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MEMORANDUM

To: Jeff Harrington / City of Astoria Public Works Director
Astoria Development Commission
John Southgate / John Southgate Consulting, LLC

Date: December 14, 2021

GRI Project No.: 6580-A

From: Christopher Ell, PE, GE

Re: Preliminary Geotechnical Assessment
Heritage Square Development
12th and Duane Street
Astoria, Oregon

This memorandum provides preliminary geotechnical considerations for the proposed Heritage Square Development concept planning. The site is located on the eastern half of the block and immediately east of the Garden of Surging Waves public space between 11th and 12th streets and Exchange and Duane streets in Astoria, Oregon. The purpose of this memorandum is to evaluate, on a preliminary basis, the existing subsurface conditions in the site vicinity and how they may affect design and construction of the planned facilities; key geotechnical site considerations for preliminary planning purposes; potential foundation alternatives; a summary of current seismic design standards applicable to the development; and recommendations for a supplemental subsurface exploration program on the site. This memorandum summarizes our preliminary conclusions and the anticipated key geotechnical considerations regarding site development in consideration of the future design effort. It should be noted that additional geotechnical work will be required once the development team has been selected. This work will include subsurface explorations, engineering analysis, and project-specific recommendations, which will be summarized in a geotechnical report.

PROJECT EXPERIENCE AND SITE BACKGROUND

GRI previously conducted a geotechnical investigation for the Garden of Surging Waves project in the western area of the block. The investigation included geotechnical borings, laboratory testing, and engineering analysis for the construction of relatively small, lightly loaded structures on the site. A report for this investigation is summarized in our December 12, 2011, report titled, "Geotechnical Investigation, Legion Block Amphitheatre and Public Space, Garden of Surging Waves, Astoria, Oregon." As part of the previous investigation, two borings were advanced on the western half of the block and two borings were advanced in the vicinity of the proposed Heritage Square Development project in the eastern portion of the block. GRI also completed subsurface investigations for several other projects near the site, including the Astoria Senior Center, near 11th and Exchange Street; Columbia Memorial Hospital Cancer Center, near 18th and Exchange Street; and Clatsop Community College-Patriot Hall Redevelopment, near 16th and Lexington

Street. Additionally, GRI has extensive experience with several other recent additions to Columbia Memorial Hospital located several blocks to the east and other structures along the waterfront.

The majority of the block currently proposed for development was previously occupied by a Safeway store. The main Safeway building has been removed and remnants of concrete loading docks, below-grade concrete basement structures, and elevated slabs from previous parking structures remain at the site. Based on our previous experience at the site and with similar projects in the site vicinity, the original site grades were substantially raised with significant thicknesses of dredge sand spoils from the Columbia River.

PROJECT DESCRIPTION

Our understanding of the project is based on our discussions with Mr. John Southgate of John Southgate Consulting, LLC. We understand the Astoria Development Commission is considering a new affordable housing building with a maximum three-story wooden structure and possibly one story below grade. The preliminary development plans may include the potential for about 80 units as part of the new building complex. Figure 1 shows a layout of the site on a boundary survey provided to GRI in 2011, which shows site features prior to completion of the Garden of Surging Waves Project. The parking lot at the southwest corner of the block is also included as available space to be utilized for the proposed development.

SITE DESCRIPTION

General

The project site is located on the eastern half of the block between 11th and 12th streets and Exchange and Duane streets in Astoria, Oregon. The site was formerly occupied by a Safeway store that has been partially removed. The site has remnants of the previous structure, including an exposed basement in the northern portion of the block with below-grade concrete slab and perimeter retaining walls supported by concrete columns and temporary steel struts. The southern portion of the site has a concrete loading dock with ramp access below site grades. The eastern portion of the block has an elevated concrete structured slab from the previous below-grade parking structure and is currently utilized as a street-grade surface parking lot. The existing American Legion Hall borders the site on the southwestern portion of the block. The site is located in relatively flat terrain in the developed downtown area of Astoria, about 700 feet south of the Columbia River waterfront. It is approximately 200 feet to 300 feet north of the adjacent foothills. Existing buildings of significant age are present along the perimeter and across the bordering streets surrounding the site.

Geology

The site is generally underlain by dredge sand fill with variable silt content. Published geologic maps of the area indicate the fill is underlain by soft, Quaternary age, alluvial silt deposits (Schlicker et al., 1972). Miocene-age marine sedimentary deposits, locally known as the Astoria Formation, underlie the site at depth. The Astoria Formation generally consists of extremely soft to soft siltstones and mudstones.

REVIEW OF SUBSURFACE CONDITIONS AND GROUNDWATER DATA

General

Subsurface materials and conditions at the site were investigated in November 2011 for the adjacent Garden of Surging Waves project. The investigation advanced four borings to depths ranging between 31.5 feet to 41.5 feet below the pavement and concrete slab surfaces at the locations shown on Figure 1. In general, the borings disclosed the following major units based on their physical characteristics and engineering properties.

a. PAVEMENT or CONCRETE SLABS
b. FILL (Silt, Sand, and Gravel)
c. SAND (Alluvium)
d. BASALT Fragments
e. SILTSTONE

Logs of the borings shown at the locations on Figure 1 are provided for preliminary informational purposes in Appendix A, designated B-1 through B-4. The following paragraphs provide information from our previous report, including a detailed description of the soil units and a discussion of the groundwater conditions at the site previously explored at the site.

a. PAVEMENT or CONCRETE SLABS

A 2-inch-thick layer of asphalt concrete (AC) pavement was encountered at the ground surface in borings B-1 and B-3 on the west side of the site. The AC is underlain by about 28 inches of crushed rock base course. Borings B-2 and B-4 were advanced through holes cored in the structured concrete slab, which varies in thickness from about 5 inches to 6 inches at borings B-2 and B-4, respectively. The ground surface is located about 10 feet to 7.5 feet below the surface of the slab in borings B-2 and B-4, respectively.

b. FILL (Silt, Sand, and Gravel)

Beneath the AC pavement on the west side of the site and at the ground surface beneath the structured slab on the east side of the site, the site is mantled with variable fill. The thickness of fill ranges from about 12.5 feet (below basement level) to about 21.5 feet (below street level), corresponding to about elevation -3.0 feet to +1.5 feet. The fill typically consists of silt, sand, and gravel. Borings B-1 and B-3 advanced near street grade on the west side of the site encountered a 6- to 10-foot-thick layer of clayey silt fill beneath the pavement base course. The clayey silt fill is rust-brown and contains some fine- to coarse-grained sand and scattered gravel and siltstone fragments. Borings B-2 and B-4 advanced below the basement level on the east side of the site encountered a 1.5- to 2.5-foot-thick layer of dark gray silt fill beneath a surficial layer of sand fill. The dark gray silt fill contains a trace to some fine-grained sand and fine organics. Based on review of blow counts and torvane shear strength values, the relative consistency of the silt fill ranges from very soft to stiff.

