Construction Contracts Administration, Procurement Contracts & Materials Management (PCMM)
Oregon State University
644 SW 13th Ave.
Corvallis, Oregon 97333

P 541-737-4261
F 541-737-5546
oregonstate.edu

5/16/2018

Oregon State University
Construction Contract Administration
Request for Qualifications #194360
Demolition Landfill Remedial Action Planning, Remediation Design and Pumice Mine Site Reclamation Design

ADDENDUM NO. 2

THIS ADDENDUM IS BEING ISSUED for clarification and/or revisions of the Request for Qualifications as noted. This document is hereby made a part of the Contract Documents to the extent as though it was originally included herein.

Item 1 ***RFQ Section 8.0 Evaluation Criteria, paragraph 8.1.1 REVISE to read:***
"Provide a brief description of your firm and the focus of the practice. List up to ten projects with scope relevant to this project that your firm is currently contracted for and at what stage the projects are in terms of completion. Do not list projects that you would not be able or willing to discuss in an interview. Also include your firm's total dollar volume for each of the last five years. (Weight: 10)"

Clarifications

Item 2 ***RFQ Section 8.0 Evaluation Criteria, paragraph 8.1.5:***
Q: *Does "utilization history" mean a listing of MBE/WBE/ESB firms contracted over the past three years? Is there additional information desired beyond that?*
A: *Yes, a listing of MBE/WBE/ESB is sufficient, however, additional information may be provided to support previous efforts, such as, but not limited to percentage of total contract awarded for MBE/WBE/ESB firms.*

Item 3 ***RFQ Enclosures, ADD the following documents, to be used for Reference Only (both attached below).***

- ***a.*** *Preliminary Geotechnical Investigation, Dated July 25, 2014, prepared by Carlson Geotechnical, A Division of Carlson Testing, Inc..*
- ***b.*** *Supplemental Geologic Reconnaissance and Preliminary Slope Stability Analysis for Eastern Portion of OSU Cascades 46-Acre Site, dated May 21, 2014, prepared by Carlson Geotechnical, A Division of Carlson Testing, Inc..*

END OF ADDENDUM NO. 2

Report of
Supplemental Geologic Reconnaissance & Preliminary Slope Stability Analysis for Eastern Portion of OSU Cascades 46-Acre Site
1707 & 1757 SW Simpson Avenue
Bend, Oregon

CGT Project Number G1303959.B

Prepared for:

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

May 21, 2014

Carlson Geotechnical

A Division of Carlson Testing, Inc.
Phone: (503) 601-8250
Fax: (503) 601-8254

Bend Office	(541) 330-9155
Eugene Office	(541) 345-0289
Salem Office	(503) 589-1252
Tigard Office	(503) 684-3460

May 21, 2014

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

Report of
Supplemental Geologic Reconnaissance &
Preliminary Slope Stability Analysis for
Eastern Portion of
OSU Cascades 46-Acre Site
1707 & 1757 SW Simpson Avenue
Bend, Oregon

CGT Project Number G1303959.B

Dear Ms. Sparks:

Carlson Geotechnical (CGT), a division of Carlson Testing, Inc. (CTI), is pleased to submit this report summarizing our supplemental geologic reconnaissance and preliminary slope stability analyses for the eastern portion of the proposed OSU Cascades 46-acre development site. This report is considered an addendum to our January 30, 2014, preliminary geotechnical report for the project. The overall project site spans two parcels located at 1707 and 1757 SW Simpson Avenue in Bend, Oregon. Our services were provided in general accordance with the scope of work detailed in a March 14, 2014, email between CGT and our client. Verbal authorization for our services was provided on March 19, 2014. Written authorization for our services was provided on March 24, 2014, by Amendment No. 1 to the December 11, 2013, "Retainer Contract Supplement, OUS Retainer Contract for Professional Consultants, Supplement No. OSU-433-P-13-90, Cascades Campus Geotechnical Engineering".

Respectfully Submitted,
CARLSON GEOTECHNICAL

CERTIFIED OREGON JEFFREY A. JONES E2235 ENGINEERING GEOLOGIST
EXPIRES 12-31-14

CERTIFIED OREGON RYAN T. HOUSER E1914 ENGINEERING GEOLOGIST
EXP 6/30/14

REGISTERED PROFESSIONAL ENGINEER 70773PE OREGON Jan. 10, 2007 BRAD MICHAEL WILCOX
EXPIRES: 6/30/2014

Jeff A. Jones, CEG	Ryan T. Houser, CEG	Brad Wilcox, P.E., G.E.
Project Engineering Geologist	Senor Engineering Geologist	Senior Geotechnical Engineer
jjones@carlsontesting.com	rhouser@carlsontesting.com	bwilcox@carlsontesting.com

Doc ID: G:\GEOTECH\PROJECTS\2013 Projects\OSU Cascades Campus\46.59-Acre Site Add'l Work - G1303959.B\Report Files\G1303959.B Report.docx

TABLE OF CONTENTS

ATTACHMENTS

1.0 INTRODUCTION & BACKGROUND

Carlson Geotechnical (CGT), a division of Carlson Testing, Inc. (CTI), is pleased to submit this report summarizing our supplemental geologic reconnaissance and preliminary slope stability analyses for the eastern portion of the proposed OSU Cascades 46-acre development site. CGT previously performed a preliminary geotechnical investigation for the site, the results of which were presented in our Report of Preliminary Geotechnical Investigation, dated January 30, 2014. This report is considered supplemental to the referenced geotechnical report.

1.1 Project Description

Plans for development at the site are generally consistent with those described in our January 30, 2014, preliminary geotechnical report for the project. In summary, development planned at the site includes construction of several academic and dormitory buildings ranging in height from 2 to 5 stories, with appurtenant onsite roads, parking, and utility infrastructure.

1.2 Previous Work

As part of our preliminary geotechnical investigation, we observed the advancement of eighteen drilled borings and thirty-five test pits at the site. Logs of those explorations were presented in Appendix C of the referenced preliminary geotechnical report. Data collected from those explorations were used, as needed, to supplement our field observations and laboratory data obtained for this assignment.

1.3 Correspondence with Project Design Team

As indicated in the referenced geotechnical report, the eastern roughly 20 acres of the project site is occupied by a former open pit pumice mine. The pit side slopes range in height from about 30 to 90 feet, with gradients ranging from near-vertical to about 1H:1V (Horizontal:Vertical). Table 6 in the referenced report presents four options for consideration by OSU Cascades with regard to development near these slopes. Options 2 and 3 included quantitative slope stability analysis to refine slope setback requirements and re-grading (flattening or shortening) the site slopes, respectively.

Conceptual grading plans have been developed by the project design team, with three primary scenarios under consideration for master planning of the project: The “Rim”, “Canyon”, and “Terrace” scenarios. The scenarios differ primarily in the degree of infilling of the former pumice pit (from least to most fill, respectively) and the location and arrangement of the proposed buildings and roadways. We understand the Canyon scenario, which maintains slopes up to about 90 feet tall, is the preferred conceptual model at this time.

We understand the site is currently considered a permitted, active aggregate mine by the mine permitting agency, the Oregon Department of Geology and Mineral Industries (DOGAMI). The mine permit must be closed prior to redevelopment of the site. One of the requirements for closing the permit is implementation of an approved reclamation plan. DOGAMI requirements for reclamation vary depending on the post-reclamation use, and typically include grading permanent slopes to gradients of 1½H:1V (Horizontal:Vertical) or flatter, as well as establishment of vegetation and other measures to stabilize the site soils and slopes. Alternative reclamation plans are allowed by DOGAMI, provided they are stamped by a Certified Engineering Geologist (CEG) licensed to practice in the State of Oregon.

At the request of OSU Cascades, CGT prepared this report to assist in the development of a mine reclamation plan as well as post-reclamation grading and development plans, specific to the eastern portion of the mine pit. This report addresses the subject portion of the mine pit, as shown on the attached Site Plan, Figure 1.

1.4 Scope of Work

CGT's scope of work for this assignment was to evaluate various slope configurations with regard to long-term slope stability and present recommendations for maximum slope gradients of site slopes constructed exclusively in cut. Our specific scope of services included:

- <u>Supplemental Geologic Reconnaissance</u>: Visit the site to perform further geologic reconnaissance of the site slopes (pit sidewalls). The reconnaissance was performed by Certified Engineering Geologists (CEGs), and included identification of geologic materials, stratigraphy, and geologic discontinuities comprising the slopes, including:
  - Type (contact, joint, fault, etc.)
  - Orientation (strike and dip)
  - Spacing
  - Degree of separation, infilling, and roughness of joint/fault surfaces
  - Continuity/length (persistence)
  - Field characterization of rock strengths and degree of weathering using simplified field tests and Schmidt hammer readings
- <u>Analysis – Geologic Structure and Strength Characteristics</u>: Based on the results of our fieldwork to date and review of published geologic mapping and literature, characterize the structure and strength characteristics of the geologic materials as they relate to slope stability.
- <u>Analysis – Slope Stability</u>: Develop representative geologic profiles to evaluate with regard to slope stability. Analyze a variety of slope configurations, as needed, to obtain an acceptable factor of safety.
- <u>Report</u>: Provide this written report summarizing the results of our geologic reconnaissance and preliminary slope stability analyses.

2.0 GEOLOGIC SETTING

As described in the referenced geotechnical report, available geologic mapping of the area[1,2] indicates that the site and immediate vicinity are underlain by Pleistocene pyroclastic deposits. These include the Tumalo Tuff, Bend Pumice, and Desert Spring Tuff.

The Tumalo Tuff (Qtu) and Bend Pumice (Qb) are thought to represent a single eruptive sequence with an age of approximately 200,000 to 400,000 years. The deposits consist of a lower airfall tephra deposit (Qb) and overlying pyroclastic flow deposit (Qtu). These deposits are generally light gray to pinkish gray and are dominated by rhyolitic to dacitic ash and lapilli pumice with varying basalt and other lithic fragments. Welding or vapor phase crystallization has produced hardened zones within these units and is variable. A maximum thickness of about 80 feet is indicated in the literature.

---

1 Sherrod, David R., et al., 2004. Geologic Map of the Bend 30- X 60-Minute Quadrangle, Central Oregon. United States Geological Survey, Geologic Investigations Series Map I-2683.

2 Mimura, Koji, 1992. Reconnaissance Geologic Map of the West Half of the Bend and the East Half of the Shevlin Park 7½' quadrangles, Deschutes County, Oregon. . United States Geological Survey, Miscellaneous Field Studies Map MF-2189.

The Desert Spring Tuff (Qds) is a rhyodacitic ash flow tuff with an age of approximately 600,000 to 700,000 years. The ashy matrix ranges in color from dark gray to brownish orange, and contains dark-gray, pumiceous lapilli and basaltic lithic fragments. The lower portion of the unit is partially welded and displays columnar jointing. A thickness of about 15 to 35 feet is indicated in the literature.

3.0 RECONNAISSANCE & LABORATORY TESTING

3.1 Supplemental Geologic Reconnaissance

CGT engineering geologists Ryan Houser, CEG, and Jeff Jones, CEG, performed a supplemental geologic reconnaissance of the site between March 24 and 26, 2014. The purpose of the reconnaissance was to refine our understanding of site geology as it pertains to stability of the site slopes, and included surface observations and measurements to characterize the geologic materials comprising the site slopes and geologic discontinuities exposed in the slope faces.

Strike and dip measurements were made on joints and fractures exposed in the slope faces. These measurements were made using an analog magnetic compass with inclinometer (Brunton compass) and conventional methods.

In order to evaluate rock strength characteristics, simplified field estimations were performed in general accordance with ODOT[3], ISRM[4], and Wyllie and Mah (adapted from Hoek)[5]. The field estimation approach is based solely on field observation and provides a qualitative evaluation of rock characteristics, including a range of compressive strength and a geologic strength index (GSI) value. The field methods include striking and scratching the rocks with a geologic hammer and qualitative characterization of the degree of rock weathering, jointing, and discontinuities. These methods are somewhat subjective, but are generally considered a reliable basis for simple rock slope stability analyses.

We also performed numerous measurements of rock strength using a Schmidt hammer (Type N). The Schmidt hammer is a device to characterize the compressive strength of concrete or rock based on the rebound of a spring-loaded mass impacting the surface of the material being tested. The hammer impacts the test material at a defined energy, and its rebound is dependent on the hardness of the material being tested. The hammer body includes a mechanical indicator that shows the amount of rebound relative to an arbitrary numeric scale that ranges from 10 to 100. The rebound value for each test is recorded by the user for later use.

3.2 Material Sampling and Laboratory Testing

A CGT representative returned to the site on April 1, 2014, to collect samples of unit Qds (Desert Spring tuff) for uniaxial compressive strength testing in the laboratory. Intact blocks, ranging in size from about 1 to 2 feet in dimension, were pried from the slope face. The in-place orientation of each block was marked on the samples, which were returned to our soils laboratory. Our laboratory staff obtained core samples from the blocks using a rotary coring machine equipped with a 3-inch diameter core barrel. The bulk samples were oriented consistent with their original, in-place orientation (i.e. with up and down consistent with the in-place

---

3 Oregon Department of Transportation, 1987. Soil and Rock Classification Manual.
4 International Society for Rock Mechanics (ISRM), 1981. Rock Characterization, Testing and Monitoring; ISRM Suggested Method. Pergamon Press, Oxford, UK.
5 Wyllie, Duncan C. and Mah, Christopher W., 2004. Rock Slope Engineering, Civil and Mining, 4th Edition. Spon Press, New York, NY.

orientation) prior to coring. The core samples were then trimmed so that the ends were square with the sides. Each trimmed core sample was measured (diameter and height) and weighed for unit weight determination, then capped for compressive strength testing. Results of the laboratory tests are presented in Appendix A of this report.

4.0 OBSERVATION & DISCUSSION

4.1 Stratigraphy

Based on the results of our geologic reconnaissance, review of geologic mapping, and previous subsurface explorations, the site slopes are characterized by three primary stratigraphic scenarios: (1) slopes comprised entirely of ash and pumice deposits (units Qtu and Qb), (2) slopes comprised entirely of ash flow tuff (unit Qds), and (3) slopes comprised of unit Qds overlain by units Qb and/or Qtu. Outside the pit, these materials are mantled with fill and surface soils. In addition to stratigraphic differences, varying degrees of jointing and faulting were also identified. These materials are discussed individually below.

The geologic contacts observable within the pit sidewalls were exposed due to recent (roughly the past 20 years) human excavation and earthwork activities and had not developed adequate exposure (for instance, due to differential weathering, erosion, etc.) to allow for direct measurement of strike and dip. The contact between unit Qb and Qds was noticeably irregular and convoluted in places, likely reflecting uneven surface topography at the time of deposition of unit Qb. The contact between units Qtu and Qb was gently undulating, generally mimicking the underlying contact between units Qb and Qds and consistent with pyroclastic airfall or flow deposition. Locally, the contact between unit Qtu and Qb were essentially planar and gently dipping along the slope face. Photographs 1 and 2 in Figure 2 shows a representative exposure of the materials and contacts described in this report.

4.1.1 Fill and Surface Soils

The native surface soils outside the pit consist of loose to medium dense, silty sand (SM) with varying amounts of gravel. The silty sand is generally on the order of 5 to 10 feet thick, as observed in our previous explorations and along the rim of the pit. A fill berm was present along the majority of the southern rim of the pit. The berm was up to about 20 feet tall and up to about 70 feet wide. The composition of the berm is unknown, but is assumed to consist primarily of silty sand with varying amounts of rock derived from nearby surface soils. In addition to the berm, similar fill soils were apparent along the eastern portion of the north slope, just west of the paved access road leading to the site from SW Simpson Road. Anecdotal evidence suggests fill in this area is likely associated with the former landfill located immediately north of the pit.

4.1.2 Tumalo Tuff (Qtu)

The Tumalo tuff was generally extremely soft (R0)[6] to very soft (R1) rock comprised of dry to moist, light gray to orange-brown, volcanic ash with varying amounts of pumice and fragments of welded tuff. The upper portion of the Tumalo tuff was welded, forming a medium hard (R3) to hard (R4), light brown, capping unit. The capping unit was generally on the order of 5 to 10 feet thick and displayed moderately developed, near-vertical, columnar jointing. Photograph 3 on Figure 3 shows a representative exposure of unit Qtu and its capping unit.

[6] "R" values assigned in general accordance with Oregon Department of Transportation (1987) Soil and Rock Classification Manual.

4.1.3 Bend Pumice (Qb)

The Bend Pumice was generally unconsolidated, light gray to brown, subangular to angular, dry to moist, pumice lapilli with varying amounts of ash and scattered basaltic fragments. This material resembled a loose to medium dense, very weakly cemented gravel.

A layer of silty sand with varying amounts of gravel was generally present at the base of unit Qb. This layer was generally on the order of 4 to 8 feet thick. Erosion of this layer appeared to progress at a more rapid rate than the overlying pumice, resulting in small overhangs in the steepest slopes.

4.1.4 Desert Spring Tuff (Qds)

The Desert Spring Tuff was generally soft (R2) to medium hard (R3), fresh to slightly weathered, dark brown to black, ash flow tuff and contained varying amounts of pumice, lithics, and scoria. The rock mass was characterized as generally massive, with little to no significant bedding.

Fracturing and jointing was observed throughout the rock mass, and was generally characterized as closed (little to no separation), clean (little to no infilling or secondary mineralization), rough, and arcuate. Fracture/joint spacing generally varied from a few inches to several feet. Fracture persistence was difficult to discern, though continuous fractures with lengths exceeding 20 to 30 feet were observed across the rock face in places. In general, the fractures were steeply dipping to near-vertical, with strikes ranging from east-west to north-south.

Several open joints were observed within the south pit wall, near cross section J-J' (shown on Figure 1). Joint separation ranged from less than 1 inch to in excess of 1 foot, and the joints appeared to extend 5 to 10 feet (possibly more) into the slope. Adjacent rock also showed signs of intersecting joints and preferential erosion, forming rough blocks up to 10 to 20 feet or more in dimension. Several of the open joints had previously been filled with concrete. Anecdotally, we interpret this was done to help stabilize the individual blocks and reduce the risk of rockfall during operation of the pit. Photograph 4 on Figure 3 shows this area.

4.2 Surface Processes

Abundant signs of erosion and rockfall were observed during our reconnaissance. As noted previously, conditions within the pit were largely the result of recent human excavation and earthwork activities. As such, our observations of surface processes within the pit are indicative of short-term performance and not necessarily an indication of long-term performance.

On slopes where units Qtu and Qb were exposed, we observed a near-constant shedding of sand- and gravel-sized particles from the slope face. Accumulation of this material was apparent at the toe of the slopes, and ranged in thickness from a few inches to more than 20 feet. The variability in accumulation is likely the result of removal in places during previous earthmoving operations in the pit and variable exposure height. Signs of on-going raveling and shallow sloughing were also apparent on these slopes. No obvious signs of deep-seated failures were observed on these slopes.

Evidence of recent rockfall was observed near the toe of slopes in various locations around the pit. Evidence included cobbles and boulders of the Qtu welded tuff capping unit that ranged in size from less than 1 foot to more than 3 feet in dimension. Cobbles and boulders of unit Qds ranged in size from less than 1 foot to more than 4 feet in dimension. The primary areas where we observed evidence of rockfall from unit Qds was in the southern wall of the pit, where exposures were tallest and slope gradients steeper. Where slopes comprised of Qds were graded flatter than about ½H:1V (primarily in the western portion of the pit, outside the area addressed by this report), we did not observe significant evidence of recent rockfall.

5.0 SLOPE STABILITY ANALYSIS

Based our geologic reconnaissance, we identified five geologic cross sections (H-H', I-I', J-J', L-L', and N-N') considered representative of the varying conditions at the site. The locations of the cross sections are shown on the attached Site Plan, Figure 1.

We performed slope stability analyses using the software program Slope/W (version 7.23) developed by Geo-Slope International, Ltd. The results of a slope stability analysis express the relative stability of a slope as a factor of safety against sliding for a potential failure surface. A factor of safety of 1.0 corresponds to the condition in which the driving and resisting forces are equal, and failure could occur as a result of small changes in the resisting or driving forces. Based on current standard practice in this region, the minimum recommended factor of safety for long-term slope stability under static conditions is 1.5, and 1.1 for short-term stability under seismic loading. Recognizing the type of development proposed at the site, the referenced factors of safety were considered minimum allowable values for permanent slopes at the site.

Quantitative slope stability analyses require geometric properties of the slope, stratigraphy, soil and rock strength parameters, and groundwater conditions. The following sections describe the methods used in determining these properties for our analyses.

5.1 Topography and Stratigraphy

Locations of our cross sections were provided to the project civil engineering consultant, KPFF Consulting Engineers, who generated profiles of existing topography for each cross section using three dimensional modeling software (AutoCAD Civil 3D). Stratigraphy for each cross section was based on field observations and review of previous subsurface explorations. For the purposes of our models, the geologic contacts were assumed to be essentially planar and relatively level, unless data from our previous subsurface explorations or field observations indicated otherwise. As noted in Section 4.1, it should be noted that the geologic contacts are, in reality, likely not as uniform as those shown in our cross sections.

5.2 Rock Structure

5.2.1 <u>Tumalo Tuff (Qtu) and Bend Pumice (Qb)</u>

No significant jointing was observed within the non-welded Qtu or unit Qb. Some bedding was apparent in both of these units. In unit Qtu, the bedding appeared to represent changes in eruptive activity at the time of deposition. Unit Qb was similar, with the exception of the lower, silty sand layer that likely represents inter-eruptive alluvial deposition. No major variation in material properties was observed across the bed contacts and the bedding is not considered a structurally controlling feature. Accordingly, these materials were modeled as a homogeneous material.

The Qtu capping unit (welded tuff) exhibited moderately developed, near-vertical, columnar jointing, with spacing on the order of 2 to 6 feet. In-place blocks of this material ranged in size from about 5 to 10 feet in long dimension. As described later in this report, CGT recommends that this material be removed from the top of slopes at the site and therefore was not included in our models incorporating final grading conditions.

5.2.2 Desert Spring Tuff (Qds)

Based on review of the strike and dip data, the jointing observed in unit Qds is generally steeply dipping to near-vertical. No significant pattern of orthogonal or other dominant pattern of joint intersection was apparent for the majority of this unit. Accordingly, this material was generally modeled as a fractured rock mass.

The jointing observed in the area of cross section J-J' appeared to consist of two sets of orthogonal joints. As noted above, some of the joints in this area were open, with separation in excess of 1 foot, and formed rough blocks up to 10 to 20 feet in dimension. Existing slope gradients ranged from about ½H:1V to near-vertical with localized overhangs in this area. The floor of the pit in this area showed signs of relatively recent, tracked equipment operation, suggesting that earthmoving had been performed in the recent past. Any signs of rockfall were therefore lacking. Safety concerns precluded direct access to this portion of the slope. Data regarding persistence (length) of jointing, condition of the rock within the slope, etc. is not available at this time. Accordingly, this material was not included in our analyses. See Section 6.3.2 for further discussion of this material.

5.3 Soil and Rock Strength

Selection of soil and rock strength parameters for slope stability analyses was performed based on field estimation, laboratory data, review of literature pertinent to geotechnical properties of pyroclastic deposits[7,8], geologic engineering judgment, and experience with similar materials.

5.3.1 Tumalo Tuff (Qtu) and Bend Pumice (Qb)

As described in Section 4.1.2, unit Qtu generally resembled an extremely soft (R0) to very soft (R1) rock that was highly friable and reduced to silty sand under hand pressure. For the purposes of our slope stability analyses, this material was treated as medium dense, weakly cemented, silty sand.

As described in Section 4.1.3, unit Qb was generally unconsolidated, subangular to angular, pumice lapilli with varying amounts of ash and scattered basaltic fragments. For the purposes of our slope stability analyses, this material was treated as medium dense, very weakly cemented gravel. The lower silty sand layer was treated as a loose to medium dense, silty sand.

Strength parameters for these units were initially assumed based on experience and judgment. The parameters were refined by back calculation, assuming existing slopes comprised of these materials were marginally stable (factor of safety slightly greater than unity). This assumption was based on the observed raveling, observation of similar slopes in the area of the site, and previous experience with similar materials. For each primary material, we modeled an imaginary slope of similar height and gradient as the existing (observed) exposures, then varied the strength parameters to achieve a factor of safety slightly greater than

---

7 Cecconi, M., Scarapazzi, M., and Viggiani, G., 2010. On the geology and the geotechnical properties of pyroclastic flow deposits of the Colli Albani, Bulletin of Engineering Geology and the Environment, May 2010, Volume 69, Issue 2, pp 185-206.

8 Bommer, J.J., Rolo, R., Mitroulia, A., Berdousis, P., 2002. Geotechnical properties and seismic slope stability of volcanic soils (Electronic resource) (Paper no. 695), The 12th European conference on earthquake engineering, Pages:1-10.

one (unity). Final strength parameters for these units and those assumed for the fill and surface soils are presented in Table 1.

Table 1: Material Parameters Used in Slope Stability Analyses

Material	"Idealized" Material Model	Angle of Internal Friction, Φ (degrees)	Cohesion, c (psf)	Total Unit Weight, γ_T (pcf)
Berm Fill & Surface Soil	Silty sand	30	0	110
Unit Qtu	Weakly cemented silty sand	36	575	80
Unit Qb	Weakly cemented gravel	40	190	75
Unit Qb – base layer	Silty sand	35	0	85

5.3.2 Desert Spring Tuff (Qds)

As described in Section 4.1.4, the Desert Spring Tuff was generally soft (R2) to medium hard (R3), fresh to slightly weathered, fractured, partially welded, ash flow tuff. The rock mass was characterized as generally massive, with little to no significant bedding. For the purposes of our slope stability analyses, this material was generally treated as a fractured rock mass, with shear strength parameters assigned using the Generalized Hoek-Brown Criterion[9]. The Generalized Hoek-Brown Criterion is a method to determine the strength of fractured rock masses in which the shear strength is represented as a non-linear shear strength curve. Conventional limit equilibrium analyses can be carried out using equivalent Mohr-Coulomb shear strength parameters provided in this manner.

Four input parameters are required by the Generalized Hoek-Brown Criterion. The input parameters were assigned in general accordance with the methods discussed by Wyllie and Mah[10], and are presented in Table 2. Uniaxial compressive strength and unit weight were assigned based on the results of laboratory data and our field estimations. The material constant (m_i) corresponds to a typical value for tuff, as indicated in Table 4.5 of Wyllie and Mah. The Geological Strength Index (*GSI*) was assigned based on the criteria shown in Table 4.3 of Wyllie and Mah. The value in parentheses is the range of values we assigned, with the average value used in the analyses. The rock mass disturbance factor (*D*) was assigned based on Table 4.6 of Wyllie and Mah and the assumption that excavation of the slopes was accomplished primarily by mechanical excavation with minor blasting.

9 Hoek, E., Carranza-Torres, C. and Corkum, B., 2002. Hoek-Brown Failure Criterion – 2002 Edition. Proceedings of the North American Rock Mechanics Society meeting in Toronto in July 2002, in "Stability Modeling with Slope/W 2007" by Geo-Slope International.

10 Wyllie, Duncan C. and Mah, Christopher W., 2004. Rock Slope Engineering, Civil and Mining, 4th Edition. Spon Press, New York, NY.

Table 2: Input Parameters for Generalized Hoek-Brown Criterion for Unit Qds

Parameter	Value
Uniaxial compressive strength σ_{ci} (psf)	85,320
Material constant m_i	13
Geological Strength Index (*GSI*) (0-100)	75 (63-87)
Rock mass disturbance factor *D* (0-1)	0.7
NOTES: Parameters assigned in general accordance with the methods discussed by Wyllie and Mah (2004). Value of GSI represents the average of the range of values assigned and shown in parentheses.	

5.4 Groundwater

Our geologic reconnaissance was conducted during a thawing period in early spring. We did not observe any signs of past or ongoing seepage from the site slopes during our reconnaissance. As discussed in Section 5.2 of our geotechnical report, static groundwater levels at and near the site are anticipated at depths in excess of 200 feet below ground surface. Accordingly, groundwater was not modeled in our stability analyses.

5.5 Seismic Considerations

In order to evaluate the stability of the slope during a design-level earthquake, we performed pseudostatic analyses that incorporate an additional lateral force to simulate cyclic ground acceleration during an earthquake. A peak ground acceleration (PGA) of 0.16g was determined for the site in accordance with the 2010 Oregon Structural Specialty Code (OSSC), as referenced in Section 10.4 of our preliminary geotechnical report. This calculation is allowed by Oregon structural codes in the absence of a site-specific evaluation of ground response from a design-level seismic event. A seismic coefficient (k_h) equal to one-half of the ground surface PGA (0.08g) was used in the pseudostatic analyses, in accordance with standard practice.

5.6 Results

5.6.1 <u>Slope Gradient Considerations</u>

Final slope gradients incorporated into our analyses were based on a combination of factors, and were influenced by our field observations of rockfall and erosion potential. Once strength parameters were established as described in Section 5.3.1 above, we then modified (flattened) the modeled slope gradient until an acceptable factor of safety was achieved. Accordingly, our stability models incorporated a maximum slope gradient of 1H:1V for units Qtu and Qb.

As discussed in Section 4.2 above, evidence of on-going rockfall was observed along the near-vertical slopes comprised of unit Qds (primarily along the south wall of the pit). Where slopes comprised of Qds were graded to about ½H:1V or flatter (primarily in the western portion of the pit, outside the area addressed by this report), we did not observe significant evidence of recent rockfall. Accordingly, our stability models incorporated a maximum slope gradient of ½H:1V for unit Qds.

5.6.2 <u>Global Stability</u>

Incorporating the maximum allowable gradients for slope materials discussed in Section 5.6.1, we performed slope stability analyses along four cross sections (H-H', I-I', L-L', and N-N'). The locations of the cross sections are shown on Figure 1. The results of our analyses for the modeled conditions are presented in Table 3. Graphical outputs of each of the conditions analyzed are presented in Figures 4 through 7.

Table 3: Factors of Safety for Slope Stability

Cross Section*	Factor of Safety	
	Static Loading	Seismic Loading**
H-H'	1.5	1.2
I-I'	2.7	2.4
L-L'	1.9	1.6
N-N'	2.6	1.5

NOTES: * Models incorporated trimming slopes to maximum gradients discussed in Section 5.6.1
** For pseudostatic analyses, seismic coefficient k_h = PGA/2 = 0.08g

6.0 RECOMMENDATIONS

Based on the results of our geologic reconnaissance and stability analyses, we derived recommended final gradients for slopes comprised of the primary geologic materials observed at the site. The recommended slope gradients reflect global stability, local stability, and rockfall. These are presented below by material type.

6.1 Existing Fill and Surface Soils

As indicated in the referenced geotechnical report, undocumented fill materials were encountered within portions of the pit. We understand that these fill materials may be removed and replaced with structural fill during site development. Additionally, a fill berm was present along the southern rim of the pit. For preliminary planning purposes, the existing fill should be removed or, if left in place in landscaping areas, graded to 3H:1V or flatter. This is due primarily to variability of the fill materials.

The native, surface soils (SM) at the top of permanent slopes should be similarly graded to 3H:1V or flatter. This is due primarily to the high erosion potential of the native, silty sand.

6.2 Tumalo Tuff (Qtu) and Bend Pumice (Qb)

6.2.1 <u>Qtu Capping Unit</u>

The Qtu capping unit (columnar jointed, welded tuff) is prone to rockfall. This material should be removed from the crest of permanent slopes at the site. This unit was generally on the order of 5 to 10 feet thick. As a guideline, the minimum distance between the crest of the slope and face of the remaining Qtu capping unit should be a minimum of 5 feet or twice the thickness of the capping unit, whichever is greater. For instance, if the design case considers a 5-foot thick capping unit, the setback distance should be at least 10 feet.

6.2.2 Qtu and Qb

Permanent cut slopes comprised of units Qtu (below the capping unit) and Qb should be graded to 1H:1V or flatter. Where exposed, the ash and pumice deposits (units Qtu and Qb) are susceptible to mass wasting (erosion) due to water, wind, and freeze-thaw action. In the long term, erosion on slopes comprised of these materials may adversely impact their stability. We recommend that permanent erosion control/surface stabilization measures be implemented to minimize erosion and help ensure long-term slope stability. Vegetation, armoring, mechanical stabilization (e.g. anchored mesh), etc. may be considered suitable erosion control/surface stabilization measures. If slopes comprised of these materials can be graded to 3H:1V or flatter, erosion control/surface stabilization measures may not be necessary. The engineering geologist and geotechnical engineer should be contacted to review finalized plans and selected gradients for cut slopes to provide supplemental recommendations for surfacing features.

6.3 Desert Spring Tuff (Qds)

6.3.1 Fractured Rock Mass (Dominant Type)

Unit Qds is also prone to rockfall, though to a lesser degree. Permanent cut slopes comprised of unit Qds that are left exposed should be graded to ½H:1V or flatter. The permanent slope gradients recommended herein will reduce, but not eliminate, the risk of rockfall occurring. The faces of permanent slopes should be scaled to remove loose materials. Rockfall protections measures should be implemented on such slopes. Rockfall protection measures may include catchment areas, rockfall barriers, mechanical stabilization (e.g. draping or anchoring), or other suitable measures, used alone or in combination with one another. Rockfall protection requirements will depend to a large degree on the location of people and improvements in relation to the slopes, as well as the nature of materials comprising the slope and the slope height. The engineering geologist and geotechnical engineer should be contacted to review finalized grading plans to assess the need for rockfall protection.

6.3.2 Open-Jointed Rock Mass (Special Case)

As described previously, numerous open joints were observed within the south pit wall, near cross section J-J'. Joint separation ranged from less than 1 inch to in excess of 1 foot, and the joints appeared to extend 5 to 10 feet (possibly more) into the slope. Adjacent rock also showed signs of intersecting joints and preferential erosion, forming rough blocks up to 10 to 20 feet or more in dimension. As indicated in Section 5.2.2, the lack of data regarding the rock structure in this area precluded quantitative stability analysis.

For preliminary planning purposes, we recommend that cut slopes in the open-jointed Qds be graded to 1H:1V or flatter. This will remove the majority of the observable, open-jointed rock and effectively lower the center of mass of the underlying jointed blocks. It is our opinion that this recommended grading should result in a stable rock slope. However, rockfall protection measures, as discussed in Section 6.3.1, are strongly recommended on these slopes. Additional evaluation, scaling, or other remediation may be warranted, depending on conditions encountered as excavation progresses. The engineering geologist should be contacted to review slope conditions during excavation and provide specific recommendations.

7.0 CORRESPONDENCE & RECOMMENDED ADDITIONAL SERVICES

Subsequent to completion of our analyses, but prior to issuance of this report, the results of our slope stability analyses and recommendations for permanent cut slope gradients were conveyed to the project design team via email and telephone conversations in the middle of April 2014. KPFF produced a conceptual grading plan reflecting grading proposed under the referenced “Canyon” plan. That plan incorporated the recommendations for maximum slope cut gradients presented in this report, as well as recommendations for construction of fill slopes presented previously in the preliminary geotechnical report.

At the time of this report, it is our understanding site grading and reclamation plans have not been finalized. Once those plans are nearing completion, we recommend the CGT engineering geologist be contacted review the proposed construction and provide supplemental recommendations for site grading, mine reclamation considerations, slope surface stabilization, rockfall protection, and other details.

8.0 LIMITATIONS & CLOSURE

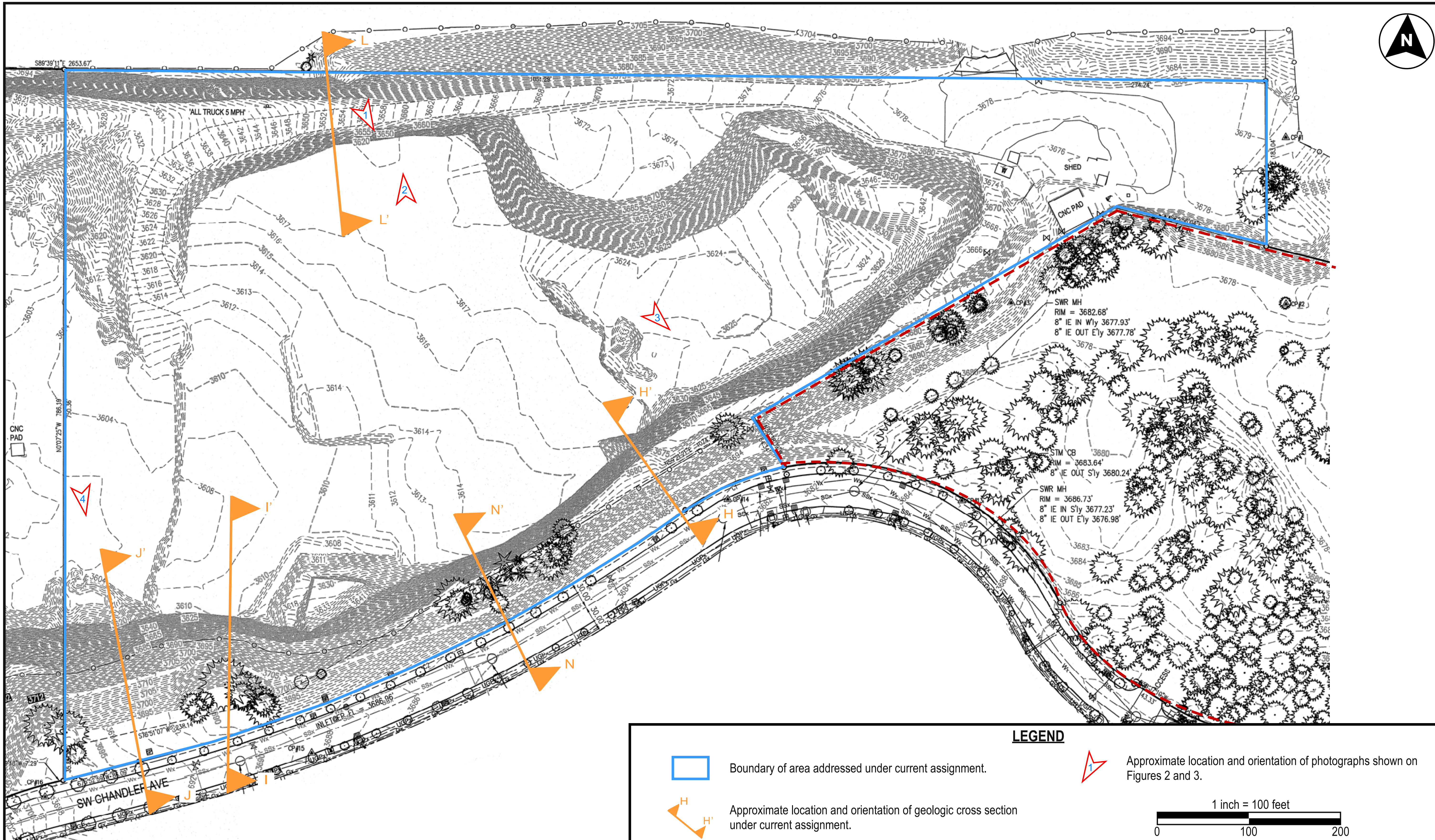
We have prepared this report for use by OSU Cascades and other members of the design and construction team for the proposed development. The opinions and recommendations contained within this report are not intended to be, nor should they be construed as, a warranty of subsurface conditions, but are forwarded to assist in the planning and design process.

