



March 14, 2019

Ann Weckback
Lewis County Public Works
2025 NE Kresky Avenue
Chehalis, Washington 98532

Via email: Ann.Weckback@lewiscountywa.gov

Regarding: Geotechnical Engineering Report
Centralia Alpha Road Culvert MP 15.79
Chehalis, Washington
PBS Project 45013.000 Phase 0005

Dear Ms. Weckback:

This report presents results of PBS Engineering and Environmental Inc. (PBS) geotechnical engineering services for the new culvert and passable fish structure located at mile post 15.79 on Centralia Alpha Road, crossing the Middle Fork Newaukum River, in Chehalis, Washington (site). The general site location is shown on the Vicinity Map, Figure 1.

PROJECT UNDERSTANDING

Current plans include replacing the existing culvert with a precast concrete box culvert to improve fish passage. The new culvert will be up to 25 feet wide and installed to a depth of up to 12 feet below the existing ground surface (bgs). The locations of PBS' explorations in relation to existing and proposed site features are shown on the Site Plan, Figure 2.

SCOPE OF SERVICES

The purpose of PBS' services was to develop geotechnical design and construction recommendations in support of the planned culvert replacement. This was accomplished by performing the following scope of services.

Literature Review

PBS reviewed various published geologic maps of the area for information regarding geologic conditions and hazards at or near the site.

Subsurface Explorations

Two borings, designated B-1 and B-2, were completed in the roadway on opposite sides of the existing culvert to explore subsurface conditions. A truck-mounted drill rig was used to advance borings to depths of up to approximately 31.5 feet bgs. In situ, standard penetration tests (SPTs) were performed at 2.5- to 5.0-foot intervals. The borings were logged and representative soil samples collected by a member of the PBS geotechnical engineering staff. The approximate boring locations are shown on the Site Plan, Figure 2.

Laboratory Testing

Samples were returned to our laboratory and classified in accordance with the Unified Soil Classification System (ASTM D2487) and/or the Visual-Manual Procedure (ASTM D2488). Laboratory tests included natural water contents, grain size analysis, and Atterberg limits tests.

Geotechnical Engineering Analysis

Data collected during the subsurface exploration, literature research, and testing were used to develop site-specific geotechnical design parameters and construction recommendations.

Report Preparation

This Geotechnical Engineering Report summarizes the results of our explorations, testing, and analyses, including information relating to the following:

- Field exploration logs and site plan showing approximate exploration locations
- Laboratory test results
- Groundwater levels and considerations
- Shallow foundation recommendations:
 - Minimum embedment
 - Estimated settlement
 - Sliding coefficient
- Lateral earth pressures for culvert wall design including:
 - Active, passive, and at-rest earth pressures
 - Allowable bearing pressure
 - Sliding coefficient
 - Groundwater and drainage considerations
- Earthwork and grading, cut, and fill recommendations:
 - Structural fill materials and preparation
 - Utility trench excavation and backfill requirements
 - Slab and pavement subgrade preparation
 - Wet weather considerations

SITE CONDITIONS

Surface Description

The site is located along Centralia Alpha Road near the intersection with Wisdorfer Road. The stream crossing is in a shallow, densely vegetated depression located approximately 550 feet east of the intersection of Centralia Alpha Road and Wisdorfer Road. The Centralia Alpha Road embankment is at an approximate elevation of 773 feet above mean sea level at the site (NAVD88).¹ The site is situated in a gentle sloping topographic depression associated with incision to the landscape by the Middle Fork Newaukum River approximately 8 feet below the Centralia Alpha roadway.

Geologic Setting

Published geologic maps of the area indicate the site is underlain by Pleistocene age alpine glacial outwash deposits of the Logan Hill Formation (Schasse, 1987).² These sediments are described as sand and gravel, with minor interbedded silt and clay of variable thickness, and were deposited over older Tertiary sedimentary and volcanic rocks.

¹ Washington Department of Natural Resources (WDNR). (2006). Lewis County Lidar data acquired in 2006. Downloaded on February 19, 2019 from <http://lidarportal.dnr.wa.gov/>.

² Schasse, H. W. (1987). Geologic Map of the Centralia Quadrangle, Washington. Washington Division of Geology and Earth Resources, map scale 1:100,000.

Subsurface Conditions

The site was explored by drilling two borings, designated B-1 and B-2, to depths of 26.5 and 31.5 feet bgs. The drilling was performed by Holt Services Inc., of Vancouver, Washington, using a truck-mounted Mobile B-60 drill rig and mid rotary drilling techniques.

Disturbed soil samples were taken in the borings at 2.5- to 5-foot intervals. Soil samples were obtained using a standard 2-inch outside diameter, split-spoon sampler following procedures prescribed for the SPT. Using the SPT, 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 (N-value). The N-value provides a measure of the relative density of granular soils, such as sands and gravels, and the consistency of cohesive soils, such as clays and plastic silts. The disturbed soil samples were examined by a member of the PBS geotechnical engineering staff in the field and then sealed in plastic bags for further examination and physical testing in our laboratory.

A relatively undisturbed sample was collected in B-1 at a depth of 6.5 feet bgs. It was obtained in a 3 inch outside diameter thin-wall Shelby tube by hydraulically pushing the tube into the undisturbed soil at the bottom of the bore hole. The soil exposed at the ends of the tube were examined and classified. After field classification, the ends of the tubes were sealed to preserve the natural moisture of the samples. The sealed tubes were returned to our laboratory for physical testing.

The boring logs (Figures A1 and A2) show the various types of materials that were encountered in the borings and the depths where the materials and/or characteristics of these materials changed, although the changes may be gradual. Where material types and descriptions changed between samples, the contacts were interpreted. The types of samples taken during drilling, along with their sample identification number, are shown to the right of the classification of materials on the boring logs. The N-values are shown farther to the right.

Initially, soil samples were classified visually in the field. Consistency, color, relative moisture, degree of plasticity and other distinguishing characteristics of the soil samples were noted. Afterward, the samples were reexamined in the PBS laboratory, various standard classification tests were conducted, and the field classifications were modified where necessary. The terminology used in the soil classifications and other modifiers are defined and presented on the attached Tables A-1 and A-2.

PBS has summarized the subsurface units as follows:

ASPHALT: Asphalt concrete (AC) pavement was encountered in borings B-1 and B-2 at the surface to 6 inches bgs.

BASEROCK: Approximately 12 inches of base rock was encountered beneath the AC in B-1 and B-2.

