PBS | Engineering + Environmental

March 26, 2015

Multnomah County Facilities Management
Attn: Mr. Mike McBride
401 N Dixon Street
Portland, Oregon

Via Email: michael.mcbride@multco.us
cc: JD.Deschamps@multco.us

Re: Additional Geotechnical Engineering Services – Feasibility Assessment
Due Diligence Services – Multnomah County Courthouse
Hawthorne Bridgehead Site, Portland, Oregon
PBS Project No. 15194.869 Task 003

INTRODUCTION AND BACKGROUND

PBS Engineering and Environmental, Inc. (PBS) is pleased to provide this supplemental feasibility/due diligence report for geotechnical engineering services in support of site selection for the proposed Multnomah County Courthouse in Portland, Oregon (Figure 1, Vicinity Map). The Hawthorne Bridgehead (site) is being considered as the site for a new courthouse building. The 0.9-acre site and is bounded by SW Madison and SW Jefferson Streets to the north and south, respectively, and SW Naito Parkway and SW 1st Avenue to the east and west (Figure 2, Site Plan). Based on available topographic data, ground surface elevations at the site range from 55 feet to 46 feet, at the northeastern and southeastern corners, respectively (WGS84 EGM96 Geoid). As part of the Multnomah County (County) due diligence efforts, PBS previously completed a Geotechnical Engineering Feasibility Assessment[1] for the site.

An existing structure on the southwestern portion of the block includes an historic, three-story, reinforced concrete building with an attached single-story, brick restaurant. An asphalt concrete surface road (an abandoned, historic Hawthorne Bridge approach) curves up and around from the southeastern to northeastern corner of the lot. The remainder of the site is covered with grass lawn, landscaping including shrubs and flowers, and occasional trees. The site has been used in this way since at least 1990 based on dated Google Earth™ imagery. Based on our conversations with County personnel and experience with similar projects, the development will include the following.

- A 14- to 17-story, steel-frame building with one level below grade
- A building footprint of approximately 28,000 square feet
- An assumed column load between 1,700 and 2,500 kips

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[1] PBS Engineering and Environmental (21 January 2015). *Geotechnical Engineering Feasibility Assessment Tasks 1 and 2, Due Diligence Services – Multnomah County Courthouse, Hawthorne Bridgehead Site, Portland Oregon.* Prepared for Mr. Mike McBride, Multnomah County Facilities Management. PBS Project No. 15194.869

The County has requested that PBS identify potential geotechnical issues that could affect the proposed plan. The purpose of our additional geotechnical engineering services was to complete site-specific explorations in order to evaluate the risk of liquefaction, and to develop conceptual foundation recommendations for use in planning. Subsurface explorations were included as part of this additional phase of geotechnical engineering services. The project stakeholders, including the County, will utilize the information in completing their due diligence review.

PURPOSE AND SCOPE OF SERVICES

Site-specific subsurface explorations were completed in order to characterize preliminary geotechnical conditions at the site. Field test data was collected to evaluate liquefaction and lateral spreading potential, and to develop additional information regarding possible foundation support.

1. **Subsurface Exploration:** PBS explored subsurface conditions at the site by drilling two borings to depths of up to 81.5 feet below the ground surface (bgs). Nearby borings presented in previous reports prepared by others indicated layers of sand within the underlying gravel unit to depths of about 80 feet bgs. Standard penetration tests (SPT) were completed at 2.5-foot intervals to 20 feet bgs, then at 5- and 10-foot intervals to the final depth of exploration. Drilling was observed by a PBS engineer and groundwater conditions were noted. A piezometer was installed in boring B-2 to allow ongoing monitoring of groundwater levels at the site following initial exploration.
2. **Soils Testing:** Collected samples were returned to our laboratory and classified in general accordance with the Unified Soil Classification, Visual-Manual Procedure. Laboratory tests included natural moisture contents, grain-size analysis, and Atterberg limits.
3. **Geotechnical Engineering Studies:** The data collected during the subsurface exploration, our previous literature research, and testing were analyzed and used to develop an opinion regarding the geotechnical feasibility for the proposed site development.
4. **Deliverable:** This supplemental geotechnical feasibility assessment report was prepared containing the results of our work, including the following information.
    - Explorations logs and approximate exploration locations
    - Groundwater considerations
    - Seismic design criteria in accordance with the 2014 Oregon Structural Specialty Code (OSSC) and discussion regarding the need for additional study (if required)
    - Results of liquefaction and lateral spreading analyses
    - Excavation and shoring considerations
    - Discussion regarding foundation types and design considerations

SUBSURFACE EXPLORATION AND CONDITIONS

Subsurface exploration included advancing two borings (designated as B-1 and B-2) to depths of approximately 81.5 feet bgs. Borings B-1 and B-2 were drilled using a truck-mounted CME-75 drill rig provided and operated by Western States Soil Conservation, Inc., of Hubbard, Oregon. The general location of the site is presented on the attached Figure 1 and the approximate locations of the borings are shown on Figure 2. Figure 2 also indicates the approximate locations of borings completed nearby by others and referenced in our previously prepared report[1]. Borings B-1 and B-2 were logged and representative soil samples were collected by a PBS staff engineer. The interpreted boring logs are presented as Figures A1 and A2 of this report.

According to published geologic mapping of the area[2], subsurface conditions consist of deposited alluvium (map unit Qff), described as fine to coarse sand, silt, and gravel.

During subsurface exploration, we encountered fill consisting of silt and sand with occasional brick fragments. The fill extended from the surface to a depth of about 6.5 to 7.5 feet bgs. Below the fill, we encountered very loose sand and very soft to medium stiff silt to approximate 17 feet bgs. The silt was underlain by gravel to depths of 39.5 to 43.5 feet bgs. A sand layer from 1 foot to 7 feet thick with a relative density of loose to very dense was encountered in the gravel in both borings. The gravel was underlain by hard silt and clay and dense sand to depths of about 55 to 56 feet bgs. Very dense sand with variable amounts of gravel and cobbles was encountered below depths of 55 to 56 feet bgs and extended to the 81.5 feet bgs termination depth of our borings.

SOILS TESTING

Samples obtained during the field explorations were examined in the PBS laboratory. The physical characteristics of the samples were noted and field classifications were modified where necessary. During the course of examination, representative samples were selected for further testing. The laboratory testing program adopted for this investigation included a variety of tests to provide data for the various engineering studies. This included standard classification tests, which consisted of visual examination, moisture contents, Atterberg limits and P200 wash analyses (percent passing the 200 mesh sieve). The classification tests yield certain index properties of the soils important to an evaluation of soil behavior. The testing procedures and results of the tests are presented in the following paragraphs. Unless noted otherwise, all test procedures were performed in general accordance with applicable ASTM International, Inc. (ASTM) standards.

Visual Classification: The soils were classified in general 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 which best described the major portion of the sample was used. Modifying terminology to further describe the samples is defined in Terminology Used to Describe Soil and Rock in the attached Table A1.

Moisture (Water) Content: 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 attached boring logs, Figures A1 and A2.

Atterberg Limits: Atterberg limits were determined on one sample (S-4) from B-1, and two samples (S-3 and S-11) from B-2, to classify soils into various groups for correlation. The results of the Atterberg limits tests, which included liquid and plastic limits, are plotted on the attached Atterberg Limits Test Results, Figure B1; and on the boring logs, Figures A1 and A2.

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[2] Beeson, M.H. and Madin, I.P., (1991). [Map]. *Geologic Map of the Portland Quadrangle, Multnomah and Washington Counties, Oregon, and Clark County, Washington*: Oregon Department of Geology and Mineral Industries, Geological Map Series 75, scale 1:24,000.

Grain-Size Analyses: The P200 wash was completed on several samples from both the borings to determine the portion of soil samples passing the No. 200 Sieve (i.e., silt and clay). The results of P200 testing are presented on the boring logs Figures A1 and A2.

GROUNDWATER

In general, groundwater is likely hydraulically connected to the Willamette River and has a down-gradient dip toward the river that is about 400 feet to the east. Perched groundwater may be encountered throughout the project site due to the variations in fill and alluvial deposits.

Although groundwater was not observed during drilling, an open standpipe piezometers was installed in B-2 to allow for direct measurement of groundwater at the site. After several days following drilling, groundwater was measured at a depth of about 31 feet bgs. This is consistent with the mapped groundwater contours developed by the USGS for the Portland area. We anticipate groundwater levels could fluctuate throughout the year.

