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May 27, 2014

Mr. Bob Goodrich, PE
OBEC Consulting Engineers
3990 Fairview Industrial Dr. SE, Ste. 200
Salem, Oregon 97302

RE: DRAFT CONCEPTUAL GEOTECHNICAL LETTER REPORT: BOECKMAN CREEK BRIDGE PLANNING ESTIMATE WILLSONVILLE, OREGON

Dear Mr. Goodrich:

This letter report presents the results of our field explorations and our conceptual geotechnical opinions to support the Boeckman Creek Bridge planning estimate. For this task, we have performed a literature review of existing subsurface data and published geologic references and performed a limited subsurface investigation that included drilling two borings at the proposed bridge abutment locations. These services are being provided in accordance with our subconsultant agreement with OBEC Consulting Engineers for Geotechnical Services.

PROJECT UNDERSTANDING

The Boeckman Creek Bridge planning estimate is part of the Boeckman Dip Bicycle/Pedestrian Enhancement (Boeckman Dip) Project. This project includes the portion of Boeckman Road between Canyon Creek Drive and Wilsonville Road in the area of the existing vertical curve (or “dip”) that extends across Boeckman Creek. The City of Wilsonville recently completed temporary improvements that included widening and construction of a sidewalk on the south side of the roadway. Future improvements might include a bridge and retaining walls that would bring this section of roadway into compliance with city and federal design standards.

LOCAL GEOLOGY AND SEISMIC SETTINGS

Local Geology

The project site is located in the Willamette Lowland at the northern end of the Central

Willamette Valley (Gannett and Caldwell, 1998). Regional and local geology of the Wilsonville area has been mapped by Schlicker and Deacon (1967), Walker and MacLeod (1991), and by O'Connor and others (2001). The Willamette Lowland is a structural depression created by tectonic forces acting on basalt flows of the middle Miocene-age (approximately 17 to 6 million years old) Columbia River Basalt Group (CRBG) and older underlying basement rock. The once relatively uniform lava surface is now extensively folded and faulted such that it lies both above and below the general elevation of the Central Willamette Valley floor. For example, the CRBG lies beneath a deep soil cover in the Wilsonville area, but it rises above the valley floor in Pete's Mountain to the east and in Parrett Mountain to the west.

At the Boeckman Dip project site, the CRBG basement is mantled by two sedimentary units. The older of the two was first described by Schlicker and Deacon (1967), who named the unit the Helvetia Formation. Wilson (1998) included the same sediments in his Hillsboro Formation (we will adopt Wilson's terminology in this report). This lower-most sequence of sediment in the Hillsboro Formation directly overlies the CRBG and consists of laterized (a weathering process that reduces rock or sediment to red soil rich in iron oxides) sand, silt, and clay. The laterite is overlain by fine-grained sediments of the catastrophic Missoula Flood episodes. The flood sediments, or Willamette Silt, were deposited rapidly during late Pleistocene time (15,000 to18,000 years ago) when tremendously large, catastrophic outburst floods from glacial Lake Missoula inundated the Columbia River system and back-flooded into the Willamette Valley. The Willamette Silt forms the lowland surface in much of the Willamette Valley above the present floodplains and below an elevation of 400 feet.

Seismic Settings

This project is subject to seismic events from three major sources: (1) Cascadia Subduction Zone (CSZ) Megathrust earthquakes at the interface of the Juan de Fuca and North American Plates; (2) deep-focus, CSZ intraplate earthquakes (within the Juan de Fuca and North American Plates); and (3) shallow-focus earthquakes in local and regional continental crustal faults. The maximum magnitude for a CSZ Megathrust event is expected to be in the range of Moment Magnitude (M_w) 8 to 9, with a possible reoccurrence interval of 500 to 600 years. Intraslab events have occurred on a frequent basis in the Puget Sound area, but there is no strong historical evidence for such events in Oregon and southern Washington. Known and suspected crustal faults in the region have been characterized by the United States Geological Survey (USGS) and the Oregon Department of Geology and Mineral Industries (DOGAMI).

According to the USGS Quaternary Fault and Fold Database of the United States (Personius, S.F., 2002), the nearest mapped Quaternary fault is the Canby-Mollala Fault approximately 5 km (3 miles) northeast of the site. Other nearby faults with evidence of movement during the Quaternary Period, listed below in Table 1, have been mapped within an approximate 20-km (12-mile) radius of the project site. Each of the faults in Table 1 is defined as a "Class A" fault by the USGS. Class A faults are those for which there is demonstrable evidence of tectonic movement during the Quaternary Period that are known or presumed to be associated with relatively large magnitude earthquakes of M_w of 6 to 7.