We have made observations based on our explorations that indicate the soil conditions at only those specific locations and only to the depths penetrated. These observations do not necessarily reflect soil types, strata thickness, or water level variations that may exist between or away from those explorations. If subsurface conditions vary from those encountered in the site explorations, CGT should be alerted to the change in conditions so that we may provide additional recommendations, if necessary. Observation by experienced personnel should be considered an integral part of the construction process.

The owner is responsible for insuring that the project designers and contractors implement our recommendations. When the design has been finalized, prior to releasing bid packets to contractors, we recommend that the design drawings and specifications be reviewed by our firm to see that our recommendations have been interpreted and implemented as intended. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification. Design review is beyond the scope of our current assignment, but can be provided for an additional fee.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor’s methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design.

Geotechnical engineering and the geologic sciences are characterized by a degree of uncertainty. Professional judgments presented in this report are based on our understanding of the proposed construction, familiarity with similar projects in the area, and on general experience. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared; no warranty, expressed or implied, is made. This report is subject to review and should not be relied upon after a period of 3 years.



LEGEND

Boundary of area addressed under current assignment.

Approximate location and orientation of geologic cross section under current assignment.

Approximate location and orientation of photographs shown on Figures 2 and 3.

1 inch = 100 feet

0 100 200

CARLSON CGT GEOTECHNICAL 503-601-8250
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

SITE PLAN SHOWING LOCATIONS OF GEOLOGIC CROSS SECTIONS

EASTERN PORTION OF OSU CASCADES 46-ACRE SITE - BEND, OREGON

CGT Job No. G1303959.B

FIGURE 1

EASTERN PORTION OF OSU CASCADES 46-ACRE SITE - BEND, OREGON
SITE PHOTOGRAPHS

Photograph 1: South pit wall. Qtu, Tumalo Tuff; Qb, Bend Pumice; Qds, Desert Spring Tuff. Line H-H' represents location of cross section H-H' for reference.

Photograph 2: Example of convoluted contact between unit Qb and Qds.

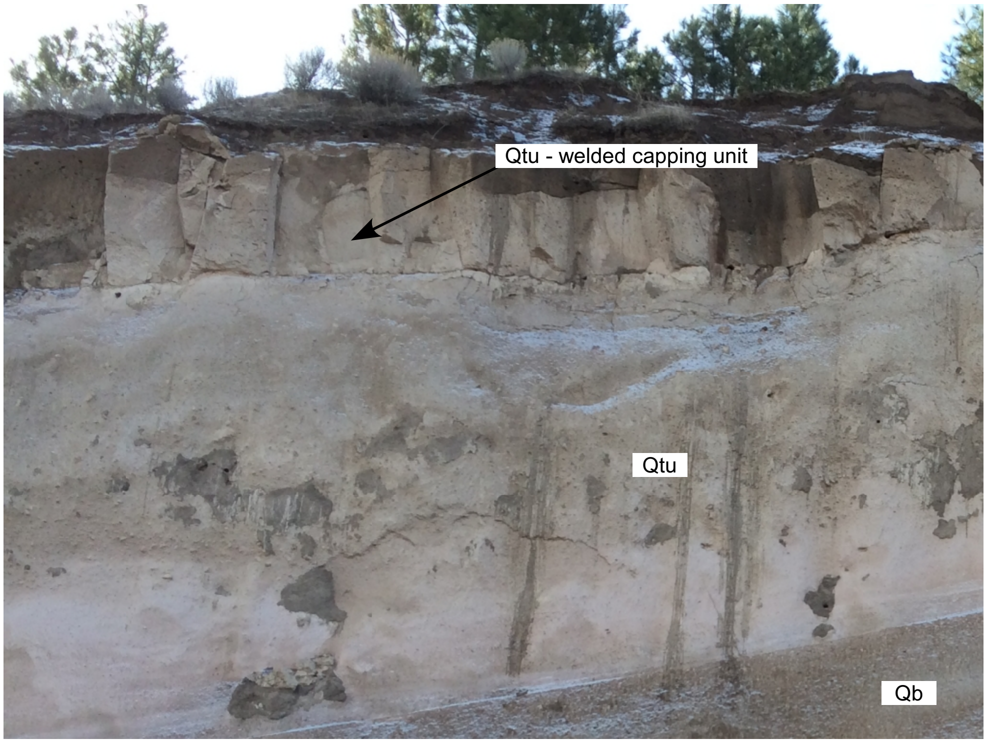
NOTE: See Figure 1 for photograph locations and orientations

Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

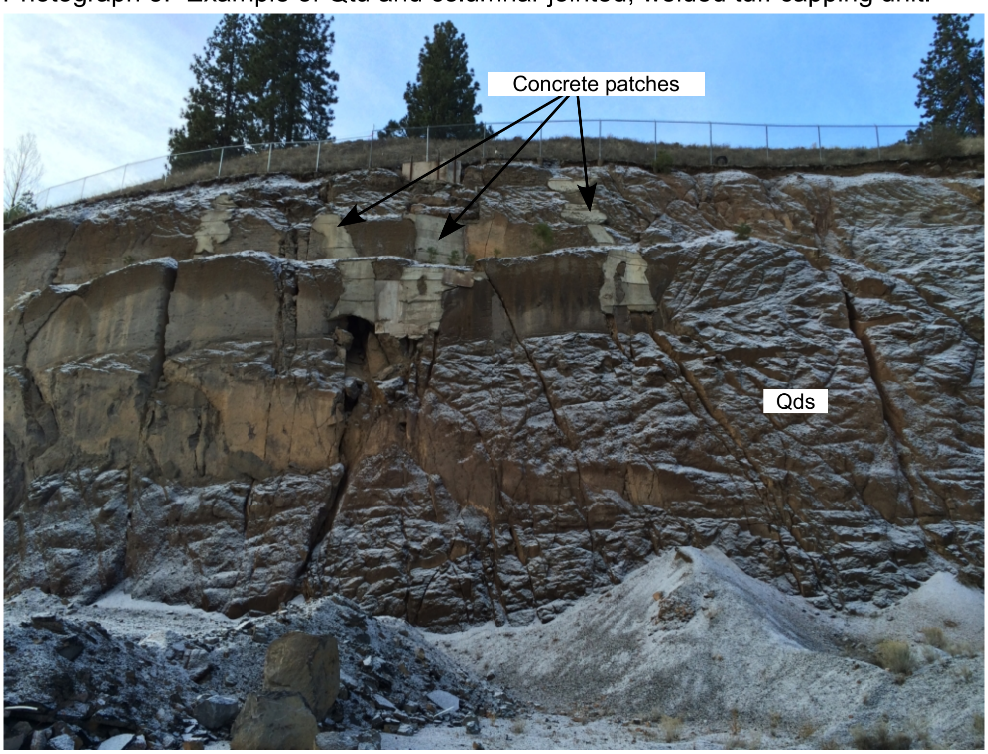
CGT Job No. G1303959.B

Figure 2

EASTERN PORTION OF OSU CASCADES 46-ACRE SITE - BEND, OREGON
SITE PHOTOGRAPHS



Photograph 3: Example of Qtu and columnar jointed, welded tuff capping unit.



Photograph 4: Example of open joints and concrete patches in unit Qds.

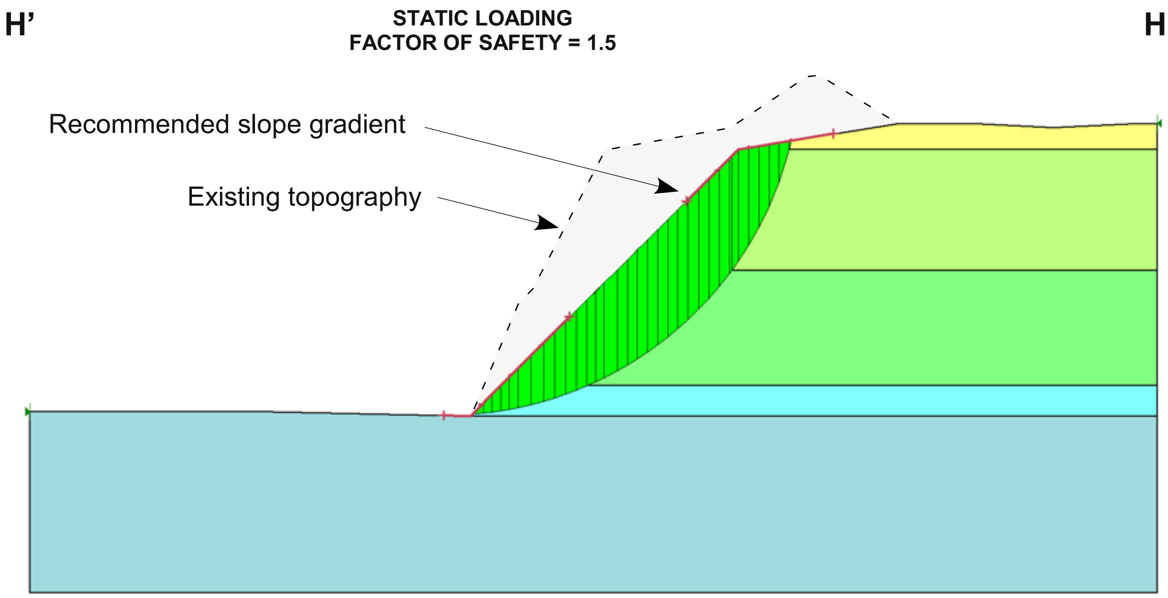
NOTE: See Figure 1 for photograph locations and orientations

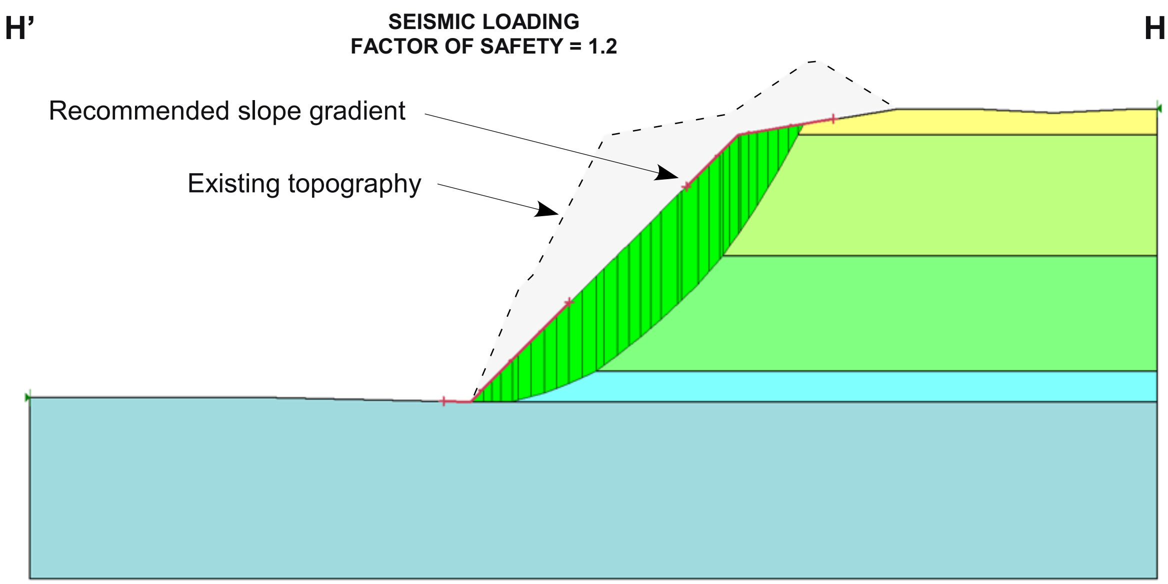
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.B

Figure 3

EASTERN PORTION OF OSU CASCADES 46-ACRE SITE - BEND, OREGON
SLOPE STABILITY PROFILE H-H'





Fill & Surface Soil	Tumalo Tuff (Qtu)
Bend Pumice (Qb)	Bend Pumice SM Base Layer
Desert Spring Tuff (Qds)	

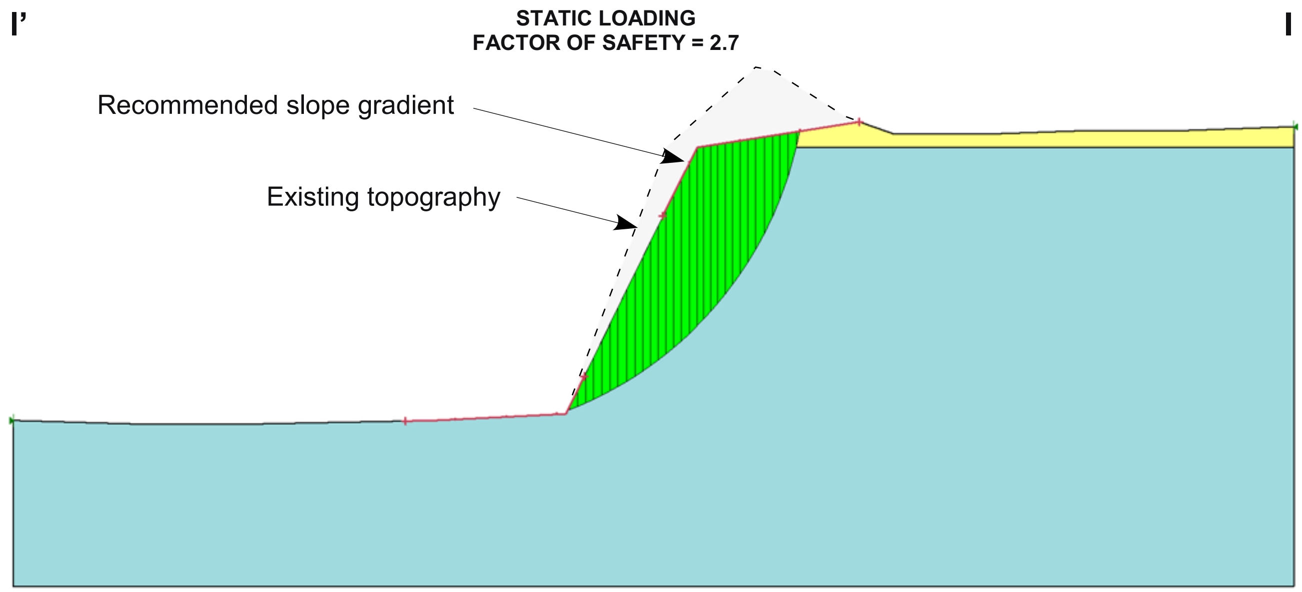
See Figure 1 for the location and orientation of Cross Section

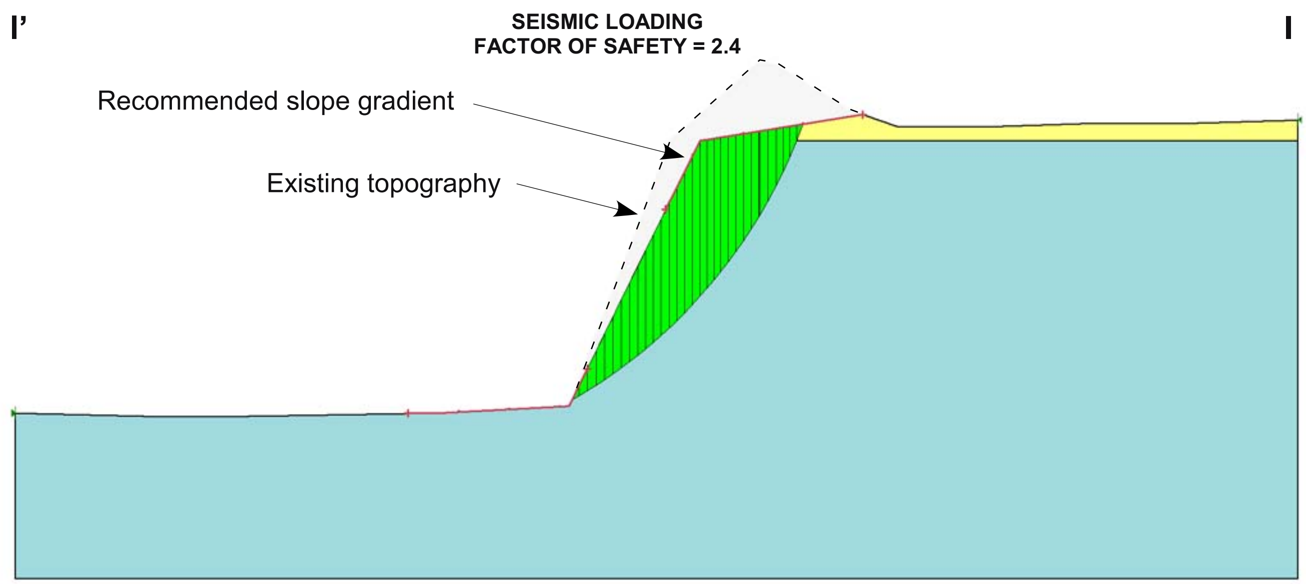
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.B

FIGURE 4

EASTERN PORTION OF OSU CASCADES 46-ACRE SITE - BEND, OREGON
SLOPE STABILITY PROFILE I-I'





Fill & Surface Soil

Desert Spring Tuff (Qds)

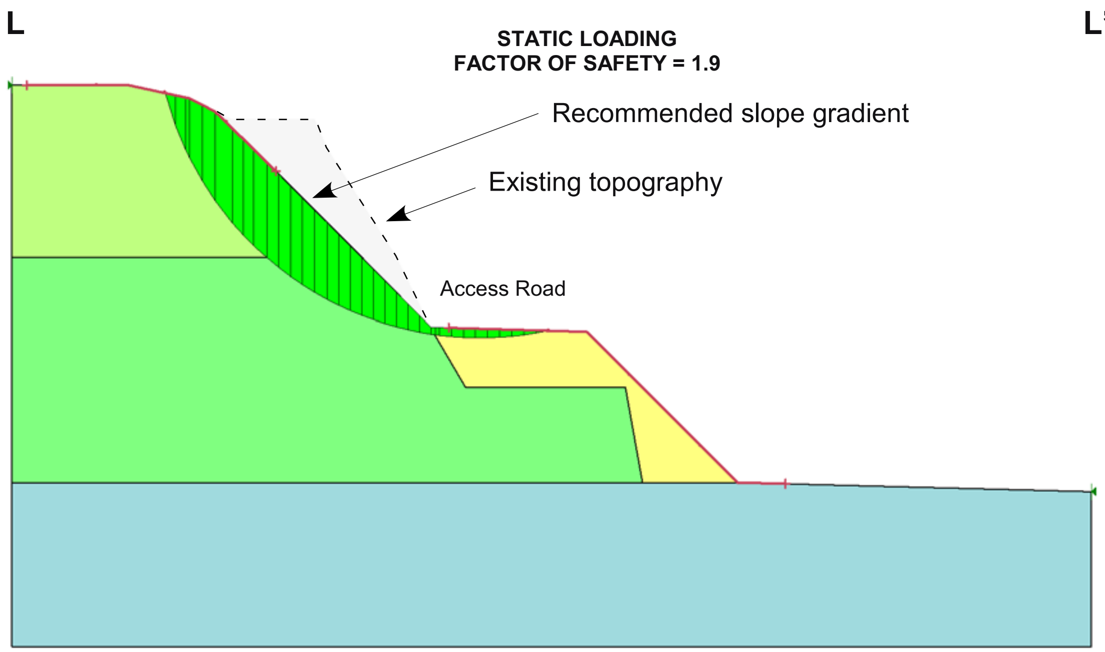
See Figure 1 for the location and orientation of Cross Section

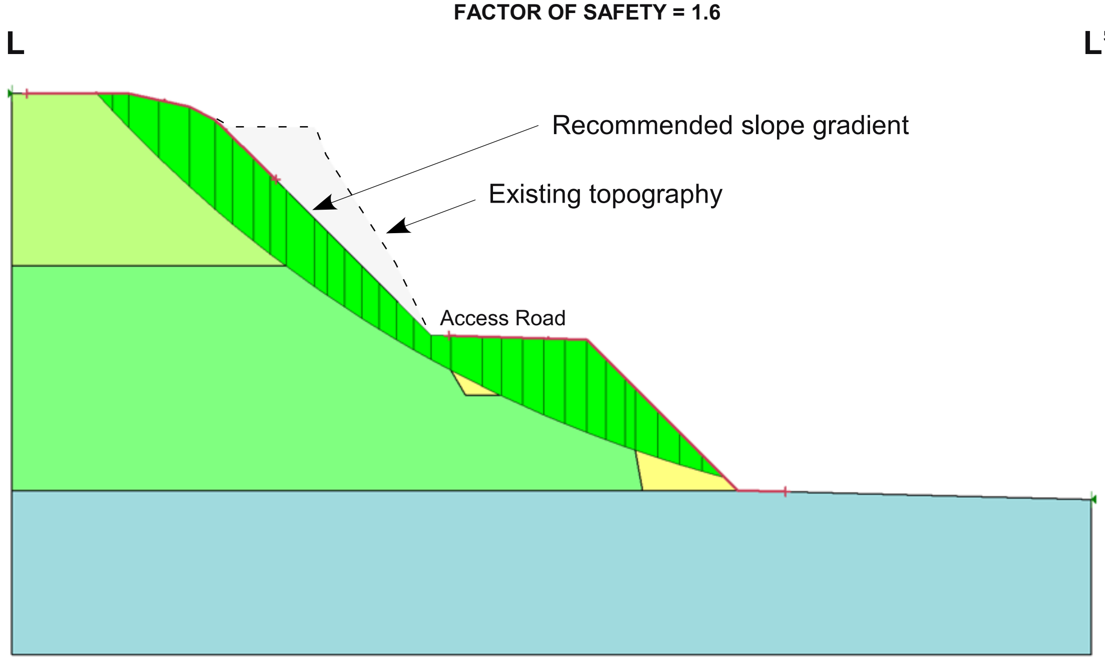
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.B

FIGURE 5

EASTERN PORTION OF OSU CASCADES 46-ACRE SITE - BEND, OREGON
SLOPE STABILITY PROFILE L-L’





Fill & Surface Soil
Bend Pumice (Qb)
Desert Spring Tuff (Qds)
Tumalo Tuff (Qtu)

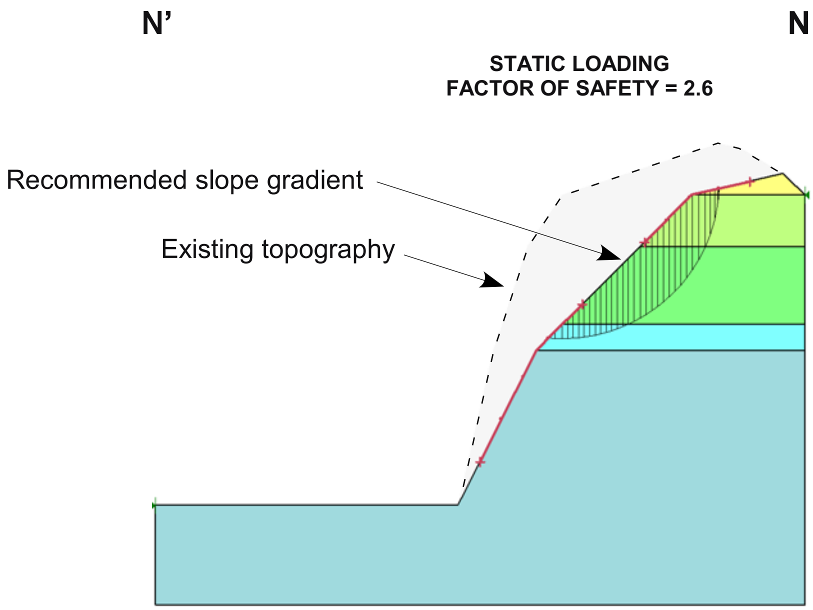
See Figure 1 for the location and orientation of Cross Section

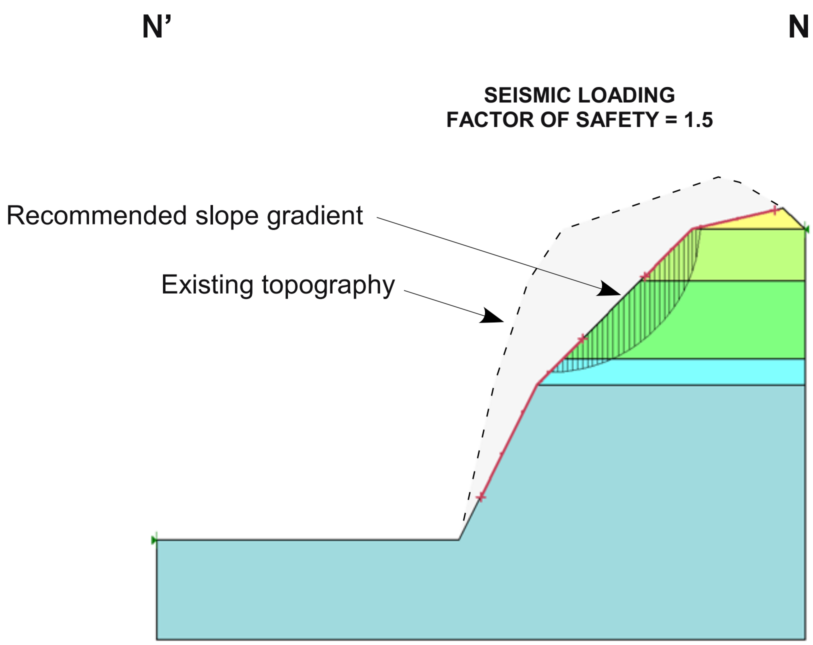
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.B

FIGURE 6

EASTERN PORTION OF OSU CASCADES 46-ACRE SITE - BEND, OREGON
SLOPE STABILITY PROFILE N-N'





Fill & Surface Soil
Tumalo Tuff (Qtu)
Bend Pumice (Qb)
Bend Pumice SM Base Layer
Desert Spring Tuff (Qds)

See Figure 1 for the location and orientation of Cross Section

CARLSON CGT GEOTECHNICAL 503-601-8250
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.B

FIGURE 7

Carlson Geotechnical
A Division of Carlson Testing, Inc.
Phone: (503) 601-8250
Fax: (503) 601-8254

Bend Office	**(541) 330-9155**
Eugene Office	**(541) 345-0289**
Salem Office	**(503) 589-1252**
Tigard Office	**(503) 684-3460**

Report of
Preliminary Geotechnical Investigation
OSU Cascades 46-Acre Site
1707 & 1757 SW Simpson Avenue
Bend, Oregon

CGT Project Number G1303959.A

Prepared for:

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

July 25, 2014

Carlson Geotechnical
A Division of Carlson Testing, Inc.
Phone: (503) 601-8250
Fax: (503) 601-8254

Bend Office	**(541) 330-9155**
Eugene Office	**(541) 345-0289**
Salem Office	**(503) 589-1252**
Tigard Office	**(503) 684-3460**

July 25, 2014

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

Report of
Preliminary Geotechnical Investigation
OSU Cascades 46-Acre Site
1707 & 1757 SW Simpson Avenue
Bend, Oregon

CGT Project Number G1303959.A

Dear Ms. Sparks:

Carlson Geotechnical (CGT), a division of Carlson Testing, Inc. (CTI), is pleased to submit this report summarizing our geotechnical investigation for the proposed OSU Cascades 46-acre development site. The project site spans two parcels located at 1707 and 1757 SW Simpson Avenue in Bend, Oregon. This report was prepared in general accordance with CGT Proposal GP6169.A, originally dated October 31, 2013 and revised December 10, 2013. Verbal authorization for our services was provided on November 21, 2013. Written authorization for our services was received on December 11, 2013, as part of the "Retainer Contract Supplement, OUS Retainer Contract for Professional Consultants, Supplement No. OSU-433-P-13-90, Cascades Campus Geotechnical Engineering". A draft version of this report was previously issued on January 30, 2014.

We appreciate the opportunity to work with you on this project. Please contact us at 503.601.8250 if you have any questions regarding this report.

Respectfully Submitted,
CARLSON GEOTECHNICAL

Brad M. Wilcox, P.E., G.E.	Jeff A. Jones, R.G., C.E.G.
Senior Geotechnical Engineer	Project Engineering Geologist
bwilcox@carlsontesting.com	jjones@carlsontesting.com

Doc ID: G:\GEOTECH\PROJECTS\2013 Projects\OSU Cascades Campus\46-Acre Site\Report G1303959.A.doc

TABLE OF CONTENTS

TABLES

ATTACHMENTS

1.0 INTRODUCTION

Carlson Geotechnical (CGT), a division of Carlson Testing, Inc. (CTI), is pleased to submit this report summarizing our preliminary geotechnical investigation for the proposed OSU Cascades 46-acre development site. The subject project site spans two parcels located at 1707 and 1757 SW Simpson Avenue in Bend, Oregon, as shown on the attached Site Location, Figure 1.

1.1 Project Description

CGT developed an understanding of the proposed project based on our correspondence with OSU Cascades and review of provided conceptual plans for the site layout, dated November 18-19, 2013. At the time of this report, the project was in the preliminary stages of planning, but will likely include the following:

- Construction of several, concrete-framed, slab-on-grade, academic and residential building(s) spaced throughout the site. Preliminary plans indicate the buildings will range from 2- to 5-stories in height. Depending on finalized locations and grading, some buildings may incorporate one or several below-grade levels. The below-grade level(s) may be fully below-grade (full basements) or daylight at the downslope end (daylight basement). Finished first floor elevations of the buildings have not been determined. Although no structural loading has been provided, we have assumed structural loads will be typical for this type of construction, with maximum column, continuous wall, and uniform floor slab loads less than 250 kips, 6 kips per lineal foot (klf), and 200 pounds per square foot (psf).
- Construction of new drive lanes and passenger car parking lots to serve the new buildings. We anticipate new pavements will be surfaced with asphaltic concrete (AC), while isolated aprons and loading docks will be surfaced with rigid (concrete) pavement.
- Construction of hardscaping features along the sides of the proposed buildings.
- Installation of underground utilities to serve the new buildings. Although no utility plans have been provided, we have assumed utility trench cuts will be up to 8 feet in depth.
- Conceptual plans include collection and diversion of stormwater into on-site infiltration facilities in accordance with the Central Oregon Stormwater Manual (COSM). The type(s), depth(s), and locations of infiltration facilities were not determined at the time of this report. No infiltration testing was performed as part of this assignment recognizing preliminary design concepts.
- Grading plans have not been developed at the time of this report. We understand finalized layout and grading of the site will be determined by OSU Cascades and the design team based, in part, on the results of the preliminary geotechnical investigation.

1.2 Scope of Work

The purpose of our work was to explore subsurface conditions at the site in order to provide preliminary geotechnical engineering recommendations for design and construction of the proposed project. This report is considered preliminary as site layout and grading plans have not been developed. Our scope of work included the following:

- Contact the Oregon Utilities Notification Center to mark the locations of public utilities at the site within a 15-foot radius of our planned explorations.

- Explore subsurface soil conditions at the site by advancing eighteen drilled borings and thirty-five test pits to depths up to about 61½ feet below ground surface (bgs).
- Classify the materials encountered in the explorations in general accordance with American Society for Testing and Materials (ASTM) D2488 (Visual-Manual Procedure).
- Collect representative, disturbed and relatively undisturbed samples of the soils encountered within the explorations in order to perform laboratory testing and to confirm our field classifications.
- Provide a technical narrative describing surface and subsurface deposits, and local geology of the site, based on the results of our explorations and published geologic mapping.
- Provide a site vicinity map and a site plan showing the locations of the explorations relative to existing site features.
- Provide logs of the explorations, including results of laboratory testing on selected soil samples.
- Provide preliminary geotechnical recommendations for site preparation and earthwork, including stripping depths, temporary excavations, subgrade preparation, wet/dry weather earthwork, utility trench excavation and backfill, general grading considerations, fill type for imported materials, use of on-site soils as structural fill, and fill compaction criteria.
- Provide preliminary geotechnical engineering recommendations for design and construction of shallow spread foundations, floor slabs, and pavements.
- Provide preliminary recommendations for the Seismic Site Class, mapped maximum considered earthquake spectral response accelerations, and site seismic coefficients.
- Provide a *qualitative* evaluation of seismic hazards at the site, including earthquake-induced settlement and landsliding, and surface rupture due to faulting or lateral spread.
- Provide this written report summarizing the results of our preliminary geotechnical investigation and recommendations for the project.

2.0 SITE DESCRIPTION

2.1 Geologic & Seismic Setting

A description of regional geology, site geology, local topography, and technical narrative describing faults within a 40-kilometer (25-mile) radius of the project is provided in the attached Appendix A.

2.2 Site Surface Conditions

Existing surface features and site topography are shown on the attached Site Plan, Figure 2. Photographs of the site taken at the time of our field investigation are shown in the attached Appendix B. The approximate 46-acre site is bordered by grass fields and landfill area to the north, a grass field and wooded parcel (proposed OSU-Cascades development property) to the east, SW Chandler Avenue to the south, and Mt. Washington Drive to the west.

The central and eastern portions of the site consisted of a sunken graded area associated with previous mining activities and are hereafter referred to as the “pit”. At the time of our fieldwork, the pit bottom was generally uneven and ascended to the west. The pit sidewalls ranged in height from about 30 to 80 feet, with slope gradients ranging from near-vertical to about 1H:1V (horizontal:vertical). No obvious signs of recent or on-going instability were noted during our reconnaissance of the sidewalls of the pit. The south border of the pit contained an approximate 10- to 20-foot tall, fill embankment (berm). The embankment was lightly vegetated with grasses and small shrubs. The top of the berm was primarily soil-covered and was being utilized as a pedestrian access (walking) path.

The western portion of the site, hereafter referred to as the "wooded parcel" was relatively undeveloped and vegetated with grasses, understory shrubs, and ponderosa pines and other evergreen trees. Several, unimproved (primarily soil-covered) access roads were present on the site. Anecdotal evidence suggests this portion of the site was previously used for staging and fill stockpiling operations at some point in the past, likely associated with mining activities at the nearby pumice mine. In terms of topography, the southwest portion of the site was relatively level to gently ascending to the north. The northwest portion of the site was somewhat hummocky, indicative of fill berms and other grading activities.

3.0 FIELD INVESTIGATION

3.1 Geotechnical Investigation

Our geotechnical investigation was performed at the site between December 20, 2013, and January 16, 2014, and included eighteen drilled soil borings (B-1 through B-17, B-10A) and thirty-five test pits (TP-1 through TP-34, TP-7A). The approximate locations of our explorations are shown on the attached Site Plan, Figure 2. Additional details of the field investigation are presented in the attached Appendix C.

3.2 Geological Reconnaissance

CGT Certified Engineering Geologist, Jeff Jones, CEG, performed a geologic reconnaissance of the pit on December 18, 2013. The purpose of the geologic site reconnaissance was to observe site surface conditions and to characterize the geologic materials and features exposed within the pit.

3.2.1 Geologic Materials

Published geologic mapping of the site vicinity is described in the attached Appendix A. For the purposes of this report, the geologic materials encountered at the site were assigned to established geologic units on the basis of visual examination only. Color, texture, grain size/shape, and stratigraphic relations provided the primary bases for geologic classification. No radiometric dating or mineralogical analysis was performed.

3.2.2 Slope Conditions

The walls of the pit generally consisted of cut slopes, with heights ranging from about 30 to 80 feet and slope gradients ranging from near-vertical to about 1H:1V (Horizontal:Vertical). The dominant materials exposed in the slopes were pyroclastic deposits, including Tumalo Tuff (Qtu), Bend Pumice (Qb) and Desert Spring Tuff (Qds). Photographs taken during the geological reconnaissance are presented in the attached Appendix B.

In general, the site slopes did not exhibit obvious signs of recent or on-going instability, spring activity, or excessive erosion. However, areas of faulting and jointing were observed within the northern and southern slopes, as discussed below.

Within the central portion of the south pit wall, extensive jointing of the rock (Qds) was observed. Joint separation ranged from less than about 1 inch to in excess of about 1 foot. Several of the joints had previously been filled with concrete, in an apparent attempt to stabilize the individual blocks and reduce the risk of rockfall during operation of the pit. No obvious signs of rockfall were apparent. Photograph 13 in Appendix B shows the area of jointing and concrete patchwork.

Within the western portion of the north pit wall, several faults were observed. The faults appeared to be steeply dipping (near-vertical), with an apparent northwest-trending strike. The sense of motion across the faults was not consistent, with evidence of both down-to-the-west and down-to-the-east offset. Based on offset of geologic contacts across the faults, the vertical component of motion ranged from less than about 1 inch to on the order of 5 feet. It was not readily apparent whether or not the faults offset the surficial soils at the top of the slope, and detailed mapping and measuring of the faults was not performed. Photograph 14 in Appendix B shows an example of the observed faulting.

It should be noted the ground surface, both within the pit and along the rim of the pit, had been extensively modified by previous earthmoving (mining) activity. Signs of past instability, rockfall, or surface expression of faulting, may have been obscured by these activities.

4.0 LABORATORY TESTING

Laboratory testing was performed on soil samples collected in the field to refine our initial field classifications and determine in-situ properties. Details related to the number and type of laboratory tests are presented in the attached Appendix C. Graphical plots of selected laboratory tests are shown in the attached Appendix D.

5.0 SUBSURFACE CONDITIONS

5.1 Soils

Recognizing the size of the project site and variability in subsurface conditions, and for discussion purposes, we divided the project site into four regions, as shown on the attached Site Plan, Figure 2. The first region, Region 1, represents the approximate east half of the pit. The second region, Region 2, represents the approximate west half of the pit. The third region, Region 3, represents the approximate south half of the wooded parcel. The fourth region, Region 4, represents the approximate north half of the wooded parcel. The following sections provide a summary of the subsurface materials encountered within each region. As discussed in Section 3.2.1 above, for the purposes of this report, the geologic materials encountered at the site were assigned to established geologic units on the basis of visual examination only.

5.1.1 Soils – Region 1

The following table presents a "checklist" of the subsurface materials encountered in the explorations performed within Region 1. Adjacent to those materials, the tabulation presents an indicator (X) whether that subsurface material was encountered within the depth explored in the subject exploration.

Table 1: Subsurface Material "Checklist" within Area of Site Designated as Region 1

Subsurface Material[1]	USCS	Subsurface Exploration																
		B-1	B-2	B-3	B-5	B-6	B-7	TP-1	TP-2	TP-3	TP-4	TP-5	TP-6	TP-7	TP-7A	TP-8	TP-9	TP-10
Undocumented Fill	GP FILL, SM FILL	X				X	X	X										
Undocumented Rubble Fill	GP-GM FILL								X	X	X	X	X	X	X	X	X	X
Silty Sand	SM		X	X	X													
Tumalo Tuff	RX {Qtu}	X	X					X										
Desert Spring Tuff	RX {Qds}		X	X			X				X		X		X		X	X
Bend Pumice	RX {Qb}			X	X	X						X		X		X		

[1]Descriptions of each subsurface material are described below.

The following paragraphs provide a summary of the subsurface materials encountered within Region 1.