CONCLUSIONS AND RECOMMENDATIONS

Geotechnical Design and Considerations

Based on our conversations with County personnel and experience with similar projects, as well as the development assumptions as stated in the Introduction and Background sections of this report, our current opinion is that support of the proposed new building on shallow spread footings is not feasible because of the loose sand lenses observed in the underlying gravel deposits. The following has been considered in this report and are discussed in more detail in the following sections.

- A 7-foot-thick layer of potentially liquefiable soil was encountered below the design groundwater depth in one of the borings and will require mitigation of at least a portion of the new building footprint.
- Installation of deep foundations should consider the proximity of existing historic buildings next to the site and the affects of construction vibration, particularly for pile driving. This may limit deep foundations to those that can be drilled into the underlying dense gravel below loose to medium dense sand lenses/layers.
- Conventional shoring techniques, as discussed in our Feasibility Assessment, appear to be feasible with consideration given to the proximity of existing historic structures and the soft sensitive, silt and clay soils.
- Temporary and permanent support of the Hawthorne Bridge approach during excavation of the ramp leading up to the bridge will result in taller shoring and permanent walls and higher forces for this area of the site when compared to the remainder of the areas that are near the existing grades of the surrounding streets.
- The soft soils encountered at the estimated depth of the below-grade-level slab will require mitigation by overexcavation and backfilling with structural fill or reinforcement with soil improvement. The soft soils will not support estimated slab loads in their current condition.

Liquefaction and Lateral Spreading

Liquefaction is defined as a decrease of the shear resistance of loose, saturated, cohesionless soil (e.g., sand) or low plasticity silt soils due to the buildup of excess pore pressures generated during an earthquake. This results in a temporary transformation of the soil deposit into a viscous fluid.

Liquefaction can result in ground settlement, foundation bearing capacity failure, and lateral spreading of ground.

With groundwater present at depths of greater than 20 to 30 feet bgs, only one lens or layer of potentially liquefiable soil was encountered. The silty sand was only encountered in B-2 from a depth of 26 to 32 feet bgs. Due to the loose nature of the soil, a sample of this material could not be collected for laboratory testing. The soil was characterized based on observation of drill cuttings.

We evaluated liquefaction at the site for a design-level, Cascadia Subduction Zone (CSZ) earthquake and crustal earthquake along the Portland Hills Fault (PHF). The analyses were completed using magnitudes (M) and peak ground surface accelerations (PGA) consistent with the respective design earthquakes. The estimated settlement for both cases was similar, with an estimated 2 to 3 inches of liquefaction-induced settlement.

Depending on the continuity of this layer and its extent under the site, liquefaction could result in lateral spreading toward the Willamette River; approximately 400 feet to the east. We estimate that lateral spreading on the order of 2 feet could occur at the site if this layer is relatively continuous and were to liquefy. Identifying the possible areal extent of this potentially liquefiable layer will be critical in order to evaluate mitigation options and associated costs.

Code-Based Seismic Design Criteria and Requirements

Due to the potential for liquefaction of some soils on portions of the site, the site should be considered Site Class F. This could be improved upon if liquefaction-susceptible soils are mitigated. Due to the potential for liquefaction and occupancy and height of the planned structure, a site-specific seismic hazard study, including site response analysis, will be required to develop site-specific values for use in the structural design. Site class is based on the average shear wave velocities of soils within 100 feet of the base of the planned new structure. This can be measure directly or correlated to Standard Penetration Test (SPT) N-values. Based on measured shear wave velocities in similar materials on adjacent sites, structural design (following mitigation) would likely be based on Site Class C.

The general seismic design criteria, in accordance with the 2014 Oregon Structural Specialty Code (OSSC), should be based on S_s equal to 0.99 g and S_1 equal to 0.42 g.

Mat Foundations

Based on the stiffness of site soils, provided the potentially liquefiable soils at the site can be mitigated, and depending on the magnitude of the structure loads, it may be feasible to support the new courthouse on a mat foundation. A mat foundation consists of a 2- to 5-foot-thick reinforced slab that distributes the weight of the structure over the entire building footprint. The use of a mat in lieu of deep foundations is normally evaluated as part of the design-level geotechnical services and must consider site-specific soil properties, actual structure loads, and tolerable settlement (usually limited to about 1 inch).

Deep Foundation Considerations

Cast-in-drilled-hole (CIDH) concrete piles are the most likely foundation type to be used at this site due to the proximity of existing brick buildings on the site, and the need for relatively high capacities to support the planned 10- to 12-story courthouse. Based on the estimated loads and possible presence of cobbles, we have preliminarily considered 12- to 30-inch-diameter CIDH concrete piles for foundation support.

Axial Capacity

Axial capacity of the CIDH or augercast piles will be derived primarily from shaft friction. The contribution from end bearing is significantly reduced due to the magnitude of displacement required to engage full end bearing in addition to the disturbance resulting from drilling operations. For an estimated pile length of 40 feet, pile capacities would range from about 250 kips to 400 kips for 12-inch diameter piles and 30-inch diameter piles, respectively. Piles should be spaced a minimum of three pile diameters, center-to-center.

Construction Considerations

Caving in the sand, gravel and cobbles and significant loss of drilling mud were observed during drilling. Construction of deep foundations may require the use of casing if “open-hole” techniques are used. In addition, a contingency should be included in the project budget and schedule for increased grout/concrete volumes.

Use of drilled piles requires full-time observation during construction to confirm subsurface conditions and construction procedures are consistent with our recommendations.

Temporary Shoring

Temporary construction excavation and site safety are the sole responsibility of the contractor who also is solely responsible for the means, methods, and sequencing of construction operations. We are providing the following information only as a service to our client for planning purposes by their design team. Under no circumstances should the information provided herein be interpreted to mean that PBS is assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

Conceptual planning includes a single-level below grade at the site. We estimate the base elevation of this level will be at a depth 12 to 15 feet bgs. Due to the proximity to existing streets and structures, there is not sufficient room to safely slope the excavation without impacting them. As a result, we recommend only using shoring that provides continuous support; open cuts will not be allowed. Although permanent groundwater was measured at a depth of about 31 feet bgs, zones of perched water may be present and may rise in response to wet weather.

A wide variety of shoring systems are available for temporary shoring and have been discussed in our previously prepared report[1]. Among the most commonly used shoring walls in the area are soldier piles with tiebacks, soil nails, or sheet piles with braces or struts. Sheet piles walls may not be feasible for this excavation due to the limits on driving or vibrating piles, as well as the gravel content of the subsurface soils. In our opinion, a soldier pile wall combined with braces and struts or tiebacks may be used for shoring. Due to the relatively low soil strengths in the soil present within 12 to 15 feet bgs, soil nails may not be feasible, and tiebacks would likely require steep declinations in order to derive their capacity from the underlying sand and gravel soils at the site.

Due to the presence of the historic buildings adjacent to the site that will remain, it may be necessary to consider shoring that is generally more rigid and can be constructed in a manner to provide continuous support of soils supporting the foundations of these structures. Possible shoring systems that meet this criteria could include a soldier pile and lagging wall using sheet pile or steel sheets as lagging that is installed prior to excavation. Alternatively, a tangent pile wall that consists of drilled concrete piles installed immediately adjacent or relatively close to one another to act as lagging. Tangent pile walls designed to cantilever (without tiebacks) will require reinforcing such as H-piles or rebar cages. Depending on the depth of excavation and subsurface conditions, reinforcing is typically installed in every other to every third or fourth pile. If drilled concrete piles are used for building support, it may be feasible to use the same equipment to construct the shoring around the existing structures and reduce mobilization costs if using another system.

Underpinning of Adjacent Historic Buildings

Due to the presence of relatively low strength soils within 12 to 15 feet bgs, the historic nature of the adjacent structures with unknown foundations, addressing these structures will be critical before and during construction. Underpinning the existing structure foundations with pin piles or micropiles that derive their capacity below the depth of excavation may be used in addition to more rigid shoring systems for excavations in the vicinity of the structures. Given the fragile nature of these structures this could be a delicate operation in order reduce the chance to damaging the structures during underpinning.

Regardless of the selected foundation installation type, shoring, or underpinning alternatives, a comprehensive pre-construction survey of adjacent structures and surrounding site features should be completed. This could include an optical survey of “targets” and benchmarks established on building walls, foundations, sidewalks and other features, measuring vibration and/or photo or video documentation. Following the survey, thresholds should be established and include contingency plans with required actions if detrimental effects are observed.