**TABLE 1: USGS CLASS A QUATERNARY FAULTS
WITHIN A 20-KM (12-MILE) RADIUS OF THE BOECKMAN DIP PROJECT SITE**

Fault Name	USGS Class	Approximate Distance and Direction from Site[1]	Slip Rate	Time Since Last Deformation[2]
Canby-Molalla Fault	A	5 km (3 mi) northeast	<0.2 mm/yr	<15 ka
Oatfield Fault	A	18 km (11 mi) northeast	<0.2 mm/yr	<1.6 ma
Newberg Fault	A	20 km (12 mi) west	<0.2 mm/yr	<1.6 ma
Portland Hills Fault	A	20 km (12 mi) northeast	<0.2 mm/yr	<1.6 ma

[1] Approximate distance from site to nearest extent of fault mapped at the ground surface
[2] ma = "Mega-annum" or million years ago; ka = "Kilo-annum" or thousand years ago

EXPLORATIONS AND SUBSURFACE CONDITIONS

Field Explorations

To obtain site-specific subsurface soil conditions for this project, we drilled two borings, designated BH-1 and BH-2 at the locations on Figure 1, Site Plan. We subcontracted the bore hole drilling to Hard Core Drilling, Inc., of Dundee, Oregon. The borings were drilled on May 5 and 6, 2014, with a truck-mounted CME-75 drill rig and using mud-rotary drilling methods and 3-$^{7}/_{8}$-inch-diameter drill bits. The boring numbers, depths, approximate ground surface, and bottom borehole elevations are summarized in Table 2, Summary of Current Borings.

TABLE 2: SUMMARY OF CURRENT BORINGS

Boring ID	Depth of Boring (ft)	Approximate Ground Surface Elevation (ft)[1]	Approximate Bottom-Hole Elevation (ft)[1]
BH-1	81.5	185	103.5
BH-2	81.5	185	103.5

[1] Ground elevations are based on hand-held GPS device

A Shannon & Wilson geologist was present during the field explorations to locate the borings, log the materials encountered in the borings, and collect soil samples. Once drilling was completed, the borings were abandoned by backfilling with bentonite grout, in accordance with Oregon Department of Water Resources requirements.

In the field, soil samples were classified visually in general accordance with ASTM D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Consistency, color, relative moisture, degree of plasticity, peculiar odors, and other distinguishing characteristics of the samples were noted. No laboratory testing was performed for this project. All soil sample descriptions were obtained from the field visual classifications. Terminology used in the soil classifications is defined in the Soil Classification and Log Key, Figure 2.

Summary logs of borings are presented in Figures 3 and 4. Soil descriptions and interfaces on the logs are interpretive, and actual changes may be gradual. The left-hand portion of the boring logs gives our interpretation of the soils encountered. The right-hand portion of the boring logs shows a graphic log, sample locations and designations, and a graphical representation of Standard Penetration Test (ASTM D1586) N-values and natural water contents.

Subsurface Soil Units

Based on the local geology summarized previously and field descriptions of the soil encountered in the borings, the materials encountered in our explorations (Borings BH-1 and BH-2) are grouped into the following three engineering soil units.

- Fill – Includes the pavement section; consists of approximately 2.5 feet of 3-inch minus crushed rock topped by 14 to 18 inches of ¾-inch minus base rock and 7 to 9 inches of asphalt concrete.

- Willamette Silt – Underlies the fill and consists 13.5 to 15.5 feet of loose to medium-dense, brown, moist, non-plastic to low-plasticity, stratified SILT (ML); SILT with Sand (SP-SM); and Silty SAND (SM). The SPT N values range between 3 and 24 blows per foot with an average of 13 blows per foot.
- Hillsboro Formation – Underlies the Willamette Silt and consists of at least 63.5 feet of medium-stiff to stiff, red-brown to brick-red to brown, moist, low-plasticity Lean CLAY (CL); below a depth of 70 feet, a few thin sandy clay and fine gravelly clay interbeds were present; total thickness of this unit is unknown. The SPT N values range between 4 and 13 blows per foot with an average of about 7 blows per foot.

These generalized engineering units are shown in the Logs of Borings, Figures 3 and 4. Contacts between the soil units may be more gradational than shown in the boring logs.

Groundwater

Groundwater levels were uncertain in the boreholes due to the mud-rotary drilling method and the clay soil that dominated the soil profile. The native clay soils in these two boreholes do not readily transmit water. The soil samples collected were all described as "moist," which is an intermediate descriptor between dry and wet. A moist clay contains enough moisture that it can be molded in the hand, but it is not saturated, and water can't be squeezed from it. We can assume, though, that a piezometric head is likely present at about the same elevation as, or maybe a little higher than, the flowing water in Boeckman Creek.

CONCEPTUAL GEOTECHNICAL OPINIONS

Site-Specific Seismic Hazards

Based on standard ODOT practice, two seismic ground motion hazard performance levels were considered for bridge design. The two ground motion levels have return periods of approximately 475 and 975 years, respectively. The lower-level ground motion (475-year) is for serviceability; and the upper-level ground motion is for no-collapse design.

The ODOT Bridge Design and Drafting Manual (BDDM) recommends peak ground acceleration (PGA) and other spectral accelerations be obtained from the 2002 USGS Seismic Hazard Maps for the Pacific Northwest Region. The design ground motions are determined by modifying the soft rock (site class B) spectral accelerations based on the Site Class (i.e., the stiffness of the site soils/rock) as provided in the ODOT BDDM. Based upon the field explorations, the subsurface conditions at the project site are characterized as Site Class E.

