Cascadia Geoservices, Inc.
190 6th Street
PO Box 1026
Port Orford, Oregon 97465
D. 541-332-0433
C.541-655-0021
Email: info@cascadiageoservices.com
www:cascadiageoservices.com

SOILS, GEOLOGY, AND HYDROLOGY REPORT- RESIDENTIAL DEVELOPMENT

Madison Avenue SW & 5th Street SW
Bandon, Oregon 97411
Coos County Map T28S R15W Sec 25BD, Tax Lot 7400 and 7500

Prepared for:
Mr. Drew George, PE
1633 Diamond Street, #20
San Diego, Ca 92109
Sent Via Email: Drew@Dgp-Inc.Com

November 24, 2020
CGS Project No. 20111

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INTRODUCTION

Cascadia Geoservices, Inc. (CGS) is pleased to submit this Soils, Geology, and Hydrology Report for Residential Development for your property (site or subject property) located on Madison Avenue SW & 5th Street SW (see Figure 1, Location Map). We understand that you are in the process of developing the site with a residential structure and are requesting that CGS provide you with a report which addresses the city of Bandon's Municipal Code 17.24.040C regarding development in a Controlled Development-Residential Zone (CD-R1). This report summarizes our project understanding and site investigation, including subsurface explorations, and provides our conclusions and recommendations for developing the site.

PROJECT UNDERSTANDING

Our understanding is based on telephone and email correspondence with you beginning on September 30, 2020 and on a preliminary site visit to the site on October 6, 2020. Our understand is further based on a second site visit on October 13, 2020 at which time 4 exploratory test pits were excavated and logged.

We understand that you are proposing to develop the site with a wood framed 2-story residential structure. We further understand that you are planning to site the home on a conventional perimeter foundation with spread footings and concrete slab. And, based on a review of the Flood Insurance Rate Map (FIRM) for Coos County Map No. 41011C0681E, the site is located in a Special Flood Hazard Area subject to inundation by a 1% chance flood. Per the City of Bandon's Municipal Ordinance 15.28, the Lowest Floor is required to be 1 foot above the Base Flood Elevation. Because of this, we recommend that you consult with the City of Bandon and a registered Oregon Land Surveyor and that a Flood Elevation Certification be issued for the site.

The site is located within an area zoned by the City of Bandon as Controlled Development Two (CD-2). Under the City's Municipal Code 17.24.040C, the city does require, prior to development, a soils, geology, and hydrology report for the subject property. The code requires that the reports be prepared by a professional geologist and professional engineer currently registered in the state of Oregon. Because our soils, geology and hydrology reports use many of the same figures, test pit logs and data, we have combined these reports together under one cover with separate headings.

SURFACE DESCRIPTION

The site is within the Coast Range Physiographic Region of southern Oregon.

The site consists of two tax lots which combined total 7,520 feet square. The site is in a residential neighborhood and is bordered on the east by a developed residential lot, on the west and north by city-maintained roads and on the south by an undeveloped, city owned alley. The site varies in elevation from approximately 15-17 feet Above Mean Sea (AMSL).

The site is located in a low-lying area north of the base of the sea cliff known locally as the Bandon Bluff. This area was at one time part of the mouth of the Coquille River prior to the river meandering to the north. Much of this area has been historically elevated with fill.

Asphalt, concrete, and vertical pipes were observed during our site visit which indicate that a structure was previously constructed and later demolished on the site. We discuss how to abandon these items in our Discussion and Recommendation section of this report.

Based on mapping done by others,[1,2], surficial soils on the site consist of Anthropocene foredune deposits consisting of fine grained eolian sands formed as deflation plane deposits. These soils are well drained and derived from mixed eolian and marine deposits. Underlying these soils are surficial sediments of Quaternary marine terrace deposits (QMTD), which consist of semi-consolidated sand, silt, clay, and gravel. Deleterious material within the soils consist of organic material formed in near-shore coastal wetlands and lagoons and driftwood.

SOILS REPORT

Section 17.20.040.C.1.B of the Bandon Municipal Code requires that a soils report be prepared by a professional civil engineer currently registered in the state of Oregon, which shall include:

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[1] United States Department of Agriculture (USDA). Natural Resource Conservation Service Web Soil Survey, retrieved from http://websoilsurvey.nrcs.usda.gov

[2] Thomas J. Wiley, et al. (2014). Geologic map of the southern Oregon coast between Port Orford and Bandon, Curry and Coos Counties, Oregon. Oregon Department of Geology and Mineral Industries (DOGAMI) Open-File Report O-14-0.

> ***data regarding the nature, distribution and strength of existing soils, conclusions and recommendations for grading, design criteria for corrective measures, and options and recommendations covering the carrying capabilities of the sites to be developed in a manner imposing the minimum variance from the natural conditions.***

To analyze the soils at the site, CGS observed the excavation of four test pits during our October 13, 2020 site visit. The test pits were excavated by Natural Origins LLC of Bandon, Oregon, using a track-mounted mini excavator. The test pits were logged by an Oregon certified engineering geologist and were excavated to observe subsurface conditions across the site and to collect soil samples for later classification and lab analysis. The test pits were excavated to a depth of up to 60 inches below ground surface (bgs) at four locations and are shown on Figure 2, Site Map. Detailed logs for the test pits are included at the end of this report as Attachment 1.

The soils encountered in our test pits from 0 to 60 inches bgs consisted of loose, fine grained sands. These soils were noted as being dry to moist and had in places a surficial root zone of up to 12 inches. In Test Pit TP-3, buried logs were encountered at 24 inches bgs. We infer that this is storm debris and that these sands are Anthropocene Age dune sands.

Upon completion, the test pits were filled with excavated material and the locations surveyed and plotted using GPS. A summary of the soils encountered in our test pits is provided as follows:

> **Fine Sands**: Encountered from 0.0 to 60.0 inches. These sands are fine grained and well-drained. In most areas, the sands are capped by variable vegetation and have a 12-inch root zone.

Laboratory Analysis

Select samples were packaged in moisture-proof bags and transported to our office where they were classified in general accordance with the Unified Soil Classification System, Visual-Manual Procedure (ASTM2488). In addition, select samples were analyzed in our laboratory (where applicable) for water content (ASTM D2216) and Percent Fines (ASTM D1140). The results are summarized below in Table 1. The Lab Analysis Reports for the samples are provided at the back of this report as Attachment 2.

Table 1: Laboratory Analysis

Sample ID	Test Pit	Depth (Inches)	Type of Soil	Water Content (%)	Percent Fines	USCS Symbol[3]	ϕ
SS-1	TP-1	20	Fine Sand	5.7	0.7	SP	28
SS-3	TP-3	48	Fine Sand	6.2	0.8	SP	28
SS-5	TP-4	48	Fine Sand	3.4	1.2	SP	28

Discussion and Recommendations Regarding Soils Report

Based on our investigation and experience with similar soils, it is CGS's opinion that the soils encountered at the site are suitable to support the proposed residential structure, provided the site is prepared in accordance with our recommendations.

We recommend that the top 4 feet of the sand be excavated and stockpiled. This area should encompass the building footprint and 5 feet around the footprint. We further recommend that a Standard Proctor based on a bulk sample of the sands be completed in accordance with ASTM D698. After excavation, the base of the cut should be rolled, wetted and tested using a nuclear densometer to determine that the optimum moisture content per the Standard Proctor is achieved and that the sands are compacted to at least 95% of dry density. Upon achieving the required compaction, lifts of 1 foot thick of the excavated sand should be placed, wetted, compacted and tested to show that the sand are compacted to at least 95% of dry density. This should be done until the pad is brought back to grade. At a minimum, the top 12" of soil and all deleterious material including vegetation, roots and logs, etc. should be removed and not used. All footings should be designed for an allowable bearing pressure of 1,500 pounds per square foot (psf) for typical residential building perimeter foundation loads. If greater loads are anticipated, we will need to evaluate the specific load scenario individually. Based on CGS' estimates, total post-construction settlement is

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[3] Classification symbols are estimated based on visual observation.

estimated to be less than ½ inch, with post-construction differential settlement of less than ½ inch over a 50-foot span.

GEOLOGY REPORT

As prescribed by section 17.20.040.C.1.B of the Bandon Municipal Code regarding a geology report for the site:

> ***This report shall include an adequate description as defined by the city manager or designate of the geology of the site, conclusions and recommendations regarding the effect of geologic conditions in the proposed development, and opinions and recommendations as to the carrying capabilities of the sites to be developed. The investigation and report shall be prepared by a professional geologist currently registered in the state of Oregon.***

The geology of the site was determined by our on-site reconnaissance and test pits, our knowledge of the area, and by a review of readily available geologic reports and maps.

The site is located is a low-lying area which was, at one time, part of the mouth of the Coquille River prior to the river meandering to the north. Much of this area has been elevated with fill. The southern boundary of the site is 440 feet north of the base of the bluff and, as such, is not impacted by erosion and instability of the slope. The site is 245 feet east of the beach vegetation line and is not impacted by coast erosion. The level building site appeared stable at the time of our site visit

Geologic Hazards

A review of the State Landslide Inventory Database on DOGAMI's Statewide Geohazards Viewer (HazVu)[4] indicates there are no landslides, earthflows, or debris flows which impact the site. The site and adjoining areas have been classified by the State as having a low susceptibility to future landslides.

A review of LIDAR for the area (a surveying technology that reveals topography by illuminating the ground with laser light) indicates that the site is level and within a

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[4] Oregon Department of Geology and Mineral Industries (DOGAMI) Oregon HazVu: Statewide Geohazards Viewer, viewed at https://gis.dogami.oregon.gov/maps/hazvu

developed area. The site has no surface breaks in topography and no anomalous landforms indicative of settlement.

Based on a review of U.S. Geological Survey maps[5], there have been no geologically young faults identified less than 0.3 miles from the subject property. As with other folds and faults located in the Cascadia forearc, it is suspected that great megathrust earthquakes along the subduction zone will cause future displacement on these faults.

Seismic Design Criteria

The subject property is in an area that is highly influenced by regional seismicity due to the proximity to the Cascadia Subduction Zone (CSZ). Current studies[6] indicate that the southern CSZ has generated maximum credible earthquakes with a moment magnitude (Mm) of 8.7 or greater every 200 to 300 years. Time-dependent probabilities currently range up to 40 percent in 50 years for a southern segment rupture.