Soil Type	USCS	Geologic Interpretation
Undocumented Gravel/Sand Fill	GP FILL, SM FILL	Man-Made Fill

Undocumented fill, ranging from gravel, sandy gravel, and silty sand, was encountered at the surface of the referenced explorations and extended to depths of about 5½ to 12½ feet bgs. The gravel fill to sandy gravel fill was generally brown to gray to black, damp to moist, and fine- to coarse-grained. The silty sand fill was generally brown to dark brown, damp to moist, fine- to medium-grained, and contained no to some gravel, cobbles, and boulders (up to 3 feet in diameter). Raw (unfactored) N-values obtained from the SPTs in these soils ranged from 9 to 50+, indicating loose to very dense relative densities.

Soil Type	USCS	Geologic Interpretation
Undocumented Rubble Fill	GP-GM FILL	Man-Made Fill

Undocumented rubble fill was encountered at the surface of the referenced explorations and extended to depths of about 2 to 25+ feet bgs. The rubble fill generally consisted of gravel, cobbles, and boulders (up to about 4 feet in diameter) in a matrix of silty sand. The rubble fill was generally brown to gray and damp. In some cases, the rubble fill contained scattered concrete debris, rebar pieces, plastic debris, and/or asphalt debris. In TP-2 and TP-3, the rubble fill extended to the full depths explored (about 25 feet bgs). This depth represented the maximum reach of the referenced track-mounted excavator.

Soil Type	USCS	Geologic Interpretation
Silty Sand	SM	Volcaniclastic Sediments

Silty sand was encountered either at the surface of, or beneath an overlying layer of tuff, within the referenced explorations and extended to depths ranging from about 8 to 31½ feet bgs. The silty sand was generally medium dense to dense, brown to orange-brown, damp, fine- to coarse-grained, and contained fine gravel and occasional pumice and tuff particles. This material exhibited very low shrinkswell properties. Raw (unfactored) N-values obtained from the SPTs in this soil ranged from 15 to 32, indicating medium dense to dense relative densities.

Soil/Rock Type	USCS	Geologic Interpretation
Tumalo Tuff, Bend Pumice, Desert Spring Tuff	RX	Pyroclastic Deposits

Tumalo Tuff, Bend Pumice, and Desert Spring Tuff were encountered below existing fill materials or the silty sand within the referenced explorations. These materials have been lumped together for discussion purposes recognizing their similar index properties and geologic origin as pyroclastic deposits. These materials extended to depths ranging from about 10 to 27 feet bgs. The Tumalo tuff was generally unconsolidated (loose to medium dense) to extremely soft (R0) to very soft (R1), damp to moist, light gray to brown to orange-brown, and contained varying amounts of pumice and welded tuff particles. The Bend Pumice was generally unconsolidated (medium dense), light gray to brown, subangular to angular, dry to moist, pumiceous, and contained varying amounts of ash. The Desert Spring Tuff was generally extremely soft (R0) to very soft (R1), slightly weathered, dark brown to black, damp to moist, and contained varying amounts of pumice, lithics, and scoria.

5.1.2 Soils – Region 2

The following table presents a "checklist" of the subsurface materials encountered in the explorations performed within Region 2. Adjacent to those materials, the tabulation presents an indicator (X) whether that subsurface material was encountered within the depth explored in the subject exploration.

Table 2: Subsurface Material "Checklist" within Area of Site Designated as Region 2

Subsurface Material[1]	USCS	Subsurface Exploration																
		B-4	B-8	B-9	B-12	TP-11	TP-12	TP-13	TP-14	TP-15	TP-16	TP-17	TP-18	TP-19	TP-20	TP-21	TP-22	TP-23
Undocumented Fill	GP FILL, SM FILL		X		X						X	X	X		X	X	X	X
Silty Sand	SM	X			X													
Desert Spring Tuff	RX {Qds}		X	X		X	X	X	X	X	X			X				X
Bend Pumice	RX {Qb}	X	X												X			
Gravel Conglomerate	RX										X							

[1]Descriptions of each subsurface material are described below.

The following paragraphs provide a summary of the subsurface materials encountered within Region 2.

Soil Type	USCS	Geologic Interpretation
Undocumented Gravel/Sand Fill	GP FILL, SM FILL	Man-Made Fill

Undocumented fill, ranging from gravel to silty sand, was encountered at the surface of the referenced explorations and extended to depths of about 12½ to 27½ feet bgs. The gravel fill was generally brown to gray, damp, coarse-grained, and contained cobbles and boulders (up to 2 feet in diameter). The silty sand fill was generally brown to black, damp to moist, dark brown, fine- to coarse-grained, and contained no to some pumice, gravel, cobbles, boulders (up to 4 feet in diameter), and scattered concrete debris, wood debris (branch, 12-inch diameter tree stump), PVC pipe debris, asphaltic concrete debris, metal debris, glass debris, and insulation debris. Raw (unfactored) N-values obtained from the SPTs in these soils ranged from 8 to 50+, indicating loose to very dense relative densities. In several cases, we anticipate the N-values determined in the field were overstated due to the presence of coarse particles. In TP-17, TP-18, TP-21, and TP-22, the silty sand fill extended to the full depths explored (about 25 feet bgs). This depth represented the maximum reach of the referenced track-mounted excavator.

Soil Type	USCS	Geologic Interpretation
Silty Sand	SM	Volcaniclastic Sediments

Silty sand was encountered beneath an overlying layer of fill or tuff within the referenced explorations and extended to depths up to about 31½ feet bgs. The silty sand was generally brown to orange-brown, damp to moist, fine- to coarse-grained, and contained fine gravel and occasional pumice. Raw (unfactored) N-values obtained from the SPTs in this soil ranged from 32 to 50+, indicating medium dense to dense relative densities.

Soil/Rock Type	USCS	Geologic Interpretation
Bend Pumice, Desert Spring Tuff, Gravel Conglomerate	RX	Pyroclastic Deposits

Bend Pumice, Desert Spring Tuff, and Gravel Conglomerate were encountered below existing fill materials within the referenced explorations. These materials have been lumped together for discussion purposes recognizing their similar index properties and geologic origin as pyroclastic deposits. These materials extended to the full depths explored in the referenced explorations, up to about 46½ feet bgs. The Bend Pumice was generally unconsolidated (loose to medium dense), light gray to brown, subangular to angular, dry to moist, pumiceous, and contained varying amounts of ash. The Desert Spring Tuff was generally extremely soft (R0) to very soft (R1), slightly weathered, dark brown to red-brown to black, damp to moist, and contained varying amounts of pumice, lithics, and scoria. The Gravel Conglomerate was generally very soft (R1), slightly weathered, light brown to orange, moist, and contained pumice in a silt/ash matrix.

5.1.3 Soils – Region 3

The following table presents a "checklist" of the subsurface materials encountered in the explorations performed within Region 3. Adjacent to those materials, the tabulation presents an indicator (X) whether that subsurface material was encountered within the depth explored in the subject exploration.

Table 3: Subsurface Material "Checklist" within Area of Site Designated as Region 3

Subsurface Material[1]	USCS	Subsurface Exploration						
		B-10	B-10A	B-11	B-13	TP-32	TP-33	TP-34
Silty Sand	SM	X	X	X	X	X	X	X
Tumalo Tuff	RX {Qtu}	X	X	X		X		
Desert Spring Tuff	RX {Qds}				X			
Bend Pumice	RX {Qb}						X	
[1]Descriptions of each subsurface material are described below.								

The following paragraphs provide a summary of the subsurface materials encountered within Region 3.

Soil Type	USCS	Geologic Interpretation
Silty Sand	SM	Volcaniclastic Sediments

Silty sand was encountered at the surface of each of the referenced explorations and extended to depths ranging from about 3 to 12 feet bgs. The silty sand was generally brown, dry to moist, fine- to coarse-grained, and contained fine gravel and occasional pumice and cobbles. Raw (unfactored) N-values obtained from the SPTs in this soil ranged from 4 to 13, indicating loose to medium dense relative densities.

Soil/Rock Type	USCS	Geologic Interpretation
Tumalo Tuff, Bend Pumice, Desert Spring Tuff	RX	Pyroclastic Deposits

Tumalo Tuff, Bend Pumice, and Desert Spring Tuff were encountered below the silty sand within the referenced explorations. These materials have been lumped together for discussion purposes recognizing their similar index properties and geologic origin as pyroclastic deposits. These materials extended to the full depths explored in the referenced explorations, up to about 61½ feet bgs. The Tumalo tuff was generally unconsolidated (loose to medium dense) to extremely soft (R0) to very soft (R1), damp to moist, light gray to brown, and contained varying amounts of pumice and welded tuff particles. The Bend Pumice was generally unconsolidated (loose to medium dense), light gray to brown, and dry to damp. The Desert Spring Tuff was generally extremely soft (R0) to very soft (R1), fresh to slightly weathered, dark brown, damp to moist, and contained varying amounts of lithics.

5.1.4 Soils – Region 4

The following table presents a "checklist" of the subsurface materials encountered in the explorations performed within Region 4. Adjacent to those materials, the tabulation presents an indicator (X) whether that subsurface material was encountered within the depth explored in the subject exploration.

Table 4: Subsurface Material "Checklist" within Area of Site Designated as Region 4

Subsurface Material[1]	USCS	Subsurface Exploration									
		B-14	B-17	TP-24	TP-25	TP-26	TP-27	TP-28	TP-29	TP-30	TP-31
Undocumented Fill	SM FILL	X	X	X	X		X		X	X	
Silty Sand	SM		X		X	X		X			X
Tumalo Tuff	RX {Qtu}			X				X	X	X	
Desert Spring Tuff	RX {Qds}					X					
Bend Pumice	RX {Qb}	X									X
[1]Descriptions of each subsurface material are described below.											

The following paragraphs provide a summary of the subsurface materials encountered within Region 4.

Soil Type	USCS	Geologic Interpretation
Undocumented Silty Sand/Pumice Fill	SM FILL	Man-Made Fill

Undocumented fill, ranging from silty sand to pumice, was encountered at the surface of the referenced explorations and extended to depths of about 7½ to 31½ feet bgs. The silty sand fill was generally brown to pink-gray, damp to moist, fine- to coarse-grained, and contained no to some pumice, gravel, cobbles, boulders (up to 2 feet in diameter). The pumice fill was generally light brown to pink to white, fine- to coarse-grained, and dry to damp. Raw (unfactored) N-values obtained from the SPTs in these soils ranged from 10 to 24, indicating medium dense relative densities. In TP-25, the silty sand fill extended to the full depth explored (about 25 feet bgs). This depth represented the maximum reach of the referenced track-mounted excavator. Based on testing of a remolded specimen, the silty sand fill exhibited "moderate" degree of specimen collapse per ASTM D5333-03.

Soil Type	USCS	Geologic Interpretation
Silty Sand	SM	Volcaniclastic Sediments

Silty sand was encountered beneath the existing fill or at the surface of the referenced explorations. The silty sand extended to depths ranging from about 6 to 36½ feet bgs. The silty sand was generally loose to medium dense, brown, dry to moist, fine- to coarse-grained, and contained fine gravel and occasional tuff fragments, gravel, and cobbles.

Soil/Rock Type	USCS	Geologic Interpretation
Tumalo Tuff, Bend Pumice, Desert Spring Tuff	RX	Pyroclastic Deposits

Tumalo Tuff, Bend Pumice, and Desert Spring Tuff were encountered below beneath the fill or the silty sand within the referenced explorations. These materials have been lumped together for discussion purposes recognizing their similar index properties and geologic origin as pyroclastic deposits. These materials extended to depths of about 9 to 30½ feet bgs in the referenced explorations. The Tumalo tuff was generally extremely soft (R0) to very soft (R1), slightly weathered, damp to moist, gray to brown to pink, and contained varying amounts of pumice and welded tuff particles. Based on testing of a remolded specimen, the Tumalo Tuff exhibited "slight" degree of specimen collapse per ASTM D5333-03. The Bend Pumice was generally unconsolidated (loose to medium dense), light gray to brown, and dry to damp. The Desert Spring Tuff was generally extremely soft (R0) to very soft (R1), fresh to slightly weathered, dark brown to black, and damp to moist.

5.2 Groundwater

We did not encounter groundwater within the depths explored at the site between December 20, 2013, and January 16, 2014. A review of well logs and water level data available at the Oregon Water Resources Department (OWRD) website[1] for wells located within about 1½ miles of the site indicates groundwater levels in excess of 240 feet bgs. It should be noted that groundwater levels vary with local topography. In addition, the groundwater levels reported on the OWRD logs often reflect the purpose of the well, so water well logs may only report deeper, confined groundwater, while geotechnical or environmental borings will often report any groundwater encountered, including shallow, unconfined groundwater. Therefore, the levels reported on the OWRD well logs referenced above are considered generally indicative of local water levels and may not reflect actual groundwater levels at the site. We anticipate that groundwater levels will fluctuate due to seasonal and annual variations in precipitation, changes in site utilization, or other factors. However, such fluctuation (if it occurs) is anticipated to be at depths well below that considered of concern for this project.

[1] Oregon Water Resources Department, 2014. Water Level Data and Hydrographs http://www.oregon.gov/owrd/pages/gw/well_data.aspx

6.0 SEISMIC CONSIDERATIONS

6.1 Seismic Hazards

The complete results of our seismic hazard evaluation for this project site are presented in Section A.1.5 of the attached Appendix A. The following highlights the results of our evaluation:

- We conclude there is a negligible risk of liquefaction at the site.
- We conclude there is a negligible risk of surface rupture from lateral spread.
- We conclude there is at least a moderate risk of slope instability from a design-level earthquake. Refer to Section 7.3 of this report for additional discussion.
- We conclude there is a low risk of surface rupture from faulting.

6.2 Seismic Site Class

Based on the results of the explorations and review of geologic mapping, we have assigned the site as Site Class D for the subsurface conditions encountered in accordance with Table 1613.5.2 of the 2010 Oregon Structural Specialty Code (2010 OSSC). Preliminary recommendations for seismic ground motion values at the site are presented in Section 10.4 of this report.

7.0 GEOTECHNICAL REVIEW & DISCUSSION

7.1 Overview

Based on the results of our field explorations and analyses, the site may be developed as conceptually described in Section 1.1 of this report. We conclude the primary geotechnical considerations for the currently planned project are:

(1) the presence of uncontrolled fill materials within portions of the site intended for development.
(2) the presence of relatively steep, tall cut slopes along the north, south, and west rims of the pit.

These considerations are described in more detail in the following sections.

7.2 Presence of Uncontrolled Fill Materials

As indicated in Sections 5.1.1, 5.1.2, and 5.1.4 of this report, uncontrolled fill materials were encountered within several of our subsurface explorations advanced within “Region 1”, “Region 2”, and “Region 4” of the project site. The attached Figure 2 shows the depths of the uncontrolled fill encountered at our exploration locations. To further help illustrate areas of the site containing significant uncontrolled fills, we have prepared a supplemental site plan (attached as Figure 4) that shows areas of the site underlain by at least 10 feet of uncontrolled fill. This plan has been prepared principally for illustrative purposes and was based on the results of our explorations, site observations, and review of topographic irregularities.

To the best of our knowledge, there is no available documentation detailing the placement and compaction of the existing fill materials at the project site. Our explorations showed the fill materials were highly variable in terms of type, composition, and relative density/compaction. The fill materials ranged from silty sand, pumice, gravel, sandy gravel, and rubble fill (cobbles, and boulders up to 4 feet in diameter). In some cases, the existing fill contained debris, including concrete, asphaltic concrete, metal, pipe fragments, glass, and/or insulation. In isolated cases, we encountered discrete organic debris, including branches and a 12-inch-diameter tree stump. No organic layers or organic-laden materials were encountered during our investigation.

Recognizing the variability in relative density/compaction, the presence of over-sized particles (over 12 inches in diameter), and in some cases, the presence of construction material debris, it is our opinion the existing uncontrolled fill materials were not placed in accordance with typical code requirements for structural fill. If relied upon for subgrade support of planned buildings, pavements, hardscaping, and/or other structural improvements, we conclude there is a moderate to high risk of uneven subgrade response below, and potential for excessive, post-construction settlements of, those features. We recommend the existing uncontrolled fill be mitigated where present within finalized locations for new structural features at the site. Given the preliminary nature of layout, grading, and design of the proposed project, it is difficult to develop “blanket” recommendations for mitigation of the existing uncontrolled fill across the site. Accordingly, we have identified options that we anticipate should be effective for mitigation of the existing fill materials in building and pavement areas for OSU Cascades’ consideration. These options are presented in the following table.

Table 5: Options for Mitigation of Existing Uncontrolled Fill

Type of Fill Present	Mitigation Options	
	Building Areas	Pavement/Exterior Hardscaping Areas
Fill Soil Primarily Free of Boulders and Large Debris	Full Removal & Replacement[1]	Full Removal & Replacement[1]
	Displacement (Driven) Piles[2]	Ground Improvement Techniques[4]
	Non-Displacement (Drilled) Piles[3]	Relocation of Feature (away from fill area)[6]
	Ground Improvement Techniques[4]	
	Earth Stabilization Columns[5]	
	Relocation of Building (away from fill area)[6]	
Fill Soil with Moderate to Heavy Concentration of Boulders and/or Large Debris	Full Removal & Replacement[1]	Full Removal & Replacement[1]
	Relocation of Building (away from fill area)[6]	Relocation of Feature (away from fill area) [6]
		Partial Removal & Geo-Grid Reinforcement (provision for increased risk)[7]

[1] Depths of fill removal and replacement will be a function of the finalized grading plan per civil engineer.
[2] Such as steel H-piles, steel pipe piles, pre-cast concrete piles, micro-piles, etc. Considered applicable for areas of relatively deep fill.
[3] Such as drilled piers. Considered applicable for areas of moderately deep fill (up to 20 feet deep).
[4] Such as deep in-place soil mixing, jet grouting, etc. Considered applicable for areas of relatively deep fill.
[5] Such as stone columns (vibro-replacement), granular piers, etc. Considered applicable for areas of relatively deep fill.
[6] Subject to preferences of owner and review of design team.
[7] This approach should help reduce, but not eliminate, the potential for post-construction settlements of fill left in-place below these features. The owner (OSU Cascades) would need to recognize and accept an increased risk of area-wide settlements from consolidation/densification of the underlying, uncontrolled fill.

As project plans are developed, we recommend the geotechnical engineer be consulted to review the plans in an effort to help determine the most practical and economic option(s) for supporting new structural features at the site. Specific geotechnical recommendations for use in design and construction of foundations, floor slabs, pavements, hardscaping, and other site features can be reasonably developed after layout and grading criteria have been established. Additional geotechnical investigation (drilled borings and/or test pits) may be recommended in some cases to further characterize subsurface conditions for the purposes of developing recommendations, particularly in areas of the site containing relatively deep, uncontrolled fill.

7.3 Presence of Relatively Steep, Tall Cut Slopes Along North, South, and West Rims of Pit

As indicated in Section 2.2 of this report, the central and eastern portions of the site consist of a former pumice mine (“pit”) and contain near-vertical sidewalls ranging from about 30 to 80 feet in height. Conceptual site layout plans provided by OSU Cascades show buildings and drive lanes may be placed above, within (by construction of fill embankments), and near the toe of the west and north sidewalls of the pit within “Region 2”. The plans also show a building and appurtenant features may be placed relatively near the toe of the south sidewall of the pumice pit within “Region 1”.

Based on the results of our explorations and geological field reconnaissance, the sidewalls of the pit consist of pyroclastic deposits, ranging from ash to lapilli tuff, ash flow tuff, or pumice. To help illustrate stratigraphy of the sideslopes, we developed seven geologic cross sections of the sidewalls (A-A’ through G-G’) using subsurface information collected from the explorations and the geological reconnaissance, presented in Appendix E. The locations of the slope cross sections are shown on Figure E1 contained within the attached Appendix E.

No areas of moderate- or large-scale (deep-seated) past or ongoing instability were evident at the site during our investigation and geological reconnaissance. Notwithstanding the preceding statement, we conclude the pit sidewalls, considering their heights, gradients, and composition, are susceptible to slope instability and rockfall, particularly if subjected to seismic loading. Generally speaking, ground shaking from design-level seismic events can induce slope failures, including landslides or rockfall, on otherwise stable (or marginally stable) slopes. As noted in Appendix A, we identified several potential sources for earthquakes in the region of the site. Accordingly, it is our opinion that the hazard level associated with slope instability and/or rockfall at the site is at least moderate.

Given the preliminary nature of layout, grading, and design of the proposed project, it is difficult to develop “blanket” geotechnical recommendations for addressing this slope hazard. Accordingly, we have identified options for OSU Cascades’ consideration. These options are presented in the following table, in order of anticipated increased cost for the project.

Table 6: Options for Consideration for Development Near Steep Site Slopes

Option	Discussion[1]
1 – Avoid Hazard through Proper Setback	• This option would include locating buildings, drive lanes, parking areas, and other structural features at a sufficient distance away from on-site slopes exceeding 1H:1V in gradient. To help illustrate setback of buildings per current OSSC requirements, the attached Figure 2 includes shading indicating minimum setback of building clearances from ascending (and descending) slopes. • Pedestrian access would be restricted from the top and bottom of the slopes through fencing or other barrier system. Draping of the slopes could also be considered to help provide protection. • This option is subject to owner preferences and review of design team.
2 – Quantitatively Analyze Slope Stability	• This option would include evaluating the stability of the existing slopes using slope stability software. The intent of this analysis would (conceptually) be to determine safety factors against slope instability and determine whether reduced slope setbacks could be achieved. • The owner is advised proceeding with quantitative stability analyses may not lead to reduction in slope setbacks.
3 – Re-grade Slopes	• This option would (conceptually) include re-grading the site slopes, where practical to do so. • Re-grading of the north, west, and south side slopes could include placement of structural fill near the toe of the cut slope to serve as a buttress. • Re-grading of the west side slope could also take the form of pulling back (flattening) the slope to achieve a flatter gradient. • This option would be subject to owner preferences and review of project civil engineer and architect.
4 – Install Retaining Structures	• This option would (conceptually) include design and installation of retaining structures to retain the existing side slopes of the pit. • Steel sheet pile walls, tieback/anchored walls, or other wall systems could be considered.

[1] The owner and design team may consider one, or a combination of the, above options to address development near steep slopes.

As project plans are developed, we recommend the geotechnical engineer be consulted to review the plans in an effort to help determine the most practical and economic option(s) for addressing the slope stability and rockfall hazard presented by the sidewalls of the pit. Depending on the option selected, the owner is advised additional geotechnical investigation and analyses may be recommended to further characterize subsurface conditions above, within, or below site slopes.

8.0 PRELIMINARY RECOMMENDATIONS: SITE PREPARATION & EARTHWORK

The preliminary recommendations presented below are provided for general planning purposes and are subject to revision once layout and grading plans for the project are further developed. Our preliminary recommendations are based on the information provided to us, results of the field investigation, laboratory data, and professional judgment. CGT has observed only a small portion of the pertinent subsurface conditions. The recommendations are based on the assumptions that the subsurface conditions do not deviate appreciably from those found during the field investigation.

8.1 Site Preparation

8.1.1 Stripping

Surface vegetation and rooted soils should be removed from within, and for a 5-foot margin around, the proposed structural fill, building, and pavement locations. Based on the results of the field explorations, stripping depths at the site are anticipated to be about ¼- to ½-foot bgs. These materials may be shallow or deeper away from the exploration locations. The geotechnical engineer or his representative should provide recommendations for actual stripping depths based on observations during site stripping. Stripped surface vegetation and rooted soils should be transported off-site for disposal, or stockpiled for later use in landscaped areas.

8.1.2 Grubbing

Grubbing of shrubs and trees should include the removal of the root mass, and roots greater than 1-inch in diameter. Grubbed materials should be transported off-site for disposal. Where root masses are removed, the resulting excavation should be properly backfilled with imported granular structural fill in conformance with Section 8.4.3.2 of this report, as needed to achieve finished subgrade elevations.

8.1.3 Existing Utilities & Below-Grade Structures

All existing utilities at the site should be identified prior to excavation. Abandoned utility lines beneath new buildings and pavements should be completely removed or grouted full. Soft, loose, or otherwise unsuitable soils encountered in utility trench excavations should be removed and replaced with imported granular structural fill in conformance with Section 8.4.3.2 of this report. No below-grade structures were encountered during our field investigation of the site. If encountered during site preparation, buried structures, including but not limited to, footings, foundation walls, slabs-on-grade, tanks, or pavements, should be completely removed and disposed of off-site.

8.1.4 Erosion Control

Erosion and sedimentation control measures should be employed in accordance with applicable City, County, and State regulations regarding erosion control.

8.2 Temporary Excavations

8.2.1 Overview

All excavations should be in accordance with applicable OSHA and state regulations. It is the contractor's responsibility to select the excavation methods, to monitor site excavations for safety, and to provide any shoring required to protect personnel and adjacent improvements. A “competent person”, as defined by OR-OSHA, should be on-site during construction in accordance with regulations presented by OR-OSHA. CGT’s current role on the project does <u>not</u> include review or oversight of excavation safety.

8.2.2 Dewatering

Recognizing the depth to regional groundwater at this site (in excess of 200 feet bgs), we do not anticipate that site excavations will require area-wide dewatering. If groundwater seepage is encountered on temporary cut slopes during construction, provisions may be required to collect and divert the water from the cut slope and reduce the potential of instability. The geotechnical engineer should be consulted in the event groundwater seepage emerges within cut slopes.

8.2.3 Utility Trenches

Temporary trench cuts should stand near vertical to depths of approximately 4 feet in the native silty sand (SM), tuff (RX), and Bend Pumice (RX) encountered at the site. Depending on time of year, some instability may occur in excessively dry, cohesionless soils within the upper few feet of the site surface. In the event that caving of the sidewalls is observed during excavation, the sidewalls should be flattened or shored. Although not anticipated, trench dewatering may be required in order to maintain dry working conditions, particularly if significant perched water and seepage is encountered. If groundwater is present at the base of utility excavations, we recommend placing trench stabilization material at the base of the excavations. Trench stabilization material should be in conformance with Section 8.4.5 of this report.

8.2.4 OSHA Soil Type

8.2.4.1 Silty Sand
Conventional earthmoving equipment in proper working condition should be capable of making cuts within this soil. For use in the planning and construction of temporary excavations at the site, an OSHA soil type "C" should be used for this soil. We anticipate some instability of the silty sand may occur if seepage occurs, particularly during or after heavy rains. If seepage is encountered that undermines the stability of the excavation, or caving of the sidewalls is observed during excavation, the sidewalls should be flattened or shored.

8.2.4.2 Tumalo Tuff, Bend Pumice & Desert Springs Tuff
Conventional earthmoving equipment in proper working condition should be capable of making cuts within the on-site tuff and pumice. Recognizing their primarily sandy nature, an OSHA soil type "C" should be used when considering temporary excavations into these materials.

8.2.5 Excavations Near Foundations

Excavations near footings should not extend within a 1H:1V (horizontal:vertical) plane projected out and down from the outside, bottom edge of the footings. In the event that excavation needs to extend below the referenced plane, temporary shoring of the excavation and/or underpinning of the subject footing may be required. The geotechnical engineer should be consulted to review proposed excavation plans for this design case to provide specific recommendations.

8.3 Wet Weather Considerations

Notwithstanding the generally arid conditions of the Bend area, soil conditions should be evaluated in the field by the geotechnical engineer or his representative at the initial stage of site preparation to determine whether the recommendations within this section should be incorporated into construction.

8.3.1 Overview

Trafficability of the near-surface, silty sand (SM) and tuff (RX) may be difficult, and significant damage to subgrade soils could occur, if earthwork is undertaken without proper precautions at times when the exposed soils are more than a few percentage points above optimum moisture content. Site preparation activities may need to be accomplished using track-mounted equipment, loading removed material onto trucks supported on granular haul roads, or other methods to limit soil disturbance. The geotechnical engineer or his representative should evaluate the subgrade during excavation by probing rather than proof rolling. Soils that have been disturbed during site preparation activities, or soft or loose areas identified during probing, should be over-excavated to firm, stable subgrade, and replaced with imported granular structural fill in conformance with Section 8.4.3.2 of this report.

8.3.2 Geotextile Separation Fabric

A geotextile separation fabric should be placed to serve as a barrier between fine-grained subgrades and imported fill in areas of repeated or heavy construction traffic. The geotextile fabric should be in conformance with Section 02320 of the most current Oregon Department of Transportation (ODOT) Standard Specification for Construction. In accordance with Table 02320-1 of ODOT specifications, the separation fabric should have minimum puncture strength (ASTM D4833) of 80 pounds and an apparent opening size (ASTM D4751) no larger than the U.S. Standard No. 30 sieve. Examples of products that currently meet these requirements include Propex Geotex 200ST and US Fabrics US200. Other products meeting the requirements set forth by ODOT specifications may be considered for separation geotextile fabric.

8.3.3 Granular Working Surfaces

Haul roads subjected to repeated heavy, tire-mounted construction traffic (e.g. dump trucks, concrete trucks, forklifts, etc.) will require a minimum of 18 inches of imported granular material. For light staging areas subjected to light, tire-mounted equipment (e.g. pickups) or track-mounted equipment, 12 inches of imported granular material should be sufficient. Additional granular material, geo-grid reinforcement, or cement amendment may be recommended based on site conditions and/or loading at the time of construction. The imported granular material should consist of imported granular structural fill in conformance with Section 8.4.3.2 of this report and have less than 5 percent passing the U.S. Standard No. 200 Sieve. The prepared subgrade should be covered with geotextile fabric prior to placement of the imported granular material. The imported granular material should be placed in a single lift and compacted using a smooth-drum, non-vibratory roller until achieving a well-keyed condition.

8.3.4 Footing Subgrade Protection

A minimum of 3 inches of imported granular material is recommended over fine-grained, foundation subgrades in order to provide protection from foot traffic during inclement weather. The imported granular material should be in conformance with Section 8.4.3.2 of this report, contain a maximum particle size of 1 inch, and have less than 5 percent passing the U.S. Standard No. 200 Sieve. The imported granular material should be placed in one lift over the prepared, undisturbed subgrade, and compacted using non-vibratory equipment until well-keyed.

8.4 Structural Fill

8.4.1 Overview

On-site or imported materials intended for use as structural fill at the site should be reviewed by the geotechnical engineer prior to placement. The geotechnical engineer or his representative should be contacted to evaluate compaction of structural fill as the material is being placed. Evaluation of compaction may take the form of in-place density tests, deflection (proof roll) tests, or other testing methods accepted by the geotechnical engineer. The following table presents recommended guidelines for frequency of density testing (where practical) of various fill designations.

Table 7: Recommended Guidelines for Frequency of Density Testing

Fill Designation	Recommended Frequency of Density Tests	
	Maximum Depth Interval	Area-Wide
General Structural Fill (Mass Grading)	Test every 1 vertical foot	At least one density test per 2,000 $feet^2$ of fill area
Utility Trench Backfill$^{\alpha}$	Test every 2 vertical feet	At least one density test per 50 feet of trench line
Pavement Base Rock$^{\alpha}$	Test at surface of section	At least one density test per 2,000 $feet^2$ of base rock area
Floor Slab Base Rock	Test at surface of section	At least one density test per 1,000 $feet^2$ of base rock area

$^{\alpha}$Testing frequency within the public right-of-way should be in conformance with the local jurisdiction requirements.

8.4.2 On-Site Materials – General Use

8.4.2.1 Silty Sand, Tumalo Tuff, Bend Pumice & Desert Springs Tuff

Re-use of these materials as structural fill is feasible, provided they are kept free of organic matter, debris, and particles larger than about 2 inches. When used as structural fill, these soils should be placed in lifts with a maximum thickness of about 9 inches at moisture contents within –1 and +3 percent of optimum, and compacted to not less than 95 percent of the material's maximum dry density as determined in accordance with ASTM D1557 (Modified Proctor).

8.4.2.2 Silty Sand Fill, Sandy Gravel Fill, Gravel Fill & Pumice Fill

Re-use of these fill materials as structural fill is feasible, provided they can be kept free of organics, debris, and other deleterious materials, and processed ("picked") free of large particles (cobbles and boulders) in excess of 4 inches in diameter. When used as structural fill, these soils should be placed in lifts with a maximum thickness of about 9 inches at moisture contents within –1 and +3 percent of optimum, and compacted to not less than 95 percent of the material's maximum dry density as determined in accordance with ASTM D1557 (Modified Proctor). Where the material contains a high concentration of over-sized particles, evaluation of relative compaction should be performed by deflection (proof roll) testing in accordance with ODOT Test Method TM 158.

8.4.2.3 Existing Rubble Fill

Re-use of the existing rubble fill (primarily consisting of cobbles, concrete debris, and boulders up to about 4 feet in diameter) as structural fill will require extensive processing (removal or crushing) of over-sized particles and debris. Due to the concentration of boulders and debris, the economics of processing this material for re-use as structural fill should be weighed. The processed/crushed material should be prepared to achieve a fill that is fairly well graded between coarse and fine. The maximum particle size should be limited to 4 inches. As a guideline, grading of this material with particles up to about 4 inches in diameter may follow that presented in the following table.

Table 8: Guideline Gradation of Processed/Crushed Rubble Fill

Sieve Size	% Passing
4 inches	100
3 inches	88 – 100
¾-inch	70 – 90
U.S. Standard No. 4	40 – 60
U.S. Standard No. 40	20 – 40
U.S. Standard No. 200	Dry Weather: Less than 12 | Wet Weather: Less than 5

When used as structural fill, this material should be placed in lifts with a maximum thickness of about 9 inches at moisture contents within –1 and +3 percent of optimum, and compacted to not less than 95 percent of the material's maximum dry density as determined in accordance with ASTM D1557 (Modified Proctor). Where the material contains a high concentration of over-sized particles, evaluation of relative compaction should be performed by deflection (proof roll) testing in accordance with ODOT Test Method TM 158. Proof roll tests should be performed at maximum intervals of every 1 vertical foot as the fill is being placed.

If the on-site soils cannot be properly moisture-conditioned and/or processed, we recommend using imported granular material for structural fill.

8.4.3 Imported Fill (General Use)

8.4.3.1 Imported Material(s) with Appreciable Fines Content

Imported fill materials with a relatively high concentration of fines (e.g. clay- to silt-sized particles) may be considered for use as structural fill during mass grading. For the purposes of discussion, a fill material containing more than 12 percent passing the U.S. Standard No. 200 Sieve constitutes a material with relatively high concentration of fines. Subject to the review of the geotechnical engineer, fill material(s) meeting this designation may be used as structural fill (general use) at the site, provided they can be moisture-conditioned and compacted in conformance with the recommendations presented in Section 8.4.2.1 of this report, and are free of organic matter, debris, and particles larger than 4 inches. Fill materials with a high concentration of fines are best suited for use during dry weather conditions, as they inherently are sensitive to changes in moisture content and are difficult, if not impossible, to adequately compact during wet weather. Specific recommendations for placement and compaction of imported fill materials with appreciable fines content can be provided by the geotechnical engineer on a case-by-case basis.

8.4.3.2 Imported Granular Fill with Low Fines Content

Imported granular fill should consist of angular pit or quarry run rock, crushed rock, or crushed gravel that is fairly well graded between coarse and fine particle sizes. The granular fill should contain no organic matter, debris, or particles larger than 4 inches, and have less than 5 percent material passing the U.S. Standard No. 200 Sieve. The percentage of fines can be increased to 12 percent of the material passing the U.S. Standard No. 200 Sieve if placed during dry weather, and provided the fill material is moisture-conditioned, as necessary, for proper compaction. As a guideline, grading of this material with particles up to about 4 inches in diameter may follow that presented in Table 8 above. Imported granular fill material should be placed in lifts with a maximum thickness of about 12 inches at moisture contents within –1 and +3 percent of optimum, and compacted to not less than 95 percent of the material's maximum dry density as determined in accordance with ASTM D1557 (Modified Proctor). Granular fill materials with high percentages of particle sizes in excess of 1½ inches are considered non-moisture-density testable materials. As an alternative to conventional density testing, compaction of these materials should be evaluated by periodic deflection (proof roll) testing in accordance with ODOT Test Method 158. Proof roll tests should be performed at maximum intervals of every 1 vertical foot as the fill is being placed.

8.4.4 Floor Slab Base Course

Floor slab base course should consist of well-graded granular material (crushed rock or gravel) containing no organic matter or debris, have a maximum particle size of ¾ inch, and have less than 5 percent material passing the U.S. Standard No. 200 Sieve. The material should be placed in one lift and compacted to not less than 95 percent of the material's maximum dry density as determined in general accordance with ASTM D1557 (Modified Proctor). As a guideline, the material should consist of a well-graded, ¾-inch minus crushed aggregate meeting the requirements of the most recent Oregon Standard Specifications for Construction, Section 2630.10, Table 02630-1 "Grading Requirements for Dense-Graded Aggregate", for ¾-inch minus rock. A guideline base course gradation criterion is presented in the following table.

Table 9: Guideline Gradation for Floor Slab Base Course

Sieve Size	% Passing (See Note 1)
1 inch	100
¾ inch	90 – 100
½ inch	-----
⅜ inch	55 – 75
¼ inch	40 – 60
U.S. Standard No. 4	-----
U.S. Standard No. 8	-----
U.S. Standard No. 10	See Note 2
U.S. Standard No. 16	-----
U.S. Standard No. 200	0 – 5

Note 1: Gradation should conform to the most current, ODOT specifications, for ¾-inch minus rock.
Note 2: Of the fraction passing the ¼-inch sieve, 40% to 60% shall pass the No. 10 sieve.

8.4.5 Trench Base Stabilization Material

If groundwater is present at the base of utility excavations, trench base stabilization material should be placed. Trench base stabilization material should consist of 1 foot of well-graded granular material with a maximum particle size of 4 inches and less than 5 percent material passing the U.S. Standard No. 4

Sieve. The material should be free of organic matter and other deleterious material, placed in one lift, and compacted until well-keyed.

8.4.6 Utility Trench Backfill

Trench backfill for the utility pipe base and pipe zone should consist of granular material as recommended by the utility pipe manufacturer. Trench backfill above the pipe zone should consist of well-graded granular material containing no organic matter or debris, have a maximum particle size of ¾ inch, and have less than 8 percent material passing the U.S. Standard No. 200 Sieve. As a guideline, trench backfill should be placed in maximum 12-inch thick lifts. The earthwork contractor may elect to use alternative lift thicknesses based on their experience with specific equipment and fill material conditions during construction in order to achieve the required compaction. The following table presents recommended relative compaction percentages for utility trench backfill.

Table 10: Utility Trench Backfill Compaction Recommendations

Backfill Zone	Recommended Minimum Relative Compaction	
	Structural Areas[1]	Landscaping Areas
Pipe Base and Within Pipe Zone	90% ASTM D1557 or pipe manufacturer's recommendation	88% ASTM D1557 or pipe manufacturer's recommendation
Above Pipe Zone	92% ASTM D1557	90% ASTM D1557
Within 3 Feet of Design Subgrade	95% ASTM D1557	90% ASTM D1557

[1]Includes proposed structural fill areas, buildings, pavements, hardscaping, etc.

