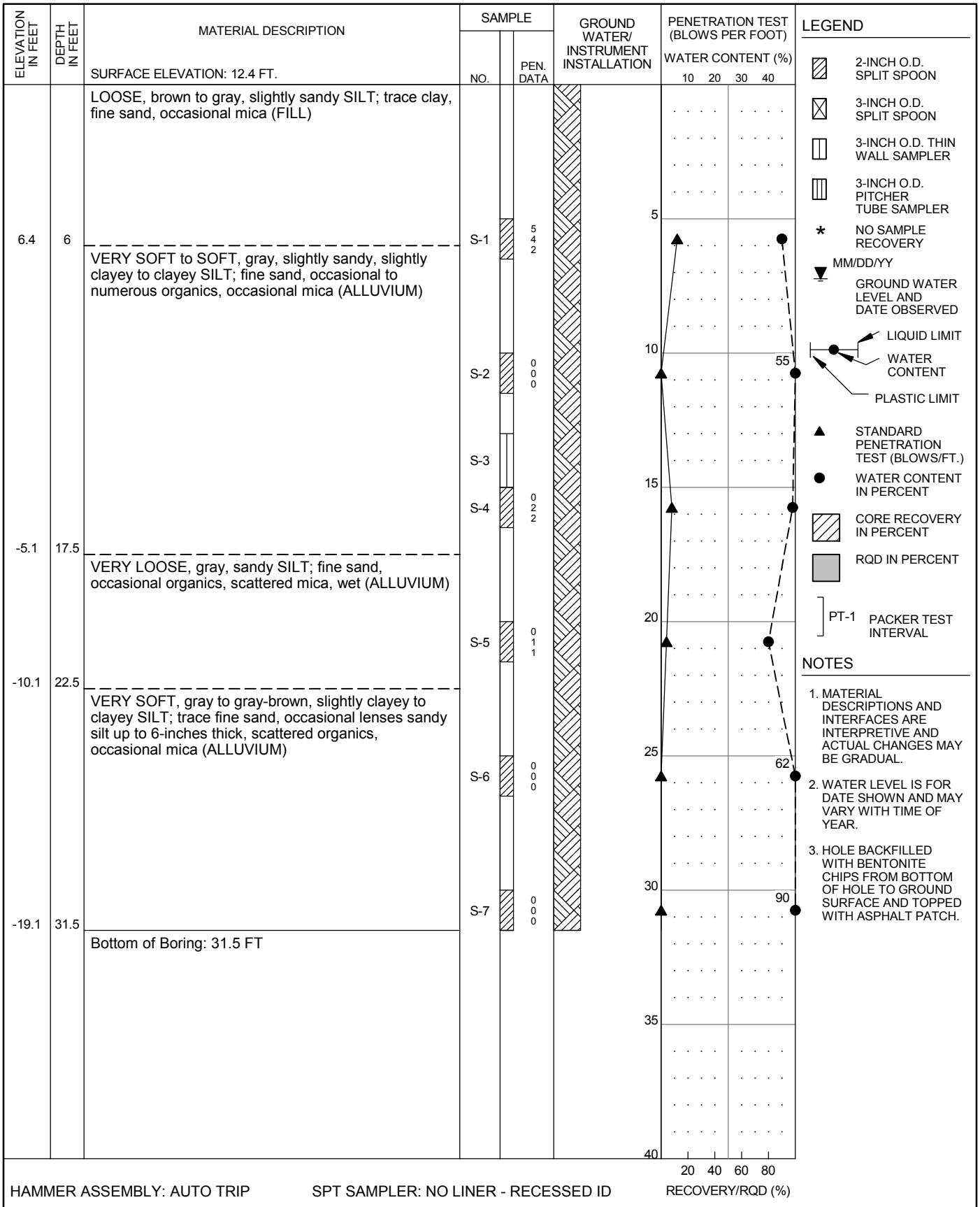
SUMMARY BORING LOG P1-CC-60 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A55



HAMMER ASSEMBLY: AUTO TRIP
SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 3/14/2014 FINISH: 3/14/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

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SUMMARY BORING LOG P1-CC-61

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

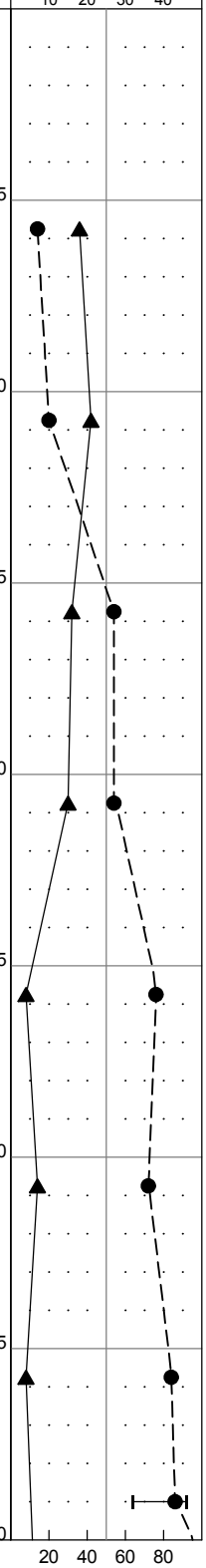
FIG. A56

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	SAMPLE PEN. DATA
		SURFACE ELEVATION: 32.5 FT.		
		MEDIUM DENSE, brown, fine to medium SAND; trace coarse sand, numerous mica, moist (FILL)	S-1	4 8 10
		… trace silt below approximately 10 feet	S-2	4 9 12
		… becomes wet below approximately 15 feet	S-3	5 7 9
			S-4	4 6 9
			S-5	1 2 2
2.3	30.2			
		SOFT to MEDIUM STIFF, gray, slightly sandy, slightly clayey to clayey SILT; occasional organics, occasional mica, moist (ALLUVIUM)	S-6	4 3 4
			S-7	0 1 3
			S-8	
-7.5	40			

GROUND WATER/ INSTRUMENT INSTALLATION

PENETRATION TEST (BLOWS PER FOOT)

WATER CONTENT (%)



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- MM/DD/YY GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. HOLE BACKFILLED WITH BENTONITE CHIPS FROM BOTTOM OF HOLE TO GROUND SURFACE.

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 3/3/2014 FINISH: 3/3/2014
DRILLING TECHNIQUE: HOLLOW STEM AUGER

CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

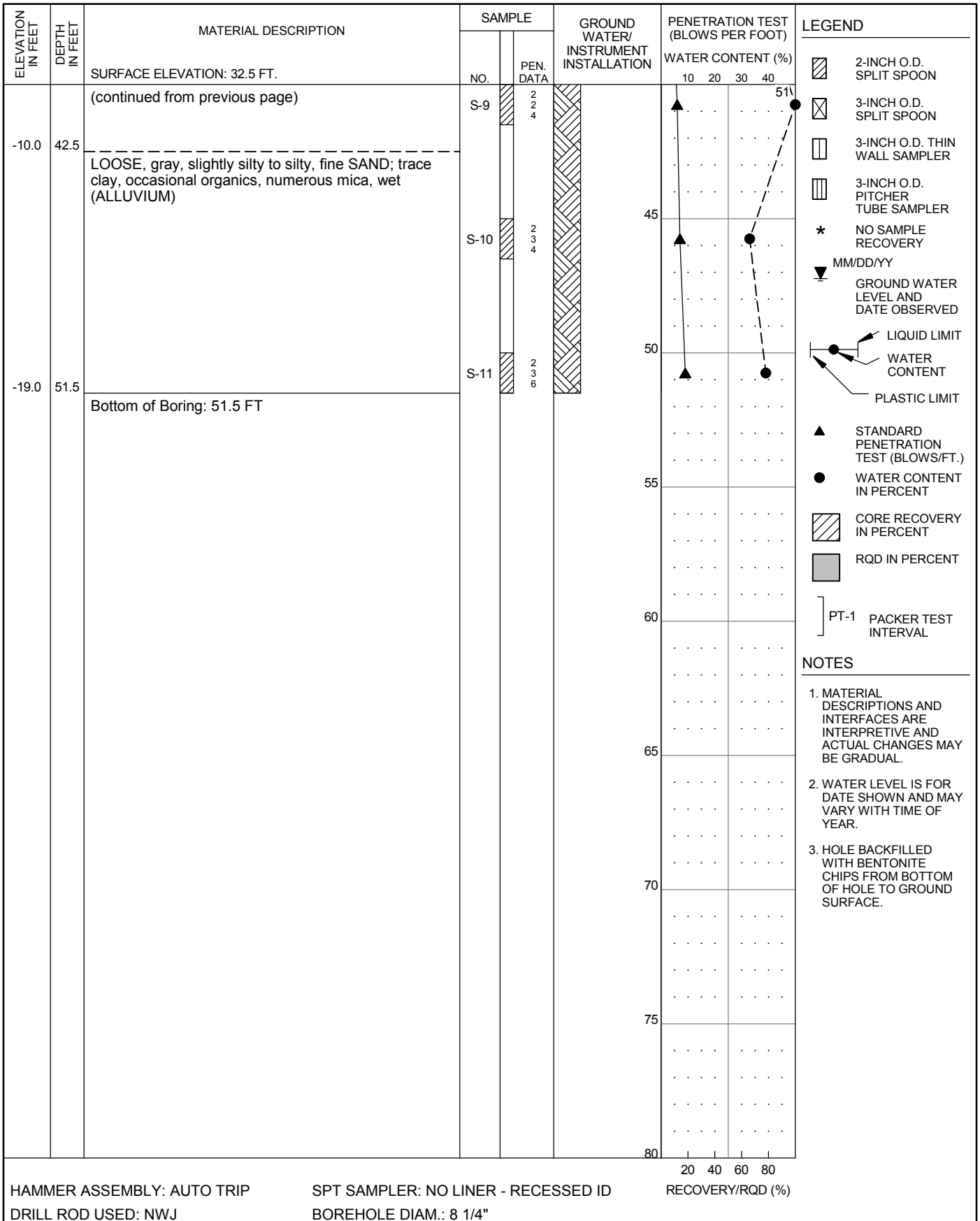
SUMMARY BORING LOG P1-CC-62 (1 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014

PROJ 2319

FIG. A57



HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: NWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 8 1/4"

DRILLER: WESTERN STATES
DATE START: 3/3/2014 FINISH: 3/3/2014
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SUMMARY BORING LOG P1-CC-62 (2 of 2)

PENINSULA DISTRICT 1 LEVEE
PORTLAND, OR

SEP 2014
PROJ 2319
FIG. A57

APPENDIX B

SUMMARY BORING LOGS
(By Others)

Appendix B – Table of Contents

Report References

(a) Summary Boring Log from – I-5: Columbia River Crossing – North Portland Harbor, report prepared by Shannon & Wilson, Inc., November 2011.

(b) Summary Boring Log from – I-5: Columbia River Crossing – Marine Drive Interchange, report prepared by Shannon & Wilson, Inc., November 2011.

(c) Summary Boring Log from – UP Connection at North Portland Road and Peninsula Junction, report prepared by Shannon & Wilson, Inc., May 2013.

(d) Summary Boring Log from – Interstate MAX Light Rail Project – Line Section 10C, report prepared by Fujitani Hilts & Associates, Inc., December 2000.

(e) Summary Boring Log from – OR99W: N. Victory Blvd. – N. Argyle St., report prepared by Shannon & Wilson, Inc., October 2013.

(f) Summary Boring Log from – I-5: Swift Interchange to Delta Park Interchange, report prepared by the Oregon Department of Transportation, December 1988.

Total Depth:	206 ft.	Northing:	107,447 ft.	Drilling Method:	Mud Rotary/Rotosonic	Hole Diam.:	5, 6 in.
Top Elevation:	36.0 ft.	Easting:	1,081,404 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YAPZ024) & Sonic	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:	Boring finished with sonic truck rig.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.)	Soil Description
35.0 / 1.0	ASPHALT CONCRETE Brown gravelly SILT. (ML) **FILL**
30.8 / 5.2	Very loose brown SAND, trace silt; moist; fine sand. (SP)
28.0 / 8.0	Loose brown silty SAND; moist; low plasticity fines; fine sand. (SM)
25.0 / 11.0	Soft to very soft brown SILT with clay, trace sand; moist; medium plasticity; fine sand. (ML)
18.0 / 18.0	Soft brown clayey SILT; wet; medium to high plasticity. (ML) **OVERBANK ALLUVIUM 2** Grades to very soft brown clayey SILT, trace sand at 24 feet. (ML)
3.0 / 33.0	Soft gray clayey SILT; moist to wet; high plasticity. (MH)
-3.0 / 39.0	

Symbol | Samples | Ground Water | Depth, ft.

S-1, S-2a, S-2b, S-3, S-4, S-5, S-6, S-7, S-8, S-9, S-10

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*

0 20 40 60 80 100

5: 6 | 10: 6 | 15: 0 | 20: 4 | 25: 0 | 30: 0 | 35: 6

0 20 40 60 80 100

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ——— Liquid Limit

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Soil Core

Grab Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-011

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A13
Sheet 1 of 6

REV 3

FIG. B1

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: EJOF Rev: AAH Typ: MAS/AEL

Total Depth:	206 ft.	Northing:	107,447 ft.	Drilling Method:	Mud Rotary/Rotosonic	Hole Diam.:	5, 6 in.
Top Elevation:	36.0 ft.	Easting:	1,081,404 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YAPZ024) & Sonic	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:	Boring finished with sonic truck rig.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Soil Description	Elev. Depth (ft.)
Very soft gray sandy SILT to gray silty SAND; wet; low plasticity; fine sand; interbedded. (ML/SM)	
OVERBANK ALLUVIUM 1	-7.0 / 43.0
Medium dense gray SAND; wet; fine sand; occasional interbeds of gray SAND with silt to 0.5-inch thick. (SP)	
SAND ALLUVIUM 2	
Medium stiff gray-brown SILT with clay and sand; wet; medium plasticity fines; fine sand. (ML) Interbed of SAND from 55.3 to 55.6 feet	-17.0 / 53.0
OVERBANK ALLUVIUM 3	-22.0 / 58.0
Medium dense gray SAND; wet; fine sand; three ~0.5-inch-thick interbeds of sandy SILT. (SP)	
SAND ALLUVIUM 2	-27.0 / 63.0
Medium dense to loose gray SAND, trace silt; wet; fine sand; micaceous. (SP)	
Soft gray SILT with sand; wet; low plasticity; fine sand; micaceous. (ML)	-42.0 / 78.0

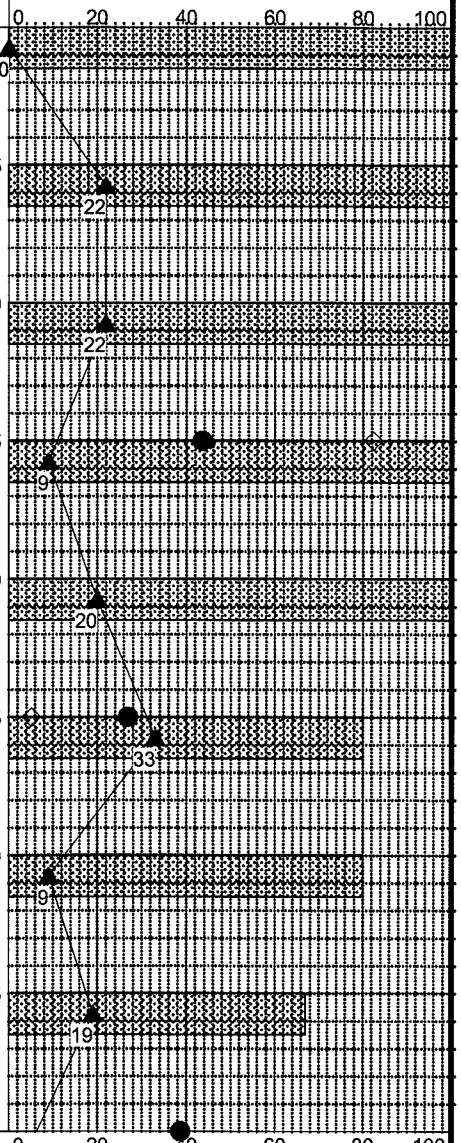
Symbol / Samples: S-11a, S-11b, S-12, S-13, S-14, S-15, S-16, S-17, S-18

Ground Water Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Shelby Tube
- Soil Core
- Grab Sample

- Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit ⊢—⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-011

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A13
Sheet 2 of 6

MASTER LOG_E_NE_24_1_03595.GPJ SHAN WIL.GDT 11/15/11 Log: EJOF Rev: AAH Typ: MAS/AEL

REV 3

FIG. B1

Total Depth:	206 ft.	Northing:	107,447 ft.	Drilling Method:	Mud Rotary/Rotosonic	Hole Diam.:	5, 6 in.
Top Elevation:	36.0 ft.	Easting:	1,081,404 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YAPZ024) & Sonic	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:	Boring finished with sonic truck rig.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

0 20 40 60 80 100

Continued:

Soft gray SILT with sand; wet; low plasticity; fine sand; micaceous. (ML)

OVERBANK ALLUVIUM 1

-47.5 / 83.5

Loose gray silty SAND; wet; nonplastic fines; fine sand; micaceous; interbedded with stiff gray clayey SILT, trace sand; medium plasticity fines; fine sand. (SM)

OVERBANK ALLUVIUM 3

-69.0 / 105.0

Very soft gray SILT to clayey SILT, trace sand; moist; medium to high plasticity; micaceous. (ML/MH)

OVERBANK ALLUVIUM 2

S-19, S-20, S-21a, S-21b, S-22, S-23, S-24, S-25

85 90 95 100 105 110 115

4, 15, 9, 6, 13, 1, NP

0 20 40 60 80 100

CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Shelby Tube
- Soil Core
- Grab Sample

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢—⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-011

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A13
Sheet 3 of 6

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: EJOF Rev: AAH Typ: MAS/AEL

REV 3

FIG. B1

Total Depth:	206 ft.	Northing:	107,447 ft.	Drilling Method:	Mud Rotary/Rotosonic	Hole Diam.:	5, 6 in.
Top Elevation:	36.0 ft.	Easting:	1,081,404 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YAPZ024) & Sonic	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:	Boring finished with sonic truck rig.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. (ft.)	Depth (ft.)	Soil Description
-84.3	120.3	Loose gray silty SAND; wet; low plasticity fines; fine sand; micaceous. (SM)
		SAND ALLUVIUM 2
-92.5	128.5	Very dense black GRAVEL, trace sand and silt; wet; fine sand; coarse angular basalt gravel. (GP)
-94.0	130.0	Gray clayey SILT; moist to wet; high plasticity. (MH)
-98.0	134.0	**OVERBANK ALLUVIUM 3**
-100.0	136.0	Gray silty SAND; wet; low plasticity fines; fine sand. (SM)
-105.0	141.0	Gray sandy GRAVEL; wet; fine subangular sand; coarse rounded gravel; scattered to numerous rounded cobbles to 4-inch diameter observed; ~90% basalt. (GP)
		Gray GRAVEL with silt and sand; low plasticity fines. (GP-GM)
		GRAVEL ALLUVIUM
-111.0	147.0	Brown GRAVEL with sand, trace silt; wet; fine subangular sand; coarse rounded gravel; numerous cobbles to 5-inch diameter observed; ~80-90% basalt. (GP)
-118.0	154.0	Brown sandy GRAVEL, trace silt; wet; medium to coarse subangular to subrounded sand; coarse rounded gravel; numerous rounded cobbles to 6-inch diameter observed; ~80-90% basalt. (GP)

Symbol / Samples: S-26, S-27, S-28, R-1, S-29, S-30, R-2

Ground Water

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*

Depth, ft.: 0, 20, 40, 60, 80, 100; 125, 130, 135, 140, 145, 150, 155

9, 50/6"

CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Shelby Tube
- Soil Core
- Grab Sample

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ——— Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-011

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A13
Sheet 4 of 6

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: EJOF Rev: AAH Typ: MAS/AEL

REV 3

FIG. B1

Total Depth:	206 ft.	Northing:	107,447 ft.	Drilling Method:	Mud Rotary/Rotosonic	Hole Diam.:	5, 6 in.
Top Elevation:	36.0 ft.	Easting:	1,081,404 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YAPZ024) & Sonic	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:	Boring finished with sonic truck rig.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

0 20 40 60 80 100

Continued:

Brown sandy GRAVEL, trace silt; wet; medium to coarse subangular to subrounded sand; coarse rounded gravel; numerous rounded cobbles to 6-inch diameter observed; ~80-90% basalt. (GP)

GRAVEL ALLUVIUM

S-31

165

170

175

R-3

180

S-32

185

190

195

S-33

R-4

0 20 40 60 80 100

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢——⊣ Liquid Limit

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Soil Core

Grab Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-011

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A13
Sheet 5 of 6

REV 3

FIG. B1

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: EJOF Rev: AAH Typ: MAS/AEL

Total Depth:	206 ft.	Northing:	107,447 ft.	Drilling Method:	Mud Rotary/Rotosonic	Hole Diam.:	5, 6 in.
Top Elevation:	36.0 ft.	Easting:	1,081,404 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YAPZ024) & Sonic	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:	Boring finished with sonic truck rig.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

0 20 40 60 80 100

Continued:

Brown sandy GRAVEL, trace silt; wet; medium to coarse subangular to subrounded sand; coarse rounded gravel; numerous rounded cobbles to 6-inch diameter observed; ~80-90% basalt. (GP)

-170.0
206.0

GRAVEL ALLUVIUM

Completed - July 22, 2010

205
210
215
220
225
230
235

0 20 40 60 80 100

Recovery (%)
◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢——⊣ Liquid Limit

LEGEND

* Sample Not Recovered
Standard Penetration Test
3" O.D. Shelby Tube
Soil Core
Grab Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-011

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A13
Sheet 6 of 6

MASTER LOG E_NE_24_1_03595.GPJ SHAN_WIL.GDT 11/15/11 Log: EJOF Rev: AAH Typ: MAS/AEL

REV 3

FIG. B1

Total Depth:	107 ft.	Northing:	107,515 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	-10.1 ft.	Easting:	1,081,576 ft.	Drilling Company:	Hardcore Drilling	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YEAA627)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Loose gray silty SAND; wet; fine to medium sand; low plasticity fines; micaceous; organic odor. (SM)

FILL

Driller notes garbage at 8 feet.

-19.1 / 9.0

Soft gray sandy SILT to silty SAND; wet; low plasticity; fine sand; stratified with silty sand layers; occasional organics; organic odor. (ML/SM)

-23.1 / 13.0

OVERBANK ALLUVIUM 1

Loose gray SAND, trace to with silt; wet; fine sand; faintly stratified; scattered organics; faint organic odor. (SP/SP-SM)

-28.1 / 18.0

SAND ALLUVIUM 1

Medium dense gray SAND, trace silt; wet; fine sand; micaceous. (SP)

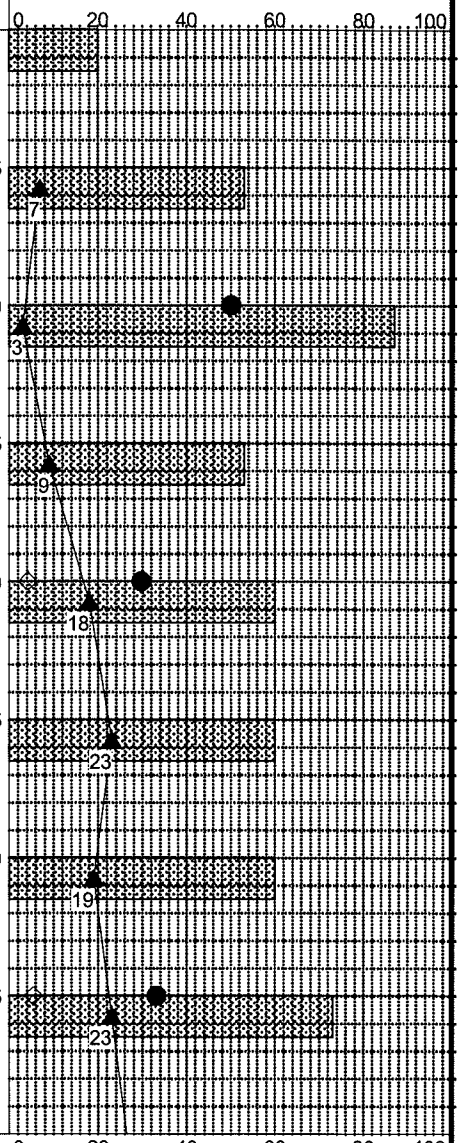
SAND ALLUVIUM 2

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- 3.25" O.D. Spoon Sample
- Standard Penetration Test
- 3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ——— Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-019

November 2011 | 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A21
Sheet 1 of 3

REV 3

FIG. B2

MASTER LOG_E_NE_24_1_03595.GPJ SHAN_WIL.GDT 11/15/11 Log: RAP Rev: PWB Typ: AEL

Total Depth:	107 ft.	Northing:	107,515 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	-10.1 ft.	Easting:	1,081,576 ft.	Drilling Company:	Hardcore Drilling	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YEAA627)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

0 20 40 60 80 100

Continued:
Medium dense gray SAND, trace silt; wet; fine sand; micaceous. (SP)

SAND ALLUVIUM 2

S-9 27

S-10 27

45

-59.1
49.0

Dense gray SAND, trace silt; wet; fine sand; micaceous. (SP)

SAND ALLUVIUM 3

S-11 35

50

S-12 31

55

S-13 39

60

-74.6
64.5

Very soft gray SILT with sand; wet; low to medium plasticity; fine sand; organic odor. (ML)

OVERBANK ALLUVIUM 2

S-14

S-15 0

65

-80.6
70.5

Very stiff gray sandy SILT; wet; low plasticity; fine sand; occasional organics. (ML)

OVERBANK ALLUVIUM 1

S-16a
S-16b 20

70

75

-86.6
76.5

Soft gray SILT with sand; wet; low plasticity; fine sand. (ML)

S-17 27

0 20 40 60 80 100

CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- 3.25" O.D. Spoon Sample
- Standard Penetration Test
- 3" O.D. Shelby Tube

- Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit — Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-019

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A21
Sheet 2 of 3

REV 3

FIG. B2

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: RAP Rev: PWB Typ: AEL

Total Depth:	107 ft.	Northing:	107,515 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	-10.1 ft.	Easting:	1,081,576 ft.	Drilling Company:	Hardcore Drilling	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YEAA627)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Dense gray-brown SAND, trace to with silt; wet; fine to medium subangular sand. (SP/SP-SM)

SAND ALLUVIUM 3

Very dense gray-brown sandy GRAVEL with cobbles; wet; medium to coarse sand; fine to coarse rounded to subangular gravel. (GP)

GRAVEL ALLUVIUM

BOULDER from 98.5 to 100 feet.

Abandoned due to caving and mud loss - December 7, 2010

Elev. Depth (ft.)

-90.6 / 80.5

-95.6 / 85.5

-110.1 / 100.0

-117.1 / 107.0

Symbol

Samples: S-18a, S-18b, S-19, S-20, S-21, S-22

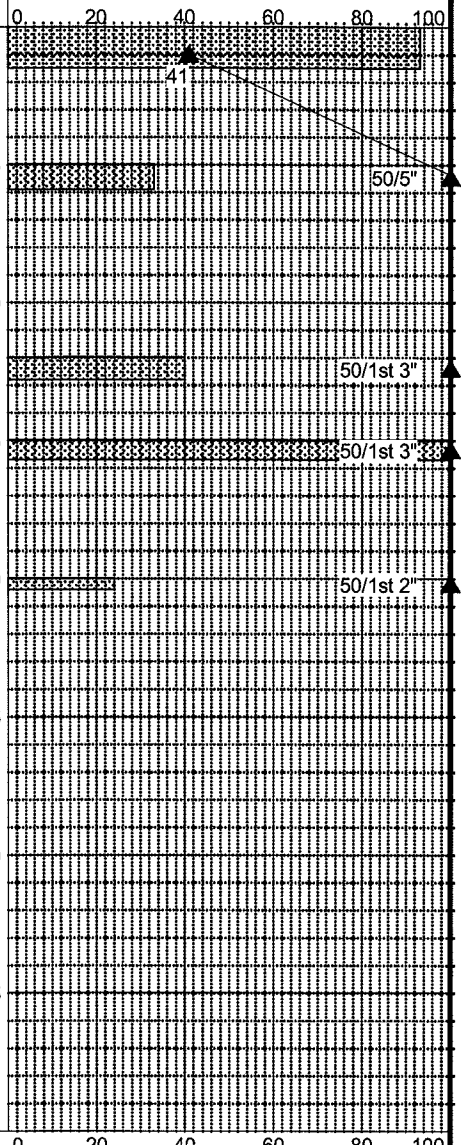
Ground Water

Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered

3.25" O.D. Spoon Sample

Standard Penetration Test

3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit — Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
North Portland Harbor
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-SC-019

November 2011 24-1-03595-010

SHANNON & WILSON, INC.
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FIG. A21
Sheet 3 of 3

REV 3

FIG. B2

MASTER_LOG_E_NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: RAP Rev: PWB Typ: AEL

Total Depth:	136.4 ft.	Northing:	107,806 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	31.7 ft.	Easting:	1,080,771 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Description	Elev. (ft.)	Depth (ft.)
ASPHALT CONCRETE	31.2	0.5
BASE AGGREGATE	30.7	1.0
Medium dense to dense brown SAND with silt, trace gravel; moist to wet; fine sand; coarse subangular gravel. (SP-SM)		
DREDGED SAND FILL		
Very loose gray-brown silty SAND; moist; low plasticity fines; fine subangular sand. (SM)	24.7	7.0
OVERBANK ALLUVIUM 1	22.2	9.5
Soft gray clayey SILT with sand; moist to wet; medium plasticity; fine sand; occasional organics. (ML)	19.2	12.5
Very soft to soft gray CLAY with sand; moist to wet; high plasticity; fine sand; occasional organics. (CL)		
OVERBANK ALLUVIUM 2		
Grades to trace sand at 25.0 feet.		
S-8: Dry Density = 85.7 pcf and 87.2 pcf		
Very loose gray sandy SILT to silty SAND; wet; nonplastic fines; fine sand; stratified layers of silty SAND and sandy SILT. (ML/SM)	-3.3	35.0

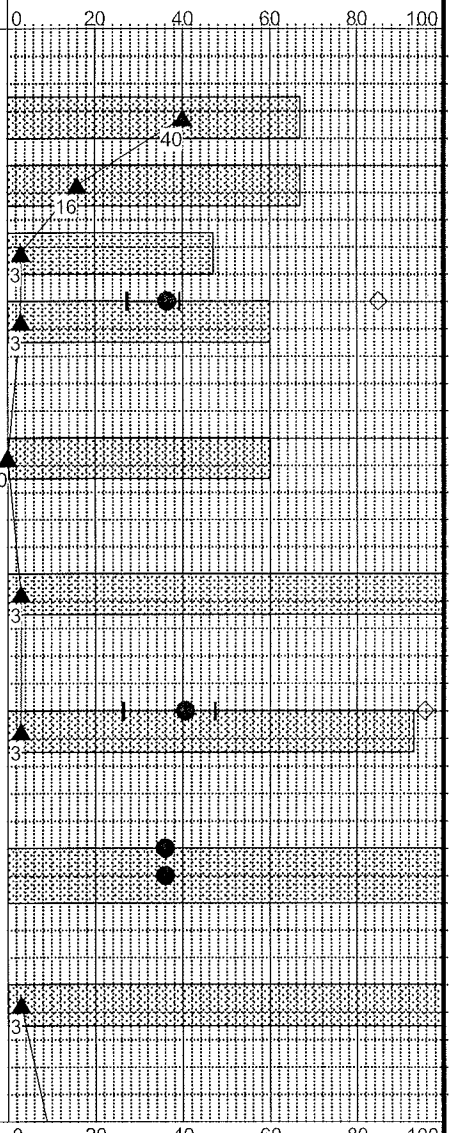
Samples: S-1, S-2, S-3, S-4, S-5, S-6, S-7, S-8, S-9

Ground Water

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢—⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-001

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A2
Sheet 1 of 4

REV 3

FIG. B3

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: RAP Rev: AAH Typ: MAS

Total Depth:	136.4 ft.	Northing:	107,806 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	31.7 ft.	Easting:	1,080,771 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

0 20 40 60 80 100

Continued:

Loose gray sandy SILT to silty SAND; wet; nonplastic fines; fine sand; stratified layers of silty SAND and sandy SILT. (ML/SM)

-10.8 / 42.5

Medium dense gray silty SAND; moist to wet; nonplastic to low plasticity fines; fine sand. (SM)

OVERBANK ALLUVIUM 1

S-10 (10) S-11 (16) S-12 (9) S-13 (1) S-14 (9) S-15 * (6) S-16 (7) S-17 (3)

-18.3 / 50.0

Very soft to stiff gray-brown sandy clayey SILT; moist to wet; medium to high plasticity; fine sand; stratified in 6-inch-thick layers with scattered to occasional woody debris; faintly micaceous. (ML, MH)

OVERBANK ALLUVIUM 2

-28.3 / 60.0

Loose gray sandy SILT; moist to wet; nonplastic to low plasticity; fine sand; stratified. (ML)

OVERBANK ALLUVIUM 1

-38.3 / 70.0

Soft to medium stiff gray-brown clayey SILT with sand to SILT with sand; moist to wet; nonplastic to medium plasticity; fine sand; occasional organic debris; organic odor. (ML)

OVERBANK ALLUVIUM 3

45 50 55 60 65 70 75

NP

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

0 20 40 60 80 100

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢—⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-001

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A2
Sheet 2 of 4

REV 3

MASTER LOG E_NE 24_1 03595.GPJ SHAN_WIL.GDT 11/15/11 Log: RAP Rev: AAH Typ: MAS

FIG. B3

Total Depth:	136.4 ft.	Northing:	107,806 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	31.7 ft.	Easting:	1,080,771 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

Continued:

Dense to hard gray-brown clayey SILT with sand to SILT with sand; moist to wet; nonplastic to medium plasticity; fine sand; occasional organic debris; organic odor. (ML)

-50.8 / 82.5

Soft gray CLAY, trace sand; moist; high plasticity; fine sand; numerous wood debris. (CL)

OVERBANK ALLUVIUM 3

-58.3 / 90.0

Medium dense gray sandy SILT; wet; low plasticity; fine sand. (ML)

OVERBANK ALLUVIUM 1

-63.3 / 95.0

Dense gray silty SAND to SAND with silt; moist; nonplastic fines; fine sand. (SM/SP-SM)

-68.3 / 100.0

Medium dense to stiff gray silty SAND to sandy SILT; moist to wet; nonplastic to low plasticity fines; fine sand; stratified layers of silty SAND and sandy SILT 0.3- to 0.5-inch-thick. (SM/ML)

-73.3 / 105.0

Soft gray clayey SILT, trace sand; moist to wet; medium plasticity; fine sand. (ML)

OVERBANK ALLUVIUM 2

S-18, S-19, S-20, S-21, S-22, S-23

32, 4, 11, 40, 11, 4

85, 90, 95, 100, 105, 110, 115

0 20 40 60 80 100

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ——— Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-001

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A2
Sheet 3 of 4

REV 3

FIG. B3

MASTER LOG E_NE 24_1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: RAP Rev: AAH Typ: MAS

Total Depth:	136.4 ft.	Northing:	107,806 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	31.7 ft.	Easting:	1,080,771 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Stiff gray sandy SILT; moist to wet; nonplastic to low plasticity fines; fine sand; stratified layers of silty SAND and sandy SILT 0.3- to 0.5-inch-thick. (SM/ML)

OVERBANK ALLUVIUM 1

-88.3 / 120.0

Very dense gray sandy GRAVEL with silt; moist to wet; medium to coarse sand; fine to coarse subangular gravel. (GP-GM)

GRAVEL ALLUVIUM

Mud loss (4 drums) at 132.5 feet.

-94.3 / 126.0

Continued driving after refusal to obtain sample S-26.

-104.7 / 136.4

Completed - May 6, 2011

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

S-24

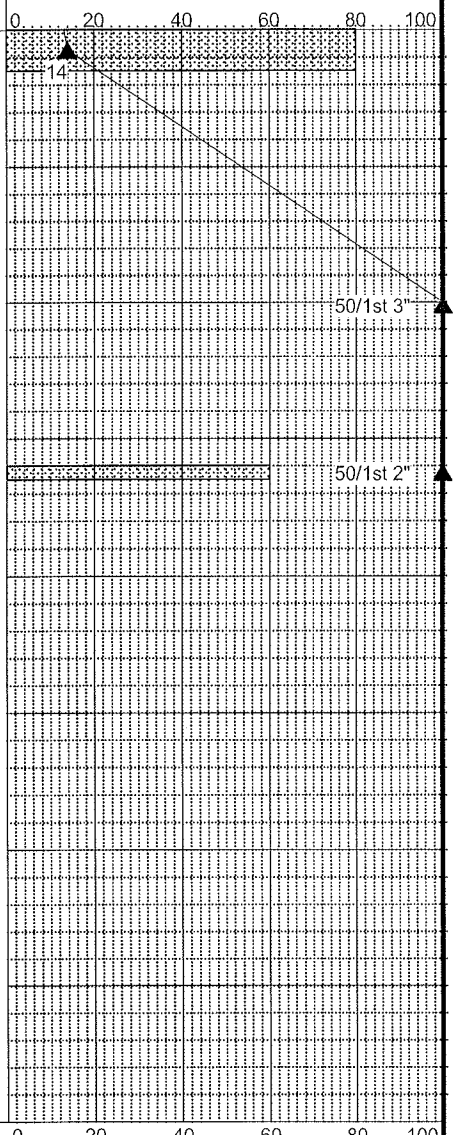
S-25 *

S-26

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢—⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-001

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
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FIG. A2
Sheet 4 of 4

REV 3

MASTER_LOG_E_NE_24_1_03595.GPJ SHAN_WIL.GDT 11/15/11 Log: RAP Rev: AAH Typ: MAS

FIG. B3

Total Depth:	135.1 ft.	Northing:	107,639 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	30.1 ft.	Easting:	1,080,959 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Soil Description	Elev. Depth (ft.)
Very dense light brown gravelly SAND with silt; moist; nonplastic fines; fine to coarse angular to subrounded gravel; fine to course angular to subrounded sand. (SP-SM)	
FILL	25.1 / 5.0
Loose to medium dense brown silty SAND to SAND with silt; fine to medium sand. (SM, SP-SM)	
DREDGED SAND FILL	20.6 / 9.5
Very soft to medium stiff dark gray to gray silty CLAY, trace sand; medium plasticity; fine sand; occasional to scattered organics; micaceous. (CL)	
Very soft gray SILT to clayey SILT with sand; moist to wet; low to medium plasticity; fine sand; micaceous. (ML)	13.4 / 16.7
Very soft gray silty CLAY with sand; moist; medium plasticity; fine sand. (CL)	9.1 / 21.0
S-8: Dry Density = 72.3 pcf	
Very soft gray clayey SILT with sand; moist to wet; medium plasticity; fine sand. (ML)	2.6 / 27.5
OVERBANK ALLUVIUM 2	
Medium dense gray silty SAND; nonplastic to low plasticity fines; micaceous.	-7.4 / 37.5

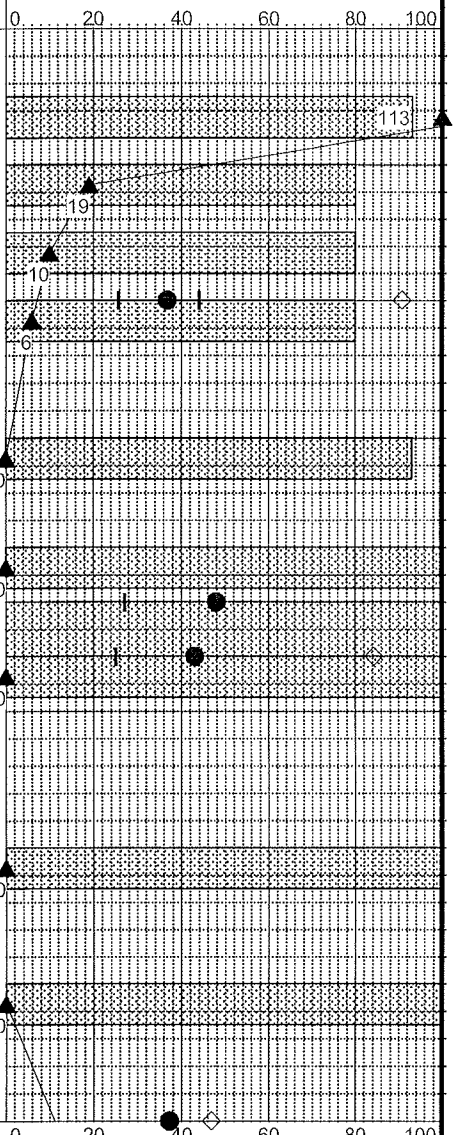
Symbol | Samples | Ground Water | Depth, ft.