The seismic design criteria for this project are based on the 2012/2015 International Building Code (IBC) (ASCE 7 Standard) and are summarized in Table 2 below.

Table 2: 2015 NEHRP Seismic Design Parameters

Seismic Design Parameters	Short Period	1 Second
Maximum Credible Earthquake Spectral Acceleration	Ss = 2.039 g	S1 = .971 g
Site Class	D = Stiff Soil	
Site Coefficient	Fa = 1.0	Fv = null
Adjusted Spectral Acceleration	SMS = 2.447 g	SM1 = null
Design Spectral Response Acceleration Parameters	SDS = 1.631 g	SD1 = null
Peak Ground Acceleration	PGA = 1.011 g	

There is now a consensus among earth scientists that much of the western US coastline, including the entire southern Oregon coast, is in an area which has been seismically

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[5] USGS Quaternary Faults viewed at https://usgs.maps.arcgis.com

[6] Goldfinger, C., et al. (2012). Turbidite Event History—Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone. U.S. Geological Survey (USGS), Professional Paper: 1661-F.

active in the recent geologic past. Our understanding of these forces is evolving and has been heightened by witnessing geologically recent earthquakes and tsunamis in similar tectonic settings in northern Indonesia (2005) and in northern Japan (2011). Based on these observations and on our knowledge of the area, we recommend that you adopt these IBC standards into your design.

Liquefaction

Liquefaction potential was assessed based on the information obtained from our test pits and using the parameters suggested in Youd & Andrus, et al., 2001. According to our seismic analysis, the site will experience a peak ground acceleration (PGA) during a design seismic event of 1.011 g. Further, groundwater is inferred to be 10.0 feet bgs. Based on the depth of groundwater and the consistency of the granular soils encountered in our test pits, it is our opinion that the liquefaction potential for the site is moderate. Our calculations indicate that if groundwater levels were to rise and liquefaction were to occur, settlement of up to 10.9 inches could occur. Our further analysis indicates that by removing and mechanically compacting the sands to 95% of dry density to a depth of 4.0 feet bgs, we can limit settlement due to liquefaction to approximately 0.5 inches. This is below the criteria for ASCE 7-16 section 12 for residential structures. Our calculations are included here as Attachment 1, Liquefaction SPT Analysis 3.3.2. This is described in more detail in our **DISCUSSION AND RECOMMENDATIONS** section of this report.

Tsunamis

Based on recent mapping and modeling done by the state of Oregon,[7] the site is within the Tsunami Inundation Zone and will be impacted by a tsunami generated by a local source Cascadia Subduction Zone Earthquake of Moment Magnitude 8.7 or greater. Because of this, we strongly recommend that you check with the City of Bandon and with the state of Oregon's Department of Geology and Mineral Industries (DOGAMI) Tsunami Resource Center[8] for current information regarding tsunami preparedness and emergency procedures.

Discussion and Recommendations Regarding Geology Report

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[7] Local Source (Cascadia Subduction Zone) Tsunami Inundation Map, Bandon, Oregon. 2012. State of Oregon Department of Geology and Mineral Industries.

[8] Viewed on-line at www.oregongeology.org

It is our opinion that the site is currently geologically stable. We base this opinion on our site inspection, our test pits, and on our review of LIDAR of the site. We note that the site is in the tsunami inundation area and will be impacted by a local source Cascadia Subduction Zone Earthquake. We recommend that you check with local and state organizations and review regarding tsunami preparedness and emergency procedures. We further note the that loose sands under the building site are susceptible to liquefaction. Because of this, we recommend that the top 4.0 feet of sand is removed and mechanically compacted to 95% of dry density. This is described in more detail in our **DISCUSSION AND RECOMMENDATIONS** section of this report

HYDROLOGY REPORT

As outlined in section 17.20.040.C.1.B of the Bandon Municipal Code regarding a hydrology report for the site:

> ***This report shall include an adequate description, as defined by the city manager or designate, of the hydrology of the site, conclusions and recommendations regarding the effect of hydrologic conditions on the proposed development, and options and recommendations covering the carrying capabilities of the sites to be developed. The investigation and report shall be prepared by a professional civil engineer currently registered in the state of Oregon***.

Groundwater was not encountered in any of our test pits to the depths of our explorations of 60 inches bgs. Similarly, the samples collected from the surficial sediments were described as dry or having low mositure. Water-well cards reviewed for surrounding properties indicate that depth to groundwater is variable in this area but typically less than 50 feet bgs. This is typical for water wells drilled within these marine terrace deposits. The water level 455.0 feet east of the site can be seen in a pond on the south bank of the Coquille River and is 10 feet lower in elevation than the site. We infer that groundwater recharge to the site is from the south and that the hydraulic gradient is to the north and the Coquille River. We further anticipate that groundwater levels will rise during periods of sustained rainfall.

Discussion and Recommendations Regarding Hydrology Report

It is our experience that perched water levels can rise locally by several feet during periods of seasonal rainfall recharge. This may be exacerbated by heavy runoff from the slope to the south. We understand that you are elevating the house because the site is below Base Flood Elevation. As such, we recommend that the site be graded to facilitate drainage away from the structure and that a robust perimeter drainage system be installed around the foundation. All surface and subsurface drainage should be directed to Bandon's storm drain system.

DISCUSSION AND RECOMMENDATIONS

Feasibility

As previously discussed in our **SOILS REPORT** section of this report, it is CGS's opinion that the soils encountered at the site are suitable to support a residential structure, provided the site is prepared in accordance with our recommendations.

The use of conventional shallow foundations is feasible, provided that the top 4 feet of the sand be excavated and stockpiled. The area excavated should encompass the building footprint and 5 feet around the footprint. We recommend that all deleterious material including logs, sod, roots, and other debris be removed and discarded off-site. We further recommend that a Standard Proctor based on a bulk sample of the sands be completed in accordance with ASTM D1557. After excavation, the base of the 4.0-foot-deep cut should be wetted, compacted, and tested using a nuclear densometer to determine that the dry density of 95% or greater per the Standard Proctor is achieved. Upon achieving the required compaction, 12-inc thick lifts should be added to the excavation and wetted, compacted, and tested until the pad is brought back to grade. All footings should be designed for an allowable bearing pressure of 1,500 pounds per square foot (psf). For footings in contact with native soils, use a coefficient of friction equal to 0.20 when calculating resistance to sliding.

All buried pipes, tanks, etc. should be removed or grouted shut. All surfaces with building foundations or pavement areas should be prepared in accordance with the **APPENDIX 1: GENERAL CONSTRUCTION CONSIDERATIONS** included at the back of this report.

We recommend that a robust perimeter drainage system be installed around the foundation and that the site be graded to facilitate drainage away from the structure. All surface and subsurface drainage should be directed to Bandon's storm drain system.

A CGS engineering geologist (or their representative) should confirm suitable bearing conditions and evaluate all footing subgrades. Observations should also confirm that loose or soft materials, organics, unsuitable fill, and old topsoil zones are removed. Localized deepening of footing excavations may be required to penetrate any deleterious materials.

If construction occurs during wet weather, we recommend that a thin layer of compacted, crushed rock be placed over the footing subgrades to help protect them from disturbance due to foot traffic and the elements.

FINAL GRADING

As indicated, the footing backfill should be graded to drain away from the structure

CONSTRUCTION OBSERVATIONS

Satisfactory pavement and earthwork performance depend on the quality of construction. Sufficient monitoring of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. We recommend that a representative from CGS be retained to observe general excavation, stripping, fill placement, footing subgrades, and subgrades for floor slabs and pavements.

Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated.

LIMITATIONS

Cascadia Geoservices, Inc.'s (CGS) professional services are performed, findings obtained, and recommendations prepared in accordance with generally accepted principles and practices for engineering geologists. No other warranty, express or implied, is made. The Customer acknowledges and agrees that:

1. CGS is not responsible for the conclusions, opinions, or recommendations made by others based upon our findings.
2. This report has been prepared for the exclusive use of the addressee, and their agents, and is intended for their use only. It is not to be photographed,

photocopied, or similarly reproduced, in total or in part, without the expressed written consent of the Customer and Cascadia Geoservices, Inc.

3. The opinions, comments, and conclusions presented in this report are based upon information derived from our literature review, historical topographic map and aerial photograph review, and on our site observations. The scope of our services is intended to evaluate soil and groundwater (ground) conditions within the primary influence or influencing the proposed development area. Our services do not include an evaluation of potential ground conditions beyond the depth of our explorations or agreed-upon scope of our work. Conditions between or beyond our site observations may vary from those encountered.
4. Recommendations provided herein are based in part upon project information provided to CGS. If the project information is incorrect or if additional information becomes available, the correct or additional information should be immediately conveyed to CGS for review.
5. The scope of services for this subsurface exploration and report did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or groundwater at this site.
6. If there is a substantial lapse of time between the submission of this report and the start of work at the site, if conditions have changed due to natural causes or construction operations at or adjacent to the site, or if the basic project scheme is significantly modified from that assumed, this report should be reviewed to determine the applicability of the conclusions and recommendations. Land use, site conditions (both on and off site), or other factors may change over time and could materially affect our findings. Therefore, this report should not be relied upon after two years from its issue, or if the site conditions change.
7. The work performed by the Consultant is not warrantied or guaranteed.
8. There is an assumed risk when building on marginal ground, sites subject to flooding, or adjacent to bluffs, sea cliffs, or on steep ground.
9. The Consultant's work will be performed to the standards of the engineering and geology professions and will be supervised by licensed professionals. Attempts at

improving marginal ground, sites subject to flooding, or adjacent to bluffs, sea cliffs, or on steep ground supporting the Customer's property may, through acts of God or otherwise, be temporary and that marginal ground, sites subject to flooding, or adjacent to bluffs, sea cliffs, or on steep ground may continue to degrade over time. The Customer hereby waives any claim that they may have against CGS for any claim, whether based on personal injury, property damage, economic loss, or otherwise, for any work performed by CGS for the Customer relating to or arising out of attempts to stabilize the marginal ground, sites subject to flooding, or bluffs, sea cliffs, or steep ground located at the Customer's property identified hereunder. It is further understood and agreed that continual monitoring of the Customer's property may be required, and that such monitoring is done by sophisticated monitoring instruments used by CGS. It is further understood and agreed that repairs may require regular and periodic maintenance by the Customer.

