April 19, 2017

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

**RE: PRELIMINARY GEOTECHNICAL ASSESSMENT
FRENCH PRAIRIE BRIDGE: BOONES FERRY ROAD – BUTTEVILLE ROAD
WILSONVILLE, OREGON**

Dear Mr. Goodrich:

This letter report presents the results of our preliminary review and conceptual geotechnical recommendations for use in planning the proposed French Prairie Bridge project in Wilsonville, Oregon. The general location of the proposed project site is shown on Figure 1, Geologic Map. Our services are being performed under a Subconsultant Agreement between OBEC Consulting Engineers (OBEC) and Shannon & Wilson, Inc., dated August 12, 2016.

SCOPE OF SERVICES

At the request of the City of Wilsonville, the OBEC team is performing an alternative selection process and providing a final recommendation for the preferred alignment and structure type for the proposed bridge in the area between the railroad and I-5. The new bridge will provide a multi-use path and accommodate emergency service vehicles across the Willamette River. Shannon & Wilson's task is to perform the site reconnaissance for the selected bridge site and to develop a preliminary geotechnical assessment to evaluate the local geology and the subsurface conditions supporting the selection of the bridge alignment and type.

EXISTING INFORMATION REVIEW

Regional Geology

The project site is located in the Willamette Lowland, at the northern end of the Central Willamette Valley (Gannett and Caldwell, 1998). The Willamette Lowland is a structural depression created by complex faulting and folding of Miocene (about 17 to 6 million years old)

Columbia River Basalt Group (CRBG) basalt flows and older underlying basement rock. Based upon the published literature review, the geologic conditions in the project area, including the west and east side of the I-5 Willamette River Bridge, are generally similar.

In the project area, the CRBG is generally overlain by Upper Miocene (approximately 10 to 5 million-year-old) deposits consisting of fine-grained micaceous fluvial and lacustrine sediments derived from the Columbia and Willamette Rivers that are collectively termed the Sandy River Mudstone (Orr and Orr, 2000). The Sandy River Mudstone is described by Gannett and Caldwell as a micaceous arkosic siltstone, mudstone, and claystone. Overlying the Sandy River Mudstone is the Pliocene (approximately 5 to 2.5 million years old) Troutdale Formation. In the Portland Basin, the Troutdale Formation is generally described as a quartzite-bearing basaltic conglomerate, vitric sandstone, and micaceous sandstone (Gannett and Caldwell, 1998). Composition and thicknesses of both the Sandy River Mudstone and the Troutdale Formation vary with location. In the project area, units assigned to the Troutdale Formation are generally finer grained. Mapping at the project site by Schlicker and others (1967) includes the Sandy River Mudstone with the Troutdale Formation and describes the overall unit as poorly indurated silt, clay, and silty sand with occasional pebble conglomerate beds. The Troutdale Formation is concealed beneath younger sediments and is exposed only in the bottom of steep ravines.

During the late stages of the last great ice age, between about 18,000 and 15,000 years ago, a lobe of the continental ice sheet repeatedly blocked and dammed the Clark Fork River in western Montana, which then formed an immense glacial lake called Lake Missoula. The lake grew until its depth was sufficient to buoyantly lift and rupture the ice dam, which allowed the entire massive lake to empty catastrophically. Once the lake had emptied, the ice sheet again gradually dammed the Clark Fork Valley and the lake refilled, leading to 40 or more repetitive outburst floods at intervals of decades (Allen and others, 2009). These repeated floods are collectively referred to as the Missoula Floods. During each short-lived Missoula Flood episode, floodwaters washed across the Idaho panhandle, through eastern Washington’s scablands, and through the Columbia River Gorge. When the floodwater emerged from the western end of the gorge, it spread out over the Portland Basin and pooled to elevations of about 400 feet, depositing a tremendous load of sediment. Boulders, cobbles, and gravel were deposited nearest the mouth of the gorge and along the main channel of the Columbia River. Cobble-gravel bars reached westward across the basin, grading to thick blankets of micaceous sand and silt (Allen and others, 2009). Ma and others (2012) divided the Missoula Flood Deposits at and near the site into two groups:

- Fine-Grained Deposits consisting of sand and silt
- Coarse-Grained Deposits consisting mostly of gravel with cobbles and boulders

The Tonquin Scablands Channels, north of the Wilsonville area, constricted flows from the Missoula Floods, creating a high-energy water surge from the Tualatin Basin in the north emptying into the Central Willamette Valley to the south. The high-velocity water flowing through the gap entrained coarse gravels, cobbles, and boulders that were dropped out of suspension when the surge lost energy opening up into the Central Willamette Valley near the I-5 Boone Bridge in Wilsonville (Thompson, 2012). As a result, much of the Wilsonville area is underlain by coarse-grained Missoula Flood Deposits. In more recent times, rivers and streams have deposited alluvial sediments in and along their channels and floodplains (Ma and others, 2012; Smith and Roe, 2015).

Seismic Setting

Earthquakes in the Pacific Northwest occur largely as a result of the collision between the Juan de Fuca plate and the North American plate. These two tectonic plates meet along a mega thrust fault called the Cascadia Subduction Zone (CSZ). The CSZ runs approximately parallel to the coastline from northern California to southern British Columbia. The compressional forces that exist between these two colliding plates cause the denser oceanic plate to descend, or subduct, beneath the continental plate at a rate of about 1.5 inches per year. This process leads to volcanism, contortion, and faulting of both crustal plates throughout much of the western regions of southern British Columbia, Washington, Oregon, and northern California. Stress built up between the colliding plates is periodically relieved through great earthquakes at the plate interface (CSZ) (Goldfinger and others, 2012).

Within our present understanding of the regional tectonic framework and historical seismicity, three broad earthquake (seismogenic) sources have been identified. These three types of earthquakes and their maximum plausible magnitudes are as follows:

- **Subduction Zone Interface Earthquakes** originate along the CSZ, which is located 25 miles beneath the coastline. Paleoseismic evidence and historic tsunami studies indicate that the most recent subduction zone thrust fault event occurred in the year 1700, probably ruptured the full length of the CSZ, and may have reached magnitude 9.

- **Deep-Focus, Intraplate Earthquakes** originate from within the subducting Juan de Fuca oceanic plate as a result of the downward bending and contortion of the plate in the CSZ. These earthquakes typically occur at a depth of 28 to 38 miles. Such events could be as large as magnitude 7.5. Examples of this type of earthquake include the 1949 magnitude 7.1 Olympia earthquake, the 1965 magnitude 6.5 earthquake between Tacoma and Seattle, and the 2001 magnitude 6.8 Nisqually earthquake. The highest rates of CSZ intraslab activity are beneath the Puget Sound area, with much lower rates observed beneath western Oregon.
- **Shallow-Focus Crustal Earthquakes** are typically located within the upper 12 miles of the continental crust. The relative plate movements along the CSZ cause not only east-west compressive strain, but dextral shear, clockwise rotation, and north-south compression of the leading edge of the North American Plate (Wells and others, 1998), which is the cause of much of the shallow crustal seismicity of engineering significance in the region. The largest known crustal earthquake in the Pacific Northwest is the 1872 North Cascades earthquake with an estimated magnitude of about 7. Other examples include the 1993 magnitude 5.6 Scotts Mill earthquake and the 1993 magnitude 6 Klamath Falls earthquake.

Shallow crustal faults and folds throughout Oregon have been located and characterized by the United States Geological Survey (USGS). Mapped fault locations and detailed descriptions can be found in the USGS Quaternary Fault and Fold Database (USGS, 2006). The database defines four categories of faults, Classes A through D, based on evidence of tectonic movement known or presumed to be associated with large earthquakes during Quaternary time (less than 1.8 million years ago). For Classes A and B, there is geologic evidence that demonstrates the existence of Quaternary deformation. However, for Class B faults, evidence of Quaternary faulting or slip is more equivocal or may not extend deep enough to be a source of significant earthquakes.

According to the USGS Fault and Fold database, the closest Class A fault to the project site is the Canby-Molalla Fault. It is mapped approximately 4.5 miles east of the site and is believed to have deformed within the past 15,000 years (Personius, 2002a). Additionally, the Newberg fault is mapped about 9 miles west of the site and the Mount Angel Fault is mapped about 10.3 miles southwest. The Newberg fault is believed to have deformed within the past 1.6 million years (Personius, 2002b) and the Mount Angel Fault within the past 15,000 years (Personius, 2012). The Oatfield fault is mapped about 10.8 miles northeast of the site and is believed to have

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deformed within the past 1.6 million years (Personius, 2002c). The CSZ itself is approximately 130 miles west of the site, with a slip rate of approximately 40 millimeters (1.5 inches) per year, and the most recent deformation occurring about 300 years ago (Personius and Nelson, 2006). Based on the mapped fault locations from the USGS database, the potential for fault rupture or near-fault effects at the site is low.