S-1, S-2, S-3, S-4, S-5, S-6 *, S-7, S-8, S-9, S-10, S-11

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢—⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-002

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
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FIG. A3
Sheet 1 of 4

REV 3

MASTER LOG E_NE 24_1 03595.GPJ SHAN_WIL.GDT 11/15/11 Log: KRK Rev: AAH Typ: ATJ/MAS

FIG. B4

Total Depth:	135.1 ft.	Northing:	107,639 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	30.1 ft.	Easting:	1,080,959 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

Continued:

Medium dense gray silty SAND; nonplastic to low plasticity fines; scattered organics; micaceous. (SM)

OVERBANK ALLUVIUM 1

-15.9 / 46.0

Very soft to soft dark gray to gray clayey SILT; moist; high plasticity; occasional to scattered organics; micaceous. (MH)

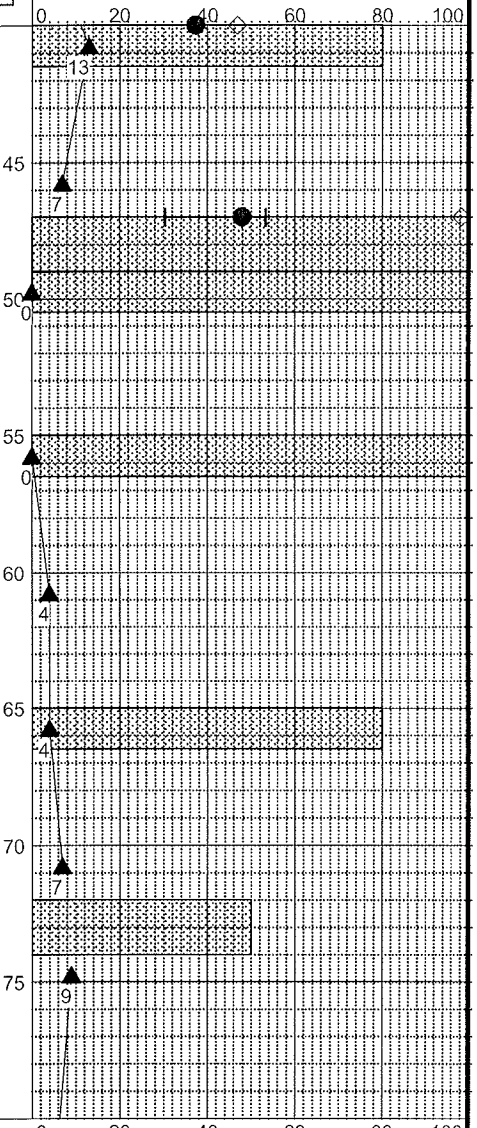
OVERBANK ALLUVIUM 2

-27.4 / 57.5

Soft dark gray clayey SILT with sand to sandy clayey SILT; moist to wet; medium plasticity; fine sand. (ML)

Grades to medium stiff to stiff at 70.0 feet.

S-12, S-13 *, S-14, S-15, S-16, S-17 *, S-18, S-19 *, S-20, S-21 *



0 20 40 60 80 100

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢—⊣ Liquid Limit

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-002

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
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FIG. A3
Sheet 2 of 4

MASTER LOG E_NE 24_1 03595.GPJ SHAN_WIL.GDT 11/15/11 Log: KRK Rev: AAH Typ: ATJ/MAS

REV 3

FIG. B4

Total Depth:	135.1 ft.	Northing:	107,639 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	30.1 ft.	Easting:	1,080,959 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Soil Description	Elev. (ft.)	Depth (ft.)
Medium stiff dark gray to gray clayey SILT with sand; moist; medium plasticity; fine sand; occasional to scattered organics; micaceous. (ML)	-49.9	80.0
Very loose to medium dense gray to dark gray silty SAND; moist; nonplastic to low plasticity fines; occasional organics; micaceous. (SM)	-52.4	82.5
Layer of clayey SILT with sand at 90.0 feet. (ML)		
OVERBANK ALLUVIUM 1		
Stiff gray SILT with sand; moist; nonplastic to low plasticity; occasional organics; micaceous. (ML)	-67.4	97.5
Decreasing sand and increasing organics at 105.0 feet.		
Stiff gray clayey SILT, trace sand; moist; high plasticity; fine sand. (MH)	-77.4	107.5
OVERBANK ALLUVIUM 2		

Symbol: S-22, S-23, S-24, S-25, S-26, S-27

Ground Water

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches

Depth, ft.: 0, 20, 40, 60, 80, 100

Blow counts: 6, 3, 13, 27, NP, 9, 9

Depth, ft.: 85, 90, 95, 100, 105, 110, 115

0 20 40 60 80 100

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢——⊣ Liquid Limit

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-002

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
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FIG. A3
Sheet 3 of 4

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: KRK Rev: AAH Typ: ATJ/MAS

REV 3

FIG. B4

Total Depth:	135.1 ft.	Northing:	107,639 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	30.1 ft.	Easting:	1,080,959 ft.	Drilling Company:	Boart Longyear	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile B-59 (94951)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Soft gray silty CLAY, trace sand; moist; low to medium plasticity; occasional organics; micaceous. (CL)

OVERBANK ALLUVIUM 2

S-29: Dry Density = 98.8 pcf

Medium dense gray clayey SAND; moist; medium plasticity fines; fine sand; micaceous. (SC)

Very dense dark gray to gray GRAVEL with sand, trace silt; fine to coarse angular to subrounded sand; fine to coarse angular to subrounded gravel. (GP)

GRAVEL ALLUVIUM

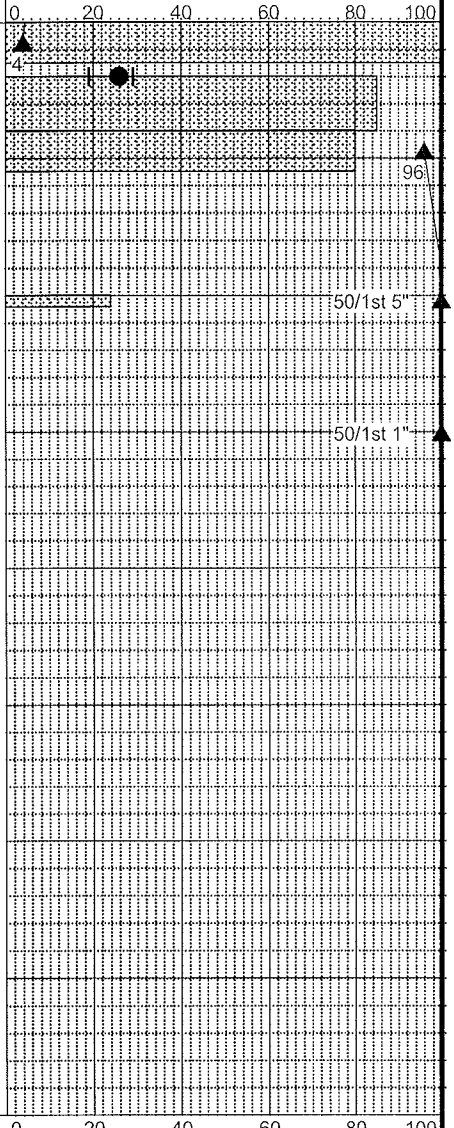
Completed - March 14, 2011

Elev. Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
-89.9 / 120.0		S-28		
		S-29		
-94.2 / 124.3		S-30		
-94.7 / 124.8				
		S-31		
-105.0 / 135.1		S-32 *		

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢——⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-002

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A3
Sheet 4 of 4

REV 3

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: KRK Rev: AAH Typ: ATJ/MAS

FIG. B4

Total Depth:	66.5 ft.	Northing:	106,472 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	36.0 ft.	Easting:	1,081,265 ft.	Drilling Company:	Hardcore Drilling	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YEAA724)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

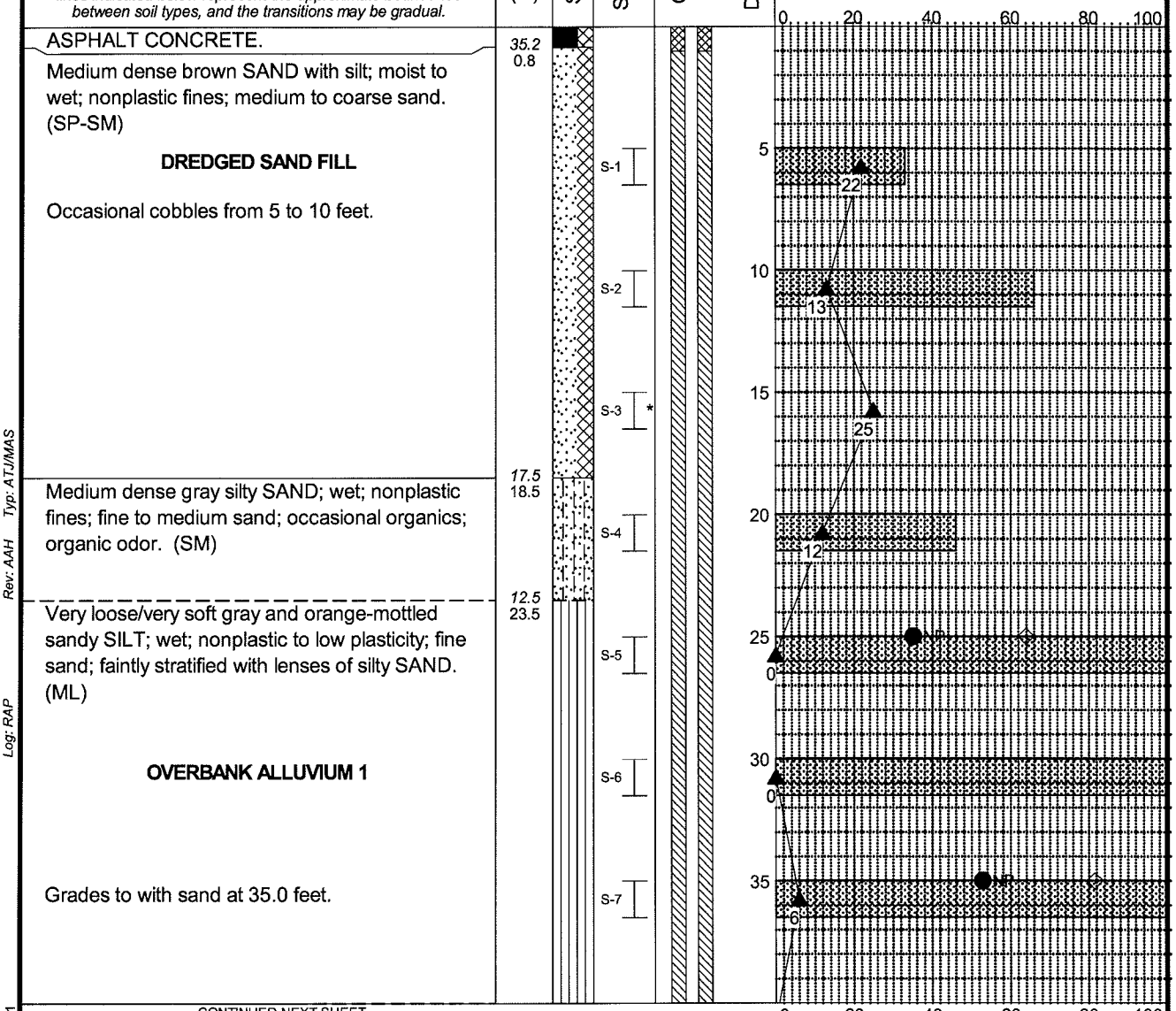
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: *140 lbs / 30 inches*



ASPHALT CONCRETE. — 35.2 / 0.8

Medium dense brown SAND with silt; moist to wet; nonplastic fines; medium to coarse sand. (SP-SM)

DREDGED SAND FILL

Occasional cobbles from 5 to 10 feet.

Medium dense gray silty SAND; wet; nonplastic fines; fine to medium sand; occasional organics; organic odor. (SM) — 17.5 / 18.5

Very loose/very soft gray and orange-mottled sandy SILT; wet; nonplastic to low plasticity; fine sand; faintly stratified with lenses of silty SAND. (ML) — 12.5 / 23.5

OVERBANK ALLUVIUM 1

Grades to with sand at 35.0 feet.

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

Standard Penetration Test

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ——— Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-006

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A7
Sheet 1 of 2

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: RAP Rev: AAH Typ: ATJ/MAS

REV 3

FIG. B5

Total Depth:	66.5 ft.	Northing:	106,472 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	4 7/8 in.
Top Elevation:	36.0 ft.	Easting:	1,081,265 ft.	Drilling Company:	Hardcore Drilling	Rod Type:	NWJ
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	CME 75 (YEAA724)	Hammer Type:	Automatic
Horiz. Datum:	CRC Project	Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Very soft to soft gray clayey SILT, trace sand; moist; medium to high plasticity; scattered organic debris; faintly stratified with occasional silty SAND lenses and seams; slight organic odor. (ML, MH)

OVERBANK ALLUVIUM 2

SAND lens with wood debris from 54.0 to 55.4 feet.

Grades to with sand at 60.0 feet.

Completed - March 8, 2011

Elev. Depth (ft.): -4.0 (40.0); -30.5 (66.5)

Symbol

Samples: S-8, S-9, S-10, S-11, S-12, S-13

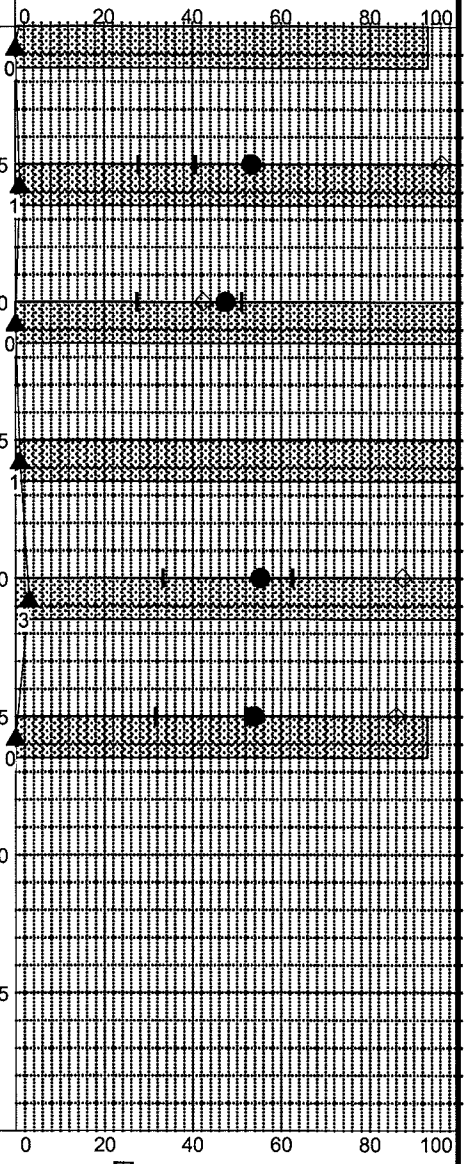
Ground Water

Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Energy-Corrected Field Blow Count [5], N_E

Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered

I Standard Penetration Test

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ——— Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location and elevation should be considered approximate.
5. Energy-corrected blow counts are not provided for non-standard samplers.

I-5 Columbia River Crossing
Marine Drive Interchange
Portland, Oregon / Vancouver, Washington

LOG OF BORING CRC-MD-006

November 2011 24-1-03595-070

SHANNON & WILSON, INC.
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FIG. A7
Sheet 2 of 2

MASTER LOG E NE 24 1 03595.GPJ SHAN WIL.GDT 11/15/11 Log: RAP Rev: AAH Typ: ATJ/MAS

REV 3

FIG. B5

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

DRILL LOG
OREGON DEPARTMENT OF TRANSPORTATION

Figure
Page **1** of **3**

Hole No. **B-1**

Project **Union Pacific Connection at North Portland and Peninsula Junctions**	Purpose	E.A. No.
Highway	County **Multnomah**	Key No.
Hole Location Northing: **712,785.00** Easting: **7,635,824.00**		Start Card No.
Equipment **CME 75 (Hammer Efficiency = 81%)**	Driller **Hardcore Drilling**	Bridge No.
Project Geologist **Cody K. Sorensen**	Recorder **Kevin R. Knapp**	Ground Elev.
Start Date **January 16, 2013** End Date **January 16, 2013**	Total Depth **100.50 ft**	Tube Height

Test Type
"A" - Auger Core
"X" - Auger
"C" - Core, Barrel Type
"N" - Standard Penetration
"U" - Undisturbed Sample
"T" - Test Pit

Rock Abbreviations

Discontinuity	Shape	Surface Roughness
J - Joint	Pl - Planar	P - Polished
F - Fault	C - Curved	Sl - Slickensided
B - Bedding	U - Undulating	Sm - Smooth
Fo - Foliation	St - Stepped	R - Rough
S - Shear	Ir - Irregular	VR - Very Rough

Typical Drilling Abbreviations

Drilling Methods	Drilling Remarks
WL - Wire Line	LW - Lost Water
HS - Hollow Stem Auger	WR - Water Return
DF - Drill Fluid	WC - Water Color
SA - Solid Auger	DP - Down Pressure
CA - Casing Advancer	DR - Drill Rate
HA - Hand Auger	DA - Drill Action

Depth (ft)	Test Type, No.	Percent Recovery	Soil / Rock: Driving Resistance / Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description (SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.)	Unit Description
0						**0.00 - 0.50 BASE AGGREGATE; (Fill)**
						0.50 - 5.00 SILT with some fine sand and trace fine gravel; ML; Gray; Low plasticity; Moist; Medium stiff; Subangular to subrounded gravel; Micaceous; (Fill)
5	N1	60	2-3-2	36	N- 1 (5.00-6.50) SILT with some fine sand and trace fine gravel; ML; Gray; Low plasticity; Moist; Medium Stiff; Subrounded to subangular gravel; Micaceous; (Fill)	
						5.00 - 15.00 Clayey SILT with some to trace fine sand; ML/MH; Gray; Low to medium plasticity; Moist; Soft to medium stiff; Micaceous; Scattered organics; (Fill)
10	N2	80	2-4-4	43	N- 2 (10.00-11.50) Clayey SILT with some fine sand; ML; Gray to dark gray; Low to medium plasticity; Moist; Medium Stiff; Micaceous; Occasional organics; (Fill)	
	N3	80	0-2-2		N- 3 (12.50-14.00) Clayey SILT with trace fine sand; ML/MH; Gray; Medium plasticity; Moist; Soft; Micaceous; Scattered organics; (Fill)	
	U1	95			U- 1 (14.50-16.50) Clayey SILT to silty CLAY with trace fine sand; CL-ML; Gray; Medium plasticity; Moist; Soft; Micaceous; Scattered organics; (Fill)	
15	N4	100	0-0-0		N- 4 (16.50-18.00) SILT with some clay and trace fine sand; ML/MH; Gray; Low to medium plasticity; Moist; Very Soft; Micaceous; Occasional organics; (Overbank Deposits)	**15.00 - 20.00 SILT with some clay and trace fine sand; ML/MH; Gray; Low to medium plasticity; Moist; Very soft; Micaceous; Occasional organics; (Overbank Deposits)**
20	N5	100	0-2-1	40	N- 5 (20.00-21.50) Sandy SILT; ML; Dark gray; Nonplastic; Wet; Soft; Fine to medium sand; Micaceous; Occasional organics; (Overbank Deposits)	**20.00 - 22.50 Sandy SILT; ML; Dark gray; Nonplastic; Wet; Soft; Fine to medium sand; Micaceous; Occasional organics; (Overbank Deposits)**
25	N6	100	0-0-0	105	N- 6 (25.00-26.50) Clayey SILT with trace fine sand; MH; Gray-brown; Low to medium plasticity; Moist; Very Soft; Micaceous; Occasional organics; (Overbank Deposits)	**22.50 - 40.00 Clayey SILT to SILT with trace fine sand; MH; Gray-brown; Low to medium plasticity; Moist to wet; Very soft to soft;**
	U2	100			U- 2 (27.00-29.00) Clayey SILT with trace fine sand; MH; Gray-brown; Low to medium plasticity; Moist; Very Soft; Micaceous; Occasional organics; (Overbank Deposits)	
30	N7	100	0-0-0	65	N- 7 (29.00-30.50) Clayey SILT with trace fine sand; ML/MH; Gray-brown; Low to medium plasticity; Moist;	

Graphic Log

Drilling Methods, Size and Remarks / Water Level/ Date

Boring drilled using 4 7/8 inch tri-cone bit from 0.0 to 97.0 feet using mud rotary drilling technique

Driller indicated material from 5.0 to 10.0 feet was soft and sticky

1/16/13
13.07

Water level taken from nearby well

Placed hammer - Rods dropped 1.5 feet

Backfill/ Instrumentation

ODOT DRILL LOG - FOR SW REVIEW 24-1-03742-002_ODOTREG1.GPJ ODOT_MANWITHSWLAB.GDT 5/21/13

REV 2

FIG. B6

Depth (ft)	Test Type, No.	Percent Recovery	Soil / Rock: Driving Resistance / Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description (SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.)	Unit Description	Graphic Log	Drilling Methods, Size and Remarks / Water Level / Date	Backfill/ Instrumentation
30					Very Soft; Occasional organics; (Overbank Deposits)	**Micaceous; Occasional organics; (Overbank Deposits)**			
35	N8	100	0-2-1		N- 8 (35.00-36.50) SILT with trace fine sand; ML; Gray-brown; Low to medium plasticity; Moist; Soft; Occasional organics; (Overbank Deposits)				
40	N9	100	0-0-2		N- 9 (40.00-41.50) Sandy SILT; ML; Gray-brown; Nonplastic to low plasticity; Wet; Very Soft; Fine sand; Micaceous; Occasional organics; (Overbank Deposits)	**40.00 - 42.00 Sandy SILT; ML: Gray-brown; Nonplastic to low plasticity; Fine sand; Micaceous; Occasional organics; (Overbank Deposits)**			
45	N10	80	7-6-7		N- 10 (45.00-46.50) Silty SAND; SM; Gray to gray-brown; Nonplastic fines; Moist to wet; Medium Dense; Micaceous; Occasional organics; (Overbank Deposits)	**42.00 - 47.00 Silty SAND; SM; Gray-brown; Nonplastic fines; Moist to wet; Medium dense; Fine to medium sand; Micaceous; Occasional organics; (Overbank Deposits)**			
50	N11	100	0-0-0		N- 11 (50.00-51.50) Clayey SILT with trace fine sand; MH; Gray-brown; Medium plasticity; Moist; Very Soft; Micaceous; Occasional organics; (Overbank Deposits)	**47.00 - 59.50 Clayey SILT with trace fine sand; ML/MH; Gray-brown; Low to medium plasticity; Moist; Very soft; Occasional to scattered organics; (Overbank Deposits)**		Placed hammer - Rods dropped 1.5 feet	
	U3	0			U- 3 (52.00-54.00) No recovery				
55	N12	100	0-0-0		N- 12 (55.00-56.50) Clayey SILT with trace fine sand; ML/MH; Gray-brown; Low to medium plasticity; Moist; Very Soft; Micaceous; Scattered organics; (Overbank Deposits)				
	U4	100			U- 4 (57.00-59.00) Clayey SILT with trace fine sand; ML/MH; Gray-brown; Low to medium plasticity; Moist; Very Soft; Micaceous; Scattered organics; (Overbank Deposits)				
60	N13 N13a N13b	100	0-5-3		N- 13 (59.00-60.50) N- 13a (59.00-59.50) Clayey SILT with some fine sand; MH; Gray-brown; Low plasticity; Moist; Very Soft; Micaceous; Scattered organics; (Overbank Deposits) N- 13b (59.50-60.50) Silty SAND; SM; Gray-brown; Nonplastic fines; Wet; Medium Dense; Micaceous; (Overbank Deposits)	**59.50 - 62.50 Silty SAND; SM; Gray-brown; Nonplastic fines; Wet; Medium dense; Fine sand; Micaceous; (Overbank Deposits)**			
65	N14	100	0-0-0		N- 14 (65.00-66.50) SILT with trace fine sand; ML; Gray-brown; Nonplastic to low plasticity; Moist; Very Soft; Micaceous; Scattered organics; (Overbank Deposits)	**62.50 - 67.50 SILT with trace fine sand; ML; Gray-brown; Nonplastic to low plasticity; Moist; Very soft; Micaceous; Scattered organics; (Overbank Deposits)**			
70	N15	100	0-0-1		N- 15 (70.00-71.50) Sandy SILT to silty SAND; ML-SM; Gray-brown to gray; Medium plasticity fines; Moist to wet; Very Soft; Fine to medium sand; Micaceous; Occasional organics; (Overbank Deposits)	**67.50 - 72.50 Sandy SILT to silty SAND; ML-SM; Gray-brown to gray; Medium plasticity fines; Moist to wet; Very soft; Fine to medium sand;**			
75									

ODOT DRILL LOG - FOR SW REVIEW 24-1-03742-002_ODOTREG1.GPJ ODOT_MANWITHSWLAB.GDT 5/21/13

REV 2

FIG. B6

Depth (ft)	Test Type, No.	Percent Recovery	Soil / Rock: Driving Resistance / Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks / Water Level/ Date	Backfill/ Instrumentation
75	N16	80	3-5-3		N- 16 (75.00-76.50) Sandy SILT; ML; Gray to gray-brown; Nonplastic; Wet; Medium Stiff; Numerous organics; (Overbank Deposits)	**Micaceous; Occasional organics; (Overbank Deposits)**			
						72.50 - 82.50 Sandy SILT; ML; Gray-brown; Nonplastic; Moist to wet; Soft to medium stiff; Fine to medium sand; Micaceous; (Overbank Deposits)			
80	N17	80	2-2-2		N- 17 (80.00-81.50) Sandy SILT; ML; Gray-brown; Nonplastic; Moist; Soft; Fine sand; Micaceous; (Overbank Deposits)				
						82.50 - 92.50 Silty SAND to SAND with some silt; SM; Gray-brown; Nonplastic fines; Moist to wet; Medium dense; Fine to medium sand; Micaceous; (Sand Alluvium)			
85	N18	100	2-6-7		N- 18 (85.00-86.50) Silty SAND; SM; Gray-brown; Nonplastic fines; Moist to wet; Medium Dense; Fine to medium sand; Micaceous; (Sand Alluvium)				
90	N19	66	7-8-9		N- 19 (90.00-91.50) SAND with some silt; SP-SM; Gray-brown; Nonplastic fines; Moist; Medium Dense; Fine sand; Micaceous; (Sand Alluvium)				
						92.50 - 98.70 Sandy SILT; ML; Gray-brown; Nonplastic; Moist to wet; Medium stiff; Fine sand; Micaceous; (Sand Alluvium)			
95	N20	80	3-3-2		N- 20 (95.00-96.50) Sandy SILT; ML; Gray-brown; Nonplastic; Moist to wet; Medium Stiff; Fine sand; Micaceous; (Sand Alluvium)				
	U5	90			U- 5 (97.00-99.00) Sandy SILT; ML; Gray-brown; Nonplastic; Moist to wet; Medium Stiff; Fine sand; Micaceous; (Sand Alluvium)				
	N21	80	2-5-6		N- 21 (99.00-100.50) Silty SAND; SM; Gray-brown; Nonplastic fines; Wet; Medium Dense; Fine sand; Micaceous; (Sand Alluvium)	**98.70 - 100.50 Silty SAND; SM; Gray-brown; Nonplastic fines; Medium dense; Fine sand; Micaceous; (Sand Alluvium)**			
100						**100.50 End of hole**			
105									
110									
115									
120									

ODOT DRILL LOG - FOR SW REVIEW 24-1-03742-002_ODOTREG1.GPJ ODOT_MANWITHSWLAB.GDT 5/21/13

REV 2

FIG. B6

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

DRILL LOG
OREGON DEPARTMENT OF TRANSPORTATION

Hole No. **B-4**

Project **Union Pacific Connection at North Portland and Peninsula Junctions**	Purpose	E.A. No.
Highway	County **Multnomah**	Key No.
Hole Location Northing: **714,120.00** Easting: **7,635,850.00**		Start Card No.
Equipment **CME 75 (Hammer Efficiency = 81%)**	Driller **Hardcore Drilling**	Bridge No.
Project Geologist **Cody K. Sorensen**	Recorder **Cody K. Sorensen**	Ground Elev.
Start Date **January 22, 2013** End Date **January 22, 2013**	Total Depth **95.20 ft**	Tube Height

Test Type
"A" - Auger Core
"X" - Auger
"C" - Core, Barrel Type
"N" - Standard Penetration
"U" - Undisturbed Sample
"T" - Test Pit

Rock Abbreviations

Discontinuity	Shape	Surface Roughness
J - Joint	Pl - Planar	P - Polished
F - Fault	C - Curved	Sl - Slickensided
B - Bedding	U - Undulating	Sm - Smooth
Fo - Foliation	St - Stepped	R - Rough
S - Shear	Ir - Irregular	VR - Very Rough

Typical Drilling Abbreviations

Drilling Methods	Drilling Remarks
WL - Wire Line	LW - Lost Water
HS - Hollow Stem Auger	WR - Water Return
DF - Drill Fluid	WC - Water Color
SA - Solid Auger	DP - Down Pressure
CA - Casing Advancer	DR - Drill Rate
HA - Hand Auger	DA - Drill Action

Depth (ft)	Test Type, No.	Percent Recovery	Soil / Rock: Driving Resistance / Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description (SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.)	Unit Description	Graphic Log	Drilling Methods, Size and Remarks / Water Level/ Date	Backfill/ Instrumentation
0						**0.00 - 0.50 BASE AGGREGATE; (Fill)**		Boring drilled from 0.0 to 95.2 feet using mud rotary drilling technique	
						0.50 - 7.00 Silty SAND with trace gravel; SM; Gray; Low plasticity fines; Moist; Dense; Fine to medium sand; Subrounded gravel; Micaceous; (Fill)			
5	N1	80	6-15-20		N- 1 (5.00-6.50) Silty SAND with trace gravel; SM; Gray; Nonplastic fines; Moist; Dense; Fine to medium sand; Subrounded gravel; Micaceous; Disturbed texture; (Fill)				
						7.00 - 19.00 Clayey SILT with trace fine to medium sand; ML/MH; Gray; Low to medium plasticity; Moist; Very stiff to stiff; Fine to medium sand; Micaceous; Slightly mottled brown; (Fill)			
10	N2	93	5-7-11	35	N- 2 (10.00-11.50) Clayey SILT with trace fine to medium sand; ML/MH; Gray; Nonplastic; Moist; Very Stiff; Micaceous; Slightly mottled brown; (Fill)			1/22/13 ▽	
15	N3	100	4-6-6		N- 3 (15.00-16.50) Clayey SILT with trace fine to medium sand; ML/MH; Gray; Low to medium plasticity; Moist; Soft; Micaceous; Slighty mottled brown; Disturbed texture; (Fill)				
						19.00 - 22.00 Silty GRAVEL with trace fine to medium sand; GM; Gray; Nonplastic to low plasticity fines; Wet; Dense; Subangular to angular gravel; Occasional cobbles; (Fill)			
20	N4	33	48-17-19	13	N- 4 (20.00-21.50) Silty GRAVEL with trace fine to medium sand; GM; Gray; Nonplastic to low plasticity fines; Wet; Dense; Subangular to angular gravel; Occasional cobbles; (Fill)				
25	U1	100			U- 1 (25.00-26.00) Clayey SILT with trace fine sand; ML; Gray; Low plasticity; Wet; Very Soft; Faintly stratified; Micaceous; (Overbank Deposits)	**22.00 - 34.00 Clayey SILT with trace fine sand; ML; Gray; Low plasticity; Wet; Very soft; Micaceous; Faintly stratified; (Overbank Deposits)**			
30									

ODOT DRILL LOG - FOR SW REVIEW 24-1-03742-002_ODOTREG1.GPJ ODOT_MANWITHSWLAB.GDT 5/20/13

REV 2

FIG. B7

Depth (ft)	Test Type, No.	Percent Recovery	Soil / Rock: Driving Resistance / Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description (SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.)	Unit Description	Graphic Log	Drilling Methods, Size and Remarks / Water Level/ Date	Backfill/ Instrumentation
30	N5	100	0-0-2	73	N- 5 (30.00-31.50) Clayey SILT with trace fine sand; ML; Gray; Low plasticity; Wet; Very Soft; Faintly stratified; Micaceous; (Overbank Deposits)				
35	N6	80	0-2-1		N- 6 (35.00-36.50) Silty SAND to sandy SILT; SM/ML; Gray; Nonplastic; Wet; Very Loose; Fine sand; Faintly stratified; Micaceous; Occasional organics; (Overbank Deposits)	**34.00 - 43.00 Silty SAND to sandy SILT; SM/ML; Gray; Nonplastic fines; Wet; Very loose; Fine sand grading to fine to medium sand; Micaceous; Stratified; Occasional organics; (Overbank Deposits)**			
40	N7	80	2-0-1	46	N- 7 (40.00-41.50) Sandy SILT to silty SAND; SM-ML; Gray; Nonplastic; Wet; Very Loose; Fine to medium sand; Stratified; Micaceous; Occasional organics; (Overbank Deposits)				
45	N8	100	0-0-0		N- 8 (45.00-46.50) SILT with some fine to medium sand; ML; Gray; Nonplastic to low plasticity; Wet; Very Soft; Stratified; Micaceous; Occasional layers of silty SAND; Scattered organics; (Overbank Deposits)	**43.00 - 54.00 SILT with some sand to sandy SILT; ML; Gray; Nonplastic to low plasticity; Wet; Very soft to soft; Fine to medium sand; Micaceous; Stratified with occasional layers of silty SAND; Scattered organics; (Overbank Deposits)**			
50	U2	100			U- 2 (50.00-52.00) SILT with some fine to medium sand; ML; Gray; Nonplastic to low plasticity; Wet; Very Soft; Stratified; Micaceous; Occasional layers of silty SAND; Scattered organics; (Overbank Deposits)				
	N9	100	2-1-3		N- 9 (52.00-53.50) Sandy SILT; ML; Gray; Nonplastic; Wet; Very Loose to soft; Fine to medium sand; Stratified; Micaceous; Scattered organics; (Overbank Deposits)				
55	N10	100	3-2-2		N- 10 (55.00-56.50) Silty SAND; SM; Gray; Nonplastic; Wet; Very Loose; Fine to medium sand; Stratified; Micaceous; Occasional layers of sandy SILT; Occasional to scattered organics; (Overbank Deposits)	**54.00 - 59.00 Silty SAND; SM; Gray; Nonplastic fines; Wet; Very loose; Fine to medium sand; Micaceous; Stratified with occasional layers of sandy SILT; Occasional to scattered organics; (Overbank Deposits)**			
60	N11	100	0-0-2		N- 11 (60.00-61.50) Clayey SILT with trace fine sand; ML; Blue-gray and gray; Low to medium plasticity; Wet; Very Soft to soft; Faintly stratified; Scattered organics; (Overbank Deposits)	**59.00 - 68.00 Clayey SILT to SILT with trace sand; MH/ML; Blue-gray to brown-gray; Medium to low plasticity; Wet; Very soft to soft; Fine sand; Faintly stratified; Scattered organics; (Overbank Deposits)**			
65	U3	100			U- 3 (65.00-67.00) SILT with trace fine sand; ML; Brown-gray; Low plasticity; Wet; Scattered organics; (Overbank Deposits)				
	N12	100	6-32-37		N- 12 (67.00-68.50)				
	N12a				N- 12a (67.00-68.00) SILT with trace fine sand; ML; Brown-gray; Low plasticity; Wet; Very Stiff to hard; Scattered organics; (Overbank Deposits)				
	N12b				N- 12b (68.00-68.50) SILT with trace fine sand; ML; Light gray; Nonplastic; Wet; Hard; Faintly stratified; (Ash Deposits)	**68.00 - 74.00 SILT with trace fine sand; ML; Light gray; Nonplastic; Wet; Hard; Faintly stratified; (Ash Deposits)**			
70	N13	100	18-25-20		N- 13 (70.00-71.50) SILT with trace fine sand; ML; Light gray; Nonplastic; Wet; Hard; Faintly stratified; (Ash Deposits)				
75						**74.00 - 78.00**			

ODOT DRILL LOG - FOR SW REVIEW 24-1-03742-002_ODOTREG1.GPJ ODOT_MANWITHSWLAB.GDT 5/20/13

REV 2

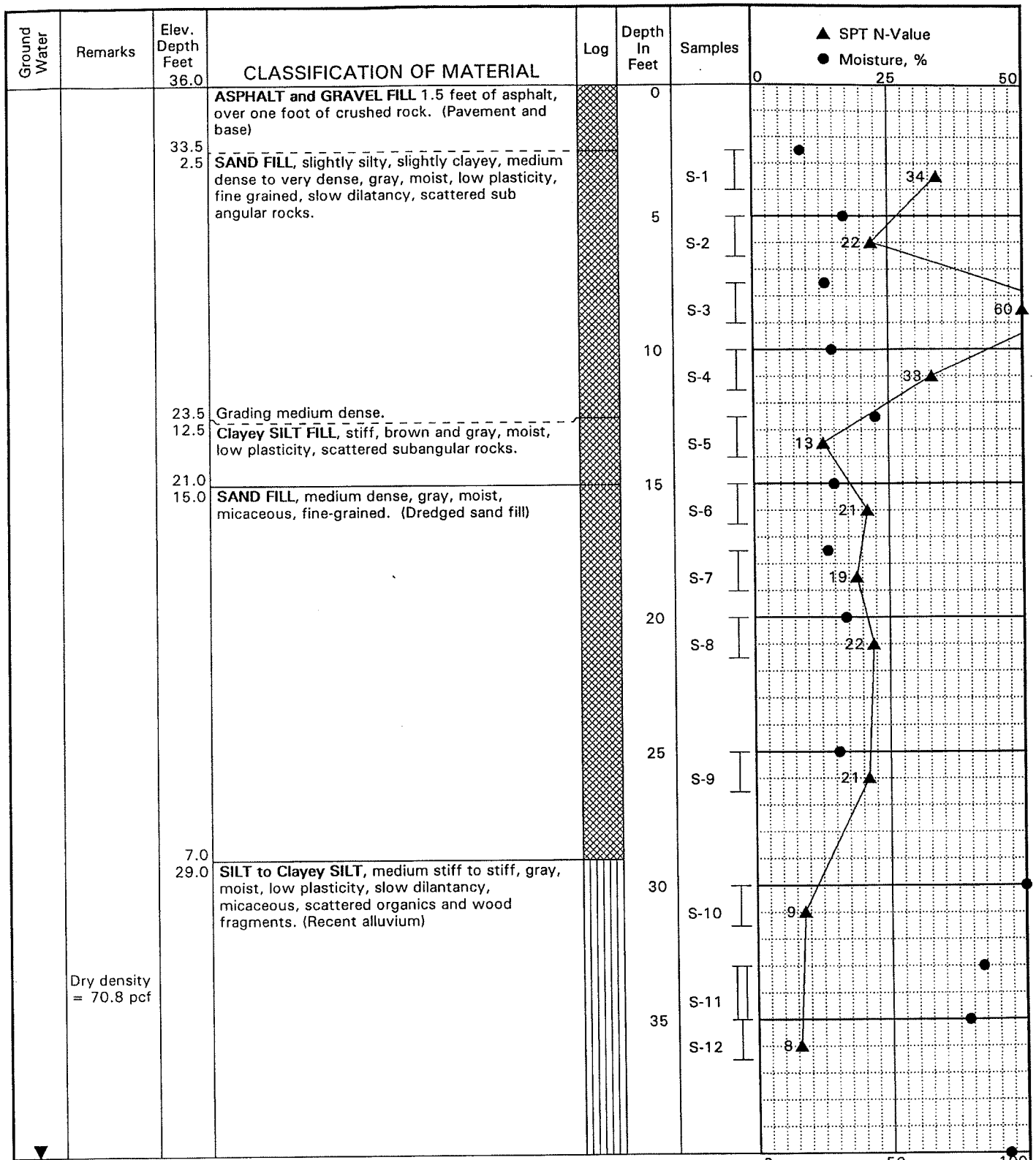
FIG. B7

Depth (ft)	Test Type, No.	Percent Recovery	Soil / Rock: Driving Resistance / Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks / Water Level/ Date	Backfill/ Instrumentation
75	N14	100	8-15-19		N- 14 (75.00-76.50) SAND with trace silt; SP; Gray; Nonplastic fines; Wet; Dense; Fine to medium sand; Stratified; Micaceous; Occasional layers of silty SAND; Occasional organics; (Sand Alluvium)	**SAND with trace silt; SP; Gray; Nonplastic fines; Wet; Dense; Fine to medium sand; Micaceous; Stratified with occasional layers of silty SAND; Occasional organics; (Sand Alluvium)**			
80	N15	80	9-10-13		N- 15 (80.00-81.50) SAND with trace silt; SP; Brown; Nonplastic fines; Wet; Medium Dense; Fine to medium sand; Micaceous; Slightly mottled red-brown and slight iron-oxidation; (Sand Alluvium)	**78.00 - 89.00 SAND with trace silt; SP; Brown; Nonplastic fines; Wet; Medium dense; Fine to medium sand; Micaceous; Slight iron-oxidation and red-brown staining at 80.0 feet; Trace fine subrounded gravel at 85.0 feet; (Sand Alluvium)**			
85	N16	73	13-8-12		N- 16 (85.00-86.50) SAND with trace silt and trace fine gravel; SP; Brown; Nonplastic fines; Wet; Medium Dense; Fine to medium sand; Subrounded gravel; Micaceous; (Sand Alluvium)				
90	N17	100	50/1st 1.5"		N- 17 (90.00-90.10) Sandy GRAVEL with trace silt; GP; Gray; Nonplastic fines; Wet; Very Dense; Fine to coarse sand; Subrounded to subangular gravel; (Gravel Alluvium)	**89.00 - 95.20 Sandy GRAVEL with trace silt: GP; Gray; Nonplastic fines; Wet; Very dense; Fine to coarse sand; Rounded to subangular gravel; (Gravel Alluvium)**			
95	N18	50	50/1st 3"		N- 18 (95.00-95.20) Sandy GRAVEL with trace silt; GP; Gray; Nonplastic fines; Wet; Very Dense; Fine to coarse sand; Subrounded to subangular gravel; (Gravel Alluvium)	**95.20 End of hole**			
100									
105									
110									
115									
120									

ODOT DRILL LOG - FOR SW REVIEW 24-1-03742-002_ODOTREG1.GPJ ODOT_MANWITHSWLAB.GDT 5/20/13

REV 2

FIG. B7



LEGEND

- = 2.0" O.D. Split Spoon Sample
- = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- = Grab Sample: Drill Cuttings
- = Core Rock Sample

NOTE:
Lines between soil/rock units are approximate and transition may be gradual.

Impervious Seal (Bentonite)
Cement Grout
Random Backfill
Granular Backfill
Ground Water Level on Date Shown
Piezometer/Inclinometer Tubing
Perforated Zone

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

Interstate MAX
Line Section 10C

LOG OF BORING C-23
page 1 of 2

October 2000 *F-3090.31*

FUJITANI HILTS & ASSOCIATES
Geotechnical Consultants
Portland, Oregon

FIG. 42

FHA

WLG IMAXE 10/27/00

FIG. B8

Ground Water	Remarks	Elev. Depth Feet	CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples	▲ SPT N-Value ● Moisture, % 0 25 50
	4/11/00		**SILT to Clayey SILT** (continued)			S-13	6▲
		-5.5					
		41.5	End of Boring, completed on 4/11/00				

0 50 100
Recovery, % RQD, %

LEGEND

- = 2.0" O.D. Split Spoon Sample
- = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- = Grab Sample: Drill Cuttings
- = Core Rock Sample

NOTE:
Lines between soil/rock units are approximate and transition may be gradual.