It will be important to maintain a schedule of completing regular, detailed observation during construction. This could include regular vertical/horizontal survey in addition to regular observation and documentation. These conditions should be compared to the conditions observed during the pre-construction survey.

Building Slab Subgrade Stabilization

Very soft silt was encountered in both borings at depths of about 12 to 18 feet, near the base of below-grade level of the proposed development. Depending on the planned depth of excavation, consideration should be given to extending the excavation to the top of the gravel encountered at depths of 17 to 17.5 feet bgs in B-2 and B-1, respectively. Extending the depth of the excavation would serve two purposes: it would remove very soft soil from beneath the slab where it could result in settlement and it would provide a thick working surface through the duration of construction, reducing concerns about softened subgrades and delays due to floor slab subgrade repairs.

LIMITATIONS

Prior to design and construction, additional subsurface explorations, laboratory testing, and geotechnical engineering analyses will be required. This report has been prepared for the exclusive use of the addressee and their architects and engineers for aiding in the conceptual planning and construction feasibility considerations of the proposed new county court house building 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 the expressed written consent of the Client and PBS. It is the addressee's responsibility to provide this report to the appropriate design professionals, building officials 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, laboratory testing, and engineering analyses. Conditions between or beyond our explorations may vary from those encountered. It is possible that soil, rock, or groundwater conditions could vary between or beyond the points explored.

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 designed and constructed project. Therefore, we recommend a contingency fund to accommodate such potential extra costs.

The scope of these geotechnical services for this subsurface exploration and geotechnical report did not include environmental assessments or evaluation of 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 report meets your current needs. If you have any questions or wish to further discuss our observations, conclusions, and recommendations, please contact us at 503.248.1939.

Sincerely,
PBS Engineering and Environmental Inc.

REGISTERED PROFESSIONAL ENGINEER
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JANUARY 15, 2002
RYAN WHITE
RENEWAL DATE: 6/30/2016

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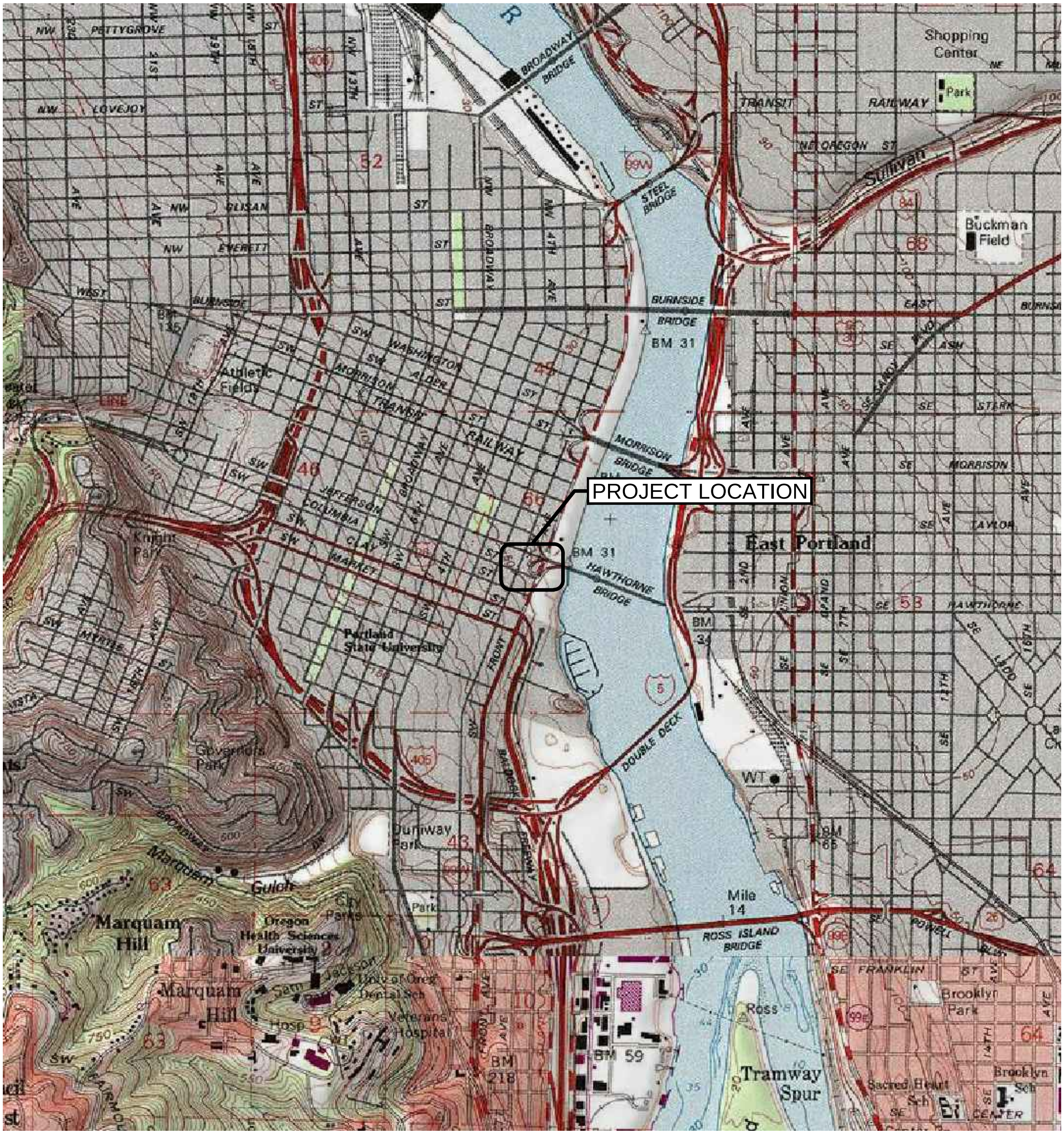
Arlan H. Rippe, PE, GE, D.GE
Senior Geotechnical Consultant

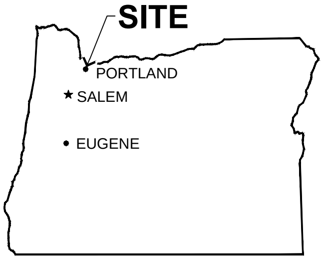
TR/RW/AR/rd

Attachments:	Figure 1 – Vicinity Map
	Figure 2 – Site Plan
	Table A-1 – Terminology Used to Describe Soil
	Table A-2 – Key to Test Pit and Boring Log Symbols
	Figures A1 through A2 – Logs for Borings B-1 and B-2
	Figure B1 – Atterberg Limits Test Results

FIGURES



SOURCE: USGS PORTLAND OR QUADRANGLE 1990.



OREGON

0' 1,000' 2,000' 4,000'

SCALE: 1" = 2,000'

