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March 14, 2019

6192 GEOTECHNICAL FEASIBILITY STUDY

City of Cannon Beach
163 East Gower Street
Cannon Beach, OR 97110

Attention: Bruce St. Denis, City Manager

SUBJECT: **Geotechnical Feasibility Study**
New Cannon Beach City Hall
South Wind Site
Cannon Beach, Oregon

As requested, GRI completed a geotechnical-feasibility study for the proposed new city hall at the South Wind site in Cannon Beach, Oregon. The purpose of our study was to evaluate, on a preliminary basis, the subsurface conditions and geologic hazards in the project area and how these conditions and hazards may affect future development of the property with a new city hall. The feasibility study included a review of available geotechnical and geologic information for the site and surrounding area, subsurface explorations, installation of field instrumentation, laboratory testing, and limited engineering analyses and seismic studies. This feasibility report summarizes our findings and presents our preliminary conclusions regarding development of the property.

BACKGROUND INFORMATION

Geologic and environmental studies have been completed by others at the site. The following reports, letters, and memoranda were reviewed, and relevant information was used for this study:

> Horning Geosciences, September 13, 2013, "Evaluation of Geologic Hazards for a 55-Acre Site in Tolovana Park, East of Highway 101; Map 4 10 6B, Northwest Quadrant of Tax Lot 800," prepared for the City of Cannon Beach.
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> Assessment Associates, Inc., October 4, 2013, "A Phase I Environmental Site Assessment, 55-Acre Partially-Forested Undeveloped, Campbell Group, LLC Tract Property, North 1/2 Section 6, Township 4 North, Range 10 West, Clatsop County, Oregon," prepared for the City of Cannon Beach.
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> Horning Geosciences, October 4, 2013, "Addendum to- Evaluation of Geologic Hazards for a 55-Acre Site in Tolovana Park, East of Highway 101; Map 4 10 6B, Northwest Quadrant of Tax Lot 800," prepared for the City of Cannon Beach.

PROJECT DESCRIPTION

We understand the City of Cannon Beach (City) is planning to construct a new city hall building and considering the South Wind site as one location for the new city hall. Information provided by SRG Partnership, Inc., the project architect, indicates the preferred building area is generally located in the northern portion of the site and shown as an orange rectangle on the Site Plan, Figure 2. Our discussions with the City and the project team indicate the new city hall building will be designed to be seismically resilient following a magnitude (M)9.0 Cascadia Subduction Zone (CSZ) event. We understand the new city hall building will be approximately 16,000 sq ft and consist of an at-grade structure with one to two above-grade levels. Conceptual information provided by Catena, the project structural engineer, indicates the structure will have maximum column loads on the order of 200 kips, and structural support will be provided by 4-ft-diameter, drilled shafts. We anticipate the project will be designed in accordance with the 2019 Oregon Structural Specialty Code (OSSC), which will reference the new 2016 American Society of Civil Engineers (ASCE) 7-16 document titled "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (ASCE 7-16).

SITE DESCRIPTION

General

The South Wind site consists of 55 acres of undeveloped land in Tolovana Park generally bordered by a residential subdivision on the north; the Coastal Mountain Range, with heavily forested and recently logged parcels of property, on the east and south; and U.S. Highway 101 on the west. Our review of the Oregon Department of Geology and Mineral Industries (DOGAMI) Statewide Landslide Information Layer of Oregon (SLIDO) maps indicates the South Wind site is located within a large area of mapped landslide topography. Historical information indicates the property was heavily forested prior to logging in the mid-1950s, and portions of the property remain heavily forested. Review of available light detection and ranging (lidar) and satellite imagery indicates the ground surface gently slopes downward from southeast to northwest across the building area towards Highway 101 at about 10H:1V (Horizontal to Vertical) or flatter.

Geologic Units and Landslides

Published geologic mapping indicates the South Wind site is underlain by sedimentary and volcanic rocks of Quaternary and Miocene age, see the Local Geologic Map, Figure 3 (Niem and Niem, 1985). The rock units include, from youngest to oldest, Quaternary Coastal Marine Terrace, Miocene marine sedimentary rocks of the Astoria Formation, and Miocene volcanic rocks of the Columbia River Basalt Group (Niem and Niem, 1985).

In general, marine terrace deposits are formed by a combination of tectonic coastal uplift and sea-level fluctuations. The Coastal Marine Terrace Deposits are underlain by massive to laminated siltstone of the Cannon Beach member of the Astoria Formation. Regionally, this unit also contains layers of sandstone. The volcanic rock that underlies the site along the eastern and southern property boundaries has been mapped as an intrusive sill of Wanapum Basalt, which is part of the Columbia River Basalt Group (Niem and Niem, 1985).

The Coastal Marine Terrace and Astoria Formation rock units at the South Wind site have been modified by landslide processes (SLIDO; Schlicker et al, 1972). In detail, the South Wind site is located within a mapped landslide with movement estimated within about the last 100 years, as referenced on the engineering geologic map of the Cannon Beach quadrangle (Schlicker et al., 1972). Review of available satellite and lidar imagery indicate the ground surface at the South Wind site has an irregular, hummocky topography, with moderate to steep slopes generally ranging from about 10 to 45%. In localized areas, the ground-surface topography displays typical landslide-related characteristics.

The SLIDO mapping shows three areas of documented localized instability and/or landslides along Highway 101. These three areas coincide with roadway fills and culverts that pass surface water from the site area to locations west of Highway 101.

GEOLOGIC RECONNAISSANCE

An Oregon-certified engineering geologist from GRI completed a walking geologic reconnaissance of the site on December 4, 2018, to conduct a visual examination of the geologic and geomorphologic conditions exposed at the ground surface, such as soils and rock exposures, indications of surficial slope instability, and site drainages, seeps, and springs. Observations made during our site reconnaissance are shown on the Geologic Reconnaissance Map, Figure 4.

A gravel access road coming off Highway 101 enters the South Wind property from the south and traverses two unnamed creeks heading north. This road ends in a gentle (less than 15°) west-sloping open area cleared of the large conifer trees present in the northern and southern drainages of the site. The open area is the preferred location for the new city hall building. Prior to reaching the open area, the road construction appears to have required a rock cut on the south side of an unnamed creek. Siltstone was observed in an exposed cut slope of the road and appeared to consist of light- to dark-brown, slightly to moderately weathered, thin to very thin bedded siltstone. Northeast of the rock cut, a concave-shaped, steeply sloping ridge is present above an area of hummocky topography. The hummocky topography is located to the southeast and northwest of the road. The curved ridge and hummocky topography suggest a likely deep-seated (>15 ft in depth) landslide crosses the road and appears to encompass both sides of the unnamed creek in this area. Water flowing in the creek bottom, from higher elevations in the east to the lower elevations to the west, crosses the road from the east in a culvert. Water flow from the west end of the culvert disappears into the ground a short distance west of the culvert outlet. The stream again reappears a short distance downstream, in an area of less gradient. Another unnamed creek channel is located north of the access road and open area being considered for the new city hall building. The creek channel in the north is broad with a poorly defined channel, creating ponding and marsh-like segments in the creek bottom.

The hillslopes above the unnamed drainages located in the southern portion of the site show relatively young, localized slumping and slope instability at several locations along both the north and south sides of the creeks. These localized areas are relatively young compared to the larger, older landslide areas of shown on DOGAMI maps. Some of the slope instability observed may be considered relatively deep seated, with failure planes likely greater than 15 ft in depth. The failures form roughly oval-shaped mounds of soil material below a slightly curved slope crest. Mature conifer trees are growing in the landslide debris. In addition, soil accumulation at the base of the southern slope of the unnamed drainage in the northern portion of the site is indicative of shallow slope failures. Thick vegetation in this area prevented direct observation of the material and channel bottom in the northern portion of the site. The approximate locations of these younger landslide deposits disclosed during our geologic reconnaissance are shown on Figure 4.

GRI walked along the Highway 101 frontage along the west portion of the site. Obvious indications of large-scale, deep-seated slope instability affecting the road were not observed. Light seepage of groundwater to the ground surface was observed at three locations along the western boundary of the site along Highway 101. As previously noted, localized, historical instability to the Highway 101 roadway likely associated with settlement of roadway fill near three culverts is reported on the SLIDO mapping.

FIELD EXPLORATIONS

General

Subsurface materials and conditions at the site were investigated between December 3 and 10, 2018, with three borings, designated B-1 through B-3. The borings were advanced to depths of about 100 to 151.5 ft below existing site grades at the approximate locations shown on Figure 2. Following completion of the borings, two vibrating-wire piezometers equipped with data loggers were installed in each of the borings at depths ranging from 50 to 150 ft for continuous measurement of piezometric (water) pressures, and inclinometer casings were installed to the base of the boreholes of borings B-2 and B-3 to monitor lateral ground movement. The drilling, sampling, and installation of instrumentation were observed by an experienced member of GRI's geotechnical engineering and/or geology staff, who maintained a log of the materials and conditions disclosed during the course of the work. Subsurface information from the explorations completed by GRI for this study are provided in Appendix A for reference.

Mud-Rotary Borings

Borings B-1 and B-3 were advanced to depths of about 100 and 151.5 ft, respectively, using mud-rotary techniques with a track-mounted drill rig provided and operated by Holt Services, Inc., of Vancouver, Washington. Disturbed and undisturbed soil samples were generally obtained from the borings at 2.5- to 5-ft intervals of depth in the upper 70 to 80 ft and 10-ft intervals below this depth. Disturbed soil samples were obtained using a 2-in.-outside-diameter (O.D.) standard split-spoon sampler or a larger, 3-in.-O.D. California-modified split-spoon (CMS) sampler. The CMS sampler was used when sample recovery was not possible with the split-spoon sampler due to the particle size of the material being sampled. Standard Penetration Tests (SPT) were conducted by driving the samplers into the soil a distance of 18 in. using a 140-lb hammer dropped 30 in. The number of blows required to drive the split-spoon sampler the last 12 in. is known as the Standard Penetration Resistance, or SPT N-value. The number of blows required to drive the CMS sampler the last 12 in. is denoted as the SPT N*-value. SPT N- and N*-values provide a measure of the relative density of granular soils and relative consistency of cohesive soils. Samples obtained from the borings were placed in airtight jars and returned to our laboratory for further classification and testing. In addition, relatively undisturbed soil samples were collected by pushing a 3-in.-O.D. Shelby tube into the undisturbed soil a maximum of 24 in. using the hydraulic ram of the drill rig. Where drilling refusal was encountered within the depth of interest, samples of rock were obtained using HQ rock coring techniques. The core samples were placed in boxes and returned to our laboratory for further examination and testing.

Logs of the mud-rotary borings and photographs of the rock cores are provided in Appendix A on Figures 1A and 3A and Figure 4A, respectively. Each log presents a summary of the various types of materials encountered in the borings and notes the depths at which the materials and/or characteristics of the materials change. To the right of the summary, the numbers and types of samples are indicated. Farther to the right, SPT N- and N*-values are shown graphically, along with natural moisture contents. The terms and symbols used to describe the materials encountered in the mud-rotary borings are defined in Tables 1A and 2A and on the attached legend.

Rotosonic Boring

Boring B-2 was advanced to a depth of about 140 ft using rotosonic drilling techniques with a track-mounted drill rig provided and operated by Yellow Jacket Drilling Services, LLC, of Portland, Oregon. Continuous 6-in.-diameter runs were obtained from the boring in 2- to 3-ft intervals and stored in flexible plastic tubing. The plastic tubing was opened in the field for visual classification, and digital photographs were taken of each run. Representative grab soil samples were carefully examined in the field and saved in plastic bags for laboratory testing.

A log of the rotosonic boring and photographs of the runs are provided in Appendix A on Figure 2A and Figures 5A through 11A, respectively. Each log presents a summary of the various types of materials encountered in the boring and notes the depths at which the materials and/or characteristics of the materials change. To the right of the summary, the numbers and types of samples are indicated. The terms and symbols used to describe the materials encountered in the rotosonic boring are defined in Tables 1A and 2A and on the attached legend.

Inclinometer Instrumentation

Inclinometer casings 140 and 150 ft long were installed in the completed boreholes of borings B-2 and B-3, respectively. An inclinometer is a device that allows measurements to be made of subsurface lateral movements. An inclinometer casing consists of 2.75-in.- O.D., acrylonitrile butadiene styrene (ABS)-plastic casing with orthogonal grooves or slots that permit a calibrated instrument to be lowered to the bottom of the casing in a fixed orientation. When the ground surrounding the casing moves, the casing distorts above the zone of movement, and the orientation of the casing changes. The inclination, or vertical orientation, of the casing is monitored by lowering an electronic measuring device to the bottom of the grooved casing and obtaining readings at 2-ft intervals as the instrument is withdrawn. An initial set of readings serves as a "benchmark" and is commonly portrayed as the vertical axis on a plot of casing deflection versus depth. All subsequent readings are then referenced to the initial readings. By comparing relative movements at fixed depths over the length of the casing, zones of horizontal movement can be identified. The total, or cumulative, displacement with respect to the base of the casing is obtained by summing the relative displacements from the bottom to the top.

The inclinometers were installed by lowering the casing to the base of the borehole and filling the annular space surrounding the casing with a cement-bentonite slurry. The slurry was placed using tremie methods starting at the bottom of the borehole. The completed installation was protected at the ground surface with a steel monument set in concrete. Following installation, a benchmark reading of each inclinometer was taken on December 12, 2018, with subsequent readings taken on January 10 and February 8, 2019. The inclinometer benchmark and subsequent readings are provided on Figures 12A and 13A.

Vibrating Wire Piezometers

Vibrating-wire piezometers were installed at depths of 50 and 90 ft in borings B-1 and B-2 and at depths of 100 and 150 ft in boring B-3. A vibrating-wire piezometer is a device that allows measurements to be made of subsurface fluid pressures. The piezometer consists of a sensitive steel diaphragm to which a vibrating-wire element is connected. A filter is used to keep out solid particles and prevent damage to the sensitive diaphragm. Changing pressures cause the diaphragm to deflect, and this deflection is measured as a change in tension and frequency of vibration of the vibrating-wire element. The square of the vibration frequency is directly proportional to the pressure applied to the diaphragm. To read the piezometer, a pulse of varying frequency is applied to the piezometer and causes the wire to vibrate at is resonant frequency. After excitation ends, the wire continues to vibrate, and a signal is transmitted to a readout box, where it is conditioned and displayed. The data on the readout box can then be converted to a fluid pressure based on the calibration data supplied by the manufacturer.

The vibrating-wire piezometers were attached to the inclinometer casing or a sacrificial piece of polyvinyl chloride (PVC) pipe and lowered to the appropriate depths in the boreholes. The annular space surrounding the casing or PVC pipe was filled with a cement-bentonite slurry using tremie methods starting at the bottom of the borehole. The completed installation was protected at the ground surface with a steel monument set in concrete. Following installation, an initial reading of each piezometer was taken on December 12, 2018, and data loggers were attached to the piezometers to allow for continuous measurement of water pressures. The water pressures recorded in each piezometer over the monitoring period are provided on Figures 14A through 16A.

SUBSURFACE CONDITIONS

General

The geologic units disclosed by the subsurface explorations are consistent with work completed by others in the project area and our understanding of the local geology. For the purpose of discussion, the materials disclosed by the borings have been grouped into the following units based on their physical characteristics and engineering properties.

1. **SURFACING**
2. **CLAY (Coastal Marine Terrace/Landslide Debris)**
3. **SILTSTONE (Astoria Formation)**
4. **BASALT (Columbia River Basalt)**

The following paragraphs provide a description of these units and a discussion of the groundwater conditions at the site.

1. SURFACING. Borings B-2 and B-3 were advanced in areas surfaced with about 1.5 ft of fragmental rock.

2. CLAY (Coastal Marine Terrace/Landslide Debris). Clay, interpreted to be Coastal Marine Terrace/Landslide Debris, was encountered at the ground surface in boring B-1 and beneath the surfacing in borings B-2 and B-3 and extends to depths of about 33 to 51 ft. In general, the clay is brown or gray with varying degrees of orange, gray, and brown mottling; has a variable silt content ranging from some silt to silty; and contains a variable amount of fine- to coarse-grained sand ranging from a trace to some sand. Gravel- to cobble-sized fragments of decomposed to moderately weathered siltstone were encountered in the unit below a depth of 25 ft in boring B-1, between depths of 10 and 12 ft in boring B-2, below a depth of 40 ft in boring B-2, and between depths of 5 and 11.5 ft in boring B-3. Gravel- to cobble-sized fragments of fresh to moderately weathered basalt were encountered in the unit below depths of 40 and 23 ft in borings B-2 and B-3, respectively. Organics were encountered throughout the unit in all the explorations. Sheared zones of clay containing wood debris were encountered at depths of about 12.5 and 27.5 ft in boring B-1, and 0.5- to 2-ft-thick layers of wood debris were encountered at depths of 18, 25, 29.5, 43, 44.5, and 46 ft in boring B-2. Fossilized worm burrows were encountered in the unit at a depth of 20 ft in boring B-1, and coniferous tree needles were encountered in the unit between depths of 27.5 to 30 ft in boring B-1 and 5 to 7 ft in boring B-2. The relative consistency of the clay is very soft to very stiff based on SPT N-values and N*-values and is typically soft to stiff. The natural moisture content of the clay ranges from 24 to 128%.

Samples of wood debris obtained at depths of 18.5, 25.5, and 46.5 ft from boring B-2 were sent to Beta Analytic, Inc., in Miami, Florida, for conventional radiocarbon age testing in accordance with the

International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC) 17025:2005 accreditation protocols. The test results indicate the wood debris obtained at depths of 18.5, 25.5, and 46.5 ft are approximately 22,720, 26,500, and greater than 43,500 years old, respectively. The conventional radiocarbon age test results are provided in Appendix B for reference.

A sample of clay obtained between depths of 50 and 52 ft from boring B-2 was sent to Benchmark Geolabs in McMinnville, Oregon, for drained residual torsional shear-strength testing in accordance with ASTM International (ASTM) D6467. The test results indicate the clay has a residual friction angle of about 10° in the normal stress range of interest. The drained residual torsional shear-strength test results are provided in Appendix C for reference.

Chaotic structure was observed near or at the base of the unit in boring B-1 below a depth of 36 ft, in boring B-2 below a depth of 46 ft, and in boring B-3 below a depth of 30 ft. The chaotic structure is interpreted to be the result of landslide processes.

3. SILTSTONE (Astoria Formation). Extremely soft (R0) to very soft (R1) siltstone was encountered beneath the Coastal Marine Terrace/Landslide Debris in all the explorations. The siltsone extends to depths of about 90 to 95 ft in borings B-1 and B-2 and the maximum depth explored of about 151.5 ft in boring B-3. In general, the siltstone is brown to gray with varying degrees of white mottling and predominantly decomposed to decomposed in the upper 20 to 30 ft, moderately weathered to a depth of about 100 ft, and fresh to slightly weathered below this depth. Zones of green to black, very soft (R1) to medium-hard (R3) siltstone with very close fractures and slickensides along the fracture faces were encountered below depths of 90.5 and 84 ft in borings B-1 and B-2, respectively. The green to black color and presence of slickensides are indications of potential contact metamorphism and/or tectonic shearing and are not interpreted to be the result of landslide processes.

A sample of siltstone obtained between depths of 45 and 47.5 ft from boring B-1 was sent to Benchmark Geolabs in McMinnville, Oregon, for drained residual torsional shear-strength testing in accordance with ASTM D6467. The test results indicate the siltstone has a residual friction angle of about 8° in the normal stress range of interest. The drained residual torsional shear-strength test results are provided in Appendix C for reference.

Boring B-3 was terminated in siltstone at a depth of about 151.5 ft.

4. BASALT (Columbia River Basalt). Soft (R2) to hard (R4), dark-gray basalt was encountered beneath the siltstone in borings B-1 and B-2 at depths of 95 and 90 ft, respectively. The basalt extends to the maximum depths explored of about 100 and 140 ft in borings B-1 and B-2, respectively. In general, the basalt is slightly weathered to fresh, brecciated in boring B-1, and closely to very closely fractured in boring B-2. Slickensides are present on the fracture faces near the contact with the overlying siltstone in boring B-2, which is an indication of potential contact metamorphism and/or tectonic shearing.

Borings B-1 and B-2 were terminated in the basalt at depths of about 100 and 140 ft, respectively.

Groundwater

We anticipate the regional groundwater level typically occurs at depth in the highly fractured basalt that underlies the site and closely matches the elevation of the Pacific Ocean. However, the vibrating-wire piezometer readings indicate perched groundwater conditions occur in the Coastal Marine Terrace/Landslide Debris that mantle the project area, particularly during the wet winter and spring months or during periods of heavy or prolonged precipitation. In addition, based on our interpretation of the piezometer readings, we anticipate artesian water conditions may develop near the contact between siltstone and basalt. Perched groundwater and artesian water-pressure measurements recorded in the piezometers are tabulated below by selected dates.

PERCHED GROUNDWATER DEPTH AND ARTESIAN WATER PRESSURES

	Perched Groundwater Depth, ft				Artesian Water-Pressure Head, ft	
Date	B-1, P-1 at 50 ft	B-2, P-1 at 50 ft	B-3, P-1 at 100 ft	B-3, P-2 at 150 ft	B-1, P-2 at 90 ft	B-2, P-2 at 90 ft
12/15/18	33.8	5.6	15.4	18.0	70.6	63.6
12/31/18	38.5	6.4	15.1	17.7	75.3	62.9
01/15/19	39.4	7.5	15.6	18.2	77.7	61.9
01/31/19	39.8	7.7	15.6	18.1	80.5	61.7
02/08/19	39.9	7.5	15.3	17.8	81.9	62.0

The vibrating-wire piezometer readings indicate the phreatic surface in the project area slopes downwards towards Highway 101. A sloping phreatic surface is an indication perched-groundwater movement through the Coastal Marine Terrace/Landslide Debris is likely occurring. Based on measurements of the piezometer installed at a depth of 50 ft in boring B-2, we anticipate the perched-groundwater level in the project area will typically occur at depths of 5 to 10 ft throughout the year; however, localized zones of perched groundwater may approach and inundate the ground surface during the wet winter and spring months or during periods of heavy or prolonged precipitation.

PRELIMINARY CONCLUSIONS

General

Subsurface explorations indicate the project area is mantled with about 40 to 50 ft of Coastal Marine Terrace/Landslide Debris consisting of clay and interbedded layers of wood debris. The Coastal Marine Terrace/Landslide Debris is underlain by siltstone of the Astoria Formation that extends to depths of about 90 to 95 ft in the project area. The lower contact of the Coastal Marine Terrace/Landslide Debris and underlying siltstone locally appears chaotic and non-homogenous, which we interpret to be an indicator of movement and shearing associated with the relatively older DOGAMI-mapped landslide deposits. The siltstone is underlain by Columbia River Basalt that extends to depths of at least 140 ft in the project area. Perched groundwater occurs at depths of about 5 to 10 ft in the project area and may approach or inundate the ground surface in localized areas during periods of heavy or prolonged rainfall.