- Impervious Seal (Bentonite)
- Cement Grout
- Random Backfill
- Granular Backfill
- Ground Water Level on Date Shown
- Piezometer/Inclinometer Tubing
- Perforated Zone

ATTERBERG LIMITS
- Liquid Limit
- Natural Water Content
- Plastic Limit

Interstate MAX
Line Section 10C

LOG OF BORING C-23
page 2 of 2

October 2000 *F-3090.31*

FUJITANI HILTS & ASSOCIATES
Geotechnical Consultants
Portland, Oregon

FIG. 42

FHA

WLG IMAXE 10/27/00

FIG. B8

Total Depth:	81.5 ft.	Northing:	~	Drilling Method:	HSA and Mud Rotary	Hole Diam.:	8 in.; 4 in.
Top Elevation:	~	Easting:	~	Drilling Company:	Subsurface Technologies	Rod Type:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	Diedrich D-50 Track	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	Hammer Efficiency = 70.9%		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Medium dense to medium stiff, brown, *Poorly Graded Sand with Silt and Sand* to *Silt with Gravel (SP-SM, ML)*; dry to moist; fine, subangular to angular gravel; nonplastic to low plasticity fines.

FILL

5.7

Loose, brown-gray, *Poorly Graded Sand (SP)*; fine to medium sand; trace nonplastic to low plasticity fines; massive; micaceous.

SAND ALLUVIUM

15.0

Interbedded sand and silt in beds approximately 2-to 3-inch thick.

20.0

Soft to stiff, gray, *Silt to Lean Clay (ML/CL)*; moist to wet; trace fine sand; low to medium plasticity; few organics; stratified; organic odor; micaceous.

FINE-GRAINED ALLUVIUM

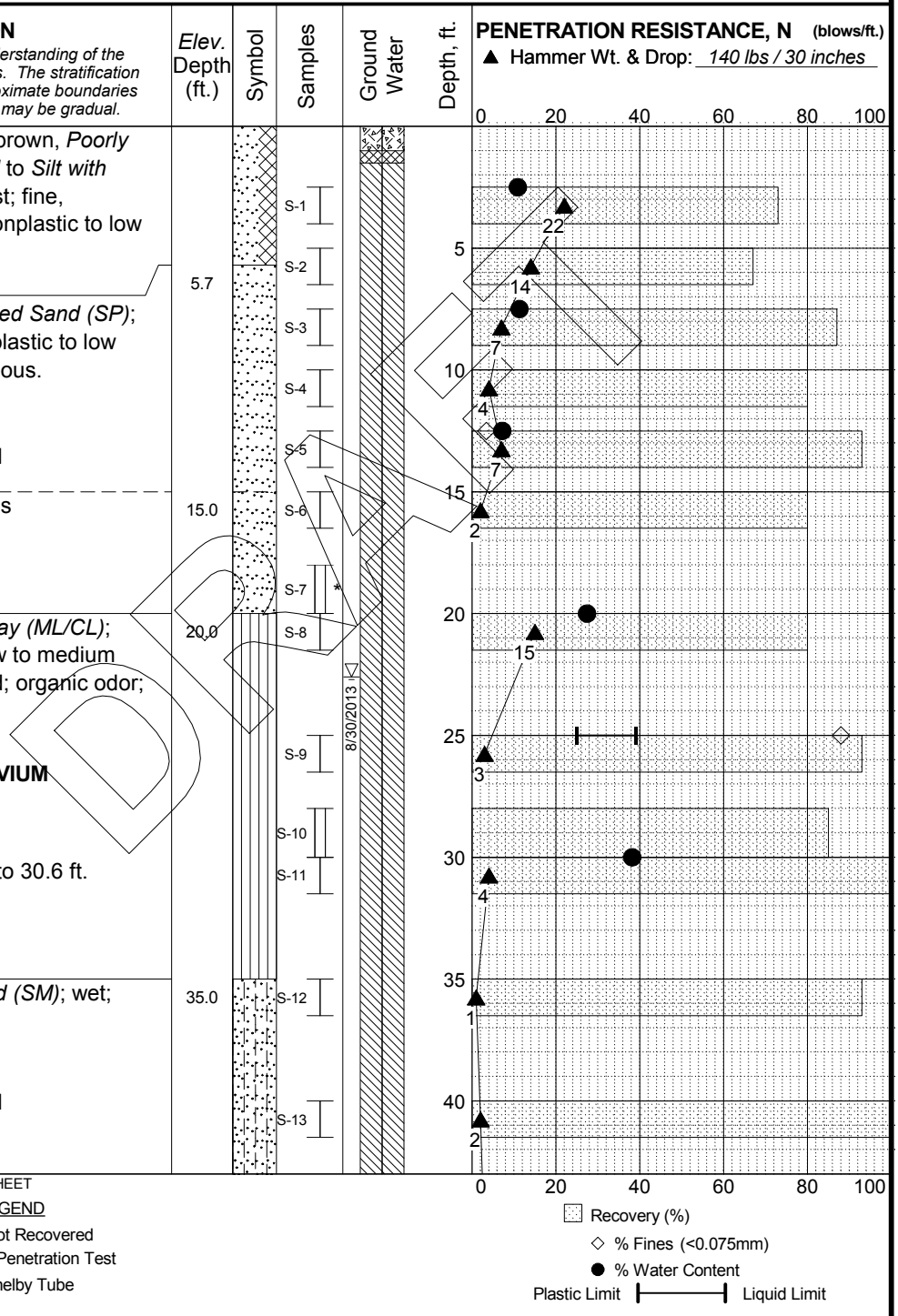
Heavily iron-oxidized from 30.0 to 30.6 ft.

35.0

Very loose, dark gray, *Silty Sand (SM)*; wet; fine sand; massive; micaceous.

SAND ALLUVIUM

CONTINUED NEXT SHEET



LEGEND

* Sample Not Recovered
Standard Penetration Test
3" O.D. Shelby Tube

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

OR99W: N. Victory Blvd - N. Argyle St
Portland, Oregon

LOG OF BORING B-6

September 2013 24-1-03778-604

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B7
Sheet 1 of 2

REV 2
FIG. B9

Rev: KE/AH Typ: MAS/ATH
Log: RAP
MASTER_LOG_E 24-1-03778.GPJ SHAN_WIL.GDT 9/27/13

Total Depth:	81.5 ft.	Northing:	~	Drilling Method:	HSA and Mud Rotary	Hole Diam.:	8 in.; 4 in.
Top Elevation:	~	Easting:	~	Drilling Company:	Subsurface Technologies	Rod Type:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	Diedrich D-50 Track	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	Hammer Efficiency = 70.9%		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Soft, dark gray, *Sandy Silt (ML)*; moist; fine sand; low plasticity; trace organics; faint organic odor.

FINE-GRAINED ALLUVIUM

45.0

Very loose, gray, *Silty Sand (SM)*; wet; fine, subangular sand; nonplastic fines.

SAND ALLUVIUM

50.0

Soft to medium stiff, gray, *Silt with Sand grading to Sandy Silt (ML)*; wet; fine sand; low plasticity; faintly stratified.

FINE-GRAINED ALLUVIUM

55.0

Medium dense, gray, *Silty Sand (SM)*; wet; fine, angular sand; nonplastic fines; trace organics (woody pieces of debris); stratified with layers of fine *Sand (SP)*; micaceous.

SAND ALLUVIUM

70.0

Medium stiff, olive-gray, *Silt to Lean Clay (ML/CL)*; wet; fine sand; medium plasticity; trace organics (rootlets).

FINE-GRAINED ALLUVIUM

75.0

Hard, light gray-brown, *Silt (ML)*; wet; nonplastic to low plasticity; contains minute voids and faint laminations; volcanic ash.

80.0

81.5

Completed - August 14, 2013

Elev. Depth (ft.)

Symbol

Samples: S-14, S-15, S-16, S-17, S-18, S-19, S-20, S-21

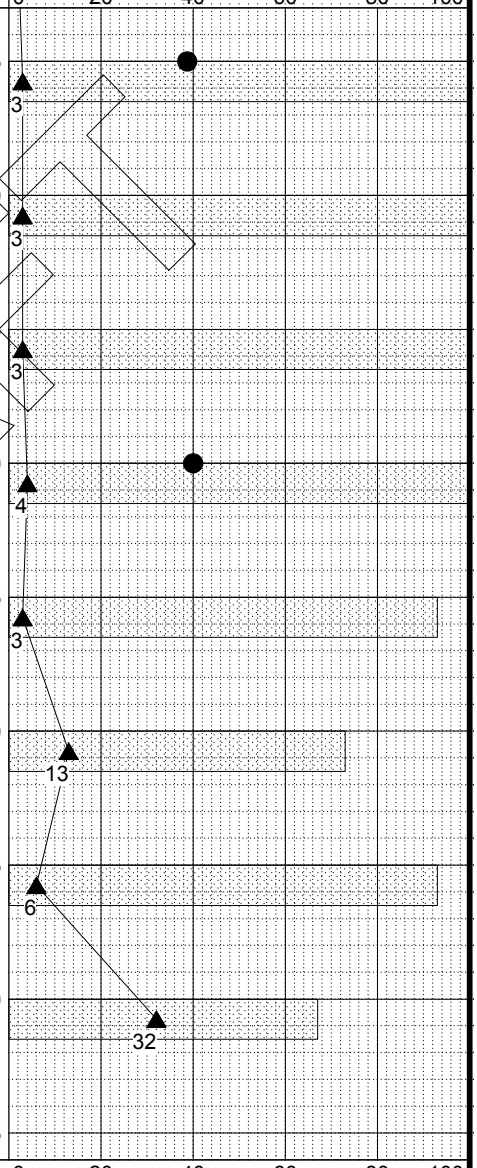
Ground Water

Geokon Model 4500S-350 kPa; Serial Number 1313962

Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

Standard Penetration Test

3" O.D. Shelby Tube

Recovery (%)

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ——— Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

OR99W: N. Victory Blvd - N. Argyle St
Portland, Oregon

LOG OF BORING B-6

September 2013 24-1-03778-604

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B7
Sheet 2 of 2

REV 2
FIG. B9

Rev: KE/AH Typ: MAS/ATH

Log: RAP

MASTER_LOG_E 24-1-03778.GPJ SHAN_WIL.GDT 9/27/13

SOILS AND GEOLOGICAL EXPLORATION LOG

HIGHWAY DIVISION

Project JANTZEN BEACH - DELTA PARK INTERCHANGE		Hole No. TB-103
Highway I-5	County Multnomah	Prefix C6261979/000/908
Purpose of Work Fill Foundation		Bridge No.
Equipment B 53 Mobile Drill RE830894		Tube Elev.
Geologist C. J. Eshelman	Driller T. Lauinger	Recorder D. Turner
Hole Location FU Line, Sta. 108 + 00 Lt. 65' C.L. Rt.		Ground Elev. 18'

Tests

"N" — Standard Penetration,	No.	5
"M" — Oregon Miniature Pile,	No.	0
"C" — Core, Barrel Type	No.	0
"U" — Undisturbed Sample, Size 2½"	No.	1

Drilling Method

8" hollow	Auger Depth	24
	Casing Depth	
	Open Depth	1.5
	Total Depth	25.5

Groundwater Level

Date	Depth
2-11-86	8'

Date Started	Date Completed	Sample Data Sheet No.
2-11-86	2-11-86	A35330

Depth, ft.	Test Type No.	Driving Resistance	Measured Recovery,	% Recovery	Hardness R. Q. D.	Graphic Log	% Natural Moisture	Material Description (Color, Consistency, Plasticity, Organic Content; Wet-Dry, Jointed-Broken, Angular-Rounded, Drill Remarks etc.)
								0 - 4' - Soft to very soft silty gravels up to 2" dia. Brown, moist.
4.0								
	N-1	5-6-7	12	66			33.5	N-1 - 4' - 4.5' - Soft, brown silty fine SAND, moist. 4.5' - 5.5' - Soft gray trace of organic SILT with trace of clay, lenses of gray silty sand. Moist. A - 4 LL = 28 PI = 3
5.5								
								Hit water table at 8'.
9.0								
	N- 2	1-1-1	18	100			38	N-2 - Extremely soft, brown silty fine Sand, trace organics, wet to moist. LL = 40 PI = 13
10.5								
14.0								
	N-3	2-3-4	18	100			41	N-3 - Very soft, gray trace of organic clayey SILT with trace of fine sand. Slightly plastic, moist. LL = 31 PI = 3
15.5								
18.0								
	U-1							U-1 - Shelby sample 18' - 20'
19.0								
	N-4	1-2-2	18	100			39	N-4 - Very soft, gray trace to some organic clayey SILT with trace of fine sand, slightly plastic, moist.
20.5								

FIG. B10

Hole No. TB-103 Page 2 of 2

Depth, ft.	Test Type No.	Driving Resistance	Measured Recovery,	% Recovery	Hardness R. Q. D.	Graphic Log	% Natural Moisture	Material Description Color / Consistency / Plasticity / Organic Content Wet-Dry / Jointed-Broken / Angular-Rounded / Drill Remarks etc.
24.0								
	N-5	3-5-6	18	100			34	N-5 - 24' - 25' - Soft gray organic clayey SILT with 1" thick lenses of sandy silt and silty fine sand.
								25 - 25.5' - Soft, gray, silty fine SAND, moist.
25.5								
								BOTTOM OF HOLE 25.5'
								Surging sand at 25.5'

FIG. B10

SOILS AND GEOLOGICAL EXPLORATION LOG

HIGHWAY DIVISION

Project JANTZEN BEACH - DELTA PARK INTERCHANGE			Hole No. TB-104
Highway I-5		County Multnomah	Prefix C6261979/000/908
Purpose of Work Fill foundation			Bridge No.
Equipment B-53 Mobile Drill RE830894			Tube Elev.
Geologist C. J. Eshelman		Driller T. Lauinger	Recorder D. Turner
Hole Location FU Line, Sta. 106 + 00	Lt. 70'	C.L. Rt.	Ground Elev. 16.5'

Tests		Drilling Method		Groundwater Level	
				Date	Depth
"N" — Standard Penetration, No. 4		8" Hollow	Auger Depth 19.5'	2-11-86	8'
"M" — Oregon Miniature Pile, No. 0			Casing Depth		
"C" — Core, Barrel Type No. 0			Open Depth 1.5'		
"U" — Undisturbed Sample, Size 2 1/2" No. 1			Total Depth 21.0		

Date Started	Date Completed	Sample Data Sheet No.
2-11-86	2-11-86	A35330

Depth, ft.	Test Type No.	Driving Resistance	Measured Recovery,	% Recovery	Hardness R. Q. D.	Graphic Log	% Natural Moisture	Material Description Color, Consistency, Plasticity, Organic Content; Wet-Dry, Jointed-Broken, Angular-Rounded, Drill Remarks etc.
								0 - 4.5' - Soft to very soft fine sandy SILT and silty fine sand. Moist.
4.5								
	N-1	2-3-3	12	66			37	N-1 - Soft, brown, trace of organic fine sandy SILT with trace of clay. Moist. A-4
6.0								
9.5								
	N-2	2-1-1	18	100			42	N-2 - Extremely soft, mottled brown, fine sandy silt and silty fine sand. Wet at top, moist, predominant. A-4
11.0								
14.5								
	N-3	3-4-4	18	100			43	N-3 - Soft, brown-gray mottled clayey SILT with trace of fine sand and 2" lense of silty clay at 15.5' LL = 46, PI = 18
16.0								
18.0								
	U-1							U-1 - Shelby sample at 16.0 - 18.0' LL=29, NP
19.5								
	N-4	Wt. of hammer	18	100			35	N-4 - Extremely soft, gray fine sandy SILT with trace of organics. A-4
21.0								
								Surging sand at 21.0'
								BOTTOM OF HOLE - 21.0'

734-3976 (REV. 12-82)

FIG. B11

SOILS AND GEOLOGICAL EXPLORATION LOG

HIGHWAY DIVISION

Project Jantzen Beach - Delta Park Interchange		Hole No. TB-106
Highway I-5	County Multnomah	Prefix C6261979/000/908
Purpose of Work Foundation Investigation		Bridge No.
Equipment B53 Mobile		Tube Elev.
Geologist C. J. Eshelman	Driller T. Lauinger	Recorder D. Turner
Hole Location VF Line, Sta. 120 + 00. Lt.	C.L. Rt. 10'	Ground Elev. 19'

Tests		Drilling Method		Groundwater Level	
"N" — Standard Penetration, No. 16		Auger Depth		Date	Depth
"M" — Oregon Miniature Pile, No.		HQ	Casing Depth 114.5	1-27-87	7.5'
"C" — Core, Barrel Type HQ No. 0			Open Depth 0.5		
"U" — Undisturbed Sample, Size 2½" No. 2			Total Depth 115.0		

Date Started	Date Completed	Sample Data Sheet No.
1-13-87	1-15-87	A-35335

Depth, ft.	Test Type No.	Driving Resistance	Measured Recovery,	% Recovery	Hardness R.Q.D.	Graphic Log	% Natural Moisture	Material Description (Color, Consistency, Plasticity, Organic Content; Wet-Dry, Jointed-Broken, Angular-Rounded, Drill Remarks etc.)
4.5								
	N-1	2-1-1	0	0				N-1 - No recovery.
6.0								
9.5								
	N-2	1-3-3	0	0				N-2 - No recovery.
11.0								
14.5								
	N-3	2-1-3	1.5	100			40.3	N-3- Soft, gray silts with some to trace of fine sand
16.0								and trace of clay, NP, quick dilatency. (ML). SM-ML
17.0								
	U-1						41.1	U-1 - Shelby sample 2.0' recovered. LL=26, NP(SM)
19.0								
19.5	N-4	1-3-5	0.2	13			36.0	N-4 - Medium stiff, gray-brown fine sandy silt w/
21								trace to some clay and small gravels. (SM-ML).
24.5								
26	N-5	7-6-8	1.3	87				N-5 - Medium dense, gray fine sand. (SP).
29.5								
	N-6	5-7-11	1.5	100			82.0	N-6 - Stiff, gray, fine silt w/trace of fine sand,
31								trace to some clay. LL=94, PI=26
34.5								
36.5	U-2							U-2 - Shelby sample. Recovered 0.5'.
40								
	N-7	7-7-9	1.5	100			34.7	N-7 - Medium dense, gray fine sand w/some silt.
41.5								(SM).
44.5								
	N-8	7-6-6	1.5	100				N-8 - Medium dense, gray fine sand w/trace of silt
46								(SM).
49.5								

FIG. B12

Hole No. TB-106 Page 2 of 2

Depth, ft.	Test Type No.	Driving Resistance	Measured Recovery.	% Recovery	Hardness R. Q. D.	Graphic Log	% Natural Moisture	Material Description Color / Consistency / Plasticity / Organic Content Wet-Dry / Jointed-Broken / Angular-Rounded / Drill Remarks etc.
49.5								
51.0	N-9	4-4-6	1.5	100			43.0	N-9 - Loose, gray fine sand w/trace of silt. (SM).
59.5								
61.0	N-10	11-13-23	1.5	100				N-10 - Dense, gray fine sand. (SP).
69.5								
	N-11	5-7-7	1.5	100			43.1	N-11 - Stiff, gray silt w/some fine sand and trace organics, some clay. LL=36, PI=7 (ML)
71.0								
79.5								
81.0	N-12	13-29-31	1.5	100				N-12 - Very dense, gray fine sand. (SP).
89.5								
91.0	N-13	10-13-20	1.5	100			34.7	N-13 - Dense gray fine sand w/some silt. (SM).
99.5								
101.0	N-14	18-22-25	1.5	100				N-14 - Hard, gray silt w/some fine sand. (ML).
109.5								
111.0	N-15	15-20-26	0	0				N-15 - No recovery.
114.5								
	N-16	50/.3'	.3'	60				N-16 - Very dense, gray fine silty sand into sandy gravels. (SM - GM).
115.0								
								BOTTOM OF HOLE - 115.0'
								1" PVC installed to 115'.

FIG. B12

Is it "DV2"? Yes!

SOILS AND GEOLOGICAL EXPLORATION LOG

HIGHWAY DIVISION

Project SWIFT INTERCHANGE - DELTA PARK INTERCHANGE		Hole No. TB-111
Highway I-5	County Multnomah	Prefix C6261979-000-908
Purpose of Work Fill Foundation		Bridge No.
Equipment B-53 Mobile		Tube Elev.
Geologist C. J. Eshelman	Driller T. Lauinger	Recorder D. Turner
Hole Location (DV3) Line, Sta. 156 + 66 Lt.	C.L. Rt. 25'	Ground Elev. 204

Tests		Drilling Method		Groundwater Level	
"N" — Standard Penetration, No. 11			Auger Depth	Date	Depth
"M" — Oregon Miniature Pile, No. 0		BW	Casing Depth 57.0'	10-28-88	8.5'
"C" — Core, Barrel Type No. 0		Drill Fluid - Water	Open Depth 1.5'		
"U" — Undisturbed Sample, Size No. 0			Total Depth 58.5'		

Date Started	Date Completed	Sample Data Sheet No.
10-27-88	10-27-88	

Depth, ft.	Test Type No.	Driving Resistance	Measured Recovery,	% Recovery	Hardness R.Q.D.	Graphic Log	% Natural Moisture	Material Description (Color, Consistency, Plasticity, Organic Content; Wet-Dry, Jointed-Broken, Angular-Rounded, Drill Remarks etc.)
2	N-1	7-6-10	0.3	20		SM FILL		N-1 - (2.0' - 3.5') - SAND, coarse with some small rounded gravels, trace of silt. Brown, moist, medium dense, (SM). Origin: Fill Material.
7	N-2	12-27-17	0.5	33		SM 10'		N-2 - (7.0' - 8.5') - SAND, medium to coarse, with some small rounded gravels, brown, moist, dense, (SM). Origin: Fill material.
12	N-3	2-4-4	1.5	100		ML	51	N-3 - (12.0' - 13.5') - SILT with trace of clay, fine to medium sand, gray - brown, moist, medium stiff, (ML).
17	N-4	1-1-2	1.2	80		SM / ML		N-4 - (17.0' - 18.5') - 17.0' - 17.3' - Same as N-3 17.3' - 18.5' - SAND with some silt and silt with some sand, gray, moist, loose - soft (SM - ML).
22	N-5	9-9-10	0.1	7		SM		N-5 - (22.0 - 23.5') - SAND with some silt, gray, moist, medium dense, (SM).
27	N-6	5-4-5	1.1	73		SM		N-6 - (27.0' - 28.5') - SAND with trace of silt, gray, moist, loose, (SM).

FIG. B13

Depth, ft.	Test Type No.	Driving Resistance	Measured Recovery,	% Recovery	Hardness R. Q. D.	Graphic Log	% Natural Moisture	Material Description Color, Consistency, Plasticity, Organic Content; Wet-Dry, Jointed-Broken, Angular-Rounded, Drill Remarks etc.
32	N-7	1-3-3	1.5	100		SM		N-7 - (32.0' - 33.5') - Same as N-6.
37	N-8	0-1-6	1.5	100		ML		N-8 - (37.0' - 38.5') - SILT with trace clay and fine sand, gray, moist, medium stiff, (ML).
42	N-9	0-1-5	1.5	100		ML		N-9 - (42.0' - 43.5') - Same as N-8.
47	N-10	1-2-5	1.5	100		SM		N-10 - (47.0' - 48.5') - SAND, some silt, trace organic material, gray, moist, loose, (SM).
57	N-11	5-9-13	1.5	100		SM		N-11 - (57.0' - 58.5') - SAND with trace of silt and lens of sand w/some silt, gray, moist, medium dense (SM).
						58.5'		BOTTOM OF HOLE - 58.5'

FIG. B13

APPENDIX C

LABORATORY TEST RESULTS

Appendix C – Table of Contents

COBBLES	GRAVEL		SAND			FINES	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

Boring No.	Sample No.	Depth, Ft.	Classification	Nat W%	LL	PL	PI
△ P1-CC-08	S-2	10	very sandy, clayey SILT	21	44	27	17
⊡ P1-CC-11	S-3	15	silty fine SAND	12	--	--	--
× P1-CC-37	S-2	10	slightly sandy, slightly clayey SILT	29	53	32	21

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GRADATION GRAPH
EMBANKMENT (1 of 2)

PENINSULA 1 LEVEE EVALUATION
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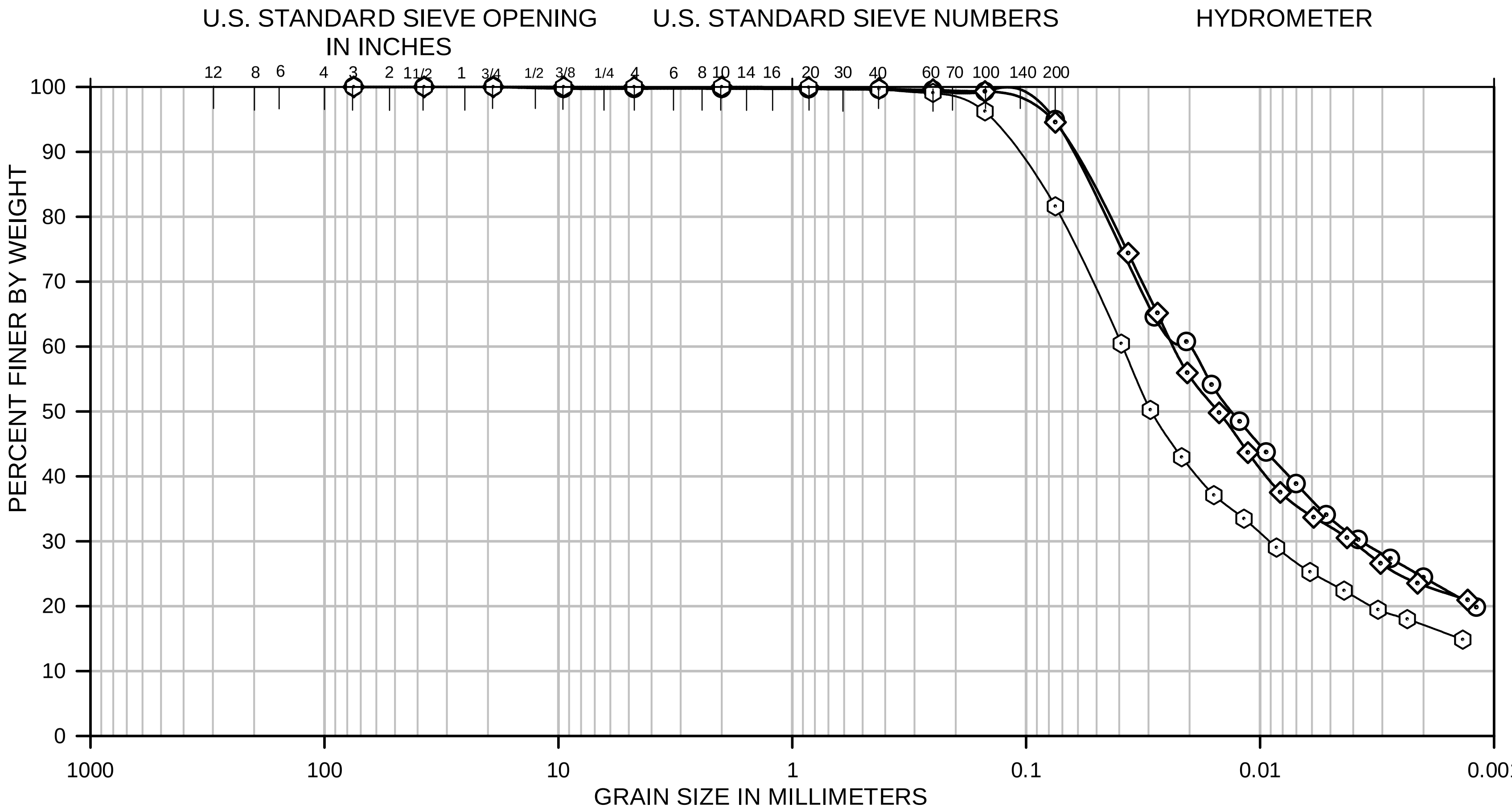
FIG. C1



COBBLES	GRAVEL		SAND			FINES	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

Boring No.	Sample No.	Depth, Ft.	Classification	Nat W%	LL	PL	PI
⊙ P1-CC-05	S-2	10	slightly sandy, slightly clayey SILT	29	34	26	8
◈ P1-CC-34	S-3	15	slightly sandy, clayey SILT	38	43	28	15
⬡ P1-CC-49	S-2	10	sandy, clayey SILT	29	41	29	12

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GRADATION GRAPH EMBANKMENT (2 of 2)

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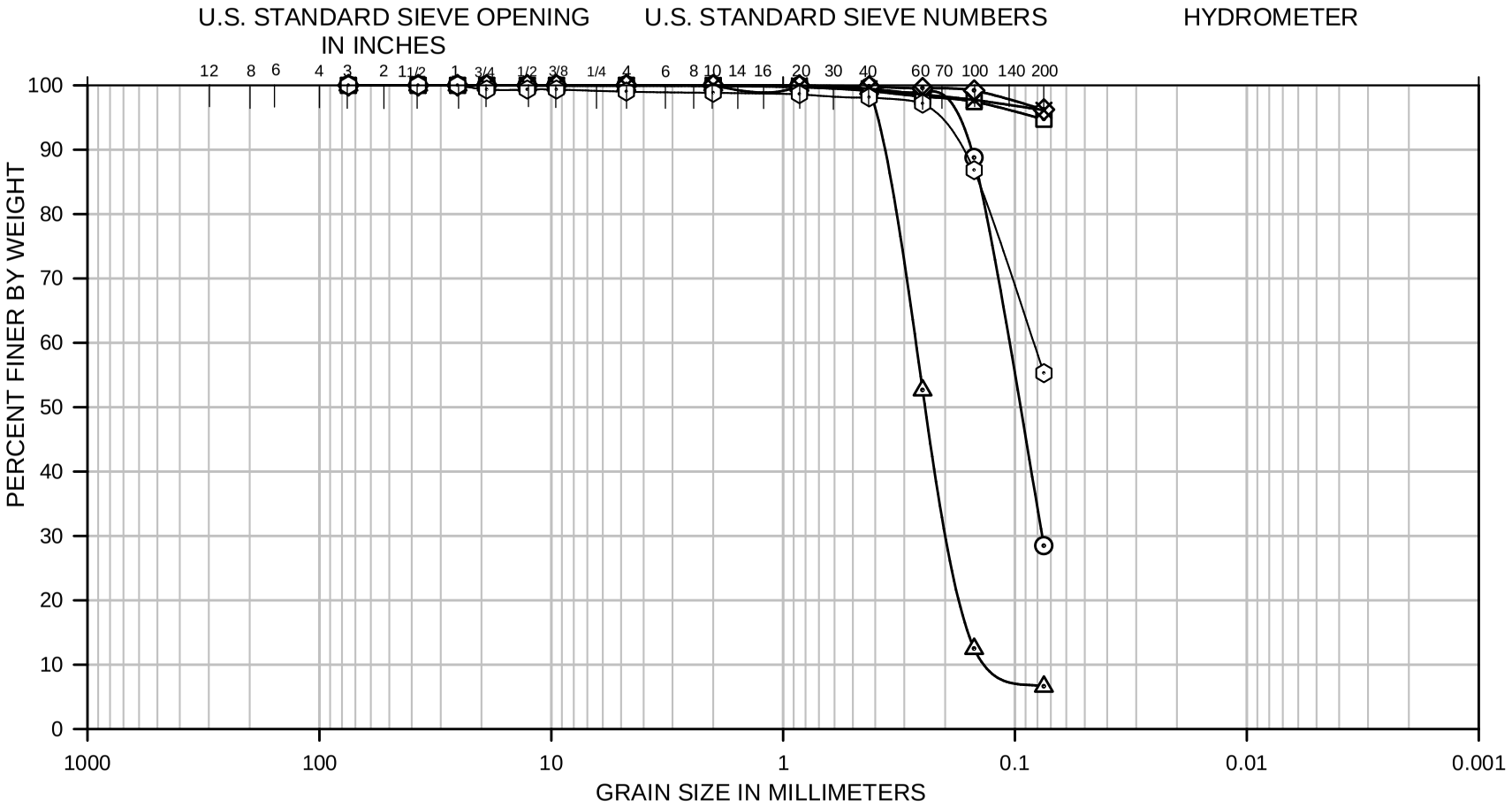
FIG. C2



COBBLES	GRAVEL		SAND			FINES	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

Boring No.	Sample No.	Depth, Ft.	Classification	Nat W%	LL	PL	PI
⊙ P1-CC-14	S-5	27	silty fine SAND	31	--	--	--
△ P1-CC-17	S-4	20	slightly silty fine SAND	27	--	--	--
⊡ P1-CC-21	S-4	20	slightly sandy, slightly clayey SILT	45	44	32	12
◇ P1-CC-28	S-5	27	slightly clayey SILT; trace sand	48	49	36	13
× P1-CC-45	S-5	20	slightly sandy, slightly clayey SILT	76	--	--	--
⬡ P1-CC-46	S-9	25	very sandy, slightly clayey SILT	31	--	--	--

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GRADATION GRAPH
FOUNDATION (1 of 3)

PENINSULA 1 LEVEE EVALUATION
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FIG. C3

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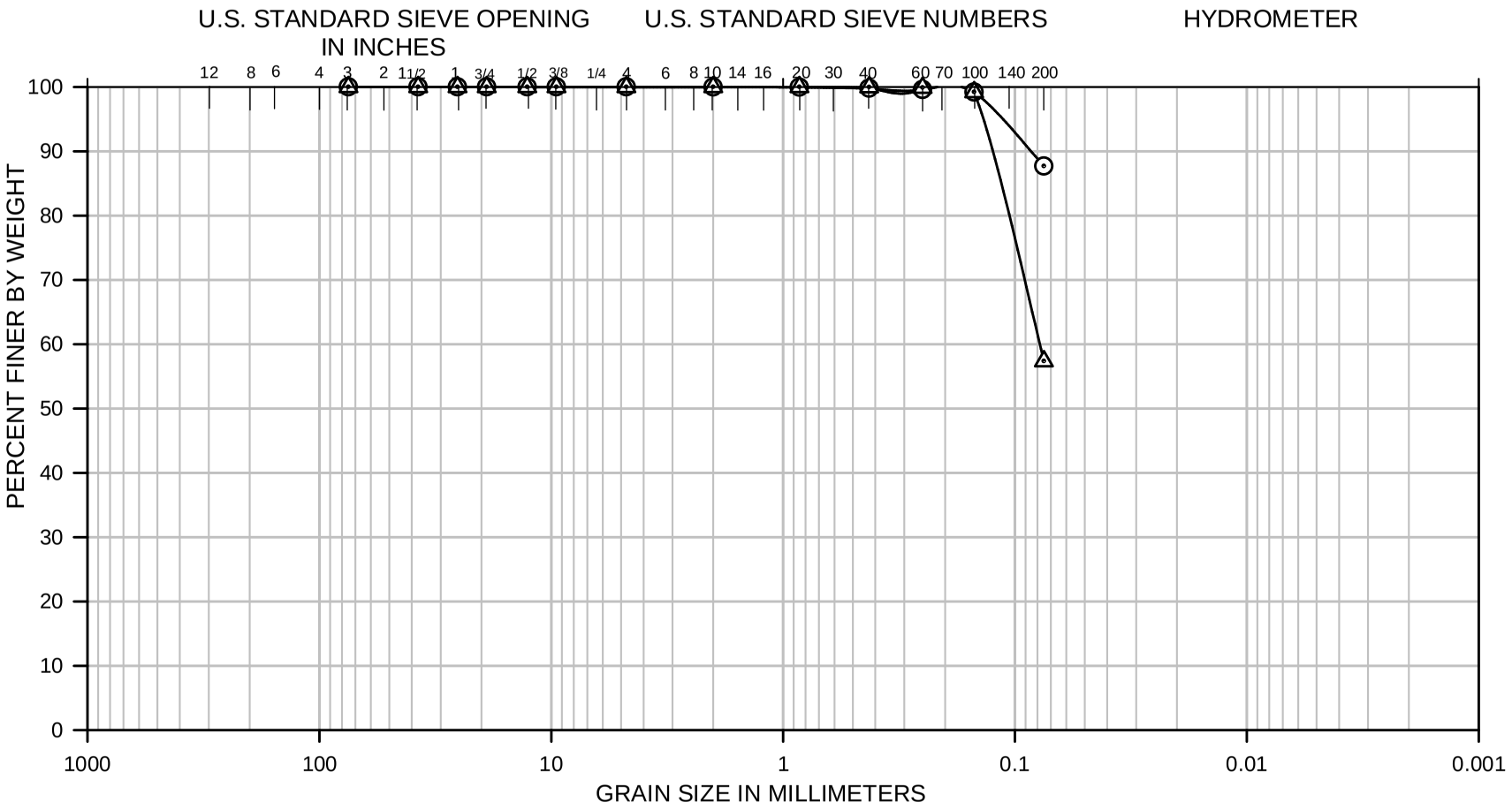

COBBLES	GRAVEL		SAND			FINES	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

Boring No.	Sample No.	Depth, Ft.	Classification	Nat W%	LL	PL	PI
⊙ P1-CC-56	S-3	15	sandy SILT	45	--	--	--
△ P1-CC-58	S-13	65	very sandy SILT; trace clay	48	--	--	--

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GRADATION GRAPH
FOUNDATION (2 of 3)

PENINSULA 1 LEVEE EVALUATION
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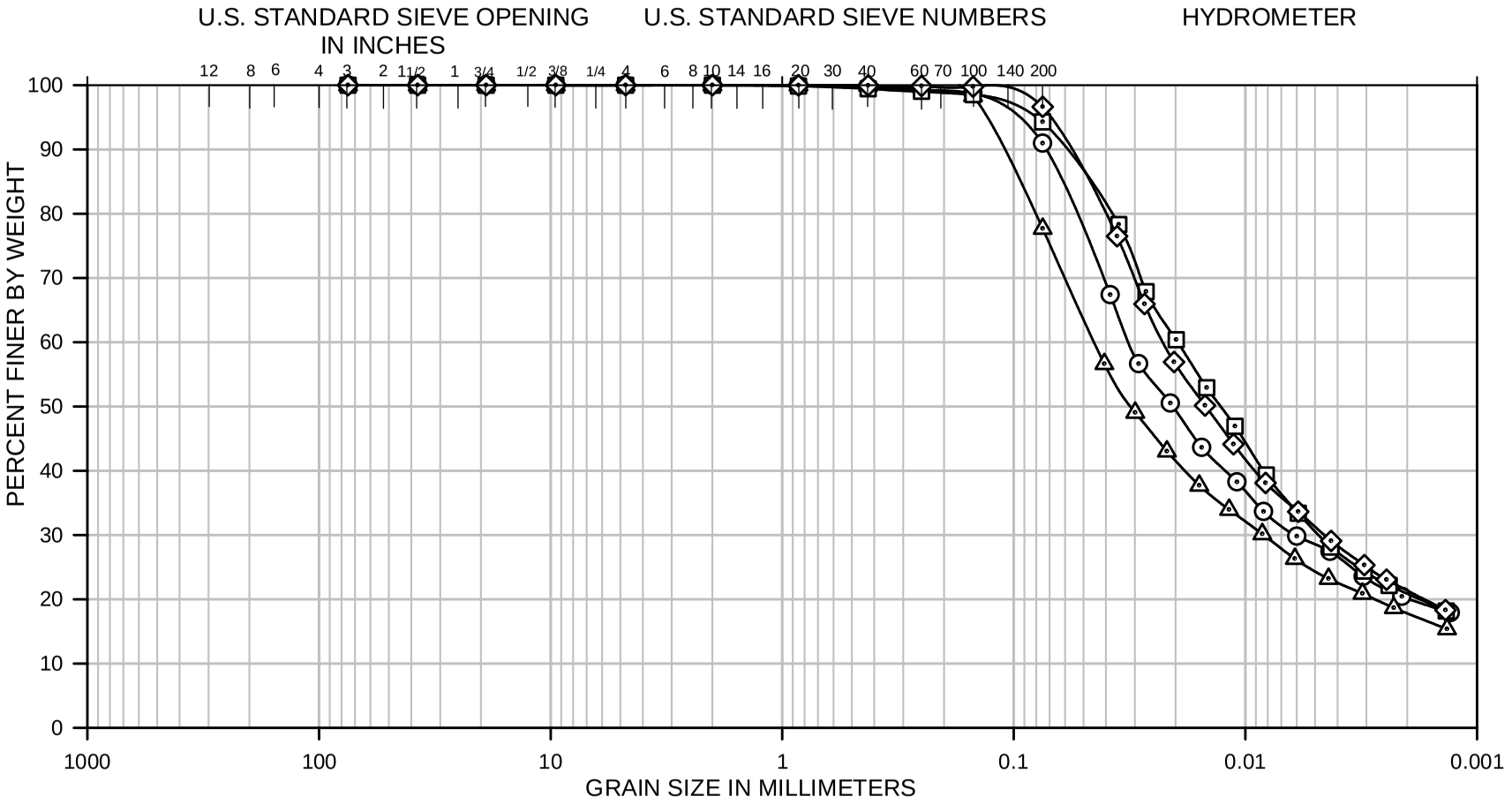
PROJ. 2319

FIG. C4



COBBLES	GRAVEL		SAND			FINES	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

Boring No.	Sample No.	Depth, Ft.	Classification	Nat W%	LL	PL	PI
⊙ P1-CC-02	S-5	25	slightly sandy, clayey SILT	40	34	26	8
△ P1-CC-43	S-5	25	sandy, slightly clayey SILT	35	--	--	--
⊡ P1-CC-54	S-6	30	slightly sandy, slightly clayey SILT	27	--	--	--
◇ P1-CC-62	S-8	40	slightly sandy, clayey SILT	35	46	32	14