PREPARED FOR: MULTNOMAH COUNTY

PBS

PROJECT #
15194.869
PHASE: 2-TASK:3

DATE
MAR 2015

VICINITY MAP

HAWTHORNE BRIDGE HEAD
PORTLAND, OREGON

FIGURE
1

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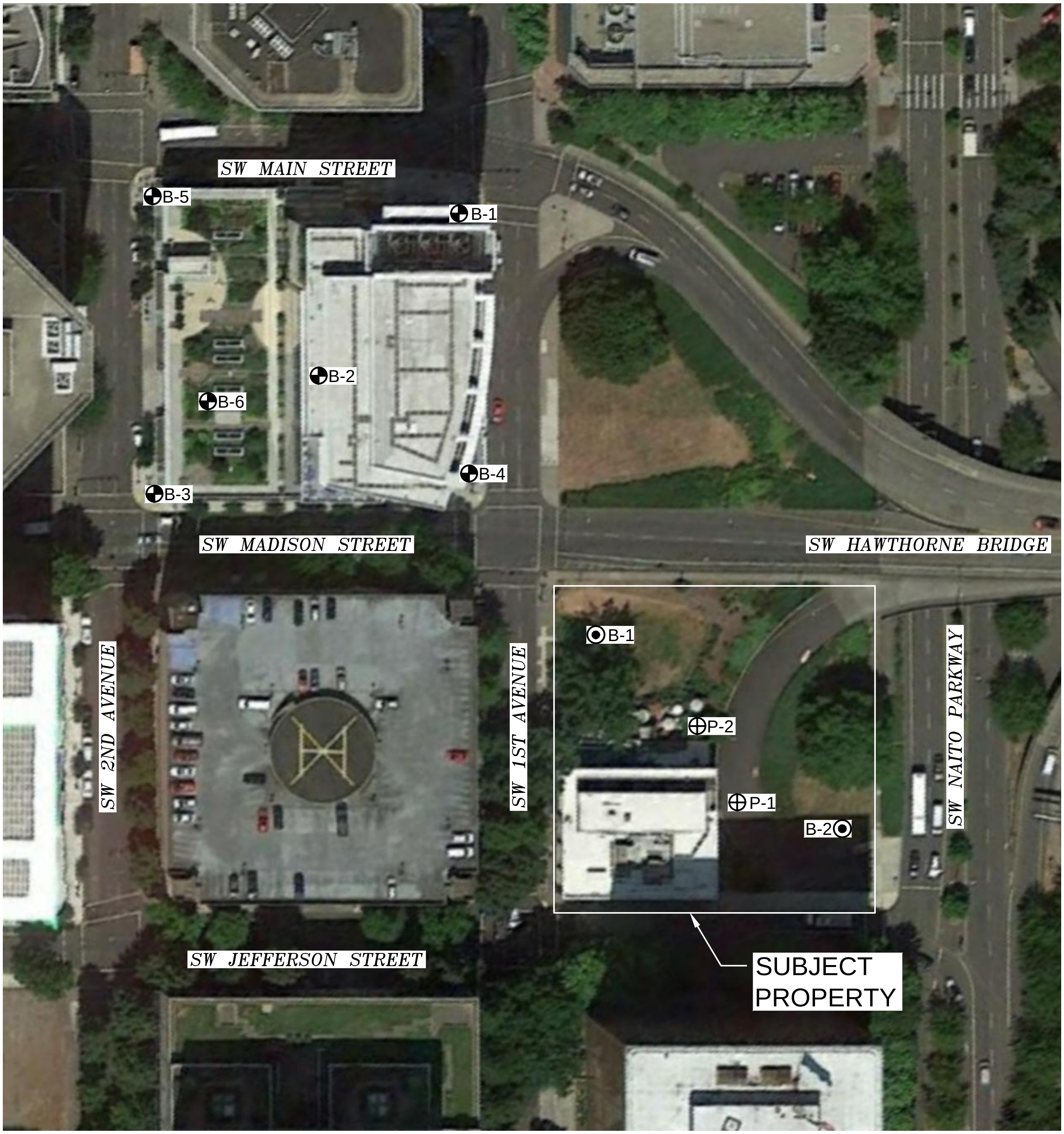

SOURCE: © 2011 GOOGLE EARTH PRO, © 2012 GOOGLE

LEGEND

◐	B-1	BORING NUMBER AND LOCATION FROM GEODESIGN REPORT DATED JUNE 2001 (B-1 THROUGH B-5) AND APRIL 2006 (B-6)
⊕	P-1	BORING NUMBER AND LOCATION FROM GRI REPORT DATED APRIL 1999
⊙	B-1	GEOPROBE® BORING NUMBER AND LOCATION

0' 50' 100' 200'

SCALE: 1" = 100'

PREPARED FOR: MULTNOMAH COUNTY

PBS

PROJECT #
15194.869
PHASE: 2-TASK:3

DATE
MAR 2015

SITE PLAN

HAWTHORNE BRIDGE HEAD
PORTLAND, OREGON

FIGURE

2

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ATTACHMENT A

Field Explorations

Table A-1
Terminology Used to Describe Soil

Soil Descriptions

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

Fine - Grained Soils (More than 50% fines passing 0.075 mm, #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 describes the terminology used to describe fine - grained soils, and varies from ASTM 2488 terminology in the use of some common terms.

Primary soil NAME, adjective and symbols			Plasticity Description	Plasticity Index (PI)
SILT ML & MH	CLAY CL & CH	ORGANIC SILT & CLAY OL & OH		
SILT		Organic SILT	Non-plastic	0 - 3
SILT		Organic SILT	Low plasticity	4 - 10
SILT / Elastic SILT	Lean CLAY	Organic clayey SILT	Medium Plasticity	10 – 20
Elastic SILT	Lean/Fat CLAY	Organic silty 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; with gravel (combined total greater than 15% but less than 30%, modifier is whichever is greater)	15% to 25%
Sandy; or gravelly (combined total greater than 30% but less than 50%, modifier is whichever is greater)	30% to 50%

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

Soil Consistency. Consistency terms are applied to fine-grained, plastic soils (i.e., PI ≥ 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. Note, SILT soils with low to non-plastic behavior (i.e. PI < 7) are 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

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Table A-1
Terminology Used to Describe Soil
2 of 2

Soil Descriptions

Coarse - Grained Soils (less than 50% fines)
Coarse-grained soil descriptions, i.e., SAND or GRAVEL, are based on that portion of materials passing a 3-inch (75mm) sieve. Coarse-grained soil group symbols are applied in accordance with ASTM D2488-06 based upon 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	Particle Diameter	
	Inches	**Millimeters**
Sand (S)	0.003 - 0.19	0.075 - 4.8
Gravel (G)	0.19 - 3.0	4.8 - 75
	Additional Constituents	
Cobble	3.0 - 12	75 - 300
Boulder	12 - 120	300 - 3050

The primary soil type is capitalized, and the amount of fines in the soil are described as indicated by the following examples. Other soil mixtures will provide similar descriptive names.

Example: Coarse-Grained Soil Descriptions with Fines

5% to less than 15% fines (Dual Symbols)	15% to less than 50% fines
GRAVEL with silt, GW-GM	Silty GRAVEL: GM
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.

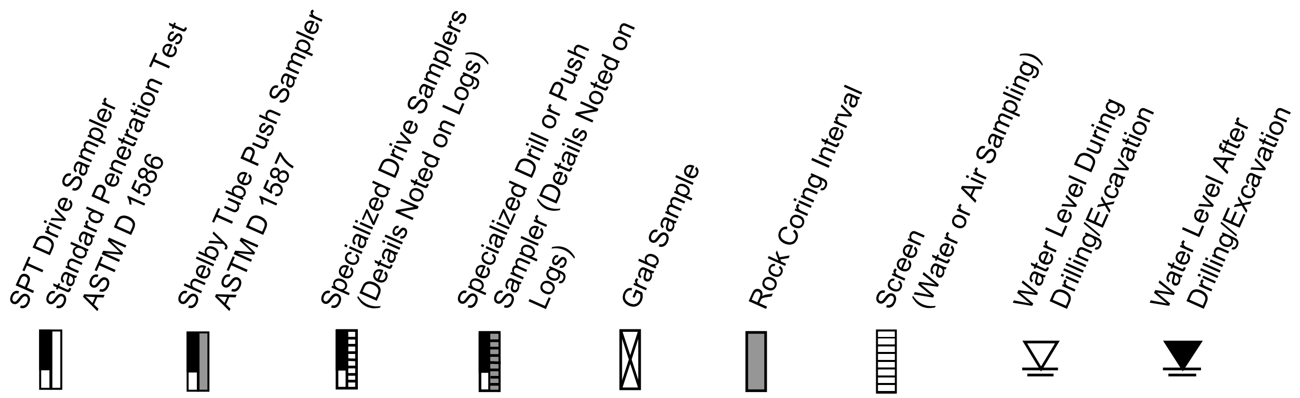
Cobble and boulder deposits may include a description of the matrix soils, as defined above.

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.