ANTICIPATED SUBSURFACE CONDITIONS

We reviewed published geologic maps and logs of explorations completed for previous projects in the vicinity of the proposed alignments including the as-built drawings of the I-5 Willamette River Bridge (Boone Bridge). The as-built drawings do not provide geotechnical information except the foundation as-built information. Therefore, the project area subsurface conditions were evaluated based upon the available borings within the project vicinity, including borings completed for the Railroad Bridge. The locations of the borings of the past projects are shown on a geologic map in Figure 1. The subsurface profile along the existing railroad bridge is presented in Figure 2 and the associated historic boring logs are attached. Based on this information, on the north side of the Willamette River, we expect that the relatively thin fine-grained flood deposit consisting of soft to medium stiff silt and loose to medium dense sandy silt to silty sand overlying (20 to 30 feet below ground surface) the coarse-grained flood deposit, sandy gravel with cobble and boulders, which, in turn, is underlain (about 50 feet below ground surface) by the Troutdale Formation, stiff to hard silty clay. The thickness of the fine-grained flood deposit may be thinner toward the I-5 Willamette River Bridge.

In the river, we expect that the relatively thin layer of Recent Alluvium, loose to medium dense silty sand, is underlain (20 to 30 feet below the mudline) by the Troutdale Formation.

On the south side of the river, we expect that relatively thick Recent Alluvium is underlain (60 to 80 feet) by either a thin layer of the coarse-grained flood deposit or the Troutdale Formation. At the south shore of the river, a relatively thin layer of the coarse-grained flood deposit (medium dense to very dense sandy gravel with cobbles and boulders) underlay the Recent Alluvium and overly the Troutdale Formation.

Based upon the local geologic map, the thickness of the Troutdale Formation may be more than 100 feet in the project area. The foundations for both the I-5 Boone Bridge and the Railroad

Bridge are founded in the Troutdale Formation. We anticipate that the foundations for the proposed bridge will be deep foundations, such as drilled shafts or driven piles founded into the Troutdale Formation.

Based upon the previous project experiences, the groundwater level may vary between elevations 60 feet and 70 feet. We expect that the groundwater level will be variable, and should be expected to fluctuate with the rise and fall of the Willamette River.

GEOLOGIC AND SEISMIC HAZARDS

We performed a site reconnaissance in early December 2016. The project site is heavily developed with residential houses, especially on the southern riverbank. We accessed the southern riverbank from the NE Butteville Road and accessed the northern riverbank from the SW Boones Ferry Road. The riverbanks are heavily covered by vegetation and trees. During the reconnaissance, we did not observe the landslide along the riverbanks. However, based upon our previous project experience in the project vicinity, the river scour causes localized riverbank slope instability. In our opinion, the primary geologic hazards of the project site include seismic induced lateral spreading and riverbank instability.

Liquefaction and Lateral Spread

Based upon our previous project experiences in the project vicinity, under 1000-year and 500-year design earthquakes, we expect that the fine-grained flood deposit and Recent Alluvium below the groundwater level along the proposed bridge alignment will be susceptible to wide-spread liquefaction and liquefaction-induced settlement. We also anticipate that there may be layers of liquefaction-susceptible sand and silt interbedded with the Coarse-Grained Flood Deposits. We expect that the riverbank slopes at the both sides of the river will be susceptible to liquefaction-induced lateral spreading.

Slope Stability

Based on the anticipated subsurface conditions and our previous project experiences in the project vicinity, we expect that the stability of the riverbank slopes will be a concern, especially under seismic conditions. The potential slope instability will impact the bridge foundations. Therefore, the proposed bridge foundations should be designed to take additional lateral loads due to slope instability, or the riverbank slopes around the proposed bridge foundations should be mitigated for the potential static and seismic slope instability.

CONCEPTUAL GEOTECHNICAL OPINIONS

We understand that the bridge will be designed in accordance with the ODOT BDDM and AASHTO design requirements. The bridge will be designed for two different levels of seismic design events: one for the operational design criteria using Cascadia Subduction Zone Earthquake (CSZE) event and one for the "Life Safety" bridge criteria using 1,000-year return-period event. Ground motion parameters for the 1000-year return-period event will be based on the 2014 USGS seismic hazard maps.

We have considered foundation alternatives including spread footings, driven piles, and drilled shafts. The spread footing alternative may not be preferred due to potential seismic liquefaction settlement. The bridges should be supported by deep foundations, including driven piles or drilled shafts. Due to the anticipated presence of the potential liquefiable fine-grained flood deposit and Recent Alluvium, the deep foundations should be founded into the Troutdale Formation. Based upon our previous experiences in the project vicinity, the Troutdale Formation is stiff to hard silt and clay; it is not liquefiable, and it can support the bridge foundations under seismic conditions. The deep foundations should be designed to take additional lateral load due to potential lateral spreading and the riverbank slope instability if the slopes are not mitigated. In that case, the driven pile foundations may not be cost effective to take additional lateral load. In our current opinion, large-diameter drilled shaft foundations may be the most cost-effective foundation alternative.

LIMITATIONS

The conclusions and recommendations contained in this letter are based on the site conditions as they reportedly exist and assume that the subsurface conditions are not significantly different from those inferred from the published maps and previous explorations.

This letter report is prepared for the exclusive use of the French Prairie Bridge project team. It should be made available for information of factual data only, and not as a warranty of subsurface conditions, such as those interpreted from published maps and reports for nearby projects, and discussions of subsurface conditions included in this letter.

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.

REGISTERED PROFESSIONAL ENGINEER
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OREGON
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AIMEE E. HOLMES
EXPIRES: 6/30/17

Aimee E. Holmes, PE, CEG
Senior Engineer | Engineering Geologist

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

AEH:RPP/hrj:aeb

Enc: Figure 1 – Geologic Map
Figure 2 – Subsurface Profile
Historic Boring Logs – Oregon Electric Railway Bridge
Important Information About Your Geotechnical/Environmental Report

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REFERENCES

Allen, J.E., Burns, M., and Burns, S., 2009, Cataclysms on the Columbia: The Great Missoula Floods (2nd ed.): Portland, Oreg., Ooligan Press, 204 p.

Burns, W.J. and Watzig, R.J., 2014, Statewide Landslide Information Database for Oregon, release 3 (SLIDO-3): Oregon Department of Geology and Mineral Industries.

Gannett, G.W. and Caldwell, R.R, 1998; Geologic Framework of the Willamette Lowland Aquifer System, Oregon and Washington: U.S. Geological Survey Professional Paper 1424-A, 32 p., 8 pls.

Goldfinger, C. and others, 2012, Turbidite Event History – Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone: U.S. Geological Survey Professional Paper 1661-F, 184 p.

Ma, Lina, Madin, I.P., Duplantis, S., and Williams, K.J., 2012, Lidar-Based Surficial Geologic Map of the Greater Portland Area: Clackamas, Columbia, Marion, Multnomah, Washington, and Yamhill Counties, Oregon and Clark County, Washington: Oregon Department of Geology and Mineral Industries, Open-File Report O-12-02, scale 1:63,360.

Orr, Elizabeth L. and Orr, William N., 2000, Geology of Oregon: Fifth Edition: Dubuque, Iowa, Kendall/Hunt.

Personius, S.F., and Nelson, A.R., compilers, 2006, Fault number 781, Cascadia subduction zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed May 18, 2015.

Schlicker, H.G. and Deacon, R.J., 1967, Engineering Geology of the Tualatin Valley region, Oregon: Oregon Department of Geology and Mineral Industries Bulletin B-60, 103 p., 5 app., 45 figs., 5 tables, 4 pls. incl. 1 geologic-hazards map and 1 depth-to-basalt map [all 1:48,000].

Shannon & Wilson, Inc.,1972, Subsurface Investigation, Proposed Relocation Oregon Electric Railway Bridge OE 43.4, Wilsonville, Oregon: Report prepared by Shannon & Wilson, Inc., Portland, Oreg., O-639, for Burlington Northern, Portland, Oreg., August, 27 p.

Shannon & Wilson, Inc., 1988, Geotechnical Investigation, Wilsonville School Addition, Wilsonville, Oregon: Report prepared by Shannon & Wilson, Inc., Portland, Oreg., O-2010-01, for West Linn School District 3J, West Linn, Oreg., February, 6 p.

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Shannon & Wilson, Inc., 1988, Pavement Investigation, Wilsonville School, Wilsonville, Oregon: Report prepared by Shannon & Wilson, Inc., Portland, Oreg., O-2018-01, for West Linn School District 3J, West Linn, Oreg., February, 5 p.

Shannon & Wilson, Inc., 2010, Final Updated Geotechnical Design Report, I-5: Wilsonville Road Interchange, Wilsonville, Oregon: Report prepared by Shannon & Wilson, Inc., Lake Oswego, Oreg., 24-1-03528-002, for Otak, Inc., Lake Oswego, Oreg., May, 40 p.