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GRADATION GRAPH
FOUNDATION (3 of 3)

PENINSULA 1 LEVEE EVALUATION
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FIG. C5

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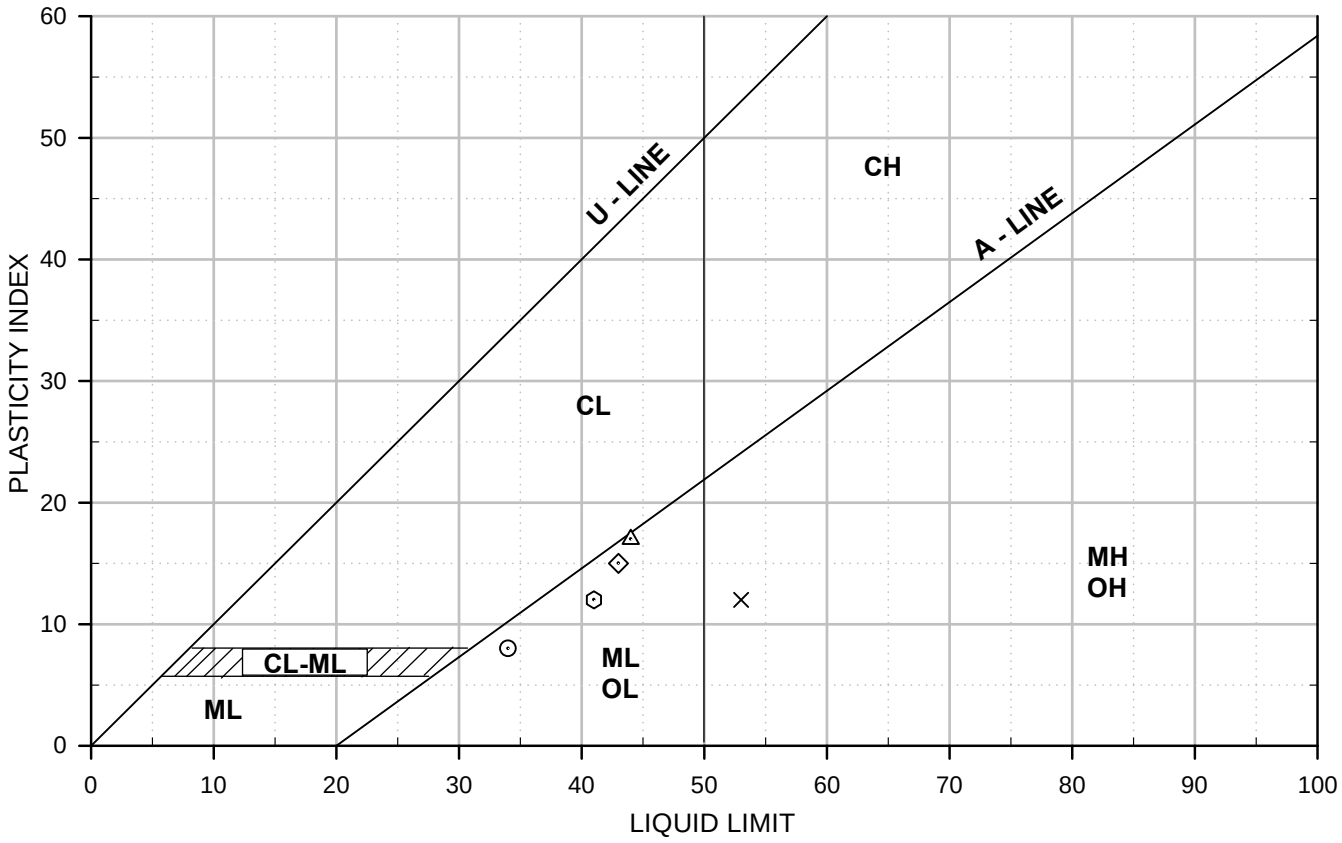

Boring No.	Sample No.	Depth (ft)
⊙ P1-CC-05	S-2	10
△ P1-CC-08	S-2	10
◇ P1-CC-34	S-3	15
× P1-CC-37	S-2	10
⬡ P1-CC-49	S-4	10

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PLASTICITY CHART EMBANKMENT SAMPLES

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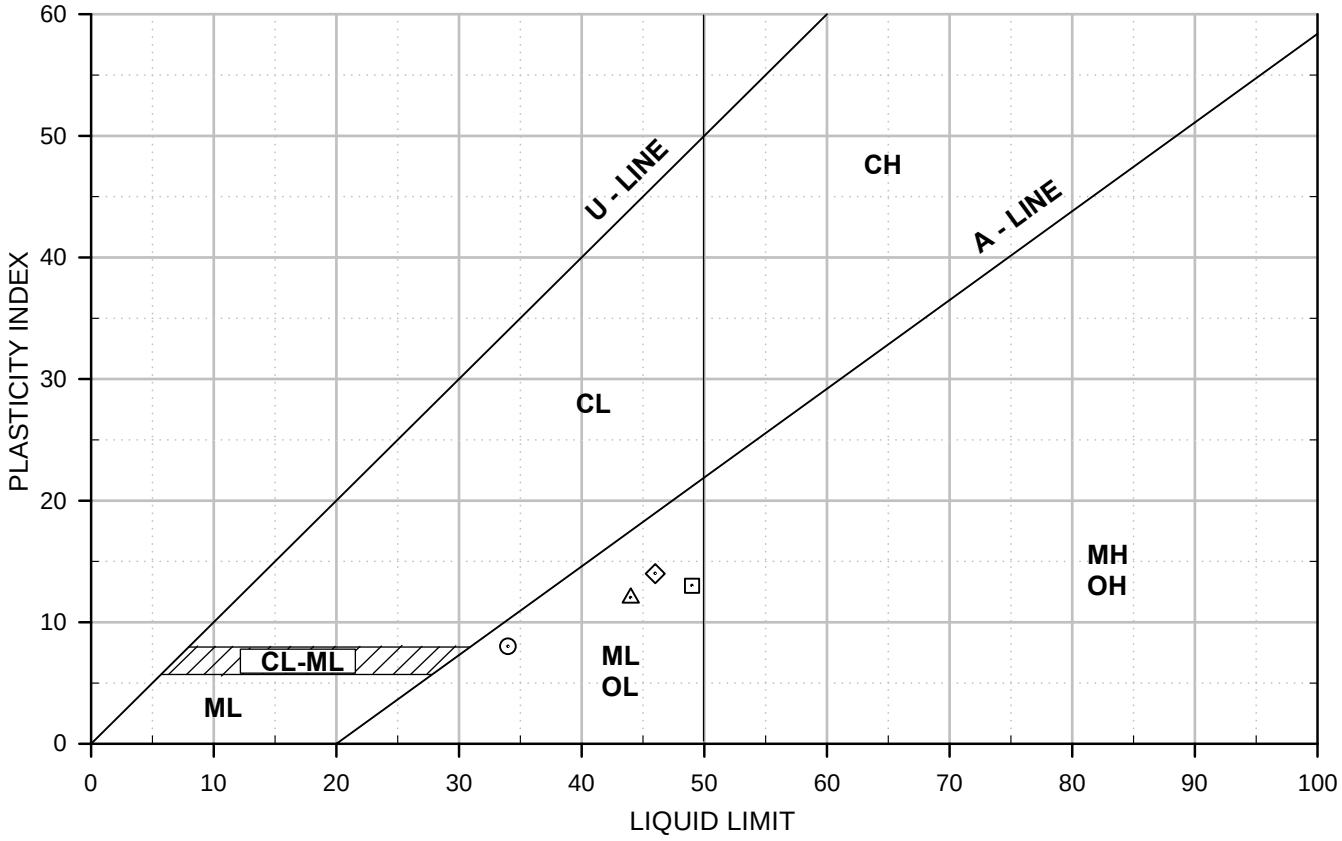
PROJ. 2319
FIG. C6



Boring No.	Sample No.	Depth (ft)
⊙ P1-CC-02	S-5	25
△ P1-CC-21	S-4	20
⊡ P1-CC-28	S-5	27
◇ P1-CC-62	S-8	40

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PLASTICITY CHART FOUNDATION SAMPLES

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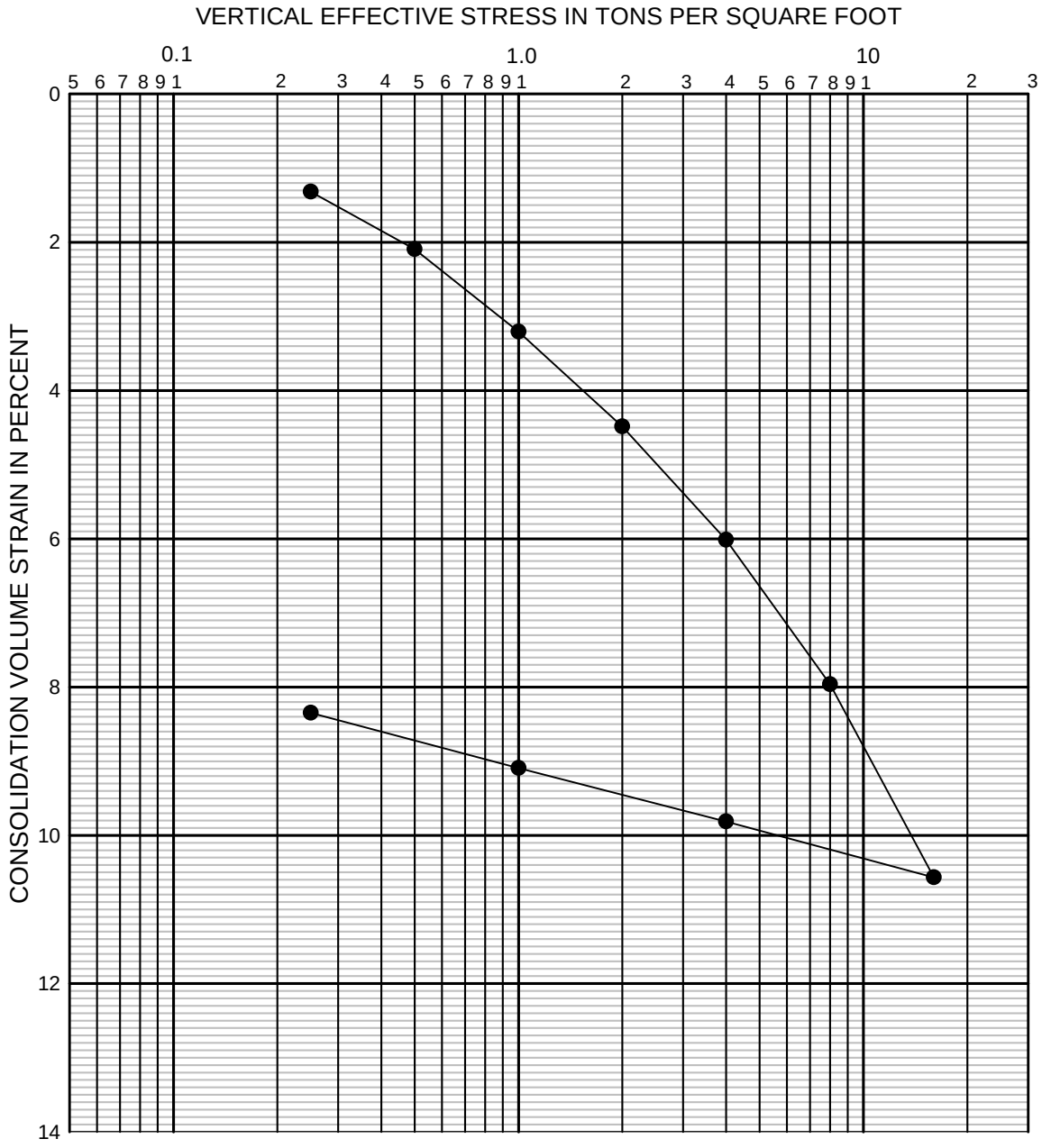
FIG. C7



* Saturated with water

P_o Existing overburden stress

P_p Estimated preconsolidation stress

Boring No. P1-CC-11 Sample No. S-3 Depth of Sample 13 to 15 ft.

Soil Description: VERY LOOSE, brown, silty fine SAND; numerous mica, moist (FILL)

☒ Undisturbed ☐ Re-compacted

Initial Conditions: Height 0.75 inches Wet Density 118 lb/ft^3

Diameter 2.50 inches Water Content 26 %

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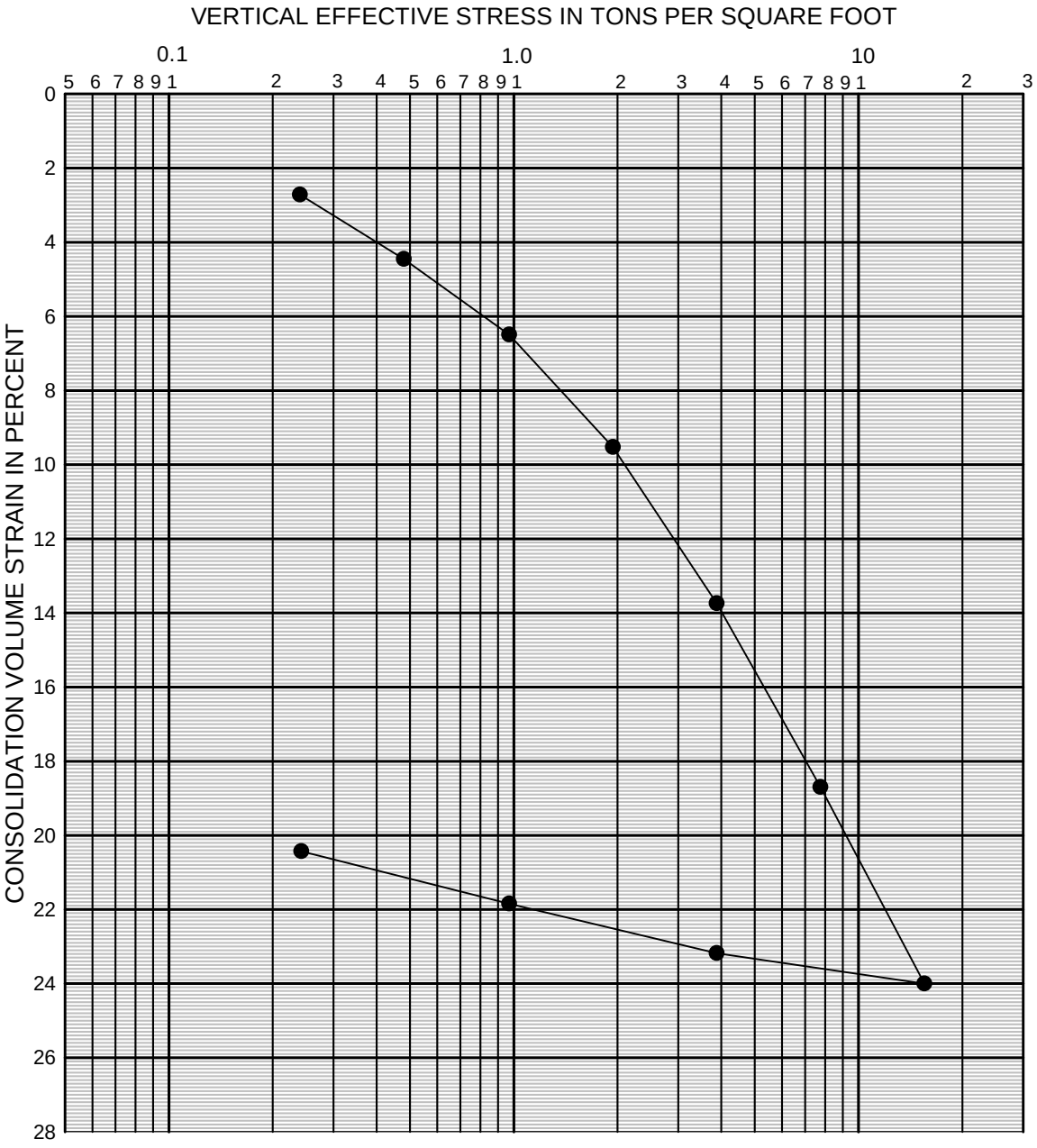
FIG. C8



* Saturated with water

P_o Existing overburden stress

P_p Estimated preconsolidation stress

Boring No. P1-CC-21 Sample No. S-4 Depth of Sample 18 to 20 ft.

Soil Description: VERY SOFT, gray, slightly sandy, slightly clayey SILT; fine sand, occasional organics, occasional mica, moist (ALLUVIUM)

☒ Undisturbed ☐ Re-compacted

Initial Conditions: Height 0.75 inches Wet Density 118 lb/ft^3

Diameter 2.50 inches Water Content 42 %

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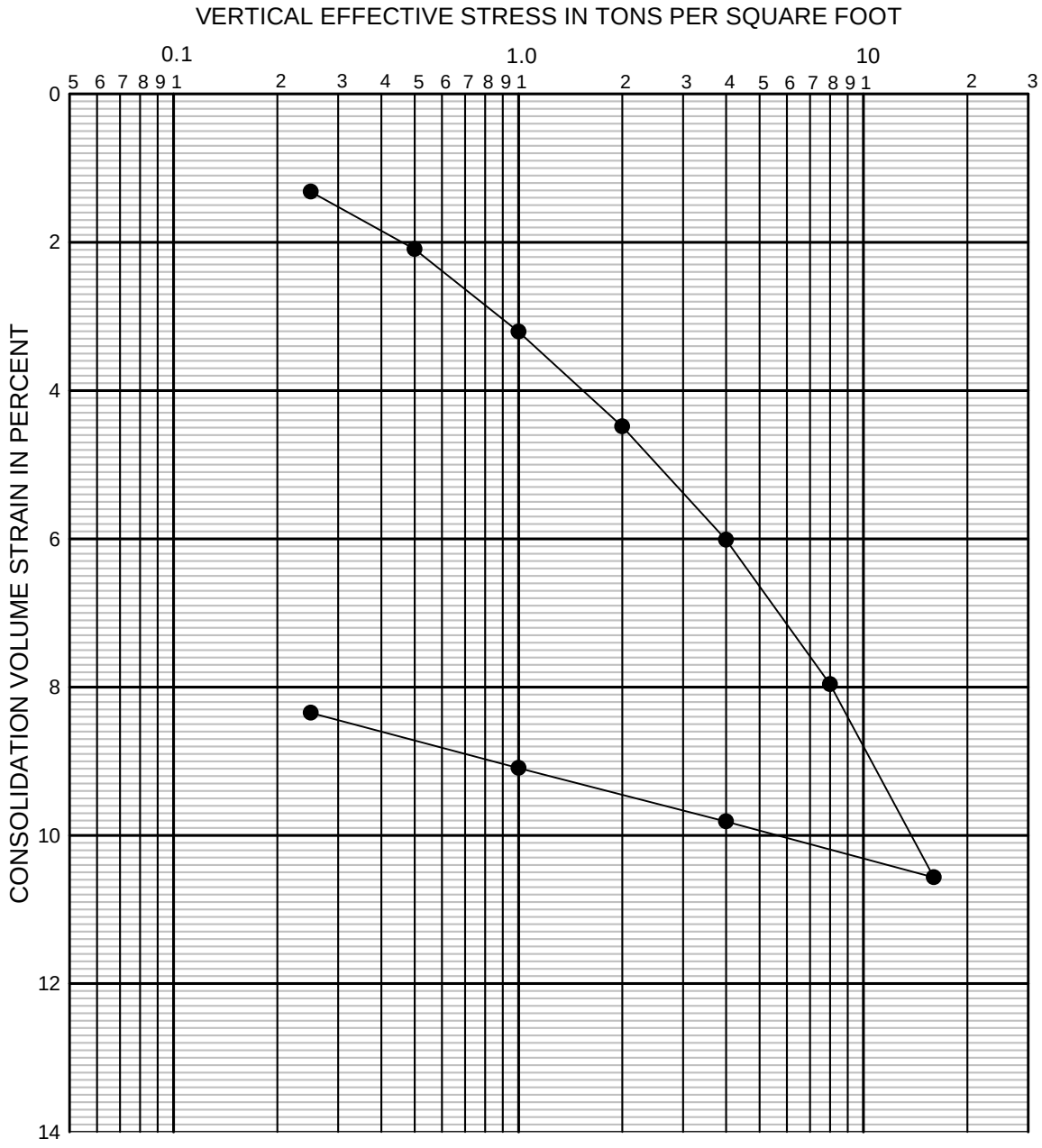
FIG. C9



* Saturated with water

P_o Existing overburden stress

P_p Estimated preconsolidation stress

Boring No. P1-CC-46 Sample No. S-9 Depth of Sample 38 to 40 ft.

Soil Description: SOFT, gray, very sandy, slightly clayey SILT; fine sand, scattered organics, occasional mica (ALLUVIUM)

☒ Undisturbed ☐ Re-compacted

Initial Conditions: Height 0.75 inches Wet Density 121 lb/ft^3

Diameter 2.50 inches Water Content 32 %

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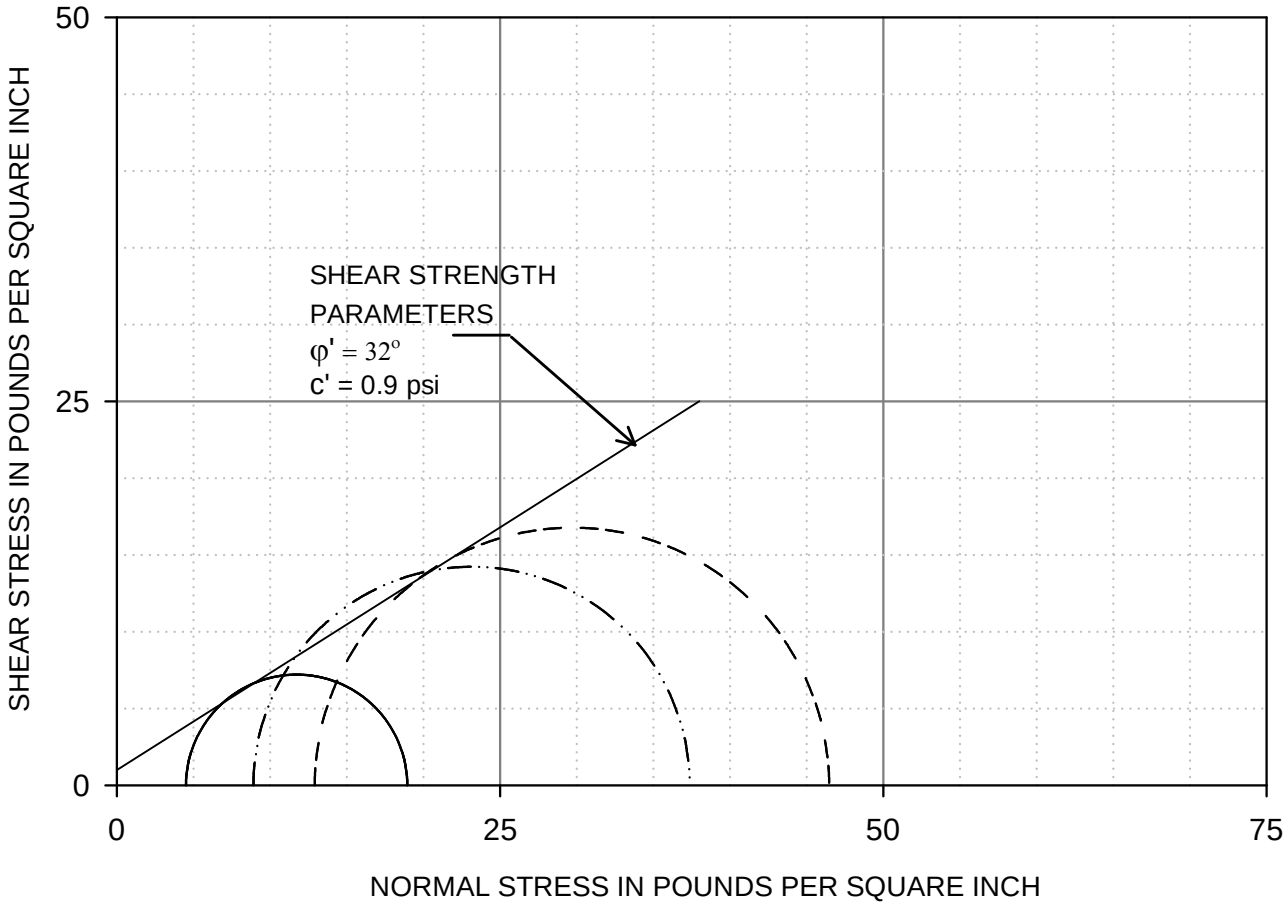
FIG. C10



LEGEND Confining Stress (psi)

———	7
—·—·—·—	14*
– – – – –	28

* failed on sand seam noted during sample preparation

☒ Undisturbed ☐ Re-compacted

Type of Test Consolidated Undrained Triaxial

Boring No. P1-CC-5 Sample No. S-2 Depth of Sample 8 to 10 ft.

Soil Description MEDIUM STIFF, blue-gray, slightly sandy, slightly clayey SILT; fine sand, trace organics, diced texture (FILL)

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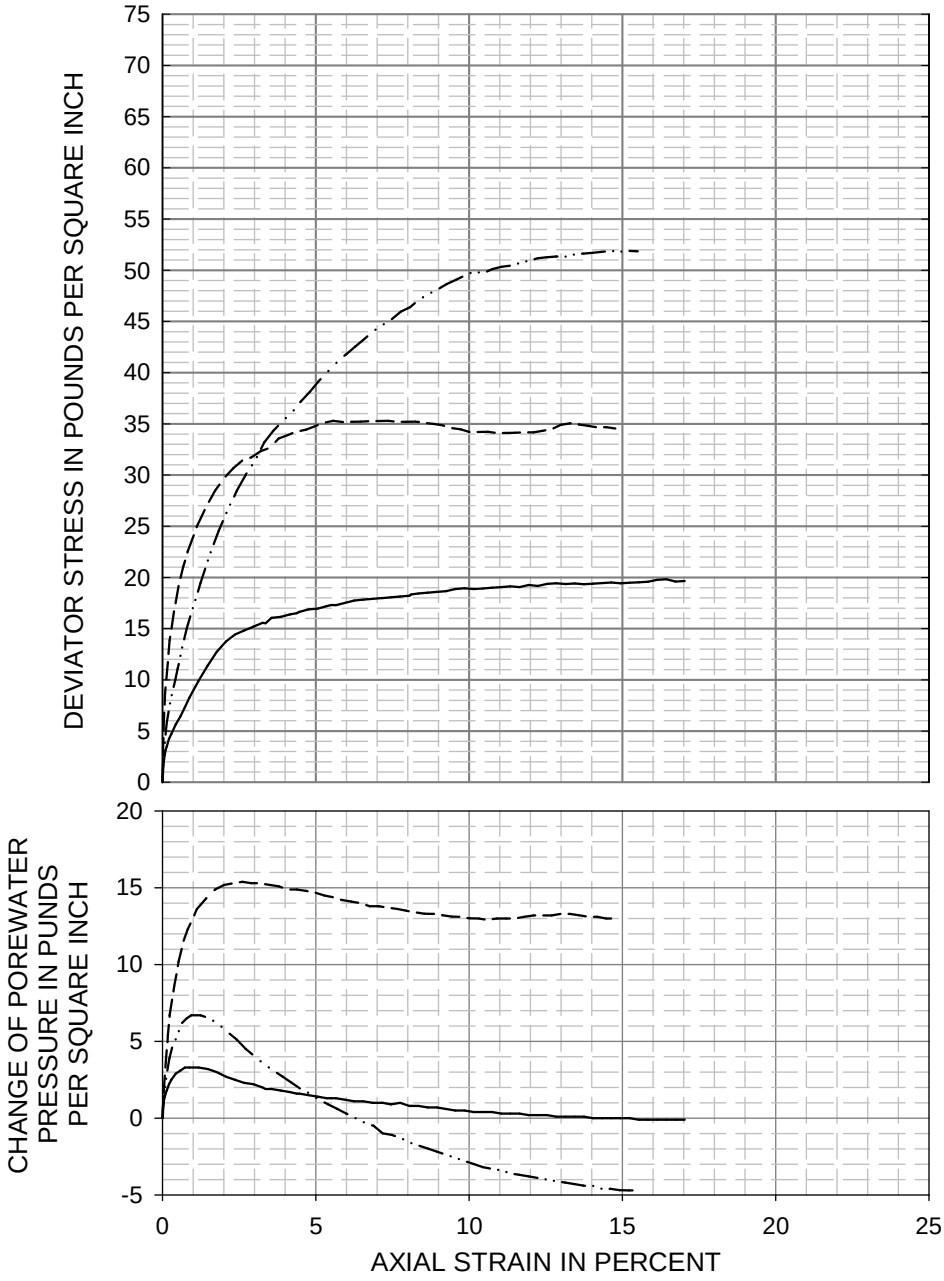
FIG. C11



Boring No. P1-CC-5

Sample No. S-2

Depth of Sample 8 - 10 ft.

☒ Undisturbed

☐ Re-compacted

Soil Description: MEDIUM STIFF, blue-gray, slightly sandy, slightly clayey SILT; fine sand, trace organics, diced texture (FILL)

	Confining Stress σ'	Length (in)	Diameter (in)	Strain Rate (%/hr)	w_c (%)	Wet Density (pcf)	Peak Stress (psi)
———	7	6.02	2.84	0.94	31	112.7	14.4
—·—·—	14*	6.01	2.83	0.95	26	119.1	28.5
– – –	28	6.06	2.85	0.95	31	112.6	33.6

* failed on sand seam noted during sample preparation

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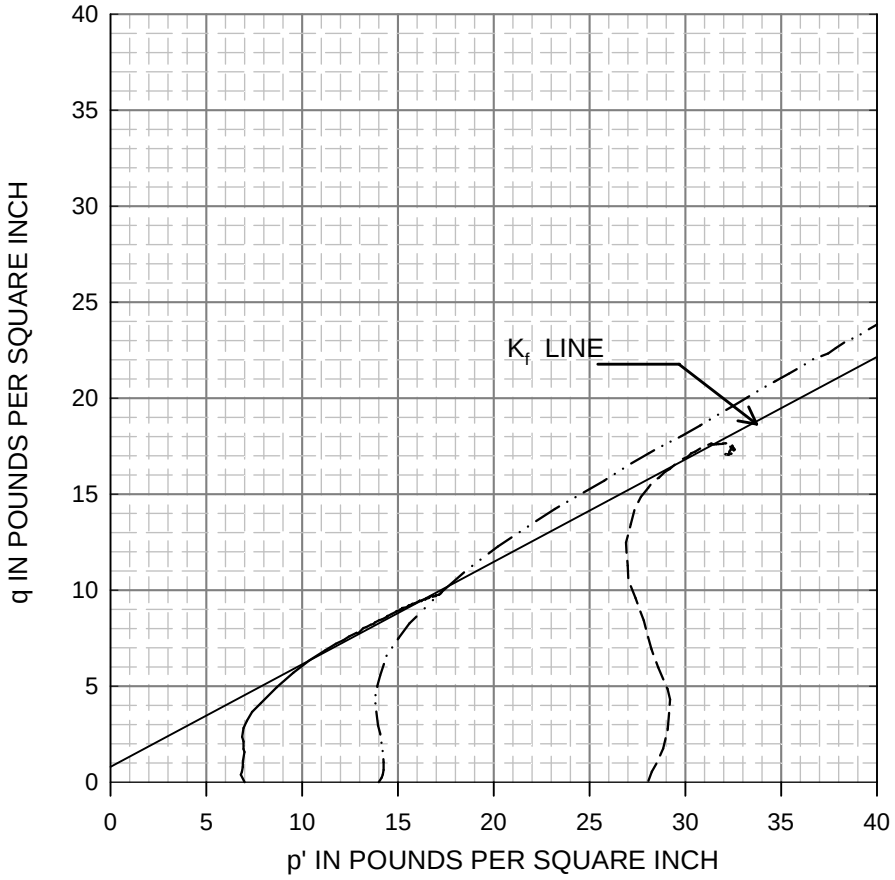
FIG. C12



Boring No. P1-CC-5

Sample No. S-2

Depth of Sample 8 - 10 ft.

☒ Undisturbed

☐ Re-compacted

Test Type: Consolidated Undrained Triaxial

Soil Description: MEDIUM STIFF, blue-gray, slightly sandy, slightly clayey SILT; fine sand, trace organics, diced texture (FILL)

Confining Stress (psi)	Length (in)	Diameter (in)	Strain Rate (%/hr)	w_C (%)	Wet Density (pcf)	Peak Stress (psi)
7	6.02	2.84	0.94	31	112.7	14.4
14*	6.01	2.83	0.95	26	119.1	28.5
28	6.06	2.85	0.95	31	112.6	33.6

* failed on sand seam noted during sample preparation

K_f STRENGTH PARAMETERS:

α = 0.06 ton/ft.^{2}

ψ = 28.1 degrees

CALCULATED MOHR DIAGRAM STRENGTH PARAMETERS:

c = 0.06 ton/ft.^{2}

ϕ' = 32.3 degrees

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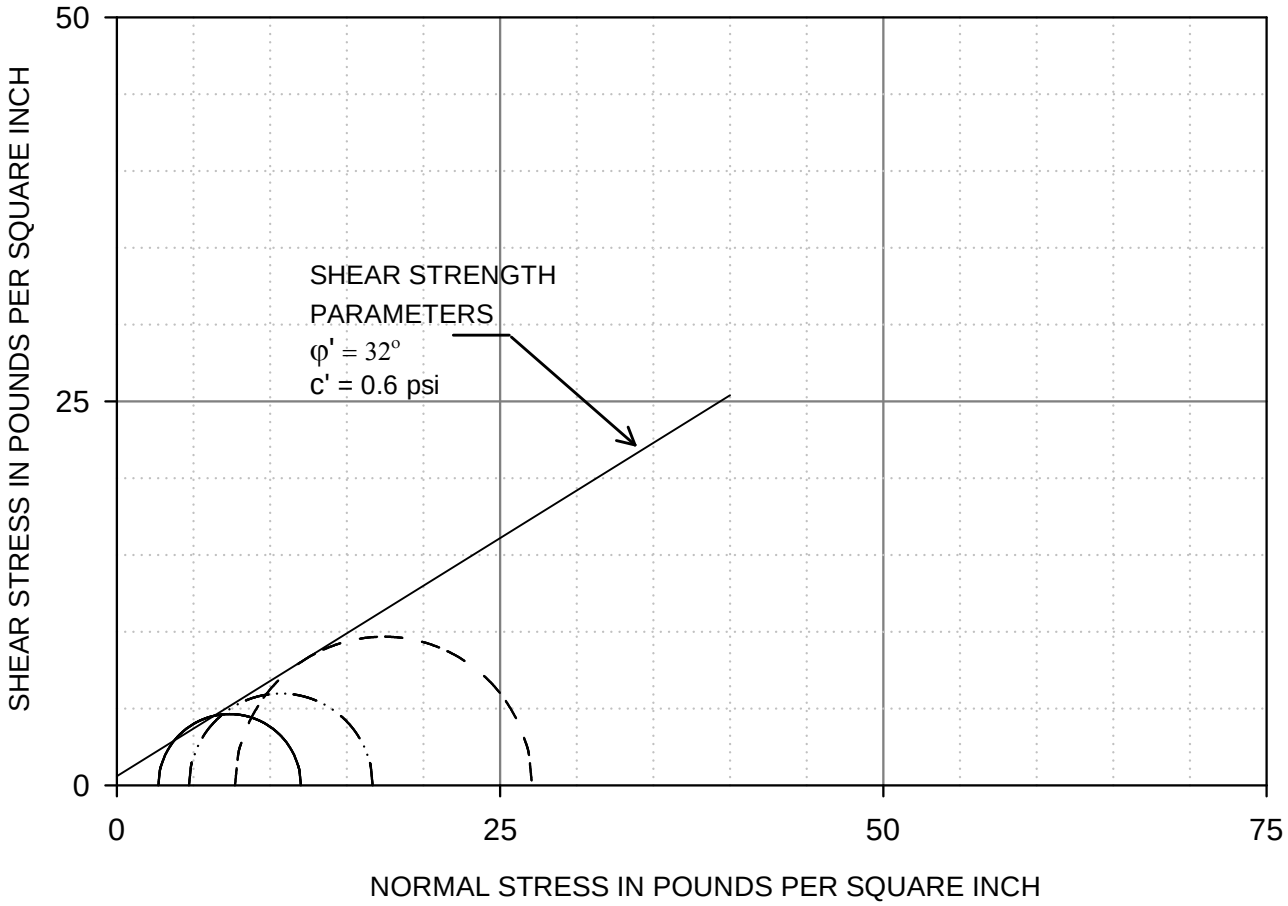
FIG. C13



LEGEND Confining Stress (psi)

———	7
—·—·—·—	14
– – – – – –	28

☒ Undisturbed ☐ Re-compacted

Type of Test Consolidated Undrained Triaxial

Boring No. P1-CC-21 Sample No. S-4 Depth of Sample 18 to 20 ft.

Soil Description VERY SOFT, gray, slightly sandy, slightly clayey SILT; fine sand, scattered organics, occasional mica, moist (ALLUVIUM)

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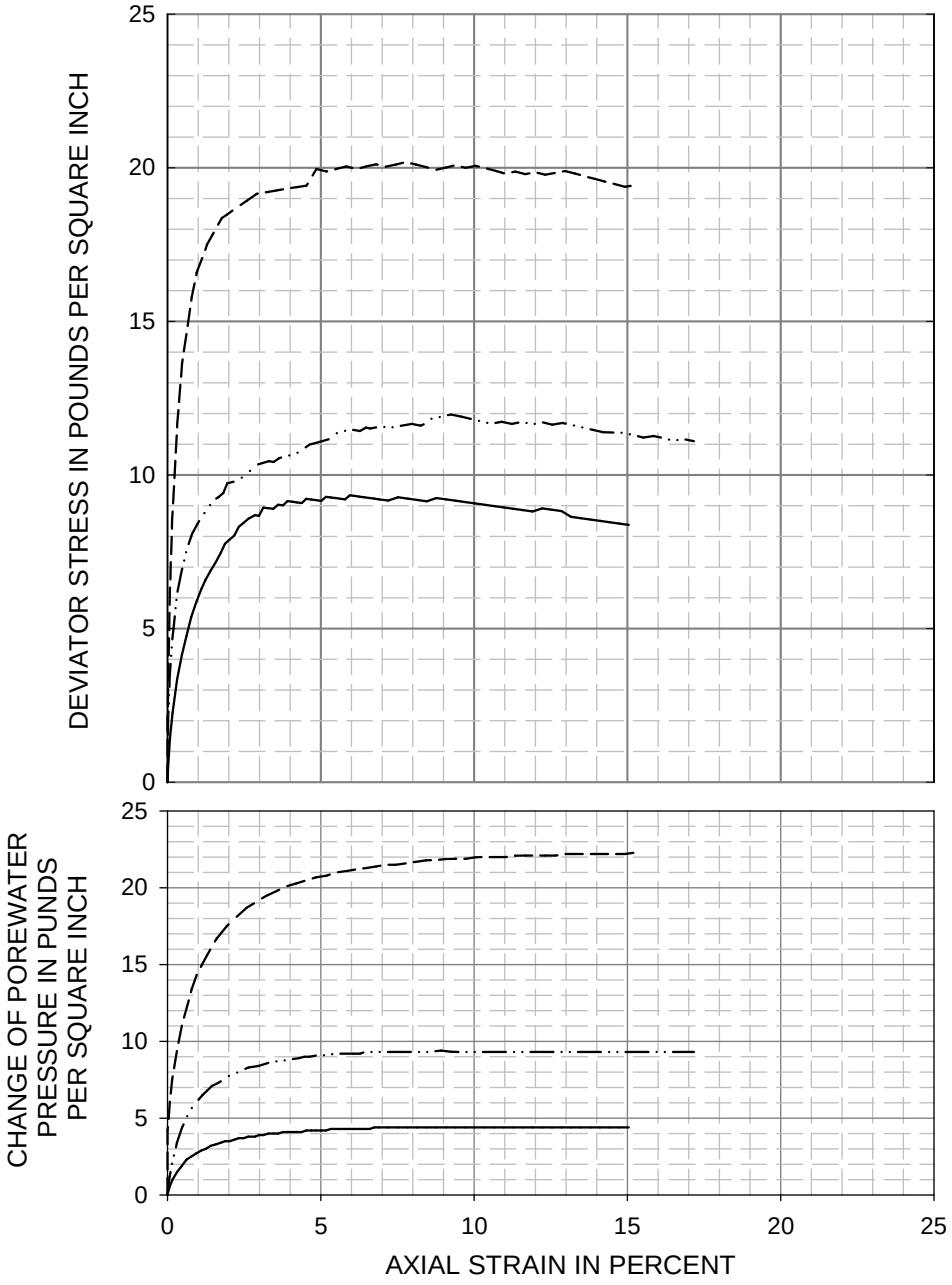
FIG. C14



Boring No. P1-CC-21

Sample No. S-4

Depth of Sample 18 - 20 ft.

