Interstate BRIDGE Replacement Program

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Geotechnical Data Report

Columbia River & North Portland Harbor Bridges

May 2024

Draft

Geotechnical Data Report

Columbia River & North Portland Harbor Bridges

Prepared for:

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ACRONYMS AND ABBREVIATIONS

ASTM	ASTM International
bgs	below ground surface
bpf	blows per foot
GDM	Geotechnical Design Manual
GDR	Geotechnical Data Report
IBR	Interstate Bridge Replacement
I.D.	Inside Diameter
LDP	Local Datum Plane
NAVD88	North American Vertical Datum of 1988
O.D.	Outside Diameter
ODOT	Oregon Department of Transportation
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
USGS	United States Geological Survey
WSDOT	Washington State Department of Transportation

1. INTRODUCTION

1.1 Purpose and Scope

This Geotechnical Data Report (GDR) was prepared by Shannon & Wilson, Inc. (Shannon & Wilson), as a subconsultant to WSP, for the Interstate Bridge Replacement (IBR) Team. This report describes the data gathering procedures and presents the test boring logs, field test data, and laboratory testing data assembled for the Columbia River and North Portland Harbor bridge portions of this project. The purpose of the exploration and testing program was to collect geotechnical data to support the IBR Team in conceptual foundation design, identification of potential seismic hazards, and alternatives analyses and cost estimates for the IBR project. No engineering analyses, conclusions, or design recommendations are contained in this report. The design alignments and concepts shown herein are subject to change. The GDR should be used by the Design-Build contractor for final design and construction of the project. Additional geotechnical explorations may be required to meet the requirements of the applicable Geotechnical Design Manual (GDM) for final design of the project features.

1.2 Project Overview

The IBR Project has been developed by the Washington State Department of Transportation (WSDOT) and the Oregon Department of Transportation (ODOT) and includes highway, bridge, and transit improvements between Vancouver, Washington and Portland, Oregon. The approximate locations of the Columbia River and North Portland Harbor Bridges segments are shown on the Vicinity Map, Figure 1-1. Conceptual Columbia River bridge alignments are shown on Figure 1-2 and conceptual North Portland Harbor bridge alignments are shown on Figure 1-3.

1.3 Existing Information

A significant amount of historical geologic and geotechnical engineering information from various sources exists along much of the project corridor. This information was used by Shannon & Wilson and the IBR team to prepare the field exploration program. The data and information from these other sources are available in project reference documents.

2. GEOLOGIC SETTING

2.1 Area Overview

The greater Portland-Vancouver metropolitan area lies within a large geologic basin created by complex folding and faulting of the basement rocks. The Columbia and Willamette Rivers converge within the Portland Basin near the IBR project site. Those large rivers, along with their tributaries, deposited a thick sedimentary basin fill through the late Miocene, Pliocene, and Pleistocene Epochs (about 12.5 million to 11,700 years ago), including well-consolidated and variably cemented sandstone and conglomerate of the Troutdale Formation. Beeson and others (1991) indicate the Troutdale Formation consists of about 100 to 400 feet of well-consolidated friable to moderately well-cemented conglomerate and sandstone deposited around 12.5 million to 2.6 million years ago. The Troutdale Formation was partially eroded during the late Pleistocene ice ages by the ancestral Columbia and Willamette Rivers (Peterson and others, 2011). As a result, the surface of the Troutdale Formation displays variable river channel topography at depths greater than 200 feet below current sea level, near the major rivers in the Portland Basin. Younger late Pleistocene and Holocene sediments from the Columbia River drainage and fills made by humans form the shallow subsurface conditions in the project area.

A series of catastrophic glacial outburst floods, called herein the Missoula Floods, directly impacted and shaped the geologic conditions at the IBR site. During the late stages of the last great ice age, between about 18,000 and 15,000 years ago, a lobe of the continental ice sheet repeatedly blocked and dammed the Clark Fork River in western Montana, which then formed an immense glacial lake called Lake Missoula. The lake grew until its depth was sufficient to buoyantly lift and rupture the ice dam, which allowed the entire massive lake to empty catastrophically. Once the lake emptied, the ice sheet again gradually dammed the Clark Fork Valley and the lake refilled, leading to 40 or more repetitive outburst floods at intervals of decades (Allen and others, 2009). During each short-lived Missoula Flood episode, floodwaters washed across the Idaho panhandle and eastern Washington scablands, and through the Columbia River Gorge to the Pacific Ocean. In the Portland Basin these floods temporarily pooled to elevations of about 400 feet, forming massive-scale sedimentary deposits as fine-grained sediment settled out of the turbid floodwater. Boulders, cobbles, and gravel were deposited nearest the mouth of the gorge, locally downstream of other hard rock outcrops that were scoured by the energetic flood waters, and elsewhere by ice rafts. Great cobble-gravel bars reached westward across the basin, grading to thick blankets of micaceous sand (Allen and others, 2009).

Following the final glacial outburst floods, the sea level rose by about 300 feet in response to glacial retreat. This rapid sea level rise formed an estuarine environment that extended far upstream in the deep channels of the Columbia River. This low energy environment rapidly filled with Holocene sandy alluvium and broad floodplains developed along the primary Columbia River channel (Peterson and others, 2011). Many areas have been altered by grading, cuts, and fills made by humans.

2.2 Generalized Geologic Deposits

The following paragraphs provide a general description of the geologic units recognized in published geologic literature, to provide the reader with an overview of the project area. Geologic or engineering soil units are not presented on the boring logs. The designer is responsible for differentiating and evaluating the relative geotechnical properties of engineering soil units based on the data provided herein and collected by their team.

Holocene Fill is present in the project area and has been important to its development. Fill was placed by humans at various times using various placement methods. Examples include shoreline expansion and shoreline protection fills, debris, and embankment fill for I-5.

Latest Pleistocene to Holocene deposits of the Columbia River consist primarily of thick layers of sand, with minor fine-grained alluvium and gravel interbeds deposited in a fluvial environment.

Pleistocene alluvium near the project site predominantly consists of silt, sand, and gravel deposits, which include Missoula Flood deposits and material reworked by the Missoula Floods. The Pleistocene alluvium overlies the Troutdale Formation and generally consists of silt, sand, and coarse-grained material consisting of mostly basaltic gravel with cobbles, boulders, and sand lenses.

Late Miocene and Pliocene Troutdale Formation of variable composition is present across much of the Portland Basin. Near the project site, Troutdale Formation is recognized as a variably cemented conglomerate. Cobbles and boulders are present in the Troutdale Formation.

3. FIELD EXPLORATIONS

3.1 General

Field explorations were conducted by Shannon & Wilson. The following sections describe details of the exploration programs. Environmental implementations and archaeological measures were employed during the field explorations. Before each borehole was started, a steel circulation casing was pushed and/or driven to seal off any circulating drill fluids from the river. All drill cuttings and drilling fluids were contained within the borehole, the circulation casing, and the re-circulation (or “mud”) tub on the barge deck. All soil cuttings and all drilling mud were collected in 55-gallon drums, which were removed from the site and disposed of by the drilling subcontractor at an appropriate facility. Turbidity monitoring was performed by Shannon & Wilson during drilling and periodic ODOT inspection of the barge was performed to confirm compliance with permitting. The IBR Team was responsible for managing the archaeological components of the exploration program. Please refer to their report for additional details.

3.2 Columbia River Bridges

Shannon & Wilson drilled six borings, designated IBR-03 through IBR-08, in the main channel of the Columbia River between November 2023 and February 2024. The locations of the borings are shown on the Site and Exploration Plan, Figure 1-2. During drilling, a Shannon & Wilson staff member was on site to locate borings, log the materials encountered, and collect soil samples. Both disturbed and undisturbed samples were collected at selected depths and continuous soil core sampling was used in some borings. The details of drilling and sampling procedures, a key to sample description terms, our logs of the materials encountered in the borings, and photographs of recovered soil core samples are presented in Appendix A, Columbia River Boring Logs and Core Photographs. Soil samples were described and identified in general accordance with the WSDOT GDM and Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), ASTM D2488. We refined our visual-manual soil descriptions and identifications based on the results of laboratory tests using elements of the Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System (USCS)), ASTM D2487. The specific terminology used in our soil descriptions is presented in Appendix A. Borehole suspension velocity logging to measure compressional and shear wave velocities of the materials encountered was performed in borings IBR-03, IBR-05, and IBR-07. Once drilling and testing were completed, all borings were backfilled with a high-solids bentonite cement grout, in accordance with Washington Department of Ecology and Oregon Water Resources Department regulations.

3.3 North Portland Harbor Bridges

Shannon & Wilson drilled two borings, designated IBR-01 and IBR-02, in the North Portland Harbor channel of the Columbia River in November 2023 and January 2024. The locations of the borings are shown on the Site and Exploration Plan, Figure 1-3. During drilling, a Shannon & Wilson staff member was on site to locate borings, log the materials encountered, and collect soil samples. Both disturbed and undisturbed samples were collected at selected depths and continuous soil core sampling was used in one boring. The details of drilling and sampling procedures, a key to sample description terms, our logs of the materials encountered in the borings, and photographs of recovered soil core samples are presented in Appendix B, North Portland Harbor Boring Logs and Core Photographs. Soil samples were described and identified in general accordance with the ODOT GDM and ASTM D2488. We refined our visual-manual soil descriptions and identifications based on the results of laboratory tests using elements of ASTM D2487. The specific terminology used in our soil descriptions is presented in Appendix B. Borehole suspension velocity logging was performed in boring IBR-02. Once drilling and testing were completed, the borings were backfilled with a high-solids bentonite cement grout, in accordance with Oregon Water Resources Department regulations.

3.4 Sampling Limitations and Difficult Drilling

Sampling methods and drilling methods have the potential to affect the sampled material. Materials encountered in the subsurface may also create difficult drilling conditions. Below is a discussion of the factors influencing sampled material and drilling conditions. Discussions of sampling methodology, drilling techniques, and boring logs are presented in Appendix A and Appendix B.

Based on observations of the drill rig action and recovered samples, and on observations of large-diameter excavations previously performed near the project site, the recovered samples from the gravel layers may not be fully representative of the in situ material. The gravel layers contain particle sizes such as cobbles and boulders larger than the diameter of conventional geotechnical samplers. These coarse gravel, cobble, and boulder clasts may be intercepted and partially sampled by a geotechnical boring but cannot be recovered and observed intact. Short drive lengths and very low sample recoveries are common with 2- to 3-inch outside diameter (O.D.) split-spoon samplers in these types of gravel layers. Rotosonic (sonic) soil core samples are capable of sampling small cobbles and coring through intercepted portions of large cobbles and boulders. However, the recovered clast sizes and distributions are still limited by the core barrel diameter.

Clasts with flat angular faces that appeared to have been freshly fractured were observed in recovered sonic core samples. Clasts that appeared to have been cut by the core barrel were also noted. Therefore, the grain size distribution curves included in the laboratory test results may include particles that were mechanically fractured or cut during drilling, suggesting smaller particle sizes than are present in the in situ material. Rotosonic drilling may also create fines as the gravel, cobbles or boulders are pulverized by the vibration and force of the drill bit. The fines are integrated into the samples and may increase the fines content of rotosonic samples which undergo grain size analysis.

Some sonic core samples appear to be segregated by grain size in the sample boxes. This segregation is often displayed by a sandy layer at the top of a run of predominantly coarse-grained gravel or by a thin up to a ¼- to ½-inch layer of fines around the circumference of a sonic core sample. Based on repeated observations and the consistency of the drill action, we suspect that the vibrations induced during rotosonic drilling may mechanically sort the sample by grain size vertically and also segregate fines to the outside of the sample. This creates sandy layers at the tops of the sonic core runs in coarser materials or a layer of fines around the circumference of the sample in both coarse-grained and sandy material. Soil samples collected for laboratory testing from the core boxes did not combine the sand layers with the adjoining gravel layers and generally included the outer layer of fines in the sand or gravel layers. There are commonly some finer-grained, sandy layers interbedded within naturally occurring gravel deposits and the observed bedding may or may not be representative of the in situ material.

During rotosonic sampling, retracting the inner core barrel may create suction at the bottom of the casing when it is withdrawn from the bottom of the borehole and retrieved through the casing for sampling. When drilling in sand, this combination of relatively low density drilling fluid and suction at the bottom of the borehole has the potential to result in heave. Heave is a condition where sand runs up into the casing due to differential water head conditions. Sand heave was encountered during rotosonic drilling in borings IBR-01 and IBR-04.

Difficult drilling conditions, including extreme mud loss, mud thinning, and hole collapse, were encountered during mud rotary drilling in borings IBR-02, IBR-03, and IBR-05.

In addition, sample recovery was sometimes difficult in both the rotosonic and mud rotary borings. In the rotosonic borings, some samples inadvertently fell out of the core barrel during retrieval and the core barrel was tripped back into the borehole to attempt to retrieve the sample. Some rotosonic core samples were not retrieved. In the mud rotary borings, some SPT samples had little or no recovery.

Difficult drilling conditions and sampling difficulties are noted on the logs in Appendix A and Appendix B. A summary of the notes from the logs is presented in Table 3-1, below.

In addition to the drilling difficulties described above, boring IBR-02 was terminated because approximately 130 feet of drill rod sheared off while drilling at 225.8 feet and the driller could not retrieve the drill bit and an approximate 1-foot section of rod from the bottom of the borehole.

Table 3-1. Difficult Drilling Conditions and Sampling Difficulties Summary

Boring Designation	Depth (ft)	Comments
IBR-01	12.5	Sand heave observed in sonic casing before Sample S2.
IBR-01	23.4	Driller switched to 4-inch ID auger sonic core barrel bit.
IBR-01	33.6	Driller switched to 4-inch ID flapper sonic core barrel bit.
IBR-01	43.6	Approximately 0.8 feet of sand heave measured in sonic casing before Sample S5.

Boring Designation	Depth (ft)	Comments
IBR-01	53.8-64	Driller switched to 4-inch ID auger sonic core barrel bit. No recovery of Sample S6. Driller switched to 4-inch ID flapper sonic core barrel bit and attempted to retrieve sample. Still no recovery.
IBR-01	64-74.2	No sample recovery in Sample S7.
IBR-01	92.4	Driller switched to 4-inch ID standard sonic core barrel bit.
IBR-01	125-127	Drill action indicates boulder from approximately 125 to 127 feet.
IBR-01	168.7-178.7	Driller attempted 20-foot sonic core run and could only penetrate 15 feet.
IBR-02	40-140	Driller noted borehole instability and sloughing between 40 and 140 feet.
IBR-02	60-105	Borehole sloughing from 60 to 105 feet.
IBR-02	109.3-162	Drill action indicates cobbles and possible boulders from 109.3 to 162 feet.
IBR-02	110.9	No sample recovery in Sample N23.
IBR-02	113-140	Lost drilling mud circulation at 113 feet. Occasional drilling mud circulation loss from 113 to 140 feet.
IBR-02	121.5	Borehole sloughing at 121.5 feet.
IBR-02	130-140	Lost drilling mud circulation and approximately 350 gallons of drilling mud loss from 130 to 140 feet. Driller used another 250 gallons of thick mud to attempt to regain circulation. Borehole sloughed and driller pulled rods to drill back down to 140 feet.
IBR-02	140-150	Approximately 1200 gallons of drilling mud loss from 140 to 150 feet.
IBR-02	150-160	Approximately 300 gallons of drilling mud loss from 150 to 160 feet.
IBR-02	160-170	Approximately 300 gallons of drilling mud loss from 160 to 170 feet.

Boring Designation	Depth (ft)	Comments
IBR-02	165-170	Drill action indicated intermittent cobbles from 165 to 170 feet.
IBR-02	170-180	Approximately 300 gallons of drilling mud loss from 170 to 180 feet.
IBR-02	180-190	Approximately 100 gallons of drilling mud loss from 180 to 190 feet.
IBR-02	187-215	Drill action indicates intermittent cobbles from 187 to 215 feet.
IBR-02	190-210	Approximately 50 gallons of drilling mud loss from 190 to 210 feet.
IBR-02	210-220	Approximately 300 gallons of drilling mud loss from 210 to 220 feet.
IBR-02	215-225.8	Drill action indicates cobbles and possible boulders from 215 to 225.8 feet.
IBR-02	225.8	Approximately 130 feet of drill rod sheared off in the borehole when drilling at 225.8 feet. Driller retrieved all but 1-foot section of rod and the bit from the bottom of the borehole. Boring terminated.
IBR-03	0-28	Slow continuous loss of drilling mud from 0 to 28 feet. Driller added grout.
IBR-03	5.7	Poor recovery in Sample N-1.
IBR-03	21-26	Approximately 50 gallons of drilling mud loss from 21 to 26 feet.
IBR-03	26-31	Approximately 50 gallons of drilling mud loss from 26 to 31 feet.
IBR-03	38.7	Bottom of Shelby tube damaged during sampling at 38.7 feet.
IBR-03	60-80	Driller noted borehole instability from 60 to 80 feet.
IBR-03	110-160	Driller noted borehole instability from 110 to 160 feet.
IBR-03	125	Borehole instability at 125 feet.
IBR-03	190-210	Lost drilling fluid circulation from 190 to 210 feet.

Boring Designation	Depth (ft)	Comments
IBR-03	217.5	Drill chatter at 217.5 feet.
IBR-03	225	Approximately 100 gallons of drilling mud loss at 225 feet.
IBR-03	232-240	Cobbles inferred from drill action from 232 to 240 feet.
IBR-03	270-271	Boulder inferred from drill action from 270 to 271 feet.
IBR-03	271-280	Cobbles inferred from drill action from 271 to 280 feet.
IBR-03	294-300	Cobbles inferred from drill action from 294 to 300 feet.
IBR-04	10	Sand heave observed in sonic casing before Sample SC-2.
IBR-04	29.5-38.6	Approximately 4.5 feet of sand heave measured in sonic casing before Sample SC-4. Sample SC-4 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.
IBR-04	47.8-57.8	Approximately 8 feet of sand heave measured in sonic casing before Sample SC-6. Sample SC-6 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.
IBR-04	70.7-79.8	Sample SC-8 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.
IBR-04	79.8	Driller switched to 4-inch ID flapper sonic core barrel bit.
IBR-04	89.3	Sand heave observed in sonic casing before Sample SC-10.
IBR-04	120.6	A portion of Sample SC-11 was recovered with Sample SC-12.
IBR-04	130.8	Sand heave observed in sonic casing before Sample SC-13.
IBR-04	140.3	Approximately 9 feet of sand heave measured in sonic casing after Sample SC-13. Driller added bentonite grout to borehole to reduce sand heave.
IBR-04	150.6	Driller switched to 4-inch ID basket sonic core barrel bit.

Boring Designation	Depth (ft)	Comments
IBR-04	160.8	Driller switched to 4-inch ID auger sonic core barrel bit.
IBR-04	170.7-179.6	Driller switched to 4-inch ID flapper sonic core barrel bit. Sample SC-17 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.
IBR-04	189-199.6	Driller switched to 4-inch ID standard sonic core barrel bit. No sample recovery in Sample SC-19.
IBR-05	60-110	Driller noted borehole instability from 60 to 110 feet.
IBR-05	175	Lost all drill mud at 175 feet.
IBR-05	192	Drill chatter at approximately 192 feet.
IBR-05	192-224	Cobbles inferred from intermittent drill chatter from 192 to 224 feet.
IBR-05	224-237	Cobbles inferred from drill action from 224 to 237 feet.
IBR-06	12.4-23.1	Poor recovery in Sample SC-2.
IBR-06	33.4	Driller switched to 4-inch flapper sonic barrel bit.
IBR-06	123.9-143.4	Driller switched to 4-inch ID auger sonic core barrel bit. Sample SC-9 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.
IBR-06	191.1-192.6	Boulder inferred from drilling action from 191.1 to 192.6 feet.
IBR-07	67.8	Performed Dames & Moore sample after N-15 to obtain additional material.
IBR-07	73.0	Performed Dames & Moore sample after N-16 to obtain additional material with no recovery.
IBR-07	78.2	Performed Dames & Moore sample after N-17 to obtain additional material with no recovery.

Boring Designation	Depth (ft)	Comments
IBR-07	83.5	Performed Dames & Moore sample after N-18 to obtain additional material with no recovery.
IBR-07	88-110	Cobbles inferred from drill action from 88 to 110 feet.
IBR-07	91-93	Boulder inferred from drill action from approximately 91 to 93 feet.
IBR-07	94.2	Performed Dames & Moore sample after N-20 to obtain additional material with no recovery.
IBR-07	98.4	No recovery of Sample N-21. Performed Dames & Moore sample after N-21 to obtain additional material with no recovery.
IBR-07	108.1	No recovery of Sample N-22. Performed Dames & Moore sample after N-22 to obtain additional material with no recovery.
IBR-07	117.1	Performed Dames & Moore sample after N-23 to obtain additional material with no recovery.
IBR-07	120-133.8	Cobbles inferred from drill action from 120 to 133.8 feet.
IBR-07	127	Driller notes very hard drilling at 127 feet.
IBR-08	47.1-67	Suspected grain-size segregation from sonic vibration in samples SC-6 and SC-7.
IBR-08	64.4-65.4	Boulder inferred from drilling action from 64.4 to 65.4 feet.
IBR-08	87.5-88.1	Cobble inferred from drilling action from 87.5 to 88.1 feet.
IBR-08	94-95.5	Boulder inferred from drilling action from 94 to 95.5 feet.
IBR-08	96	Driller noted very hard drilling at 96 feet.

Note: See logs in Appendix A and Appendix B for additional information and notes.

4. LABORATORY TESTING

The samples we obtained during our field explorations were transported to our laboratory for further examination. We then selected representative samples for a suite of laboratory tests. The overall soil-testing program included visual-manual identifications and descriptions, moisture content analyses, Atterberg Limits tests, particle-size analyses, and analytical testing for corrosivity potential. All tests were performed in accordance with applicable ASTM International test standards. The results of the laboratory tests and a brief description of the test procedures are presented in Appendices D and E for the Columbia River and North Portland Harbor Bridges, respectively.

5. LIMITATIONS

This Geotechnical Data Report provides a compilation of field and laboratory data collected for use by the design and construction teams for the Interstate Bridge Replacement Program. No engineering analyses, conclusions, or design recommendations are contained in this report. This report was prepared for the exclusive use of the IBR Team, WSDOT, and ODOT for the Interstate Bridge Replacement Program. It should be made available to prospective contractors for use as factual data only. It does not represent a warranty of subsurface conditions.

The data contained herein are based upon site conditions as they existed during the time of our subsurface exploration program. Additionally, the explorations provide information only about the subsurface conditions at the drilled locations at the time of drilling using the means and methods described in this report. It cannot be assumed that the subsurface conditions throughout the project area are similar to those disclosed by the explorations. Within the limitations of the scope, schedule, and budget, the data presented in this report were collected and presented in accordance with generally accepted professional geotechnical practice in this area at the time this report was prepared. No other warranty, expressed or implied, is made. Additional geotechnical explorations may be required to meet the requirements of the applicable Geotechnical Design Manual (GDM) for final design of the project features.

If there is substantial lapse of time between the submission of this report and completion of the final design and the start of work at the site, or if conditions have changed because of natural or manmade forces, we recommend that this report be reviewed with respect to the changed conditions or the time lapse.

The scope of our geotechnical services did not include environmental site assessments or evaluations regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below the site, or for evaluation or disposal of contaminated soils or groundwater associated with construction, should any be encountered, except as noted in this report.

Appendix F includes a document, “Important Information About Your Geotechnical/Environmental Report,” to assist you and others in understanding the use and limitations of geotechnical documents.

6. REFERENCES

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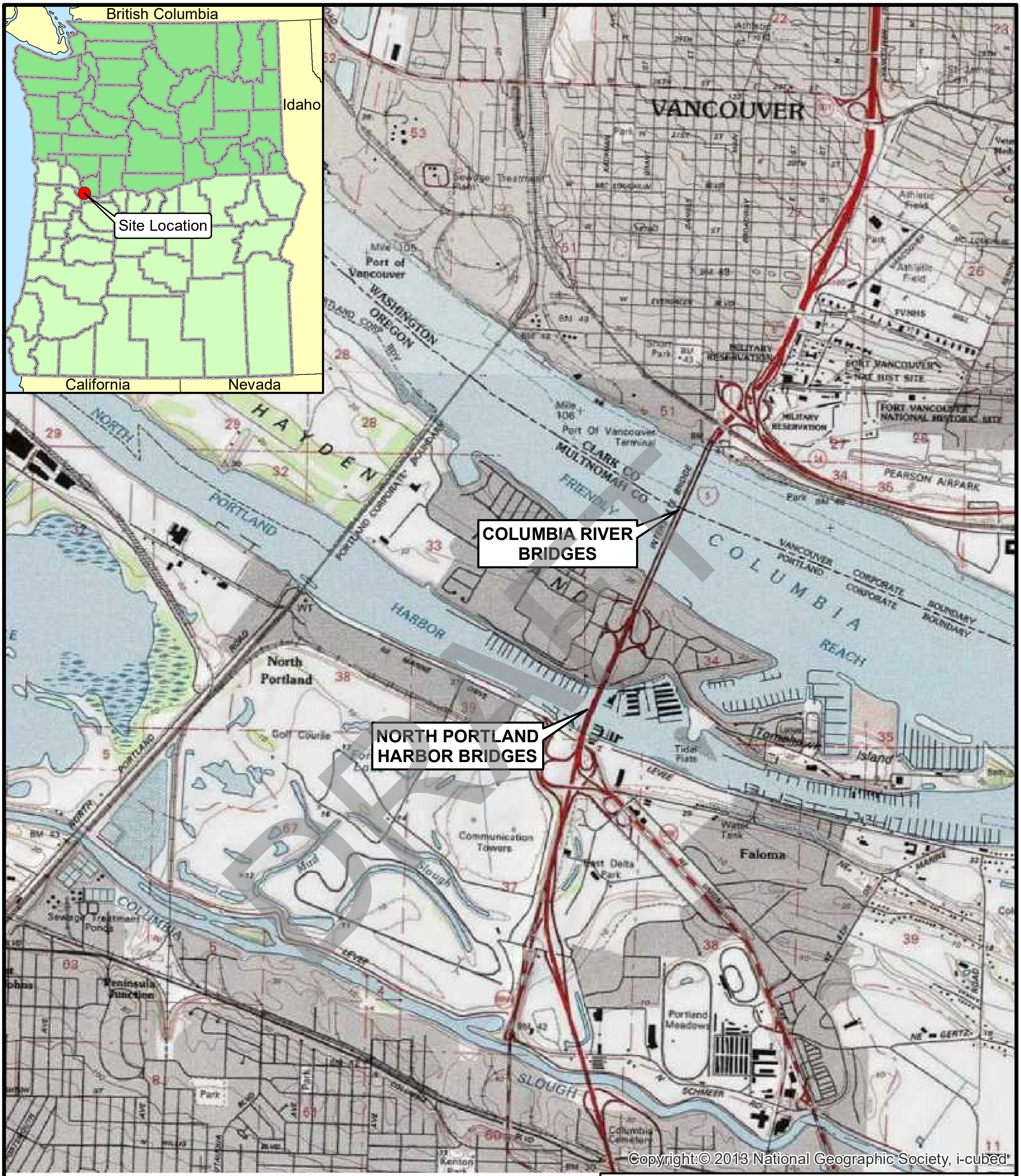

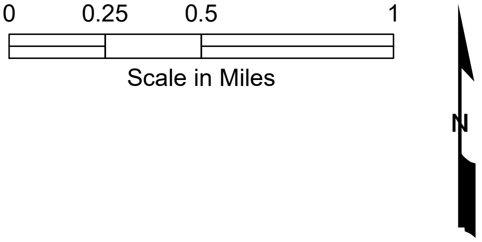

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

VICINITY MAP

May 2024
105511

SHANNON & WILSON

FIG. 1-1

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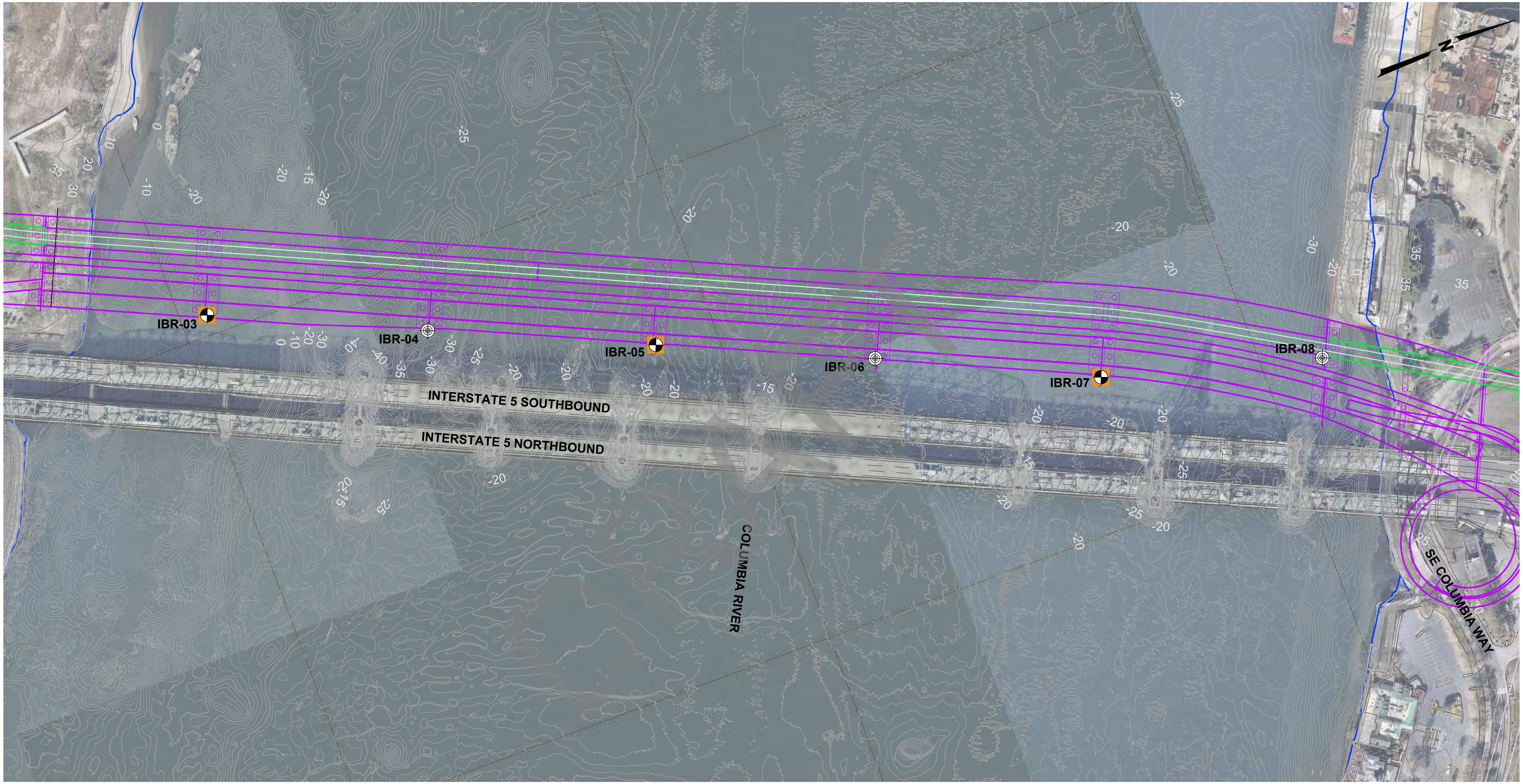

LEGEND

◑ Location of Mud Rotary Boring

⊕ Location of Rotosonic Boring

□ Borehole Suspension Velocity Profile

0 200 400

Scale in Feet

NOTES

1. Aerial imagery downloaded from ProjectWise on April 13, 2023.
2. Existing topography and bathymetry from files downloaded from ProjectWise on May 10, 2023.
3. Existing features from files downloaded from ProjectWise on February 5, 2024.
4. Conceptual Alternative 102 features from files downloaded from ProjectWise on February 5, 2024.

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

SITE AND EXPLORATION PLAN
COLUMBIA RIVER BRIDGES

May 2024 105511

SHANNON & WILSON

FIG. 1-2

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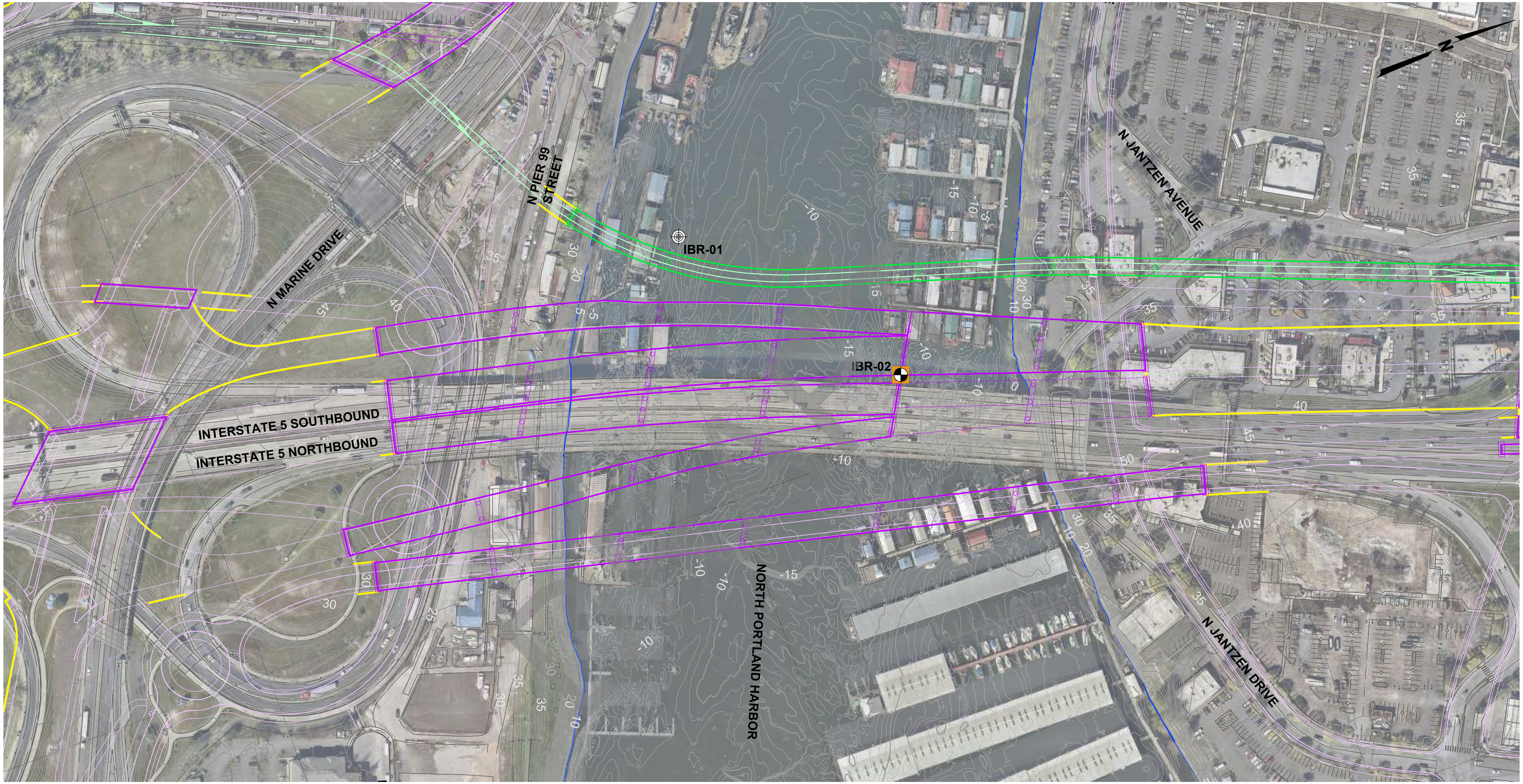

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Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

SITE AND EXPLORATION PLAN NORTH PORTLAND HARBOR BRIDGES

May 2024 105511

SHANNON & WILSON

FIG. 1-3

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APPENDIX A.
COLUMBIA RIVER BORING LOGS AND CORE PHOTOGRAPHS
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1. GENERAL

Shannon & Wilson drilled six geotechnical borings in the main channel of the Columbia River for the IBR Project. Boring logs and core photographs from the two borings drilled in North Portland Harbor are presented separately in Appendix B. All borings were drilled from a barge over water. Table A-1 summarizes exploration designation, borehole coordinates, depth, and other details. The borings were completed between November 7, 2023, and February 23, 2024. All borings were surveyed during drilling by the design team relative to the IBR Project's Local Datum Plane (LDP) system. Elevations for the project are North American Vertical Datum of 1988 (NAVD88). Exploration locations are shown on the Site and Exploration Plan, Figure 1-2.

This appendix describes the techniques used to advance and sample the borings, presents logs of the materials encountered during drilling, and details the borehole backfill. Downhole suspension velocity testing was also conducted in each of the three mud rotary borings. These tests are described with their results in Appendix C, Borehole Suspension Logging Results.

Table A-1. Columbia River Drilling Summary

Exploration Designation	Northing (ft)[A]	Easting (ft)[A]	Mudline Elevation (ft)[B]	Total Depth (ft)	Drilling Method	Start Date	End Date
IBR-03	110582.3	1083179.1	-0.53	300.3	Mud Rotary	1/29/2024	2/9/2024
IBR-04	110986.4	1083359.0	-29.7	250.0	Rotosonic	11/7/2023	11/13/2023
IBR-05	111405.1	1083544.5	-21.9	261.0	Mud Rotary	2/13/2024	2/23/2024
IBR-06	111808.0	1083722.7	-18.5	237.2	Rotosonic	11/28/2023	11/29/2023
IBR-07	112219.6	1083915.4	-23.1	133.8	Mud Rotary	1/3/2024	1/8/2024
IBR-08	112649.2	1084033.3	-25.0	110.9	Rotosonic	11/14/2023	11/15/2023

Notes:
A IBR Project LDP, defined as Washington State Plane South/1.0000576 (US Survey Feet)
B NAVD88 (US Survey Feet)

2. DRILLING OVERVIEW

The geotechnical borings were drilled with two drill rigs provided and operated by Western States Soil Conservation, Inc. (Western States), of Hubbard, Oregon. The borings were drilled from a floating barge that was provided and operated by Mark Marine Service, Inc., of Washougal, Washington. Three borings were drilled using mud rotary techniques and three borings were drilled using rotosonic techniques. Drilling supervision, including sample collection and field logging of subsurface material, was performed by Shannon & Wilson.

3. GEOTECHNICAL DRILLING AND SAMPLING METHODOLOGY

3.1 Mud Rotary Drilling Technique

For mud rotary drilling performed over water, before the borehole is started, a steel circulation casing is pushed and/or driven to a depth of approximately 10 to 15 feet below the mud line (or more depending on conditions), sealing off any circulating drill fluids from the river. Often, the circulation casing is pushed to refusal using the drill rig hydraulic system or driven with a casing hammer. Once the casing is sealed below the mud line, the boring is advanced using a tri-cone bit and a string of hollow drill rods (narrower than the bit) through which bentonite drilling mud is pumped. The mud is mixed on site using water and powdered bentonite. The drilling mud serves to cool the bit, keep the hole open, and flush the cuttings to the surface. Returning drill mud is typically passed through the circulation casing from the borehole to a screen and tub that is situated over the circulation casing on the deck of the barge. The screen collects the drill cuttings from the borehole, and the tub collects the mud for recirculation back into the hole. If fine-grained, cohesive soils are encountered, other styles of drill bits may also be used with the mud-rotary method, such as scraper or drag bits.

3.1.1 Standard Penetration Test (SPT) Sampling

Disturbed samples were collected in the mud rotary borings at 2-, 5-, or 10-foot intervals using a standard 2-inch outside-diameter (O.D.) split spoon sampler in conjunction with Standard Penetration Testing. In a Standard Penetration Test (SPT), ASTM D1586, the sampler is driven 18 inches into the soil using a 140-pound hammer dropped 30 inches. The number of blows required to drive the sampler the last 12 inches is defined as the standard penetration resistance, or N-value. The SPT N-value provides a measure of in situ relative density of cohesionless soils (silt, sand, and gravel) and the consistency of cohesive soils (silt and clay). In some instances, a 3-inch-O.D. Dames & Moore sampler was used to collect disturbed samples. A 140-pound hammer was used to drive these larger-diameter samplers. All disturbed samples were visually identified and described in the field at the time of sampling, sealed in a labeled plastic jar or bag to retain moisture, and returned to the laboratory for additional examination and testing.

SPT N-values can be significantly affected by several factors, including the efficiency of the hammer used. Measured efficiencies of the automatic hammers used for this project, based on available information we received from our drilling subcontractor, are shown on the boring logs. The field recorded N-values are summarized on the boring logs. For any non-standard sized sampler, the field recorded N-value was corrected back to an SPT value per the AASHTO Manual on Subsurface Investigations (1988). Field recorded N-values, shown numerically on the logs, have not been corrected for hammer efficiency, overburden pressure, flexure of the rods, or silt content. N-values corrected only for sampler size and hammer energy are shown graphically on the boring logs as N_{60} values. An SPT was considered to have met refusal where more than 50 blows were required to drive the 2-inch-O.D. sampler 6 inches (100 blows for larger-O.D. samplers). In this case, the blows are reported as 50 over the distance driven in 50 blows, such as 50/4”. Sample recovery is identified as a percentage of material retained for the length the sampler was driven.

3.1.2 Geotechnical Relatively Undisturbed Sampling

Relatively undisturbed samples were collected in some mud rotary borings in 3-inch-OD thin-wall Shelby tubes, which were hydraulically pushed into the undisturbed soil at the bottoms of boreholes. The soils exposed at the ends of the tubes were examined and described in the field. After examination, the ends of the tubes were sealed to preserve the natural moisture of the samples. The sealed tubes were stored in the upright position, and care was taken to avoid shock and vibration during their transport and storage in the laboratory.

3.2 Rotosonic Drilling Technique

During rotosonic drilling, also referred to as sonic rotary drilling, an inner core barrel is rotated while an oscillator in the drill head imposes a high frequency vibration into the drill rods and core barrel. This forces the core barrel and drill bit to be physically vibrating up and down in addition to being forced down and rotating. These three forces, vibration, rotation, and downward force combine to advance the core barrel through soil or bedrock. As the core barrel is advanced the center fills with the soil or rock it is being advanced through. When the core barrel is advanced a certain distance determined by the length of the core barrel it is stopped. An over-casing is advanced over the outside of the core barrel to the same depth as the core barrel tip using the same sonic vibration, rotation, and downward force. The over casing protects the borehole integrity and prevents the borehole from collapsing as the core barrel is retrieved. Multiple over casings may be used to maintain borehole integrity and reduce the outside forces on the inner core barrel and inner casings. The inner core barrel is retracted to the surface where it is emptied into long cylindrical bags as a long soil core or rock core sample. This alternating process of core barrel and over casing advancement with core barrel retrieval is continued to the terminal depth of the borehole.

3.2.1 Rotosonic Continuous Sampling

To retrieve a core sample, the core barrel is withdrawn from the hole and the sample is extruded into tubular plastic bags using vibration. During this exploration program, the boreholes were advanced in five- to twenty-foot intervals while continuously core sampling. The bags of approximately 4- to 6-inch diameter core were placed into wooden boxes and logged and photographed by a Shannon & Wilson geology staff member. Due to disturbance to the soil column during drilling and bagging of the sample, sample recoveries and discreet grab sample depths should be considered approximate.

4. BOREHOLE ABANDONMENT

Once drilling and testing were completed, all borings were backfilled with a high-solids bentonite cement grout, in accordance with Washington Department of Ecology and Oregon Water Resources Department regulations.

5. MATERIAL DESCRIPTIONS

In the field, soil samples were described and identified in accordance with Chapter 4 of the WSDOT Geotechnical Design Manual (2022). The ASTM International (ASTM) D2488 Visual-Manual method was also used as a guide in determining the key diagnostic properties of soils. Consistency, color, relative moisture, degree of plasticity, peculiar odors, and other distinguishing characteristics of the samples were noted. Once returned to the laboratory, the samples were re-examined, various standard laboratory tests were conducted, and the field descriptions and identifications were modified where necessary. We refined our visual-manual soil descriptions and identifications based on the results of the laboratory tests, using elements of the Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), ASTM D2487. Please refer to the WSDOT Geotechnical Design Manual (2022) and ASTM D2487 for definitions of descriptive terminology used in the boring logs.

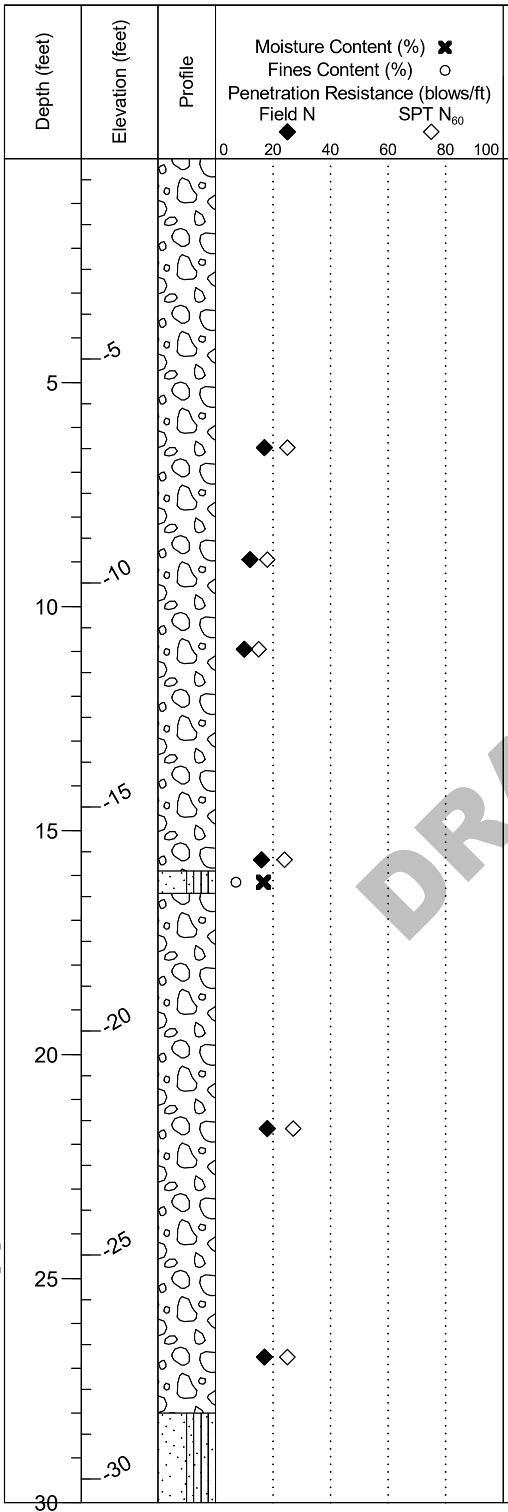
The WSDOT Geotechnical Design Manual does not provide quantification of cobble and/or boulder constituents, instead only indicates their presence. Cobbles are defined as “particles of rock that will pass a 12-inch square opening and be retained on a 3-inch sieve” and boulders are defined as “particles of rock that will not pass a 12-inch square opening.” The soil group name in ASTM D2487 and D2488 is based on the portion of the soil sample passing the 3-inch sieve. Refer to the photographs of samples obtained through rotosonic core drilling for estimating the quantities of cobble/boulder constituents recovered from those explorations. It should be noted that the samples presented in the photographs have been disturbed and the finer- and coarser-grained fractions can be segregated during drilling, sampling, and handling.

6. BORING LOGS AND CORE PHOTOGRAPHS

Summary logs of the borings are attached to this appendix. Logs of borings that included soil coring are followed by core photographs. Soil descriptions and interfaces on the logs are interpretive and actual changes may be gradual. The left-hand side of the drill logs provides depth and elevation with a graphic log. The center of the log shows individual sample intervals and identifications, feet recovery, Standard Penetration Test data, natural moisture contents, fines contents, and a list of laboratory tests. The right-hand portion provides material descriptions, miscellaneous comments, and a graphic depicting hole backfill details.

LOG OF BORING IBR-03

Project: Interstate Bridge Replacement Program
Job Number: Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30
Northing: 110,582.3 feet *Latitude:* 45.615499 deg.
Driller/Inspector: Adonis&Ray&Richard (Western States) / Connor McCord (S&W)
Easting: 1,083,179.1 feet *Longitude:* -122.677511 deg.
Start Card: N/A
Elevation: -0.5 feet *Collector:* Region Survey
Drilling Method: Mud Rotary *Hole Diam.:* 5.5 in
Horizontal/Vertical Datum: IBR Project / NAVD88
Equipment: CME-850XR Track Rig (ID:417612) *Rod Type:* NWJ
Started: January 29, 2024 *Completed:* February 9, 2024
Hammer Type: AutoHammer *Historic Efficiency:* 89.4%



Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
				-Slow continuous loss of drilling mud from 0 to 28 feet. Driller added grout. *-Suspension logging performed between depths of 47.6 and 282.2 feet.*		
11 11 6 (17) Rec=0.1'	⧗	N-1		**GP**: POORLY GRADED GRAVEL, subangular to rounded, medium dense, gray to brown, wet, homogeneous, fine to coarse gravel, poor sample recovery.		
10 6 6 (12) Rec=0.2'	⧗	N-2		**GP**: POORLY GRADED GRAVEL, subangular to rounded, medium dense, gray to brown, wet, homogeneous, fine to coarse gravel, poor sample recovery.		
8 5 5 (10) Rec=0.2'	⧗	N-3		**GP**: POORLY GRADED GRAVEL, subangular to rounded, loose, gray to brown, wet, homogeneous, fine to coarse gravel, poor sample recovery.		
13 8 8 (16) Rec=1.0'	⧗	N-4	GS	[N-4A] 14.9 to 15.9: **GP**: POORLY GRADED GRAVEL WITH COBBLES AND POSSIBLE BOULDERS, subrounded to rounded, medium dense, gray, wet, homogeneous, fine to coarse gravel. [N-4B] 15.9 to 16.4: **SP-SM**: POORLY GRADED SAND WITH SILT AND GRAVEL, subangular to rounded, medium dense, gray, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous.		
11 9 9 (18) Rec=0.6'	⧗	N-5		**GP**: POORLY GRADED GRAVEL, subrounded to rounded, medium dense, gray, wet, homogeneous, fine to coarse gravel. *-Approximately 50 gallons of drilling mud loss from 21 to 26 feet.*		
15 8 9 (17) Rec=0.7'	⧗	N-6		**GP**: POORLY GRADED GRAVEL WITH SAND, subangular to rounded, medium dense, dark gray, wet, homogeneous, fine to coarse gravel, fine to coarse sand.		
				-Driller noted smoother drilling at 28 feet. *-Approximately 50 gallons of drilling mud loss from 26 to 31 feet.*		

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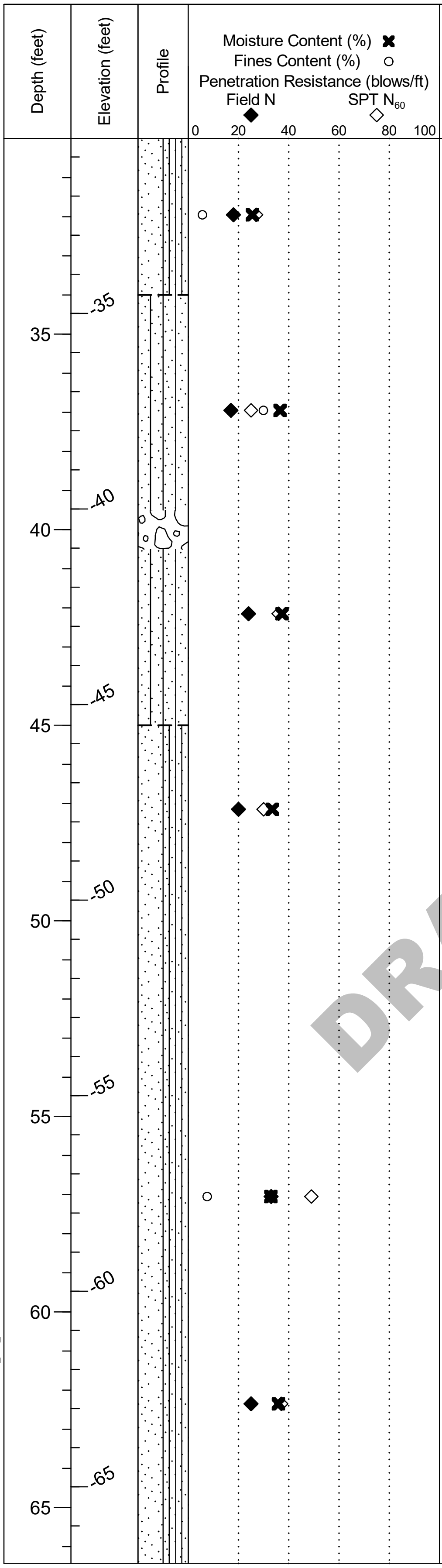
LOG OF BORING IBR-03

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
12 8 10 (18) Rec=0.8'	⧗	N-7	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to coarse sand, non-plastic, micaceous.		
13 12 5 (17) Rec=0.2'	⧗	N-8	GS	**SM**: SILTY SAND WITH GRAVEL, subangular to rounded, medium dense, gray to brown, wet, homogeneous, fine gravel, fine to coarse sand, low to medium plasticity, micaceous.		
Rec=0.8'	◪	U-1		**SM**: SILTY SAND, subangular to rounded, gray to brown, moist to wet, stratified, fine to coarse sand, non-plastic to low plasticity, stratified with SANDY SILT (ML), micaceous. *-Bottom of shelby tube damaged. Gravel inferred from drill action from 39.5 to 40.5 feet.*		
5 12 12 (24) Rec=1.3'	⧗	N-9		**SM**: SILTY SAND, subangular to rounded, medium dense, gray to brown, moist to wet, stratified, fine to medium sand, nonplastic to low plasticity, stratified with SANDY SILT (ML), micaceous.		
9 10 10 (20) Rec=1.2'	⧗	N-10		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.		
14 16 17 (33) Rec=1.0'	⧗	N-11	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to coarse sand, non-plastic, micaceous. *-Driller noted borehole instability from 60 to 80 feet.*		
16 12 13 (25) Rec=1.2'	⧗	N-12		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to coarse sand, non-plastic, micaceous.		