Shannon & Wilson, Inc., 2015, Draft Geotechnical Report, Willamette River Water Treatment Plant 2015 Master Plan Update, Wilsonville, Oregon: Report prepared by Shannon & Wilson, Inc., Lake Oswego, Oreg., 24-1-03928-005, for Carollo Engineers, Inc., Portland, Oreg., October, 36 p.

Smith, Rachel L. and Roe, Warren P., 2015, Oregon Geologic Data Compilation Release 6 (OGDC-6): Oregon Department of Geology and Mineral Industries.

Squier Associates, "Project Memorandum, Wilsonville Water Treatment Plant (WWTP), Assessment of Boulders Encountered at Finished Water Pipeline Undercrossing," Prepared for Montgomery/Watson, 2001.

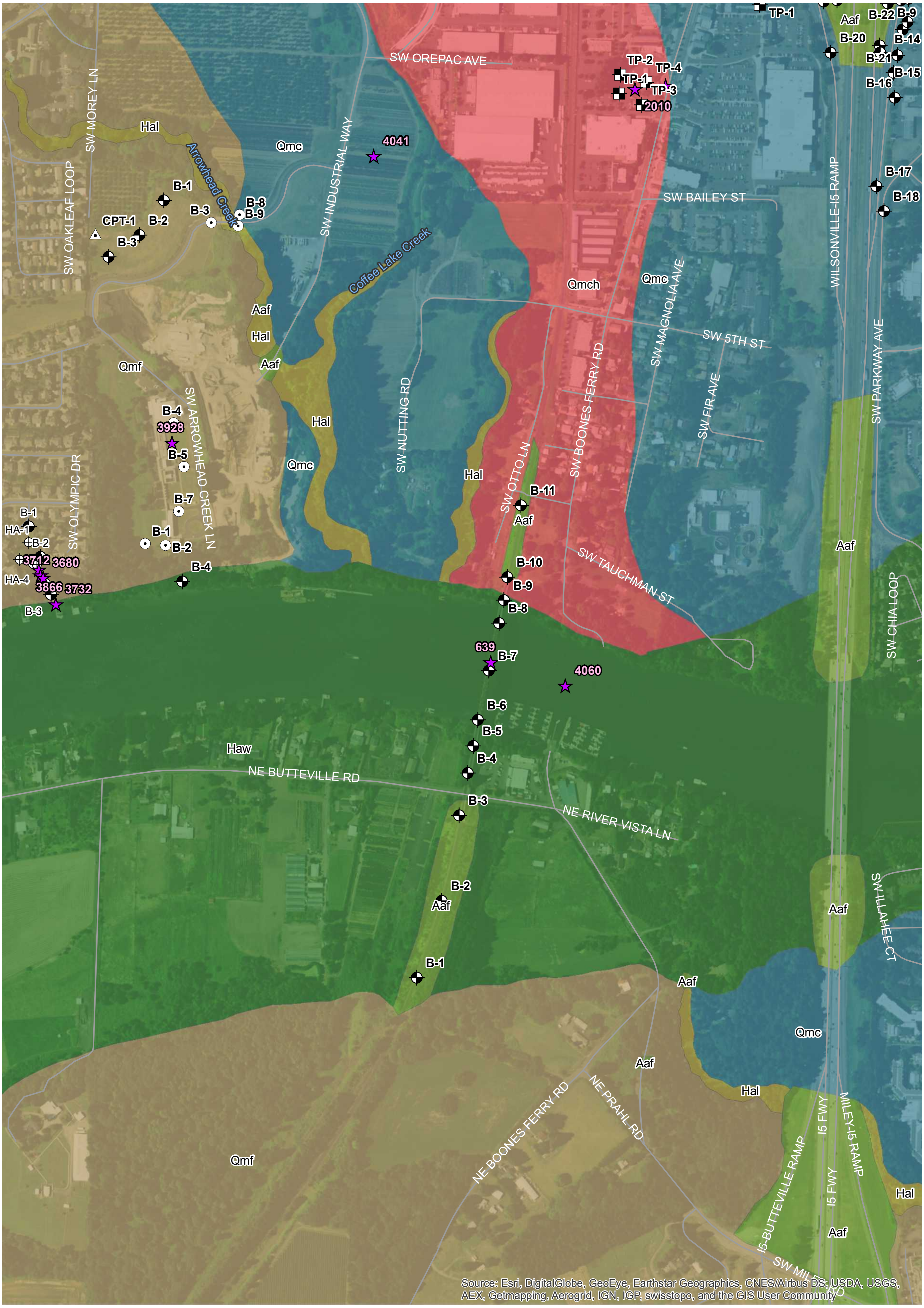
Squier Associates, "Project Memorandum, Wilsonville Water Treatment Plant (WWTP), Geotechnical Analyses and Recommendations in Support of 30 Percent Design Effort," Prepared for Montgomery/Watson, 2000.

Squier Associates, "Project Memorandum, Wilsonville Water Treatment Plant (WWTP), Evaluation and Recommendations of East Abutment Foundations in Support of 30 Percent Design Effort of Entrance Road Bridge," Prepared for Montgomery/Watson, 2000.

Thompson, Rick, 2012, The Tualatin and Yamhill Valleys in Northwest Oregon: The Pleistocene Post, Newsletter of the Ice Age Floods Institute, Spring 2012, p. 6-11.

U.S. Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed April, 23, 2014, from USGS web site: http//earthquake.usgs.gov/hazards/qfaults/.

Wells, R. E., Weaver, C. S., and Blakely, R. J., 1998, Fore arc migration in Cascadia and its neotectonic significance; Geology, v. 26, p. 759-762.



LEGEND

- ★ General Location of Shannon & Wilson Project
- Aaf - Artificial fill
- Hal - Alluvium of lowland streams
- Haw - Alluvium of the Willamette River
- Qmch - Missoula flood deposits, channel facies
- Qmc - Missoula flood deposits, coarse-grained facies
- Qmf - Missoula flood deposits, fine-grained

0 250 500 1,000

Scale in Feet

NOTES

1. Geologic mapping from Open-File Report O-12-02 by DOGAMI.

French Prairie Bridge
Boones Ferry Road - Butteville Road
Wilsonville, Oregon

GEOLOGIC MAP

January 2017 24-1-04060-001

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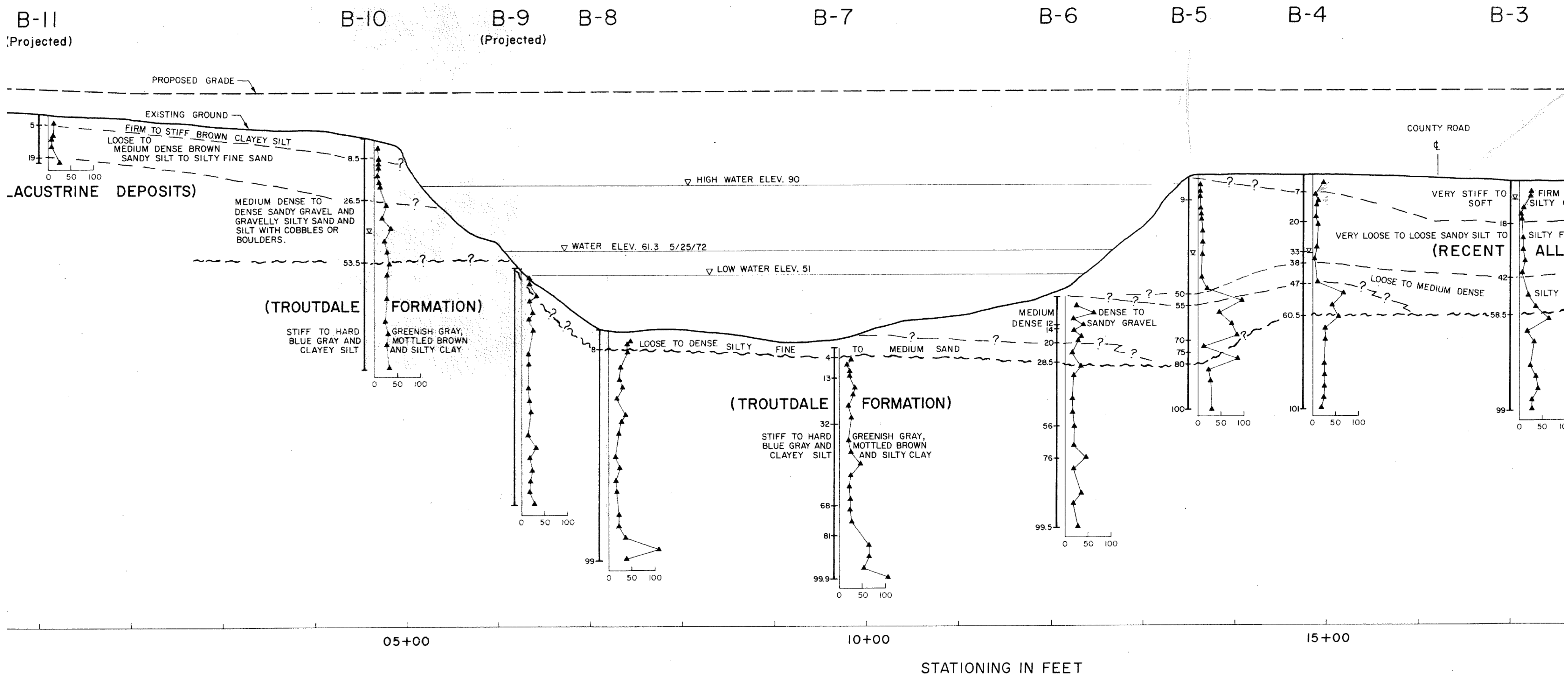
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1

FIG. 1



0 48 96

Approximate Vertical Scale in Feet

0 120 240

Approximate Horizontal Scale in Feet

Vertical Exaggeration = 2.5x

NOTES

1. Profile adapted from Figure 31 of report titled: "Subsurface Investigation Proposed Relocation Oregon Electric Railway Bridge OE 43.4 Wilsonville, Oregon", dated July, 1972.
2. See Figure 1 for approximate boring locations.