☒ Undisturbed

☐ Re-compacted

Soil Description: VERY SOFT, gray, slightly sandy, slightly clayey SILT; fine sand, scattered organics, occasional mica, moist (ALLUVIUM)

	Confining Stress σ'	Length (in)	Diameter (in)	Strain Rate (%/hr)	w_c (%)	Wet Density (pcf)	Peak Stress (psi)
———	7	5.77	2.84	0.99	90	94.1	9.3
—·—·—	14	5.53	2.80	1.05	62	102.8	12.0
– – –	28	5.75	2.85	0.97	80	96.4	19.4

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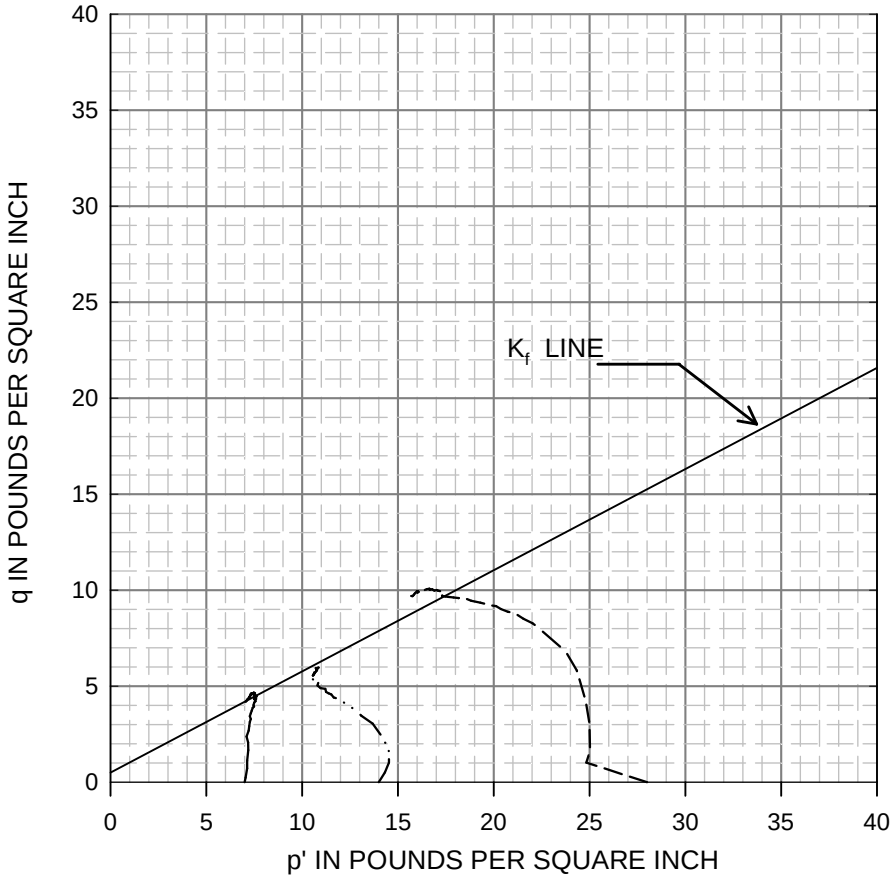
FIG. C15



Boring No. P1-CC-21

Sample No. S-4

Depth of Sample 18 - 20 ft.

☒ Undisturbed

☐ Re-compacted

Test Type: Consolidated Undrained Triaxial

Soil Description: VERY SOFT, gray, slightly sandy, slightly clayey SILT; fine sand, scattered organics, occasional mica, moist (ALLUVIUM)

Confining Stress (psi)	Length (in)	Diameter (in)	Strain Rate (%/hr)	w_C (%)	Wet Density (pcf)	Peak Stress (psi)
7	5.77	2.84	0.99	90	94.1	9.3
14	5.53	2.80	1.05	62	102.8	12.0
28	5.75	2.85	0.97	80	96.4	19.4

K_f STRENGTH PARAMETERS:

α = 0.04 ton/ft.^{2}

ψ = 27.8 degrees

CALCULATED MOHR DIAGRAM STRENGTH PARAMETERS:

c = 0.04 ton/ft.^{2}

ϕ' = 31.8 degrees

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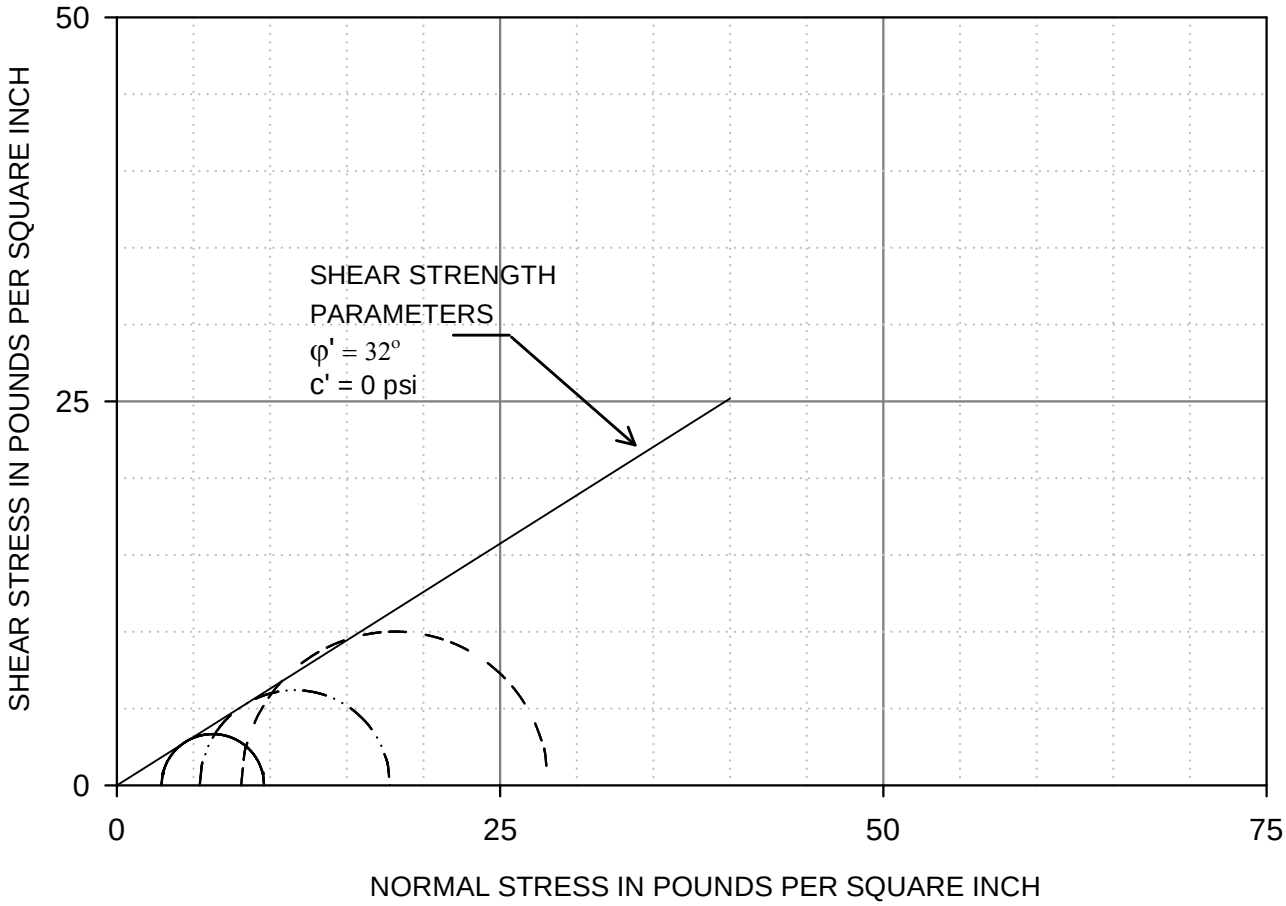
FIG. C16



LEGEND Confining Stress (psi)

———	7
—·—·—·—	14
– – – – –	28

☒ Undisturbed ☐ Re-compacted

Type of Test Consolidated Undrained Triaxial

Boring No. P1-CC-45 Sample No. S-5 Depth of Sample 18 to 20 ft.

Soil Description VERY SOFT, gray, slightly sandy, slightly clayey SILT; fine sand, scattered organics (ALLUVIUM)

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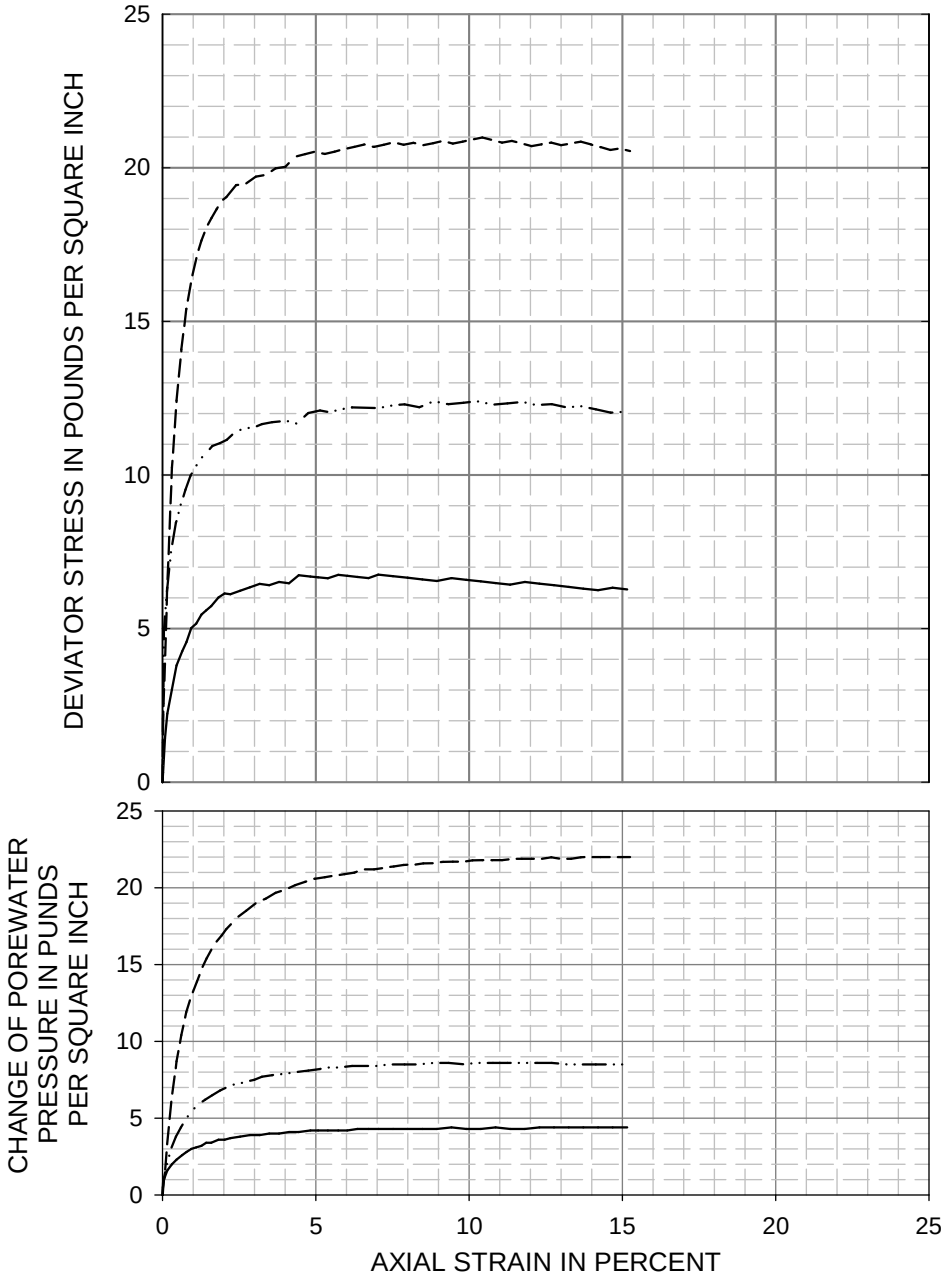
FIG. C17



Boring No. P1-CC-45

Sample No. S-5

Depth of Sample 18 - 20 ft.

☒ Undisturbed

☐ Re-compacted

Soil Description: VERY SOFT, gray, slightly clayey, sandy SILT; fine sand, scattered organics (RIVER ALLUVIUM)

	Confining Stress σ'	Length (in)	Diameter (in)	Strain Rate (%/hr)	w_c (%)	Wet Density (pcf)	Peak Stress (psi)
———	7	6.00	2.85	1.00	76	96.6	6.7
—·—·—	14	6.00	2.84	1.00	71	98.5	12.4
— — —	28	6.00	2.84	0.96	75	96.8	21.0

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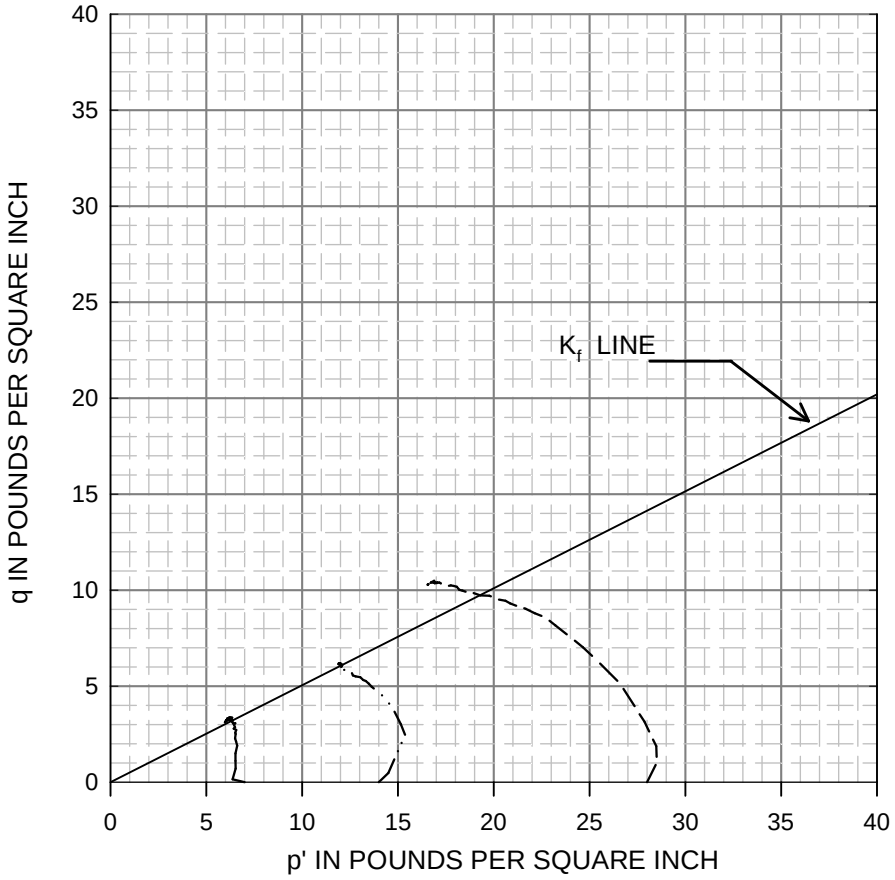
FIG. C18



Boring No. P1-CC-45

Sample No. S-5

Depth of Sample 18 - 20 ft.

☒ Undisturbed

☐ Re-compacted

Test Type: Consolidated Undrained Triaxial

Soil Description: VERY SOFT, gray, slightly clayey, sandy SILT; fine sand, scattered organics (RIVER ALLUVIUM)

Confining Stress (psi)	Length (in)	Diameter (in)	Strain Rate (%/hr)	w_C (%)	Wet Density (pcf)	Peak Stress (psi)
7	6.00	2.85	1.00	76	96.6	6.7
14	6.00	2.84	1.00	71	98.5	12.4
28	6.00	2.84	0.96	75	96.8	21.0

K_f STRENGTH PARAMETERS:

α = 0 ton/ft.^{2}

ψ = 27.3 degrees

CALCULATED MOHR DIAGRAM STRENGTH PARAMETERS:

c = 0 ton/ft.^{2}

ϕ' = 31.1 degrees

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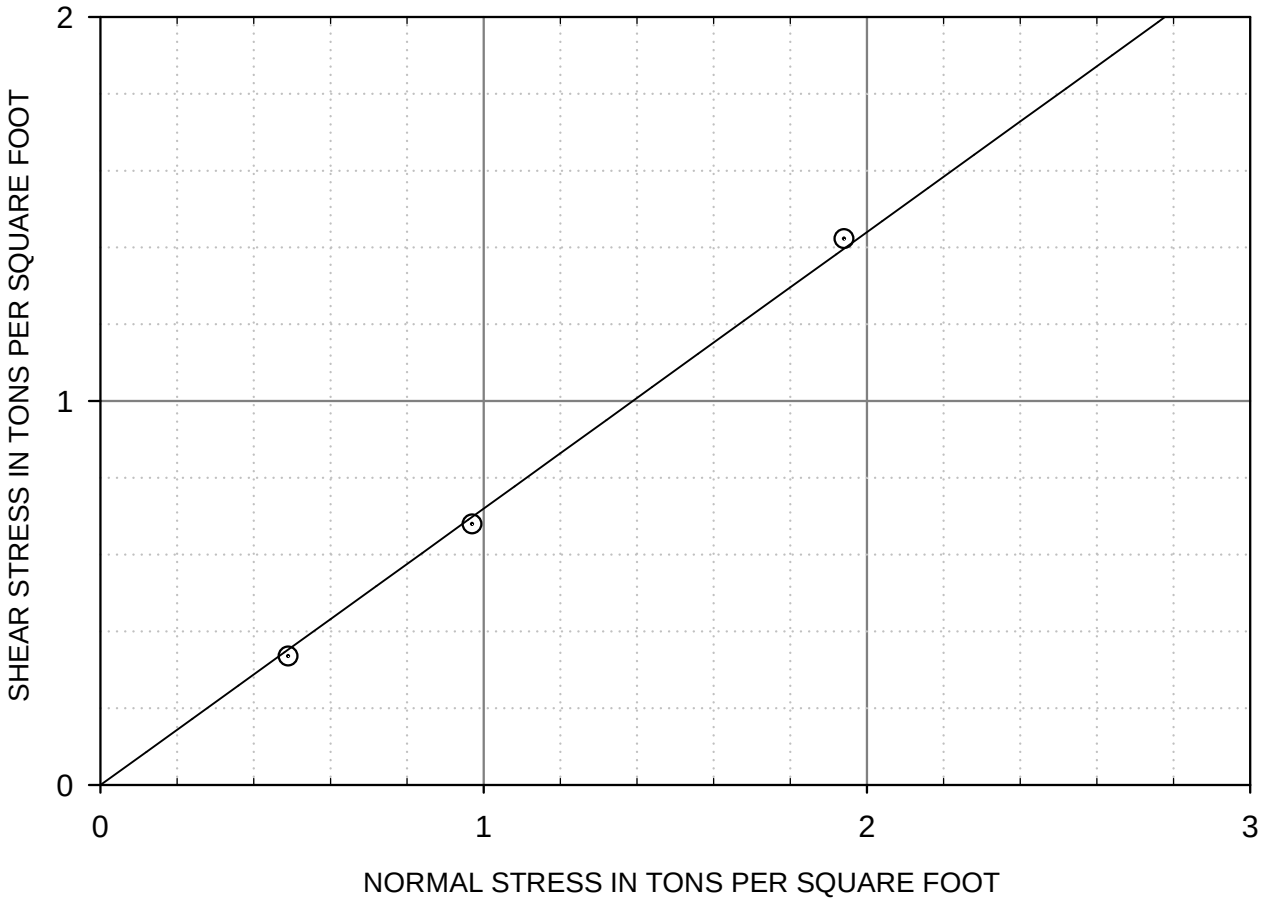
CONSOLIDATED UNDRAINED TRIAXIAL TEST DATA PLOTS

PENINSULA 1 LEVEE EVALUATION
PORTLAND, OREGON

SEP 2014

PROJ. 2319

FIG. C19



Boring No. P1-CC-11 Sample No. S-3 Depth of Sample 14 to 14.3 ft.

Soil Description: VERY LOOSE, brown, silty FINE SAND; numerous mica, moist (FILL)

☒ Undisturbed ☐ Compacted ☒ Consolidated ☐ Unconsolidated

Liquid Limit: Non-Plastic Plastic Limit: Non-Plastic

RESULTS:

Normal Stress (ton/ft.^{2})	0.49	0.97	1.94
⊙ Peak Stress (ton/ft.^{2})	0.34	0.68	1.42

PEAK STRENGTH PARAMETERS:

c = 0 ton/ft.^{2}

ϕ' = 36 degrees

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DIRECT SHEAR TEST

PENINSULA 1 LEVEE EVALUATION
PORTLAND, OREGON

SEP 2014
PROJ. 2319
FIG. C20

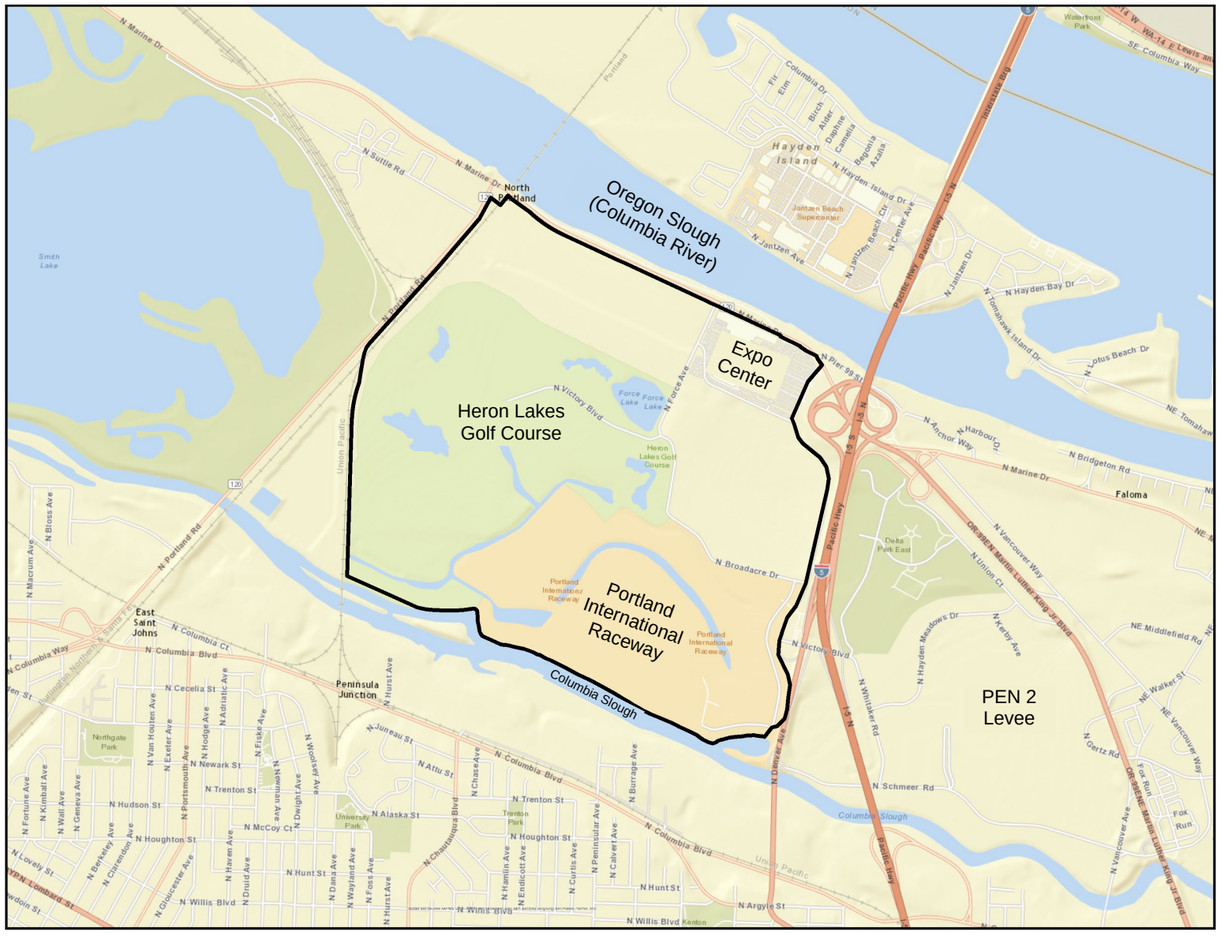
APPENDIX D

GROUP MACKENZIE CONSULTANTS

PEN 1 Levee – As-Built Maps

October 2014

PEN 1 LEVEE RECERTIFICATION
AS-BUILT MAPS



Vicinity Map

NOT TO SCALE

CLIENT

MULTNOMAH COUNTY DRAINAGE
DISTRICT #1
1880 NE ELROD DR.
PORTLAND, OR 97211
PHONE: 503.281.5675
CONTACT: SARA MORRISSEY

CIVIL ENGINEER

MACKENZIE
1515 SE WATER AVE.
P.O. BOX 14310
PORTLAND, OR 97293
PHONE: 503.224.9560
CONTACT: TIM MCGUIRE, P.E.

GEOTECHNICAL ENGINEER

CORNFORTH CONSULTANTS
10250 SW GREENBURG RD., SUITE 111
PORTLAND, OR 97223
PHONE: 503.452.1100
CONTACT: MIKE MEYER

SURVEYOR

GIBBS & OLSON
1405 17TH AVE., SUITE 300
LONGVIEW, WA 98632
PHONE: 360.425.0991
CONTACT: RICH WILLIAMS

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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
COVER SHEET

DATE:

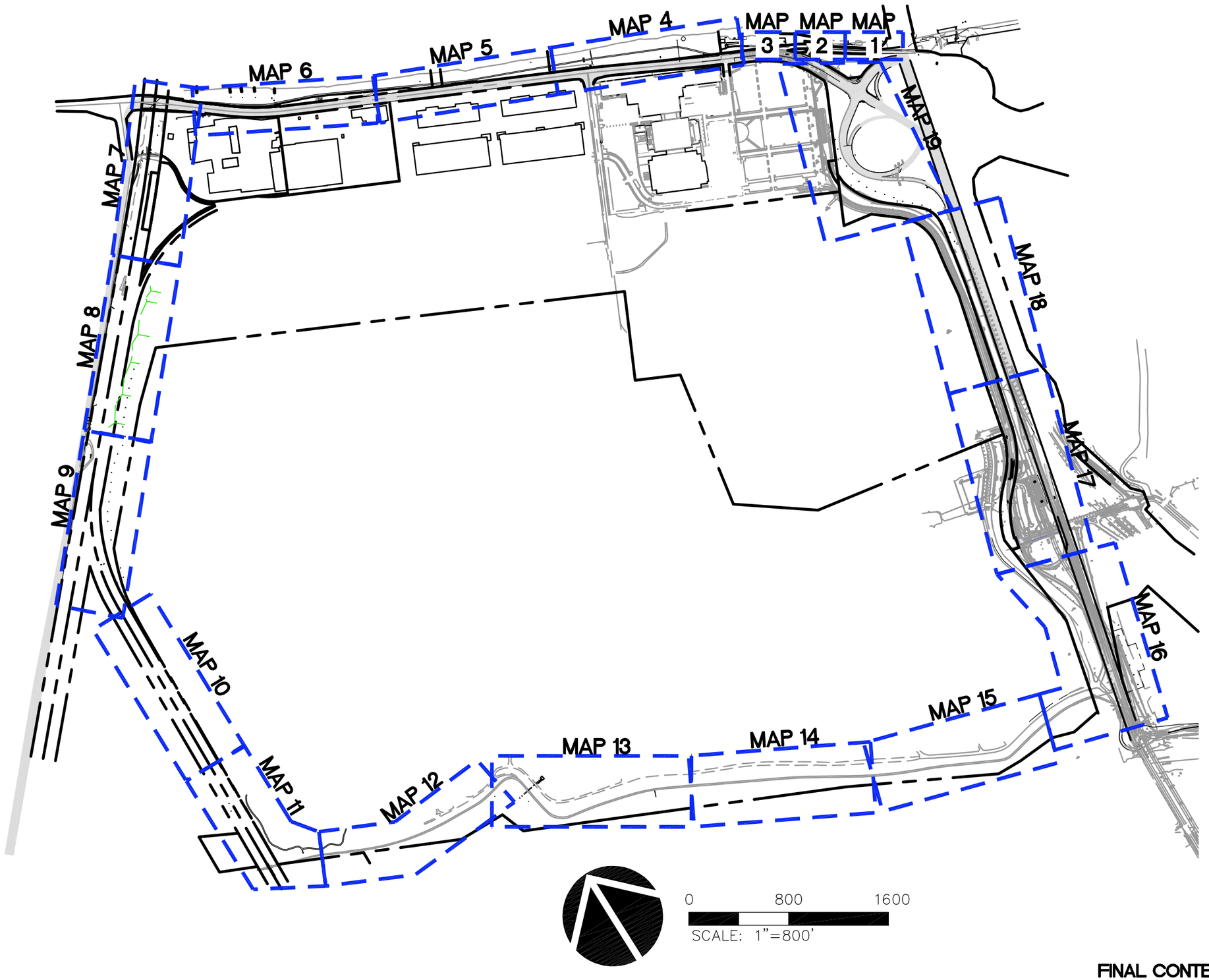
DRAWN BY:

CHECKED BY:

SHEET:
T1.0

JOB NO:
2140170.00

PUBLIC
FINAL CONTENT - 10.03. 2014



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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
KEY MAP

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
T1.1

JOB NO:
2140170.00

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FINAL CONTENT - 10.03. 2014

LEGEND

LEVEE CENTERLINE/CONTROL LINE

APPROXIMATE TOE OF LEVEE

EXISTING GUARDRAIL

GRAVEL

EXISTING FENCE

EXISTING FLOOD WALL

EXISTING WALL

EXISTING STORM LINE — STM

EXISTING WATER LINE — WAT

EXISTING GAS LINE — G

EXISTING TELEPHONE LINE — T

EXISTING SANITARY SEWER — SS

EXISTING POWER LINE — P

EXISTING PGE UNDERGROUND — E

EXISTING POLES YARD LIGHT

EXISTING GUARD POSTS

EXISTING HDYRANTS 3 PORT

EXISTING WATER METERS

EXISTING VALVES GATE FL

EXISTING WATER VAULTS — W

EXISTING MISC. MAIL BOX

EXISTING MISC. SIGN

EXISTING VEGETATION CONIFER TREE

EXISTING VEGETATION DECIDUOUS TREE

PROPOSED VEGETATION DECIDUOUS TREE

EXISTING CONTROL ANGLE POINT

EXISTING CONTROL BENCH MARK

EXISTING CONTROL SPOT ELEV.

EXISTING GAS METER

EXISTING GAS VALVE

EXISTING POWER POLE

EXISTING POWER POLE ANCHOR

EXISTING POWER TOWER

EXISTING POWER TRANSFORMER

EXISTING POWER VAULT — P

EXISTING SEWER CLEANOUT

EXISTING SEWER MH

EXISTING STORM CULVERT

EXISTING STORM GENERIC MH

EXISTING TELEPHONE POLE

EXISTING TELEPHONE POLE ANCHOR

EXISTING TELEPHONE RISER

EXISTING TELEPHONE VAULT — T

CORNFORTH CONSULTANTS BORING (2014) — P2-CC-7

PREVIOUS BORINGS BY OTHERS — CRC-SC-011

DATUM/BENCHMARK

GIBBS & OLSON POINT #102
CITY OF PORTLAND BENCH MARK #2680
HELD FOR VERTICAL
HORIZONTAL COORDINATES ARE OREGON NORTH NAD 83
N: 717041.603
E: 7637872.149
VERTICAL ARE NAVD88
ELEVATION: 31.489

GIBBS & OLSON POINT #103
CITY OF PORTLAND BENCH MARK #3405
HELD FOR VERTICAL
HORIZONTAL COORDINATES ARE OREGON NORTH NAD 83
N: 715593.569
E: 7641362.644
VERTICAL ARE NAVD88
ELEVATION: 31.290

GIBBS & OLSON POINT #DEA1540
D.EVANS & ASSOC. COLUMBIA CROSSING POINT #1540
HELD FOR VERTICAL
HORIZONTAL COORDINATES ARE OREGON NORTH NAD 83
N: 710717.082
E: 7642333.849
VERTICAL ARE NAVD88
ELEVATION: 39.288

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SHEET TITLE:
LEGEND + NOTES

DATE:

DRAWN BY:

CHECKED BY:

SHEET:
T1.2

JOB NO:
2140170.00

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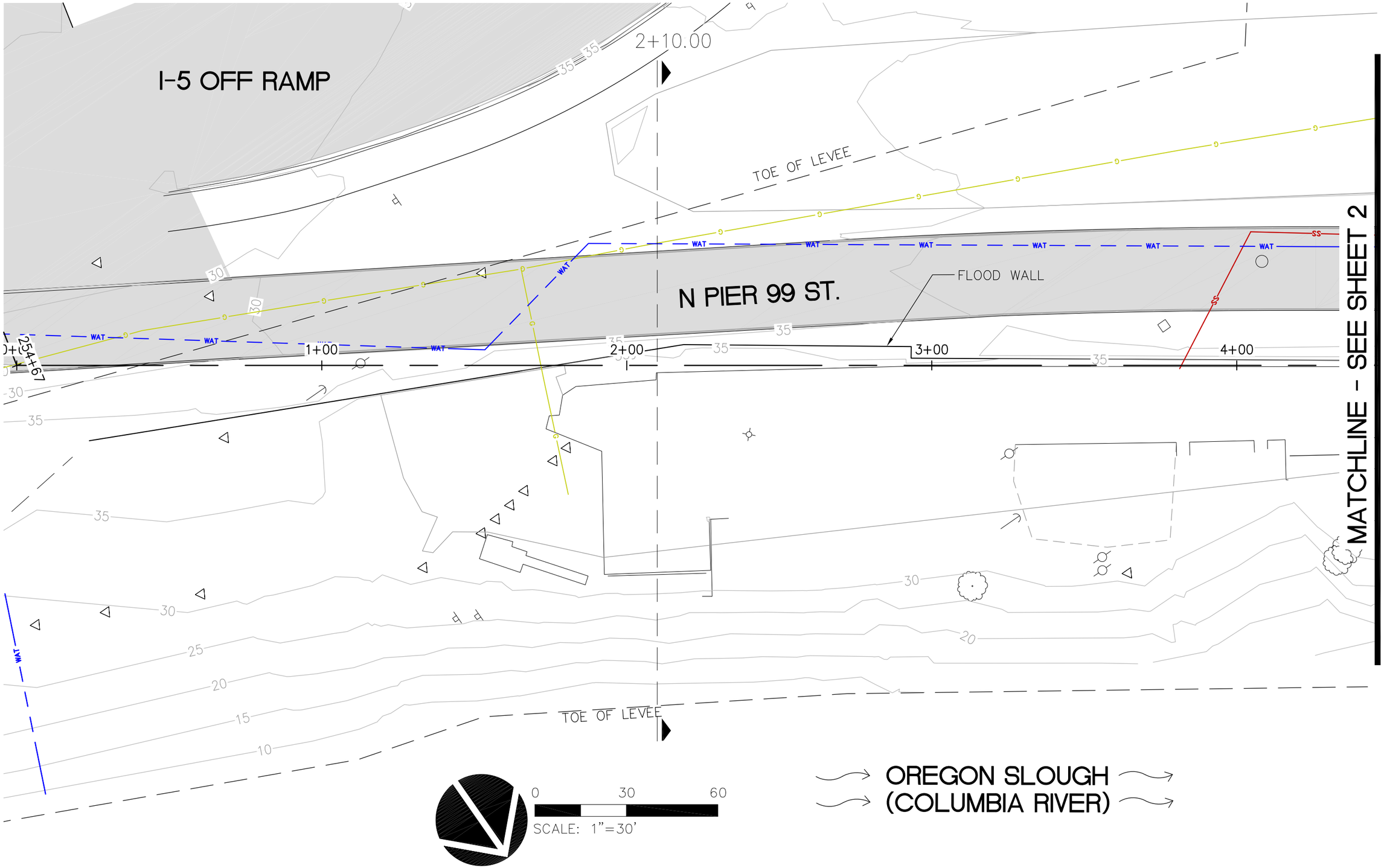
FINAL CONTENT - 10.03. 2014



MATCHLINE - SEE SHEET 2

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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 1

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
1

JOB NO:
2140170.00

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FINAL CONTENT - 10.03. 2014

P1-CC-1

N MARINE DR.

N PIER 99 ST.

CRC-SC-011

5+00.00

263+00

263+55

5+00

6+00

7+00

8+00

MATCHLINE - SEE SHEET 1

MATCHLINE - SEE SHEET 3

SD MH
IE OUT(18")=21.4

18" CMP
IE=20.81

CRC-SC-019

10" CSP

8" SD

4" PVC
IE=35.92

TOE OF LEVEE

OREGON SLOUGH
(COLUMBIA RIVER)

0 30 60

SCALE: 1"=30'

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214017000\CIVIL\P1-02.DWG BTS 10/08/14 13:13 1:30.00

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PEN 1 LEVEE RECERTIFICATION

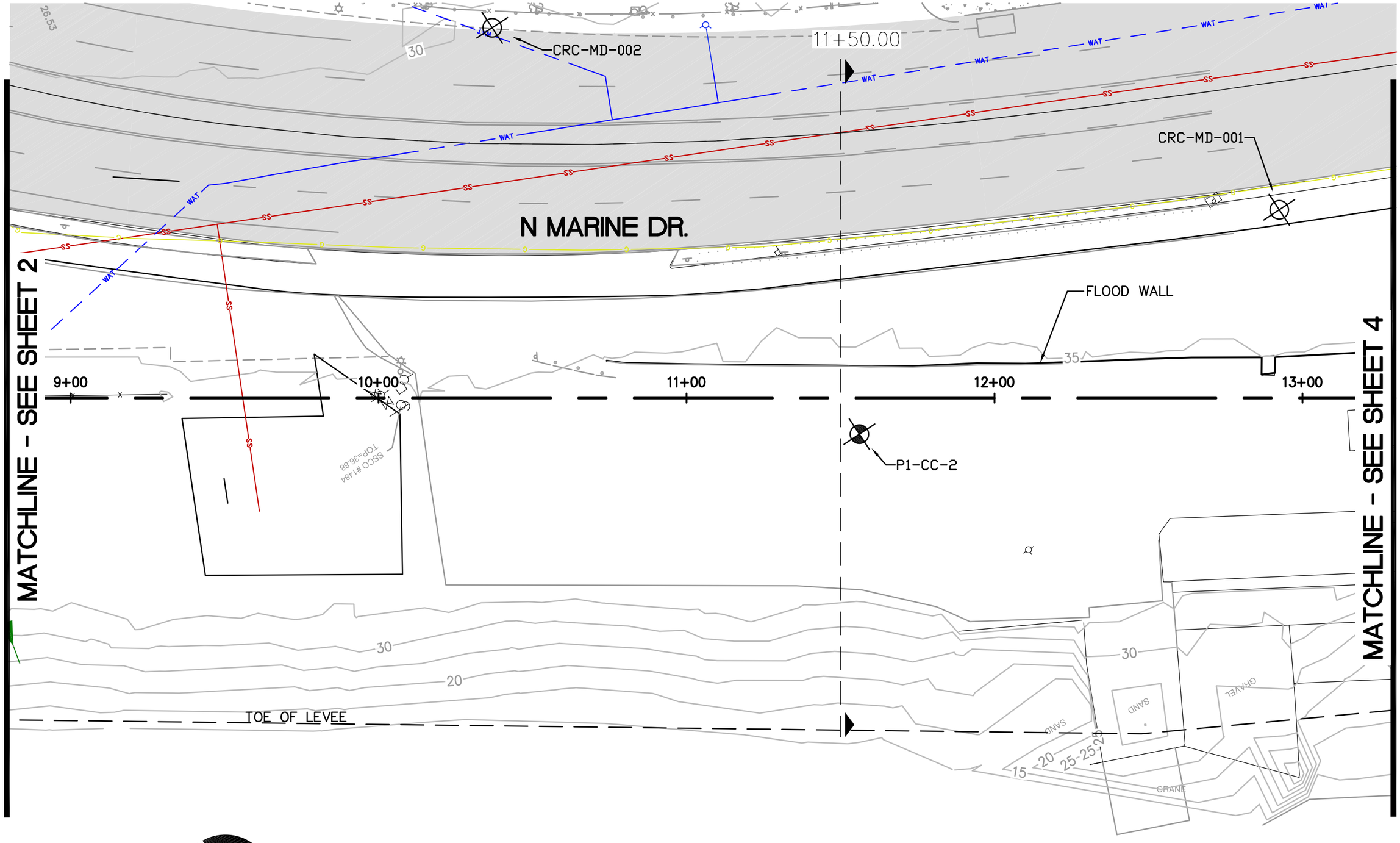
SHEET TITLE:
MAP 2

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
2

JOB NO:
2140170.00



0 30 60

SCALE: 1"=30'

P1-CC-3

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214017000\CIVIL\P1-03.DWG BTS 10/08/14 13:17 1:30.00

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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 3

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
3

JOB NO:
2140170.00

MATCHLINE – SEE SHEET 3

MATCHLINE – SEE SHEET 5

N MARINE DR.

N FORCE AVE.