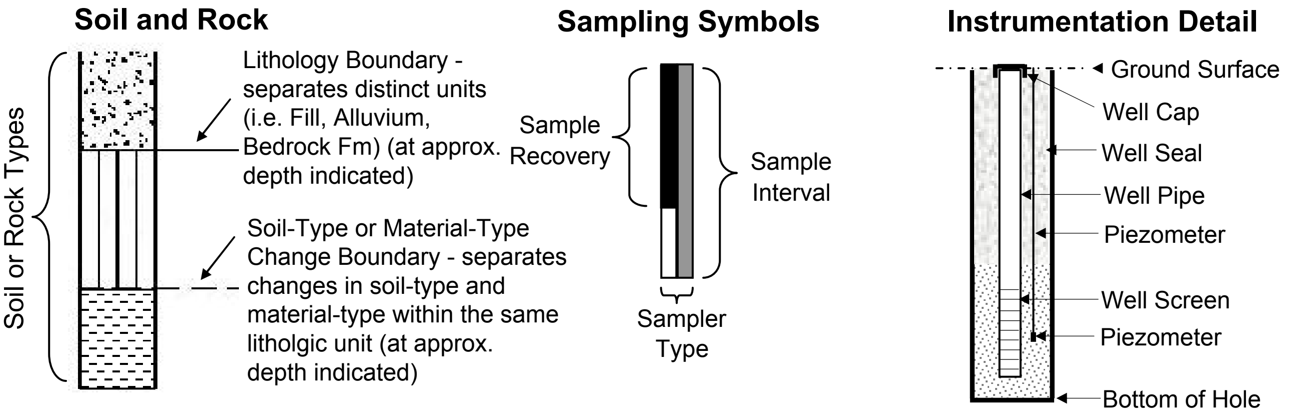
Relative Density Term	SPT N-value
Very loose	0 - 4
Loose	5 - 10
Medium dense	11 - 30
Dense	31 - 50
Very dense	> 50

Table A-2
Key To Test Pit and Boring Log Symbols

SAMPLING DESCRIPTIONS[1]



LOG GRAPHICS



Geotechnical Testing/Acronym Explanations

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

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[1] Note: Details of soil and rock classification systems are available on request.

Rev. 02/23/15

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MCC - HAWTHORNE BRIDGEHEAD
SW 1ST AND MADISON, PORTLAND, OR

BORING B-1

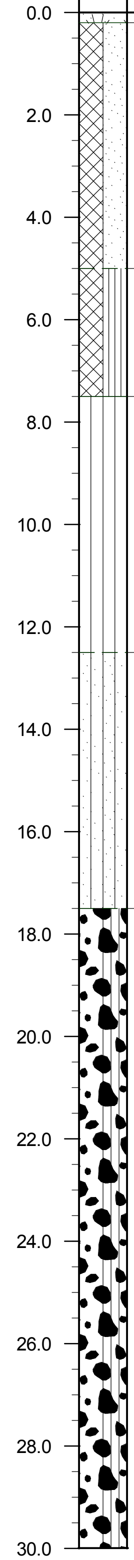
PBS PROJECT NUMBER:
15194.869

APPROX. BORING B-1 LOCATION:
(See Site Plan)

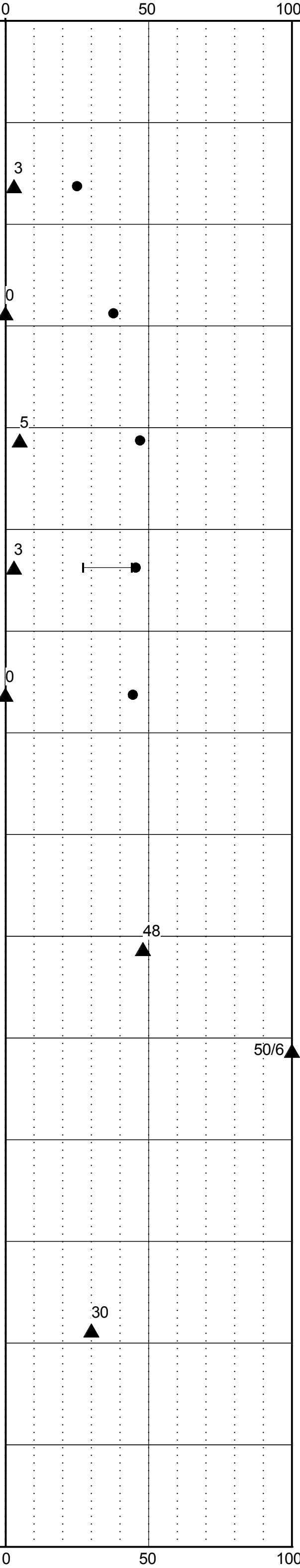
NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

▲ BLOW COUNT
✧ DYNAMIC CONE PENETROMETER
● MOISTURE CONTENT %
▥ RQD%
▨ CORE REC%

Surface Conditions: Grass



DEPTH	MATERIAL DESCRIPTION	TESTING	SAMPLE ID	BLOW COUNT	INSTALLATION AND COMMENTS
0.2	2 inch thick root zone				
	Very loose brown gray poorly graded SAND (SP); fine sand; moist. **FILL**		S-1	3	
5.0	Very soft brown SILT (ML); low plasticity; moist; brick fragments.		S-2	0	
7.5	Medium stiff brown SILT (ML); medium plasticity; moist.		S-3	5	
	becomes soft	ATT	S-4	3	LL = 44% PL = 27% PI = 17%
12.5	Very soft brown SILT (ML) with sand; low plasticity; fine sand; moist.	P200	S-5	0	P200 = 73%
			S-6		350 psi from 0 to 12 inches; 400 psi from 12 to 24 inches; psi increases exponentially at 17.5 feet bgs
17.5	Dense gray brown well graded GRAVEL (GW-GM) with silt and sand; low plasticity; fine to coarse sand; subangular, fine to coarse gravel; moist.		S-7	48	Lost mud at 19 feet bgs
	becomes very dense		S-8	50/6	Lost whole mud tub at 22 feet bgs
	becomes medium dense		S-9	30	Caving at 25 feet bgs Lost two whole mud tubs at 26 feet bgs



DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 3 7/8 inches
HAMMER EFFICIENCY PERCENT: 85
LOGGING COMPLETED: 2/18/15

FIGURE A1

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MCC - HAWTHORNE BRIDGEHEAD
SW 1ST AND MADISON, PORTLAND, OR

BORING B-1
(continued)

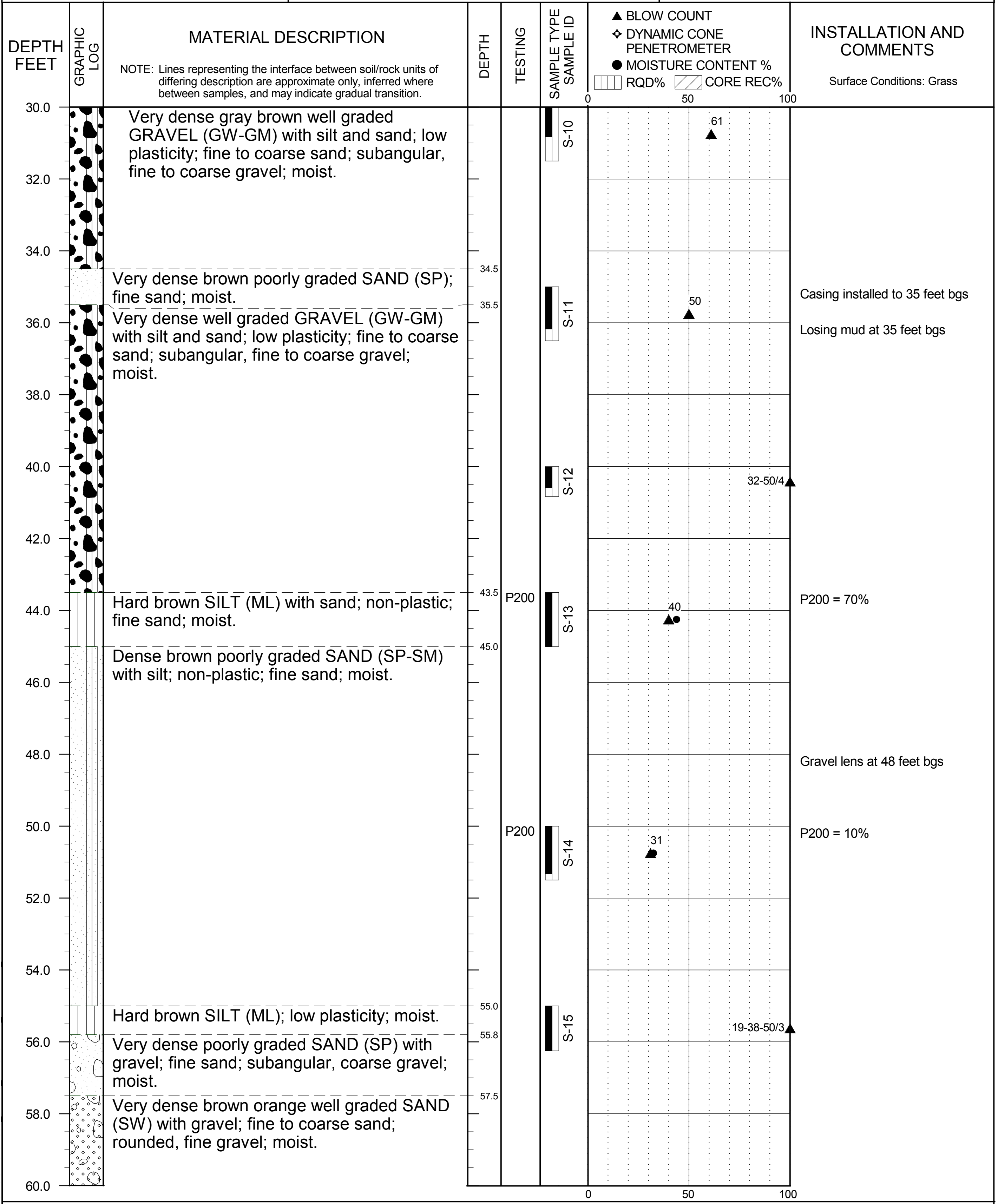
PBS PROJECT NUMBER:
15194.869

APPROX. BORING B-1 LOCATION:
(See Site Plan)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