The following preliminary conclusions are provided to assist the design team with project planning. For purposes of discussion, we interpret the project area to be underlain by landslide debris to the top of the Astoria Formation siltstone or to depths of about 33 to 51 ft below existing site grades. For the purpose of our analyses, we simplified this range of depths to a landslide debris thickness of 45 ft below existing site grades in the building area.

Preliminary Slope Stability Analyses

General. Preliminary analyses of ground-surface stability in the building area were performed with the aid of the software program SLIDE 8.0, developed by Rocscience, Inc., of Toronto, Canada. The static and seismic equilibrium of the ground surface was evaluated using Spencer and Morgenstern-Price's method of slices, which satisfies both force and moment equilibrium. The output of the analysis is the factor of safety, defined as the ratio of the forces and moments resisting movement, such as the shear strength of the soil, to the forces and moments driving movement of the soil mass, such as earthquake ground motions. During an earthquake, the resisting forces may decrease due to generation of excess pore-water pressures, and the driving forces will vary with each cycle of loading; therefore, the factor of safety is constantly fluctuating. As the factor of safety decreases and approaches 1.0, the relative stability of the building area is considered to decrease. A factor of safety less than 1.0 implies the soil mass is not in equilibrium, and lateral movement is likely to occur during that cycle of seismic loading. The acceleration that results in a factor of safety of 1.0 is defined as the yield acceleration. Methodologies recommended by Newmark (1965) were used to estimate the lateral movement of the ground surface when the earthquake accelerations exceed the yield acceleration.

Slope Model. The existing topography and generalized subsurface conditions in the building area were used to develop a SLIDE 8.0 model to evaluate the static and seismic stabilities of the ground surface. The model used for global-stability analyses was developed from a cross section and generalized subsurface profile considered characteristic of the site in the building area. The generalized subsurface profile for the model was based on our subsurface explorations, piezometer readings, and laboratory test results. Given the limited subsurface information available uphill of the building area, a well log completed for a T-Mobile tower site located on the hillside immediately south of the South Wind site was also used to develop the generalized subsurface profile and is provided in Appendix D for reference. For our analyses, a water-pressure grid was developed based on the piezometer measurements from borings B-1 and B-2. The following table summarizes the various soil units and strength parameters assumed in our preliminary analyses, which are based on laboratory testing and interpretation of subsurface conditions.

ENGINEERING PROPERTIES OF SOIL LAYERS

Material Name (Geologic Unit)	Unit Weight γ, pcf	Strength Type	Cohesion, psf	Friction Angle ϕ′	Compressive Strength (UCS), psi	GSI	mi	D
Terrace Deposits (Coastal Marine Terrace/Landslide Debris)	120	Mohr-Coulomb	200	28°	-	-	-	
Wood Debris (Coastal Marine Terrace/Landslide Debris)	19(1)	Mohr-Coulomb	200(1)	16°(1)	-	-	-	
Slip Surface (Coastal Marine Terrace/Landslide Debris)	120	Mohr-Coulomb	0	18°	-	-	-	
Siltstone (Astoria Formation)	125	Generalized Hoek-Brown	-	-	100	30 to 50	5 to 9	0.7 to 1.0
Basalt (Columbia River Basalt)	140	Generalized Hoek-Brown	-	-	35,000	80	25	1.0

Note:

1) Geotechnical parameters based on published literature (Azhar et al., 2016).

The geotechnical parameters for each soil type used in our slope model were determined based on laboratory testing, published literature, and our experience with similar soil conditions. The contact between the Coastal Marine Terrace/Landslide Debris and underlying siltstone appears chaotic and non-homogenous, which was interpreted to be a potential slip surface subject to historical movement and shearing. As discussed in the **Subsurface Conditions** section of this report, the drained residual torsional shear-strength test results indicate the clay near the contact has a residual friction angle of about 10° in the normal stress range of interest. However, research data indicate the residual strength of clay soils increases at a rate of about 10% per log cycle of shearing velocity (Kulhawy and Mayne, 1990). We estimate the earthquake velocity from a M9.0 event occurring on the CSZ would be about 8 orders of magnitude greater than the velocity of shearing during the residual torsional shear-strength test. This would increase the residual friction angle from 10° under static loading to 18° under earthquake loading.

Earthquake Motions. In accordance with ASCE 7-16, the potential for seismically induced displacement of the ground surface should be evaluated at the Maximum Credible Earthquake (MCE_G) level. The MCE_G-level earthquake is generally defined as a probabilistic earthquake that produces ground motions with a 2% probability of exceedance in 50 years, or 2,475-year return period. A suite of accelerograms from subduction-zone earthquakes were selected and scaled to best represent the MCE_G-level peak ground acceleration PGA_M of 0.73 g determined for the site. The selected time histories include records from the Maule, Chile (2010), and Tohoku, Japan (2011).

Analyses Results. Using the SLIDE 8.0 model, our analyses indicate the static global factor of safety and yield acceleration for the unimproved building area are about 2.6 and 0.21 g, respectively. The slope models used for our stability analyses of the unimproved building area are provided on Figures 5 and 6. Using the scaled acceleration earthquake records, a Newmark time-history analysis was completed to estimate the potential for seismically induced movement in the building area. Our analyses indicate about 4 ft of lateral movement of the ground surface toward Highway 101 could occur during a code-based seismic event under existing free-field conditions (no building or other improvements). The lateral movement will primarily occur on the contact between the overlying Coastal Marine Terrace/Landslide Debris and underlying siltstone at a depth of about 45 ft below the ground surface in the building area. We estimate vertical displacement due to slope movement could approach half of the estimated horizontal displacement. The methods used to estimate the seismically induced movement of the ground surface are highly sensitive to selected shear strengths, yield accelerations, groundwater levels, and acceleration time histories and consequently are an approximate estimate of the actual displacement that may occur. Seismic events of lesser magnitudes or the same magnitude occurring at greater epicentral distances from the site would be expected to produce smaller horizontal and vertical displacements of the ground surface.

Preliminary Foundation Support

General. We understand the city hall building will have maximum column loads on the order of 200 kips. Based on the potential for seismically induced lateral movement of the ground surface and the presence of wood debris that may decompose over time, it is our opinion support for the new city hall building will need to be provided by a deep-foundation system embedded in the siltstone or tipped in the basalt that underlies the site. Our correspondence with the design team indicates 4-ft-diameter, drilled shafts are being considered on a preliminary basis for support of the new city hall building. We anticipate down-drag loads associated with decomposition of the wood-debris layers and seismically induced lateral loading will control design of the foundation system.

Axial Design Criteria. Capacities for drilled shafts depend on shaft diameter, structural strength of the shaft, and depth of penetration into the siltstone that underlies the site. However, ground settlement associated with decomposition of the wood-debris layers will induce large down-drag loads on the shafts and significantly reduce the compressive capacity. Static analyses were performed to estimate the down-drag loads induced on the shafts and determine the penetration criteria required to support the maximum column loads. On a preliminary basis, we estimate a 4-ft-diameter, drilled shaft will need to be socketed at least 45 ft into the underlying siltstone for a total depth of about 90 ft to achieve an allowable capacity of 200 kips due to downdrag loads in the upper 45 ft. This value assumes a factor of safety of 2.0 for compressive loading. Alternatively, the shaft diameter can be increased to 6 ft and the rock-socket length can be decreased to 25 ft to achieve an allowable capacity of 200 kips. It should be understood these capacities are preliminary and should only be used for project planning.

Lateral Seismic Support. As previously discussed, our preliminary analyses indicate about 4 ft of lateral movement of the ground surface toward Highway 101 could occur to a depth of 45 ft in the building area due to a code-based seismic event. The drilled shafts supporting the building will also provide shear resistance and increase the stability of the ground surface in the building area; however, the structural strength of the shaft in conjunction with the available soil resistance must be sufficient to resist the seismically induced lateral forces from the inertial load of the structure and kinematic load of the soil. Using the SLIDE 8.0 model and the scaled earthquake records, a sensitivity analysis was completed to evaluate the drilled-shaft support and configuration required to reduce lateral movement of the building. The conceptual foundation layout provided by Catena was used to model the drilled shafts supporting the building and additional 4-ft-diameter, drilled shafts were modeled as shear piles uphill of the building area.

For our analyses, the software program LPILE, developed by Ensoft, Inc., of Austin, Texas, was used to estimate the shear capacity of 4-ft-diameter, drilled shafts and the corresponding lateral soil movement required to mobilize that capacity without developing a plastic hinge in the shafts. The following table summarizes the structural parameters used to model the drilled shafts in LPILE and provides the results of our LPILE analyses.

PRELIMINARY LPILE ANALYSES INPUTS AND RESULTS

Support Name	Concrete Strength, ksi	Reinforcement	Steel Grade, ksi	Soil Movement, in.	Siltstone Socket Length, ft	Shear Capacity, kips
4-ft-Diameter Drilled Shafts	4	12 - #8 Vertical Bars	60	18 in.	45	470
4-ft-Diameter Shear Piles	6	14 - #14 Vertical Bars	60	10 in.	15	650

Based on the results of our LPILE analyses, we anticipate the shafts supporting the building can accommodate 18 in. of lateral soil movement without developing a plastic hinge and mobilize 470 kips of shear resistance. For the uphill mitigation, we anticipate 4-ft-diameter, drilled shafts (shear piles) socketed at least 15 ft into the underlying siltstone for a total length of about 60 ft can mobilize 650 kips of shear resistance with at least

10 in. of lateral soil movement. Deflection, shear, and moment diagrams from our LPILE analyses are provided on Figures 7 and 8. The structural engineer should review the associated pile stresses to evaluate acceptable deformation/stresses.

Our preliminary slope-stability analyses indicate a plastic hinge will likely develop in the drilled shafts supporting the building due to excessive lateral movement during a code-based seismic event; therefore, uphill mitigation will likely be required to meet the seismic-performance criteria of the structure. On a preliminary basis, we estimate about 50 to 100 shear piles will likely be required for uphill mitigation. For our analyses, the shear piles were spaced about 20 ft apart. Assuming the building is about 150 ft wide, a total of nine rows of five to 11 shear piles (a total of 45 to 99 shear piles) will likely be required for uphill mitigation to meet the seismic-performance criteria for the building. The slope models used for our analyses are provided on Figures 9 through 11, which show the critical yield acceleration for each model. Using the critical yield accelerations and the scaled earthquake records, Newmark time-history analyses were completed to estimate lateral movement of the ground surface in the building area. The Newmark time-history analysis results are summarized in the table below.

PRELIMINARY NEWMARK TIME HISTORY ANALYSES

			Lateral Ground Movement, in.			
Earthquake/Year	**Magnitude, M**	**Record Used**	**Existing Conditions, Fig. 6**	**No Uphill Shear Piles, Fig 9**	**Five Uphill Shear Piles per Row, Fig. 10**	**11 Uphill Shear Piles per Row, Fig 11**
Tohoku/2011	9.0	IBR008NS	17	14	10	6
Tohoku/2011	9.0	MYG006EW	25	21	14	10
Tohoku/2011	9.0	MYG015NS	49	41	29	18
Tohoku/2011	9.0	FKS020EW	51	44	32	22
Maule/2010	8.8	VinaDelMar_NS	22	17	10	5
	Average		**33**	**27**	**19**	**12**

Summary

The South Wind site is located within a mapped landslide, as referenced on the published engineering geologic map of the Cannon Beach quadrangle (Schlicker et al., 1972). However, our interpretation of lidar imagery, our site reconnaissance observations, review of limited inclinometer measurements, and results of our preliminary analyses suggest the proposed building area is not underlain by an "active" landslide subject to continuous, creep-like static movements. It is our interpretation the landslide deposits directly under the building area are not presently moving (i.e., active). It should be understood our landslide-activity interpretation for the building area is primarily based on the lack of obvious indications of large-scale, deep-seated slope instability affecting the building area, such as ground cracks, hummocky topography, and bulging of the ground along Highway 101, as well as limited inclinometer-monitoring data and the results of our preliminary analyses. During our site reconnaissance, GRI did observe the access road into the site crosses a relatively young, deep-seated landslide with debris deposited on the east and west sides of the road. The disappearing stream observed suggests openings in the ground creating conduits for water. These observations are consistent with landslide debris. In addition, the valley walls of the unnamed drainages that cross the site form east to the west have relatively young, shallow, and potentially deep-seated failures that may require substantial setbacks from the edge of the slope.

Although there is no evidence to suggest the building area is underlain by an active landslide, subsurface information disclosed by the explorations and our experience with similar projects and geologic units on the northwest Oregon coast suggest movement of the Coastal Marine Terrace/Landslide Debris could have occurred during past seismic events. On a preliminary basis, our analyses indicate about 4 ft of lateral movement of the ground surface toward Highway 101 could occur during a code-based earthquake. Based on the potential for seismically induced lateral movement of the ground surface and the presence of wood debris that may decompose over time, it is our opinion support for the new city hall building will need to be provided by a deep-foundation system embedded in the siltstone or tipped in the basalt that underlies the site. Additional uphill mitigation will likely be required to limit seismically induced lateral movement of the building. For this study, GRI assumed building support would be provided by 4-ft-diameter, drilled shafts and uphill mitigation would consist of 4-ft-diameter, drilled shafts installed as shear piles. It should be understood using drilled shafts for shear support uphill of the building represents one method for reducing seismic movement of the ground surface. Additional methods, such as jet grout, ground anchors, and re-grading the uphill area, may also be possible and should be evaluated further if this site is selected for the new city hall. Support for infrastructure, such as roadways and parking lots, will depend on the desired performance level. However, our site-reconnaissance observations and interpretation of lidar imagery suggest a portion of the access road located south of the proposed building may be underlain by a younger landslide. The presence of younger landslides within the South Wind property boundary is an important consideration for infrastructure planning.

LIMITATIONS

This report has been prepared to aid the City of Cannon Beach with rough order of magnitude (ROM) cost development for construction of the new city hall building on the South Wind site and should be considered preliminary. The preliminary conclusions provided in this report are based on the data obtained from three subsurface explorations advanced at the locations indicated on Figure 2 and other sources of information discussed in this report. In the performance of subsurface explorations, specific information is obtained at specific locations at specific times, and variations in soil conditions may exist across the site. This report does not reflect any variations that may occur.

The conclusions provided in this report are preliminary in nature and should not be used for design purposes. Additional subsurface explorations and engineering analyses will be necessary to develop criteria and guidelines for final design.

Please contact the undersigned if you have any questions regarding this report.

Submitted for GRI,

18281
JAN 16, 1996
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Wesley Spang

Renews 06/2020

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References

Azhar, A.T.S., Norhaliza, W., Ismail, B., Abdullah, M.E., and Zakaria, M.N., 2016, Comparison of shear strength properties for undisturbed and reconstituted parit nipah peat, johor, International Engineering Research and Innovation Symposium (IRIS), IOP Conference Series, Materials Science and Engineering 160 (2016) 012058.

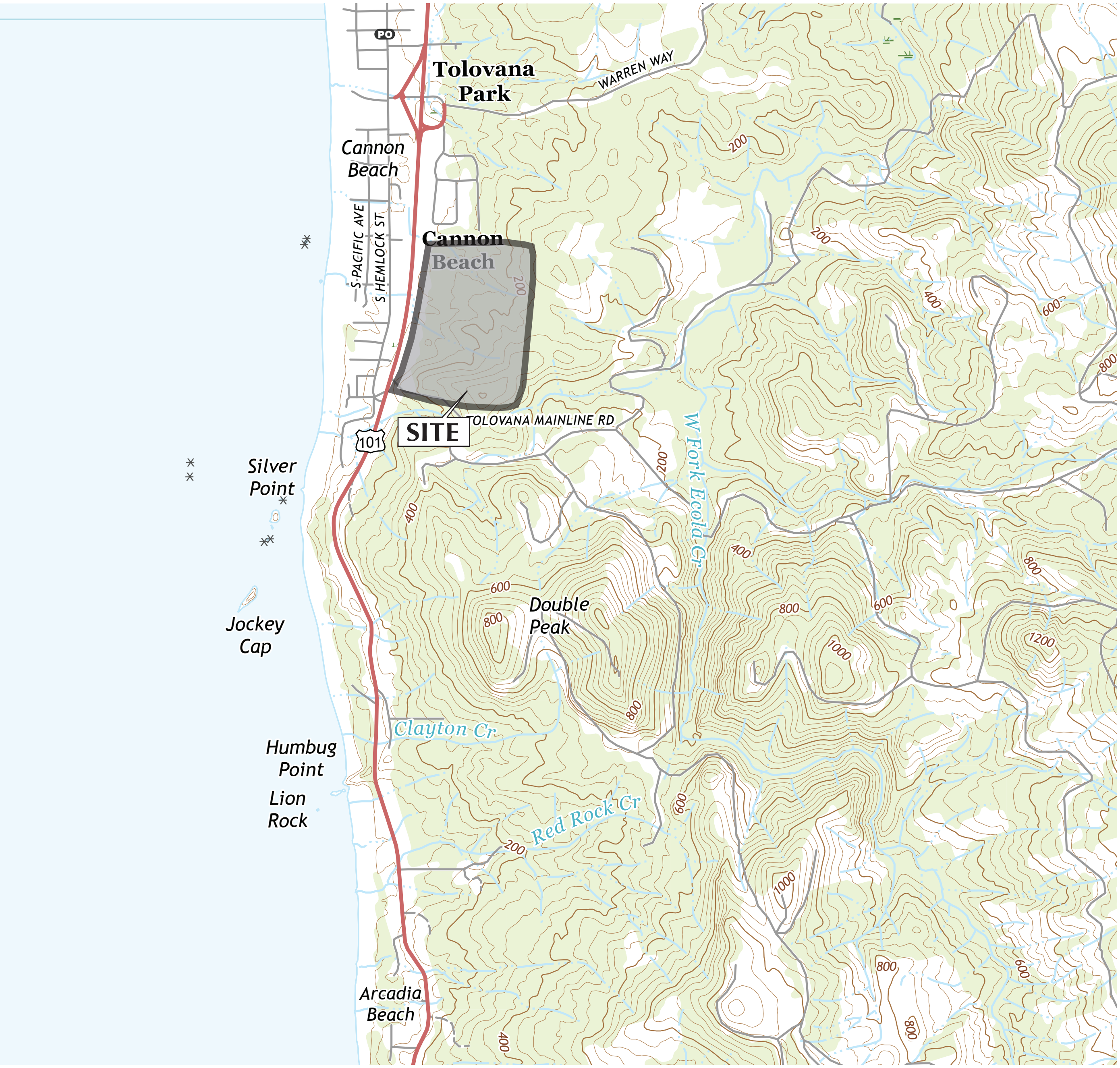
Kulhawy, F.H., and Mayne, P.W., 1990, Manuel on estimating soil properties for foundation design, EL-6800, Research Project 1493-6, prepared for Cornell University.

Oregon Department of Geology and Mineral Industries (DOGAMI), 2016, Statewide landslide information database of Oregon release 3.2 (SLIDO-3.2), accessed 11/20/2018 from DOGAMI website: http://www.oregongeology.org/slido/index.html.

Newmark, N.M., 1965, Effects of earthquakes on dams and embankments: Geotechnique 15, pp. 139-159.

Niem, A.R., and Niem, W.A., 1985, Oil and gas investigation of the Astoria Basin, Clatsop and Northernmost Tillamook counties, Northwest Oregon, Oregon Department of Geology and Mineral Industries, Oil and Gas Investigation 14.

Schlicker, H.G, Deacon, R.J., Beaulieu, J.D., and Olcott, G.W., 1972, Environmental geology of the coastal region of Tillamook and Clatsop counties, Oregon, Oregon Department of Geology and Mineral Industries, Bulletin 74.



USGS TOPOGRAPHIC MAP
ARCH CAPE, OREG. (2017)

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

VICINITY MAP

MAR. 2019 JOB NO. 6192 FIG. 1

◐ BORINGS COMPLETED BY GRI (DECEMBER 3-10, 2018)

A A' CROSS SECTION USED IN SLOPE STABILITY ANALYSIS

SITE PLAN FROM FILE BY SRG PARTNERSHIP, 2018

North

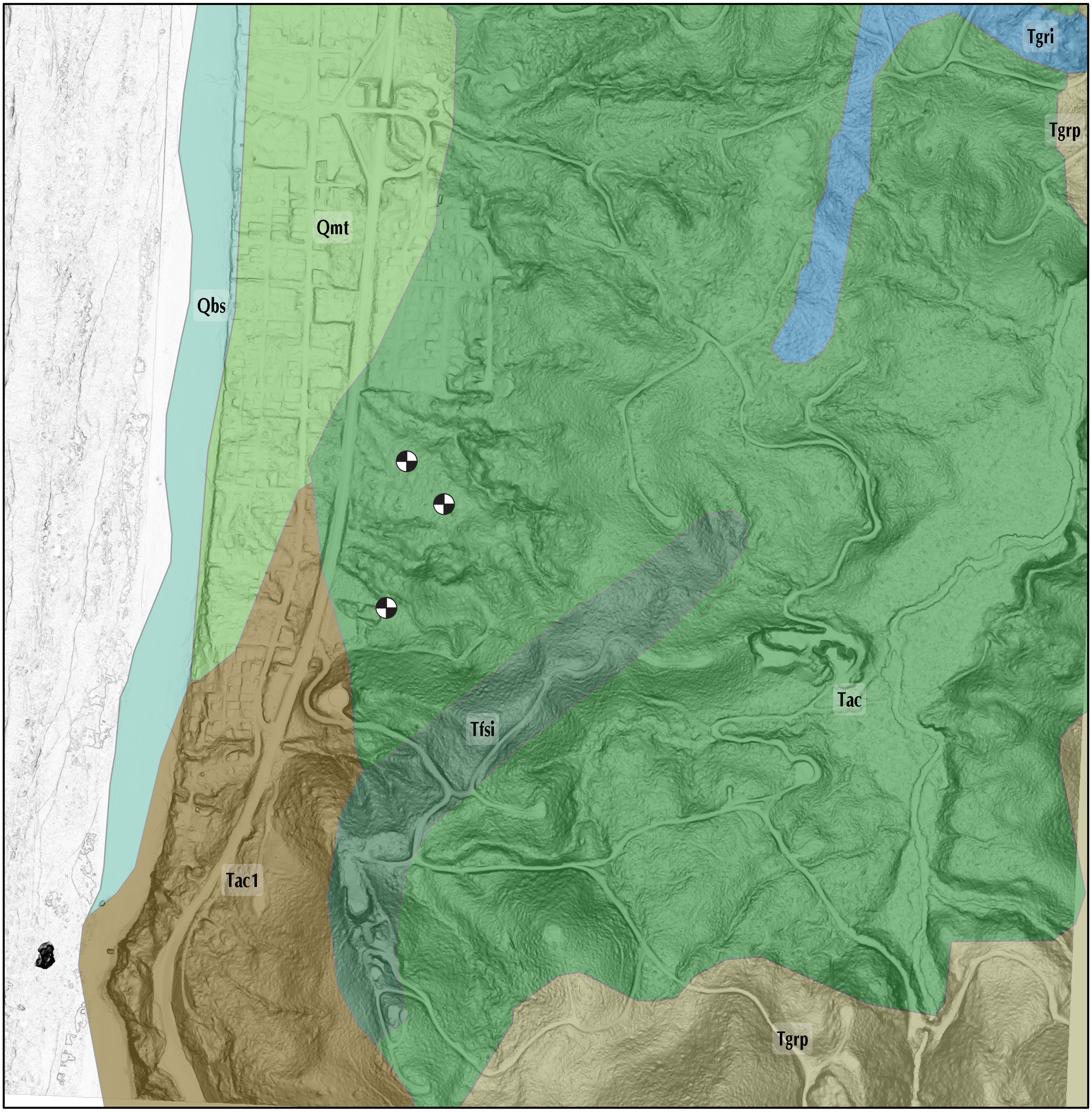
0 180 360 FT

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

SITE PLAN

MAR. 2019 JOB NO. 6192 FIG. 2



- 🟦 Qbs - QUATERNARY BEACH SAND
- 🟩 Qmt - COASTAL MARINE-TERRACE DEPOSITS
- 🟩 Tac - ASTORIA FORMATION, CANNON BEACH MEMBER
- 🟫 Tac1 - ASTORIA FORMATION, CANNON BEACH MEMBER
- 🟩 Tfsi - WANAPUM BASALT, INTRUSIVE FRENCHMAN SRINGS MEMBER
- 🟦 Tgri - INTRUSIVE GRANDE RONDE BASALT
- 🟨 Tgrp - GRANDE RONDE BASALT, SUBAERIAL BASALT FLOWS