8.4.7 Controlled Low-Strength Material (CLSM)

CLSM is a self-compacting, cementitious material that is typically considered when backfilling localized areas. CLSM is sometimes referred to as "controlled density fill" or CDF. Due to its flowable characteristics, CLSM typically can be placed in restricted-access excavations where placing and compacting fill is difficult. If chosen for use at this site, we recommend the CLSM be in conformance with Section 00442 of the most recent, State of Oregon, Standard Specifications for Highway Construction. The geotechnical engineer's representative should observe placement of the CLSM and obtain samples for compression testing in accordance with ASTM D4832. As a guideline, for each day's placement, two compressive strength specimens from the same CLSM sample should be tested. The results of the two individual compressive strength tests should be averaged to obtain the reported 28-day compressive strength.

8.5 Additional Considerations

8.5.1 Drainage Considerations

Subsurface drains should be connected to the nearest storm drain, on-site stormwater infiltration facilities (designed by others), or other suitable discharge point. If on-site infiltration of stormwater is considered, the geotechnical engineer should be consulted to review the proposed construction. Paved surfaces, and ground near or adjacent to buildings, should be sloped to drain away from the buildings. Surface water from pavement surfaces and open spaces should be collected and routed to a suitable discharge point. Surface water should not be directed into foundation drains or onto site slopes.

8.5.2 Freezing Weather Considerations

For construction that occurs during extended periods of sub-freezing temperatures, the following special provisions are recommended:

- Structural fill should not be placed over frozen ground.
- Frozen soil should not be placed as structural fill.
- Fine-grained soils should not be placed as structural fill during sub-freezing temperatures.

Identification of frozen soils at the site should be in accordance with ASTM D4083-01 "Standard Practice for Description of Frozen Soils (Visual-Manual Procedure)" or other method approved by the geotechnical engineer. The geotechnical engineer can aid the contractor with supplemental recommendations for earthwork that will take place during extended periods of sub-freezing weather, as required.

8.6 Permanent Slopes

Permanent cut or fill slopes constructed at the site should be graded at 2H:1V or flatter. Constructed slopes should be overbuilt by a few feet depending on their size and gradient so that they can be properly compacted prior to being cut to final grade. The surface of all slopes should be protected from erosion by mulching, seeding, sodding, or other acceptable means. Construction of fill slopes on surfaces exceeding 5H:1V in declivity should be keyed and benched into the sloped surface. The geotechnical engineer should be consulted to review proposed fill slopes and provide supplemental geotechnical recommendations for site preparation and construction as grading plans are being developed.

8.7 Foundation Setback from Ascending Slopes

Section 1808.7.1 of the 2010 OSSC requires that foundations be a sufficient depth to provide horizontal setback from an ascending slope exhibiting gradients in excess of 1H:1V. As stated therein, the required setback shall be measured by assigning "*…the toe of the slope shall be assumed to be at the intersection of a horizontal plane drawn from the top of the foundation and a plane drawn tangent to the slope at an angle of 45 degrees to the horizontal*." Using this criterion, and the provided topographic plan (prepared by others), we approximated the minimum setback by providing an overlay (orange shading) within the attached Supplemental Site Plan, Figure 4. For preliminary planning, we recommend buildings be setback beyond the overlay shown on the attached Figure 4. If final layout includes placing building(s) within this overlay, the geotechnical engineer should be consulted to review the proposed construction.

8.8 Foundation Setback from Descending Slopes

Section 1808.7.2 of the 2010 OSSC requires that foundations be a sufficient depth to provide horizontal setback from a descending slope exhibiting gradients in excess of 1H:1V. As stated therein, "*…the required setback shall be measured from an imaginary plane 45 degrees to the horizontal, projected upward from the toe of the slope*." Using this criterion, and the provided topographic plan (prepared by others), we approximated the minimum setback from the west sidewall of the pit by providing an overlay (red shading) within the attached Supplemental Site Plan, Figure 4. For preliminary planning, we recommend buildings be setback beyond the overlay shown on the attached Figure 4. If final layout includes placing building(s) within this overlay, the geotechnical engineer should be consulted to review the proposed construction.

9.0 PRELIMINARY RECOMMENDATIONS: PAVEMENT DESIGN

The following recommendations are provided assuming the native silty sand (SM) is encountered at design subgrade elevation for new pavements. As mentioned previously, portions of the site containing relatively deep, uncontrolled fill will require special consideration for developing subgrade support of new pavements. In these cases, the geotechnical engineer should be consulted to develop specific supplemental recommendations for pavements once layout and grading plans are being developed.

9.1 Subgrade Preparation

After site stripping as recommended above, but prior to placement of base course material or structural fill, the prepared native subgrade should be scarified to a depth of 12 inches below design subgrade elevation, moisture-conditioned to +/- 2 percent of optimum moisture content, and re-compacted with suitable equipment. The subgrade should be compacted to not less than 95 percent of the material's maximum dry density as determined by ASTM D1557 (Modified Proctor). The geotechnical engineer or his representative should perform in-place density testing of the compacted subgrade to confirm proper compaction and moisture-conditioning. In addition, a proof roll test of the compacted subgrade should be performed with a fully-loaded, 10- to 12-cubic yard, dump truck (or equivalent loaded water truck) in order to identify areas of excessive yielding. The geotechnical engineer or his representative should witness the proof roll test(s). If areas of soft soil or excessive yielding are identified, the affected material should be over-excavated to firm, stable subgrade, and replaced with imported granular structural fill in conformance with Section 8.4.3.2 of this report. Pavement subgrade surfaces should be crowned (or sloped) for proper drainage in accordance with specifications provided by the project civil engineer.

9.2 Flexible Pavements

9.2.1 Input Parameters

Our pavement section designs were based on the American Association of State Highway and Transportation Officials (AASHTO) 1993 "Design of Pavement Structures" manual. A number of design assumptions and variables were required in order to develop design sections for pavements proposed at the site. The following table presents the input parameters assumed for the design:

Table 11: Input Parameters Used in Asphalt Pavement Design

Input Parameter	Design Value[1]	Input Parameter		Design Value[1]
Pavement Design Life	20 years	Resilient Modulus	Subgrade[3]	6,000 psi
Annual Percent Growth	0 percent		Crushed Aggregate Base	22,500 psi
Serviceability	4.2 initial, 2.2 terminal	Structural Coefficient	Crushed Aggregate Base	0.10
Reliability	85 percent		Asphalt	0.42
Standard Deviation	0.49	Vehicle Traffic[4] (range in ESAL)	APAO Level I (Very Light)	Less than 10,000
Drainage Factor[2]	1.0		APAO Level II (Light)	Less than 50,000

1 If any of the above parameters are incorrect, please contact us so that we may revise our recommendations, if warranted.
2 Assumes good drainage away from pavement, base, and subgrade is achieved by proper crowning of subgrades.
3 Values based on experience with similar soils and assumes subgrade is prepared in conformance with Section 9.1 of this report.
4 ESAL = Total 18-Kip equivalent single axle load. Traffic levels taken from Table 3.1 of APAO manual. If actual traffic levels will be above those identified above, the geotechnical engineer should be consulted.

9.2.2 Recommended Minimum Sections

The following table presents the minimum asphalt pavement sections for various traffic loads indicated in the preceding table, based on the referenced AASHTO procedures.

Table 12: Recommended Minimum Asphalt Pavement Sections

Material	APAO Traffic Loading	
	Level I (Passenger Car Parking)	Level II (Entrance/Service Drive Lanes)
Asphalt Pavement (inches)	3	3½
Crushed Aggregate Base (inches)[1]	6	8
Subgrade Soils	Prepared in conformance with Section 9.1 of this report.	

1 Thickness shown assumes dry weather construction. A granular sub-base section and/or a geotextile separation fabric may be required in wet conditions in order to support construction traffic and protect the subgrade. Refer to Section 8.3 for additional discussion.

Asphalt pavement and base course material should conform to the most current State of Oregon, Standard Specifications for Highway Construction. Place aggregate base in one lift, and compact to not less than 95 percent of the material's maximum dry density as determined in general accordance with ASTM D1557 (Modified Proctor). Asphalt pavement should be compacted to at least 91 percent of the material's theoretical maximum density as determined in general accordance with ASTM D2041 (Rice Specific Gravity).

9.3 Rigid (Concrete) Pavements

9.3.1 Input Parameters

Design of the rigid pavement sections presented below was based on the assumed parameters presented in the following table and the referenced AASHTO design manual. If any of the items listed need revision, please contact us and we will reassess the provided design sections. Jointing, reinforcement, and surface finish should be performed in accordance with the project civil engineer, architect, and owner requirements.

Table 13: Input Parameters Used in Concrete Pavement Design

Parameter / Discussion		Design Value
Standard Deviation		0.39
Load Transfer Devices incorporated?		Yes; Load Transfer Coefficient = 3.2
Minimum Concrete Modulus of Rupture		600 psi
Concrete Elastic Modulus		5.0 x 10^6 psi
Minimum Air-Entrained Concrete Comp. Strength		4,000 psi
Vehicle Traffic[1] (range)	APAO Level I (Very Light)	Less than 10,000 ESAL
	APAO Level II (Light)	Less than 50,000 ESAL

1 ESAL = Total 18-Kip equivalent single axle load. If actual traffic levels will be above those identified above, the geotechnical engineer should be consulted.

9.3.2 Recommended Minimum Sections

The following table presents the recommended minimum concrete pavement sections based on the referenced AASHTO procedures.

Table 14: Recommended Minimum Concrete Pavement Sections

Material	APAO Traffic Loading	
	Level I (Passenger Car Traffic Only)	**Level II** (Entrance/Service Drive Lanes)
Portland Cement Concrete, PCC[1] (inches)	5	6
Leveling Course, Sand or All-Weather Base[2,3] (inches)	2	2
Subgrade Soils	Prepared in conformance with Section 9.1 of this report	

1 Concrete strength and other properties should be in conformance with Table 13 above.
2 Leveling course thickness should be a minimum of four times the maximum particle size. Example. If crushed rock up to ¾ inch in diameter is used, the leveling course should be at least 3 inches thick.
3 Assumes dry weather construction. Increased base rock sections and/or a geotextile separation fabric may be required in wet conditions in order to support construction traffic and protect the subgrade. Refer to Section 8.3 for additional discussion

10.0 PRELIMINARY RECOMMENDATIONS: STRUCTURAL DESIGN

The following recommendations are provided assuming the native silty sand (SM), native tuff (RX), or the native Bend Pumice (RX) are encountered at design subgrade elevation for new foundations. As mentioned previously, portions of the site containing relatively deep, uncontrolled fill will require special consideration for developing subgrade support of new buildings. In these cases, the geotechnical engineer should be consulted to develop specific supplemental recommendations for foundations and floor slabs once layout and grading plans are being developed.

10.1 Shallow Spread Foundations

10.1.1 Subgrade Preparation

Satisfactory subgrade support for shallow foundations can be obtained from the native, medium dense to better, silty sand (SM), the native tuff (RX), the native Bend Pumice (RX), or structural fill that is properly placed and compacted on these materials during construction. The geotechnical engineer or his representative should be contacted to observe subgrade conditions prior to placement of forms, reinforcement steel, or structural backfill (if required). If soft, loose, or otherwise unsuitable soils are encountered, they should be over-excavated as recommended by the geotechnical representative at the time of construction. The resulting over-excavation should be brought back to grade with imported granular structural fill in conformance with Section 8.4.3.2 of this report. The maximum particle size of foundation granular pads should be limited to 1½ inches. All granular pads for footings should be constructed a minimum of 6 inches wider on each side of the footing for every vertical foot of over-excavation.

10.1.2 Minimum Footing Width & Embedment

Minimum footing widths should be in conformance with the most recent, Oregon Structural Specialty Code (OSSC). Individual spread footings should have a minimum width of 24 inches. Subject to review of the structural engineer, we recommend continuous wall footings have a minimum width of 18 inches. To help mitigate potential frost action, all perimeter footings should be founded a minimum of 18 inches below the lowest adjacent grade. Interior footings should be founded a minimum of 12 inches below the interior surfacing element (e.g. concrete slab).

10.1.3 Bearing Pressure & Settlement

Footings founded as recommended above should be proportioned for a maximum allowable soil bearing pressure of 2,000 pounds per square foot (psf). This bearing pressure is a net bearing pressure, applies to the total of dead and long-term live loads, and may be increased by one-third when considering seismic or wind loads. For foundations founded as recommended above, and assumed maximum loads indicated in Section 1.1, total settlement of foundations is anticipated to be less than 1½ inches. Differential settlements between adjacent columns and/or bearing walls should not exceed ¾ inch. If an increased soil bearing pressure is desired, and/or the estimated foundation settlements need to be reduced, the geotechnical engineer should be consulted.

10.1.4 Lateral Capacity

A maximum passive (equivalent fluid) earth pressure of 150 pounds per cubic foot (pcf) is recommended for design of footings confined by the native soils described above, or imported granular structural fill that is properly placed and compacted during construction. The recommended earth pressure was computed using a factor of safety of 1½, which is appropriate due to the amount of movement required to develop full passive resistance. In order to develop the above capacity, the following should be understood:

1. Concrete must be poured neat in excavations or the foundations must be backfilled with imported granular structural fill,
2. The adjacent grade must be level,

3. The static ground water level must remain below the base of the footings throughout the year.
4. Adjacent floor slabs, pavements, or the upper 12-inch-depth of adjacent, unpaved areas should not be considered when calculating passive resistance.

An ultimate coefficient of friction equal to 0.35 may be used when calculating resistance to sliding for footings founded on the native soils described above. An ultimate coefficient of friction equal to 0.45 may be used when calculating resistance to sliding for footings founded on a minimum of 6 inches of imported granular structural fill (crushed rock) that is properly placed and compacted during construction.

10.1.5 Subsurface Drainage

Placement of perimeter foundation drains is recommended at the base elevations of continuous wall footings on the outside of footings. Foundation drains should consist of a minimum 4-inch-diameter, perforated, HDPE (High Density Polyethylene) drainpipe wrapped with a non-woven geotextile filter fabric. The drains should be backfilled with a minimum of 2 cubic feet of open graded drain rock per lineal foot of pipe. The drain rock should be encased in a geotextile filter fabric in order to provide separation from the surrounding soils. Foundation drains should be positively sloped and should outlet to a suitable discharge point. The geotechnical engineer or his representative should be contacted to observe the drains prior to backfilling. Roof drains should not be tied into foundation drains.

10.2 Shallow Mat Foundations

10.2.1 Subgrade Preparation

Satisfactory static subgrade support for shallow mat foundations can be achieved by a minimum of 6 inches of imported granular fill (“crushed rock base”) placed on the native, medium dense to better, silty sand (SM), the native Tumalo Tuff (RX/SM), or structural fill that is properly placed and compacted on these materials during construction. The crushed rock base is recommended to provide a more uniform surface for placing concrete and supporting the mat foundation. The crushed rock base should be in conformance with Section 8.4.4 of this report and extend a minimum of 1-foot wider on each side of the mat foundation. The geotechnical engineer or his representative should observe foundation subgrade conditions prior to placement of the crushed rock base. If soft, loose, organic, or otherwise unsuitable soils are encountered, they should be over-excavated as recommended by the geotechnical representative at the time of construction.

10.2.2 Minimum Embedment

To help mitigate potential frost action, mat foundations should be founded a minimum of 18 inches below the lowest, permanent, adjacent grade.

10.2.3 Allowable Soil Bearing Pressure

For the proposed construction (up to five-story, concrete-framed buildings), we anticipate the maximum uniform contact pressure (from dead and long-term live loads) acting on the respective mat foundation will be less than 1,000 pounds per square foot (psf). This value may be considered the recommended maximum allowable soil bearing pressure for use in preliminary design. This bearing pressure is a net bearing pressure, applies to the total of dead and long-term live loads, and may be increased by ⅓ when considering seismic or wind loads. If an increased allowable soil bearing pressure is desired, the geotechnical engineer should be consulted.

10.2.4 Modulus of Subgrade Reaction

For mat foundations founded as recommended above, a modulus of subgrade reaction up to 150 pci may be used for design. If an increased subgrade modulus is desired, the geotechnical engineer should be consulted.

10.2.5 Lateral Capacity

The recommendations presented in Section 10.1.4 are applicable for mat foundations confined by the native soils described above or imported granular structural fill that is properly placed and compacted during construction. An ultimate coefficient of friction equal to 0.45 may be used when calculating resistance to sliding for mat foundations founded as recommended.

10.2.6 Post-Construction Settlement (Static Loading)

For the recommended design bearing pressure, total post-construction settlement of mat foundations is anticipated to be less than 1 inch. Similarly, differential settlement (i.e. tilt) across uniformly-loaded mat foundations should not exceed ½ inch.

10.3 Floor Slabs & Exterior Hardscaping

10.3.1 Subgrade Preparation

Satisfactory subgrade support for slabs constructed on-grade, supporting up to 200 psf area loading, can be obtained from the native, medium dense to better, silty sand (SM), the native tuff (RX), the native Bend Pumice (RX), or structural fill that is properly placed and compacted on these materials during construction. The geotechnical engineer or his representative should observe foundation subgrade conditions prior to placement of the crushed rock base. If soft, loose, organic, or otherwise unsuitable soils are encountered, they should be over-excavated as recommended by the geotechnical representative at the time of construction.

10.3.2 Crushed Rock Base

Concrete floor slabs should be supported on a minimum 6-inch-thick layer of crushed rock (base rock) in conformance with Section 8.4.4 of this report. For design cases where a vapor barrier or retarder is not placed below the slab, we recommend “choking” the surface of the base rock with fine sand just prior to concrete placement. Choking means the voids between the largest aggregate particles are filled with sand, but does not provide a layer of sand above the base rock. Choking the base rock surface reduces the lateral restraint on the bottom of the concrete during curing.

10.3.3 Design Considerations

For floor slabs constructed as recommended, a modulus of subgrade reaction of 150 pounds per cubic inch (pci) is recommended for the design of the floor slab. Floor slabs constructed as recommended will likely settle less than ½-inch. For general floor slab construction, slabs should be jointed around columns and walls to permit slabs and foundations to settle differentially.

10.3.4 Subgrade Moisture Considerations

Liquid moisture and moisture vapor may be encountered at the subgrade surface. The recommended crushed rock base is anticipated to provide protection against liquid moisture. Where moisture vapor emission through the slab must be minimized, e.g. impervious floor coverings, storage of moisture sensitive materials directly on the slab surface, etc., a vapor retarding membrane or vapor barrier below the slab should be considered. Factors such as cost, special considerations for construction, floor coverings, and end use suggest that the decision regarding a vapor retarding membrane or vapor barrier be made by the architect and owner.

If a vapor retarder or vapor barrier is placed below the slab, its location should be based on current American Concrete Institute (ACI) guidelines, ACI 302 Guide for Concrete Floor and Slab Construction. In some cases, this indicates placement of concrete directly on the vapor retarder or barrier. Please note that the placement of concrete directly on impervious membranes increases the risk of plastic shrinkage cracking and slab curling in the concrete. Construction practices to reduce or eliminate such risk, as described in ACI 302, should be employed during concrete placement.

10.4 Seismic Design

As indicated in Section 6.2 of this report, the site was assigned as Site Class D. Earthquake ground motion parameters for the site were obtained based on the United States Geological Survey (USGS) Seismic Design Values for Buildings - Ground Motion Parameter Calculator[2]. The site Latitude 44.043421° North and Longitude -121.338768° West were input as the site location. The following table shows the recommended seismic design parameters for the site per Section 1613.5 of the 2010 OSSC.

Table 15: Seismic Ground Motion Values

Parameter		Value[1]
Mapped Acceleration Parameters	Spectral Acceleration, 0.2 second (S_s)	0.395g
	Spectral Acceleration, 1.0 second (S_1)	0.165g
Coefficients (Site Class D)	Site Coefficient, 0.2 sec. (F_A)	1.484
	Site Coefficient, 1.0 sec. (F_V)	2.139
Adjusted MCE Spectral Response Parameters	MCE Spectral Acceleration, 0.2 sec. (S_{MS})	0.587g
	MCE Spectral Acceleration, 1.0 sec. (S_{M1})	0.353g
Design Spectral Response Accelerations	Design Spectral Acceleration, 0.2 seconds (S_{DS})	0.391g
	Design Spectral Acceleration, 1.0 second (S_{D1})	0.236g

[1]Value presented for design under 2010 OSSC and is subject to change with building code updates. The geotechnical engineer should be consulted to finalize recommendations for seismic design at the time of building design.

2 United States Geological Survey, 2014. Seismic Design Parameters determined using:, "U.S. Seismic Design Maps Web Application - Version 3.1.0," from the USGS website http://earthquake.usgs.gov.

11.0 RECOMMENDED ADDITIONAL SERVICES

11.1 Design Review

Geotechnical design review of project plans is of paramount importance, particularly for large or complex projects. As indicated previously, we recommend the geotechnical engineer be consulted to review project plans as they are being developed to provide supplemental recommendations for design and construction.

11.2 Observation of Construction

Satisfactory earthwork, foundation, floor slab, and pavement performance depends to a large degree 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. Subsurface conditions observed during construction should be compared with those encountered during subsurface explorations, and recognition of changed conditions often requires experience. We recommend qualified personnel visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those observed to date and anticipated in this report.

We recommend the geotechnical engineer or his representative attend a pre-construction meeting coordinated by the contractor and/or owner. The geotechnical engineer or his representative should provide observations and/or testing of at least the following earthwork elements during construction:

- Site Stripping and Grubbing
- Subgrade Preparation for Structural Fills, Shallow Foundations, Floor Slabs, and Pavements
- Compaction of Structural Fill, Foundation Backfill, and Utility Trench Backfill
- Placement of Foundation Drains
- Compaction of Floor Slab Base Rock and Pavement Base Rock
- Compaction of Asphaltic Concrete for Pavements

It is imperative that the owner and/or contractor request earthwork observations and testing at a frequency sufficient to allow the geotechnical engineer to provide a final letter of compliance for the earthwork activities.

12.0 LIMITATIONS & CLOSURE

We have prepared this report for use by OSU Cascades and other members of the design and construction team for the proposed development. The opinions and recommendations contained within this report are not intended to be, nor should they be construed as, a warranty of subsurface conditions, but are forwarded to assist in the planning and design process.

We have made observations based on our explorations that indicate the soil conditions at only those specific locations and only to the depths penetrated. These observations do not necessarily reflect soil types, strata thickness, or water level variations that may exist between or away from those explorations.

If subsurface conditions vary from those encountered in the site explorations, CGT should be alerted to the change in conditions so that we may provide additional geotechnical recommendations, if necessary. Observation by experienced geotechnical personnel should be considered an integral part of the construction process.

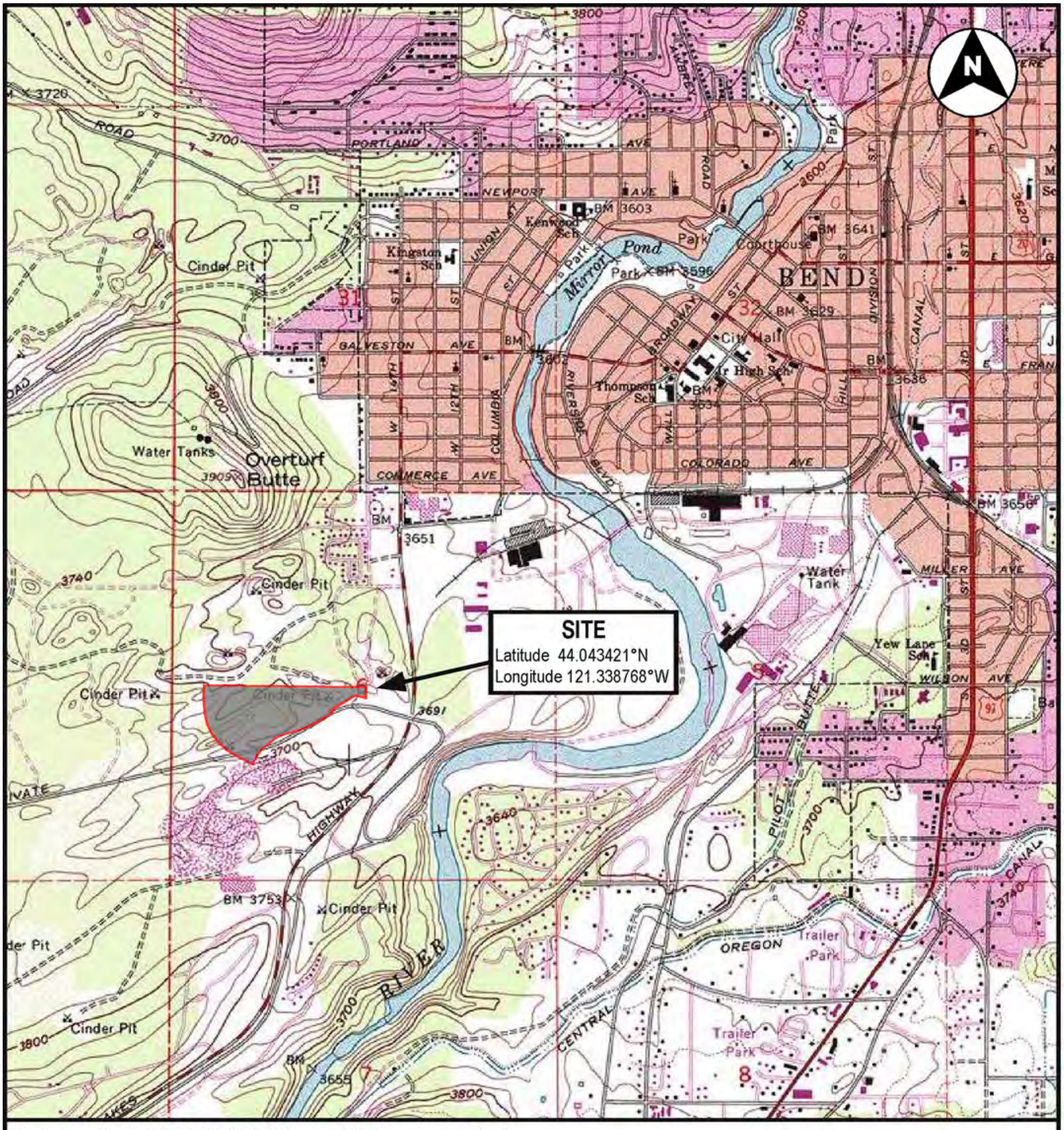
The owner is responsible for insuring that the project designers and contractors implement our recommendations. When the design has been finalized, prior to releasing bid packets to contractors, we recommend that the design drawings and specifications be reviewed by our firm to see that our recommendations have been interpreted and implemented as intended. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification. Design review is beyond the scope of our current assignment, but can be provided for an additional fee.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design.

Geotechnical engineering and the geologic sciences are characterized by a degree of uncertainty. Professional judgments presented in this report are based on our understanding of the proposed construction, familiarity with similar projects in the area, and on general experience. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared; no warranty, expressed or implied, is made. This report is subject to review and should not be relied upon after a period of 3 years.

SITE LOCATION

OSU CASCADES 46-ACRE SITE - BEND, OREGON



Map created with TOPO!™, © 2006 National Geographic Holdings
USGS 7.5 Minute Topographic Map Series, Bend, Oregon Quadrangle.

Township 18 South, Range 12 East, Section 6 Willamette Meridian

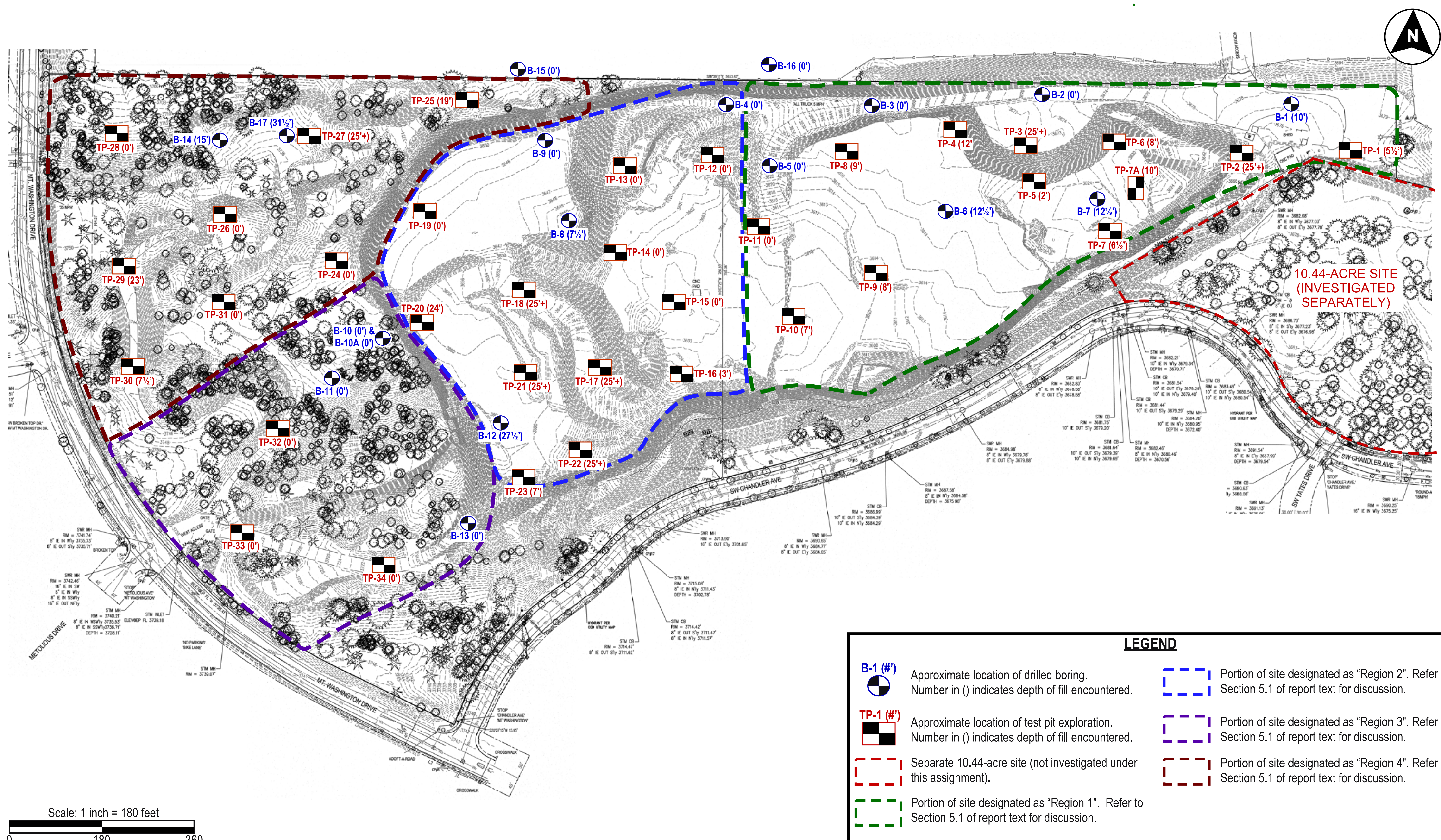
Approximate Scale: 1 inch = 2,000 feet

0 2000 4000

CARLSON CGT GEOTECHNICAL 503-601-8250
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.A

FIGURE 1



Carlson Geotechnical P.O. Box 23814 Tigard, Oregon 97281 503-601-8250	**SITE PLAN** ***OSU CASCADES 46-ACRE SITE - BEND, OREGON***	**CGT Job No. G1303959.A**	**FIGURE 2**

Drilled Boring	Latitude (deg)	Longitude (deg)	Surface Elevation* (feet)
B-01	44.0441	-121.3345	3677
B-02	44.0442	-121.3365	3671
B-03	44.0441	-121.3378	3652
B-04	44.0441	-121.3389	3625
B-05	44.0437	-121.3386	3625
B-06	44.0434	-121.3373	3617
B-07	44.0437	-121.3360	3625
B-08	44.0435	-121.3400	3651
B-09	44.0439	-121.3404	3648
B-10	44.0429	-121.3414	3702
B-11	44.0426	-121.3417	3710
B-12	44.0423	-121.3406	3661
B-13	44.0417	-121.3409	3710
B-14	44.0439	-121.3426	3732
B-15	44.0443	-121.3406	3705
B-16	44.0444	-121.3387	3695
B-17	44.0439	-121.3420	3710

Test Pit	Latitude (deg)	Longitude (deg)	Surface Elevation* (feet)
TP-01	44.0438	-121.3341	3678
TP-02	44.0439	-121.3349	3671
TP-03	44.0439	-121.3366	3672
TP-04	44.0439	-121.3371	3618
TP-05	44.0437	-121.3366	3625
TP-06	44.0439	-121.3361	3623
TP-07	44.0434	-121.3359	3623
TP-07A	44.0437	-121.3357	3620
TP-08	44.0438	-121.3380	3617
TP-09	44.0432	-121.3378	3614
TP-10	44.0430	-121.3384	3608

Test Pit	Latitude (deg)	Longitude (deg)	Surface Elevation* (feet)
TP-11	44.0434	-121.3388	3609
TP-12	44.0438	-121.3391	3601
TP-13	44.0438	-121.3397	3588
TP-14	44.0433	-121.3398	3600
TP-15	44.0431	-121.3394	3601
TP-16	44.0426	-121.3392	3606
TP-17	44.0427	-121.3399	3637
TP-18	44.0432	-121.3405	3650
TP-19	44.0436	-121.3412	3648
TP-20	44.0430	-121.3412	3659
TP-21	44.0427	-121.3404	3656
TP-22	44.0423	-121.3400	3651
TP-23	44.0421	-121.3404	3670
TP-24	44.0432	-121.3417	3707
TP-25	44.0441	-121.3407	3710
TP-26	44.0435	-121.3426	3723
TP-27	44.0439	-121.3419	3734
TP-28	44.0441	-121.3433	3713
TP-29	44.0432	-121.3433	3741
TP-30	44.0426	-121.3432	3745
TP-31	44.0430	-121.3425	3710
TP-32	44.0424	-121.3421	3726
TP-33	44.0418	-121.3424	3734
TP-34	44.0416	-121.3414	3721

*Surface Elevations determined from provided topographic plan (reproduced and shown on Figure 2) and should be considered approximate.

CARLSON CGT GEOTECHNICAL 503-601-8250

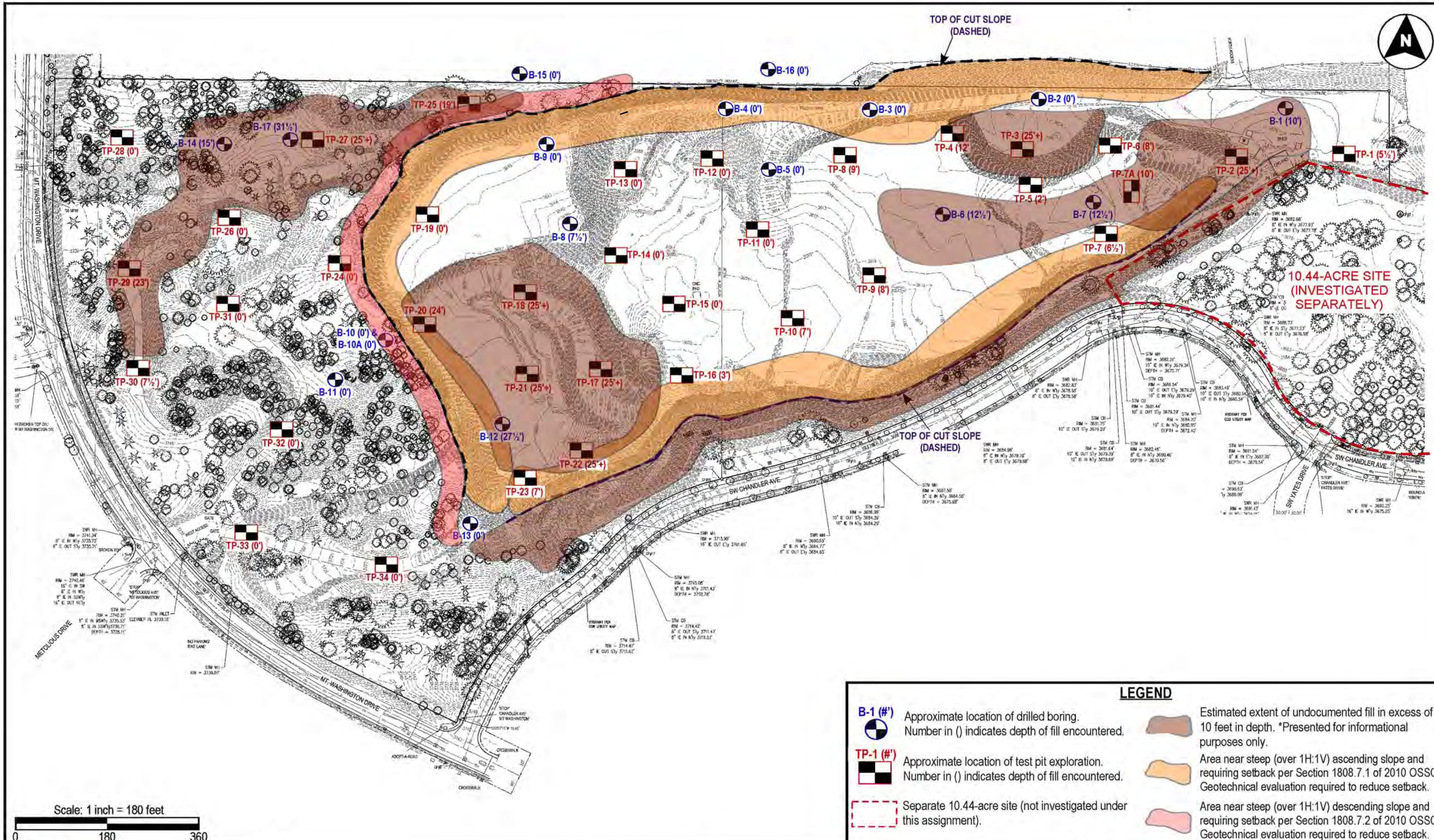
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

OSU CASCADES 46-ACRE SITE

EXPLORATION COORDINATES

CGT Project No. G1303959.A

FIGURE 3



LEGEND

B-1 (#')	Approximate location of drilled boring. Number in () indicates depth of fill encountered.
TP-1 (#')	Approximate location of test pit exploration. Number in () indicates depth of fill encountered.
	Separate 10.44-acre site (not investigated under this assignment).
	Estimated extent of undocumented fill in excess of 10 feet in depth. *Presented for informational purposes only.
	Area near steep (over 1H:1V) ascending slope and requiring setback per Section 1808.7.1 of 2010 OSSC. Geotechnical evaluation required to reduce setback.
	Area near steep (over 1H:1V) descending slope and requiring setback per Section 1808.7.2 of 2010 OSSC. Geotechnical evaluation required to reduce setback.