French Prairie Bridge
Boones Ferry Road - Butteville Road
Wilsonville, Oregon

SUBSURFACE PROFILE

January 2017 24-1-04060-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

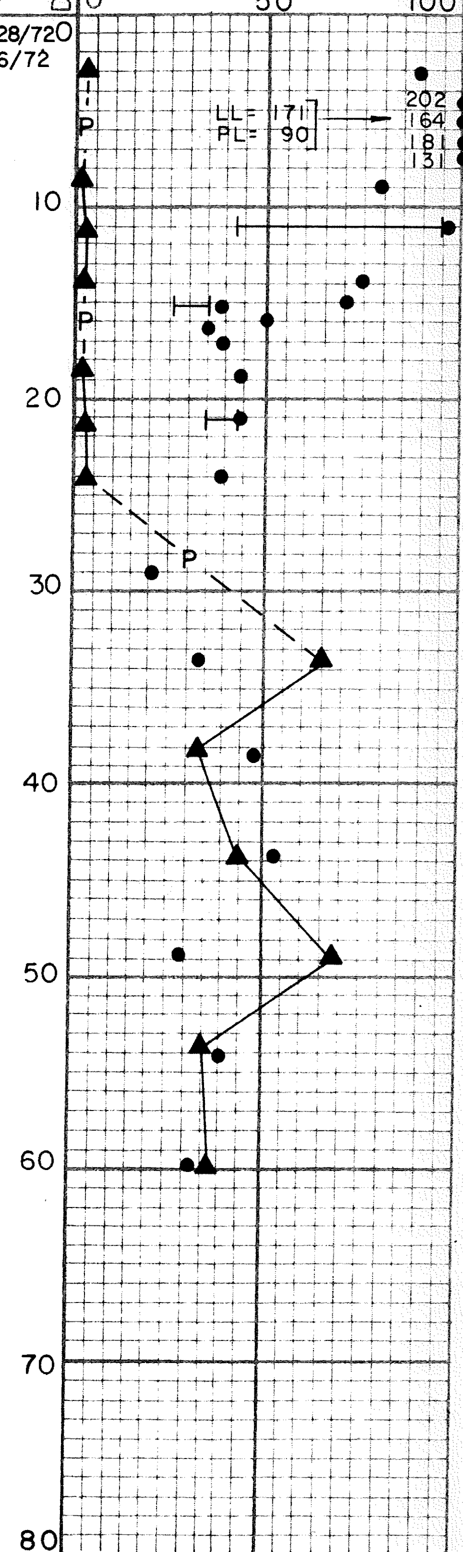
FIG. 2

File: I:\EF\24-1 PDX\04000s\04060 French Prairie Bridge\Graphics\CAD\OE Profile.dwg Date: 01-23-2017 Author: aeh

SOIL DESCRIPTION Surface Elevation 88.5'	DEPTH, feet	SAMPLES
Very soft, dark gray organic CLAY with abundant decayed organic matter.	0	1 I, 2 II, 3 I, 4 I, 5 I
Very soft dark gray silty CLAY to clayey SILT.	15	6 II, 7 I, 8 I
Very loose, dark gray sandy SILT.	22	9 I
Very dense gray slightly sandy GRAVEL with scattered wood fragments.	27	10 II, 11 I
Dense, greenish-gray sandy SILT grading to clayey sandy SILT.	36	12 I, 13 I, 14 I
Hard, light gray silty CLAY with scattered iron stained pockets.	49	15 I, 16 I
Bottom of Boring Completed 4/26/72	60	

GROUND WATER ▽ 4/28/72, 6/6/72

STANDARD PENETRATION RESISTANCE (140 lb. weight, 30" drop) ▲ Blows per foot



NOTE 1. Soil description and interfaces are interpretive and actual changes may be gradual

2. Water level is for date shown and may vary with time of year

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Impervious seal
- ▽ Water level
- ■ Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

Atterberg limits: Liquid limit, Natural water content, Plastic limit

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-1

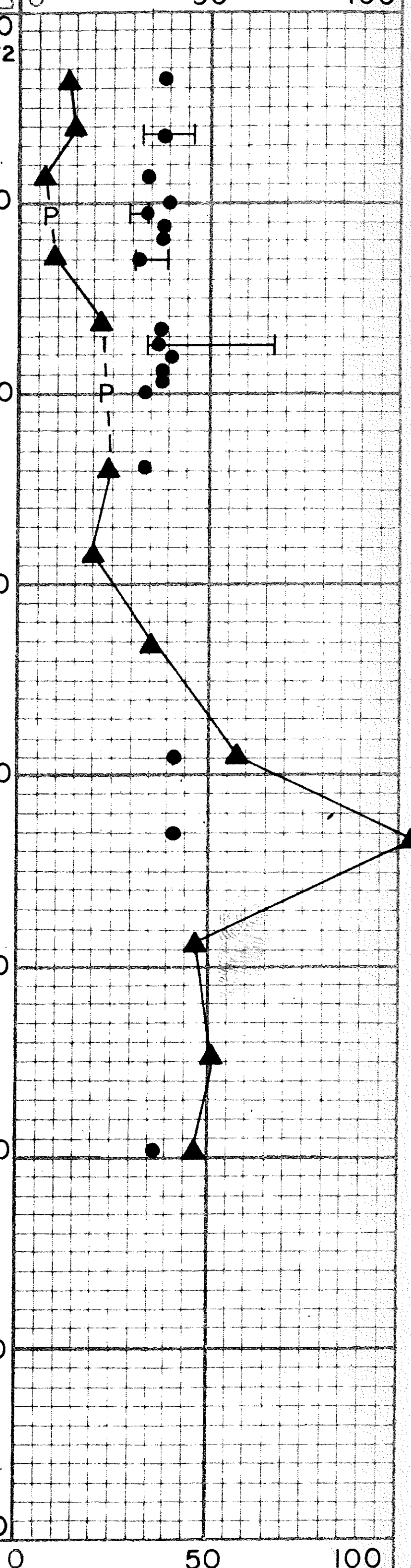
JUNE, 1972 0-639

SHANNON & WILSON, INC.
Soil Mechanics & Foundation Engineers

FIG. 3

SOIL DESCRIPTION Surface Elevation 87.5'	DEPTH, feet	SAMPLES
Stiff to firm, brown to dark gray clayey SILT with scattered roots and organic material.	0	1 I, 2 I, 3 I
Firm gray slightly clayey sandy SILT to medium dense to dense sandy SILT.	10	4 II, 5 I, 6 I, 7 II, 8 I
Medium dense to dense brown silty fine and medium to coarse SAND with fine gravel.	25	9 I, 10 I
Hard greenish gray clayey SILT.	36	11 I
Dense to very dense greenish gray silty fine to medium SAND with scattered fine gravel.	43.5	12 I, 13 I, 14 I
Hard, brown clayey SILT with pockets of silty CLAY		15 I
Bottom of Boring Completed 4/25/72	60	

GROUND WATER: 4/28/72, 6/6/72



NOTE 1. Soil description and interfaces are interpretive and actual changes may be gradual

2. Water level is for date shown and may vary with time of year

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit, Natural water content, Plastic limit
- Impervious seal
- ▽ Water level
- ■ Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-2