◐ BORING COMPLETED BY GRI
(DECEMBER 3-10, 2018)

MODIFIED FROM: OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DIGITAL DATA SERIES OGDC-6

North

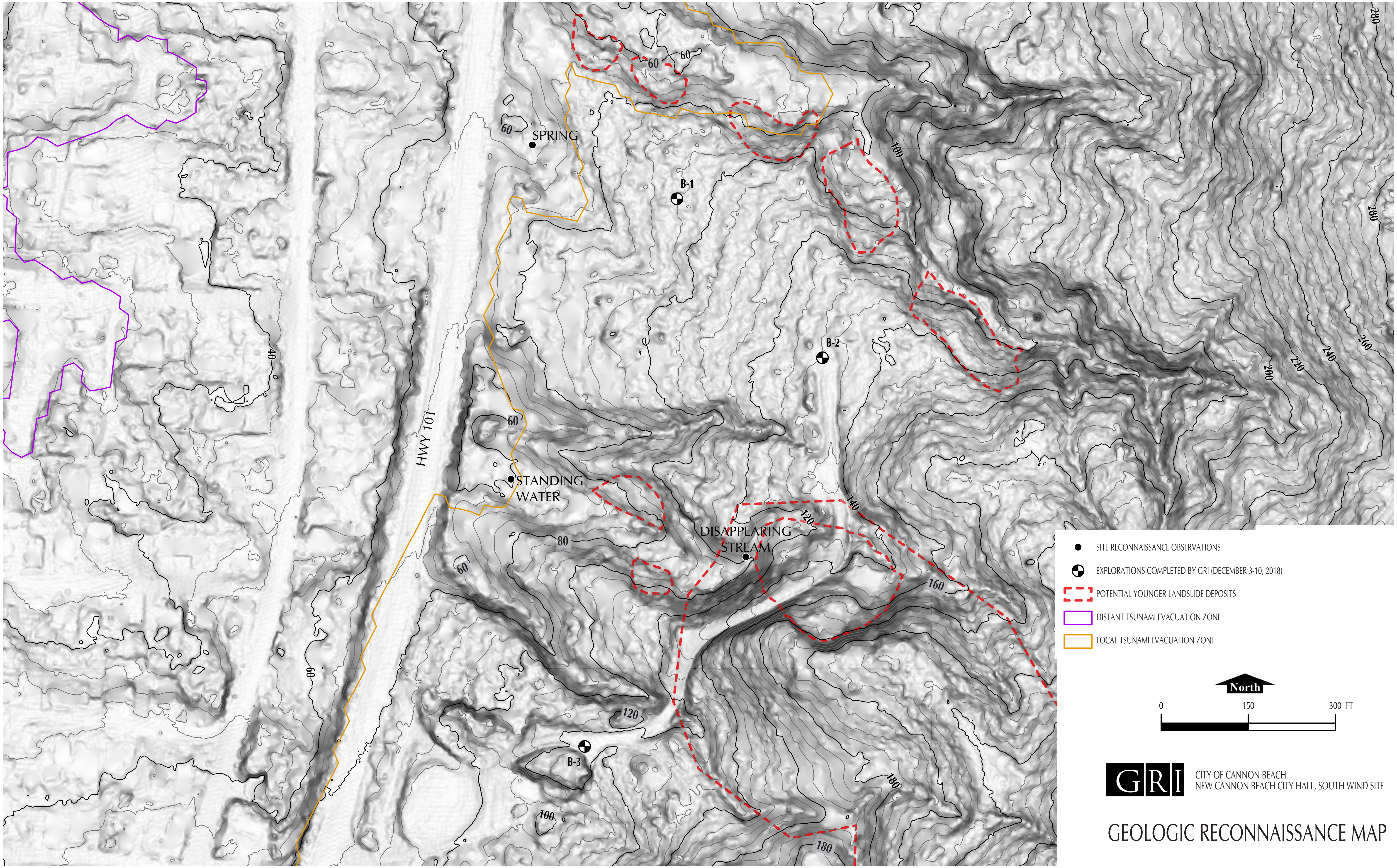
0 900 1,800 FT

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

LOCAL GEOLOGIC MAP

MAR. 2019 JOB NO. 6192 FIG. 3

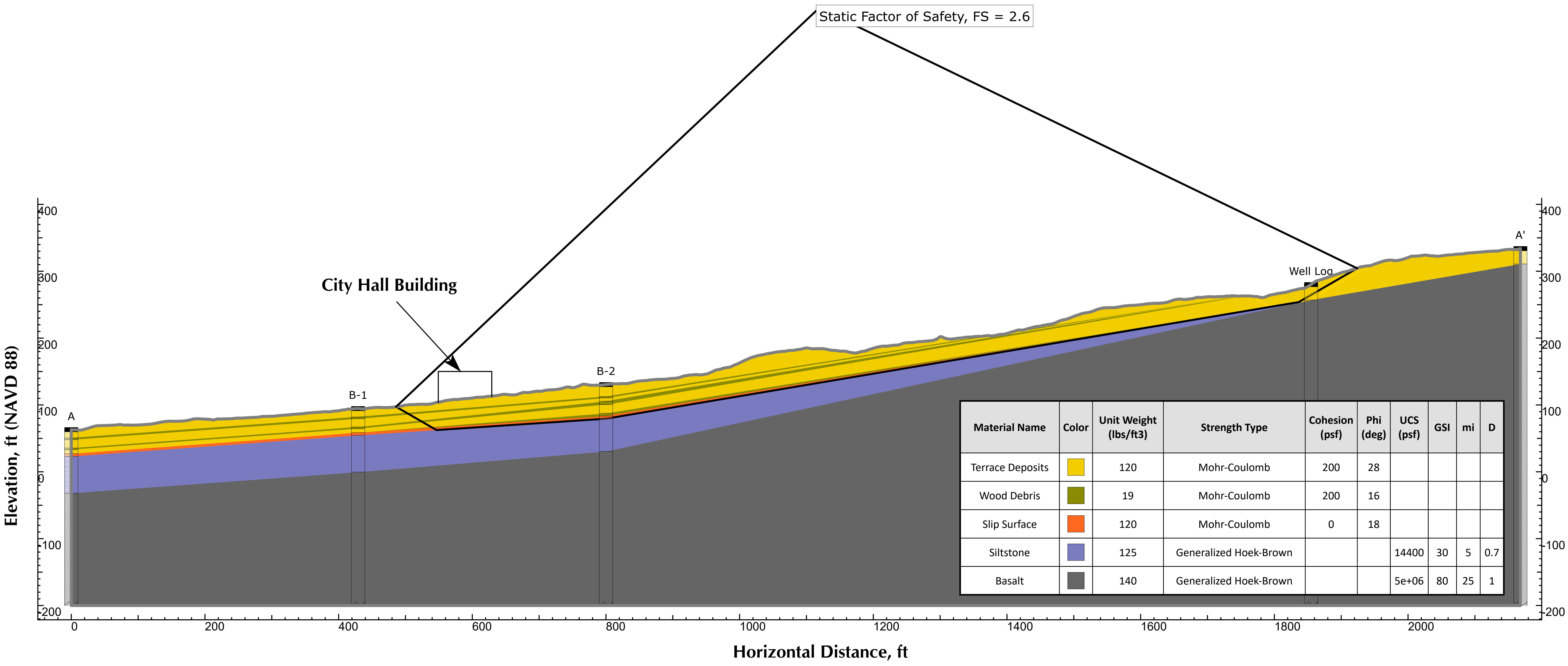


GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

GEOLOGIC RECONNAISSANCE MAP

MAR. 2019 JOB NO. 6192 FIG. 4



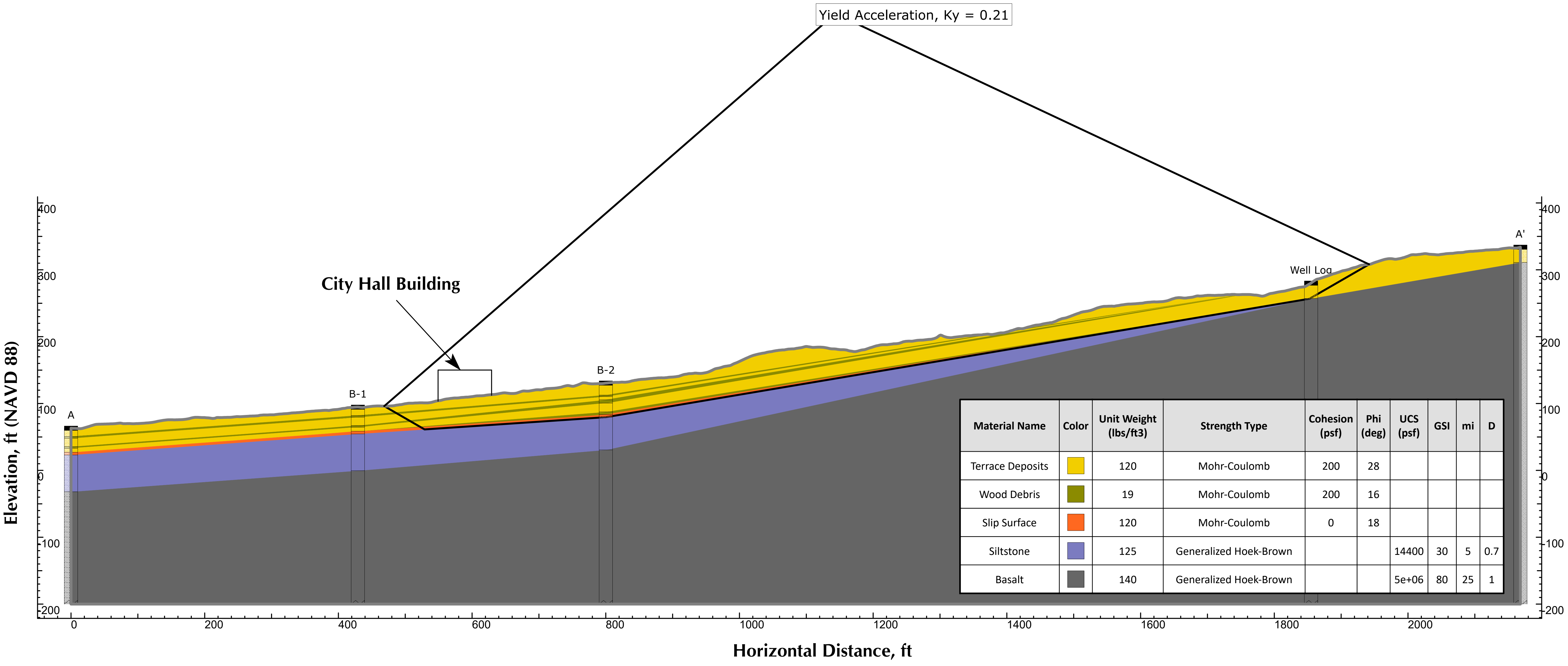
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	UCS (psf)	GSI	mi	D
Terrace Deposits	🟨	120	Mohr-Coulomb	200	28				
Wood Debris	🟫	19	Mohr-Coulomb	200	16				
Slip Surface	🟧	120	Mohr-Coulomb	0	18				
Siltstone	🟪	125	Generalized Hoek-Brown			14400	30	5	0.7
Basalt	⬛	140	Generalized Hoek-Brown			5e+06	80	25	1

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

SLOPE STABILITY MODEL
EXISTING - STATIC

MAR. 2019 JOB NO. 6192 FIG. 5



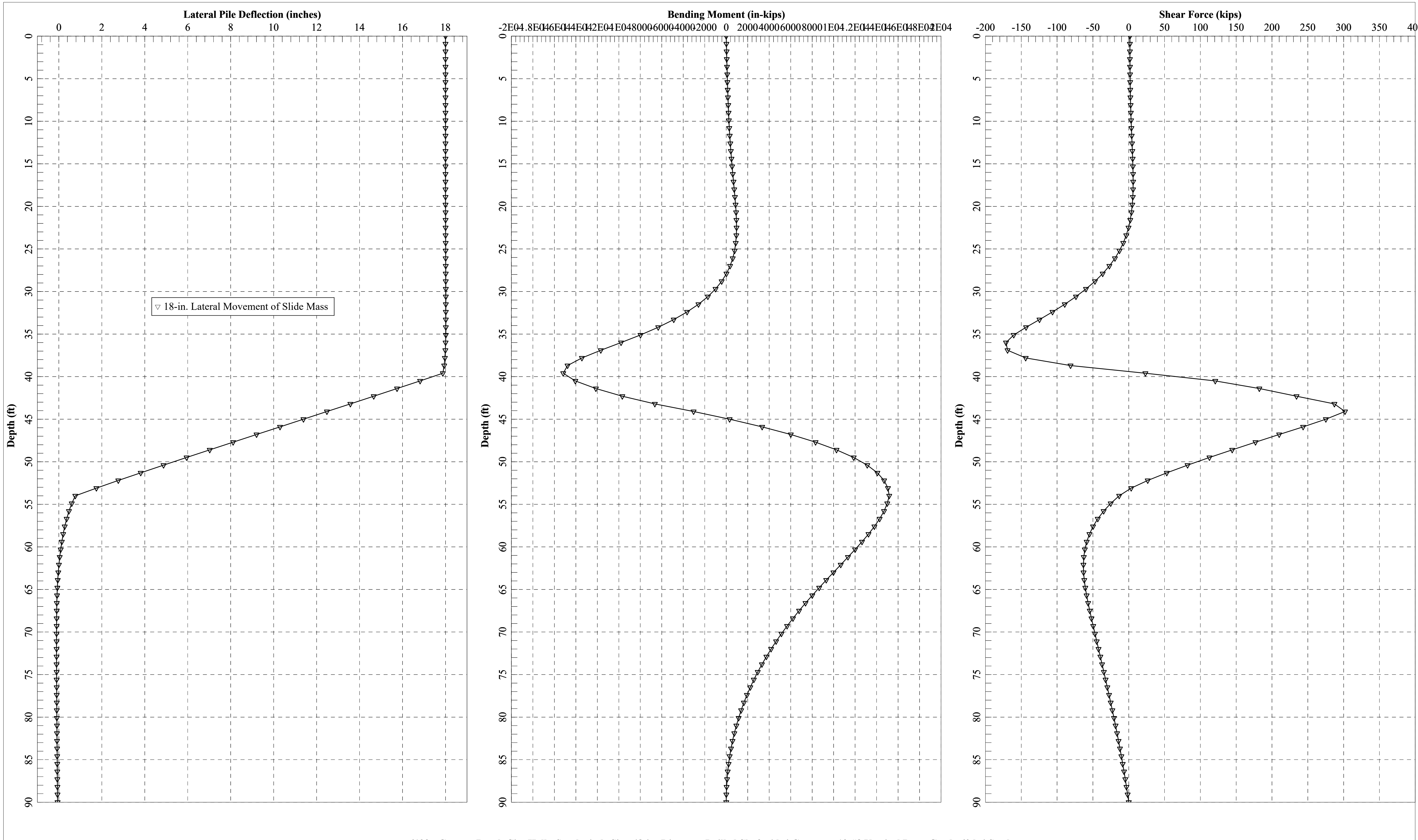
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	UCS (psf)	GSI	mi	D
Terrace Deposits	🟨	120	Mohr-Coulomb	200	28				
Wood Debris	🟫	19	Mohr-Coulomb	200	16				
Slip Surface	🟧	120	Mohr-Coulomb	0	18				
Siltstone	🟪	125	Generalized Hoek-Brown			14400	30	5	0.7
Basalt	⬛	140	Generalized Hoek-Brown			5e+06	80	25	1

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

SLOPE STABILITY MODEL
EXISTING - SEISMIC

MAR. 2019 JOB NO. 6192 FIG. 6



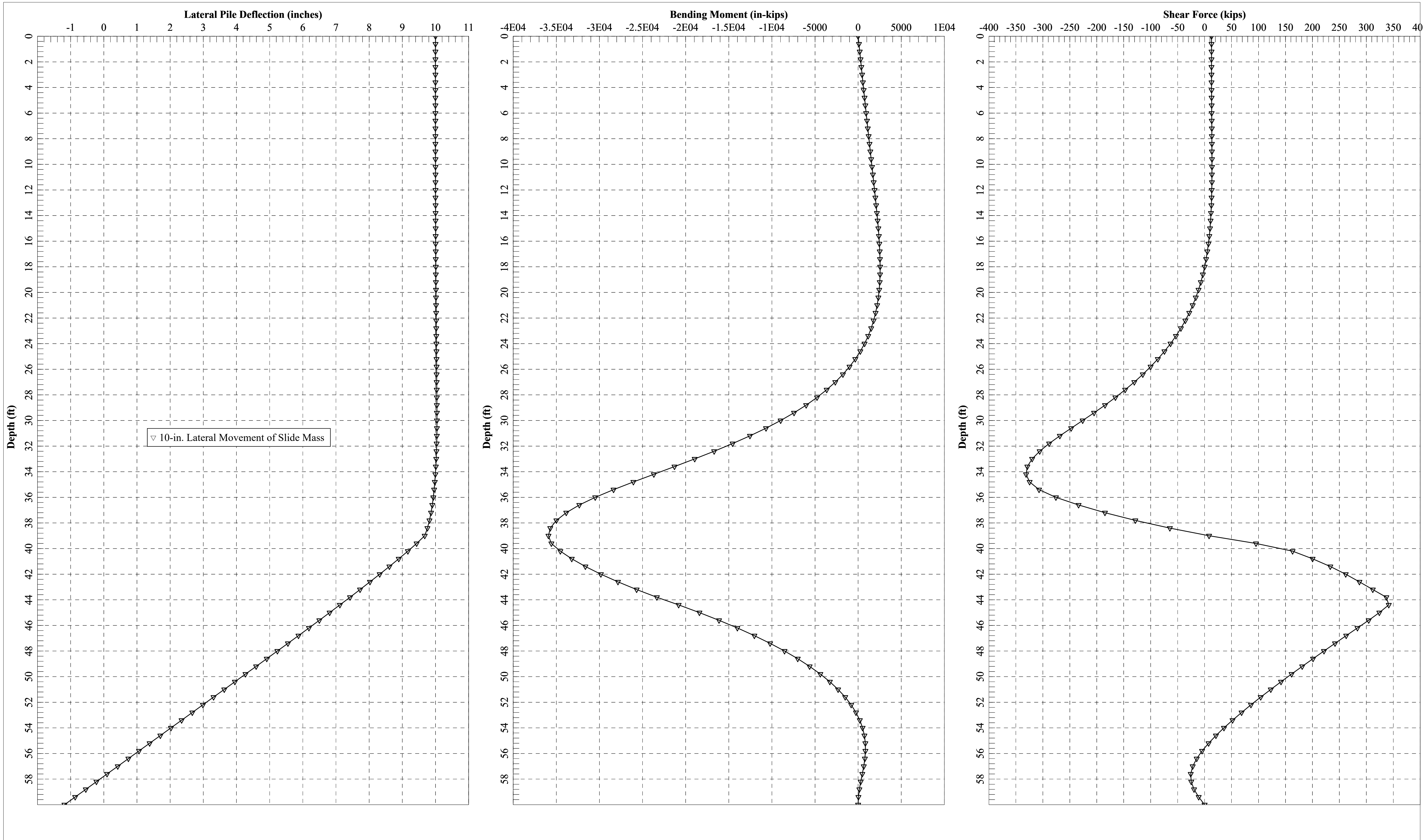
6192 - Cannon Beach City Hall - Southwinds Site, 48-in.-Diameter Drilled Shaft, 4 ksi Concrete, 12-#8 Vertical Bars, Grade 60 ksi Steel

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

LPILE ANALYSIS
FOR BUILDING SUPPORT

MAR. 2019 JOB NO. 6192 FIG. 7



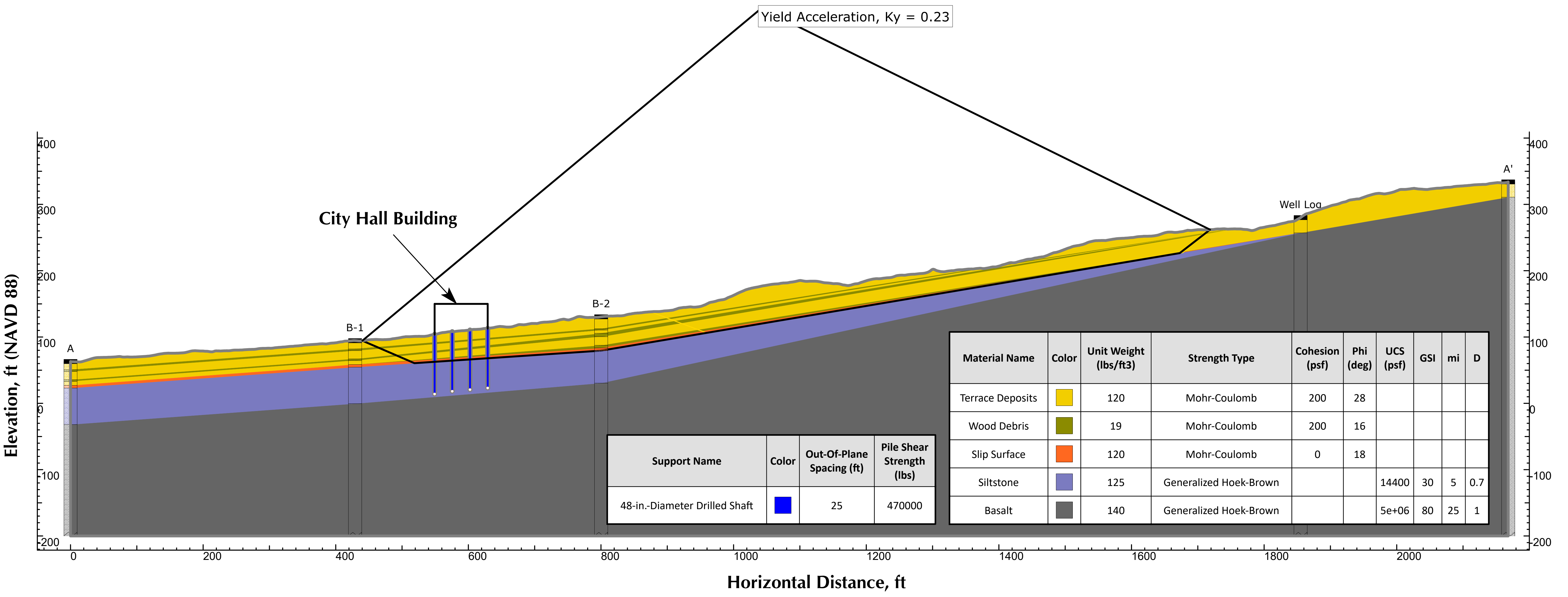
6192 - Cannon Beach City Hall - Southwinds Site, 48-in.-Diameter Drilled Shaft, 6 ksi Concrete, 14-#14 Vertical Bars, Grade 60 ksi Steel