▲ BLOW COUNT
✧ DYNAMIC CONE PENETROMETER
● MOISTURE CONTENT %
▥ RQD%
▨ CORE REC%

Surface Conditions: Grass



DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	BLOW COUNT	INSTALLATION AND COMMENTS
30.0	Very dense gray brown well graded GRAVEL (GW-GM) with silt and sand; low plasticity; fine to coarse sand; subangular, fine to coarse gravel; moist.			S-10	61	
34.5	Very dense brown poorly graded SAND (SP); fine sand; moist.	34.5				
35.5	Very dense well graded GRAVEL (GW-GM) with silt and sand; low plasticity; fine to coarse sand; subangular, fine to coarse gravel; moist.	35.5		S-11	50	Casing installed to 35 feet bgs Losing mud at 35 feet bgs
40.0				S-12	32-50/4	
43.5	Hard brown SILT (ML) with sand; non-plastic; fine sand; moist.	43.5	P200	S-13	40	P200 = 70%
45.0	Dense brown poorly graded SAND (SP-SM) with silt; non-plastic; fine sand; moist.	45.0				
48.0						Gravel lens at 48 feet bgs
50.0			P200	S-14	31	P200 = 10%
55.0	Hard brown SILT (ML); low plasticity; moist.	55.0		S-15	19-38-50/3	
55.8	Very dense poorly graded SAND (SP) with gravel; fine sand; subangular, coarse gravel; moist.	55.8				
57.5	Very dense brown orange well graded SAND (SW) with gravel; fine to coarse sand; rounded, fine gravel; moist.	57.5				
60.0						

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 3 7/8 inches
HAMMER EFFICIENCY PERCENT: 85
LOGGING COMPLETED: 2/18/15

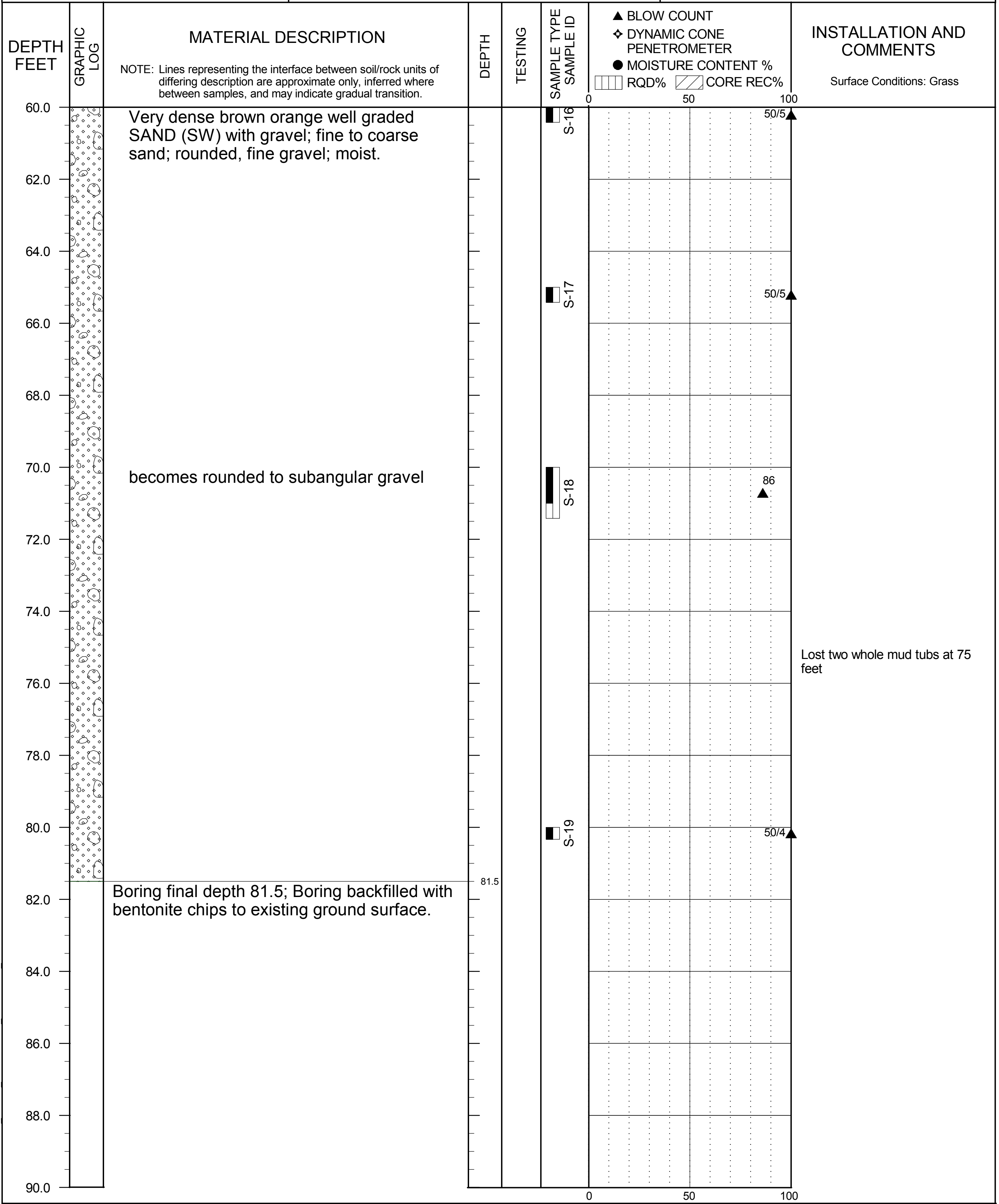
FIGURE A1

MCC - HAWTHORNE BRIDGEHEAD
SW 1ST AND MADISON, PORTLAND, OR

PBS PROJECT NUMBER:
15194.869

BORING B-1
(continued)

APPROX. BORING B-1 LOCATION:
(See Site Plan)



NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Surface Conditions: Grass

DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE ID	BLOW COUNT	INSTALLATION AND COMMENTS
60.0	Very dense brown orange well graded SAND (SW) with gravel; fine to coarse sand; rounded, fine gravel; moist.			S-16	50/5	
				S-17	50/5	
70.0	becomes rounded to subangular gravel			S-18	86	
						Lost two whole mud tubs at 75 feet
80.0				S-19	50/4	
	Boring final depth 81.5; Boring backfilled with bentonite chips to existing ground surface.	81.5				

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 3 7/8 inches
HAMMER EFFICIENCY PERCENT: 85
LOGGING COMPLETED: 2/18/15

FIGURE A1

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MCC - HAWTHORNE BRIDGEHEAD
SW 1ST AND MADISON, PORTLAND, OR

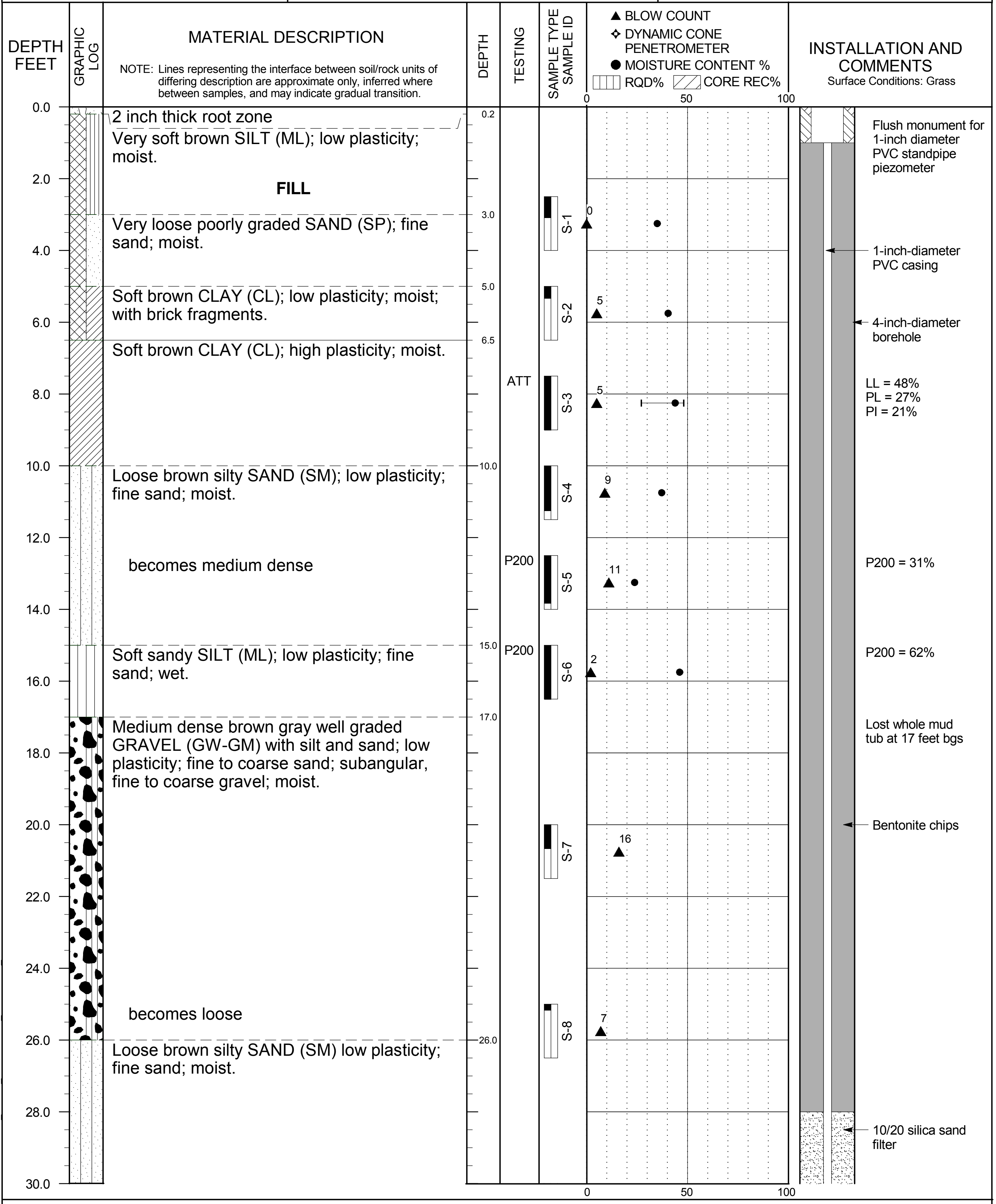
PBS PROJECT NUMBER:
15194.869

BORING B-2

APPROX. BORING B-2 LOCATION:
(See Site Plan)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Surface Conditions: Grass



DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE ID	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	2 inch thick root zone	0.2				Flush monument for 1-inch diameter PVC standpipe piezometer
	Very soft brown SILT (ML); low plasticity; moist. **FILL**					
3.0	Very loose poorly graded SAND (SP); fine sand; moist.	3.0		S-1	0	1-inch-diameter PVC casing
5.0	Soft brown CLAY (CL); low plasticity; moist; with brick fragments.	5.0		S-2	5	4-inch-diameter borehole
6.5	Soft brown CLAY (CL); high plasticity; moist.	6.5	ATT	S-3	5	LL = 48% PL = 27% PI = 21%
10.0	Loose brown silty SAND (SM); low plasticity; fine sand; moist.	10.0		S-4	9	
	becomes medium dense		P200	S-5	11	P200 = 31%
15.0	Soft sandy SILT (ML); low plasticity; fine sand; wet.	15.0	P200	S-6	2	P200 = 62%
17.0	Medium dense brown gray well graded GRAVEL (GW-GM) with silt and sand; low plasticity; fine to coarse sand; subangular, fine to coarse gravel; moist.	17.0		S-7	16	Lost whole mud tub at 17 feet bgs Bentonite chips
	becomes loose			S-8	7	
26.0	Loose brown silty SAND (SM) low plasticity; fine sand; moist.	26.0				10/20 silica sand filter
30.0						

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 3 7/8 inches
HAMMER EFFICIENCY PERCENT: 85
LOGGING COMPLETED: 2/19/15

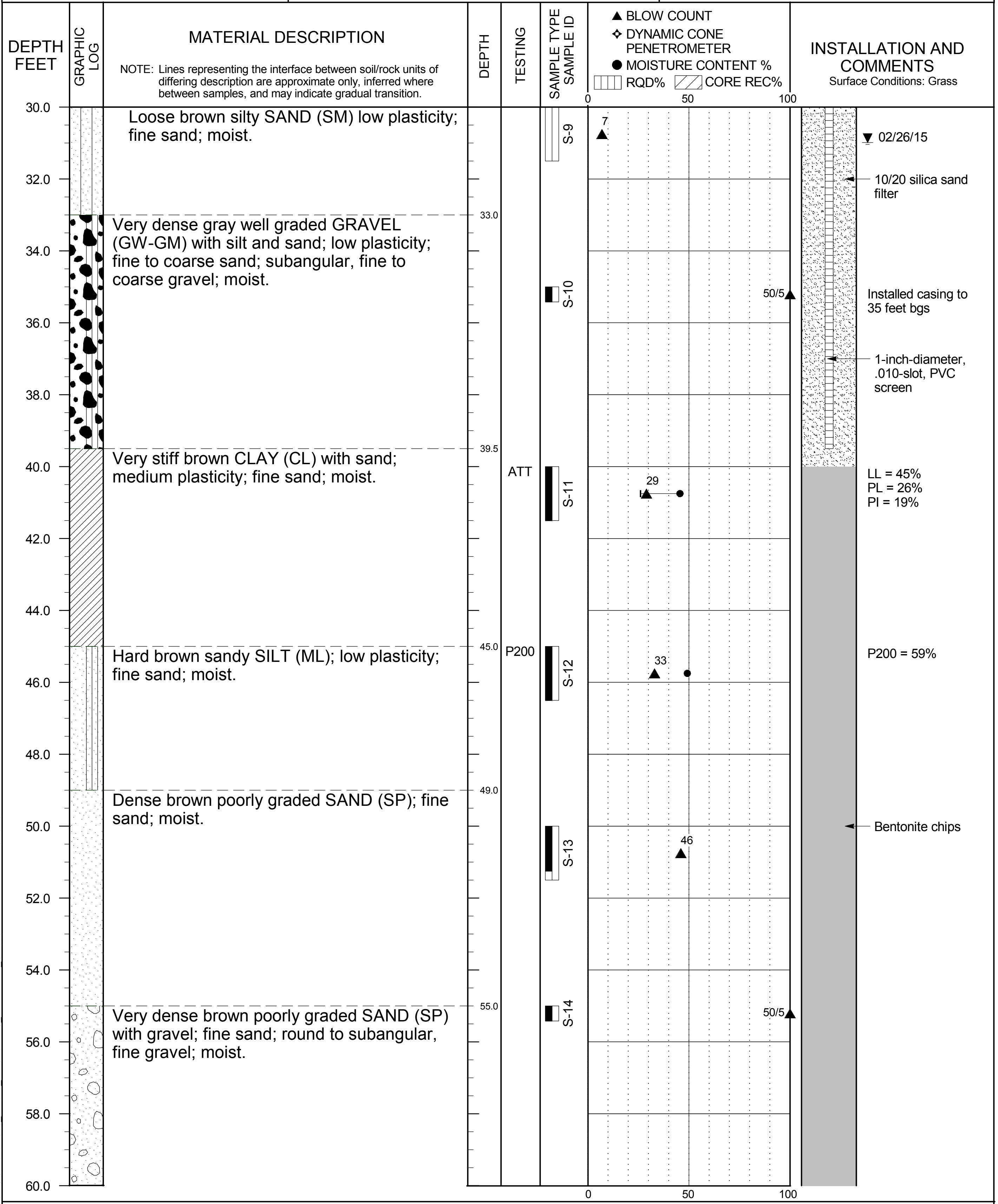
FIGURE A2

MCC - HAWTHORNE BRIDGEHEAD
SW 1ST AND MADISON, PORTLAND, OR

PBS PROJECT NUMBER:
15194.869

BORING B-2
(continued)