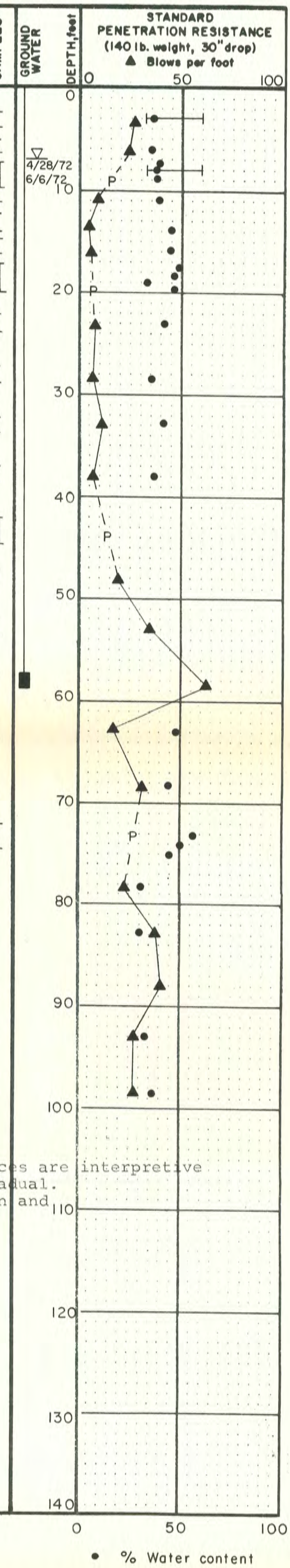
JUNE, 1972 0-639

SHANNON & WILSON, INC.
Soil Mechanics & Foundation Engineers

FIG. 4

SOIL DESCRIPTION Surface Elevation: 91.2'	DEPTH, feet	SAMPLES
Very stiff becoming soft brown silty CLAY.	0	1, 2, 3, 4, 5, 6
Loose gray sandy SILT to silty very fine SAND.	18	7, 8, 9, 10, 11
Medium dense to dense gray silty fine to medium SAND.	42	*12, 13, 14
Very stiff to hard, blue-gray silty CLAY with pockets of brown clayey SILT.	58.5	15, 16, 17, 18, 19, 20, 21, 22, 23
Bottom of Boring Completed 4/24/72	99	

GROUND WATER: 4/28/72, 6/6/72



Note: 1. Soil description and interfaces are interpretive and actual changes may be gradual.
2. Water level is for date shown and may vary with time of year.

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
- Water level
- Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-3

JUNE, 1972 0-639

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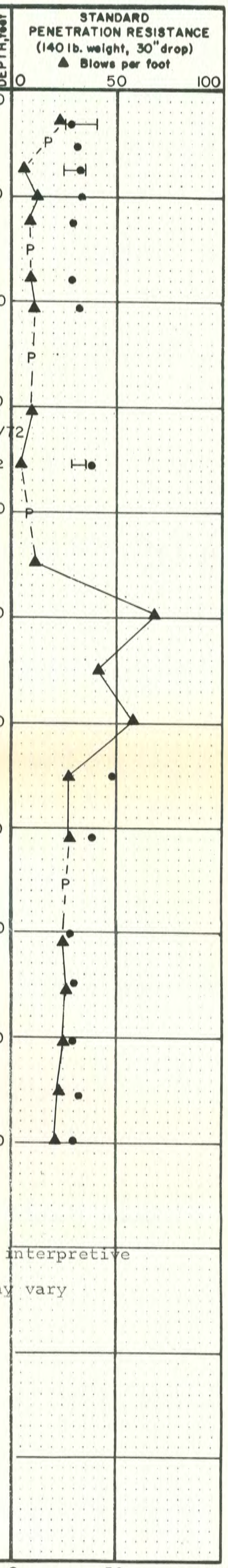
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 5

SOIL DESCRIPTION Surface Elevation:~94'	DEPTH, feet	SAMPLES
Very stiff dark brown silty CLAY.	0	1 I, 2 II
Loose to medium dense, brown slightly clayey sandy SILT grading to sandy SILT. Firm clayey SILT lense at 12 to 14 feet.	7	3 I, 4 I, 5 I, 6 II, 7 I
Loose to medium dense, brown silty fine SAND.	20	8 I, 9 II, 10 I
Soft to firm, gray clayey SILT.	33	11 I
Loose to medium dense brown slightly silty fine to medium SAND.	38	12 II, 13 I
Very dense, brown slightly clayey silty sandy GRAVEL.	47	14 I, 15 I
Very stiff, mottled blue-gray and mottled brown silty CLAY with pockets of clayey SILT.	60.5	16 I, 17 I, 18 I, 19 II, 20 I, 21 I, 22 I, 23 I, 24 I
Bottom of Boring Completed 4/21/72	101	

GROUND WATER: ▽ 4/28/72 (about 31 ft); ▽ 6/6/72 (about 35 ft)



Note: 1. Soil description and interfaces are interpretive and actual changes may be gradual.
2. Water level is for date shown and may vary with time of year.

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
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- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-4

JUNE, 1972 0-639

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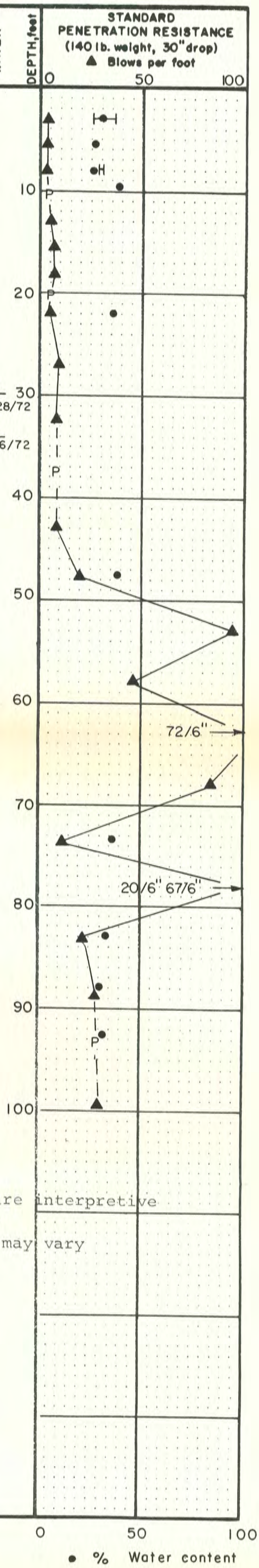
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 6

DEPTH, feet	SOIL DESCRIPTION — Surface Elevation: 92.6'
0	Very loose to loose, dark brown slightly clayey sandy SILT to sandy SILT.
9	Loose to medium dense brown sandy SILT to silty very fine SAND.
50	Very dense gray silty fine to medium SAND with gravel.
55	Very dense brown sandy GRAVEL.
70	Stiff gray clayey SILT.
75	Very dense brown SAND and GRAVEL.
80	Very stiff to hard, mottled blue-gray to mottled brown silty CLAY with pockets of silt.
100	Bottom of Boring Completed 4/21/72

SAMPLES: 1 I, 2 I, 3 I, 4 II, 5 I, 6 I, 7 I, 8 II, 9 I, 10 I, 11 I, 12 II, 13 I, 14 I, 15 I, 16 I, 17 I, 18 I, 19 I, 20 I, 21 I, 22 I, 23 II, 24 I

GROUND WATER: ▽ 4/28/72; ▽ 6/6/72



Note: 1. Soil description and interfaces are interpretive and actual changes may be gradual.

2. Water level is for date shown and may vary with time of year.

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
- ▽ Water level
- ■ Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-5

JUNE, 1972 0-639

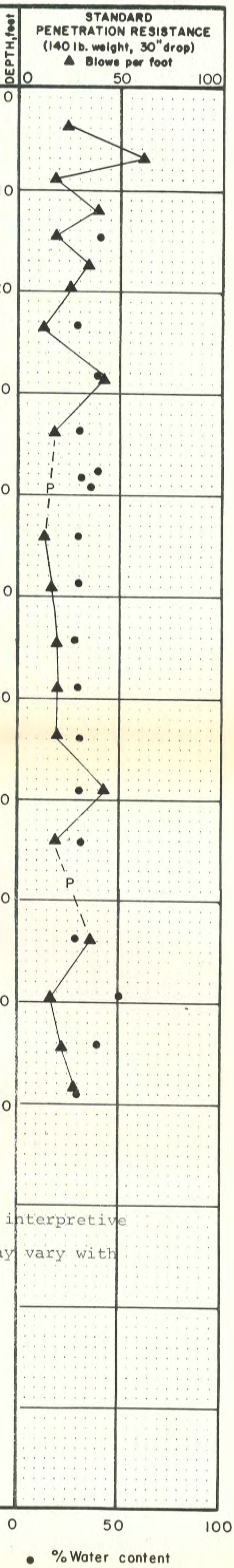
SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 7

SOIL DESCRIPTION Mudline Elevation: ~42'	DEPTH, feet
Medium dense to dense gray silty sandy GRAVEL.	0
Soft to firm brown clayey SILT.	12
Medium dense to dense gray silty fine to medium SAND and sandy GRAVEL with abundant wood frags.	14
Dense gray sandy SILT to silty fine SAND with scattered gravel.	20
Stiff to verystiff brown to mottled gray silty CLAY to clayey SILT.	28.5
Medium dense to dense gray sandy SILT.	56
Very stiff to hard gray silty CLAY to clayey SILT.	70
Bottom of Boring Completed 5/5/72	99.5

SAMPLES: 1 I, 2 I, 3 I, 4 I, 5 I, 6 I, 7 I, 8 I, 9 I, 10 I, 11 II, 12 I, 13 I, 14 I, 15 I, 16 I, 17 I, 18 I, 19 II, 20 I, 21 I, 22 I, 23 I

GROUND WATER



Note: 1. Soil description and interfaces are interpretive and actual changes may be gradual.
2. Water level is for date shown and may vary with time of year.