SD MH
RIM=31.39

SD CB
RIM=31.0

14+00

15+00

16+00

17+00

18+00

19+00

20+00

21+00

22+00

23+00

24+00

25+00

26+00

27+00

23+00.00

TOE OF LEVEE

P1-CC-4

P1-CC-5

P1-CC-6

CONCRETE CASON

SD MH
RIM=23.59

12" SD CULVERT
IE=22.5

6" SD CULVERT
IE=11.75

12" SD CULVERT
IE=22.5

24" CMP
IE=21.21

TOE OF LEVEE

12" SD CULVERT #2297
IE=23.97

12" CMP
IE=24.98

OREGON SLOUGH
(COLUMBIA RIVER)

0 100 200

SCALE: 1"=100'

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214017000\CIVIL\P1-04.DWG BTS 10/08/14 13:36 1:100.00

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PROJECT:
PEN 1 LEVEE
RECERTIFICATION

SHEET TITLE:
MAP 4

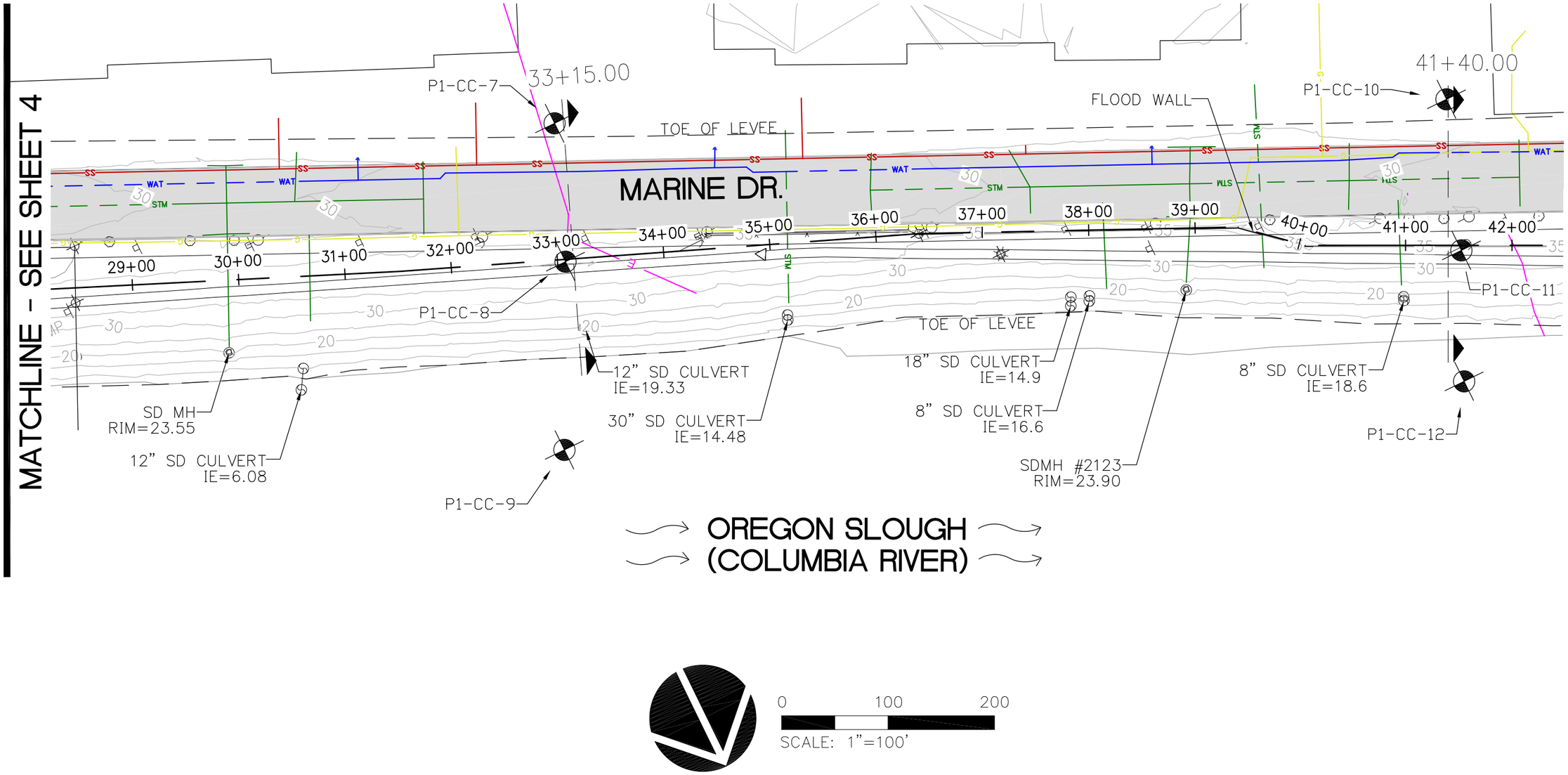
DATE:

DRAWN BY:
BTS

CHECKED BY:
RVS

SHEET:
4

JOB NO:
2140170.00



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PROJECT:
PEN 1 LEVEE
RECERTIFICATION

SHEET TITLE:
MAP 5

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
5

JOB NO:
2140170.00

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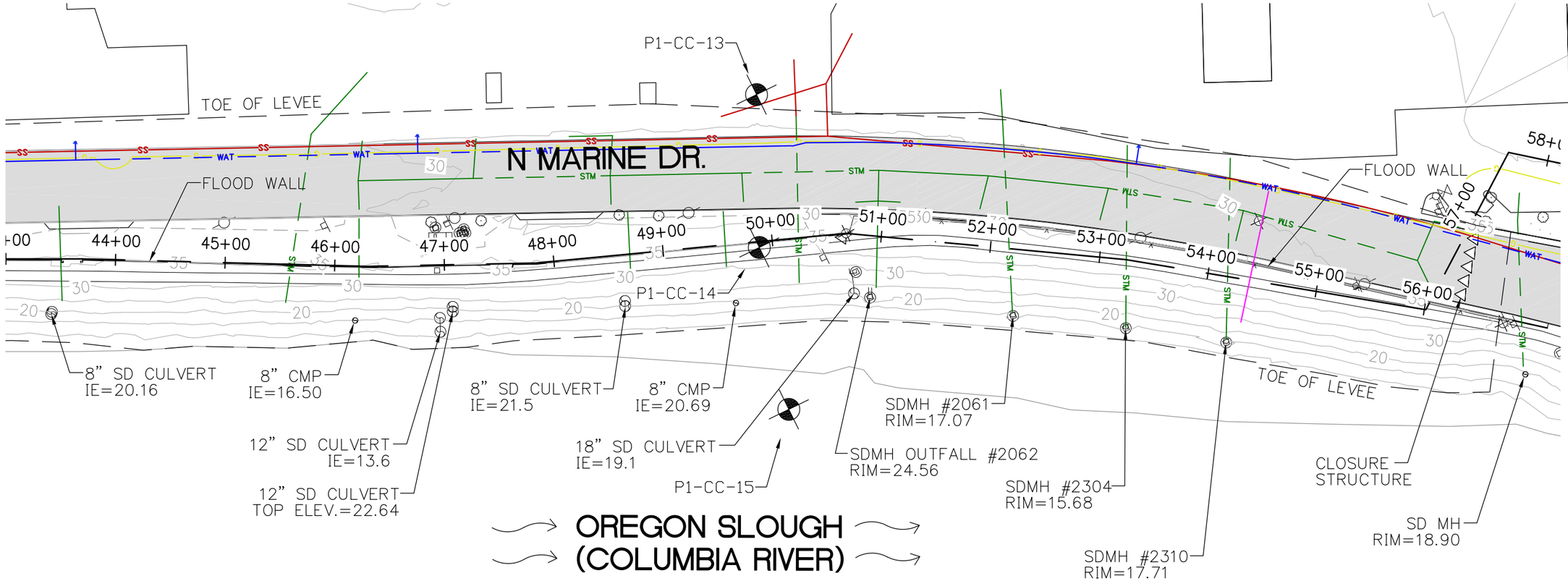
FINAL CONTENT - 10.03. 2014

MATCHLINE - SEE SHEET 5



MATCHLINE - SEE SHEET 7

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RECERTIFICATION

SHEET TITLE:
MAP 6

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
6

JOB NO:
2140170.00

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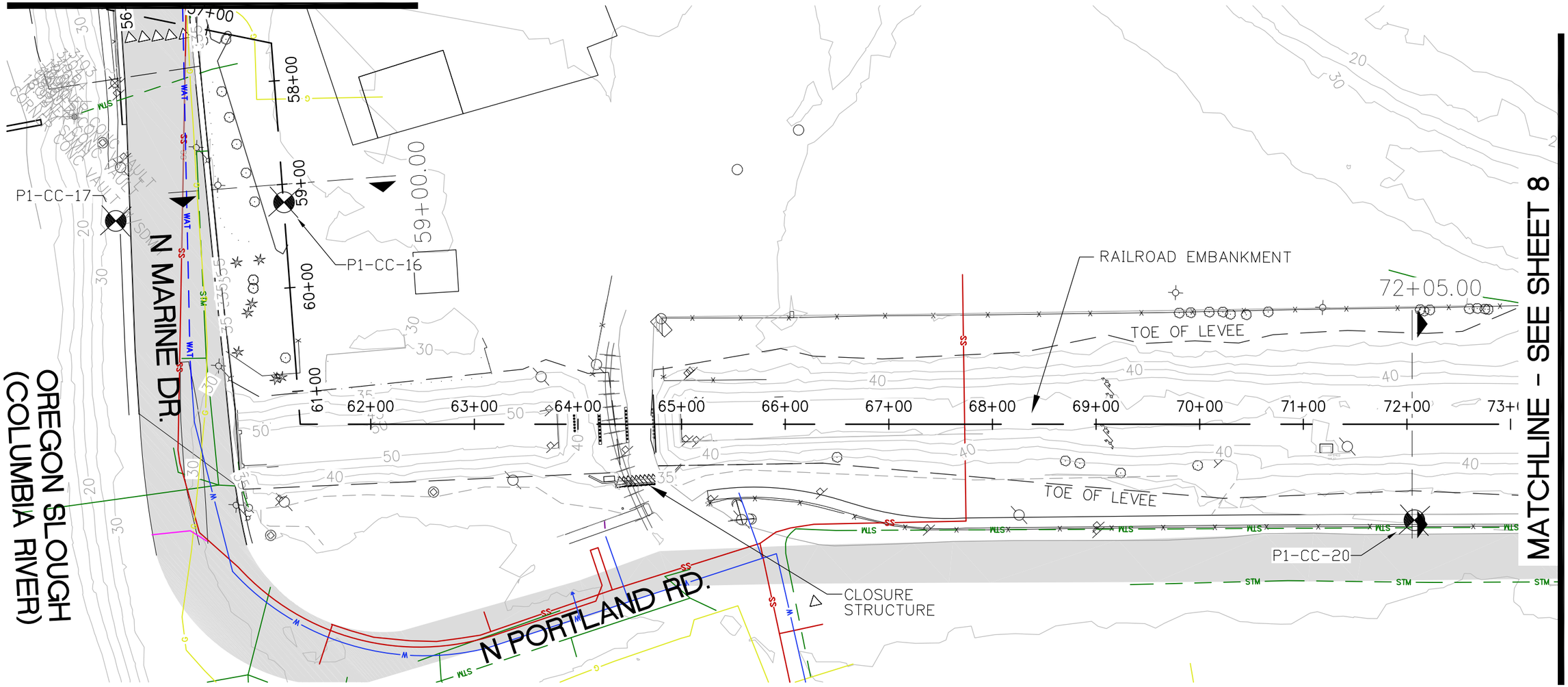
FINAL CONTENT - 10.03. 2014

MATCHLINE - SEE SHEET 6



0 100 200

SCALE: 1"=100'

MATCHLINE - SEE SHEET 8

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PROJECT:
PEN 1 LEVEE
RECERTIFICATION

SHEET TITLE:
MAP 7

DATE:

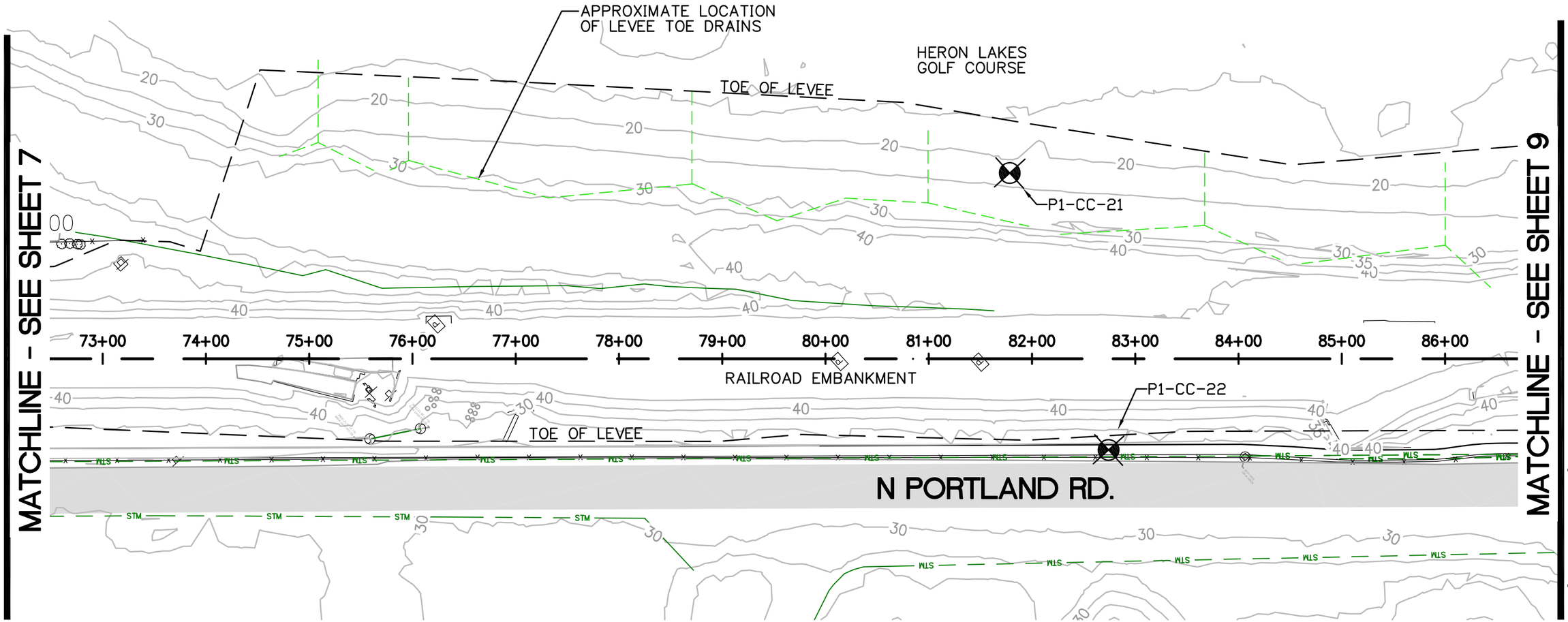
DRAWN BY:
BTS
CHECKED BY:
RVS

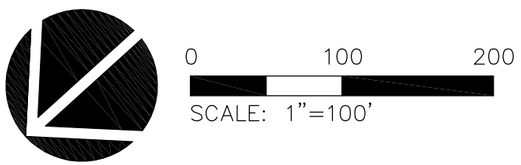
SHEET:
7

JOB NO:
2140170.00

PUBLIC
FINAL CONTENT - 10.03. 2014

214017000\CIVIL\P1-07.DWG BTS 10/02/14 15:51 1:100.00





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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 8

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
8

JOB NO:
2140170.00

PUBLIC
FINAL CONTENT - 10.03. 2014

MATCHLINE - SEE SHEET 8

MATCHLINE - SEE SHEET 10

HERON LAKES
GOLF COURSE

TOE OF LEVEE

89+60.00

P1-CC-23

P1-CC-26

100+35.00

88+00 89+00 90+00 91+00 92+00 93+00 94+00 95+00 96+00 97+00 98+00 99+00 100+00 101+00 102+00 103+00

RAILROAD EMBANKMENT

TOE OF LEVEE

SW-B-4

TREATMENT POND

RAILROAD EMBANKMENT

N PORTLAND RD.

P1-CC-25

EXISTING STORM DRAIN
NO ELEVATION DATA AVAILABLE

0 100 200
SCALE: 1"=100'

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214017000\CIVIL\P1-09.DWG RVS 08/08/14 13:42 1:100.00

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PROJECT:
PEN 1 LEVEE
RECERTIFICATION

SHEET TITLE:
MAP 9

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
9

JOB NO:
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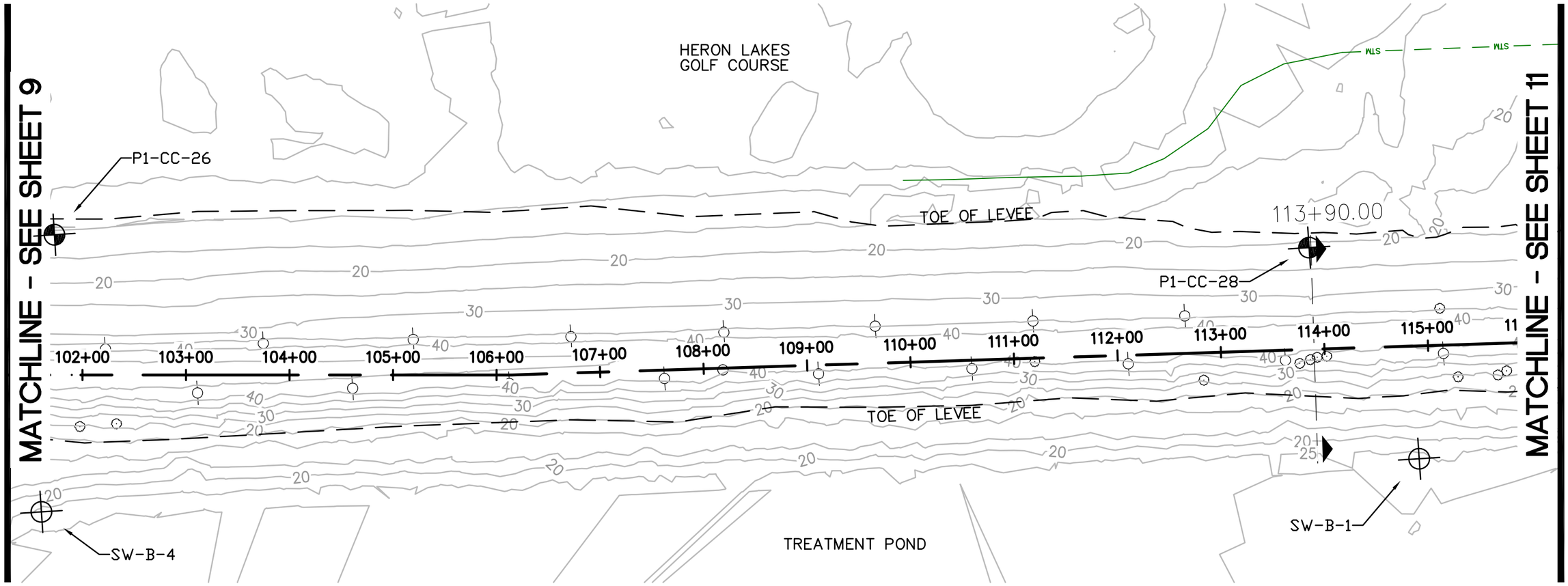

0 100 200
SCALE: 1"=100'

CLIENT:
MCDD #1
1880 NE ELROD DR.
PORTLAND, OR 97211

PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 10

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
10

JOB NO:
2140170.00

PUBLIC
FINAL CONTENT - 10.03. 2014

MATCHLINE - SEE SHEET 12

MATCHLINE - SEE SHEET 10

HERON LAKES GOLF COURSE

6" MALARKEY METHANE GAS LINE

COLUMBIA SLOUGH

TOE OF LEVEE

TOE OF LEVEE

P1-CC-30

P1-CC-31

P1-CC-32

126+50.00

124+30.97

117+00 118+00 119+00 120+00 121+00 122+00 123+00 124+00

125+00 126+00 127+00 129+00

0 100 200

SCALE: 1"=100'

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CLIENT:
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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 11

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
11

JOB NO:
2140170.00

PUBLIC
FINAL CONTENT - 10.03. 2014

214017000\CIVIL\P1-11.DWG RVS 07/29/14 10:50 1:100.00

MATCHLINE – SEE SHEET 11

MATCHLINE – SEE SHEET 13

HERON LAKES
GOLF COURSE

6" MALARKEY
METHANE GAS
LINE

135+75.00

TOE OF LEVEE

TOE OF LEVEE

P1-CC-33

P1-CC-34

P1-CC-35

131+00 132+00 133+00 134+00 135+00 136+00 137+00 138+00 139+00 140+00 141+00 142+00 143+00 144+00 145+00

COLUMBIA SLOUGH

0 100 200

SCALE: 1"=100'

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PROJECT:
PEN 1 LEVEE
RECERTIFICATION

SHEET TITLE:
MAP 12

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
12

JOB NO:
2140170.00

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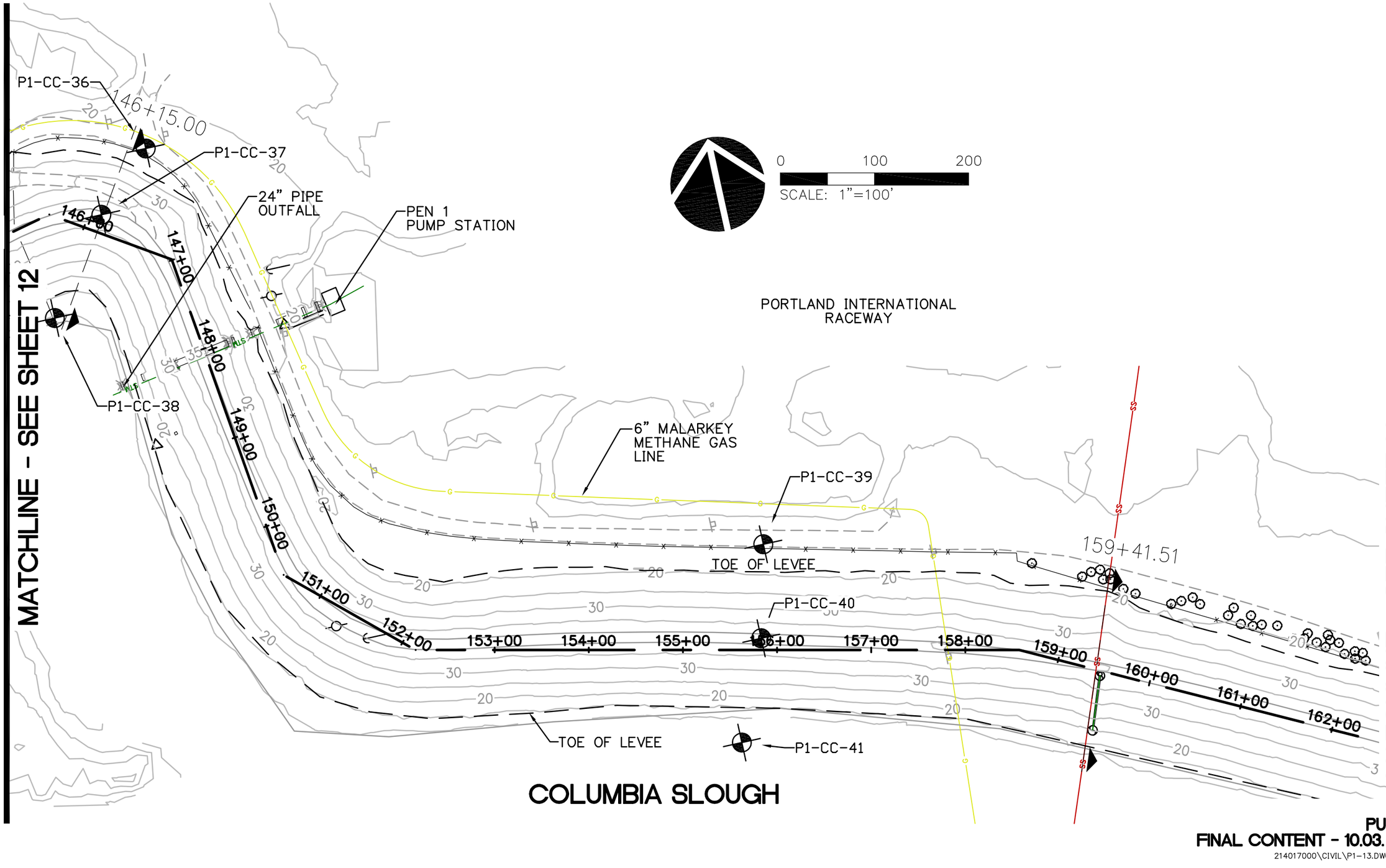


PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 13

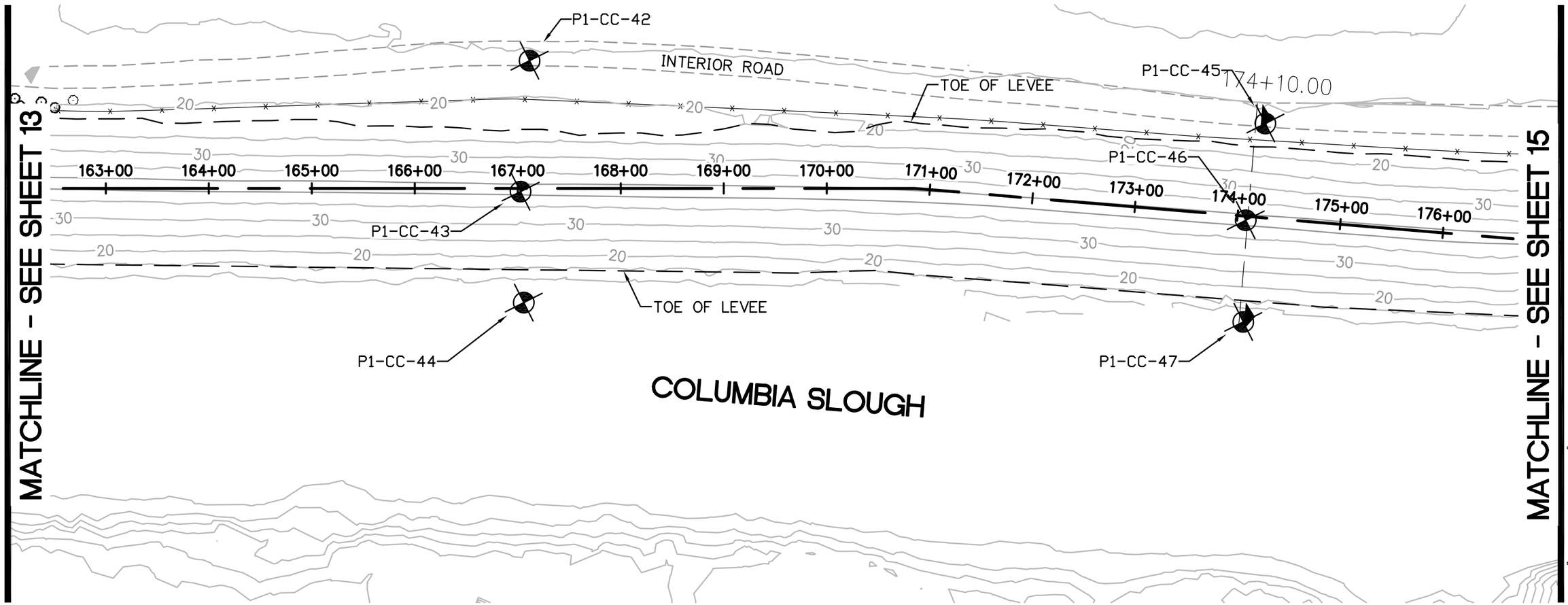
DATE:

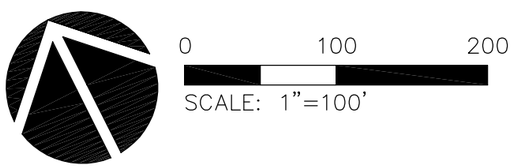
DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
13

JOB NO:
2140170.00

PUBLIC
FINAL CONTENT - 10.03. 2014





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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 14

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
14

JOB NO:
2140170.00

PUBLIC
FINAL CONTENT - 10.03. 2014

214017000\CIVIL\P1-14.DWG RVS 08/08/14 13:53 1:100.00

MATCHLINE - SEE SHEET 14

PORTLAND INTERNATIONAL
RACEWAY

TOE OF LEVEE

P1-CC-48

P1-CC-49

P1-CC-50

TOE OF LEVEE

177+00 178+00 179+00 180+00 181+00 182+00 183+00 184+00 185+00 186+00 187+00 188+00 189+00 190+00 191+00

20 30

COLUMBIA SLOUGH

MATCHLINE - SEE SHEET 16

0 100 200

SCALE: 1"=100'

PUBLIC
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214017000\CIVIL\P1-15.DWG RVS 08/08/14 13:57 1:100.00

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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:

DATE:

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BTS
CHECKED BY:
RVS

SHEET:
15

JOB NO:
2140170.00

MATCHLINE - SEE SHEET 15

0 100 200

SCALE: 1"=100'

PORTLAND INTERNATIONAL RACEWAY

P1-CC-52

P1-CC-53

P1-CC-51

P1-CC-54

CURRENT LEVEE ℄ STATIONING

SD CULVERT IE=34.37

DH-111

205+00.00

TOE OF LEVEE

N DENVER AVE.

199+22 199+00 200+00 201+00 202+00 203+00 204+00 205+00 206+00 207+00 208+00 209+00 210+00 211+00 212+00

12" SD CULVERT IE=28.26

C-23

P1-CC-55

HISTORIC DISTRICT BOUNDARY LINE

EXISTING STORM DRAIN NO ELEVATION DATA AVAILABLE

STA:199+22.32 CURRENT LEVEE = STA 199+25.21 HISTORIC DISTRICT BOUNDARY LINE

MATCHLINE - SEE SHEET 17

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SHEET TITLE:
MAP 16

DATE:

DRAWN BY:
BTS
CHECKED BY:
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SHEET:
16

JOB NO:
2140170.00

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FINAL CONTENT - 10.03. 2014

214017000\CIVIL\P1-16.DWG BTS 10/02/14 16:00 1:100.00

MATCHLINE - SEE SHEET 16

MATCHLINE - SEE SHEET 18

P1-CC-56

214+53.00

TOE OF LEVEE

B-6

214+00

215+00

216+00

217+00

218+00

219+00

N EXPO RD.

N VICTORY BLVD.

DELTA PARK/VANPORT
MAX STATION

220+00

221+00

222+00

223+00

224+00

225+00

225+23.00

CURRENT LEVEE
℄ STATIONING

P1-CC-57

226+00

227+00

228+00

229+00

I-5 SOUTHBOUND (OFF RAMP)

213+00

214+00

215+00

216+00

217+00

218+00

219+00

220+00

221+00

222+00

223+00

224+00

225+00

226+00

P1-CC-58

TOE OF LEVEE

HISTORIC DISTRICT
BOUNDARY LINE

DH-106

0 100 200

SCALE: 1"=100'

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SHEET TITLE:
MAP 17

DATE:

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BTS
CHECKED BY:
RVS

SHEET:
17

JOB NO:
140170.00

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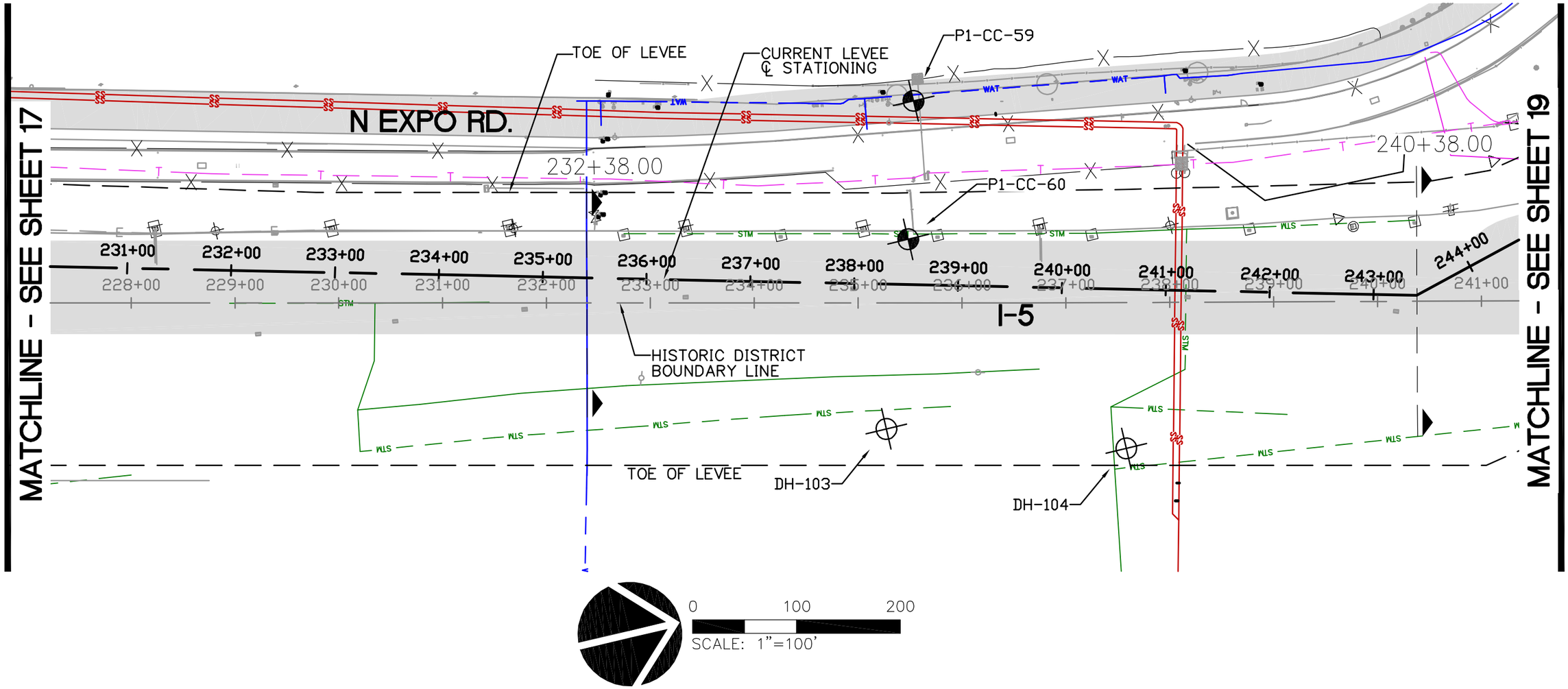
214017000\CIVIL\P1-17.DWG BTS 10/03/14 08:10 1:100.00



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SHEET TITLE:
MAP 18

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
18

JOB NO:
2140170.00

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214017000\CIVIL\P1-18.DWG RVS 08/21/14 11:04 1:100.00

P1-CC-61

EXPO CENTER

CURRENT LEVEE
℄ STATIONING

N EXPO RD.

TOE OF LEVEE

P1-CC-62

CRC-MD-006

N MARINE DR.

CRC-SC-011

P1-CC-1

I-5

HISTORIC DISTRICT
BOUNDARY LINE

MATCHLINE - SEE SHEET 18

0 100 200
SCALE: 1"=100'

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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
MAP 19

DATE:

DRAWN BY:
BTS
CHECKED BY:
RVS

SHEET:
19

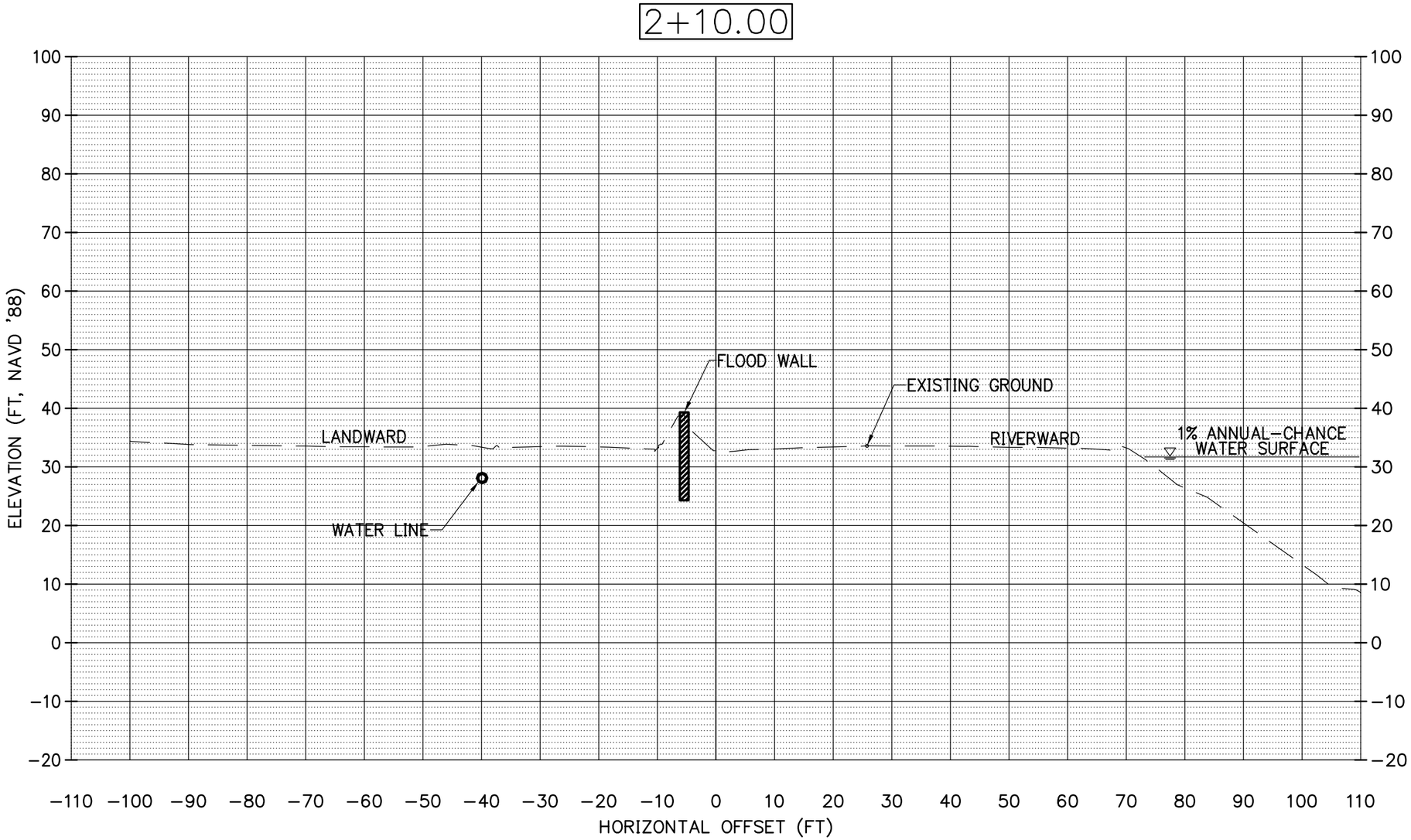
JOB NO:
2140170.00

APPENDIX E

GROUP MACKENZIE CONSULTANTS

PEN 1 Levee – As-Built Cross-Sections

October 2014



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PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
SECTION 2+10

DATE:

DRAWN BY:

CHECKED BY:

SHEET:

JOB NO:
2140170.00

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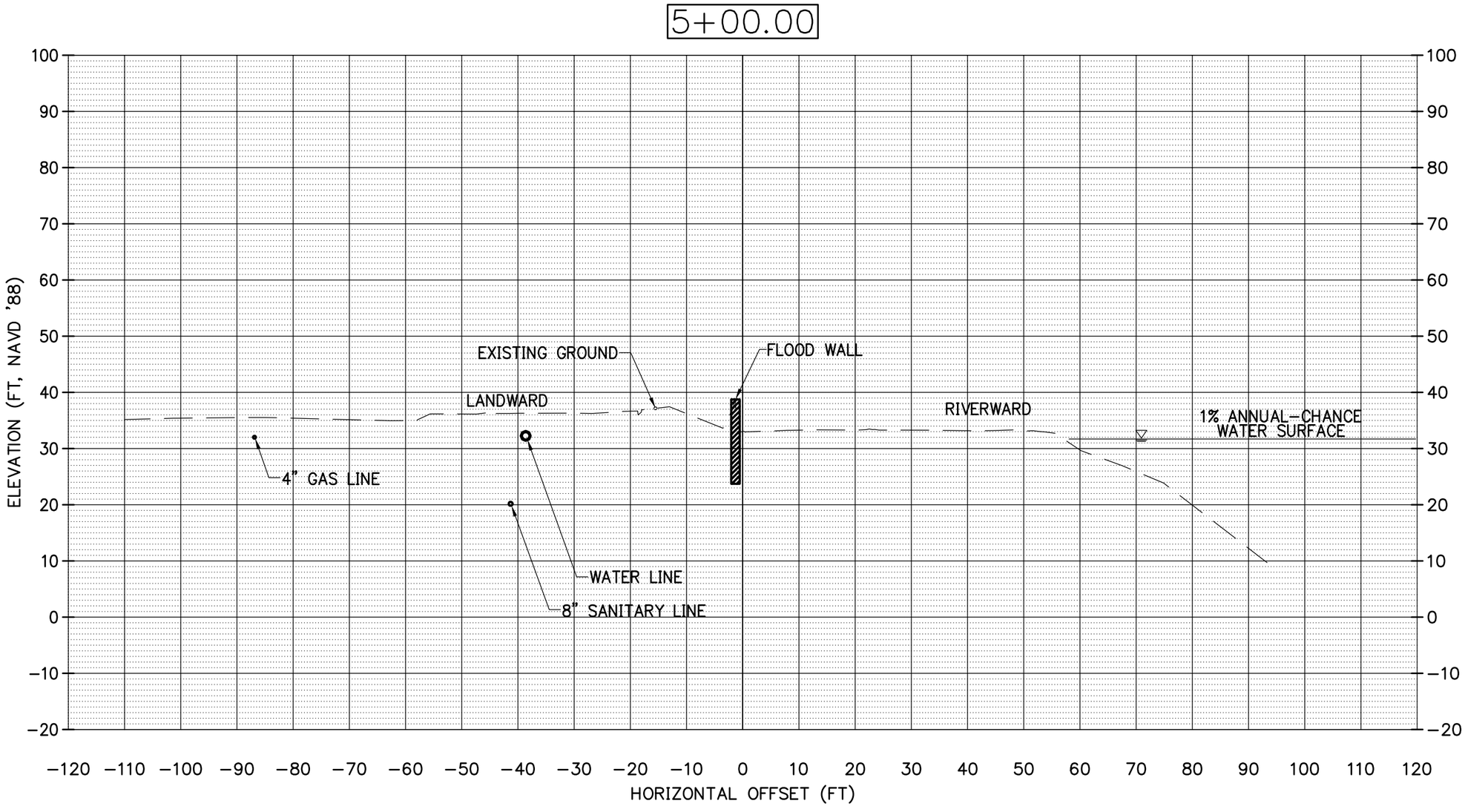
FINAL CONTENT - 10.03. 2014



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PROJECT:
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SHEET TITLE:
SECTION 5+00

DATE:

DRAWN BY:

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SHEET:

JOB NO:
2140170.00

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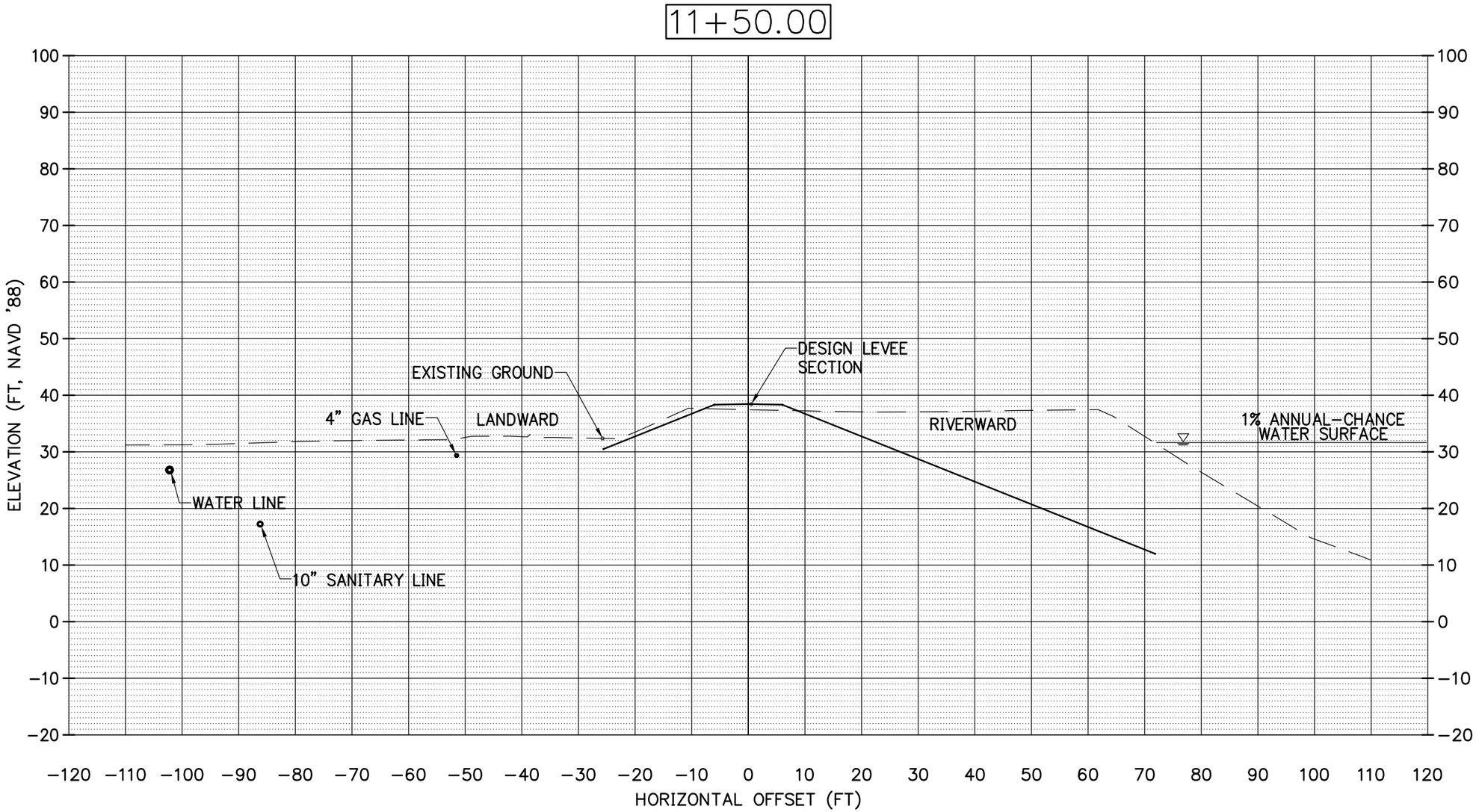

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SHEET TITLE:
SECTION 11+50

DATE:

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JOB NO:
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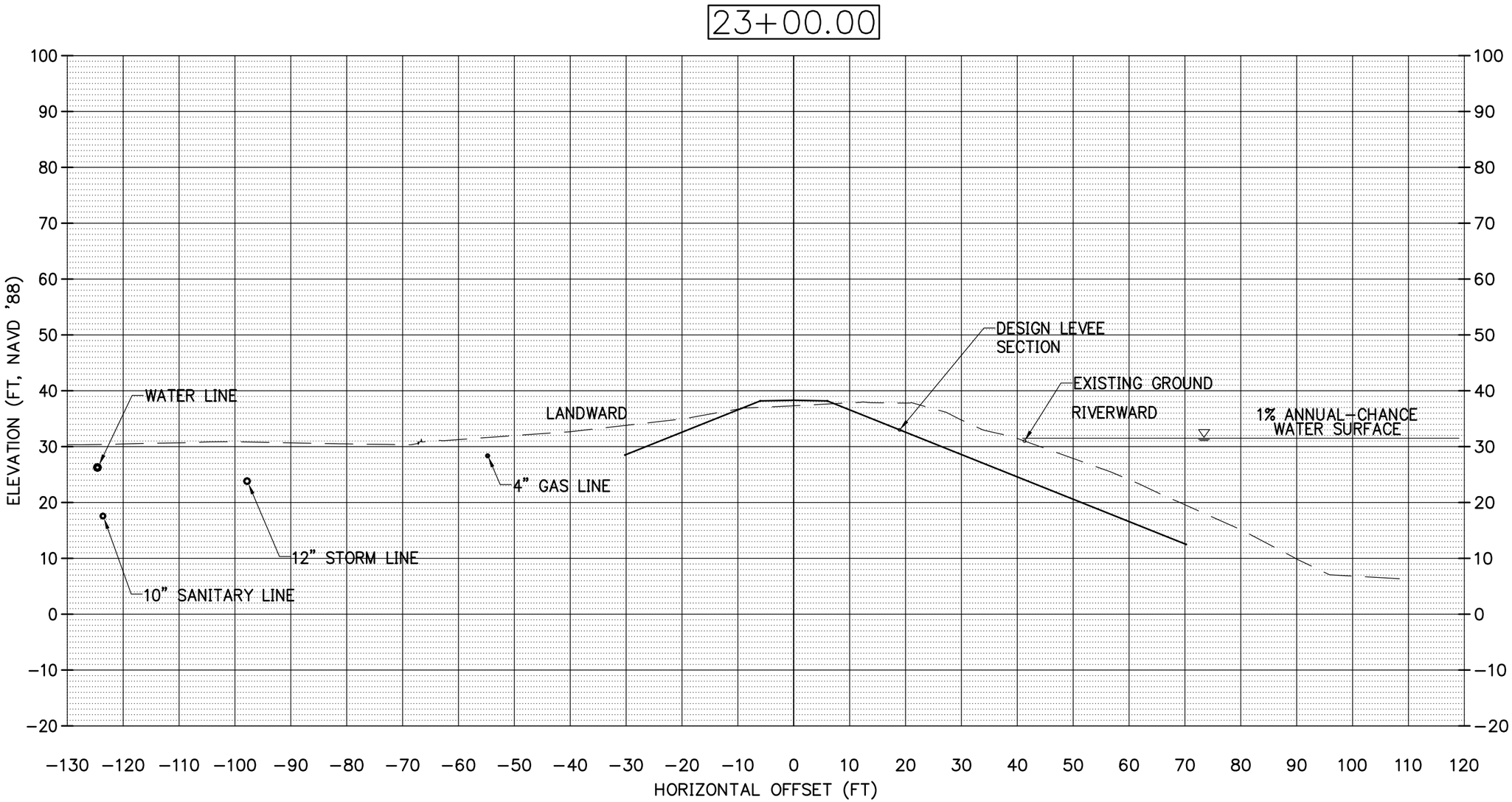

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SHEET TITLE:
SECTION 23+00

DATE:

DRAWN BY:

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SHEET:

JOB NO:
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PUBLIC
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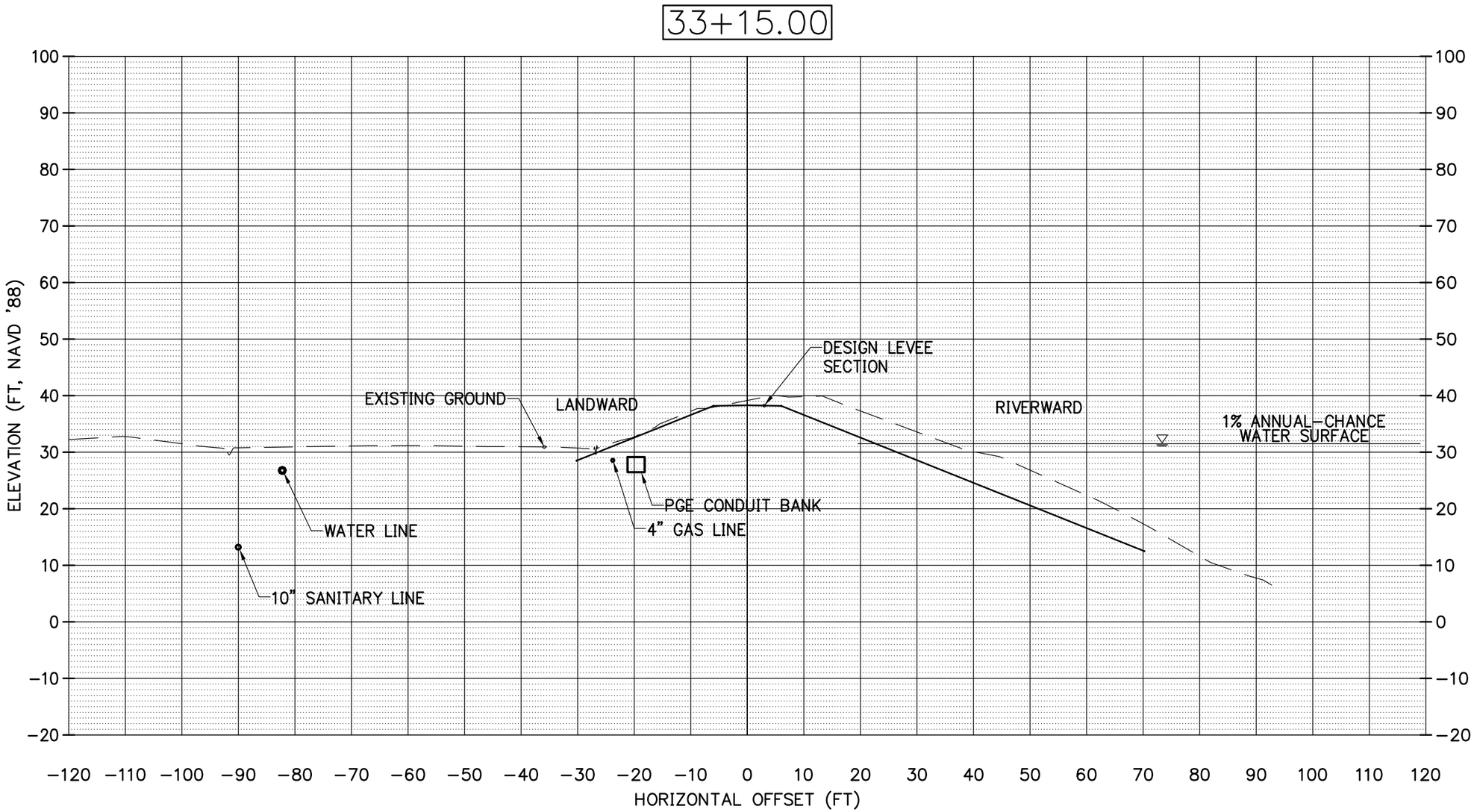
214017000\CIVIL\170PSITE-PEN1.DWG BTS 10/03/14 08:43 1:20.00



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SHEET TITLE:
SECTION 33+15

DATE:

DRAWN BY:

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SHEET:

JOB NO:
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214017000\CIVIL\170PSITE-PEN1.DWG BTS 10/03/14 08:44 1:20.00

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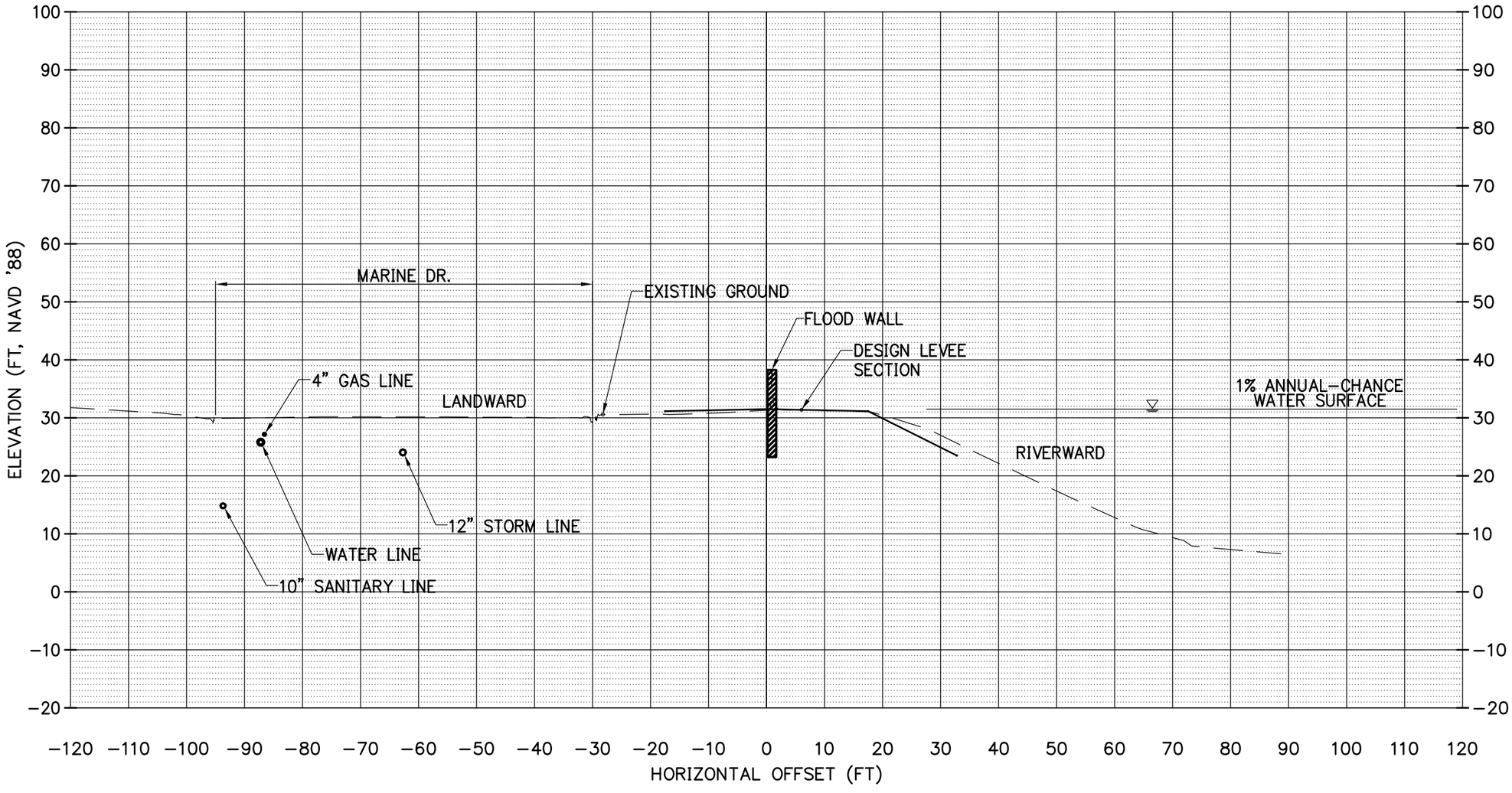
41+40.00



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PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
SECTION 41+40

DATE:

DRAWN BY:

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SHEET:

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PUBLIC
FINAL CONTENT - 10.03.2014

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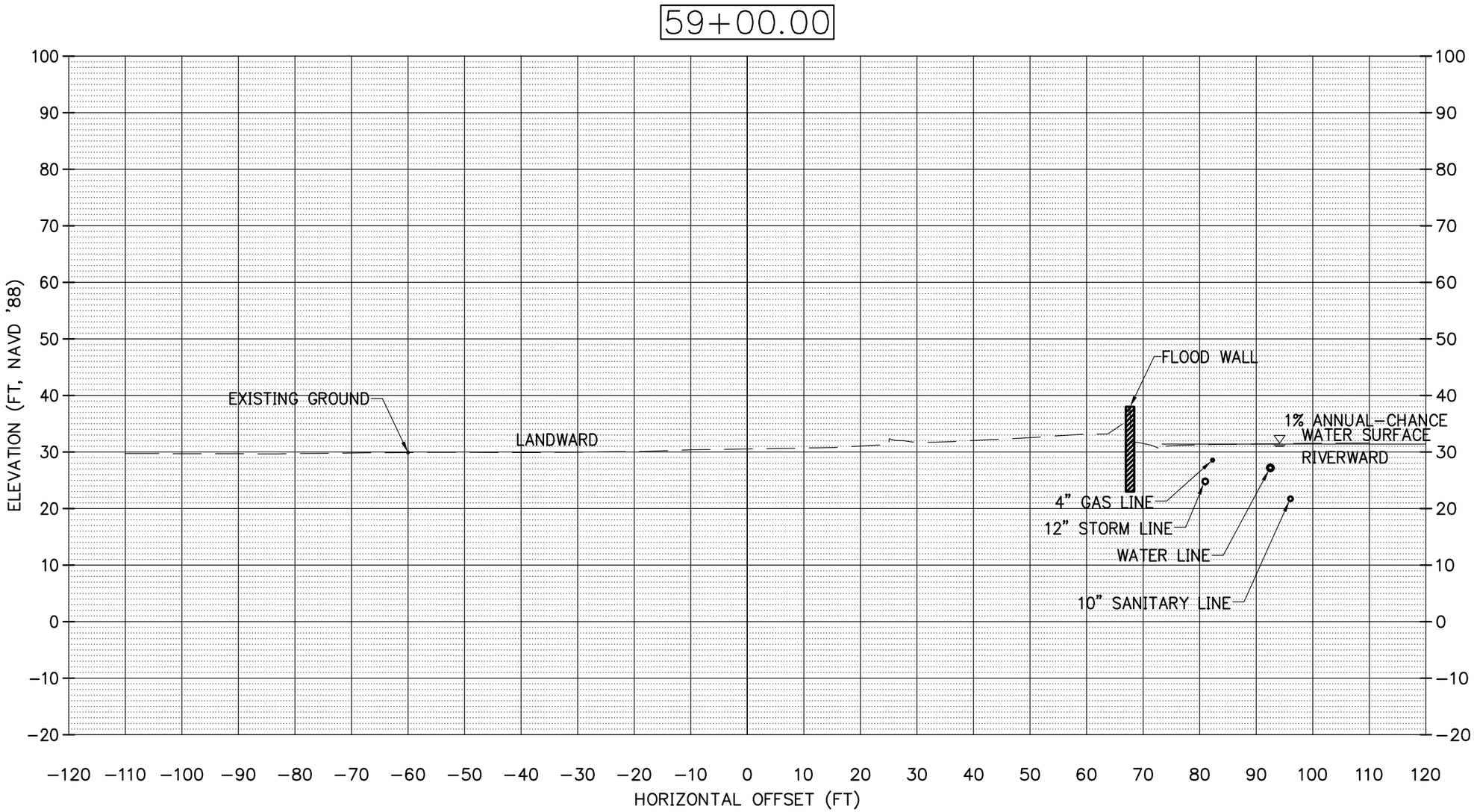

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SHEET TITLE:
SECTION 59+00

DATE:

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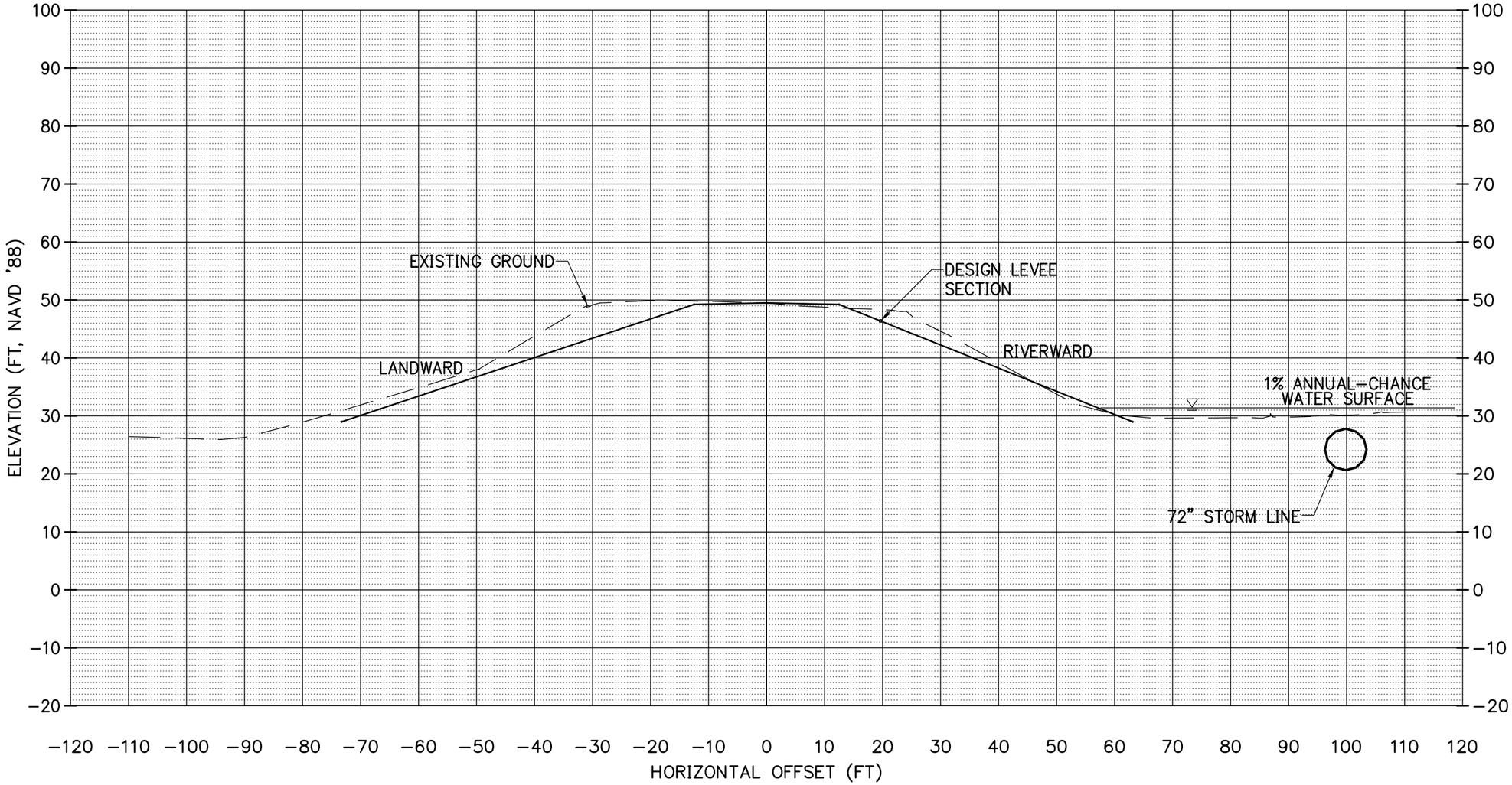
FINAL CONTENT - 10.03. 2014

72+05.00



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SHEET TITLE:
SECTION 72+05

DATE:

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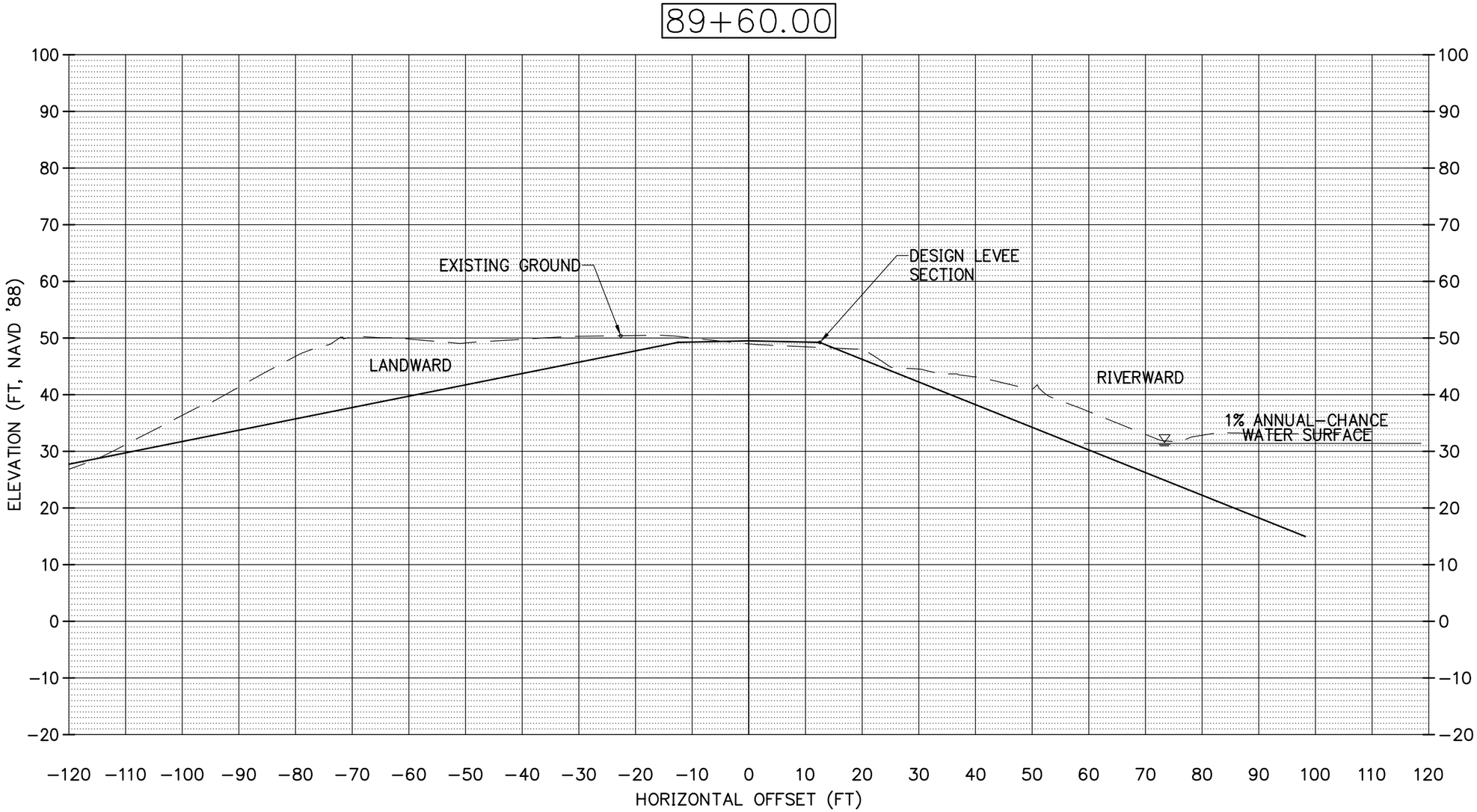

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SHEET TITLE:
SECTION 89+60

DATE:

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SHEET:

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FINAL CONTENT - 10.03. 2014

214017000\CIVIL\170PSITE-PEN1.DWG RVS 07/29/14 10:28 1:20.00

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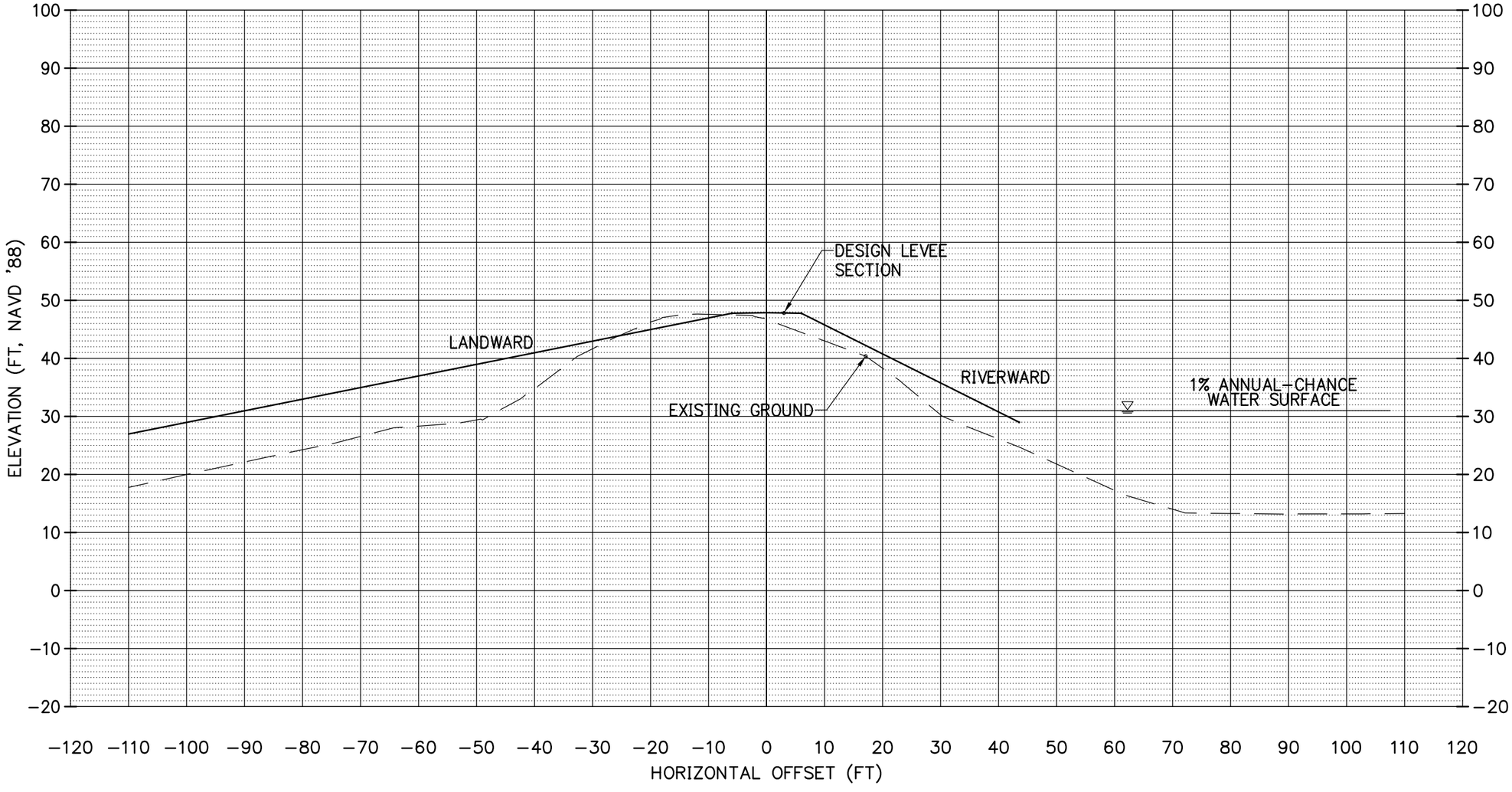
100+35.00



PROJECT:
PEN 1 LEVEE RECERTIFICATION

SHEET TITLE:
SECTION 100+35

DATE:

DRAWN BY:

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SHEET:

JOB NO:
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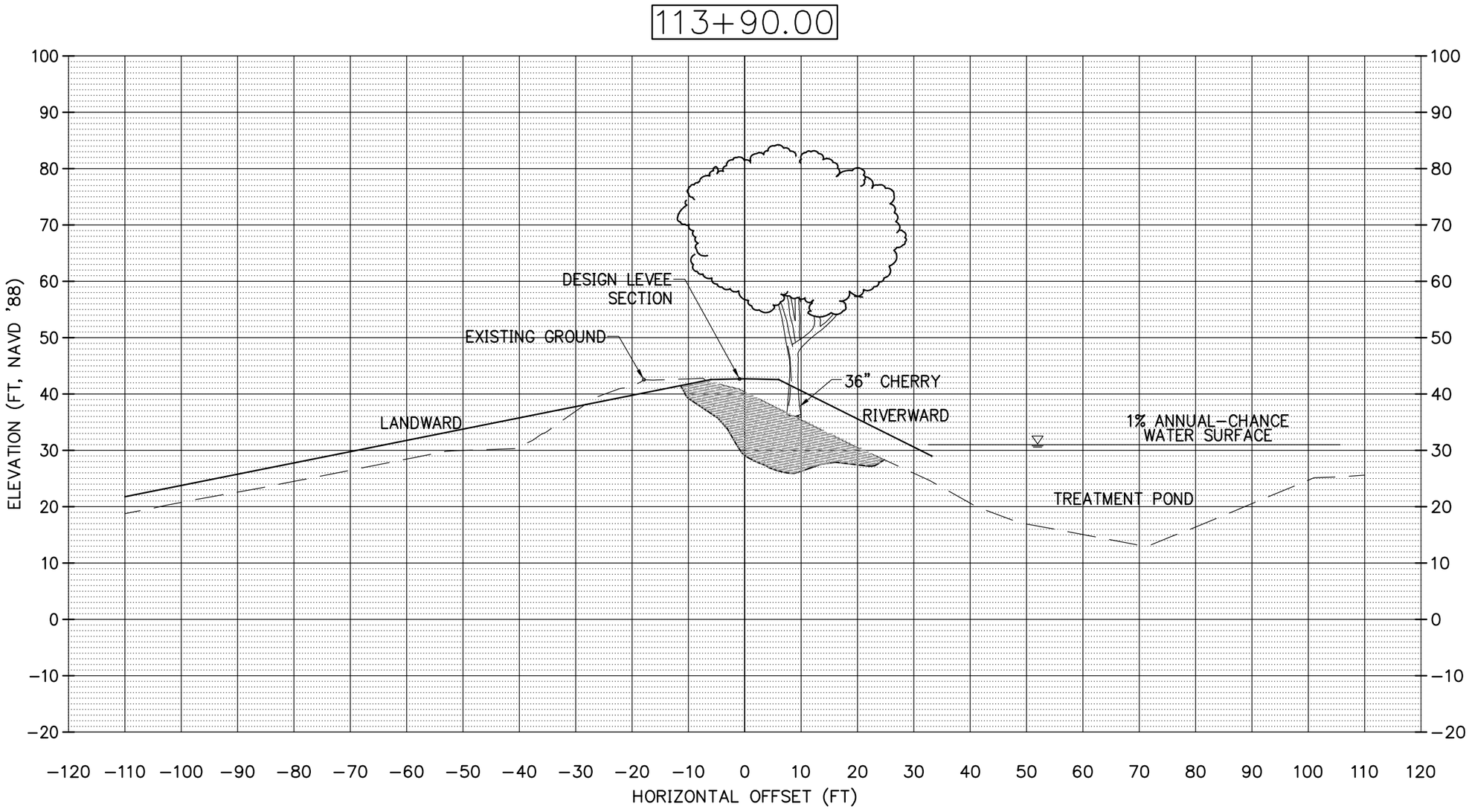

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SHEET TITLE:
SECTION 113+90

DATE:

DRAWN BY:

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SHEET:

JOB NO:
2140170.00

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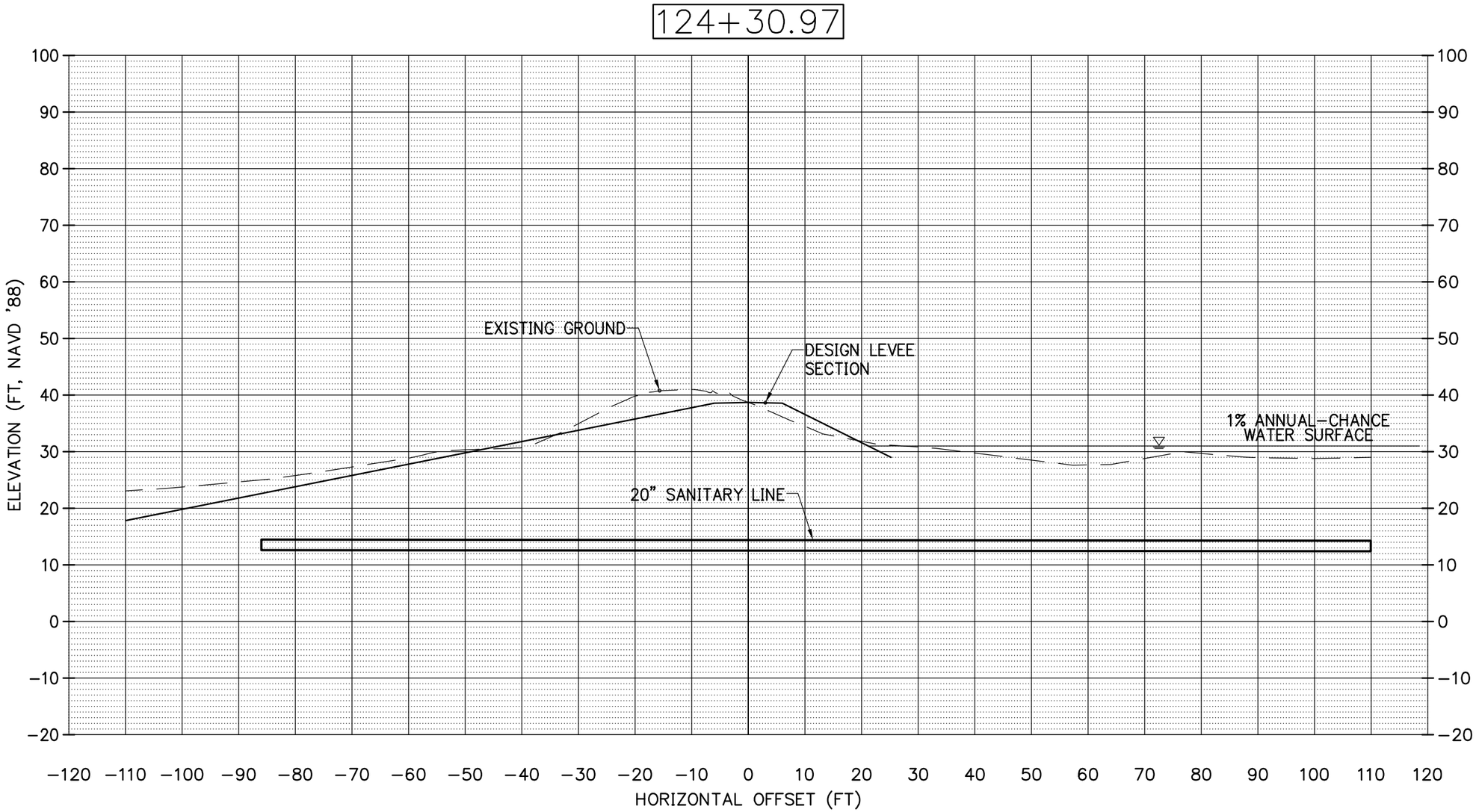

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SHEET TITLE:
SECTION 124+30.97

DATE:

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SHEET:

JOB NO:
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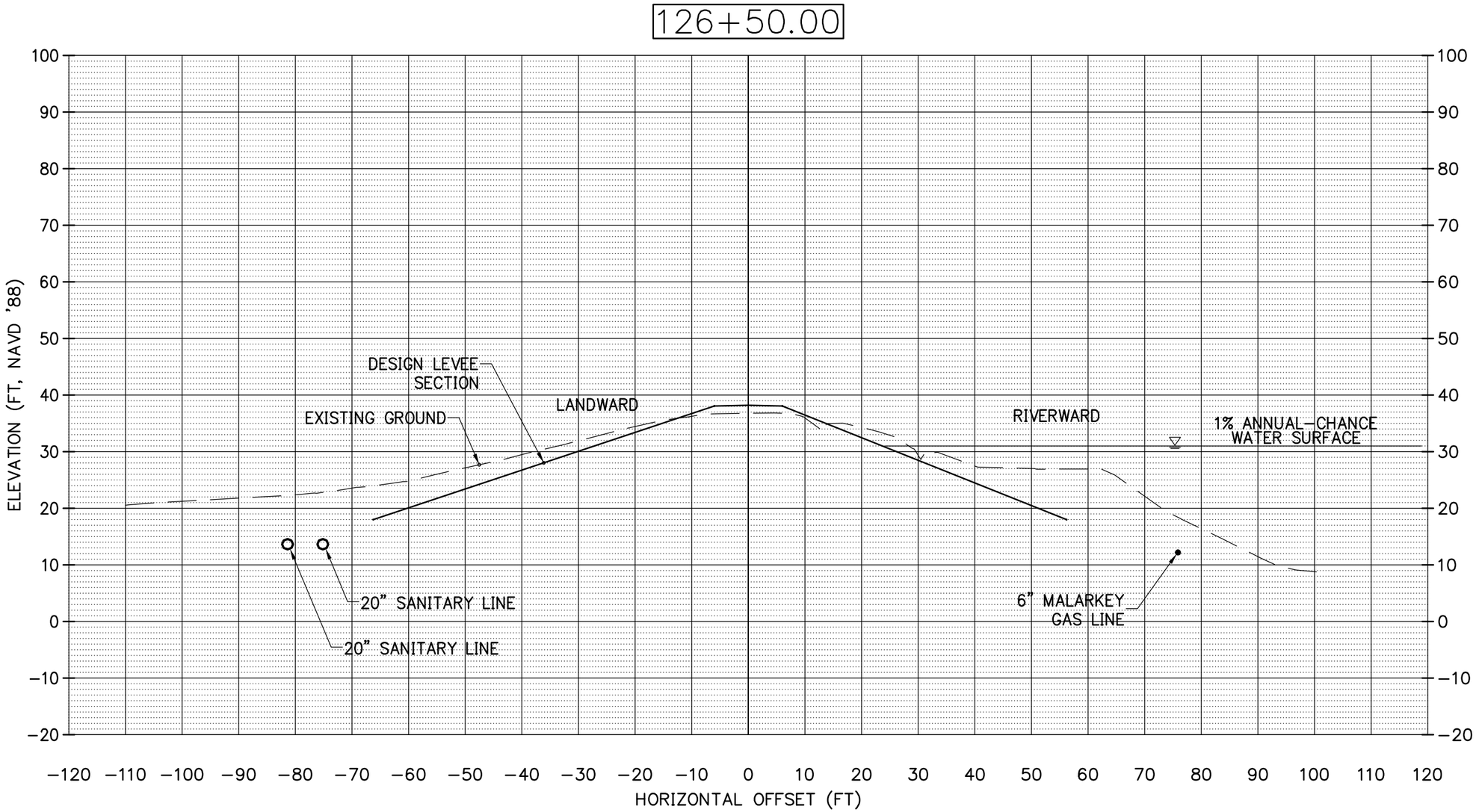