APPROX. BORING B-2 LOCATION:
(See Site Plan)



NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE ID	BLOW COUNT	INSTALLATION AND COMMENTS
30.0	Loose brown silty SAND (SM) low plasticity; fine sand; moist.			S-9	7	▼ 02/26/15 10/20 silica sand filter
33.0	Very dense gray well graded GRAVEL (GW-GM) with silt and sand; low plasticity; fine to coarse sand; subangular, fine to coarse gravel; moist.	33.0		S-10	50/5	Installed casing to 35 feet bgs 1-inch-diameter, .010-slot, PVC screen
39.5	Very stiff brown CLAY (CL) with sand; medium plasticity; fine sand; moist.	39.5	ATT	S-11	29	LL = 45% PL = 26% PI = 19%
45.0	Hard brown sandy SILT (ML); low plasticity; fine sand; moist.	45.0	P200	S-12	33	P200 = 59%
49.0	Dense brown poorly graded SAND (SP); fine sand; moist.	49.0		S-13	46	Bentonite chips
55.0	Very dense brown poorly graded SAND (SP) with gravel; fine sand; round to subangular, fine gravel; moist.	55.0		S-14	50/5	
60.0						

MCC - HAWTHORNE BRIDGEHEAD
SW 1ST AND MADISON, PORTLAND, OR

PBS PROJECT NUMBER:
15194.869

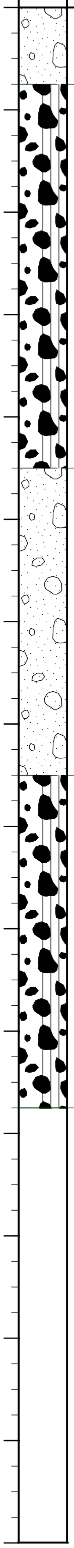
BORING B-2
(continued)

APPROX. BORING B-2 LOCATION:
(See Site Plan)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Legend: ▲ BLOW COUNT; ✧ DYNAMIC CONE PENETROMETER; ● MOISTURE CONTENT %; ▥ RQD%; ▨ CORE REC%

Surface Conditions: Grass



DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	BLOW COUNT	INSTALLATION AND COMMENTS
60.0	Very dense brown poorly graded SAND (SP) with gravel; fine sand; round to subangular, fine gravel; moist.					
	Very dense brown well graded GRAVEL (GW-GM) with silt and sand; non-plastic; fine to coarse sand; subangular, fine to coarse gravel; moist.	61.5				
				S-15	50/5	Bentonite chips
	Very dense poorly graded SAND (SP) with gravel; fine sand, rounded, fine gravel; moist.	69.0				
				S-16	50/6	
						Cobble at 73 feet
	Very dense brown well graded GRAVEL (GW-GM) with silt and sand; non-plastic; fine to coarse sand; subangular, fine to coarse gravel; moist.	75.0				Cobble at 75 feet
				S-17	29-50/3	
	Boring final depth 81.5; Open hole peizometer installed.	81.5				
90.0						

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Rikli

BIT DIAMETER: 3 7/8 inches
HAMMER EFFICIENCY PERCENT: 85
LOGGING COMPLETED: 2/19/15

FIGURE A2

ATTACHMENT B

Laboratory Tests

PBS Engineering + Environmental
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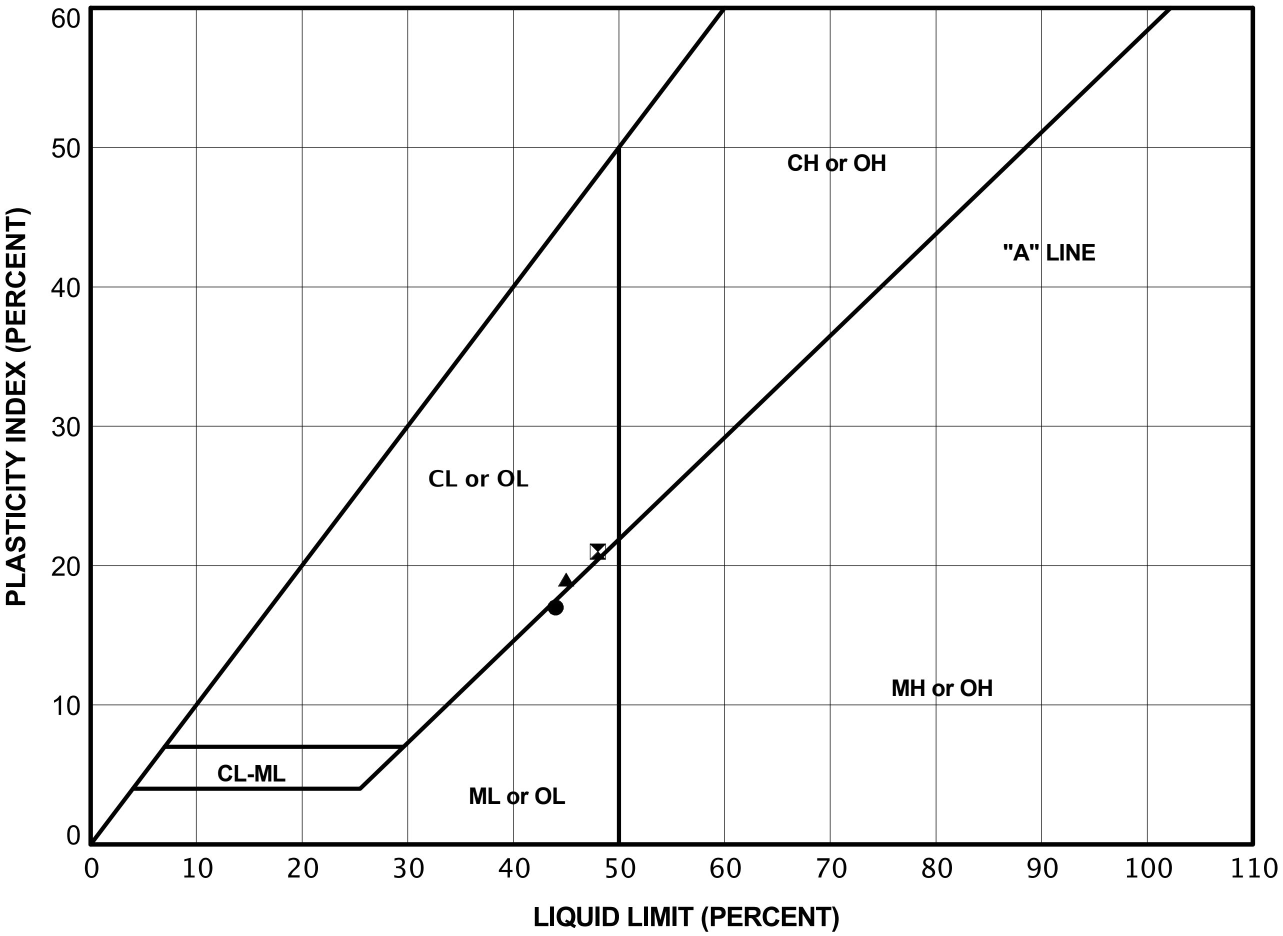
ATTERBERG LIMITS TEST RESULTS

MCC - HAWTHORNE BRIDGEHEAD
SW 1ST AND MADISON, PORTLAND, OR

PBS PROJECT NUMBER:
15194.869

TEST METHOD: ASTM D4318



KEY	EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	NATURAL MOISTURE CONTENT (PERCENT)	PERCENT PASSING NO. 40 SIEVE (PERCENT)	LIQUID LIMIT (PERCENT)	PLASTIC LIMIT (PERCENT)	PLASTICITY INDEX (PERCENT)
●	B-1	S-4	10.0	45	NA	44	27	17
⧗	B-2	S-3	7.5	44	NA	48	27	21
▲	B-2	S-11	40.0	46	NA	45	26	19

ATTERBERG LIMITS 15194.869_022015_TR.GPJ PBS_DATATMPL_GEO.GDT PRINT DATE: 3/15/15:RW

FIGURE B1