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

LPILE ANALYSIS FOR SHEAR REINFORCEMENT

MAR. 2019 JOB NO. 6192 FIG. 8



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
48-in.-Diameter Drilled Shaft	🟦	25	470000

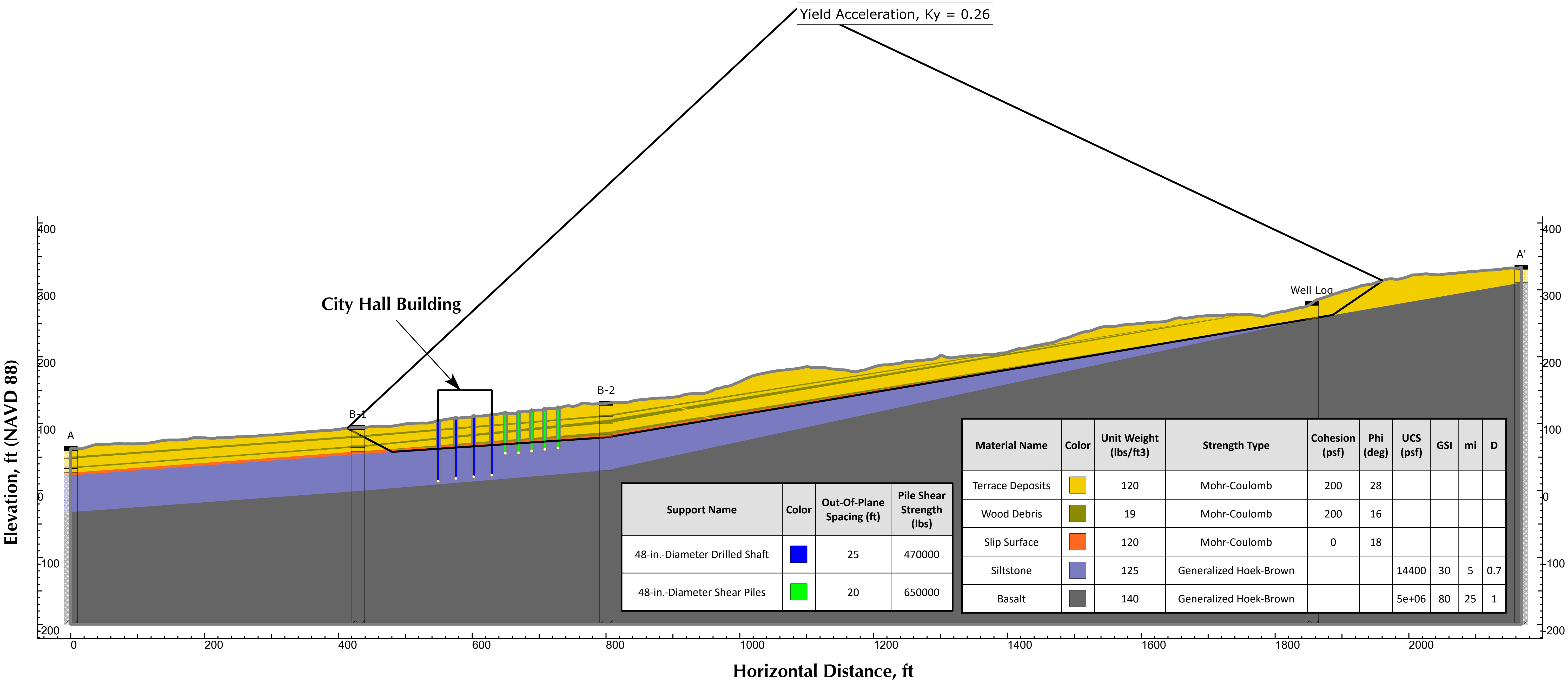
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	UCS (psf)	GSI	mi	D
Terrace Deposits	🟨	120	Mohr-Coulomb	200	28				
Wood Debris	🟩	19	Mohr-Coulomb	200	16				
Slip Surface	🟧	120	Mohr-Coulomb	0	18				
Siltstone	🟪	125	Generalized Hoek-Brown			14400	30	5	0.7
Basalt	⬛	140	Generalized Hoek-Brown			5e+06	80	25	1

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

SLOPE STABILITY MODEL
NO UPHILL MITIGATION - SEISMIC

MAR. 2019 JOB NO. 6192 FIG. 9



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
48-in.-Diameter Drilled Shaft	🟦	25	470000
48-in.-Diameter Shear Piles	🟩	20	650000

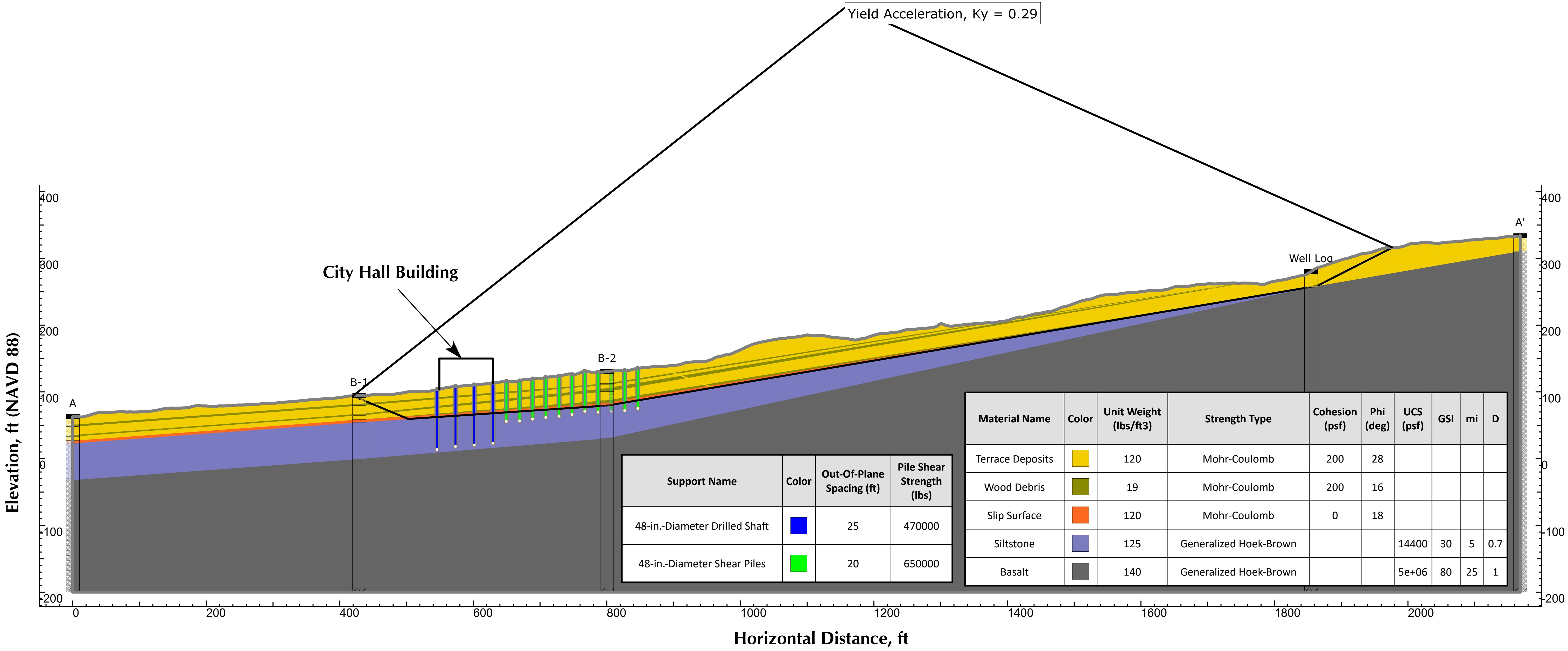
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	UCS (psf)	GSI	mi	D
Terrace Deposits	🟨	120	Mohr-Coulomb	200	28				
Wood Debris	🟫	19	Mohr-Coulomb	200	16				
Slip Surface	🟧	120	Mohr-Coulomb	0	18				
Siltstone	🟪	125	Generalized Hoek-Brown			14400	30	5	0.7
Basalt	⬛	140	Generalized Hoek-Brown			5e+06	80	25	1

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

SLOPE STABILITY MODEL
5 UPHILL SHEAR PILES - SEISMIC

MAR. 2019 JOB NO. 6192 FIG. 10



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
48-in.-Diameter Drilled Shaft	🟦	25	470000
48-in.-Diameter Shear Piles	🟩	20	650000

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	UCS (psf)	GSI	mi	D
Terrace Deposits	🟨	120	Mohr-Coulomb	200	28				
Wood Debris	🟫	19	Mohr-Coulomb	200	16				
Slip Surface	🟧	120	Mohr-Coulomb	0	18				
Siltstone	🟪	125	Generalized Hoek-Brown			14400	30	5	0.7
Basalt	⬛	140	Generalized Hoek-Brown			5e+06	80	25	1

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

SLOPE STABILITY MODEL
11 UPHILL SHEAR PILES - SEISMIC

MAR. 2019 JOB NO. 6192 FIG. 11

APPENDIX A

Field Explorations and Instrumentation Data

Table 1A: GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values), blows per ft
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-values), blows per ft	Torvane or Undrained Shear Strength, tsf
Very Soft	0 - 2	less than 0.125
Soft	2 - 4	0.125 - 0.25
Medium Stiff	4 - 8	0.25 - 0.50
Stiff	8 - 15	0.50 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	over 30	over 2.0

Grain-Size Classification

Boulders:
- $>$12 in.

Cobbles:
- 3 - 12 in.

Gravel:
- $^{1}/_{4}$ - $^{3}/_{4}$ in. (fine)
- $^{3}/_{4}$ - 3 in. (coarse)

Sand:
- No. 200 - No. 40 sieve (fine)
- No. 40 - No. 10 sieve (medium)
- No. 10 - No. 4 sieve (coarse)

Silt/Clay:
- pass No. 200 sieve

Modifier for Subclassification

	Primary Constituent SAND or GRAVEL	Primary Constituent SILT or CLAY
Adjective	Percentage of Other Material (by weight)	
trace:	5 - 15 (sand, gravel)	5 - 15 (sand, gravel)
some:	15 - 30 (sand, gravel)	15 - 30 (sand, gravel)
sandy, gravelly:	30 - 50 (sand, gravel)	30 - 50 (sand, gravel)
trace:	$<$5 (silt, clay)	*Relationship of clay and silt determined by plasticity index test*
some:	5 - 12 (silt, clay)	
silty, clayey:	12 - 50 (silt, clay)	

Table 2A: GUIDELINES FOR CLASSIFICATION OF ROCK

RELATIVE ROCK WEATHERING SCALE

Term	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 discoloration in rock fabric. Decomposition extends up to 1 in. 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 Decomposed	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.

RELATIVE ROCK HARDNESS SCALE

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife and scratched with fingernail.	100 - 1,000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1,000 - 4,000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4,000 - 8,000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8,000 - 16,000 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.	> 16,000 psi

RQD AND ROCK QUALITY

Relation of RQD and Rock Quality

RQD (Rock Quality Designation), %	Description of Rock Quality
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

Terminology for Planar Surface

Bedding	Joints and Fractures	Spacing
Laminated	Very Close	< 2 in.
Thin	Close	2 in. – 12 in.
Medium	Moderately Close	12 in. – 36 in.
Thick	Wide	36 in. – 10 ft
Massive	Very Wide	> 10 ft

Table 3A

SUMMARY OF LABORATORY RESULTS

Sample Information						Atterberg Limits			
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	Soil Type
B-1	S-1	2.5	–	63	–	–	–	–	CLAY
	S-2	5.0	–	61	–	–	–	–	CLAY
	S-3	7.5	–	66	–	–	–	–	CLAY
	S-4	10.0	–	70	–	–	–	–	CLAY
	S-6	15.0	–	95	–	–	–	–	CLAY
	S-7	17.5	–	75	–	–	–	–	CLAY
	S-8	20.0	–	49	–	–	–	–	CLAY
	S-9	22.5	–	65	–	–	–	–	CLAY
	S-10	25.0	–	72	–	–	–	–	CLAY
	S-12	30.0	–	49	–	–	–	–	CLAY
	S-13	32.5	–	53	–	–	–	–	CLAY
	S-14	35.0	–	52	–	–	–	–	CLAY
	S-15	37.5	–	42	–	–	–	–	CLAY
B-2	S-1	2.0	–	67	–	–	–	–	CLAY
	S-2	4.5	–	61	–	–	–	–	CLAY
	S-3	9.5	–	58	–	–	–	–	CLAY
	S-4	11.5	–	49	–	–	–	–	CLAY
	S-5	14.5	–	60	–	–	–	–	CLAY
	S-6	19.5	–	128	–	–	–	–	WOOD DEBRIS
	S-7	29.0	–	81	–	–	–	–	CLAY
	S-8	39.0	–	60	–	–	–	–	CLAY
	S-9	49.0	–	42	–	–	–	–	CLAY
B-3	S-1	5.0	–	24	–	–	–	–	CLAY
	S-2	10.0	–	47	–	–	–	–	CLAY
	S-3	15.0	–	46	–	–	–	–	CLAY
	S-5	23.0	–	37	–	–	–	–	CLAY
	S-6	25.0	–	65	–	–	–	–	CLAY
	S-7	30.0	–	55	–	–	–	–	CLAY

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
▩	FILL
⁂	GRAVEL; clean to some silt, clay, and sand
⁂	Sandy GRAVEL; clean to some silt and clay
⁂	Silty GRAVEL; up to some clay and sand
⁂	Clayey GRAVEL; up to some silt and sand
⬚	SAND; clean to some silt, clay, and gravel
⬚	Gravelly SAND; clean to some silt and clay
▥	Silty SAND; up to some clay and gravel
▧	Clayey SAND; up to some silt and gravel
▥	SILT; up to some clay, sand, and gravel
▥	Gravelly SILT; up to some clay and sand
▥	Sandy SILT; up to some clay and gravel
▥	Clayey SILT; up to some sand and gravel
▧	CLAY; up to some silt, sand, and gravel
▧	Gravelly CLAY; up to some silt and sand
▧	Sandy CLAY; up to some silt and gravel
▧	Silty CLAY; up to some sand and gravel
▧	CLAY with heavy wood debris
⬚	WOOD DEBRIS

BEDROCK SYMBOLS

Symbol	Typical Description
⊞	BASALT
▤	MUDSTONE
▤	SILTSTONE
▤	SANDSTONE

SURFACE MATERIAL SYMBOLS

Symbol	Typical Description
■	Asphalt concrete PAVEMENT
■	Portland cement concrete PAVEMENT
⁂	Crushed rock BASE COURSE

SAMPLER SYMBOLS

Symbol	Sampler Description
I	2.0-in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
▮	Shelby tube sampler with recovery (ASTM D1587)
▮	3.0-in. O.D. split-spoon sampler with recovery (ASTM D3550)
⊠	Grab Sample
▯	Rock core sample interval
▮	Sonic core sample interval
░	Geoprobe sample interval

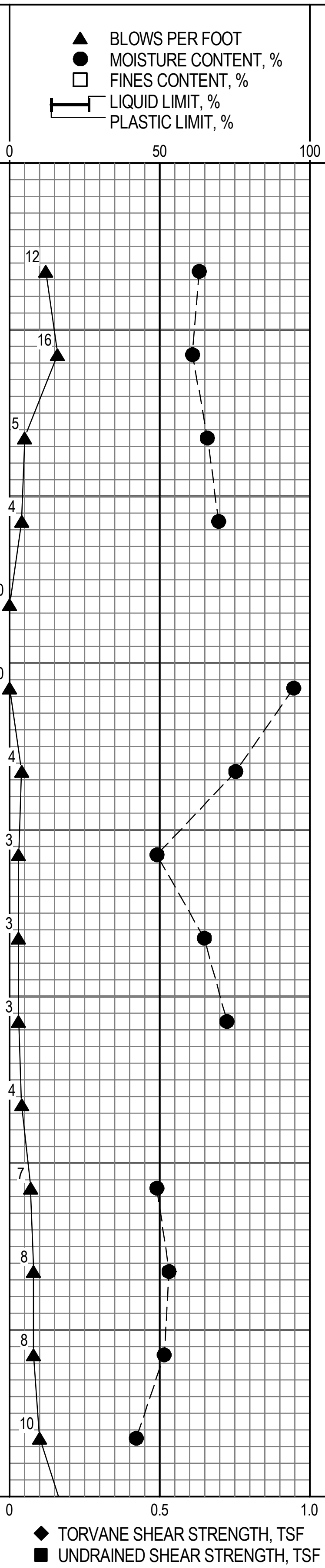
INSTALLATION SYMBOLS

Symbol	Symbol Description
▥	Flush-mount monument set in concrete
▥	Concrete, well casing shown where applicable
▨	Bentonite seal, well casing shown where applicable
⬚	Filter pack, machine-slotted well casing shown where applicable
▥	Grout, vibrating-wire transducer cable shown where applicable
Ⓟ	Vibrating-wire pressure transducer
▥	1-in.-diameter solid PVC
▥	1-in.-diameter hand-slotted PVC
▥	Grout, inclinometer casing shown where applicable

FIELD MEASUREMENTS

Symbol	Typical Description
▽	Groundwater level during drilling and date measured
▼	Groundwater level after drilling and date measured
▧	Rock core recovery (%)
▨	Rock quality designation (RQD, %)

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL Surface Elevation: Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		CLAY, some silt to silty, trace to some fine- to medium-grained sand, brown mottled orange and gray, medium stiff to stiff, contains organics (Coastal Marine Terrace/Landslide Debris)			S-1		3 4 8	
5					S-2		3 6 10	
					S-3		1 2 3	
10					S-4		1 2 2	
		---dark brown mottled orange and gray, very soft to soft below 12.5 ft, contains wood debris between depths of 12.5 to 15 ft			S-5		0 0 0	
15					S-6		0 0 0	
		---soft to medium stiff below 17.5 ft			S-7		1 2 2	
20		---contains fossilized worm burrows at 20 ft, gray below 20 ft			S-8		1 1 2	
					S-9		0 2 1	
25		---contains trace medium-grained-sand- to gravel-sized fragments of decomposed SILTSTONE below 25 ft			S-10		0 1 2	
		---dark brown mottled gray and orange below 27.5 ft, contains wood debris with coniferous tree needles between depths of 27.5 to 30 ft			S-11		1 2 2	
30		---medium stiff to stiff below 30 ft			S-12		1 3 4	
					S-13		2 3 5	
35		---chaotic structure below 36 ft			S-14		3 3 5	
					S-15		2 4 6	
40								



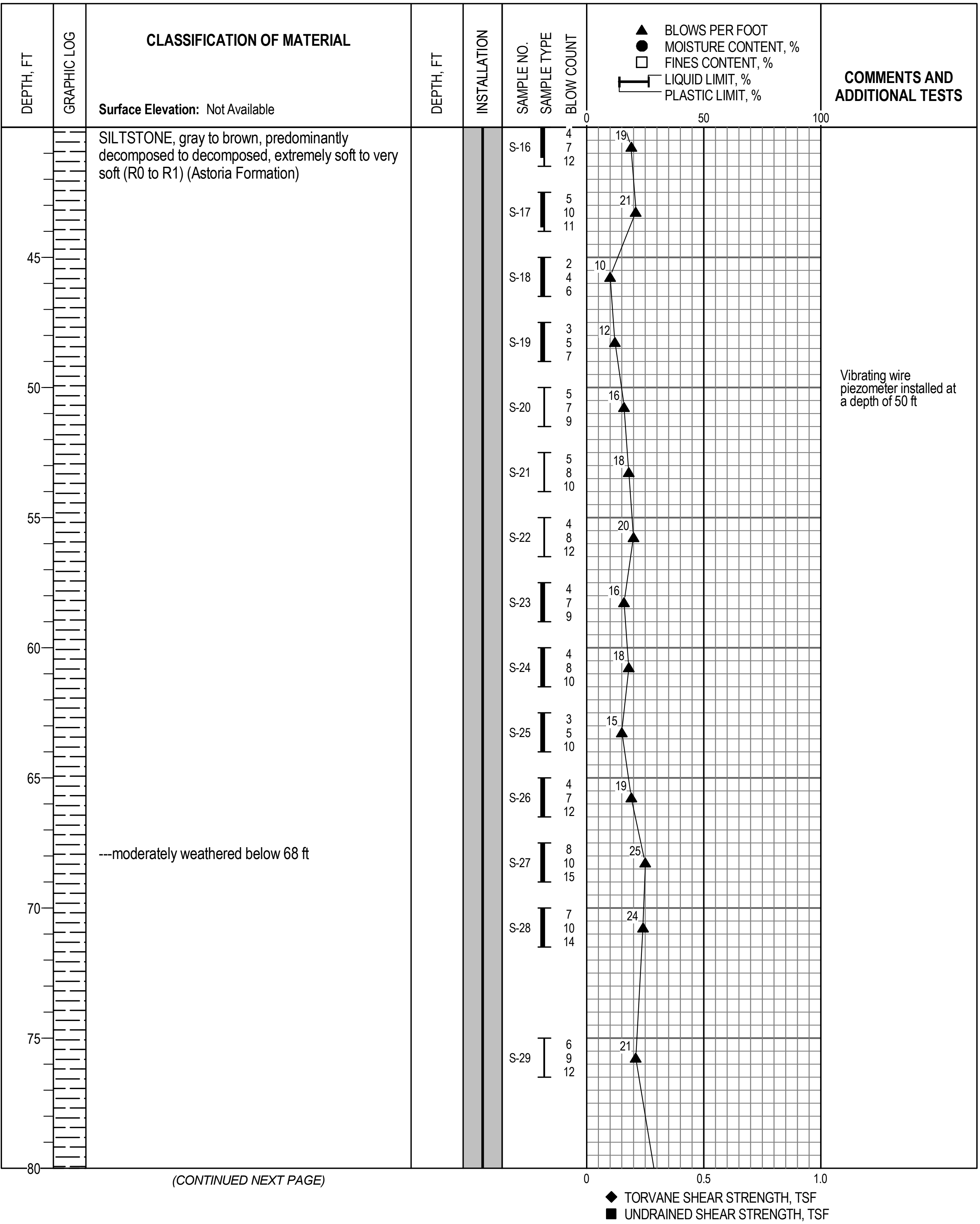
(CONTINUED NEXT PAGE)