The nearest mapped potentially active fault is the Canby-Mollala Fault approximately 5-km (3-miles) northeast of the site. According to AASHTO, the Near-Fault Effects may be considered in the development of ground motions, especially for major or very important bridges with a natural period greater than 0.5 seconds. In our opinion, modification of design ground motion for near-fault effects and/or vertical acceleration is not necessary because we believe that the proposed bridge may not be a major or very important bridge.

We evaluated the potential for earthquake-induced geologic hazards, including liquefaction and associated effects such as lateral spreading, liquefaction-induced settlement, slope instability, ground surface fault rupture, and earthquake-induced flooding. The on-site soils are not susceptible to liquefaction or related effects by assuming that the groundwater level is below the Willamette Silt, approximately 20 feet below the existing ground surface.

Bridge Foundations

The bridge can be supported by deep foundations, including driven piles or drilled shafts. Due to the presence of the deep clay deposit, the deep foundations should be designed as friction piles or shafts. The bearing resistances of the deep foundations are dependent on the pile or shaft diameters and embedment depths. Based upon the explored subsurface conditions, the drilled shafts may be constructed using uncased holes.

Bridge Approach Retaining Wall or Embankment

Construction of the MSE walls and the roadway embankments will result in settlement. While the majority of the settlement will occur during the construction period or shortly after construction, in the Willamette Silt, the presence of the lean clay (Hillsboro Formation) will result in some post-construction settlement. Therefore, an expected post-construction settlement period of approximately two to three months may be required prior to pavement construction and utility installation at the top of the MSE walls and embankments, as well as for any other settlement-sensitive facilities on the MSE walls and embankments. The actual settlement period will be determined based upon the height of the wall or embankment.

LIMITATIONS

The conclusions and recommendations contained in this letter are based on the site conditions as they reportedly exist and assume that the information included on the drawings is representative of the subsurface conditions beneath the site; i.e., the subsurface conditions are not significantly different from the explored borings and those inferred from the geologic map.

This report is prepared for the exclusive use of the City of Wilsonville and OBEC Consulting Engineers for the Boeckman Creek Bridge planning estimates. It should be made available for information of factual data only, and not as a warranty of subsurface conditions and discussions of subsurface conditions included in this letter.

Please note that our scope of services did not include any environmental assessment or evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below the site.

Shannon & Wilson has prepared the attached, "Important Information About Your Geotechnical/Environmental Report," to assist you and others in understanding the use and limitations of our reports.

Sincerely,

SHANNON & WILSON, INC.

Risheng (Park) Piao, PE, GE
Vice President | Geotechnical Engineer

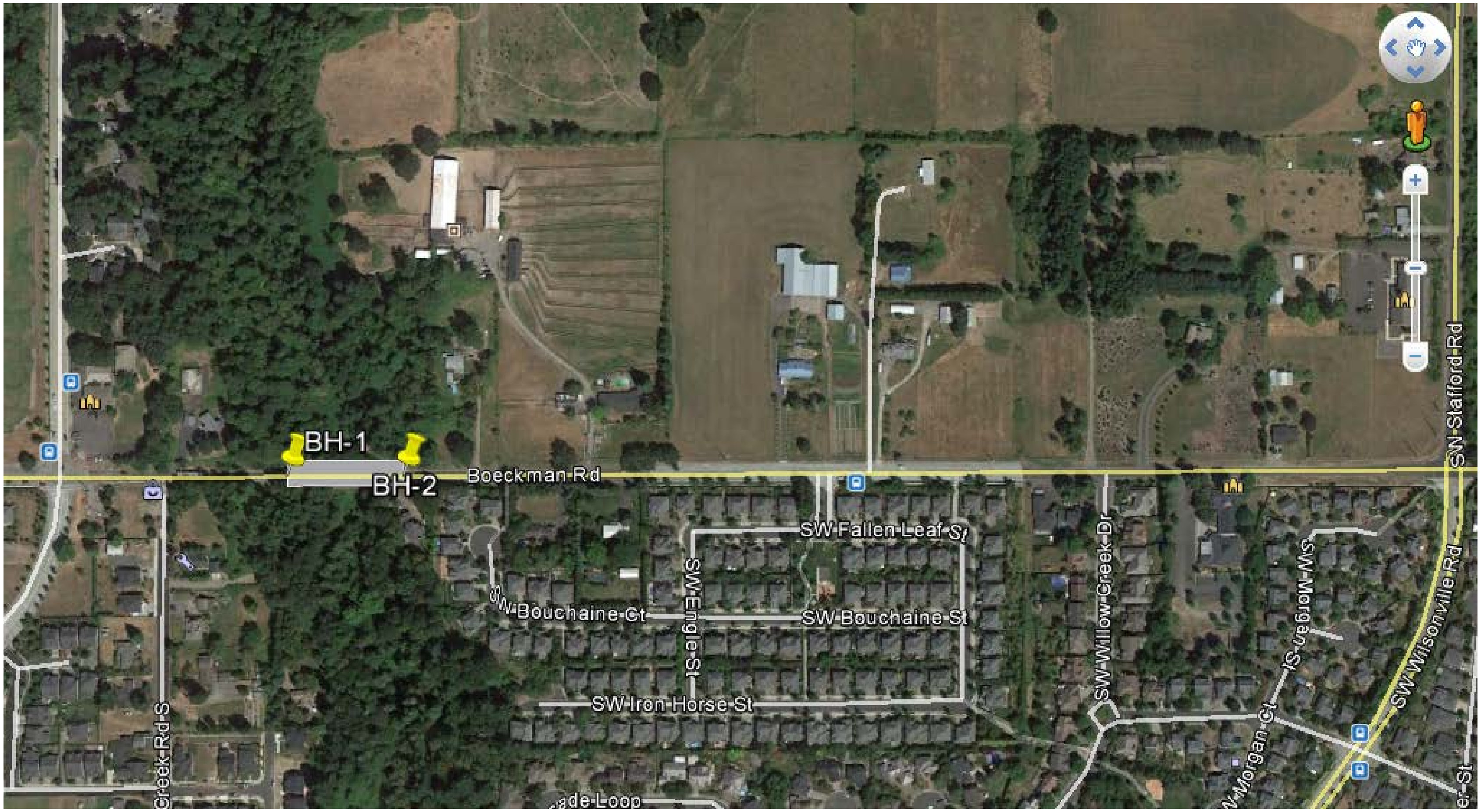
Kim Elliott, CEG
Senior Principal | Engineering Geologist