LEAN CLAY FILL (CL FILL): Lean clay fill was encountered in borings B-1 and B-2 from approximately 18 inches bgs to 5.5 feet bgs in B-1 and 7 feet bgs in B-2. The clay was generally soft to medium stiff with SPT N-Values between 2 to 5 blows per foot (bpf), brown, red-brown, and orange, moist, exhibited medium plasticity, contained fine- to medium-grained sand and trace subrounded gravel up to ½-inch diameter.

SILT (ML): Soft silt was encountered in B-1 and B-2 from 5.5 to 9 feet bgs and 7 to 8 feet bgs

respectively. The material had an SPT N-value of 2 and only required 100 pounds per square inch (psi) of down pressure to advance the Shelby tube 24 inches. The material was dark gray, moist, exhibited low to medium plasticity, and contained decomposed organics.

LEAN CLAY (CL): Lean clay was encountered in B-1 from 8 to 11.5 feet bgs. The material was medium stiff with an SPT N-value of 5, tan to orange, moist, exhibited medium plasticity, and contained fine-grained sand.

CLAYEY SAND with GRAVEL (SC) and SILTY SAND with GRAVEL (SM): Clayey sand with gravel to silty sand with gravel was encountered in borings B-1 and B-2 to depths of 31.5 and 18 feet bgs, respectively. The material was loose to dense with SPT N-values between 9 to 52 bpf. The material color ranged from pale yellow to pink and pale orange to tan, indicating in situ weathering of the material, contained fine- to coarse-grained sand, had fines that exhibited low to medium plasticity, and contained fine- to coarse-grained, rounded gravels up to 1-inch diameter.

WEATHERED GLACIAL OUTWASH In general, the fines encountered higher in the stratigraphic column exhibited higher plasticity and the fines encountered lower exhibited low plasticity. Gravel content also increased with depth.

POORLY GRADED GRAVEL with SILT and SAND (GP-GM): Poorly graded gravel with silt and sand was encountered in boring B-1 from 18 feet bgs to 26.5 feet bgs. The material was dense to very dense with SPT N-values between 48 bpf and 50 blows for 3 inches, dark gray, moist, fines that exhibited low plasticity, contained fine- to coarse-grained sand, and rounded gravels up to 3-inches in diameter.

Groundwater

Static groundwater was not encountered during our explorations to the depths explored. Please note that groundwater levels can fluctuate during the year depending on climate, irrigation, extended periods of precipitation, drought, and other factors. Generally, the highest groundwater levels occur in late winter and early spring and the lowest levels in late summer and early fall. We recommend that the contractor determine the actual groundwater levels at the time of construction to determine potential groundwater impacts.

LABORATORY TESTING

Soil samples obtained during our exploration were returned to the laboratory to aid in soil classification and to evaluate the material's general physical properties and engineering characteristics. Laboratory tests included natural moisture contents, grain-size analyses, and Atterberg limits. Laboratory test results are presented on the boring logs and on the attached Figures B1 and B2.

The applicable ASTM methods were used to perform the laboratory tests and included the following.

Visual Classification

The soils were classified in accordance with the Unified Soil Classification System with certain other terminology, such as the relative density or consistency of the soil deposits, in general accordance with engineering practice. In determining the soil type (that is, gravel, sand, silt, or clay) the term that best described the major portion of the sample was used. Modifying terminology to further describe the samples is defined on the attached Table A-1.

Moisture (Water) Contents

Natural moisture content determinations were made on samples of the fine-grained soils (that is, silts, clays, and silty sands). The natural moisture content is defined as the ratio of the weight of water to dry weight of soil, expressed as a percentage. The results of the moisture content determinations are presented on the exploration logs and the attached Figure B2.

Grain-Size Analyses (P200 Wash)

Washed sieve analyses (P200) were completed on samples to determine the portion of soil samples passing the No. 200 Sieve (i.e., silt and clay). The results of the P200 test results are presented on the exploration logs and on Figure B2.

Atterberg Limits

Atterberg limits were determined for select samples for classifying soils into various groups for correlation. The results of the Atterberg limits tests, which included liquid and plastic limits, are plotted on the attached Figure B1 and on the exploration logs, Figures A1 and A2.

CONCLUSIONS AND RECOMMENDATIONS

Geotechnical Design Considerations

Borings B-1 and B-2 encountered subsurface conditions of undocumented fill to approximately 7 feet bgs that consisted of lean clay, underlain by native materials consisting of silt, clayey and silty sand with gravel, and poorly graded gravel to 31.5 feet. Materials that may be susceptible to scour due to the hydraulics of the stream should not be used or should be properly protected. Our current understanding is that cobbles and boulders will be used to construct the streambed inside the culvert, with infilling from migration of streambed sediment.

Based on our observations and analyses, foundation support on shallow spread footings is feasible. Excavation with conventional equipment is feasible but may be difficult in the dense gravel and hard silt and clay; a large excavator (such as a CAT 235 or larger) equipped with rock teeth may be necessary.

Shallow Foundations

Shallow spread footings, underlain by 12-inch-thick crushed rock pads over medium dense silty to clayey sand, may be used to support loads associated with the proposed new closed-bottom culvert, provided the following recommendations are followed.

Footing Preparation: Foundation subgrades at a depth of approximately 12 feet bgs at the proposed culvert will likely consist of medium dense clayey or silty sand. Due to the relatively high moisture contents of soils at that elevation and the presence of soils containing fine-grained silt and clay, we recommend culvert footings be founded on a minimum 12-inch-thick layer of granular fill. If soft/loose conditions are encountered at this elevation, the crushed rock fill should be underlain by 12 inches of angular pit run rock (6-inch-minus stabilization rock; see the Foundation Base Aggregate section, below) and geotextile stabilization fabric, such as Mirafi 500X, or an approved equivalent.

A representative from PBS should confirm suitable bearing conditions and evaluate all footing subgrades. Observations should also confirm that loose or soft materials have been removed from new footing excavations and concrete slab-on-grade areas. Localized deepening of footing excavations may be required to penetrate soft, wet, or deleterious materials.

Crushed Rock Pads: If groundwater or soft/loose soil conditions are observed at or near the base of the proposed foundation (exposed design subgrade elevation) we recommend over-excavating 12 inches and

backfilling with stabilization material in a single lift, and compacting using a large, smooth-drum, non-vibratory roller, until the rock is dense and well keyed. Stabilization rock should be capped with approximately 6 inches of foundation base aggregate (as described in the Construction Considerations section of this report). Crushed rock pads should be planned to extend a minimum of 1 foot laterally beyond the edges of footings. PBS understands the layer of crushed rock may be installed across the entire base of the excavation to act as a working pad for construction traffic. Depending on subsurface and groundwater conditions at the time of construction, increasing the thickness of the crushed rock working pad to support construction traffic and protect the foundation subgrades may be necessary.