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SHEET TITLE:
SECTION 126+50

DATE:

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SHEET:

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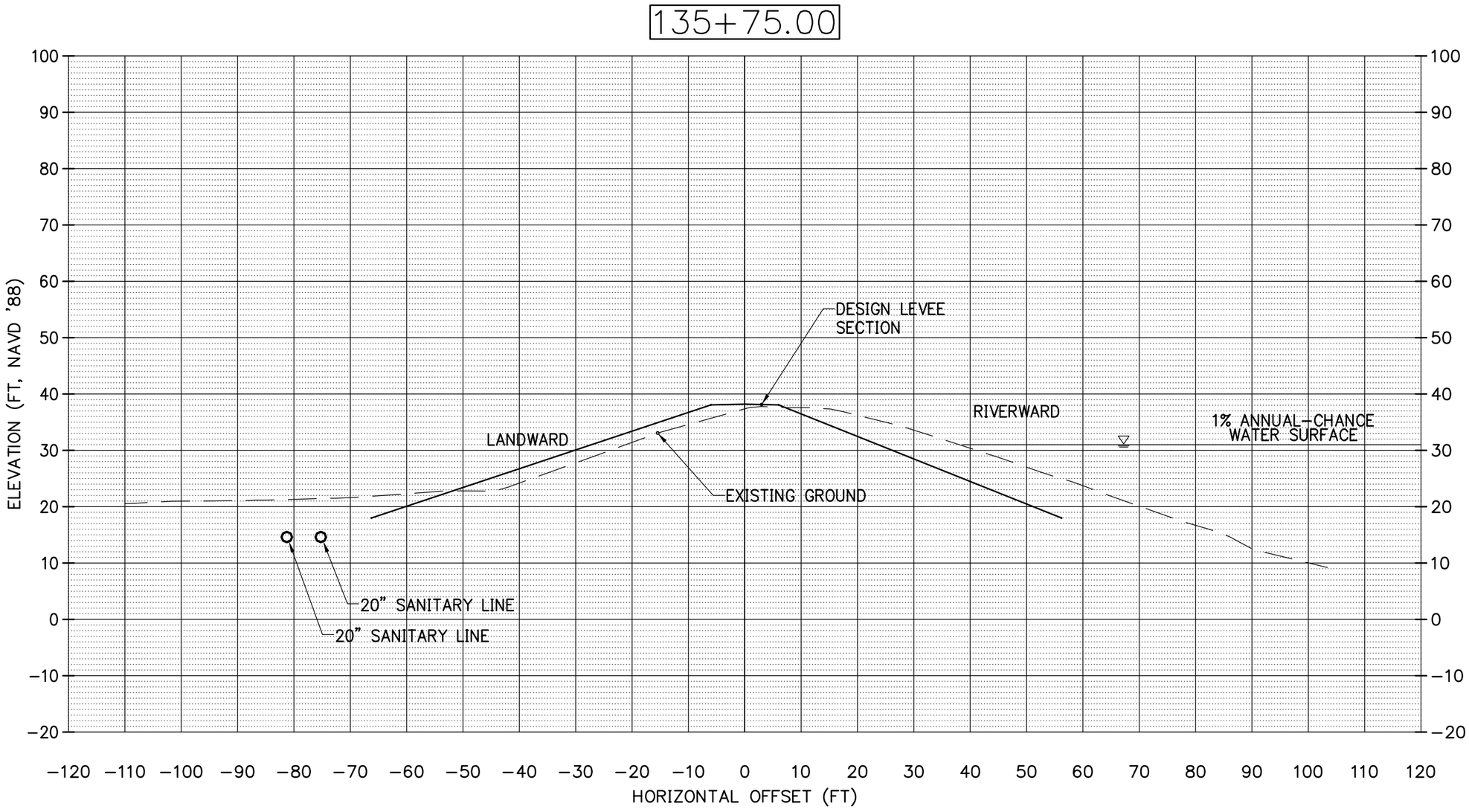

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PROJECT:
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SHEET TITLE:
SECTION 135+75

DATE:

DRAWN BY:

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SHEET:

JOB NO:
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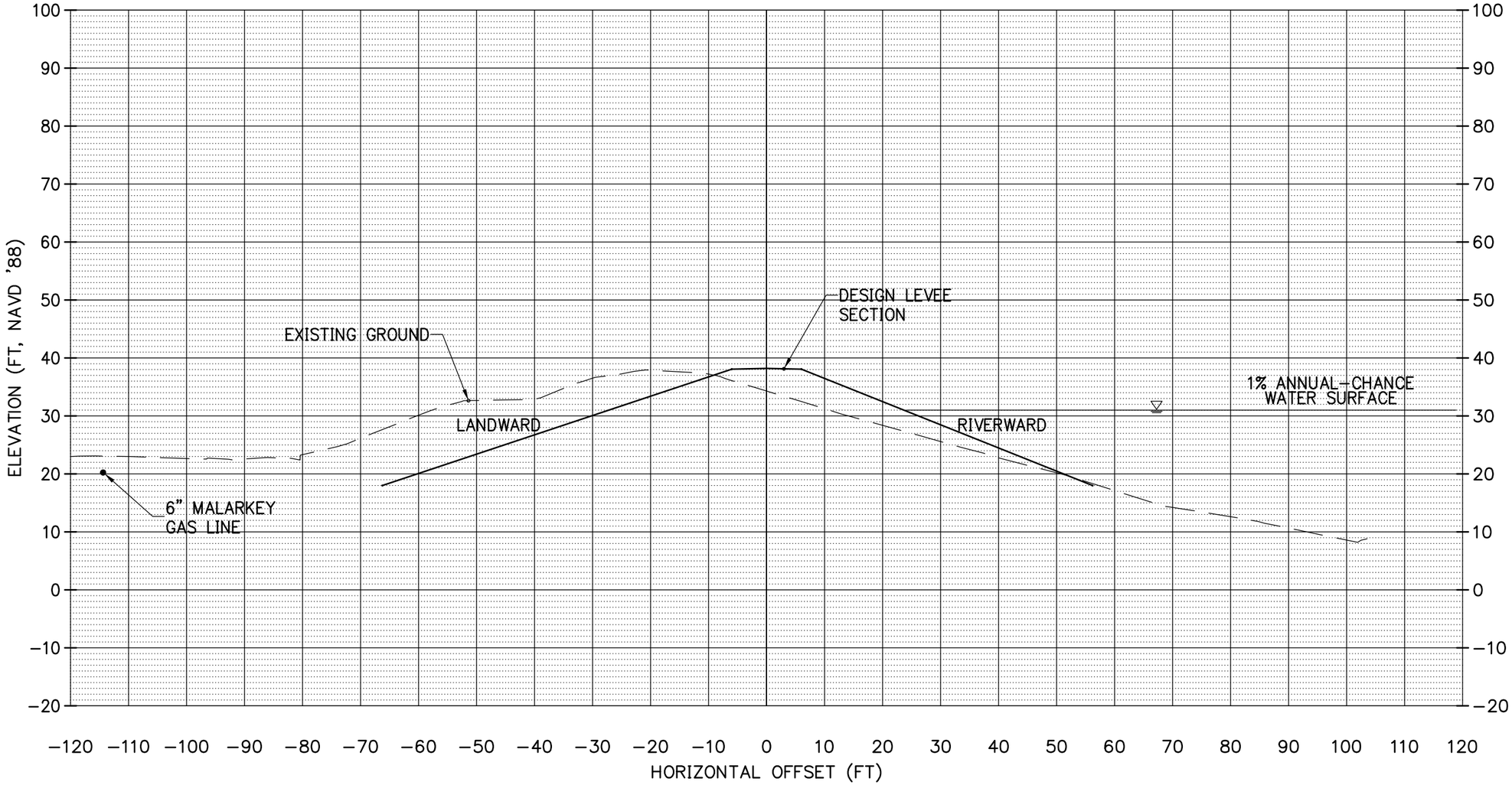
146+15.00



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SHEET TITLE:
SECTION 146+15

DATE:

DRAWN BY:

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SHEET:

JOB NO:
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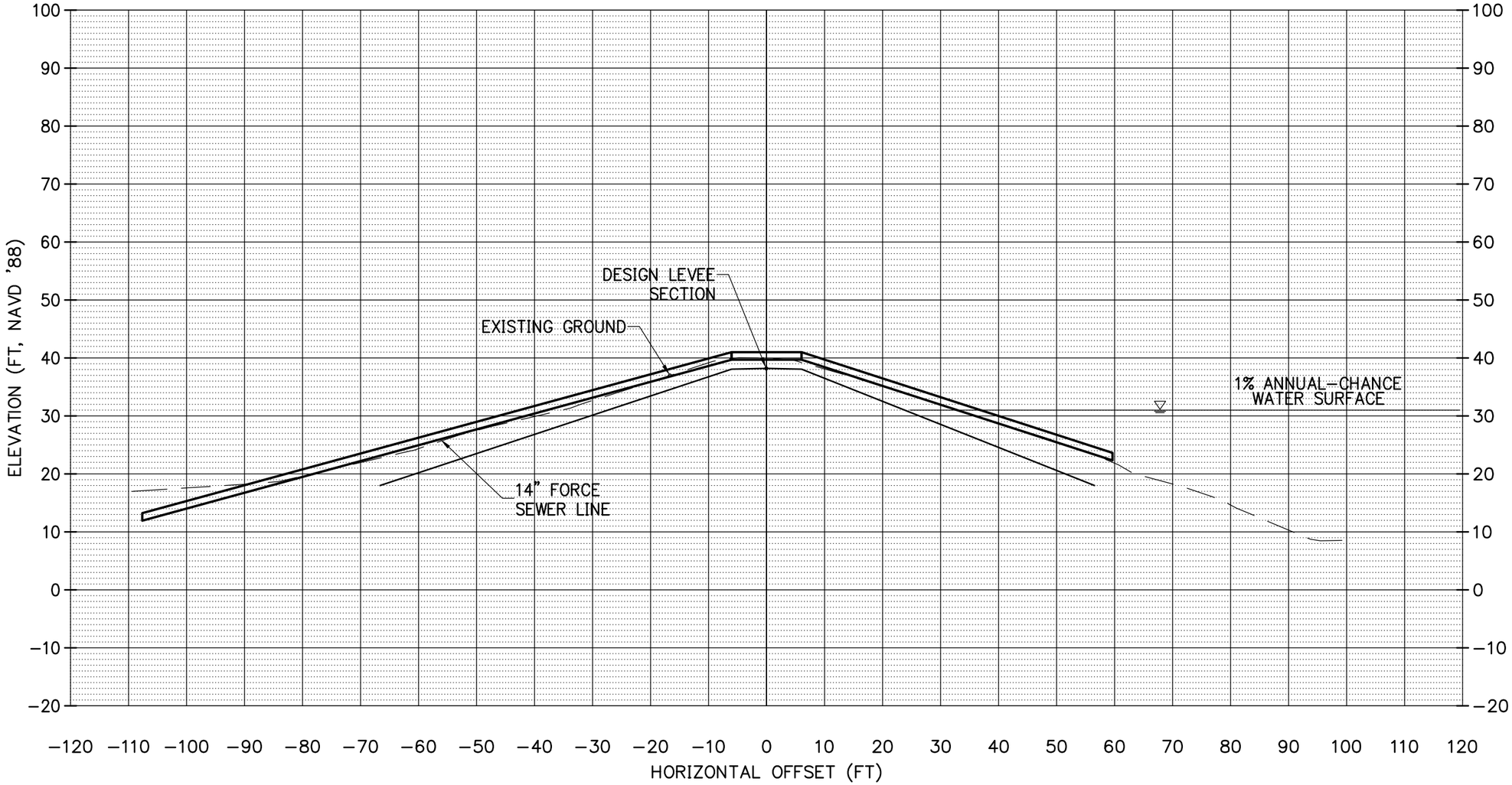
159+41.51



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SHEET TITLE:
SECTION 159+41.51

DATE:

DRAWN BY:

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SHEET:

JOB NO:
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214017000\CIVIL\170PSITE-PEN1.DWG RVS 09/02/14 09:17 1:20.00

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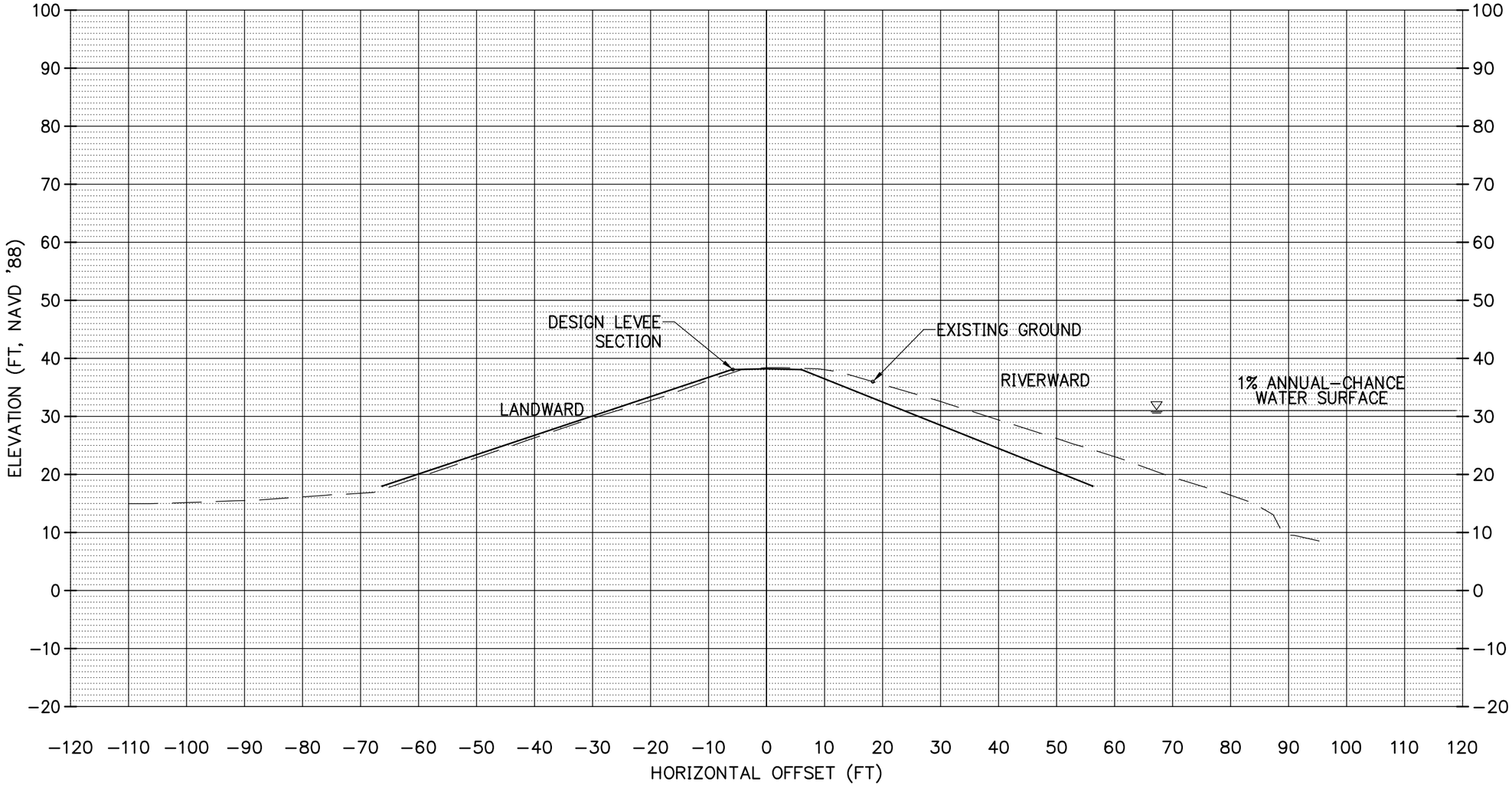
174+10.00



PROJECT:
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SHEET TITLE:
SECTION 174+10

DATE:

DRAWN BY:

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SHEET:

JOB NO:
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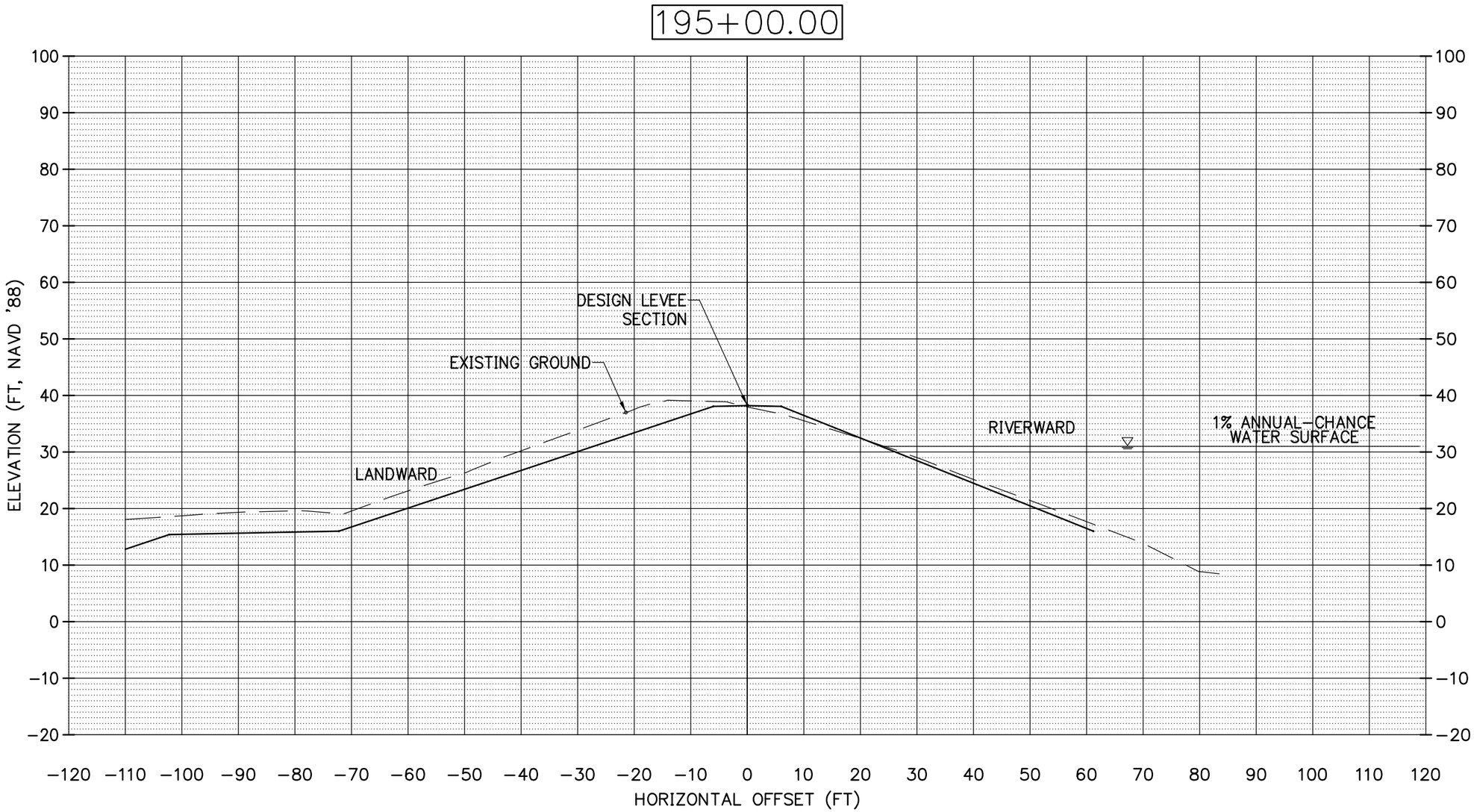

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SHEET TITLE:
SECTION 195+00

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JOB NO:
2140170.00

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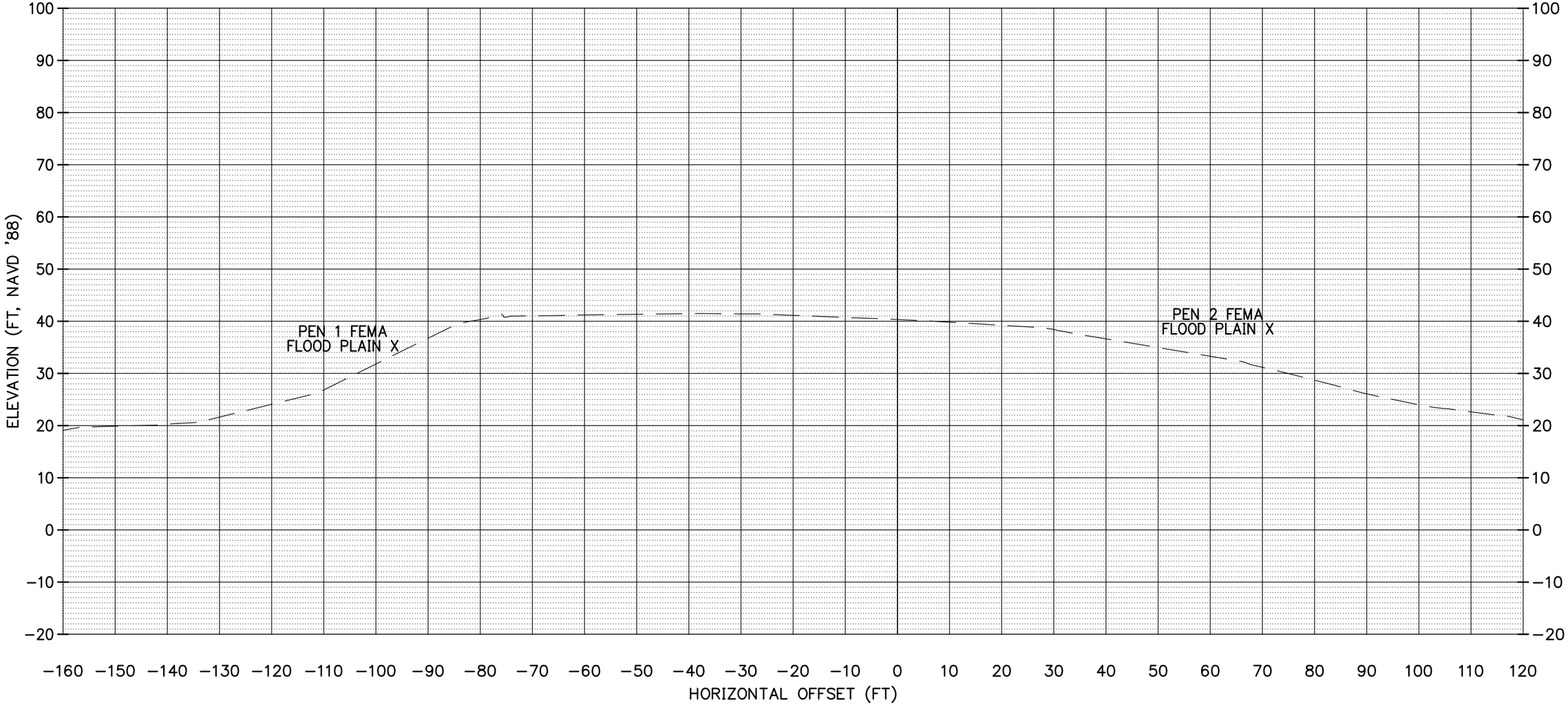
205+00.00



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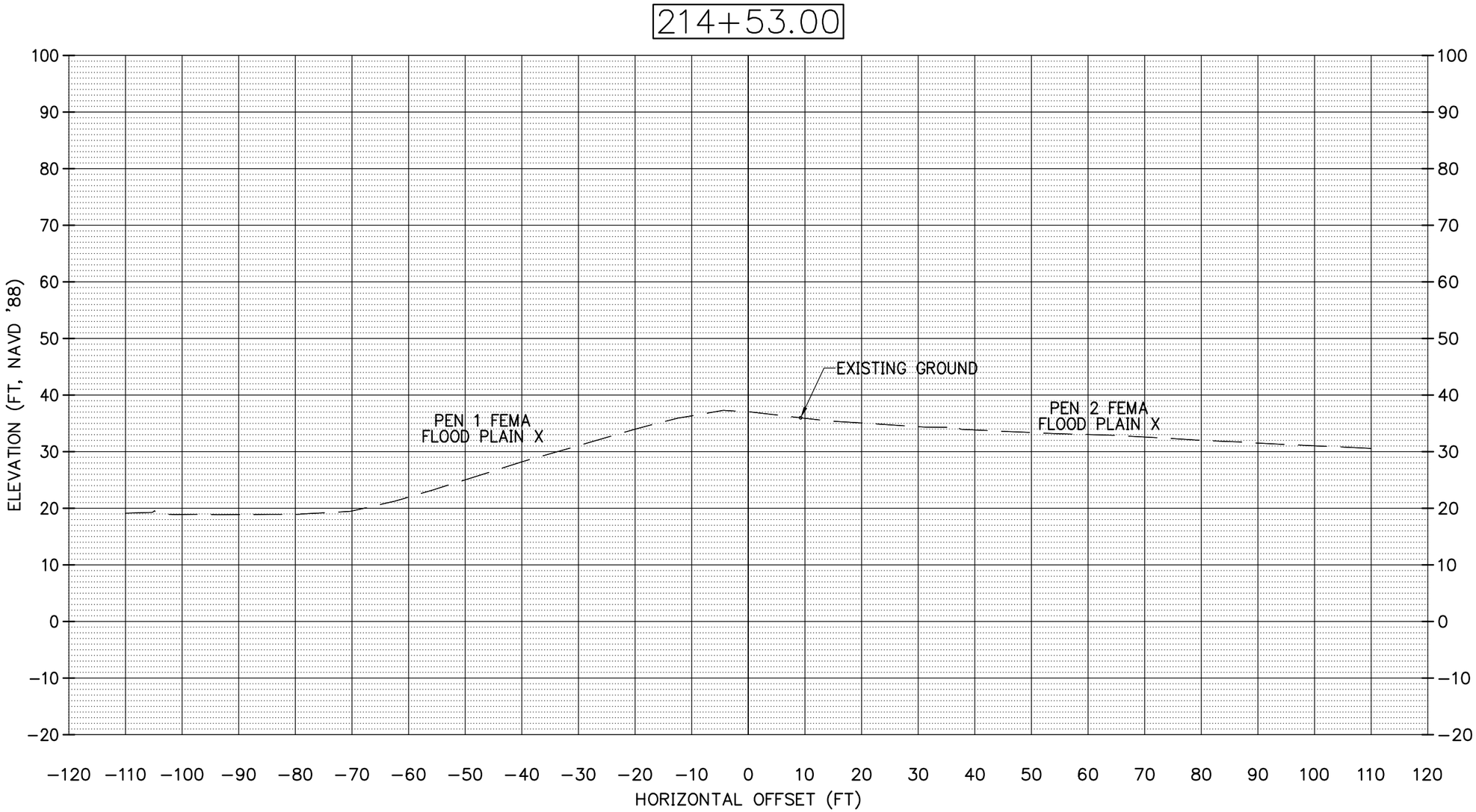

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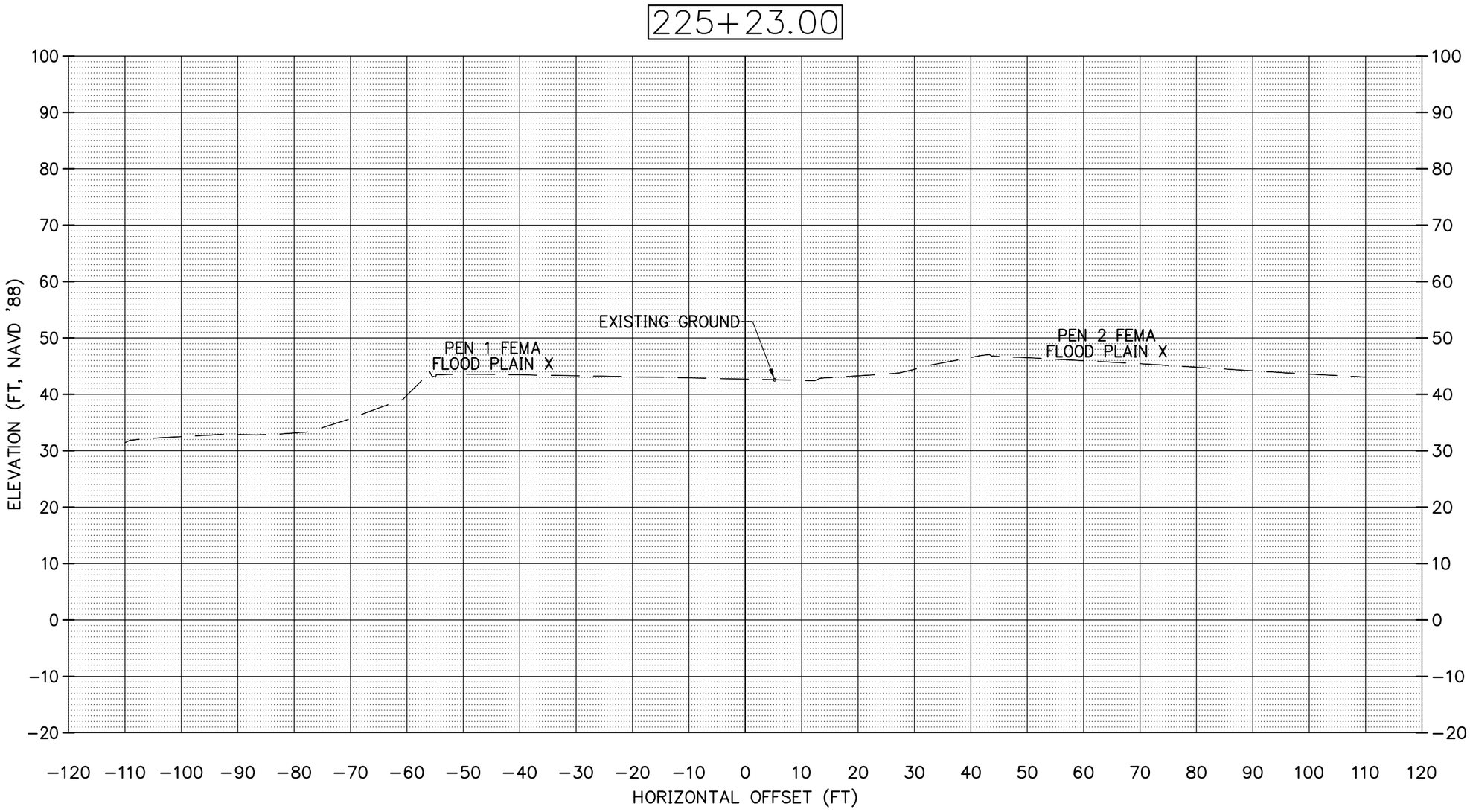

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SHEET TITLE:
SECTION 225+23

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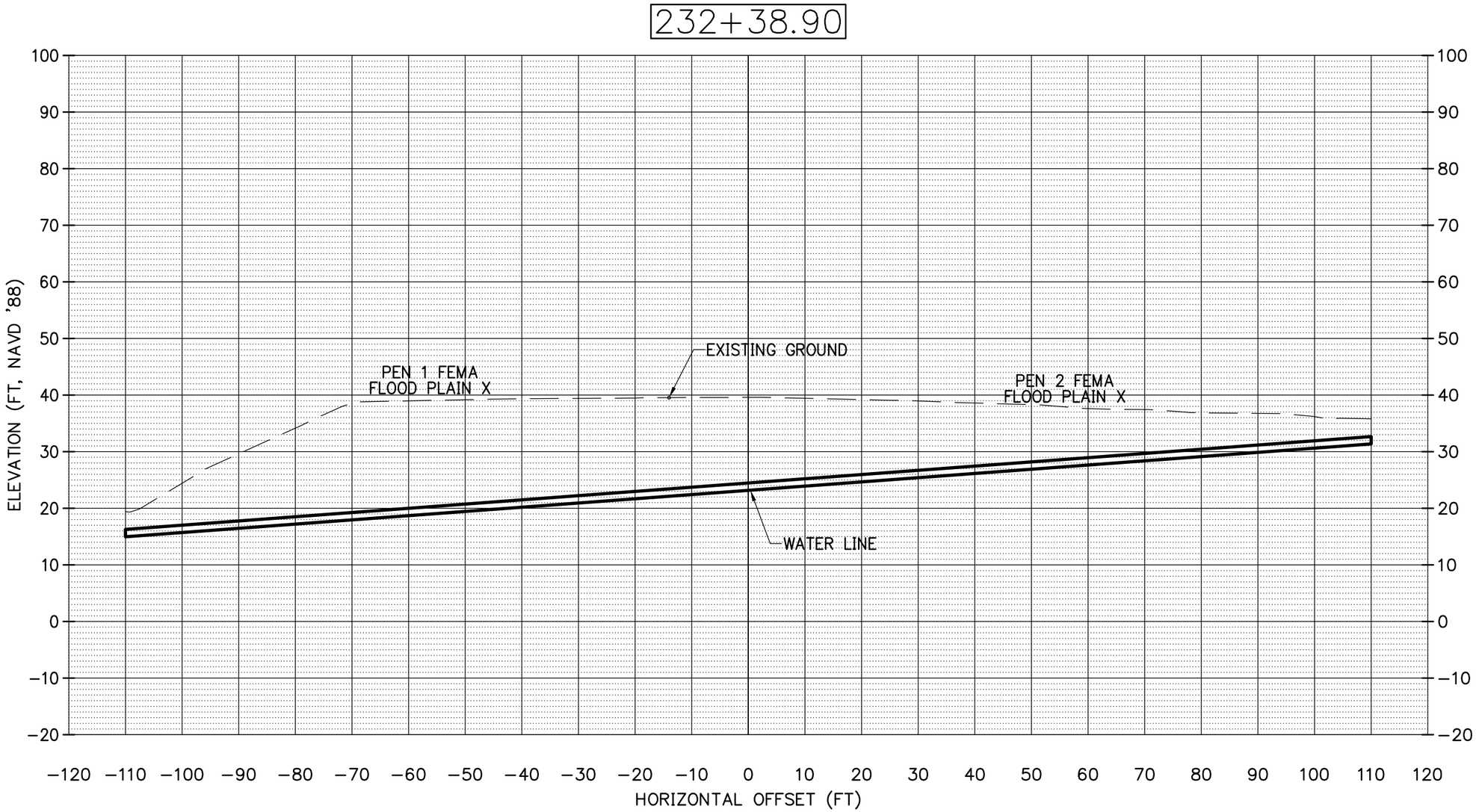

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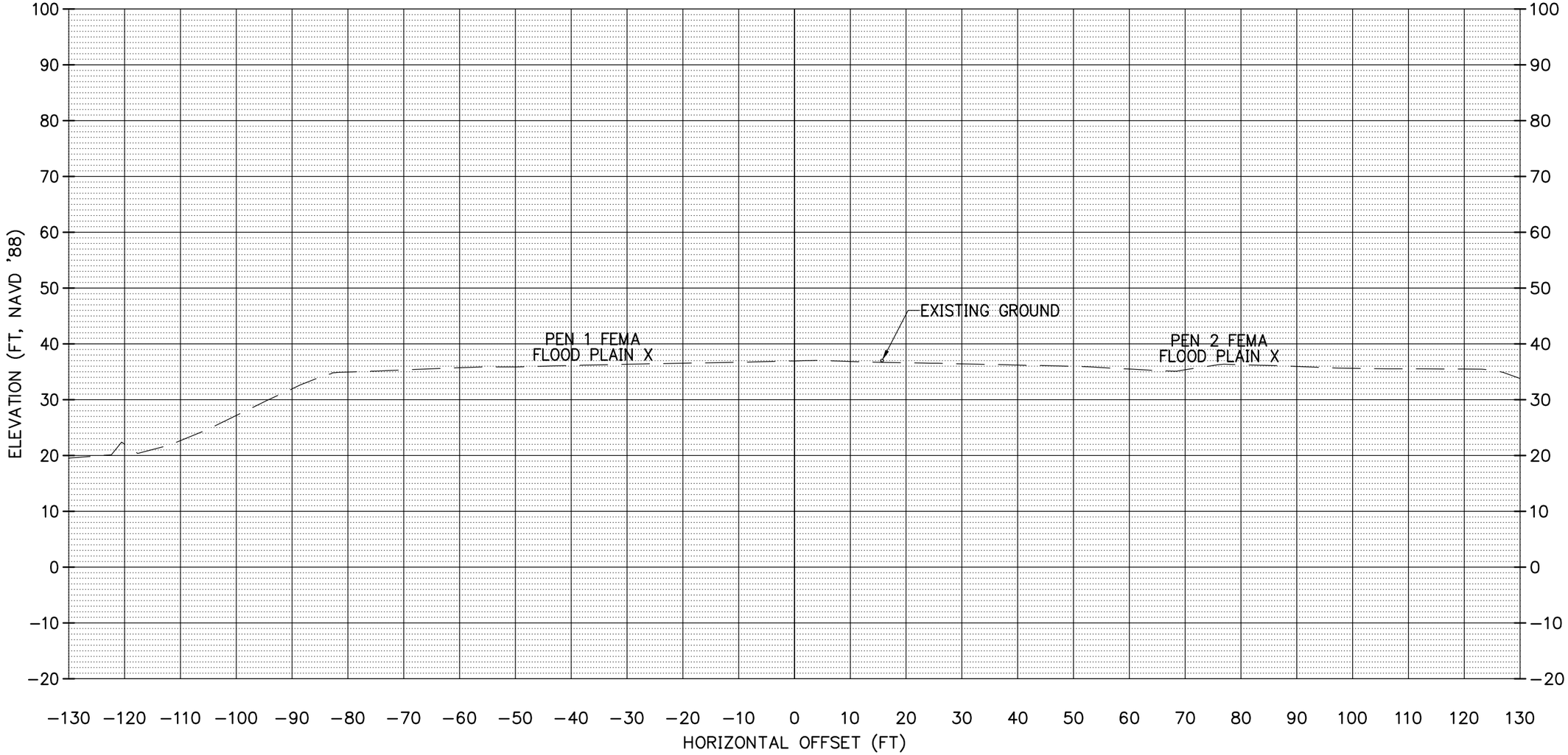
240+38.00



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SECTION 240+38

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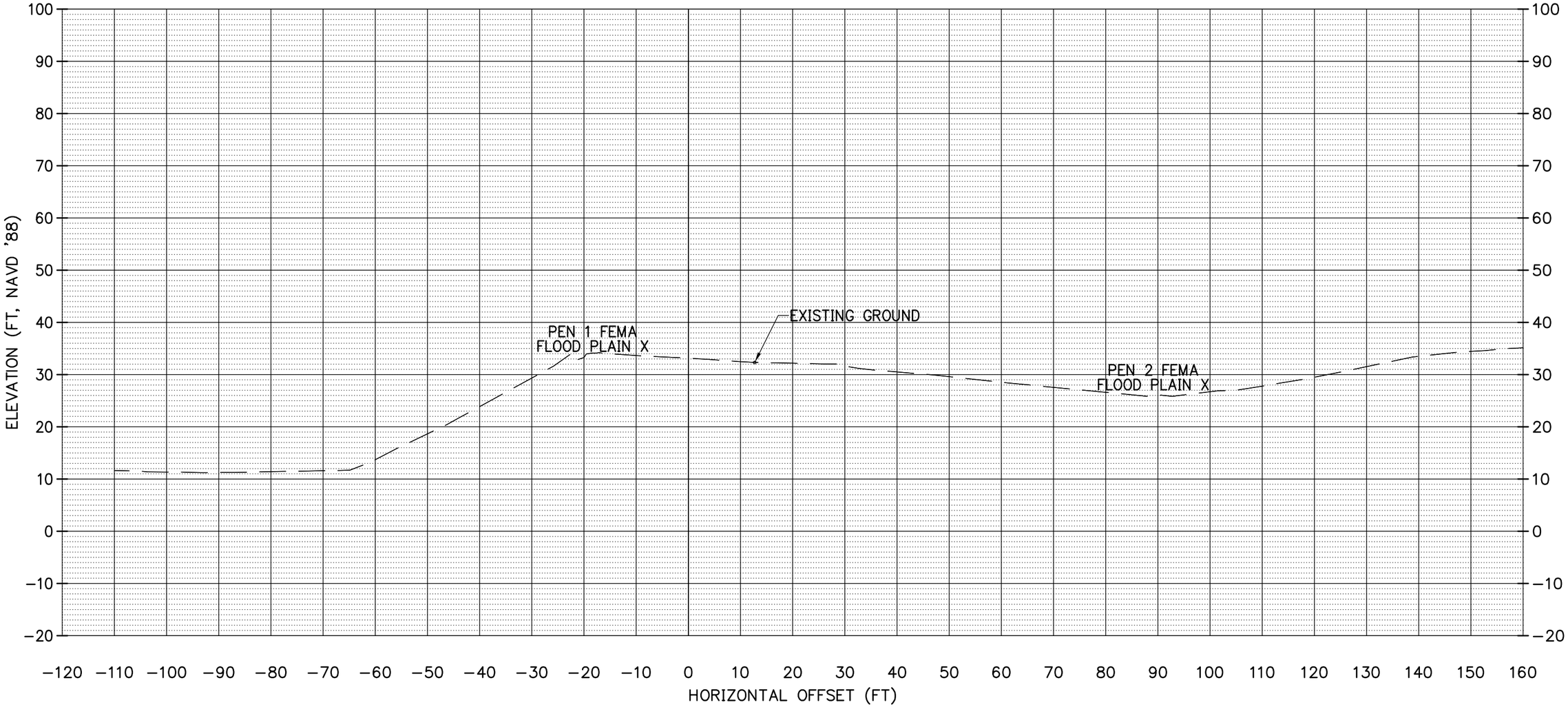
252+36.00



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