Geotechnical Investigation Report
Property: PMA #1594
City of Seattle, Washington

April 2017

ERRG Project No. 20170012

Prepared for:

City of Seattle, Real Estate Services
Department of Finance and Administrative Services Seattle Municipal Tower
700 Fifth Avenue, Suite 4112
Seattle, WA 98104-5042

Prepared by:

ERRG

Engineering Remediation Resources Group, Inc.
15333 NE 90th Street
Redmond, WA 98052

Geotechnical Investigation Report
Property: PMA #1594
City of Seattle, Washington

Submitted by:
Engineering/Remediation Resources Group, Inc.

Signature	April 11, 2017 Date
Spencer Slominski, PE, PMP	Project Manager

CERTIFICATION

I hereby certify that this Geotechnical Investigation Report has been prepared in accordance with good engineering practices.

Spencer Slominski, P.E.
Civil Engineer No. 52438

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Abbreviations and Acronyms

AC	asphaltic concrete
ASTM	ASTM International
bgs	below ground surface
CRB	crushed rock base
EHSI	EHS-International, Inc.
ERRG	Engineering/Remediation Resources Group, Inc.
g	gravity
IBC	International Building Code
mm	millimeter
psf	pounds per square foot

Section 1. Introduction

Engineering/Remediation Resources Group, Inc. (ERRG) performed a geotechnical investigation on behalf of the City of Seattle at seven contiguous lots (PMA #1594) located at Yakima Avenue S and S Irving in Seattle, Washington (Figure 1). The purpose of this investigation was to obtain subsurface data to be used in the preliminary design and construction of the structures (low-income townhomes) at the site. This report presents the results of our subsurface exploration and preliminary design recommendations.

1.1. SITE DESCRIPTION

The site consists of seven rectangular contiguous lots, totaling 16,477 square feet, located at the northeast corner of the intersection at Yakima Avenue S and S Irving, in Seattle, Washington (Figure 1). The parcel numbers for the property are 364410-0185, 364410-0190, 364410-0195, 364410-0200, 364410-0205, 364410-0210, and 364410-0215. The legal descriptions for the properties are: Lots 5 through 11, Block 3, Jackson and Rainier Street Addition recorded in Volume 3 of Plats, page 65, Records of King County, WA. Currently, the lot is undeveloped, vegetated with shrubs and grass, and surrounded in all directions by residential neighborhoods (Figure 2). Approximately 40 percent of the property is steep slope, with an average 30-foot drop in elevation from east to west. The City's geographic information system shows no other critical environmental areas.

1.2. SCOPE OF SERVICES

The investigation included reviewing available geologic literature and conducting a subsurface exploration, including advancing two subsurface borings and collecting soil samples for laboratory analysis of geotechnical engineering properties of soil. Specifically, ERRG completed the following tasks during the geotechnical investigation:

- Reviewed databases and maps for geologic hazards and sensitive areas
- Directed two subsurface borings, and collected standard penetration measurements
- Submitted soil samples to a certified analytical laboratory for geotechnical analysis
- Evaluated the subsurface soil and groundwater conditions in the test borings
- Conducted an engineering analysis of the subsurface conditions to develop general construction recommendations, including:
  - site preparation recommendations;
  - use of onsite soil for structural fill;

- grading and earthwork procedures;
- foundation design criteria, including soil-bearing and lateral load capacities;
- floor slab subgrade preparation; and
- subgrade preparation recommendations beneath pavement areas.

- Prepared this geotechnical report to present with the results of the database review and field conditions encountered.

1.3. REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 2 describes the geologic conditions based on the review of databases and maps
- Section 3 summarizes the subsurface exploration activities, including laboratory analysis
- Section 4 identifies the geologic hazards and mitigation measures based on the results and observations made during subsurface exploration activities
- Section 5 presents the preliminary design recommendations based on the results of the geotechnical investigation
- Section 6 presents the limitations pertaining to this investigation
- Section 7 lists the documents and guidance used to prepare this report

Figures are presented after Section 7. Also, the following supporting information is appended to this report:

- Appendix A, Boring Logs
- Appendix B, Geophysical Engineering Laboratory Results

Section 2. Geologic Conditions

ERRG reviewed the "Geologic Map of Surficial Deposits in Seattle 30' by 60 ' Quadrangle, Washington" (Yount et al., 1993), and "The Geological Map of Seattle – A Progress Report" (Troost et al., 2005) to inform the evaluation of geologic conditions at the site. The review indicated that soil in the vicinity of the site consists of Vashon advanced outwash deposits (Map Unit Qva), deposits of the Pleistocene Fraser Glaciation period, and their contact with Pre-Fraser non-glacial deposits. The Vashon advanced outwash consists of clean pebbly sand that was deposited ahead of the advancing glacial ice about 12,000 years ago. Qva consists of moderately to well-sorted sand and gravel deposited by streams issuing from the advancing ice sheet. Silt lenses locally present in the upper part and common in the lower part. Generally unconsolidated to slightly consolidated. These geologic conditions were generally similar to the findings of the subsurface exploration (see Section 3).

ERRG also reviewed the Geologic Hazard Areas Map prepared by King County (imap database). The review indicated that the site is not mapped as landslide and seismic hazard areas. The area is mapped in the Seattle Fault Zone, which represents the area where several parallel strands of the Seattle fault have either broken the ground surface or caused deformation of the geologic materials. In Seattle, evidence for offset along the Seattle fault consists of uplifted beach deposits, down-dropped tidal marshes, offset strata, and deformation such as sheared and tightly folded strata near the leading (northern) edge of the fault. The Seattle fault is one of several active crustal faults in the Puget Lowland undergoing further research. The location of the Seattle fault zone was derived from mapping by Troost et al. (2005).

Based on the review, the runoff is medium, the erosion hazard is low, and no flooding hazards were mapped at the site or adjoining properties. The slippage potential is low at the site, and no critical areas were mapped at the site or adjoining properties.

Section 3. Subsurface Exploration

This section describes the subsurface exploration activities completed by ERRG during the geotechnical investigation, as well as the lithologic evaluation and laboratory analysis of collected soil samples. ERRG performed the project in conjunction with EHS-International, Inc. (EHSI) who was on site to collect environmental samples (soil and groundwater) for analysis. All investigation activities were conducted on March 1, 2017.

3.1. FIELD ACTIVITIES AND OBSERVATIONS

Prior to drilling activities ERRG cleared the eastern edge of the property to allow the drill rig to access the site. ERRG then used a hollow-stem auger to advance two borings to a maximum depth of 50 feet below ground surface (bgs), collected continuous cores to log the soil lithology, and collected and submitted two soil samples to HWA Geosciencies, Inc. in Bothell, Washington, for geotechnical analysis. The soil samples were collected from a Dames and Moore standard penetration test (SPT) sampler driven at 5-foot intervals. Appendix A contains the boring logs describing the lithology. Figure 2 shows the boring locations. Appendix B includes the analytical laboratory report.

During field activities, groundwater seepage was encountered in Borehole 1 at a depth of approximately 10 feet bgs. Surface water infiltration appears to be conductive beneath the due to sands and gravels, which were underlain by very dense silt. It is unknown if the water encountered was the result of drainage from the upslope properties or a small groundwater seep in the underlying the site. As a result, EHSI collected a groundwater sample for chemical analysis. Groundwater was not encountered in Borehole 2 during the subsurface exploration.

3.2. LITHOLOGIC EVALUATION

During field activities, ERRG's registered gelogist logged continuous cores to evaluate the site lithology. Based on the boring logs (Appendix A), subsurface soil at the site consists of organic silty sand/silt (topsoil) covering the surface of the lot, and the root zone extends to about 1.5 to 2 feet bgs. The topsoil, which was encountered in each of the explorations conducted, is unsuitable for structural support. Underlying the topsoil are glacial deposits consisting of medium dense to dense silty/sand and silt, clay with gravel. The materials become very dense at about 2.5 feet bgs and are underlain at approximately 10 feet bgs by glacial outwash materials, which are primarily a gray fine sandy silt and clay that is hard and non-plastic in composition. Borehole 1 was located at an elevation 15 feet higher than Borehole 2. The subsurface materials encountered in Borehole were primarily silt, while those encountered in Borehole 2 were clay.

The upper beds of the deposits possess a high shear strength, have low compressibility characteristics, and are suitable for direct foundation support. However, at a depth of 45 to 50 feet, the material softened to become stiff to firm. The lower blow counts at depth may be indicative of a remnant slide plane.

3.3. LABORATORY ANALYSIS FOR GEOPHYSICAL PARAMETERS

ERRG personnel delivered the soil samples to HWA Geosciencies, Inc. in Bothell, Washington, on March 3, 2017, for geotechnical analysis. The samples were delivered in resealable plastic bags and were designated with exploration identification number and depth of sampling. The samples were classified for engineering purposes based on visual manual methods; Appendix B shows the classification for the samples.

- Moisture Content of Soil: The moisture content of the soil samples (percent by dry mass) was determined in general accordance with ASTM International (ASTM) Standard D2216.
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits): Selected samples were tested using the one-point method specified in ASTM D4318. The results are reported on the attached Liquid Limit, Plastic Limit, and Plasticity Index report.
- Particle Size Analysis of Soil: The samples were tested to determine the particle size distribution in general accordance with ASTM D422, using both sieve and hydrometer analysis. Only the portion of the sample passing the 2.0-millimeter (mm) sieve was tested; Table 1 below shows the amount of material retained on the 2.0-mm sieve. The results are plotted on the attached Particle Size Analysis of Soil Report, and indicate the moisture content of the soil samples at the time of testing.

Table 1. Percent Retained on 2.0-mm Sieve

Borehole ID No.	Depth (feet bgs)	Percent Retained on 2.0-mm Sieve (%)
BH-1	5	8.8
BH-1	10	0.1
BH-1	15	0.7
BH-2	5	1.6
BH-2	10	0.3
BH-2	15	0.0

Section 4. Geologic Hazards and Mitigation Measures

This section describes potential geological hazards for the site as well as mitigation measures.

4.1. LANDSLIDE HAZARDS AND MITIGATION

During the subsurface exploration activities, ERRG performed a site reconnaissance and evaluated the slope stability condition of the site. No obvious features (such as curved trees, tension cracks, etc.) suggesting past or recent deep-seated landslides were observed at the site or at the adjacent roadways or sidewalk access to the south.

Because dense to hard glacially consolidated soil forms the core of the site, the chance of deep-seated global land sliding is low. As a result, as long as concentrated stormwater flows resulting from site grading and development are not allowed to discharge directly onto the site slopes, no other landslide hazard mitigation measures are required at the site. Based on our site reconnaissance, ERRG believes that the site is generally in stable condition and the proposed development will not adversely affect slope stability if the geotechnical recommendations are incorporated into final design and construction.

4.2. LIQUEFACTION

Based on Table 1613.5.2 in the 2012 International Building Code (IBC), the site soil is Class D. The earthquake spectral response acceleration at short periods (S_s) is 138% gravity (g) and at 1-second periods (S_1) is 53% g.

Liquefaction is a phenomenon where soil strength is reduced or completely lost because of an increase in water pressure induced by vibrations from a seismic event. Liquefaction mainly affects geologically recent deposits of fine-grained sands that are below the groundwater table. Soil of this nature derive its strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates the intergranular friction, thus reducing or eliminating the soil's strength.

ERRG reviewed the results of the field and laboratory testing and assessed the potential for liquefaction of the site's soil during an earthquake. Based on the soil conditions, the potential for soil liquefaction during a seismic event is low. This conclusion has been confirmed by the King County's map.

4.3. EROSION HAZARDS AND MITIGATION

The property will have a moderate potential for erosion if vegetation is removed from the area. To mitigate and reduce the erosion hazard and potential for offsite sediment transport, ERRG recommends the following:

1. Surface water should not be allowed to flow across the site over unprotected surfaces.
2. All storm water from impermeable surfaces, including driveways and roofs, should be tight-lined to a suitable infiltration system.
3. Silt fences should be placed and maintained around the downslope perimeter of the proposed construction area throughout the entire construction phase.
4. Soils that are to be reused should be stored under plastic to reduce erosion from the stockpile.
5. The construction access road should contain swales to intercept runoff and collect sediments.

Section 5. Preliminary Design Recommendations

This section summarizes the general recommendations based on the geotechnical investigation results, as well as other geotechnical design considerations. The main geotechnical issues for the site include foundation support, driveway design, subgrade preparation, erosion control, and drainage considerations. All recommendations provided in this section should be incorporated into the final design drawings and construction specifications.

5.1. SITE PREPARATION AND EROSION CONTROL

Site preparation should incorporate installing erosion control measures, stripping vegetation, and excavating for subsurface drainage and foundation structures. Silt fences should be installed surrounding the areas to be disturbed by construction activity to prevent sediment-laden surface runoff from being discharged off site. Construction areas within the building footprint should be protected with plastic sheeting.

The proposed site development will likely require temporary cuts exceeding 2.5 feet to install the slab on-grade foundation and footers for the townhomes. The excavation will remove most of the existing loose site soil and organic topsoil. However, some loose soil may remain and footings should be stepped to extend down to the dense soil. Fill soil is not anticipated within the building footprint. Once clearing, grubbing, and other site preparation activities are complete, cuts and fills can be made to establish the desired grades.

Based on the clay content of the site soil, excavated site soil is unsuitable for use as structural fill. If construction occurs in wet weather or site grading requires additional material, ERRG recommends using imported structural fill for site grading.

Prior to use, a geotechnical engineer should examine and test all materials imported to the site for use as structural fill. Structural fill materials should be placed in uniform loose layers not exceeding 8 inches and compacted to a minimum of 95 percent of the soil's maximum density, as determined by ASTM D1557 (Modified Proctor). The moisture content of the soil at the time of compaction should be within 2 percent of its optimum, as determined by ASTM D1557.

5.2. FOUNDATIONS

Based on the site conditions and the proposed construction, it is ERRG's opinion that conventional slab on-grade pads with spread footing systems can be used to support the structures. Footings should extend down a minimum of 1 foot below the pad grade and be supported on the dense native soil, or on structural fill that extends down to the dense soil, as shown on Figure 3. The structural fill prism below the footings should be as wide as it is deep, plus the width of the footing, to adequately transfer the loads to the underlying dense soil, or as recommended by the geotechnical engineer. Individual spread footings may be used for supporting columns, and strip footings may be used for bearing walls. ERRG's recommended design criteria for the foundations are as follows:

- Allowable bearing pressure, including all dead and live loads
  - Dense site soil = 2,500 pounds per square foot (psf)
  - Structural fill = 2,500 psf
- Minimum depth to bottom of perimeter and interior footings
  - Below the adjacent grade = 18 inches
- Minimum width of wall footings = 24 inches
- Minimum lateral dimension of column footings = 24 inches

Anticipated settlement of footings founded on the medium dense to dense outwash soil should be on the order of 1 inch. A geotechnical engineer should inspect all footing areas prior to placement of concrete to verify the design-bearing capacity of the soil has been attained, and that construction conforms to the recommendations contained in this report. Such inspections may be required by the City of Seattle. Footing drains should be placed around all perimeter footings, as shown on Figure 3 and described in Section 5.4.

The following geotechnical parameters should be used for the foundation design in accordance with the 2012 International Building Code (2012 IBC).

- Site Class "C" (see Table 1615.1.1 in 2012 IBC)
- Sg = 138% g (see Figure 1516[1] in 2012 IBC)
- Sl = 53% g (see Figure 1516[2] in 2012 IBC)

5.3. SLAB-ON-GRADE FLOORS

Most of the subgrade soil in the cut should be dense and unyielding and acceptable to place the capillary break. Loose to medium dense soil should be removed and replaced with compacted structural fill. To avoid moisture buildup on the subgrade, slab-on-grade floors should be placed on a capillary break, which is in turn placed on the prepared subgrade. The capillary break should consist of a minimum 6-inch-thick free-draining layer of gravel or crushed rock containing no more than 5 percent finer than a No. 4 sieve (1/4-inch opening). A vapor barrier, such as a 6-mil plastic membrane, is recommended over the capillary break to reduce water vapor transmission through the slab. Blue 2-inch foam board may be placed above the vapor barrier to provide additional insulation if radiant heating is installed. Two to 4 inches of sand may be placed over the barrier membrane and foam board for protection during construction. Concrete should be reinforced with #4 rebar imbedded on a minimum of 12-inch centers each way.

5.4. DRAINAGE

It is necessary to install footing drains to prevent hydrostatic pressure buildup beneath the foundation. The drains should consist of a 4-inch minimum diameter, perforated or slotted, rigid drain pipe laid at or just below the base of the footing with a gradient sufficient to generate flow (see Figure 3). The drain line should be bedded on, surrounded by, and covered with free-draining washed rock (minimum thickness of 12 inches), which runs the entire length of the wall to within 1 foot of the final grade and ties into a footing drain system. The drain rock should be wrapped with a geotextile filter fabric, such as Mirafi 140N or equivalent.

Roof and surface runoff should not discharge into the footing drain system, but should be handled by a separate rigid tight line drain. During construction, the grades adjacent to walls should be sloped downward away from the structures a minimum gradient of 2 percent for a distance of at least 6 feet measured perpendicular to the walls to achieve surface drainage. ERRG recommends that sufficient cleanouts be installed to allow for periodic maintenance of the footing drain and downspout tight-line systems.

Final exterior grades should promote free and positive drainage away from the building area. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building area. For non-pavement locations, ERRG recommends providing a minimum drainage gradient of 3 percent for a minimum distance of 10 feet from the building perimeter. In paved locations, a minimum gradient of 1 percent should be provided unless provisions are included for collection and disposal of surface water adjacent to the structure.

5.5. UTILITY TRENCH BACKFILL

Utility pipes should be bedded and backfilled in accordance with the most current version of the Washington State Department of Transportation/American Public Works Association specifications. For site utilities located within right-of-ways, bedding and backfill should be completed in accordance with City of Seattle specifications. The trench backfill should be placed and compacted as structural fill, as described in Section 5.1.

Where utilities occur below unimproved areas, the degree of compaction can be reduced to a minimum of 90 percent of the soil's maximum density as determined by ASTM 698. As noted, excavated onsite soil without organics would be suitable for use as structural fill. The backfill material should satisfy the structural fill requirements listed in Section 5.1.

5.6. DRIVEWAY

The asphalt or concrete driveway should consist of a minimum of 1-foot free-draining layer of gravel or 4-inch crushed rock overlain by 6 inches of crushed rock gravel containing no more than 5 percent finer than a No. 4 sieve (1/4-inch opening). If concrete is used to pave the driveway, #4 rebar should be embedded on a minimum of 12-inch centers.

For driveway and parking with typical passenger vehicle traffic, 2 inches of asphaltic concrete (AC) over 4 inches of crushed rock base (CRB) should be used. The paving materials used should conform to the Washington State Department of Transportation specifications for class B AC and CRB surfacing.

Section 6. Limitations

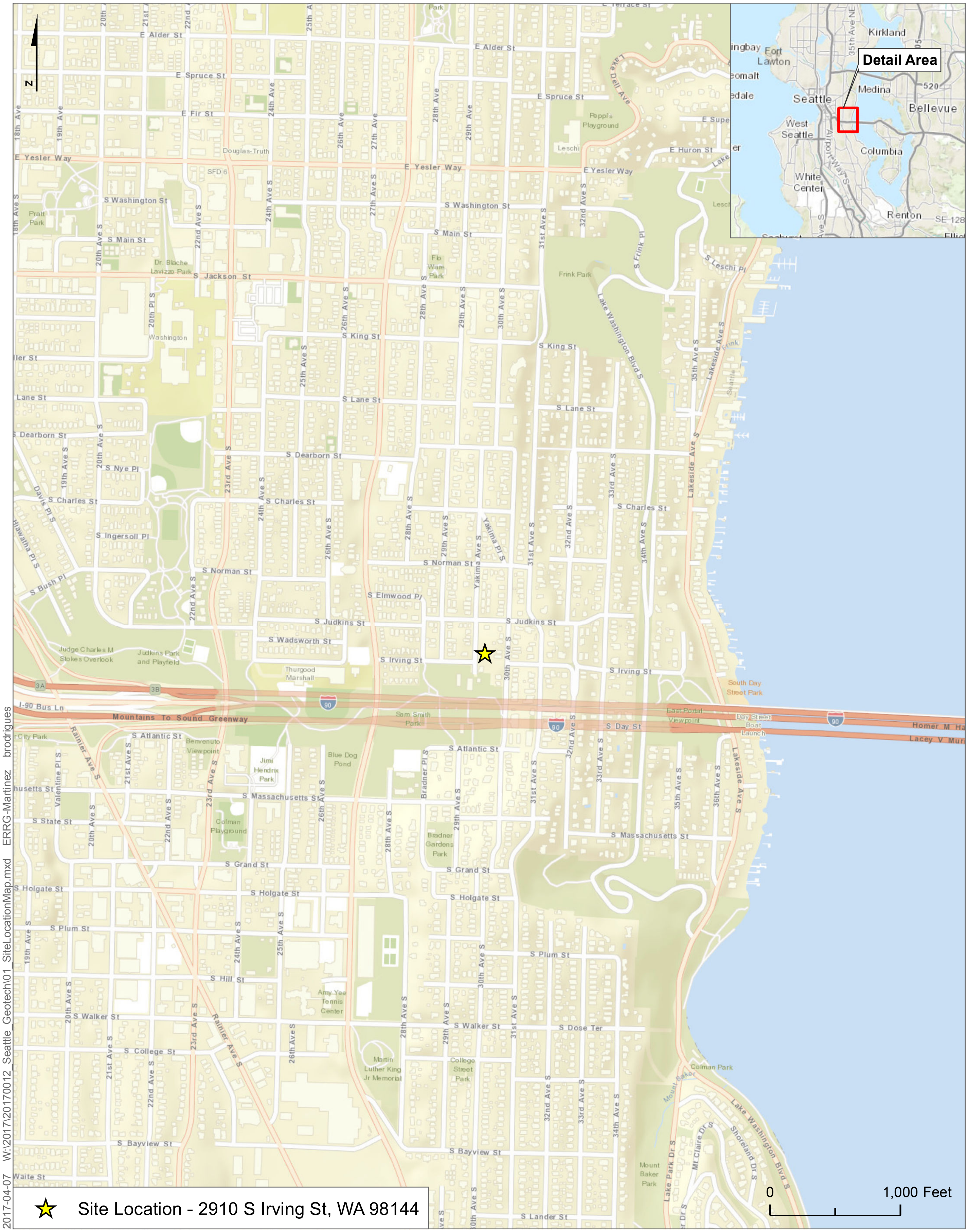
ERRG's findings and recommendations are based on field observations and professional experience and judgment. The recommendations are ERRG's professional opinion derived in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area. No warranty is expressed or implied. If soil conditions vary from those encountered during this investigation, site excavation, or construction, additional geotechnical consultation should be conducted to revise the recommendations identified in this report.

Section 7. References

INTERNATIONAL CODE COUNCIL. (2011). 2012 international building code. Country Club Hills, Ill, ICC.

Figures

Figure 1. Site Location and Vicinity Map



2017-04-07 W:\2017\20170012_Seattle_Geotech\01_SiteLocationMap.mxd ERRG-Martinez brodrigues

Figure 1. Site Location and Vicinity Map
City of Seattle, Washington

ERRG

Figure 2. Site Map and Subsurface Exploration Locations

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Figure 2. Site Map and Subsurface Exploration Locations
City of Seattle, Washington

ERRG

Figure 3. Foundation Cross Section C-C

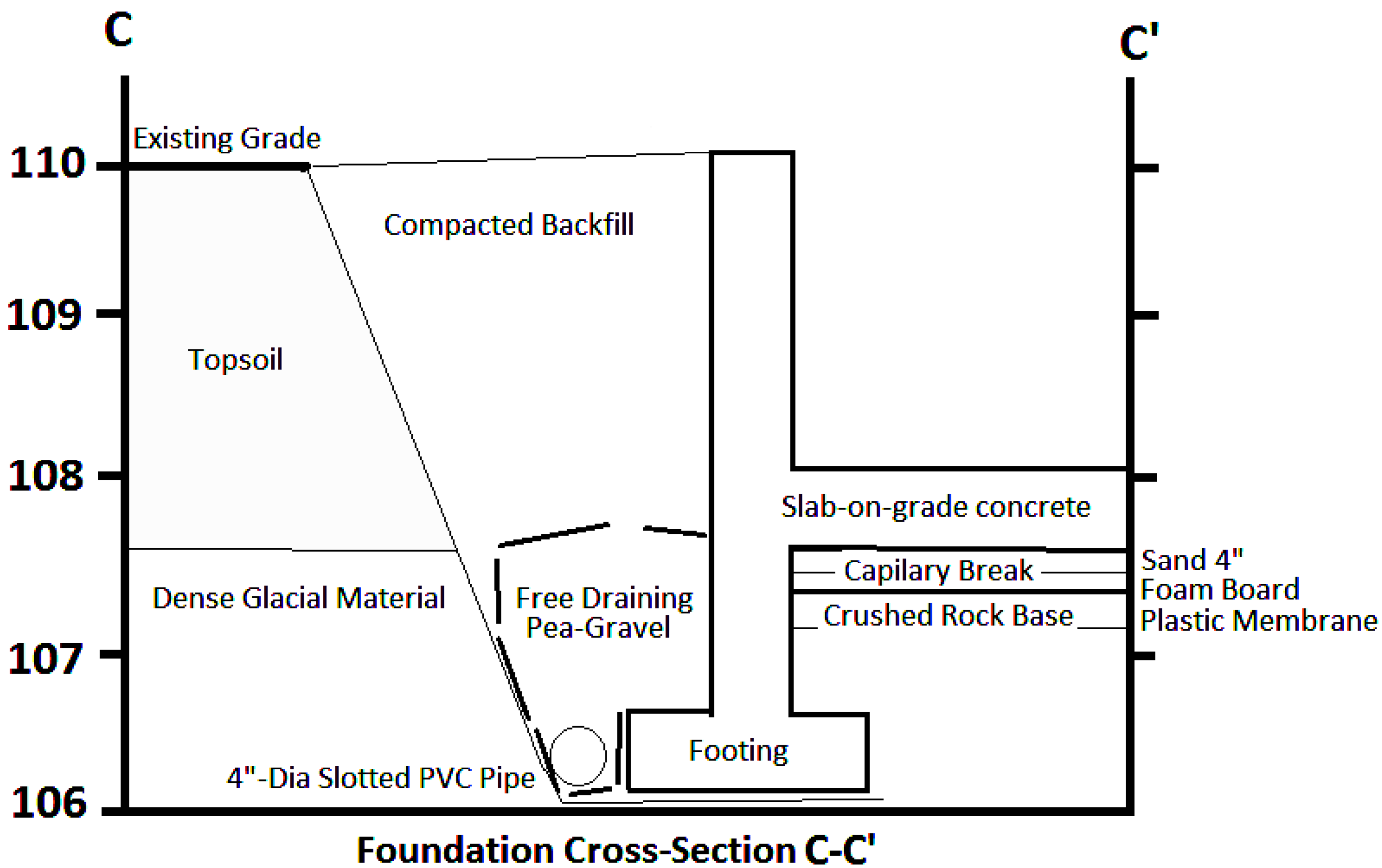

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Figure 3. Foundation Cross Section C-C'

City of Seattle, Washington

ERRG

Appendix A. Boring Logs

Boring Number BH-1 **ERRG Project No.** ______
Project PMA # 1594 **Location** NE corner of Yakima Ave S and S Irving, Seattle, WA
Date: 3-1-17 **Equipment** Cascade Drilling EC 95 Track Drill

Penetration Results	**Sample Depth (feet)**	**PID (ppm)**	**Depth (feet)**	**Lithologic Description**	**Soil Classification**
			0	**Topsoil Brambles and Grass**	
				Dk. Brown Silty Fine to Coarse SAND	SM
			1	with Gravel ½"- 2" Angular Damp,	
				Medium Dense with Decaying Organic	
			2	Material and Roots	
			3	Brown Silty Fine to Coarse SAND	SM
				with Gravel ½"- 3" Sub-rounded	
			4	Moist Medium Dense to Dense with	
				Roots	
45	BH-1@5'		5		
50 for 4"					
			6		
			7		
				Glacial Outwash	
			8	Gray Silty Fine to Coarse SAND	SM
				with Gravel ½"- 1" Sub-rounded Moist,	
			9	Dense - Very Dense Saturated with	
22				Groundwater	
30	BH-1@10'		10		
35					
			11	Olive Brown Fine Sandy SILT	ML
				Wet, Hard	
			12		
			13		
			14		
19	BH-1@15'		15		
36					
40			16		
			17		
			18		
			19		
19					
30	BH-1@20'		20		
40					

Penetration Sample Depth PID (ppm) Depth Lithologic Description Soil Classification

Boring Number BH-1 ERRG Project No.
Project PMA # 1594 Location NE corner of Yakima Ave S and S Irving, Seattle, WA
Date: 3-1-17 Equipment Cascade Drilling EC 95 Track Drill

Penetration Results	Sample Depth (feet)	PID (ppm)	Depth (feet)	Lithologic Description	Soil Classification
			21	Gray Fine Sandy SILT Wet, Hard (continued)	ML
			22		
			23		
			24		
14 25 30	BH-1@25’		25	Becomes Moist, and Very Stiff	ML
			26		
			27		
			28		
			29		
23 36 40	BH-1@30’		30	Hard	
			31		
			32		
			33		
			34	Becomes Dry and Hard	
20 37 50	BH-1@35’		35		
			36		
			37		
			38		
			39		
15 23 20	BH-1@40’		40		
			41		
			42		

Boring Number **BH-1** **ERRG Project No.**
Project **PMA # 1594** **Location** **NE corner of Yakima Ave S and S Irving, Seattle, WA**
Date: **3-1-17** **Equipment** **Cascade Drilling EC 95 Track Drill**

Results	(feet)	(feet)		
			Gray Fine Sandy SILT Dry, Stiff (continued)	ML
		43		
		44		
12 12 14	BH-1@45'	45		
		46		
		47		
		48		
		49		
6 8 9	BH-1@50'	50	Moist and Firm	ML

END OF BORING

Boring Number **BH-2** **ERRG Project No.** ______
Project **PMA # 1594** **Location** **NE corner of Yakima Ave S and S Irving, Seattle, WA**
Date: **3-1-17** **Equipment** **Cascade Drilling EC 95 Track Drill**

Penetration Results	Sample Depth (feet)	PID (ppm)	Depth (feet)	Lithologic Description	Soil Classification
			0	**Topsoil – Grass and Brambles**	
				Tan Fine to Coarse Sandy SILT	SM/ML
			1	with Gravel ½"- 2" Angular Damp,	
				Stiff/Medium Dense with Decaying Organic	
			2	Material and Roots	
			3	Brown Fine Sandy Silty CLAY	ML/CL
				with Gravel ½" – 2" Subrounded,	
			4	Moist, Medium Dense - Dense	
5					
10	BH-2@5'		5	**Glacial Outwash**	
20				Olive Brown Silty CLAY	ML/CL
			6	Wet, Hard	
			7		
			8		
			9		
45	BH-2@10'		10		
50				Gray Fine Sandy CLAY	CL
			11	Wet, Hard	
			12		
			13		
			14		
31	BH-2@15'		15		
30					
35			16		
			17		
			18		
			19		
30					
27	BH-2@20'		20		
50					

Penetration Sample Depth PID (ppm) Depth Lithologic Description Soil Classification

Boring Number BH-2 ERRG Project No.
Project PMA # 1594 Location NE corner of Yakima Ave S and S Irving, Seattle, WA
Date: 3-1-17 Equipment Cascade Drilling EC 95 Track Drill

Penetration Results	Sample Depth (feet)	PID (ppm)	Depth (feet)	Lithologic Description	Soil Classification
			21	Gray Fine Sandy CLAY Moist, Hard (continued)	CL
			22		
			23		
			24		
20 20 40	BH-2@25'		25	Becomes Moist, and Very Stiff	CL
			26		
			27		
			28		
			29		
16 18 23	BH-2@30'		30	Hard	
			31		
			32		
			33		
			34	Becomes Dry and Hard	
13 18 21	BH-2@35'		35		
			36		
			37		
			38		
			39		
11 13 13	BH-2@40'		40		
			41		
			42		

Boring Number **BH-2** **ERRG Project No.** ______
Project **PMA # 1594** **Location** **NE corner of Yakima Ave S and S Irving, Seattle, WA**
Date: **3-1-17** **Equipment** **Cascade Drilling EC 95 Track Drill**

Results	(feet)	(feet)		
			Gray Fine Sandy CLAY Dry, Stiff (continued)	CL
		43		
		44		
13 18 28	BH-2@45'	45		
		46		
		47		
		48		
		49		
15 23 30	BH-2@50'	50	Moist and Firm	CL

END OF BORING

Appendix B. Geophysical Engineering Laboratory Results

March 15, 2017
HWA Project No. 2017-032-23 Task 100

ERRG, Inc.
15333 NE 90th Street
Redmond, Washington 98052

Attention: Mr. Spencer Slominski

Subject: **Materials Laboratory Report**
Particle size and Atterberg Limits Testing
City of Seattle

Dear Mr. Slominski;

In accordance with your request, HWA GeoSciences Inc. (HWA) performed laboratory testing for the above referenced project. Herein we present the results of our laboratory analyses, which are summarized on the attached reports and in Table 1. The laboratory testing program was performed in general accordance with your instructions and appropriate ASTM Standards as outlined below.

SAMPLE DESCRIPTION: The subject samples were delivered to our laboratory on March 3, 2017 by ERRG. personnel. The samples were delivered in re-sealable plastic bags and were designated with exploration ID and depth of sampling. The samples were classified for engineering purposes based on visual manual methods, the classification for these samples is shown on the attached Figures 1 through 3.

MOISTURE CONTENT OF SOIL: The moisture content of the soil samples (percent by dry mass) was determined in general accordance with ASTM D 2216. The results are shown on the attached Figures, 1 through 3.

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ATTERBERG LIMITS): Selected samples were tested using method ASTM D 4318, one-point method. The results are reported on the attached Liquid Limit, Plastic Limit, and Plasticity Index report, Figure 2.

PARTICLE SIZE ANALYSIS OF SOILS: The samples were tested to determine the particle size distribution in general accordance with ASTM D422, using both sieve and hydrometer analysis. As requested by the client only the portion of the sample passing the 2.0 mm sieve was tested, the amount of material retained on the 2.0 mm sieve is shown the table below. The results are plotted on the attached Particle Size Analysis of Soil Report, Figure 1 which also indicates the moisture content of the soil samples at the time of testing.

Sample ID	Retained on the 2.0 mm Sieve (%)
BH-1 @ 5 ft.	8.8
BH-1 @ 10 ft.	0.1
BH-1 @ 15 ft.	0.7
BH-2 @ 5 ft.	1.6
BH-2 @ 10 ft.	0.3
BH-2 @ 15 ft.	0.0

CLOSURE: Experience has shown that test values on soil and other natural materials vary with each representative sample. As such, HWA has no knowledge as to the extent and quantity of material the tested samples may represent. HWA also makes no warranty as to how representative either the samples tested or the test results obtained are to actual field conditions. It is a well-established fact that sampling methods present varying degrees of disturbance that affect sample representativeness.

No copy should be made of this report except in its entirety.

We appreciate the opportunity to provide laboratory testing services on this project. Should you have any questions or comments, or if we may be of further service, please call.

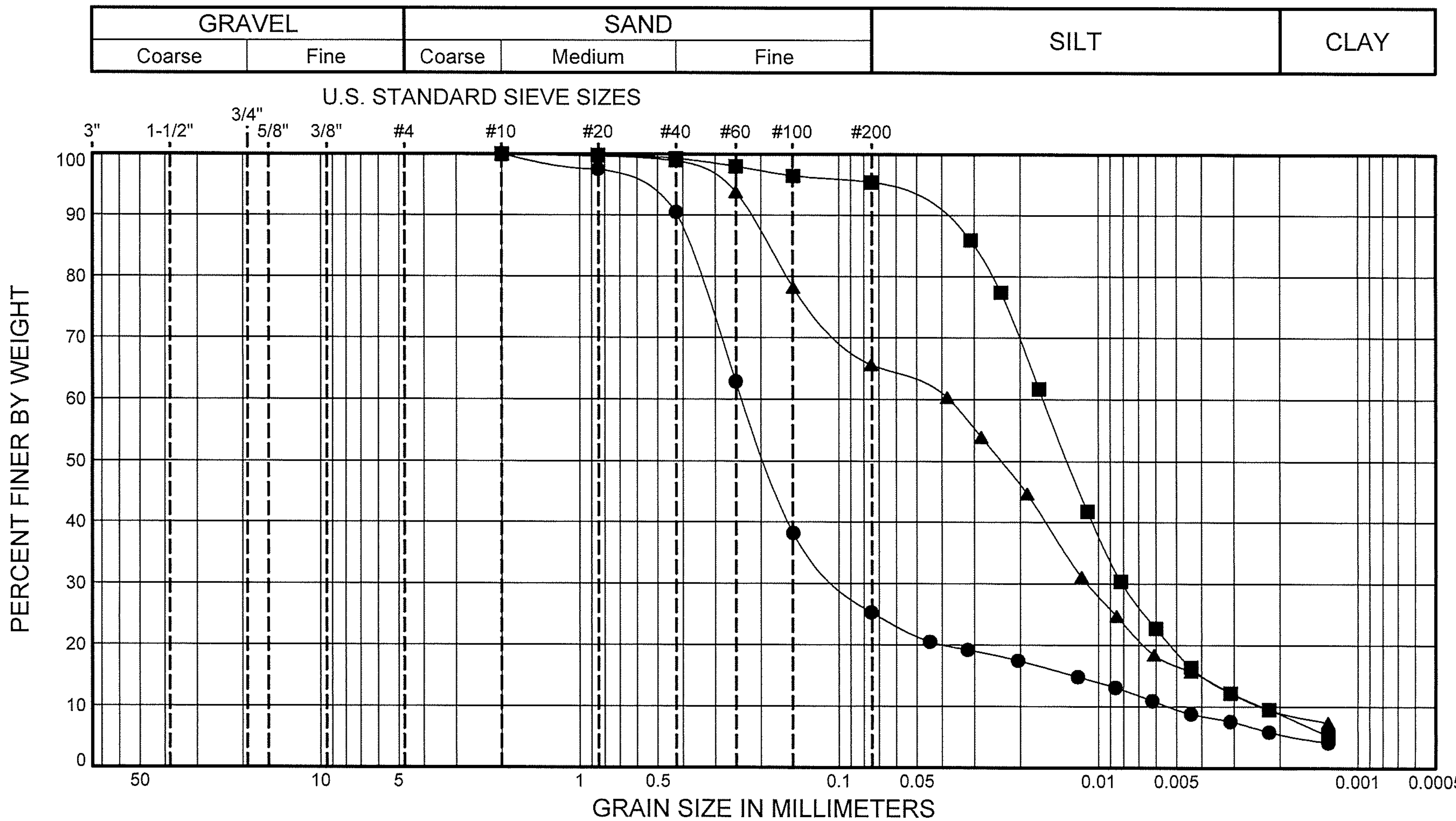
HWA GEOSCIENCES INC.

Jessica Herrera
Materials Laboratory Manager

Steven E. Greene, L.G., L.E.G.
Principal Engineering Geologist
Vice President

Attachments:

Figures 1 -2 Particle Size Analysis of Soils
Figure 2 Liquid Limit, Plastic Limit and Plasticity Index of Soils



SYMBOL	SAMPLE	DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	BH-1	5.0 - 6.5	(SM) Dark grayish brown, silty SAND	14					74.7	25.3
■	BH-1	10.0 - 11.5	(ML) Olive brown, SILT	24	NP	NP	NP		4.6	95.4
▲	BH-1	15.0 - 16.5	(ML) Grayish brown, sandy SILT	23	18	15	3		34.4	65.6

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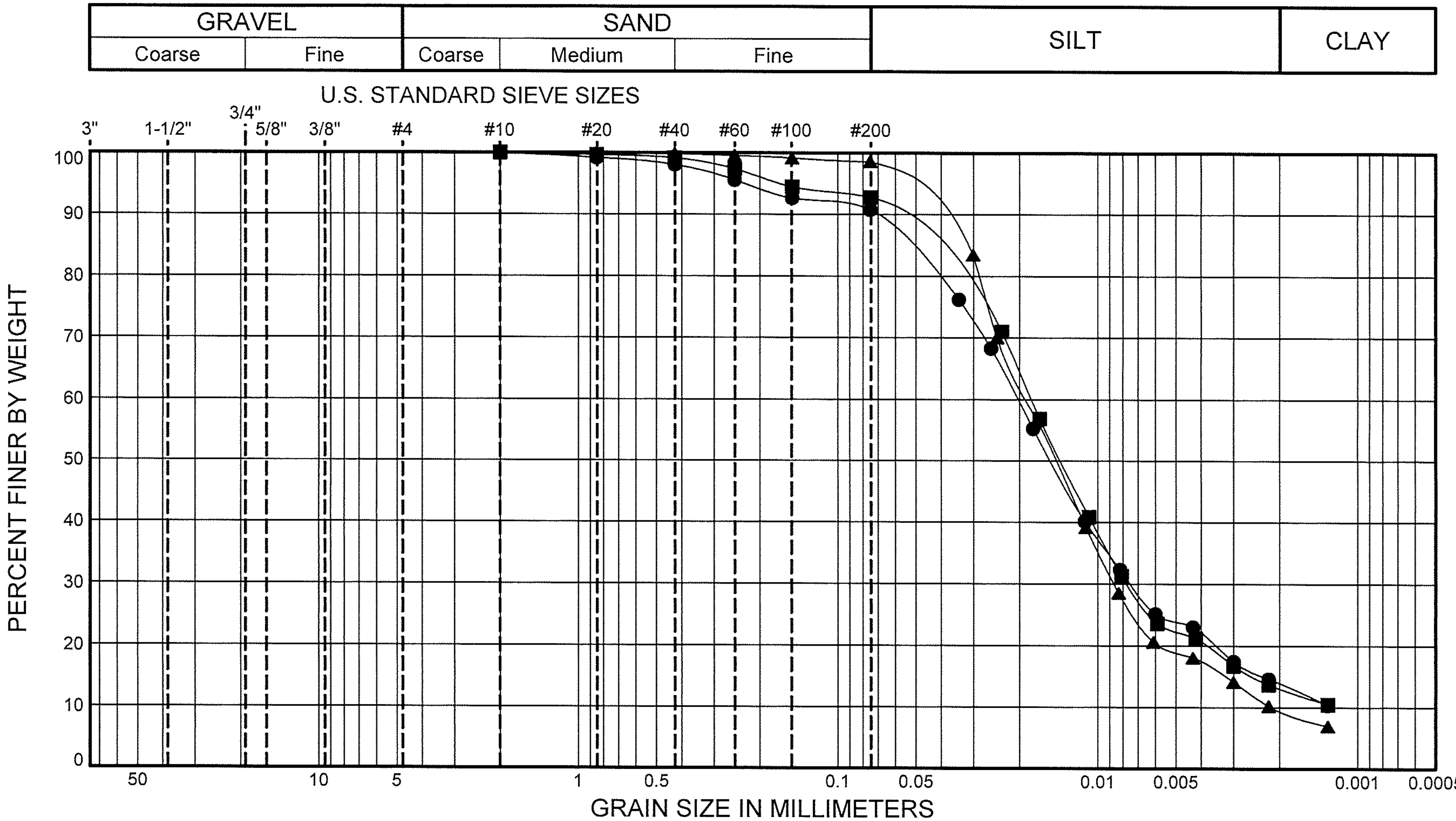
PARTICLE-SIZE ANALYSIS OF SOILS METHOD ASTM D422

PROJECT NO.: 2017-032-23 T100 FIGURE: 1



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	BH-2		5.0 - 6.5	(CL) Olive brown, Lean CLAY	25					9.3	90.7
■	BH-2		10.0 - 11.5	(CL) Gray, Lean CLAY	26	32	23	9		7.2	92.8
▲	BH-2		15.0 - 16.5	(CL) Gray, Lean CLAY	24	49	26	23		1.4	98.6

HWA GEOSCIENCES INC.

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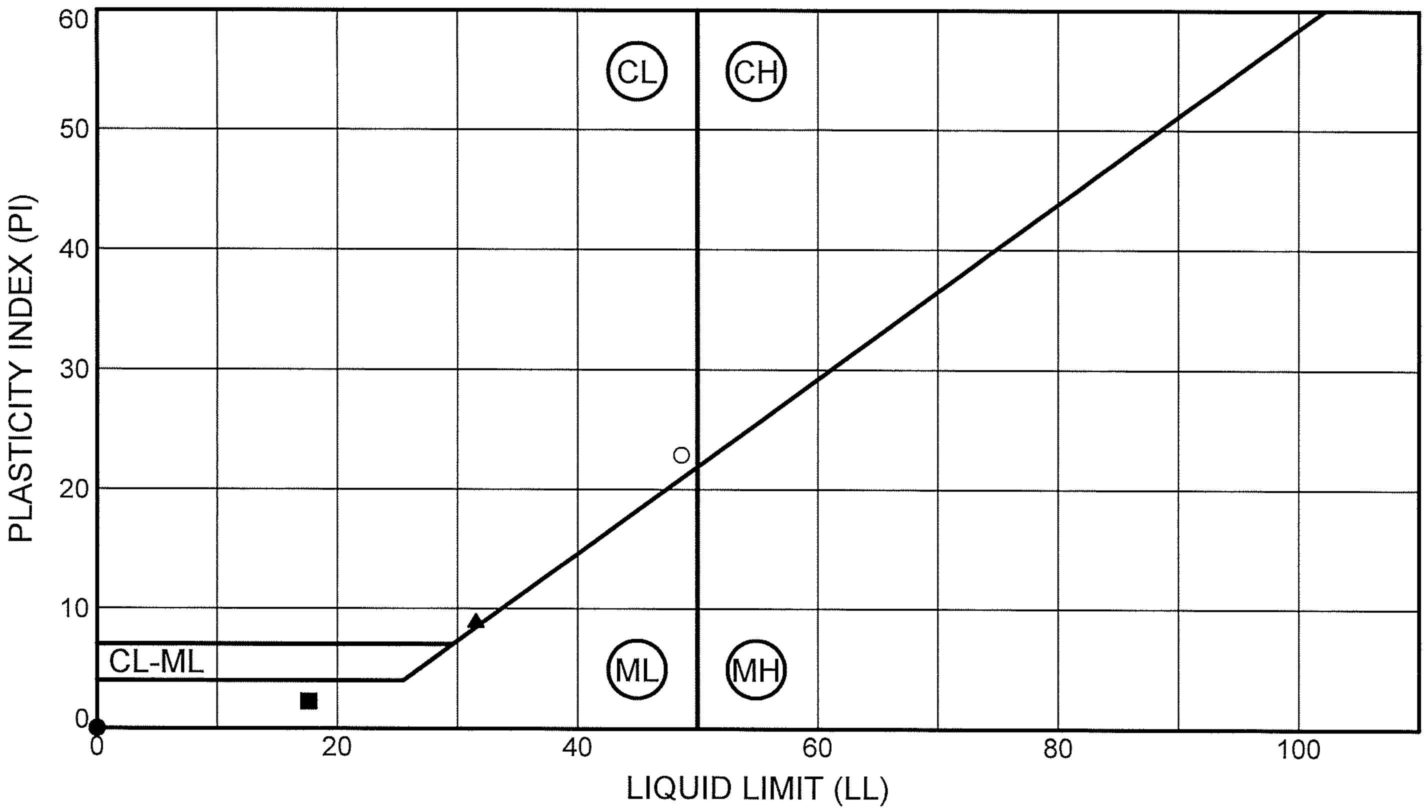
City of Seattle

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2017-032-23 T100 FIGURE: 2

HWAGRSZ 2017-032 T100.GPJ 3/15/17



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	BH-1		10.0 - 11.5	(ML) Olive brown, SILT	24	NP	NP	NP	95.3
■	BH-1		15.0 - 16.5	(ML) Grayish brown, sandy SILT	23	18	15	3	65.1
▲	BH-2		10.0 - 11.5	(CL) Gray, Lean CLAY	26	32	23	9	92.5
○	BH-2		15.0 - 16.5	(CL) Gray, Lean CLAY	24	49	26	23	98.6

HWA GEOSCIENCES INC.

Laboratory Testing For
ERRG, Inc.
City of Seattle

LIQUID LIMIT, PLASTIC LIMIT AND
PLASTICITY INDEX OF SOILS
METHOD ASTM D4318

PROJECT NO.: 2017-032-23 T100 FIGURE: 3