10. The Customer shall indemnify, defend, at the Customer's sole expense, and hold harmless CGS, affiliated companies of CGS, its partners, joint ventures, representatives, members, designees, officers, directors, shareholders, employees, agents, successors, and assigns (Indemnified Parties) from and against any and all claims for bodily injury or death, damage to property, demands, damages, and expenses (including but not limited to investigative and repair costs, attorney's fees and costs, and consultant's fees and costs) (hereinafter "Claims") which arise or are in any way connected with the work performed, materials furnished, or services provided under this Agreement by CGS or its agents.

PROFESSIONAL QUALIFICATIONS

To review our professional qualifications, please visit our website at www.CascadiaGeoservices.com.

Sincerely,

Cascadia Geoservices, Inc.

ERIC T. OBERBECK
1332
Eric Oberbeck

86454PE
MARCH 12, 2019
STEPHAN R. STYS
EXPIRATION DATE: 06/30/22

Eric Oberbeck, CEG
Expires June 1, 2021

FIGURES

Figure 1, Location Map

Figure 2, Site Map

ATTACHMENTS

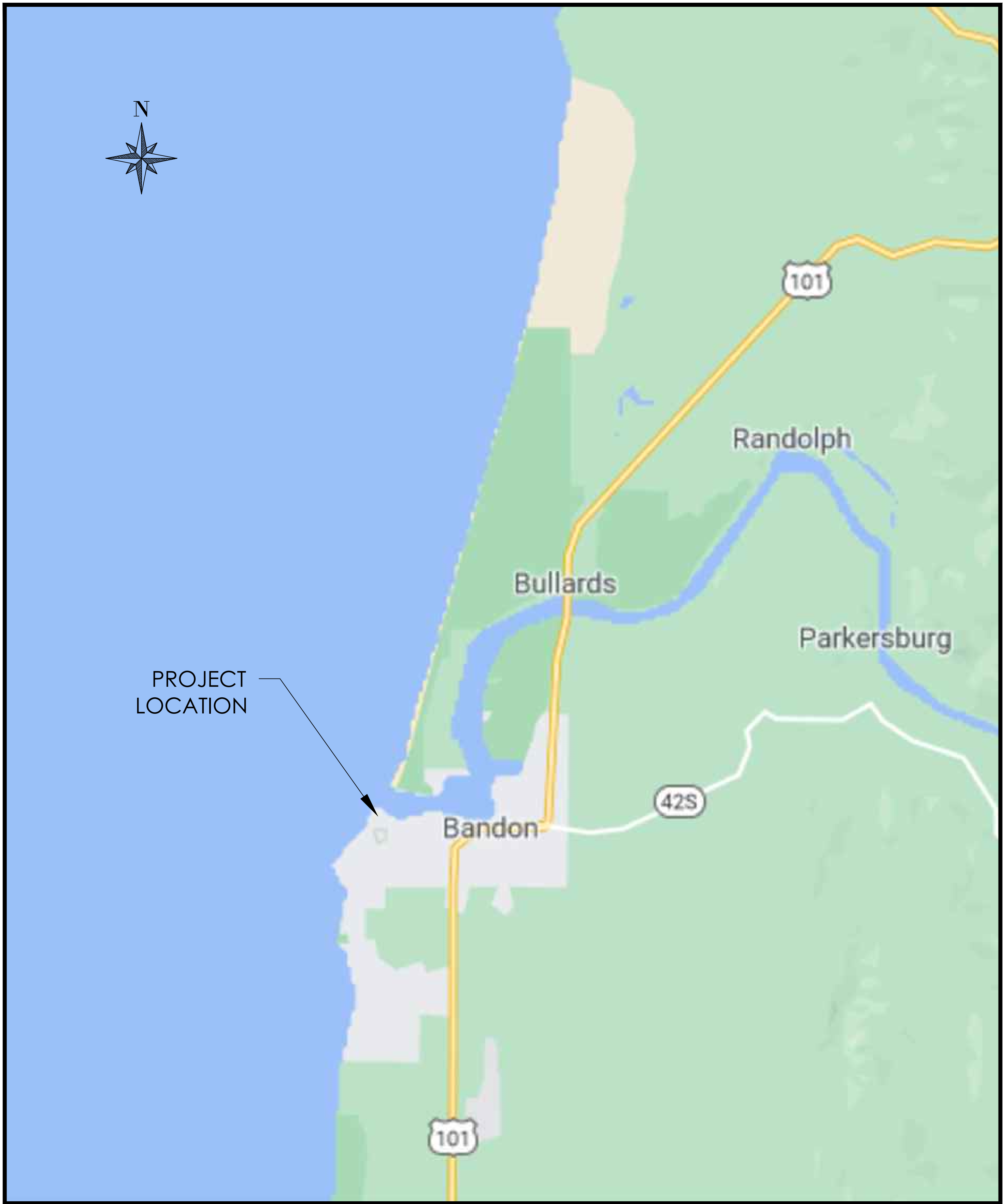
Attachment 1 – Test Pit Logs

Attachment 2 - Lab Report

APPENDIXES

Appendix 1. Liquefaction SPT Analysis 3.3.2

Appendix 2: General Construction Considerations



CASCADIA Geoservices, Inc
Geologists & Engineers

Drawn By: BAC
Date: 11/10/2020

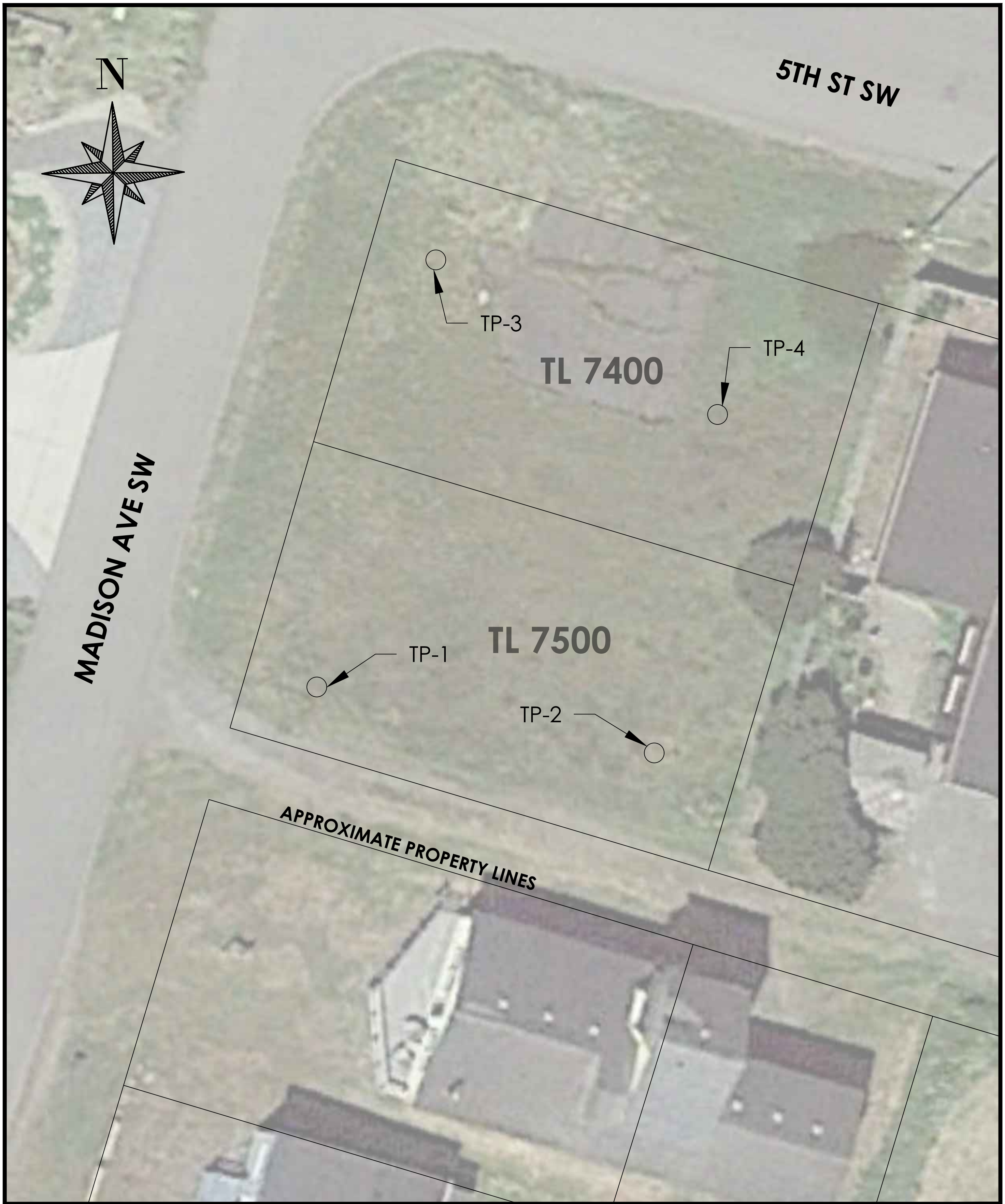
0 1" = 1 MILE 1"

LOCATION MAP

FIGURE 1

GEORGE GEO ASSESSMENT

28S15W25BD, 7500
BANDON, OREGON 97411



CASCADIA
Geoservices, Inc
Geologists & Engineers

Drawn By: BAC Date: 11/10/2020	0 1" = 20' 1"	**SITE MAP**	FIGURE
GEORGE GEO ASSESSMENT		28S15W25BD, 7500 BANDON, OREGON 97411	2

TABLE 1 SOILS
FIELD CLASSIFICATIONS

SOIL DESCRIPTION FORMAT	
(1) consistency,	(9) structure,
(2) color,	(10) cementation,
(3) grain size,	(11) reaction to HCL,
(4) classification name [secondary PRIMARY additional];	(12) odor,
(5) moisture,	(13) groundwater seepage,
(6) plasticity of fines,	(14) caving,
(7) angularity	**(15) (unit name and/or origin),**
(8) shape,	

Note: Bolded items are the minimum required elements for a soil description.