Beneath the silt fill on the west side of the site and at the ground surface beneath the slab on the east side of the site, the borings encountered sand fill. The thickness of the sand fill ranges from about 7 feet to 12 feet in borings B-1 and B-3 and about 2.5 feet to 10 feet in borings B-2 and B-4. The sand is gray, fine-grained, and contains varying percentages of silt ranging from a trace to silty, scattered gravel, and fine organics. The relative density of the sand fill is very loose to loose. Abundant wood debris, likely associated with the December 7, 1922, Astoria fire, was encountered at the base of the sand fill in all of the borings.

Beneath the sand fill in borings B-3 and B-4, the borings encountered a 1.5- to 3-foot-thick layer of gravel fill that ranges from rounded to angular and contains a matrix of silt, sand, and clay. The relative density of the gravel fill is medium dense to very dense.

c. SAND (Alluvium)

The fill described above is underlain by sand that extends to a maximum depth of 39 feet at the location of B-1; B-2 was terminated in sand at a depth of 31.5 feet below the surface of the existing concrete slab. The sand is gray, fine grained, and contains varying percentages of silt ranging from a trace of silt to silty. Scattered gravel, siltstone fragments, and fine organics are present within the sand and suggest the material is possibly fill. The relative density of the sand ranges from loose to medium dense and is typically loose. It should be noted that previous studies and boring logs indicated the lower sand unit may be possible fill. However, based on our recent understanding of the historical use of the site, the material is likely alluvium, and the depth of fill is likely as described above. The depth of alluvium and fill should be confirmed by additional borings in the forthcoming subsurface investigation.

d. BASALT Fragments

Cobble- to boulder-size fragments of dark gray basalt were encountered beneath the sand in borings B-1 and B-3. The thickness of the unit is about 2 feet to 2.5 feet in boring B-3; boring B-1 was terminated in basalt fragments at a depth of 41.5 feet below the ground surface. Based on the drill action, we estimate the fragments are angular and the size of cobbles or boulders.

e. SILTSTONE

Boring B-3 encountered siltstone beneath the basalt fragments and boring B-4 encountered siltstone beneath the alluvial sand. The siltstone is typically gray brown, is extremely soft (R0), and its relative weathering is fresh. Borings B-3 and B-4 were terminated in siltstone at a depth of 40 feet and 36.5 feet, respectively. While penetration into the siltstone was limited, our experience in the area indicates rock hardness typically increases with depth up to R2 (soft).

Groundwater

The borings were advanced using mud-rotary methods, which does not permit direct measurement of groundwater conditions during drilling. Based on our experience with other nearby projects, we anticipate *t*he groundwater level at the site will fluctuate with seasonal precipitation and the approximate tide levels of the Columbia River. We anticipate the local groundwater level typically occurs at depths of about 10 feet to 15 feet; however, shallow perched groundwater levels can occur following prolonged, intense rainfall. Shallow groundwater will also occur during flood stages of the Columbia River. It should be noted that prior to the recent site improvements, the adjacent site of the Astoria Senior Center had a history of shallow groundwater issues, including basement flooding and standing water observed at street grade.

PRELIMINARY GEOTECHNICAL CONSIDERATIONS

General

Depending on the final layout of the building and other facilities, we anticipate the key geotechnical considerations for the project will include the necessity of deep foundations to support the structure; maintaining control of the shallow groundwater in below-grade excavations and future basement structures; and depending on the type of deep foundation selected, the need to perform vibration and settlement monitoring of adjacent structures with driven displacement piles, or alternatively, the handling and disposal of potentially contaminated spoils from drilled piles that typically use non-displacement methods.

Other geotechnical considerations include the need for significant demolition of existing remnant concrete structures from previous buildings and parking areas and the liquefaction potential of the underlying dredge sand fill. We assume the seismic concerns for liquefaction in the underlying loose, saturated dredge sand fills will be mitigated using a deep foundation system to support the structure and slab. Temporary shoring for basement structures may also have challenges, given that the use of tie-backs for shoring walls adjacent to roadways may be limited by the available right-of-way space or existing utilities within typical anchor zones. If anchors are necessary, the use of shorter anchors in more significant numbers could be considered, but often results in less anchor capacity and efficiency. Alternatively, braced excavations are likely feasible.

The following preliminary geotechnical considerations are provided to assist the design team with initial project planning during Phase 1. Further recommendations will be provided for final design during a later phase.

Soils and Groundwater

Based on our review of the subsurface explorations previously completed for the adjacent project and our experience in the project area, we anticipate the site is mantled with varying depths of sand, silt, and gravel fill overlying alluvial sand, which is underlain by siltstone bedrock. Near the eastern half of the block, the relative density of the sand fill is primarily very loose to loose, and the relative consistency of the silty fill soils are typically very soft to medium stiff. Intermittent layers of very dense gravel, cobbles, and boulders were encountered within the sand and silt deposits, as well as wood debris. Siltstone of the Astoria Formation was encountered at depths between about 36.5 feet below street grade (E.L. -13.5 feet) to 34 feet below basement grade (E.L. -19.0 feet) in the southwestern and southeastern areas of the site, respectively.

Due to the close proximity of the Columbia River, the groundwater level at the site will rise and fall in response to river fluctuations and rainfall. In general, we anticipate the static groundwater level is about 15 feet below the existing ground surface and may approach the ground surface during the wet, winter and spring months or following periods of prolonged or intense precipitation.

Seismic Considerations

General Code Requirements

At this time, the project is in the conceptual phase. However, we anticipate the new structure will be wood framed with up to three above-grade levels and possibly one below-grade level. We anticipate the proposed building will be designed in accordance with the 2019 Oregon Structural Specialty Code (OSSC), which incorporates recommendations for seismic design from the American Society of Civil Engineers (ASCE) document 7-16, *Minimum Design Loads for Building and Other Structures* (ASCE 7-16). The ASCE 7-16 seismic-hazard levels are based on a Risk-Targeted Maximum Considered Earthquake (MCE_R). The ground motions associated with the probabilistic MCE_R represent a targeted risk level of 1% in 50 years' probability of collapse in the direction of maximum horizontal response. These risk-targeted ground motions are generally developed by applying adjustment factors of directivity and risk coefficients to the 2% probability of exceedance in 50 years or a 2,475-year return-period hazard level. The risk-targeted probabilistic values are also subject to a deterministic limit.

The OSSC is currently in the process of being updated and largely incorporating changes made to the 2021 International Building Code (IBC), which are primarily related to structural detailing requirements. The new OSSC will likely need to be referenced, given that it is expected to come out in 2022. It should be noted that the next version of ASCE-7 is available and has some significant changes; however, it is not expected to be adopted by the IBC until 2024 and the OSSC until 2025.