Bearing Pressure: Due to the width of the box culvert and limited soil cover, the applied bearing pressure over the base of the culvert will be relatively low, less than 1,000 pounds per square foot (psf). Foundations can be designed using an allowable bearing pressure of 2,500 psf with an effective footing width of 8 feet or greater.

Foundation Static Settlement: Based on the proposed culvert configuration and associated soil removal, no additional load will be applied at the base of the culvert and we estimate post-construction settlement will be less than about 1 inch.

Lateral Resistance: Lateral loads can be resisted by passive earth pressure on the sides of footings and box culvert walls, and by friction at the base of the box culvert foundation. A passive earth pressure calculated using an equivalent fluid weight (EFW) of 250 pounds per cubic foot (pcf) may be used for footings confined by native soils and new structural fills above groundwater and 120 pcf below groundwater. The allowable passive pressure has been reduced by one-half to account for the large amount of deformation required to mobilize full passive resistance. This should only be applied to the outside of culvert walls. For passive resistance on the inside of the culvert, the depth of possible scour should be considered. For footings supported on crushed rock pads, use a coefficient of friction equal to 0.3 when calculating resistance to sliding and a net normal force (considering uplift below groundwater). These values do not include a factor of safety (FS).

Lateral Earth Pressures: The walls of the proposed new culvert should be designed to resist at-rest earth pressures using an EFW of 65 pcf. Vertical surcharge loads, q , should be considered and be equal to $0.6q$, applied as a uniform horizontal surcharge over the full height of the wall. These values assume that the wall is vertical and the backfill behind the wall is horizontal.

Construction Considerations

Site Preparation

Construction of the new culvert will require large areas of cut and subsequent backfill. Based on the estimated depth of the proposed culvert, review of the preliminary design drawings, and our understanding that open excavation techniques will be used in construction, we estimate excavation will be on the order of 12 feet deep and 30 feet wide at the base, and up to 80 feet wide at the road grade, which corresponds to temporary slope inclinations of approximately 1.5H:1V (horizontal to vertical). Based on the results of our geotechnical exploration and analyses, we believe some of the on-site material may be reused as backfill. However, this is dependent on the contractor's ability to dry the soil to within 2 percent of the optimum moisture content, as well as using adequately sized compaction equipment and applying the required energy during site grading. Reusing the on-site silt and clay as backfill is likely not feasible. Fill should be benched into excavation side slopes as the lifts are compacted.

Subgrade Verification/Proofrolling

Following site preparation, including excavation for new foundations but prior to placing aggregate base for the foundations, the exposed subgrade should be evaluated by a PBS representative. The finished pavement subgrade, following backfill of the culvert, should be proofrolled with a fully loaded dump truck or similar heavy, rubber-tire construction equipment to identify unsuitable areas. If evaluation of the subgrades occurs during wet conditions, or if proofrolling the subgrades will result in disturbance, they should be evaluated by qualified personnel using a steel foundation probe. We recommend that PBS be retained to observe proofrolling and perform the subgrade verifications. Unsuitable areas identified during the field evaluation should be recompacted or be excavated to firm ground and replaced with structural fill.

Wet Weather and Wet Soil Conditions

Due to the presence of fine-grained silt and clay in the near-surface materials at the site, construction equipment may have difficulty operating on the near-surface soils once the pavement has been removed. Protection of the subgrade is the responsibility of the contractor. Soils that have been disturbed during site preparation activities, or unsuitable areas identified during proofrolling or probing, should be removed to firm ground and replaced with compacted structural fill. Our current understanding is that equipment will be staged on the existing AC pavement. Some damage to the existing AC should be anticipated.

Excavation and Temporary Slopes

PBS understands open excavation techniques will be used to install the new culvert. This is acceptable provided the excavation is configured in accordance with the Occupational Safety and Health Administration (OSHA) requirements, groundwater seepage is not present, and with the understanding that some sloughing may occur. The excavation sidewalls should be flattened if sloughing occurs or seepage is present.

All excavations should be made in accordance with applicable OSHA and state regulations. The contractor is solely responsible for adherence to the OSHA requirements.

Structural Fill

Excavation required to install the new structure will likely be on the order of 12 feet deep (below existing road grade). Culvert backfill should be placed over subgrades that have been prepared in conformance with the Site Preparation, Wet Weather and Wet Soil Conditions, and Imported Granular Materials sections of this report.

Structural fill and backfill should only be installed on subgrades that have been prepared in accordance with the preceding recommendations. Structural fill material should consist of relatively well-graded soil, or an approved rock product that is free of organic material and debris, and contains particles less than 4 inches nominal dimension. The suitability of soil for use as compacted structural fill will depend on the gradation and moisture content of the soil when it is placed. As the amount of fines (material finer than the US Standard No. 200 Sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and compaction becomes more difficult to achieve. Soils containing more than about 5 percent fines cannot consistently be compacted to a dense, non-yielding condition when the water content is significantly greater (or significantly less) than optimum.

A wide range of material may be used as structural fill; however, all material used should be free of organic matter or other unsuitable materials and should meet the specifications provided in the 2018 Standard Specifications for Road, Bridge, and Municipal Construction, Washington State Department of Transportation (WSDOT SS, 2018)³

³ Washington State Department of Transportation (WSDOT SS). (2018). Standard Specifications for Road, Bridge, and Municipal Construction, M 41-10, Olympia, Washington.

depending on the application. A brief characterization of some of the acceptable materials and our recommendations for their use as structural fill is provided as follows.

On-Site Soil: The soils encountered in our explorations are generally suitable for placement as structural fill during dry weather when moisture content can be maintained by air drying and/or addition of water. However, due to the presence of silt and clay soils and high moisture contents, reuse of on-site soils for fill may not be feasible. In PBS' opinion, significant drying of soils will be required to achieve optimum moisture content for compaction.

If used as fill, the material should be free of any organic or deleterious material, with grain size less than 4 inches in diameter. The material should be compacted to at least 92 percent of the maximum dry density, as determined by ASTM D1557 (modified proctor) and shall be placed in a maximum uncompacted thickness of 8 inches. Zones of sand and gravel containing variable amounts of silt can be reused as structural fill provided they meet the specified gradation requirements discussed in the following sections and are compacted to a minimum of 92 percent of the maximum dry density in accordance with ASTM D1557.

Imported Granular Materials: Imported granular material used during periods of wet weather or for haul roads, culvert foundation pad subgrades, staging areas, etc., should be pit or quarry run rock, crushed rock, or crushed gravel and sand, and should meet the specifications provided in WSDOT SS 9-03.14(2) – Select Borrow. However, the imported granular material should also be fairly well graded between coarse and fine material and of the fraction passing the US Standard No. 4 Sieve, less than 5 percent by dry weight should pass the US Standard No. 200 Sieve.

Imported granular material should be placed in lifts with a maximum uncompacted thickness of 9 inches and be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

During wet conditions, where imported granular material is placed over soft-soil subgrades, we recommend a geotextile be placed between the subgrade and imported granular material. Depending on site conditions, the geotextile should meet WSDOT SS 9-33.2 – Geosynthetic Properties for soil separation or stabilization. The geotextile should be installed in conformance with WSDOT SS 2-12.3 – Construction Geosynthetic (Construction Requirements) and, as applicable, WSDOT SS 2-12.3(2) – Separation or WSDOT SS 2-12.3(3) – Stabilization.

Foundation Base Aggregate: Imported granular material placed at the base of excavations for spread footings should be clean, crushed rock or crushed gravel, and sand that is fairly well graded between coarse and fine. The granular materials should contain no deleterious materials, have a maximum particle size of 1 inch, and meet WSDOT SS 9-03.12(1)A – Gravel Backfill for Foundations (Class A). The imported granular material should be placed in one lift and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

Pavement Base Aggregate: Imported granular material used as base aggregate (base rock) along roadway alignments should be clean, crushed rock or crushed gravel, and sand that is fairly well graded between coarse and fine. The base aggregate should meet the gradation defined in WSDOT SS 9-03.9(3) – Crushed Surfacing Base Course and Top Course. The base aggregate should be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

ADDITIONAL SERVICES AND CONSTRUCTION OBSERVATIONS

In most cases, other services beyond completion of a geotechnical engineering report are necessary or desirable to complete the project. Occasionally, conditions or circumstances arise that require the performance of additional work that was not anticipated when the geotechnical report was written. PBS offers a range of environmental, geological, geotechnical, and construction services to suit the varying needs of our clients.

Satisfactory earthwork performance depends on the quality of construction. Sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. We recommend that PBS be retained to observe general excavation, stripping, fill placement and compaction, and exposed footing and pavement subgrades. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated.

LIMITATIONS

This report has been prepared for the exclusive use of the addressee and their engineers for aiding in the design and construction of the proposed development and is not to be relied upon by other parties. It is not to be photographed, photocopied, or similarly reproduced, in total or in part, without express written consent of the client and PBS. It is the addressee's responsibility to provide this report to the appropriate design professionals, county public works office, and contractors to assure correct implementation of the recommendations.

The opinions, comments, and conclusions presented in this report are based upon information derived from our literature review, field explorations, and laboratory testing. It is possible that soil, rock, or groundwater conditions could vary between or beyond the points explored. If soil, rock, or groundwater conditions are encountered during construction that differ from those described herein, the client is responsible for ensuring that PBS is notified immediately so that we may reevaluate the conclusions of this report.

Unanticipated soil and rock conditions and seasonal soil moisture and groundwater variations are commonly encountered and cannot be fully determined by merely taking soil samples or soil borings. Such variations may result in changes to our recommendations and may require additional funds for expenses to attain a properly constructed project. Therefore, we recommend a contingency fund to accommodate such potential extra costs.

The scope of services for this subsurface exploration and geotechnical report did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or groundwater at this site.

If there is a substantial lapse of time between the submission of this report and the start of work at the site, if conditions have changed due to natural causes or construction operations at or adjacent to the site, or if the basic project scheme is significantly modified from that assumed, this report should be reviewed to determine the applicability of the conclusions and recommendations presented herein. Land use, site conditions (both on and off site), or other factors may change over time and could materially affect our findings; therefore, this report should not be relied upon after three years from its issue, or in the event that the site conditions change.

CLOSING

We trust this Geotechnical Engineering Report meets your current needs. If you have any questions or wish to further discuss our observations, conclusions, and recommendations, please contact Ryan White at 503.417.7608.

Sincerely,



Shaun Cordes, LG, LEG
Project Engineering Geologist
PBS Engineering and Environmental Inc.



Ryan White, PE, GE (OR)
Geotechnical Engineering Group Manager
PBS Engineering and Environmental Inc.

Figures

- Figure 1. Vicinity Map
- Figure 2. Site Plan

Attachment A: Field Explorations

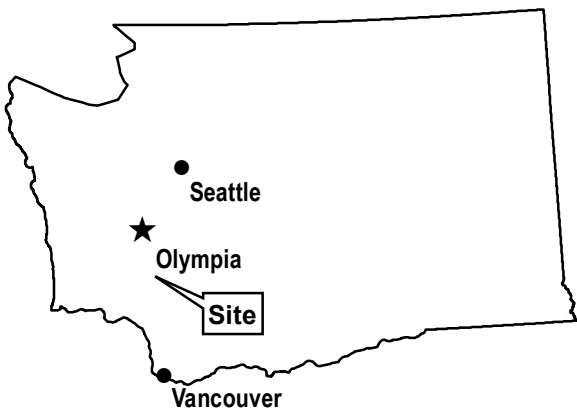
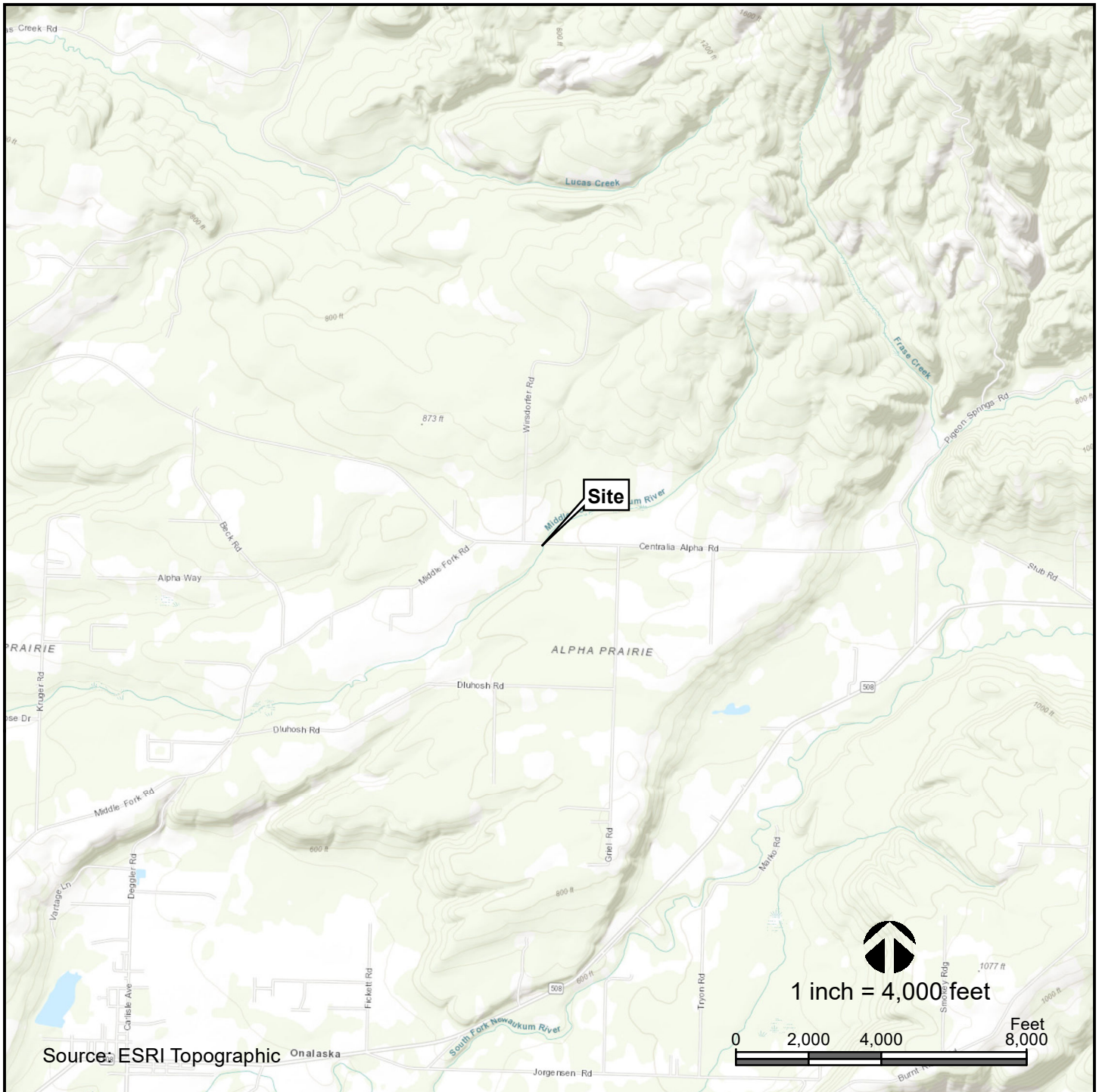
- Table A-1. Terminology Used to Describe Soil
- Table A-2. Key to Test Pit and Boring Log Symbols
- Figures A1–A2. Logs for Borings B-1 and B-2

Attachment B: Laboratory Testing

- Figure B1. Atterberg Limits Test Results
- Figure B2. Summary of Lab Results

SC:RW:rg

Figures



VICINITY MAP

CENTRALIA - ALPHA ROAD
 CULVERT MP 15.79
 CHEHALIS, WASHINGTON

DATE: MAR 2019 · PROJECT: 45013.000




FIGURE

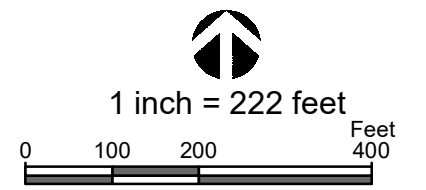
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EXPLANATION

 B-1 - Boring name and approximate location

SOURCES: ESRI World Imagery Basemap and Washington Department of Natural Resources Watercourse database



SITE PLAN

**CENTRALIA - ALPHA ROAD
CULVERT MP 15.79
CHEHALIS, WASHINGTON**

DATE: MAR 2019 · PROJECT: 45013.000



FIGURE

2

Attachment A

Field Explorations

Soil Descriptions

Soils exist in mixtures with varying proportions of components. The predominant soil, i.e., greater than 50 percent based on total dry weight, is the primary soil type and is capitalized in our log descriptions (SAND, GRAVEL, SILT, or CLAY). Smaller percentages of other constituents in the soil mixture are indicated by use of modifier words in general accordance with the ASTM D2488-06 Visual-Manual Procedure. "General Accordance" means that certain local and common descriptive practices may have been followed. In accordance with ASTM D2488-06, group symbols (such as GP or CH) are applied on the portion of soil passing the 3-inch (75mm) sieve based on visual examination. The following describes the use of soil names and modifying terms used to describe fine- and coarse-grained soils.

Fine-Grained Soils (50% or greater fines passing 0.075 mm, No. 200 sieve)

The primary soil type, i.e., SILT or CLAY is designated through visual-manual procedures to evaluate soil toughness, dilatency, dry strength, and plasticity. The following outlines the terminology used to describe fine-grained soils, and varies from ASTM D2488 terminology in the use of some common terms.

Primary soil NAME, Symbols, and Adjectives			Plasticity Description	Plasticity Index (PI)
SILT (ML & MH)	CLAY (CL & CH)	ORGANIC SOIL (OL & OH)		
SILT		Organic SILT	Non-plastic	0 – 3
SILT		Organic SILT	Low plasticity	4 – 10
SILT/Elastic SILT	Lean CLAY	Organic SILT/ Organic CLAY	Medium Plasticity	10 – 20
Elastic SILT	Lean/Fat CLAY	Organic CLAY	High Plasticity	20 – 40
Elastic SILT	Fat CLAY	Organic CLAY	Very Plastic	>40

Modifying terms describing secondary constituents, estimated to 5 percent increments, are applied as follows:

Description	% Composition	
With Sand	% Sand ≥ % Gravel	15% to 25% plus No. 200
With Gravel	% Sand < % Gravel	
Sandy	% Sand ≥ % Gravel	≤30% to 50% plus No. 200
Gravelly	% Sand < % Gravel	

Borderline Symbols, for example CH/MH, are used when soils are not distinctly in one category or when variable soil units contain more than one soil type. **Dual Symbols**, for example CL-ML, are used when two symbols are required in accordance with ASTM D2488.

Soil Consistency terms are applied to fine-grained, plastic soils (i.e., $PI \geq 7$). Descriptive terms are based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84, as follows. SILT soils with low to non-plastic behavior (i.e., $PI < 7$) may be classified using relative density.

Consistency Term	SPT N-value	Unconfined Compressive Strength	
		tsf	kPa
Very soft	Less than 2	Less than 0.25	Less than 24
Soft	2 – 4	0.25 – 0.5	24 – 48
Medium stiff	5 – 8	0.5 – 1.0	48 – 96
Stiff	9 – 15	1.0 – 2.0	96 – 192
Very stiff	16 – 30	2.0 – 4.0	192 – 383
Hard	Over 30	Over 4.0	Over 383

Soil Descriptions

Coarse - Grained Soils (less than 50% fines)

Coarse-grained soil descriptions, i.e., SAND or GRAVEL, are based on the portion of materials passing a 3-inch (75mm) sieve. Coarse-grained soil group symbols are applied in accordance with ASTM D2488-06 based on the degree of grading, or distribution of grain sizes of the soil. For example, well-graded sand containing a wide range of grain sizes is designated SW; poorly graded gravel, GP, contains high percentages of only certain grain sizes. Terms applied to grain sizes follow.

Material NAME	Particle Diameter	
	Inches	Millimeters
SAND (SW or SP)	0.003 – 0.19	0.075 – 4.8
GRAVEL (GW or GP)	0.19 – 3	4.8 – 75
Additional Constituents:		
Cobble	3 – 12	75 – 300
Boulder	12 – 120	300 – 3050

The primary soil type is capitalized, and the fines content in the soil are described as indicated by the following examples. Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 percent. Other soil mixtures will have similar descriptive names.

Example: Coarse-Grained Soil Descriptions with Fines

>5% to < 15% fines (Dual Symbols)	≥15% to < 50% fines
Well graded GRAVEL with silt: GW-GM	Silty GRAVEL: GM
Poorly graded SAND with clay: SP-SC	Silty SAND: SM

Additional descriptive terminology applied to coarse-grained soils follow.

Example: Coarse-Grained Soil Descriptions with Other Coarse-Grained Constituents










Coarse-Grained Soil Containing Secondary Constituents	
With sand or with gravel	≥ 15% sand or gravel
With cobbles; with boulders	Any amount of cobbles or boulders.

Cobble and boulder deposits may include a description of the matrix soils, as defined above.

Relative Density terms are applied to granular, non-plastic soils based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84.

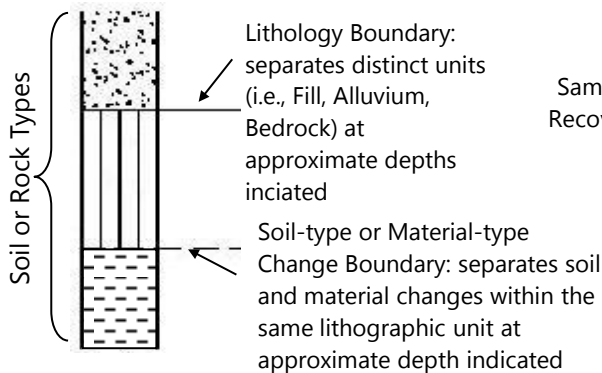
Relative Density Term	SPT N-value
Very loose	0 – 4
Loose	5 – 10
Medium dense	11 – 30
Dense	31 – 50
Very dense	> 50

SAMPLING DESCRIPTIONS

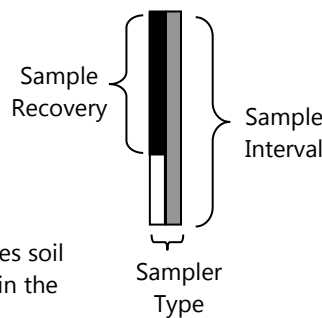
 SPT Drive Sampler Standard Penetration Test ASTM D 1586	 Shelby Tube Push Sampler ASTM D 1587	 Specialized Drive Samplers (Details Noted on Logs)	 Specialized Drill or Push Sampler (Details Noted on Logs)	 Grab Sample	 Rock Coring Interval	 Screen (Water or Air Sampling)	 Water Level During Drilling/Excavation	 Water Level After Drilling/Excavation
--	--	--	--	--	---	--	--	---

LOG GRAPHICS

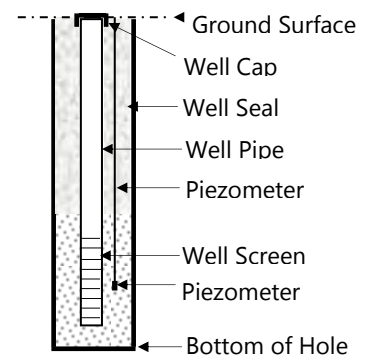
Soil and Rock



Sampling Symbols



Instrumentation Detail



Geotechnical Testing Acronym Explanations

PP	Pocket Penetrometer	HYD	Hydrometer Gradation
TOR	Torvane	SIEV	Sieve Gradation
DCP	Dynamic Cone Penetrometer	DS	Direct Shear
ATT	Atterberg Limits	DD	Dry Density
PL	Plasticity Limit	CBR	California Bearing Ratio
LL	Liquid Limit	RES	Resilient Modulus
PI	Plasticity Index	VS	Vane Shear
P200	Percent Passing US Standard No. 200 Sieve	bgs	Below ground surface
OC	Organic Content	MSL	Mean Sea Level
CON	Consolidation	HCL	Hydrochloric Acid
UC	Unconfined Compressive Strength		

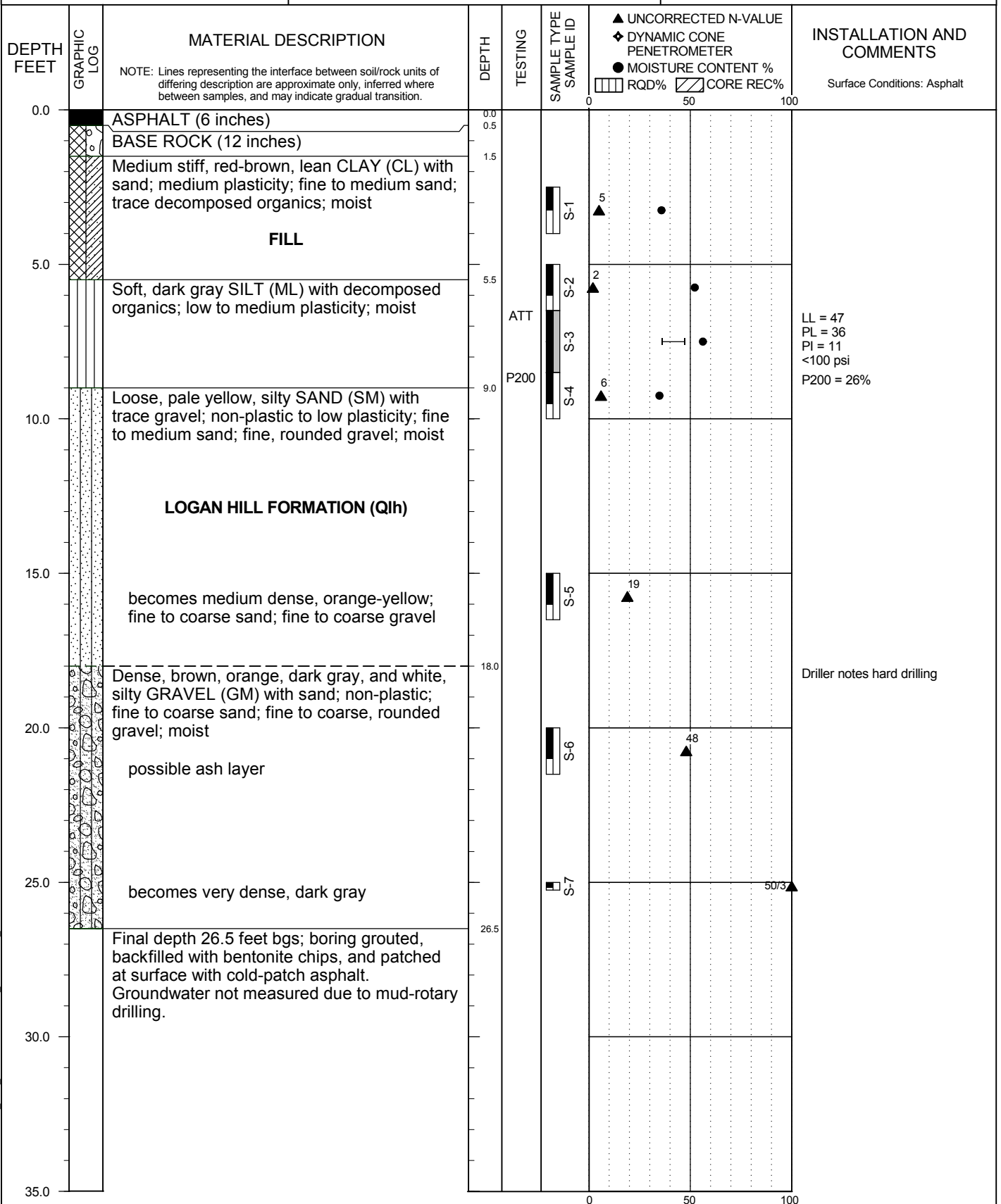


CENTRALIA-ALPHA ROAD
CHEHALIS, WASHINGTON

BORING B-1

PBS PROJECT NUMBER:
45013.000 Phase 0005

APPROX. BORING B-1 LOCATION:
46.615524, -122.675498



BORING LOG 45013.000PH5 B1-2 20190226.GPJ PBS_DATATMPL_GEO.GDT PRINT DATE: 3/6/19.RPG

DRILLING METHOD: Mud Rotary - Tricone
DRILLED BY: Holt Services, Inc.
LOGGED BY: D. Eibert

BIT DIAMETER: 3 7/8 inches
HAMMER EFFICIENCY PERCENT: 79
LOGGING COMPLETED: 2/14/19

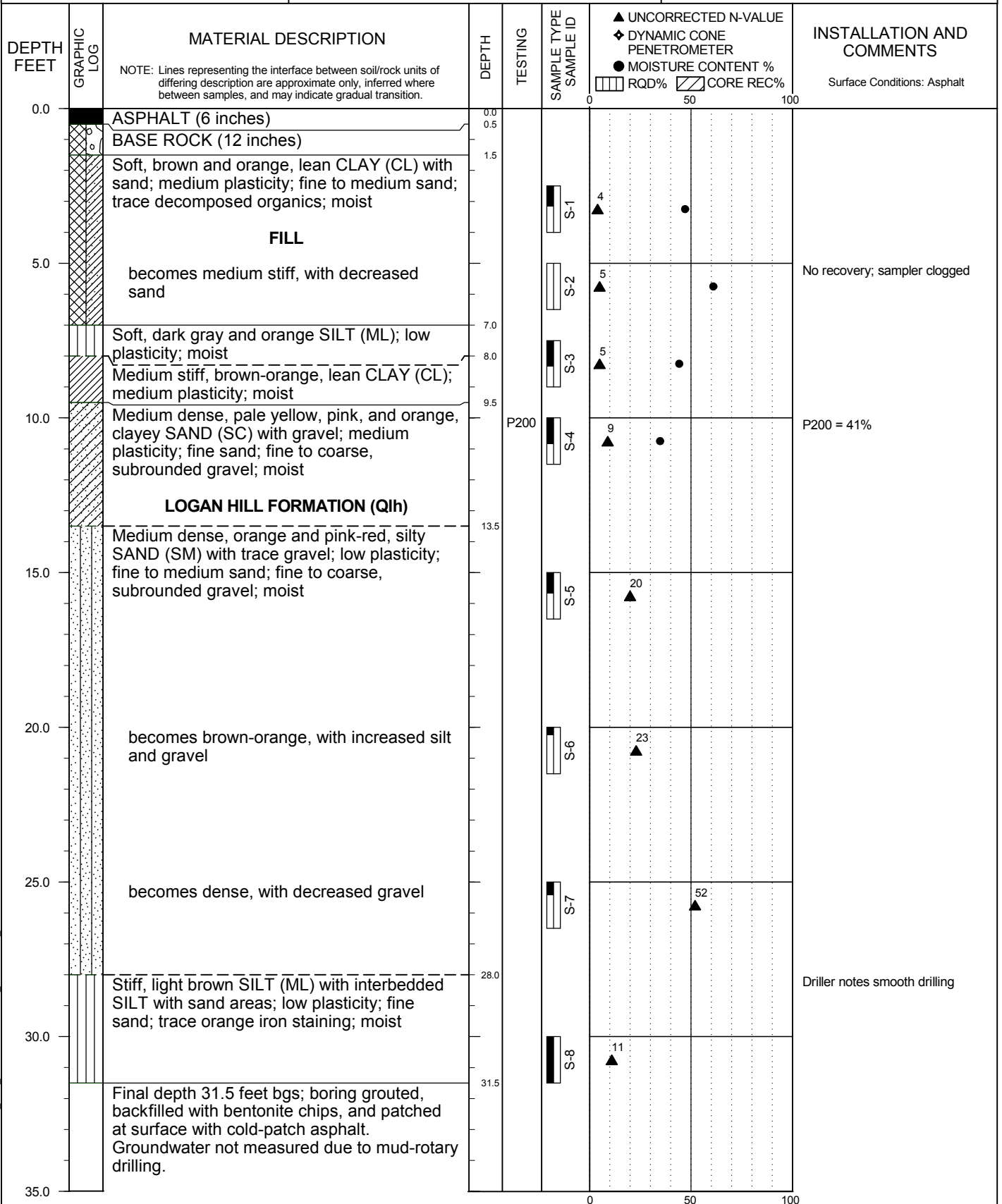


CENTRALIA-ALPHA ROAD
CHEHALIS, WASHINGTON

BORING B-2

PBS PROJECT NUMBER:
45013.000 Phase 0005

APPROX. BORING B-2 LOCATION:
46.615520, -122.675333



BORING LOG 45013.000PH5 B1-2 20190226.GPJ PBS_DATATMPL_GEO.GDT PRINT DATE: 3/6/19.RPG

DRILLING METHOD: Mud Rotary - Tricone
DRILLED BY: Holt Services, Inc.
LOGGED BY: D. Eibert

BIT DIAMETER: 3 7/8 inches
HAMMER EFFICIENCY PERCENT: 79
LOGGING COMPLETED: 2/14/19

FIGURE A2
Page 1 of 1

Attachment B

Laboratory Testing

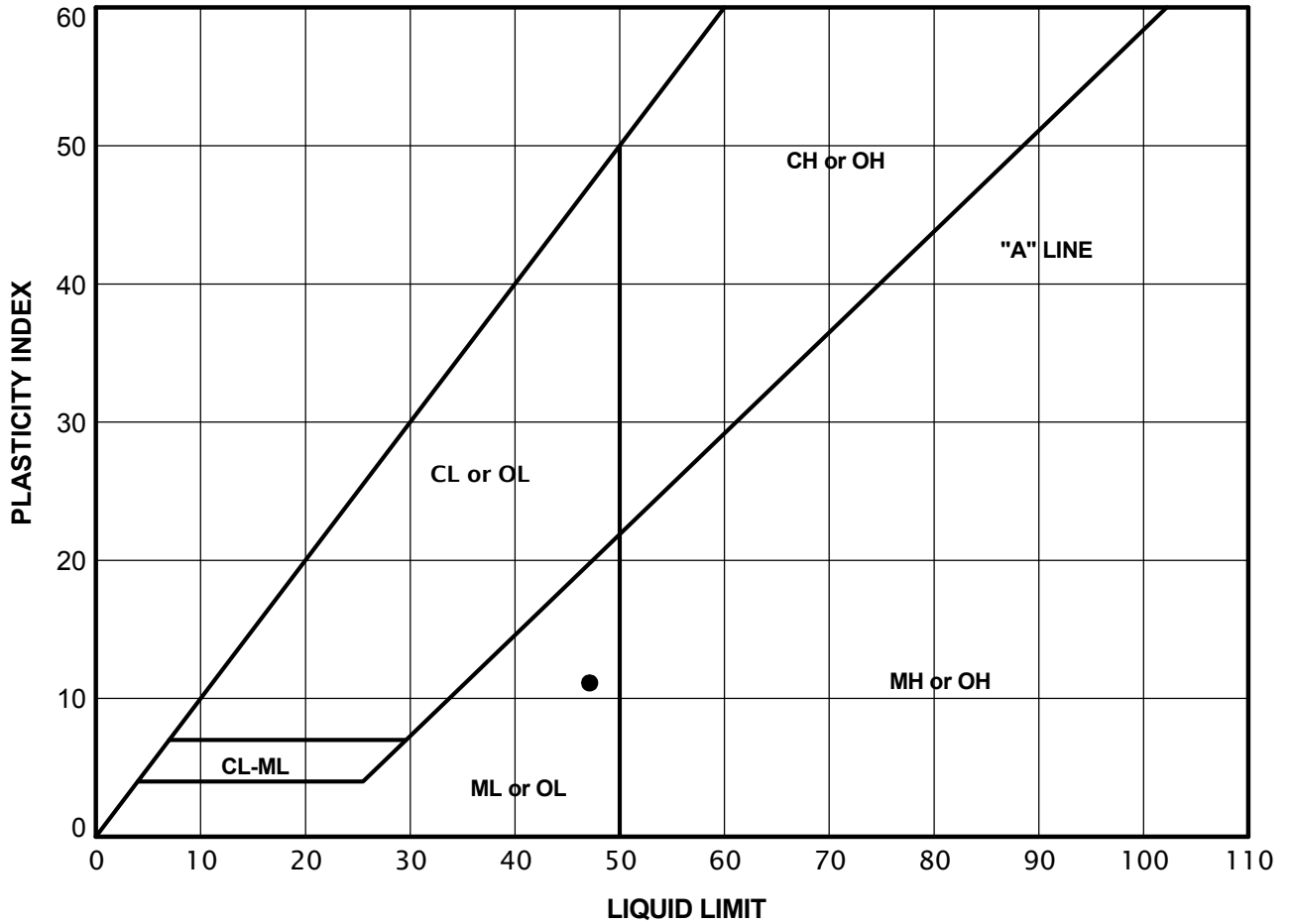


ATTERBERG LIMITS TEST RESULTS

CENTRALIA-ALPHA ROAD
CHEHALIS, WASHINGTON

PBS PROJECT NUMBER:
45013.000 Phase 0005

TEST METHOD: ASTM D4318



KEY	EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	NATURAL MOISTURE CONTENT (PERCENT)	PERCENT PASSING NO. 40 SIEVE (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	B-1	S-3	6.5	56.1	NA	47	36	11

FIGURE B1
Page 1 of 1

_ATTERBERG LIMITS 45013.000PH5_B1-2_20190226.GPJ PBS_DATA\TPL_GEO.GDT PRINT DATE: 3/6/19.RPG



SUMMARY OF LABORATORY DATA

CENTRALIA-ALPHA ROAD
CHEHALIS, WASHINGTON

PBS PROJECT NUMBER:
45013.000 Phase 0005

SAMPLE INFORMATION				MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT (PERCENT)	PLASTIC LIMIT (PERCENT)	PLASTICITY INDEX (PERCENT)
B-1	S-1	2.5		35.7							
B-1	S-2	5		52.1							
B-1	S-3	6.5		56.1				47	36	11	
B-1	S-4	8.5		34.7			26				
B-2	S-1	2.5		47.0							
B-2	S-2	5		60.9							
B-2	S-3	7.5		44.1							
B-2	S-4	10		34.7			41				