1. CONSISTENCY - COARSE-GRAINED

TERM	SPT (140-LB. HAMMER)[1]	D & M SAMPLER (140-LB. HAMMER)[1]	DYNAMIC CONE PENETROMETER PENETRATION RATE SAMPLER (DCP)[4,5,6]	FIELD TEST (USING ½-INCH REBAR)
Very loose	0 – 4	0 – 11	0 – 2	Easily penetrated when pushed by hand
Loose	4 – 10	11 – 26	2 – 5	Easily penetrated several inches when pushed by hand
Medium dense	10 – 30	26 – 74	6 – 31	Easily to moderately penetrated when driven by 5 lb. hammer
Dense	30 – 50	74 – 120	32 – 42	Penetrated 1-foot with difficulty when driven by 5 lb. hammer
Very dense	>50	>120	>43	Penetrated only few inches when driven by 5 lb. hammer

1. CONSISTENCY - FINE-GRAINED

TERM	SPT (140-LB. HAMMER)[1]	D & M SAMPLER (140-LB. HAMMER)[1]	DYNAMIC CONE PENETROMETER PENETRATION RATE SAMPLER (DCP)[5,6]	POCKET PEN.[2]	TORVANE[3]	FIELD TEST
Very soft	<2	<3	<2	<0.25	<0.13	Easily penetrated several inches by fist
Soft	2 – 4	3 – 6	2 – 3	0.25 – 0.5	0.13 – 0.25	Easily penetrated several inches by thumb
Medium stiff	5 – 8	7 – 12	4 – 7	0.50 – 1.0	0.25 – 0.5	Can be penetrated several inches by thumb with moderate effort
Stiff	9 – 15	13 – 25	8 – 16	1.0 – 2.0	0.5 – 1.0	Readily indented by thumb but penetrated only with great effort
Very stiff	16 – 30	26 – 65	17 – 27	2.0 – 4.0	1.0 – 2.0	Readily indented by thumbnail
Hard	>30	>65	>28	>4.0	>2.0	Difficult to indent by thumbnail

1 Standard penetration resistance (SPT N-value); Dames and Moore (D & M) sampler, number of blows/ft. for last 12" and 30" drop. Unconfined
2 compressive strength with pocket penetrometer; in tons per square foot (tsf).
3 Undrained shear strength with torvane (tsf).
4 Up to maximum medium-size sand grains only.
5 Dynamic cone penetration resistance; number of blows/inch.
6 Reference: George F. Sowers et. al. "Dynamic Cone for Shallow In-Situ Penetration Testing of In-Situ Soils, ASTM STP 399, ASTM, , pg. 29. 1966.

2. COLOR

Use common colors. For combinations use hyphens. To describe tint use modifiers: pale, light, and dark. For color variations use adjectives such as "mottled" or "streaked". Soil color charts may be required by client. **Examples:** red-brown; or orange-mottled pale green; or dark brown.

3. GRAIN SIZE

DESCRIPTION		SIEVE*	OBSERVED SIZE
boulders		–	>12"
cobbles		–	3" – 12"
gravel	coarse	¾" – 3"	¾" – 3"
	fine	#4 – ¾"	4.75 mm (0.19") – ¾"
sand	coarse	#10 – #4	2.0 – 4.75 mm
	medium	#40 – #10	0.425 – 2.0 mm
	fine	#200 – #40	0.075 – 0.425 mm
fines		<#200	<0.075 mm

4. CLASSIFICATION NAME

* Use of #200 field sieve encouraged for estimating percentage of fines.

	NAME AND MODIFIER TERMS	CONSTITUENT PERCENTAGE	CONSTITUENT TYPE
Coarse grained	GRAVEL, SAND, COBBLES, BOULDERS	>50%	PRIMARY
	sandy, gravelly, cobbley, bouldery	30 – 50%	secondary
	silty, clayey*	15 – 50%	
	with (gravel, sand, cobbles, boulders)	15 – 30%	additional
	with (silt, clay)*	5 – 15%	
	trace (gravel, sand, cobbles, boulders)		
	trace (silt, clay)*	<5%	
Fine grained	CLAY, SILT*	>50%	PRIMARY
	silty, clayey*	30 – 50%	secondary
	sandy, gravelly		
	with (sand, gravel, cobbles, boulders)	15 – 30%	additional
	with (silt, clay)*		
	trace (sand, gravel, cobbles, boulders)	5 – 15%	
	trace (silt, clay)*		
Organic	PEAT	50 – 100%	PRIMARY
	organic (soil name)	15 – 50%	secondary
	(soil name) with some organics	5 – 15%	additional

* For classification and naming fine-grained soil: dry strength, dilatancy, toughness, and plasticity testing are performed (see Describing Fine-Grained Soil page 2). Confirmation requires laboratory testing (Atterberg limits and hydrometer).

TABLE 1 SOILS
FIELD CLASSIFICATIONS

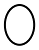
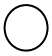
5. MOISTURE

Term	Field Test
dry	absence of moisture, dusty, dry to touch
moist	contains some moisture
wet	visible free water, usually saturated

6. PLASTICITY OF FINES

See "Describing fine-grained Soil" on Page 2.

7. ANGULARITY

 rounded 	 Angular 
 subrounded 	 Subangular 

8. Shape

Term	Observation
flat	particles with width/thickness ratio >3
elongated	particles with length/width ratio >3
flat and elongated	particles meet criteria for both flat and elongated

9. STRUCTURE

Term	Observation
stratified	alternating layers >1 cm thick, describe variation
laminated	alternating layers <1 cm thick, describe variation
fissured	contains shears and partings along planes of weakness
slickensides	partings appear glossy or striated
blocky	breaks into lumps, crumbly
lensed	contains pockets of different soils, describe variation
homogenous	same color and appearance throughout

10. CEMENTATION

Term	Field Test
weak	breaks under light finger pressure
moderate	breaks under hard finger pressure
strong	will not break with finger pressure

11. REACTION TO HCL

Term	Field Test
none	no visible reaction
weak	bubbles form slowly
strong	vigorous reaction

12. ODOR

Describe odor as organic; or potential non-organic*
*Needs further investigation

13. GROUNDWATER SEEPAGE

Describe occurrence (i.e. from soil horizon, fissures with depths) and rate:
slow (<1 gpm); moderate (1-3 gpm); fast (>3 gpm)

14. CAVING

Describe occurrence (depths, soils) and amount with term

Test Pits	minor (<1 ft^3)	moderate (1-3 ft^3)	Severe (>3 ft^3)

15. (UNIT NAME/ORIGIN)

Name of stratigraphic unit (e.g. Willamette Silt), and/or origin of deposit (Topsoil, Alluvium, Colluvium, Decomposed Basalt, Loess, Fill, etc.).

DESCRIBING FINE-GRAINED SOIL

	Field Test			
Name	Plasticity (A below)	Dry Strength (B below)	Dilatancy Reaction (C below)	Toughness of Thread (D below)
SILT	non-plastic, low	none, low	rapid	low
SILT with some clay	low	low, medium	rapid, slow	low, medium
clayey SILT	low, medium	medium	slow	medium
silty CLAY	medium	medium, high	slow, none	medium, high
CLAY with some silt	high	High	none	high
CLAY	high	very high	none	high
organic SILT	non-plastic, low	low, medium	slow	low, medium
organic CLAY	medium, high	medium to very high	none	medium, high

A. PLASTICITY

Term	Observation
non-plastic	A 1/8" (3-mm) thread cannot be rolled at any water content.
low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
high	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

B. DRY STRENGTH

Term	Observation
none	Dry specimen crumbles into powder with mere pressure of handling.
low	Dry specimen crumbles into powder with some finger pressure.
medium	Dry specimen breaks into pieces or crumbles with considerable finger pressure.
high	Dry specimen cannot be broken with finger pressure. Will break into pieces between thumb and a hard surface.
very high	Dry specimen cannot be broken between thumb and a hard surface.

C. DILATANCY REACTION

Term	Observation
none	No visible change in the specimen.
slow	Water appears slowly on surface of specimen during shaking and doesn't disappear or disappears slowly upon squeezing.
rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

D. TOUGHNESS OF THREAD

Term	Observation
low	Only slight hand pressure is required to roll the thread near the plastic limit. The thread and lump are weak and soft.
medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and lump have medium stiffness.
high	Considerable hand pressure is required to roll the thread to near the plastic limit. The thread and lump have very high stiffness.

TABLE 2

KEY TO TEST PIT AND BORING LOG SYMBOLS

SAMPLE NUMBER ACRONYMS/WATER SYMBOLS

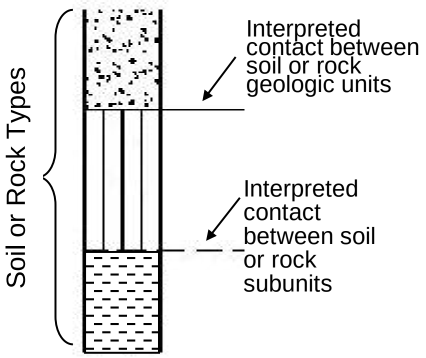
DM - Dames & Moore Sampler
GR - Grab or Bulk Samples
OS - Osterberg (Piston) Sampler
C - Rock Core
SA - Screen Air Sampling
SW - Screen Water Sampling
SS - SPT Standard Penetration Drive Sampler (ASTM D1586)
ST - Shelby Tube Push Sampler (ASTM D1587)

Water Level During Drilling/ Excavation ▽

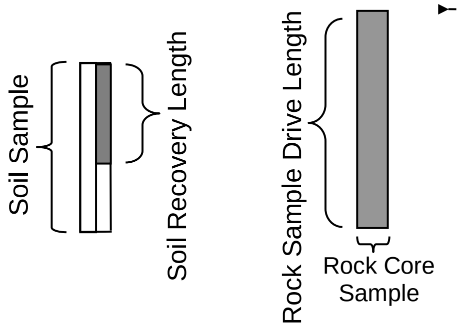
Water Level on Date Measured ▼

LOG GRAPHICS/INSTALLATIONS

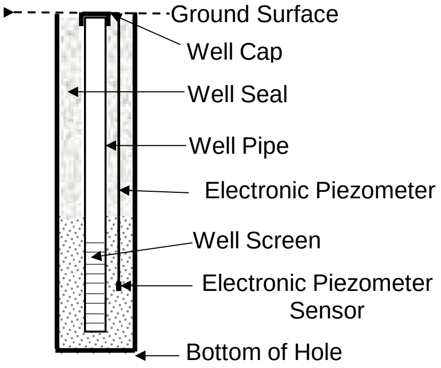
Soil and Rock



Soil and Rock Sampling Symbols



Instrumentation Detail



GEOTECHNICAL FIELD & LABORATORY TESTING/ACRONYM EXPLANATIONS

ATT	Atterberg Limits	OC	Organic Content
AMSL	Above Mean Sea Level	OD	Outside Diameter
BGS	Below ground surface	P200	Percent Passing U.S. Standard No. 200 Sieve
CBR	California Bearing Ratio	PI	Plasticity Index
CON	Consolidation	PL	Plasticity Limit
DCP	Dynamic Cone Penetrometer	PP	Pocket Penetrometer
DD	Dry Density	RES	Resilient Modulus
DS	Direct Shear	SC	Sand Cone
GPS	Global Positioning System	SIEV	Sieve Gradation
HCL	Hydrochloric Acid	SP	Static Penetrometer
HYD	Hydrometer Gradation	TOR	Torvane
kPa	kiloPascal	UC	Unconfined Compressive Strength
LL	Liquid Limit	VS	Vane Shear

