GEOTECHNICAL REPORT

PROPOSED DEVELOPMENT
3411 – 23TH AVENUE WEST
SEATTLE, WASHINGTON

Project No. 18-355
March 2019

Prepared for:

Mr. Alex Mason

PanGEO INCORPORATED

Geotechnical & Earthquake
Engineering Consultants

PanGEO
INCORPORATED
Geotechnical & Earthquake Engineering Consultants

March 18, 2019
File No. 18-355

Mr. Alex Mason
400 112th Avenue NE, #300
Bellevue, WA 98004

Subject: **Geotechnical Report**
Proposed Development
3411 – 23rd Avenue West, Seattle, WA

Dear Mr. Mason,

Attached please find our geotechnical report for the proposed development in Seattle, Washington. This report documents the subsurface conditions at the site and presents our geotechnical engineering recommendations for the proposed development.

In summary, based on the borings drilled, the project site is generally underlain by fill overlying Advance Outwash and Lawton Clay. Based on the soil conditions and anticipated finish floor elevations, in our opinion, a deep foundation system, such as small diameter driven pipe piles (pin piles), should be used to support the proposed rowhouse building.

We appreciate the opportunity to work on this project. Please call if there are any questions.

Sincerely,

H. Michael Xue, P.E.
Senior Geotechnical Engineer

Encl.: Geotechnical Report

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SEATTLE, WASHINGTON

1.0 INTRODUCTION

This report presents the results of a geotechnical engineering study that was undertaken to support the design and construction of the proposed development at the above site in Seattle, Washington. We completed our study in accordance with our proposal dated October 12, 2018, which was approved on October 30, 2018. Our service scope included reviewing available geologic and geotechnical data in the site vicinity, drilling two test borings and advance three hand borings at the site, performing engineering analyses, and developing the geotechnical design recommendations presented in this report.

2.0 PROJECT AND SITE DESCRIPTION

The subject site is an approximately 7,000 square foot lot located at 3411 – 23rd Avenue West in Seattle, Washington (see Vicinity Map, Figure 1). The site is rectangular in shape, and is bordered to the east by 23rd Avenue West, to the west by an alley, and to the north and south by existing single- and multi-family buildings (see Figure 2). The site is currently occupied by a multi-family building in the eastern portion of the site. Based on review of the topographic survey map, the site generally slopes down from west to east with an average gradient of about 12 percent with a total vertical relief of about 16 feet between the east and west property lines.

We understand that you plan to remove the existing building and to construct a 3-unit rowhouse building in the eastern portion of the site (see Figure 2). Based on review of the preliminary design plans, the proposed rowhouse building will be 3-story wood frame structure with concrete slab floors. We anticipate that site grading for the proposed project will involve cuts and fill on the order of about 2 feet or less for the foundation construction. We also understand that another townhome/rowhouse building may be constructed in the western portion of the site in the future. However, the design information for the future west building is not available at this time.

The conclusions and recommendations in this report are based on our understanding of the proposed development, which is in turn based on the project information provided. If the above project description is incorrect, or the project information changes, we should be consulted to review the recommendations contained in this study and make modifications, if needed.

3.0 SUBSURFACE EXPLORATIONS

PanGEO completed two test borings (PG-1 and PG-2) at the subject site on October 30, 2018. The approximate locations of the borings are indicated on the attached Figure 2. The borings were drilled to depths of about 14 feet in PG-1 and 21½ feet in PG-2, using a hand-operated portable drill rig owned and operated by CN Drilling of Seattle, Washington.

The hand-operated portable drill rig was equipped with 4-inch outside diameter hollow stem augers. Soil samples were obtained from the borings at 2½- and 5-foot depth intervals in general accordance with Standard Penetration Test (SPT) sampling methods (ASTM test method D-1586) in which the samples are obtained using a 2-inch outside diameter split-spoon sampler. The sampler was driven into the soil a distance of 18 inches using a 140-pound weight freely falling a distance of 30 inches. The number of blows required for each 6-inch increment of sampler penetration was recorded. The number of blows required to achieve the last 12 inches of sample penetration is defined as the SPT N-value. The N-value provides an empirical measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils.

A geologist from PanGEO was present during the field exploration to observe the drilling, assist in sampling, and to describe and document the soil samples obtained from the borings. The soil samples were described and field classified in general accordance with the symbols and terms outlined in Figure A-1, and the summary boring logs are included as Figures A-2 and A-3.

In addition to PG-1 and PG-2, three hand borings (HB-1 through HB-3) were excavated around the proposed building to further evaluate the near-surface soil conditions on October 30th and November 29th, 2018. The approximate hand boring locations are also plotted on Figure 2. The hand borings were excavated to depths of about 3 to 5½ feet, the maximum depths for hand auger refusal and feasible depth for hand tools, below the existing grade. The hand borings were excavated using hand auger and tools, and the relative density and consistency of the underlying soil was estimated based on probing the soils inside the hand borings and the difficulty of completing the excavation. The summary hand boring logs are included as Figures A-4 through A-6.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 SITE GEOLOGY

Based on our review of *The Geologic Map of Seattle – A Progress Report* (Troost, et al., 2005) the surficial geology in the vicinity of the site is mapped as Advance Outwash (Map Unit: Qva) and Lawton Clay (Map Unit: Qvlc).

Troost, et al. describes Advance Outwash (Qva) as moderately to well sorted, slightly oxidized sand and gravel that has been overridden by glacial ice and is typically dense. Lawton Clay (Qvlc) typically consists of as laminated to massive silt, clayey silt, and silty clay deposited in lowland proglacial lakes that was subsequently overridden by glacial ice and is typically very stiff to hard

4.2 ORIGINAL STREET GRADING PROFILES

Based on our review of the historic street grading profiles obtained from the City of Seattle archives, original grades along the east property line (33' west of the 23rd Avenue West centerline) were raised about 5 to 12 feet in the past street grading, which is generally consistent with the existing fill thickness observed in PG-2. Although the street grading profile did not contain any grading information at the site, it is our opinion that it is likely fill was also placed in the eastern portion of the site from previous on-site developments and past street grading.

4.3 SOIL

The soil conditions encountered in the test borings generally consisted of fill overlying Advance Outwash and Lawton Clay. A summary description of the generalized soil units encountered in the test borings is presented below. Please refer to the summary boring logs in Appendix A for more details.

> ***UNIT 1: Fill*** – Fill was encountered below the topsoil to a depth of about 7 feet below the surface at PG-1 and 16 feet in PG-2. Fill encountered in PG-1 generally consisted of very loose to loose, brown, silty sand with gravel, occasional organics and brick fragments. Fil encountered in PG-2 generally consisted of very loose, moist to wet, gray-brown, silty sand with occasional rootlets.
>
> ***UNIT 2: Advance Outwash*** – Below the fill, boring PG-1 generally encountered dense, wet, medium sand with gravel to about 9 feet below the existing grade. We interpret this

unit as the Advance Outwash mapped on the west side of the site. This unit was not encountered in PG-2.

***UNIT 3: Lawton Clay Deposits* –** Below Unit 2 in PG-1 and below Unit 1 in PG-2, the borings encountered stiff to hard, moist, gray silt and clay. This unit extended to the termination depth in of 14 and 21½ feet in PG-1 and PG-2, respectively. We interpret this unit as the Lawton Clay mapped on the east side of the site.

4.4 Groundwater

Perched groundwater was encountered between about 6 and 9 feet in PG-1, and between about 9 and 10 feet in PG-2 during drilling. The groundwater was perched atop the Lawton Clay deposits. It should be noted that groundwater levels will vary depending on the season, local subsurface conditions, and other factors. Groundwater levels are normally highest during the winter and early spring.

5.0 SITE STABILITY AND ECA CONSIDERATIONS

5.1 Historical Landslides

According to the City of Seattle GIS maps, the eastern portion of the site is mapped as a potential landslide ECA due to its geologic conditions. The site is not mapped as a steep slope ECA or a known slide ECA.

As part of our study, we reviewed records of historical landslides in the Seattle Landslide Study commissioned by the Seattle Public Utilities (SPU) to gain a general understanding of the past landslide activities in the project vicinity. Our review of the Seattle Landslide Study indicated that there were four past known slides in the project area:

1. 3212 – 23rd Avenue W – Located approximately one block south of the site. Occurred in January 1997;
2. 3232 – 23rd Avenue W – Located about one block south of the site. Occurred in January 1997.
3. 3253 – 23rd Avenue W – Located approximately one-half block south of the site. Occurred in January 1986; and
4. 3616 - 24th Avenue W – Located approximately one block northwest of the site. Occurred in February 1983.

Based on the limited information from the City's records, these known slides are generally small in size, and are located in the steeper slope areas or associated with the retaining wall failure.

5.2 SITE STABILITY

A site reconnaissance was conducted on October 30 and November 29, 2018. During our site reconnaissance, we did not observe obvious evidence of slope instability at the subject site. The existing house foundations are observed to be in a good condition. Based on the results of our field exploration, our field observations, the gentle topography at the site, and minimal grading proposed, it is our opinion that the proposed development as currently planned will not adversely impact the subject site and surrounding properties, provided that the project is properly design and constructed.

6.0 GEOTECHNICAL RECOMMENDATIONS

6.1 SEISMIC DESIGN PARAMETERS

The Table 1 provides seismic design parameters for the site that are in conformance with the 2015 editions of the International Building Code (IBC), which specifies a design earthquake having a 2% probability of occurrence in 50 years (return interval of 2,475 years), and the 2008 USGS seismic hazard maps. The spectral response accelerations were obtained from the USGS Earthquake Hazards Program Interpolated Probabilistic Ground Motion website (2008 data) for the project latitude and longitude.

Table 1 – Summary Seismic Design Parameters per 2015 IBC

Site Class	Spectral Acceleration at 0.2 sec. (g)	Spectral Acceleration at 1.0 sec. (g)	Site Coefficients		Design Spectral Response Parameters	
	S_S	S_1	F_a	F_v	S_{DS}	S_{D1}
D	1.318	0.512	1.0	1.50	0.879	0.512

Soil Liquefaction Potential: Based on the minor perched groundwater and very thin layers of wet sand layers above silt encountered in the test borings, it is our opinion that the potential for soil liquefaction at the site during the design earthquake is considered to be low. The proposed building will be supported by pin piles, which will effectively mitigate potential minor ground settlement during a strong earthquake, if occurs.

6.2 Building Foundations

6.2.1 General

Based on the soil conditions and anticipated building finish floor elevations, in our opinion, the proposed rowhouse building should be supported on small diameter pipe piles (pin piles) due to the presence of variable thickness of loose fill below the planned foundation level. The future west building may be supported either by conventional footings or pin piles, depending on the planned foundation elevations. PanGEO can provide additional design input after the future building design is finalized. The following sections present our recommendations for the pin pile foundations and shallow footings.

6.2.2 Pin Pile Foundations

***Pin Pile Sizes* -** In our opinion, 3-, 4-inch diameter, Schedule 40, steel pipes (pin piles) may be used to support the new structures. Three, four-inch diameter pin piles are typically installed using small hammers mounted on a small excavator.

***Pin Pile Capacity* -** The number of piles required depends on the magnitude of the design load. Allowable axial compression capacities of 6 and 10 tons may be used for the 3-, 4-inch diameter pin piles, respectively, with an approximate factor of safety of 2. Penetration resistance required to achieve the capacities will be determined based on the hammer used to install the pile. Tensile capacity of pin piles should be ignored in design calculations.

It is our experience that the driven pipe pile foundations should provide adequate support with total settlements on the order of ½-inch or less.

Pile splices may be made with compression fitted sleeve pipe couplers (see Typical Splicing Detail on page 8). Splicing using welding of pipe joints should not be used, as welds will typically be broken during driving.

Three-, four-, and six-inch diameter piles are typically installed using small (approximately 850 to 3,000 pound) hammers mounted to a small excavator. The criterion for driving refusal is defined as the minimum amount of time (in seconds) required to achieve one inch of penetration, and it varies with the size of hammer used for pile driving. For 3-, 4-inch pin piles, the Table 2 is a summary of driving refusal criteria for different hammer sizes that are commonly used:

Table 2 - Summary of Commonly-Accepted Driving Criteria for 3-, 4-inch Pin Pile with a 6, 10-ton Allowable Axial Compression Load

Hammer Model	Hammer Weight (lb) / Blows per minute	3" Pile Refusal Criteria (seconds per inch of penetration)	4" Pile Refusal Criteria (seconds per inch of penetration)
Hydraulic TB 325	850 / 900	10	16
Hydraulic TB 425	1,100 / 900	6	10
Hydraulic TB 725X	2,000 / 600	3	4

Please note that these refusal criteria were established empirically based on previous load tests on 3-, 4-inch pin piles. Contractors may select a different hammer for driving these piles, and propose a different driving criterion. In this case, it is the contractor's responsibility to demonstrate to the Engineer's satisfaction that the design load can be achieved based on their selected equipment and driving criteria.

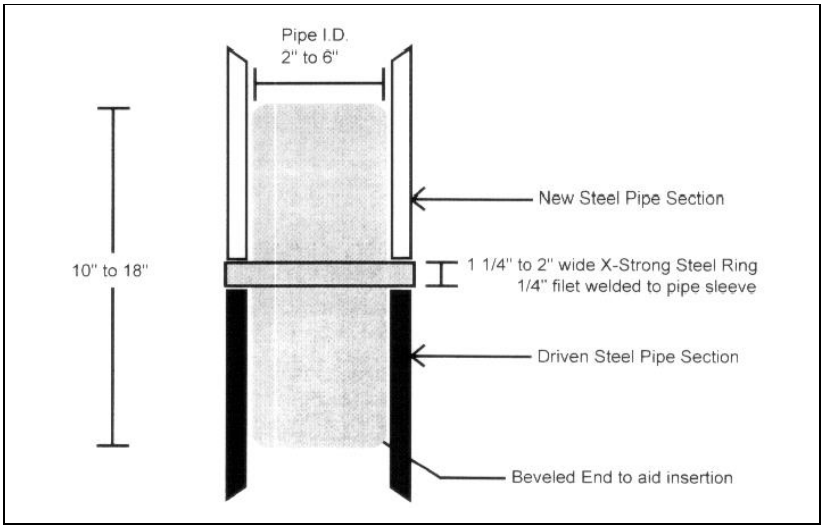
Pin Pile Specifications - We recommend that the following specifications be included on the foundation plan:

1. Three-, four-, or six-inch diameter piles should consist of Schedule-40, ASTM A-53 Grade "A" pipe.

2. The piles shall be driven to refusal as shown in Table 2 above.

3. Piles shall be driven in nominal sections and connected with compression fitted sleeve couplers (see typical detail on below) We discourage welding of pipe joints, particularly when galvanized pipe is used, as we have frequently observed welds broken during driving.

4. The geotechnical engineer of record or his/her representative shall observe pin pile installation.



Typical Splicing Detail

The quality of a pin pile foundation is dependent, in part, on the experience and professionalism of the installation company. We recommend that a company with experienced personnel be selected to install the piles.

Lateral Forces - The capacity of pin pipes to resist lateral loads is very limited and should not be used in design. Therefore, lateral forces from wind or seismic loading should be resisted by the passive earth pressures acting against the pile caps and below-grade walls or from battered piles (batter no steeper than 3(H):12(V)). ***Friction at the base of pile-supported concrete grade beam should be ignored in the design calculations.*** Passive resistance values may be determined using an equivalent fluid weight of 200 pounds per cubic foot (pcf). This value includes a safety factor of about 1.5 assuming that properly compacted granular fill will be placed adjacent to and surrounding the pile caps and grade beams.

Grade Beam/Pile Cap Embedment - We recommend that the grade beams and pile caps located around the perimeter of the structure be embedded such that the bottom of the grade beam is at least 16 inches below the adjacent ground surface.

Estimated Pile Length – The subsurface conditions at the site will likely vary substantially across the site. Based on the soil conditions at the site and our experience in the project area, for planning and cost estimating purposes, we estimate that pin pile lengths of about 10 to 20 feet.

Obstructions – Obstructions may be encountered during pile driving. Where possible, the obstructions should be removed to facilitate the pile driving. If obstructions cannot be removed, the structural engineer of record should be notified to revise the pile layout to accommodate the adjustment.

6.2.3 Conventional Footings

As previously indicated, a future building may be constructed in the western portion of the site. If the foundation level of the future west building is near the existing grade, it is our opinion that it is appropriate to support the building with pin piles. However, if the foundation level is near the anticipated native bearing soils (i.e. 7 in PG-1), it is our opinion that conventional shallow footings may be considered. The following sections present our recommendations for the shallow footing design. PanGEO can provide additional design input after the future building design is finalized.

An allowable soil bearing pressure of 2,500 pounds per square feet (psf) may be used to size the footings bearing on dense, native soils or structural fill placed on the native dense soils. The recommended allowable bearing pressure is for dead plus live loads. For allowable stress design, the recommended bearing pressure may be increased by one-third for transient loading, such as wind or seismic forces. Continuous and individual spread footings should have minimum widths of 18 and 24 inches, respectively. Footings should be placed at least 18 inches below final exterior grade. Interior footings should be placed at least 12 inches below the top of slab. We anticipate that limited foundation soil over-excavation in localized areas may be needed to expose the competent native bearing soils.

Total and differential settlements are anticipated to be within tolerable limits for foundation designed and constructed as discussed above. For the proposed building supported by conventional footings bearing on competent native soil and structural fill, the building settlement under static loading conditions is estimated to be less than approximately one inch, and differential settlement should be less than about ½ inch. Most settlement should occur during construction as loads are applied.

Lateral Resistance: Lateral forces from wind or seismic loading may be resisted by a combination of passive earth pressures acting against the embedded portions of the foundations and walls, and by friction acting on the base of the foundations. Passive resistance values may be determined using an equivalent fluid weight of 300 pounds per cubic foot (pcf). This value includes a factor safety of at least 1.5 assuming that densely compacted structural fill will be placed adjacent to the sides of the foundation. A friction coefficient of 0.35 may be used to determine the frictional resistance at the base of the foundation. This coefficient includes a factor of safety of approximate 1.5. Unless covered by pavements or slabs, the passive resistance in the upper 12 inches of soil should be neglected.

Footing Subgrade Preparation: All footing subgrades should be carefully prepared. The adequacy of footing subgrade should be verified by a representative of PanGEO, prior to placing forms or rebar. The footing subgrade should be in a dense condition prior to concrete pour. Any over-excavations in the footing areas should be backfilled with Seattle Type 2 or 17 material and should be placed in think lifts and compacted to a dense condition. Footing excavations should be observed by PanGEO to confirm that the exposed footing subgrade is consistent with the expected conditions and adequate to support the design bearing pressure.

It should be noted that the onsite soils are highly moisture sensitive, and can be easily disturbed when exposed to moisture. If footing construction will be constructed during wet weather conditions, the exposed footing subgrade should be adequate protected. This may be accomplished with at least 3 inches of lean-mix concrete, or 4 to 6 inches of crushed surfacing base course (CSBC).

6.3 CONCRETE RETAINING/BASEMENT WALLS

Retaining walls, if needed, should be properly designed to resist the lateral earth pressures exerted by the soils behind the wall. Proper drainage provisions should also be provided behind the walls to intercept and remove groundwater that may be present behind the wall. Our geotechnical recommendations for the design and construction of the retaining/basement walls are presented below.

6.3.1 Lateral Earth Pressures

Concrete cantilever walls should be designed for an equivalent fluid pressure of 35 pcf for level backfills behind the walls assuming the walls are free to rotate. If walls are to be restrained at the top from free movement, such as basement walls, equivalent fluid pressures of 45 pcf should be used for level backfills behind the walls. Walls with a maximum 2H:1V backslope should be designed for an active and at rest earth pressure of 50 and 60 pcf, respectively.

Permanent walls should be designed for an additional uniform lateral pressure of 8H psf for seismic loading, where H corresponds to the buried depth of the wall. The recommended lateral pressures assume that the backfill behind the wall consists of a free draining and properly compacted fill with adequate drainage provisions.

6.3.2 Wall Surcharge

Surcharge loads, where present, should also be included in the design of basement walls. We recommend that a lateral load coefficient of 0.35 be used to compute the lateral pressure on the wall face resulting from surcharge loads located within a horizontal distance of one-half wall height.

6.3.3 Lateral Resistance

Lateral forces from wind or seismic loading and unbalanced lateral earth pressures may be resisted by a combination of passive earth pressures acting against the embedded portions of the foundation and by friction acting on the base of the foundation. Passive resistance values may be determined using an equivalent fluid weight of 300 pounds per cubic foot (pcf). A friction coefficient of 0.35 may be used to determine the frictional resistance at the base of the foundation. Both of these values include a safety factor of at least 1.5.

6.3.4 Wall Drainage

Provisions for wall drainage should consist of a 4-inch diameter perforated drainpipe placed behind and at the base of the wall footings, embedded in 12 to 18 inches of clean crushed rock or pea gravel wrapped with a layer of filter fabric. A minimum 18-inch wide zone of free draining granular soils (i.e. clean washed or crushed rock) is recommended to be placed adjacent to the wall for the full height of the wall. Alternatively, a composite drainage material, such as Miradrain 6000, may be used in lieu of the clean crushed rock or pea gravel. This alternative may be preferable if a soldier pile system is used for temporary shoring. The drainpipe at the base of the wall should be graded to direct water to a suitable outlet.

6.3.5 Wall Backfill

In our opinion, the on-site excavated soils are not suitable for use as wall backfill. We recommended that wall backfill consist of free draining granular soils, such as Seattle Mineral Aggregate Type 17 (2014 City of Seattle Standard Specifications, 9-03.12(2)) or approved equivalent.

Wall backfill should be moisture conditioned to within about 3 percent of optimum moisture content, placed in loose, horizontal lifts less than 8 inches in thickness, and systematically compacted to a dense and relatively unyielding condition and to at least 95 percent of the maximum dry density, as determined using test method ASTM D 1557. Within 5 feet of the wall, the backfill should be compacted to 90 percent of the maximum dry density.

6.4 CONCRETE SLAB-ON-GRADE

In our opinion, conventional concrete slab-on-grade floors may be used. The floor slabs should be supported on recompacted on-site sand or compacted structural fill. Any on-site soils at the slab subgrade that cannot be recompacted to a dense condition should be over-excavated 12 inches and over-excavation should be replaced with compacted structural fill.

Interior concrete slab-on-grade floors should be underlain by a capillary break consisting of at least of 4 inches of pea gravel or compacted ¾-inch, clean crushed rock (less than 3 percent fines). The capillary break material should also have no more than 10 percent passing the No. 4 sieve and less than 5 percent by weight of the material passing the U.S. Standard No. 100 sieve. The capillary break should be placed on the subgrade that has been compacted to a dense and unyielding condition. A 10-mil polyethylene vapor barrier should also be placed directly below the slab. We also recommend that construction joints be incorporated into the floor slab to control cracking.

6.5 TEMPORARY EXCAVATIONS

As currently planned, temporary excavations for the proposed construction will be on the order of 2 feet or less. We anticipate the excavations to encounter loose fill over dense sand and hard silt. All temporary excavations should be performed in accordance with Part N of WAC (Washington Administrative Code) 296-155. The contractor is responsible for maintaining safe excavation slopes and/or shoring.

Based on the subsurface conditions at the site, for planning purposes, it is our opinion that temporary excavations for the proposed construction may be sloped 1H:1V or flatter. Based on our current understanding of the building layout and anticipated basement finished floor elevations, it appears that sufficient space is available for unsupported open cuts for the east building, and the east and west sides of the west building. However, temporary shoring may be needed along portions of the north and south sides of the west building. Where space may be limited, the use of L-shaped footings may be required to conserve space for the temporary cuts.

The temporary excavations and cut slopes should be re-evaluated in the field during construction based on actual observed soil conditions, and may need to be flattered in the wet seasons and should be covered with plastic sheets. The cut slopes should be covered with plastic sheets in the rainy season. We also recommend that heavy construction equipment, building materials, excavated soil, and vehicular traffic should not be allowed within a distance equal to 1/3 the slope height from the top of any excavation.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 SITE PREPARATION

Site preparation for the proposed project includes removing the existing building, clearing and excavations to the design subgrade. All stripped surface materials should be properly disposed off-site or be "wasted" on site in non-structural landscaping areas.

Following site excavations, the adequacy of the subgrade where structural fill, foundations, slabs, or pavements are to be placed should be verified by a representative of PanGEO. The subgrade soil in the improvement areas, if recompacted and still yielding, should also be over-excavated and replaced with compacted structural fill or CDF/lean-mix concrete.

7.2 MATERIAL REUSE

In the context of this report, structural fill is defined as compacted fill placed under footings, concrete stairs and landings, and slabs, or other load-bearing areas. In our opinion, the on-site soils are not suitable to be reused as structural fill. Structural fill should consist of imported, well-grade, granular material, such as City of Seattle Type 2 and 17 or WSDOT Gravel Borrow. Well-graded recycled concrete may also be considered as a source of structural fill. Use of recycled concrete as structural fill should be approved by the geotechnical engineer. The on-site soil can be used as general fill in the non-structural and landscaping areas. If use of the on-site soil is planned, the excavated soil should be stockpiled and protected with plastic sheeting to prevent softening from rainfall in the wet season.

7.3 STRUCTURAL FILL PLACEMENT AND COMPACTION

Structural fill should be moisture conditioned to within about 3 percent of optimum moisture content, placed in loose, horizontal lifts less than 8 inches in thickness, and systematically compacted to a dense and relatively unyielding condition and to at least 95 percent of the maximum dry density, as determined using test method ASTM D 1557.

Depending on the type of compaction equipment used and depending on the type of fill material, it may be necessary to decrease the thickness of each lift in order to achieve adequate compaction. PanGEO can provide additional recommendations regarding structural fill and compaction during construction.

7.4 Erosion and Drainage Considerations

Surface runoff can be controlled during construction by careful grading practices. Typically, this includes the construction of shallow, upgrade perimeter ditches or low earthen berms to collect runoff and prevent water from entering the excavation. All collected water should be directed to a positive and permanent discharge system such as a City of Seattle storm sewer.

It should be noted that the site soils are prone to surficial erosion. Special care should be taken to avoid surface water on open cut excavations. We recommend that the exposed temporary slopes be covered with plastic sheeting.

Permanent control of surface water and roof runoff should be incorporated in the final grading design. In addition to these sources, irrigation and rain water infiltrating into landscape and planter areas adjacent to paved areas or building walls should also be controlled. All collected runoff should be directed into conduits that carry the water away from the pavement or structure and into City of Seattle storm drain systems or other appropriate outlets. Adequate surface gradients should be incorporated into the grading design such that surface runoff is directed away from structures.

7.5 Wet Earthwork Recommendations

General recommendations relative to earthwork performed in wet weather or in wet conditions are presented below:

- Earthwork should be performed in small areas to minimize subgrade exposure to wet weather. Excavation or the removal of unsuitable soil should be followed promptly by the placement and compaction of clean structural fill. The size and type of construction equipment used may have to be limited to prevent soil disturbance.

- During wet weather, the allowable fines content of the structural fill should be reduced to no more than 5 percent by weight based on the portion passing ¾-inch sieve. The fines should be non-plastic.

- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water.

- Geotextile silt fences should be strategically located to control erosion and the movement of soil. Erosion control measures should be installed along all the property boundaries.

- Excavation slopes and soils stockpiled on site should also be covered with plastic sheets.

8.0 ADDITIONAL SERVICES

We anticipate the City of Seattle will require a plan review and geotechnical special inspections to confirm that our recommendations are properly incorporated into the design and construction of the proposed development. Specifically, we anticipate that the following construction support services may be needed:

- Review final project plans and specifications;
- Verify implementation of erosion control measures;
- Observe the stability of open cut slopes;
- Observe the installation of soldier piles;
- Verify adequacy of foundation and slab subgrades;
- Observe the installation of pin piles;
- Confirm the adequacy of the compaction of structural backfill;
- Observe installation of subsurface drainage provisions, and;
- Other consultation as may be required during construction.

Modifications to our recommendations presented in this report may be necessary, based on the actual conditions encountered during construction.

9.0 LIMITATIONS

We have prepared this report for use by Mr. Alex Mason and the project design team. Recommendations contained in this report are based on a site reconnaissance, review of pertinent subsurface information, and our understanding of the project. The study was performed using a mutually agreed-upon scope of work.

Variations in soil conditions may exist between the explorations and the actual conditions underlying the site. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at the site that are different from those described in this report, we should be notified immediately to review the applicability of our recommendations. Additionally, we should also be notified to review the applicability of our recommendations if there are any changes in the project scope.

The scope of our work does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design. Additionally, the scope of our work specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances. We are not mold consultants nor are our recommendations to be interpreted as being preventative of mold development. A mold specialist should be consulted for all mold-related issues.

This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

It is the client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk. Any party other than the client who wishes to use this report shall notify PanGEO of such intended use and for permission to copy this report. Based on the intended use of the report, PanGEO may require that additional work be performed and that an updated report be reissued. Noncompliance with any of these requirements will release PanGEO from any liability resulting from the use this report.

Within the limitation of scope, schedule and budget, PanGEO engages in the practice of geotechnical engineering and endeavors to perform its services in accordance with generally accepted professional principles and practices at the time the Report or its contents were prepared. No warranty, express or implied, is made.

We appreciate the opportunity to be of service to you on this project. Please feel free to contact our office with any questions you have regarding our study, this report, or any geotechnical engineering related project issues.

Sincerely,

3/18/2019

John A. Manke, G.I.T.
Staff Geologist

H. Michael Xue, P.E.
Senior Geotechnical Engineer

10.0 REFERENCES

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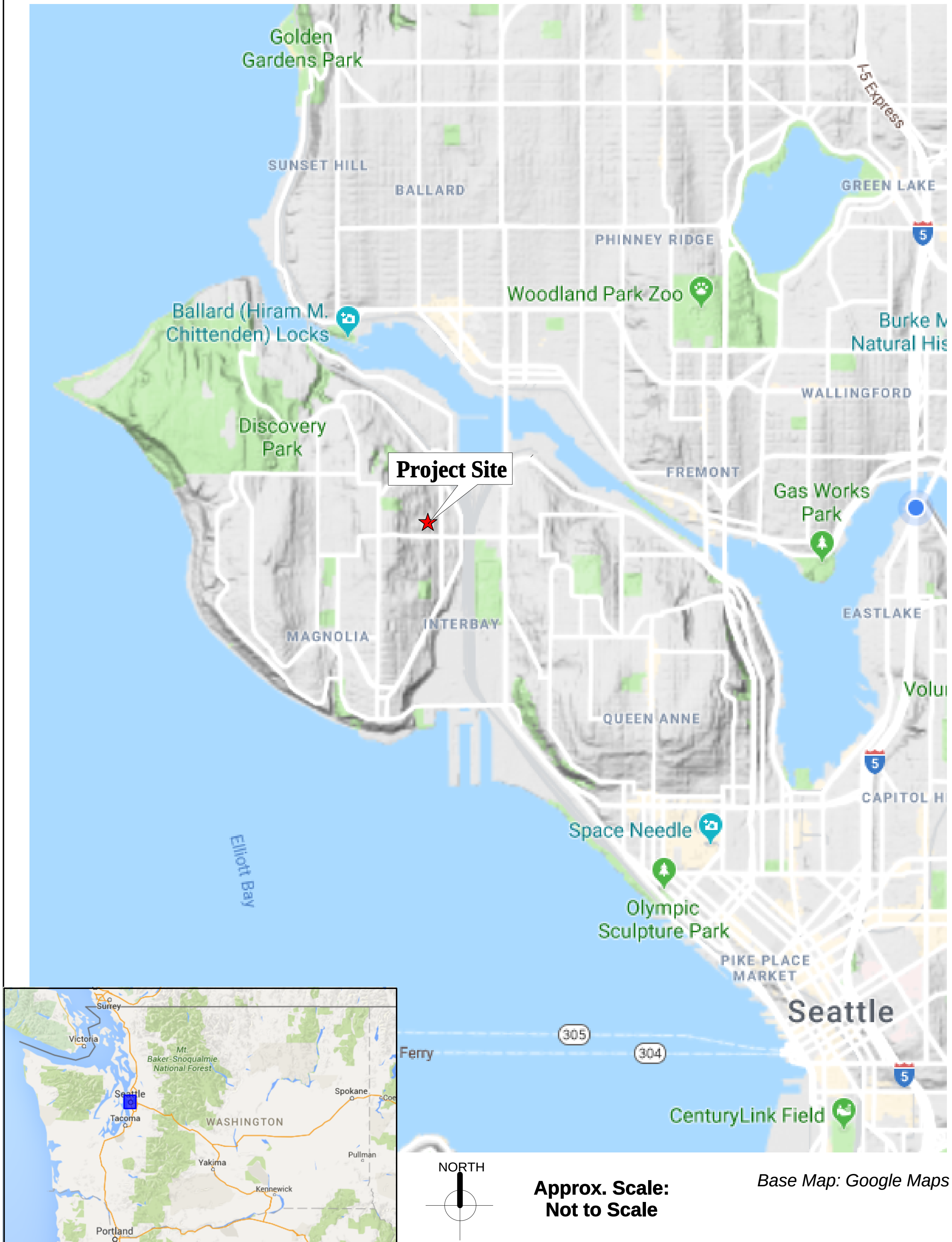


NORTH

Approx. Scale: Not to Scale

Base Map: Google Maps

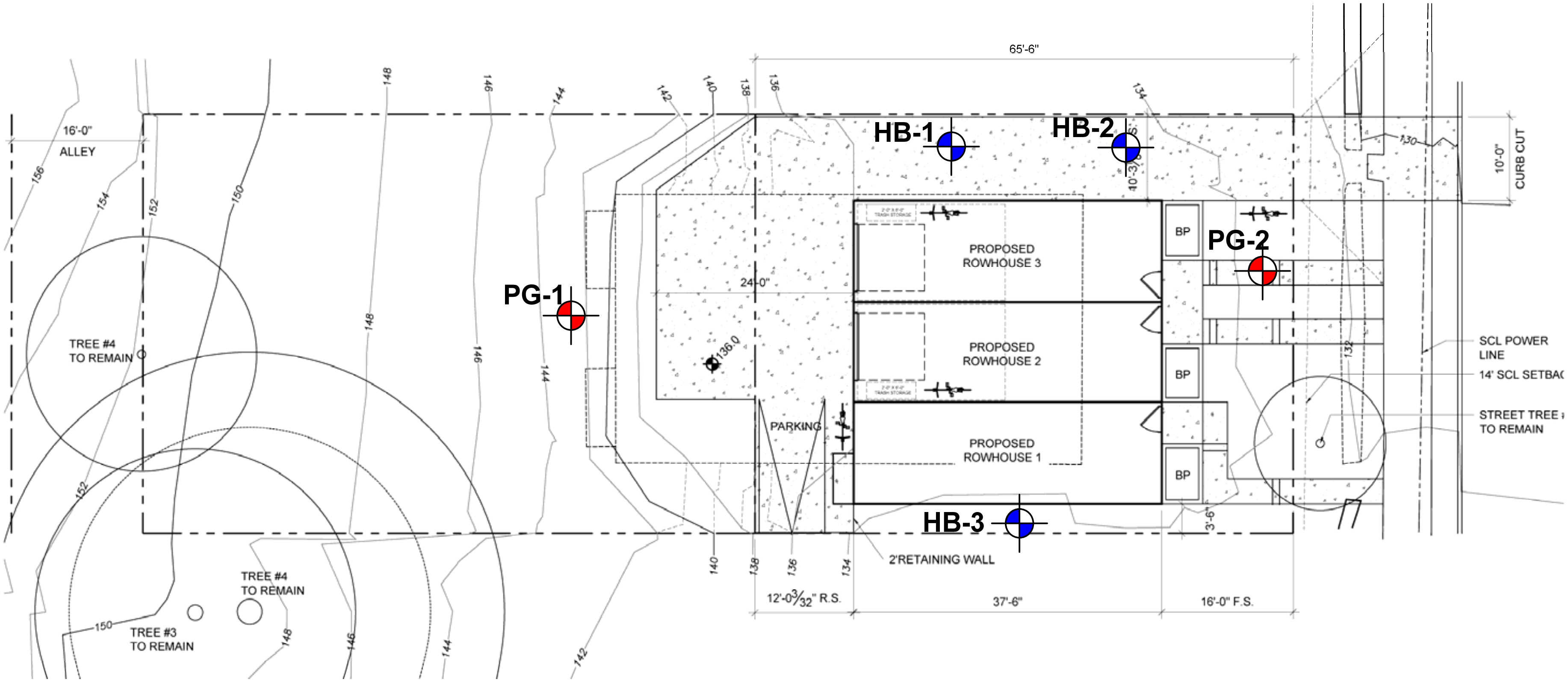
PanGEO INCORPORATED

Proposed Development
3411 - 23rd Avenue West
Seattle, Washington

VICINITY MAP

Project No. **18-355**

Figure No. **1**



N

Approx. Scale
1" = 20'

Legend:

Approx. Test Boring Locations

Approx. Hand Boring Locations

Note: Base map modified from Site Plan in Design Packet V2, dated March 11, 2019.

PanGEO INCORPORATED	**Proposed Development 3411 - 23rd Avenue West Seattle, Washington**	**SITE AND EXPLORATION PLAN**	
		Project No. **18-355**	Figure No. **2**

APPENDIX A

SUMMARY TEST AND HAND BORING LOGS

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean CLAY
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes: 1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.

2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

Layered:	Units of material distinguished by color and/or composition from material units above and below	Fissured:	Breaks along defined planes
Laminated:	Layers of soil typically 0.05 to 1mm thick, max. 1 cm	Slickensided:	Fracture planes that are polished or glossy
Lens:	Layer of soil that pinches out laterally	Blocky:	Angular soil lumps that resist breakdown
Interlayered:	Alternating layers of differing soil material	Disrupted:	Soil that is broken and mixed
Pocket:	Erratic, discontinuous deposit of limited extent	Scattered:	Less than one per foot
Homogeneous:	Soil with uniform color and composition throughout	Numerous:	More than one per foot
		BCN:	Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	Sand	
Cobbles:	3 to 12 inches	Coarse Sand:	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		Medium Sand:	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	Fine Sand:	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	Silt	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

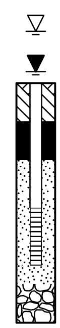
ATT	Atterberg Limit Test
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

- 2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
- 3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
- Non-standard penetration test (see boring log for details)
- Thin wall (Shelby) tube
- Grab
- Rock core
- Vane Shear

MONITORING WELL



- Groundwater Level at time of drilling (ATD)
- Static Groundwater Level
- Cement / Concrete Seal
- Bentonite grout / seal
- Silica sand backfill
- Slotted tip
- Slough
- Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

LOG KEY 13-104_LOGS.GPJ PANGEO.GDT 6/18/13

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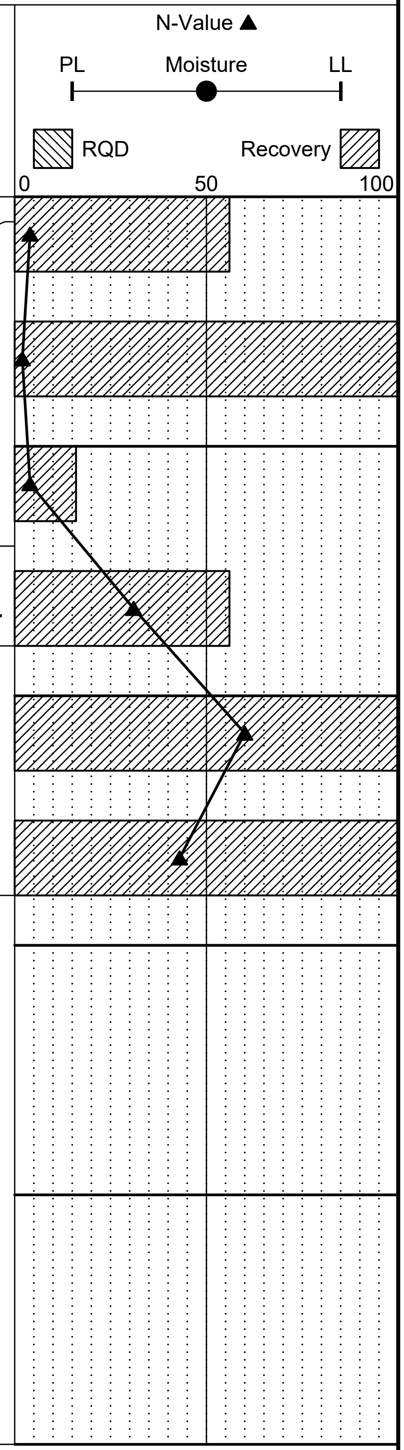
Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	3411 23rd Ave W	Surface Elevation:	142.5ft
Job Number:	18-355	Top of Casing Elev.:	N/A
Location:	3411 23rd Ave W, Seattle, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1		1 2 2			Topsoil: 6 inches thick. Very loose, moist, very silty SAND with trace gravel; rootlets. **(Fill).**
	S-2		1 1 1			
5	S-3		1 1 3			Becomes wet.
	S-4		15 16 15			Dense, wet, gray, medium SAND with gravel. **(Advance Outwash).**
10	S-5		12 25 35			Hard, moist, gray clayey SILT with trace fine sand; laminated. **(Lawton Clay).**
	S-6		14 21 22			Layer of wet, silty fine sand from about 12.5 to 13.5 feet.
15						Boring terminated at about 14 feet below ground surface. Perched groundwater was encountered from about 6 to 9 feet during drilling.
20						
25						



Completion Depth:	14.0ft
Date Borehole Started:	10/30/18
Date Borehole Completed:	10/30/18
Logged By:	J. Manke
Drilling Company:	CN Drilling

Remarks: Borings drilled using an acker hand portable drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with a rope and cathead mechanism. Surface elevation estimated based on the City of Seattle GIS map.

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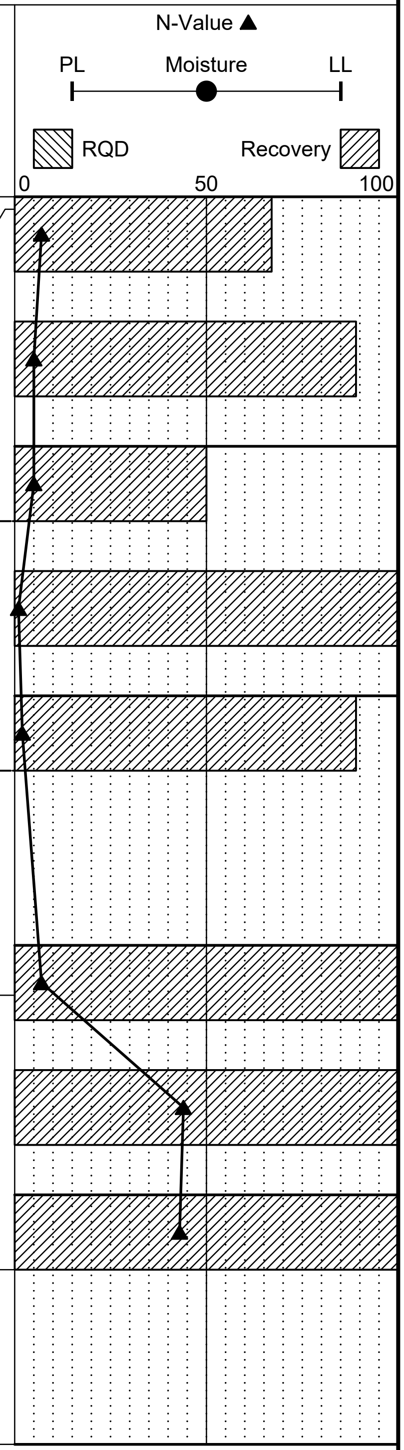
LOG OF TEST BORING PG-1

Figure A-2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	3411 23rd Ave W	Surface Elevation:	134.0ft
Job Number:	18-355	Top of Casing Elev.:	N/A
Location:	3411 23rd Ave W, Seattle, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
0				Topsoil: 3 inches thick.
	S-1	1 2 5		Loose, brown, silty SAND with gravel; rootlets, with brick and charcoal fragments throughout. **(Fill).**
	S-2	3 2 3		
5	S-3	6 3 2		
				Very loose, moist, gray-brown, silty SAND; occasional rootlets. **(Fill).**
	S-4	1 0 1		
10	S-5	1 0 2		Becomes wet and gray.
				Very soft, moist, gray clayey SILT; trace roots and organics. **(Fill).**
15	S-6	1 2 5		
				Stiff, moist, gray, silty CLAY; medium plastic, laminated. **(Lawton Clay).**
	S-7	10 18 26		Becomes hard silty CLAY.
20	S-8	16 18 25		
				Boring terminated at about 21.5 feet below ground surface. Perched groundwater was observed from about 10 to 16 feet during drilling.
25				



Completion Depth:	21.5ft
Date Borehole Started:	10/30/18
Date Borehole Completed:	10/30/18
Logged By:	J. Manke
Drilling Company:	CN Drilling

Remarks: Borings drilled using an acker hand portable drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with a rope and cathead mechanism. Surface elevation estimated based on the City of Seattle GIS map.

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LOG OF TEST BORING PG-2

Figure A-3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	3411 23rd Ave W	Surface Elevation:	135.0ft
Job Number:	18-355	Top of Casing Elev.:	N/A
Location:	3411 23rd Ave W, Seattle, WA	Drilling Method:	Hand Auger
Coordinates:	Northing: , Easting:	Sampling Method:	N/A

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION	N-Value ▲ PL Moisture LL; RQD / Recovery (0 50 100)
0						Landscaping topsoil: 6 inches thick.	
						Loose to medium dense, moist, gray-brown, silty SAND. **(Fill).**	
						Stiff, moist, gray, SILT; with occasional laminated oxidized layers. **(Lawton Clay).**	
						Hand boring terminated at about 3 feet below ground surface. Groundwater was not encountered during excavation.	
5							
10							
15							
20							
25							

Completion Depth:	3.0ft
Date Borehole Started:	10/30/18
Date Borehole Completed:	10/30/18
Logged By:	J. Manke
Drilling Company:	N/A

Remarks: Hand borings excavated using a hand auger and hand tools. Relative density estimated based on the difficulty of advancing the hand auger and probing. Surface elevation estimated based on the City of Seattle GIS map.

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LOG OF TEST BORING HB-1

Figure A-4

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	3411 23rd Ave W	Surface Elevation:	135.0ft
Job Number:	18-355	Top of Casing Elev.:	N/A
Location:	3411 23rd Ave W, Seattle, WA	Drilling Method:	Hand Auger
Coordinates:	Northing: , Easting:	Sampling Method:	N/A

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION	N-Value ▲ / PL — Moisture ● — LL / RQD / Recovery (0 50 100)
0						Loose to medium dense, moist, gray-brown, silty SAND with gravel. **(Fill).**	
5						Stiff, moist, gray, SILT; occasional laminated oxidized layers. **(Lawton Clay).**	
						Hand boring terminated at about 5.3 feet below ground surface. Groundwater was not encountered during excavation.	
10							
15							
20							
25							

Completion Depth: 5.3ft
Date Borehole Started: 10/30/18
Date Borehole Completed: 10/30/18
Logged By: J. Manke
Drilling Company: N/A

Remarks: Hand borings excavated using a hand auger and hand tools. Relative density estimated based on the difficulty of advancing the hand auger and probing. Surface elevation estimated based on the City of Seattle GIS map.

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LOG OF TEST BORING HB-2

Figure A-5

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	3411 23rd Ave W	Surface Elevation:	134.0ft
Job Number:	18-355	Top of Casing Elev.:	N/A
Location:	3411 23rd Ave W, Seattle, WA	Drilling Method:	Hand Auger
Coordinates:	Northing: , Easting:	Sampling Method:	N/A

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION	N-Value ▲ / PL Moisture LL / RQD Recovery (0 50 100)
0						Loose to medium dense, moist, gray-brown, silty SAND with gravel. **(Fill).**	
						Soft, very moist, gray, SILT with sand; organics. **(Fill).**	
5						Hand boring terminated at about 5 feet below ground surface due to refusal on a rock. Groundwater was not encountered during excavation.	
10							
15							
20							
25							

Completion Depth: 5.0ft
Date Borehole Started: 11/29/18
Date Borehole Completed: 11/29/18
Logged By: J. Manke
Drilling Company: N/A

Remarks: Hand borings excavated using a hand auger and hand tools. Relative density estimated based on the difficulty of advancing the hand auger and probing. Surface elevation estimated based on the City of Seattle GIS map.

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LOG OF TEST BORING HB-3

Figure A-6

The stratification lines represent approximate boundaries. The transition may be gradual.