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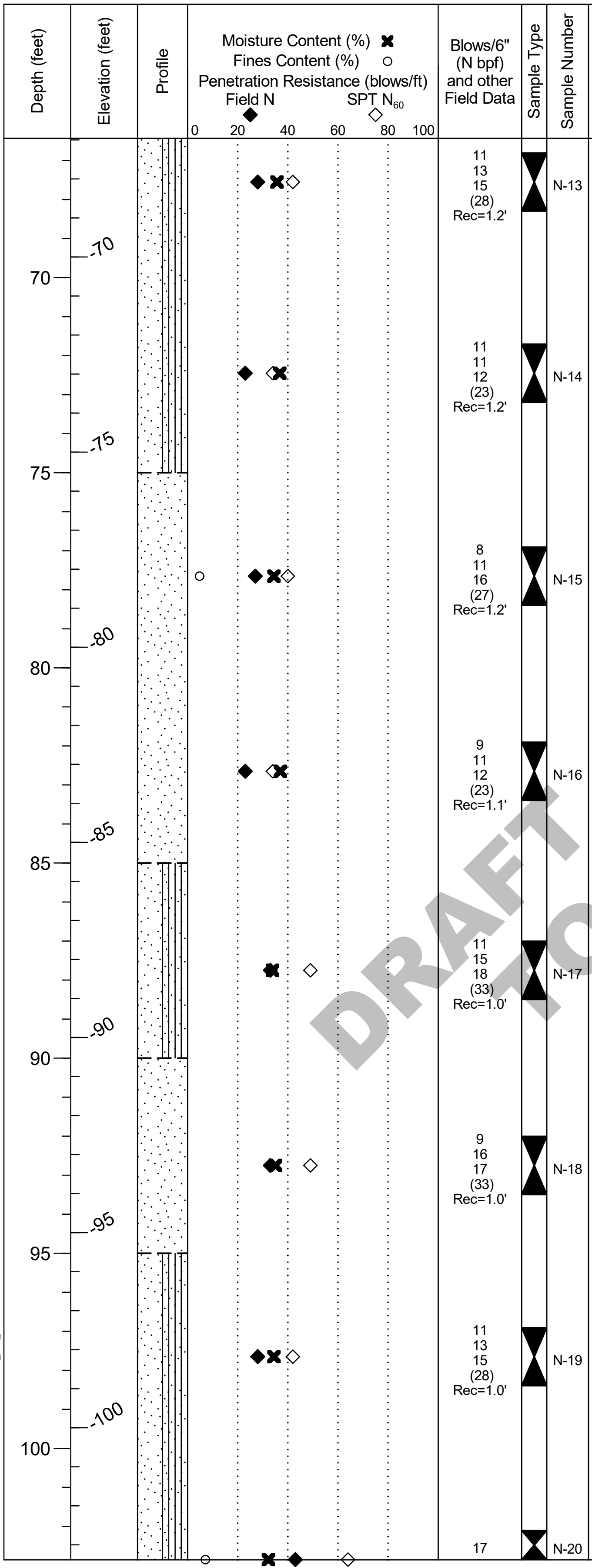
LOG OF BORING IBR-03

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
11 13 15 (28) Rec=1.2'	N-13		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to coarse sand, non-plastic, micaceous.
11 11 12 (23) Rec=1.2'	N-14		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
8 11 16 (27) Rec=1.2'	N-15	GS	**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.
9 11 12 (23) Rec=1.1'	N-16		**SP**: POORLY GRADED SAND, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, micaceous.
11 15 18 (33) Rec=1.0'	N-17		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
9 16 17 (33) Rec=1.0'	N-18		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.
11 13 15 (28) Rec=1.0'	N-19		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
17	N-20		

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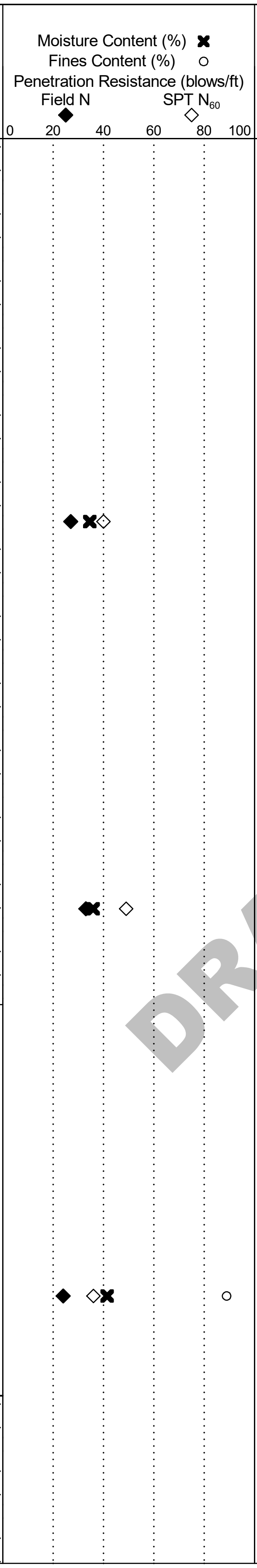
LOG OF BORING IBR-03

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
	-105	20 23 (43) Rec=1.2'	N-20	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine sand, non-plastic, micaceous.
105					
	-110				
110					*-Driller noted borehole instability from 110 to 160 feet.*
		15 13 14 (27) Rec=1.2'	N-21		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
	-115				
115					
	-120				
120					
		13 16 17 (33) Rec=1.2'	N-22		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
	-125				
125					*-Borehole instability at 125 feet: SILT (ML) observed in top of sampler that was pushed through to reopen hole to sample at 140 feet.*
	-130				
130					
		4 8 16 (24) Rec=1.5'	N-23	GS, AL	**ML**: SILT, very stiff, gray, moist, stratified, low plasticity, with trace fine sand, stratified with SANDY SILT (ML), micaceous.
	-135				
135					

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LOG OF BORING IBR-03

Project: Interstate Bridge Replacement Program

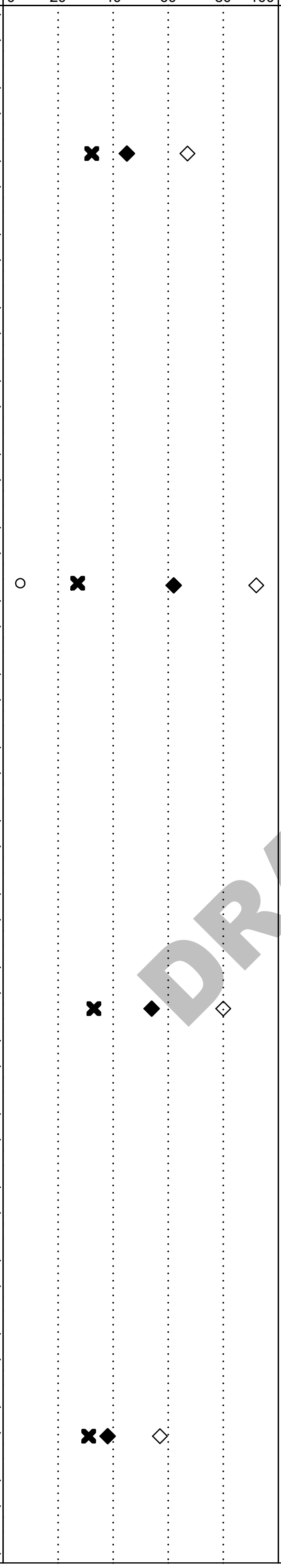
Job Number: Y-12435

Route & MP Range: SR 005 MP 0.00 - 0.30

Depth (feet): 140, 145, 150, 155, 160, 165, 170, 175

Elevation (feet): -140, -145, -150, -155, -160, -165, -170, -175

Moisture Content (%) ✖ Fines Content (%) ○ Penetration Resistance (blows/ft) Field N ◆ SPT N_{60} ◇



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
16 23 22 (45) Rec=1.1'	N-24		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
26 31 31 (62) Rec=1.0'	N-25	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, very dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
13 29 25 (54) Rec=0.8'	N-26		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, very dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
22 19 19 (38) Rec=0.9'	N-27		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.

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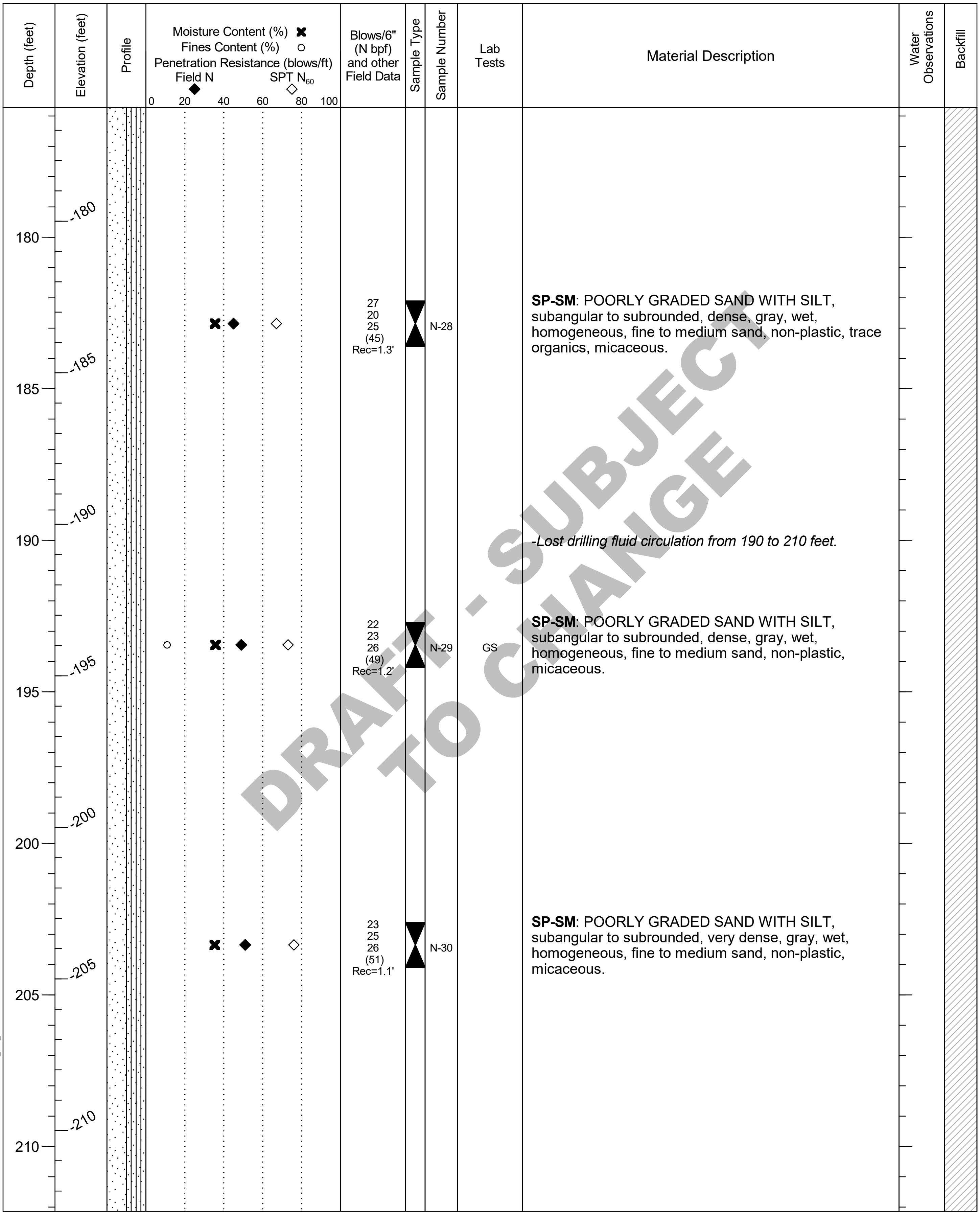
LOG OF BORING IBR-03

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
27 20 25 (45) Rec=1.3'	N-28		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, trace organics, micaceous.
			-Lost drilling fluid circulation from 190 to 210 feet.
22 23 26 (49) Rec=1.2'	N-29	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
23 25 26 (51) Rec=1.1'	N-30		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, very dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.

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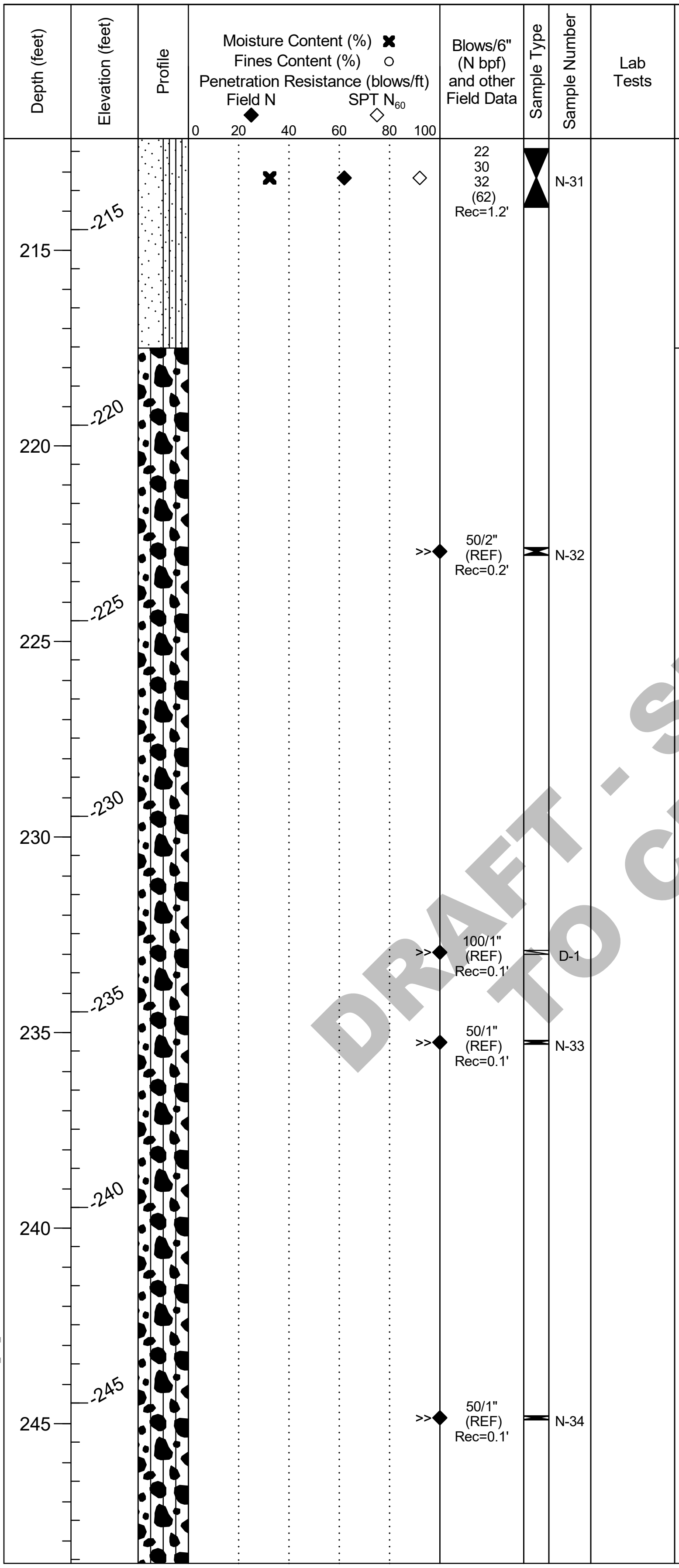
Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Material Description

SP-SM: POORLY GRADED SAND WITH SILT, subangular to subrounded, very dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.

-Drill chatter at 217.5 feet.

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, gray and yellowish brown, moist, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, micaceous.

-Approximately 100 gallons of drilling mud loss at 225 feet.

-Cobbles inferred from drill action from 232 to 240 feet.

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, dark gray to brown, moist, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, micaceous.

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, dark gray to brown, moist, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, micaceous.

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, gray and yellowish brown, moist, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, iron oxide staining, micaceous.

Water Observations

Backfill

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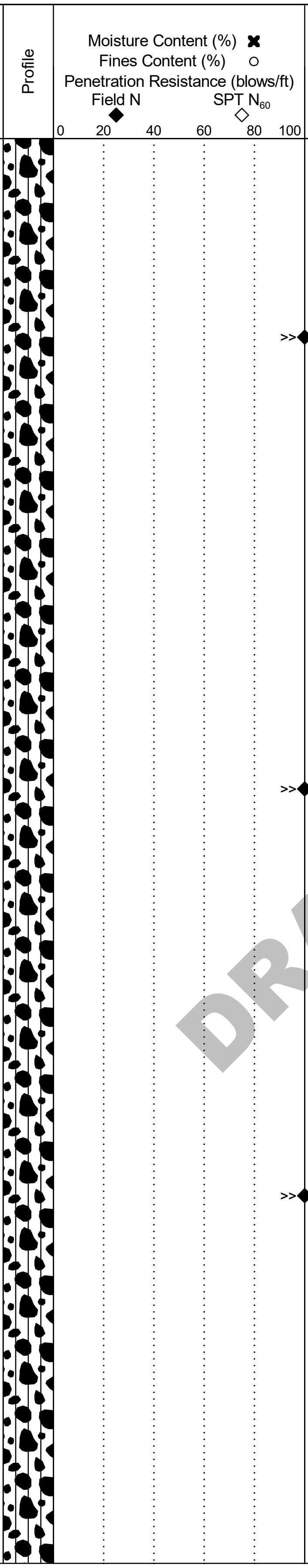
Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30

Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
	-250							
250								
		50/1" (REF) Rec=0.1'		N-35		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, limited sample recovery, description inferred from drill action.		
	-255							
255								
	-260							
260								
	-265							
265		50/0.5" (REF) Rec=0.1'		N-36		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, limited sample recovery, description inferred from drill action.		
	-270							
270						*-Boulder inferred from drill action from 270 to 271 feet.* *-Cobbles inferred from drill action from 271 to 280 feet.*		
	-275							
275		50/0.5" (REF) Rec=0.1'		N-37		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, limited sample recovery, description inferred from drill action.		
	-280							
280								
	-285					**GM**: SILTY GRAVEL WITH SAND WITH COBBLES		
285								



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LOG OF BORING IBR-03

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30

Depth (feet)	Elevation (feet)	Profile	Moisture Content (%) ✖ Fines Content (%) ○ Penetration Resistance (blows/ft) Field N ◆ SPT N_{60} ◇ 0 20 40 60 80 100	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
			>>◆	50/0.5" (REF) Rec=0.1'		N-38		AND POSSIBLE BOULDERS, angular to rounded, very dense, gray, reddish brown, and yellowish brown, moist, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, iron oxide staining, micaceous.		▨
	-290									
290										
	-295							*-Cobbles inferred from drill action from 294 to 300 feet.*		
295										
	-300									
300			>>◆	50/0" (REF) Rec=0.0'		N-39		NO RECOVERY		

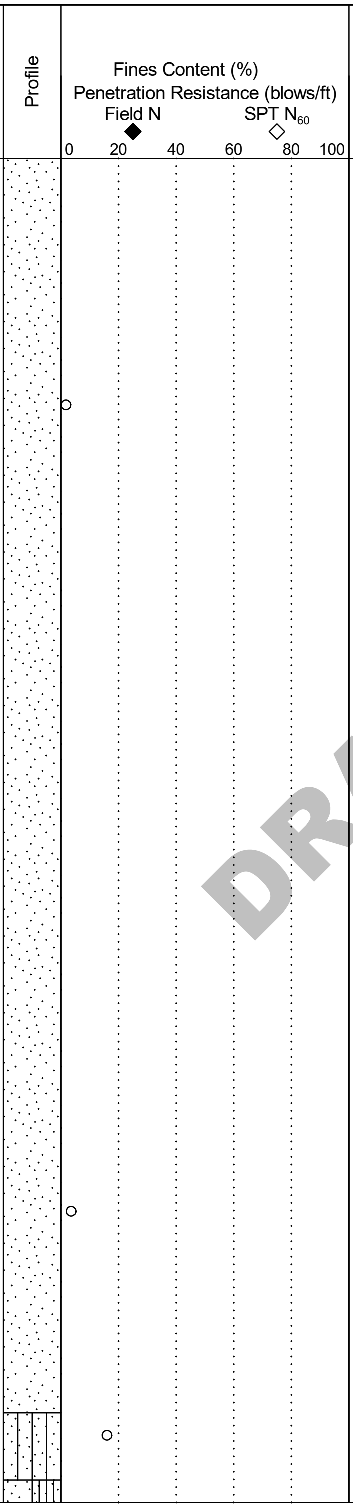
HOLE ENDED AT 300.3 FEET ON 2-9-2024

NOTES:

1. This is a summary log of the boring. Soil/rock descriptions are derived from visual field identifications and laboratory test data (where tested). See exploration log legend for explanation of graphics and abbreviations.
2. The implied accuracy of the location information displayed on this log is typically sub-meter (X,Y) when collected using GPS methods by the Geotechnical Office and sub-centimeter (X,Y,Z) when collected by the Region survey crew.
3. Where oversized samplers were used, a correction was made to the N-value per the AASHTO Manual on Subsurface Investigations, 1988. Blow counts per 6-inch increment have not been corrected.
4. The groundwater level(s), if shown, represents observations made during drilling. The groundwater level should be considered approximate and will vary based on seasonal and other effects.

LOG OF BORING IBR-04

Project:	Interstate Bridge Replacement Program	*Job Number:*	Y-12435
		Route & MP Range:	SR 005 MP 0.00 - 0.30
Northing:	110,986.4 feet	*Latitude:*	45.616624 deg.
Easting:	1,083,359.0 feet	*Longitude:*	-122.676835 deg.
Elevation:	-29.7 feet	*Collector:*	Region Survey
Horizontal/Vertical Datum:	IBR Project / NAVD88		
Started:	November 7, 2023	*Completed:*	November 13, 2023
Driller/Inspector:	Alex McCann (Western States) / Connor McCord (S&W)		
Start Card:	N/A		
Drilling Method:	Sonic Rotary	*Hole Diam.:*	8 & 6 in
Equipment:	Geoprobe 8150LS Sonic Track Rig	*Rod Type:*	N/A
Hammer Type:	N/A		



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
0	-30				*-Driller using 6-inch ID standard sonic core barrel bit.*
5	-35	Rec=5.0'	SC-1	GS	**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.
10	-40				*-Sand heave observed in sonic casing before Sample SC-2.*
15	-45	Rec=5.0'	SC-2		**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.
20	-50				
25	-55	Rec=9.5'	SC-3	GS	[SC-3A] 20 to 28: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, trace organics and wood fragments, with trace fine gravel, micaceous.
				GS	[SC-3B] 28 to 29.5: **SM**: SILTY SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
30		Rec=7.5'	SC-4		*-Approximately 4.5 feet of sand heave measured in*

CONTINUED NEXT PAGE *(see last page for notes)*

LOG OF BORING IBR-04

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30

Depth (feet)	Elevation (feet)	Profile	Fines Content (%) Penetration Resistance (blows/ft) Field N ◆ SPT N60 ◇ 0 20 40 60 80 100	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
	-60							*sonic casing before Sample SC-4.*		
				Rec=7.5'		SC-4		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous. *-Sample SC-4 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.*		
35	-65									
40	-70									
			○				GS			
				Rec=9.2'		SC-5		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, non-plastic, with trace fine gravel, micaceous.		
45	-75									
								-Approximately 8 feet of sand heave measured in sonic casing before Sample SC-6.		
50	-80							[SC-6A] 47.8 to 53: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous. *-Sample SC-6 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.*		
				Rec=10.0'		SC-6				
			○				GS			
55	-85							[SC-6B] 53 to 57.8: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.		
60	-90							[SC-7A] 57.8 to 64: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.		
				Rec=12.9'		SC-7				
								[SC-7B] 64 to 70.7: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.		
65	-95		○				GS			

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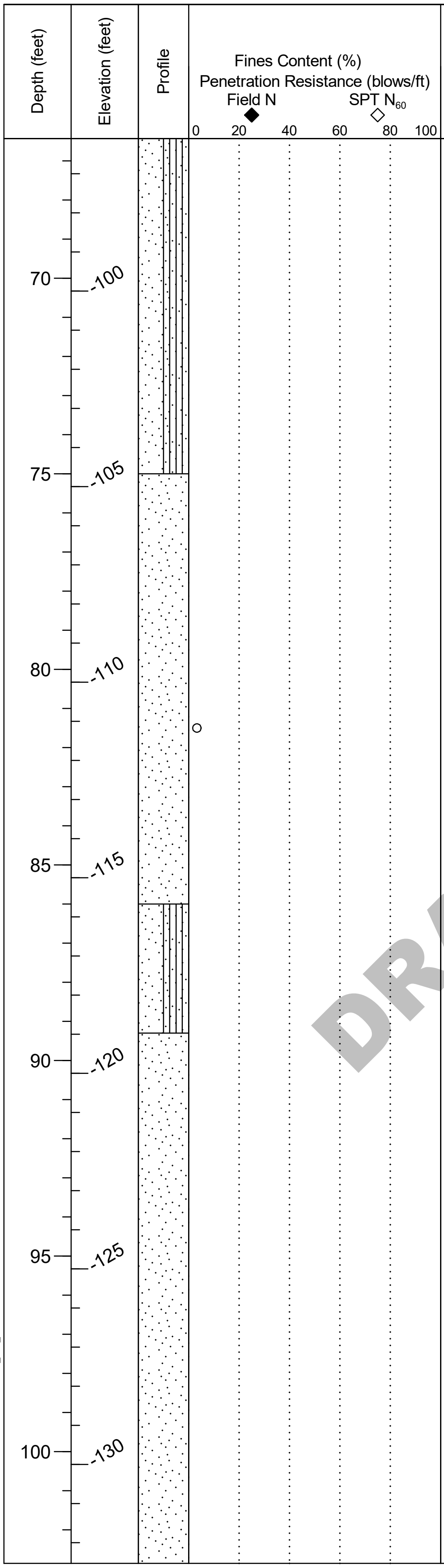
LOG OF BORING IBR-04

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
Rec=12.9'	SC-7		[SC-7B] 64 to 70.7: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
			[SC-8A] 70.7 to 75: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous. -*Sample SC-8 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.*
Rec=9.1'	SC-8		[SC-8B] 75 to 79.8: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous. -*Driller switched to 4-inch ID flapper sonic core barrel bit.*
Rec=9.5'	SC-9	GS	[SC-9A] 79.8 to 86: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.
			[SC-9B] 86 to 89.3: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, stratified, fine to coarse sand, non-plastic, trace organics, with trace fine gravel, stratified with SANDY SILT (ML), micaceous.
Rec=10.0'	SC-10		-*Sand heave observed in sonic casing before Sample SC-10.* **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel.

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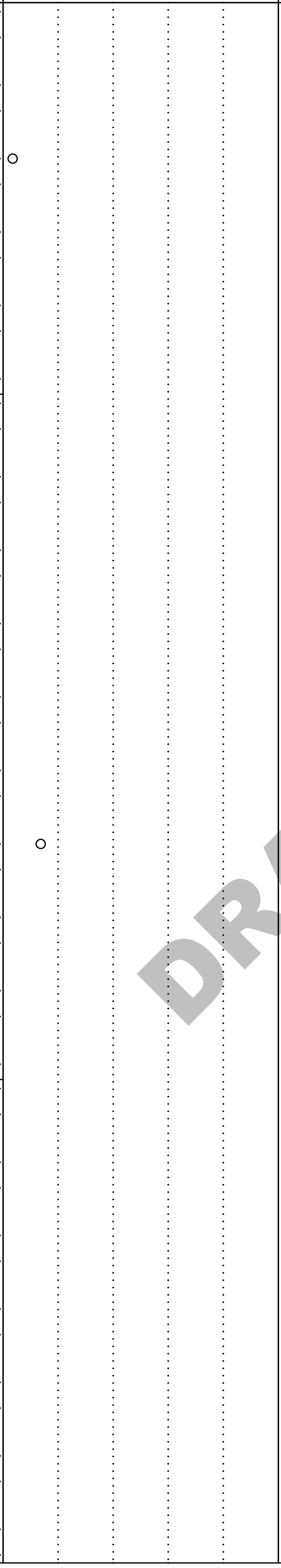
LOG OF BORING IBR-04

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
105	-135				
		Rec=10.0'	SC-10	GS	**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel.
110	-140				[SC-11A] 109.3 to 112: **SP**: POORLY GRADED SAND, subangular to subrounded, grayish brown, wet, homogeneous, fine to medium sand, iron oxide staining, micaceous.
115	-145	Rec=11.3'	SC-11		
					[SC-11B] 112 to 120.6: **SM**: SILTY SAND, subangular to subrounded, gray, wet, homogeneous, fine sand, non-plastic, micaceous.
					-A portion of Sample SC-11 was recovered with Sample SC-12.
120	-150				
				GS	[SC-12A] 120.6 to 128: **SM**: SILTY SAND, subangular to subrounded, gray, wet, homogeneous, fine sand, non-plastic, micaceous.
125	-155	Rec=5.1'	SC-12		
					[SC-12B] 128 to 130.8: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous. *-Sand heave observed in sonic casing before Sample SC-13.*
130	-160				
					SP-SM: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous, poor sample recovery.
135	-165	Rec=4.8'	SC-13		

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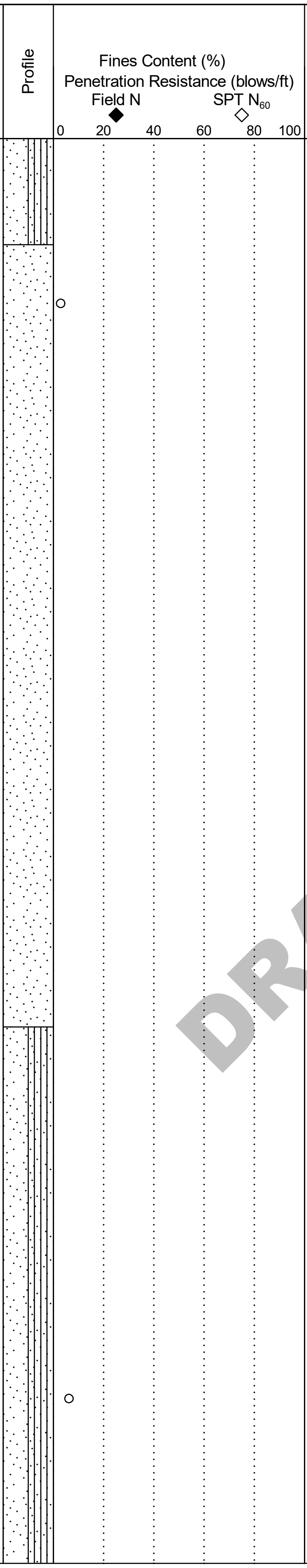
LOG OF BORING IBR-04

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
140	-170	Rec=4.8'	SC-13		*-Approximately 9 feet of sand heave measured in sonic casing after Sample SC-13. Driller added bentonite grout to borehole to reduce sand heave.* [SC-14A] 140.3 to 142: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, non-plastic, micaceous.
				GS	
145	-175	Rec=7.7'	SC-14		[SC-14B] 142 to 150.6: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, micaceous.
150	-180				*-Driller switched to 4-inch ID basket sonic core barrel bit.*
155	-185	Rec=10.2'	SC-15		**SP**: POORLY GRADED SAND, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, micaceous.
160	-190				*-Driller noted harder, smooth drilling at approximately 160 feet.* *-Driller switched to 4-inch ID auger sonic core barrel bit.* [SC-16A] 160.8 to 162: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, micaceous.
165	-195	Rec=4.9'	SC-16		[SC-16B] 162 to 170.7: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, homogeneous, fine to coarse sand, non-plastic, with trace fine gravel, micaceous, poor sample recovery.
170	-200				*-Driller switched to 4-inch ID flapper sonic core barrel bit.*
				GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, non-plastic, trace wood fragments from 170.7 to 172 feet, with trace fine gravel, micaceous, poor sample recovery.
		Rec=4.5'	SC-17		
175	-205				

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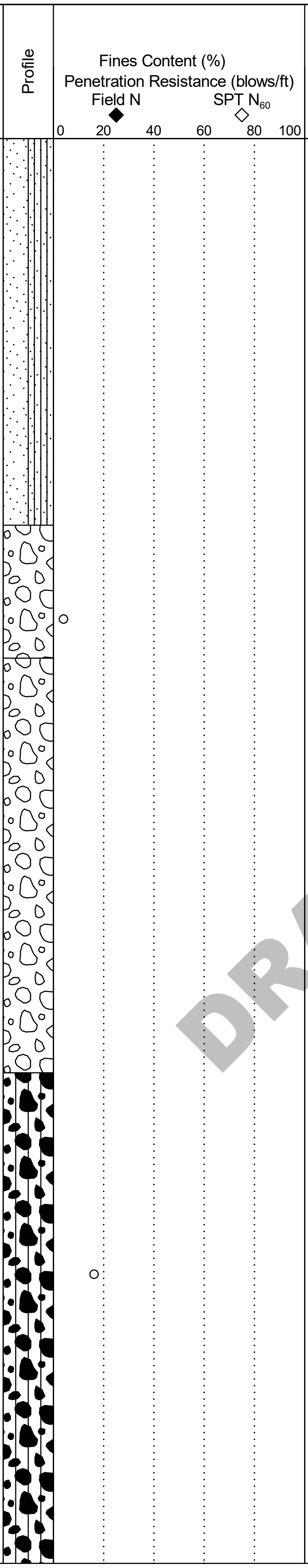
LOG OF BORING IBR-04

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
		Rec=4.5'	SC-17		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, non-plastic, trace wood fragments from 170.7 to 172 feet, with trace fine gravel, micaceous, poor sample recovery. *-Sample SC-17 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.*		
180	-210				[SC-18A] 179.6 to 185.6: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, stratified, fine to coarse sand, non-plastic, with trace fine gravel, stratified with SILTY SAND (SM), micaceous.		
185	-215	Rec=9.4'	SC-18		*-Driller noted harder drilling at approximately 185 feet.*		
				GS	*-Grain size analysis distribution may not be representative due to fractured clasts.* [SC-18B] 185.6 to 189: **GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray, wet, fine to coarse gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.		
190	-220				*-Driller switched to 4-inch ID standard sonic core barrel bit.*		
195	-225	Rec=0.0'	SC-19		NO RECOVERY *-No sample recovery from 189 to 199.6 feet. GP: POORLY GRADED GRAVEL WITH SAND inferred from drill action.*		
200	-230				*-Driller switched to 4-inch ID auger sonic core barrel bit.*		
205	-235	Rec=10.2'	SC-20	GS	*-Grain size analysis distribution may not be representative due to fractured clasts.* **GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, low plasticity, zones of cementation, iron oxide staining, micaceous, fractured clasts from sonic drilling.		
210	-240						
		Rec=10.4'	SC-21				

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LOG OF BORING IBR-04

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30

Depth (feet)	Elevation (feet)	Fines Content (%) Penetration Resistance (blows/ft) Field N ◆ SPT N60 ◇ (0 20 40 60 80 100)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
215	-245		Rec=10.4'	SC-21		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, moist, stratified, fine to coarse gravel, fine to coarse sand, low plasticity, stratified with SILTY SAND WITH GRAVEL (SM), zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.		
220	-250							
		○			GS			
225	-255		Rec=10.0'	SC-22		**GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subrounded to rounded, gray and brown, moist to wet, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, fractured clasts from sonic drilling. *-Grain size analysis distribution may not be representative due to fractured clasts.*		
230	-260							
235	-265		Rec=10.0'	SC-23		**GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subrounded to rounded, gray and brown, moist to wet, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 4 inches, fractured clasts from sonic drilling.		
240	-270					*-Material from 240.2 to 245 feet was dropped while bagging. Description based on observed disturbed material and drill action.*		
245	-275		Rec=9.8'	SC-24		**GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subrounded to rounded, gray and brown, moist to wet, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 4 inches, fractured clasts from sonic drilling.		

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Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30

Depth (feet)	Elevation (feet)	Profile	Fines Content (%) Penetration Resistance (blows/ft) Field N ◆ SPT N_{60} ◇ 0 20 40 60 80 100	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
250		▨		Rec=9.8'	▯	SC-24				▨

HOLE ENDED AT 250.0 FEET ON 11-13-2023

NOTES:

1. This is a summary log of the boring. Soil/rock descriptions are derived from visual field identifications and laboratory test data (where tested). See exploration log legend for explanation of graphics and abbreviations.
2. The implied accuracy of the location information displayed on this log is typically sub-meter (X,Y) when collected using GPS methods by the Geotechnical Office and sub-centimeter (X,Y,Z) when collected by the Region survey crew.
3. Where oversized samplers were used, a correction was made to the N-value per the AASHTO Manual on Subsurface Investigations, 1988. Blow counts per 6-inch increment have not been corrected.
4. The groundwater level(s), if shown, represents observations made during drilling. The groundwater level should be considered approximate and will vary based on seasonal and other effects.

SC-1
0.0'
to
10.0'

SC-2
10.0'
to
15.0'

SC-2
15.0'
to
20.0

SC-3
20.0'
to
25.0'

SC-3
25.0'
to
29.5'

SC-4
29.5'
to
35.0'

Note: Sample SC-4 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-04
CORE PHOTOGRAPHS

May 2024 105511

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Sheet 1 of 7

SC-4
35.0'
to
38.6'

Note: Sample SC-4 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

SC-5
38.6'
to
43.0'

SC-5
43.0'
to
47.8'

SC-6
47.8'
to
53.8'

Note: Sample SC-6 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

SC-6
53.8'
to
57.8'

Note: Sample SC-6 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

SC-7
57.8'
to
64.0'

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Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-04
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON

SC-7
64.0'
to
70.7'

SC-8
70.7'
to
79.8'

Note: Sample SC-8 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

SC-9
79.8'
to
84.8'

SC-9
84.8'
to
89.3'

SC-10
89.3'
to
94.3'

SC-10
94.3'
to
109.3'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-04
CORE PHOTOGRAPHS

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SHANNON & WILSON Sheet 3 of 7

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-11
109.3'
to
115.0'

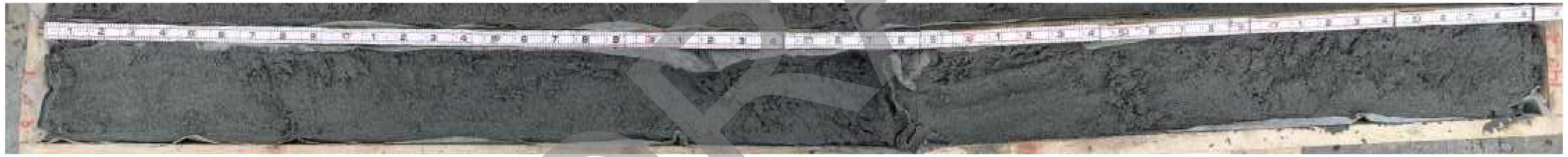
SC-11
115.0'
to
120.6'

Note: A portion of Sample SC-11 was recovered with Sample SC-12.

SC-12
120.6'
to
130.8'

Note: A portion of Sample SC-11 was recovered with Sample SC-12.

SC-13
130.8'
to
140.3'



SC-14
140.3'
to
145.3'

SC-14
145.3'
to
150.6'

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Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-04
CORE PHOTOGRAPHS

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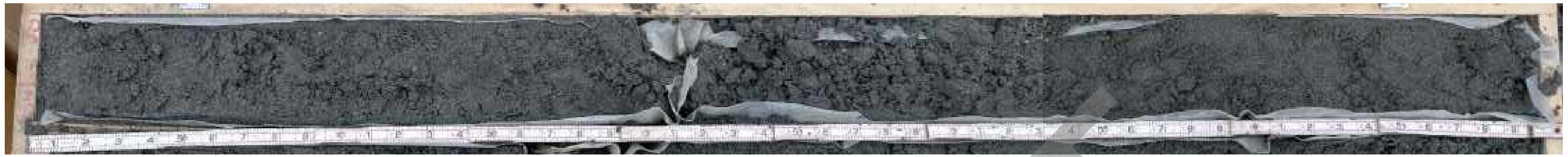
SHANNON & WILSON

SC-15
150.6'
to
155.0'

SC-15
155.0'
to
160.8'



SC-16
160.8'
to
170.7'

SC-17
170.7'
to
179.6'

Note: Sample SC-17 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

SC-18
179.6'
to
184.0'

SC-18
184.0'
to
189.0'

SC-19 - No Recovery

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-04
CORE PHOTOGRAPHS

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Sheet 5 of 7

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-20
199.6'
to
201.3'

SC-20
201.3'
to
206.3'

SC-20
206.3'
to
209.8'

SC-21
209.8'
to
216.2'

SC-21
216.2'
to
220.2'

SC-22
220.2'
to
225.2'

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Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-04
CORE PHOTOGRAPHS

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SHANNON & WILSON

Sheet 6 of 7

SC-22
225.2'
to
230.2'

SC-23
230.2'
to
235.2'

SC-23
235.2'
to
240.2'

SC-24 - Material from 240.2 to 245.0 feet was dropped while bagging. Material discarded.

SC-24
245.0'
to
250.2'

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Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-04
CORE PHOTOGRAPHS

May 2024 105511

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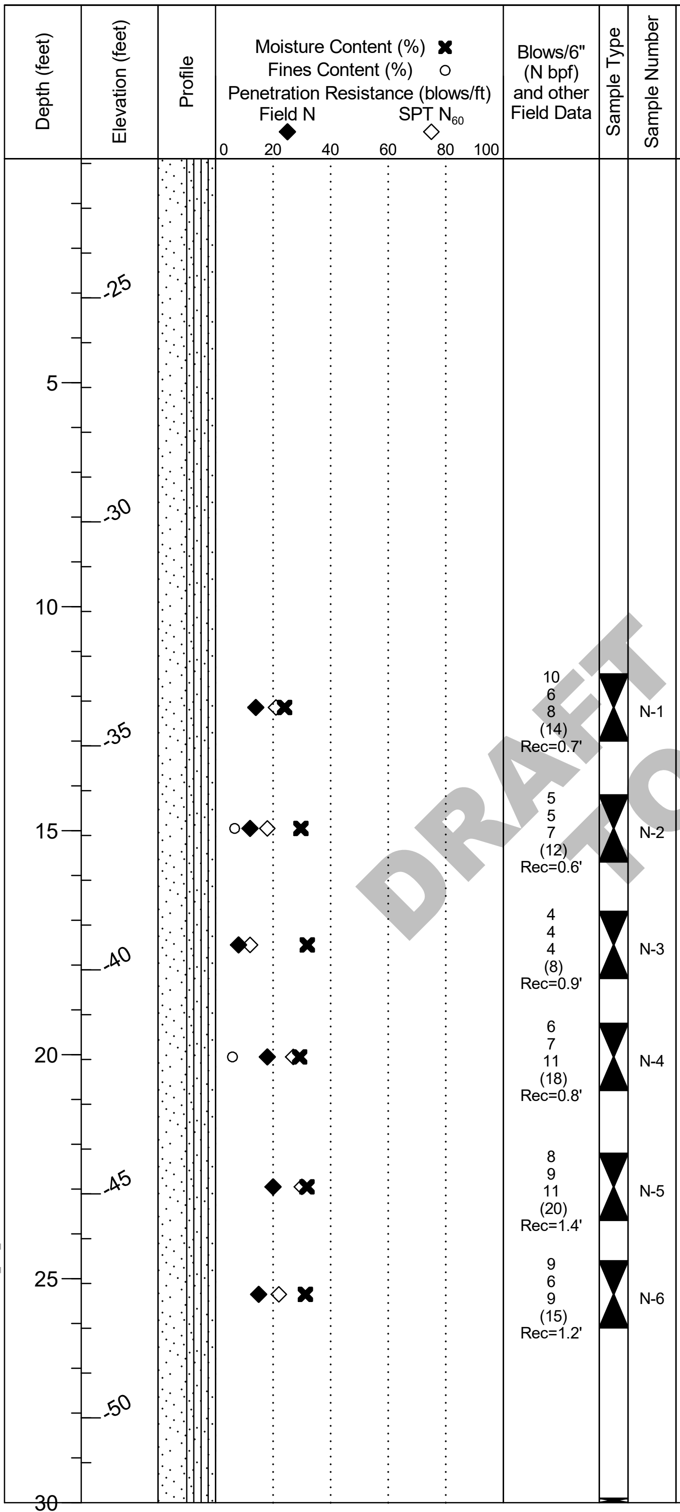
Sheet 7 of 7

LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program
Job Number: Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30
Northing: 111,405.1 feet *Latitude:* 45.617778 deg.
Driller/Inspector: Richard Wiggins (Western States) / Connor McCord (S&W)
Easting: 1,083,544.5 feet *Longitude:* -122.676155 deg.
Start Card: N/A
Elevation: -21.9 feet *Collector:* Region Survey
Drilling Method: Mud Rotary *Hole Diam.:* 5.5 in
Horizontal/Vertical Datum: IBR Project / NAVD88
Equipment: CME-850XR Track Rig (ID:417612) *Rod Type:* NWJ
Started: February 13, 2024 *Completed:* February 23, 2024
Hammer Type: AutoHammer *Historic Efficiency:* 89.4%



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
			-*Suspension logging performed between depths of 41.0 and 244.4 feet.*
10 6 8 (14) Rec=0.7'	N-1		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to coarse sand, non-plastic, trace wood fragments, micaceous.
5 5 7 (12) Rec=0.6'	N-2	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, trace wood fragments, micaceous.
4 4 4 (8) Rec=0.9'	N-3		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, loose, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
6 7 11 (18) Rec=0.8'	N-4	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
8 9 11 (20) Rec=1.4'	N-5		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
9 6 9 (15) Rec=1.2'	N-6		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.

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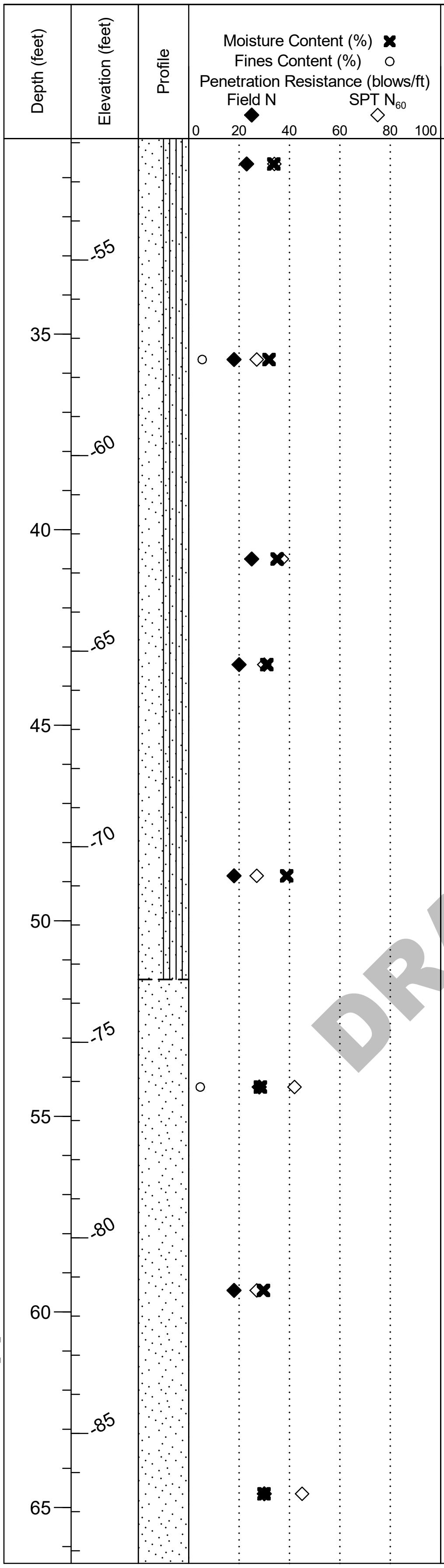
LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
10 12 11 (23) Rec=1.3'	N-7		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
9 9 9 (18) Rec=1.5'	N-8	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine sand, non-plastic, micaceous.
10 12 13 (25) Rec=1.2'	N-9		*-Wood debris observed in cuttings from 40 to 50 feet.* **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, trace organics and wood fragments, micaceous.
8 9 11 (20) Rec=1.5'	N-10		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
6 7 11 (18) Rec=1.5'	N-11		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, stratified, fine to medium sand, non-plastic, stratified with SANDY SILT (ML), micaceous.
			-Trace fine gravel observed in drill cuttings from approximately 50 to 55 feet.
10 12 16 (28) Rec=1.0'	N-12	GS	**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.
6 7 11 (18) Rec=1.0'	N-13		**SP**: POORLY GRADED SAND, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, micaceous. *-Driller noted borehole instability from 60 to 110 feet.*
12 13 17 (30) Rec=1.0'	N-14		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.

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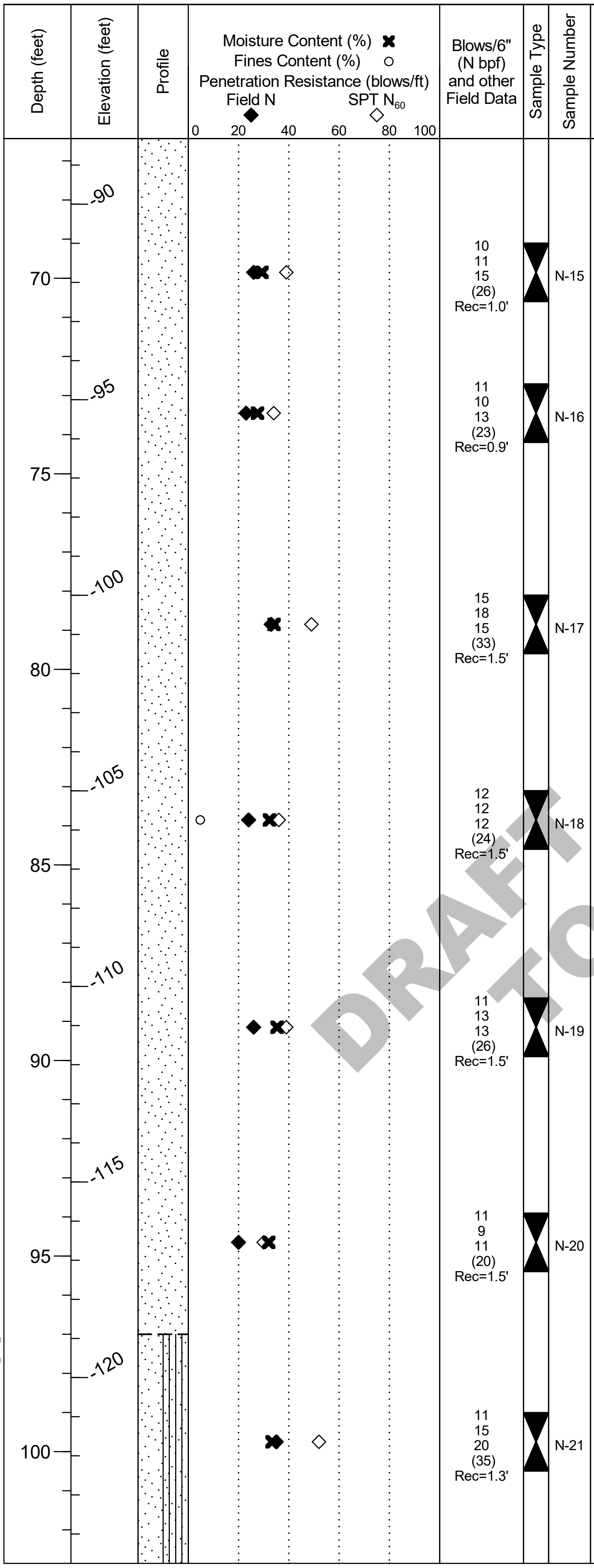
LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
10 11 15 (26) Rec=1.0'	N-15		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.
11 10 13 (23) Rec=0.9'	N-16		**SP**: POORLY GRADED SAND, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, micaceous.
15 18 15 (33) Rec=1.5'	N-17		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.
12 12 12 (24) Rec=1.5'	N-18	GS	**SP**: POORLY GRADED SAND, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, micaceous.
11 13 13 (26) Rec=1.5'	N-19		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.
11 9 11 (20) Rec=1.5'	N-20		**SP**: POORLY GRADED SAND, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, micaceous.
11 15 20 (35) Rec=1.3'	N-21		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.