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
- Water level
- Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-6

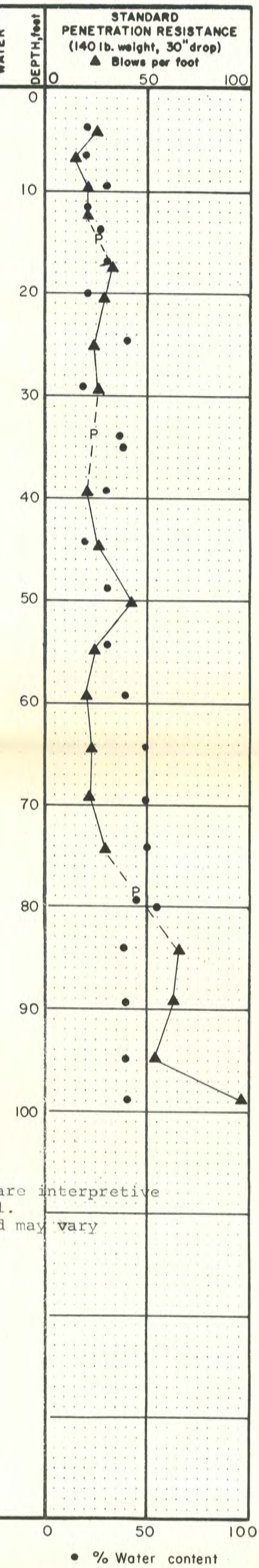
JUNE, 1972 0-639

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 8

Mudline **Elevation:~20'**

DEPTH, feet	SOIL DESCRIPTION	SAMPLES
0	Loose to medium dense brown silty fine to medium SAND.	
4	Very stiff mottled blue-gray silty CLAY with pockets of brown clayey SILT.	1, 2, 3, 4
13	Very stiff to hard brown silty CLAY with pockets of blue-gray clayey SILT.	5, 6, 7, 8, 9
32	Very stiff to hard gray clayey SILT with scattered lenses of sandy and gravelly SILT and decomposed wood fragments.	10, 11, 12, 13, 14, 15, 16
68	Very stiff to hard blue-gray silty CLAY with scattered lenses of silty fine sand.	17, 18, 19
81	Very dense blue-gray sandy SILT with scattered mica flakes, grading to clayey silt at bottom.	20, 21, 22, 23
99.9	Bottom of Boring Completed 5/4/72	



Note:
1. Soil description and interfaces are interpretive and actual changes may be gradual.
2. Water level is for date shown and may vary with time of year.

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
- Water level
- Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

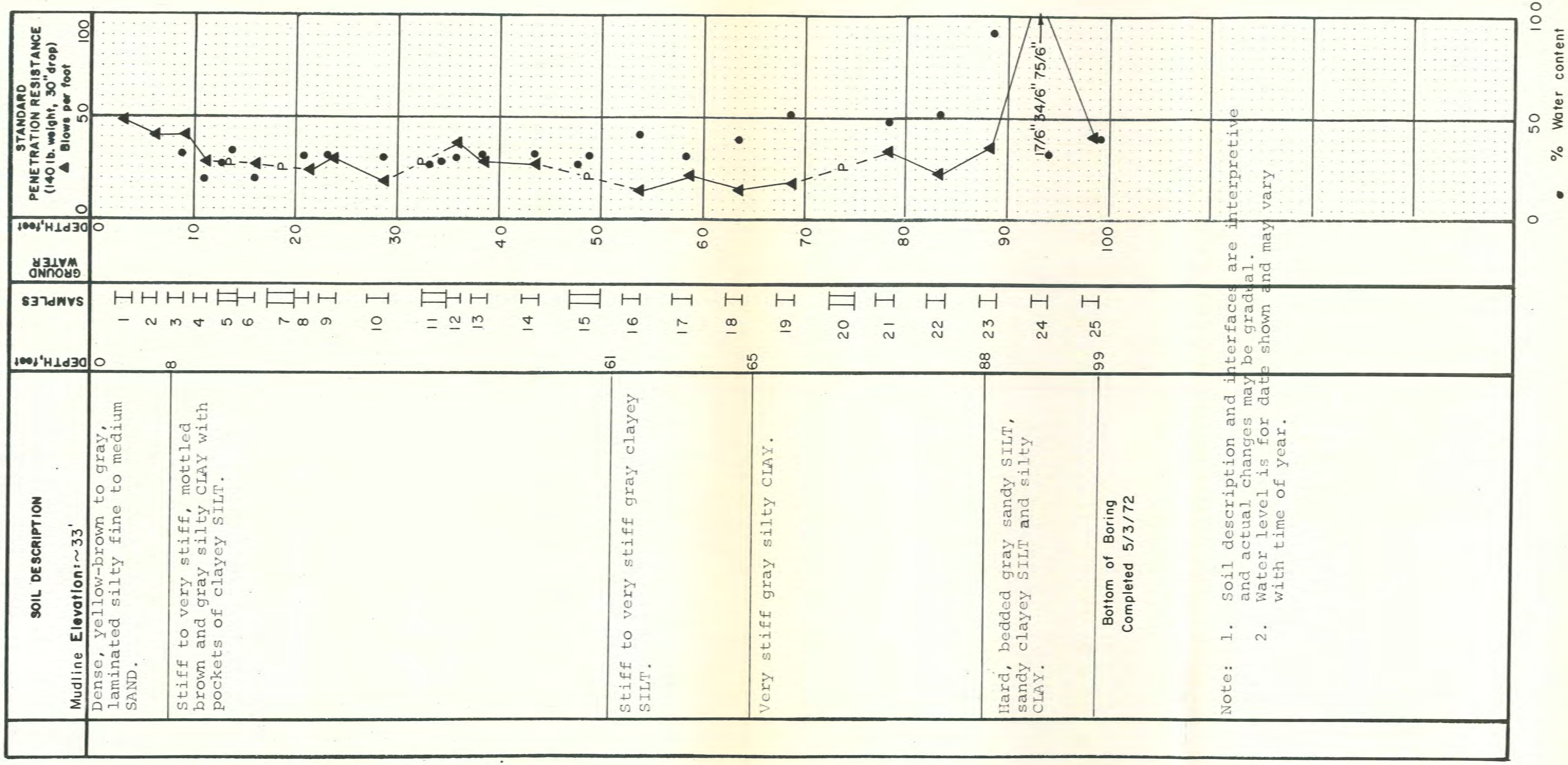
WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-7

JUNE, 1972 0-639

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 9



LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- Atterberg limits: Liquid limit, Natural water content, Plastic limit
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-8

JUNE, 1972 0-639

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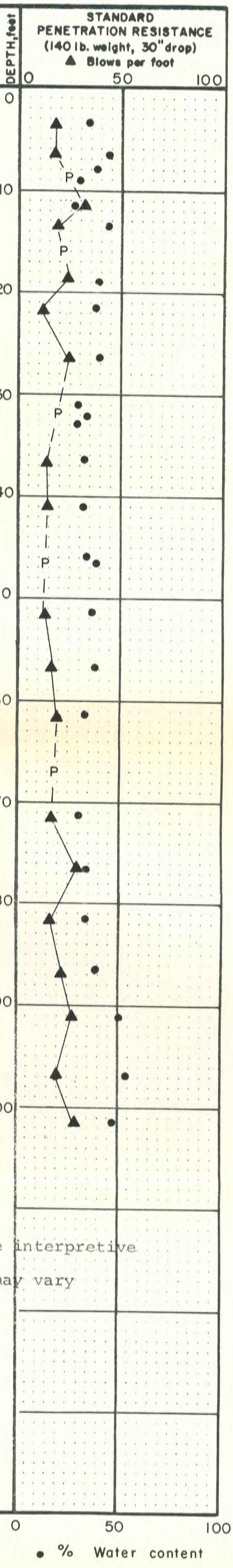
FIG. 10

SOIL DESCRIPTION Mudline **Elevation:~55'**	DEPTH, feet	SAMPLES	GROUND WATER
Very stiff gray silty CLAY.	0		
Very stiff to hard blue-gray, mottled brown silty CLAY.	5	1 – 17	
Very stiff gray clayey SILT.	70	18 – 24	
Bottom of Boring Completed 5/2/72	102		



Note: 1. Soil description and interfaces are interpretive and actual changes may be gradual.
2. Water level is for date shown and may vary with time of year.

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

Atterberg limits:
- Liquid limit
- Natural water content
- Plastic limit

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-9

JUNE, 1972 0-639

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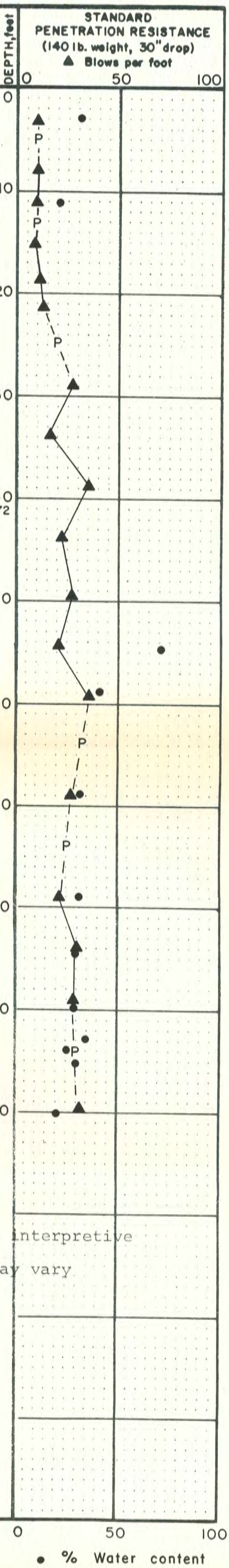
FIG. 11

DEPTH, feet	SOIL DESCRIPTION Surface Elevation: 110.9'	SAMPLES
0	Firm to stiff brown clayey SILT.	1, 2
8.5	Loose to medium dense brown sandy SILT to silty fine SAND.	3, 4, 5, 6, 7, 8, 9
26.5	Medium dense to dense sandy GRAVEL and gravelly silty SAND and SILT - cobble or boulder at 40 and 49 feet.	10, 11, 12, 13, 14
53.5	Very stiff to hard, greenish-gray, mottled blue-gray and mottled brown silty CLAY with pockets of clayey SILT.	15, 16, 17, 18, 19, 20, 21, 22, 23, 24
100	Bottom of Boring Completed 5/2/72	

GROUND WATER: ▽ 40, 6/6/72



Note: 1. Soil description and interfaces are interpretive and actual changes may be gradual.
2. Water level is for date shown and may vary with time of year.

LEGEND

- Ι 2.0" O.D. split spoon sample
- ΙΙ 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
- ▽ Water level
- ▮ Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

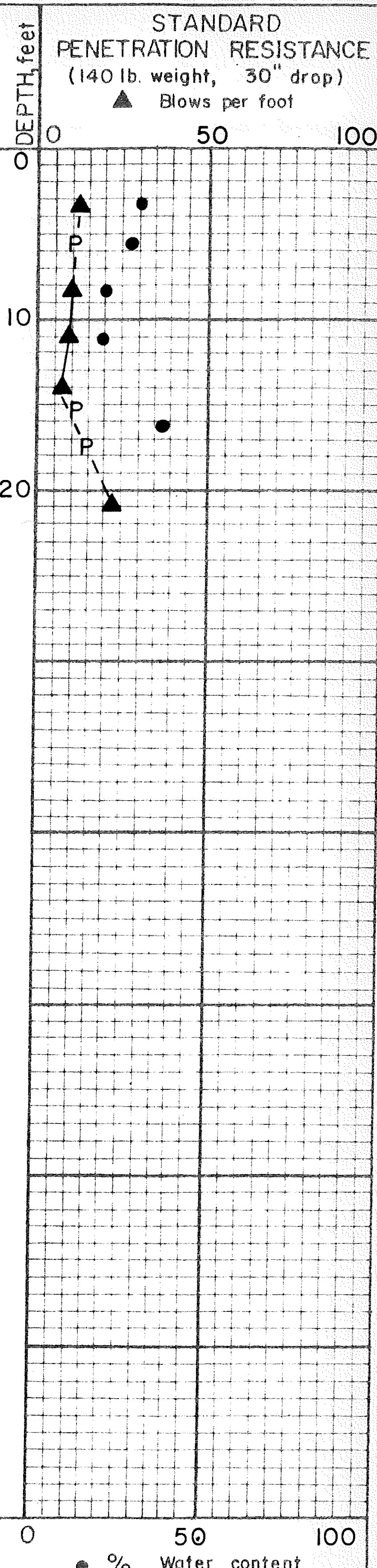
WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-10

JUNE, 1972 SHANNON & WILSON 0-639
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 12

SOIL DESCRIPTION Surface Elevation 122.5'	DEPTH, feet	SAMPLES	GROUND WATER
Stiff dark brown clayey sandy SILT with scattered roots.	0	1 I	
Loose to medium dense brown sandy SILT to silty very fine SAND.	5	2 II, 3 I, 4 I, 5 I, 6 II, 7 II	
Sandy SILT and COBBLES.	19	8 I	DRY 6/6/72
Bottom of Boring Completed 5/2/72	21.5		



NOTE 1. Soil description and interfaces are interpretive and actual changes may be gradual

2. Water level is for date shown and may vary with time of year

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit, Natural water content, Plastic limit
- Impervious seal
- ∇ Water level
- ■ Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE
WILSONVILLE, OREGON

LOG OF BORING NO. B-11

JUNE, 1972 0-639

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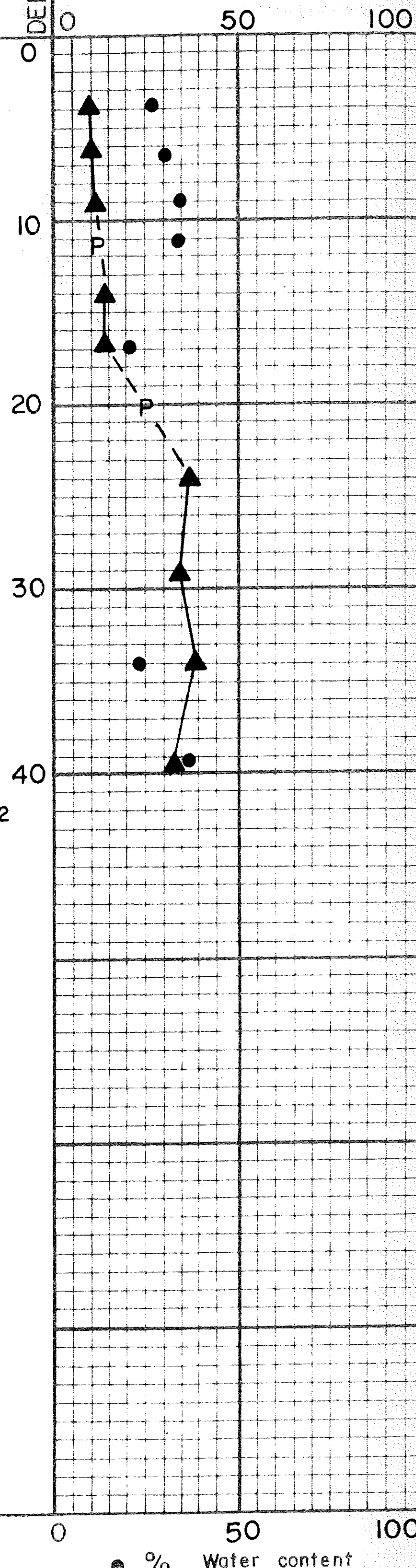
FIG. 13

SOIL DESCRIPTION Surface Elevation 156.3'	DEPTH, feet	SAMPLES	GROUND WATER
Stiff brown clayey SILT with scattered sand.	0	1 I 2 I 3 I	
Medium dense brown sandy SILT.	11	4 II 5 I 6 I	
Dense brown slightly silty fine to medium SAND.	18	7 II 8 I 9 I	
Medium dense to dense brown sandy SILT.	28.5	10 I 11 I	
Bottom of Boring Completed 4/27/72	40		DRY 6/6/72

STANDARD PENETRATION RESISTANCE (140 lb. weight, 30" drop)

▲ Blows per foot



NOTE 1. Soil description and interfaces are interpretive and actual changes may be gradual

2. Water level is for date shown and may vary with time of year

LEGEND

I 2.0" O.D. split spoon sample	Impervious seal
II 3.0" O.D. thin-wall sample	▽ Water level
* Sample not recovered	■ Piezometer tip
Atterberg limits	P Sampler pushed
Liquid limit	USC Unified Soil Classification
Natural water content	
Plastic limit	

WILLAMETTE RIVER BRIDGE 43.4

WILSONVILLE, OREGON

LOG OF BORING NO. B-12

JUNE, 1972 0-639

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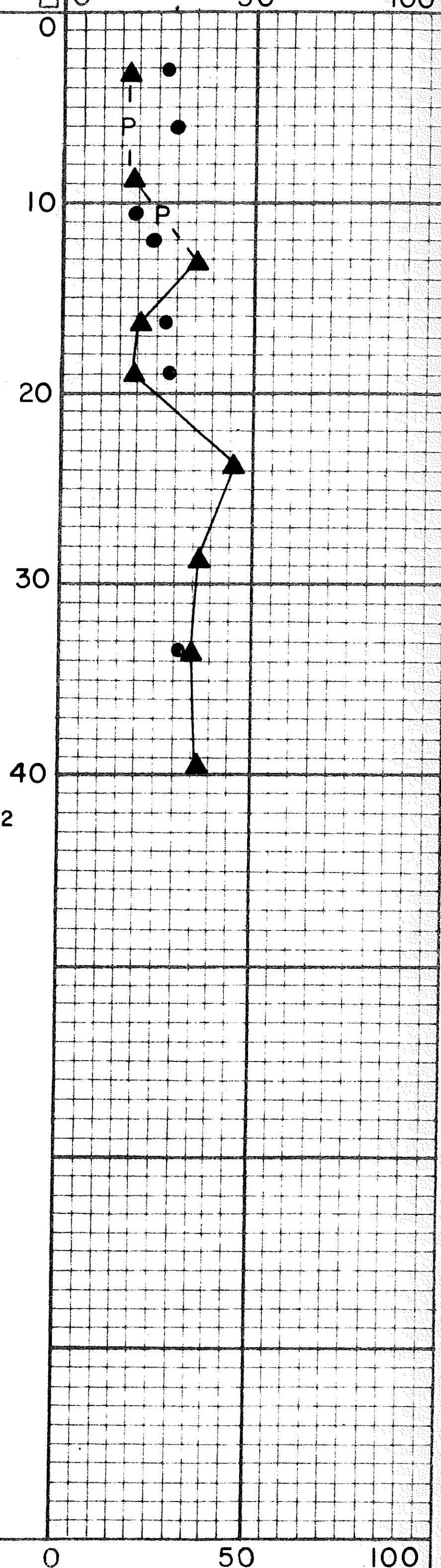
FIG.14

SOIL DESCRIPTION	DEPTH, feet	SAMPLES	GROUND WATER
Surface Elevation ~160'			
Medium dense brown sandy SILT to very fine SAND.	0	1 I, 2 II, 3 I, 4 II, 5 I	
Very stiff brown clayey SILT.	16	6 I, 7 I	
Dense brown slightly silty fine SAND.	19		
Dense light brown silty very fine SAND to sandy SILT.	22.5	8 I, 9 I, 10 I, 11 I	
Bottom of Boring Completed 4/28/72	40		DRY 6/6/72

STANDARD PENETRATION RESISTANCE
(140 lb. weight, 30" drop)
▲ Blows per foot



● % Water content

NOTE 1. Soil description and interfaces are interpretive and actual changes may be gradual

2. Water level is for date shown and may vary with time of year

LEGEND

I 2.0" O.D. split spoon sample	Impervious seal
II 3.0" O.D. thin-wall sample	▽ Water level
* Sample not recovered	■ Piezometer tip
Atterberg limits: Liquid limit, Natural water content, Plastic limit	P Sampler pushed
	USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-13

JUNE, 1972 0-639

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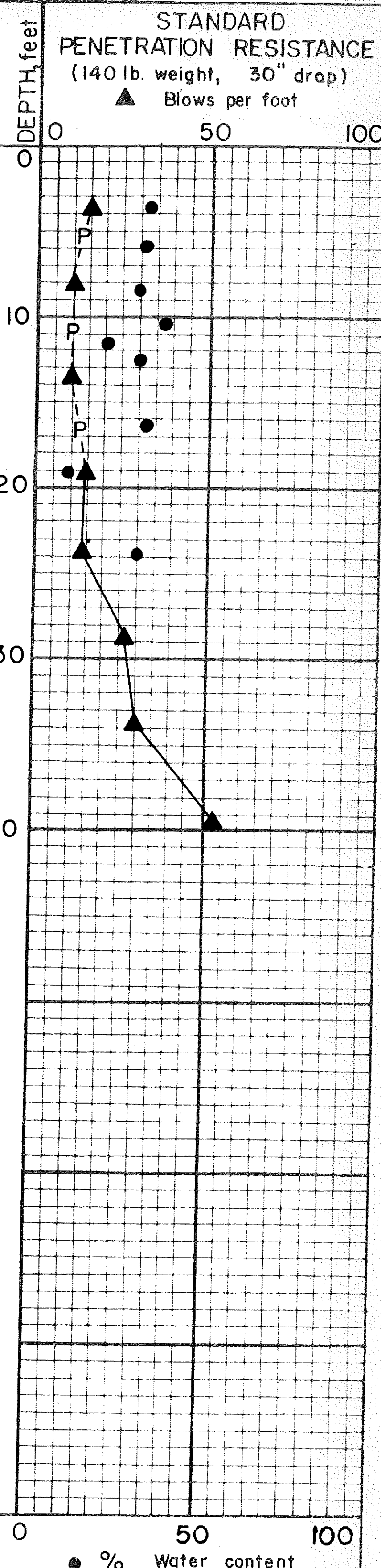
FIG. 15

SOIL DESCRIPTION Surface Elevation~174'	DEPTH, feet	SAMPLES
Stiff brown clayey SILT.	0	1
Loose to medium dense brown sandy SILT.	4	2, 3, 4, 5
Medium dense brown clayey sandy SILT.	16	6, 7, 8
Medium dense becoming dense to very dense brown sandy SILT to silty very fine SAND.	25	9, 10, 11
Bottom of Boring Completed 4/28/72	40	

GROUND WATER: DRY 6/6/72



NOTE 1. Soil description and interfaces are interpretive and actual changes may be gradual
2. Water level is for date shown and may vary with time of year

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- ✳ Sample not recovered
- Atterberg limits: Liquid limit, Natural water content, Plastic limit
- Impervious seal
- ▽ Water level
- ■ Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4
WILSONVILLE, OREGON

LOG OF BORING NO. B-14

JUNE, 1972 0-639

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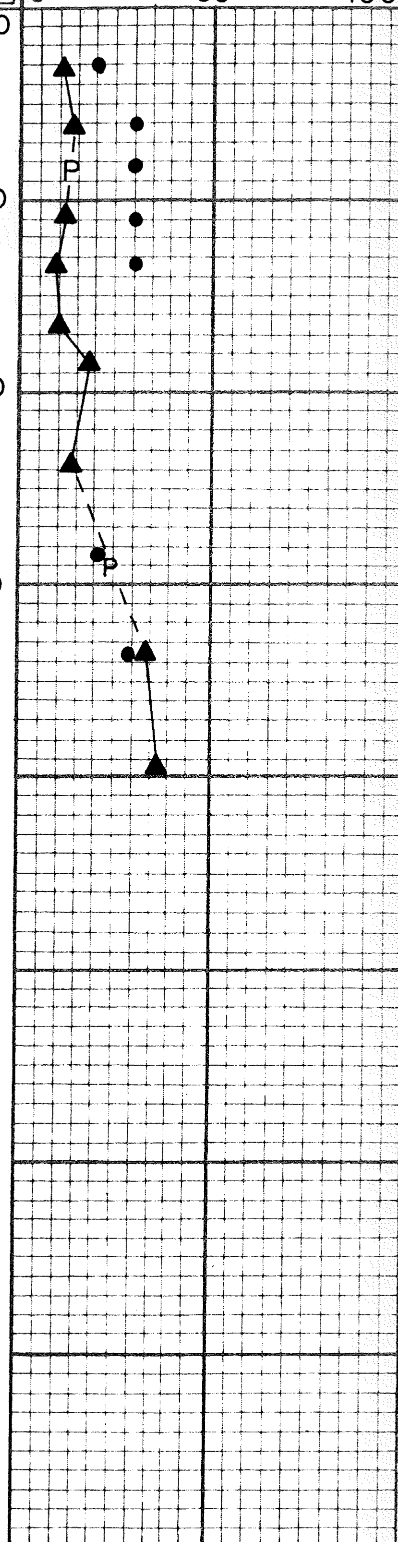
FIG. 16

SOIL DESCRIPTION Surface Elevation~174'	DEPTH, feet	SAMPLES	GROUND WATER
Medium dense, brown sandy clayey to slightly clayey SILT.	0	1, 2	
Loose to medium dense brown sandy SILT.	8	3, 4, 5, 6, 7, 8, 9	
Dense brown silty fine SAND.	33	10, 11	DRY 6/6/72
Bottom of Boring Completed 5/1/72	40		



NOTE 1. Soil description and interfaces are interpretive and actual changes may be gradual

2. Water level is for date shown and may vary with time of year

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- * Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
- ▽ Water level
- ■ Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

WILLAMETTE RIVER BRIDGE 43.4

WILSONVILLE, OREGON

LOG OF BORING NO. B-15

JUNE, 1972 0-639

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Soil Mechanics & Foundation Engineers

FIG. 17

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