ENVIRONMENTAL TESTING/ACRONYM EXPLANATIONS

ATD	At Time of Drilling	ND	Not Detected
BGS	Below ground surface	NS	No Sheen
CA	Sample Submitted for Chemical Analysis	PID	Photoionization Detector Headspace Analysis
HS	High Sheen		
MS	Moderate Sheen	PPM	Parts Per Million

TEST PITS

CASCADIA GEOSERVICES
PROJECT NO: 20111

GEORGE PROPERTY
MADISON AVENUE SW & 5TH STREET SW
BANDON, OREGON

Cascadia Geoservices
190 6th Street
Mail: PO Box 1026
Port Orford, Oregon 97465

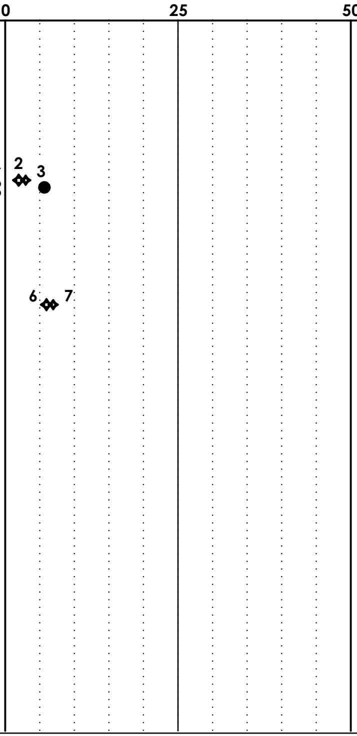
Direct: 541-332-0433
Cell: 541-655-0021
Email: eric@cascadiageoservices.com
Web: www.cascadiageoservices.com

Legend:
- ◆ DYNAMIC PENETROMETER (DP or DCP)
- ☒ STATIC PENETROMETER (SP)
- ● MOISTURE CONTENT (%)
- INDEX PROPERTIES (IP)
- NUCLEAR DENSITY (ND)
- DRY DENSITY (DD)
- SIEVE (SIEV)

TP-1

SURFACE CONDITIONS: Dry

DEPTH IN FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE/ SAMPLE ID	COMMENTS
0.0	ROOT ZONE to 1.0 foot bgs Tan, fine-grained SAND; dry, poorly graded	0.0			
1.0		1.0			
2.0	**HOLOCENE DUNE SAND**		P200 DCPs	☒ SS-1	P200 = 1% W% = 5.7%
4.0	becomes medium dense		DCPs		Caving from 4.0 to 5.0 feet bgs
5.0	Final depth 5.0 feet bgs; hole abandoned due to caving, test pit backfilled with excavated material	5.0			No groundwater observed to the depth explored

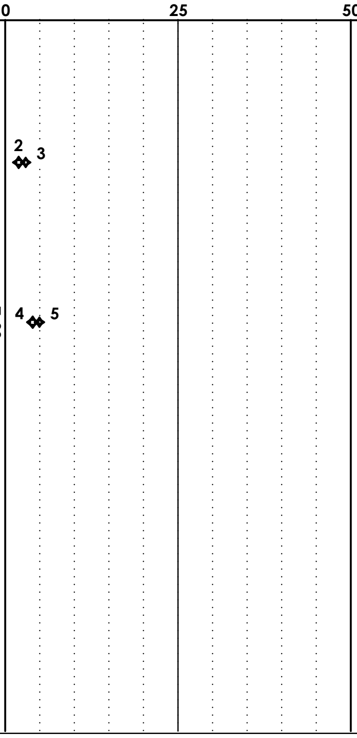


TP-1 Location: SW Corner Lat: 43.009579 Long: -124.438861 Completed: 10/13/2020

TP-2

SURFACE CONDITIONS: Dry

DEPTH IN FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE/ SAMPLE ID	COMMENTS
0.0	ROOT ZONE to 1.0 foot bgs Tan, fine-grained SAND; dry, poorly graded	0.0			
1.0		1.0			
2.0	**HOLOCENE DUNE SAND**		DCPs		
4.0	becomes medium dense, medium-grained SAND		DCPs	☒ SS-2	
5.0	Final depth 5.0 feet bgs; hole abandoned due to caving, test pit backfilled with excavated material	5.0			Caving at 5.0 feet bgs No seepage observed to the depth explored



TP-2 Location: SE Corner Lat: 43.119542 Long: -124.428618 Completed: 10/13/2020

EXCAVATION METHOD: Mini Excavator
EXCAVATED BY: Shane Dougherty
LOGGED BY: E. Oberbeck

TEST PITS	GEORGE PROPERTY MADISON AVENUE SW & 5TH STREET SW BANDON, OREGON	**Cascadia Geoservices** 190 6th Street Mail: PO Box 1026 Port Orford, Oregon 97465 Direct: 541-332-0433 Cell: 541-655-0021 Email: eric@cascadiageoservices.com Web: www.cascadiageoservices.com
CASCADIA GEOSERVICES PROJECT NO: 20111		

◆ DYNAMIC PENETROMETER (DP or DCP)
☒ STATIC PENETROMETER (SP)
● MOISTURE CONTENT (%)
INDEX PROPERTIES (IP)
NUCLEAR DENSITY (ND)
DRY DENSITY (DD)
SIEVE (SIEV)

TP-3

SURFACE CONDITIONS: Dry

Scale: 0 — 25 — 50

DEPTH IN FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE/ SAMPLE ID	◆ / ●	COMMENTS
0.0	ROOT ZONE to 1.0 foot bgs	0.0				
	Loose, tan, fine-grained SAND; moist					
1.0	**HOLOCENE DUNE SAND**	1.0				
2.0	buried log (driftwood)		DCPs		◆ 2 ◆ 3	
3.0						
4.0	becomes medium-grained SAND		P200 DCP	☒ SS-3	◆ 3 ●	P200 = 1% W% = 6.2%
5.0	Final depth 5.0 feet bgs; hole abandoned due to caving, test pit backfilled with excavated material	5.0				Caving at 5.0 feet bgs No seepage observed to the depth explored
6.0						
7.0						
8.0						
9.0						

TP-3 Location: NW Corner Lat: 43.119831 Long: -124.428754 Completed: 10/13/2020

TP-4

SURFACE CONDITIONS: Dry

Scale: 0 — 25 — 50

DEPTH IN FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE/ SAMPLE ID	◆ / ●	COMMENTS
0.0	Loose, fine-grained SAND	0.0				
1.0	**HOLOCENE DUNE SAND**					
2.0						
3.0	becomes medium-grained SAND					
4.0			P200 DCP	☒ SS-5	◆ 3 ●	P200 = 1% W% = 3.4%
5.0	Final depth 5.0 feet bgs; test pit backfilled with excavated material	5.0				Caving at 5.0 feet bgs No seepage observed to the depth explored
6.0						
7.0						
8.0						
9.0						

TP-4 Location: NE Corner Lat: 43.119692 Long: -124.428569 Completed: 10/13/2020

EXCAVATION METHOD: Mini Excavator
EXCAVATED BY: Shane Dougherty
LOGGED BY: E. Oberbeck

CASCADIA GEOSERVICES, INC.
Material Laboratory
1099 S 4th Street
Coos Bay, Oregon 97420
P.541-294-6915

Attachment 2

Project No.: 20111
Testing Date: 24-Oct-20
Tests Performed: Water Content, Soil Finer Than 75µm
Standards Followed: D2216, D1140
Performed By: Stephan Stys

Water Content (D2216)

Sample Name	SS-1	SS-3	SS-5								
Pan Letter	A	B	C								
M_c = Mass of Container, g	1.11	1.10	1.28								
M_{cms} = Mass of Container and Moist Specimen, g	24.43	26.37	25.78								
M_{cds} = Mass of Container and Dry Specimen, g	23.18	24.90	24.97								
M_s = Mass of Oven Dry Specimen = M_{cds} - M_c, g	22.07	23.80	23.69								
M_w = Mass of Water = M_{cms} - M_{cds}, g	1.25	1.47	0.81								
w = Water Content = M_w/M_s X 100%	5.7%	6.2%	3.4%								

% Finer Than 75µm (D1140)

Sample Name	SS-1	SS-3	SS-5								
Pan Letter	A	B	C								
M_c = Mass of Container, g	1.11	1.10	1.28								
M_{cds} = Mass of Container and Dry Specimen, g	23.18	24.90	24.97								
M_{crs} = Mass of Container and Retained Specimen, g	23.03	24.72	24.68								
M_s = Mass of Oven Dry Specimen = M_{cds} - M_c, g	22.07	23.80	23.69								
M_r = Mass of Retained Specimen = M_{crs} - M_c, g	21.92	23.62	23.40								
% Finer Than 75µm = Ms - M_w/M_s X 100%	0.7%	0.8%	1.2%								

Appendix 1

Liquefaction SPT Analysis 3.3.2

Organization: **Cascadia Geoservices Inc**
Project Name: **George Madison Avenue SW**
Job #: **20111**
Analysis by: **EO**
Date: **11/17/2020**

Input Parameters

Units: **English**

Variable	**Value**	**Variable**	**Value**
Peak Ground Acceleration	0.990 g	Design GWT (Historical)	4.00 ft
Earthquake Magnitude	6.9 MW	Site GWT	4.0 ft
Bottom Depth	16.00 ft	Average Soil Unit Weight	
Bore Hole Diameter	4.0 in	above GWT	101.0 pcf
Rod Length Height Stick up	4.9 ft	below GWT	127.3 pcf
Correction for Sample Liners	Yes	Sloping Ground	Yes

Geotechnical Properties

#	Material Type	USCS	Bottom Depth, ft	Consistency	Flags	SPT field	Fines Content, %	Energy Ratio, %
1	Structural Fill	95%	4.00	Competent	Unsaturated	25	10	50
2	Granular Soil	SP	16.00	Medium Dense	Unsaturated	12	10	50

Results

Settlement: 0.51 in
Lateral Displacement: 0.00 ft

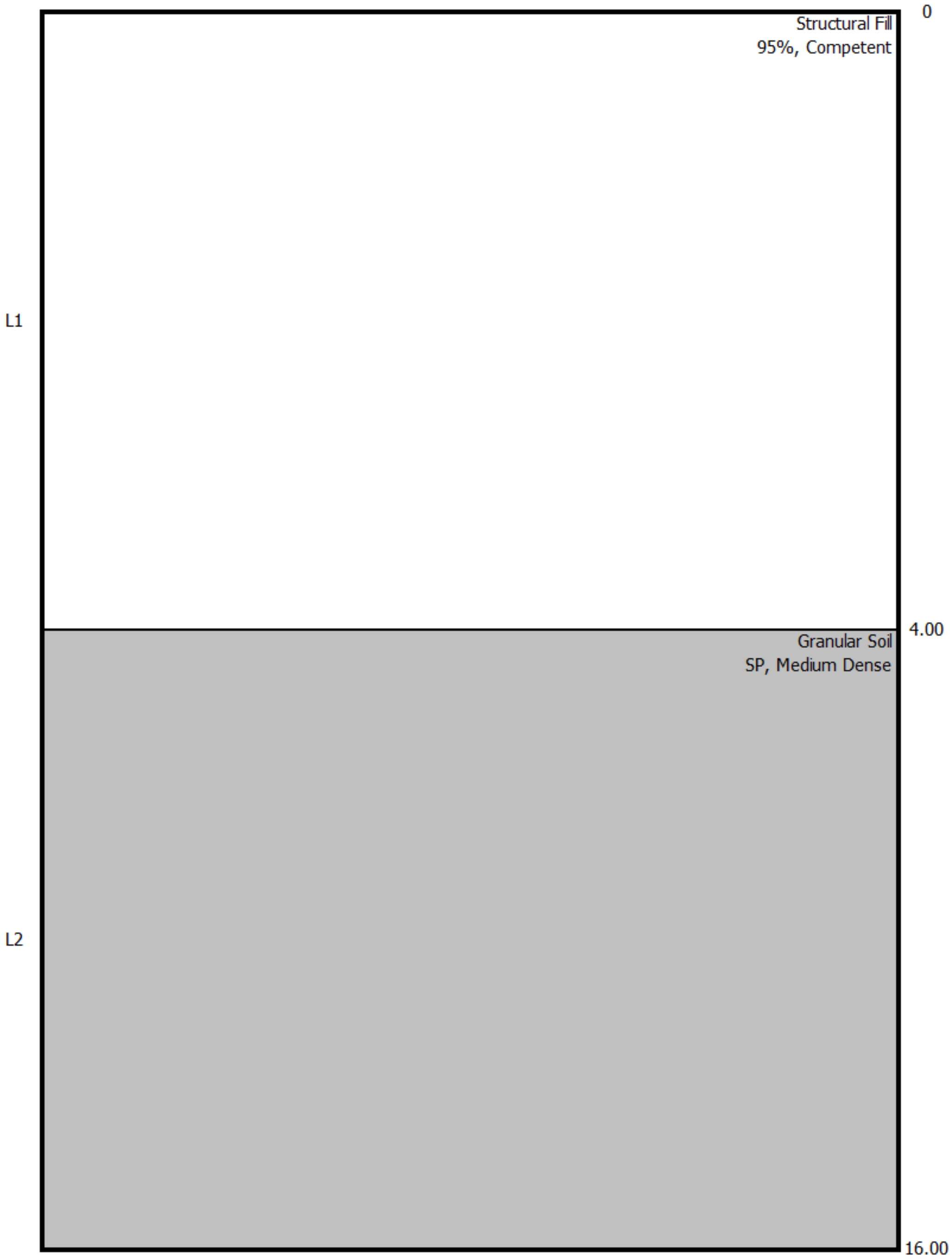


Fig. 1: Subsurface profile

Liquefaction Analysis - Set 1/4

Sample #	Depth, ft	C_E	C_B	C_R	C_S	N_{60}
1	4.00	0.83	1.00	0.75	1.30	20.31
2	16.00	0.83	1.00	0.95	1.14	10.86

Liquefaction Analysis - Set 2/4

Sample #	Depth, ft	σ V, psf	σ V', psf	C_N	$(N_1)_{60}$
1	4.00	404.0	404.0	1.70	34.53
2	16.00	1931.6	1182.8	1.32	14.35

Liquefaction Analysis - Set 3/4

Sample #	Depth, ft	ΔN-Fines	$(N_1)_{60}$-CS	Stress Reduc.	CSR	MSF-Sand
1	4.00	1.15	35.68	0.995	0.640	1.171
2	16.00	1.15	15.50	0.946	0.994	1.171

Liquefaction Analysis - Set 4/4

Sample #	Depth, ft	K_σSand	CRR-M=7.5 & σvc=1	CRR	Liq. F.S.
1	4.00	1.100	1.28	n.a	n.a
2	16.00	1.065	0.16	n.a	n.a

Dynamic Settlement - Set 1/2

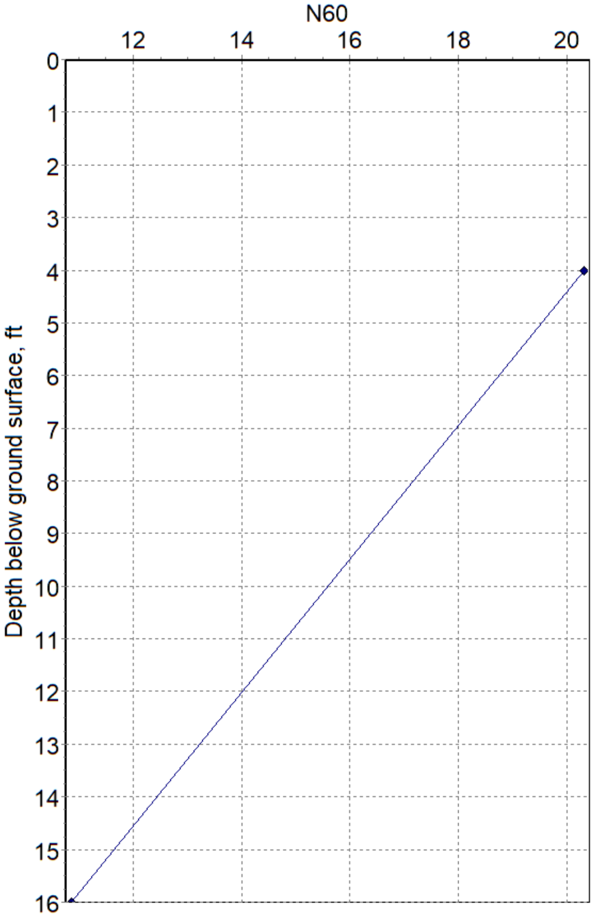
Sample #	Depth, ft	Lim. Shear Strain, γlim	Fα Parameter	Max. Shear Strain, γmax	ΔH I, ft
1	4.00	0.02	-0.485	0.000	4.00
2	16.00	0.26	0.733	0.000	12.00

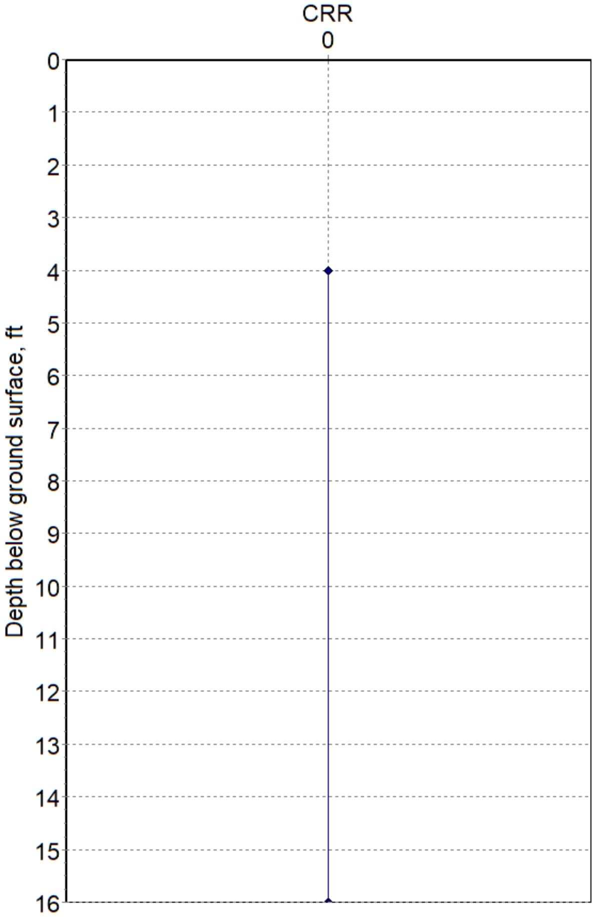
Dynamic Settlement - Set 2/2

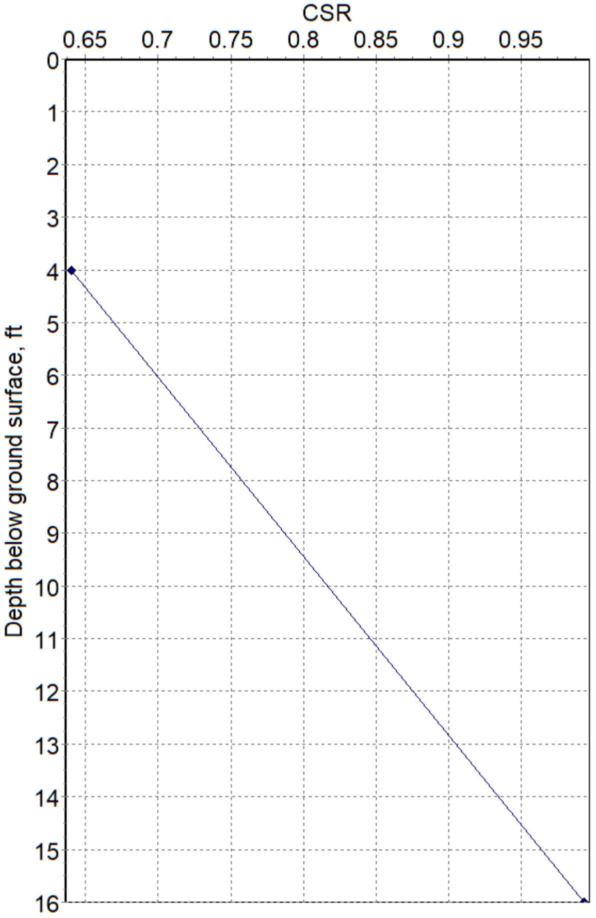
Sample #	Depth, ft	Vert. Consol. Str, εV	Dyn. Sett, in	Accum. Sett, in
1	4.00	0.000	0.043	0.043
2	16.00	0.000	0.472	0.515