Liquefaction and Cyclic Softening

Liquefaction is a process by which loose, saturated, granular materials, such as clean sand, temporarily lose stiffness and strength during and immediately after a seismic event. This degradation in soil properties may be substantial and abrupt, particularly in loose sands. Liquefaction occurs as seismic shear stresses propagate through saturated soil and distort the soil structure, causing loosely packed groups of particles to contract or collapse. If drainage is impeded and cannot occur quickly, the collapsing soil structure causes the pore-water pressure to increase between the soil grains. If the pore-water pressure becomes sufficiently large, the inter-granular stresses become small and the granular layer temporarily behaves as a viscous fluid rather than a solid. The ratio of pore-water pressure to effective stress is defined as Ru, and as Ru values increase, there is an increased risk of settlement, loss of bearing capacity, lateral spreading, and/or slope instability, particularly along waterfront areas. Liquefaction-induced settlement occurs as the elevated pore-water pressures dissipate and the soil consolidates after the earthquake.

The term cyclic softening is typically associated with fine-grained soils and describes a relatively gradual and progressive increase in shear strain with load cycles. Excess pore pressures may increase due to the cyclic loading but will generally be less than the total overburden stress (i.e., Ru < 1). Shear strains accumulate with additional loading cycles, but an abrupt or sudden decrease in shear stiffness is not typically observed. Settlement due to post-seismic consolidation can occur, particularly in lower-plasticity silts. Large shear strains can develop and strength loss related to soil sensitivity may be a concern.

On a conceptual-level basis, our review of the existing subsurface explorations and experience at the site indicate the project area is likely underlain by relatively loose sand soils susceptible to liquefaction and/or strength loss during a code-based MCE_R seismic event. Previous studies in the area indicate associated seismic-induced settlements on the order of 12 inches (+/-) may occur based on our understanding of fill thicknesses at the site. A portion of this settlement would occur during shaking, with the large majority occurring over the preceding hour.

Tsunami Hazards

Based on our understanding of the proposed site location, proximity to the nearby Columbia River, and previous modeling performed at adjacent sites, a tsunami hazard associated with the nearby Cascadia Subduction Zone (CSZ) is likely present at the site. A review of the ASCE 7-16 2,475 years' probabilistic tsunami model in the site vicinity indicates inundation will terminate north of the project site on Marine Drive. However, deterministic modeling completed by the Oregon Department of Geology and Mineral Industries (DOGAMI) indicates the site is susceptible to inundation from both the XL and XXL events. These events are associated with a full-rupture M_W 9+ event on the CSZ and an average interevent period of about 1,050 years to 1,200 years. It should be noted the generally available tsunami modeling presented by ASCE utilizes a relatively coarse grid of about 60 m (2 arc seconds).

Coseismic Subsidence

Modeling of megathrust earthquake ruptures on the CSZ indicates sequences of interseismic uplift and coseismic coastal subsidence. Leonard et al. (2010), Witter et al. (2011), and ASCE 7-16 present profiles of coastal deformations from Northern California to Southern British Columbia based on this geologic information. Based on a review of information from a nearby project provided by Witter et al. (2011), subsidence on the order of 2.3 meters and 3.5 meters are anticipated for the

L1 and XXL1 CSZ earthquake events. The ASCE 7-16 documentation indicates the estimated 2,500-year probabilistic subsidence is 1.8 meters.

Other Seismic Hazards

Due to site topography and the proximity to existing infrastructure between the site and the Columbia River, the potential for liquefaction-induced lateral spreading is low. Based on fault mapping conducted by the U.S. Geological Survey, the weighted location of the CSZ rupture is about 26 kilometers from the site (Personius et al., 2003). Unless occurring on a previously unmapped or unknown fault, the risk of fault rupture at the site is very low to low.

Foundations

At this time, we anticipate the maximum column loads for the structure will be less than approximately 100 kips. Based on the estimated foundation loads and potential for seismically induced settlement, it is our opinion that it will be necessary to support structural loads using a deep-foundation system or ground improvement tipped in the siltstone that underlies the site. Deep-foundation elements that may be used to support the building include driven piles or continuous-flight auger (CFA) piles. Other methods that could be explored further include appropriate ground-improvement alternatives such as deep soil mixing (DSM) and engineered aggregate piers. The following table summarizes some of the advantages and disadvantages of each of the foundation-support alternatives considered appropriate for this project.

Foundation Support Alternatives

FOUNDATION SUPPORT ALTERNATIVES

System	Advantages	Disadvantages
1) Driven Steel Pipe Piles to Siltstone	▪ Mitigation for seismic settlement if driven to rock. ▪ Can provide uplift resistance. ▪ Ductile lateral performance. ▪ Local contractors can perform this work.	▪ Need to consider noise, vibration, and settlement monitoring of adjacent improvements during installation. Poor vibration and settlement monitoring results could result in a change order for a different deep foundation system during construction. ▪ Down-drag effects reduce capacity, requiring larger/more piles. ▪ Often requires corrosion protection. ▪ Costs are typically higher than other alternatives.
2) Augercast Piles or Drilled Displacement Piers to siltstone	▪ Typically, lower cost than steel piles. ▪ Can provide uplift resistance. ▪ Relatively low vibration and noise compared to driven piles.	▪ Down-drag effects reduce capacity, requiring larger/more piles. ▪ QA/QC can be more difficult. ▪ Likely limited advancement into the underlying siltstone.

System	Advantages	Disadvantages
3) Mat Foundation Supported on Aggregate Pier Ground Improvement	• Mat footing mitigates larger differential settlements from shallower ground improvement. • Aggregate piers are typically cheaper than other ground improvement types.	• Mat footings cost more relative to spread footings. • Installation of aggregate piers will necessitate the use of a mandrel-based installation system. • Does not provide uplift resistance. • Need to consider vibration and settlement of adjacent improvements during installation. • Does not mitigate scour.
4) Spread Footings/Grade Beams Supported on Deep Soil Mixing (DSM) Column Ground Improvement	• Spread footings are most cost effective. • Can provide limited uplift resistance.	• Limited embedment into the underlying siltstone. • Deep soil mixing is relatively expensive. • Produces cement laden spoils equal to approximately 20 % to 50% of the DSM volume. • Experienced northwest contractors are limited.

The appropriate foundation support type for this project will depend on the desired seismic performance criteria and tsunami resilience. In our opinion, CFA piles would be the most economical foundation support type if handling and disposal of dredge spoils from the pile excavations can be completed in a cost-effective manner. We understand the dredge spoils may contain contaminants that exceed the lower threshold for contaminated material. If CFA piles are not desirable, driven piles would also be an economical alternative. However, it is possible that vibrations from driven piles could pose a risk for potential settlement or cracking of adjacent buildings. Given the close proximity to existing older buildings that may include elements of un-reinforced masonry and the presence of very loose sand that may be supporting adjacent buildings on shallow spread footings, the use of driven piles should be performed simultaneously with vibration and settlement monitoring of adjacent structures.

Additional Subsurface Explorations Recommended

Based on our review of existing site conditions and subsurface conditions near the project site, and our understanding of the proposed development, we recommend additional explorations be completed to understand further conditions that may affect design and construction. Based on our current understanding, we recommend completing a minimum of two additional borings, which include at least one boring extending a minimum of 30 feet into the underlying siltstone to provide information for foundations support, temporary shoring, confirm depth of dredge fill materials present below the site, and to monitor and better understand groundwater conditions below the site. Based on the proximity of the area groundwater depth and the proposed below-grade improvements, we recommend at least one boring be instrumented with a vibrating-wire piezometer with a datalogger to monitor the depth of groundwater at a future basement or below-grade excavation location. Figure 2 shows possible locations of the additional borings and groundwater instrumentation. The proposed exploration locations are subject to change and should be based on actual locations of building structures when plans are available. The costs associated with subsurface investigations will vary depending on the actual development details and typically range around 5% of total design costs. The presence of poor soils conditions or geologic and seismic hazards can significantly increase costs; whereas, the existing geotechnical information available for the project will reduce the effort that will be necessary to complete final design.

LIMITATIONS

The information provided in this memorandum is intended to assist the design team with initial project planning. It should be understood that subsurface information for the site is preliminary, and the geotechnical considerations provided in this memorandum are based on our preliminary review of these subsurface explorations. Our recommendations are tailored to assist the Astoria Development Commission and their agents for preliminary planning purposes and may be based on professional opinion from available information at the time of the report. We assume a detailed geotechnical subsurface investigation and report will be completed for the project when plans are further developed.

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

Submitted for GRI,

Christopher K. Ell, PE, GE Principal	Jason D. Bock, PE Principal

This document has been submitted electronically.

6552-A PRELIMINARY GEOTECHNICAL MEMORANDUM

REFERENCES

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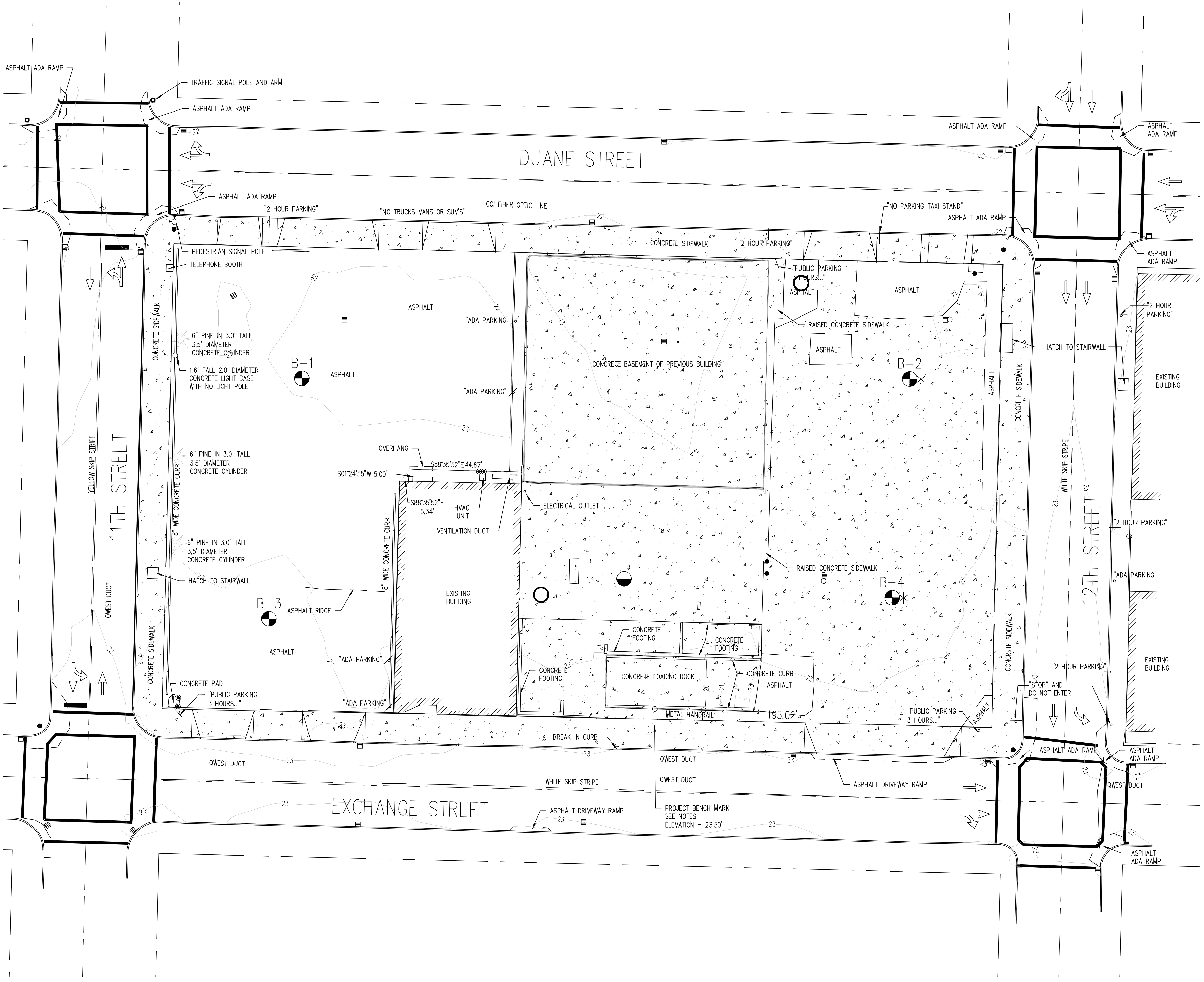


○ PROPOSED EXPLORATION LOCATIONS

◍ BORING MADE BY GRI (NOVEMBER 17 & 18, 2011)

◒ EXTRA CORE

✳ BORINGS REQUIRING CONCRETE CORING

SITE PLAN FROM FILE BY NORTHWEST SURVEYING, INC., DATED OCTOBER 22, 2011

GRI
CITY OF ASTORIA
GARDEN OF SURGING WAVES

SITE PLAN

DEC. 2021 JOB NO. 6580 FIG. 1

APPENDIX A

Boring Logs from Previous Site Explorations

Table 1A

GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

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

Description of Consistency for Fine-Grained (Cohesive) Soils

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

Grain-Size Classification

Boulders:
  >12 inches

Cobbles:
  3-12 inches

Gravel:
  ¼ - ¾ inch (fine)
  ¾ - 3 inches (coarse)

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

Silt/Clay:
  Pass No. 200 sieve

Modifier for Subclassification

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

Table 2A

GUIDELINES FOR CLASSIFICATION OF ROCK

Relative Rock Weathering Scale

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

Relative Rock Hardness Scale

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	It can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with the point of a geology pick. It can be peeled by a pocketknife and scratched with a fingernail.	100 - 1,000 psi
Soft	R2	It can be peeled by a pocketknife with difficulty. It cannot be scratched with a fingernail. Shallow indentation made by firm blow of geology pick.	1,000 - 4,000 psi
Medium Hard	R3	It can be scratched by a knife or pick. The specimen can be fractured with a single firm blow of hammer/geology pick.	4,000 - 8,000 psi
Hard	R4	It can be scratched with a knife or pick only with difficulty. Several hard hammer blows are required to fracture the specimen.	8,000 - 16,000 psi
Very Hard	R5	It cannot be scratched by a knife or sharp pick. The specimen requires many blows of a hammer to fracture or chip. Hammer rebounds after impact.	> 16,000 psi

Rock Quality Designation (RQD) and Rock Quality

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

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

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
⁙	LANDSCAPE MATERIALS
▩	FILL
▨	GRAVEL; clean to some silt, clay, and sand
▨	Sandy GRAVEL; clean to some silt and clay
▨	Silty GRAVEL; up to some clay and sand
▨	Clayey GRAVEL; up to some silt and sand
░	SAND; clean to some silt, clay, and gravel
░	Gravelly SAND; clean to some silt and clay
░	Silty SAND; up to some clay and gravel
░	Clayey SAND; up to some silt and gravel
▥	SILT; up to some clay, sand, and gravel
▥	Gravelly SILT; up to some clay and sand
▥	Sandy SILT; up to some clay and gravel
▥	Clayey SILT; up to some sand and gravel
▧	CLAY; up to some silt, sand, and gravel
▧	Gravelly CLAY; up to some silt and sand
▧	Sandy CLAY; up to some silt and gravel
▧	Silty CLAY; up to some sand and gravel
≋	PEAT

BEDROCK SYMBOLS

Symbol	Typical Description
⊞	BASALT
▤	MUDSTONE
▤	SILTSTONE
▤	SANDSTONE

SURFACE MATERIAL SYMBOLS

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

SAMPLER SYMBOLS

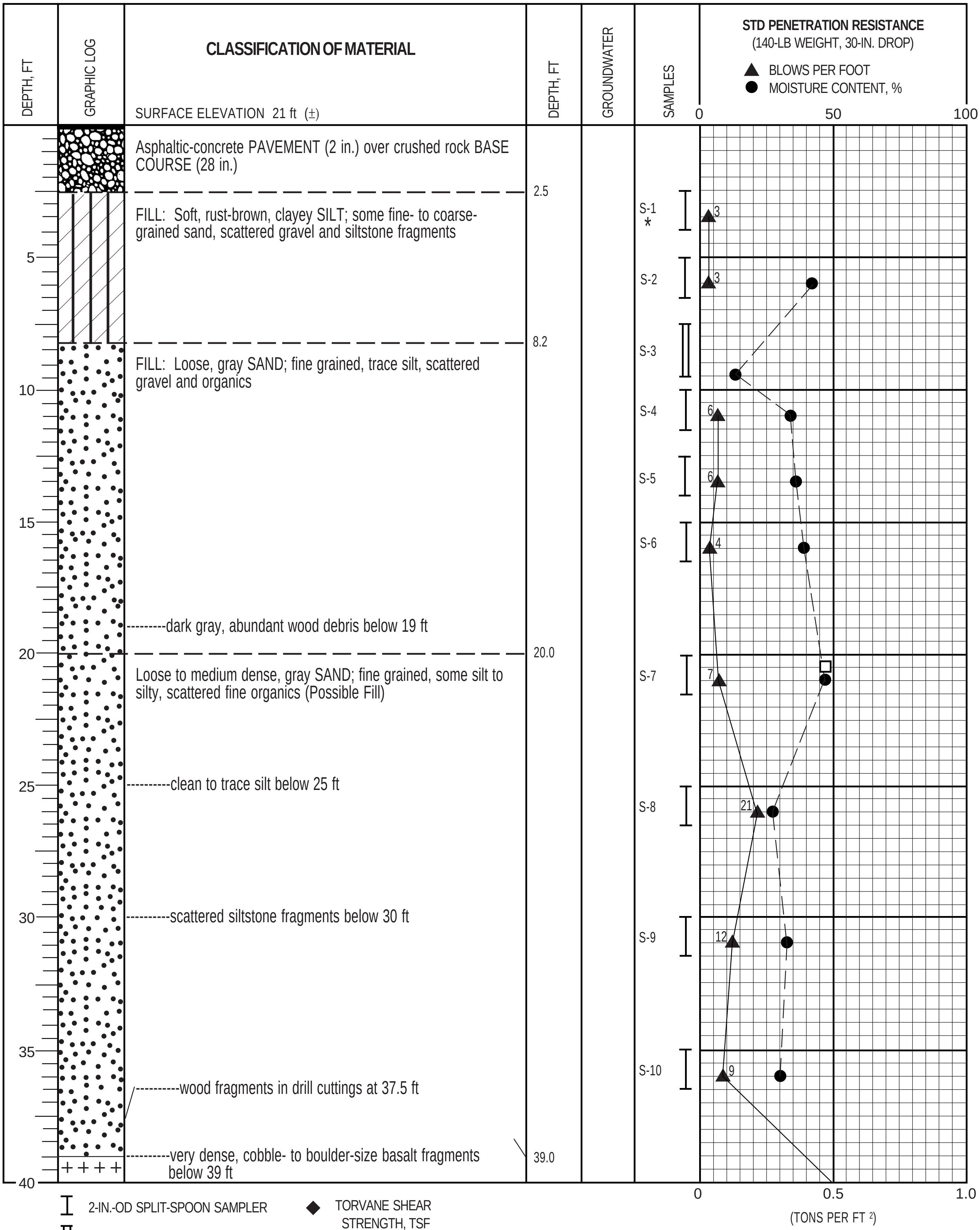
Symbol	Sampler Description
Ⅰ	2.0 in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
▮	Shelby tube sampler with recovery (ASTM D1587)
▮	3.0 in. O.D. split-spoon sampler with recovery (ASTM D3550)
⊠	Grab Sample
▯	Rock core sample interval
▮	Sonic core sample interval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

INSTALLATION SYMBOLS

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

FIELD MEASUREMENTS

Symbol	Typical Description
∇	Groundwater level during drilling and date measured
▼	Groundwater level after drilling and date measured
▧	Rock/sonic core or push probe recovery (%)
▧	Rock quality designation (RQD, %)



Asphaltic-concrete PAVEMENT (2 in.) over crushed rock BASE COURSE (28 in.)

FILL: Soft, rust-brown, clayey SILT; some fine- to coarse-grained sand, scattered gravel and siltstone fragments

FILL: Loose, gray SAND; fine grained, trace silt, scattered gravel and organics

---------dark gray, abundant wood debris below 19 ft

Loose to medium dense, gray SAND; fine grained, some silt to silty, scattered fine organics (Possible Fill)

----------clean to trace silt below 25 ft

---------scattered siltstone fragments below 30 ft

----------wood fragments in drill cuttings at 37.5 ft

---------very dense, cobble- to boulder-size basalt fragments below 39 ft

I 2-IN.-OD SPLIT-SPOON SAMPLER

II 3-IN.-OD THIN-WALLED SAMPLER

G GRAB SAMPLE OF DRILL CUTTINGS

▌ NX CORE RUN

◆ TORVANE SHEAR STRENGTH, TSF

☐ PERCENT PASSING NO. 200 SIEVE (WASHED)

* NO RECOVERY

|—SLOTTED PVC PIPE

▼ Water Level (date)

Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-1

DEC. 2011

JOB. NO. 5277

FIG. 1A

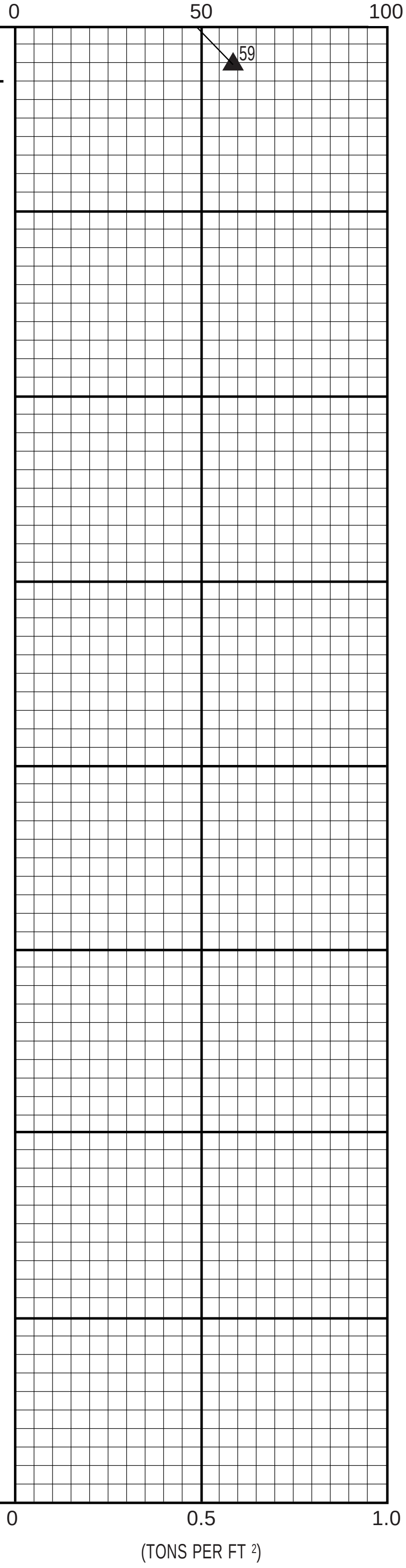
CLASSIFICATION OF MATERIAL

SURFACE ELEVATION 21 ft (±)

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	GROUNDWATER	SAMPLES
40	+ + + + + + + +	Very dense, dark gray BASALT; cobble- to boulder-size fragments (Possible Fill)	41.5		S-11 I
		(11/17/2011)			
45					

STD PENETRATION RESISTANCE
(140-LB WEIGHT, 30-IN. DROP)

▲ BLOWS PER FOOT
● MOISTURE CONTENT, %



I 2-IN.-OD SPLIT-SPOON SAMPLER

II 3-IN.-OD THIN-WALLED SAMPLER

G GRAB SAMPLE OF DRILL CUTTINGS

▌ NX CORE RUN

|—SLOTTED PVC PIPE

▼ Water Level (date)

◆ TORVANE SHEAR STRENGTH, TSF

☐ PERCENT PASSING NO. 200 SIEVE (WASHED)

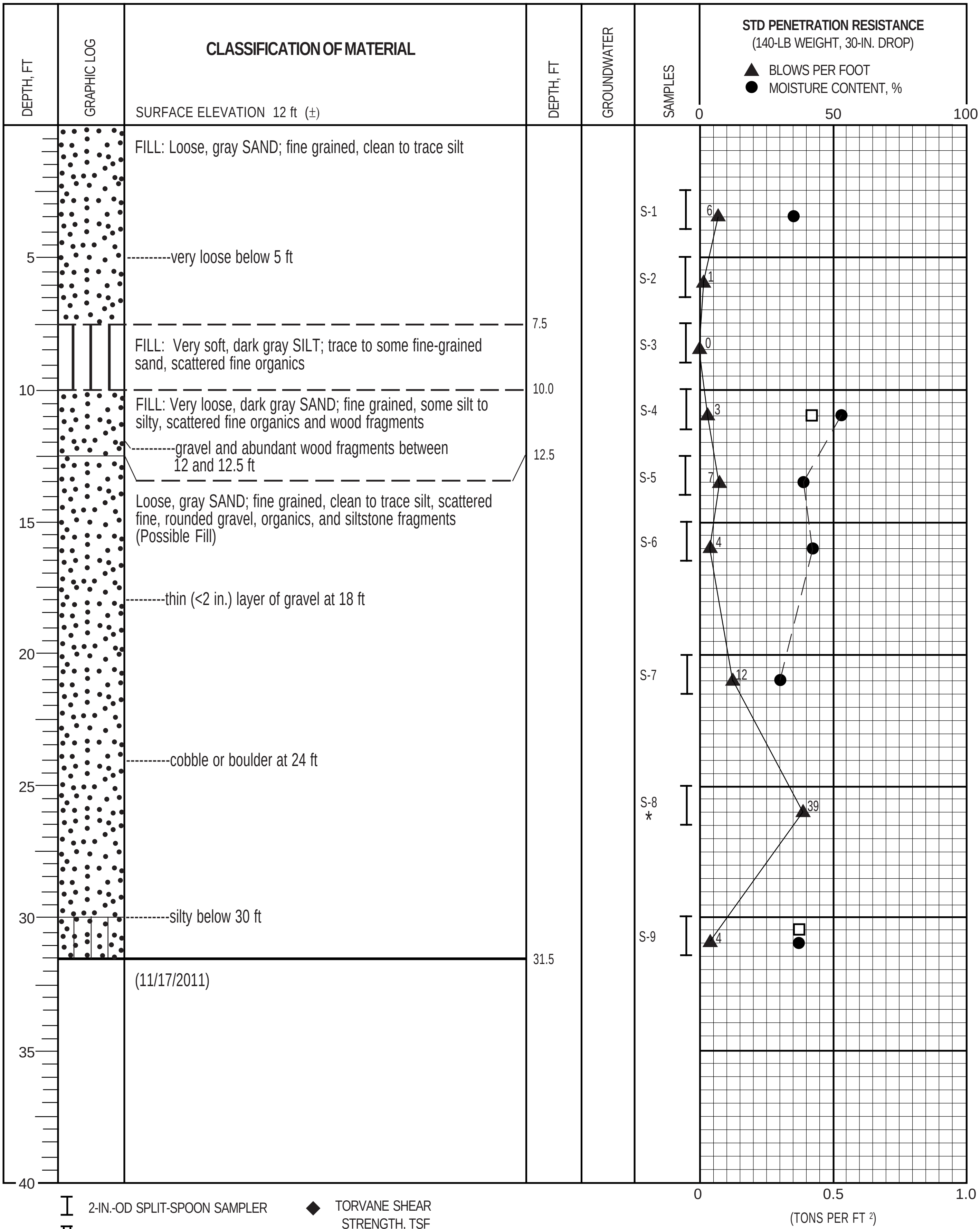
* NO RECOVERY

Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-1 (cont.)

DEC. 2011 JOB. NO. 5277 FIG. 1A



FILL: Loose, gray SAND; fine grained, clean to trace silt

----------very loose below 5 ft

FILL: Very soft, dark gray SILT; trace to some fine-grained sand, scattered fine organics

FILL: Very loose, dark gray SAND; fine grained, some silt to silty, scattered fine organics and wood fragments

---------gravel and abundant wood fragments between 12 and 12.5 ft

Loose, gray SAND; fine grained, clean to trace silt, scattered fine, rounded gravel, organics, and siltstone fragments (Possible Fill)

---------thin (<2 in.) layer of gravel at 18 ft

---------cobble or boulder at 24 ft

---------silty below 30 ft

(11/17/2011)

Ι 2-IN.-OD SPLIT-SPOON SAMPLER

Ⅱ 3-IN.-OD THIN-WALLED SAMPLER

G GRAB SAMPLE OF DRILL CUTTINGS

▮ NX CORE RUN

|—SLOTTED PVC PIPE

▼ Water Level (date)

◆ TORVANE SHEAR STRENGTH, TSF

☐ PERCENT PASSING NO. 200 SIEVE (WASHED)

* NO RECOVERY

Liquid Limit

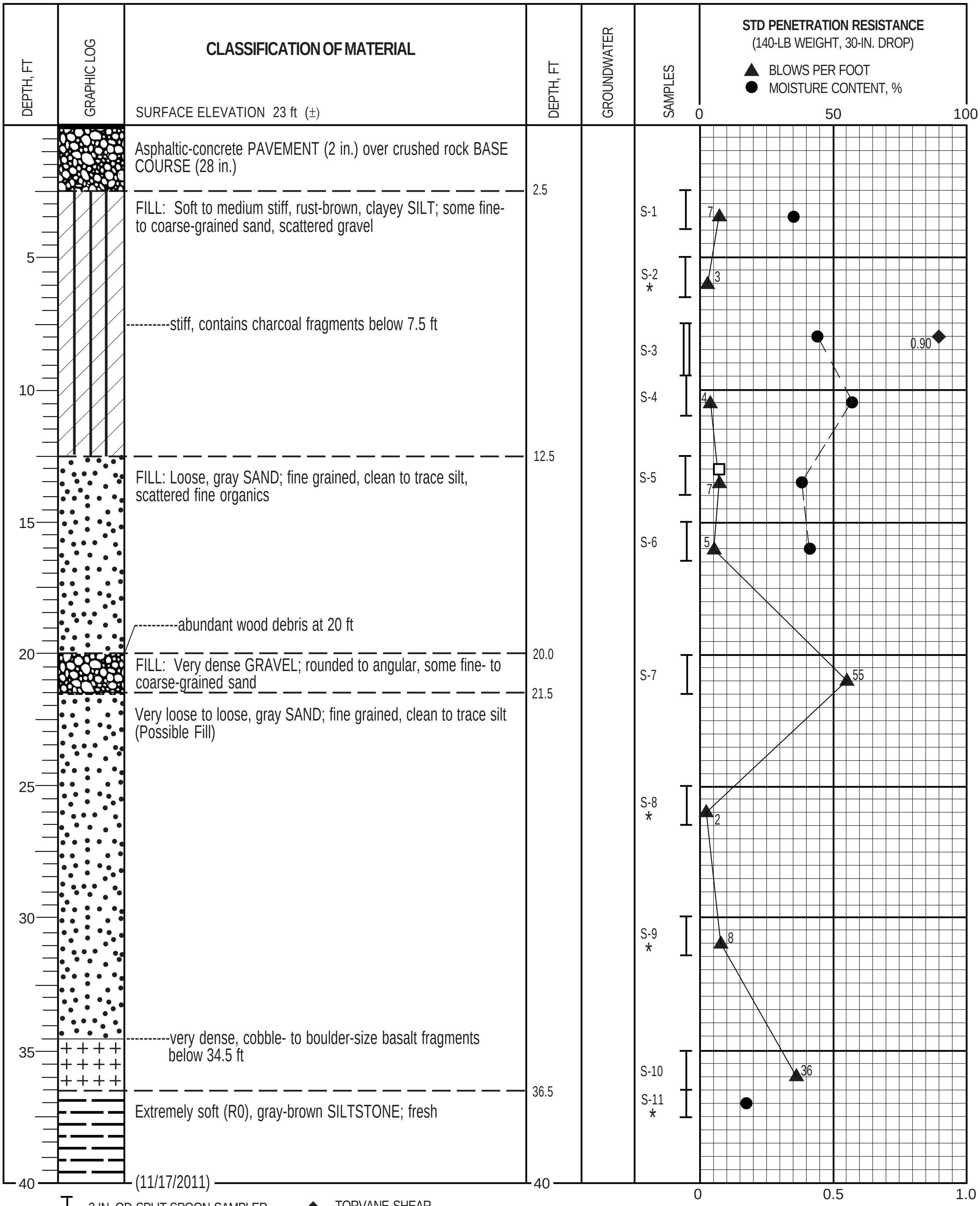
Moisture Content

Plastic Limit

GRI

BORING B-2

DEC. 2011 JOB. NO. 5277 FIG. 2A



Depth, ft	Classification of Material
	Asphaltic-concrete PAVEMENT (2 in.) over crushed rock BASE COURSE (28 in.)
2.5	FILL: Soft to medium stiff, rust-brown, clayey SILT; some fine- to coarse-grained sand, scattered gravel
	---------stiff, contains charcoal fragments below 7.5 ft
12.5	FILL: Loose, gray SAND; fine grained, clean to trace silt, scattered fine organics
	---------abundant wood debris at 20 ft
20.0	FILL: Very dense GRAVEL; rounded to angular, some fine- to coarse-grained sand
21.5	Very loose to loose, gray SAND; fine grained, clean to trace silt (Possible Fill)
	---------very dense, cobble- to boulder-size basalt fragments below 34.5 ft
36.5	Extremely soft (R0), gray-brown SILTSTONE; fresh
40	(11/17/2011)

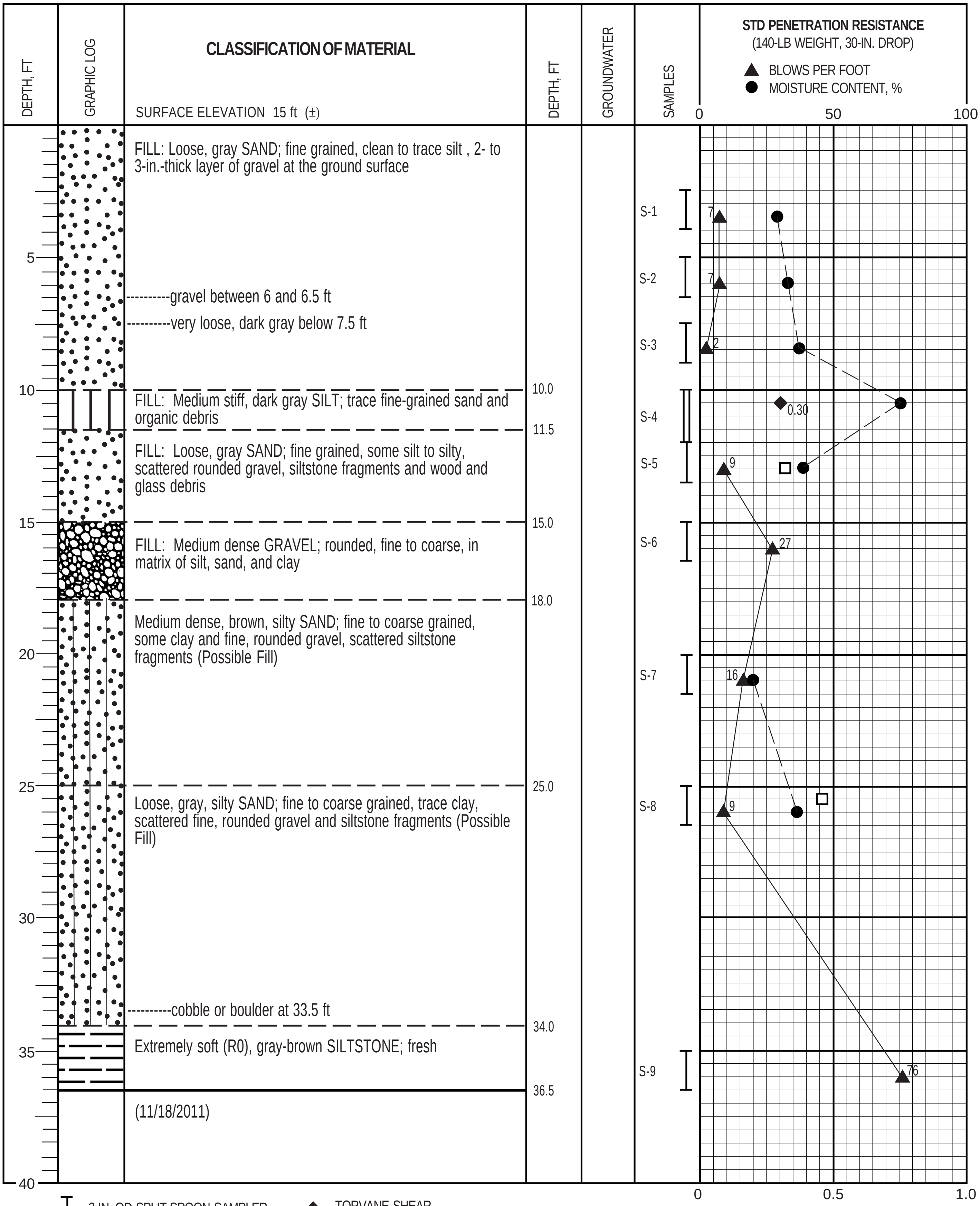
I 2-IN.-OD SPLIT-SPOON SAMPLER
II 3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
▮ NX CORE RUN
|—SLOTTED PVC PIPE
▼ Water Level (date)

◆ TORVANE SHEAR STRENGTH, TSF
☐ PERCENT PASSING NO. 200 SIEVE (WASHED)
* NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-3

DEC. 2011 JOB. NO. 5277 FIG. 3A



DEPTH, FT	CLASSIFICATION OF MATERIAL
	SURFACE ELEVATION 15 ft (±)
	FILL: Loose, gray SAND; fine grained, clean to trace silt , 2- to 3-in.-thick layer of gravel at the ground surface
	---------gravel between 6 and 6.5 ft
	---------very loose, dark gray below 7.5 ft
10.0	FILL: Medium stiff, dark gray SILT; trace fine-grained sand and organic debris
11.5	FILL: Loose, gray SAND; fine grained, some silt to silty, scattered rounded gravel, siltstone fragments and wood and glass debris
15.0	FILL: Medium dense GRAVEL; rounded, fine to coarse, in matrix of silt, sand, and clay
18.0	Medium dense, brown, silty SAND; fine to coarse grained, some clay and fine, rounded gravel, scattered siltstone fragments (Possible Fill)
25.0	Loose, gray, silty SAND; fine to coarse grained, trace clay, scattered fine, rounded gravel and siltstone fragments (Possible Fill)
	---------cobble or boulder at 33.5 ft
34.0	Extremely soft (R0), gray-brown SILTSTONE; fresh
36.5	(11/18/2011)

I 2-IN.-OD SPLIT-SPOON SAMPLER

II 3-IN.-OD THIN-WALLED SAMPLER

G GRAB SAMPLE OF DRILL CUTTINGS

▮ NX CORE RUN

|—SLOTTED PVC PIPE

▼ Water Level (date)

◆ TORVANE SHEAR STRENGTH, TSF

☐ PERCENT PASSING NO. 200 SIEVE (WASHED)

* NO RECOVERY

Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-4

DEC. 2011 JOB. NO. 5277 FIG. 4A