Water Observations

Backfill

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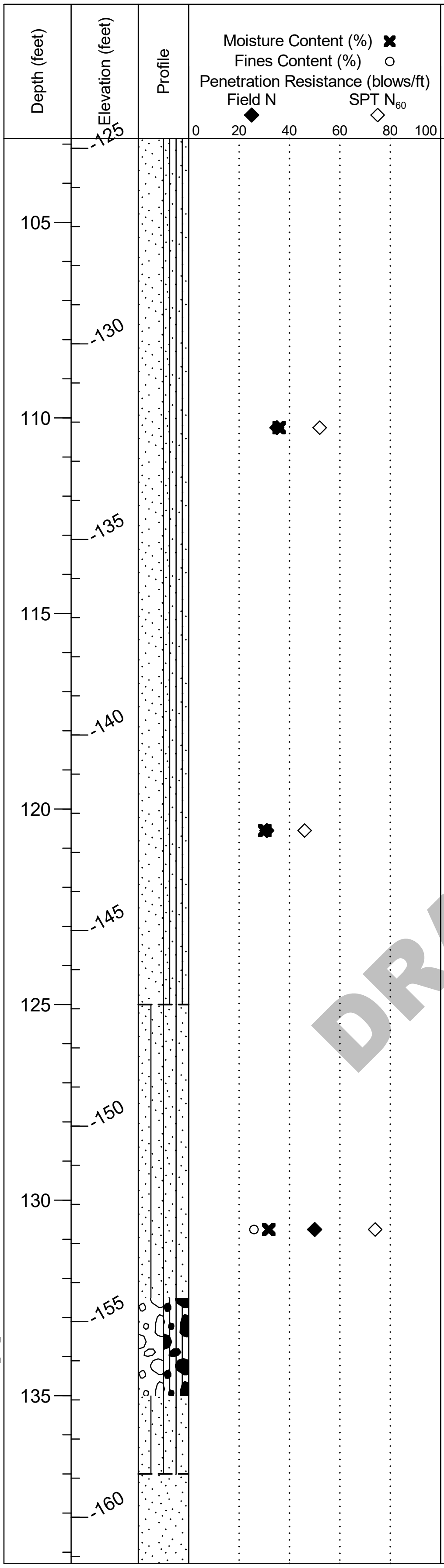
LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
13 17 18 (35) Rec=1.5'	N-22		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
17 14 17 (31) Rec=1.5'	N-23		**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
13 22 28 (50) Rec=1.0'	N-24	GS	**SM**: SILTY SAND, subangular to subrounded, dense, gray, wet, stratified, fine to coarse sand, non-plastic to low plasticity, stratified with SILT WITH SAND (ML), micaceous. *-Gravelly layer inferred from drill action from 132.5 feet to 135 feet.*

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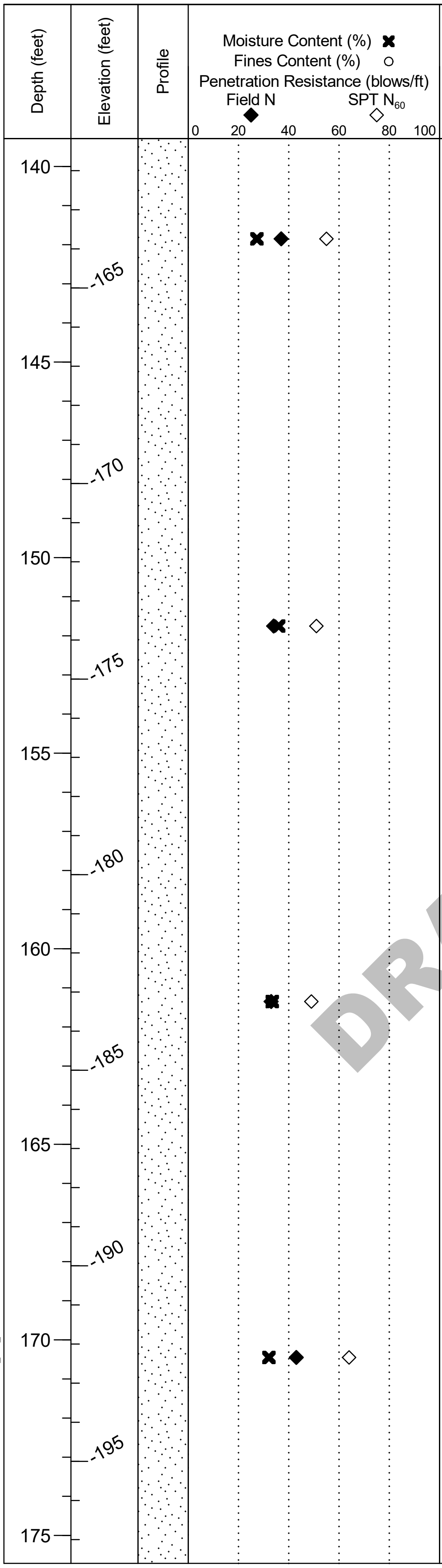
LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program

Job Number: Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
18 18 19 (37) Rec=1.3'	⧗	N-25		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.		
14 15 19 (34) Rec=1.0'	⧗	N-26		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.		
17 15 18 (33) Rec=1.2'	⧗	N-27		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.		
15 21 22 (43) Rec=1.2'	⧗	N-28		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.		
				-Lost all drill mud at 175 feet.		

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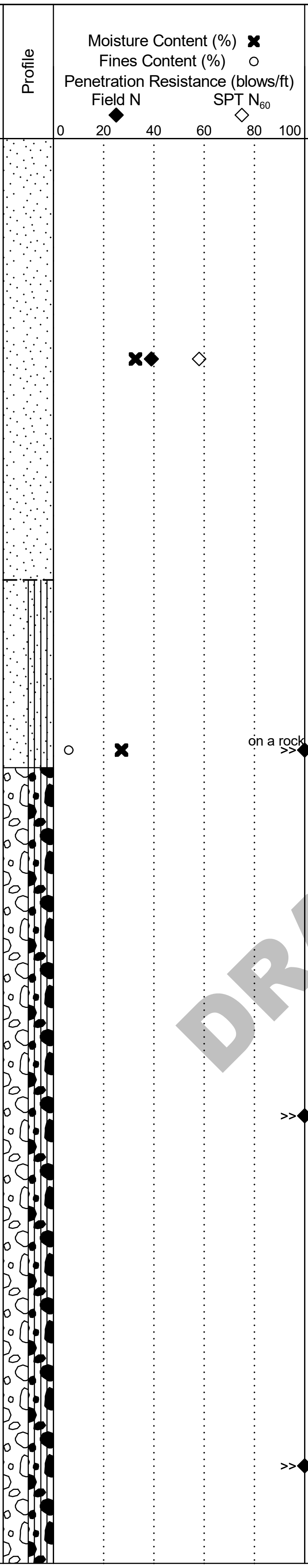
LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
	-200							
180								
		15 18 21 (39) Rec=1.3'		N-29		**SP**: POORLY GRADED SAND, subangular to subrounded, dense, gray, wet, homogeneous, fine to medium sand, micaceous.		
	-205							
185								
	-210							
190								
		19 50/5" (REF) Rec=0.9'		N-30	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.		
	-215					*-Driller noted harder drilling and drill chatter at approximately 192 feet.*		
195						*-Cobbles inferred from intermittent drill chatter from 192 to 224 feet.*		
	-220							
200		50/2" (REF) Rec=0.2'		N-31		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, dark gray and brown, moist, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous.		
	-225							
205								
	-230							
210		50/4" (REF) Rec=0.2'		N-32		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, dark gray and yellowish brown, moist, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous.		

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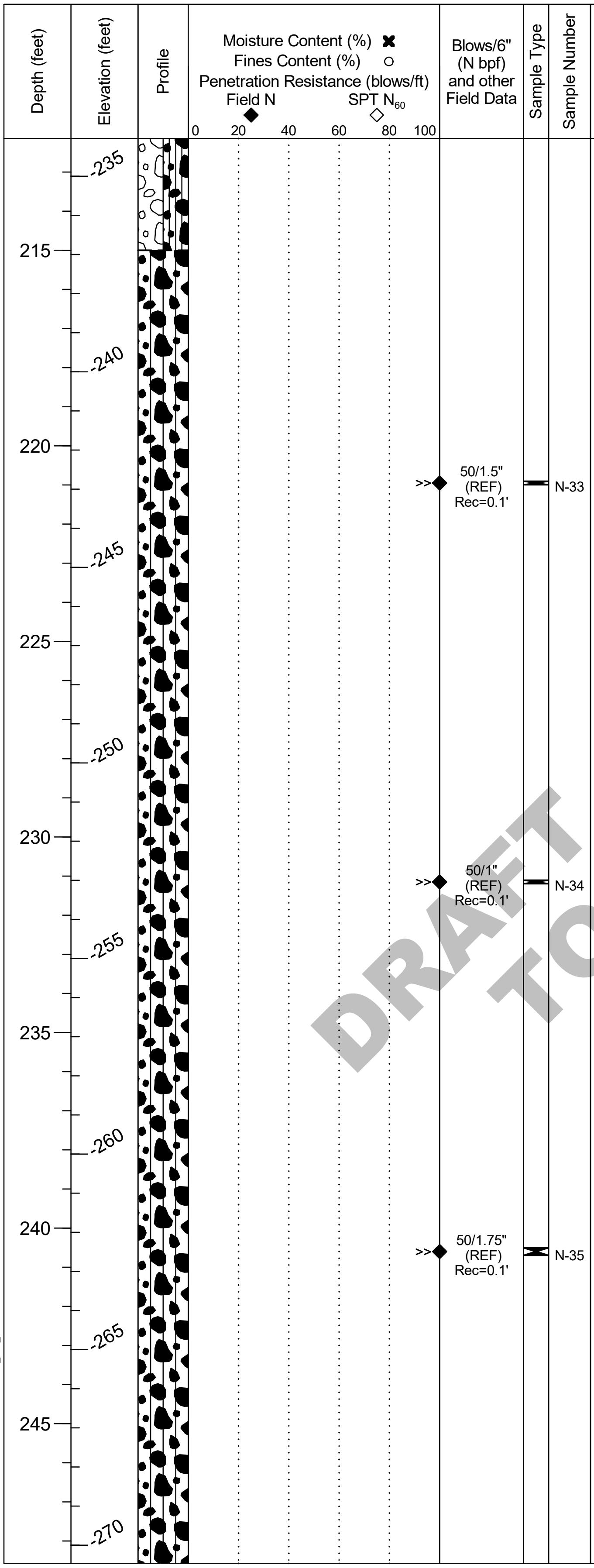
LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number
50/1.5" (REF) Rec=0.1'	N-33
50/1" (REF) Rec=0.1'	N-34
50/1.75" (REF) Rec=0.1'	N-35

Material Description

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, dark gray and yellowish brown, moist, fine to coarse gravel, non-plastic, micaceous, zones of cementation.

-Cobbles inferred from drill action from 224 to 237 feet.

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, limited sample recovery, description inferred from drill action.

-Driller noted smoother drilling with intermittent drill chatter below 237 feet.

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, limited sample recovery, description inferred from drill action.

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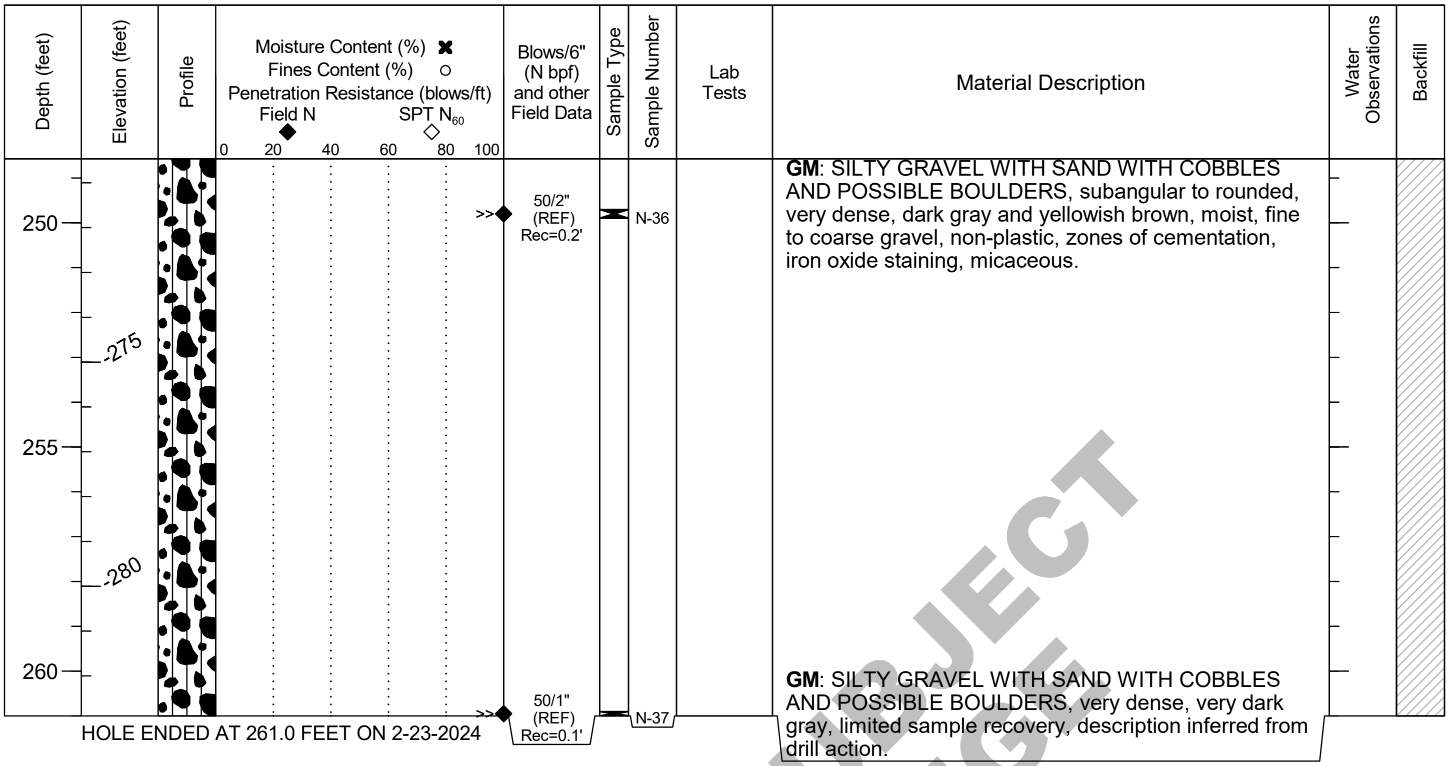
LOG OF BORING IBR-05

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, dark gray and yellowish brown, moist, fine to coarse gravel, non-plastic, zones of cementation, iron oxide staining, micaceous.

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, very dark gray, limited sample recovery, description inferred from drill action.

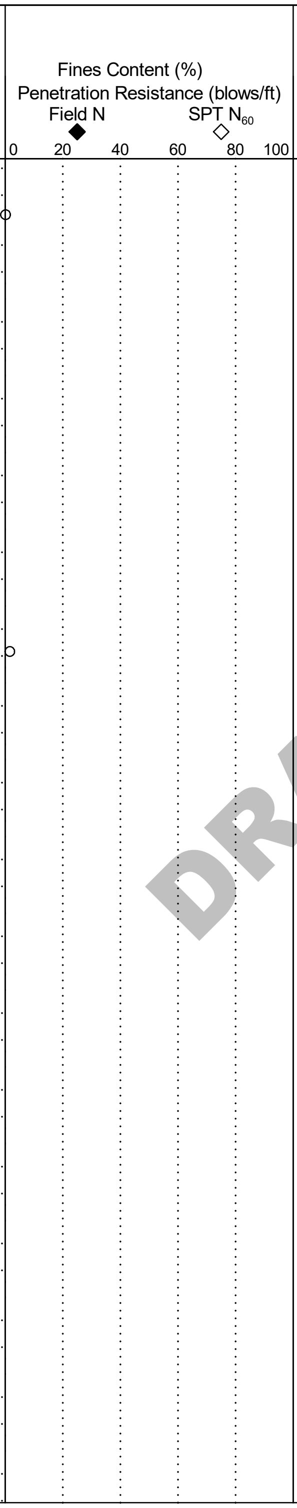
HOLE ENDED AT 261.0 FEET ON 2-23-2024

NOTES:

1. This is a summary log of the boring. Soil/rock descriptions are derived from visual field identifications and laboratory test data (where tested). See exploration log legend for explanation of graphics and abbreviations.
2. The implied accuracy of the location information displayed on this log is typically sub-meter (X,Y) when collected using GPS methods by the Geotechnical Office and sub-centimeter (X,Y,Z) when collected by the Region survey crew.
3. Where oversized samplers were used, a correction was made to the N-value per the AASHTO Manual on Subsurface Investigations, 1988. Blow counts per 6-inch increment have not been corrected.
4. The groundwater level(s), if shown, represents observations made during drilling. The groundwater level should be considered approximate and will vary based on seasonal and other effects.

LOG OF BORING IBR-06

Project: Interstate Bridge Replacement Program
Job Number: Y-12435
Route & MP Range: SR 005 MP 0.00 - 0.30
Northing: 111,808.0 feet
Latitude: 45.618904 deg.
Driller/Inspector: Alex McCann (Western States) / Connor McCord (S&W)
Easting: 1,083,722.7 feet
Longitude: -122.675503 deg.
Start Card: N/A
Elevation: -18.5 feet
Collector: Region Survey
Drilling Method: Sonic Rotary
Hole Diam.: 8 in
Horizontal/Vertical Datum: IBR Project / NAVD88
Equipment: Geoprobe 8150LS Sonic Track Rig
Rod Type: N/A
Started: November 28, 2023
Completed: November 29, 2023
Hammer Type: N/A



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description	Backfill
					-Driller using 6-inch ID flapper sonic core barrel bit.	▨
	-20			GS		
5						
	-25	Rec=7.0'	SC-1		**SP**: POORLY GRADED SAND, subangular to subrounded, gray and brown, wet, homogeneous, fine to coarse sand, trace wood fragments, with trace fine gravel, with trace shell fragments, micaceous.	
10						
	-30			GS		
15						
	-35					
		Rec=2.7'	SC-2		**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous, poor sample recovery.	
20						
	-40					
25						
	-45	Rec=10.3'	SC-3		**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous.	
30						

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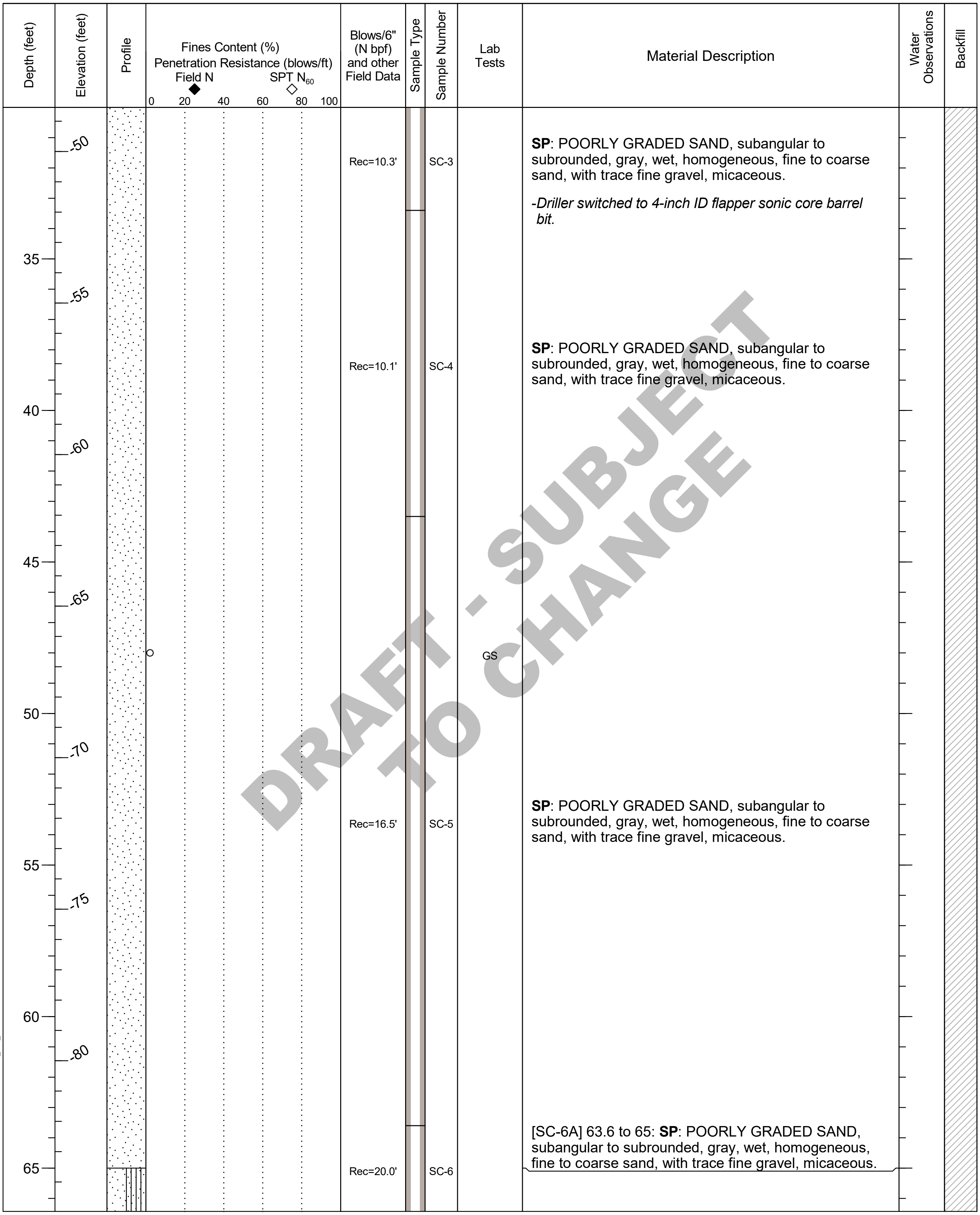
LOG OF BORING IBR-06

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
Rec=10.3'	SC-3		**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous. *-Driller switched to 4-inch ID flapper sonic core barrel bit.*
Rec=10.1'	SC-4		**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous.
		GS	
Rec=16.5'	SC-5		**SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous.
			[SC-6A] 63.6 to 65: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous.
Rec=20.0'	SC-6		

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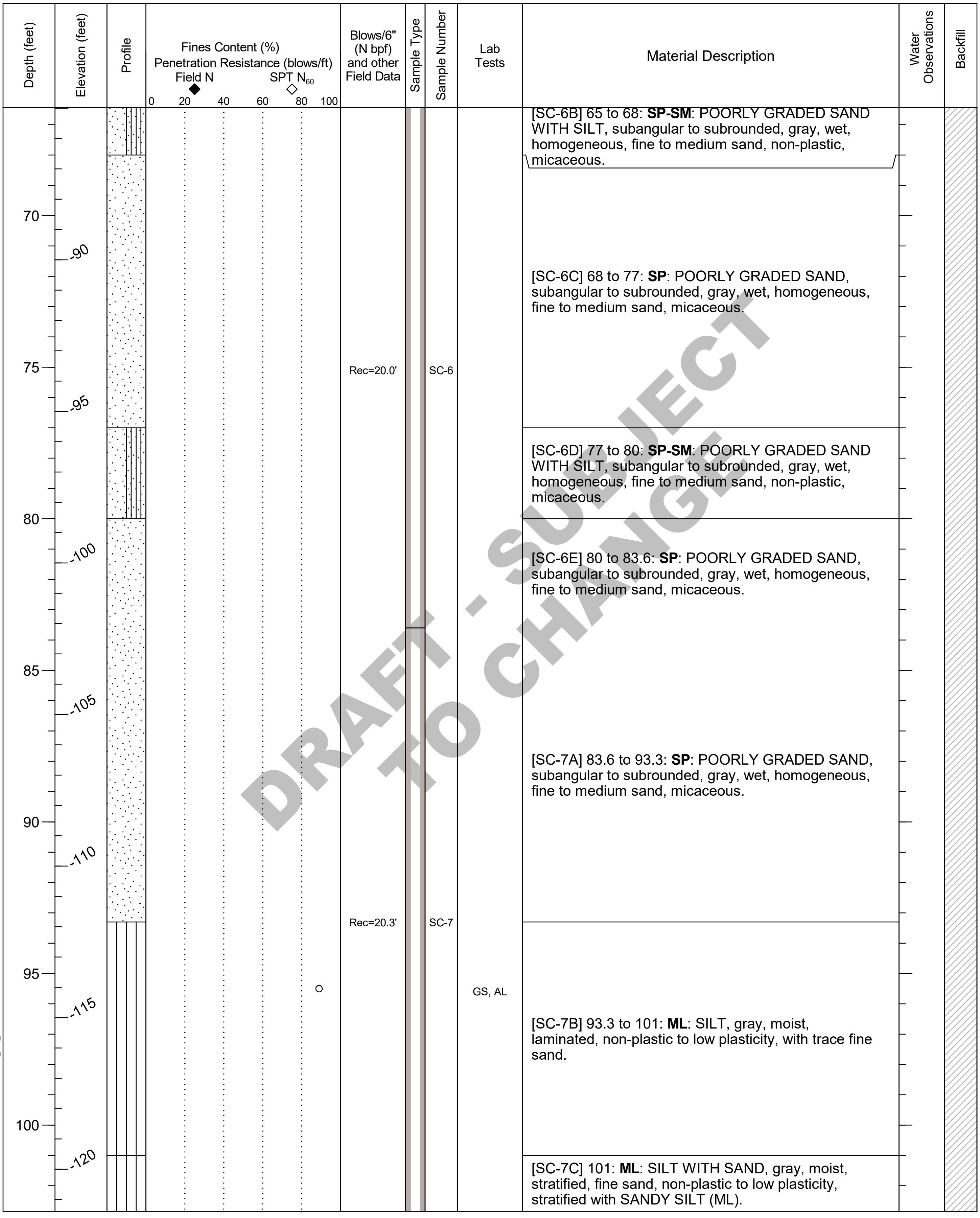
LOG OF BORING IBR-06

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests
75	Rec=20.0'	SC-6	
93.3	Rec=20.3'	SC-7	
95.5			GS, AL

[SC-6B] 65 to 68: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.

[SC-6C] 68 to 77: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.

[SC-6D] 77 to 80: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.

[SC-6E] 80 to 83.6: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.

[SC-7A] 83.6 to 93.3: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.

[SC-7B] 93.3 to 101: **ML**: SILT, gray, moist, laminated, non-plastic to low plasticity, with trace fine sand.

[SC-7C] 101: **ML**: SILT WITH SAND, gray, moist, stratified, fine sand, non-plastic to low plasticity, stratified with SANDY SILT (ML).

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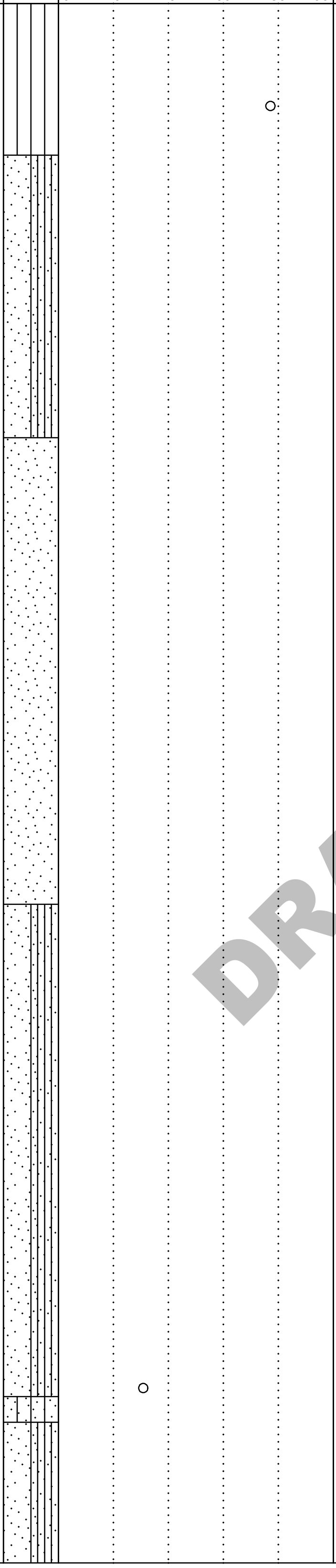
LOG OF BORING IBR-06

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
		Rec=20.3'	SC-7		
105	-125			GS	[SC-8A] 103.9 to 106.4: **ML**: SILT WITH SAND, gray, moist, stratified, fine sand, non-plastic to low plasticity, stratified with SANDY SILT (ML).
110	-130				[SC-8B] 106.4 to 113: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, wet, homogeneous, fine sand, non-plastic, micaceous.
		Rec=17.0'	SC-8		
115 120	-135 -140				[SC-8C] 113 to 123.9: **SP**: POORLY GRADED SAND, subangular to subrounded, gray, wet, homogeneous, fine to medium sand, micaceous.
125 130	-145 -150				*-Driller switched to 4-inch ID auger sonic core barrel bit.* [SC-9A] 123.9 to 135.4: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, non-plastic, micaceous. *-Sample SC-9 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.*
		Rec=16.0'	SC-9		
135				GS	[SC-9B] 135.4 to 136: **SM**: SILTY SAND, subangular to subrounded, gray, moist, homogeneous, fine sand, non-plastic, micaceous.
	-155				[SC-9C] 136 to 143.4: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, non-plastic, micaceous.

Sample Type | Water Observations | Backfill

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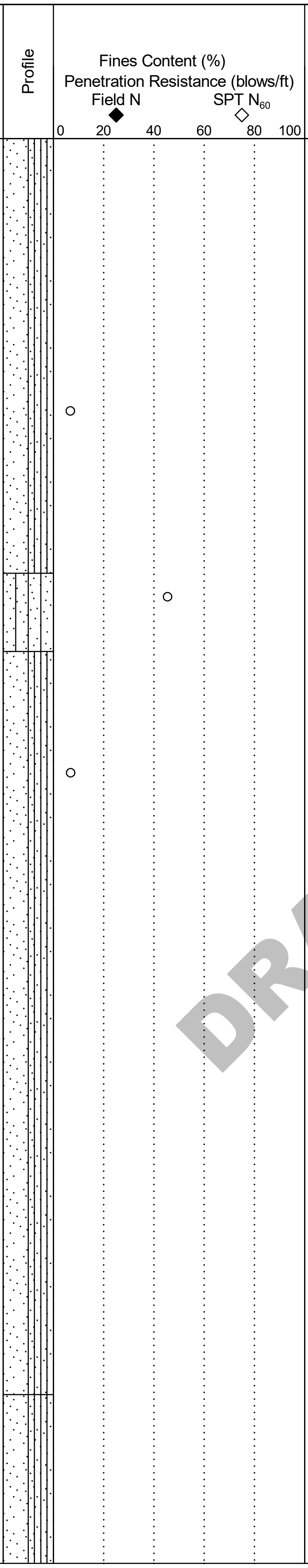
LOG OF BORING IBR-06

Project: Interstate Bridge Replacement Program
Job Number: Y-12435
Route & MP Range: SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
140	-160	Rec=16.0'	SC-9		[SC-9C] 136 to 143.4: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, non-plastic, micaceous.
145	-165	Rec=8.0'	SC-10	GS	[SC-10A] 143.4 to 150.4: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, homogeneous, fine sand, non-plastic, micaceous.
150	-170			GS, AL	[SC-10B] 150.4 to 152.4: **SM**: SILTY SAND, subangular to subrounded, gray, moist to wet, homogeneous, fine sand, non-plastic, micaceous.
155	-175			GS	
160	-180	Rec=20.2'	SC-11		[SC-11A] 152.4 to 171.4: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, gray, moist to wet, homogeneous, fine to medium sand, non-plastic, with trace fine gravel, micaceous.
165	-185				
170	-190				*-Driller noted harder drilling at approximately 171 feet.*
					[SC-11B] 171.4 to 172.6: **SP-SM**: POORLY GRADED SAND WITH SILT AND GRAVEL, subangular to subrounded, gray, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous.
175		Rec=20.5'	SC-12		[SC-12A] 172.6 to 180: **SP-SM**: POORLY GRADED SAND WITH SILT AND GRAVEL, subangular to subrounded, gray, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous.

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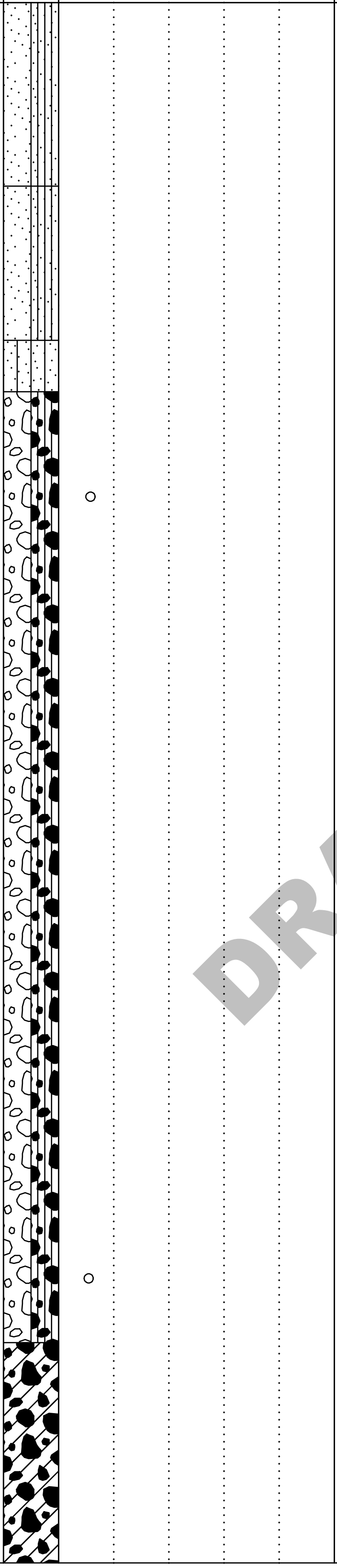
SHANNON & WILSON

LOG OF BORING IBR-06

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Profile	Fines Content (%) Penetration Resistance (blows/ft)	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
	-195							[SC-12A] 172.6 to 180: **SP-SM**: POORLY GRADED SAND WITH SILT AND GRAVEL, subangular to subrounded, gray, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous.		
180	-200							[SC-12B] 180 to 183.6: **SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, dark gray, wet, homogeneous, fine to coarse sand, non-plastic, micaceous.		
185	-205			Rec=20.5'		SC-12	GS	*-Driller noted harder drilling at approximately 184 feet.* [SC-12C] 183.6 to 184.8: **SM**: SILTY SAND, subangular to subrounded, dark gray, wet, homogeneous, fine to coarse sand, non-plastic, micaceous. *-Grain size analysis distribution may not be representative due to fractured clasts.* [SC-12D] 184.8 to 193.1: **GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND BOULDERS, subangular to rounded, gray and brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous.		
190	-210							*-Boulder inferred from drilling action from 191.1 to 192.6 feet.*		
195	-215							[SC-13A] 193.1 to 199.1: **GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.		
200	-220			Rec=15.3'		SC-13		[SC-13B] 199.1 to 207: **GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, low plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.		
205	-225						GS	*-Grain size analysis distribution may not be representative due to fractured clasts.*		
210	-230			Rec=14.5'		SC-14		[SC-13C] 207 to 208.4: **GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling. [SC-14A] 208.4 to 213: **GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND		

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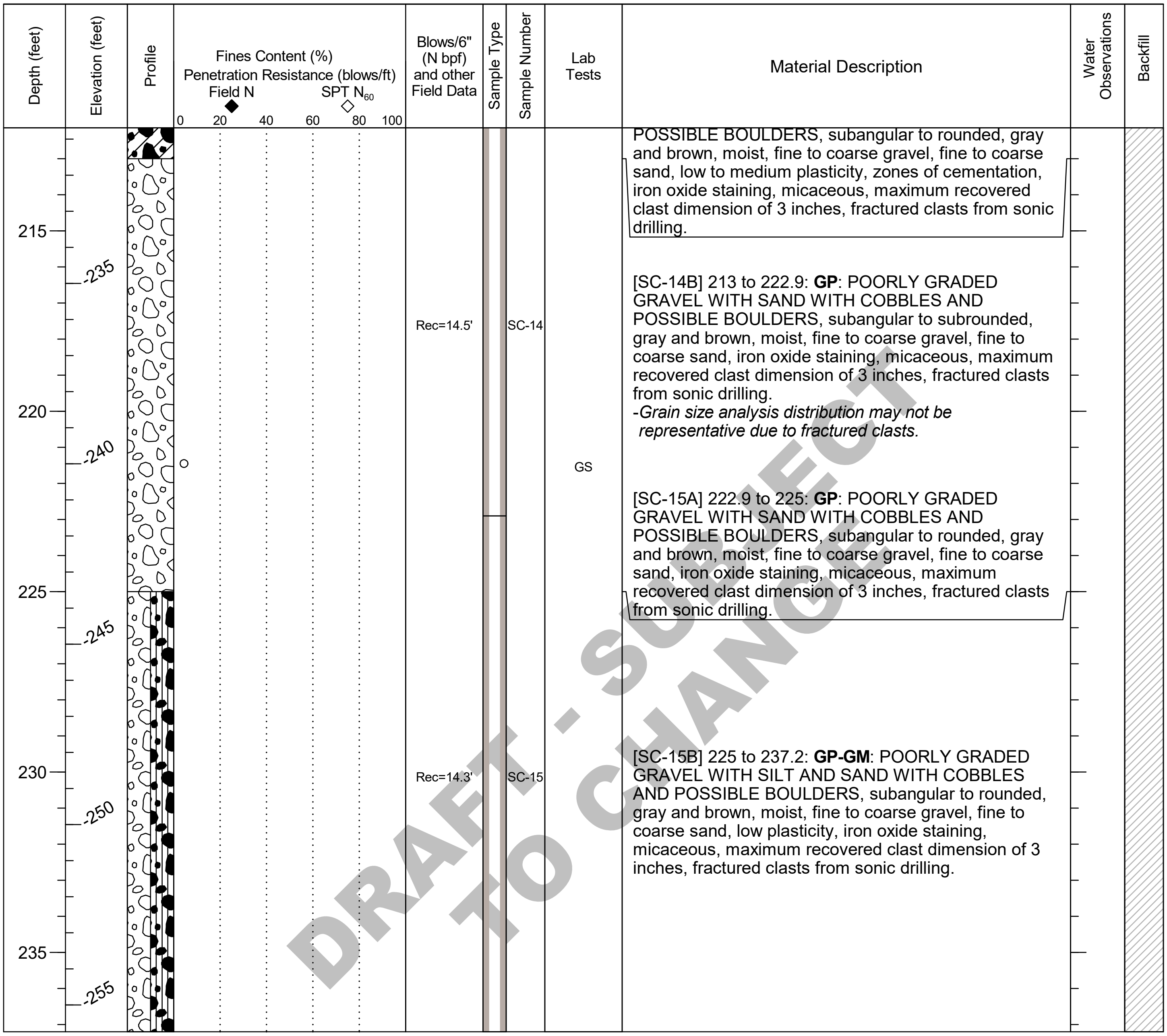
LOG OF BORING IBR-06

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



POSSIBLE BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.

[SC-14B] 213 to 222.9: **GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to subrounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.
-*Grain size analysis distribution may not be representative due to fractured clasts.*

[SC-15A] 222.9 to 225: **GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.

[SC-15B] 225 to 237.2: **GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, low plasticity, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.

HOLE ENDED AT 237.2 FEET ON 11-29-2023

NOTES:

1. This is a summary log of the boring. Soil/rock descriptions are derived from visual field identifications and laboratory test data (where tested). See exploration log legend for explanation of graphics and abbreviations.
2. The implied accuracy of the location information displayed on this log is typically sub-meter (X,Y) when collected using GPS methods by the Geotechnical Office and sub-centimeter (X,Y,Z) when collected by the Region survey crew.
3. Where oversized samplers were used, a correction was made to the N-value per the AASHTO Manual on Subsurface Investigations, 1988. Blow counts per 6-inch increment have not been corrected.
4. The groundwater level(s), if shown, represents observations made during drilling. The groundwater level should be considered approximate and will vary based on seasonal and other effects.

SC-1
0.0'
to
5.0'

SC-1
5.0'
to
12.4'

SC-2
12.4'
to
23.1'

SC-3
23.1'
to
28.1'

SC-3
28.1'
to
33.4'

SC-4
33.4'
to
38.4'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

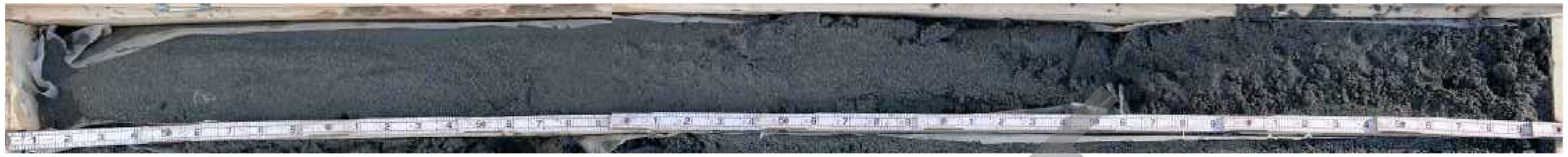
May 2024 105511

SHANNON & WILSON Sheet 1 of 8

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-4
38.1'
to
43.5'

SC-5
43.5'
to
48.5'



SC-5
48.5'
to
53.5'

SC-5
53.5'
to
63.6'

SC-6
63.6'
to
68.6'

SC-6
68.6'
to
73.6'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON Sheet 2 of 8

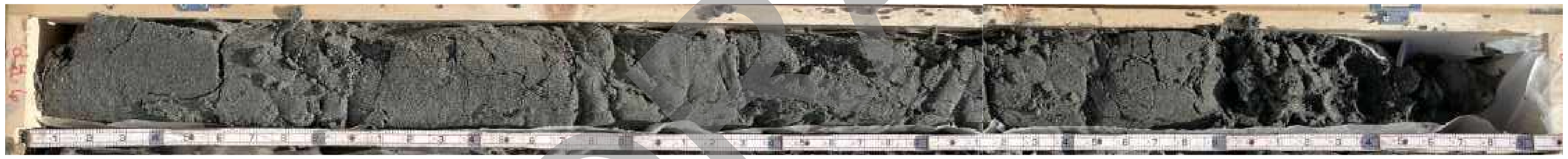
File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-6
73.6'
to
78.6'

SC-6
78.6'
to
83.6'

SC-7
83.6'
to
88.6'

SC-7
88.6'
to
93.6'



SC-7
93.6'
to
98.6'

SC-7
98.6'
to
103.9'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

May 2024 105511

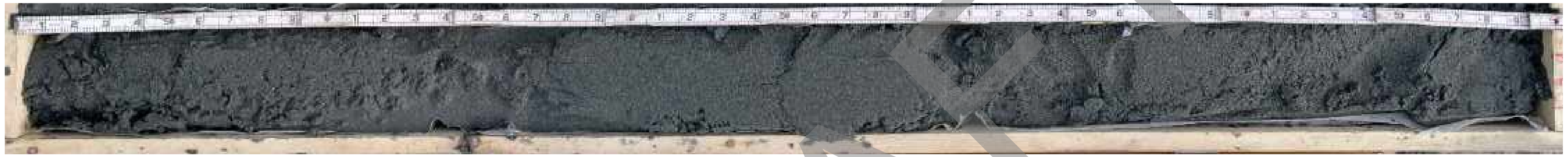
SHANNON & WILSON Sheet 3 of 8

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-8
103.9'
to
108.6'

SC-8
108.6'
to
113.6'

SC-8
113.6'
to
123.9'



SC-9
123.9'
to
128.9'

Note: Sample SC-9 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

SC-9
128.9'
to
133.9'

Note: Sample SC-9 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

SC-9
133.9'
to
143.4'

Note: Sample SC-9 initially fell out of sonic core barrel; tripped core barrel back in to retrieve sample.

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON

Sheet 4 of 8

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-10
143.4'
to
148.4'

SC-10
148.4'
to
152.4'

SC-11
152.4'
to
153.9'

SC-11
153.9'
to
158.9'

SC-11
158.9'
to
163.9'

SC-11
163.9'
to
168.9'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON Sheet 5 of 8

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-11
168.9'
to
172.6'

SC-12
172.6'
to
177.6'

SC-12
177.6'
to
182.6'

SC-12
182.6'
to
187.6'

SC-12
187.6'
to
193.1'

SC-13
193.1'
to
198.1'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON

Sheet 6 of 8

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-13
198.1'
to
203.1'

SC-13
203.1'
to
208.4'

SC-14
208.4'
to
213.4'

SC-14
213.4'
to
218.4'

SC-14
218.4'
to
222.9'

SC-15
222.9'
to
227.9'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON

Sheet 7 of 8

File: P:\PDX\105000s\105511 WSDOT-ODOT Inte\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-15
227.9'
to
232.2'

SC-15
232.2'
to
237.2'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-06
CORE PHOTOGRAPHS

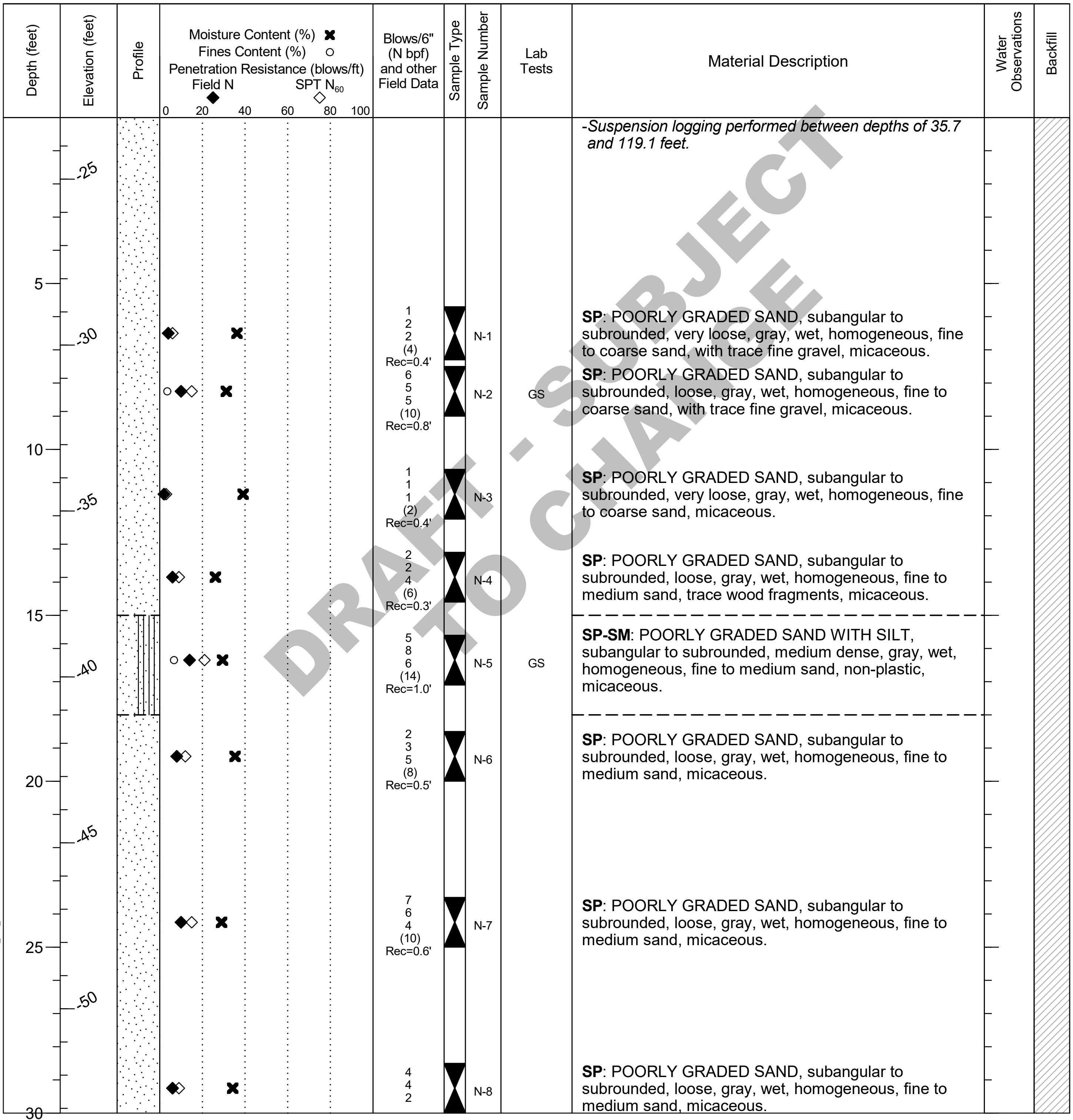
May 2024 105511

SHANNON & WILSON Sheet 8 of 8

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

LOG OF BORING IBR-07

Project: Interstate Bridge Replacement Program
Job Number: Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30
Northing: 112,219.6 feet *Latitude:* 45.620047 deg.
Driller/Inspector: Josh&Aaron (Western States) / Connor McCord (S&W)
Easting: 1,083,915.4 feet *Longitude:* -122.674794 deg.
Start Card: N/A
Elevation: -23.1 feet *Collector:* Region Survey
Drilling Method: Mud Rotary *Hole Diam.:* 8 & 6 in
Horizontal/Vertical Datum: IBR Project / NAVD88
Equipment: CME-850XR Track Rig (ID:417612) *Rod Type:* NWJ
Started: January 3, 2024 *Completed:* January 8, 2024
Hammer Type: AutoHammer *Historic Efficiency:* *89.4%*



-*Suspension logging performed between depths of 35.7 and 119.1 feet.*

Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
1 2 2 (4) Rec=0.4'	N-1		**SP**: POORLY GRADED SAND, subangular to subrounded, very loose, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous.
6 5 5 (10) Rec=0.8'	N-2	GS	**SP**: POORLY GRADED SAND, subangular to subrounded, loose, gray, wet, homogeneous, fine to coarse sand, with trace fine gravel, micaceous.
1 1 1 (2) Rec=0.4'	N-3		**SP**: POORLY GRADED SAND, subangular to subrounded, very loose, gray, wet, homogeneous, fine to coarse sand, micaceous.
2 2 4 (6) Rec=0.3'	N-4		**SP**: POORLY GRADED SAND, subangular to subrounded, loose, gray, wet, homogeneous, fine to medium sand, trace wood fragments, micaceous.
5 8 6 (14) Rec=1.0'	N-5	GS	**SP-SM**: POORLY GRADED SAND WITH SILT, subangular to subrounded, medium dense, gray, wet, homogeneous, fine to medium sand, non-plastic, micaceous.
2 3 5 (8) Rec=0.5'	N-6		**SP**: POORLY GRADED SAND, subangular to subrounded, loose, gray, wet, homogeneous, fine to medium sand, micaceous.
7 6 4 (10) Rec=0.6'	N-7		**SP**: POORLY GRADED SAND, subangular to subrounded, loose, gray, wet, homogeneous, fine to medium sand, micaceous.
4 4 2	N-8		**SP**: POORLY GRADED SAND, subangular to subrounded, loose, gray, wet, homogeneous, fine to medium sand, micaceous.