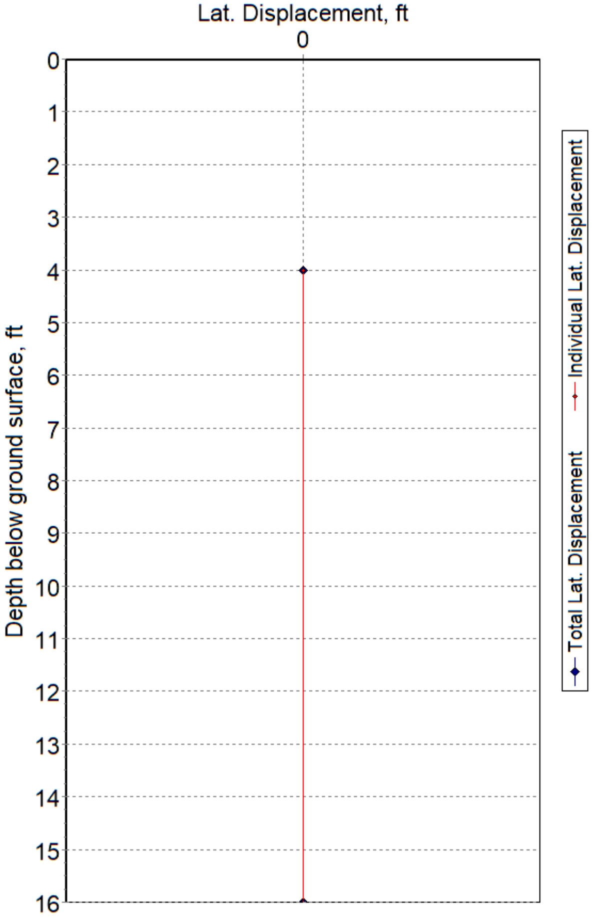
Lateral Displacement

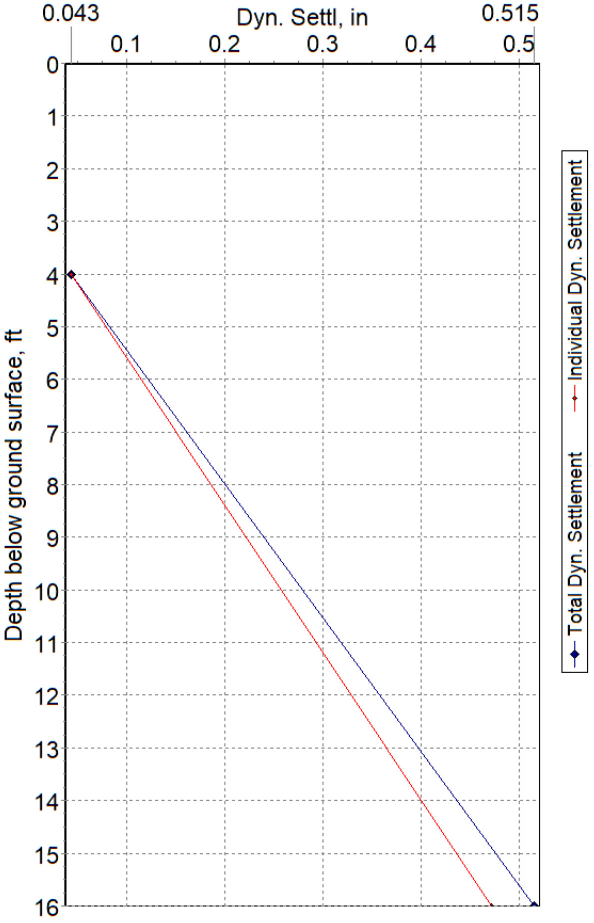
Sample #	Depth, ft	Max. Shear Str, γmax	ΔH I, ft	Lat. Displ. (ΔLDi), ft	Accum. Lat. Displ, ft
1	4.00	0.000	4.00	0.000	0.000
2	16.00	0.000	12.00	0.000	0.000

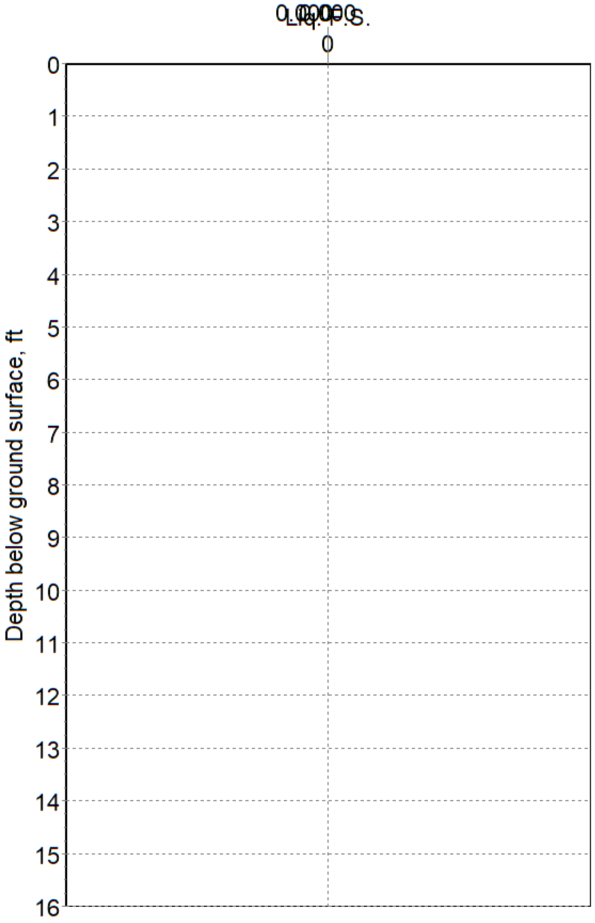

N60
12
14
16
18
20
Depth below ground surface, ft
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


CRR
0
Depth below ground surface, ft
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


CSR
0.65
0.7
0.75
0.8
0.85
0.9
0.95
Depth below ground surface, ft
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


Lat. Displacement, ft
0
Depth below ground surface, ft
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Total Lat. Displacement
Individual Lat. Displacement





References:

1. "Soil Liquefaction During Earthquakes",
   I.M. Idriss & R.W. Boulanger, 2008, MNO-12, EERI
2. LiquefactionSPT by SoilStructure.com

1.0 APPENDIX 2: GENERAL CONSTRUCTION CONSIDERATIONS

Site Preparation

Site preparation should include removal of existing structures and foundations. Underground utility lines, vaults, or tanks should be removed or grouted full if left in place. The excavations resulting from removal of footings, buried tanks, etc., should be backfilled with compacted structural fill. The base of these excavations should be excavated to firm subgrade before filling with sides sloped to allow for uniform compaction.

Materials generated during demolition of existing improvements should be transported off-site or stockpiled in areas designated by the owner. Organic and clay rich soils are typically not suitable for use as structural fill but may be used for landscaping and general backfill. Asphalt, concrete, and base rock materials may be crushed and recycled for use as general fill.

Trees and shrubs should be removed from all pavement and improvement areas. In addition, root balls should be grubbed out to the depth of the roots, which could exceed 3 feet bgs. Depending on the methods used to remove the root balls, considerable disturbance and loosening of the subgrade could occur during site grubbing. Soil disturbed during grubbing operations should be removed to expose firm undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

The existing topsoil zone should be stripped and removed from all proposed building pads, pavement, and improvement areas and for a 5-foot margin around such areas. Please review **Discussion Section** of this report to ascertain the actual stripping depth. All loose fill and organics soils should be removed. Greater stripping depths may be required to remove localized zones of loose or organic soil. Greater stripping depths may be anticipated in areas with thicker vegetation and shrubs and where fill is present. The actual stripping depth should be based on field observations at the time of construction.

Stripped organic material should be transported off-site for disposal or used in landscaped areas.

Following stripping and prior to placing fill, pavement, or building improvements, the exposed subgrade should be evaluated by probing or proofrolling. The subgrade should be proofrolled with a fully loaded 10 yard or larger dump truck or similar heavy rubber-tire construction equipment to identify soft, loose, or unsuitable areas. A member of CGS's staff should observe the proofrolling. Soft or loose zones identified during testing should be compacted to an unyielding condition or excavated and replaced with structural fill, as discussed in the "Structural Fill" section of this appendix.

Wet-Weather Conditions

Trafficability on the near-surface soils may be difficult during or after extended wet periods or when surface soils become saturated. Soils that have been disturbed during site-preparation activities, or soft or loose zones identified during probing or proofrolling, should be removed and replaced with compacted structural fill.

The thickness of the granular material for access roads and building areas will depend on the amount and type of construction traffic. A 12- to 18-inch-thick mat of imported granular material is sufficient for most staging areas. The granular mat for haul roads and areas with repeated heavy construction traffic typically needs to be increased to between 18 to 24 inches. The actual thickness of haul roads and staging areas should be based on the amount and type of traffic anticipated and the type of underlying soils present. Imported granular material should be placed in one lift over the undisturbed subgrade and compacted using a smooth-drum, non-vibratory roller. Additionally, a geotextile fabric should be placed as a barrier between the subgrade and imported granular material in areas of repeated construction traffic.

2.0 MATERIALS SECTION

Structural fill should be placed over subgrade that has been prepared in conformance with the "Site Preparation" and "Wet-Weather Conditions" sections of this report. A wide range of material may be used as structural fill; however, all material used should be free of organic matter or other unsuitable materials and should meet the specifications provided in the 2018 ODOT *Oregon Standards Specifications for Construction* (ODOT SS, 2018)[1] depending on the application. A brief characterization of some of the acceptable materials is provided below.

Native Soils

Native soils are suitable for use as general fill only if they meet the requirements of ODOT SS 00330.12 – Borrow Material. Laboratory testing is required to determine if the moisture content of the near-surface soils is greater than the soils' optimum moisture content required for satisfactory compaction. To adequately compact the soil, it may be necessary to moisture condition the soil to within 2 to 3 percentage points of the optimum moisture content. In most instances, moisture conditioning will be difficult due to the fine-grained nature of the soil.

Imported Granular Material

Imported granular material used during periods of wet weather or for haul roads, building pad subgrades, staging areas, etc., should be pit or quarry run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in ODOT SS 00330.12 – Borrow Material and ODOT SS 00330.13 – Selected General Backfill. In addition, the imported granular material should also be well-graded between coarse and fine material and have less than 5 percent by weight passing the U.S. Standard No. 200 Sieve.

Imported granular material should be placed in lifts with a maximum uncompacted thickness of 8 to 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D 698. During the wet season or when wet subgrade conditions exist, the initial lift should be approximately 18 inches in uncompacted thickness and should be compacted by rolling with a smooth-drum roller without using vibratory action.

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[1] View online at https://www.oregon.gov

Where imported granular material is placed over soft-soil subgrades, we recommend a geotextile be placed as a barrier between the subgrade and imported granular material. Depending on site conditions, the geotextile should meet ODOT SS 2320.10 – Geosynthetics, Acceptance, for soil separation or stabilization. The geotextile should be installed in conformance with ODOT SS 0350.40 – Geosynthetic Construction.

Trench Backfill

Trench backfill placed beneath, adjacent to, and for at least 2 feet above utility lines (i.e., the pipe zone) should consist of well-graded granular material with a maximum particle size of 1.5 inches and less than 10 percent by weight passing the U.S. Standard No. 200 Sieve and should meet the standards prescribed by ODOT SS 405.12 – Pipe Zone Bedding. The pipe zone backfill should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D 698, or as required by the pipe manufacturer or local building department.

Within roadway alignments or beneath building pads, the remainder of the trench backfill should consist of well-graded granular material with a maximum particle size of 2.5 inches, less than 10 percent by weight passing the U.S. Standard No. 200 Sieve, and should meet standards prescribed by OSSC 405.14 – Trench Backfill, Class A or B. This material should be compacted to at least 92 percent of the maximum dry density, as determined by ASTM D 698, or as required by the pipe manufacturer or local building department. The upper 2 feet of the trench backfill should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D 698.

Outside of structural improvement areas (e.g., roadway alignments or building pads), trench backfill placed above the pipe zone may consist of general fill materials that are free of organics and materials over 6 inches in diameter and meet ODOT SS 00330.12 – Borrow Material and ODOT SS 00405.14 – Trench Backfill, Class C, D, or E. This general trench backfill should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D 698, or as required by the pipe manufacturer or local building department.

Stabilization Material

Stabilization rock should consist of imported granular material that is well-graded, angular, crushed rock consisting of 4- or 6-inch-minus material with less than 2 percent passing the U.S. Standard No. 4 Sieve. The material should be free of organic matter and other deleterious material.

Retaining Wall Backfill

Backfill material placed behind retaining walls and extending a horizontal distance of 0.5H, where H is the height of the retaining wall, should consist of select granular material meeting ODOT SS 00510.12 – Granular Wall Backfill. We recommend that the select granular wall backfill be separated from general fill, native soil, and/or topsoil using a geotextile fabric which meets the requirements provided in ODOT SS 02320.10 – Geosynthetics, Acceptance. The geotextile should be installed in conformance with ODOT SS 00350.40 – Geosynthetic Construction.

The wall backfill should be compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D 698. However, backfill located within a horizontal distance of 3 feet from the retaining walls should only be compacted to approximately 90 percent of the maximum dry density, as determined by ASTM D 698. Backfill placed within 3 feet of the wall should be compacted in lifts less than 6 inches thick using hand-operated tamping equipment (such as, a jumping jack or vibratory plate compactors). If flat work (sidewalks or pavements) will be placed atop the wall backfill, we recommend that the upper 2 feet of material be compacted to 95 percent of the maximum dry density, as determined by ASTM D 698.

Trench and Retaining Wall Drain Backfill

Backfill in a 2-foot zone against the back of retaining walls and for subsurface trench drains should consist of drain rock meeting the specifications provided in ODOT SS 00430.11 – Granular Drain Backfill Material. The drain rock should be wrapped in a geotextile fabric that meets the specifications provided in ODOT SS 02320.10 – Geosynthetics, Acceptance, for soil separation and/or stabilization.

The geotextile should be installed in conformance with ODOT SS 00350.40 – Geosynthetic Construction.

Footing Base

Imported granular material placed at the base of footings should be clean crushed rock or crushed gravel, and sand that is well-graded between coarse and fine. The granular materials should contain no deleterious materials, have a maximum particle size of 1.5 inches, and meet ODOT SS 00330.14 – Select Granular Backfill. The imported granular material should be placed on one lift and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D 698.

Floor Slab Base Aggregate

Base aggregate for floor slabs should be clean crushed rock or crushed gravel. The base aggregate should contain no deleterious materials, meet specifications provided in ODOT SS 00330.14 – Select Granular Backfill, and have less than 5 percent weight by passing the U.S. Standard No. 200 Sieve. The imported granular material should be placed in one lift and compacted to at least 95 percent of the maximum dry density, as determined by ASTM D 698.

Pavement Base Aggregate

Imported granular material used as base aggregate (base rock) along roadway alignments should be clean crushed rock or crushed gravel and sand that is fairly well-graded between coarse and fine. The base aggregate should meet the gradation defined in ODOT SS 02630.10 – Dense-Graded Aggregate 1”-0”, depending upon application, with the exception that the aggregate has less than 5 percent passing a U.S. Standard No. 200 Sieve. The base aggregate should be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D 698.

3.0 PERMANENT SLOPES

SETBACK

The 2017 Oregon Residential Specialty Code , Section R. 403.1.9.1 (code) requires that buildings adjacent to descending slope surfaces be founded in firm material with an embedment and setback from the slope surface sufficient to provide vertical and lateral support for the footing without detrimental settlement. When determining setbacks, the code recommends a minimum setback of at least the smaller of H/3 and 40 feet for descending slopes and the smaller of H/2 and 15 feet from ascending slopes. For slopes steeper than 100%, the setback shall be measured from an imaginary plane 45 degrees to the horizontal projected upward from the toe of the slope. We provide our setback recommendations in our **DISCUSSION AND RECOMMENDATIONS** section of this report.

Permanent cut and fill slopes up to 15 feet high may typically be built to a gradient as steep as 2 Horiziontal:1Vertical (2H:1V) dependent upon the type of soils and or rock present. However, cut slopes over 15 feet tall should be limited to a gradient of 2.5H:1V or should be partially retained by a retaining wall. Slopes that will be maintained by mowing should not be constructed steeper than 3H:1V. Newly constructed fill slopes should be over-built by at least 12 inches and then trimmed back to the required slope to maintain a firm face.

Access roads and pavements should be setback a minimum of 5 feet from the top of cut and fill slopes. Slopes should be covered with erosion control netting and planted with appropriate vegetation to provide protection against erosion as soon as possible after grading. A mixture of perennial and annual grasses works well. Surface water runoff should be collected and directed away from slopes to prevent water from running down the face of the slope.

4.0 DRAINAGE CONSIDERATIONS

The contractor shall be made responsible for temporary drainage of surface water and groundwater, as necessary, to prevent standing water and/or erosion at the working surface. The ground surface around the structures should be sloped to create a minimum gradient of 2 percent away from the building foundations for a distance of at least 5 feet. Surface water should be directed away from all buildings into drainage swales or into a storm drainage system. "Trapped" planting areas or ponds should not be created next to any building without providing means for drainage. The roof downspouts should discharge onto splash blocks or paving that direct water away from the building or into smooth-walled underground drain lines that carry the water to appropriate discharge locations at least 10 feet away from any buildings. If built on a sloped or cut fill building site, drainage should not be directed onto the descending slope.

Foundation Drains

CGS recommends that foundation drains be installed around the perimeter foundations of all structures including buildings and tanks. The foundation drains should be at least 12 inches below the base of the slab. The foundation drain should consist of perforated collector pipes embedded in a minimum 2-foot-wide zone of angular drain rock. The drain rock should meet specifications provided in the "Structural Fill" section of this report. The drain rock should be wrapped in a geotextile fabric. The collector pipes should discharge at an appropriate location away from the base of the footings. Unless measures are taken to prevent backflow into the wall's drainage system, the discharge pipe should not be tied directly into the stormwater drain system.

The contractor should refer to the following 2008 *Oregon Standards Specifications for Construction* (ODOT SS, 2008) sections with regard to backfill materials and geosynthetics. Local or municipal standards may also apply. The contractor should check with the jurisdictional permitting office to determine applicability of local or municipal standards.

5.0 WET-SOIL CONDITIONS

If cohesive soils are present on the site, they will be susceptible to disturbance during periods of sustained rainfall. Trafficability or grading operations within the exposed soils may be difficult during or after extended wet periods or when the moisture content of the soils is more than a few percentage points above optimum. Soils disturbed during site-preparation activities, or soft or loose zones identified during probing, should be removed, and replaced with compacted structural fill.

6.0 EXCAVATION

Trench cuts in native materials should stand vertical to a depth of approximately 4 feet, provided no groundwater seepage is present in the trench walls. Open excavation, which may be used to excavate trenches with depths deeper than 4 feet and shallower than 8 feet, can be done with the walls of the excavation cut at a slope of 1H:1V, provided groundwater seepage is not present and with the understanding that some sloughing may occur. The trenches should be flattened to 1.5H:1V if excessive sloughing occurs or seepage is present.

Water levels may fluctuate during the wet months of the year. If shallow groundwater is observed during construction, the use of a trench shield (or other approved temporary shoring) is recommended for cuts that extend below groundwater seepage or if vertical walls are desired for cuts deeper than 4 feet. The ultimate type and design of the shoring and dewatering systems used for this project should be the responsibility of the contractor who is in the best position to choose systems that fit the plan of operation. All excavations should be made in accordance with applicable Occupational Safety and Health Administration and State regulations.