Logged By: M. Rauthause	**Drilled by:** Holt Services, Inc.
Date Started: 12/7/18	**GPS Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** CME 850 Track-Mounted Drill Rig **Hole Diameter:** 4 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:**
Note: See Legend for Explanation of Symbols	

GRI

BORING B-1

MAR. 2019 JOB NO. 6192 FIG. 1A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

SILTSTONE, gray to brown, predominantly decomposed to decomposed, extremely soft to very soft (R0 to R1) (Astoria Formation)

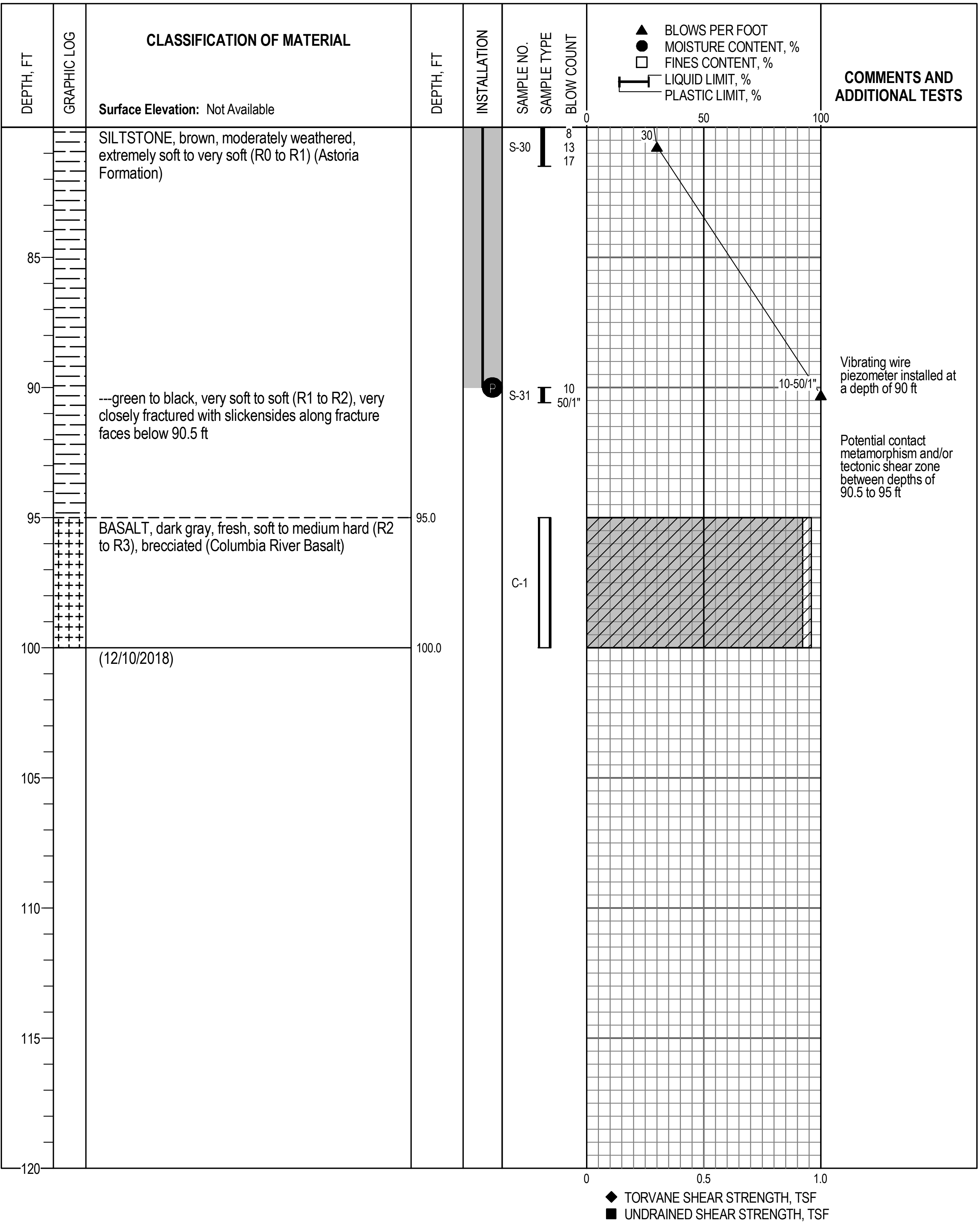
---moderately weathered below 68 ft

SAMPLE NO.	BLOW COUNT	BLOWS PER FOOT
S-16	4 7 12	19
S-17	5 10 11	21
S-18	2 4 6	10
S-19	3 5 7	12
S-20	5 7 9	16
S-21	5 8 10	18
S-22	4 8 12	20
S-23	4 7 9	16
S-24	4 8 10	18
S-25	3 5 10	15
S-26	4 7 12	19
S-27	8 10 15	25
S-28	7 10 14	24
S-29	6 9 12	21

COMMENTS AND ADDITIONAL TESTS

Vibrating wire piezometer installed at a depth of 50 ft

(CONTINUED NEXT PAGE)



Surface Elevation: Not Available

SILTSTONE, brown, moderately weathered, extremely soft to very soft (R0 to R1) (Astoria Formation)

---green to black, very soft to soft (R1 to R2), very closely fractured with slickensides along fracture faces below 90.5 ft

BASALT, dark gray, fresh, soft to medium hard (R2 to R3), brecciated (Columbia River Basalt)

(12/10/2018)

Vibrating wire piezometer installed at a depth of 90 ft

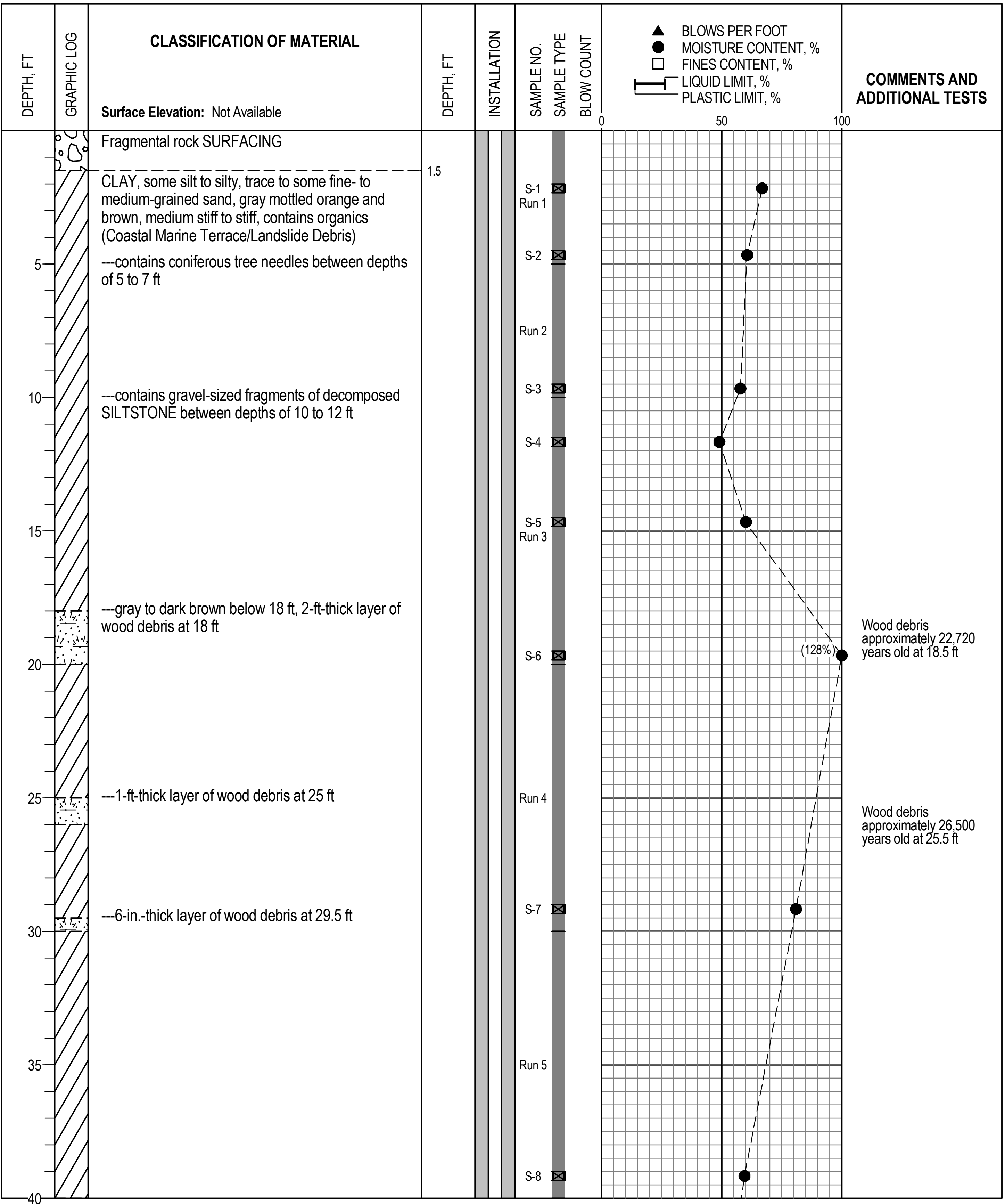
Potential contact metamorphism and/or tectonic shear zone between depths of 90.5 to 95 ft

GRI BORING LOG (GPS) - NO ELEV GRI DATA TEMPLATE.GDT 2/26/19

GRI

BORING B-1

MAR. 2019 JOB NO. 6192 FIG. 1A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

Fragmental rock SURFACING

CLAY, some silt to silty, trace to some fine- to medium-grained sand, gray mottled orange and brown, medium stiff to stiff, contains organics (Coastal Marine Terrace/Landslide Debris)

---contains coniferous tree needles between depths of 5 to 7 ft

---contains gravel-sized fragments of decomposed SILTSTONE between depths of 10 to 12 ft

---gray to dark brown below 18 ft, 2-ft-thick layer of wood debris at 18 ft

---1-ft-thick layer of wood debris at 25 ft

---6-in.-thick layer of wood debris at 29.5 ft

COMMENTS AND ADDITIONAL TESTS

Wood debris approximately 22,720 years old at 18.5 ft

Wood debris approximately 26,500 years old at 25.5 ft

(CONTINUED NEXT PAGE)

◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: N. Utevsky	**Drilled by:** Yellow Jacket Drilling Services
Date Started: 12/3/18	**GPS Coordinates:** Not Available

Drilling Method: Roto Sonic
Equipment: Terre Sonic 150
Hole Diameter: 7 in.
Note: See Legend for Explanation of Symbols

Hammer Type: Not Used
Weight:
Drop:
Energy Ratio:

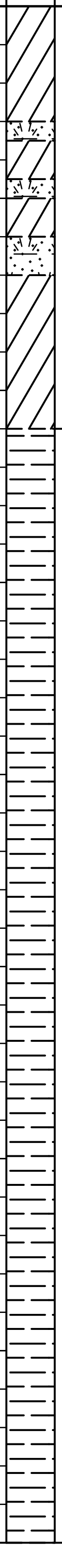
GRI

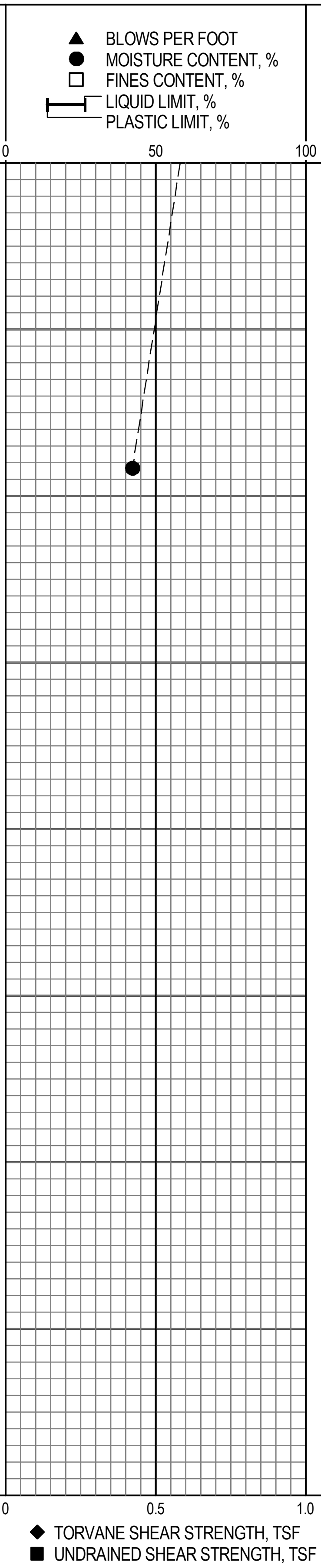
BORING B-2

MAR. 2019 JOB NO. 6192 FIG. 2A

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.	COMMENTS AND ADDITIONAL TESTS
	CLAY, some silt to silty, trace to some fine- to medium-grained sand, brown, medium stiff to stiff, contains organics; contains gravel- to cobble-sized fragments of moderately weathered to predominantly decomposed SILTSTONE and fresh to moderately weathered BASALT (Coastal Marine Deposits) ---6-in.-thick layer of wood debris at 43 ft ---6-in.-thick layer of wood debris at 44.5 ft ---1-ft-thick layer of wood debris at 46 ft, chaotic structure below 46 ft			
45			Run 6	
				Wood debris greater than 43,500 years old at 46.5 ft
			S-9	
50				Vibrating wire piezometer installed at a depth of 50 ft
	SILTSTONE, brown, predominantly decomposed to decomposed, extremely soft to very soft (R0 to R1), very closely fractured (Astoria Formation)	51.0		
55			Run 7	
			S-10	
60				
65			Run 8	
			S-11	
70				
	---gray mottled white, moderately weathered below 73 ft			
75			Run 9	
			S-12	
80				





(CONTINUED NEXT PAGE)

GRI

BORING B-2

MAR. 2019 JOB NO. 6192 FIG. 2A

Surface Elevation: Not Available

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		SILTSTONE, gray mottled white, moderately weathered, extremely soft to very soft (R0 to R1) (Astoria Formation)			Run 10			
		---green to black, very soft to medium hard (R1 to R3), very closely fractured with slickensides along fracture faces below 84 ft			S-13 S-14	☒ ☒		
85								
					Run 11 S-15	☒		Potential contact metamorphism and/or tectonic shear zone between depths of 84 to 90 ft
90		BASALT, dark gray, fresh to slightly weathered, medium hard to hard (R3 to R4), closely to very closely fractured with slickensides along fracture faces (Columbia River Basalt)	90.0	P				Vibrating wire piezometer installed at a depth of 90 ft
95					Run 12			
					S-16	☒		
100								
105					Run 13			
					S-17	☒		
110								
115					Run 14			
					S-18	☒		
120								

▲ BLOWS PER FOOT
● MOISTURE CONTENT, %
☐ FINES CONTENT, %
LIQUID LIMIT, %
PLASTIC LIMIT, %
0 50 100

(CONTINUED NEXT PAGE)

0 0.5 1.0
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

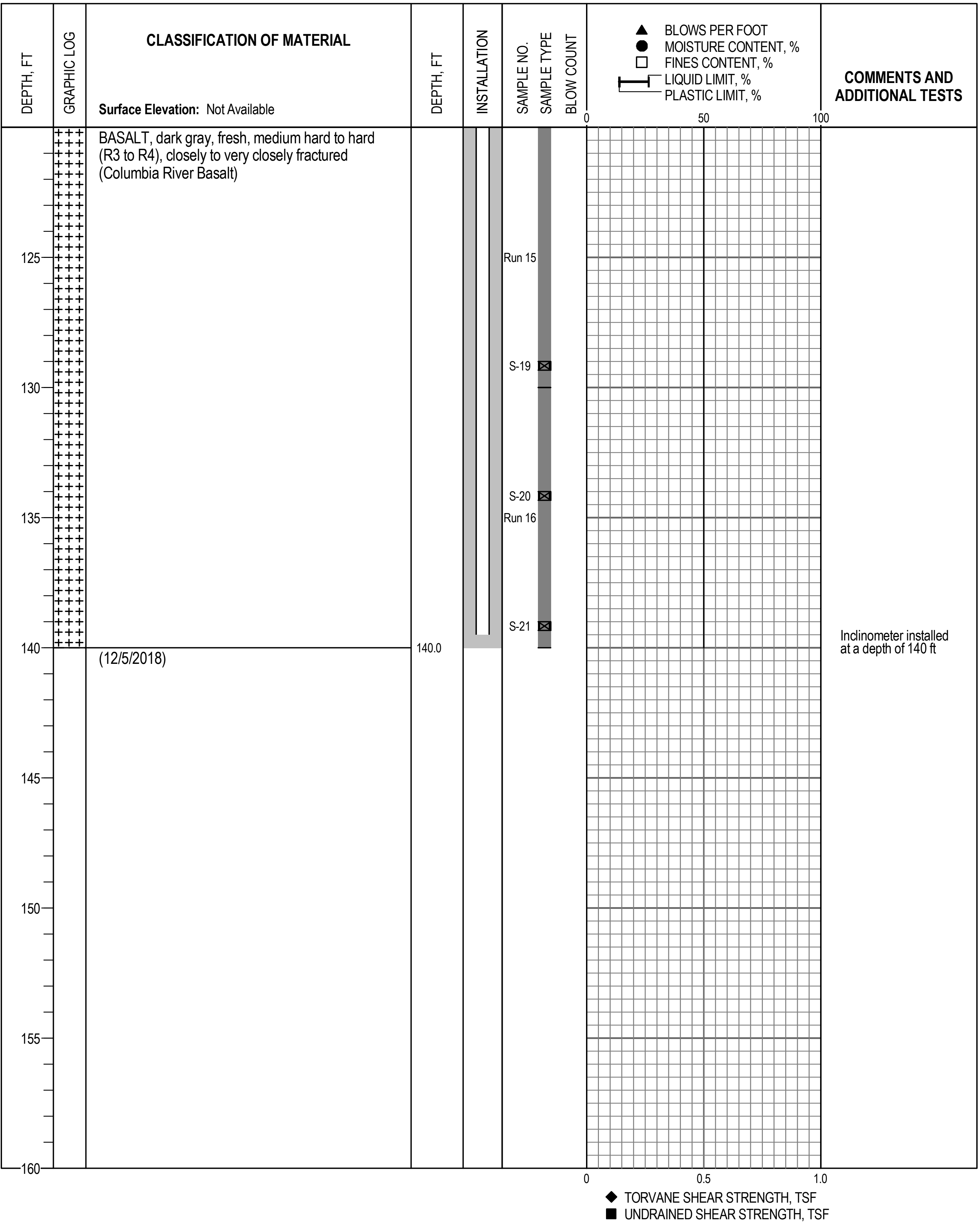
GRI

BORING B-2

MAR. 2019 JOB NO. 6192 FIG. 2A

CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available



BASALT, dark gray, fresh, medium hard to hard (R3 to R4), closely to very closely fractured (Columbia River Basalt)

(12/5/2018)

COMMENTS AND ADDITIONAL TESTS

Inclinometer installed at a depth of 140 ft

GRI

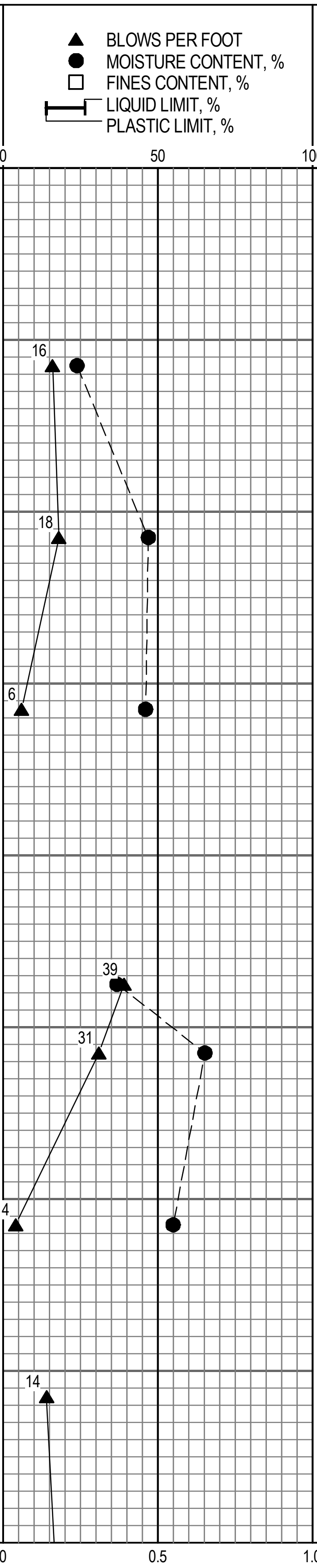
BORING B-2

MAR. 2019 JOB NO. 6192 FIG. 2A

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL
0	Fragmental rock SURFACING
1.5	CLAY, some silt to silty, trace to some fine- to coarse-grained sand, gray mottled orange and brown, stiff to very stiff, contains organics (Coastal Marine Terrace/Landslide Debris) ---contains gravel-sized fragments of decomposed SILTSTONE between depths of 5 to 11.5 ft ---contains gravel- to cobble-sized fragments of fresh to moderately weathered BASALT below 23 ft ---dark gray, soft to medium stiff, chaotic structure below 30 ft
33.0	SILTSTONE, dark brown, predominantly decomposed to decomposed, extremely soft (R0) (Astoria Formation)

SAMPLE NO.	BLOW COUNT	BLOWS PER FOOT
S-1	4 9 7	16
S-2	6 8 10	18
S-3	2 3 3	6
S-4		
S-5	16 20 19	39
S-6	15 13 18	31
S-7	1 1 3	4
S-8		
S-9	3 6 8	14



◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

COMMENTS AND ADDITIONAL TESTS

(CONTINUED NEXT PAGE)

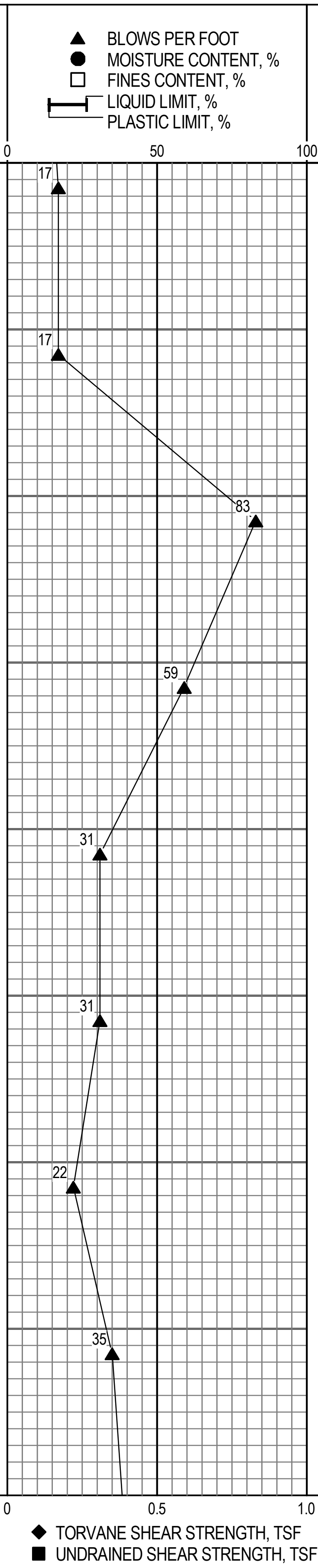
Logged By: M. Rauthause
Drilled by: Holt Services, Inc.
Date Started: 12/3/18
GPS Coordinates: Not Available
Drilling Method: Mud Rotary
Equipment: CME 850 Track-Mounted Drill Rig
Hole Diameter: 5 in.
Hammer Type: Auto Hammer
Weight: 140 lb
Drop: 30 in.
Energy Ratio:
Note: See Legend for Explanation of Symbols

GRI

BORING B-3

MAR. 2019 JOB NO. 6192 FIG. 3A

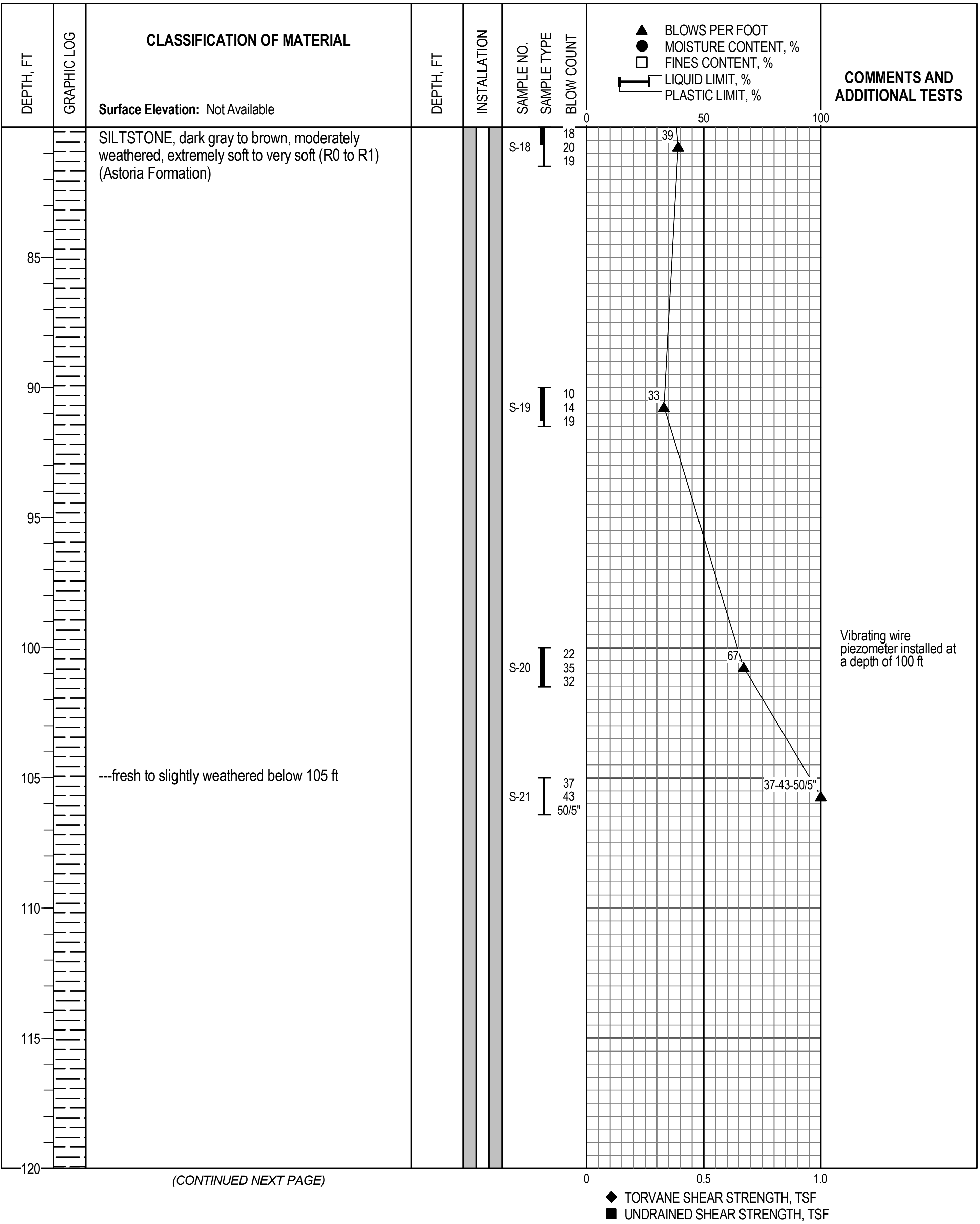
DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		SILTSTONE, dark brown, predominantly decomposed to decomposed, extremely soft (R0) (Astoria Formation)			S-10		5 8 9	
45					S-11		3 7 10	
50		---moderately weathered, extremely soft to very soft (R0 to R1) below 50 ft			S-12		30 50 33	
55					S-13		15 24 35	
60					S-14		7 12 19	
65					S-15		6 12 19	
70					S-16		4 7 15	
75					S-17		11 21 14	
80								



(CONTINUED NEXT PAGE)

BORING B-3

MAR. 2019 JOB NO. 6192 FIG. 3A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

SILTSTONE, dark gray to brown, moderately weathered, extremely soft to very soft (R0 to R1) (Astoria Formation)

---fresh to slightly weathered below 105 ft

SAMPLE NO.	BLOW COUNT
S-18	18 20 19
S-19	10 14 19
S-20	22 35 32
S-21	37 43 50/5"

COMMENTS AND ADDITIONAL TESTS

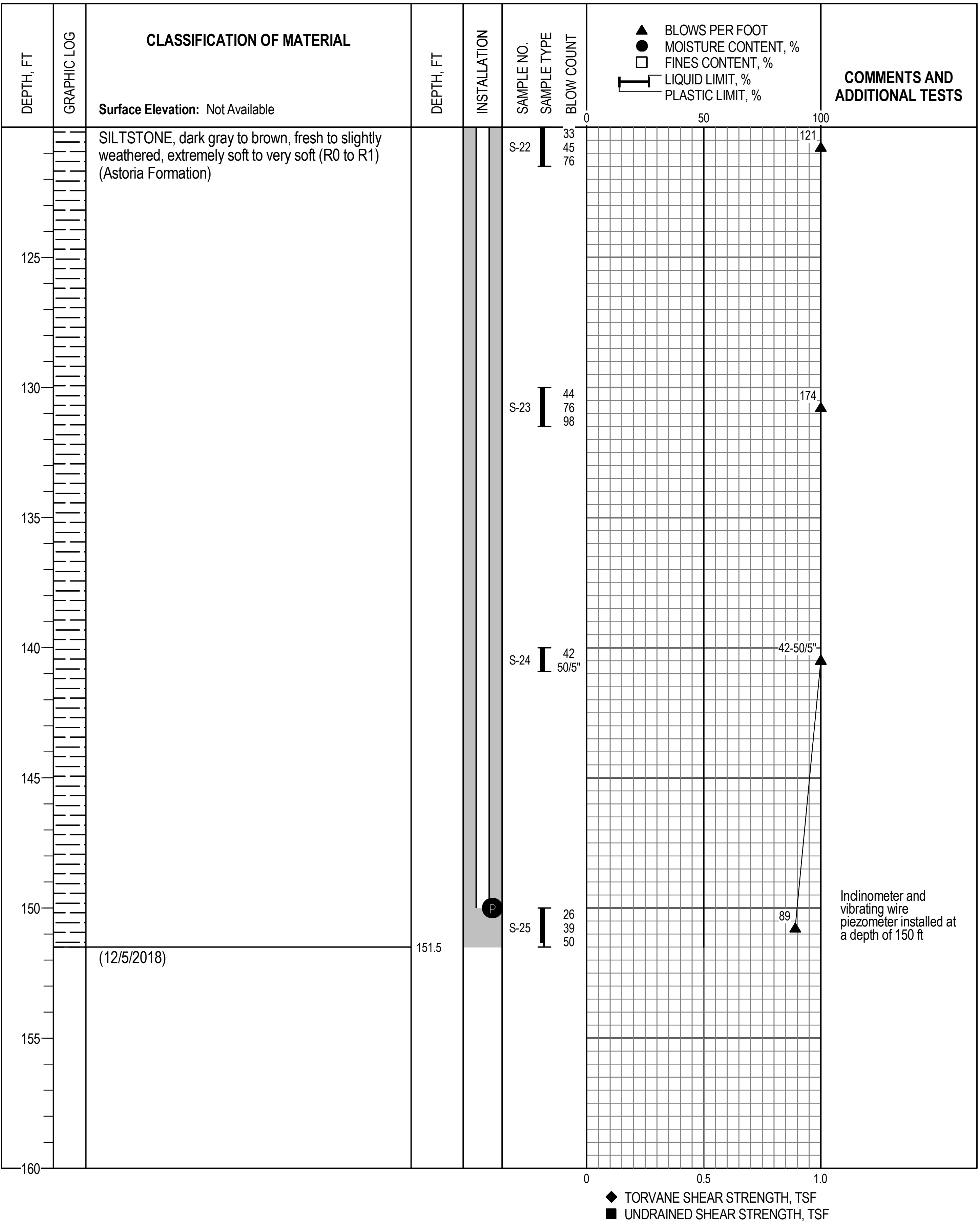
Vibrating wire piezometer installed at a depth of 100 ft

(CONTINUED NEXT PAGE)

GRI

BORING B-3

MAR. 2019 JOB NO. 6192 FIG. 3A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

SILTSTONE, dark gray to brown, fresh to slightly weathered, extremely soft to very soft (R0 to R1) (Astoria Formation)

(12/5/2018)

SAMPLE NO.	BLOW COUNT
S-22	33 45 76
S-23	44 76 98
S-24	42 50/5"
S-25	26 39 50

COMMENTS AND ADDITIONAL TESTS

Inclinometer and vibrating wire piezometer installed at a depth of 150 ft

GRI BORING LOG (GPS) - NO ELEV GRI DATA TEMPLATE.GDT 2/26/19

GRI

BORING B-3

MAR. 2019 JOB NO. 6192 FIG. 3A

BORING B-1: 95 - 100 FT

ROCK CORE PHOTOGRAPH

MAR. 2019 JOB NO. 6192 FIG. 4A

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

CORE PHOTOGRAPHS

(BORING B-2)

MAR. 2019 JOB NO. 6192 FIG. 5A

GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

CORE PHOTOGRAPHS

(BORING B-2, CONTINUED)

MAR. 2019 JOB NO. 6192 FIG. 6A

GRI
CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

CORE PHOTOGRAPHS

(BORING B-2, CONTINUED)

MAR. 2019 JOB NO. 6192 FIG. 7A


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 7
DEPTH 59-60ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 60-61.5ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 61.5-63ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 63-64ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 64-65.5ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 65.5-67ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 67-68ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 68-69.5ft


PROJECT 6192
DATE 12/3/18
BORING B-2
RUN 8
DEPTH 69.5-70ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 9
DEPTH 70-70.5ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 9
DEPTH 70.5-72ft

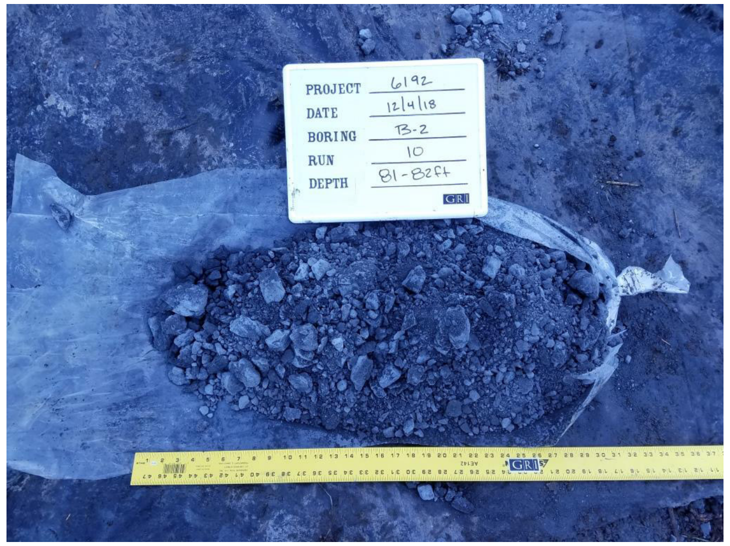

PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 9
DEPTH 72-73ft

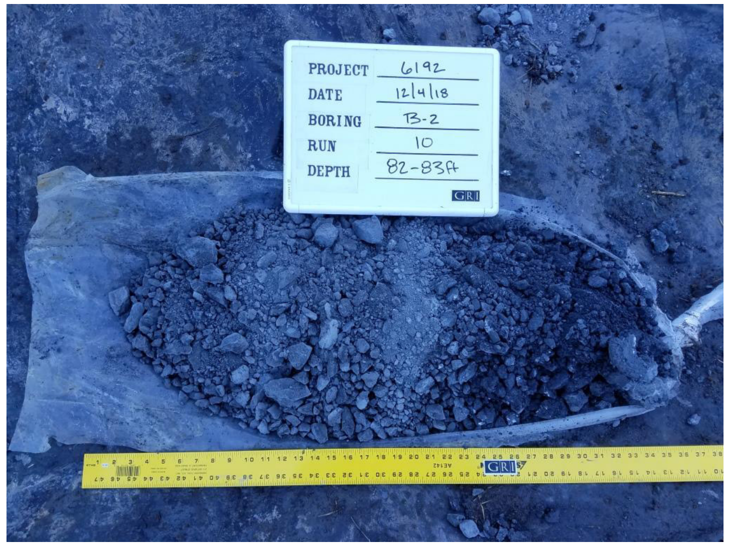
GRI
CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

CORE PHOTOGRAPHS

(BORING B-2, CONTINUED)

MAR. 2019 JOB NO. 6192 FIG. 8A





GRI

CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

CORE PHOTOGRAPHS

(BORING B-2, CONTINUED)

MAR. 2019 JOB NO. 6192 FIG. 9A


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 11
DEPTH 88-90ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 12
DEPTH 90-91ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 12
DEPTH 91-94ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 12
DEPTH 94-96ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 12
DEPTH 96-98.5ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 12
DEPTH 98.5-100ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 13
DEPTH 100-103ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 13
DEPTH 103-106ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 13
DEPTH 106-107ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 13
DEPTH 107-110ft

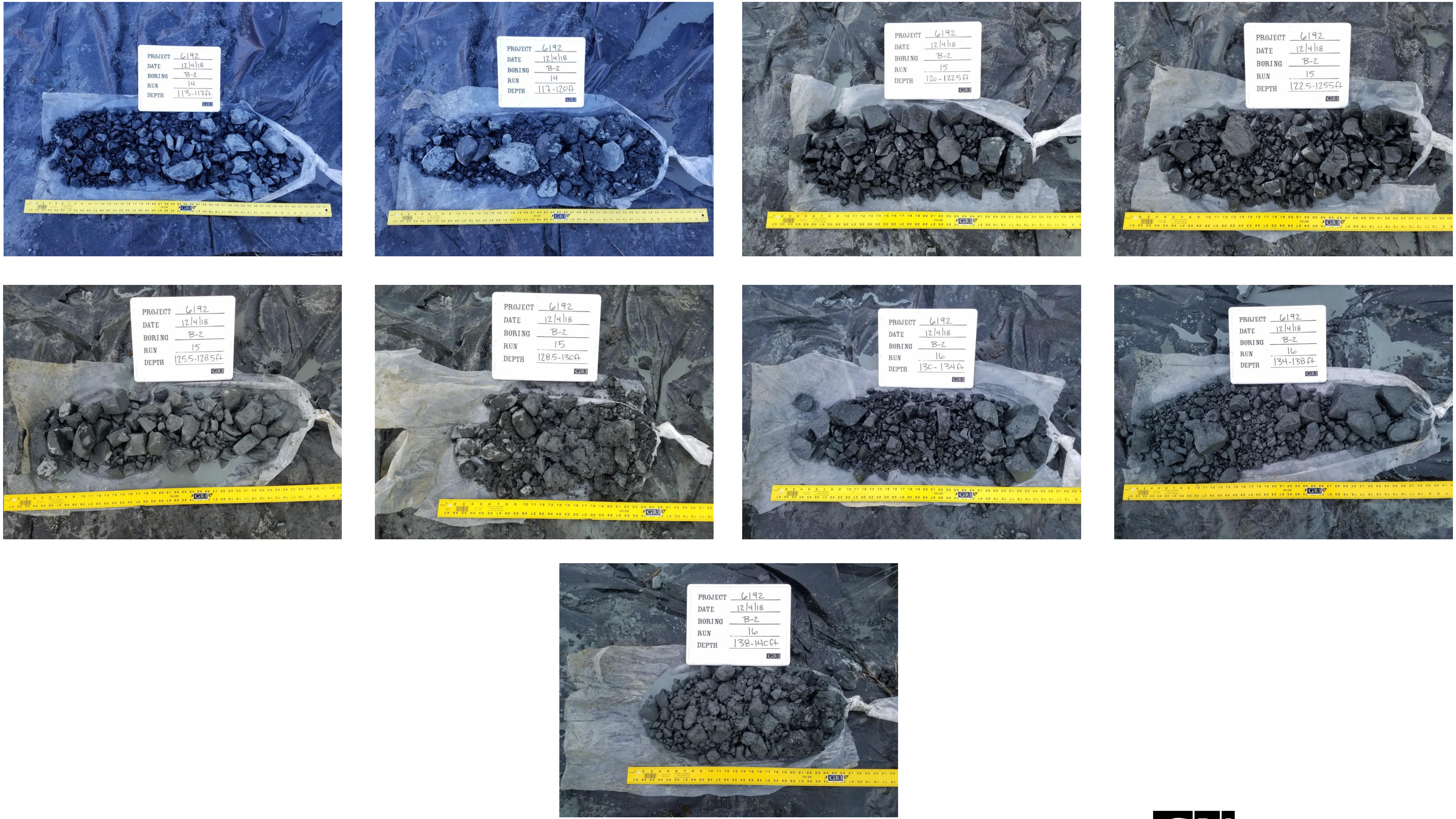

PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 14
DEPTH 110-112ft


PROJECT 6192
DATE 12/4/18
BORING B-2
RUN 14
DEPTH 112-113ft

GRI
CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

CORE PHOTOGRAPHS
(BORING B-2, CONTINUED)

MAR. 2019 JOB NO. 6192 FIG. 10A



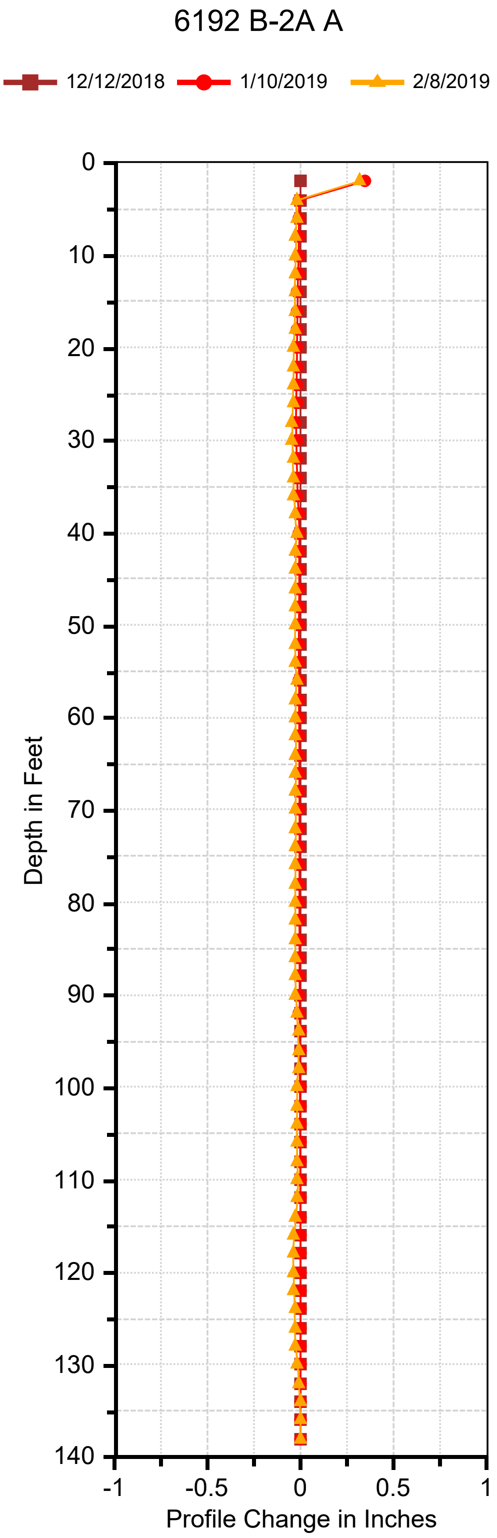
GRI

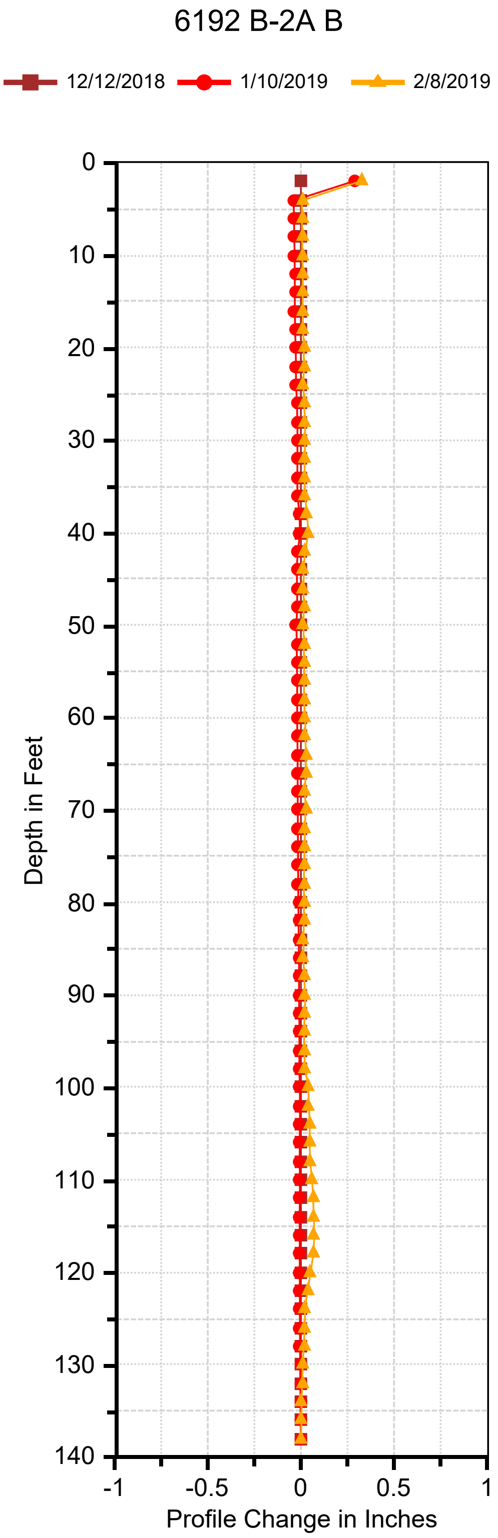
CITY OF CANNON BEACH
NEW CANNON BEACH CITY HALL, SOUTH WIND SITE

CORE PHOTOGRAPHS

(BORING B-2, CONTINUED)