KEE:RPP/amn

Enc: References

Figure 1 – Site Plan
Figure 2 – Soil Classification and Log Key
Figure 3 – Boring BH-1
Figure 4 – Boring BH-2
Attachment A – Important Information About Your Geotechnical/Environmental Report

M:\3867 Boeckman road Dip Bridge\ROW Permit\ROW Permit Request.pdf



NORTH

IMAGE NOT TO SCALE

BH-1

APPROXIMATE BOREHOLE LOCATION AND NUMBER

Boeckman Dip Bicycle/Pedestrian Enhancement Wilsonville, Oregon	
BOREHOLE LOCATION PLAN	
May 2014	24-1-03867-001
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	**FIG. 1**

FIG. 1

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1]All percentages are by weight of total specimen passing a 3-inch sieve.
[2]The order of terms is: *Modifying Major with Minor*.
[3]Determined based on behavior.
[4]Determined based on which constituent comprises a larger percentage.
[5]Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS

Bentonite Cement Grout	Surface Cement Seal
Bentonite Grout	Asphalt or Cap
Bentonite Chips	Slough
Silica Sand	Inclinometer or Non-perforated Casing
Gravel	Vibrating Wire Piezometer
Perforated or Screened Casing	

PERCENTAGES TERMS [1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1]Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

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Wilsonville, Oregon

SOIL DESCRIPTION AND LOG KEY

May 2014 24-1-03867-001

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FIG. 2
Sheet 1 of 3

2013_BORING_CLASS1 24-1-03867-001.GPJ SW2013LIBRARYPDX.GLB SWNEW.GDT 5/27/14

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW		Well-Graded Gravel; Well-Graded Gravel with Sand
			GP		Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM		Silty Gravel; Silty Gravel with Sand
			GC		Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW		Well-Graded Sand; Well-Graded Sand with Gravel
			SP		Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM		Silty Sand; Silty Sand with Gravel
			SC		Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL		Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH		Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat or other highly organic soils (see ASTM D4427)

FILL	Placed by humans, both engineered and nonengineered. May include various soil materials and debris.		The Fill graphic symbol is combined with the soil graphic that best represents the observed material

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the *CL-ML* area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

3. The soil graphics above represent the various USCS identifications (i.e., *GP*, *SM*, etc.) and may be augmented with additional symbology to represent differences within USCS designations. *Sandy Silt (ML)*, for example, may be accompanied by the *ML* soil graphic with sand grains added.

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Wilsonville, Oregon

SOIL DESCRIPTION AND LOG KEY

May 2014 | 24-1-03867-001

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FIG. 2
Sheet 2 of 3

2013_BORING_CLASS2 24-1-03867-001.GPJ SW2013LIBRARYPDX.GLB SWNEW.GDT 5/27/14

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICTY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4%
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10%
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20%
High	It take considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20%

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

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[2]Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
approx.	Approximate/Approximately
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

Boeckman Dip Pedestrian Enhancement Project
Wilsonville, Oregon

SOIL DESCRIPTION AND LOG KEY

May 2014 24-1-03867-001

SHANNON & WILSON, INC.
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FIG. 2
Sheet 3 of 3