CARLSON CGT GEOTECHNICAL 503-601-8250
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

SUPPLEMENTAL SITE PLAN

OSU CASCADES 46-ACRE SITE - BEND, OREGON

CGT Job No. G1303959.A

FIGURE 4

Appendix A: Geologic & Seismic Setting

OSU-Cascades 46-acre Site
1707 & 1757 Simpson Avenue
Bend, Oregon

CGT Project No. G1303959.A

July 25, 2014

Prepared For:

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

Prepared By:

Carlson Geotechnical

A.1.1 Regional Geology

The site is located in central Oregon, along the eastern margin of the High Cascades geologic province. Cascade volcanism was triggered during the Eocene when the Farallon plate began subducting beneath the North American plate. Andesitic lavas and tuffs erupting from the western Cascades covered the region, with volcanism continuing episodically through the Oligocene. The Western Cascades were subjected to tilting and folding during the middle Miocene, followed by a period of intense, widespread volcanism that included the eruption of the Columbia River Basalts to the northeast and other eruptions to the southeast. The active volcanism narrowed to an area only slightly wider than the present High Cascade Range by about 7 million years ago. The Western Cascades were subjected to uplift, mild folding, and faulting between 4 and 5 million years ago[1], followed by the eruption of numerous large shield volcanoes during the Pliocene, which gave rise to the High Cascades. The High Cascades are composed primarily of basalt, interspersed with tuffs and ash-flows. Glaciation during the Pleistocene eroded the volcanoes into horns and arêtes, and redistributed volcanic sediments into the surrounding basins. Many of the High Cascade Volcanoes are considered active or potentially active.

A.1.2 Local Geology

Available geological mapping of the area[2,3] indicates that the site and immediate vicinity are underlain by Pleistocene pyroclastic deposits. These include the Shevlin Park Tuff, Tumalo Tuff, and Bend Pumice.

The Shevlin Park Tuff (Qs) is a dark gray, andesitic ash flow tuff and is the youngest of the Pleistocene pyroclastic deposits mapped in the area, with an age of approximately 170,000 years. Comprised of two pyroclastic flows, the Shevlin Park Tuff consists of a lower, densely welded, ash-rich deposit overlain by an upper, pumice-rich deposits that exhibit vapor phase crystallization (post-depositional hardening). A maximum thickness of about 150 feet is indicated in the literature.

The Tumalo Tuff (Qtu) and Bend Pumice (Qb) are thought to represent a single eruptive sequence with an age of approximately 200,000 to 400,000 years. The deposits consist of a lower airfall tephra deposit (Bend Pumice) and overlying pyroclastic flow deposit (Tumalo Tuff). These deposits are generally light gray to pinkish gray and are dominated by rhyolitic to dacitic ash and lapilli pumice with varying basalt and other lithic fragments. Welding or vapor phase crystallization has produced hardened zones within these units and is variable. A maximum thickness of about 80 feet is indicated in the literature.

The Desert Spring Tuff (Qds) is a rhyodacitic ash flow tuff with an age of approximately 600,000 to 700,000 years. The ashy matrix ranges in color from dark gray to brownish orange, and contains dark-gray, pumiceous lapilli and basaltic lithic fragments. The lower portion of the unit is partially welded and displays columnar jointing. A thickness of about 15 to 35 feet is indicated in the literature.

---

1. Orr, Elizabeth L. and Orr, William N., Geology of Oregon, fifth edition. Kendall/Hunt Publshing Company, 2000.
2. Sherrod, David R., et al., 2004. Geologic Map of the Bend 30- X 60-Minute Quadrangle, Central Oregon. United States Geological Survey, Geologic Investigations Series Map I-2683.
3. Mimura, Koji, 1992. Reconnaissance Geologic Map of the West Half of the Bend and the East Half of the Shevlin Park 7½' quadrangles, Deschutes County, Oregon. . United States Geological Survey, Miscellaneous Field Studies Map MF-2189.

A.1.3 Local Topography

The site is located on a relatively flat bench west of the Deschutes River in southwestern Bend, Oregon. Topography in the vicinity of the site is shown on the Bend, Oregon, 7½ minute quadrangle[4], excerpted on Figure 1 of the geotechnical report. The topographic map does not show areas of hummocky topography or steep, arcuate-shaped slopes typical of ancient landslides in the immediate vicinity of the site.

The majority of the site (central and eastern portions) is occupied by an inactive pumice pit. At the time of our fieldwork, the pit bottom was generally uneven and ascended to the west. The pit sidewalls ranged in height from about 30 to 80 feet, with slope gradients ranging from near-vertical to about 1H:1V (Horizontal:Vertical). No obvious signs of recent or on-going instability were noted during our reconnaissance of the site.

A.1.4 Earthquake Sources & Seismicity

The site is located in a tectonically active area that may be affected by crustal earthquakes, intra-slab earthquakes, or large subduction zone earthquakes.

A.1.4.1 <u>Crustal Sources</u>

Crustal earthquakes typically occur at depths ranging from 15 to 40 kilometers (about 9 to 25 miles) bgs[5]. A search was performed on the USGS website[6] to identify known crustal seismic sources within 40 kilometers (about 25 miles) of the project site. Our review identified several sources, which are summarized in Table A1 and described in detail in the following sections.

---

4 United States Geologic Survey, 1979. Topographic map of the Airlie South, Oregon, 7.5 Minute Quadrangle.
5 Geomatrix Consultants, 1995. Seismic Design Mapping, State of Oregon: unpublished report prepared for Oregon Department of Transportation, Personal Services Contract 11688, January 1995.
6 U.S. Geologic Survey, 2012. Quaternary Fault and Fold Database, http://earthquake.usgs.gov/qfaults/

Table A1: Fault, Characteristic Earthquake Magnitude, and Distance from Site[5]

USGS Fault No.	Earthquake Source	Char. Mag	Type of Fault	USGS Fault Class^ʎ^	Fault Orientation (strike & dip)	Approximate Earthquake depth	Fault Trace Distance & Direction from Site
838	La Pine graben faults	6.0[Ŧ]	Normal	A	N0E 60 to 70 W	15 to 40 km (9 to 25 miles)	31 km (19 miles) SW
841	Unnamed faults near Millican Valley	6.0[Ŧ]	Right Lateral Strike Slip	A	N54W 90 (Vertical)	15 to 40 km (9 to 25 miles)	22 km (14 miles) SW
842	Unnamed faults near Kiwa Butte	6.0[Ŧ]	Normal	A	N45W 90 (Vertical)	15 to 40 km (9 to 25 miles)	17 km (10 miles) SW
852	Sisters fault zone	6.7[β]	Normal	A	N26W 90 (Vertical)	15 to 40 km (9 to 25 miles)	3 km (2 miles) NE
853b	Metolius fault zone, Rimrock-Tumalo section	7.4[β]	Normal	A	N29W 70-90 SW	15 to 40 km (9 to 25 miles)	60 meters (200 feet)WSW
853c	Metolius fault zone, Northwest Rift section	7.4[β]	Normal	A	N26W 70 SW	15 to 40 km (9 to 25 miles)	4 km (2½ miles) W

ʎ USGS Fault Classes from USGS Earthquake Hazards Program, 2002 National Seismic Hazard Maps
Class A: Fault with convincing evidence of Quaternary activity (ACTIVE)
Class B: Fault that requires further study in order to confidently define earthquake potential (POTENTIALLY ACTIVE)
Ŧ Characteristic earthquake magnitude from Section 1803.3.2.1 of the 2010 OSSC - Design Earthquake.
β Characteristic earthquake magnitude from USGS Earthquake Hazards Program, 2002 National Seismic Hazard Maps – Fault Parameters.

A.1.4.1.1 La Pine Graben faults (USGS 838)

The buried La Pine Graben is a composite of two grabens separated by north-northeast trending Pliocene and Pleistocene lava, situated between Newberry Volcano and the axis of the High Cascades[7]. These structures consist of a group of normal faults that may be volcanic in origin[8]. The La Pine graben faults primarily offset Miocene volcanic rock and Plio-Pleistocene bedrock. The Dilman Meadows fault, a La Pine graben fault discovered in 2001, appears to offset glacial outwash deposits as well as several younger alluvial deposits. Some of the offset alluvial deposits contain tephra from the Mount Mazama eruption from approximately 7,600 years ago[9]. Based on the available cross-cutting relationships and slip rates, the anticipated recurrence interval for the La Pine graben faults is in excess of 7,000 years. However, it should be noted that most of the faults associated with the La Pine graben have a much longer anticipated recurrence interval, based on their most recent movements.

7 Geomatrix Consultants, 1995. *Ibid*.
8 Personius, S.F., compiler, 2002. Fault number 838, La Pine graben faults, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.
9 Personius, S.F., compiler, 2002. Fault number 838, La Pine graben faults, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

A.1.4.1.2 Unnamed faults near Millican Valley (USGS 841)

The Unnamed faults near Millican Valley consist of a 40-kilometer-long group of northwest-trending right-lateral strike-slip faults[10]. No Quaternary fault scarps had been identified, however, upper Miocene to Pleistocene volcanic rocks have been offset, suggesting recent deformation. Slip rates indicate very long recurrence intervals.

A.1.4.1.3 Unnamed faults near Kiwa Butte (USGS 842)

The Unnamed faults near Kiwa Butte consist of a 7-kilometer-long group of northwest-trending normal faults which parallel the volcanoes in the late Quaternary Mount Bachelor volcanic chain[11]. No fault scarps have been identified, but aerial photograph analysis suggests Quaternary displacement.

A.1.4.1.4 Sisters fault zone (USGS 852)

The Sisters fault zone consists of numerous, northwest striking normal faults within a 20-kilometer-wide by 52-kilometer-long fault zone[12]. Individual faults within this zone are discontinuous and generally short (less than 8 kilometers in length). Based on the available literature, the sense of movement along the fault zone is unclear, but is usually considered to be a high-angle normal fault with a considerable strike-slip component. Similarly, dip direction and angle are not well defined, so are generally considered to be near vertical. Its structural role is uncertain, and it is thought that it may represent a structural transition between the Brothers and Metolius Fault zones (located to the southeast and south, respectively), the eastern boundary of the High Cascades Province, or the northern apex of the Basin and Range Province.

The Sisters fault potentially offsets glacial deposits, suggesting activity as recent as 10,000 years ago[13]. However, a 2001 study indicates that the youngest deformation occurred approximately 100,000 years before present[14]. Other portions of the fault, such as in the area of the site, range in age of most recent deformation from 50,000 to 700,000 years before present[15].

A.1.4.1.5 Metolius fault zone (USGS 853)

The Metolius fault zone consists of numerous, mostly southwest-dipping normal faults within a 94-kilometer-long fault zone[16]. The Metolius fault zone likely forms part of the eastern boundary of the Cascades graben. Due to the complex and variable nature of the Metolius fault zone, it is typically split into the Green Ridge, Rimrock-Tumalo, and Northwest Rift zone sections. Two of these sections are mapped within 40 kilometers of the site, as follows:

---

10 Personius, S.F., compiler, 2002. Fault number 841, Unnamed faults near Millican Valley, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

11 Personius, S.F., compiler, 2002. Fault number 842, Unnamed faults near Kiwa Butte, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

12 Personius, S.F., compiler, 2002. Fault number 852, Sisters fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

13 Geomatrix Consultants, 1995. *Ibid.*

14 Ake, J., LaForge, R., and Hawkins, F., 2001. Probabilistic Seismic Hazard Analysis for Wickiup Dam – Deschutes project, central Oregon: U.S. Bureau of Reclamation Seismotectonic Report 2000-04.

15 Personius, S.F., compiler, 2002. Fault number 852, Sisters fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

16 Personius, S.F., compiler, 2002. Fault number 853, Metolius fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

Rimrock-Tumalo section (USGS 853b)

The Rimrock-Tumalo section of the Metolius fault zone consists of a 45-kilometer-long series of high-angle normal faults[17]. Faults within this section offset the Pleistocene Bend Pumice, Tumalo Tuff, and Shevlin Park Tuff, as well as some of the overlying alluvial and glacial outwash deposits. The age of most recent deformation is estimated as Late Quaternary (less than 130,000 years), with a very low (less than 0.2 mm/year) slip rate and no estimated recurrence interval.

Northwest Rift zone section (USGS 853c)

The Northwest Rift zone section of the Metolius fault zone consists of a 43-kilometer-long series of high-angle normal faults located at the northwest end of Newberry Crater. Aerial photograph analysis suggests possible Holocene displacement of Newberry volcanics, but no unequivocal evidence has been identified supporting such activity. The return interval is considered to be at least 5,000 years, but is likely on the order of 15,000 years or more[18].

A.1.4.2 Cascadia Subduction Zone Seismic Sources

The Cascadia Subduction Zone (CSZ) is a 1,000-kilometer-long (620-mile) zone of active tectonic convergence where oceanic crust of the Juan De Fuca Plate is subducting beneath the North American continental plate at a rate of about 3 to 4 centimeters (1¼ inches) per year[19]. The fault trace is located off of the Oregon Coast, approximately 325 kilometers (200 miles) west of the site. Two primary sources of seismicity are associated with the CSZ: the interface between the two plates, and faulting within the subducting plate. These sources are detailed below. The location of the CSZ and associated sources of seismicity are shown on the attached Figure A1.

A.1.4.2.1 Plate Interface Source

Very little seismicity has occurred on the plate interface in historic time, and as a result, the seismic potential of the CSZ is a subject of scientific controversy. The lack of seismicity may be interpreted as a period of quiescent stress buildup between large magnitude earthquakes, or characteristic of the long-term behavior of the subduction zone. A growing body of geologic evidence; however, strongly suggests that large prehistoric subduction zone earthquakes have occurred[20,21,22,23]. This evidence includes: (1) buried tidal marshes recording episodic, sudden subsidence along the coast of northern California, Oregon, and Washington; (2) burial of subsided tidal marshes by tsunami wave deposits; (3) paleoliquefaction features; and (4) geodetic uplift patterns on the Oregon Coast. Radiocarbon dates on buried tidal marshes indicate a recurrence interval

---

17 Personius, S.F., compiler, 2002. Fault number 853b, Metolius fault zone, Rimrock-Tumalo section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

18 Personius, S.F., compiler, 2002. Fault number 853c, Metolius fault zone, Northwest Rift zone section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.

19 DeMets, C., Gordon, R.G., Argus, D.F., Stein, S., 1990. Current plate motions: Geophysical Journal International, v. 101, p. 425-478.

20 Geomatrix Consultants, 1995. *Ibid*.

21 Atwater, B.F., 1992. Geologic evidence for earthquakes during the past 2,000 years along the Copalis River, southern coastal Washington: Journal of Geophysical Research, v. 97, p. 1901-1919.

22 Carver, G., 1992. Late Cenozoic tectonics of coastal northern California: American Association of Petroleum Geologists-SEPM Field Trip Guidebook, May, 1992.

23 Peterson, C.D., Darioenzo, M.E., Burns, S.F., and Burris, W.K., 1993. Field trip guide to Cascadia paleoseismic evidence along the northern California coast: evidence of subduction zone seismicity in the central Cascadia margin: Oregon Geology, v. 55, p. 99 144.

for major subduction zone earthquakes of 250 to 650 years, with the last major event occurring 300 years ago[24,25,26,27,28]. Due to the lack of historical data on large subduction zone earthquakes, a typical depth for the occurrence of a subduction zone earthquake was inferred from models presented by the USGS and Geomatrix Consultants in 1995[29], and is roughly 10 to 25 kilometers (about 6 to 16 miles) bgs. This spans an approximate 75-kilometer (42-mile) wide area roughly centered on the Oregon coastline, with its eastern margin located approximately 210 kilometers (130 miles) west of the site.

A.1.4.2.2 Intra-Slab Source

The subducting Juan De Fuca (oceanic) Plate dips at an angle of 10 to 20 degrees as it descends beneath the North American plate. The curvature of the subducted plate increases as the advancing edge moves east, creating extensional forces within the plate. Normal faulting occurs in response to these extensional forces. This region of maximum curvature and faulting of the slab is where large intra-slab earthquakes are expected to occur, and is located at depths ranging from 30 to 60 kilometers (18 to 37 miles)[30], approximately 100 kilometers (62 miles) west of the site[31] (see attached Figure A1). Historically, the seismicity rate within the Juan De Fuca Plate beneath Oregon is very low in northern Oregon and southwest Washington, and extremely low along the southern and central Oregon coast[32,33,34].

A.1.4.3 Historical Earthquakes

The following table lists earthquakes with magnitudes larger than M4.9 that have occurred within 300 kilometers (186 miles) of the project since 1873[35].

[24] Geomatrix Consultants, 1995. *Ibid*.
[25] Atwater, B.F., 1992. *Ibid*.
[26] Carver, G., 1992. *Ibid*.
[27] Peterson, C.D., Darioenzo, M.E., Burns, S.F., and Burris, W.K., 1993. *Ibid*.
[28] Personius, S.F., and Nelson, A.R., compilers, 2005. Fault number 781, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.
[29] Geomatrix Consultants, 1995. *Ibid*.
[30] Geomatrix Consultants, 1995. *Ibid*.
[31] McCrory, Blair, Oppenheimer, and Walter, 2004. Depth to the Juan de Fuca slab beneath the Cascadia subduction margin – A 3-D model for storing earthquakes: U.S. Geological Survey Data Series 91.
[32] Geomatrix Consultants, 1995. *Ibid*.
[33] Geomatrix Consultants, 1993. Seismic margin Earthquake For the Trojan Site: Final Unpublished Report For Portland General Electric Trojan Nuclear Plant, Rainier, Oregon, May 1993.
[34] Personius, S.F., and Nelson, A.R., compilers, 2005. Fault number 781, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults.
[35] Wong et al, 2000. Wong, I. Silva, W. Bott, J., Wright, D., Thomas, P., Gregor, N., Li, S., Mabey, M., Sojourner, A., Wang, Y. IMS-15. Earthquake Scenario and Probabilistic Ground Shaking Maps for the Portland, Oregon, Metropolitan area. Portland Hills Fault M6.8 Earthquake, Peak Horizontal Acceleration at the Ground Surface.

Table A2: Historical Earthquakes (M4.9 or greater) within 300 kilometers (186 miles) of the site since 1873

Date	Magnitude	Distance from Site	Approximate Location
March 25, 1993	M5.6	149 km (93 miles)	23 km (14 miles) ESE of Woodburn, OR (Scotts Mills)
July 19, 1930	M5.0	182 km (113 miles)	15 km (9 miles) WNW of Salem, OR
October 12, 1877	M5.4*	186 km (116 miles)	10 km (6 miles) ESE of Portland, OR
December 29, 1941	M5.0	194 km (121 miles)	1 km (1 miles) S of Portland, OR
December 16, 1953	M5.0	194 km (121 miles)	7 km (4 miles) WSW of Portland, OR
September 21, 1993	M6.0	197 km (122 miles)	24 km (15 miles) ESE of Mt McLoughlin, OR
November 06, 1962	M5.5	199 km (124 miles)	8 km (5 miles) NNE of Portland, OR
September 21, 1993	M5.9	201 km (125 miles)	23 km (14 miles) WNW of Klamath Falls, OR
December 04, 1993	M5.1	202 km (126 miles)	20 km (12 miles) WNW of Klamath Falls, OR
May 30, 1968	M5.1	226 km (140 miles)	16 km (10 miles) NNE of Adel, OR
September 17, 1961	M5.1	228 km (142 miles)	20 km (12 miles) SSE of Mt St Helens, WA
June 03, 1968	M5.0	235 km (146 miles)	10 km (6 miles) NE of Adel, OR
November 17, 1957	M5.0	239 km (149 miles)	18 km (11 miles) S of Tillamook, OR
March - May, 1980	M4.9 - M5.2	250 km (155 miles)	27 events at Mt St Helens, WA
May 18, 1980	M5.7	249 km (155 miles)	1 km (1 miles) NNE of Mt St Helens, WA

* Estimated from historical accounts.

A.1.5 Seismic Hazards

A.1.5.1 Liquefaction

In general, liquefaction occurs when deposits of loose/soft, saturated, cohesionless soils, generally sands and silts, are subjected to strong earthquake shaking. If these deposits cannot drain quickly enough, pore water pressures can increase, approaching the value of the overburden pressure. The shear strength of a cohesionless soil is directly proportional to the effective stress, which is equal to the difference between the overburden pressure and the pore water pressure. When the pore water pressure increases to the value of the overburden pressure, the shear strength of the soil reduces to zero, and the soil deposit can liquefy. The liquefied soils can undergo rapid consolidation or, if unconfined, can flow as a liquid. Structures supported by the liquefied soils can experience rapid, excessive settlement, shearing, or even catastrophic failure.

The susceptibility of sands, gravels, and sand-gravel mixtures to liquefaction is typically assessed based on penetration resistance, as measured using SPTs, CPTs, or Becker Hammer Penetration tests (BPTs). For fine-grained soils, susceptibility to liquefaction is evaluated based on penetration resistance and plasticity, among other characteristics. Criteria for identifying non-liquefiable, fine-grained soils are constantly evolving. Current practice to identify non-liquefiable, fine-grained soils is based on plasticity characteristics of the soils, as follows: (1) liquid limit greater than 47 percent, (2) plasticity index greater than 20 percent, and (3) moisture content less than 85 percent of the liquid limit[36].

[36] Seed, R.B. et al., 2003. Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework. Earthquake Engineering Research Center Report No. EERC 2003-06.

Based on the lack of saturated conditions and generally dense conditions, the on-site soils are considered non-liquefiable.

A.1.5.2 Seismically-Induced Slope Instability

As described in the geotechnical report, the sidewalls of the former pumice pit ranged in height from about 30 to 80 feet, with slope gradients ranging from near-vertical to about 1H:1V (Horizontal:Vertical). Slopes with such heights and gradients are generally more susceptible to slope instability. Seismic shaking can induce slope failures, including landslides and rockfall, on otherwise stable (or marginally stable) slopes. As noted above, several potential sources for earthquakes are located in the region of the site. Accordingly, it is our opinion that the risk of seismically-induced slope instability at the site is at least moderate.

Quantitative slope stability analyses could be performed to further refine the level of risk associated with seismically-induced slope instability at the site. Such analysis was beyond the scope of this assignment, but could be performed for an additional fee. In the absence of additional analysis, the recommendations regarding slope setback presented in the geotechnical report should be adhered to in development of the site.

A.1.5.3 Surface Rupture

A.1.5.3.1 Faulting

The site is located within the Rimrock-Tumalo section of the Metolius fault zone. One fault strand is mapped within approximately 200 feet of the site, located to the west-southwest. As indicated in Section A.1.4.1.5 above, faults within this section offset the Pleistocene Bend Pumice, Tumalo Tuff, and Shevlin Park Tuff, which underly the site, as well as some of the overlying alluvial and glacial outwash deposits. The USGS has assigned a very low (less than 0.2 mm/year) slip rate and has not assigned a recurrence interval for this section, with the age of most recent deformation estimated as Late Quaternary (less than 130,000 years).

In addition to the mapped faults, we identified locations within the pumice pit where faulting and offset of the Pleistocene Bend Pumice and Tumalo Tuff was apparent. Offset on these faults was generally on the order of a few inches to several feet. These faults are likely related to the mapped fault zone. It was not readily apparent whether the observed faults offset the overlying alluvium, and detailed mapping was not performed. Photographs showing examples of the observed faulting and jointing are included in Appendix B.

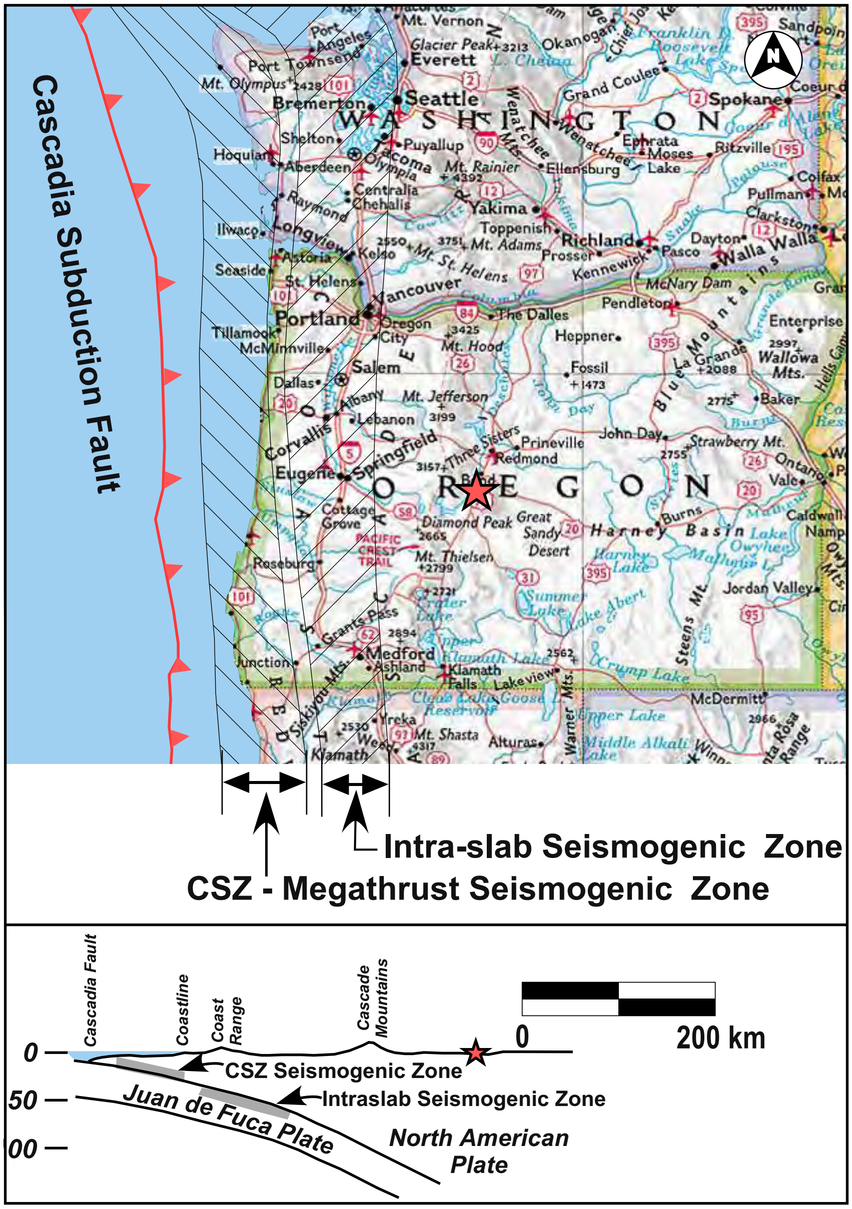
Recognizing the low slip rates assigned to these faults and the lack of evidence suggesting recent deformation, the risk of surface rupture at the site due to faulting is generally considered low. Detailed investigation of the faults observed at the site could be performed to further characterize this risk. Such investigation might include detailed mapping of the faults, trenching across the fault traces, geophysical surveys, lidar or other high-resolution ground surveys, etc.

A.1.5.3.2 Lateral Spread

Surface rupture due to lateral spread can occur on sites underlain by laterally continuous liquefiable soils that are located on or immediately adjacent to slopes steeper than about 3 degrees (20H:1V), and/or adjacent to a free face, such as a stream bank or the shore of an open body of water. During lateral spread, the materials overlying the liquefied soils are subject to lateral movement downslope or toward the free face. Given the lack of liquefiable soils at the site, the risk of surface rupture due to lateral spread is considered negligible.

OSU CASCADES 46-ACRE SITE - BEND, OREGON

CASCADIA SUBDUCTION ZONE



SITE LOCATION

McCrory, Blair, Oppenheimer, and Walter, 2004. Depth to the Juan de Fuca slab beneath the Cascadia subduction margin - A 3-D model for storing earthquakes: U.S. Geological Survey Data Series 91.

Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.A

FIGURE A1

Appendix B: Site Photographs

OSU-Cascades 46-acre Site
1707 & 1757 Simpson Avenue
Bend, Oregon

CGT Project No. G1303959.A

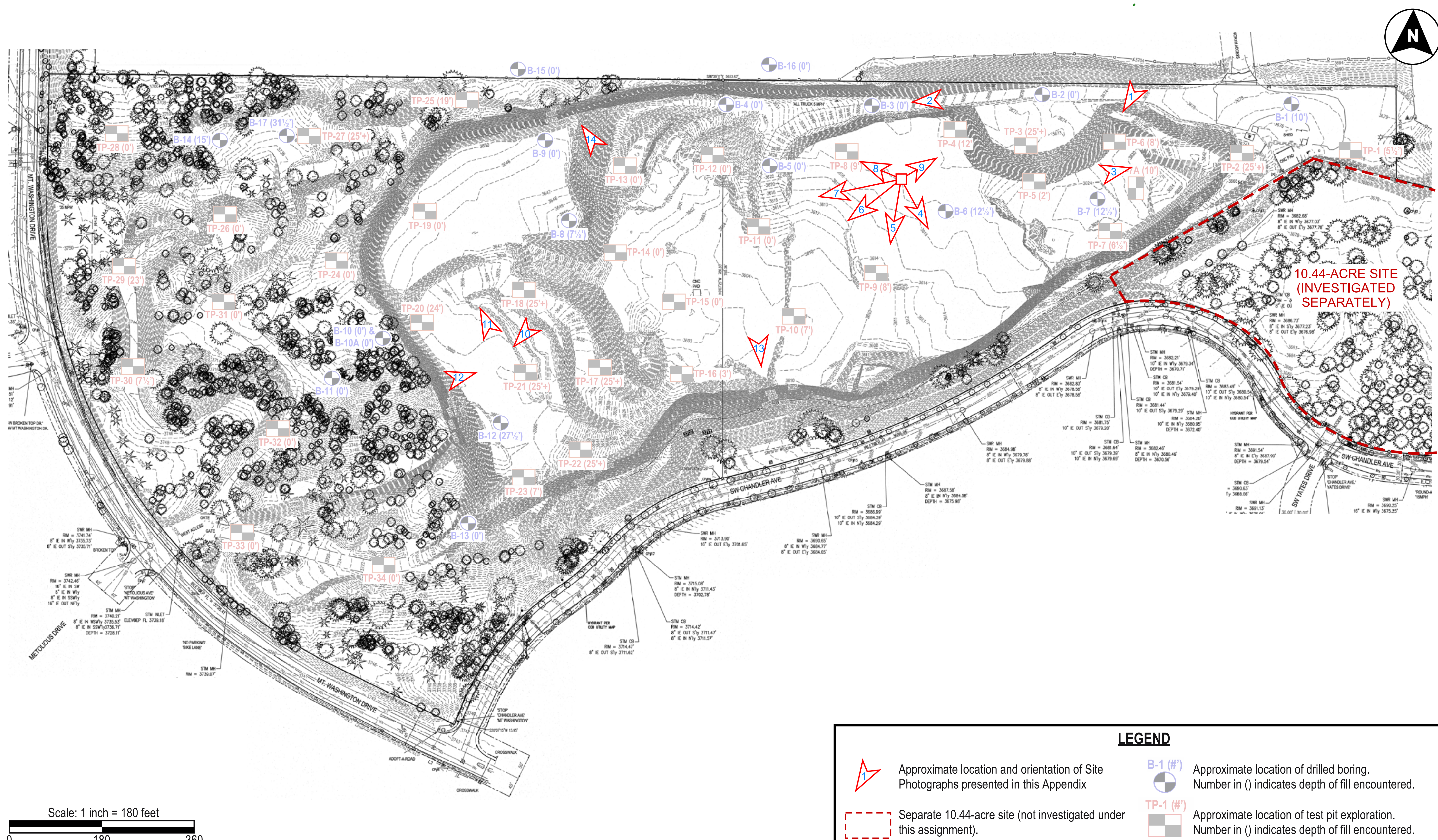
July 25, 2014

Prepared For:

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

Prepared By:

Carlson Geotechnical



LEGEND

Approximate location and orientation of Site Photographs presented in this Appendix

Separate 10.44-acre site (not investigated under this assignment).

B-1 (#') Approximate location of drilled boring. Number in () indicates depth of fill encountered.

TP-1 (#') Approximate location of test pit exploration. Number in () indicates depth of fill encountered.

Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CARLSON CGT GEOTECHNICAL 503-601-8250

SITE PLAN SHOWING PHOTOGRAPH LOCATIONS

OSU CASCADES 46-ACRE SITE - BEND, OREGON

CGT Job No. G1303959.A

FIGURE B1

OSU CASCADES 46-ACRE SITE - BEND, OREGON
SITE PHOTOGRAPHS

Photograph 1

Photograph 2

OSU CASCADES 46-ACRE SITE - BEND, OREGON
SITE PHOTOGRAPHS

Photograph 3

Photograph 4

Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

OSU CASCADES 46-ACRE SITE - BEND, OREGON
SITE PHOTOGRAPHS

Photograph 5

Photograph 6

CARLSON CGT GEOTECHNICAL 503-601-8250
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.A

APPENDIX B

Photograph 7

Photograph 8

Photograph 9

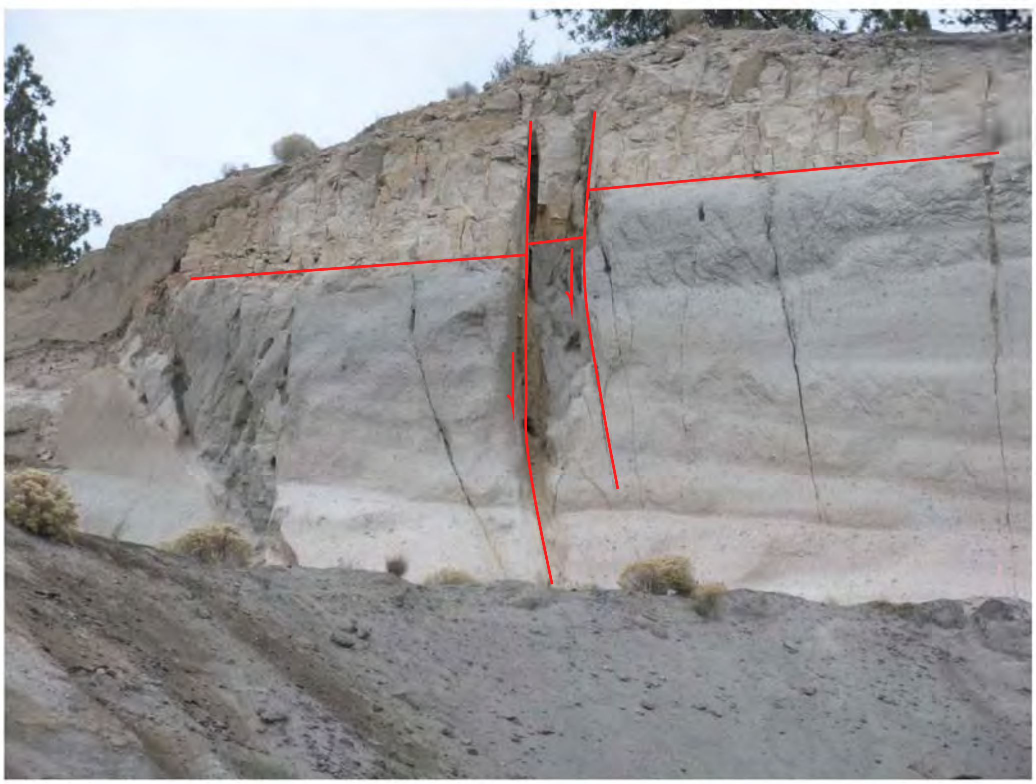
Photograph 10

Photograph 11

Photograph 12

OSU CASCADES 46-ACRE SITE - BEND, OREGON
SITE PHOTOGRAPHS

Photograph 13:
Showing extensive jointing and concrete patching.



Photograph 14:
Showing example of observed faulting. Red lines indicate fault traces, geologic contact marker, and relative offset.

Carlson Geotechnical
A Division of Carlson Testing, Inc.
Phone: (503) 601-8250
Fax: (503) 601-8254

Bend Office	(541) 330-9155
Eugene Office	(541) 345-0289
Salem Office	(503) 589-1252
Tigard Office	(503) 684-3460

Appendix C: Field Investigation & Laboratory Testing

OSU-Cascades 46-acre Site
1707 & 1757 Simpson Avenue
Bend, Oregon

CGT Project No. G1303959.A

July 25, 2014

Prepared For:

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

Prepared By:

Carlson Geotechnical

C1.0 OVERVIEW

Our geotechnical investigation was performed at the site between December 20, 2013, and January 16, 2014, and included eighteen drilled soil borings (B-1 through B-17, B-10A) and thirty-five test pits (TP-1 through TP-34, TP-7A). The approximate locations of our explorations are shown on the Site Plan (Figure 2) attached to the geotechnical report. The locations of the explorations were determined in the field using a handheld GPS receiver (Garmin GPSmap 60CSx). The latitude and longitude for each exploration were determined using desktop GIS software and input into the handheld GPS receiver for use in locating in the field. The locations should be considered approximate within the accuracy of the GPS receiver, on average about 30 feet (+/-) as reported by the manufacturer. Figure 3 attached to the geotechnical report shows the coordinates for each exploration. The surface elevation for each exploration was estimated from the topographic survey that forms the basis for Figure 2 attached to the geotechnical report. Elevations shown on the logs should be considered approximate to within (+/-) 1 foot.

C2.0 DRILLED BORINGS

C2.1 Overview

CGT observed the advancement of eighteen drilled borings (B-1 through B-17, B-10A) at the site to depths ranging from about 9 to 51½ feet below ground surface (bgs). Borings B-1 through B-14 were advanced using a Deidrich D-50 track-mounted drill rig, while borings B-15, B-16, B-17, and B-10A were advanced using a Diedrich D-50 truck-mounted drill rig. Both drill rigs were provided and operated by our subcontractor, Subsurface Technologies, of North Plains, Oregon. Hollow stem auger and mud rotary drilling methods were used to advance the borings. Upon completion, the borings were backfilled with granular bentonite.

C2.2 In-Situ Testing

Standard Penetration Tests (SPTs) were generally conducted within the borings at 2½- to 5-foot intervals to the full depths explored. The SPTs were conducted using a standard split-spoon sampler in general accordance with ASTM D1586. The SPT is performed by driving a split-spoon sampler into the undisturbed formation located at the bottom of the advanced boring with repeated blows of a 140-pound hammer falling a vertical distance of 30 inches. The number of blows (N-value) required to drive the sampler the last 12 inches of an 18-inch sample interval is used to characterize the soil consistency or relative density. Each drill rig was equipped with an automatic hammer, which was used to conduct the SPTs. It should be noted that automatic hammers generally produce lower SPT values than those obtained using a traditional safety hammer (cathead). Studies have generally indicated that penetration resistances may vary by a factor of 0.8 to 1.3 between the two methods[1]. According to the driller, the automatic hammer on the track-mounted drill rig had hammer efficiency (ETR_{hammer}) of 71 percent, resulting in an efficiency factor of about 1.2. Similarly, the automatic hammer on the truck-mounted drill

[1] Youd, et al. 2002. Liquefaction Resistance of Soils: Summary Report from the NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils. Journal of Geotechnical and Environmental Engineering.

rig had an ETR_{hammer} of 79 percent, resulting in an efficiency factor of about 1.3. We have considered these efficiencies in our description of soil relative density, and in our evaluation of soil strength and compressibility. The SPT values listed on the attached boring logs are "raw" values and have not been adjusted.