MAR. 2019 JOB NO. 6192 FIG. 11A

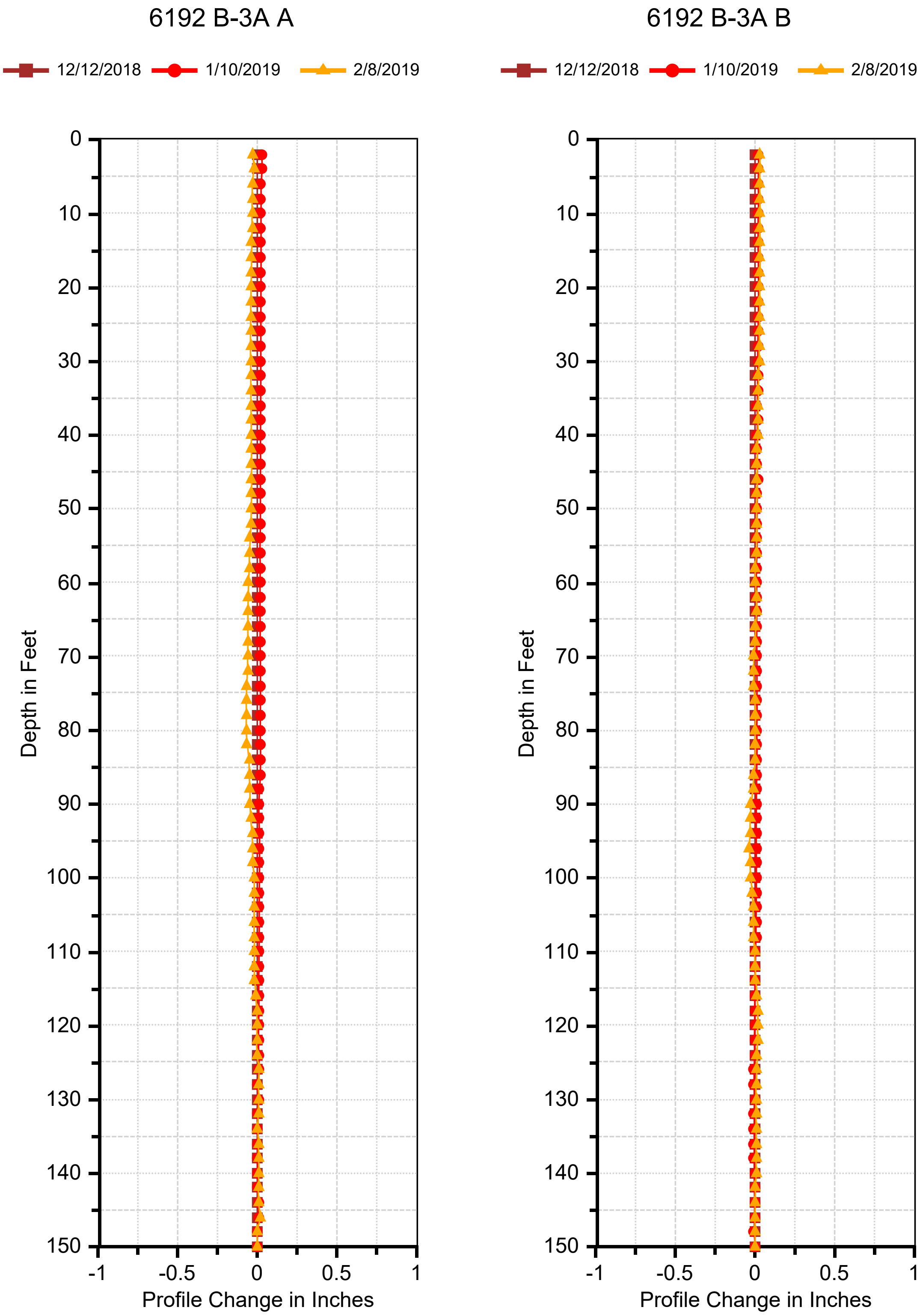




GRI

INCLINOMETER SUMMARY
BORING B-2

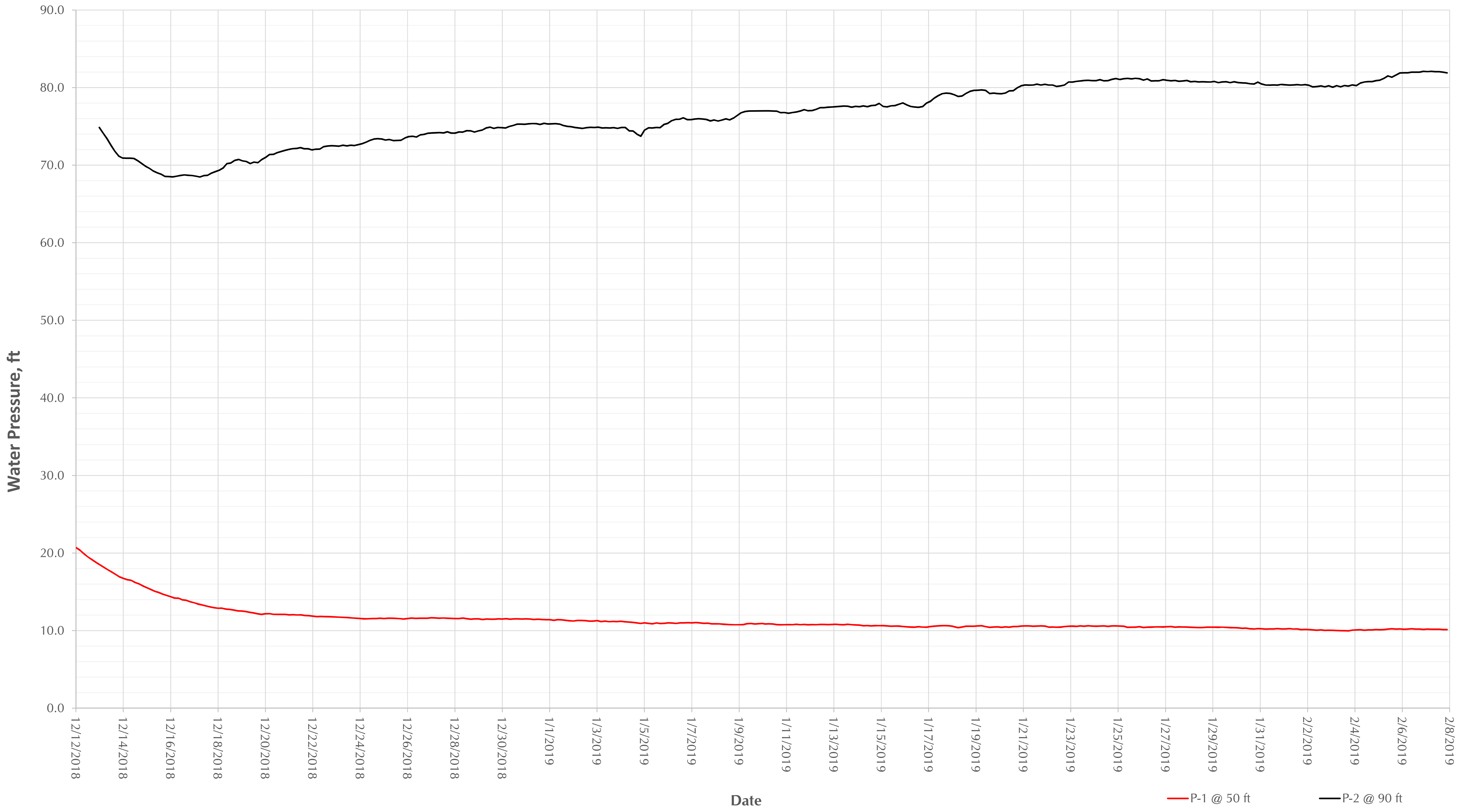
MAR. 2019 JOB NO. 6192 FIG. 12A



GRI

INCLINOMETER SUMMARY
BORING B-3

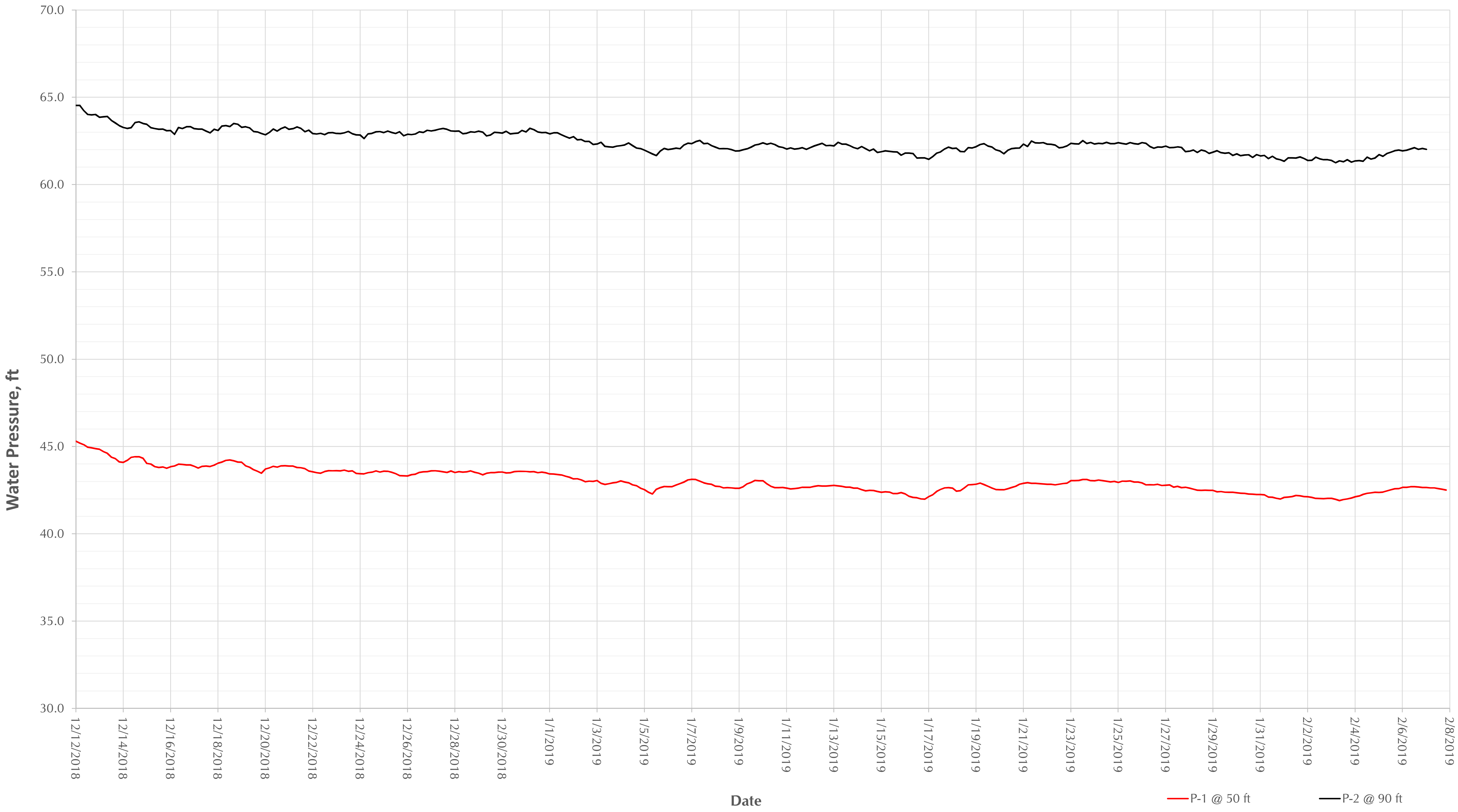
MAR. 2019 JOB NO. 6192 FIG. 13A



GRI

PIEZOMETER SUMMARY
BORING B-1

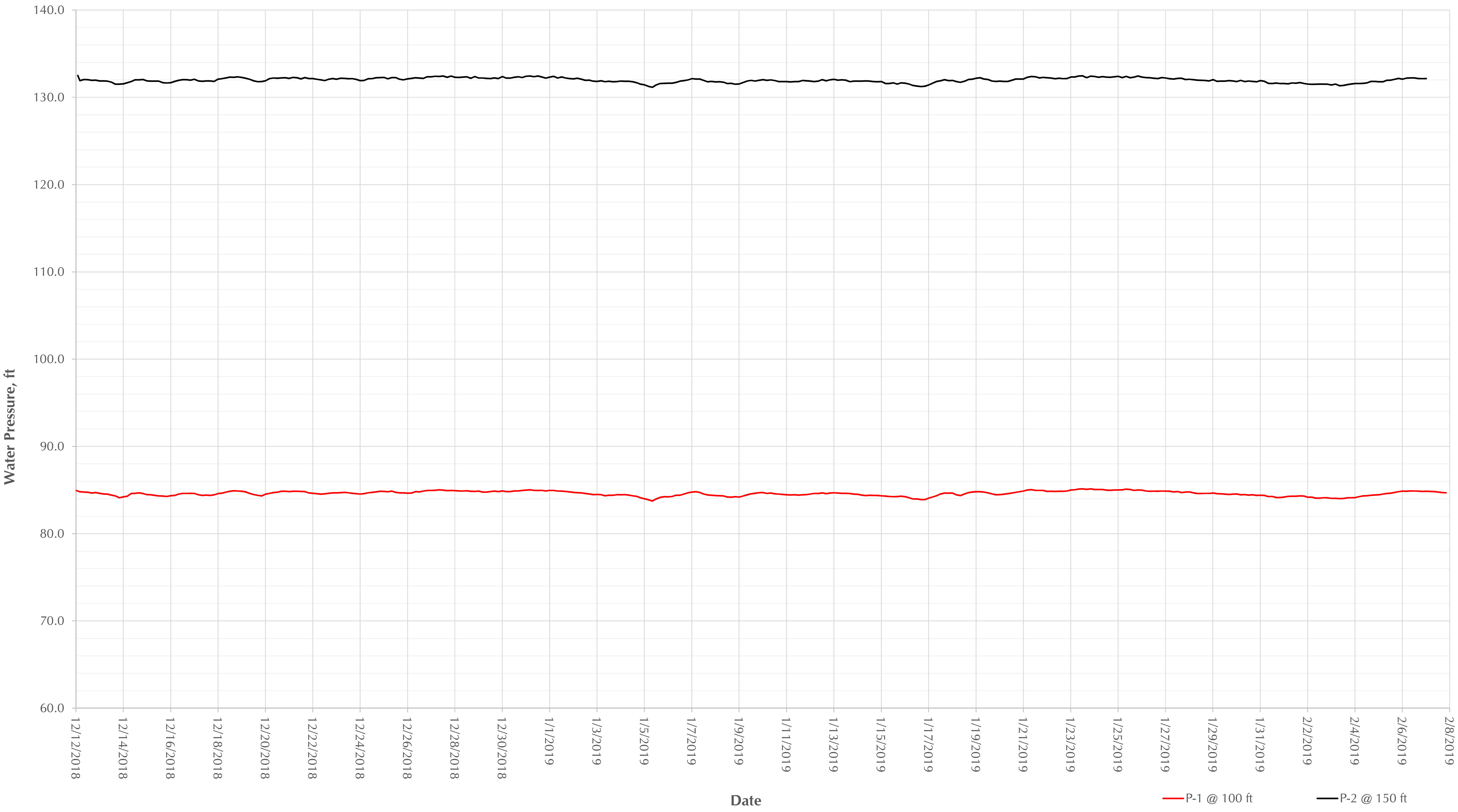
MAR. 2019 JOB NO. 6192 FIG. 14A



GRI

PIEZOMETER SUMMARY
BORING B-2

MAR. 2019 JOB NO. 6192 FIG. 15A



PIEZOMETER SUMMARY
BORING B-3

MAR. 2019 JOB NO. 6192 FIG. 16A

APPENDIX B

Conventional Radiocarbon Age Test Results

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2005-Accredited Testing Laboratory

December 21, 2018

Mr. Gregory Martin
GRI
9750 Nimbus Avenue
Beaverton, OR 97008
United States

RE: Radiocarbon Dating Results

Dear Mr. Martin,

Enclosed are the radiocarbon dating results for three samples recently sent to us. The report sheet contains the Conventional Radiocarbon Age (BP), the method used, material type, and applied pretreatments, any sample specific comments and, where applicable, the two-sigma calendar calibration range. The Conventional Radiocarbon ages have been corrected for total isotopic fractionation effects (natural and laboratory induced).

All results (excluding some inappropriate material types) which fall within the range of available calibration data are calibrated to calendar years (cal BC/AD) and calibrated radiocarbon years (cal BP). Calibration was calculated using one of the databases associated with the 2013 INTCAL program (cited in the references on the bottom of the calibration graph page provided for each sample.) Multiple probability ranges may appear in some cases, due to short-term variations in the atmospheric 14C contents at certain time periods. Looking closely at the calibration graph provided and where the BP sigma limits intercept the calibration curve will help you understand this phenomenon.

Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

All work on these samples was performed in our laboratories in Miami under strict chain of custody and quality control under ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 accreditation protocols. Sample, modern and blanks were all analyzed in the same chemistry lines by qualified professional technicians using identical reagents and counting parameters within our own particle accelerators. A quality assurance report is posted to your directory for each result.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Chris Patrick

Digital signature on file

Chris Patrick Director

REPORT OF RADIOCARBON DATING ANALYSES

Gregory Martin
GRI

Report Date: December 21, 2018
Material Received: December 10, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 512337	**S-5B-18.5**	**22720 +/- 80 BP**	IRMS δ13C: -25.9 o/oo

(95.4%) **25408 - 24781 cal BC** **(27357 - 26730 cal BP)**

Submitter Material: Woody Material
Pretreatment: (wood) acid/alkali/acid
Analyzed Material: Wood
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 5.91 +/- 0.06 pMC
Fraction Modern Carbon: 0.0591 +/- 0.0006
D14C: -940.89 +/- 0.59 o/oo
Δ14C: -941.37 +/- 0.59 o/oo(1950:2,018.00)
Measured Radiocarbon Age: (without d13C correction): 22740 +/- 80 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), “present” = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Beta Analytic
TESTING LABORATORY

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Gregory Martin	Report Date: December 21, 2018
GRI	Material Received: December 10, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 512338	**S-6B-25.5**	**26500 +/- 100 BP**	IRMS δ13C: -25.8 o/oo

(95.4%) **29055 - 28626 cal BC** **(31004 - 30575 cal BP)**

Submitter Material: Woody Material
Pretreatment: (wood) acid/alkali/acid
Analyzed Material: Wood
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 3.69 +/- 0.05 pMC
Fraction Modern Carbon: 0.0369 +/- 0.0005
D14C: -963.08 +/- 0.46 o/oo
∆14C: -963.38 +/- 0.46 o/oo(1950:2,018.00)
Measured Radiocarbon Age: (without d13C correction): 26510 +/- 100 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

REPORT OF RADIOCARBON DATING ANALYSES

Gregory Martin
GRI

Report Date: December 21, 2018
Material Received: December 10, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 512339	**S-8B-46.5**	**> 43500 BP**	IRMS δ13C: -25.4 o/oo

Submitter Material: Woody Material
Pretreatment: (wood) acid/alkali/acid
Analyzed Material: Wood
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: < 0.44 pMC
Fraction Modern Carbon: < 0.0044
D14C: < -995.5 o/oo
Δ14C: < -995.6 o/oo(1950:2,018.00)
Measured Radiocarbon Age: (without d13C correction): NA
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(highest probability ranges: INTCAL13)

(Variables: d13C = -25.9 o/oo)

Laboratory number **Beta-512337**

Conventional radiocarbon age **22720 ± 80 BP**

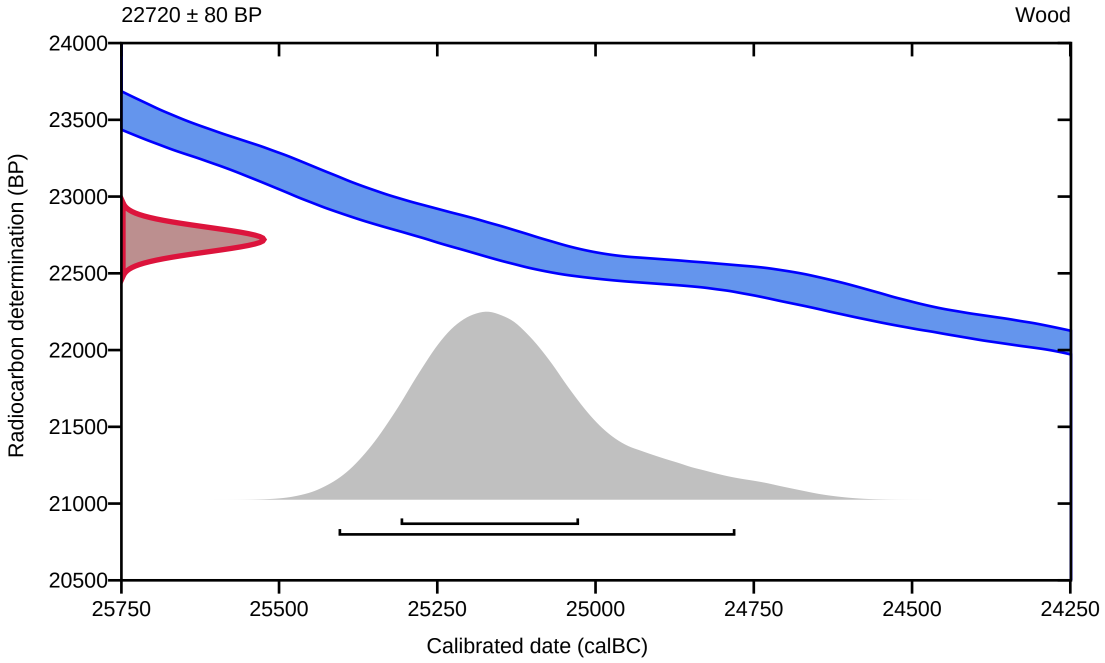
95.4% probability

(95.4%)	25408 - 24781 cal BC	(27357 - 26730 cal BP)

68.2% probability

(68.2%)	25310 - 25028 cal BC	(27259 - 26977 cal BP)

S-5B-18.5



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(highest probability ranges: INTCAL13)

(Variables: d13C = -25.8 o/oo)

Laboratory number **Beta-512338**

Conventional radiocarbon age **26500 ± 100 BP**

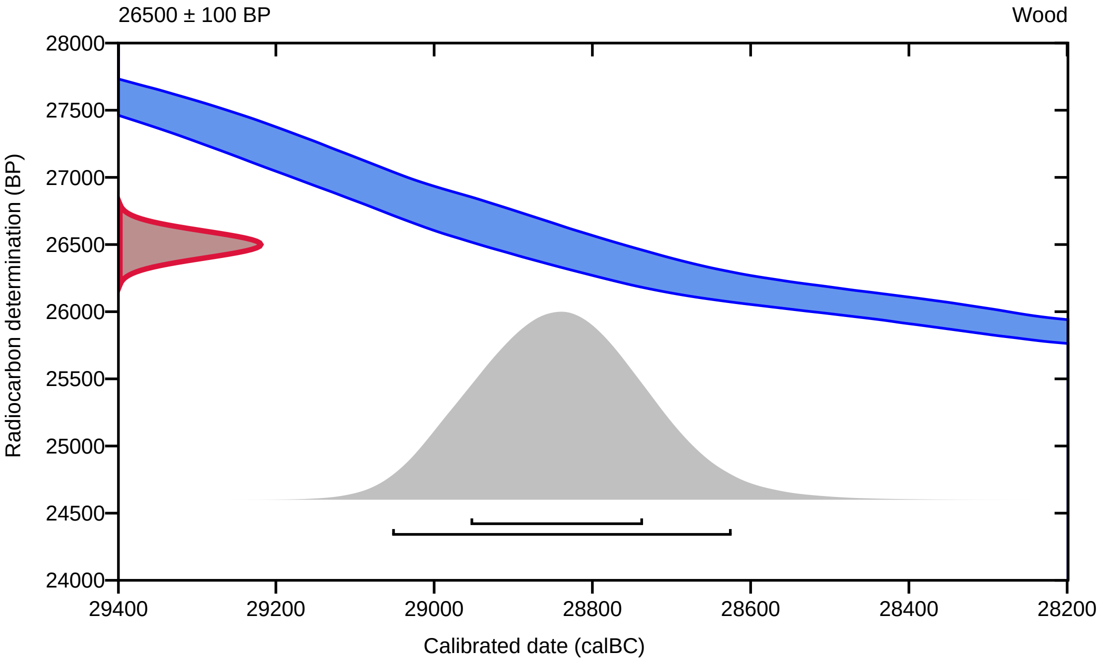
95.4% probability

(95.4%)	29055 - 28626 cal BC	(31004 - 30575 cal BP)

68.2% probability

(68.2%)	28956 - 28738 cal BC	(30905 - 30687 cal BP)

S-6B-25.5



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

APPENDIX C

Drained Residual Torsional Shear Strength Test Results

BENCHMARK GEOLABS

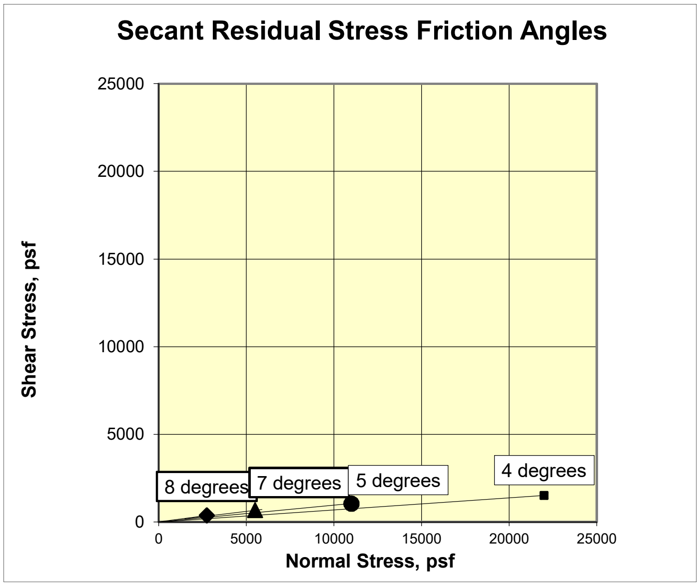
Drained Residual Torsional Shear Strength
(ASTM D6467)

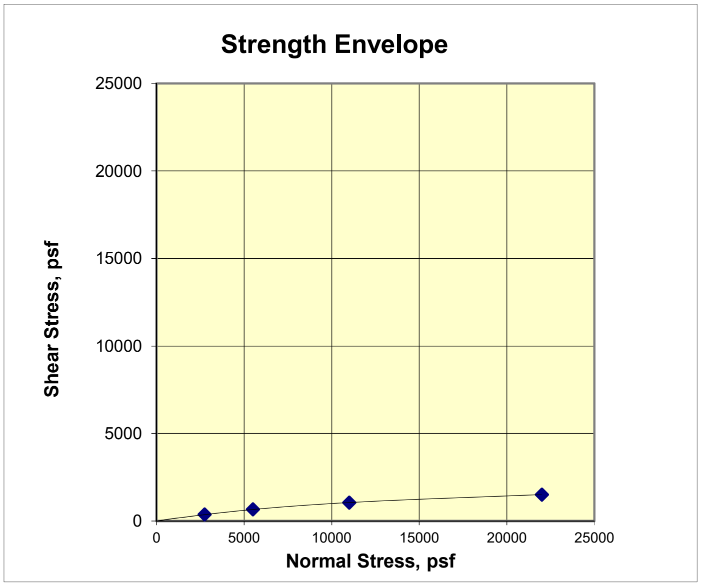
BGL Job No.:	028-016	**Boring:**	B-1	**Date:**	1/2/2019	**Clay, %:**	52.2
Client:	GRI	**Sample:**	S-18/S-19	**By:**	PJ	**LL:**	79.6
Project Name:	Cannon Beach	**Depth (ft):**	45-47.5	**Checked:**	PJ	**PL:**	30.3
Project Number:	6192	**Test Type:**	Reconstituted Residual			**Sample Preparation:**	<#40

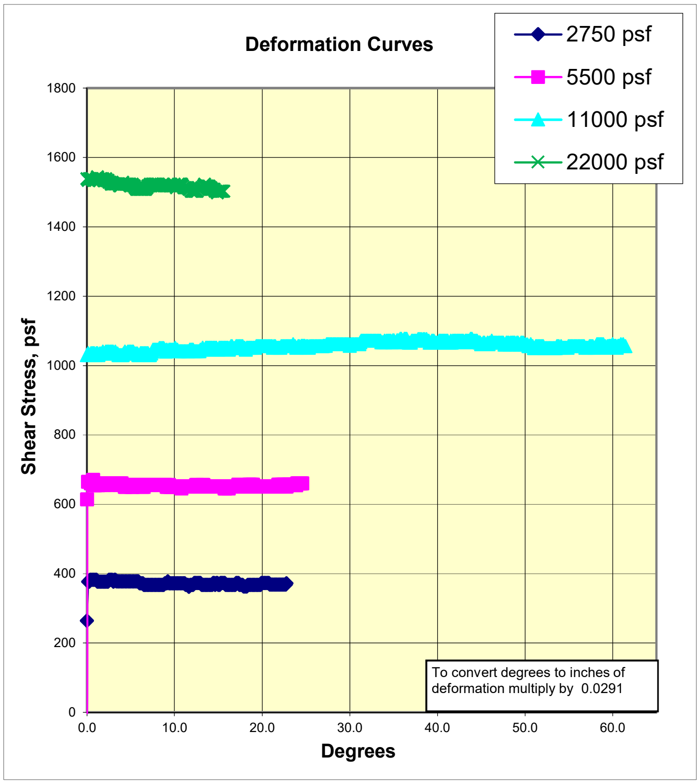
Soil Type: Dark Gray Fat CLAY

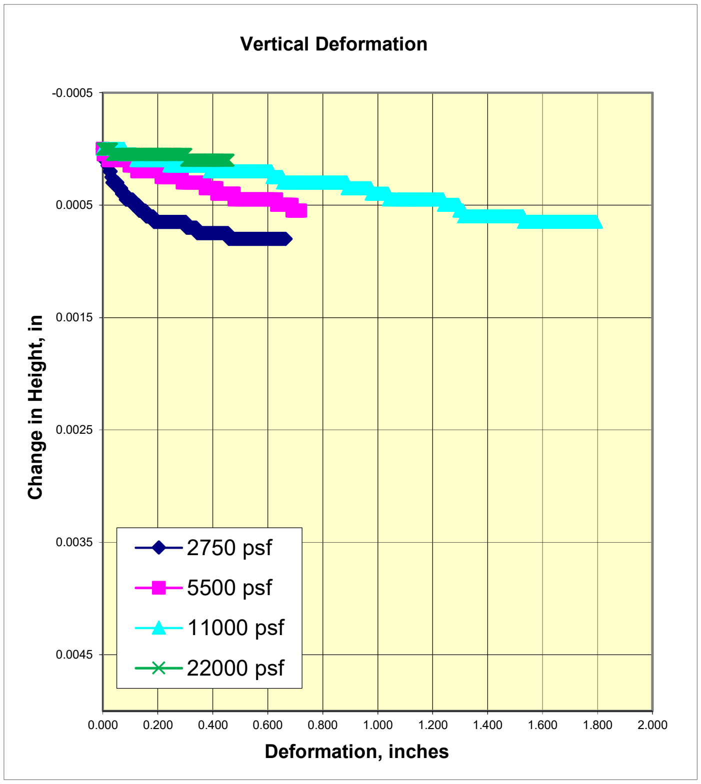
Normal Stress, psf	2750	5500	11000	22000
Secant Phi, deg.:	8	7	5	4

Remarks: A small friction correction was applied to each point. This material was extremely difficult to get into a residual condition without disturbing the shear plane. The shear strength of the 22 ksf point was still slowly dropping at the end of the test. The actual shear strength may be slightly lower than the reported value.


Secant Residual Stress Friction Angles


Strength Envelope


Deformation Curves


Vertical Deformation

BENCHMARK GEOLABS

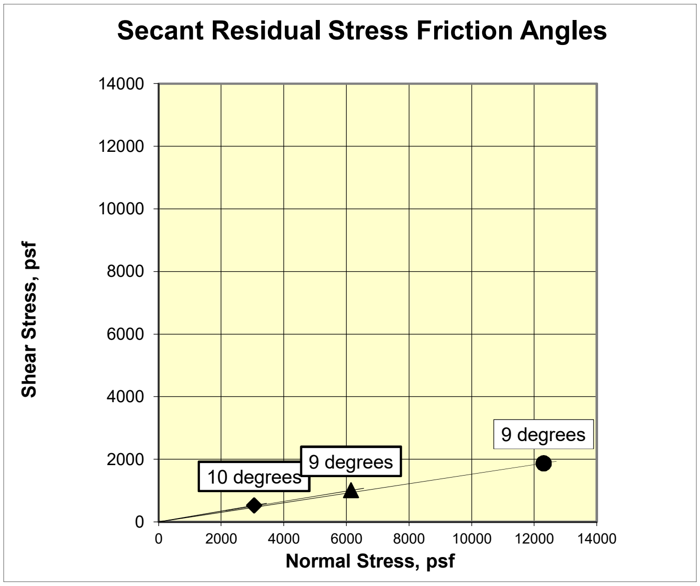
Drained Residual Torsional Shear Strength
(ASTM D6467)

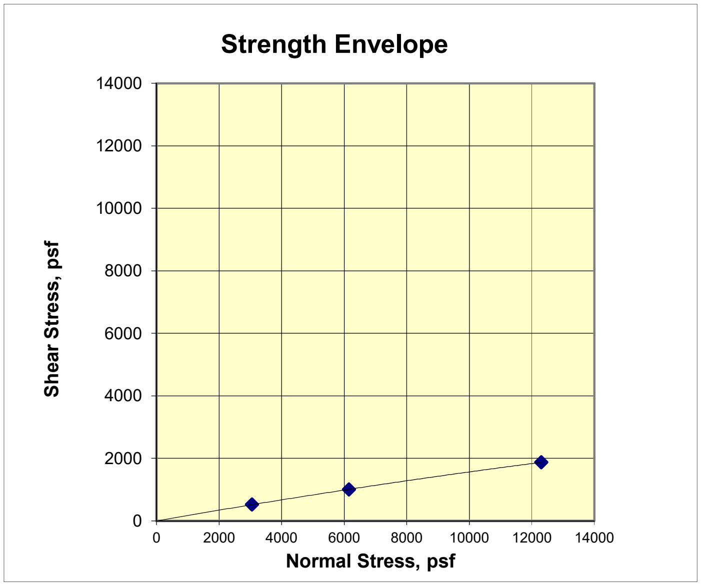
BGL Job No.:	028-016	**Boring:**	B-2	**Date:**	1/10/2019	**Clay, %:**	23.5
Client:	GRI	**Sample:**	Run 7	**By:**	PJ	**LL:**	62.3
Project Name:	Cannon Beach	**Depth (ft):**	50-52	**Checked:**	PJ	**PL:**	27.9
Project Number:	6192	**Test Type:**	Reconstituted Residual			**Sample Preparation:**	<#40

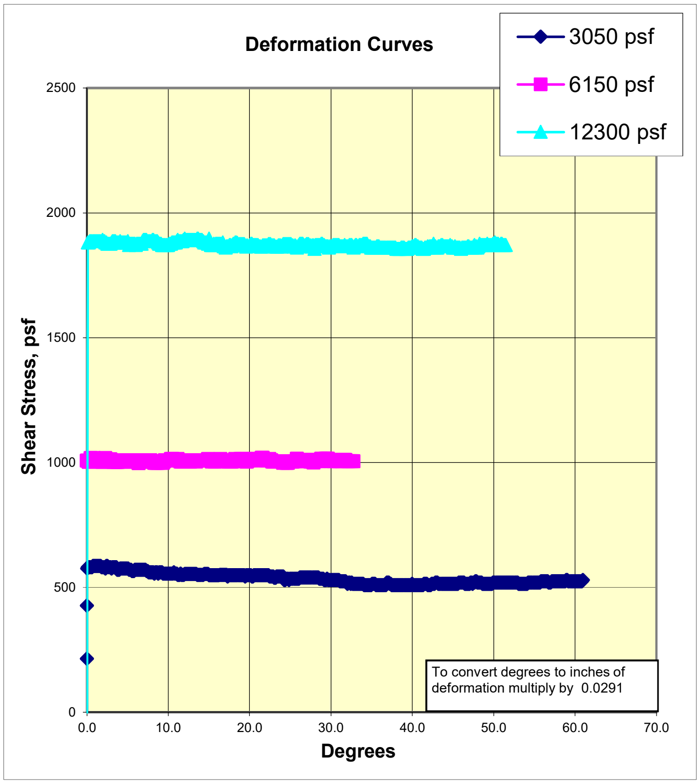
Soil Type: Very Dark Gray Gravelly Fat CLAY

Normal Stress, psf	3050	6150	12300
Secant Phi, deg.:	10	9	9

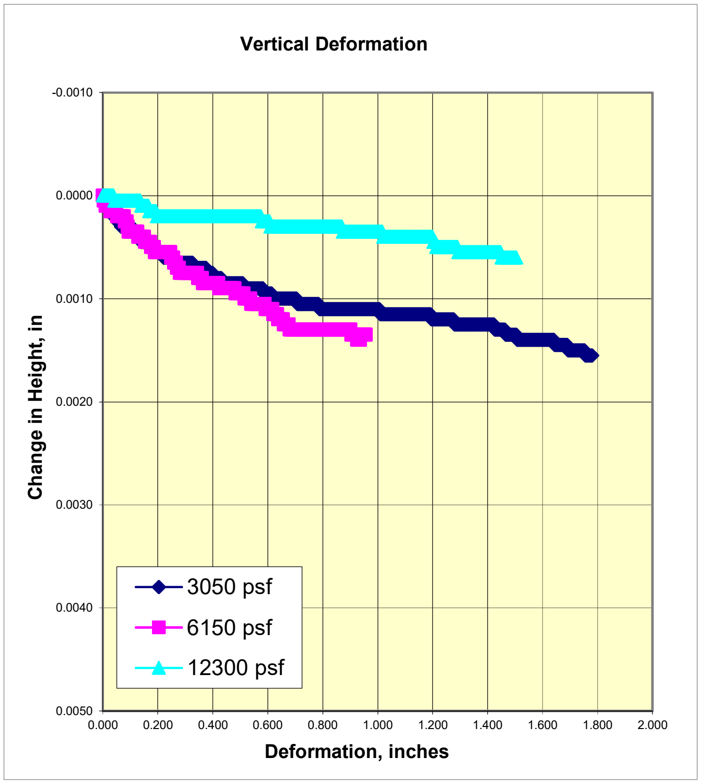
Remarks: A small friction correction was applied to each point.







To convert degrees to inches of deformation multiply by 0.0291



APPENDIX D

Well Log

CLAT 51703

STATE OF OREGON
GEOTECHNICAL HOLE REPORT
(as required by OAR 690-240-035)

(1) OWNER/PROJECT:
Hole Number B-1

Name T-MOBILE

Address 1500 NE IRVING ST SUITE 530

City PORTLAND State OREGON Zip 97232

(2) TYPE OF WORK
☑ New ☐ Deepening ☐ Alteration (repair/recondition) ☒ Abandonment

(3) CONSTRUCTION:
☐ Rotary Air ☐ Hand Auger ☑ Hollow Stem Auger

☐ Rotary Mud ☐ Cable Tool ☐ Push Probe ☐ Other

(4) TYPE OF HOLE:
☑ Uncased Temporary ☐ Cased Permanent

☐ Uncased Permanent ☐ Slope Stability ☐ Other

(5) USE OF HOLE: GEOTECHNICAL

(6) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Hole 35 ft.

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds
8	0	35	BENT CHIPS	35	0	18 SKS

Backfill placed from ____ ft. to ____ ft. Material ____

Filter Pack placed from ____ ft. to ____ ft. Size of pack ____

(7) CASING/SCREEN:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	N/A				☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Screen:					☐	☐	☐	☐
					☐	☐	☐	☐

Slot size ____

(8) WELL TEST:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Permeability ____ Yield ____ GPM ____

Conductivity ____ PH ____

Temperature of water NONE °F Depth artesian flow found ____ ft.

Was water analysis done? ☐ Yes ☐ No

By whom? ____

Depth of strata analyzed. From ____ ft. to ____ ft.

Remarks: ____

(9) LOCATION OF HOLE by legal description:
County CLATSUP Latitude ____ Longitude ____

Township 4 N Range 10 W WM.

Section 6 SE 1/4 SW 1/4

Tax Lot 1800 Lot ____ Block ____ Subdivision ____

Street Address of Well (or nearest address) TOLOVANA MAINLAND ROAD

Map with location indentified must be attached

(10) STATIC WATER LEVEL:
NONE ft. below land surface. Date 3/4/03

Artesian pressure ____ lb. per square inch. Date ____

(11) SUBSURFACE LOG:
Ground Elevation ____

Material Description	From	To	SWL
BROWN GRAVELLY CLAY	1	23	
REDDISH BROWN SAND STONE	23	35	

Date Started 3/4/03 Date Completed 3/4/03

(12) ABANDONMENT LOG:

Material Description	From	To	Sacks or Pounds
BENT CHIPS	35	0	18 SKS

RECEIVED
MAR 26 2003
WATER RESOURCES DEPT
SALEM, OREGON

Date started 3/4/03 Date Completed 3/4/03

Professional Certification
(to be signed by a licensed water supply or monitoring well constructor, or registered geologist or civil engineer).

I accept responsibility for the construction, alteration, or abandonment work performed on during the construction dates reported above. All work performed during this time is in compliance with Oregon geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License or Registration Number 10400

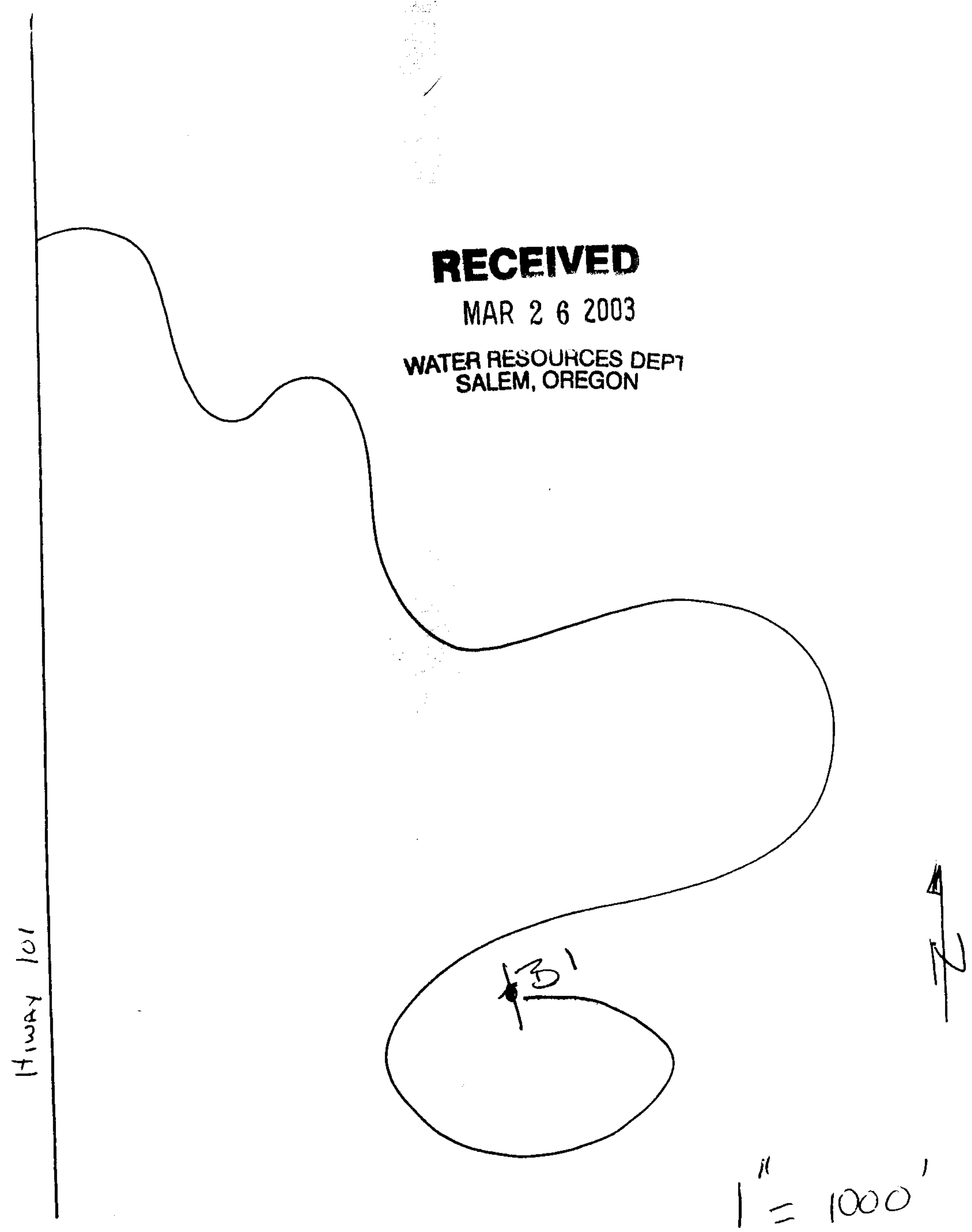
Signed Allen Meeuwsen Date 3-5-03

ALLEN MEEUWSEN

Affiliation SUBSURFACE TECHNOLOGIES

THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER


Hiway 101
31'
N
1" = 1000'