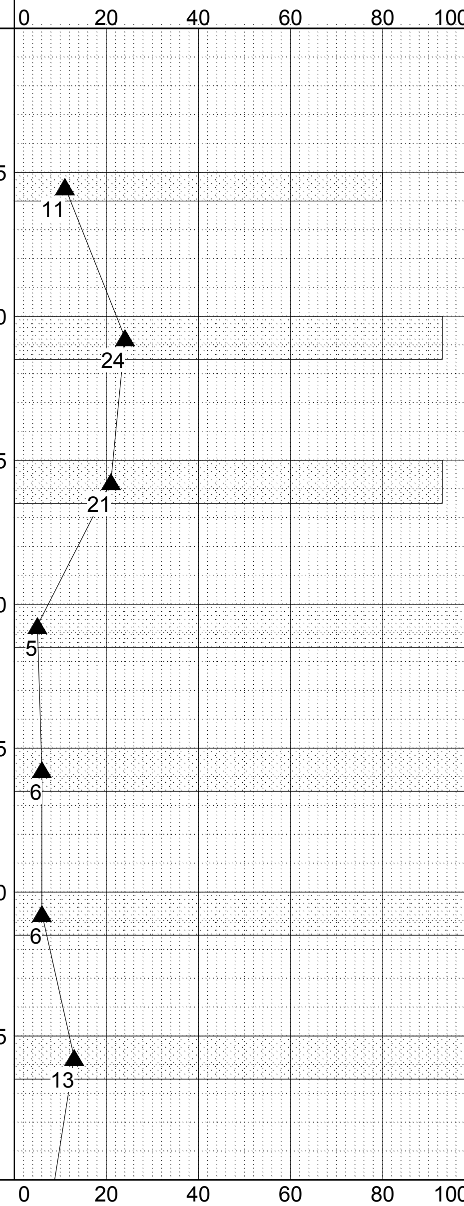
Total Depth:	81.5 ft.	Northing:	~	Drilling Method:	Mud Rotary
Top Elevation:	~ 185 ft.	Easting:	~	Drilling Company:	Hardcore Drilling
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME-75
Horiz. Datum:		Offset:	~	Other Comments:	

Hole Diam.:	3 7/8 in.
Rod Type:	NWJ
Hammer Type:	Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.*	*Elev.* Depth (ft.)	Samples	Depth, ft.
9-in. asphalt pavement.	*184.2* 0.8		
Base rock 18-in. **FILL**	*182.7* 2.3		
Rock fill 3-in.-minus.	*180.1* 4.9		5
Loose grading to medium dense, brown, *Silty Sand Grading* to *Poorly Graded Sand (SP-SM)*; moist; trace laminated silt interbeds; nonplastic; fine grained; trace silt; trace orange iron stain. **WILLAMETTE SILT**		S-1 S-2 S-3	10 15
Medium stiff grading to stiff, red-brown grading to brick-red, *Lean Clay (CL)*; moist; medium plasticity. **HILLSBORO FORMATION**	*164.6* 20.4	S-4 S-5 S-6 S-7	20 25 30 35

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

LEGEND

Standard Penetration Test

Recovery (%)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

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Wilsonville, Oregon

LOG OF BORING BH-1

May 2014 24-1-03867-001

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FIG. 3
Sheet 1 of 3

REV 3

Total Depth: 81.5 ft.	Northing: ~	Drilling Method: Mud Rotary	Hole Diam.: 3 7/8 in.
Top Elevation: ~ 185 ft.	Easting: ~	Drilling Company: Hardcore Drilling	Rod Type: NWJ
Vert. Datum:	Station: ~	Drill Rig Equipment: CME-75	Hammer Type: Automatic
Horiz. Datum:	Offset: ~	Other Comments:	

SOIL DESCRIPTION

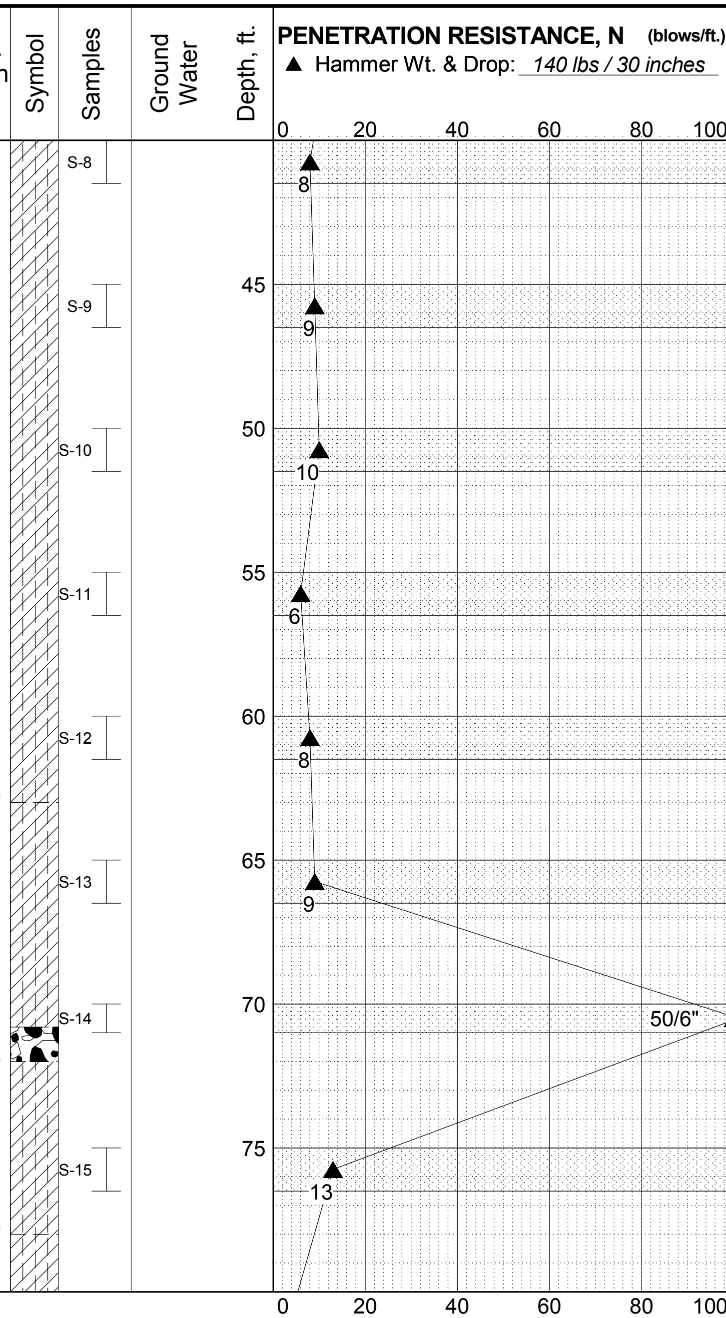
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