C3.0 TEST PITS

CGT observed the excavation of thirty-five test pits (TP-1 through TP-34, TP-7A) at the site to depths ranging from about 2½ to 25 feet bgs. The test pits were excavated using a John Deere 330, track-mounted excavator equipped with a 3-foot-wide, toothed digging bucket provided and operated by our subcontractor, Jack Robinson & Sons of Bend, Oregon. Upon completion, the test pit excavations were loosely backfilled with the excavation spoils.

C4.0 SOIL SAMPLING & LOGGING

Soil samples were obtained at the referenced intervals during advancement of the borings using the referenced split-spoon samplers. In addition, two relatively undisturbed (thin-walled tube) soil samples were collected in boring B-10A by hydraulically pushing the tubes into the soil horizon at the respective sampling depth. Within the test pits, grab samples were obtained from the excavation spoils as the test pits were advanced. A member of CGT's geotechnical staff collected the samples and logged the soils in general accordance with the Unified Soil Classification System (USCS). An explanation of the USCS is provided on the attached Soil Classification Criteria and Terminology, Figure C1. Rock (tuff) observed within the explorations was logged in accordance with the Oregon Department of Transportation (ODOT) Soil and Rock Classification Manual[2]. An explanation of the rock classification is shown on the attached ODOT Rock Classification Criteria and Terminology, Figure C2. All SPT and grab soil samples were stored in sealable plastic bags upon completion of our field examination and transported to our laboratory. Our geological staff visually examined all samples returned to our laboratory in order to refine the initial field classifications.

C5.0 LABORATORY TESTING

Laboratory testing was performed on soil samples collected in the field to refine our initial field classifications and determine in-situ properties. Laboratory testing included 38 moisture content determinations (ASTM D2216), nine particle-size distribution (sieve) tests (ASTM C136/117), and two unit weight determinations (weight-volume measurement). The results of these tests are shown on the attached Exploration Logs, Figures C3 through C56. Graphical plots of the sieve tests are shown in the attached Appendix D. Laboratory testing also included two collapsible potential tests on remolded soil samples in general accordance with ASTM D5333-03. Testing was performed on remolded samples due to the brittle and sandy nature of the site soils. These tests were performed to characterize the potential for swell/collapse of the site soils following wetting. Results of the collapsible potential tests are shown in the attached Appendix D.

---

[2] Oregon Department of Transportation, 1987. Soil and Rock Classification Manual.

SOIL CLASSIFICATION CRITERIA AND TERMINOLOGY

OSU CASCADES 46-ACRE SITE - BEND, OREGON

Classification of Terms and Content	USCS Grain Size		
NAME : MINOR Constituents (12-50%); MAJOR Constituents (>50%); Slightly (5-12%) Relative Density or Consistency Color Moisture Content Plasticity Trace Constituents (0-5%) Other: Grain Shape, Approximate gradation, Organics, Cement, Structure, Odor... Geologic Name or Formation: Fill, Willamette Silt, Till, Alluvium...	Fines		<#200 (.075 mm)
	Sand	Fine Medium Coarse	#200 - #40 (.425 mm) #40 - #10 (2 mm) #10 - #4 (4.75)
	Gravel	Fine Coarse	#4 - 0.75 inch 0.75 inch - 3 inches
	Cobbles		3 to 12 inches; scattered <15% est., numerous >15% est.
	Boulders		> 12 inches

Relative Density or Consistency

Granular Material		Fine-Grained (cohesive) Materials				
SPT N-Value	**Density**	**SPT N-Value**	**Torvane tsf Shear Strength**	**Pocket Pen tsf Unconfined**	**Consistency**	**Manual Penetration Test**
		<2	**<0.13**	**>0.25**	**Very Soft**	**Thumb penetrates more than 1 inch**
0 - 4	**Very Loose**	**2 - 4**	**0.13 - 0.25**	**0.25 - 0.50**	**Soft**	**Thumb penetrates about 1 inch**
4 - 10	**Loose**	**4 - 8**	**0.25 - 0.50**	**0.50 - 1.00**	**Medium Stiff**	**Thumb penetrates about 1/4 inch**
10 - 30	**Medium Dense**	**8 - 15**	**0.50 - 1.00**	**1.00 - 2.00**	**Stiff**	**Thumb penetrates less than 1/4 inch**
30 - 50	**Dense**	**15 - 30**	**1.00 - 2.00**	**2.00 - 4.00**	**Very Stiff**	**Readily indented by thumbnail**
>50	**Very Dense**	**>30**	**>2.00**	**>4.00**	**Hard**	**Difficult to indent by thumbnail**

Moisture Content

Dry: Absence of moisture, dusty, dry to the touch
Damp: Some moisture but leaves no moisture on hand
Moist: Leaves moisture on hand
Wet: Visible free water, likely from below water table

	Plasticity	Dry Strength	Dilatancy	Toughness
ML	Non to Low	Non to Low	Slow to Rapid	Low, can't roll
CL	Low to Med.	Medium to High	None to Slow	Medium
MH	Med to High	Low to Medium	None to Slow	Low to Medium
CH	Med to High	High to V. High	None	High

Structure

Stratified: Alternating layers of material or color >6 mm thick
Laminated: Alternating layers < 6 mm thick
Fissured: Breaks along definate fracture planes
Slickensided: Striated, polished, or glossy fracture planes
Blocky: Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lenses: Has small pockets of different soils, note thickness
Homogeneous: Same color and appearance throughout

Unified Soil Classification Chart (Visual-Manual Procedure) (Similar to ASTM Designation D-2488)

Major Divisions			Group Symbols	Typical Names
Coarse Grained Soils: More than 50% retained on No. 200 sieve	Gravels: 50% or more *retained* on the No. 4 sieve	Clean Gravels	GW	Well graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands: more than 50% *passing* the No. 4 Sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly-graded sands and gravelly sands, little or no fines
		Sands with Fines	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils: 50% or more Passes No. 200 Sieve	Silt and Clays Low Plasticity Fines		ML	Inorganic silts, rock flour, clayey silts
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
			OL	Organic silt and organic silty clays of low plasticity
	Silt and Clays High Plasticity Fines		MH	Inorganic silts, clayey silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils

CARLSON CGT GEOTECHNICAL 503-601-8250

Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

CGT Job No. G1303959.A

FIGURE C1

ODOT ROCK CLASSIFICATION CRITERIA AND TERMINOLOGY
OSU CASCADES 46-ACRE SITE - BEND, OREGON

Table 22: Scale of Relative Rock Weathering

Designation	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discloration in rock fabric. Decomposition extends up to 1 inch into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Weathered	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Table 24: Stratification Terms

TERM	CHARACTERISTICS
laminations	thin beds (<1 cm.)
fissle	tendency to break along laminations
parting	tendency to break parallel to bedding, any scale
foliation	non-depositional, e.g., segregation and layering of minerals in metamorphic rocks

Table 23: Scale of Relative Rock Hardness

Term	Hardness Designation	Field Identificaiton	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be idented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of geology pick. Can be peeled by pocket knife. Scratched with finger nail.	100-1000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow idention made by firm blow of geology pick.	1000-4000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4000-8000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard blows required to fracture specimen.	8000-16000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16000 psi

*Tables adapted from the 1987 Soil and Rock Classification Manual, Oregon Department of Transportation

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C3

Boring B-01

CLIENT Oregon State University System

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT NUMBER G1303959.A

PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/11/13

ELEVATION DATUM NGVD29 (from Figure 2)

DRILLING CONTRACTOR Subsurface Technologies

GROUND ELEVATION 3677 ft

DRILLING METHOD Mud Rotary with Auto-Hammer

GROUND WATER LEVELS:

LOGGED BY Travis Farstvedt **CHECKED BY** JAJ

AT TIME OF DRILLING ---

NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer

AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ / 0 20 40 60 80 100
3675		GP FILL	**GRAVEL FILL:** Dark gray to black, moist, angular and up to 1-inch in diameter.		0	SPT B1-1	44	19-12-10 (22)			
3670		SM FILL	**SILTY SAND FILL:** Dark brown, moist, fine to medium grained, with some fine gravel (up to ¾-inch in diameter).		5	SPT B1-2	33	8-5-4 (9)			
						SPT B1-3	56	5-4-5 (9)			
3665		RX {Qtu}	**LAPILLI TUFF:** Unconsolidated, loose, orange-brown, moist, angular to subangular pumice, few fines. {Qtu - Tumalo Tuff}.		10	SPT B1-4	56	5-4-4 (8)			
3660					15	SPT B1-5	89	3-3-4 (7)			
					20	SPT B1-6	50	50/1"			>>
3655			•Boring terminated at about 20 feet bgs. •No caving or groundwater encountered within depth explored. •Boring backfilled with bentonite chips upon completion.								
3650											
3645											

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C4

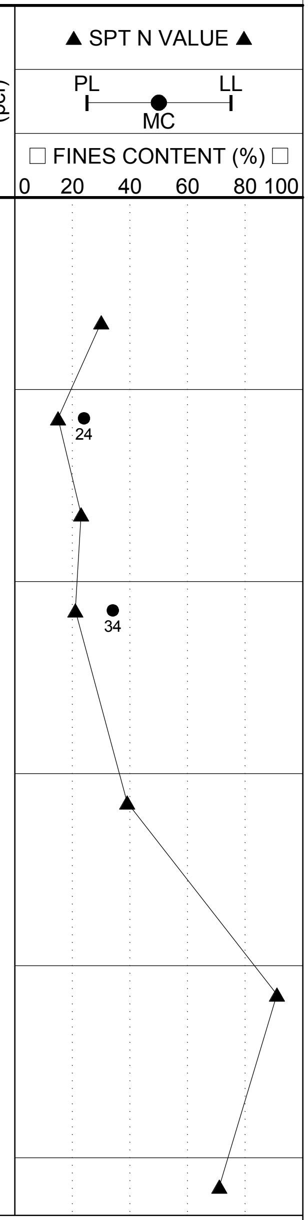
Boring B-02

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/11/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3671 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION
3670 – 3663	SM	**SILTY SAND:** Medium dense, moist, brown, fine to coarse grained, with varying amounts of angular to subrounded gravel of pumice and dark brown tuff. {Volcaniclastic Sediments}
3663 – 3651	RX {Qtu}	**ASH to LAPILLI TUFF:** Extremely soft to very soft (R0 to R1), brown, moist, with subangular pumice and fragments of welded tuff. {Qtu - Tumalo Tuff}
3651 – 3644.5	RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown, moist, with scattered scoria. {Qds - Desert Spring Tuff}

SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)
SPT B2-1	78	12-20-10 (30)
SPT B2-2	56	12-8-7 (15)
SPT B2-3	89	12-9-14 (23)
SPT B2-4	78	14-12-9 (21)
SPT B2-5	56	6-10-29 (39)
SPT B2-6	83	29-41-50 (91)
SPT B2-7	89	31-35-36 (71)



•Boring terminated at about 26½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C5

Boring B-03

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/12/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3652 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3650		RX {Qb}	**LAPILLI TUFF:** Unconsolidated, medium dense, light gray and brown, moist, subangular to angular, pumiceous. {Qb - Bend Pumice}		0	SPT B3-1	89	7-8-7 (15)			
					5	SPT B3-2	72	7-9-9 (18)			
3645						SPT B3-3	78	8-8-9 (17)			
3640		SM	**SILTY SAND:** Medium dense, moist, brown, with subangular pumice and fragments of dark brown tuff. {Volcaniclastic Sediments}		10	SPT B3-4	67	8-10-15 (25)			
3635		RX {Qds}	**ASH FLOW TUFF:** Very soft (R1), slightly weathered, dark brown to black, moist, with angular pumice and lithics, and sand-filled fractures. {Qds - Desert Spring Tuff}		15	SPT B3-5	78	20-39-45 (84)			
3630					20	SPT B3-6	91	45-50/5"			>>
3625					25	SPT B3-7	56	21-35-50 (85)			

3620

•Boring terminated at about 26½ feet bgs on hard tuff.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C6

Boring B-04

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/16/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3625 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	FINES CONTENT (%)
3625	RX {Qb}	**LAPILLI TUFF:** Unconsolidated, medium dense, light gray, moist, pumiceous. {Qb - Bend Pumice}	0				
				SPT B4-1	78	7-8-9 (17)	
3620			5	SPT B4-2	89	7-7-8 (15)	86
				SPT B4-3	89	7-8-8 (16)	
3615			10	SPT B4-4	89	7-7-7 (14)	
3610			15	SPT B4-5	89	6-6-5 (11)	99
3605		Increased ash content below about 20 feet.	20	SPT B4-6	100	9-10-11 (21)	
3600			25				
	SM	**SILTY SAND:** Dense, moist, orange-brown, with subangular basalt gravel. {Volcaniclastic Sediments}					
3595			30	SPT B4-7	89	19-18-14 (32)	
3590							

•Boring terminated at about 31½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C7

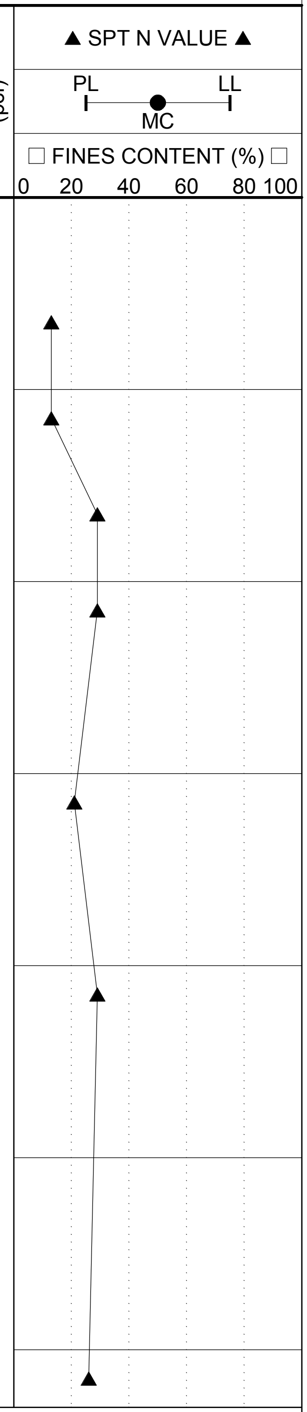
Boring B-05

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/12/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3625 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)
	RX {Qb}	**LAPILLI TUFF:** Unconsolidated, medium dense, light gray, moist, with angular to subangular pumice. {Qb - Bend Pumice}	0			
				SPT B5-1	56	8-6-7 (13)
3620			5	SPT B5-2	67	7-7-6 (13)
		Light brown to brown, with increased ash content below about 7½ feet.		SPT B5-3	56	12-13-16 (29)
3615	SM	**SILTY SAND:** Medium dense, moist, brown, with subangular pumice and subrounded clasts of dark brown ash tuff. {Volcaniclastic Sediments}	10	SPT B5-4	89	13-15-14 (29)
3610			15	SPT B5-5	78	8-10-11 (21)
3605			20	SPT B5-6	89	12-13-16 (29)
3600			25			
3595			30	SPT B5-7	56	12-13-13 (26)
3590						

Columns also headed: GRAPHIC LOG, GROUNDWATER, POCKET PEN. (tsf), DRY UNIT WT. (pcf)



•Boring terminated at about 31½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

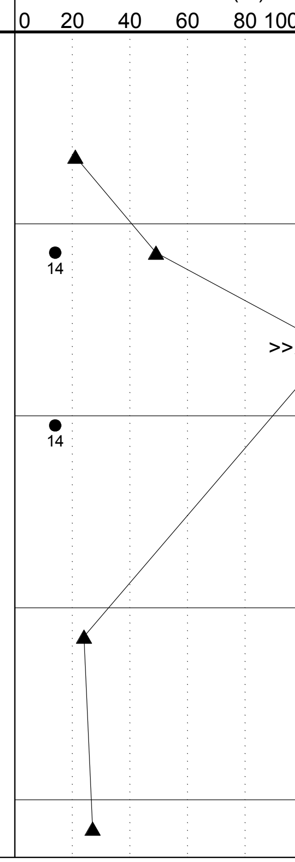
FIGURE C8

Boring B-06

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/12/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3617 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
3615		SP FILL	**SANDY GRAVEL FILL:** Brown to gray, damp, fine to coarse grained with gravels up to 1 inch in diameter.		0					
						SPT B6-1	56	5-5-16 (21)		
3610					5	SPT B6-2	44	15-25-24 (49)		
			Dark brown and damp at about 7½ feet bgs.			SPT B6-3	59	29-33-50/5"		
3605					10	SPT B6-4	100	50		
		RX {Qb}	**ASH TUFF:** Unconsolidated, medium dense, moist, gray to brown, with angular to subangular pumice. {Qb - Bend Pumice}							
3600					15	SPT B6-5	67	10-11-13 (24)		
3595					20	SPT B6-6	89	12-13-14 (27)		
3590										
3585										

▲ SPT N VALUE ▲
PL MC LL
☐ FINES CONTENT (%) ☐



•Boring terminated at about 21½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

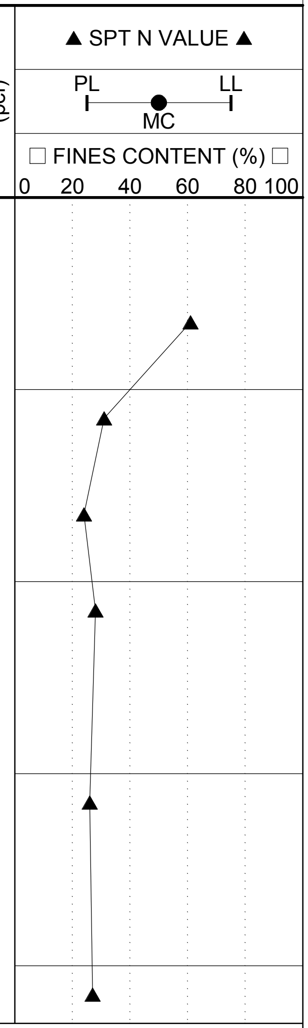
FIGURE C9

Boring B-07

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/12/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3625 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)
3625–3620	GP FILL	**SANDY GRAVEL FILL:** Moist, dark gray to gray, fine to coarsed grained sand with angular gravel up to 1-inch in diameter, and occasional boulders.	0–5	SPT B7-1	56	31-39-22 (61)
3620–3612.5	SM FILL	**SILTY SAND FILL:** Moist, brown to dark brown, moist, with angular basalt gravel and pumice.	5–12.5	SPT B7-2	33	1-7-24 (31)
				SPT B7-3	72	13-12-12 (24)
				SPT B7-4	78	12-13-15 (28)
3612.5–3603.5	RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown, moist, with scattered scoria. {Qds - Desert Spring Tuff}	12.5–21.5	SPT B7-5	78	12-12-14 (26)
				SPT B7-6	56	12-13-14 (27)

•Boring terminated at about 21½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.



Elevation scale: 3620, 3615, 3610, 3605, 3600, 3595, 3590. Depth scale: 0, 5, 10, 15, 20.

Columns: GROUNDWATER, GRAPHIC LOG, POCKET PEN. (tsf), DRY UNIT WT. (pcf)

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C10

Boring B-08

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/13/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3651 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MC (%)
3650	SM FILL	**SILTY SAND FILL:** Damp, dark brown to black, with scattered light gray pumice.	0				
				SPT B8-1	67	6-3-5 (8)	
3645			5	SPT B8-2	67	7-6-6 (12)	
	RX {Qb}	**LAPILLI TUFF:** Unconsolidated, medium dense, damp, light gray to brown. {Qb - Bend Pumice}		SPT B8-3	78	6-5-6 (11)	
3640			10	SPT B8-4	44	5-3-4 (7)	53
3635	RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown, moist, with scattered scoria. {Qds - Desert Spring Tuff}	15	SPT B8-5	56	8-9-10 (19)	
3630		Becomes red-brown at about 20 feet bgs.	20	SPT B8-6	67	6-5-6 (11)	32
3625			25	SPT B8-7	44	10-12-10 (22)	
3620		Scoria are flattened and elongated.	30	SPT B8-8	56	6-8-10 (18)	
			35				

Column headings also printed: GRAPHIC LOG, GROUNDWATER, POCKET PEN. (tsf), DRY UNIT WT. (pcf), ▲ SPT N VALUE ▲, PL, MC, LL, ☐ FINES CONTENT (%) ☐, 0 20 40 60 80 100

(Continued Next Page)

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

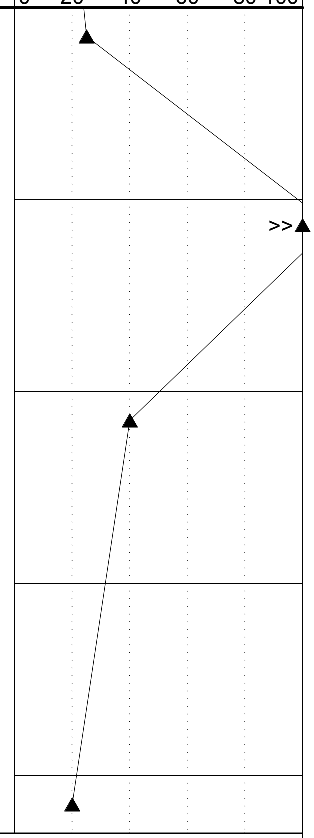
FIGURE C10

Boring B-08

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
3615		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown, moist, with scattered scoria. {Qds - Desert Spring Tuff} *(continued)*		35	SPT B8-9	89	9-11-14 (25)		
3610			Extremely soft to very soft (R0 to R1), moderately weathered, orange-brown, with distorted and elongated pumice and scattered angular basalt fragments.		40	SPT B8-10	100	25-41-50/4"		
3605					45	SPT B8-11	100	8-8-32 (40)		
3600					50					
3595					55	SPT B8-12	100	6-7-13 (20)		
3590										
3585										
3580										

▲ SPT N VALUE ▲
PL MC LL
☐ FINES CONTENT (%) ☐



•Boring terminated at about 56½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite grout upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C11

Boring B-09

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/13/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3648 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		RX {Qds}	**ASH FLOW TUFF:** Soft (R2), slightly weathered, dark brown to black, moist. {Qds - Desert Spring Tuff}		0						
3645						SPT B9-1	100	36-50/1"			>>▲
					5	SPT B9-2	100	50/4"			>>▲
3640						SPT B9-3	100	50/4"			>>▲
					10	SPT B9-4	100	50/4"			>>▲
3635											
			Fractures/joints filled with orange-brown sand below about 15 feet.		15	SPT B9-5	100	33-41-45 (86)			▲

3630

•Boring terminated at about 15½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

3625
3620
3615

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C12

Boring B-10

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/18/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3702 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MC
3702	SM	**SILTY SAND:** Loose, moist, brown, fine to medium grained.	0				
3700				SPT B10-1	56	3-2-2 (4)	18
3697	RX {Qtu}	**ASH TUFF:** Unconsolidated, loose to medium dense, dry to moist, brown and light gray, with subangular to subrounded pumice. {Qtu - Tumalo Tuff} Pinkish-gray below about 7½ feet.	5	SPT B10-2	56	3-3-4 (7)	
3695				SPT B10-3	78	11-12-14 (26)	
3692			10	SPT B10-4	78	11-13-15 (28)	31
3690							
3687			15	SPT B10-5	89	13-17-20 (37)	
3685							
3682		Increasing pumice content below about 20 feet.	20	SPT B10-6	78	15-17-20 (37)	
3680							
3677			25	SPT B10-7	44	15-17-19 (36)	36
3675							
3672			30	SPT B10-8	56	10-11-14 (25)	
3670							
			35				

Column headings also printed: GRAPHIC LOG, GROUNDWATER, POCKET PEN. (tsf), DRY UNIT WT. (pcf), ▲ SPT N VALUE ▲, PL — MC — LL, ☐ FINES CONTENT (%) ☐, 0 20 40 60 80 100

(Continued Next Page)

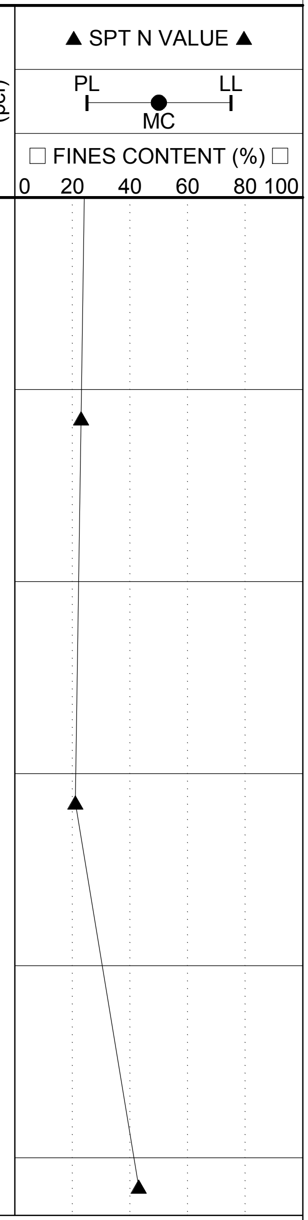
Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C12

Boring B-10

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
3665		RX {Qtu}	**ASH TUFF:** Unconsolidated, loose to medium dense, dry to moist, brown and light gray, with subangular to subrounded pumice. {Qtu - Tumalo Tuff} *(continued)*		35					
3660		RX {Qb}	**LAPILLI TUFF:** Unconsolidated, medium dense, dry to moist, light gray. {Qb - Bend Pumice}		40	SPT B10-9	56	9-10-13 (23)		
3655					45					
3650					50	SPT B10-10	61	9-9-12 (21)		
3645		SM	**SILTY SAND:** Medium dense, dry to moist, brown, with angular to subrounded red and black lithics and pumice. {Volcaniclastic Sediments}		55					
3640					60	SPT B10-11	56	15-22-21 (43)		
3635			•Boring terminated at about 61½ feet bgs. •No caving or groundwater encountered within depth explored. •Boring backfilled with bentonite grout upon completion.							
3630										



Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C14

Boring B-10A

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 1/16/14
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3702 ft
DRILLING METHOD Hollow Stem Auger
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Truck Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3700		SM	**SILTY SAND:** Loose, moist, brown, fine to medium grained. Lithology derived from nearby B-10.		0–5						
3695		RX {Qtu}	**ASH TUFF:** Unconsolidated, loose to medium dense, dry to moist, brown and light gray, with subangular to subrounded pumice. {Qtu - Tumalo Tuff} SHB10-1: Refer to Appendix D for results of Collapse Test (ASTM D5333-03).		5	SH B10-1				51	MC 3
						SH B10-2					

•Boring terminated at about 9 feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite upon completion.

Elevation scale: 3690, 3685, 3680, 3675, 3670

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C15

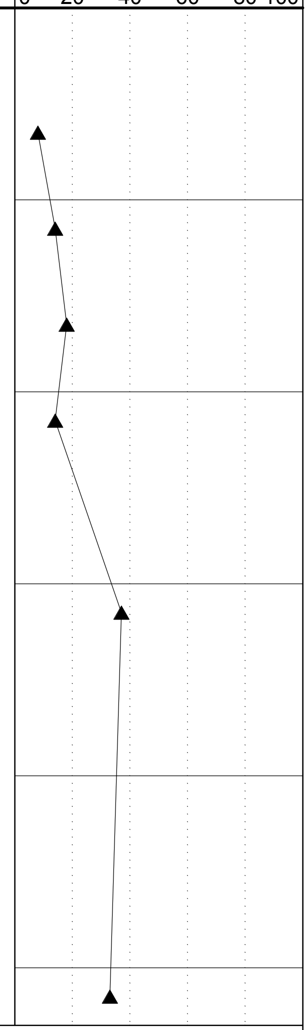
Boring B-11

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/18/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3710 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
3710	SM	**SILTY SAND:** Loose, brown, moist, fine-grained, pumiceous.	0					
	RX {Qtu}	**ASH TUFF:** Unconsolidated, medium dense, dry to moist, light gray to brown, with subrounded and slightly elongated pumice. {Qtu - Tumalo Tuff}		SPT B11-1	17	3-4-4 (8)		
3705			5	SPT B11-2	33	8-6-8 (14)		
				SPT B11-3	56	8-10-8 (18)		
3700			10	SPT B11-4	56	3-6-8 (14)		
3695		Dense, with increasing angular to subangular pumice at about 15 feet bgs.	15	SPT B11-5	56	14-17-20 (37)		
3690			20					
3685			25	SPT B11-6	56	13-15-18 (33)		
3680								
3675								

▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)



•Boring terminated at about 26½ feet bgs on hard tuff.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C16

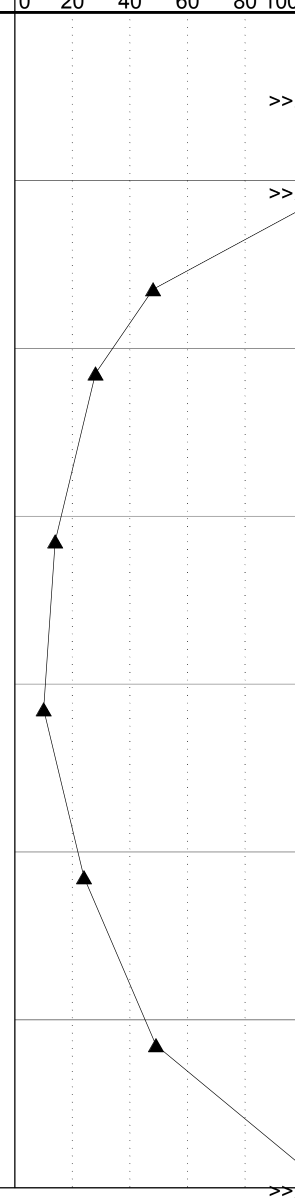
Boring B-12

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/13/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3661 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)
3660		GP FILL	**GRAVEL FILL:** Damp, gray, with gravels up to 3-inches in diameter, fine to coarse grained sand, cobbles up to 12-inches in diameter, and boulders up to 2-feet in diameter.		0
3655		SM FILL	**SILTY SAND FILL:** Damp, brown, fine to coarse grained sand with pumice up to 2-inches in diameter. With angular gravel up to 1-inch in diameter. Concrete debris at about 25 feet bgs.		5
3632		SM	**SILTY SAND:** Dense to very dense, damp, brown, fine to medium grained sand with pumice and gravel up to 1-inch in diameter. {Volcaniclastic Sediments}		28
3625			Basalt chips in sampler tip. •Boring terminated at about 35 feet bgs. •No caving or groundwater encountered within depth explored. •Boring backfilled with bentonite chips upon completion.		35

SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
SPT B12-1	33	50/3"		
SPT B12-2	111	28-50/3"		
SPT B12-3	89	10-10-38 (48)		
SPT B12-4	78	5-15-13 (28)		
SPT B12-5	0	8-9-5 (14)		
SPT B12-6	56	11-5-5 (10)		
SPT B12-7	11	4-1-23 (24)		
SPT B12-8	56	13-24-25 (49)		
SPT B12-9	100	50/2"		

▲ SPT N VALUE ▲
PL MC LL
☐ FINES CONTENT (%) ☐



Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

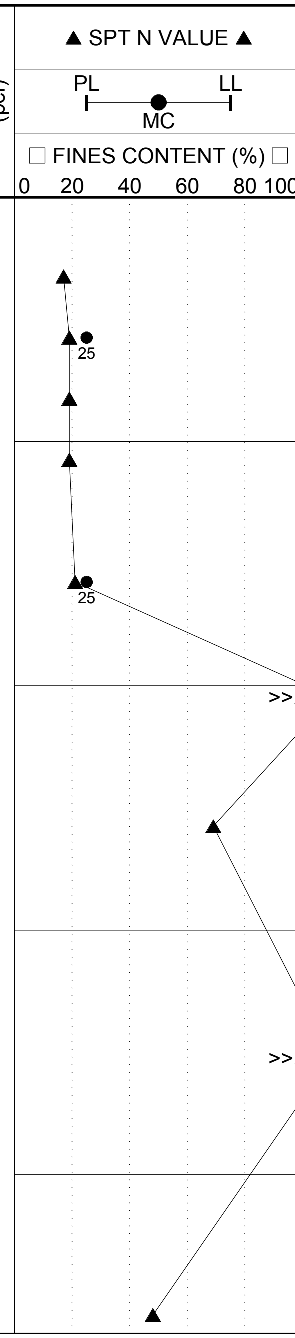
FIGURE C17

Boring B-13

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/19/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3710 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION
3710–3705	SM	**SILTY SAND:** Medium dense, damp, brown, fine to medium grained sand with some subangular gravel up to ¾-inch in diameter.
3705–3663.5	RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), fresh to slightly weathered, dark brown, moist, with subangular to subrounded basalt and other lithics and sand-filled joints/fractures. {Qds - Desert Spring Tuff}

SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	FINES CONTENT (%)
SPT B13-1	56	11-10-7 (17)	
SPT B13-2	56	6-9-10 (19)	25
SPT B13-3	56	8-8-11 (19)	
SPT B13-4	67	7-10-9 (19)	
SPT B13-5	78	10-12-9 (21)	25
SPT B13-6	100	30-50/5"	
SPT B13-7	83	35-37-32 (69)	
SPT B13-8	83	33-50	
SPT B13-9	100	50/5"	
SPT B13-10	67	21-23-25 (48)	



•Boring terminated at about 46½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C18

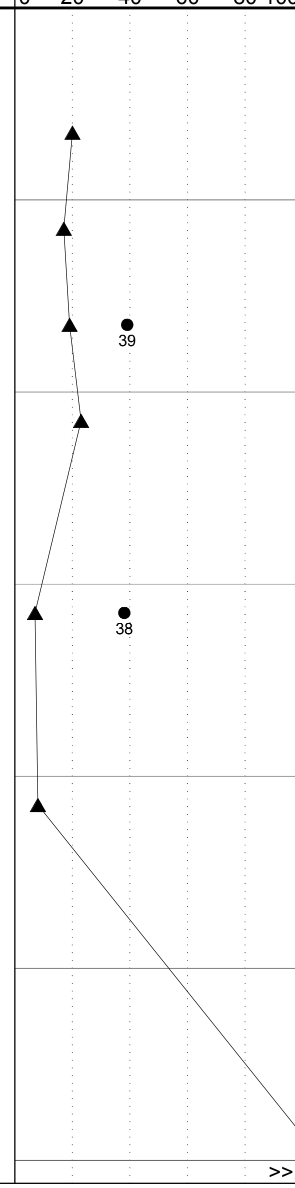
Boring B-14

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/18/13
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3732 ft
DRILLING METHOD Mud Rotary with Auto-Hammer
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Track Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)
3730, 3725, 3720	SM FILL	**SILTY SAND FILL:** Moist, pinkish-gray to brown, ashy, with subrounded, weathered pumice.	0 – 15
3715, 3710, 3705	RX {Qb}	**ASH TUFF:** Unconsolidated, loose, moist, light brown, with subangular, weathered pumice. {Qb - Bend Pumice}	15 – 30

SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MC (%)
SPT B14-1	67	8-9-11 (20)	
SPT B14-2	78	8-8-9 (17)	
SPT B14-3	78	7-8-11 (19)	39
SPT B14-4	67	11-12-11 (23)	
SPT B14-5	22	5-3-4 (7)	38
SPT B14-6	22	3-3-5 (8)	
SPT B14-7	100	27-50/1"	



3700

•Boring terminated at about 30½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite chips upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

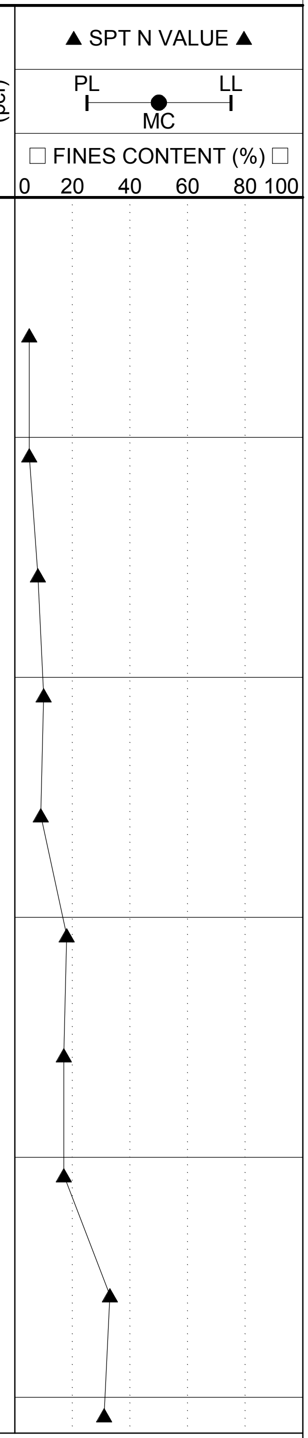
FIGURE C19

Boring B-15

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 1/16/14
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3705 ft
DRILLING METHOD Mud Rotary
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Truck Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION
3705–3697	SM	**SILTY SAND:** Loose, damp, light brown, with some pumice.
3697–3677	RX {Qtu}	**ASH TUFF:** Unconsolidated, loose, damp, light gray, with pumice. {Qtu - Tumalo Tuff}
3677–3653.5	RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), brown to dark brown, moist. {Qds - Desert Spring Tuff}

SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)
SPT B15-1	22	5-3-2 (5)
SPT B15-2	56	4-2-3 (5)
SPT B15-3	56	4-4-4 (8)
SPT B15-4	56	5-5-5 (10)
SPT B15-5	67	4-4-5 (9)
SPT B15-6	78	8-8-10 (18)
SPT B15-7	89	8-8-9 (17)
SPT B15-8	67	6-9-8 (17)
SPT B15-9	100	13-15-18 (33)
SPT B15-10	89	13-15-16 (31)



•Boring terminated at about 51½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with grout upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C20

Boring B-16

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 1/16/14
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3695 ft
DRILLING METHOD Mud Rotary
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Truck Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)
3695 – 3687	SM	**SILTY SAND:** Loose, brown, moist, and with some pumice.	0	SPT B16-1	22	4-3-2 (5)
3687 – 3643.5	RX {Qtu}	**ASH TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, light brown, moist. {Qtu - Tumalo Tuff}	10	SPT B16-2	56	2-3-2 (5)
		Light gray below about 15 feet.		SPT B16-3	56	5-5-6 (11)
			20	SPT B16-4	100	11-13-12 (25)
				SPT B16-5	89	12-17-15 (32)
			30	SPT B16-6	89	15-17-18 (35)
		Light brown below about 35 feet.		SPT B16-7	89	17-16-17 (33)
			40	SPT B16-8	89	12-15-18 (33)
				SPT B16-9	89	17-21-26 (47)
			50	SPT B16-10		15-18-22 (40)

Elevation scale: 3690, 3685, 3680, 3675, 3670, 3665, 3660, 3655, 3650, 3645, 3640

SPT N VALUE plot (0 20 40 60 80 100); PL — MC — LL; FINES CONTENT (%)

•Boring terminated at about 51½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with grout upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C21

Boring B-17

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 1/16/14
ELEVATION DATUM NGVD29 (from Figure 2)
DRILLING CONTRACTOR Subsurface Technologies
GROUND ELEVATION 3710 ft
DRILLING METHOD Hollow Stem Auger
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** JAJ
AT TIME OF DRILLING ---
NOTES Deidrich D-50 Truck Drill Rig with Automatic SPT Hammer
AFTER DRILLING ---

ELEVATION (ft)	U.S.C.S.	MATERIAL DESCRIPTION
3710–3677	SM FILL	**SILTY SAND FILL:** Damp, light brown, consists of a mix of tuffaceous materials. SHB17-2: Refer to Appendix D for results of Collapse Test (ASTM D5333-03). With trace of discrete wood debris at about 30 feet bgs.
3677–3673.5	SM	**SILTY SAND:** Medium dense, dry, brown, fine to coarse grained, with pumice and fragments of dark brown ash tuff. {Volcaniclastic Sediments}

SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MC (%)
SPT B17-1	56	5-9-9 (18)			26
SH B17-2	100			74	22
SPT B17-3	100	4-8-11 (19)			23
SPT B17-4	89	7-11-13 (24)			26
SPT B17-5	100	8-10-12 (22)			32
SPT B17-6	89	4-5-5 (10)			37
SPT B17-7	89	4-6-5 (11)			26
SPT B17-8	100	6-6-5 (11)			22

•Boring terminated at about 36½ feet bgs.
•No caving or groundwater encountered within depth explored.
•Boring backfilled with bentonite pellets upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C22

Test Pit TP-01

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3678 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3675		SM FILL	**SILTY SAND FILL:** Damp, brown, with gravel, cobbles, and boulders up to 3 feet in diameter. Moderate excavation difficulty.		0–5.5						
3670		RX {Qtu}	**LAPILLI TUFF:** Unconsolidated, loose, damp, light brown, pumiceous. Easy excavation difficulty. {Qtu - Tumalo Tuff}		5.5–15	GRAB TP1-1					MC 21
3665						GRAB TP1-2					

•Test pit terminated at about 15 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3660

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C23

Test Pit TP-02

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3671 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3670		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 4 feet in dimension, in a matrix of brown, silty sand. Sidewalls caved during excavation.		0						
3665					5						
3660					10						
3655					15						
3650					20						
3645					25						

•Test pit terminated at about 25 feet bgs.
•No groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C24

Test Pit TP-03

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3672 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3670, 3665, 3660, 3655, 3650		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 4 feet in dimension, in a matrix of brown, silty sand. Scattered concrete and rebar debris encountered. Minor caving of sidewalls during excavation.		0, 5, 10, 15, 20, 25						
3645			•Test pit terminated at about 25 feet bgs. •No groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C25

Test Pit TP-04

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3618 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3615, 3610		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 4 feet in dimension, in a matrix of brown, silty sand. Scattered concrete, rebar, and plastic debris encountered. Moderate excavation difficulty.		0, 5, 10						
3605		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		15	GRAB TP4-1					

•Test pit terminated at about 17 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C26

Test Pit TP-05

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3625 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3625		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 4 feet in dimension, in a matrix of brown, silty sand. Scattered concrete and asphalt debris encountered. Moderate excavation difficulty.		0						
		RX {Qb}	**LAPILLI TUFF:** Unconsolidated, loose to medium dense, dry to damp, light gray. Easy excavation difficulty. {Qb - Bend Pumice}								
3620					5						MC 47
						GRAB TP5-1					
3615					10	GRAB TP5-2					
3610			•Test pit terminated at about 14 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								
3605											

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C27

Test Pit TP-06

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3623 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / □ FINES CONTENT (%) □ (0 20 40 60 80 100)
3620, 3615		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 3 feet in dimension, in a matrix of brown, silty sand. Scattered concrete, rebar, and plastic debris encountered. Moderate excavation difficulty.		0, 5						
3610		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		10	GRAB TP6-1					

•Test pit terminated at about 14 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3605

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C28

Test Pit TP-07

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3623 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
					0						
3620		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 3 feet in dimension, in a matrix of brown, silty sand. Scattered concrete debris encountered. Moderate excavation difficulty.		5						
3615		RX {Qb}	**LAPILLI TUFF:** Unconsolidated, loose to medium dense, dry to damp, light gray. Easy excavation difficulty. {Qb - Bend Pumice}		10	GRAB TP7-1					
3610											
3605											

•Test pit terminated at about 13 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C29

Test Pit TP-07A

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3620 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
					0						
3615		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt and welded tuff boulders up to about 3 feet in dimension, in a matrix of brown, silty sand. Moderate excavation difficulty.		5						
3610					10						
3605		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		15	GRAB TP7A-1					
3600											

•Test pit terminated at about 16 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C30

Test Pit TP-08

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3617 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / □ FINES CONTENT (%) □ (0 20 40 60 80 100)
3615 3610		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 3 feet in dimension, in a matrix of brown, silty sand. Scattered concrete debris encountered. Minor caving of sidewalls during excavation. Moderate excavation difficulty.		0 5						
3605		RX {Qb}	**LAPILLI TUFF:** Unconsolidated, loose to medium dense, dry to damp, light gray. Easy excavation difficulty. {Qb - Bend Pumice}		10	GRAB TP8-1					MC: 32

•Test pit terminated at about 14½ feet bgs.
•No groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3600

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C31

Test Pit TP-09

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3614 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / □ FINES CONTENT (%) □ 0 20 40 60 80 100
3614–3610		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 2 feet in dimension, in a matrix of brown, silty sand. Scattered concrete, rebar, and asphalt debris encountered. Moderate excavation difficulty.		0–5						
3605		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		10	GRAB TP9-1					

•Test pit terminated at about 11 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Elevation scale: 3610, 3605, 3600, 3595

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C32

Test Pit TP-10

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3608 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3605		GP-GM FILL	**RUBBLE FILL:** Damp, brown to gray, gravel, cobbles, basalt boulders up to about 2 feet in dimension, in a matrix of brown, silty sand. Moderate excavation difficulty.		0 5						
3600 3595		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		10	GRAB TP10-1					

•Test pit terminated at about 14 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3590

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C33

Test Pit TP-11

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3609 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3605		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		0 5	GRAB TP11-1					

•Test pit terminated at about 6 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3600
3595
3590

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C34

Test Pit TP-12

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3601 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3600		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		0						
3595					5	GRAB TP12-1					22

•Test pit terminated at about 6 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Elevation scale: 3590, 3585

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C35

Test Pit TP-13

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/20/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3588 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
					0						
3585		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}			GRAB TP13-1					
					5						
3580											
3575											
3570											

•Test pit terminated at about 8 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C36

Test Pit TP-14

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3600 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3600		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		0	GRAB TP14-1					
3595					5						
3590			•Test pit terminated at about 8 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								
3585											
3580											

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C37

Test Pit TP-15

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3601 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3600		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		0						
					5	GRAB TP15-1					MC: 21
3595											

•Test pit terminated at about 6 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3590

3585

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C38

Test Pit TP-16

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3606 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3605		SM FILL	**SILTY SAND FILL:** Damp, gray to dark gray, fine to coarse grained sand with subangular gravel up to 1-inch in diameter.		0						
3600		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		5						
3595		RX	**GRAVEL CONGLOMERATE:** Very soft (R1), slightly weathered, light brown to orange, with rounded pumice in laminated silt/ash matrix. Moderate excavation difficulty.		10	GRAB TP16-1					
3590			•Test pit terminated at about 12 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C39

Test Pit TP-17

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3637 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3635, 3630, 3625, 3620, 3615		SM FILL	**SILTY SAND FILL:** Dry to damp, brown, fine to coarse grained sand with varying amounts of angular gravel and subangular boulders up to 3½-feet in diameter. Abundant concrete debris and welded tuff boulders to 3 feet bgs. Moderate excavation difficulty. Wooden branch, ~6-inches in diameter, at about 7 feet bgs.		0, 5, 10, 15, 20, 25						
3610			•Test pit terminated at about 25 feet bgs. •No groundwater encountered within depth explored. •Caving encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C40

Test Pit TP-18

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3650 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SM FILL	**SILTY SAND FILL:** Dry to moist, brown, fine to coarse grained sand and pumice, boulders up to 3-feet in diameter, and some concrete. Moderate excavation difficulty.		0						
3645					5						
3640					10						
3635					15						
3630					20						
3625					25						
3620			•Test pit terminated at about 25 feet bgs. •No groundwater encountered within depth explored. •Caving encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C41

Test Pit TP-19

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3648 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
					0						
3646		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}								
3644			•Test pit terminated at about 2½ feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								
3642											
3640											
3638											
3636											
3634											
3632											
3630											
3628											

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C42

Test Pit TP-20

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3659 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL ● MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
					0						
3655		SM FILL	**SILTY SAND FILL:** Damp, brown, fine to coarse grained sand, angular gravel, boulders up to 3-feet in diameter, and some concrete and rebar. Scattered PVC pipes. Moderate excavation difficulty.		5						
3650					10						
3645					15						
3640					20						
			Isolated pieces of asphalt and concrete encountered between about 20 and 24 feet bgs.								
3635		RX (Qb)	**LAPILLI TUFF:** Unconsolidated, loose, damp, light brown, with pumice up to 1-inch in diameter.		25						
3630			•Test pit terminated at about 25 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C43

Test Pit TP-21

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3656 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3655		SM FILL	**SILTY SAND FILL:** Damp, brown, fine to coarse grained sand, angular gravel, boulders up to 3-feet in diameter, and some concrete and rebar. Moderate excavation difficulty.		0						
3650					5						
3645			Pieces of metal encountered at about 10 feet bgs.		10						
3640			Welded tuff boulders encountered at about 16 feet bgs.		15						
3635					20						
3630					25						

•Test pit terminated at about 25 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C44

Test Pit TP-22

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3651 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3650			**SILTY SAND FILL:** Damp, brown, fine to coarse grained sand, angular gravel, boulders up to 3-feet in diameter, and some concrete, rebar, and PVC pipe debris. Moderate excavation difficulty.		0						
3645			Layer of glass and fiberglass insulation debris encountered between about 6 and 7 feet bgs.		5						
3640		SM FILL	Tree stump, ~12 inches in diameter, encountered at about 10 feet bgs.		10						
3635					15						
3630					20						
3625			•Test pit terminated at about 25 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.		25						

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C45

Test Pit TP-23

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/17/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3670 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
		SM FILL	**SILTY SAND FILL:** Damp, brown, fine to coarse grained sand, angular gravel, boulders up to 3-feet in diameter, and some concrete, rebar, and PVC pipe debris. Moderate excavation difficulty. Some broken glass encountered at about 3 feet bgs.		0						
3665					5						
		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}			GRAB TP23-1					19
3660					10						
3655			•Test pit terminated at about 12 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								
3650											

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C46

Test Pit TP-24

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3707 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3705		SM	**SILTY SAND:** Loose to medium dense, dry, brown, fine to medium grained sand, with pumice and gravel to ¾-inch. Some roots to ½-inch, and islolated cobbles to 10-inches. Moderate digging effort required.		0	GRAB TP24-1					MC: 11
3700					5						
		RX {Qtu}	**ASH FLOW TUFF:** Very soft (R1), slightly weathered, brown to gray. Hard excavation difficulty.			GRAB TP24-2					

•Test pit terminated at about 9 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3695

3690

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C47

Test Pit TP-25

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3710 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3710 – 3690		SM FILL	**SILTY SAND FILL:** Dry, brown, coarse grained sand, pumice and gravel up to ¾-inch in diameter. Some roots to 1-inch in diameter, cobbles and boulders to 2-feet in diameter. Moderate digging effort required.		0 – 19						
3690 – 3687		SM	**SILTY SAND:** Medium dense, dry, light gray to orange, ashy matrix. Medium excavation difficulty.		19 – 23	GRAB TP25-1					

Elevation scale: 3705, 3700, 3695, 3690, 3685, 3680. Depth scale: 0, 5, 10, 15, 20.

- •Test pit terminated at about 23 feet bgs.
- •No groundwater encountered within depth explored.
- •Some caving observed within depth explored.
- •Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C48

Test Pit TP-26

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3723 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL ● MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
					0						
3720		SM	**SILTY SAND:** Medium dense, dry, brown to light brown, fine to coarse grained sand, with pumice and some roots to ½-inch in diameter. Moderate digging effort required.		5	GRAB TP26-1					
3715		RX {Qds}	**ASH FLOW TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, dark brown to black, moist. Moderate excavation difficulty. {Qds - Desert Spring Tuff}		10	GRAB TP26-2					
3710											

•Test pit terminated at about 13 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3705

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C49

Test Pit TP-27

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3734 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / □ FINES CONTENT (%) □ 0 20 40 60 80 100
		SM FILL	**SILTY SAND FILL:** Dry to damp, light brown, fine to coarse grained sand with pumice. Moderate excavation difficulty.		0						
						GRAB TP27-1					
3730					5						
3725					10						
3720					15						
3715					20						
3710					25						
3705			•Test pit terminated at about 25 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C50

Test Pit TP-28

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3713 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / □ FINES CONTENT (%) □ (0 20 40 60 80 100)
3713–3710		SM	**SILTY SAND:** Medium dense, dry, brown, fine to medium grained sand. Abundant roots to ½-inch in diameter. Moderate digging effort required.		0–5						
						GRAB TP28-1					MC 4
3705		RX {Qtu}	**ASH TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, light gray with elongated pumice and minor welding, moist. Moderate excavation difficulty.								

•Test pit terminated at about 9 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Elevation scale: 3710, 3705, 3700, 3695

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C51

Test Pit TP-29

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3741 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
3740		SM FILL	**PUMICE FILL:** Dry, light brown to pink, fine to coarse grained sand with pumice. Moderate digging effort required.		0						
						GRAB TP29-1					
3735					5						
3730					10						
3725					15						
			Abundant white pumice encountered between about 17 and 23 feet bgs.								
3720					20						
		RX {Qtu}	**ASH TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, light gray with minor welding, moist. Moderate excavation difficulty.		25						
3715			•Test pit terminated at about 25 feet bgs. •No groundwater encountered within depth explored. •Some caving observed within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C52

Test Pit TP-30

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3745 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
		SM FILL	**PUMICE FILL:** Light brown to pink, dry, fine to coarse grained sand and pumice. Moderate digging effort required. Tumalo tuff fill.		0	GRAB TP30-1					MC 22
3740					5						
		RX {Qtu}	**ASH TUFF:** Very soft (R1), slightly weathered, light gray to pink, moist, with pumice, other lithics, and minor welding. Moderate to hard excavation difficulty.			GRAB TP30-2					MC 10
3735					10						
3730											
3725											

•Test pit terminated at about 14 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C53

Test Pit TP-31

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3710 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / □ FINES CONTENT (%) □ 0 20 40 60 80 100
					0						
		SM	**SILTY SAND:** Medium dense, dry, brown, fine to medium grained sand, with pumice and gravel to 1-inch. Moderate digging effort required.			GRAB TP31-1					
3705					5						
		RX {Qb}	**LAPILLI TUFF:** Unconsolidated, loose to medium dense, dry to damp, light gray to brown. {Qb - Bend Pumice}			GRAB TP31-2					
3700					10						
3695			•Test pit terminated at about 14 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								
3690											

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C54

Test Pit TP-32

CLIENT Oregon State University System

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT NUMBER G1303959.A

PROJECT LOCATION Simpson Avenue - Bend, Oregon

DATE STARTED 12/23/13

ELEVATION DATUM NGVD29 (from Figure 2)

EXCAVATION CONTRACTOR Jack Robinson & Sons

GROUND ELEVATION 3726 ft

EXCAVATION METHOD Test Pit

GROUND WATER LEVELS:

LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones

SEEPAGE ---

NOTES John Deere 330C Excavator

AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3725		SM	**SILTY SAND:** Medium dense, dry, light brown, fine to medium grained sand, with pumice and scattered roots up to ½-inch in diameter. Moderate digging effort required.		0	GRAB TP32-1					MC 3
3720					5						
		RX {Qtu}	**ASH TUFF:** Extremely soft to very soft (R0 to R1), slightly weathered, light gray with minor welding, dry to damp. Moderate excavation difficulty.			GRAB TP32-2					MC 3
3715					10						
3710											

- Test pit terminated at about 13 feet bgs.
- No caving or groundwater encountered within depth explored.
- Test pit loosely backfilled with excavation spoils upon completion.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C55

Test Pit TP-33

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3734 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
3730, 3725		SM	**SILTY SAND:** Brown, dry to damp, fine to medium grained sand, with gravel, subangular and up to 1½-inch Some roots to ½-inch. Isolated cobble to 12-inches. Moderate digging effort required.		0, 5, 10	GRAB TP33-1					9
3720		RX {Qb}	**LAPILLI TUFF:** Unconsolidated, loose to medium dense, moist, light gray to brown. {Qb - Bend Pumice}			GRAB TP33-2					49

•Test pit terminated at about 14 feet bgs.
•No caving or groundwater encountered within depth explored.
•Test pit loosely backfilled with excavation spoils upon completion.

3715

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

FIGURE C56

Test Pit TP-34

CLIENT Oregon State University System
PROJECT NAME OSU Cascades 46 Acre Site
PROJECT NUMBER G1303959.A
PROJECT LOCATION Simpson Avenue - Bend, Oregon
DATE STARTED 12/23/13
ELEVATION DATUM NGVD29 (from Figure 2)
EXCAVATION CONTRACTOR Jack Robinson & Sons
GROUND ELEVATION 3721 ft
EXCAVATION METHOD Test Pit
GROUND WATER LEVELS:
LOGGED BY Travis Farstvedt **CHECKED BY** Jeff Jones
SEEPAGE ---
NOTES John Deere 330C Excavator
AFTER EXCAVATION ---

ELEVATION (ft)	GRAPHIC LOG	U.S.C.S.	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL — MC — LL / ☐ FINES CONTENT (%) ☐ (0 20 40 60 80 100)
					0						
3720		SM	**SILTY SAND:** Medium dense, dry, brown, fine to medium grained sand, with pumice and scattered roots to ½-inch in diameter and cobbles to 10-inches in diameter. Moderate digging effort required.			GRAB TP34-1					MC 6
3715					5						
3710					10						
3705			•Test pit terminated at about 12 feet bgs. •No caving or groundwater encountered within depth explored. •Test pit loosely backfilled with excavation spoils upon completion.								

Appendix D: Laboratory Test Results

OSU-Cascades 46-acre Site
1707 & 1757 SW Simpson Avenue
Bend, Oregon

CGT Project No. G1303959.A

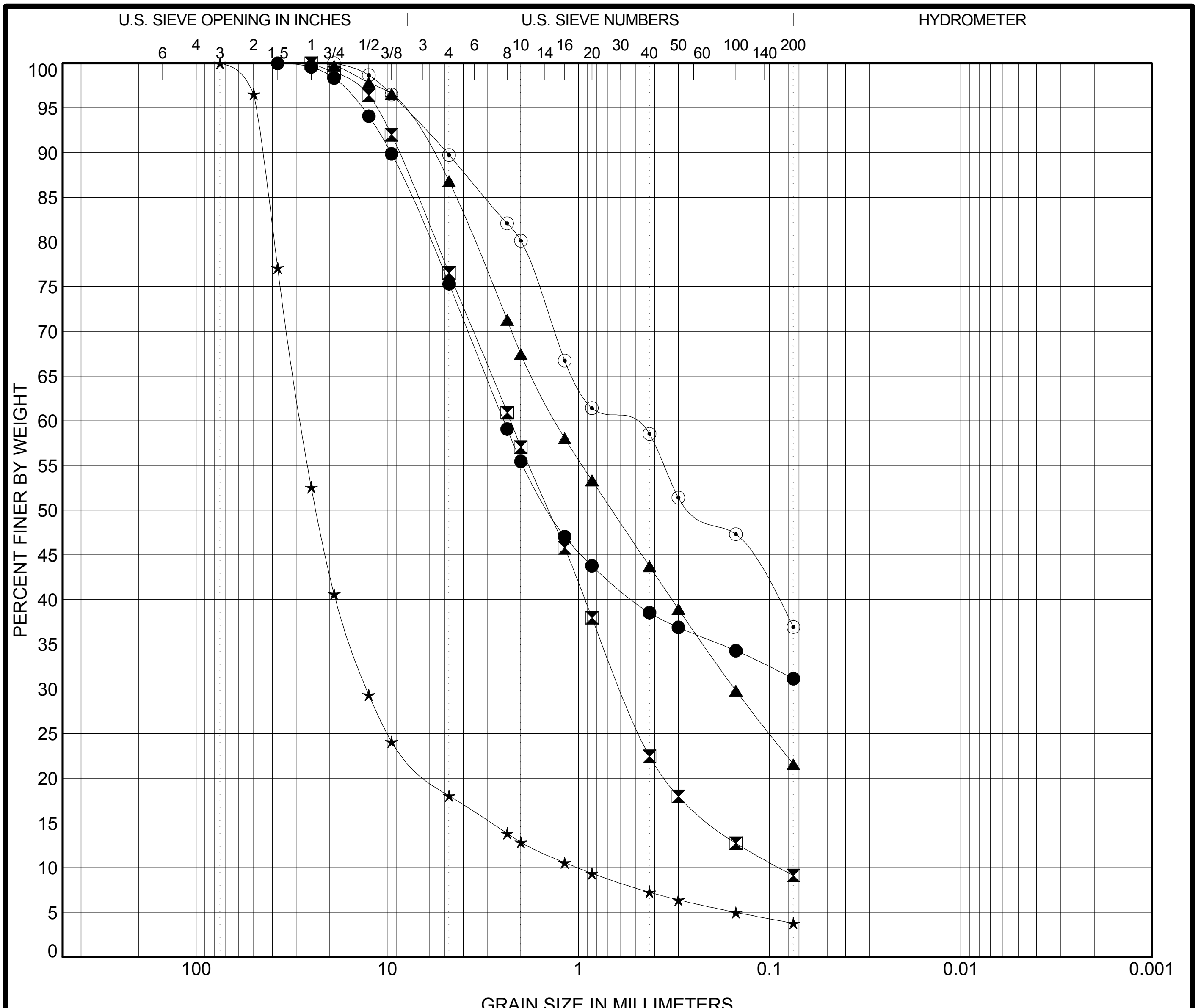
July 25, 2014

Prepared For:

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

Prepared By:

Carlson Geotechnical



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**TP-01**	**6.5**	**Silty Sand (SM) with Gravel**					
⧗	**TP-05**	**5.0**	**Sand with Silt (SW-SM) and Gravel**				**1.76**	**25.51**
▲	**TP-24**	**2.5**	**Silty Sand (SM)**					
★	**TP-28**	**6.0**	**Poorly Graded Gravel (GP)**				**5.73**	**27.90**
⊙	**TP-30**	**3.0**	**Silty Sand (SM)**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP-01**	**6.5**	**37.5**	**2.456**			**24.7**	**44.2**	**31.1**	
⧗	**TP-05**	**5.0**	**25**	**2.269**	**0.595**	**0.089**	**23.5**	**67.4**	**9.1**	
▲	**TP-24**	**2.5**	**25**	**1.317**	**0.152**		**13.2**	**65.3**	**21.6**	
★	**TP-28**	**6.0**	**75**	**28.271**	**12.814**	**1.013**	**82.0**	**14.3**	**3.8**	
⊙	**TP-30**	**3.0**	**19**	**0.605**			**10.3**	**52.8**	**36.9**	

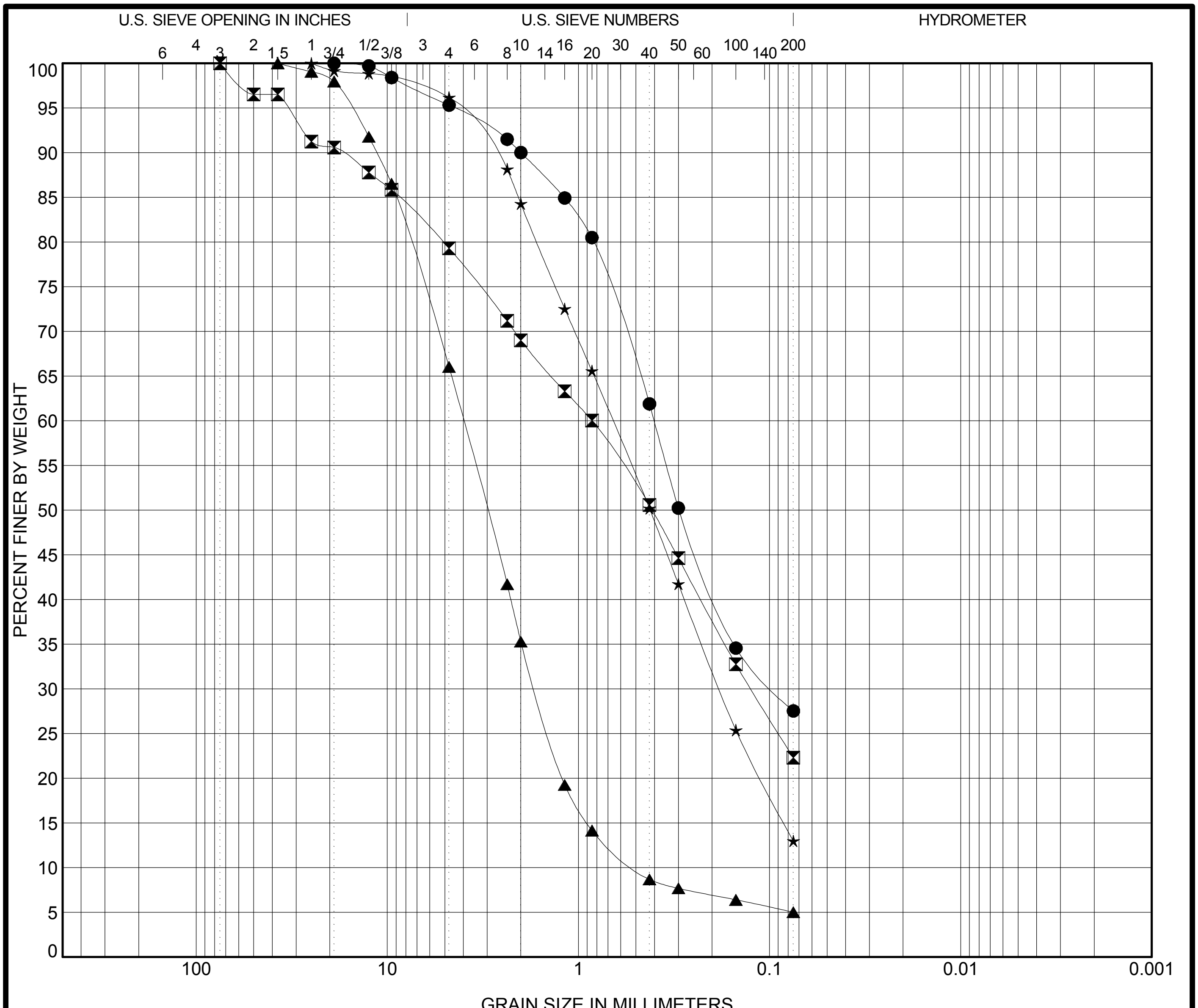
CARLSON CGT GEOTECHNICAL 503-601-8250
Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250
Fax:

GRAIN SIZE DISTRIBUTION

Project: OSU Cascades 46 Acre Site

Location: Simpson Avenue - Bend, Oregon

Number: G1303959.A



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**TP-32**	**2.5**	**Silty Sand (SM)**					
⧗	**TP-33**	**4.0**	**Silty Sand (SM) with Gravel**					
▲	**TP-33**	**13.5**	**Sand with Silt (SW-SM) and Gravel**				**1.41**	**7.95**
★	**TP-34**	**3.0**	**Silty Sand (SM)**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP-32**	**2.5**	**19**	**0.402**	**0.096**		**4.7**	**67.8**	**27.5**	
⧗	**TP-33**	**4.0**	**75**	**0.848**	**0.125**		**20.7**	**57.0**	**22.3**	
▲	**TP-33**	**13.5**	**37.5**	**3.993**	**1.681**	**0.502**	**34.0**	**61.0**	**5.0**	
★	**TP-34**	**3.0**	**25**	**0.661**	**0.182**		**3.8**	**83.2**	**13.0**	

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250
Fax:

GRAIN SIZE DISTRIBUTION

Project: OSU Cascades 46 Acre Site

Location: Simpson Avenue - Bend, Oregon

Number: G1303959.A

Carlson Testing, Inc.

Bend	(541) 330-9155
Eugene	(541) 345-0289
Geotechnical	(503) 601-8250
Salem	(503) 589-1252
Tigard	(503) 684-3460

COLLAPSIBLE POTENTIAL TEST (ASTM D5333-03): DATA

Figure D2

CTI Project #:	G1303959.A
Test Start Date:	1/24/2014

Sample ID:	B10A-1	
Sample Depth:	6.5	feet bgs
Sample Prep:	Remolded	------>
Sample Initial M%	3	%
Sample Final M%	28	%
Initial Specimen Height, h_o	1.0000	inch
Initial Dial Reading at Seating	0.0004	inch

Target MoistUnit Weight:	51.3	pcf
Remolded Moist Unit Weight in Ring:	57.6	pcf

Loading/Unloading Phase

Load Increment	Total Stress (psf)	Strain ϵ (%)	Total ΔH (in.)	1 hr. ΔH Value (in.)	1 hr. ΔH Value - d_o (in.)	24 hr. ΔH Value (in.)	24 hr. ΔH Value - d_o (in.)
1	125	0.0100	0.0001	0.0005	0.0001	---	---
2	250	0.0700	0.0007	0.0011	0.0007	---	---
3	500	0.2700	0.0027	0.0031	0.0027	---	---
4	1000	0.6400	0.0064	0.0068	0.0064	---	---
5	2000	1.3200	0.0132	0.0136	0.0132	---	---
6	4000	2.4800	0.0248	0.0252	0.0248	---	---
After Wetting	4000	3.5500	0.0355	0.0345	0.0341	0.0359	0.0355
7	8000	5.7000	0.0566	---	---	0.057	0.057
8	10000	6.3100	0.0627	---	---	0.063	0.063
9	2000	5.7800	0.0578	---	---	0.058	0.058
10	125	5.3300	0.0533	---	---	0.054	0.053

Soil Specimen Wetting

Time (min.)	Total Stress (psf)	Wetted	Total ΔH (in.)	Total ΔH - 1hr do (in.)
0	4000	No	0.0252	0.0000
0.1	4000	Yes	0.0260	0.0008
0.25	4000	Yes	0.0267	0.0015
0.5	4000	Yes	0.0279	0.0027
1	4000	Yes	0.0297	0.0045
2	4000	Yes	0.0320	0.0068
4	4000	Yes	0.0328	0.0076
8	4000	Yes	0.0334	0.0082
15	4000	Yes	0.0337	0.0085
30	4000	Yes	0.0341	0.0089
60	4000	Yes	0.0345	0.0093
1440	4000	Yes	0.0359	0.0107

Carlson Testing, Inc.

Bend	(541) 330-9155
Eugene	(541) 345-0289
Geotechnical	(503) 601-8250
Salem	(503) 589-1252
Tigard	(503) 684-3460

COLLAPSIBLE POTENTIAL TEST (ASTM D5333-03): Plots

Figure D2 (cont.)

CTI Project #:	G1303959.A
Test Start Date:	1/24/2014

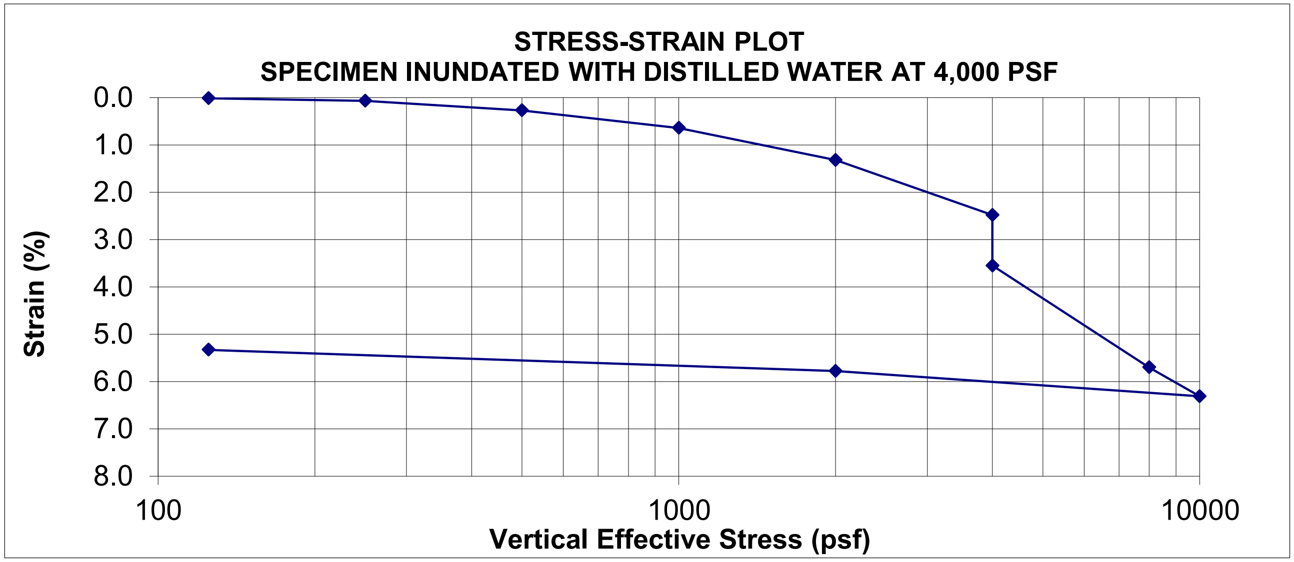
Sample ID:	B10A-1
Sample Depth:	6.5

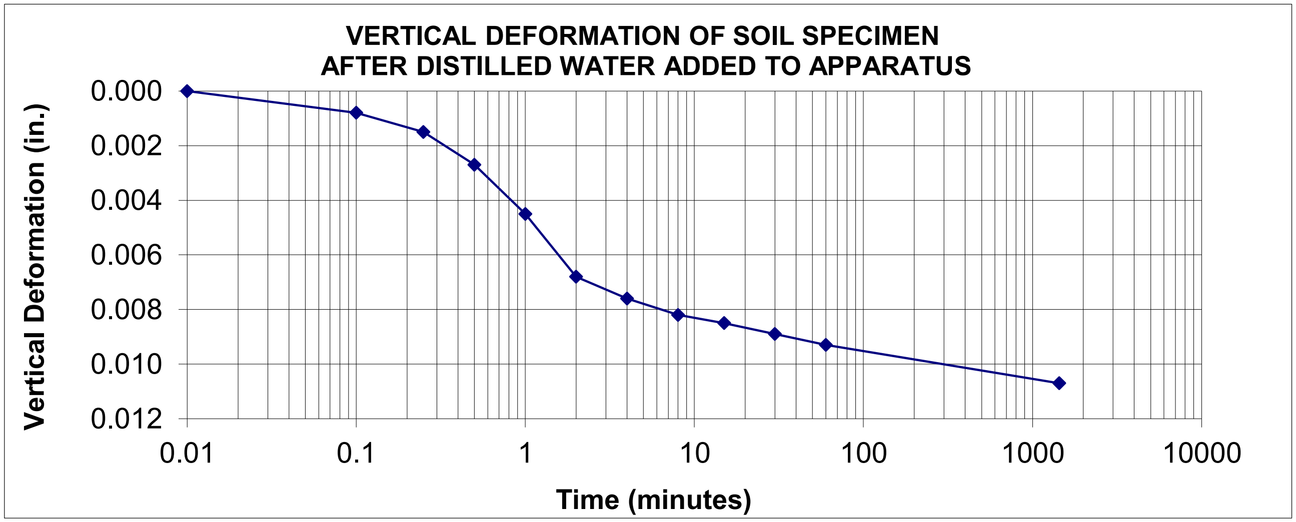
Total Stress (psf)	Strain ϵ (%)
125	0.0100
250	0.0700
500	0.2700
1000	0.6400
2000	1.3200
4000	2.4800
4000	3.5500
8000	5.7000
10000	6.3100
2000	5.7800
125	5.3300

Collapsible Index, I_e (%)	1.1
Degree of Specimen Collapse	Slight

Specimen Wetting at 4,000 psf

Time (min.)	Total ΔH - 1hr d_o (in.)
0.01	0.0000
0.1	0.0008
0.25	0.0015
0.5	0.0027
1	0.0045
2	0.0068
4	0.0076
8	0.0082
15	0.0085
30	0.0089
60	0.0093
1440	0.0107





Bend (541) 330-9155
Eugene (541) 345-0289
Geotechnical (503) 601-8250
Salem (503) 589-1252
Tigard (503) 684-3460

Carlson Testing, Inc.

COLLAPSIBLE POTENTIAL TEST (ASTM D5333-03): DATA

Figure D3

CTI Project #:	G1303959.A
Test Start Date:	1/24/2014

Sample ID:	B17-2	
Sample Depth:	10	feet bgs
Sample Prep:	Remolded	------>
Sample Initial M%	22	%
Sample Final M%	53	%
Initial Specimen Height, h_o	1.0000	inch
Initial Dial Reading at Seating	0.0010	inch

Target MoistUnit Weight:	74	pcf
Remolded Moist Unit Weight in Ring:	68.9	pcf

Loading/Unloading Phase

Load Increment	Total Stress (psf)	Strain ε (%)	Total ΔH (in.)	1 hr. ΔH Value (in.)	1 hr. ΔH Value - d_o (in.)	24 hr. ΔH Value (in.)	24 hr. ΔH Value - d_o (in.)
1	125	0.0000	0.0000	0.0010	0.0000	---	---
2	250	0.0000	0.0000	0.0010	0.0000	---	---
3	500	0.2000	0.0020	0.0030	0.0020	---	---
4	1000	0.2000	0.0020	0.0030	0.0020	---	---
5	2000	0.3000	0.0030	0.0040	0.0030	---	---
6	4000	1.5000	0.0150	0.0160	0.0150	---	---
After Wetting	4000	6.2000	0.062	0.0620	0.0610	0.063	0.062
7	8000	8.9000	0.0880	---	---	0.089	0.088
8	10000	9.7000	0.0960	---	---	0.097	0.096
9	2000	8.6000	0.0860	---	---	0.087	0.086
10	125	8.5000	0.0850	---	---	0.086	0.085

Soil Specimen Wetting

Time (min.)	Total Stress (psf)	Wetted	Total ΔH (in.)	Total ΔH - 1hr do (in.)
0	4000	No	0.0160	0.0000
0.1	4000	Yes	0.0230	0.0070
0.25	4000	Yes	0.0300	0.0140
0.5	4000	Yes	0.0360	0.0200
1	4000	Yes	0.0510	0.0350
2	4000	Yes	0.0560	0.0400
4	4000	Yes	0.0580	0.0420
8	4000	Yes	0.0600	0.0440
15	4000	Yes	0.0600	0.0440
30	4000	Yes	0.0610	0.0450
60	4000	Yes	0.0620	0.0460
1440	4000	Yes	0.0630	0.0470

Carlson Testing, Inc.

Bend	(541) 330-9155
Eugene	(541) 345-0289
Geotechnical	(503) 601-8250
Salem	(503) 589-1252
Tigard	(503) 684-3460

COLLAPSIBLE POTENTIAL TEST (ASTM D5333-03): Plots

Figure D3 (cont.)

CTI Project #:	G1303959.A
Test Start Date:	1/24/2014

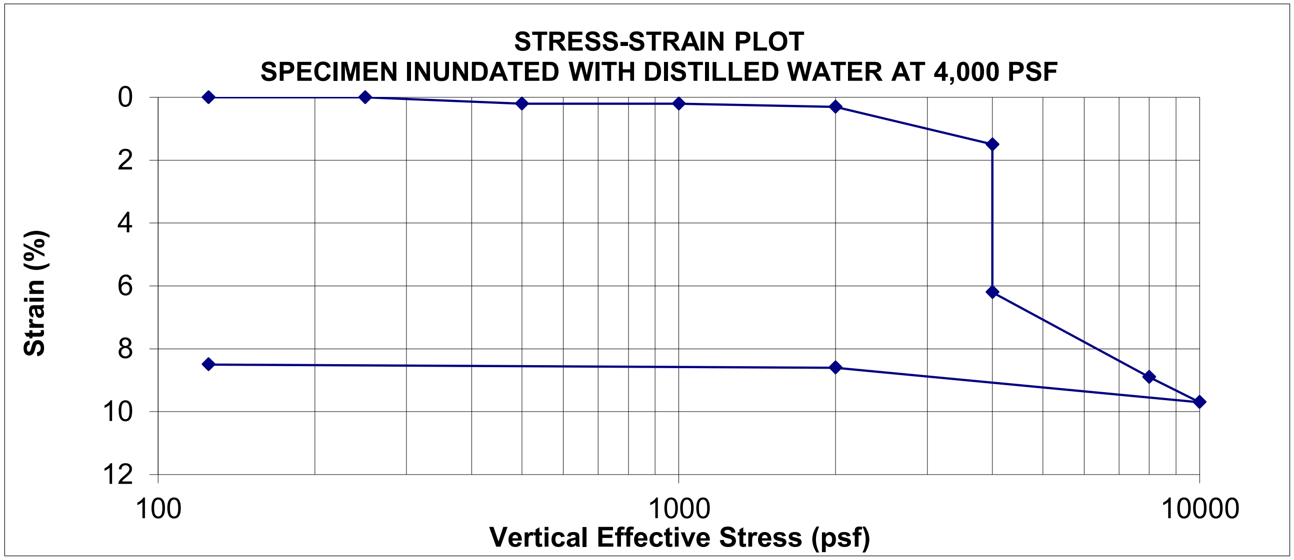
Sample ID:	B17-2
Sample Depth:	10

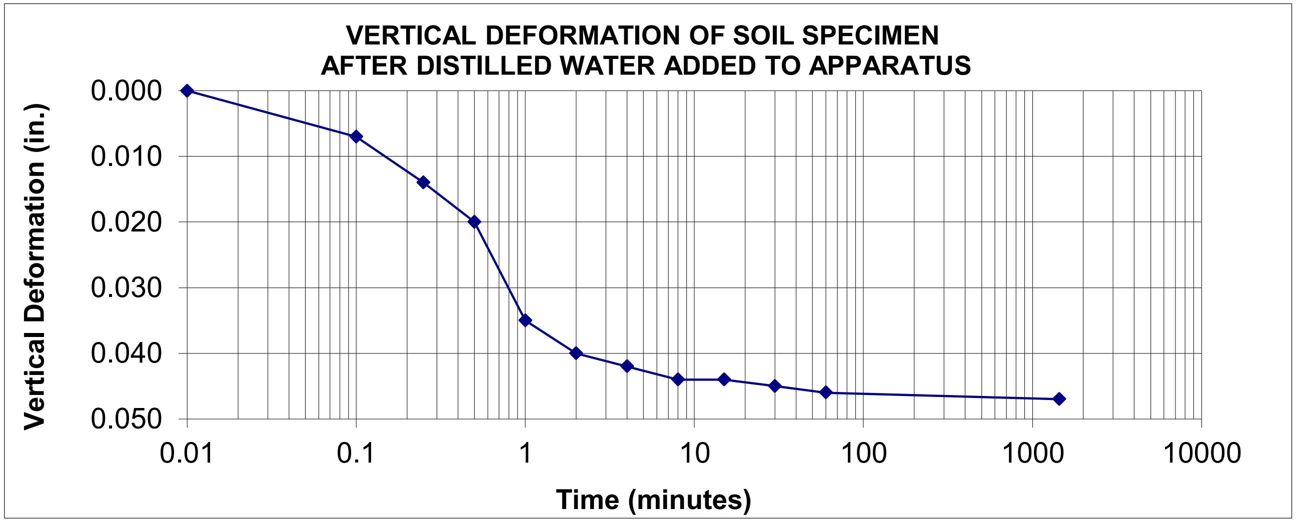
Total Stress (psf)	Strain ϵ (%)
125	0.0000
250	0.0000
500	0.2000
1000	0.2000
2000	0.3000
4000	1.5000
4000	6.2000
8000	8.9000
10000	9.7000
2000	8.6000
125	8.5000

Collapsible Index, I_e (%)	4.7
Degree of Specimen Collapse	Moderate

Specimen Wetting at 4,000 psf

Time (min.)	Total ΔH - 1hr d_o (in.)
0.01	0.0000
0.1	0.0070
0.25	0.0140
0.5	0.0200
1	0.0350
2	0.0400
4	0.0420
8	0.0440
15	0.0440
30	0.0450
60	0.0460
1440	0.0470





Carlson Geotechnical
A Division of Carlson Testing, Inc.
Phone: (503) 601-8250
Fax: (503) 601-8254

Bend Office	**(541) 330-9155**
Eugene Office	**(541) 345-0289**
Salem Office	**(503) 589-1252**
Tigard Office	**(503) 684-3460**

Appendix E: Geologic Cross Sections

OSU-Cascades 46-acre Site
1707 & 1757 Simpson Avenue
Bend, Oregon

CGT Project No. G1303959.A

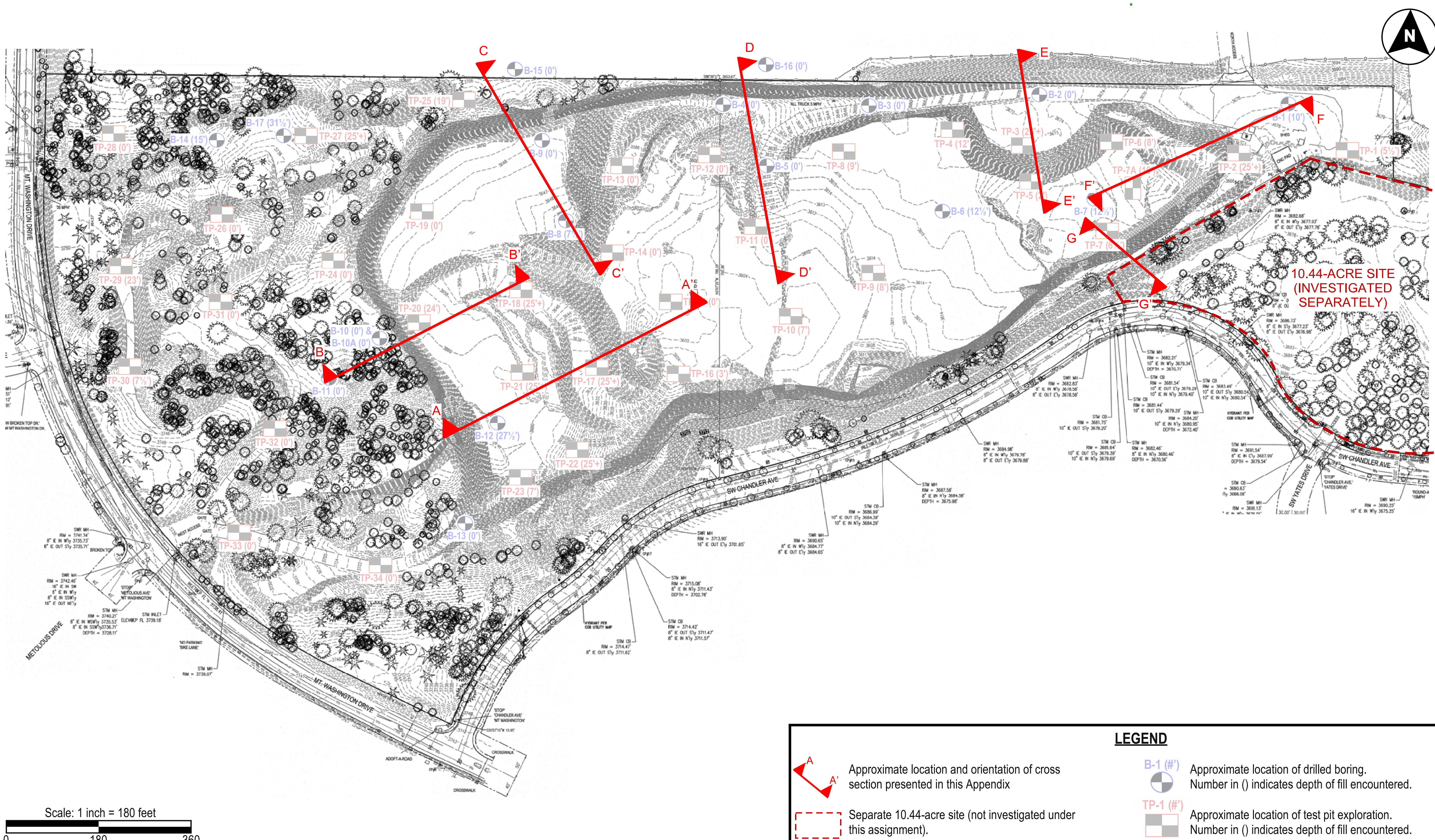
July 25, 2014

Prepared For:

OSU-Cascades
Attn: Ms. Kelly Sparks / AVP Finance & Strategic Planning
650 SW Columbia Street, Suite 7250
Bend, Oregon 97702

Prepared By:

Carlson Geotechnical



LEGEND

A — A'	Approximate location and orientation of cross section presented in this Appendix
(dashed red line)	Separate 10.44-acre site (not investigated under this assignment).
B-1 (#')	Approximate location of drilled boring. Number in () indicates depth of fill encountered.
TP-1 (#')	Approximate location of test pit exploration. Number in () indicates depth of fill encountered.

CARLSON CGT GEOTECHNICAL 503-601-8250
Carlson Geotechnical
P.O. Box 23814
Tigard, Oregon 97281

SITE PLAN SHOWING LOCATIONS OF CROSS SECTIONS

OSU CASCADES 46-ACRE SITE - BEND, OREGON

CGT Job No. G1303959.A

FIGURE E1

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

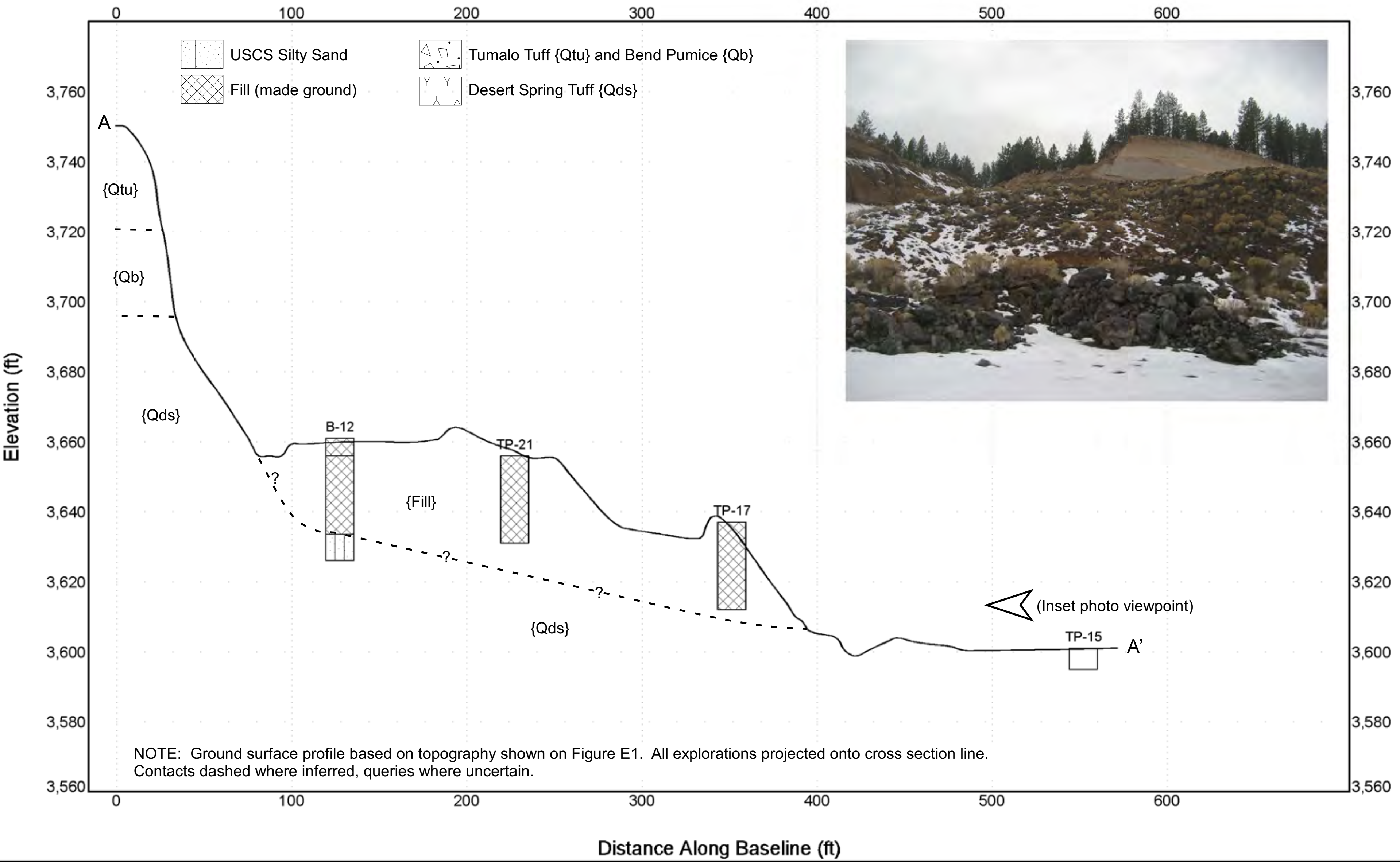
GEOLOGIC CROSS SECTION A-A'

CLIENT Oregon State University System

PROJECT NUMBER G1303959.A

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT LOCATION Simpson Avenue - Bend, Oregon



STRATIGRAPHY & GW - A SIZE - MODIFIED G1303959A.GPJ GINT US.GDT 1/23/14

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

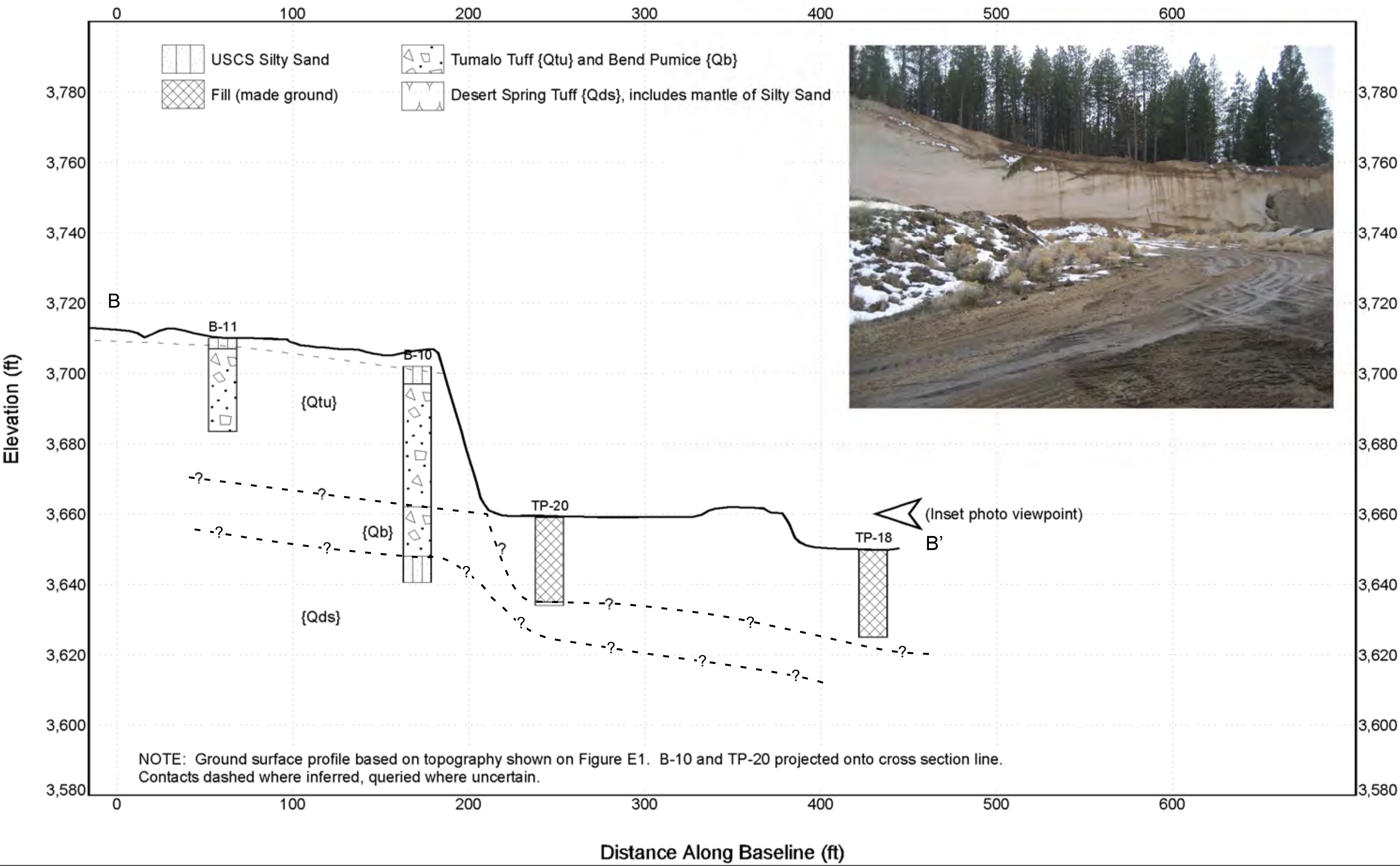
GEOLOGIC CROSS SECTION B-B'

CLIENT Oregon State University System

PROJECT NUMBER G1303959.A

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT LOCATION Simpson Avenue - Bend, Oregon



STRATIGRAPHY & GW - A SIZE - MODIFIED G1303959A.GPJ GINT US.GDT 1/27/14

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

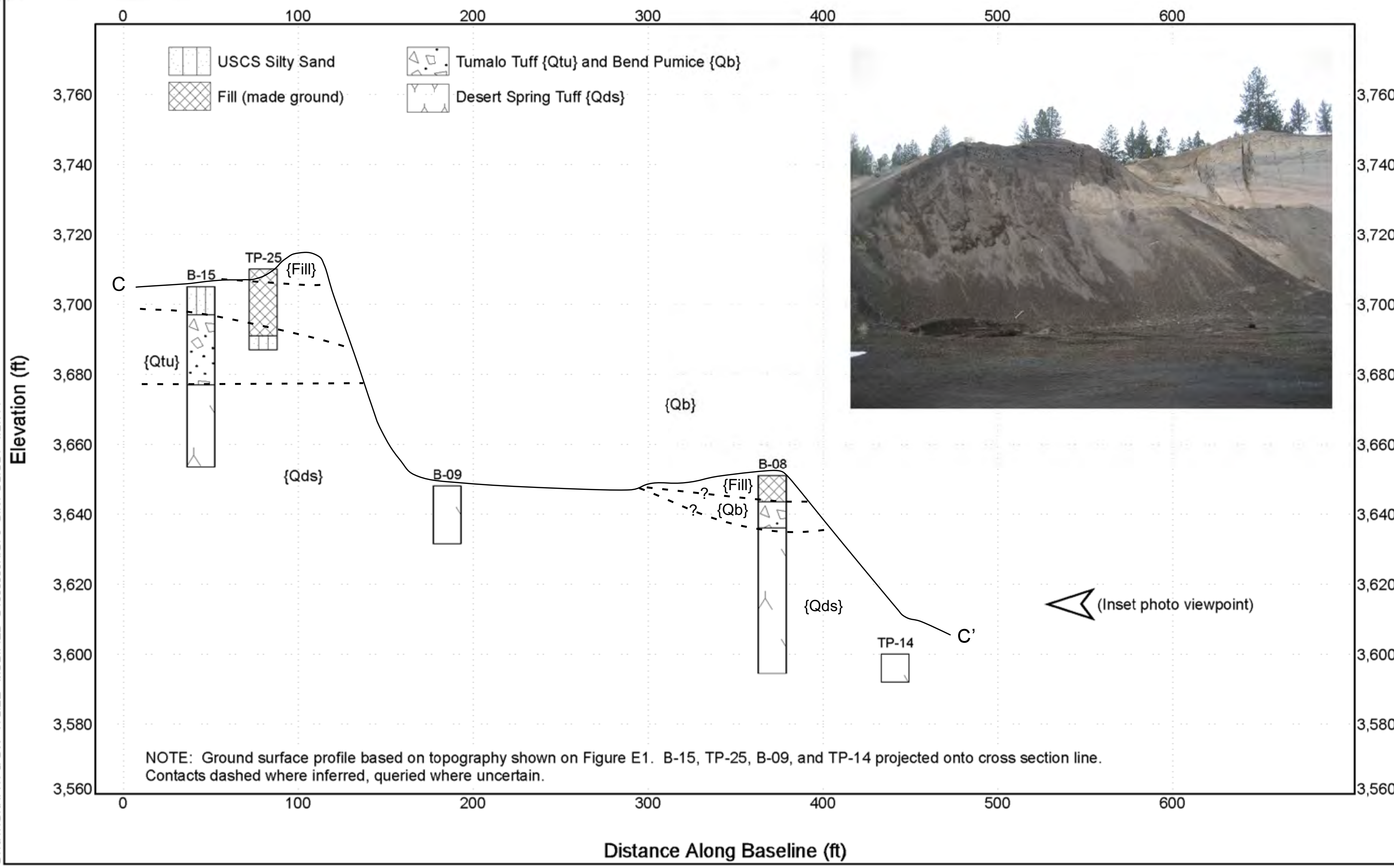
GEOLOGIC CROSS SECTION C-C'

CLIENT Oregon State University System

PROJECT NUMBER G1303959.A

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT LOCATION Simpson Avenue - Bend, Oregon



NOTE: Ground surface profile based on topography shown on Figure E1. B-15, TP-25, B-09, and TP-14 projected onto cross section line. Contacts dashed where inferred, queried where uncertain.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

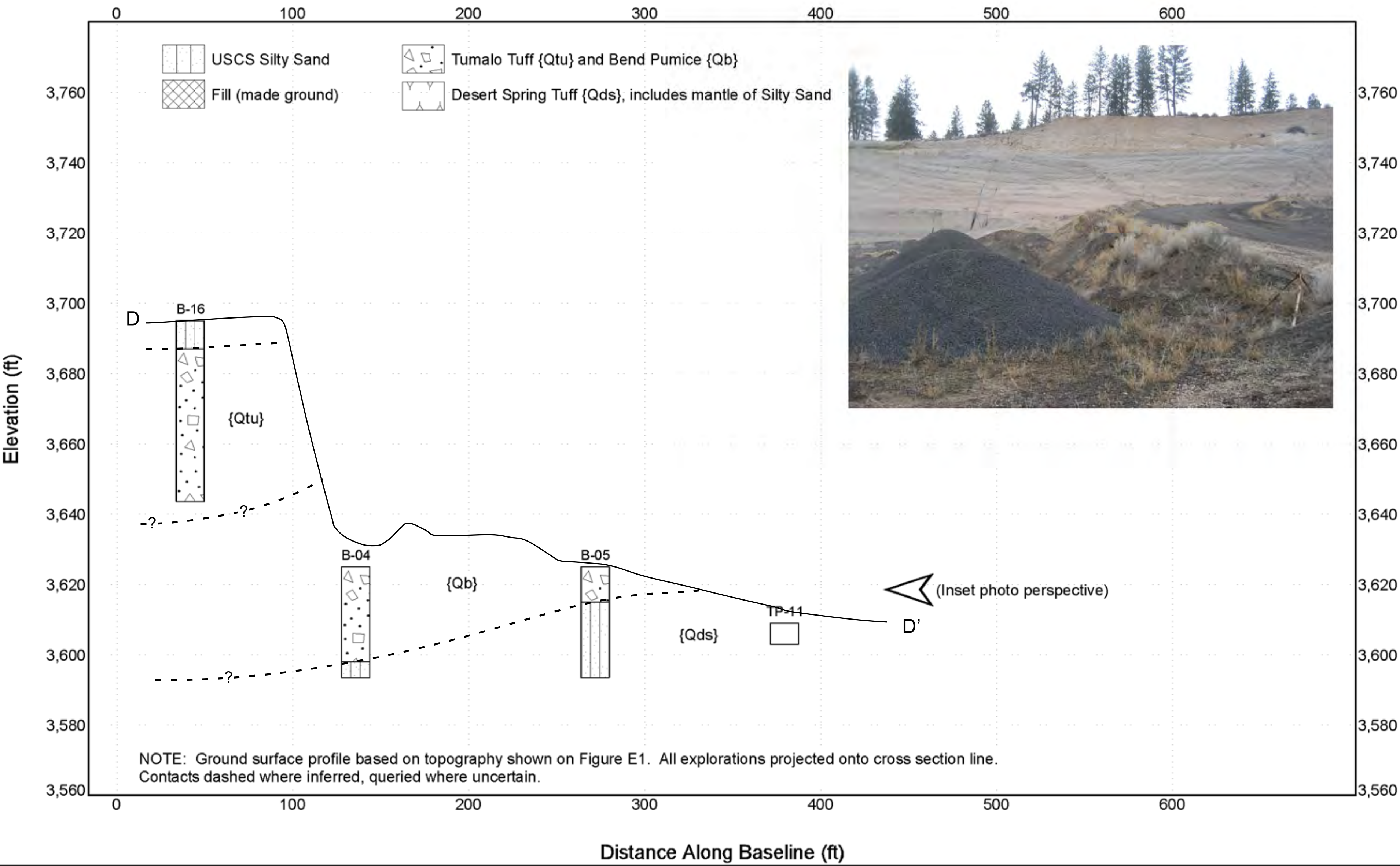
GEOLOGIC CROSS SECTION D-D'

CLIENT Oregon State University System

PROJECT NUMBER G1303959.A

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT LOCATION Simpson Avenue - Bend, Oregon



STRATIGRAPHY & GW - A SIZE - MODIFIED G1303959A.GPJ GINT US.GDT 1/23/14

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

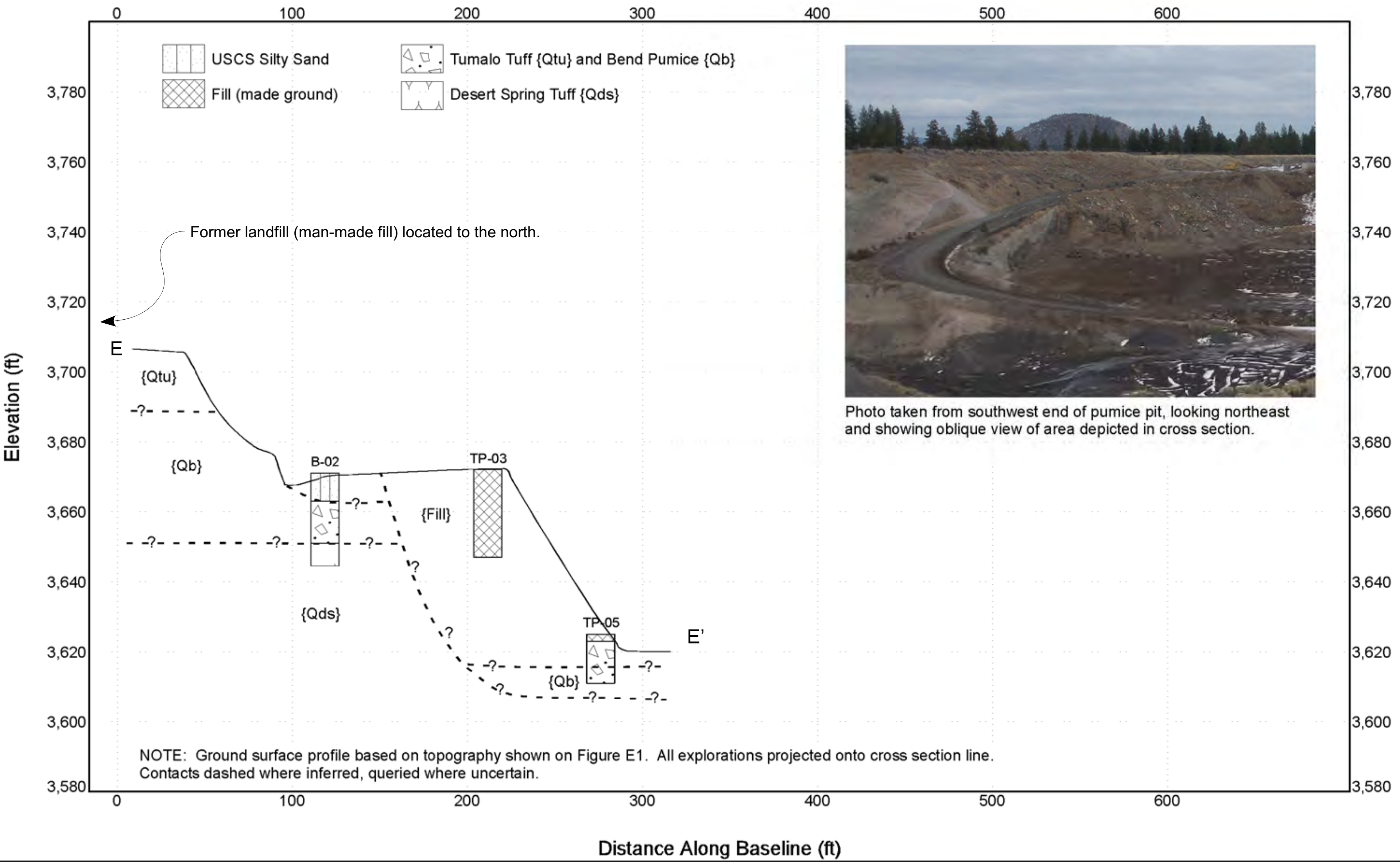
GEOLOGIC CROSS SECTION E-E'

CLIENT Oregon State University System

PROJECT NUMBER G1303959.A

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT LOCATION Simpson Avenue - Bend, Oregon



STRATIGRAPHY & GW - A SIZE - MODIFIED G1303959A.GPJ GINT US.GDT 1/23/14

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

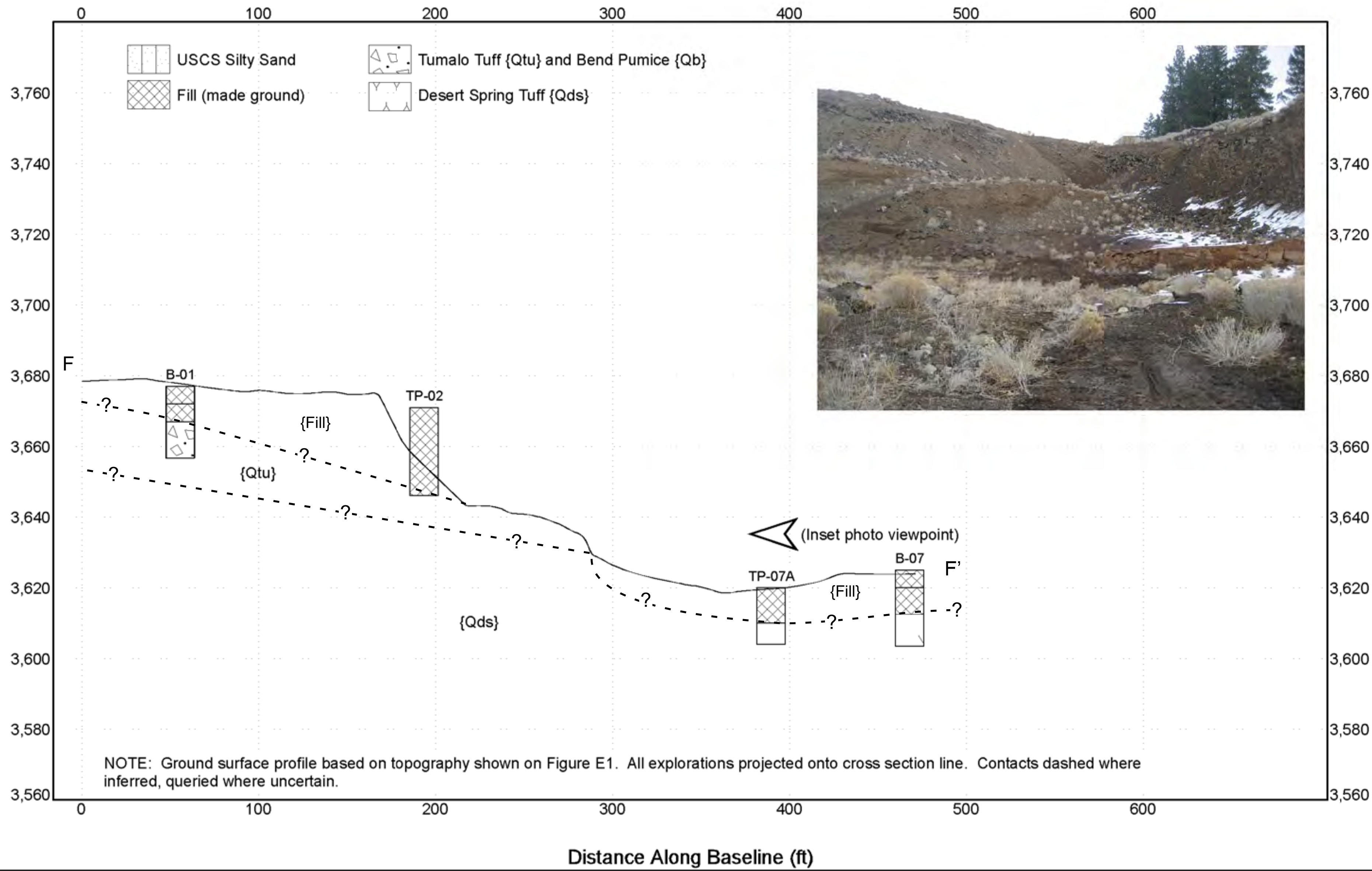
GEOLOGIC CROSS SECTION F-F'

CLIENT Oregon State University System

PROJECT NUMBER G1303959.A

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT LOCATION Simpson Avenue - Bend, Oregon



STRATIGRAPHY & GW - A SIZE - MODIFIED G1303959A.GPJ GINT US.GDT 1/27/14

Carlson Geotechnical
7185 SW Sandburg Street, Suite 110
Tigard, OR 97223
Telephone: 503-601-8250

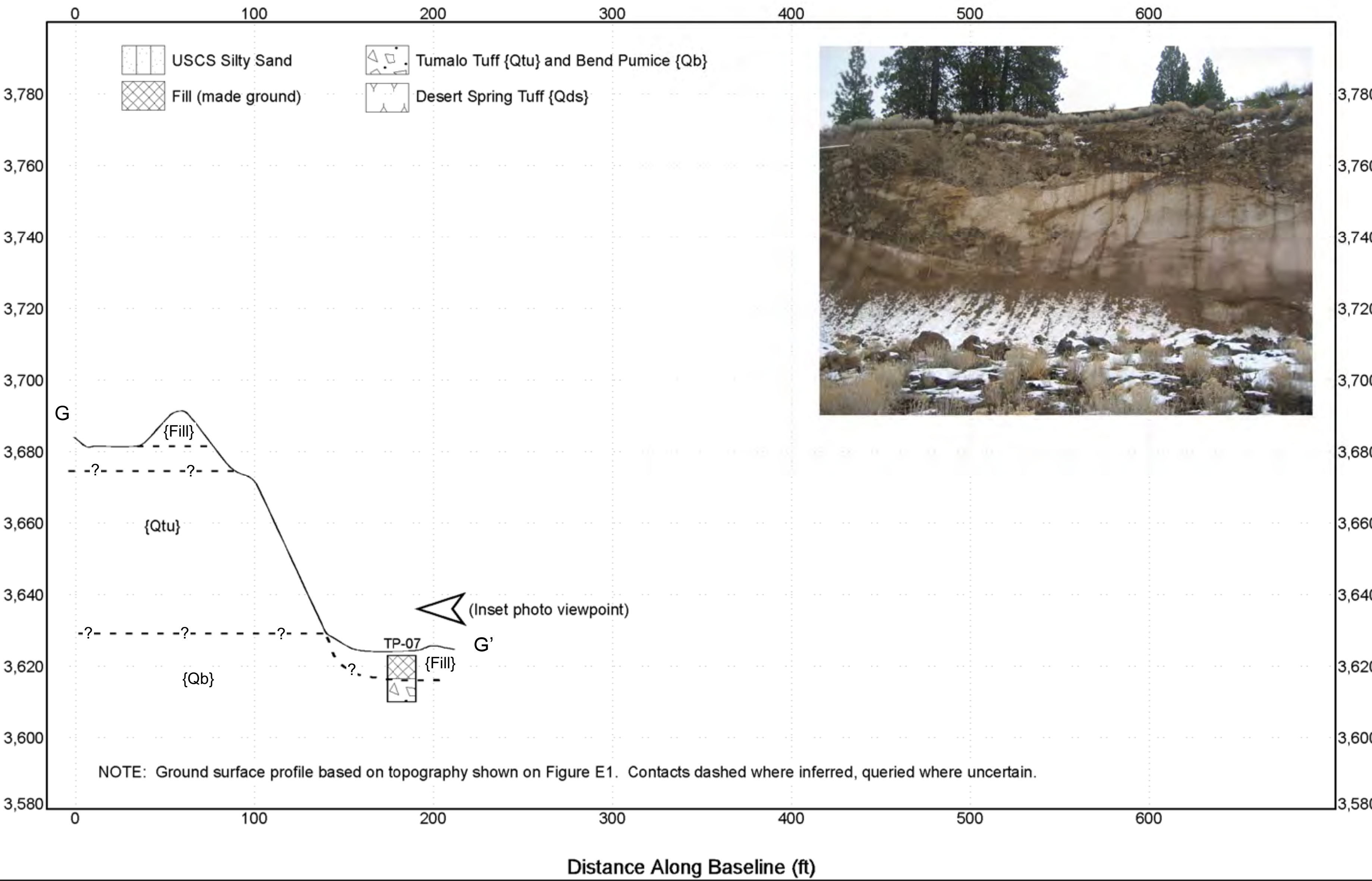
GEOLOGIC CROSS SECTION G-G'

CLIENT Oregon State University System

PROJECT NUMBER G1303959.A

PROJECT NAME OSU Cascades 46 Acre Site

PROJECT LOCATION Simpson Avenue - Bend, Oregon



NOTE: Ground surface profile based on topography shown on Figure E1. Contacts dashed where inferred, queried where uncertain.

STRATIGRAPHY & GW - A SIZE - MODIFIED G1303959A.GPJ GINT US.GDT 1/23/14