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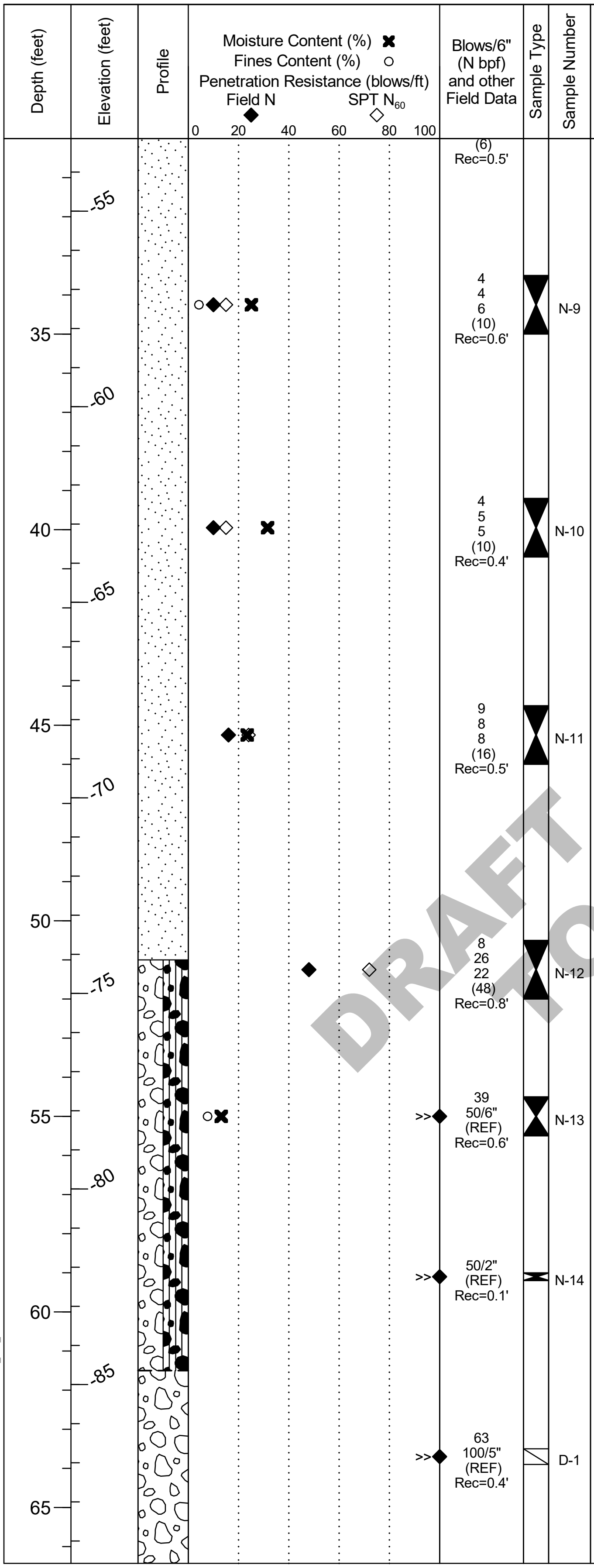
LOG OF BORING IBR-07

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



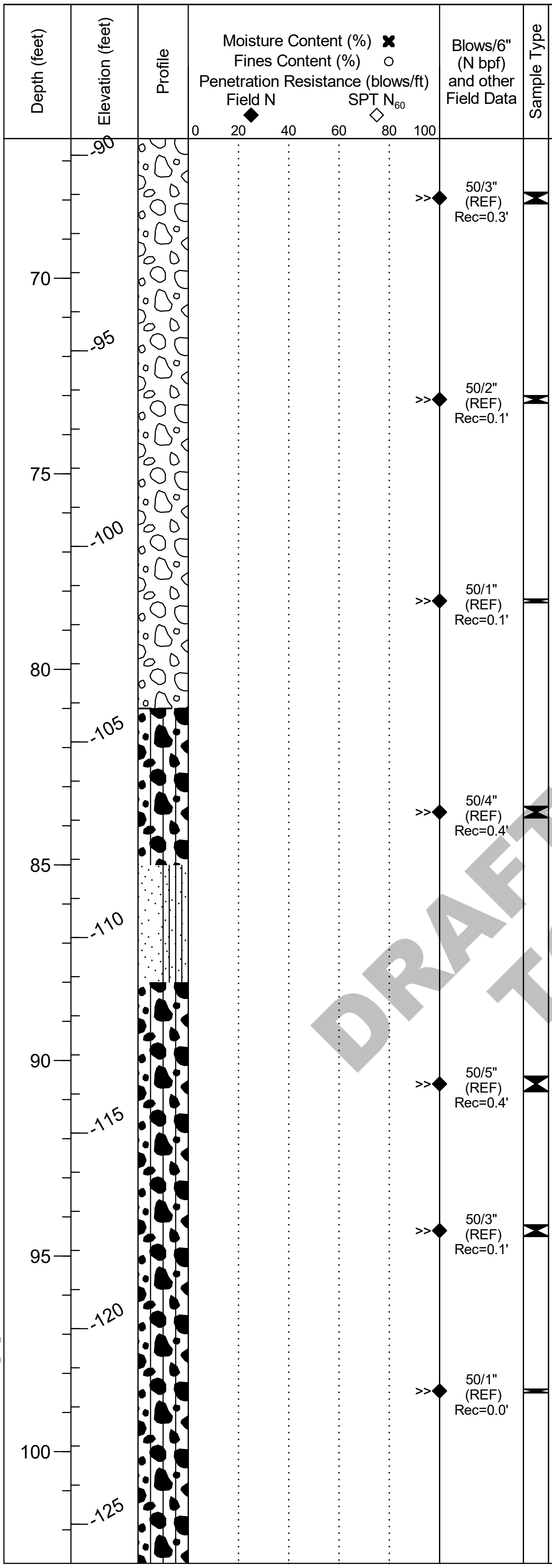
Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
(6) Rec=0.5'			
4 4 6 (10) Rec=0.6'	N-9	GS	**SP**: POORLY GRADED SAND, subangular to subrounded, loose, gray, wet, homogeneous, fine to coarse sand, with trace fine to coarse gravel, micaceous.
4 5 5 (10) Rec=0.4'	N-10		**SP**: POORLY GRADED SAND, subangular to subrounded, loose, grayish brown, wet, homogeneous, fine to coarse sand, micaceous.
9 8 8 (16) Rec=0.5'	N-11		**SP**: POORLY GRADED SAND, subangular to subrounded, medium dense, grayish brown, wet, homogeneous, fine to coarse sand, micaceous.
8 26 22 (48) Rec=0.8'	N-12		[N-12A] 50.5 to 51: **SP**: POORLY GRADED SAND, subangular to rounded, grayish brown, wet, homogeneous, fine to coarse sand, micaceous. [N-12B] 51 to 52: **GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, dense, grayish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic.
39 50/6" (REF) Rec=0.6'	N-13	GS	**GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, grayish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic.
50/2" (REF) Rec=0.1'	N-14		**GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, reddish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic.
63 100/5" (REF) Rec=0.4'	D-1		**GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, grayish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand.

Water Observations | Backfill

CONTINUED NEXT PAGE *(see last page for notes)*

LOG OF BORING IBR-07

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests
50/3" (REF) Rec=0.3'	N-15	
50/2" (REF) Rec=0.1'	N-16	
50/1" (REF) Rec=0.1'	N-17	
50/4" (REF) Rec=0.4'	N-18	
50/5" (REF) Rec=0.4'	N-19	
50/3" (REF) Rec=0.1'	N-20	
50/1" (REF) Rec=0.0'	N-21	

Material Description

GP: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, grayish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand.
-*Performed Dames & Moore sample after N-15 to obtain additional material.*

-*Driller notes harder drilling at 73 feet.*
GP: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, grayish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand.
-*Attempted Dames & Moore sample after N-16, no recovery.*

GP: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, grayish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, micaceous.
-*Attempted Dames & Moore sample after N-17, no recovery.*

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, gray and yellowish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic, zones of cementation, iron oxide staining, micaceous.
-*Attempted Dames & Moore sample after N-18, no recovery.*
-*Driller notes smoother drilling from 85 to 88 feet, sandy layer inferred.*

-*Cobbles inferred from drill action from 88 to 110 feet.*

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND BOULDERS, subangular to rounded, very dense, reddish brown, wet, homogeneous, fine to coarse gravel, fine to coarse sand, non-plastic.
-*Boulder inferred from drill action from approximately 91 to 93 feet.*

GM: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, limited sample recovery, description inferred from drill action.
-*Attempted Dames & Moore sample after N-20, no recovery.*

NO RECOVERY
-*Attempted Dames & Moore sample after N-21, no recovery.*

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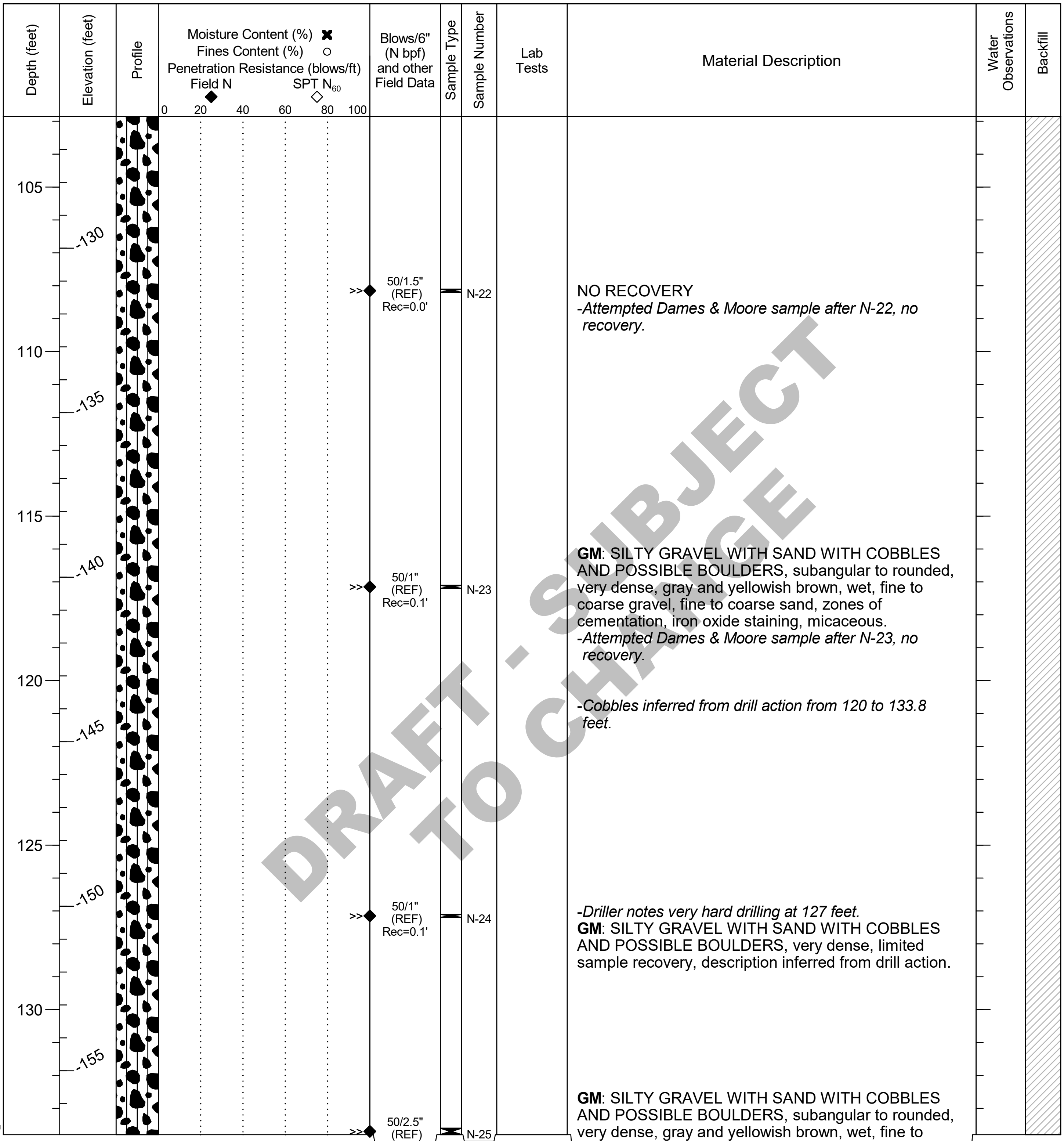
LOG OF BORING IBR-07

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description
50/1.5" (REF) Rec=0.0'		N-22		NO RECOVERY *-Attempted Dames & Moore sample after N-22, no recovery.*
50/1" (REF) Rec=0.1'		N-23		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, gray and yellowish brown, wet, fine to coarse gravel, fine to coarse sand, zones of cementation, iron oxide staining, micaceous. *-Attempted Dames & Moore sample after N-23, no recovery.* *-Cobbles inferred from drill action from 120 to 133.8 feet.*
50/1" (REF) Rec=0.1'		N-24		*-Driller notes very hard drilling at 127 feet.* **GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, very dense, limited sample recovery, description inferred from drill action.
50/2.5" (REF) Rec=0.2'		N-25		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, very dense, gray and yellowish brown, wet, fine to coarse gravel, fine to coarse sand, non-plastic, zones of cementation, iron oxide staining, micaceous.

HOLE ENDED AT 133.8 FEET ON 1-8-2024

NOTES:

1. This is a summary log of the boring. Soil/rock descriptions are derived from visual field identifications and laboratory test data (where tested). See exploration log legend for explanation of graphics and abbreviations.
2. The implied accuracy of the location information displayed on this log is typically sub-meter (X,Y) when collected using GPS methods by the Geotechnical Office and sub-centimeter (X,Y,Z) when collected by the Region survey crew.

CONTINUED NEXT PAGE *(see last page for notes)*

LOG OF BORING IBR-07

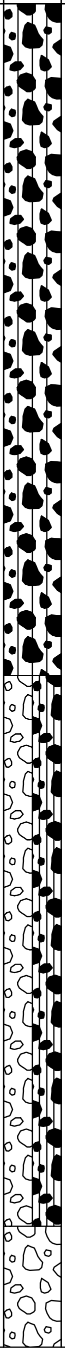
Project: Interstate Bridge Replacement Program
Job Number: Y-12435
Route & MP Range: SR 005 MP 0.00 - 0.30

Depth (feet)	Elevation (feet)	Profile	Moisture Content (%) ✖ Fines Content (%) ○ Penetration Resistance (blows/ft) Field N ◆ SPT N_{60} ◇ 0 20 40 60 80 100	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill

3. Where oversized samplers were used, a correction was made to the N-value per the AASHTO Manual on Subsurface Investigations, 1988. Blow counts per 6-inch increment have not been corrected.
4. The groundwater level(s), if shown, represents observations made during drilling. The groundwater level should be considered approximate and will vary based on seasonal and other effects.

LOG OF BORING IBR-08

Project: Interstate Bridge Replacement Program
Job Number: Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30
Northing: 112,649.2 feet *Latitude:* 45.621233 deg.
Driller/Inspector: Alex&Josh (Western States) / Connor McCord (S&W)
Easting: 1,084,033.3 feet *Longitude:* -122.674380 deg.
Start Card: N/A
Elevation: -25.0 feet *Collector:* Region Survey
Drilling Method: Sonic Rotary *Hole Diam.:* 6 & 5 in
Horizontal/Vertical Datum: IBR Project / NAVD88
Equipment: Geoprobe 8150LS Sonic Track Rig *Rod Type:* N/A
Started: November 14, 2023 *Completed:* November 15, 2023
Hammer Type: N/A



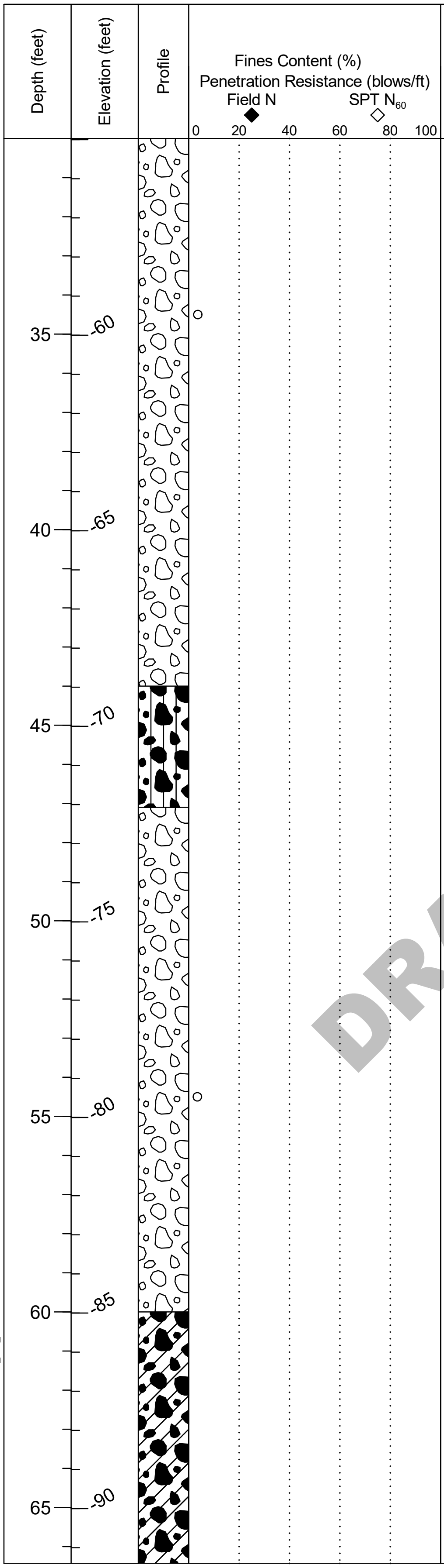
Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
0	-25				*-Driller using 5-inch ID standard sonic core barrel bit.*		▨
		Rec=7.0'	SC-1		**GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subrounded to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, maximum recovered clast dimension of 4 inches, fractured clasts from sonic drilling.		▨
5	-30						▨
10	-35	Rec=10.0'	SC-2		[SC-2A] 7 to 15: **GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subrounded to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling. *-A portion of Sample SC-2 was dropped while bagging. Description based on observed recovered material and drill action.*		▨
15	-40				[SC-2B] 15 to 17: **GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to subrounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, non-plastic, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.		▨
20	-45	Rec=7.3'	SC-3		**GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, non-plastic, maximum recovered clast dimension of 6 inches, fractured clasts from sonic drilling. *-Approximately 3 feet of Sample SC-3 was lost while bagging. Description based on observed recovered material and drill action.*		▨
25	-50				*-Driller switched to 4-inch ID standard sonic core barrel bit.*		▨
		Rec=7.7'	SC-4		**GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, fractured clasts from sonic drilling.		▨
30							

CONTINUED NEXT PAGE *(see last page for notes)*

VERSION 0.7
DRAFT

STANDARD BORING LOG-S&W LOGO 105511_IBR_WSDOT.GPJ 2020 WSDOT GINT TEMPLATE.GDT 5/31/24

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description
Rec=7.7'	SC-4	GS	*-Grain size analysis distribution may not be representative due to fractured clasts.* **GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, fractured clasts from sonic drilling.
Rec=7.2'	SC-5		[SC-5A] 37.5 to 44: **GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling. [SC-5B] 44 to 47.1: **GM**: SILTY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, non-plastic to low plasticity, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.
Rec=7.4'	SC-6	GS	*-Grain size analysis distribution may not be representative due to fractured clasts.* **GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, micaceous, maximum recovered clast dimension of 4 inches, fractured clasts from sonic drilling, suspected grain-size segregation from sonic vibration.
Rec=9.9'	SC-7		*-Driller noted harder drilling at approximately 57 feet.* [SC-7A] 57 to 60: **GP**: POORLY GRADED GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and brown, wet, fine to coarse gravel, fine to coarse sand, micaceous, maximum recovered clast dimension of 4 inches, fractured clasts from sonic drilling, suspected grain-size segregation from sonic vibration. [SC-7B] 60 to 67: **GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, low to medium plasticity, iron oxide staining, micaceous, iron oxide staining, micaceous, maximum recovered clast dimension of 12 inches, fractured clasts from sonic drilling. *-Boulder inferred from drilling action from 64.4 to 65.4 feet.*

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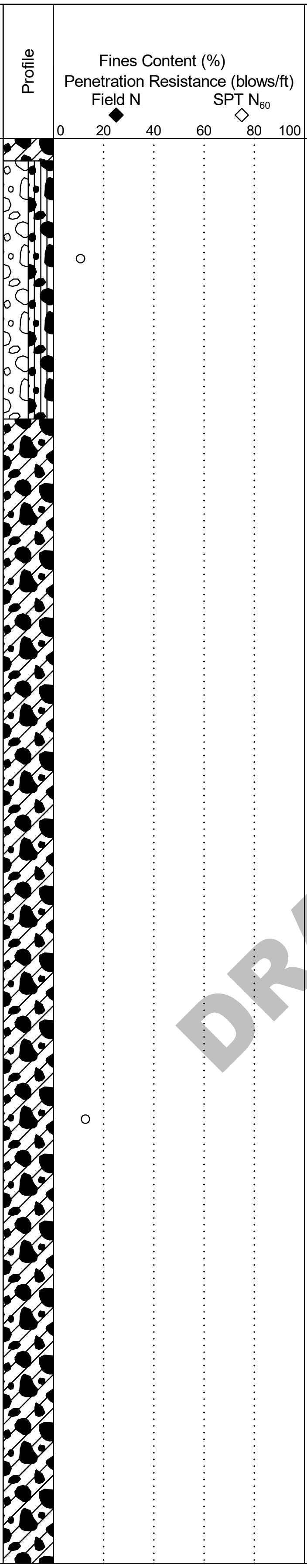
LOG OF BORING IBR-08

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30



Depth (feet)	Elevation (feet)	Blows/6" (N bpf) and other Field Data	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
		Rec=9.9'	SC-7				
					-*Grain size analysis distribution may not be representative due to fractured clasts.* **GP-GM**: POORLY GRADED GRAVEL WITH SILT AND SAND WITH COBBLES AND BOULDERS, subangular to rounded, gray and brown, moist, fine to coarse gravel, fine to coarse sand, low plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling.		
				GS			
70	-95	Rec=6.6'	SC-8				
75	-100						
					GM/GC: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and yellowish brown, moist, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, fractured clasts from sonic drilling.		
80	-105	Rec=12.2'	SC-9				
85	-110						
					-*Cobble inferred from drilling action from 87.5 to 88.1 feet.*		
90	-115				-*Grain size analysis distribution may not be representative due to fractured clasts.* **GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND BOULDERS, subangular to rounded, gray and yellowish brown, moist, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 3 inches, fractured clasts from sonic drilling. -*Boulder inferred from drilling action from 94 to 95.5 feet.*		
		Rec=10.3'	SC-10	GS			
95	-120						
					-*Driller noted very hard drilling at 96 feet.* -*Sample SC-11 fell out of barrel while bagging. Description based on observed disturbed material and drill action.* **GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and yellowish brown, moist, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 5 inches, fractured clasts from sonic drilling.		
100	-125	Rec=14.8'	SC-11				

STANDARD BORING LOG-S&W LOGO 105511_IBR_WSDOT.GPJ 2020 WSDOT GINT TEMPLATE.GDT 5/31/24

CONTINUED NEXT PAGE *(see last page for notes)*

LOG OF BORING IBR-08

Project: Interstate Bridge Replacement Program *Job Number:* Y-12435 *Route & MP Range:* SR 005 MP 0.00 - 0.30

Depth (feet)	Elevation (feet)	Profile	Fines Content (%) Penetration Resistance (blows/ft) Field N ◆ SPT N60 ◇ 0 20 40 60 80 100	Blows/6" (N bpf) and other Field Data	Sample Type	Sample Number	Lab Tests	Material Description	Water Observations	Backfill
105	-130									▨
				Rec=14.8'		SC-11		**GM/GC**: SILTY/CLAYEY GRAVEL WITH SAND WITH COBBLES AND POSSIBLE BOULDERS, subangular to rounded, gray and yellowish brown, moist, fine to coarse gravel, fine to coarse sand, low to medium plasticity, zones of cementation, iron oxide staining, micaceous, maximum recovered clast dimension of 5 inches, fractured clasts from sonic drilling.		▨
110	-135									▨

HOLE ENDED AT 110.9 FEET ON 11-15-2023

NOTES:

1. This is a summary log of the boring. Soil/rock descriptions are derived from visual field identifications and laboratory test data (where tested). See exploration log legend for explanation of graphics and abbreviations.
2. The implied accuracy of the location information displayed on this log is typically sub-meter (X,Y) when collected using GPS methods by the Geotechnical Office and sub-centimeter (X,Y,Z) when collected by the Region survey crew.
3. Where oversized samplers were used, a correction was made to the N-value per the AASHTO Manual on Subsurface Investigations, 1988. Blow counts per 6-inch increment have not been corrected.
4. The groundwater level(s), if shown, represents observations made during drilling. The groundwater level should be considered approximate and will vary based on seasonal and other effects.

SC-1
0.0'
to
3.5'

SC-1
3.5'
to
7.0'

SC-2
7.0'
to
17.0'

Note: A portion of Sample SC-2 was dropped while bagging. Material discarded.

SC-3
17.0'
to
22.0'

Note: Approximately 3 feet of Sample SC-3 was lost while bagging. Material discarded.

SC-3
22.0'
to
27.3'

Note: Approximately 3 feet of Sample SC-3 was lost while bagging. Material discarded.

SC-4
27.3'
to
37.5'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-08
CORE PHOTOGRAPHS

May 2024
105511

SHANNON & WILSON

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-5
37.5'
to
47.1'

SC-6
47.1'
to
57.0'

Note: Possible grain size segregation from sonic drilling.

SC-7
57.0'
to
62.0'

Note: Possible grain size segregation from sonic drilling.

SC-7
62.0'
to
67.0'

SC-8
67.0'
to
72.0'

SC-8
72.0'
to
73.6'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-08
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON

Sheet 2 of 4

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-9
73.6'
to
75.0'

SC-9
75.0'
to
79.0'

SC-9
79.0'
to
84.0'

SC-9
84.0'
to
85.8'

SC-10
85.8'
to
88.1'

SC-10
88.1'
to
93.1'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-08
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON | Sheet 3 of 4

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

SC-10
93.1'
to
96.1'

SC-11
96.1'
to
99.0'

Note: Sample SC-11 was dropped while bagging. Disturbed material collected from barge deck and boxed.

SC-11
99.0'
to
105.0'

Note: Sample SC-11 was dropped while bagging. Disturbed material collected from barge deck and boxed.

SC-11
105.0'
to
110.9

Note: Sample SC-11 was dropped while bagging. Disturbed material collected from barge deck and boxed.

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

BORING IBR-08
CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON

Sheet 4 of 4

APPENDIX B.
NORTH PORTLAND HARBOR BORING LOGS AND CORE PHOTOGRAPHS
TABLE OF CONTENTS

TABLES

ATTACHMENTS

Drill Logs and Core Photographs
Boring IBR-01
Boring IBR-02

1. GENERAL

Shannon & Wilson drilled two geotechnical borings in the North Portland Harbor channel of the Columbia River for the IBR Project. Boring logs and core photographs from the six borings drilled in the main channel of the Columbia River are presented separately in Appendix A. All borings were drilled from a barge over water. Table B-1 summarizes exploration designation, borehole coordinates, depth, and other details. The borings were completed between November 16, 2023, and January 25, 2024. Both borings were surveyed during drilling by the design team relative to the IBR Project's Local Datum Plane (LDP) system. Elevations for the project are North American Vertical Datum of 1988 (NAVD88). Exploration locations are shown on the Site and Exploration Plan, Figure 1-3.

This appendix describes the techniques used to advance and sample the borings, presents logs of the materials encountered during drilling, and details borehole backfill. Downhole suspension velocity testing was also conducted in the mud rotary boring. These tests are described with their results in Appendix C, Borehole Suspension Logging Results.

Table B-1. North Portland Harbor Drilling Summary

Exploration Designation	Northing (ft)[A]	Easting (ft)[A]	Mudline Elevation (ft)[B]	Total Depth (ft)	Drilling Method	Start Date	End Date
IBR-01	107606.2	1081681.0	-9.3	209.9	Rotosonic	11/16/2023	11/21/2023
IBR-02	107927.5	1082095.2	-10.2	225.8	Mud Rotary	1/9/2024	1/25/2024

Notes:

A IBR Project LDP, defined as Washington State Plane South/1.0000576 (US Survey Feet)

B NAVD88 (US Survey Feet)

2. DRILLING OVERVIEW

The geotechnical borings were drilled with two drill rigs provided and operated by Western States Soil Conservation, Inc. (Western States), of Hubbard, Oregon. The borings were drilled from a floating barge that was provided and operated by Mark Marine Service, Inc., of Washougal, Washington. One boring was drilled using mud rotary techniques and one boring was drilled using rotosonic techniques. Drilling supervision, including sample collection and field logging of subsurface material, was performed by Shannon & Wilson.

3. GEOTECHNICAL DRILLING AND SAMPLING METHODOLOGY

3.1 Mud Rotary Drilling Technique

For mud rotary drilling performed over water, before the borehole is started, a steel circulation casing is pushed and/or driven to a depth of approximately 10 to 15 feet below the mud line (or more depending on conditions), sealing off any circulating drill fluids from the river. Often, the circulation casing is pushed to refusal using the drill rig hydraulic system or driven with a casing hammer. Once the casing is sealed below the mud line, the boring is advanced using a tri-cone bit and a string of hollow drill rods (narrower than the bit) through which bentonite drilling mud is pumped. The mud is mixed on site using water and powdered bentonite. The drilling mud serves to cool the bit, keep the hole open, and flush the cuttings to the surface. Returning drill mud is typically passed through the circulation casing from the borehole to a screen and tub that is situated over the circulation casing on the deck of the barge. The screen collects the drill cuttings from the borehole, and the tub collects the mud for recirculation back into the hole. If fine-grained, cohesive soils are encountered, other styles of drill bits may also be used with the mud-rotary method, such as scraper or drag bits.

3.1.1 Standard Penetration Test (SPT) Sampling

Disturbed samples were collected in the mud rotary borings at 2-, 5-, or 10-foot intervals using a standard 2-inch outside-diameter (O.D.) split spoon sampler in conjunction with Standard Penetration Testing. In a Standard Penetration Test (SPT), ASTM D1586, the sampler is driven 18 inches into the soil using a 140-pound hammer dropped 30 inches. The number of blows required to drive the sampler the last 12 inches is defined as the standard penetration resistance, or N-value. The SPT N-value provides a measure of in situ relative density of cohesionless soils (silt, sand, and gravel) and the consistency of cohesive soils (silt and clay). In some instances, a 3-inch-O.D. Dames & Moore sampler was used to collect disturbed samples. A 140-pound hammer was used to drive these larger-diameter samplers. All disturbed samples were visually identified and described in the field at the time of sampling, sealed in a labeled plastic jar or bag to retain moisture, and returned to the laboratory for additional examination and testing.

SPT N-values can be significantly affected by several factors, including the efficiency of the hammer used. Measured efficiencies of the automatic hammers used for this project, based on available information we received from our drilling subcontractor, are shown on the boring logs. The field recorded N-values are summarized on the boring logs. Field recorded N-values, shown numerically on the logs, have not been corrected for hammer efficiency, overburden pressure, flexure of the rods, or silt content. An SPT was considered to have met refusal where more than 50 blows were required to drive the 2-inch-O.D. sampler 6 inches (100 blows for larger-O.D. samplers). In this case, the blows are reported as 50 over the distance driven in 50 blows, such as 50/4”. Sample recovery is identified as a percentage of material retained for the length the sampler was driven.

3.1.2 Geotechnical Relatively Undisturbed Sampling

Relatively undisturbed samples were collected in some mud rotary borings in 3-inch-OD thin-wall Shelby tubes, which were hydraulically pushed into the undisturbed soil at the bottoms of boreholes. The soils exposed at the ends of the tubes were examined and described in the field. After examination, the ends of the tubes were sealed to preserve the natural moisture of the samples. The sealed tubes were stored in the upright position, and care was taken to avoid shock and vibration during their transport and storage in the laboratory.

3.2 Rotosonic Drilling Technique

During rotosonic drilling, also referred to as sonic rotary drilling, an inner core barrel is rotated while an oscillator in the drill head imposes a high frequency vibration into the drill rods and core barrel. This forces the core barrel and drill bit to be physically vibrating up and down in addition to being forced down and rotating. These three forces, vibration, rotation, and downward force combine to advance the core barrel through soil or bedrock. As the core barrel is advanced the center fills with the soil or rock it is being advanced through. When the core barrel is advanced a certain distance determined by the length of the core barrel it is stopped. An over-casing is advanced over the outside of the core barrel to the same depth as the core barrel tip using the same sonic vibration, rotation and downward force. The over casing protects the borehole integrity and prevents the borehole from collapsing as the core barrel is retrieved. Multiple over casings may be used to maintain borehole integrity and reduce the outside forces on the inner core barrel and inner casings. The inner core barrel is retracted to the surface where it is emptied into long cylindrical bags as a long soil core or rock core sample. This alternating process of core barrel and over casing advancement with core barrel retrieval is continued to the terminal depth of the borehole.

3.2.1 Rotosonic Continuous Sampling

To retrieve a core sample, the core barrel is withdrawn from the hole and the sample is extruded into tubular plastic bags using vibration. During this exploration program, the boreholes were advanced in five- to twenty-foot intervals while continuously core sampling. The bags of approximately 4- to 6-inch diameter core were placed into wooden boxes and logged and photographed by a Shannon & Wilson geology staff member. Due to disturbance to the soil column during drilling and bagging of the sample, sample recoveries and discreet grab sample depths should be considered approximate.

4. BOREHOLE ABANDONMENT

Once drilling and testing were completed, all borings were backfilled with a high-solids bentonite cement grout, in accordance with Oregon Water Resources Department regulations.

5. MATERIAL DESCRIPTIONS

In the field, soil samples were described and identified in accordance with Chapter 5 of the ODOT Geotechnical Design Manual (2023). The ASTM International (ASTM) D2488 Visual-Manual method was also used as a guide in determining the key diagnostic properties of soils. Consistency, color, relative moisture, degree of plasticity, peculiar odors, and other distinguishing characteristics of the samples were noted. Once returned to the laboratory, the samples were re-examined, various standard laboratory tests were conducted, and the field descriptions and identifications were modified where necessary. We refined our visual-manual soil descriptions and identifications based on the results of the laboratory tests, using elements of the Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), ASTM D2487. Please refer to the ODOT Geotechnical Design Manual (2023) and ASTM D2487 for definitions of descriptive terminology used in the boring logs.

The ODOT Geotechnical Design Manual requires an estimated percentage by volume of cobble and/or boulder constituents, to be based on “recovered intersected or observed lengths and/or drill rig behavior.” Cobbles are defined as “particles of rock that will pass a 12-inch square opening and be retained on a 3-inch sieve” and boulders are defined as “particles of rock that will not pass a 12-inch square opening.” Due to the limitations inherent in obtaining representative samples of particles larger than the sampler diameter, the rough volume estimates provided on the logs should not be relied on. Any cobble and boulder estimates provided in a Geotechnical Baseline Report (or similar document) for the project shall take precedence over the volume estimates on these boring logs. The soil group name in ASTM D2487 and D2488 is based on the portion of the soil sample passing the 3-inch sieve. Refer to the photographs of samples obtained through rotosonic core drilling for estimating the quantities of cobble/boulder constituents recovered from those explorations. It should be noted that the samples presented in the photographs have been disturbed and the finer- and coarser-grained fractions can be segregated during drilling, sampling, and handling.

6. BORING LOGS AND CORE PHOTOGRAPHS

Summary logs of the borings are attached to this appendix. Logs of borings that included soil coring are followed by core photographs. Soil descriptions and interfaces on the logs are interpretive and actual changes may be gradual. The left-hand portion of the drill logs gives depth, individual sample intervals and identifications, percent recovery, Standard Penetration Test data, and natural moisture content measurements. Material descriptions are shown in the center of the drill log, and the right-hand portion provides a graphic log, selected laboratory test results (Atterberg limits and percent fines), miscellaneous comments, and a graphic depicting hole backfill details.

SHANNON & WILSON

DRILL LOG

OREGON DEPARTMENT OF TRANSPORTATION

Page **1** of **8**

			Hole No. **IBR-01**
Project **Interstate Bridge Replacement Program**		Purpose **Bridge Structure**	E.A. No. **N/A**
Highway **001**		County **Multnomah**	Key No. **N/A**
Hole Location Northing: **107,606.2**	Easting: **1,081,681.0**		Start Card No. **N/A**
Equipment **Geoprobe 8150LS Sonic Track Rig**		Driller **Western States/John & Alex**	Bridge No. **N/A**
Project Geologist **Veronica Biesiada, RG**		Recorder **Connor McCord**	Ground Elev. **-9.3 ft.**
Start Date **November 16, 2023**	End Date **November 21, 2023**	Total Depth **209.00 ft**	Tube Height **N/A**

Test Type

"A" - Auger Core	"GP" - GeoProbe®
"X" - Auger	"T" - Test Pit
"C" - Core, Barrel Type	
"N" - Standard Penetration	
"D&M" - Dames & Moore	
"U" - Undisturbed Sample	

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: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
0	S1	60				S- 1 (0.00-12.50) SAND to SAND with trace silt and gravel, SP; dark gray (2.5Y 4/1), wet, fine subrounded gravel, fine to coarse sand, micaceous.	**0.00 - 14.00** **SAND to SAND with trace silt and gravel, SP; dark gray (2.5Y 4/1), wet, fine subrounded gravel, fine to coarse sand, micaceous.**		Borehole drilled from barge using rotosonic drilling technique (8-inch hole). Driller using 6-inch ID standard sonic core barrel bit. S1: 1% gravel, 98% sand, 1% fines.		
5											
10											
	S2	55				S- 2 (12.50-23.40).			Sand heave observed in sonic casing before Sample S2.		
	S2A					S- 2A (12.50-14.00) SAND to SAND with trace silt and gravel, SP; dark gray (2.5Y 4/1), wet, fine subrounded gravel, fine to coarse sand, micaceous.					
	S2B					S- 2B (14.00-23.40) SAND with some silt, SP-SM; dark gray (2.5Y 4/1), nonplastic fines, wet, fine to coarse sand, micaceous.	**14.00 - 30.00** **SAND with some silt, SP-SM; dark gray (2.5Y 4/1), nonplastic fines, wet, fine to coarse sand, micaceous.**				
15											
19											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
19											
20											
									S2B: 89% sand, 11% fines.		
	S3 S3A	25				S- 3 (23.40-33.60) Poor sample recovery. S- 3A (23.40-30.00) SAND with some silt, SP-SM; dark gray (2.5Y 4/1), nonplastic fines, wet, fine to coarse sand, micaceous.			Driller switched to 4-inch ID auger sonic core barrel bit (6-inch hole).		
25											
30	S3B					S- 3B (30.00-33.60) SAND with trace silt, SP; dark gray (2.5Y 4/1), wet, fine to medium sand, micaceous.	**30.00 - 41.00** **SAND with trace silt, SP; dark gray (2.5Y 4/1), wet, fine to medium sand, micaceous.**				
	S4 S4A	60				S- 4 (33.60-43.60). S- 4A (33.60-41.00) SAND with trace silt, SP; dark gray (2.5Y 4/1), wet, fine to medium sand, micaceous.			Driller switched to 4-inch ID flapper sonic core barrel bit.		
35									S4A: 97% sand, 3% fines.		
									Driller noted soft drilling from approximately 38 to 41 feet.		
40											
	S4B					S- 4B (41.00-43.60) Silty SAND, SM; dark gray (2.5Y 4/1), nonplastic to low plasticity fines, moist to wet, fine sand, laminated, micaceous, trace organics and wood fragments.	**41.00 - 45.10** **Silty SAND, SM; dark gray (2.5Y 4/1), nonplastic to low plasticity fines, moist to wet, fine sand, laminated, micaceous, trace organics and wood fragments.**		S4B: 58% sand, 42% fines.		
	S5 S5A	60				S- 5 (43.60-53.80). S- 5A (43.60-45.10) Silty SAND, SM; dark gray (2.5Y 4/1), nonplastic to low plasticity fines, moist to wet, fine to medium sand, laminated, micaceous, trace organics and wood fragments.			Approximately 0.8 feet of sand heave measured before Sample S5.		
45	S5B					S- 5B (45.10-47.60) Clayey SILT with trace sand, MH; dark grayish brown (2.5Y 4/2), medium plasticity, moist, fine sand, micaceous, trace organics and wood fragments.	**45.10 - 47.60** **Clayey SILT with trace sand, MH; dark grayish brown (2.5Y 4/2), medium plasticity, moist, fine**		Atterberg Limits S5B: LL=52, PL=31, PI=21; 7% sand, 93% fines.		
48											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
48	S5C					S- 5C (47.60-53.80) Silty SAND, SM; dark gray (2.5Y 4/1) to dark grayish brown (2.5Y 4/2), nonplastic to low plasticity fines, moist, fine to medium sand, micaceous.	**sand, micaceous, trace organics and wood fragments.** **47.60 - 53.80** **Silty SAND, SM; dark gray (2.5Y 4/1) to dark grayish brown (2.5Y 4/2), nonplastic to low plasticity fines, moist, fine to medium sand, micaceous.**				
50									Driller noted soft drilling from 50 to 75 feet.		
	S6	0				S- 6 (53.80-64.00) No Recovery.	**53.80 - 74.20** **No Recovery.**		Driller switched to 4-inch ID auger sonic core barrel bit. No recovery. Attempted to retrieve sample by switching to 4-inch ID flapper sonic core barrel bit.		
55											
									No sample recovery from 53.8 to 74.2 feet. Inferred Silty SAND to SAND with some silt, SM/SP-SM, based on drill action.		
60											
	S7	0				S- 7 (64.00-74.20) No Recovery.			Driller using 4-inch ID flapper sonic core barrel bit.		
65											
70											
	S8 S8A	40				S- 8 (74.20-82.50). S- 8A (74.20-76.70) SAND with some silt, SP-SM; dark gray (2.5Y 4/1), nonplastic fines, moist to wet, fine to medium sand, micaceous.	**74.20 - 76.70** **SAND with some silt, SP-SM; dark gray (2.5Y 4/1), nonplastic**				
75									S8A: 94% sand, 6% fines.		
76											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/Date	Backfill/Instrumentation
76							**fines, moist to wet, fine to medium sand, micaceous.**				
	S8B					S- 8B (76.70-82.50) Silty SAND, SM; dark grayish brown (2.5Y 4/2), nonplastic to low plasticity fines, wet, fine to medium sand, stratified with Sandy SILT, ML, micaceous, trace organics and wood fragments.	**76.70 - 83.60** **Silty SAND, SM; dark grayish brown (2.5Y 4/2), nonplastic to low plasticity fines, wet, fine sand, stratified with Sandy SILT, ML, micaceous, trace organics and wood fragments.**				
80											
	S9	100				S- 9 (82.50-92.50).			Atterberg Limits S9A: LL=22, PL=20, PI=2; 62% sand, 38% fines.		
	S9A					S- 9A (82.50-83.60) Silty SAND, SM; dark grayish brown (2.5Y 4/2), nonplastic to low plasticity fines, wet, fine sand, stratified with Sandy SILT, ML, micaceous, trace organics and wood fragments.					
	S9B					S- 9B (83.60-92.50) Silty SAND with trace gravel, SM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, moist to wet, fine subrounded to rounded gravel, fine to coarse sand, micaceous.	**83.60 - 92.50** **Silty SAND with trace gravel, SM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, moist to wet, fine subrounded to rounded gravel, fine to coarse sand, micaceous.**				
85									Driller noted harder drilling at approximately 86 feet.		
90									*NOTE: Grain size analysis distributions from samples below 92.5 feet may not be representative due to fractured clasts.*		
	S10	100				S- 10 (92.50-103.40).	**92.50 - 93.70** **Gravelly SAND with trace silt, SP; dark gray (2.5Y 4/1) to dark grayish brown (2.5Y 4/2), moist to wet, fine to coarse subrounded to well rounded gravel, fine to coarse sand, micaceous.**		Driller switched to 4-inch ID standard sonic core barrel bit.		
	S10A					S- 10A (92.50-93.70) Gravelly SAND with trace silt, SP; dark gray (2.5Y 4/1) to dark grayish brown (2.5Y 4/2), moist to wet, fine to coarse subrounded to well rounded gravel, fine to coarse sand, micaceous.			S10A: 38% gravel, 58% sand, 4% fines.		
	S10B					S- 10B (93.70-96.10) SILT with some sand and trace gravel, with cobbles, ML; dark gray (2.5Y 4/1) to dark grayish brown (2.5Y 4/2), nonplastic, moist to wet, estimated 30-40% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 6 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand.	**93.70 - 96.10** **SILT with some sand and trace gravel, with cobbles, ML; dark gray (2.5Y 4/1) to dark grayish brown (2.5Y 4/2), nonplastic, moist to wet, estimated 30-40% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 6 inches, fine to coarse subrounded to well rounded gravel, fine to coarse sand.**		Atterberg Limits S10B: LL=NP, PL=NP, PI=NP; 7% gravel, 17% sand, 76% fines; original field sample had 12% cobbles by weight.		
95											
	S10C					S- 10C (96.10-103.40) Sandy GRAVEL with trace silt, with cobbles and possible boulders, GP; gray (2.5Y 5/1) to dark gray (2.5Y 4/1), moist to wet, estimated 25-35% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 6 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.			S10C: 64% gravel, 33% sand, 3% fines; original field sample had 4% cobbles by weight.		
100											
	S11	50				S- 11 (103.40-113.70) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; gray (2.5Y 5/1) to dark gray (2.5Y 4/1), nonplastic fines, wet,	**96.10 - 113.70** **Sandy GRAVEL with trace to some silt,**		S11: 53% gravel, 35% sand, 12% fines; original field sample had 17%		
105											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
105 105						estimated 40-50% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 7 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.	**with cobbles and possible boulders, GP/GP-GM; gray (2.5Y 5/1) to dark gray (2.5Y 4/1), nonplastic fines, moist to wet, estimated 25-50% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 7 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.**		cobbles by weight.		
110											
	S12	100				S- 12 (113.70-124.40) GRAVEL with some sand and trace silt, with cobbles and possible boulders, GW; gray (2.5Y 5/1), dark gray (2.5Y 4/1), and dark grayish brown (2.5Y 4/3), moist to wet, estimated 25-35% by volume R4-R5 subrounded basalt cobbles, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling, cobbles and boulders inferred from drill action.	**113.70 - 135.60** **GRAVEL with some sand and trace silt, with cobbles and boulders, GW; gray (2.5Y 5/1), dark gray (2.5Y 4/1), and dark grayish brown (2.5Y 4/3), moist to wet, estimated 25-50% by volume R4-R5 basalt cobbles and boulders with maximum recovered clast dimension of 16 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.**		S12: 72% gravel, 25% sand, 3% fines.		
115											
120											
	S13	13				S- 13 (124.40-135.60) GRAVEL with some sand and trace silt, with cobbles and boulders, GW; dark gray (2.5Y 4/1), moist to wet, estimated 40-50% by volume R4-R5 basalt cobbles and boulders with maximum recovered clast dimension of 16 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, low recovery, fractured clasts from sonic drilling.					
125									Drill action indicates boulder from approximately 125 to 127 feet.		
130											
133											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
133											
135											
	S14	80				S- 14 (135.60-145.40) GRAVEL with some sand and silt, with cobbles and possible boulders, GP-GM; gray (2.5Y 5/1), dark gray (2.5Y 4/1), and dark grayish brown (2.5Y 4/3), nonplastic fines, wet, estimated 35-45% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 4 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.	**135.60 - 146.60 GRAVEL with some sand and silt, with cobbles and possible boulders, GP-GM; gray (2.5Y 5/1), dark gray (2.5Y 4/1), and dark grayish brown (2.5Y 4/3), nonplastic fines, wet, estimated 20-45% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 4 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.**				
140											
145											
	S15 S15A	100				S- 15 (145.40-154.40). S- 15A (145.40-146.60) GRAVEL with some sand and silt, with cobbles and possible boulders, GP-GM; gray (2.5Y 5/1), dark gray (2.5Y 4/1), and dark grayish brown (2.5Y 4/3), nonplastic fines, wet, estimated 20-30% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 3 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, fractured clasts from sonic drilling.			Driller noted harder drilling at approximately 146 feet.		
	S15B					S- 15B (146.60-154.40) Silty/Clayey GRAVEL with some sand, with cobbles and possible boulders, GM/GC; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic to medium plasticity fines, moist, estimated 20-30% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 3 inches, fine to coarse, subangular to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, zones of weak cementation, cobbles and boulders inferred from drill action, fractured clasts from sonic drilling.	**146.60 - 171.00 Silty/Clayey GRAVEL with some sand, with cobbles and possible boulders, GM/GC; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic to medium plasticity fines, moist, estimated 15-30% by volume R4-R5, subrounded basalt cobbles with maximum recovered clast dimension of 3 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, zones of weak cementation, fractured clasts from sonic drilling.**		S15B: 62% gravel, 25% sand, 13% fines.		
150											
	S16	100				S- 16 (154.40-163.70) Silty/Clayey GRAVEL with some sand, with cobbles and possible boulders, GM/GC; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic to medium plasticity fines, moist, estimated 15-25% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 2 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, zones of weak cementation, fractured clasts from sonic drilling.					
155											
160											
162											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
162											
	S17 S17A	100				S- 17 (163.70-178.70). S- 17A (163.70-171.00) Silty/Clayey GRAVEL with some sand, with cobbles and possible boulders, GM/GC; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic to medium plasticity fines, moist, estimated 20-30% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 3 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, zones of weak cementation, fractured clasts from sonic drilling.			Driller attempted a 20-foot run; could only penetrate 15 feet.		
165											
170											
	S17B					S- 17B (171.00-178.70) GRAVEL with some sand and silt, with cobbles and possible boulders, GP-GM; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic fines, moist to wet, estimated 20-30% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 3 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, fractured clasts from sonic drilling.	**171.00 - 209.00 GRAVEL with some sand and some silt, with cobbles and possible boulders to Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic fines, moist to wet, estimated 20-40% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 4 inches, fine to coarse subrounded to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, fractured clasts from sonic drilling.**				
175											
	S18	100				S- 18 (178.70-193.90) GRAVEL with some sand and silt to Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic fines, moist to wet, estimated 25-35% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 4 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, fractured clasts from sonic drilling.			S18: 64% gravel, 30% sand, 6% fines.		
180											
185											
190											

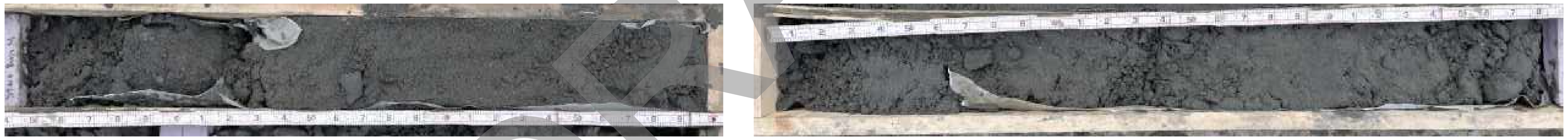
Depth (ft)	Test Type, No.	Percent Recovery	Soil Driving Resistance	Rock Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
190											
	S19	100				S- 19 (193.90-209.00) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic fines, moist to wet, estimated 30-40% by volume R4-R5 subrounded basalt cobbles with maximum recovered clast dimension of 3 inches, fine to coarse subangular to well rounded gravel, fine to coarse sand, micaceous, iron oxide staining, fractured clasts from sonic drilling.					
195											
200											
205											
							209.00 **End of hole.**				
210											
215											
219											

S-1
0.0'
to
12.5'

S-2
12.5'
to
23.4'

S-3
23.4'
to
33.6'

S-4
33.6'
to
43.6'



S-5
43.6'
to
53.8'

S-6 - No Recovery
S-7 - No Recovery

S-8
74.2'
to
82.5'

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Interstate Bridge Replacement Program
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CORE PHOTOGRAPHS

May 2024 105511

SHANNON & WILSON

S-9
82.5'
to
92.5'

S-10
92.5'
to
97.5'

S-10
97.5'
to
103.4'

S-11
103.4'
to
113.7'

S-12
113.7'
to
118.7'

S-12
118.7'
to
124.4'

Interstate Bridge Replacement Program
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May 2024 105511

SHANNON & WILSON Sheet 2 of 5

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

S-13
124.4'
to
135.6'

S-14
135.6'
to
141.9'

S-14
141.9'
to
145.4'

S-15
145.4'
to
149.9'

S-15
149.9'
to
154.4'

S-16
154.4'
to
159.0'

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SHANNON & WILSON

Sheet 3 of 5

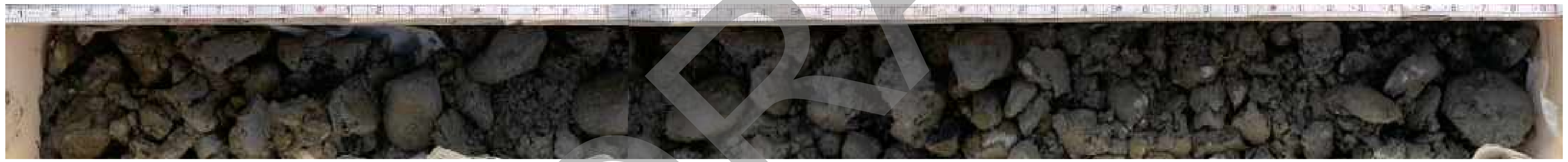
File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

S-16
159.0'
to
163.7'

S-17
163.7'
to
168.7'

S-17
168.7'
to
173.7'

S-17
173.7'
to
178.7'



S-18
178.7'
to
183.7'

S-18
183.7'
to
188.7'

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

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File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

S-18
188.7'
to
192.0'

S-18
192.0'
to
193.9'

S-19
193.9'
to
198.9'

S-19
198.9'
to
203.9'

S-19
203.9'
to
207.2'

S-19
207.2'
to
209.0'

File: P:\PDX\105000s\105511 WSDOT-ODOT Intel\DRAFTING\Core Photos.dwg Date: 05-30-2024 Author: AEH

Interstate Bridge Replacement Program
Portland, Oregon / Vancouver, Washington

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SHANNON & WILSON Sheet 5 of 5

SHANNON & WILSON

DRILL LOG

OREGON DEPARTMENT OF TRANSPORTATION

		Hole No. **IBR-02**
Project **Interstate Bridge Replacement Program**	Purpose **Bridge Structure**	E.A. No. **N/A**
Highway **001**	County **Multnomah**	Key No. **N/A**
Hole Location Northing: **107,927.5** Easting: **1,082,095.2**		Start Card No. **N/A**
Equipment **CME-850XR Track Rig (ID: 417612, Hammer Efficiency=89.4%)**	Driller **Western States/Aaron & Wyatt**	Bridge No. **N/A**
Project Geologist **Veronica Biesiada, RG**	Recorder **Connor McCord**	Ground Elev. **-10.2 ft.**
Start Date **January 9, 2024** End Date **January 25, 2024**	Total Depth **225.80 ft**	Tube Height **N/A**

Test Type

"A" - Auger Core
"X" - Auger
"C" - Core, Barrel Type
"N" - Standard Penetration
"D&M" - Dames & Moore
"U" - Undisturbed Sample
"GP" - GeoProbe®
"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: Driving Resistance	Rock: 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, Strength, 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 - 12.00** **Silty SAND, SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, loose, fine to medium sand, micaceous, occasional plastic debris.**		Borehole drilled from barge using mud rotary drilling technique (5.5-inch hole). Suspension logging performed between depths of 72.2 and 213.3 feet.		
5											
10											
	N1	47	2-3-2		30	N- 1 (10.50-12.00) Silty SAND with trace gravel, SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, loose, fine rounded gravel, fine to medium sand, micaceous, occasional plastic debris.			N1: 1% gravel, 86% sand, 13% fines.		
							12.00 - 14.70 **Silty SAND with trace gravel, SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, loose, fine rounded gravel, fine to coarse sand, micaceous.**				
	N2	73	4-5-4		30	N- 2 (12.70-14.20) Silty SAND, SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, loose, fine to coarse sand, micaceous.					
15							**14.70 - 19.20** **SAND with trace silt and gravel, SP; dark grayish brown (2.5Y 4/2), wet, loose, fine rounded gravel, fine to coarse sand, micaceous.**				
	N3	33	1-2-3		35	N- 3 (15.20-16.70) SAND with trace silt and gravel, SP; dark grayish brown (2.5Y 4/2), wet, loose, fine rounded gravel, fine to coarse sand, micaceous.					
	N4	60	1-2-3		39	N- 4 (17.20-18.70) SAND with trace silt and gravel, SP; dark grayish brown (2.5Y 4/2), wet, loose, fine rounded gravel, fine to coarse sand, micaceous.			N4: 3% gravel, 93% sand, 4% fines.		
19											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance / Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
19						**19.20 - 43.00** **SAND with trace silt, SP; dark grayish brown (2.5Y 4/2), wet, loose to medium dense, fine to medium sand, micaceous.**				
20	N5	53	5-5-5	40	N- 5 (19.70-21.20) SAND with trace silt, SP; dark grayish brown (2.5Y 4/2), wet, loose to medium dense, fine to medium sand, micaceous.					
	N6	53	2-5-5	33	N- 6 (23.30-24.80) SAND with trace silt, SP; dark grayish brown (2.5Y 4/2), wet, loose to medium dense, fine to medium sand, micaceous.			N6: 97% sand, 3% fines.		
25										
	N7	40	3-3-3	36	N- 7 (28.10-29.60) SAND with trace silt, SP; dark grayish brown (2.5Y 4/2), wet, loose, fine to medium sand, micaceous.					
30										
	N8	60	5-6-6	32	N- 8 (32.90-34.40) SAND with trace silt, SP; dark grayish brown (2.5Y 4/2), wet, medium dense, fine to medium sand, micaceous.					
35										
	N9	73	6-9-9	31	N- 9 (37.70-39.20) SAND with trace silt, SP; dark grayish brown (2.5Y 4/2), wet, medium dense, fine to medium sand, micaceous.					
40								Driller noted borehole instability from 40 to 140 feet. Redrilled multiple times.		
						43.00 - 50.00 **SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.**				
45										
	N10	67	7-8-7	31	N- 10 (45.90-47.40) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.			N10: 95% sand, 5% fines.		
48										

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance / Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
48										
50						**50.00 - 54.00** **SAND with trace to some silt and trace gravel, SP/SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, very loose, fine rounded gravel, fine to coarse sand, stratified with SILT with sand, ML, micaceous.**				
	N11	33	1-2-1	35	N- 11 (52.40-53.90) SAND with trace silt and trace gravel, SP; dark grayish brown (2.5Y 4/2), wet, very loose, fine rounded gravel, fine to coarse sand, micaceous.			N11: 1% gravel, 95% sand, 4% fines.		
						54.00 - 93.00 **SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.**				
	U1	100			U- 1 (54.30-56.30) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, fine to medium sand, stratified with SILT with sand, ML, micaceous.					
55										
	N12	47	6-8-8	37	N- 12 (56.30-57.80) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.					
60								Borehole sloughing from 60 to 105 feet.		
	N13	73	9-13-15	31	N- 13 (61.20-62.70) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine sand, micaceous.			N13: 94% sand, 6% fines.		
65										
	N14	33	10-11-11	33	N- 14 (66.20-67.70) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.					
70										
	N15	60	10-12-14	33	N- 15 (71.10-72.60) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.			N15: 94% sand, 6% fines.		
75										
76										

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance / Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
76	N16	53	14-13-14	31	N- 16 (76.10-77.60) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.					
80										
	N17	53	10-12-17	33	N- 17 (80.70-82.20) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.					
85										
	N18	40	10-11-12	35	N- 18 (85.70-87.20) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.					
90	N19	60	15-14-12	31	N- 19 (90.10-91.60) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, medium dense, fine to medium sand, micaceous.			N19: 92% sand, 8% fines.		
						93.00 - 109.30 SAND with some silt to SAND with some silt and trace gravel, SP-SM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, wet, dense, fine subrounded gravel, fine to coarse sand, micaceous.				
95	N20	73	13-20-19	32	N- 20 (94.90-96.40) SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, dense, fine to medium sand, micaceous.					
100	N21	67	15-20-15	24	N- 21 (99.60-101.10) SAND with some silt and trace gravel, SP-SM; dark grayish brown (2.5Y 4/2), nonplastic fines, wet, dense, fine subrounded gravel, fine to coarse sand, micaceous.			N21: 5% gravel, 85% sand, 10% fines.		
105										

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
105 105											
	N22	33	14-14-23		34	N- 22 (105.40-106.90) SAND with some silt and trace gravel, SP-SM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, wet, dense, fine to coarse sand, micaceous.					
							109.30 - 145.00 Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand.		Driller noted harder drilling at 109.3 feet. Drill action indicates cobbles and possible boulders from 109.3 to 162 feet.		
110											
	N23	0	50/1st 0.5"			N- 23 (110.90-110.95) No Recovery.					
									Lost drilling mud circulation at 113 feet. Occasional drilling mud circulation loss from 113 to 140 feet.		
115											
120											
	N24	67	50/1st 3"			N- 24 (121.20-121.50) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, Dames & Moore sample attempted over same interval with no recovery.			Borehole sloughing at 121.5 feet.		
125											
130	N25	100	50/1st 2"			N- 25 (129.90-130.10) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dense, limited sample recovery, description based on drill action.			Lost drilling mud circulation and approximately 350 gallons of drilling mud loss from 130 to 140 feet. Driller used another 250 gallons of thick mud to attempt to		
133											

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance / Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks / Water Level/Date	Backfill/Instrumentation
133								regain circulation. Pulled drill rods and redrilled to 140 feet through slough.	
135									
140	N26	100	50/1st 1"		N- 26 (140.10-140.20) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dense, limited sample recovery, description based on drill action, Dames & Moore sample attempted over same interval with no recovery.			Approximately 1200 gallons of drilling mud loss from 140 to 150 feet.	
145						**145.00 - 162.00 GRAVEL with some sand and trace silt, with cobbles and possible boulders, GP; very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.**			
	D&M1	50	100/1st 4"		D&M- 1 (149.30-149.60) GRAVEL with some sand and trace silt, with cobbles and possible boulders, GP; limited sample recovery, description based on drill action.				
150	N27	100	50/1st 6"		N- 27 (150.00-150.50) GRAVEL with some sand and trace silt, with cobbles and possible boulders, GP; very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.			Approximately 300 gallons of drilling mud loss from 150 to 160 feet.	
155								Driller noted easier drilling from 154 to 155 feet.	
160	N28	63	44-50/3"		N- 28 (159.90-160.70) GRAVEL with some sand and trace silt, with cobbles and possible boulders, GP; very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.			Approximately 300 gallons of drilling mud loss from 160 to 170 feet.	
162									

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance / Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
162						**162.00 - 185.00 Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dark gray (2.5Y 3/1), dark grayish brown (2.5Y 4/2), dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic fines, wet, very dense, fine to coarse, subangular to well rounded gravel, fine to coarse sand, iron oxide staining.**		Driller noted smooth drilling from 162 to 165 feet. Drill action indicated intermittent cobbles from 165 to 170 feet.		
165										
	D&M2	50	57-58-68		D&M- 2 (169.20-170.70) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), nonplastic fines, wet, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.					
170								Approximately 300 gallons of drilling mud loss from 170 to 180 feet. Driller noted smooth drilling from 170 to 187 feet.		
	N29	80	17-32-50		N- 29 (170.70-172.20) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dark gray (2.5Y 3/1) to dark grayish brown (2.5Y 4/2), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.					
175										
	N30	67	45-46-43		N- 30 (177.90-179.40) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; dark gray (2.5Y 4/1), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.					
180								Approximately 100 gallons of drilling mud loss from 180 to 190 feet.		
185						**185.00 - 205.00 Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand,**				
	N31	25	50/1st 5"		N- 31 (187.80-188.20) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; very dense, limited sample recovery, description based on drill action.			Drill action indicates intermittent cobbles from 187 to 215 feet.		
190										

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance / Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
190						**iron oxide staining.**		Approximately 50 gallons of drilling mud loss from 190 to 210 feet.		
195										
	N32	54	38-36-50/4"		N- 32 (198.50-199.80) Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.					
200										
205						**205.00 - 215.00 Gravelly SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.**				
	N33	53	50-48-48	15	N- 33 (208.50-210.00) Gravelly SAND with some silt, SP-SM; dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/3), nonplastic fines, wet, very dense, fine to coarse subangular to well rounded gravel, fine to coarse sand, iron oxide staining.			N33: 42% gravel, 51% sand, 7% fines.		
210								Approximately 300 gallons of drilling mud loss from 210 to 220 feet. Drill action indicates cobbles and possible boulders from 215 feet to end of hole.		
215						**215.00 - 225.80 Sandy GRAVEL with some silt, with cobbles and possible boulders, GP-GM, very dense, limited sample recovery, description based on drill action.**				
219	N34	50	50/1st 2"		N- 34 (218.10-218.30) Sandy GRAVEL with some silt,					

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: 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, Strength, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
219						with cobbles and possible boulders, GP-GM; very dense, limited sample recovery, description based on drill action.					
220											
225											
							225.80 **End of hole.**		Approximately 130 feet of drill rod sheared off when drilling at 225.8 feet and driller could not retrieve an approximate 1-foot section of rod from the bottom of the borehole. Boring terminated.		
230											
235											
240											
245											
247											

APPENDIX C.
BOREHOLE SUSPENSION LOGGING RESULTS
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ATTACHMENTS

GEOVision Report 24016-01
Global Geophysics Report 114-0108.000

1. GENERAL

GEOVision Geophysical Services (GEOVision) of Corona, California and Global Geophysics of Redmond, Washington performed the downhole geophysical measurements of compression (P) and shear (S) wave velocities using a method known as OYO P-S Suspension Logging. The logging was conducted while the borings were open prior to backfill and the data collected can be used to generate a profile showing wave velocities with depth. Measurements were taken at approximately 1.6-foot depth intervals using a down-hole probe that contains a wave source and two geophones. A description of the testing procedures and the geophysical logs are located at the end of this appendix in the reports provided by GEOVision and Global Geophysics. GEOVision performed suspension logging in borings IBR-02, IBR-03, and IBR-05. Global Geophysics performed suspension logging in boring IBR-07.

BOREHOLE GEOPHYSICS
PORT INTERSTATE BRIDGE REPLACEMENT
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March 12, 2024

Report 24016-01 Rev 0

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INTRODUCTION

GEO*Vision* acquired PS Suspension velocity data in three boreholes at the I-5 bridge replacement project in Vancouver, Washington. A GEOVision Professional Engineer reviewed fieldwork, data analysis, and report preparation. A summary of the instrumentation, methods, data analysis, and final results follows.

SCOPE OF WORK

This report presents the results of PS Suspension velocity data acquired in three boreholes as detailed in Table 1. The purpose of these measurements was to supplement stratigraphic information by acquiring shear wave and compressional wave velocities as a function of depth.

The OYO PS Suspension Logging System was used to obtain in-situ horizontal shear (S_H), and compressional (P) wave velocity measurements in three uncased boreholes at 1.6-foot intervals. Measurements followed **GEO***Vision* Procedure for PS Suspension Seismic Velocity Logging, revision 1.5. Acquired data were analyzed, and a profile of velocity versus depth was produced for both S_H and P waves.

A detailed reference for the PS Suspension velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

Data were processed and compiled to generate profiles of the preceding parameters versus depth.

INSTRUMENTATION

Suspension Velocity

Suspension velocity measurements were performed using the suspension PS logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geo (RG). This system directly determines the average velocity of a 3.3-foot-high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in this survey is approximately 22 feet, with the center point of the receiver pair 12.5 feet above the bottom end of the probe.

The probe receives control signals from, and sends the digitized receiver signals to, instrumentation on the surface via an armored conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data using a sheave of known circumference fitted with a digital rotary encoder.

The entire probe is suspended in the borehole by the cable; therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it passes through the casing and grout annulus (if present) and impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H-wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 6.3-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (feet versus inches scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again, and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), and sample rate to optimize the quality of the data before recording.

Verification of the calibration of the Suspension P-S digital recorder is performed at least every twelve months using a NIST traceable frequency source and counter and **GEO***Vision* Suspension P-S Seismic Logger/Recorder Calibration Procedure Revision 2.1. Calibration records are reproduced in Appendix B.

MEASUREMENT PROCEDURES

Suspension Velocity

Three boreholes were logged with the PS Suspension tool. Measurements followed the **GEO***Vision* Procedure for PS Suspension Seismic Velocity Logging, revision 1.5. Prior to logging, the probe was positioned with the top of the probe even with a stationary reference point. The electronic depth counter was set to the distance between the mid-point of the receiver and the top of the probe, minus the height of the stationary reference point, if any, verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the borings, stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded to disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring.

DATA ANALYSIS

Suspension Velocity

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot (1.0 meter) segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into a Microsoft Excel® template to complete the velocity calculations based on the arrival time picks made in PSLOG. The Microsoft Excel® analysis files were previously delivered. Due to the longevity of this project, results were delivered at intervals as requested.

The P-wave velocity over the 6.3-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in Microsoft Excel®, for a check of the reasonableness of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.8 feet to correspond to the mid-point of the 6.3-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, the recorded digital waveforms were analyzed to locate clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital Fast Fourier Transform – Inverse Fast Fourier Transform (FFT – IFFT) lowpass filtering was used to remove the higher frequency P-wave signal from the S_H-wave signal. Different filter cutoffs were used to separate P- and S_H-waves at different depths, ranging from 600 Hz in the slowest zones to 4000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H-wave signal being filtered.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.3-foot interval from source to receiver 1 was plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.8 feet to correspond to the mid-point of the 6.3-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.35 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Velocity

Suspension R1-R2 P- and S_H-wave velocities for boreholes IBR-02, IBR-03 and IBR-05 are plotted in Figures 4 through 6; data are compiled in Tables 3 through 5 respectively. The associated Microsoft Excel® analysis files accompany this report. Included in the analysis files are Poisson's Ratio calculations, tabulated data, and plots.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-3 in Appendix A to aid in visual comparison. Note that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.3 feet, creating a significant smoothing relative to the R1-R2 plots. The S-R1 velocity data displayed in these figures are also presented in Tables A-1 through A-3, respectively.

DISCUSSION OF RESULTS

Suspension Velocity

Suspension PS velocity data are ideally collected in uncased fluid filled boreholes, as was the case for these boreholes.

Suspension PS velocity data quality is judged based upon 5 criteria.

- Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
- Consistency between data from adjacent depth intervals.
- Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
- Clarity of P-wave and S_H -wave onset, as well as damping of later oscillations.
- Consistency of profile between adjacent borings, if available.

Table 6 summarizes the evaluation of the borehole datasets with respect to these criteria.
These data indicate good consistency between R1-R2 and S-R1 velocities, and consistency between adjacent depths.

To improve reliability and minimize uncertainty, whenever possible, travel time differences were determined from several arrivals on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. In addition, velocities from travel times from S-R1 were also determined and used to verify the velocities derived from the travel times between receivers R1-R2.

Quality Assurance

These borehole geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Velocity Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable, with an estimated accuracy of +/- 5%. Depth indications are very reliable with an estimated accuracy of +/- 0.2 feet. Standardized field procedures and quality assurance checks contribute to the reliability of these data.

CERTIFICATION

All geophysical data, analysis, interpretations, conclusions, and recommendations in this document have been prepared under the supervision of and reviewed by a **GEO***Vision* California Professional Geophysicist.

Prepared by

3/12/2024

Robert Steller
Senior Geophysicist
GEO*Vision* Geophysical Services

Date

Reviewed and approved by

J. G. DIEHL
No. 30362

3/12/2024

John Diehl
California Professional Engineer, P.E. 30362
GEO*Vision* Geophysical Services

Date

* This geophysical investigation was conducted under the supervision of a California Professional Geophysicist or Engineer using industry standard methods and equipment. A high degree of professionalism was maintained during all aspects of the project from the field investigation and data acquisition, through data processing, interpretation and reporting. All original field data files, field notes and observations, and other pertinent information are maintained in the project files and are available for the client to review for a period of at least one year.

A professional geophysicist's certification of interpreted geophysical conditions comprises a declaration of his/her professional judgment. It does not constitute a warranty or guarantee, expressed or implied, nor does it relieve any other party of its responsibility to abide by contract documents, applicable codes, standards, regulations or ordinances.

FIGURES

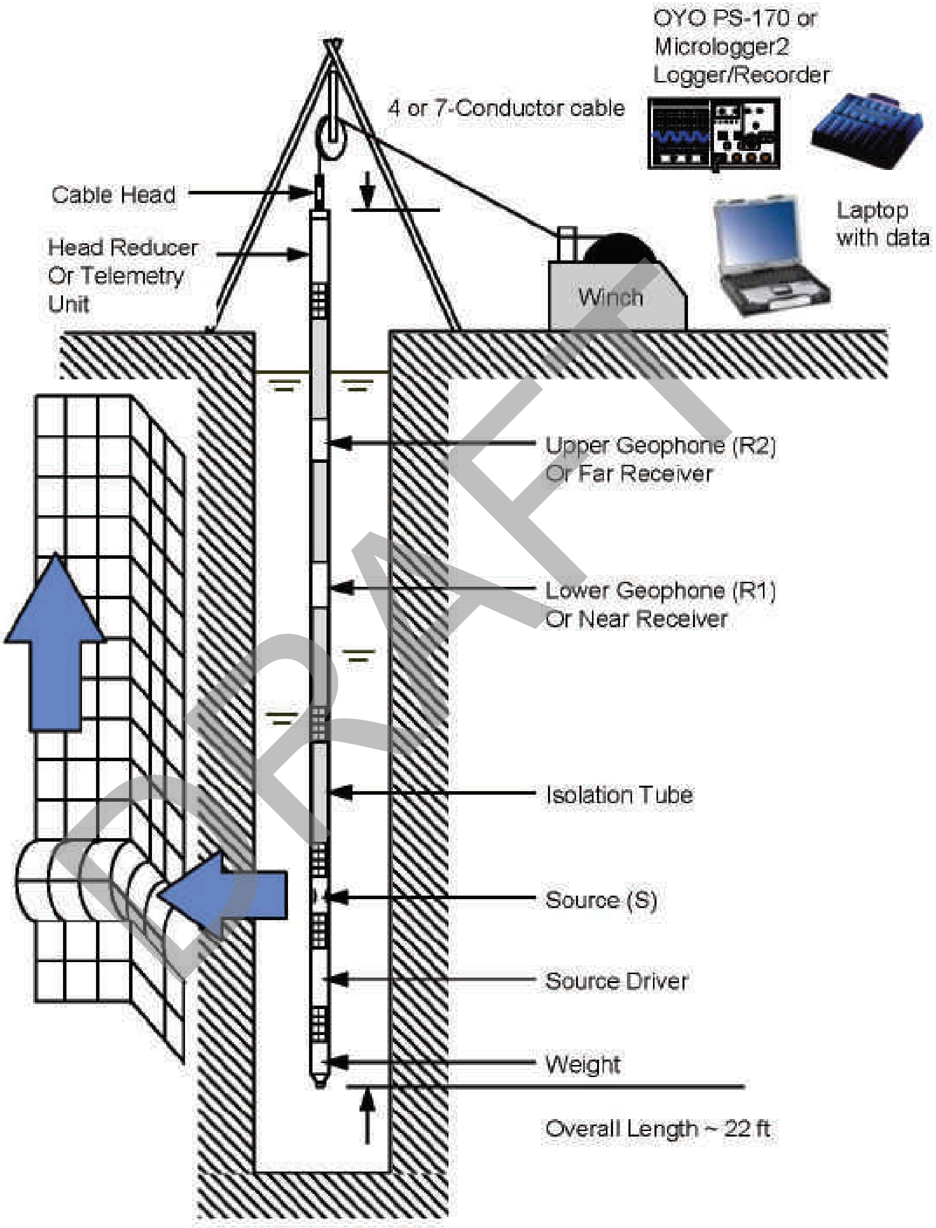


Figure 1: Concept illustration of P-S logging system

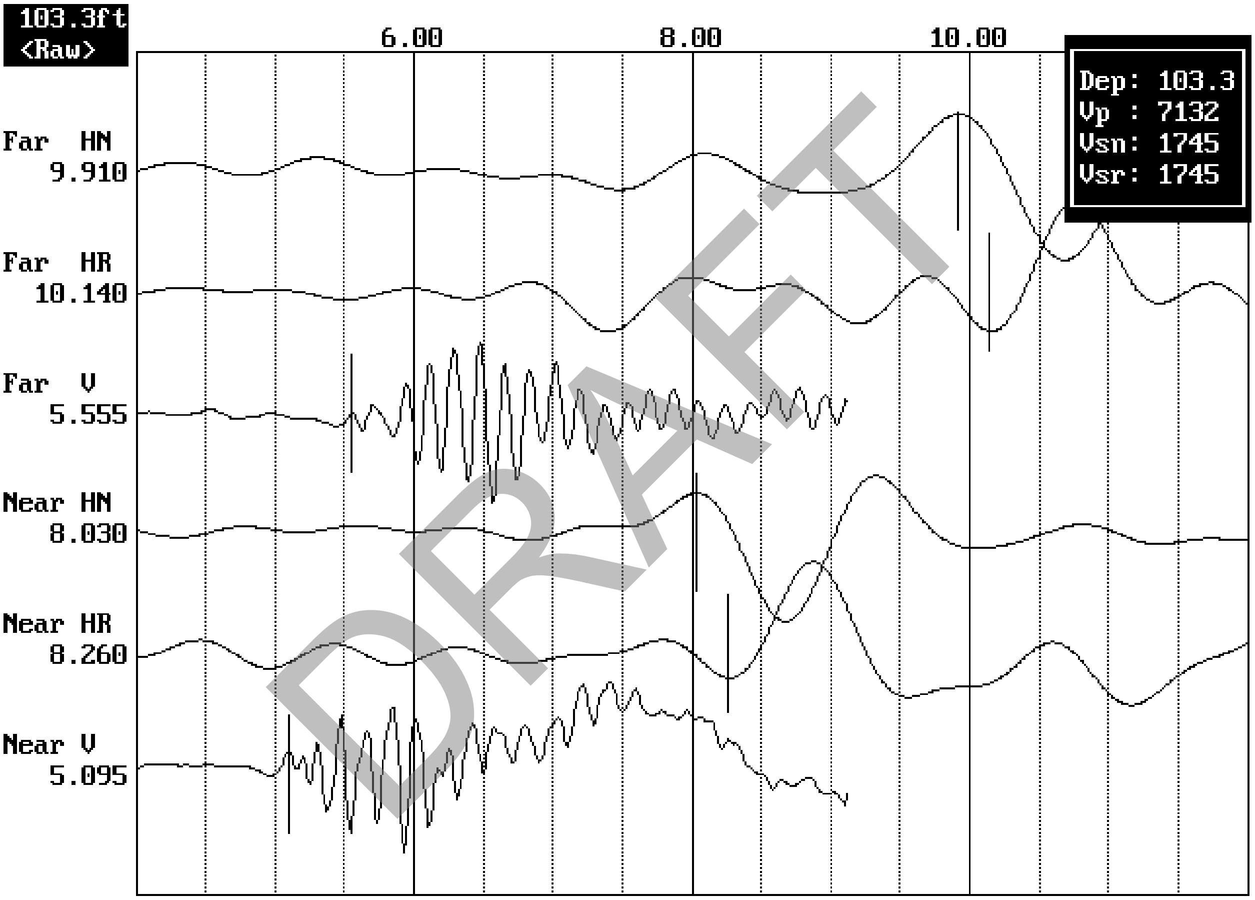


Figure 2: Example of filtered (1400 Hz lowpass) suspension record

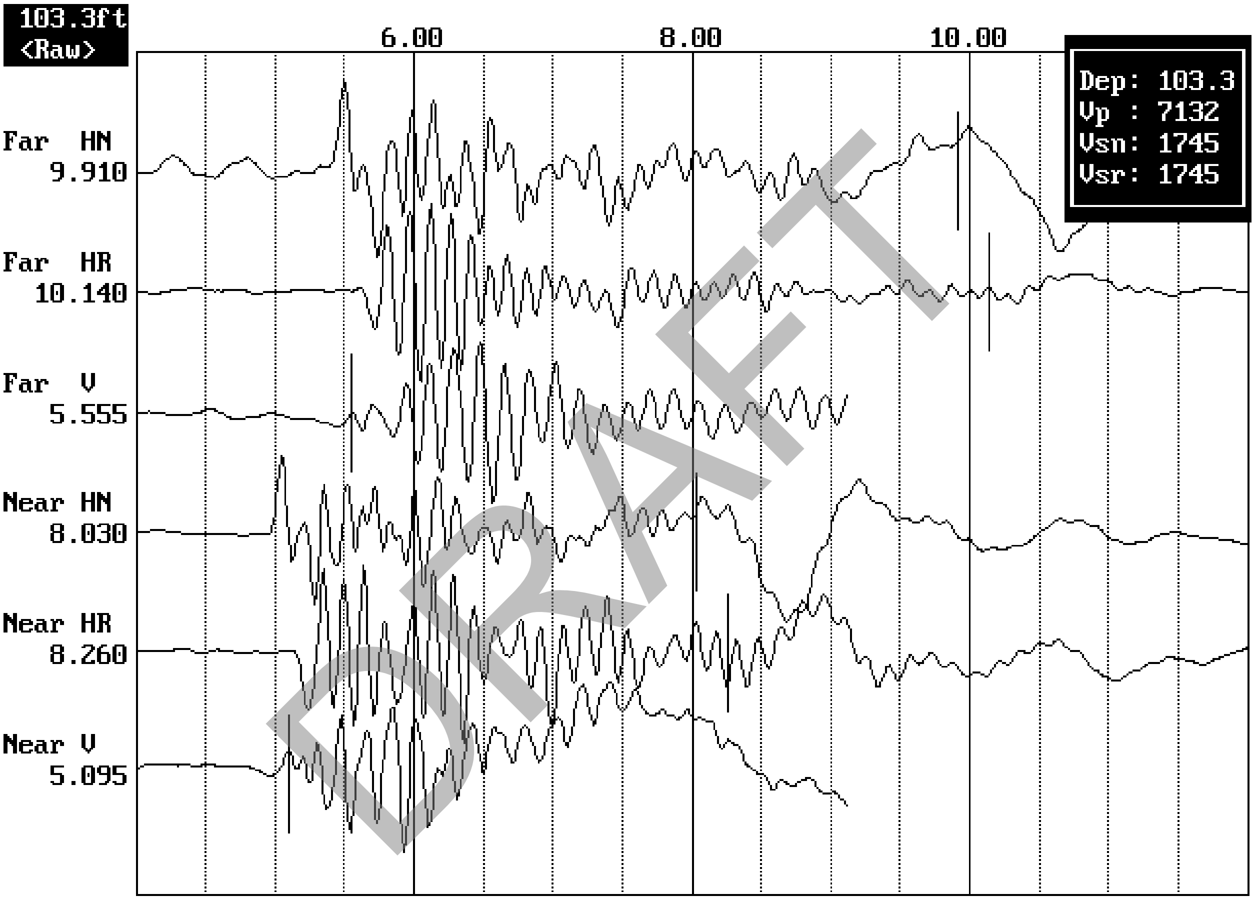


Figure 3. Example of unfiltered suspension record

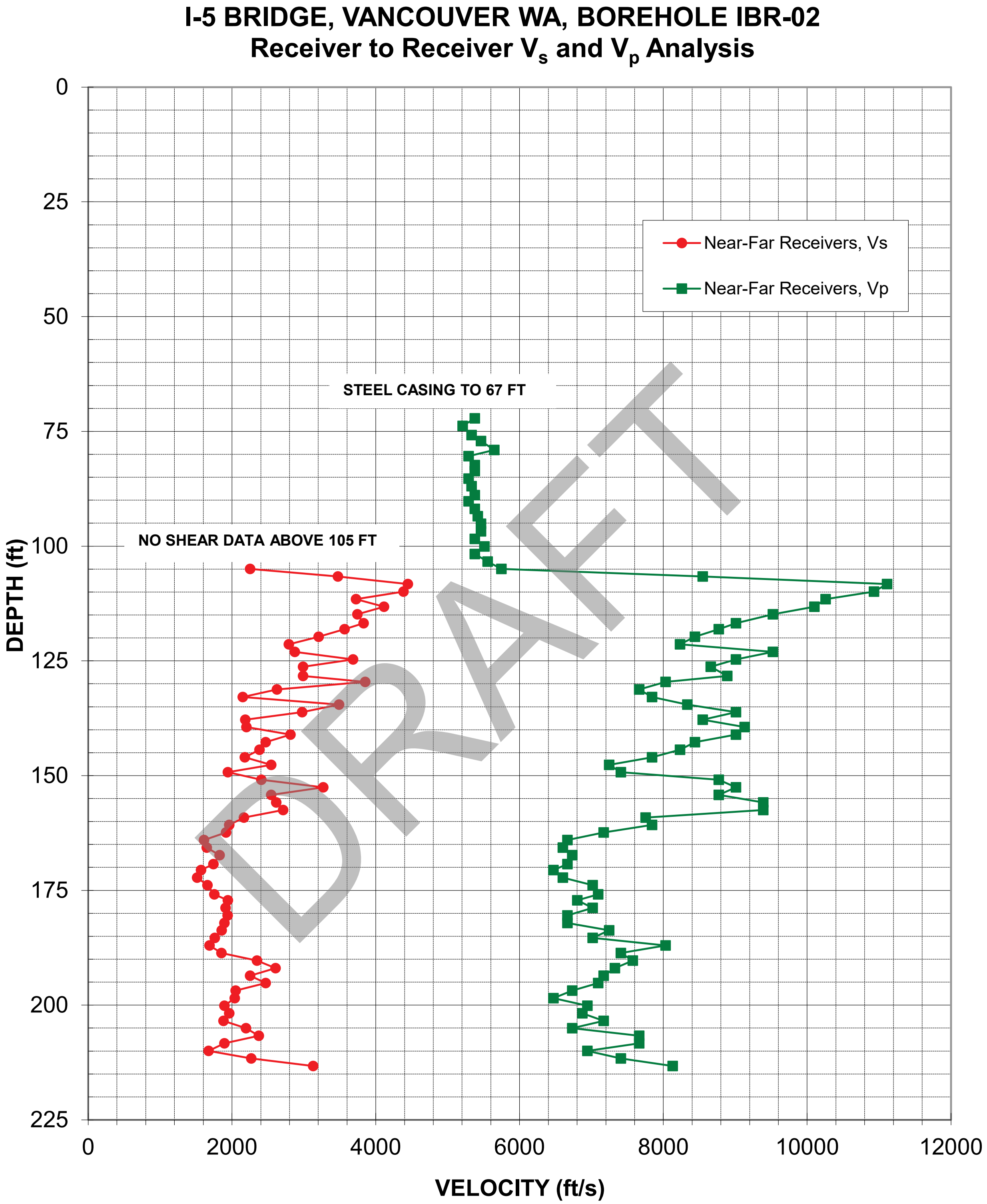


Figure 4: Borehole IBR-02, Suspension R1-R2 P- and S_H-wave velocities

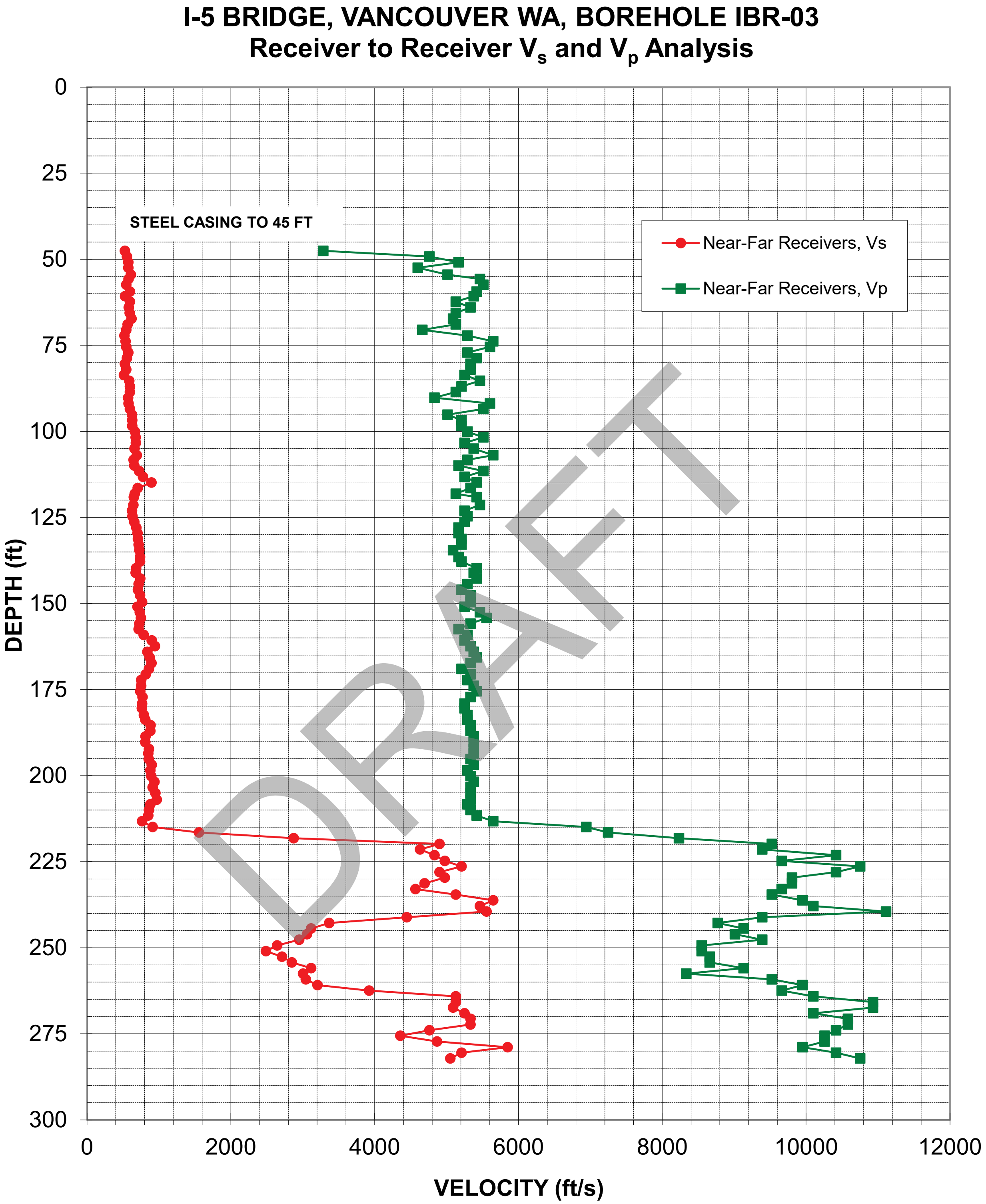


Figure 5: Borehole IBR-03, Suspension R1-R2 P- and S_H-wave velocities

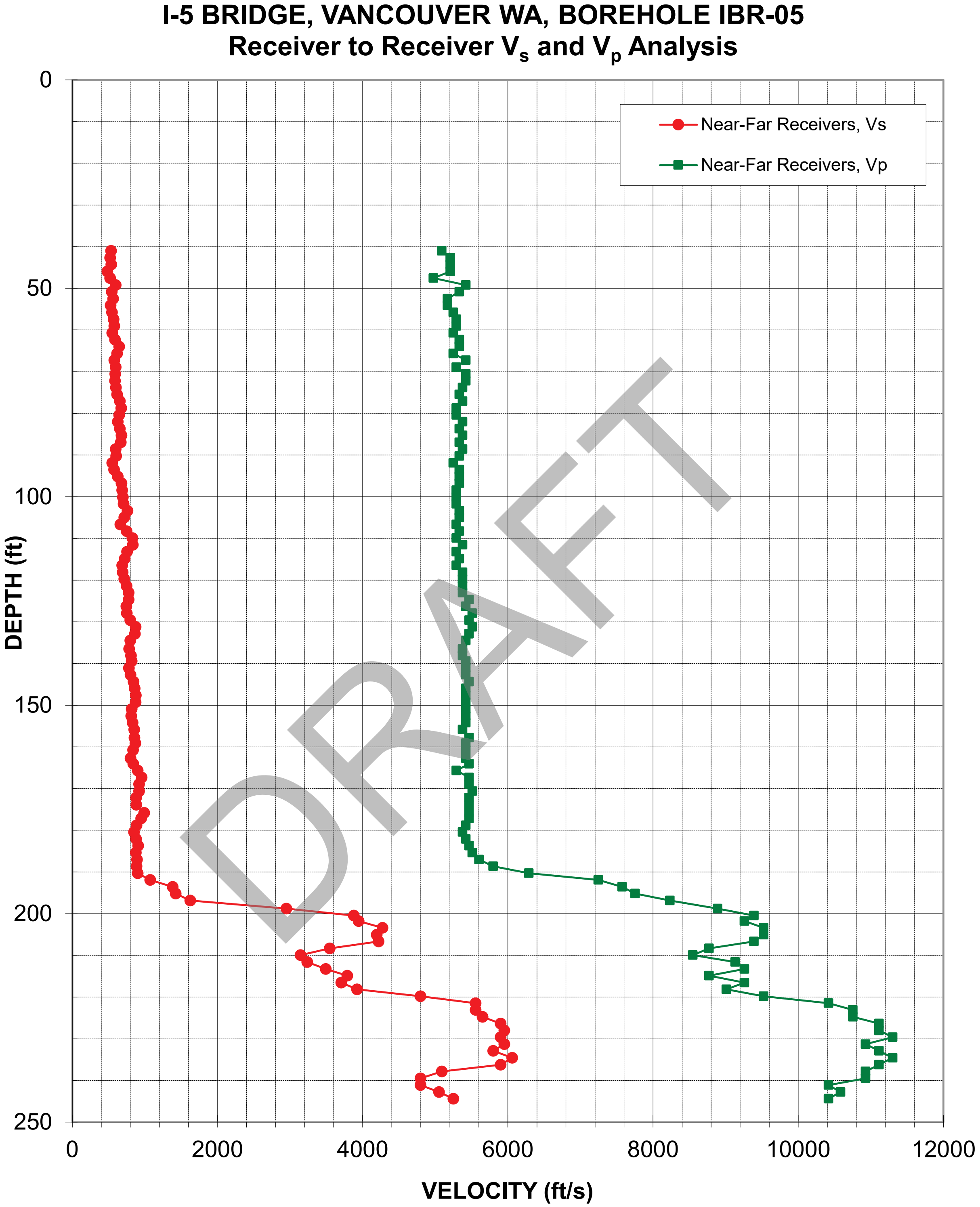


Figure 6: Borehole IBR-05, Suspension R1-R2 P- and S_H-wave velocities

TABLES

Table 1. Borehole Logging Dates and Locations

BOREHOLE NUMBER	DATE(S) LOGGED	COORDINATES[1]		
		NORTHING	EASTING	ELEVATION (FEET)
IBR-02	1/25/2024	107927.501	1082095.207	NA
IBR-03	2/2/2024	110582.302	1083176.112	NA
IBR-05	2/23/2024	111405.141	1083544.515	NA

(1) Coordinates in project coordinate system, provided by client

(2) To convert to NAD83, multiply by a scale factor of 1.0000576.

Table 2. Logging Tools, Depth Ranges and Sample Intervals

BOREHOLE NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	SAMPLE INTERVAL (FEET)	DATE(S) LOGGED
IBR-02	SUSPENSION DOWN 01	67.26 – 213.26	1.64	1/25/2024
IBR-03	SUSPENSION DOWN 01	45.93 – 282.15	1.64	2/2/2024
IBR-05	SUSPENSION DOWN 01	39.37 – 244.42	1.64	2/23/2024

Table 3. Borehole IBR-02, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-2

American Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(ft)	(ft/s)	(ft/s)	
72.2	-	5380	-
73.8	-	5210	-
75.8	-	5330	-
77.1	-	5460	-
79.1	-	5650	-
80.4	-	5290	-
82.4	-	5380	-
83.7	-	5380	-
85.3	-	5290	-
86.9	-	5330	-
88.9	-	5380	-
90.2	-	5290	-
91.9	-	5380	-
93.5	-	5420	-
95.1	-	5460	-
96.8	-	5460	-
98.4	-	5380	-
100.1	-	5510	-
101.7	-	5380	-
103.4	-	5560	-
105.0	2250	5750	0.41
106.6	3470	8550	0.40
108.3	4440	11110	0.40
109.9	4390	10930	0.40
111.6	3720	10260	0.42
113.2	4120	10100	0.40
114.8	3750	9520	0.41
116.8	3830	9010	0.39
118.1	3570	8770	0.40
119.8	3210	8440	0.42
121.4	2790	8230	0.44
123.0	2870	9520	0.45
124.7	3680	9010	0.40
126.3	2990	8660	0.43
128.3	2990	8890	0.44
129.6	3850	8030	0.35
131.2	2620	7660	0.43
132.9	2150	7840	0.46

Metric Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(m)	(m/s)	(m/s)	
22.0	-	1640	-
22.5	-	1590	-
23.1	-	1630	-
23.5	-	1670	-
24.1	-	1720	-
24.5	-	1610	-
25.1	-	1640	-
25.5	-	1640	-
26.0	-	1610	-
26.5	-	1630	-
27.1	-	1640	-
27.5	-	1610	-
28.0	-	1640	-
28.5	-	1650	-
29.0	-	1670	-
29.5	-	1670	-
30.0	-	1640	-
30.5	-	1680	-
31.0	-	1640	-
31.5	-	1690	-
32.0	690	1750	0.41
32.5	1060	2610	0.40
33.0	1350	3390	0.40
33.5	1340	3330	0.40
34.0	1140	3130	0.42
34.5	1250	3080	0.40
35.0	1140	2900	0.41
35.6	1170	2750	0.39
36.0	1090	2670	0.40
36.5	980	2570	0.42
37.0	850	2510	0.44
37.5	880	2900	0.45
38.0	1120	2750	0.40
38.5	910	2640	0.43
39.1	910	2710	0.44
39.5	1170	2450	0.35
40.0	800	2340	0.43
40.5	660	2390	0.46

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-2

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
134.5	3490	8330	0.39
136.2	2980	9010	0.44
137.8	2190	8550	0.47
139.4	2200	9130	0.47
141.1	2810	9010	0.45
142.7	2470	8440	0.45
144.4	2380	8230	0.45
146.0	2180	7840	0.46
147.6	2540	7250	0.43
149.3	1940	7410	0.46
150.9	2410	8770	0.46
152.6	3270	9010	0.42
154.2	2540	8770	0.45
155.8	2610	9390	0.46
157.5	2710	9390	0.45
159.1	2160	7750	0.46
160.8	1960	7840	0.47
162.4	1920	7170	0.46
164.0	1610	6670	0.47
165.7	1650	6600	0.47
167.3	1830	6730	0.46
169.3	1740	6670	0.46
170.6	1570	6470	0.47
172.2	1520	6600	0.47
173.9	1660	7020	0.47
175.9	1750	7090	0.47
177.2	1940	6800	0.46
178.8	1910	7020	0.46
180.5	1940	6670	0.45
182.1	1890	6670	0.46
183.7	1860	7250	0.46
185.4	1760	7020	0.47
187.0	1690	8030	0.48
188.7	1850	7410	0.47
190.3	2350	7580	0.45
191.9	2600	7330	0.43
193.6	2250	7170	0.45
195.2	2470	7090	0.43
196.9	2050	6730	0.45
198.5	2040	6470	0.44

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
41.0	1060	2540	0.39
41.5	910	2750	0.44
42.0	670	2610	0.47
42.5	670	2780	0.47
43.0	860	2750	0.45
43.5	750	2570	0.45
44.0	730	2510	0.45
44.5	660	2390	0.46
45.0	780	2210	0.43
45.5	590	2260	0.46
46.0	730	2670	0.46
46.5	1000	2750	0.42
47.0	780	2670	0.45
47.5	800	2860	0.46
48.0	830	2860	0.45
48.5	660	2360	0.46
49.0	600	2390	0.47
49.5	580	2180	0.46
50.0	490	2030	0.47
50.5	500	2010	0.47
51.0	560	2050	0.46
51.6	530	2030	0.46
52.0	480	1970	0.47
52.5	460	2010	0.47
53.0	510	2140	0.47
53.6	530	2160	0.47
54.0	590	2070	0.46
54.5	580	2140	0.46
55.0	590	2030	0.45
55.5	580	2030	0.46
56.0	570	2210	0.46
56.5	540	2140	0.47
57.0	510	2450	0.48
57.5	560	2260	0.47
58.0	720	2310	0.45
58.5	790	2230	0.43
59.0	690	2180	0.45
59.5	750	2160	0.43
60.0	630	2050	0.45
60.5	620	1970	0.44

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-2

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
200.1	1890	6940	0.46	61.0	580	2120	0.46
201.8	1960	6870	0.46	61.5	600	2090	0.46
203.4	1880	7170	0.46	62.0	570	2180	0.46
205.1	2190	6730	0.44	62.5	670	2050	0.44
206.7	2370	7660	0.45	63.0	720	2340	0.45
208.3	1890	7660	0.47	63.5	580	2340	0.47
210.0	1680	6940	0.47	64.0	510	2120	0.47
211.6	2270	7410	0.45	64.5	690	2260	0.45
213.3	3130	8130	0.41	65.0	950	2480	0.41

Notes: "-" means no data available at that particular interval of depth.