SOIL DESCRIPTION	Elev. Depth (ft.)
Continued: Medium stiff grading to stiff, red-brown grading to brick-red, *Lean Clay (CL)*. Trace orange iron stain; sub-vertical seems of gray clay. Trace relict coarse sand texture. Three 2- to-3-in. clayey sand interbeds. **HILLSBORO FORMATION**	
Stiff, brown, *Lean Clay (CL)*; moist; contains occasional 1- to-3-in.-thick silty sand layers at least one of which contains silt laminae; medium plasticity.	122.0 / 63.0
Gravel lens with cobbles.	114.2 / 70.8
Stiff, brown-orange-gray mottled, *Sandy Lean Clay (CL)*; moist; stratified silty fine to coarse sand; medium plasticity; brown and blue clay and silty to clayey sand; highly weathered; blue clay has a relict sand texture.	113.0 / 72.0
Soft, brown, *Lean Clay (CL)*; moist; three 1- to-3in.-thick sandy clay; low plasticity.	107.0 / 78.0

CONTINUED NEXT SHEET

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

⌶ Standard Penetration Test

Recovery (%)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Boeckman Dip Pedestrian Enhancement Project
Wilsonville, Oregon

LOG OF BORING BH-1

May 2014 24-1-03867-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3
Sheet 2 of 3

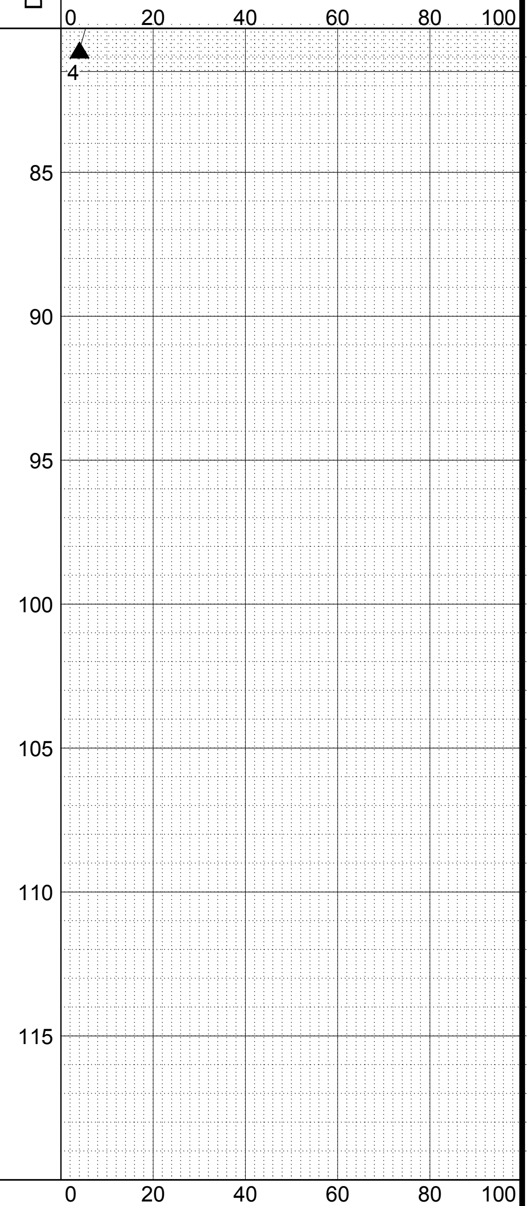
REV 3

Total Depth:	*81.5 ft.*	Northing:	~	Drilling Method:	*Mud Rotary*	Hole Diam.:	*3 7/8 in.*
Top Elevation:	*~ 185 ft.*	Easting:	~	Drilling Company:	*Hardcore Drilling*	Rod Type:	*NWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME-75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Soil Description	Elev. Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Continued: Soft, brown, *Lean Clay (CL)*; moist; contains three 1- to-3in.-thick sandy clay interbeds.	*103.5* 81.5		S-16		
Completed - May 5, 2014					

PENETRATION RESISTANCE, N (blows/ft.)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND
Standard Penetration Test

Recovery (%)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Boeckman Dip Pedestrian Enhancement Project
Wilsonville, Oregon

LOG OF BORING BH-1

May 2014 24-1-03867-001

SHANNON & WILSON, INC.
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FIG. 3
Sheet 3 of 3

REV 3

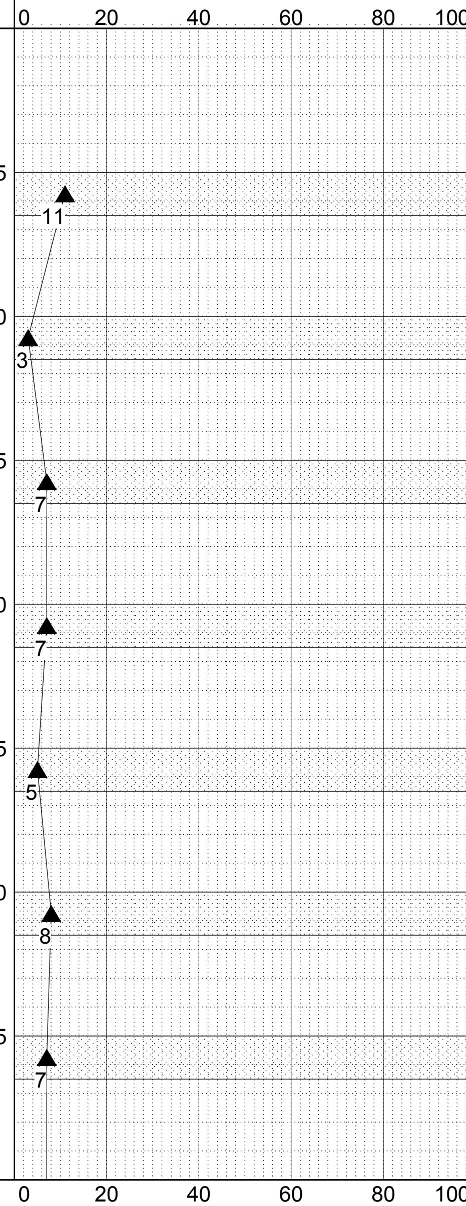
Total Depth:	81.5 ft.	Northing:	~	Drilling Method:	Mud Rotary
Top Elevation:	~ 185 ft.	Easting:	~	Drilling Company:	Hardcore Drilling
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME-75
Horiz. Datum:		Offset:	~	Other Comments:	

Hole Diam.: 3 7/8 in.
Rod Type: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Soil Description	Elev. / Depth (ft.)	Samples	Depth, ft.
A/C pavement.	184.4 / 0.6		
Base rock.	183.2 / 1.8		
Rock fill. **FILL**	180.5 / 4.5		
Medium dense grading to loose, brown grading to gray at 6.2-ft., *Silty Sand (SM)*; moist; low plasticity; micaceous. **WILLAMETTE SILT**	172.5 / 12.5	S-1, S-2	5, 10
Medium stiff, gray, *Silt (ML)*; moist; low plasticity; micaceous.	167.0 / 18.0	S-3	15
Medium stiff, gray, *Lean Clay (CL)*; moist; medium plasticity.	162.0 / 23.0	S-4	20
Medium stiff, gray and red-brown mottled grading to brick-red below 27-ft., *Lean Clay (CL)*; moist; medium plasticity; red-brown mottling appears to be sand layers completely weathered to clay. **HILLSBORO FORMATION**		S-5, S-6, S-7	25, 30, 35

PENETRATION RESISTANCE, N (blows/ft.)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

LEGEND
Standard Penetration Test

Recovery (%)
● % Water Content
Plastic Limit —●— Liquid Limit

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Boeckman Dip Pedestrian Enhancement Project
Wilsonville, Oregon

LOG OF BORING BH-2

May 2014 24-1-03867-001

SHANNON & WILSON, INC.
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FIG. 4
Sheet 1 of 3

REV 3

Total Depth: *81.5 ft.*	Northing: ~	Drilling Method:	*Mud Rotary*	Hole Diam.:	*3 7/8 in.*
Top Elevation: *~ 185 ft.*	Easting: ~	Drilling Company:	*Hardcore Drilling*	Rod Type:	*NWJ*
Vert. Datum:	Station: ~	Drill Rig Equipment:	*CME-75*	Hammer Type:	*Automatic*
Horiz. Datum:	Offset: ~	Other Comments:			

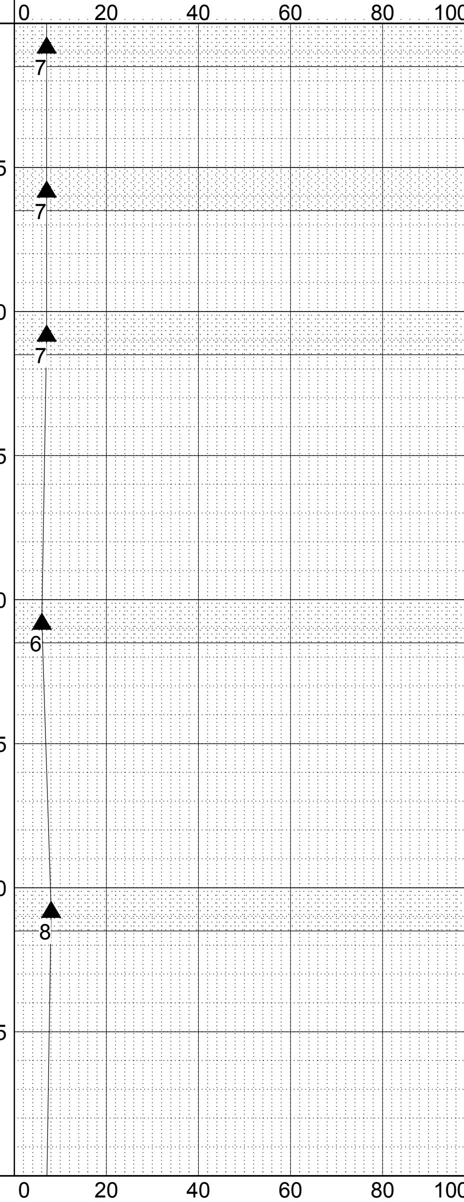
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