Table 4. Borehole IBR-03, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
45.9	-	-	-
47.6	520	3280	0.49
49.2	560	4760	0.49
50.9	570	5170	0.49
52.5	570	4600	0.49
54.5	610	5010	0.49
55.8	580	5460	0.49
57.4	550	5510	0.50
59.4	600	5420	0.49
60.7	530	5380	0.50
62.3	600	5130	0.49
64.0	580	5330	0.49
65.6	590	5130	0.49
67.3	620	5090	0.49
68.9	560	5130	0.49
70.5	540	4660	0.49
72.2	520	5290	0.50
73.8	540	5650	0.50
75.5	550	5600	0.50
77.1	570	5290	0.49
78.7	560	5420	0.49
80.4	520	5330	0.50
82.0	540	5330	0.49
83.7	510	5250	0.50
85.3	590	5460	0.49
86.9	600	5210	0.49
88.6	600	5130	0.49
90.2	570	4830	0.49
91.9	580	5600	0.49
93.5	600	5510	0.49
95.1	630	5010	0.49
96.8	630	5210	0.49
98.4	630	5210	0.49
100.1	670	5290	0.49
101.7	680	5510	0.49
103.4	680	5250	0.49
105.0	660	5380	0.49
107.0	690	5650	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
14.0	-	-	-
14.5	160	1000	0.49
15.0	170	1450	0.49
15.5	180	1580	0.49
16.0	180	1400	0.49
16.6	190	1530	0.49
17.0	180	1670	0.49
17.5	170	1680	0.50
18.1	180	1650	0.49
18.5	160	1640	0.50
19.0	180	1560	0.49
19.5	180	1630	0.49
20.0	180	1560	0.49
20.5	190	1550	0.49
21.0	170	1560	0.49
21.5	170	1420	0.49
22.0	160	1610	0.50
22.5	160	1720	0.50
23.0	170	1710	0.50
23.5	180	1610	0.49
24.0	170	1650	0.49
24.5	160	1630	0.50
25.0	170	1630	0.49
25.5	160	1600	0.50
26.0	180	1670	0.49
26.5	180	1590	0.49
27.0	180	1560	0.49
27.5	170	1470	0.49
28.0	180	1710	0.49
28.5	180	1680	0.49
29.0	190	1530	0.49
29.5	190	1590	0.49
30.0	190	1590	0.49
30.5	200	1610	0.49
31.0	210	1680	0.49
31.5	210	1600	0.49
32.0	200	1640	0.49
32.6	210	1720	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
108.3	650	5290	0.49
109.9	660	5170	0.49
111.6	720	5510	0.49
113.2	780	5250	0.49
114.8	890	5420	0.49
116.5	710	5330	0.49
118.1	660	5130	0.49
119.1	650	5420	0.49
121.4	640	5460	0.49
123.0	630	5250	0.49
124.7	630	5290	0.49
126.3	660	5250	0.49
128.0	690	5170	0.49
129.6	700	5170	0.49
131.2	710	5210	0.49
132.9	720	5210	0.49
134.5	730	5090	0.49
136.5	740	5170	0.49
137.8	740	5210	0.49
139.8	680	5420	0.49
141.1	680	5380	0.49
142.7	740	5420	0.49
144.4	720	5290	0.49
146.0	710	5210	0.49
147.6	740	5330	0.49
149.6	770	5330	0.49
150.9	700	5250	0.49
152.6	730	5460	0.49
154.2	750	5560	0.49
155.8	730	5330	0.49
157.5	720	5170	0.49
159.1	790	5290	0.49
160.8	900	5250	0.48
162.4	950	5330	0.48
164.0	840	5380	0.49
165.7	870	5420	0.49
167.3	890	5330	0.49
169.0	860	5210	0.49
170.6	820	5330	0.49
172.2	750	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
33.0	200	1610	0.49
33.5	200	1580	0.49
34.0	220	1680	0.49
34.5	240	1600	0.49
35.0	270	1650	0.49
35.5	220	1630	0.49
36.0	200	1560	0.49
36.3	200	1650	0.49
37.0	200	1670	0.49
37.5	190	1600	0.49
38.0	190	1610	0.49
38.5	200	1600	0.49
39.0	210	1580	0.49
39.5	210	1580	0.49
40.0	220	1590	0.49
40.5	220	1590	0.49
41.0	220	1550	0.49
41.6	220	1580	0.49
42.0	220	1590	0.49
42.6	210	1650	0.49
43.0	210	1640	0.49
43.5	230	1650	0.49
44.0	220	1610	0.49
44.5	220	1590	0.49
45.0	220	1630	0.49
45.6	230	1630	0.49
46.0	210	1600	0.49
46.5	220	1670	0.49
47.0	230	1690	0.49
47.5	220	1630	0.49
48.0	220	1580	0.49
48.5	240	1610	0.49
49.0	270	1600	0.48
49.5	290	1630	0.48
50.0	260	1640	0.49
50.5	270	1650	0.49
51.0	270	1630	0.49
51.5	260	1590	0.49
52.0	250	1630	0.49
52.5	230	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
173.9	750	5380	0.49
175.5	740	5420	0.49
177.2	770	5330	0.49
179.1	770	5250	0.49
180.5	760	5250	0.49
182.4	790	5290	0.49
183.7	810	5290	0.49
185.4	880	5330	0.49
187.0	880	5330	0.49
188.7	810	5380	0.49
190.3	810	5380	0.49
192.3	860	5380	0.49
193.6	850	5380	0.49
195.2	860	5330	0.49
196.9	900	5380	0.49
198.5	880	5290	0.49
200.1	890	5330	0.49
201.8	940	5380	0.48
203.4	910	5330	0.48
205.1	950	5330	0.48
207.0	970	5330	0.48
208.3	880	5290	0.49
210.0	860	5330	0.49
211.6	850	5420	0.49
213.3	760	5650	0.49
214.9	910	6940	0.49
216.5	1560	7250	0.48
218.2	2870	8230	0.43
219.8	4900	9520	0.32
221.5	4630	9390	0.34
223.1	4830	10420	0.36
224.7	4980	9660	0.32
226.4	5210	10750	0.35
228.0	4900	10420	0.36
229.7	4980	9800	0.33
231.3	4690	9800	0.35
232.9	4570	9660	0.36
234.6	5130	9520	0.30
236.2	5650	9950	0.26
237.9	5460	10100	0.29

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
53.0	230	1640	0.49
53.5	230	1650	0.49
54.0	230	1630	0.49
54.6	230	1600	0.49
55.0	230	1600	0.49
55.6	240	1610	0.49
56.0	250	1610	0.49
56.5	270	1630	0.49
57.0	270	1630	0.49
57.5	250	1640	0.49
58.0	250	1640	0.49
58.6	260	1640	0.49
59.0	260	1640	0.49
59.5	260	1630	0.49
60.0	270	1640	0.49
60.5	270	1610	0.49
61.0	270	1630	0.49
61.5	290	1640	0.48
62.0	280	1630	0.48
62.5	290	1630	0.48
63.1	300	1630	0.48
63.5	270	1610	0.49
64.0	260	1630	0.49
64.5	260	1650	0.49
65.0	230	1720	0.49
65.5	280	2120	0.49
66.0	470	2210	0.48
66.5	880	2510	0.43
67.0	1490	2900	0.32
67.5	1410	2860	0.34
68.0	1470	3180	0.36
68.5	1520	2940	0.32
69.0	1590	3280	0.35
69.5	1490	3180	0.36
70.0	1520	2990	0.33
70.5	1430	2990	0.35
71.0	1390	2940	0.36
71.5	1560	2900	0.30
72.0	1720	3030	0.26
72.5	1670	3080	0.29

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(ft)	(ft/s)	(ft/s)	
239.5	5560	11110	0.33
241.1	4440	9390	0.36
242.8	3370	8770	0.41
244.4	3120	9130	0.43
246.1	3060	9010	0.43
247.7	2950	9390	0.45
249.3	2650	8550	0.45
251.0	2490	8550	0.45
252.6	2710	8660	0.45
254.3	2850	8660	0.44
255.9	3120	9130	0.43
257.6	3000	8330	0.43
259.2	3040	9520	0.44
260.8	3210	9950	0.44
262.5	3920	9660	0.40
264.1	5130	10100	0.33
265.8	5130	10930	0.36
267.4	5090	10930	0.36
269.0	5250	10100	0.32
270.7	5330	10580	0.33
272.3	5330	10580	0.33
274.0	4760	10420	0.37
275.6	4360	10260	0.39
277.2	4870	10260	0.35
278.9	5850	9950	0.24
280.5	5210	10420	0.33
282.2	5050	10750	0.36

Metric Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(m)	(m/s)	(m/s)	
73.0	1690	3390	0.33
73.5	1350	2860	0.36
74.0	1030	2670	0.41
74.5	950	2780	0.43
75.0	930	2750	0.43
75.5	900	2860	0.45
76.0	810	2610	0.45
76.5	760	2610	0.45
77.0	830	2640	0.45
77.5	870	2640	0.44
78.0	950	2780	0.43
78.5	920	2540	0.43
79.0	930	2900	0.44
79.5	980	3030	0.44
80.0	1200	2940	0.40
80.5	1560	3080	0.33
81.0	1560	3330	0.36
81.5	1550	3330	0.36
82.0	1600	3080	0.32
82.5	1630	3230	0.33
83.0	1630	3230	0.33
83.5	1450	3180	0.37
84.0	1330	3130	0.39
84.5	1480	3130	0.35
85.0	1780	3030	0.24
85.5	1590	3180	0.33
86.0	1540	3280	0.36

Table 5. Borehole IBR-05, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-05

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
39.4	-	-	-
41.0	540	5090	0.49
42.7	520	5210	0.49
44.3	540	5210	0.49
45.9	480	5210	0.50
47.6	520	4980	0.49
49.2	600	5420	0.49
50.9	540	5330	0.49
52.5	560	5170	0.49
54.1	530	5170	0.49
55.8	550	5250	0.49
57.4	570	5290	0.49
59.1	580	5290	0.49
60.7	550	5250	0.49
62.3	590	5330	0.49
64.0	640	5330	0.49
65.6	620	5250	0.49
67.3	580	5420	0.49
68.9	600	5290	0.49
70.5	590	5420	0.49
72.2	590	5420	0.49
73.8	600	5380	0.49
75.5	620	5330	0.49
77.1	650	5380	0.49
78.7	670	5290	0.49
80.4	640	5290	0.49
82.0	630	5380	0.49
83.7	650	5330	0.49
85.3	680	5380	0.49
86.9	670	5330	0.49
88.6	600	5380	0.49
90.2	600	5330	0.49
91.9	550	5250	0.49
93.5	570	5330	0.49
95.1	630	5330	0.49
96.8	680	5330	0.49
98.4	690	5290	0.49
100.1	700	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
12.0	-	-	-
12.5	160	1550	0.49
13.0	160	1590	0.49
13.5	160	1590	0.49
14.0	150	1590	0.50
14.5	160	1520	0.49
15.0	180	1650	0.49
15.5	170	1630	0.49
16.0	170	1580	0.49
16.5	160	1580	0.49
17.0	170	1600	0.49
17.5	170	1610	0.49
18.0	180	1610	0.49
18.5	170	1600	0.49
19.0	180	1630	0.49
19.5	200	1630	0.49
20.0	190	1600	0.49
20.5	180	1650	0.49
21.0	180	1610	0.49
21.5	180	1650	0.49
22.0	180	1650	0.49
22.5	180	1640	0.49
23.0	190	1630	0.49
23.5	200	1640	0.49
24.0	210	1610	0.49
24.5	200	1610	0.49
25.0	190	1640	0.49
25.5	200	1630	0.49
26.0	210	1640	0.49
26.5	200	1630	0.49
27.0	180	1640	0.49
27.5	180	1630	0.49
28.0	170	1600	0.49
28.5	180	1630	0.49
29.0	190	1630	0.49
29.5	210	1630	0.49
30.0	210	1610	0.49
30.5	210	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-05

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
101.7	710	5290	0.49
103.4	760	5330	0.49
105.0	720	5330	0.49
106.6	660	5290	0.49
108.3	750	5330	0.49
109.9	830	5290	0.49
111.6	830	5380	0.49
113.2	750	5290	0.49
114.8	720	5330	0.49
116.5	690	5290	0.49
118.1	690	5380	0.49
119.8	720	5380	0.49
121.4	750	5380	0.49
123.0	780	5380	0.49
124.7	780	5460	0.49
126.3	740	5420	0.49
128.0	750	5510	0.49
129.6	800	5460	0.49
131.2	870	5510	0.49
132.9	860	5460	0.49
134.5	800	5420	0.49
136.5	780	5380	0.49
138.1	810	5380	0.49
139.4	820	5420	0.49
141.1	780	5420	0.49
142.7	800	5420	0.49
144.4	840	5460	0.49
146.0	860	5420	0.49
147.6	870	5420	0.49
149.3	870	5420	0.49
150.9	820	5420	0.49
152.6	810	5420	0.49
154.2	830	5420	0.49
155.8	850	5380	0.49
157.8	860	5460	0.49
159.1	870	5420	0.49
160.8	840	5420	0.49
162.7	800	5420	0.49
164.0	840	5460	0.49
165.7	900	5290	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
31.0	220	1610	0.49
31.5	230	1630	0.49
32.0	220	1630	0.49
32.5	200	1610	0.49
33.0	230	1630	0.49
33.5	250	1610	0.49
34.0	250	1640	0.49
34.5	230	1610	0.49
35.0	220	1630	0.49
35.5	210	1610	0.49
36.0	210	1640	0.49
36.5	220	1640	0.49
37.0	230	1640	0.49
37.5	240	1640	0.49
38.0	240	1670	0.49
38.5	230	1650	0.49
39.0	230	1680	0.49
39.5	240	1670	0.49
40.0	270	1680	0.49
40.5	260	1670	0.49
41.0	240	1650	0.49
41.6	240	1640	0.49
42.1	250	1640	0.49
42.5	250	1650	0.49
43.0	240	1650	0.49
43.5	240	1650	0.49
44.0	260	1670	0.49
44.5	260	1650	0.49
45.0	270	1650	0.49
45.5	270	1650	0.49
46.0	250	1650	0.49
46.5	250	1650	0.49
47.0	250	1650	0.49
47.5	260	1640	0.49
48.1	260	1670	0.49
48.5	270	1650	0.49
49.0	250	1650	0.49
49.6	240	1650	0.49
50.0	260	1670	0.49
50.5	270	1610	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-05

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
167.3	960	5460	0.48
169.0	920	5460	0.49
170.6	920	5510	0.49
172.2	880	5460	0.49
173.9	880	5460	0.49
175.9	990	5460	0.48
177.2	950	5460	0.48
178.8	880	5420	0.49
180.5	850	5380	0.49
182.1	880	5420	0.49
183.7	910	5460	0.49
185.4	870	5510	0.49
187.0	890	5600	0.49
188.7	880	5800	0.49
190.3	900	6290	0.49
191.9	1070	7250	0.49
193.6	1380	7580	0.48
195.2	1420	7750	0.48
196.9	1630	8230	0.48
198.8	2950	8890	0.44
200.5	3880	9390	0.40
201.8	3940	9260	0.39
203.4	4270	9520	0.37
205.1	4190	9520	0.38
206.7	4220	9390	0.37
208.3	3550	8770	0.40
210.0	3140	8550	0.42
211.6	3240	9130	0.43
213.3	3490	9260	0.42
214.9	3790	8770	0.39
216.5	3700	9260	0.40
218.2	3920	9010	0.38
219.8	4800	9520	0.33
221.5	5560	10420	0.30
223.1	5560	10750	0.32
224.7	5650	10750	0.31
226.4	5900	11110	0.30
228.0	5950	11110	0.30
229.7	5900	11300	0.31
231.3	5950	10930	0.29

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
51.0	290	1670	0.48
51.5	280	1670	0.49
52.0	280	1680	0.49
52.5	270	1670	0.49
53.0	270	1670	0.49
53.6	300	1670	0.48
54.0	290	1670	0.48
54.5	270	1650	0.49
55.0	260	1640	0.49
55.5	270	1650	0.49
56.0	280	1670	0.49
56.5	270	1680	0.49
57.0	270	1710	0.49
57.5	270	1770	0.49
58.0	270	1920	0.49
58.5	330	2210	0.49
59.0	420	2310	0.48
59.5	430	2360	0.48
60.0	500	2510	0.48
60.6	900	2710	0.44
61.1	1180	2860	0.40
61.5	1200	2820	0.39
62.0	1300	2900	0.37
62.5	1280	2900	0.38
63.0	1290	2860	0.37
63.5	1080	2670	0.40
64.0	960	2610	0.42
64.5	990	2780	0.43
65.0	1060	2820	0.42
65.5	1150	2670	0.39
66.0	1130	2820	0.40
66.5	1200	2750	0.38
67.0	1460	2900	0.33
67.5	1690	3180	0.30
68.0	1690	3280	0.32
68.5	1720	3280	0.31
69.0	1800	3390	0.30
69.5	1810	3390	0.30
70.0	1800	3440	0.31
70.5	1810	3330	0.29

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole IBR-05

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
232.9	5800	11110	0.31	71.0	1770	3390	0.31
234.6	6060	11300	0.30	71.5	1850	3440	0.30
236.2	5900	11110	0.30	72.0	1800	3390	0.30
237.9	5090	10930	0.36	72.5	1550	3330	0.36
239.5	4800	10930	0.38	73.0	1460	3330	0.38
241.1	4800	10420	0.37	73.5	1460	3180	0.37
242.8	5050	10580	0.35	74.0	1540	3230	0.35
244.4	5250	10420	0.33	74.5	1600	3180	0.33

Notes: "-" means no data available at that particular interval of depth.

Table 6. Summary of PS Suspension Data Quality Evaluation Using Five Criteria

	Criteria	IBR-02	IBR-03	IBR-05
1	Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.	Yes, consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data. No S_H -wave data above 105 ft due to incorrect instrument settings.	Yes, consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.	Yes, consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2	Consistency between data from adjacent depth intervals.	Yes, good consistency between data from adjacent depth intervals.	Yes, good consistency between data from adjacent depth intervals.	Yes, good consistency between data from adjacent depth intervals.
3	Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)	Yes, consistent relationship between P-wave and S_H -wave profiles. All data is below water table	Yes, consistent relationship between P-wave and S_H -wave profiles. All data is below water table	Yes, consistent relationship between P-wave and S_H -wave profiles. All data is below water table
4	Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.	Yes, clear P-wave and S_H-wave onsets, good damping of later oscillations.	Yes, clear P-wave and S_H-wave onsets, good damping of later oscillations.	Yes, clear P-wave and S_H-wave onsets, good damping of later oscillations.
5	Consistency of profile between adjacent borings, if available.	Yes, similar velocity shallow profiles for all boreholes, variable at depth.	Yes, similar velocity shallow profiles for all boreholes, variable at depth.	Yes, similar velocity shallow profiles for all boreholes, variable at depth.

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT
SOURCE TO RECEIVER
ANALYSIS RESULTS

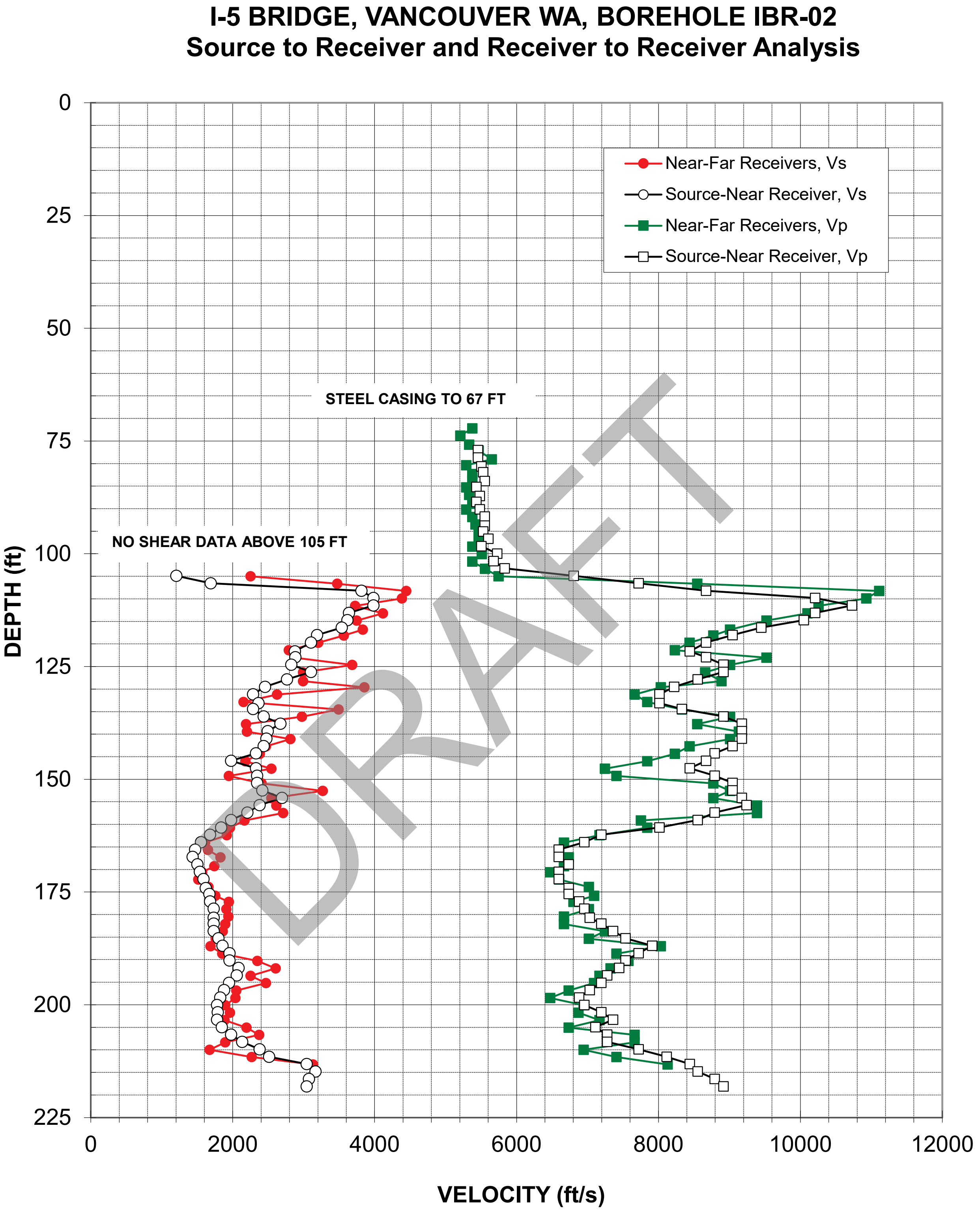


Figure A-1: Borehole IBR-02, Suspension S-R1 P- and SH-wave velocities

Table A-1. Borehole IBR-02, S - R1 analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-2

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
77.0	-	5460	-
78.7	-	5460	-
80.6	-	5500	-
81.9	-	5530	-
83.9	-	5550	-
85.2	-	5430	-
87.2	-	5480	-
88.5	-	5430	-
90.1	-	5480	-
91.8	-	5550	-
93.7	-	5550	-
95.1	-	5530	-
96.7	-	5600	-
98.3	-	5500	-
100.0	-	5730	-
101.6	-	5680	-
103.3	-	5830	-
104.9	1210	6810	0.48
106.5	1690	7720	0.47
108.2	3810	8670	0.38
109.8	3980	10210	0.41
111.5	3980	10730	0.42
113.1	3640	10210	0.43
114.7	3620	10050	0.43
116.4	3540	9450	0.42
118.0	3190	9040	0.43
119.7	3100	8670	0.43
121.6	2880	8440	0.43
122.9	2880	8670	0.44
124.6	2830	8920	0.44
126.2	3100	8920	0.43
127.9	2760	8550	0.44
129.5	2450	8220	0.45
131.1	2290	8010	0.46
133.1	2360	8010	0.45
134.4	2290	8330	0.46
136.1	2430	8920	0.46

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
23.5	-	1660	-
24.0	-	1660	-
24.6	-	1680	-
25.0	-	1690	-
25.6	-	1690	-
26.0	-	1660	-
26.6	-	1670	-
27.0	-	1660	-
27.5	-	1670	-
28.0	-	1690	-
28.6	-	1690	-
29.0	-	1690	-
29.5	-	1710	-
30.0	-	1680	-
30.5	-	1750	-
31.0	-	1730	-
31.5	-	1780	-
32.0	370	2070	0.48
32.5	510	2350	0.47
33.0	1160	2640	0.38
33.5	1210	3110	0.41
34.0	1210	3270	0.42
34.5	1110	3110	0.43
35.0	1100	3060	0.43
35.5	1080	2880	0.42
36.0	970	2760	0.43
36.5	950	2640	0.43
37.1	880	2570	0.43
37.5	880	2640	0.44
38.0	860	2720	0.44
38.5	950	2720	0.43
39.0	840	2610	0.44
39.5	750	2510	0.45
40.0	700	2440	0.46
40.6	720	2440	0.45
41.0	700	2540	0.46
41.5	740	2720	0.46

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-2

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
137.7	2670	9170	0.45
139.3	2490	9170	0.46
141.0	2470	9170	0.46
142.6	2430	9040	0.46
144.3	2330	8790	0.46
145.9	1980	8670	0.47
147.6	2330	8440	0.46
149.2	2340	8790	0.46
150.8	2340	9040	0.46
152.5	2420	9040	0.46
154.1	2690	9170	0.45
155.8	2380	9240	0.46
157.4	2210	8790	0.47
159.0	1980	8550	0.47
160.7	1840	8010	0.47
162.3	1680	7190	0.47
164.0	1550	6960	0.47
165.6	1470	6590	0.47
167.2	1440	6590	0.48
168.9	1500	6730	0.47
170.5	1540	6590	0.47
172.2	1590	6590	0.47
174.1	1620	6730	0.47
175.4	1670	6730	0.47
177.1	1680	6880	0.47
178.7	1730	6960	0.47
180.7	1730	7030	0.47
182.0	1730	7190	0.47
183.6	1730	7360	0.47
185.3	1800	7540	0.47
186.9	1860	7910	0.47
188.6	1950	7720	0.47
190.2	1950	7540	0.46
191.8	2080	7450	0.46
193.5	2060	7280	0.46
195.1	1950	7190	0.46
196.8	1880	7030	0.46
198.4	1820	6880	0.46
200.0	1780	6960	0.47

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
42.0	810	2800	0.45
42.5	760	2800	0.46
43.0	750	2800	0.46
43.5	740	2760	0.46
44.0	710	2680	0.46
44.5	600	2640	0.47
45.0	710	2570	0.46
45.5	710	2680	0.46
46.0	710	2760	0.46
46.5	740	2760	0.46
47.0	820	2800	0.45
47.5	730	2820	0.46
48.0	670	2680	0.47
48.5	600	2610	0.47
49.0	560	2440	0.47
49.5	510	2190	0.47
50.0	470	2120	0.47
50.5	450	2010	0.47
51.0	440	2010	0.48
51.5	460	2050	0.47
52.0	470	2010	0.47
52.5	480	2010	0.47
53.1	490	2050	0.47
53.5	510	2050	0.47
54.0	510	2100	0.47
54.5	530	2120	0.47
55.1	530	2140	0.47
55.5	530	2190	0.47
56.0	530	2240	0.47
56.5	550	2300	0.47
57.0	570	2410	0.47
57.5	600	2350	0.47
58.0	600	2300	0.46
58.5	630	2270	0.46
59.0	630	2220	0.46
59.5	590	2190	0.46
60.0	570	2140	0.46
60.5	560	2100	0.46
61.0	540	2120	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-2

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
201.7	1790	7190	0.47
203.3	1780	7360	0.47
205.0	1850	7110	0.46
206.6	1980	7280	0.46
208.2	2130	7280	0.45
209.9	2380	7720	0.45
211.5	2510	8120	0.45
213.2	3040	8440	0.43
214.8	3170	8550	0.42
216.4	3070	8790	0.43
218.1	3040	8920	0.43

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
61.5	550	2190	0.47
62.0	540	2240	0.47
62.5	560	2170	0.46
63.0	600	2220	0.46
63.5	650	2220	0.45
64.0	730	2350	0.45
64.5	770	2470	0.45
65.0	930	2570	0.43
65.5	960	2610	0.42
66.0	940	2680	0.43
66.5	930	2720	0.43

Notes: "-" means no data available at that particular interval of depth.

I-5 BRIDGE, VANCOUVER WA, BOREHOLE IBR-03
Source to Receiver and Receiver to Receiver Analysis

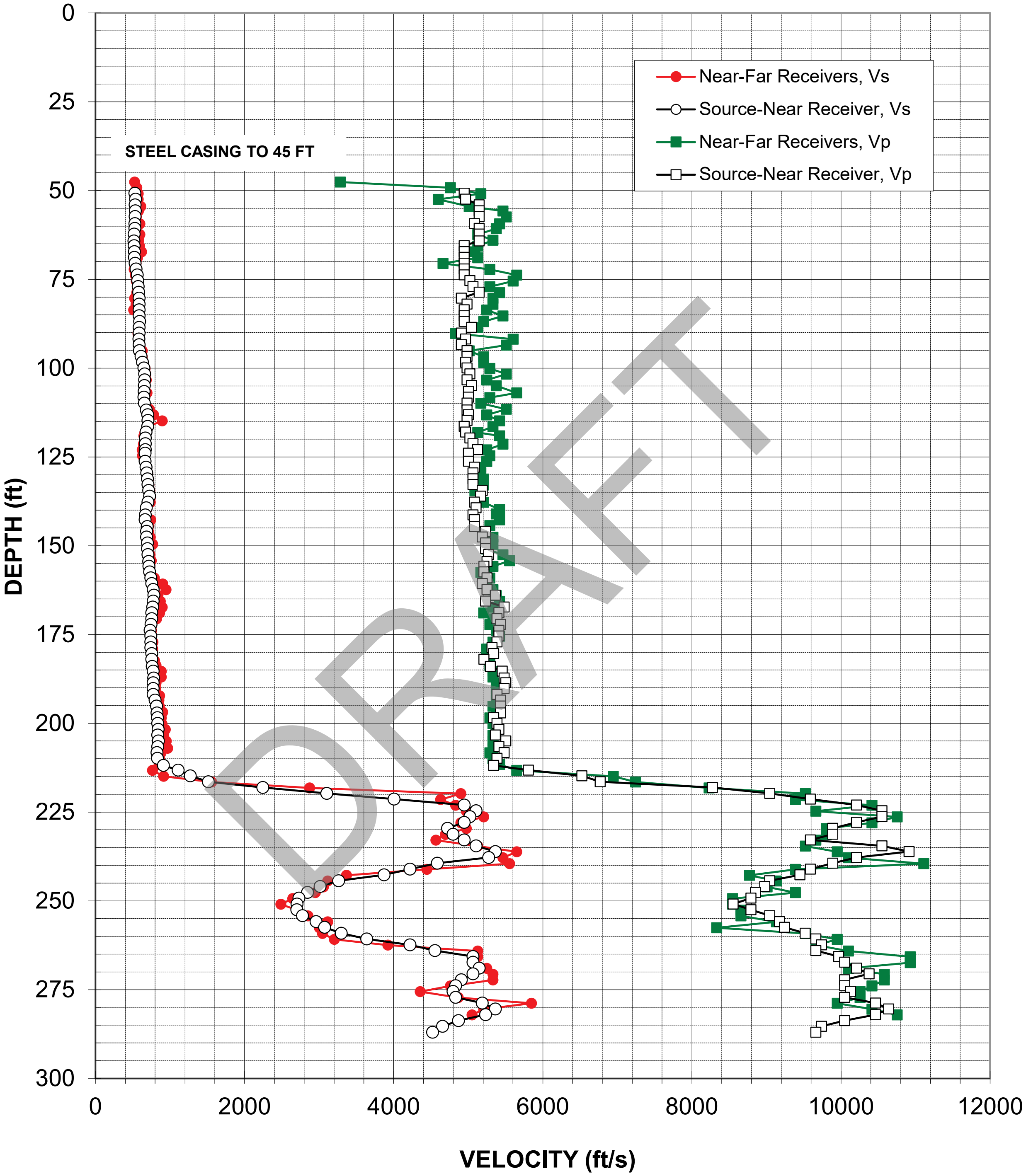


Figure A-2: Borehole IBR-03, Suspension S-R1 P- and SH-wave velocities

Table A-2. Borehole IBR-03, S - R1 analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Source and Near Receiver	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(ft)	(ft/s)	(ft/s)	
50.8	530	4950	0.49
52.4	540	4960	0.49
54.0	530	5150	0.49
55.7	540	5150	0.49
57.3	530	5150	0.49
59.3	530	5080	0.49
60.6	530	5150	0.49
62.2	520	5150	0.49
64.2	520	5150	0.49
65.5	520	4950	0.49
67.2	520	4950	0.49
68.8	520	4950	0.49
70.5	530	4950	0.49
72.1	540	4950	0.49
73.7	560	4950	0.49
75.4	570	5020	0.49
77.0	570	5060	0.49
78.7	580	5150	0.49
80.3	580	4910	0.49
81.9	580	4980	0.49
83.6	580	4950	0.49
85.2	580	4950	0.49
86.9	590	4950	0.49
88.5	590	5040	0.49
90.1	580	4910	0.49
91.8	580	4960	0.49
93.4	580	4910	0.49
95.1	590	4980	0.49
96.7	610	4980	0.49
98.3	630	4960	0.49
100.0	650	4980	0.49
101.6	660	5020	0.49
103.3	660	4980	0.49
104.9	660	5040	0.49
106.5	650	5000	0.49
108.2	650	5000	0.49
109.8	660	4980	0.49
111.8	680	4980	0.49
113.1	700	5000	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(m)	(m/s)	(m/s)	
15.5	160	1510	0.49
16.0	160	1510	0.49
16.5	160	1570	0.49
17.0	160	1570	0.49
17.5	160	1570	0.49
18.1	160	1550	0.49
18.5	160	1570	0.49
19.0	160	1570	0.49
19.6	160	1570	0.49
20.0	160	1510	0.49
20.5	160	1510	0.49
21.0	160	1510	0.49
21.5	160	1510	0.49
22.0	170	1510	0.49
22.5	170	1510	0.49
23.0	170	1530	0.49
23.5	170	1540	0.49
24.0	180	1570	0.49
24.5	180	1500	0.49
25.0	180	1520	0.49
25.5	180	1510	0.49
26.0	180	1510	0.49
26.5	180	1510	0.49
27.0	180	1540	0.49
27.5	180	1500	0.49
28.0	180	1510	0.49
28.5	180	1500	0.49
29.0	180	1520	0.49
29.5	190	1520	0.49
30.0	190	1510	0.49
30.5	200	1520	0.49
31.0	200	1530	0.49
31.5	200	1520	0.49
32.0	200	1540	0.49
32.5	200	1530	0.49
33.0	200	1530	0.49
33.5	200	1520	0.49
34.1	210	1520	0.49
34.5	210	1530	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
114.7	700	4980	0.49
116.4	700	4950	0.49
118.0	680	4960	0.49
119.7	670	5020	0.49
121.3	670	5060	0.49
122.9	670	5130	0.49
123.9	660	5000	0.49
126.2	660	5000	0.49
127.9	680	5080	0.49
129.5	690	5060	0.49
131.1	700	5060	0.49
132.8	700	5060	0.49
134.4	710	5190	0.49
136.1	730	5170	0.49
137.7	700	5080	0.49
139.3	680	5100	0.49
141.3	670	5060	0.49
142.6	660	5080	0.49
144.6	690	5080	0.49
145.9	690	5230	0.49
147.6	690	5190	0.49
149.2	700	5230	0.49
150.8	700	5230	0.49
152.5	700	5280	0.49
154.4	710	5250	0.49
155.8	720	5210	0.49
157.4	730	5210	0.49
159.0	740	5250	0.49
160.7	760	5190	0.49
162.3	770	5250	0.49
164.0	780	5360	0.49
165.6	770	5230	0.49
167.2	770	5480	0.49
168.9	760	5410	0.49
170.5	760	5390	0.49
172.2	750	5430	0.49
173.8	730	5410	0.49
175.4	740	5410	0.49
177.1	740	5390	0.49
178.7	740	5320	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
35.0	210	1520	0.49
35.5	210	1510	0.49
36.0	210	1510	0.49
36.5	200	1530	0.49
37.0	200	1540	0.49
37.5	200	1560	0.49
37.8	200	1530	0.49
38.5	200	1530	0.49
39.0	210	1550	0.49
39.5	210	1540	0.49
40.0	210	1540	0.49
40.5	210	1540	0.49
41.0	220	1580	0.49
41.5	220	1580	0.49
42.0	210	1550	0.49
42.5	210	1560	0.49
43.1	200	1540	0.49
43.5	200	1550	0.49
44.1	210	1550	0.49
44.5	210	1590	0.49
45.0	210	1580	0.49
45.5	210	1590	0.49
46.0	210	1590	0.49
46.5	210	1610	0.49
47.1	220	1600	0.49
47.5	220	1590	0.49
48.0	220	1590	0.49
48.5	230	1600	0.49
49.0	230	1580	0.49
49.5	240	1600	0.49
50.0	240	1640	0.49
50.5	240	1590	0.49
51.0	230	1670	0.49
51.5	230	1650	0.49
52.0	230	1640	0.49
52.5	230	1660	0.49
53.0	220	1650	0.49
53.5	230	1650	0.49
54.0	230	1640	0.49
54.5	230	1620	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
180.4	760	5340	0.49
182.0	760	5210	0.49
184.0	760	5300	0.49
185.3	770	5460	0.49
187.2	780	5480	0.49
188.6	770	5500	0.49
190.2	770	5480	0.49
191.8	770	5390	0.49
193.5	800	5430	0.49
195.1	820	5430	0.49
197.1	820	5430	0.49
198.4	830	5340	0.49
200.0	840	5390	0.49
201.7	840	5410	0.49
203.3	840	5360	0.49
205.0	850	5500	0.49
206.6	840	5410	0.49
208.2	830	5480	0.49
209.9	830	5390	0.49
211.9	910	5340	0.48
213.2	1110	5810	0.48
214.8	1270	6530	0.48
216.4	1510	6770	0.47
218.1	2240	8270	0.46
219.7	3100	9040	0.43
221.4	4010	9590	0.39
223.0	4950	10210	0.35
224.7	5100	10550	0.35
226.3	5020	10550	0.35
227.9	4950	10210	0.35
229.6	4720	9890	0.35
231.2	4800	9890	0.35
232.9	4950	9590	0.32
234.5	5100	10550	0.35
236.1	5360	10910	0.34
237.8	5280	10210	0.32
239.4	4590	9890	0.36
241.1	4220	9590	0.38
242.7	3870	9450	0.40
244.3	3260	9040	0.43

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
55.0	230	1630	0.49
55.5	230	1590	0.49
56.1	230	1610	0.49
56.5	240	1660	0.49
57.1	240	1670	0.49
57.5	240	1680	0.49
58.0	240	1670	0.49
58.5	240	1640	0.49
59.0	240	1660	0.49
59.5	250	1660	0.49
60.1	250	1660	0.49
60.5	250	1630	0.49
61.0	250	1640	0.49
61.5	260	1650	0.49
62.0	250	1640	0.49
62.5	260	1680	0.49
63.0	250	1650	0.49
63.5	250	1670	0.49
64.0	250	1640	0.49
64.6	280	1630	0.48
65.0	340	1770	0.48
65.5	390	1990	0.48
66.0	460	2060	0.47
66.5	680	2520	0.46
67.0	950	2760	0.43
67.5	1220	2920	0.39
68.0	1510	3110	0.35
68.5	1560	3220	0.35
69.0	1530	3220	0.35
69.5	1510	3110	0.35
70.0	1440	3010	0.35
70.5	1460	3010	0.35
71.0	1510	2920	0.32
71.5	1560	3220	0.35
72.0	1640	3330	0.34
72.5	1610	3110	0.32
73.0	1400	3010	0.36
73.5	1290	2920	0.38
74.0	1180	2880	0.40
74.5	990	2760	0.43

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-3

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
246.0	3010	8980	0.44
247.6	2840	8850	0.44
249.3	2730	8790	0.45
250.9	2710	8550	0.44
252.5	2700	8790	0.45
254.2	2780	9040	0.45
255.8	2960	9170	0.44
257.5	3070	9240	0.44
259.1	3300	9520	0.43
260.7	3640	9660	0.42
262.4	4220	9740	0.38
264.0	4550	9660	0.36
265.7	5060	9970	0.33
267.3	5060	10050	0.33
268.9	5150	10210	0.33
270.6	5060	10380	0.34
272.2	4910	10050	0.34
273.9	4830	10050	0.35
275.5	4800	10130	0.36
277.1	4830	10050	0.35
278.8	5190	10460	0.34
280.4	5360	10640	0.33
282.1	5230	10460	0.33
283.7	4870	10050	0.35
285.3	4650	9740	0.35
287.0	4520	9660	0.36

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
75.0	920	2740	0.44
75.5	870	2700	0.44
76.0	830	2680	0.45
76.5	820	2610	0.44
77.0	820	2680	0.45
77.5	850	2760	0.45
78.0	900	2800	0.44
78.5	940	2820	0.44
79.0	1000	2900	0.43
79.5	1110	2950	0.42
80.0	1290	2970	0.38
80.5	1390	2950	0.36
81.0	1540	3040	0.33
81.5	1540	3060	0.33
82.0	1570	3110	0.33
82.5	1540	3160	0.34
83.0	1500	3060	0.34
83.5	1470	3060	0.35
84.0	1460	3090	0.36
84.5	1470	3060	0.35
85.0	1580	3190	0.34
85.5	1640	3240	0.33
86.0	1590	3190	0.33
86.5	1480	3060	0.35
87.0	1420	2970	0.35
87.5	1380	2950	0.36

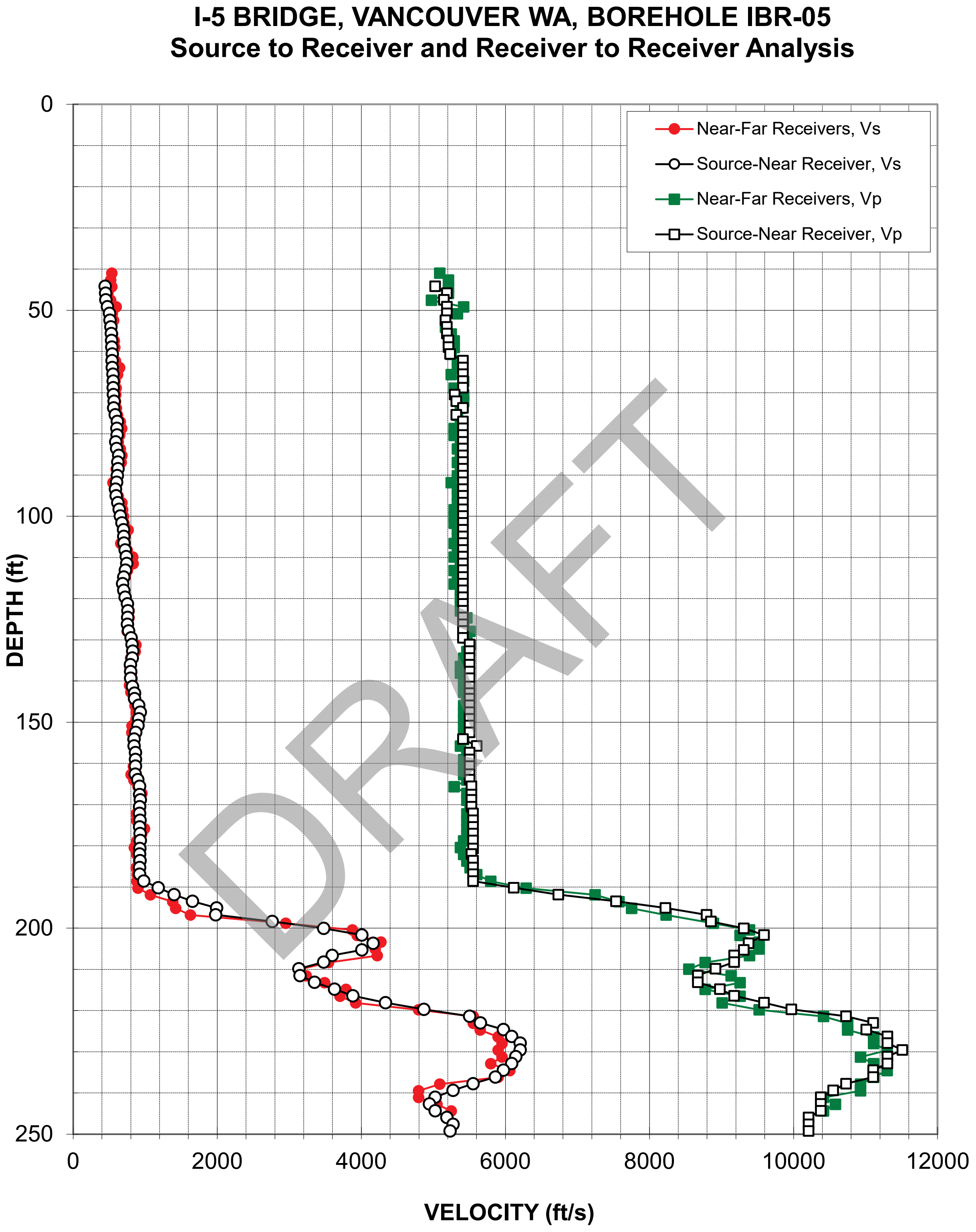


Figure A-3: Borehole IBR-05, Suspension S-R1 P- and SH-wave velocities

Table A-3. Borehole IBR-05, S - R1 analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-05

American Units			
Depth at Midpoint Between Source and Near Receiver	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(ft)	(ft/s)	(ft/s)	
44.2	440	5020	0.50
45.8	450	5190	0.50
47.5	450	5150	0.50
49.1	480	5190	0.50
50.8	500	5190	0.50
52.4	510	5170	0.50
54.0	520	5190	0.49
55.7	530	5190	0.49
57.3	530	5210	0.49
59.0	540	5210	0.49
60.6	540	5230	0.49
62.2	540	5410	0.49
63.9	540	5410	0.49
65.5	550	5410	0.49
67.2	560	5410	0.49
68.8	550	5410	0.49
70.5	560	5300	0.49
72.1	570	5320	0.49
73.7	560	5410	0.49
75.4	590	5320	0.49
77.0	610	5410	0.49
78.7	610	5410	0.49
80.3	610	5410	0.49
81.9	590	5410	0.49
83.6	600	5410	0.49
85.2	630	5410	0.49
86.9	620	5410	0.49
88.5	620	5410	0.49
90.1	610	5410	0.49
91.8	600	5410	0.49
93.4	590	5410	0.49
95.1	600	5410	0.49
96.7	620	5410	0.49
98.3	640	5410	0.49
100.0	650	5410	0.49
101.6	680	5410	0.49
103.3	700	5410	0.49
104.9	700	5410	0.49
106.5	710	5410	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(m)	(m/s)	(m/s)	
13.5	140	1530	0.50
14.0	140	1580	0.50
14.5	140	1570	0.50
15.0	150	1580	0.50
15.5	150	1580	0.50
16.0	160	1580	0.50
16.5	160	1580	0.49
17.0	160	1580	0.49
17.5	160	1590	0.49
18.0	160	1590	0.49
18.5	170	1590	0.49
19.0	160	1650	0.49
19.5	170	1650	0.49
20.0	170	1650	0.49
20.5	170	1650	0.49
21.0	170	1650	0.49
21.5	170	1610	0.49
22.0	170	1620	0.49
22.5	170	1650	0.49
23.0	180	1620	0.49
23.5	190	1650	0.49
24.0	190	1650	0.49
24.5	190	1650	0.49
25.0	180	1650	0.49
25.5	180	1650	0.49
26.0	190	1650	0.49
26.5	190	1650	0.49
27.0	190	1650	0.49
27.5	190	1650	0.49
28.0	180	1650	0.49
28.5	180	1650	0.49
29.0	180	1650	0.49
29.5	190	1650	0.49
30.0	190	1650	0.49
30.5	200	1650	0.49
31.0	210	1650	0.49
31.5	210	1650	0.49
32.0	210	1650	0.49
32.5	220	1650	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-05

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
108.2	720	5410	0.49
109.8	740	5410	0.49
111.5	740	5410	0.49
113.1	730	5410	0.49
114.7	700	5410	0.49
116.4	690	5410	0.49
118.0	700	5410	0.49
119.7	720	5410	0.49
121.3	750	5410	0.49
122.9	760	5410	0.49
124.6	760	5410	0.49
126.2	750	5410	0.49
127.9	770	5410	0.49
129.5	800	5410	0.49
131.1	820	5500	0.49
132.8	830	5500	0.49
134.4	820	5500	0.49
136.1	800	5500	0.49
137.7	800	5500	0.49
139.3	800	5500	0.49
141.3	820	5500	0.49
143.0	850	5500	0.49
144.3	850	5500	0.49
145.9	910	5500	0.49
147.6	930	5500	0.49
149.2	910	5500	0.49
150.8	900	5500	0.49
152.5	870	5500	0.49
154.1	850	5410	0.49
155.8	850	5600	0.49
157.4	860	5500	0.49
159.0	860	5500	0.49
160.7	860	5500	0.49
162.6	860	5500	0.49
164.0	900	5500	0.49
165.6	920	5530	0.49
167.6	920	5530	0.49
168.9	930	5530	0.49
170.5	920	5530	0.49
172.2	920	5550	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
33.0	220	1650	0.49
33.5	230	1650	0.49
34.0	230	1650	0.49
34.5	220	1650	0.49
35.0	210	1650	0.49
35.5	210	1650	0.49
36.0	210	1650	0.49
36.5	220	1650	0.49
37.0	230	1650	0.49
37.5	230	1650	0.49
38.0	230	1650	0.49
38.5	230	1650	0.49
39.0	230	1650	0.49
39.5	250	1650	0.49
40.0	250	1680	0.49
40.5	250	1680	0.49
41.0	250	1680	0.49
41.5	240	1680	0.49
42.0	240	1680	0.49
42.5	240	1680	0.49
43.1	250	1680	0.49
43.6	260	1680	0.49
44.0	260	1680	0.49
44.5	280	1680	0.49
45.0	280	1680	0.49
45.5	280	1680	0.49
46.0	270	1680	0.49
46.5	260	1680	0.49
47.0	260	1650	0.49
47.5	260	1710	0.49
48.0	260	1680	0.49
48.5	260	1680	0.49
49.0	260	1680	0.49
49.6	260	1680	0.49
50.0	270	1680	0.49
50.5	280	1690	0.49
51.1	280	1690	0.49
51.5	280	1690	0.49
52.0	280	1690	0.49
52.5	280	1690	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-05

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
173.8	930	5550	0.49
175.4	920	5550	0.49
177.1	930	5550	0.49
178.7	930	5550	0.49
180.7	930	5550	0.49
182.0	920	5530	0.49
183.6	930	5550	0.49
185.3	920	5550	0.49
186.9	920	5550	0.49
188.6	980	5550	0.48
190.2	1180	6120	0.48
191.8	1400	6730	0.48
193.5	1660	7540	0.47
195.1	1990	8220	0.47
196.8	1980	8790	0.47
198.4	2760	8850	0.45
200.0	3480	9310	0.42
201.7	4010	9590	0.39
203.7	4160	9380	0.38
205.3	4010	9310	0.39
206.6	3600	9170	0.41
208.2	3480	9170	0.42
209.9	3130	8920	0.43
211.5	3150	8670	0.42
213.2	3350	8670	0.41
214.8	3630	8980	0.40
216.4	3880	9170	0.39
218.1	4340	9590	0.37
219.7	4870	9970	0.34
221.4	5500	10730	0.32
223.0	5650	11110	0.33
224.7	5970	11010	0.29
226.3	6090	11300	0.30
227.9	6210	11300	0.28
229.6	6210	11510	0.30
231.2	6150	11300	0.29
232.9	6090	11300	0.30
234.5	5970	11110	0.30
236.1	5860	11110	0.31
237.8	5550	10730	0.32

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
53.0	280	1690	0.49
53.5	280	1690	0.49
54.0	280	1690	0.49
54.5	280	1690	0.49
55.1	280	1690	0.49
55.5	280	1690	0.49
56.0	280	1690	0.49
56.5	280	1690	0.49
57.0	280	1690	0.49
57.5	300	1690	0.48
58.0	360	1860	0.48
58.5	430	2050	0.48
59.0	510	2300	0.47
59.5	610	2510	0.47
60.0	600	2680	0.47
60.5	840	2700	0.45
61.0	1060	2840	0.42
61.5	1220	2920	0.39
62.1	1270	2860	0.38
62.6	1220	2840	0.39
63.0	1100	2800	0.41
63.5	1060	2800	0.42
64.0	960	2720	0.43
64.5	960	2640	0.42
65.0	1020	2640	0.41
65.5	1110	2740	0.40
66.0	1180	2800	0.39
66.5	1320	2920	0.37
67.0	1480	3040	0.34
67.5	1680	3270	0.32
68.0	1720	3380	0.33
68.5	1820	3360	0.29
69.0	1860	3450	0.30
69.5	1890	3450	0.28
70.0	1890	3510	0.30
70.5	1870	3450	0.29
71.0	1860	3450	0.30
71.5	1820	3380	0.30
72.0	1790	3380	0.31
72.5	1690	3270	0.32

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole IBR-05

American Units			
Depth at Midpoint Between Source and Near Receiver	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(ft)	(ft/s)	(ft/s)	
239.4	5280	10550	0.33
241.1	5020	10380	0.35
242.7	4950	10380	0.35
244.3	5020	10380	0.35
246.0	5190	10210	0.33
247.6	5280	10210	0.32
249.3	5230	10210	0.32

Metric Units			
Depth at Midpoint Between Source and Near Receiver	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(m)	(m/s)	(m/s)	
73.0	1610	3220	0.33
73.5	1530	3160	0.35
74.0	1510	3160	0.35
74.5	1530	3160	0.35
75.0	1580	3110	0.33
75.5	1610	3110	0.32
76.0	1590	3110	0.32

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION RECORDS

MICRO PRECISION CALIBRATION, INC
2165 N. Glassell St.,
Orange, CA 92865
714-901-5659

AC-1969

Certificate of Calibration

Date: Jul 19, 2023 **Cert No. 5523631030212482**

Customer:

GEOVISION

1124 OLYMPIC DR.
CORONA CA 92881

		Work Order #:	LA-90060016
		Purchase Order #:	23230-230629-02
MPC Control #:	AM6767	Serial Number:	160023
Asset ID:	160023	Department:	N/A
Gage Type:	LOGGER	Performed By:	JOSE ACEVES
Manufacturer:	OYO	Received Condition:	IN TOLERANCE
Model Number:	3403	Returned Condition:	IN TOLERANCE
Size:	N/A	Cal. Date:	July 11, 2023
Temp/RH:	22.2°C / 34.9%	Cal. Interval:	12 MONTHS
Location:	Calibration performed at MPC facility	Cal. Due Date:	July 11, 2024

Calibration Notes:

This certificate supersedes certificate numbers 5523631030211232 and 5523631030211964 due to correction of clerical issues.

See attached data sheet for calculations (1 Page).
Calibrated IAW customer supplied data form Rev 2.1
Frequency measurement uncertainty = 0.0005 Hz
Unit calibrated with the following Laptop: Panasonic CF-31 Serial number: 3HTYB54089
Calibrated To >4:1 TUR
Calibration performed in accordance with approved GEOVision procedure Rev 2.1

Standards Used to Calibrate Equipment

I.D.	Description.	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
DB8748	GPS TIME AND FREQUENCY RECEIVER	58503A	3625A01225	HEWLETT PACKARD	Apr 30, 2025	5523631030042245
LAS0052	Waveform Generator	33250A	MY40029031	AGILENT	Oct 31, 2023	551220085839149
LAS0033	UNIVERSAL COUNTER	53131A	3546A14968	HEWLETT PACKARD	May 31, 2024	5523631030047964

Calibrating Technician: Jose A
JOSE ACEVES

QC Approval: Ilya Vaks
ILYA VAKS

STATEMENTS OF PASS OR FAIL CONFORMANCE: The uncertainty of measurement has been taken into account when determining compliance with specification. All measurements and test results guard banded to ensure the probability of false-accept does not exceed 2% in compliance with ANSI/NCSL Z540.3-2006.

THE CALIBRATION REPORT STATUS:
PASS- Term used when compliance statement is given, and the measurement result is PASS.
PASS^{z}- Term used when compliance statement is given, and the measurement result is conditional passed or PASS^{z}.
FAIL- Term used when compliance statement is given, and the measurement result is FAIL.
FAIL^{z}- Term used when compliance statement is given, and the measurement result is conditional failed or FAIL^{z}.
REPORT OF VALUE - Term used when reported measurement is not requiring compliance statement in report.
ADJUSTED- When adjustments are made to an instrument which changes the value of measurement from what was measured as found to new value as left.
LIMITED - When an instrument fails calibration but is still functional in a limited manner.

The expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%, unless otherwise stated.
This calibration report complies with ISO/IEC 17025:2017, ANSI/NCSL Z540.3-2006 and ANSI/NCSL Z540.1-1994. Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. All standards are traceable to SI through the National Institute of Standards and Technology (NIST) and/or recognized national or international standards laboratories. Services rendered include proper manufacturer's service instruction and are warranted for no less than thirty (30) days. The information on this report pertains only to the instrument identified, this may not be reproduced in part or in a whole without the prior written approval of the issuing MP Calibration Laboratory.

MICRO PRECISION

MICRO PRECISION CALIBRATION, INC
2165 N. Glassell St.,
Orange, CA 92865
714-901-5659

ilac-MRA
ANAB
ANSI National Accreditation Board
ACCREDITED
ISO/IEC 17025
CALIBRATION AND DIMENSIONAL MEASUREMENT
AC-1969

Certificate of Calibration

Date: Jul 19, 2023 **Cert No. 5523631030212482**

Procedures Used in this Event

Procedure Name	Description
GEOVISION SEISMIC Rev. 2.1	Seismic Logger/Recorder Calibration Procedure, Rev. 2.1

Calibrating Technician: Jose A

JOSE ACEVES

QC Approval: Ilya Vaks

ILYA VAKS

STATEMENTS OF PASS OR FAIL CONFORMANCE: The uncertainty of measurement has been taken into account when determining compliance with specification. All measurements and test results guard banded to ensure the probability of false-accept does not exceed 2% in compliance with ANSI/NCSL Z540.3-2006.

THE CALIBRATION REPORT STATUS:
PASS- Term used when compliance statement is given, and the measurement result is PASS.
PASS^{z}- Term used when compliance statement is given, and the measurement result is conditional passed or PASS^{z}.
FAIL- Term used when compliance statement is given, and the measurement result is FAIL.
FAIL^{z}- Term used when compliance statement is given, and the measurement result is conditional failed or FAIL^{z}.
REPORT OF VALUE - Term used when reported measurement is not requiring compliance statement in report.
ADJUSTED- When adjustments are made to an instrument which changes the value of measurement from what was measured as found to new value as left.
LIMITED - When an instrument fails calibration but is still functional in a limited manner.

The expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%, unless otherwise stated.
This calibration report complies with ISO/IEC 17025:2017, ANSI/NCSL Z540.3-2006 and ANSI/NCSL Z540.1-1994. Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. All standards are traceable to SI through the National Institute of Standards and Technology (NIST) and/or recognized national or international standards laboratories. Services rendered include proper manufacturer's service instruction and are warranted for no less than thirty (30) days. The information on this report pertains only to the instrument identified, this may not be reproduced in part or in a whole without the prior written approval of the issuing MP Calibration Laboratory.

GEOVision
geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160023	Calibration date:	7/11/2023
By:	Micro Precision	Due date:	7/11/2024
Counter mfg.:	Hewlett-Packard	Model no.:	34401A
Serial no.:	3546A14968	Calibration date:	5/9/2023
By:	Micro Precision	Due date:	5/9/2024
Signal generator mfg.:	Agilent	Model no.:	33250A
Serial no.:	MY40029031	Calibration date:	10/24/22
By:	Microprecision	Due date:	10/31/23
Laptop controller mfg.:	Panasonic	Model no.:	Toughbook CF-31
Serial no.:	3HTYB54089	Calibration date:	N/A

SYSTEM SETTINGS:

Gain:	2
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7-11-23 8:26am

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found + 0.22% As left + 0.22%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	101	179.6	50.11	180.0	50.00	180.2	49.94
100.0	100.0	100	102	90.00	100.0	90.10	99.9	90.00	100.0
200.0	200.0	50	103	45.00	200.0	45.00	200.0	45.05	199.8
500.0	500.0	20	104	17.98	500.6	18.00	500.0	18.00	500.0
1000	1000	10	105	9.000	1000	9.000	1000.0	9.010	998.9
2000	2000	5	106	4.495	2002	4.505	1998	4.495	2002

Calibrated by: Jose Acevet 7/11/2023
Name Date Signature

Witnessed by: Emily Feldman 7/11/2023
Name Date Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.1 February 7, 2012

Global Geophysics
P. O. Box 2229
Redmond, WA, 98073-2229
Tel: 425-890-4321
Fax: 206-582-0838

January 31, 2024 Our Ref.: 114-0108.000

Shannon & Wilson, Inc.
3990 Collins Way, Suite 100
Lake Oswego, OR 97035

Attention: Cody Sorensen

RE: REPORT ON THE SUSPENSION LOGGING FOR I5 COLUMBIA RIVER BRIDGE, PORTPLAND, OREGON

Dear Mr. Sorensen:

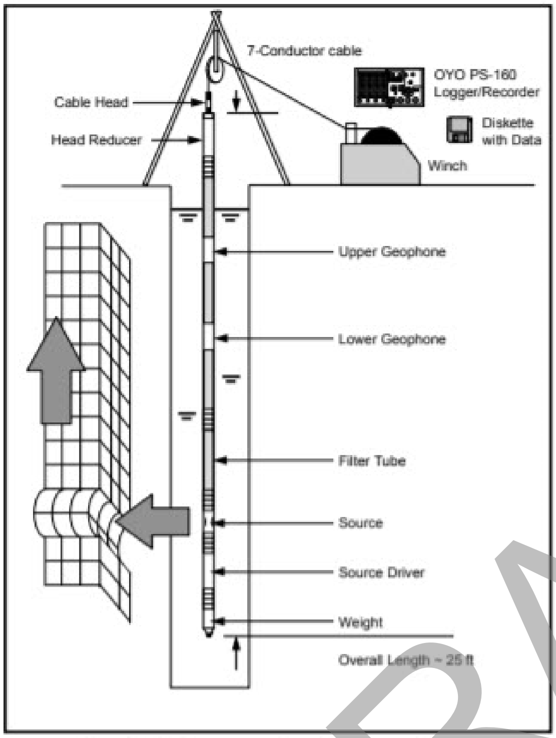
Global Geophysics conducted borehole suspension logging in borehole IBR-07 at I5 Columbia River Bridge on January 8, 2024. The objective of the geophysical investigation was to determine shear and compressional wave velocities.

METHODOLOGY AND INSTRUMENTATION

Suspension Logging

Soil velocity measurements were obtained using a suspension PS logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. Data obtained with this system was used to calculate the average velocity of the soil column surrounding the boring by measuring the elapsed time of a wave propagating upward through the soil column from the transmitter to the receivers over a distance of 3.3 feet. The receivers that detect the wave, and the source that generates the wave, are moved as a unit down the boring at fixed intervals producing relatively constant amplitude signals at each depth where measurements are obtained.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear wave source (SH) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder. The separation of the two receivers is 3.28 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 21 feet. The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4-conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 1.3-foot circumference sheave fitted with a digital rotary encoder. The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and SH-waves in the surrounding soil and rock as it passes through the casing and grout annulus and impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location.



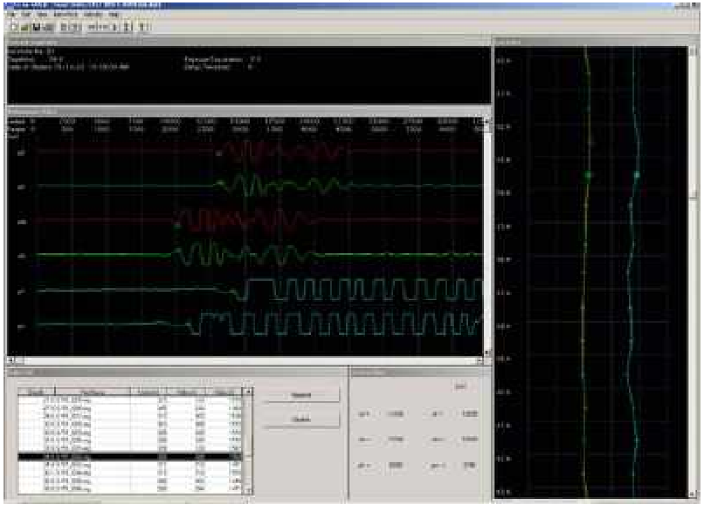
Oyo PS Suspension Logger Setup

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and SH-wave arrivals; reversal of the source changes the polarity of the SH-wave pattern but not the P-wave pattern.

QUALITY ASSESMENT ON SITE

The data quality was carefully monitored during acquisition. Polarity reversal for shear wave and strong s-wave data must be observed and confirmed. An example data is shown below.



RESULTS

Table 1: The s-wave and p-wave velocities from IBR-07

The depth was referred to the top of the mudtub. Bottom of the casing was at 73.5 ft. Mudline was at approximate 43 ft.

Depth from top of the mudtub (ft)	Dpeth from mudline (ft)	S-wave velocity (ft/s)	P-wave velocity (ft/s)	Note
78.7	35.7	912	5128	Good data
82.0	39.0	746	5128	
85.3	42.3		5469	Poor s-wave data
88.6	45.6		5469	
91.9	48.9	1460	5292	Good data
95.1	52.1	1398	7133	
98.4	55.4	2116	7457	
102.0	59.0	3281	8412	
105.0	62.0	3455	8868	
108.3	65.3	2982	8202	
111.5	68.5	3550	8635	
114.8	71.8	4688	9941	
118.4	75.4	4101	9373	
121.4	78.4	4688	9941	
124.7	81.7	4688	10253	
128.3	85.3	2982	7133	
131.2	88.2	1901	5965	
134.5	91.5	3752	8868	
137.8	94.8	4373	9373	
141.1	98.1	4688	9941	
144.4	101.4	3752	8635	
147.6	104.6	3645	8868	
150.6	107.6	3656	8635	
154.5	111.5	4531	9373	
157.8	114.8	4531	9649	
160.8	117.8	5469	9649	
162.1	119.1	5965	10584	

Figure 1: IBR-07 S-wave and P-wave velocity vs depth plot

LIMITATIONS OF THE GEOPHYSICAL METHODS

Global geophysics services are conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions subject to the time limits and financial and physical constraints applicable to the services. Suspension logging is a remote sensing geophysical method that may not detect all subsurface layer changes.

CLOSURE

I trust that this report will meet your immediate requirements. Please contact me if you have any questions or concerns regarding this report or my services.

Sincerely,

Global Geophysics

John

John Liu, Ph.D., R.G.
Principal Geophysicist

APPENDIX D.
COLUMBIA RIVER LABORATORY TEST RESULTS
TABLE OF CONTENTS

ATTACHMENTS

Atterberg Limits Summary
Grain Size Analysis Summaries
Corrosivity Potential Test Results

1. GENERAL

The soil samples obtained during the field explorations were described and identified in the field in accordance with the WSDOT Geotechnical Design Manual (2022). The samples were then reviewed in Shannon & Wilson's laboratory. Physical characteristics of the samples were noted, and field descriptions and identifications were modified as necessary. During examination, select samples were chosen for further testing. We refined our descriptions and identifications based on the results of the laboratory tests, in accordance with the WSDOT Geotechnical Design Manual (2022) and ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

The soil testing program included moisture content analyses, Atterberg limits determinations, particle-size analyses, and corrosivity testing. Testing was performed by Shannon & Wilson, GeoTesting Express (GTX) of Acton, MA, and TEi – Testing Services of Salt Lake City, UT, subcontracted through GeoTesting Express. All testing was completed in general accordance with applicable ASTM International standards. General descriptions of the tests are summarized in the following paragraphs. Laboratory test results from the two borings drilled in North Portland Harbor are presented separately in Appendix E.

2. SOIL TESTING

2.1 Moisture (Natural Water) Content

Natural moisture content analyses were performed in general accordance with ASTM D2216 on selected soil samples. The natural moisture content is a measure of the relative amount of moisture in the soil at the time the explorations are performed and is defined as the ratio of water weight to dry soil weight, expressed as a percentage. Results of the moisture content analyses are presented on the boring logs in Appendix A.

2.2 Atterberg Limits

Atterberg limits were determined on selected samples in general accordance with ASTM D4318. This analysis yields index parameters of the soil that are useful in soil identification, as well as in a number of analyses, including liquefaction analysis. An Atterberg limits test determines a soil's liquid limit (LL) and plastic limit (PL). These are the maximum and minimum moisture contents at which the soil exhibits plastic behavior. A soil's plasticity index (PI) can be determined by subtracting PL from LL. The WSDOT Geotechnical Design Manual (2022) does not define terms to describe the plasticity of soils. For the purposes of soil description, the terms defined in the ODOT Geotechnical Design Manual (2023) were also applied to the Columbia River boring descriptions. ODOT uses the term nonplastic to refer to soils with a PI of 0 to 3, low plasticity for soils with a PI range of 3 to 15, medium plasticity for soils with a PI range of 15 to 30, and high plasticity for soils with a PI greater than 30. Results of Atterberg limits tests are presented in the Atterberg Limits Summary attached to this appendix.

2.3 Particle-Size Analyses

Particle-size analyses were conducted on selected samples to determine their grain-size distributions. Grain size distributions were determined in general accordance with ASTM D6913, D422, and D1140, as applicable. For select samples, a wet sieve analysis was performed to determine the percentage (by weight) of each sample passing the No. 200 (0.075 mm) sieve. For a subset of these samples, the material retained on the No. 200 sieve was shaken through a series of sieves to determine the distribution of the plus No. 200 fraction (ASTM D6913/D422). For some samples, only the percentage of the sample passing the No. 200 (0.075mm) sieve was determined (ASTM D1140). For all particle-size analyses, the percentage of material passing the No. 200 sieve is presented on the boring logs in Appendix A. More complete results of particle size analyses performed on samples from the Columbia River borings are presented in the Grain Size Analysis Summaries attached to this appendix.

2.3.1 Rotosonic Core Samples

As discussed in the report, the grain size distribution curves included in the laboratory test results may include particles that were mechanically fractured, cut, or pulverized during drilling, suggesting increased fines content or smaller particle sizes than are present in the in situ material.

Where cobble-sized particles were retained on the 3-inch sieve, two grain size distribution plots are provided for the tested specimen: one that includes the mass of the material retained on the 3-inch sieve and one based on the mass of the material that passes through the 3-inch sieve. Soil names are based on the portion of the material that passes through the 3-inch sieve, in accordance with ASTM D2487, and "with cobbles" is added to the end of the soil name.

2.4 Corrosivity Testing

Analytical corrosivity testing was performed on selected soil samples from to evaluate the corrosivity potential of the soil. The corrosivity test suite included resistivity, chloride concentration, soil pH, sulfide concentration, and sulfate concentration. Analytical testing was performed by GeoTesting Express of Acton, Massachusetts and by TEi – Testing Services of Salt Lake City, Utah subcontracted through GeoTesting Express. The analytical testing reports and results are attached to the end of this appendix.

The corrosion potential of a soil is primarily evaluated by comparing measured pH, resistivity, and sulfate and chloride concentrations to the values specified in Section 10.7.5 of the AASHTO LFRD Bridge Design Specifications (9th Edition, 2020).

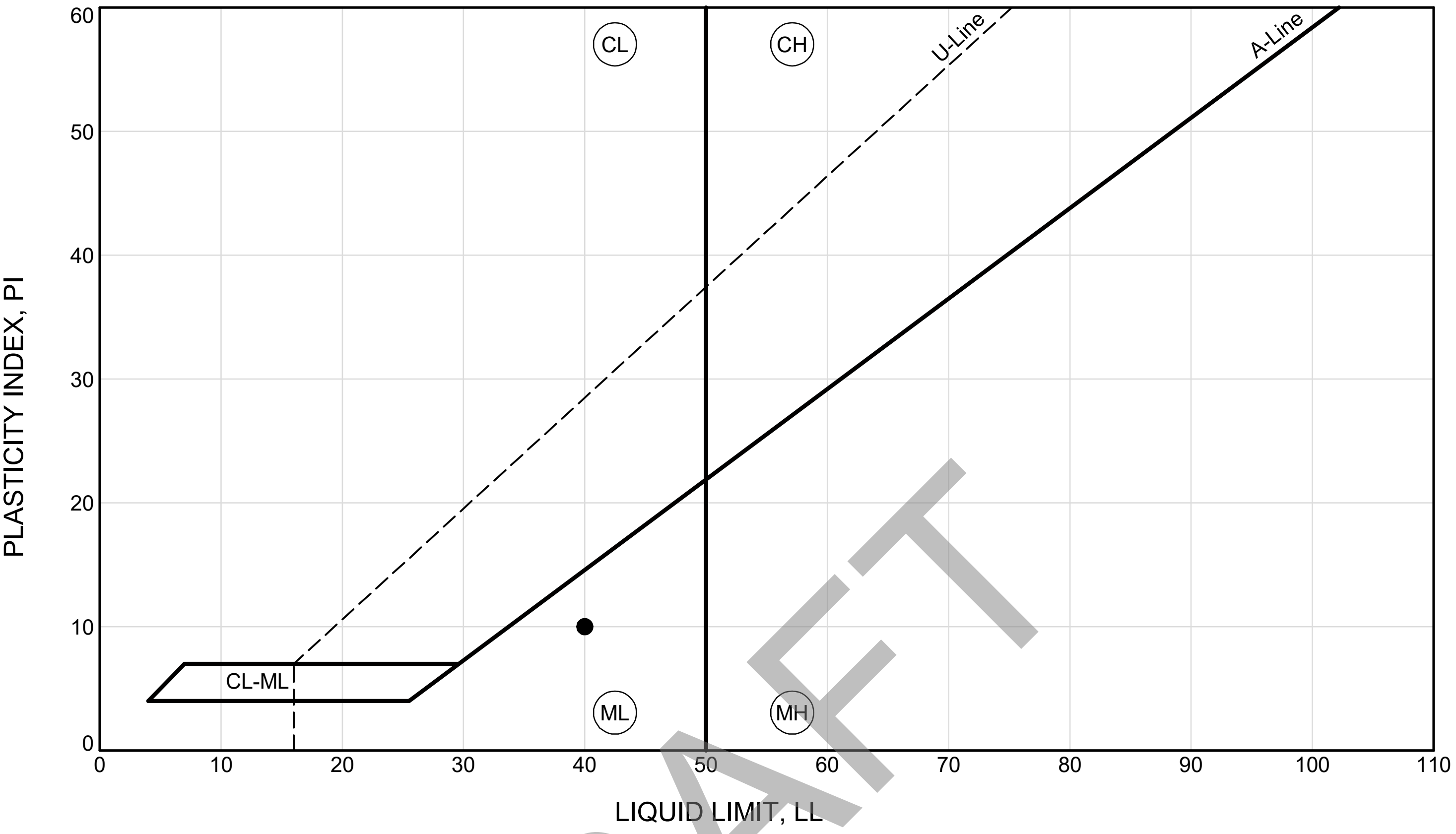
Soil pH is a measurement of the hydrogen ion activity of the soil. Soil pH is reported in Standard Units (S.U.) on a scale ranging from 0 to 14, with 7 being neutral. Soils with a pH less than 7 are considered acidic, and soils with a pH greater than 7 are considered alkaline. According to the AASHTO specifications, soils with a pH less than 5.5 and soils with a pH between 5.5 and 8.5 that also have high organic content are considered potentially corrosive.

Resistivity (expressed as ohms-centimeter or ohms-cm) is the numerical expression of the ability of a soil to impede the transmission of an electrical current. Resistivity is the inverse of conductivity and is dependent on the presence of ions, their concentrations, mobility, and valence, as well as soil moisture and temperature. The AASHTO specifications state that effects of corrosion and deterioration shall be considered if resistivity values are less than 2,000 ohms-cm.

Sulfate and chloride concentrations were also measured. Sulfates can be converted to sulfides by naturally occurring bacteria. Sulfides, when allowed to oxidize, will produce sulfuric acid, which is highly corrosive. Chlorides will also chemically react and facilitate dissolution reactions with metals and concrete. According to the AASHTO specifications, the soil is considered corrosive if the concentration of sulfate or chloride is greater than 1,000 parts per million.

ATTERBERG LIMITS SUMMARY

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**



Symbol	Hole No.	Depth (feet)	Sample No.	USCS	Description	Comment	MC (%)	LL	PL	PI	Fines (%)	Silt (%)	Clay (%)
●	IBR-03	131.7	N-23	ML	SILT		41	40	30	10	88.9		
	IBR-06	95.0	S-7B	ML	SILT			n/a	n/a	NP	88.9		
	IBR-06	150.0	S-10B	SM	SILTY SAND			n/a	n/a	NP	45.4		

** Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the Atterberg Limits only.*

ABBREVIATIONS:
LL = liquid limit; MC = moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; USCS = Unified Soil Classification System code
USCS codes listed on graph: CL = lean clay; CH = fat clay; ML = silt; MH = elastic silt; CL-ML = silty clay

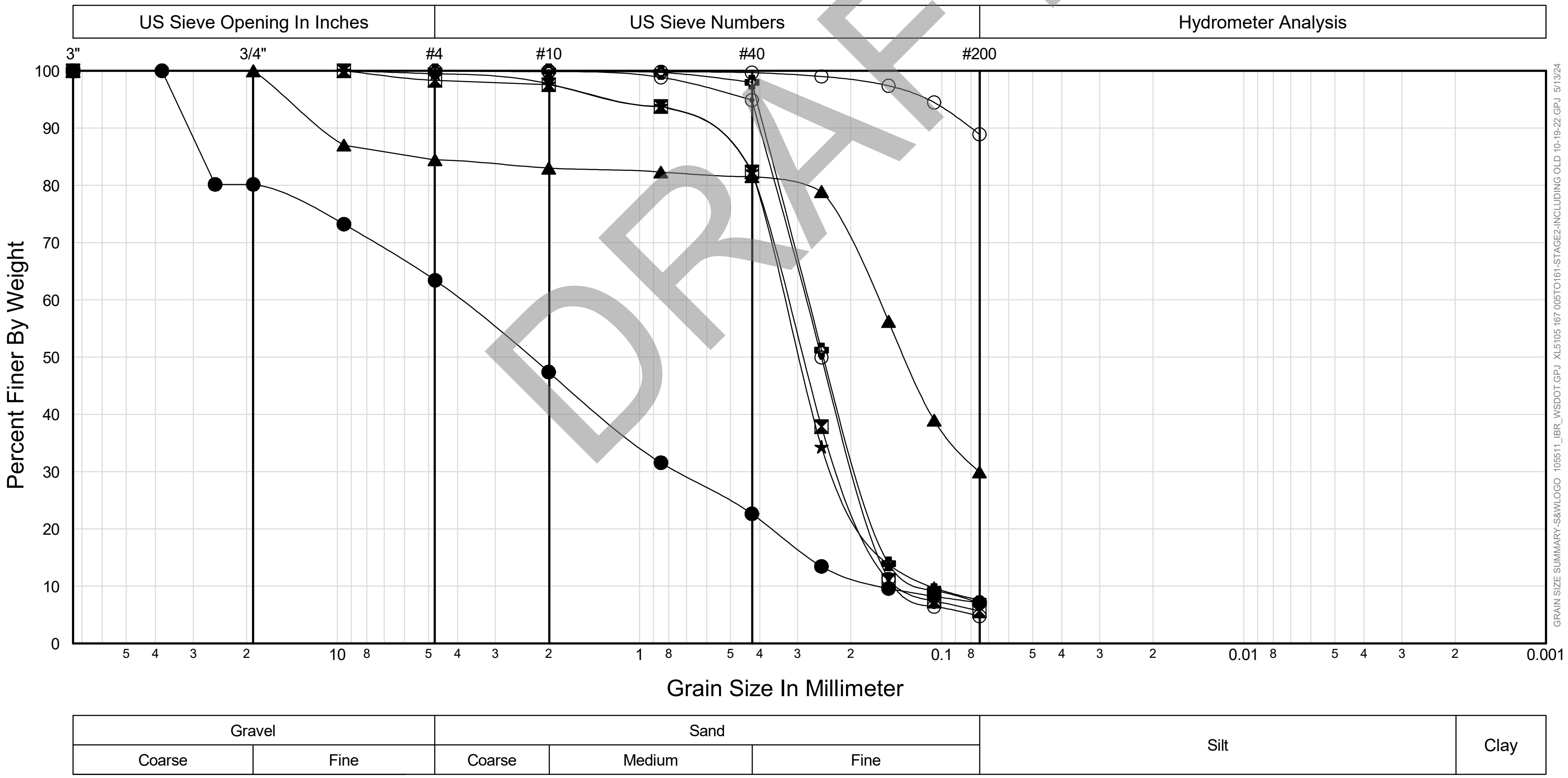
SHANNON & WILSON

GRAIN SIZE ANALYSIS SUMMARY FOR IBR-03

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	15.9	N-4B	*SP-SM**	*POORLY GRADED SAND with SILT and GRAVEL**	3-13-24	17						36.6	56.3	7.1	0.9	25	31.061	3.951	2.303	0.753	0.365	0.158
⧗	31.2	N-7	*SP-SM**	*POORLY GRADED SAND with SILT**	3-13-24	26						1.7	92.7	5.7	1.0	2	0.676	0.326	0.289	0.215	0.178	0.136
▲	36.2	N-8	*SM**	*SILTY SAND with GRAVEL**	3-13-24	37						15.6	54.5	29.9			11.157	0.163	0.132	0.075		
★	56.3	N-11	*SP-SM**	*POORLY GRADED SAND with SILT**	3-13-24	33						0.5	92.0	7.6	1.4	3	0.674	0.332	0.297	0.224	0.175	0.109
⊙	76.9	N-15	*SP**	*POORLY GRADED SAND**	3-13-24	34						0.0	95.3	4.8	1.0	2	0.401	0.282	0.250	0.192	0.168	0.137
✤	102.1	N-20	*SP-SM**	*POORLY GRADED SAND with SILT**	3-13-24	32						0.0	92.9	7.1	1.1	2	0.388	0.276	0.246	0.187	0.163	0.112
○	131.7	N-23	*ML**	*SILT**	3-13-24	41	40	30	10			0.0	11.1	88.9			0.080					

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*



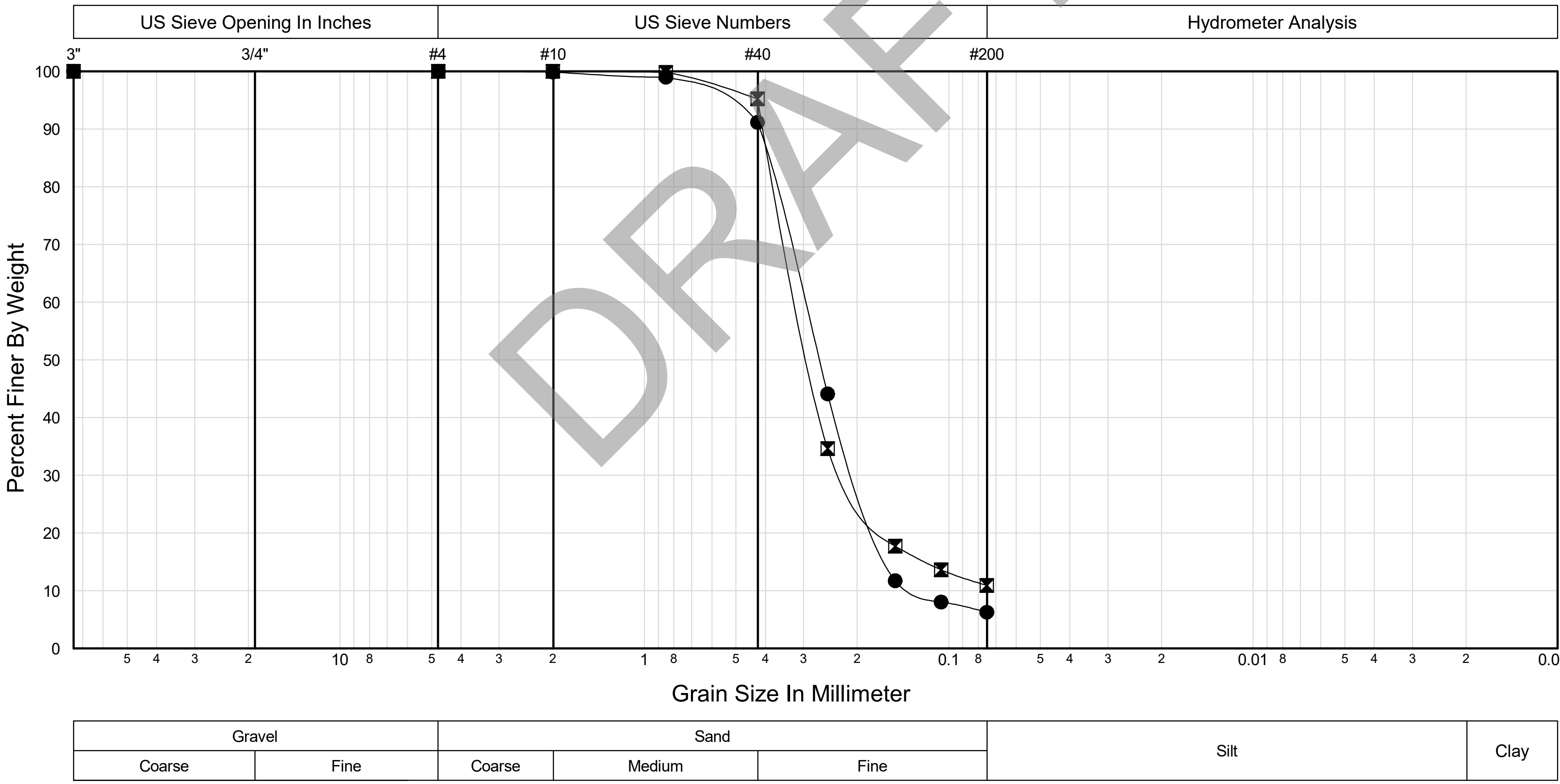
GRAIN SIZE SUMMARY-S&WLOGO 105511_IBR_WSDOT.GPJ XL5105 167 005TO161-STAGE2-INCLUDING OLD 10-19-22.GPJ 5/13/24

GRAIN SIZE ANALYSIS SUMMARY FOR IBR-03

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	152.0	N-25	*SP-SM**	*POORLY GRADED SAND with SILT**	3-13-24	27						0.0	93.7	6.3	1.1	2	0.420	0.299	0.267	0.200	0.171	0.128
☒	192.7	N-29	*SP-SM**	*POORLY GRADED SAND with SILT**	3-13-24	36						0.0	89.1	10.9	2.3	5	0.406	0.312	0.286	0.218	0.161	

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*

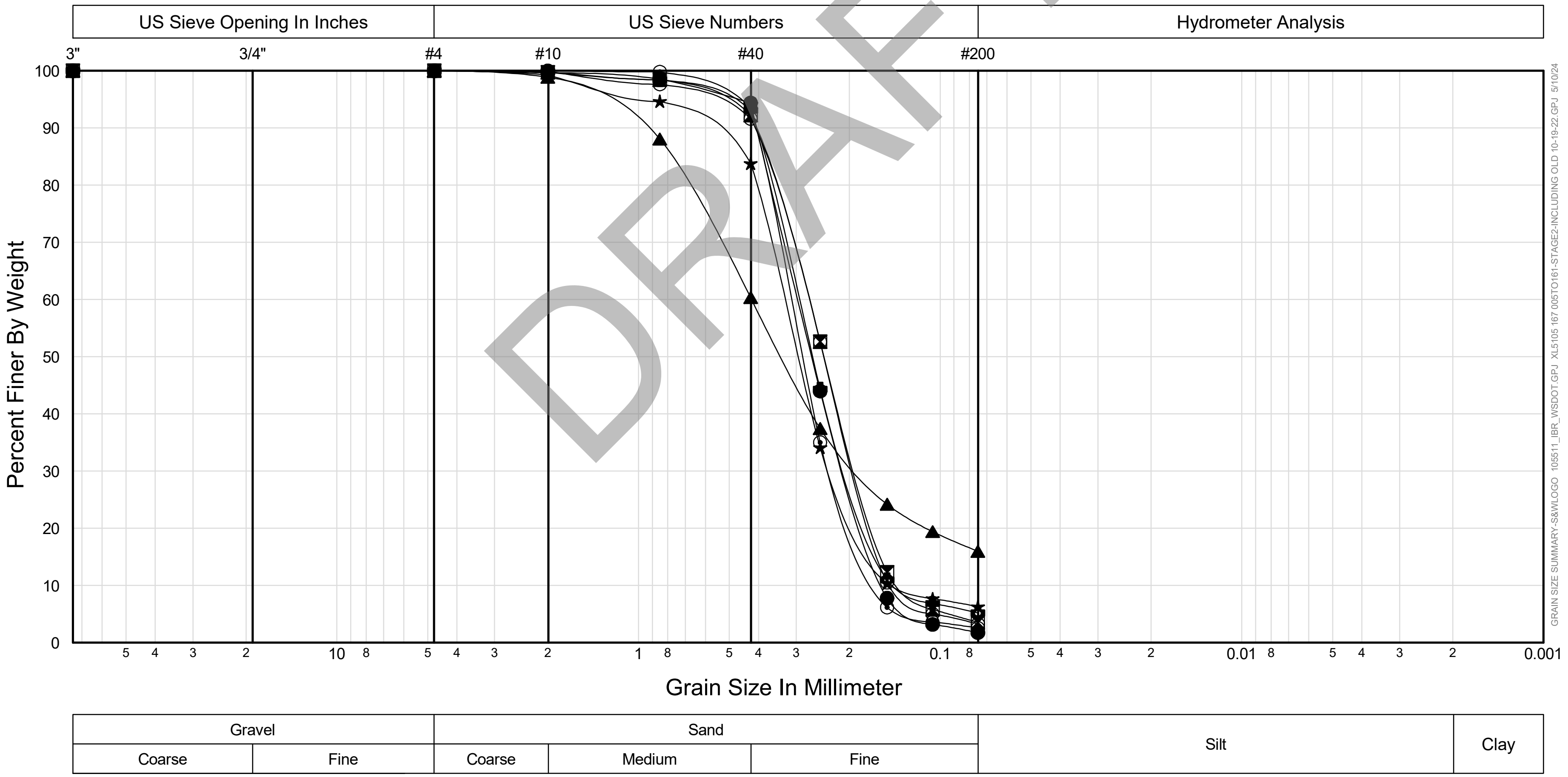


GRAIN SIZE ANALYSIS SUMMARY FOR IBR-04

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	5.0	S-1	*SP**	*POORLY GRADED SAND**	1-2-24							0.0	98.3	1.7	0.9	2	0.406	0.296	0.266	0.205	0.178	0.155
⊠	23.0	S-3A	*SP**	*POORLY GRADED SAND**	1-2-24							0.0	96.5	3.5	1.0	2	0.412	0.276	0.242	0.188	0.165	0.133
▲	28.0	S-3B	*SM**	*SILTY SAND**	1-2-24							0.0	84.0	16.0			0.991	0.422	0.335	0.188	0.111	
★	41.0	S-5	*SP-SM**	*POORLY GRADED SAND with SILT**	1-2-24							0.0	93.7	6.3	1.1	2	0.631	0.330	0.296	0.229	0.185	0.143
⊙	53.0	S-6B	*SP**	*POORLY GRADED SAND**	1-2-24							0.0	97.5	2.6	1.0	2	0.412	0.314	0.286	0.229	0.192	0.161
✿	64.0	S-7B	*SP-SM**	*POORLY GRADED SAND with SILT**	1-3-24							0.0	94.8	5.2	1.0	2	0.411	0.297	0.266	0.201	0.172	0.138
○	81.0	S-9A	*SP**	*POORLY GRADED SAND**	1-3-24							0.0	96.7	3.3	0.9	2	0.416	0.277	0.242	0.190	0.168	0.145

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*

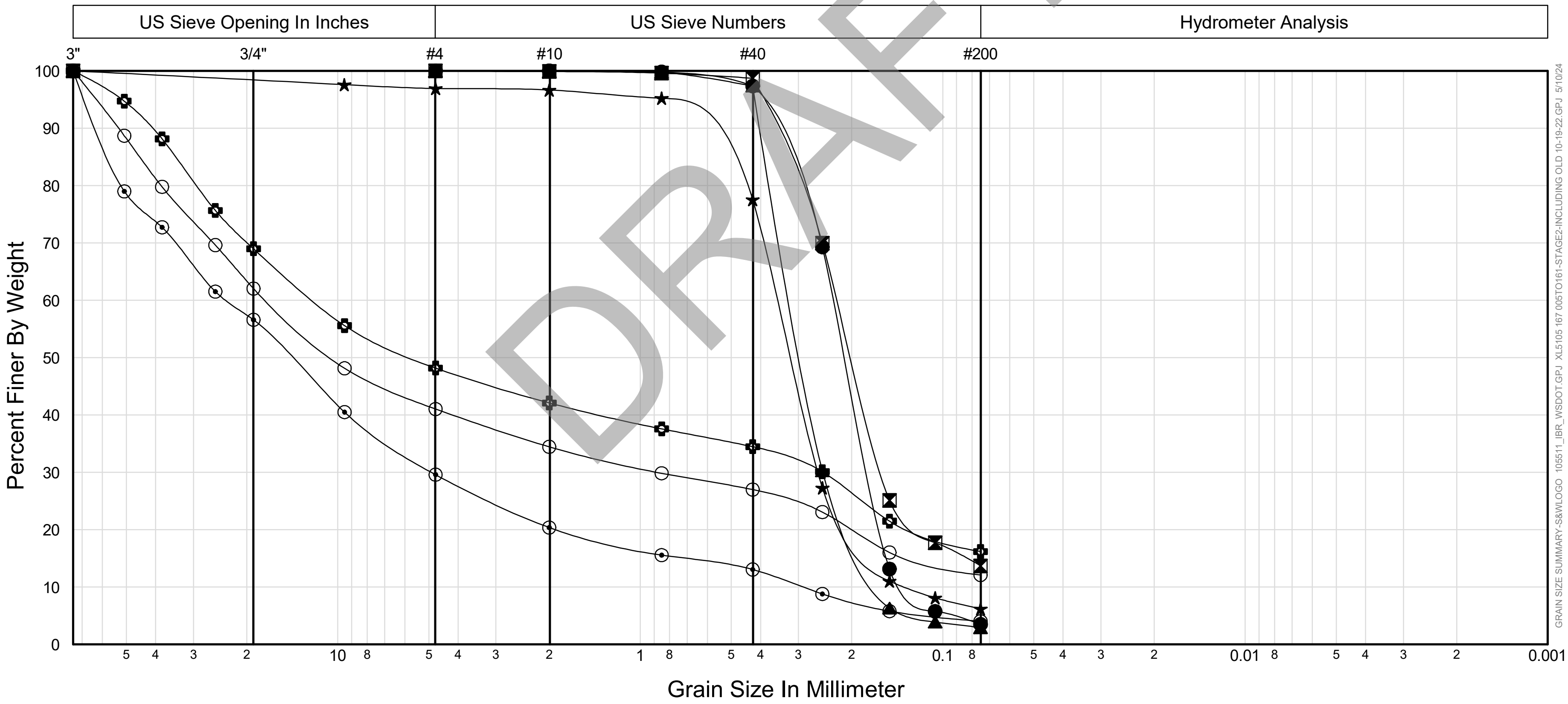


GRAIN SIZE ANALYSIS SUMMARY FOR IBR-04

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	106.0	S-10	*SP**	*POORLY GRADED SAND**	1-3-24							0.0	96.5	3.5	1.0	2	0.370	0.230	0.210	0.175	0.160	0.129
⧗	122.0	S-12A	*SM**	*SILTY SAND**	1-3-24							0.0	86.3	13.7			0.362	0.223	0.199	0.159	0.118	
▲	143.0	S-14B	*SP**	*POORLY GRADED SAND**	1-3-24							0.0	97.1	2.9	1.2	2	0.401	0.316	0.292	0.249	0.201	0.162
★	171.0	S-17	*SP-SM**	*POORLY GRADED SAND with SILT**	1-3-24							3.1	90.7	6.2	1.4	3	0.692	0.353	0.318	0.257	0.199	0.133
⊙	187.0	S-18B	*GP**	*POORLY GRADED GRAVEL with SAND**	1-23-24							70.4	25.5	4.0	3.5	80	62.306	23.235	14.307	4.878	1.876	0.291
✚	203.5	S-20	*GM**	*SILTY GRAVEL with SAND**	1-24-24							51.8	32.0	16.2			41.328	11.945	5.638	0.249	0.124	
○	221.0	S-22	*GM**	*SILTY GRAVEL with SAND**	1-24-24							59.0	28.9	12.1	0.9	331	53.145	17.162	10.423	0.877	0.200	

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*



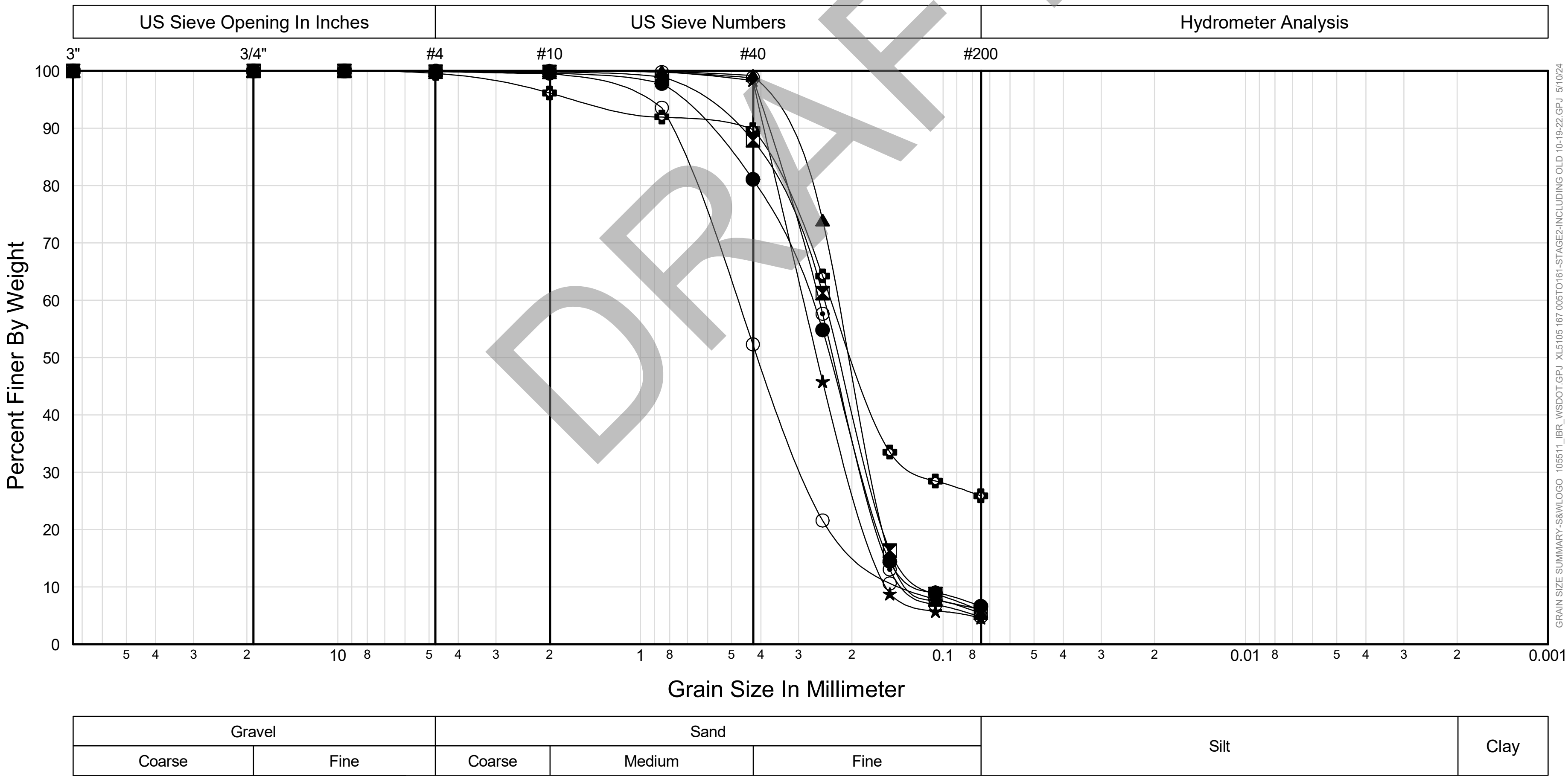
Gravel		Sand			Silt	Clay
Coarse	Fine	Coarse	Medium	Fine		

GRAIN SIZE ANALYSIS SUMMARY FOR IBR-05

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	14.2	N-2	*SP-SM**	*POORLY GRADED SAND with SILT**	3-14-24	30						0.1	93.2	6.6	1.1	2	0.615	0.278	0.235	0.183	0.161	0.113
⧗	19.3	N-4	*SP-SM**	*POORLY GRADED SAND with SILT**	3-14-24	29						0.2	94.0	5.9	1.1	2	0.484	0.246	0.220	0.175	0.156	0.112
▲	34.9	N-8	*SP-SM**	*POORLY GRADED SAND with SILT**	3-14-24	32						0.0	94.6	5.4	1.1	2	0.350	0.221	0.203	0.170	0.156	0.118
★	53.5	N-12	*SP**	*POORLY GRADED SAND**	3-14-24	28						0.0	95.4	4.6	0.9	2	0.391	0.288	0.261	0.201	0.175	0.153
⊙	83.1	N-18	*SP**	*POORLY GRADED SAND**	3-14-24	32						0.0	95.2	4.8	1.0	2	0.379	0.258	0.229	0.182	0.162	0.126
✿	130.0	N-24	*SM**	*SILTY SAND**	3-14-24	32						0.4	73.7	25.9			0.456	0.233	0.197	0.118		
○	190.9	N-30	*SP-SM**	*POORLY GRADED SAND with SILT**	3-14-24	27						0.0	93.9	6.1	1.2	3	0.801	0.484	0.408	0.289	0.232	0.139

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*

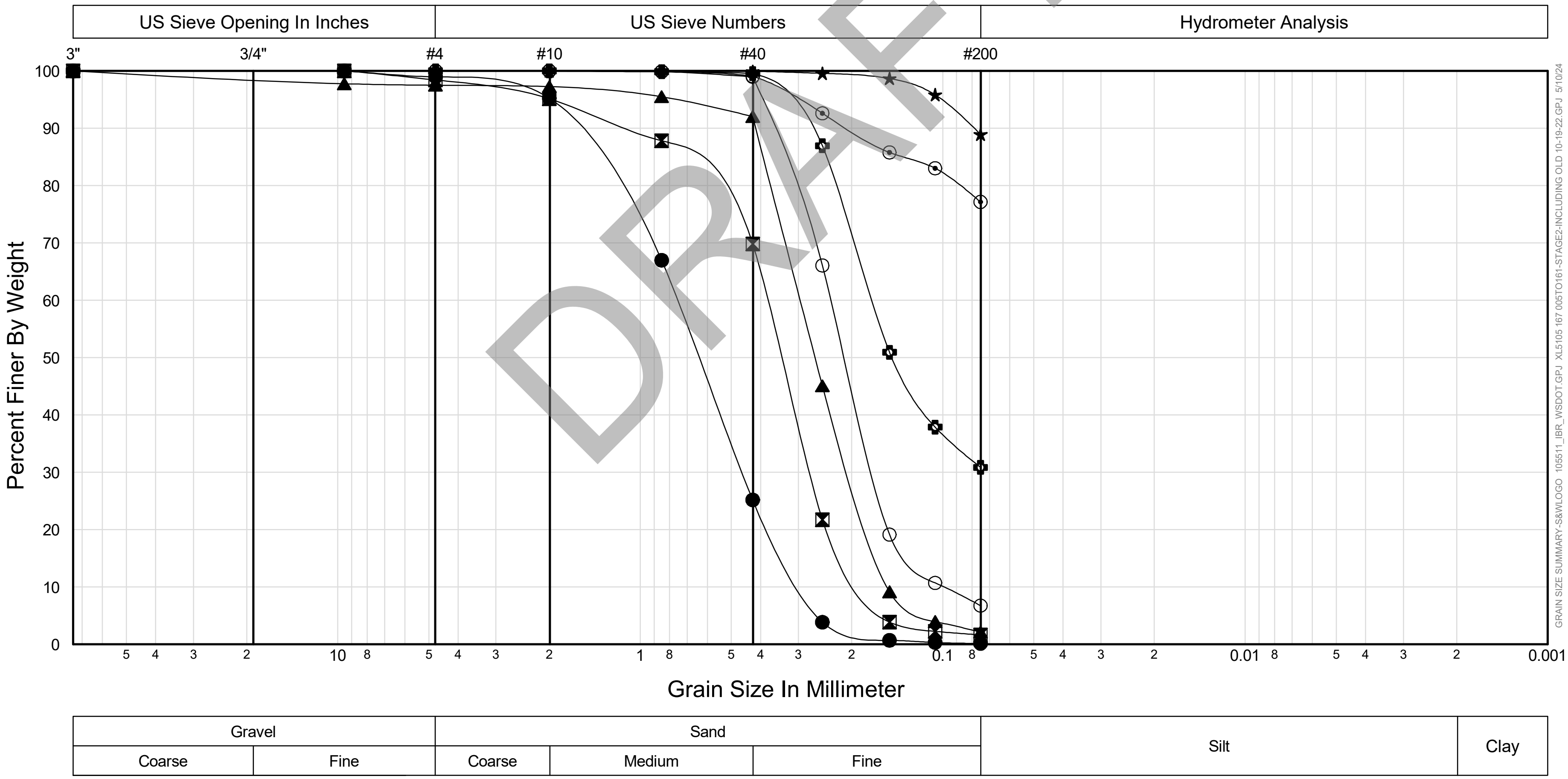


GRAIN SIZE ANALYSIS SUMMARY FOR IBR-06

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	1.0	S-1	*SP**	*POORLY GRADED SAND**	1-3-24							1.1	98.8	0.1	1.0	3	1.707	0.757	0.642	0.460	0.374	0.291
⧗	10.0	S-1	*SP**	*POORLY GRADED SAND**	1-3-24							1.6	96.8	1.6	1.1	2	1.098	0.381	0.341	0.274	0.238	0.179
▲	45.0	S-5	*SP**	*POORLY GRADED SAND**	1-3-24							2.5	95.4	2.1	0.9	2	0.415	0.296	0.264	0.202	0.175	0.152
★	95.0	S-7B	ML	SILT	1-3-24		n/a	n/a	NP			0.0	11.1	88.9			0.079					
⦿	105.0	S-8A	*ML**	*SILT with SAND**	1-3-24							0.0	22.9	77.1			0.206					
✜	135.4	S-9B	*SM**	*SILTY SAND**	1-3-24							0.0	69.2	30.9			0.285	0.171	0.146			
○	146.0	S-10A	*SP-SM**	*POORLY GRADED SAND with SILT**	1-3-24							0.0	93.3	6.7	1.2	2	0.368	0.234	0.210	0.169	0.151	0.100

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*

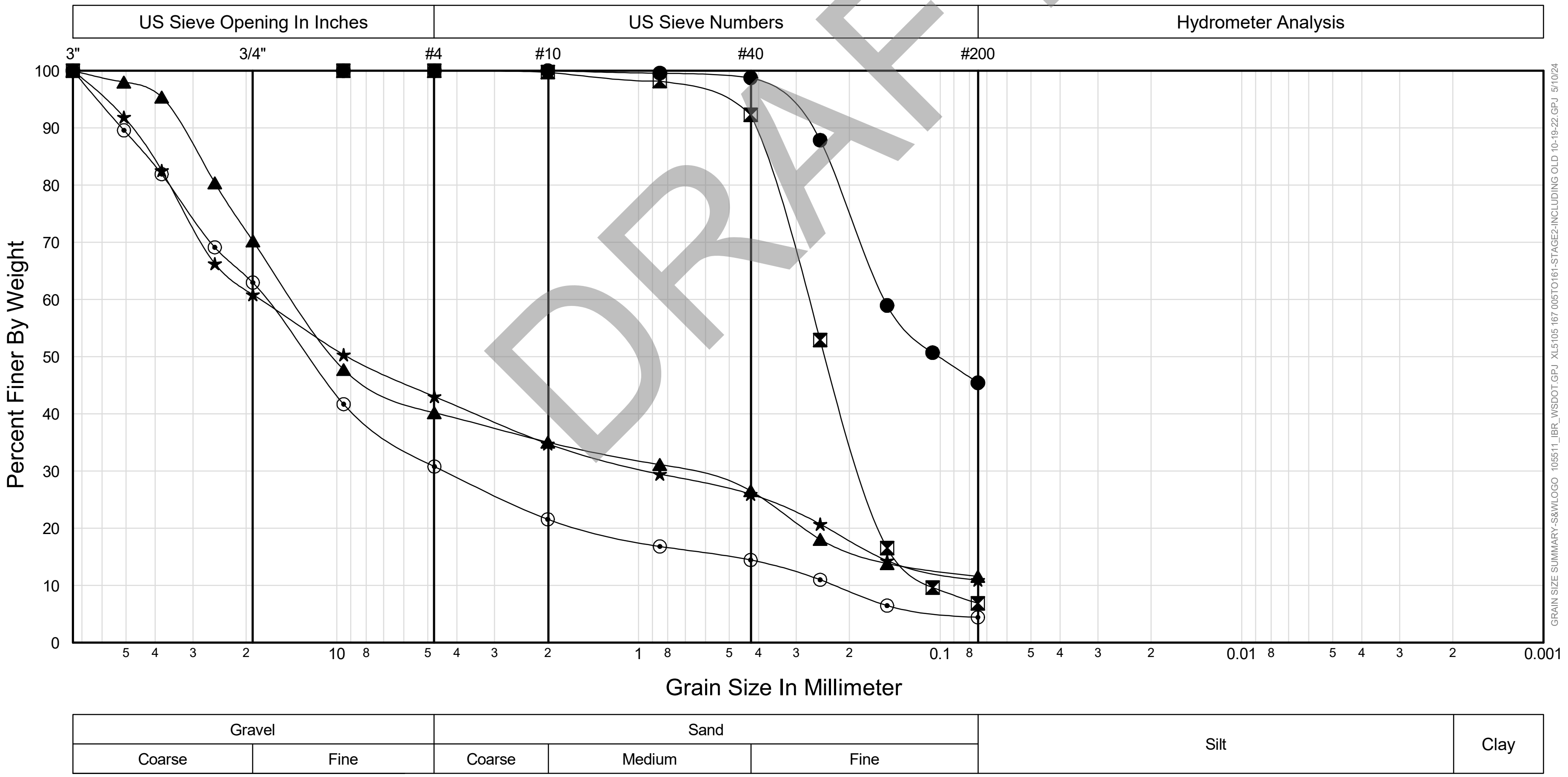


GRAIN SIZE ANALYSIS SUMMARY FOR IBR-06

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	150.0	S-10B	SM	SILTY SAND	1-3-24		n/a	n/a	NP			0.0	54.6	45.4			0.278	0.153	0.101			
⊠	155.0	S-11A	*SP-SM**	*POORLY GRADED SAND with SILT**	1-3-24							0.0	93.2	6.8	1.1	3	0.412	0.275	0.240	0.181	0.158	0.108
▲	186.0	S-12D	*GP-GM**	*POORLY GRADED GRAVEL with SILT and SAND**	1-25-24							59.8	28.6	11.6	0.8	301	32.943	13.860	10.185	0.717	0.282	
★	204.0	S-13B	*GP-GM**	*POORLY GRADED GRAVEL with SILT and SAND, with COBBLES** (cobbles not included in data)	1-25-24							57.0	32.1	10.9	0.8	289	47.936	17.964	9.199	0.927	0.236	
⊙	220.0	S-14B	GP	POORLY GRADED GRAVEL with SAND	1-25-24							69.2	26.4	4.4	5.1	77	51.623	17.258	12.456	4.419	1.510	0.224

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*



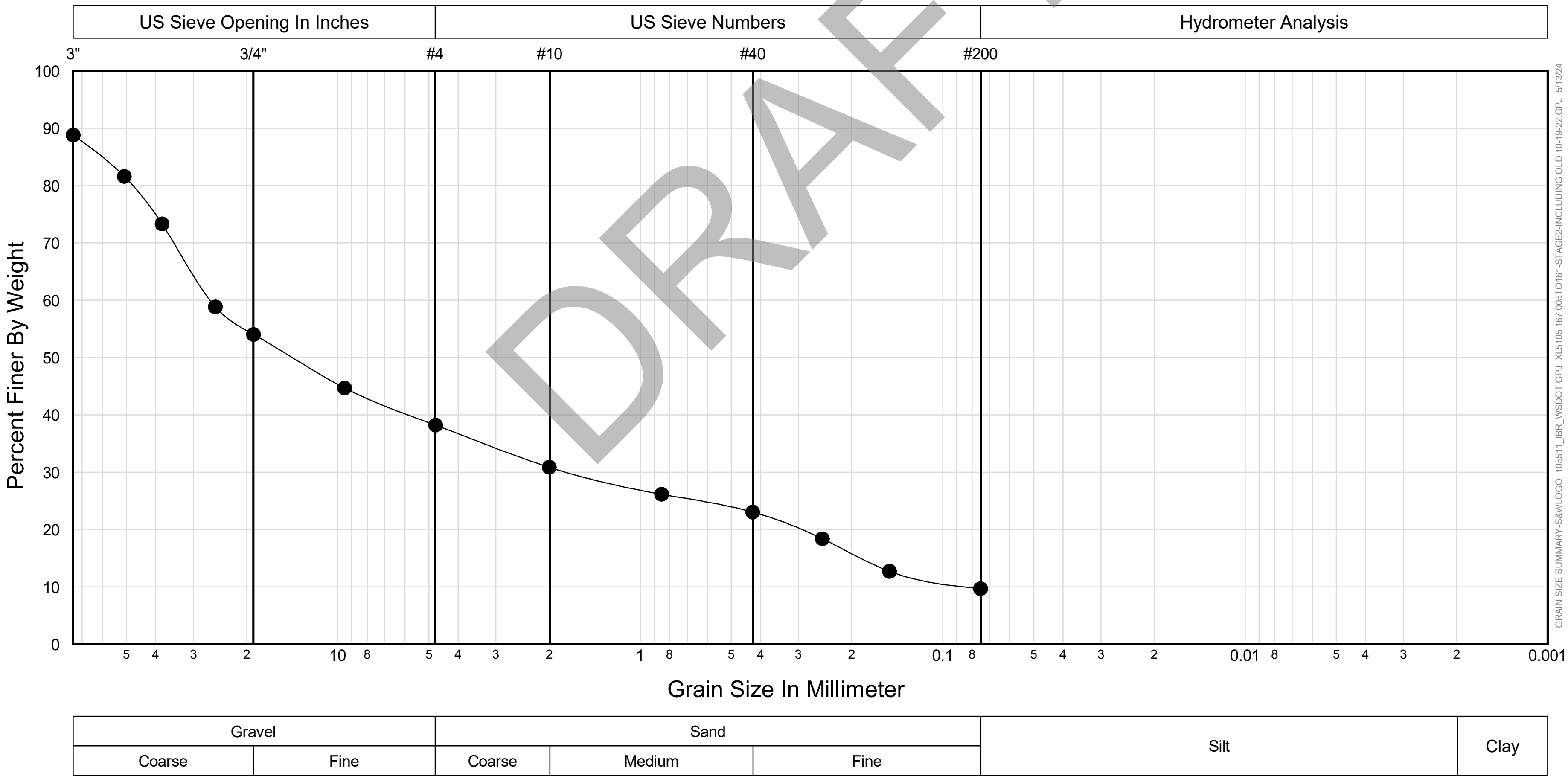
GRAIN SIZE SUMMARY-S&WLOGO 105511_IBR_WSDOT.GPJ XL5105 167 005TO161-STAGE2-INCLUDING OLD 10-19-22.GPJ 5/10/24

GRAIN SIZE ANALYSIS SUMMARY FOR IBR-06(+3-in.)

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	204.0	S-13B	*GW-GM**	*POORLY GRADED GRAVEL with SILT and SAND, with COBBLES** (cobbles included in data)	1-25-24							50.6	28.5	9.7	1.4	326		26.232	14.084	1.708	0.300	0.080

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*



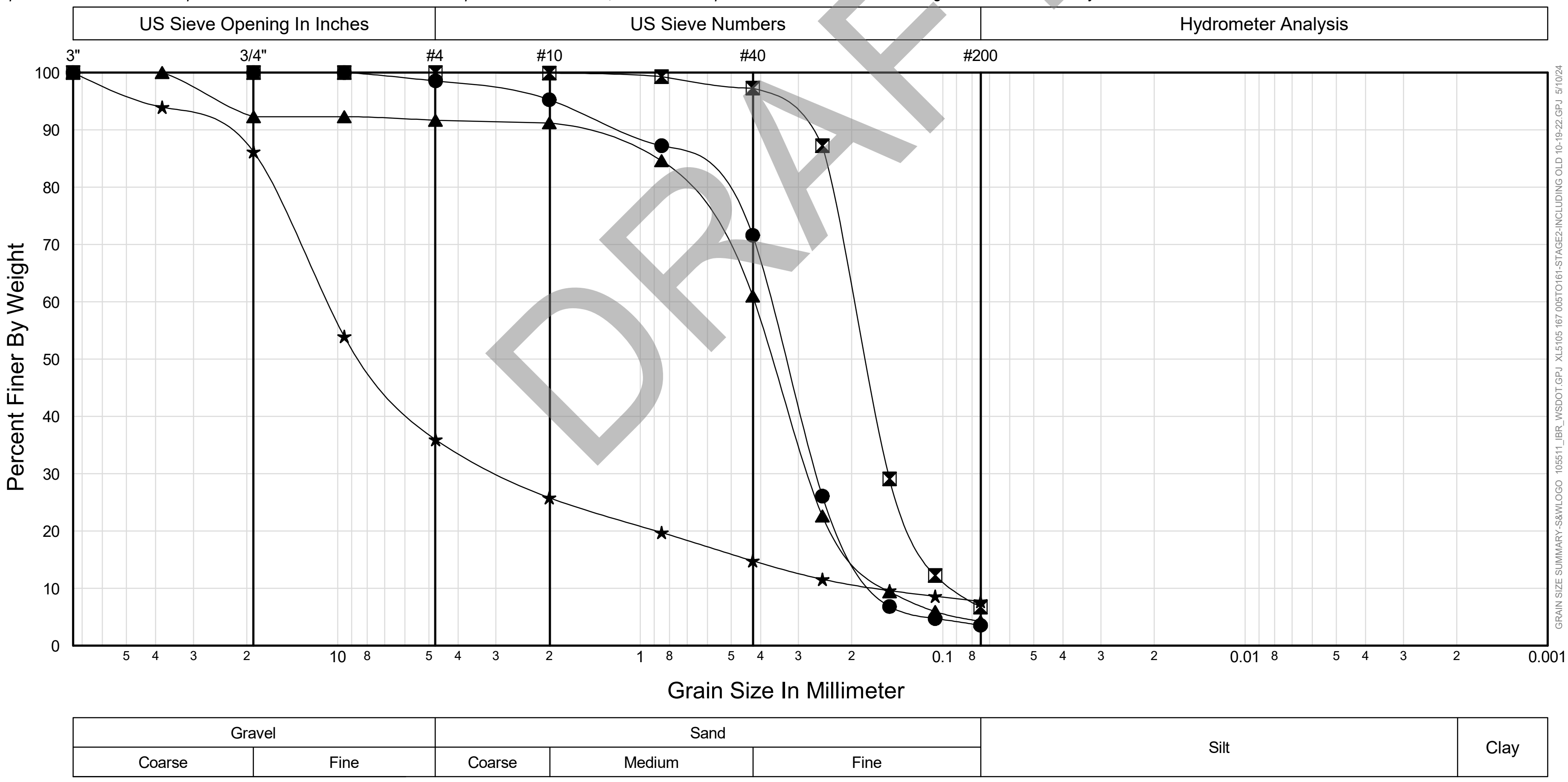
GRAIN SIZE SUMMARY-S&WLOGO 105511_IBR_WSDOT.GPJ XL5105 167 005TO161-STAGE2-INCLUDING OLD 10-19-22.GPJ 5/13/24

GRAIN SIZE ANALYSIS SUMMARY FOR IBR-07

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	7.5	N-2	*SP**	*POORLY GRADED SAND**	3-14-24	31						1.5	95.0	3.5	1.1	2	1.141	0.371	0.330	0.262	0.213	0.163
⊠	15.6	N-5	*SP-SM**	*POORLY GRADED SAND with SILT**	3-14-24	30						0.0	93.3	6.7	1.3	2	0.289	0.197	0.180	0.151	0.124	0.092
▲	33.5	N-9	*SP**	*POORLY GRADED SAND**	3-14-24	25						8.3	87.5	4.2	1.2	3	1.710	0.419	0.365	0.277	0.226	0.154
★	54.5	N-13	*GP-GM**	*POORLY GRADED GRAVEL with SILT and SAND**	3-14-24	13						64.0	28.3	7.7	4.5	65	26.737	10.839	8.172	2.858	0.883	0.167

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*



SHANNON & WILSON

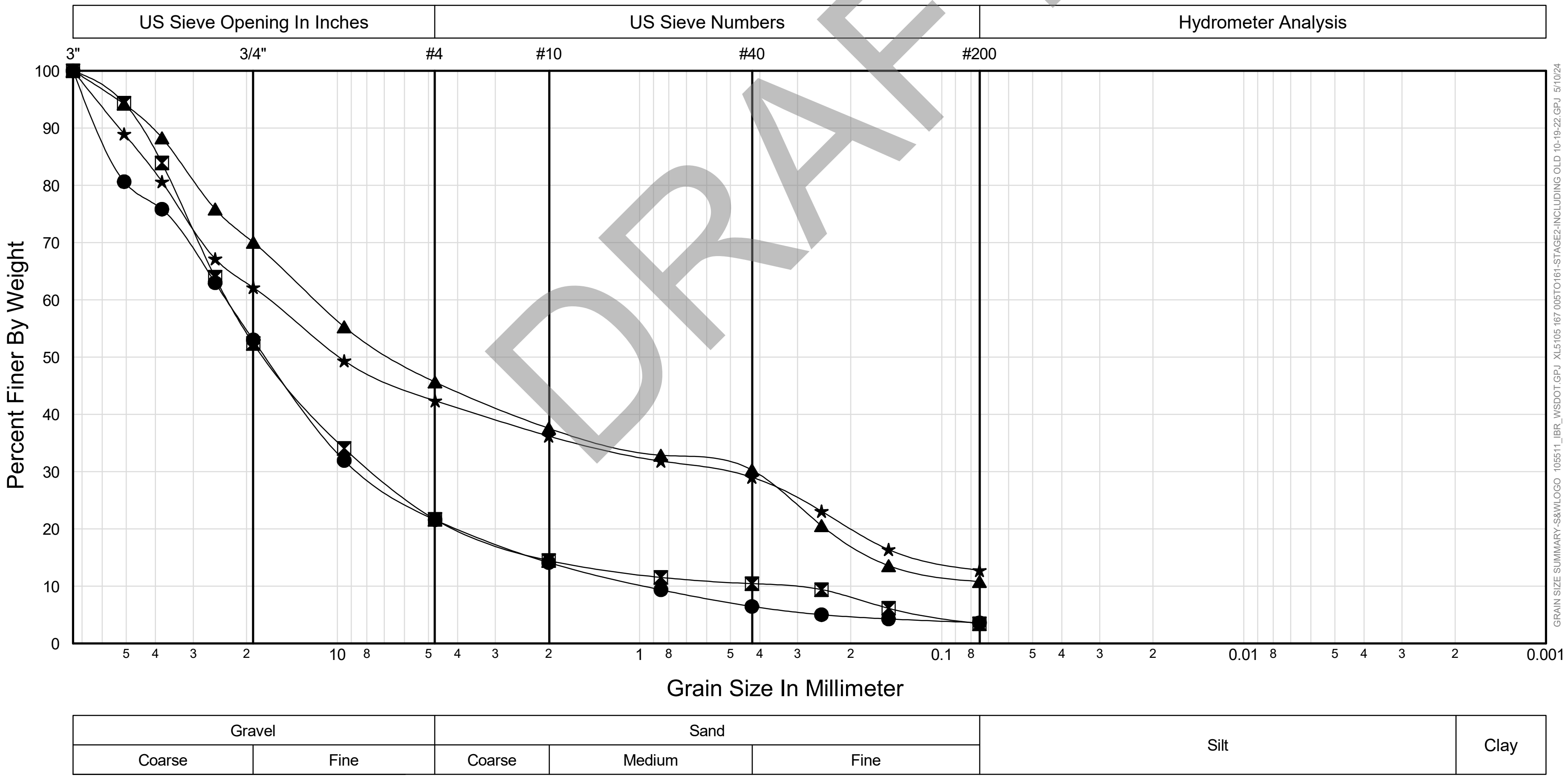
GRAIN SIZE ANALYSIS SUMMARY FOR IBR-08

Sheet 1 of 1

Job No: **Y-12435**
Project: **Interstate Bridge Replacement Program**

Symbol	Depth (feet)	Sample No.	USCS	Description	Test Date	MC (%)	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	C_c	C_u	D_{90} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	D_{20} (mm)	D_{10} (mm)
●	32.0	SC-4	*GP**	*POORLY GRADED GRAVEL with SAND**	1-19-24							78.4	18.0	3.6	3.1	24	61.335	23.289	17.210	8.348	3.956	0.954
⊠	52.0	SC-6	*GP**	*POORLY GRADED GRAVEL with SAND**	1-19-24							78.4	18.2	3.4	7.3	68	45.062	23.009	17.358	7.573	3.894	0.340
▲	68.0	SC-8	*GP-GM**	*POORLY GRADED GRAVEL with SILT and SAND**	1-19-24							54.4	34.8	10.8	0.2	194	41.425	11.857	6.499	0.418	0.240	
★	90.0	SC-10	*GM**	*SILTY GRAVEL with SAND**	1-23-24							57.6	29.6	12.8			52.682	16.903	9.835	0.539	0.197	

**Sample was assumed to be non-plastic based on visual-manual examination procedures. Therefore, the ASTM Group Name is estimated based on the grain size distribution only.*



GRAIN SIZE SUMMARY-S&WLOGO 105511_IBR_WSDOT.GPJ XL5105 167 005TO161-STAGE2-INCLUDING OLD 10-19-22.GPJ 5/10/24

Client:	Shannon & Wilson, Inc.
Project Name:	IBR
Project Location:	Portland, OR
GTX #:	318519
Test Date:	01/26/24
Tested By:	nmk
Checked By:	ank

Laboratory pH of Soil by ASTM G51

Boring ID	Sample ID	Depth, ft	Description	Soil Temperature, ° C	Average pH Reading
IBR-01	SC-4A	33-36	Moist, dark gray sand	21	6.32
IBR-04	SC-3B	28-29.5	Moist, very dark gray sand	20.8	6.11
IBR-06	SC-1A	1-1.5	Moist, very dark reddish gray sand	21.3	6.44

Notes:

Client:	Shannon & Wilson
Project:	IBR
Location:	Portalnd, OR
GTX#:	318519
Test Date:	01/30/24
Due Date:	2/8/2024
Tested By:	NMK
Checked By:	ank

Laboratory Measurement of Soil Resistivity Using the Wenner Four-Electrode Method by ASTM G57 (Laboratory Measurement)

Boring ID	Sample ID	Depth, ft.	Sample Description	Electrical Resistivity, ohm-cm	Electrical Conductivity, $(\text{ohm-cm})^{-1}$
IBR-01	SC-4A	33-36 ft	Moist, dark gray sand	5,864	1.71E-04
IBR-04	SC-3B	28-29.5 ft	Moist, very dark gray sand	8,646	1.16E-04
IBR-06	SC-1A	1-1.5 ft	Moist, very dark gray reddish sand	43,422	2.30E-05

testing services sm

PO Box 572455 / Salt Lake City UT 84157-2455 / USA
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GEOTESTING EXPRESS INCORPORATED
125 NAGOG PARK
ACTON MA 01720-3451
USA

Analysis No.	TS-A2411681
Report Date	31 January 2024
Date Sampled	25 January 2024
Date Received	29 January 2024
Where Sampled	Acton, MA USA
Sampled By	Client

This is to attest that we have examined: Soil: Project: IBR; Site Location: - — -; Job Number: GTX-318519

When examined to the applicable requirements of:

ASTM D 512-12*	“Standard Test Methods for Chloride Ion in Water” Method B
ASTM D 516-16	“Standard Test Method for Sulfate Ion in Water”
ASTM G 200-20	“Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil”

Results:

ASTM D 512 - Chloride Method B

Sample		Results		Minimum Detection Limit
		ppm (mg/kg)	%[1]	
SC-1A		17.	0.0017	10.
IBR-06	1.0 – 1.5’			
SC-3B		< 10.	< 0.0010	
IBR-04	28.0 – 28.5’			
SC-4A		< 10.	< 0.0010	
IBR-01	33.0 – 36.0’			

NOTE: [1]Percent by weight after drying and prepared as per the Standard. *Withdrawn 2021 without Replacement

DRAFT

ASTM D 516 – Sulfates (Soluble)

Sample		Results		Minimum Detection Limit
		ppm (mg/kg)	%[1]	
SC-1A		< 10.	< 0.0010	10.
IBR-06	1.0 – 1.5’			
SC-3B		10.	0.0010	
IBR-04	28.0 – 28.5’			
SC-4A		10.	0.0010	
IBR-01	33.0 – 36.0’			

NOTE: [1]Percent by weight after drying and prepared as per the Standard.

ASTM G 200 – Reduction Oxidation Potential (REDOX)

Sample		Results	Minimum Detection Limit
SC-1A		109.7 @ 21.1 ºC	0.1mV
IBR-06	1.0 – 1.5’		
SC-3B		122.5 @ 21.0 ºC	
IBR-04	28.0 – 28.5’		
SC-4A		138.9 @ 21.2 ºC	
IBR-01	33.0 – 36.0’		

NOTE: Prepared as per the Standard.

END OF ANALYSIS

USEPA Laboratory ID UT00930

Merrill Gee

Merrill Gee P.E. – Engineer in Charge

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APPENDIX E.
NORTH PORTLAND HARBOR LABORATORY TEST RESULTS
TABLE OF CONTENTS

ATTACHMENTS

1. GENERAL

The soil samples obtained during the field explorations were described and identified in the field in accordance with the ODOT Geotechnical Design Manual (2023). The samples were then reviewed in Shannon & Wilson's laboratory. Physical characteristics of the samples were noted, and field descriptions and identifications were modified as necessary. During examination, select samples were chosen for further testing. We refined our descriptions and identifications based on the results of the laboratory tests, in accordance with the ODOT Geotechnical Design Manual (2023) and ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

The soil testing program included moisture content analyses, Atterberg limits determinations, particle-size analyses, and corrosivity testing. Testing was performed by Shannon & Wilson, GeoTesting Express (GTX) of Acton, MA, and TEi – Testing Services of Salt Lake City, UT, subcontracted through GeoTesting Express. All testing was completed in general accordance with applicable ASTM International standards. General descriptions of the tests are summarized in the following paragraphs. Laboratory test results from the six borings drilled in the main channel of the Columbia River are presented separately in Appendix D.

2. SOIL TESTING

2.1 Moisture (Natural Water) Content

Natural moisture content analyses were performed in general accordance with ASTM D2216 on selected soil samples. The natural moisture content is a measure of the relative amount of moisture in the soil at the time the explorations are performed and is defined as the ratio of water weight to dry soil weight, expressed as a percentage. Results of the moisture content analyses are presented on the boring logs in Appendix B.

2.2 Atterberg Limits

Atterberg limits were determined on selected samples in general accordance with ASTM D4318. This analysis yields index parameters of the soil that are useful in soil identification, as well as in a number of analyses, including liquefaction analysis. An Atterberg limits test determines a soil's liquid limit (LL) and plastic limit (PL). These are the maximum and minimum moisture contents at which the soil exhibits plastic behavior. A soil's plasticity index (PI) can be determined by subtracting PL from LL. For the purposes of soil description, ODOT uses the term nonplastic to refer to soils with a PI of 0 to 3, low plasticity for soils with a PI range of 3 to 15, medium plasticity for soils with a PI range of 15 to 30, and high plasticity for soils with a PI greater than 30. Results of Atterberg limits tests are presented in Figure E1.

2.3 Particle-Size Analyses

Particle-size analyses were conducted on selected samples to determine their grain-size distributions. Grain size distributions were determined in general accordance with ASTM D6913, D422, and D1140, as applicable. For select samples, a wet sieve analysis was performed to determine the percentage (by weight) of each sample passing the No. 200 (0.075 mm) sieve. For a subset of these samples, the material retained on the No. 200 sieve was shaken through a series of sieves to determine the distribution of the plus No. 200 fraction (ASTM D6913/D422). For some samples, only the percentage of the sample passing the No. 200 (0.075mm) sieve was determined (ASTM D1140). For other samples, the particle size distribution of material finer than the No. 200 sieve was also determined using a hydrometer analysis (ASTM D422). For all particle-size analyses, the percentage of material passing the No. 200 sieve is presented on the boring logs in Appendix A. More complete results of particle size analyses performed on samples from the North Portland Harbor borings are presented in Figure E2.

2.3.1 Rotosonic Core Samples

As discussed in the report, the grain size distribution curves included in the laboratory test results may include particles that were mechanically fractured, cut, or pulverized during drilling, suggesting increased fines content or smaller particle sizes than are present in the in situ material.

Where cobble-sized particles were retained on the 3-inch sieve, two grain size distribution plots are provided for the tested specimen: one that includes the mass of the material retained on the 3-inch sieve and one based on the mass of the material that passes through the 3-inch sieve. Soil names are based on the portion of the material that passes through the 3-inch sieve, in accordance with ASTM D2487, and “with cobbles” is added to the end of the soil name.

2.4 Corrosivity Testing

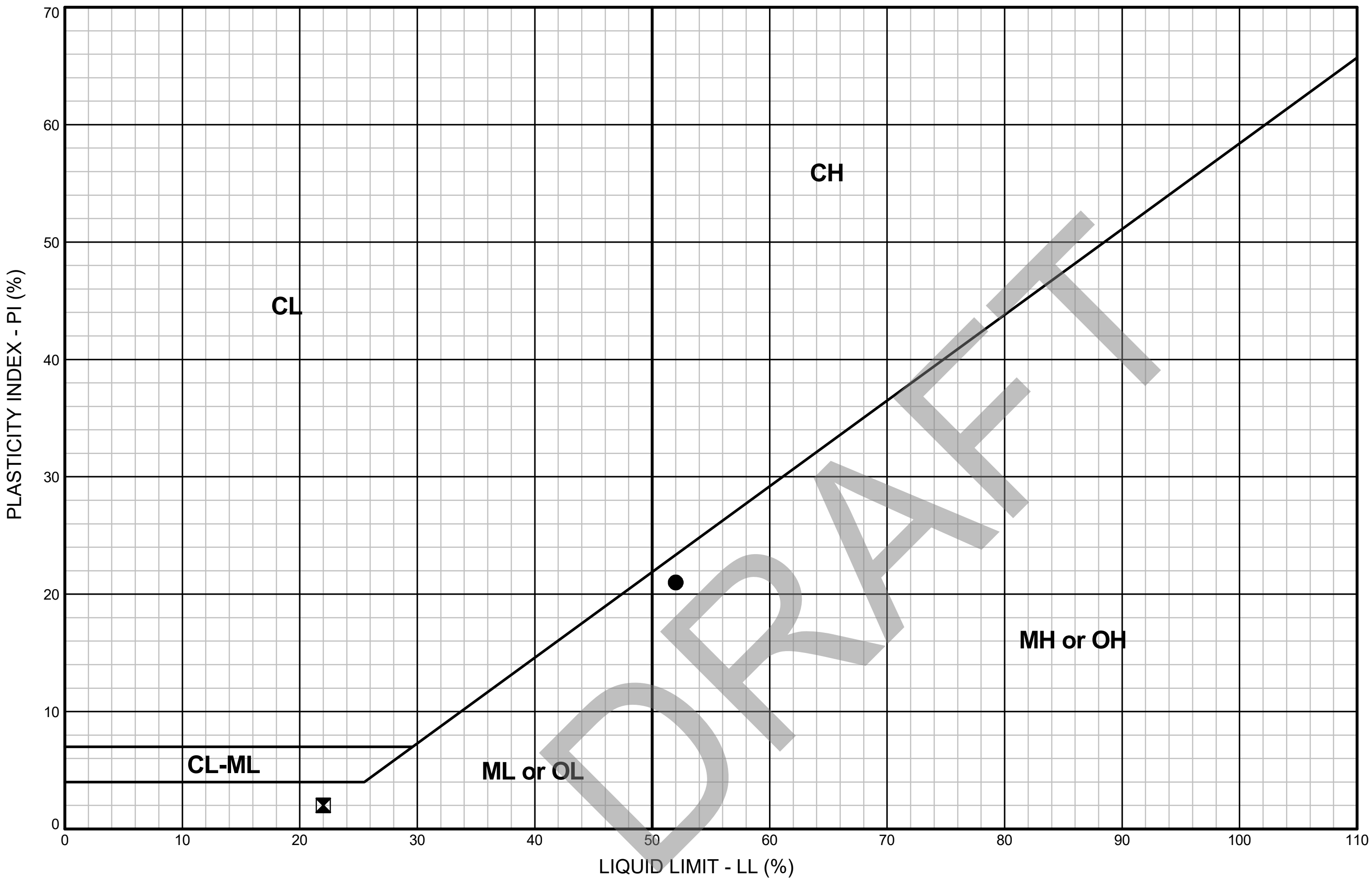
Analytical corrosivity testing was performed on selected soil samples from to evaluate the corrosivity potential of the soil. The corrosivity test suite included resistivity, chloride concentration, soil pH, sulfide concentration, and sulfate concentration. Analytical testing was performed by GeoTesting Express of Acton, Massachusetts and by TEi – Testing Services of Salt Lake City, Utah subcontracted through GeoTesting Express. The analytical testing reports and results are attached to the end of this appendix.

The corrosion potential of a soil is primarily evaluated by comparing measured pH, resistivity, and sulfate and chloride concentrations to the values specified in Section 10.7.5 of the AASHTO LFRD Bridge Design Specifications (9th Edition, 2020).

Soil pH is a measurement of the hydrogen ion activity of the soil. Soil pH is reported in Standard Units (S.U.) on a scale ranging from 0 to 14, with 7 being neutral. Soils with a pH less than 7 are considered acidic, and soils with a pH greater than 7 are considered alkaline. According to the AASHTO specifications, soils with a pH less than 5.5 and soils with a pH between 5.5 and 8.5 that also have high organic content are considered potentially corrosive.

Resistivity (expressed as ohms-centimeter or ohms-cm) is the numerical expression of the ability of a soil to impede the transmission of an electrical current. Resistivity is the inverse of conductivity and is dependent on the presence of ions, their concentrations, mobility, and valence, as well as soil moisture and temperature. The AASHTO specifications state that effects of corrosion and deterioration shall be considered if resistivity values are less than 2,000 ohms-cm.

Sulfate and chloride concentrations were also measured. Sulfates can be converted to sulfides by naturally occurring bacteria. Sulfides, when allowed to oxidize, will produce sulfuric acid, which is highly corrosive. Chlorides will also chemically react and facilitate dissolution reactions with metals and concrete. According to the AASHTO specifications, the soil is considered corrosive if the concentration of sulfate or chloride is greater than 1,000 parts per million.



NOTES

1) Atterberg limits tests were performed in general accordance with ASTM D4318 unless otherwise noted in the report.

2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.

3) Plasticity adjectives used in sample descriptions correspond to plasticity index as follows:
- Nonplastic (NP) (< 3%)
- Low Plasticity (3 to 15%)
- Medium Plasticity (15 to 30%)
- High Plasticity (> 30%)

BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	LL %	PL %	PI %[3]	NAT. W.C. %	FINES %
● IBR-01, S5B	45.1	*MH*	*Clayey SILT with trace sand*	52	31	21		93
☒ IBR-01, S9A	82.5	*SM*	*Silty SAND*	22	20	2		38
IBR-01, S10B	93.7	*ML*	*SILT with some sand and trace gravel, with cobbles (cobbles not included in data)*	NP	NP	NP		76

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ATTERBERG LIMITS RESULTS

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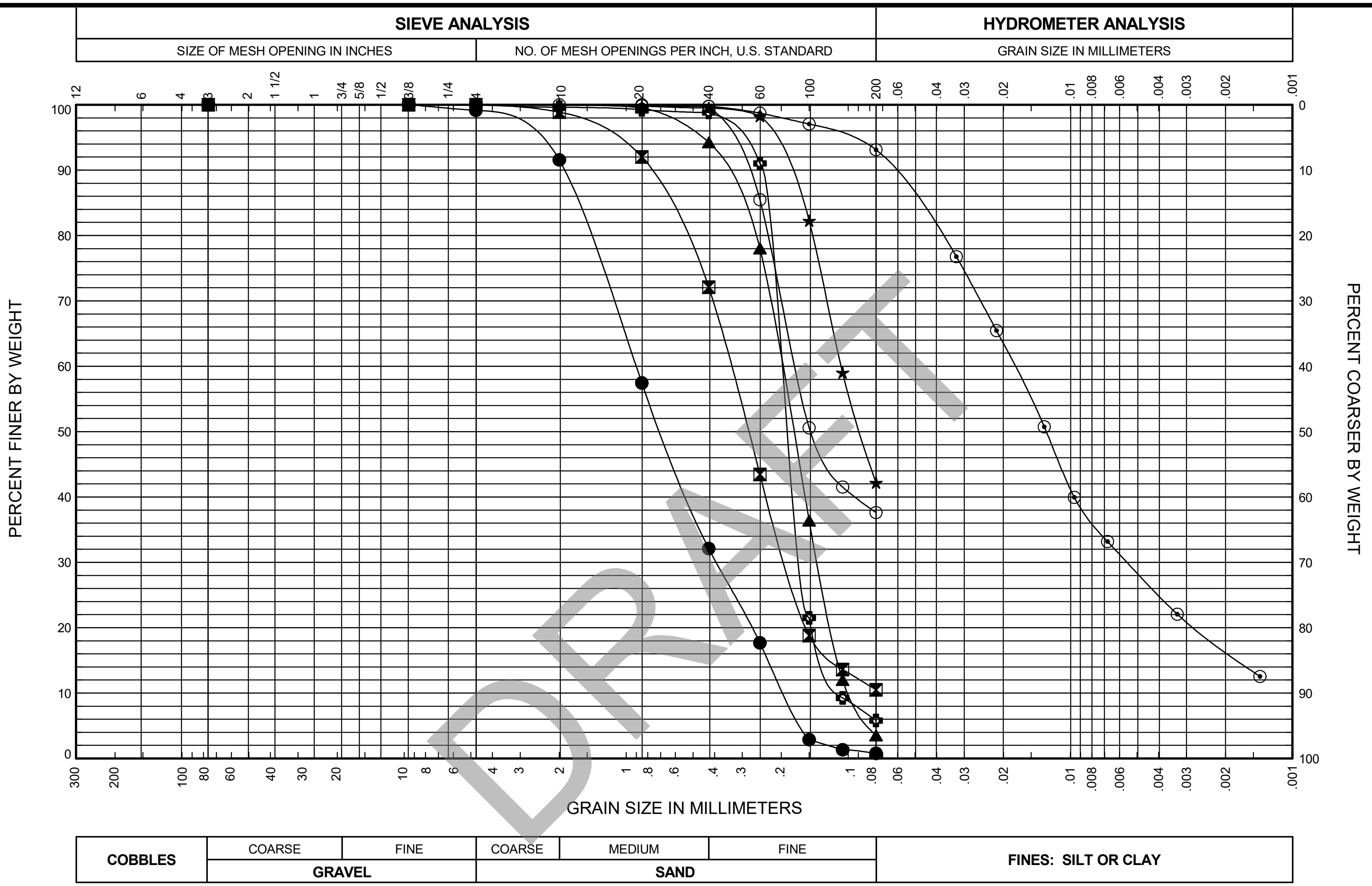
FIG. E1

NOTES:
1) Sieve analyses were performed in general accordance with ASTM D6913, sieve with hydrometer analyses were performed in general accordance with ASTM D422, and amount finer than #200 sieve analyses were performed in general accordance with ASTM D1140 unless otherwise noted in the report.
2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● IBR-01, S1	0.0	*SP*	*SAND with trace silt*	1	98	1		
⧗ IBR-01, S2B	14.0	*SP-SM*	*SAND with some silt*	0	89	11		
▲ IBR-01, S4A	33.6	*SP*	*SAND with trace silt*	0	96	4		
★ IBR-01, S4B	41.0	*SM*	*Silty SAND*	0	58	42		
⊙ IBR-01, S5B	45.1	*MH*	*Clayey SILT with trace sand*	0	7	93		
✿ IBR-01, S8A	74.2	*SP-SM*	*SAND with some silt*	0	94	6		
○ IBR-01, S9A	82.5	*SM*	*Silty SAND*	0	62	38		

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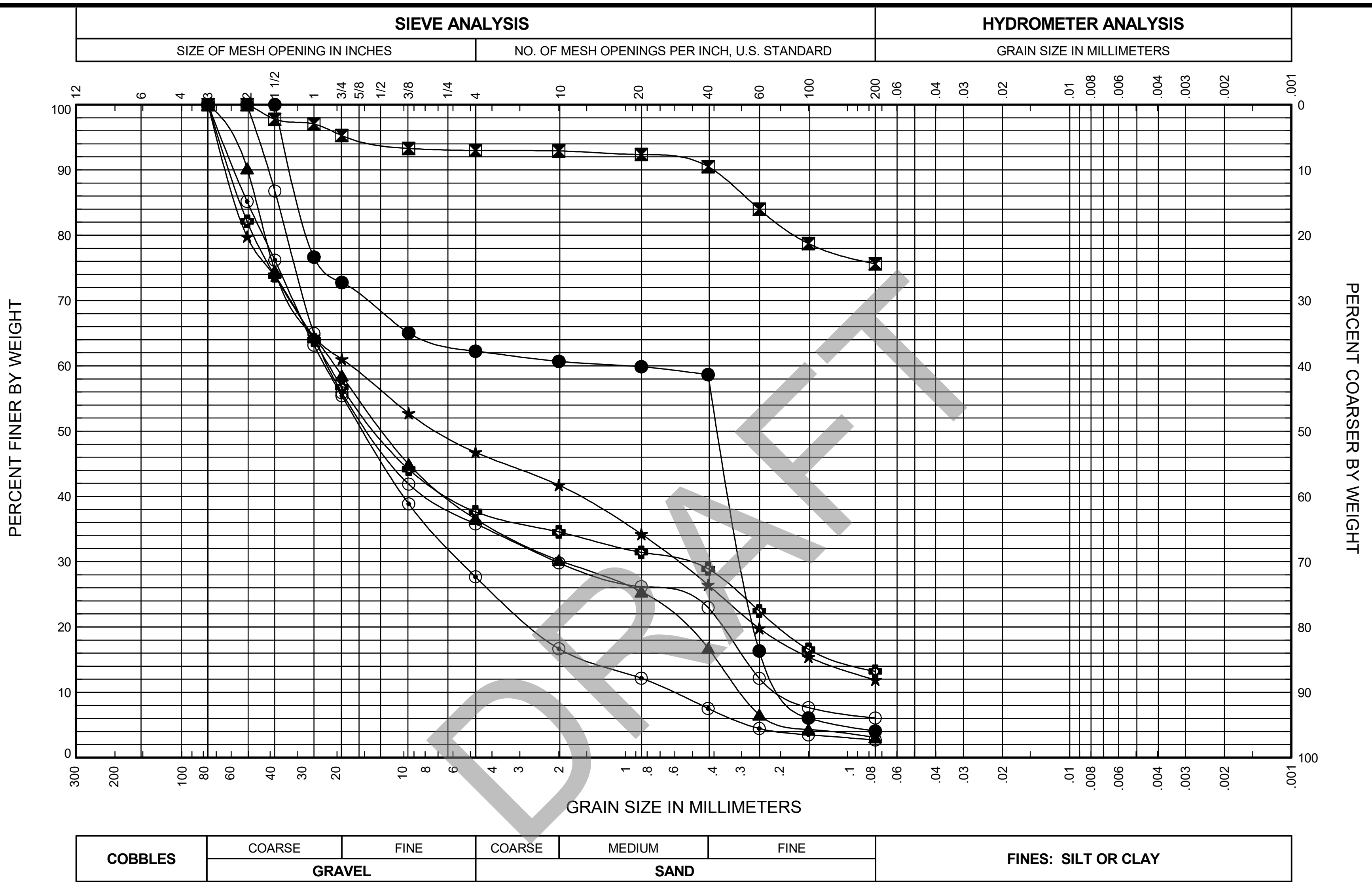
FIG. E2
Sheet 1 of 4

FIG. E2

NOTES:
1) Sieve analyses were performed in general accordance with ASTM D6913, sieve with hydrometer analyses were performed in general accordance with ASTM D422, and amount finer than #200 sieve analyses were performed in general accordance with ASTM D1140 unless otherwise noted in the report.
2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● IBR-01, S10A	92.5	*SP*	*Gravelly SAND*	38	58	4		
⧗ IBR-01, S10B	93.7	*ML*	*SILT with some sand and trace gravel, with cobbles (cobbles not included in data)*	7	17	76		
▲ IBR-01, S10C	96.1	*GP*	*Sandy GRAVEL, with cobbles (cobbles not included in data)*	63	33	3		
★ IBR-01, S11	103.4	*GP-GM*	*Sandy GRAVEL with some silt, with cobbles (cobbles not included in data)*	53	35	12		
⊙ IBR-01, S12	113.7	*GW*	*GRAVEL with some sand*	72	25	3		
✚ IBR-01, S15B	146.6	*GM/GC*	*Silty/Clayey GRAVEL with some sand*	62	24	13		
○ IBR-01, S18	178.7	*GP-GM*	*Sandy GRAVEL with some silt*	64	30	6		

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FIG. E2
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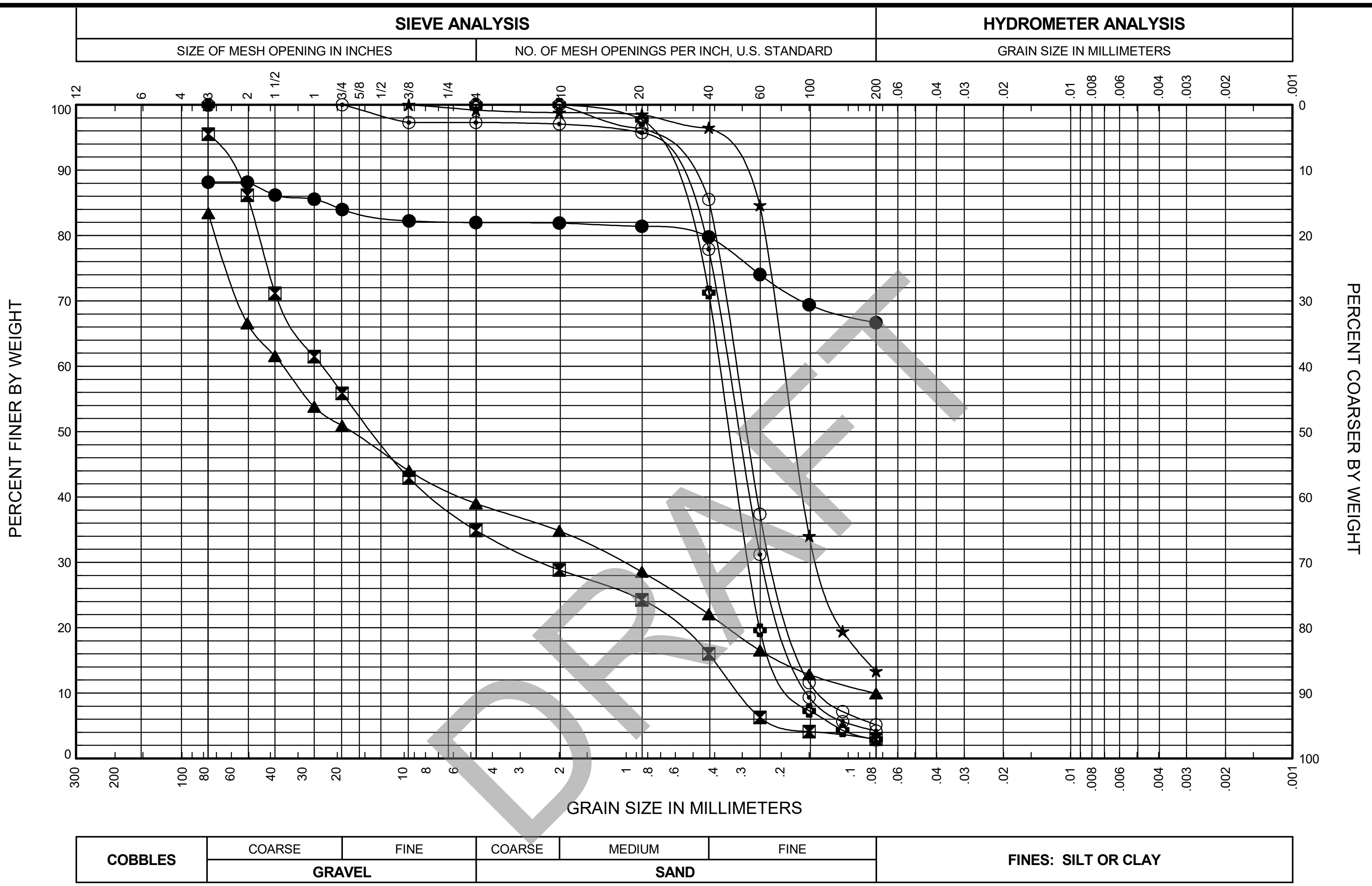

NOTES:
1) Sieve analyses were performed in general accordance with ASTM D6913, sieve with hydrometer analyses were performed in general accordance with ASTM D422, and amount finer than #200 sieve analyses were performed in general accordance with ASTM D1140 unless otherwise noted in the report.
2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.

BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● IBR-01(+3-in.), S10B	93.7	*ML*	*SILT with some sand and trace gravel, with cobbles (cobbles included in data)*	6	15	67		
⧗ IBR-01(+3-in.), S10C	96.1	*GP*	*Sandy GRAVEL, with cobbles (cobbles included in data)*	61	32	3		
▲ IBR-01(+3-in.), S11	103.4	*GP-GM*	*Sandy GRAVEL with some silt, with cobbles (cobbles included in data)*	44	29	10		
★ IBR-02, N1	10.5	*SM*	*Silty SAND*	1	86	13	30	
⊙ IBR-02, N4	17.2	*SP*	*SAND with trace silt*	3	93	4	39	
✤ IBR-02, N6	23.3	*SP*	*SAND with trace silt*	0	97	3	33	
○ IBR-02, N10	45.9	*SP-SM*	*SAND with some silt*	0	95	5	31	

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Portland, Oregon / Vancouver, Washington

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FIG. E2
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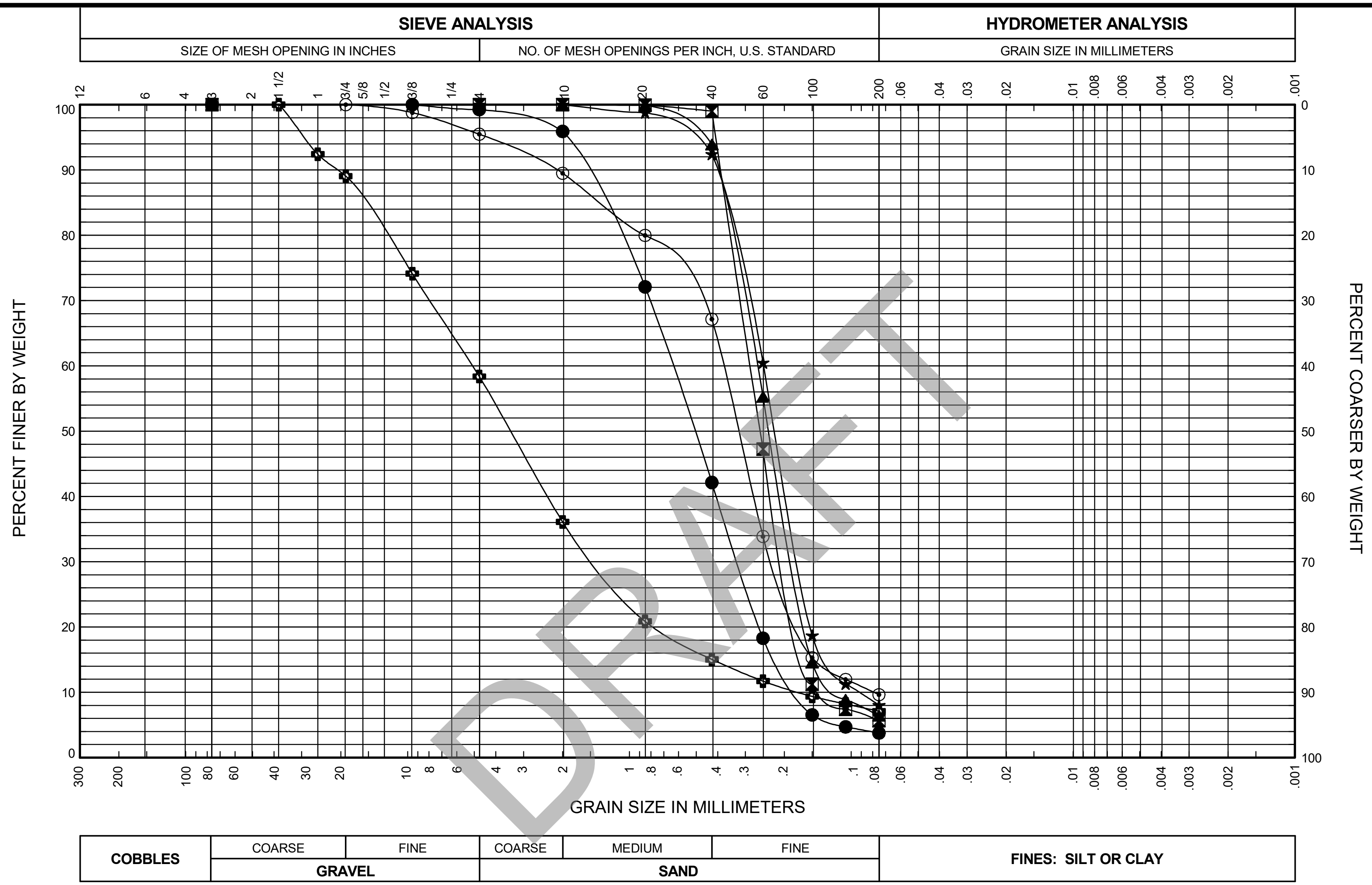
FIG. E2



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● IBR-02, N11	52.4	*SP*	*SAND with trace silt*	1	95	4	35	
⧗ IBR-02, N13	61.2	*SP-SM*	*SAND with some silt*	0	94	6	31	
▲ IBR-02, N15	71.1	*SP-SM*	*SAND with some silt*	0	94	6	33	
★ IBR-02, N19	90.1	*SP-SM*	*SAND with some silt*	0	92	8	31	
⊙ IBR-02, N21	99.6	*SP-SM*	*SAND with some silt and trace gravel*	5	86	10	24	
✥ IBR-02, N33	208.5	*SP-SM*	*Gravelly SAND with some silt*	42	51	7	15	

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Portland, Oregon / Vancouver, Washington

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FIG. E2
Sheet 4 of 4

GSA MAIN 105511 IBR ODOT.GPJ SHAN WIL.GDT 5/13/24

NOTES:

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2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.

FIG. E2

Client:	Shannon & Wilson, Inc.
Project Name:	IBR
Project Location:	Portland, OR
GTX #:	318519
Test Date:	01/26/24
Tested By:	nmk
Checked By:	ank

Laboratory pH of Soil by ASTM G51

Boring ID	Sample ID	Depth, ft	Description	Soil Temperature, ° C	Average pH Reading
IBR-01	SC-4A	33-36	Moist, dark gray sand	21	6.32
IBR-04	SC-3B	28-29.5	Moist, very dark gray sand	20.8	6.11
IBR-06	SC-1A	1-1.5	Moist, very dark reddish gray sand	21.3	6.44

Notes:

Client:	Shannon & Wilson
Project:	IBR
Location:	Portalnd, OR
GTX#:	318519
Test Date:	01/30/24
Due Date:	2/8/2024
Tested By:	NMK
Checked By:	ank

Laboratory Measurement of Soil Resistivity Using the Wenner Four-Electrode Method by ASTM G57 (Laboratory Measurement)

Boring ID	Sample ID	Depth, ft.	Sample Description	Electrical Resistivity, ohm-cm	Electrical Conductivity, $(\text{ohm-cm})^{-1}$
IBR-01	SC-4A	33-36 ft	Moist, dark gray sand	5,864	1.71E-04
IBR-04	SC-3B	28-29.5 ft	Moist, very dark gray sand	8,646	1.16E-04
IBR-06	SC-1A	1-1.5 ft	Moist, very dark gray reddish sand	43,422	2.30E-05

testing services sm

PO Box 572455 / Salt Lake City UT 84157-2455 / USA
TEL +1 801 262 2448 · FAX +1 801 262 9870 · www.TEi-TS.com

GEOTESTING EXPRESS INCORPORATED
125 NAGOG PARK
ACTON MA 01720-3451
USA

Analysis No.	TS-A2411681
Report Date	31 January 2024
Date Sampled	25 January 2024
Date Received	29 January 2024
Where Sampled	Acton, MA USA
Sampled By	Client

This is to attest that we have examined: Soil: Project: IBR; Site Location: - — -; Job Number: GTX-318519

When examined to the applicable requirements of:

ASTM D 512-12*	“Standard Test Methods for Chloride Ion in Water” Method B
ASTM D 516-16	“Standard Test Method for Sulfate Ion in Water”
ASTM G 200-20	“Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil”

Results:

ASTM D 512 - Chloride Method B

Sample		Results		Minimum Detection Limit
		ppm (mg/kg)	%[1]	
SC-1A		17.	0.0017	10.
IBR-06	1.0 – 1.5’			
SC-3B		< 10.	< 0.0010	
IBR-04	28.0 – 28.5’			
SC-4A		< 10.	< 0.0010	
IBR-01	33.0 – 36.0’			

NOTE: [1] Percent by weight after drying and prepared as per the Standard. *Withdrawn 2021 without Replacement

ASTM D 516 – Sulfates (Soluble)

Sample		Results		Minimum Detection Limit
		ppm (mg/kg)	%[1]	
SC-1A		< 10.	< 0.0010	10.
IBR-06	1.0 – 1.5'			
SC-3B		10.	0.0010	
IBR-04	28.0 – 28.5'			
SC-4A		10.	0.0010	
IBR-01	33.0 – 36.0'			

NOTE: [1]Percent by weight after drying and prepared as per the Standard.

ASTM G 200 – Reduction Oxidation Potential (REDOX)

Sample		Results	Minimum Detection Limit
SC-1A		109.7 @ 21.1 ºC	0.1mV
IBR-06	1.0 – 1.5'		
SC-3B		122.5 @ 21.0 ºC	
IBR-04	28.0 – 28.5'		
SC-4A		138.9 @ 21.2 ºC	
IBR-01	33.0 – 36.0'		

NOTE: Prepared as per the Standard.

END OF ANALYSIS

USEPA Laboratory ID UT00930

Merrill Gee

Merrill Gee P.E. – Engineer in Charge

DRAFT

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APPENDIX F.

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIROMENTAL REPORT

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the Geoprofessional Business Association (https://www.geoprofessional.org)