SOIL DESCRIPTION	Elev. Depth (ft.)	Samples	Depth, ft.
Continued: Medium stiff, gray and red-brown mottled grading to brick-red below 27-ft., *Lean Clay (CL)*.		S-8	
Scattered black specks, organics?		S-9	45
Scattered relict coarse sand grains completely weathered to red, black, orange, and yellow clay.		S-10	50
HILLSBORO FORMATION			55
One 4-in.-thick clayey sand layer at 60-ft.		S-11	60
Medium stiff, brown, *Lean Clay (CL)*; moist; medium plasticity; trace gray and orange mottling.	*120.0* 65.0		65
		S-12	70
			75

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

LEGEND

Standard Penetration Test

Recovery (%)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Boeckman Dip Pedestrian Enhancement Project
Wilsonville, Oregon

LOG OF BORING BH-2

May 2014 24-1-03867-001

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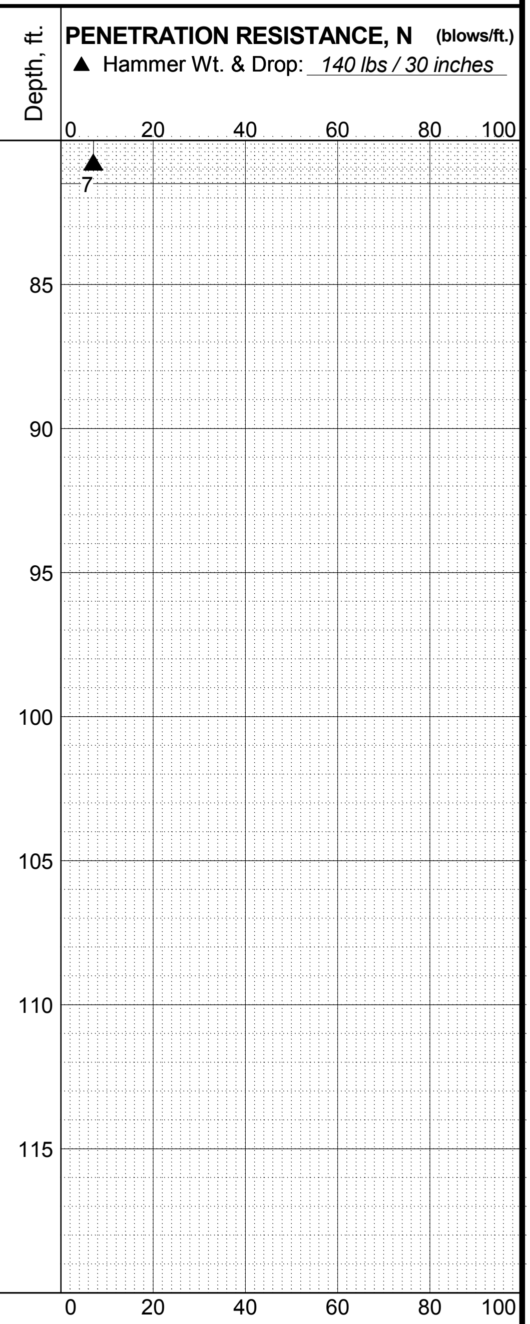
FIG. 4
Sheet 2 of 3

REV 3

MASTER_LOG_E 24-1-03867-001.GPJ SW2013LIBRARYPDX.GLB SHAN_WIL.GDT 5/27/14 Log: KEE Rev: Typ: PAR

Total Depth:	*81.5 ft.*	Northing:	~	Drilling Method:	*Mud Rotary*	Hole Diam.:	*3 7/8 in.*
Top Elevation:	*~ 185 ft.*	Easting:	~	Drilling Company:	*Hardcore Drilling*	Rod Type:	*NWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME-75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.*	*Elev.* Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Continued: Medium stiff, brown, *Lean Clay (CL)*. Trace sand and fine gravel; 1.5- to-3in.-thick interbeds of sand and fine gravel completely weathered to fines. Completed - May 6, 2014	*103.5* 81.5		S-13		



LEGEND
Standard Penetration Test

● % Water Content
Plastic Limit ├─●─┤ Liquid Limit

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
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4. The hole location and elevation should be considered approximate.

Boeckman Dip Pedestrian Enhancement Project
Wilsonville, Oregon

LOG OF BORING BH-2

May 2014 24-1-03867-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 4
Sheet 3 of 3

REV 3

MASTER_LOG_E 24-1-03867-001.GPJ SW2013LIBRARYPDX.GLB SHAN_WIL.GDT 5/27/14 *Log: KEE* *Rev:* *Typ: PAR*

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland