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March 10, 2020

Mr. Gregg Petrie
601 Dexter Avenue North
Seattle, Washington 98109
VIA E-mail: gpetrie@copiersnw.com

Geotechnical Engineering Letter
Petrie Residence Additions and Liquefaction Assessment
2431 – 60th Avenue SE
Mercer Island, Washington
NGA File No. 1159920

Dear Mr. Petrie:

This letter presents the results of our geotechnical engineering evaluation of the proposed Petrie Residence Additions project on Mercer Island, Washington.

INTRODUCTION

The project site is located at 2431 – 60th Avenue SE on Mercer Island, Washington, as shown on the Vicinity Map in Figure 1. The purpose of this study is to explore and characterize the site's surface and subsurface conditions and to provide geotechnical recommendations for the proposed site development. Our services were generally completed in accordance with the proposal signed by you on February 5, 2020.

The site is currently occupied by an existing single-family residence within the eastern portion of the approximately 0.43-acre, rectangular-shaped property. The property gently slopes westward toward the shoreline along Lake Washington. The proposed development plan consists of adding additions to the existing single-family residence and constructing a new detached garage, along with a 30-foot by 16-foot in-ground pool on the downslope side of the residence. We understand the pool will be between 4 and 6 feet in depth, maximum. The property is located within several critical areas as mapped by the City of Mercer Island, including landslide hazards, erosion hazards, and seismic hazards. We were retained to explore the subsurface soil conditions throughout the site, and provide a geotechnical assessment on the potential for liquefaction to affect the proposed development. The existing site layout is shown on the Site Plan in Figure 2.

For our use in preparing this letter, we have been provided with a topographic map of the property titled "Petrie Property," dated November 20, 2019 and produced by CORE Design. We have also been provided with a preliminary site plan and plan set dated January 22, 2020 and produced by Anderson Architecture.

SCOPE

The purpose of this study is to explore and characterize the site surface and subsurface conditions, and provide general recommendations for site development. Specifically, our scope of services included the following:

1. Reviewing available soil and geologic maps of the area.
2. Exploring the subsurface soil and groundwater conditions within the vicinity of the proposed development with hand auger explorations.
3. Mapping the conditions on the slopes, performing shallow hand-tool excavations, cross-sections, and evaluating current slope stability conditions within the vicinity of the site.
4. Performing grain-size sieve analysis on soil samples, as necessary.
5. Providing recommendations for foundation support and embedment, as needed.
6. Providing recommendations for earthwork.
7. Providing recommendations for temporary and permanent slopes.
8. Providing recommendations for temporary shoring, as needed.
9. Providing recommendations for retaining walls.
10. Providing recommendations for slab and pavement subgrade preparation.
11. Providing recommendations for utility installation.
12. Providing recommendations for site drainage and erosion control.
13. Documenting the results of our findings, conclusions, and recommendations in a written geotechnical letter.

SITE CONDITIONS

Surface Conditions

The subject site consists of a rectangular-shaped parcel approximately 0.43 acres in area. The property is bordered to the east by 60th Avenue SE, to the north and south by existing residential development, and to the west by shoreline along Lake Washington. The site is currently occupied by a 1,490 square foot residence in the central portion of the site, and a 440 square foot attached garage to the east. Most of the eastern portion of the property is paved, and surface modifications elsewhere on the property include two short retaining walls in the central- and western portion of the property, and a rockery along Lake Washington forming the westernmost property line. In general, the site slopes gently to the west, as shown on Cross Section A-A' in Figure 3.

The site is vegetated with grass areas and landscaping plants throughout the property, but also includes sparse deciduous landscaping trees. A network of buried irrigation lines are located below the backyard areas. Besides Lake Washington, we did not encounter surface water during our visit to the site on February 19, 2020.

Subsurface Conditions

Geology: The Geologic Map of Mercer Island, Washington, by Kathy G. Troost, Wisher, A.P., et al. (USGS, 2006) was reviewed for this site. The majority of the site is mapped as fine-grained deposits of pre-Olympia age (Qpof), with lacustrine deposits (Ql) associated with the lowering of Lake Washington in 1916 mapped in the lower portions of the site near the shoreline. There are nearby areas mapped as pre-Olympia non-glacial deposits (Qpon). The mapped fine-grained deposits are described as hard silt and clay with sandy interbeds. The lake deposits are described as silt and clay with local sand layers in a very loose to medium dense condition. The nearby non-glacial deposits are described as sand, silt, clay, and organic deposits in a discontinuous layer.

In general, our explorations generally encountered fine sandy silt with clay in upper, eastern areas of the site, silty fine to medium sand with varying amounts of gravel in central areas, and clean sand immediately adjacent to Lake Washington in the lower, western portion of the site. Generally consistent with their mapped descriptions, we have interpreted these soils to be Qpof, Qpon, and Ql, respectively.

Explorations: The subsurface conditions within the site were explored on February 19, 2020 by completing seven shallow hand-auger boreholes throughout the property. Explorations were completed to depths ranging from 2.0 to 5.6 feet below the existing ground surface. The approximate locations of our explorations are shown on the Site Plan in Figure 2. A geologist from NGA was present during explorations, examined soils and geologic conditions encountered, obtained samples of different soil types, and maintained exploration logs.

The soils were visually classified in general accordance with the Unified Soil Classification System, presented in Figure 4. Logs of our hand auger explorations are attached to this report and are presented as Figure 5. We present a summary of the subsurface conditions below. For a detailed description of the subsurface conditions, exploration logs should be reviewed.

Explorations can be grouped into three categories based on location within the site. In upper, eastern portions of the site, Hand Augers 1 and 2 exposed a surficial mantle of 1.8 to 3.0 feet of undocumented fill containing brick fragments and debris. Underlying materials consisted of oxidized, light gray fine sandy silt becoming clayey with depth, and silty fine to medium sand in a medium dense or better condition.

We interpreted these soils to be consistent with the mapped fine-grained deposits, Qpof. Hand Augers 1 and 2 terminated within these native soils at depths of 5.0 feet.

Central portions of the site, including backyard areas exposed undocumented fill associated with retaining wall construction, and up to 2.8 feet of undocumented fill upslope from the retaining wall. In Hand Augers 3 and 7, the fill is underlain by gray-brown to light gray silty fine to coarse sand with varying amounts of gravel in a medium dense or better condition. Just below the retaining wall, Hand Auger 6 exposed dense silty fine to medium sand with gravel at a depth of 0.6 feet below surficial fill. We interpreted these soils to be consistent with the non-glacial deposits (Qpon) mapped nearby. Hand Augers 3, 4, 6, and 7 were terminated within these soils at depths between and 2.0 and 5.6 feet below the existing ground surface.

Hand Auger 5 encountered clean sand beneath a surficial 0.8-foot layer of topsoil fill, coarsening downward with depth. Hand Auger 5 terminated within the lacustrine soils at a depth of 4.0 feet below the existing grade.

Hydrogeologic Conditions

Moderate groundwater seepage was observed in Hand Auger 3 at a depth of 4.2 feet below the surface, and saturated soils were encountered in Hand Auger 5 near the termination depth of 4.0 feet. We would interpret seepage in Hand Auger 3 to be perched water, and seepage in Hand Auger 5 to be associated with the groundwater table corresponding to Lake Washington. Perched water occurs when surface water infiltrates through less dense, more permeable soils and accumulates on top of a relatively low permeability material, such as the dense deposits encountered below the retaining wall. Perched water does not represent a regional groundwater "table" within the upper soil horizons. Perched water tends to vary spatially and is dependent upon the amount of rainfall. We would expect the amount of perched groundwater to decrease during drier times of the year and increase during wetter periods.

SENSITIVE AREA EVALUATION

Seismic Hazard

We reviewed the 2018 International Building Code (IBC) for seismic site classification for this project. Since very dense or better soils are interpreted to underlie the site at depth, the site best fits the IBC description for Site Class D.

Table 1 below provides seismic design parameters for the site that are in conformance with the 2018 IBC, which specifies a design earthquake having a two percent probability of occurrence in 50 years (return interval of 2,475 years), and the 2008 USGS seismic hazard maps.

Table 1 – 2018 IBC Seismic Design Parameters

Site Class	Spectral Acceleration at 0.2 sec. (g) S_s	Spectral Acceleration at 1.0 sec. (g) S_1	Site Coefficients		Design Spectral Response Parameters	
			F_a	F_v	S_{DS}	S_{D1}
D	1.378	0.531	1.000	1.500	0.919	0.531

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.

Fault Rupture: The site is contained within the Seattle Fault Zone (SFZ): an active, shallow region of seismicity within central Puget Sound. The latest recorded rupture within the SFZ has been dated to approximately 1,100 years before the present. The nearest fault strand in the zone is located approximately 0.8 miles to the south of the site. The SFZ can produce a M6—7.5 earthquake on a recurrence interval of several hundred years. In our opinion, the risk of a surface fault rupture within this specific site is low, given available data.

Liquefaction: Hazards associated with seismic activity include liquefaction potential and amplification of ground motion. Liquefaction is caused by a rise in pore pressures in a loose, fine sand deposit beneath the groundwater table. We did not encounter loose, fine sand beneath proposed additions. It is our opinion that the medium dense or better deposits interpreted to underlie the development areas of the site have a low potential for liquefaction or amplification of ground motion. However, a moderate liquefaction hazard may be present in low areas of the property adjacent to Lake Washington, especially within approximately 60 feet from the shoreline. The proposed development is not located within the potentially liquefiable soils near the shoreline, but rather will be supported on the medium dense or better native deposits that have a low risk for liquefaction.

Seiches: Seiches are lake waves caused by seismic offset or attenuation during an earthquake, or by severe atmospheric disturbances. Due to the presence of shoreline along Lake Washington on this site, there is a risk of damage to infrastructure and docks in close proximity to potential wave action. Lake Washington has experienced seiche activity after the 2001 Nisqually Earthquake, after the Alaskan earthquake in 1964, and during severe weather in 1993, closing the I-90 floating bridge. It is our opinion that the proposed development is located sufficiently distal from the shoreline to avoid direct impacts from potential seiche activity.

Erosion Hazard

The criteria used for determination of the erosion hazard for affected areas include soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to vegetative cover and the specific surface soil types, which are related to the underlying geologic soil units. The Soil Survey of King County Area, Washington, by the Natural Resources Conservation Service (NRCS), classifies the development portions of the site as Kitsap silt loam, 2 to 8 percent slopes. The erosion hazard listed for the exposed soils on the property is slight. It is our opinion that the erosion hazard for the site soils should be low in areas where vegetation is not disturbed.

Landslide Hazard

Portions of the site are mapped as a Potential Slide Area by the City of Mercer Island. The City defines Landslide Hazard Areas as those containing (1) historic failures, (2) slopes greater than 15 percent with permeable sediment overlying impermeable materials *and* containing groundwater seepage, (3) areas showing evidence of past movement or underlain by mass wastage, (4) susceptible to stream erosion, or (5) slopes greater than 40 percent, as set forth in MICC 19.16.010. The steepest slopes within the site were measured to have gradients up to 13 degrees (23 percent grade), but no groundwater seepage emanates from site slopes. The shallow soils underlying the site appear to be medium dense deposits of pre-Olympia age. None of the other criterion were encountered within the site or immediate vicinity during our explorations and field measurements. Based on this, we do not consider the site slopes as landslide hazard areas.

The core of the slopes consists primarily of glacially consolidated soils. Relatively shallow sloughing failures as well as surficial erosion are natural processes and should be expected on unprotected slopes during extreme environmental conditions. This is especially true within the loose surficial and undocumented fill soils on the slopes. Proper retaining wall construction, site grading and drainage, as well as foundation placement as recommended in the following geotechnical documentation should help maintain and enhance current stability conditions.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion, from a geotechnical standpoint, that the proposed site additions and in-ground pool development is feasible. Our explorations indicated that the site was underlain by a surficial layer of undocumented fill, with an underlying layer of medium dense or better native soils at depth. The native soils should provide adequate support for foundation, slab, and pavement loads. We recommend that the new structures be designed utilizing shallow foundations. Footings should extend through any loose soil, and be founded on the underlying medium dense or better native bearing soil, or structural fill extending to these soils. The competent soil should typically be encountered approximately three to five feet below the existing surface throughout the site, based on our explorations. Deeper, localized areas of undocumented fill may also exist in unexplored areas of the site. This condition, if encountered, would require deeper excavations in foundation, slab, and pavement areas to remove the unsuitable soils.

The soils encountered on this site are considered moisture-sensitive and may disturb easily when wet. We recommend that construction take place during the drier summer months, if possible. If construction is to take place during wet weather, the soils may disturb and additional expenses and delays may be expected due to the wet conditions. Additional expenses could include the need for placing a blanket of rock spalls to protect exposed subgrades and construction traffic areas, and erecting silt fences and straw bales to prevent muddy water from leaving the site.

Erosion Control

The erosion hazard for the on-site soils is listed as slight for exposed soils, but actual erosion potential will be dependent on how the site is graded and how water is allowed to concentrate. Best Management Practices (BMPs) should be used to control erosion. Areas disturbed during construction should be protected from erosion. Erosion control measures may include diverting surface water away from the stripped or disturbed areas. Silt fences and/or straw bales should be erected to prevent muddy water from leaving the site. Disturbed areas should be planted as soon as practical and the vegetation should be maintained until it is established. Erosion potential of areas not stripped of vegetation should be low.

Site Preparation and Grading

After erosion control measures are implemented, site preparation should consist of removing loose soils, topsoil, and any undocumented fill from foundations, slab, and pavement areas, to expose medium or better native bearing soils at depth. The stripped soil should be removed from the site or stockpiled for later use as a landscaping fill. Based on our observations, we anticipate native, medium dense or better soil to be encountered at approximately three to five feet throughout explored areas of the site. We should note that additional deeper areas of unsuitable soils and/or undocumented fill could be encountered in unexplored areas of the site, particularly on the westernmost portion of the subject site and in the existing volunteer garden area. This condition, if encountered, would require deeper excavations in foundation, slab, and pavement areas to remove the unsuitable soils.

After site preparation, if the exposed subgrade is deemed loose, it should be compacted to a non-yielding condition and then proof-rolled with a heavy, rubber-tired piece of equipment. Areas observed to pump or weave during the proof-roll test should be reworked to structural fill specifications or over-excavated and replaced with properly compacted structural fill or rock spalls. If loose soils are encountered in the foundation areas, the loose soils should be removed and replaced with rock spalls. If significant surface water flow is encountered during construction, this flow should be diverted around work areas, and exposed subgrades should be maintained in a semi-dry condition.

If wet conditions are encountered, alternative site grading techniques might be necessary. These could include using large excavators equipped with wide tracks and a smooth bucket to complete site grading, and covering exposed subgrade with a layer of crushed rock for protection. If wet conditions are encountered or construction is attempted in wet weather, the subgrade should not be compacted, as this could cause further subgrade disturbance. In wet conditions, it may be necessary to cover the exposed subgrade with a layer of crushed rock as soon as it is exposed to protect the moisture sensitive soils from disturbance by machine or foot traffic during construction. The prepared subgrade should be protected from construction traffic and surface water should be diverted around areas of prepared subgrade.

Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, including the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open, and the presence of surface or groundwater. It is exceedingly difficult under these variable conditions to estimate a stable, temporary, cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations at all times as indicated in OSHA guidelines for cut slopes.

The following information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Nelson Geotechnical Associates, Inc. assumes responsibility for job site safety. Job site safety is the sole responsibility of the project contractor.

For planning purposes, we recommend that temporary cuts be no steeper than 2H:1V. If significant groundwater seepage or surface water flow were encountered, we would expect that flatter inclinations would be necessary. We recommend that cut slopes be protected from erosion. The slope protection measures may include covering cut slopes with plastic sheeting and diverting surface runoff away from the top of cut slopes. We do not recommend vertical slopes for cuts deeper than four feet, if worker access is necessary. We recommend that cut slope heights and inclinations conform to appropriate OSHA/WISHA regulations.

Permanent cut and fill slopes should be no steeper than 2H:1V. However, flatter inclinations may be required in areas where loose soils are encountered. Permanent slopes should be vegetated and the vegetative cover maintained until established.

Foundations

Conventional shallow spread foundations should be placed on medium or better native bearing soils, or be supported on structural fill or rock spalls extending to those soils. Medium dense soils should be encountered approximately three to five feet below ground surface within the proposed residence footprint areas, based on our explorations. Additional areas of unsuitable soils and/or undocumented fill could be encountered in unexplored areas of the site. Where undocumented fill or less dense soils are encountered at footing bearing elevation, the subgrade should be over-excavated to expose suitable bearing soil. The over-excavation may be filled with structural fill, or the footings may be extended down to the competent, native, bearing soils. If footings are supported on structural fill, the fill zone should extend outside the edges of the footing a distance equal to half of the depth of the over-excavation below the bottom of footing.

Footings should extend at least 18 inches below the lowest adjacent finished ground surface for frost protection and bearing capacity considerations. Foundations should be designed in accordance with the 2018 IBC. Footing widths should be based on the anticipated loads and allowable soil bearing pressure. Water should not be allowed to accumulate in footing trenches. All loose or disturbed soil should be removed from the foundation excavation prior to placing concrete.

For foundations constructed as outlined above, we recommend an allowable bearing pressure of not more than 2,000 pounds per square foot (psf) be used for the design of footings founded on the medium dense or better native bearing soils or rock spalls extending to the competent native material. The foundation bearing soil should be evaluated by a representative of NGA. We should be consulted if higher bearing pressures are needed. Current IBC guidelines should be used when considering increased allowable bearing pressure for short-term transitory wind or seismic loads. Potential foundation settlement using the recommended allowable bearing pressure is estimated to be less than 1-inch total and ½-inch differential between adjacent footings or across a distance of about 20 feet, based on our experience with similar projects.

Lateral loads may be resisted by friction on the base of the footing and passive resistance against the subsurface portions of the foundation. A coefficient of friction of 0.35 may be used to calculate the base friction and should be applied to the vertical dead load only. Passive resistance may be calculated as a triangular equivalent fluid pressure distribution. An equivalent fluid density of 200 pounds per cubic foot (pcf) should be used for passive resistance design for a level ground surface adjacent to the footing. This level surface should extend a distance equal to at least three times the footing depth.

These recommended values incorporate safety factors of 1.5 and 2.0 applied to the estimated ultimate values for frictional and passive resistance, respectively. To achieve this value of passive resistance, the foundations should be poured "neat" against the native medium dense soils or compacted fill should be used as backfill against the front of the footing. We recommend that the upper one foot of soil be neglected when calculating the passive resistance.

Retaining Walls

The pool side walls and any other retaining walls associated with the pool should be designed and constructed as follows. Retaining walls on the downslope side should be embedded at least an additional one foot into medium dense or better native soils. The lateral pressure acting on subsurface retaining walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement which can occur as backfill is placed, wall drainage conditions, and the inclination of the backfill. For walls that are free to yield at the top at least one thousandth of the height of the wall (active condition), soil pressures will be less than if movement is limited by such factors as wall stiffness or bracing (at-rest condition). We recommend that walls supporting horizontal backfill and not subjected to hydrostatic forces, be designed using a triangular earth pressure distribution equivalent to that exerted by a fluid with a density of 40 pcf for yielding (active condition) walls, and 60 pcf for non-yielding (at-rest condition) walls.

These recommended lateral earth pressures are for a drained granular backfill and are based on the assumption of a horizontal ground surface behind the wall for a distance of at least the height of the wall, and do not account for surcharge loads. Additional lateral earth pressures should be considered for surcharge loads acting adjacent to walls and within a distance equal to the height of the wall. This would include the effects of surcharges such as floor slab loads, slopes, or other surface loads. We could consult with the structural engineer regarding additional loads on retaining walls during final design, if needed.

The lateral pressures on walls may be resisted by friction between the foundation and subgrade soil, and by passive resistance acting on the below-grade portion of the foundation. Recommendations for frictional and passive resistance to lateral loads are presented in the **Foundations** subsection.

All wall backfill should be well compacted as outlined in the **Structural Fill** subsection. Care should be taken to prevent the buildup of excess lateral soil pressures due to over-compaction of the wall backfill. This can be accomplished by placing wall backfill in 8-inch loose lifts and compacting the backfill with small, hand-operated compactors within a distance behind the wall equal to at least one-half the height of the wall. The thickness of the loose lifts should be reduced to accommodate the lower compactive energy of the hand-operated equipment. The recommended level of compaction should still be maintained.

Permanent drainage systems should be installed for retaining walls. Recommendations for these systems are found in the **Subsurface Drainage** subsection. We recommend that we be retained to evaluate the proposed wall drain backfill material and observe installation of the drainage systems.

Other types of retaining walls such as reinforced-earth block walls or rockeries and solider pile walls could be utilized at this site. Final wall types will depend on final wall locations, heights, and budget. We could work with the designers regarding wall designs during the later stages of the project.

Structural Fill

General: Fill placed beneath foundations, pavement, or other settlement-sensitive structures should be placed as structural fill. Structural fill, by definition, is placed in accordance with prescribed methods and standards, and is monitored by an experienced geotechnical professional or soils technician. Field monitoring procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction. The area to receive the fill should be suitably prepared as described in the **Site Preparation and Grading** subsection prior to beginning fill placement. Sloping areas to receive fill should be benched using a minimum 8-foot wide horizontal benches into competent soils.

Materials: Structural fill should consist of a good quality, granular soil, free of organics and other deleterious material, and be well graded to a maximum size of about three inches. All-weather fill should contain no more than five-percent fines (soil finer than U.S. No. 200 sieve, based on that fraction passing the U.S. 3/4-inch sieve). Some of the more granular on-site soils may be suitable for use as structural fill; however, this will be highly dependent on the moisture content of the soil during construction. The use of the on-site soils as structural fill during wet weather will be very difficult, if not impossible. We should be retained to evaluate all proposed structural fill material prior to placement.

Fill Placement: Following subgrade preparation, placement of structural fill may proceed. All filling should be accomplished in uniform lifts up to eight inches thick. Each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill underlying building areas and pavement subgrade should be compacted to a minimum of 95 percent of its maximum dry density. Maximum dry density, in this report, refers to that density as determined by the ASTM D-1557 Compaction Test procedure. The moisture content of the soils to be compacted should be within about two percent of optimum so that a readily compactable condition exists. It may be necessary to over-excavate and remove wet soils in cases where drying to a compactable condition is not feasible. All compaction should be accomplished by equipment sufficient to attain the desired degree of compaction and should be tested.

Slab-on-Grade

Slabs-on-grade should be supported on subgrade soils prepared as described in the **Site Preparation and Grading** subsection of this report. We recommend that all floor slabs be underlain by at least six inches of free-draining gravel with less than three percent by weight of the material passing Sieve #200 for use as a capillary break. We recommend that the capillary break be hydraulically connected to the footing drain system to allow free drainage from under the slab. A suitable vapor barrier, such as heavy plastic sheeting (6-mil, minimum), should be placed over the capillary break material. An additional 2-inch-thick moist sand layer may be used to cover the vapor barrier. This sand layer is optional, and is intended to be used to protect the vapor barrier membrane and to aid in curing the concrete.

Pavements

Pavement subgrade preparation and structural filling where required, should be completed as recommended in the **Site Preparation and Grading** and **Structural Fill** subsections of this report. The pavement subgrade should be proof-rolled with a heavy, rubber-tired piece of equipment, to identify soft or yielding areas that require repair. The pavement section should be underlain by a stable subgrade. We should be retained to observe the proof-rolling and recommend subgrade repairs prior to placement of the asphalt or hard surfaces.

Utilities

We recommend that underground utilities be bedded with a minimum 6 inches of pea gravel prior to backfilling the trench with on-site or imported material. Trenches within settlement sensitive areas should be compacted to 95 percent of the modified proctor as described in the **Structural Fill** subsection of this report. Trenches located in non-structural areas should be compacted to a minimum 90 percent of the maximum dry density. Trench backfill compaction should be tested.

Site Drainage

Surface Drainage: The finished ground surface should be graded such that stormwater is directed to an approved stormwater collection system. Water should not be allowed to stand in any areas where footings, slabs, or pavements are to be constructed. Final site grades should allow for drainage away from the residences. We suggest that the finished ground be sloped at a minimum downward gradient of three percent, for a distance of at least 10 feet away from the residences. Surface water should be collected by permanent catch basins and drain lines, and be discharged into an approved discharge system away from the structures, property boundaries, or any sloping ground.

Subsurface Drainage: If groundwater seepage is encountered during construction, we recommend that the contractor slope the bottom of the excavation and collect the water into ditches and small sump pits where the water can be pumped out and routed into a permanent storm drain.

We recommend the use of footing drains around the structures. Footing drains should be installed at least one foot below planned finished floor elevation. The drains should consist of a minimum 4-inch-diameter, rigid, slotted or perforated, PVC pipe surrounded by free-draining material wrapped in a filter fabric. We recommend that the free-draining material consist of an 18-inch-wide zone of clean (less than three-percent fines), granular material. Pea gravel is an acceptable drain material. The free-draining material should extend to one foot below the finished surface. The top foot of backfill should consist of impermeable soil placed over plastic sheeting or building paper to minimize surface water or fines migration into the footing drain. Footing drains should discharge into tightlines leading to an approved collection and discharge point with convenient cleanouts to prolong the useful life of the drains. Roof drains should not be connected to wall or footing drains.

CONSTRUCTION MONITORING

We recommend NGA be retained to provide monitoring and consultation services during construction to confirm that conditions encountered are consistent with those indicated by explorations, to provide recommendations for design changes should the conditions revealed differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

Specifically, we should be retained to provide construction monitoring services during the earthwork phase of the project to evaluate subgrade conditions, temporary cut conditions, fill compaction, and drainage system installation.

USE OF THIS LETTER

NGA has prepared this letter for Mr. Gregg Petrie and his agents, for use in the planning and design of the development on this site only. The scope of our work does not include services related to construction safety precautions and 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. There are possible variations in subsurface conditions between the explorations and also with time. Our report, conclusions, and interpretations should not be construed as a warranty of subsurface conditions. A contingency for unanticipated conditions should be included in the budget and schedule.

We recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications. We should be contacted a minimum of one week prior to construction activities and could attend pre-construction meetings if requested.

Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this report was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

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It has been a pleasure to provide service to you on this project. If you have any questions or require further information, please call.

Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.

Carston T. Curd, GIT
Project Geologist

Khaled M. Shawish, PE
Principal

CTC:KMS:dy

Six Figures Attached

cc: Leif Anderson – Anderson Architecture, L.AndersonArchitecture@gmail.com

VICINITY MAP

Not to Scale

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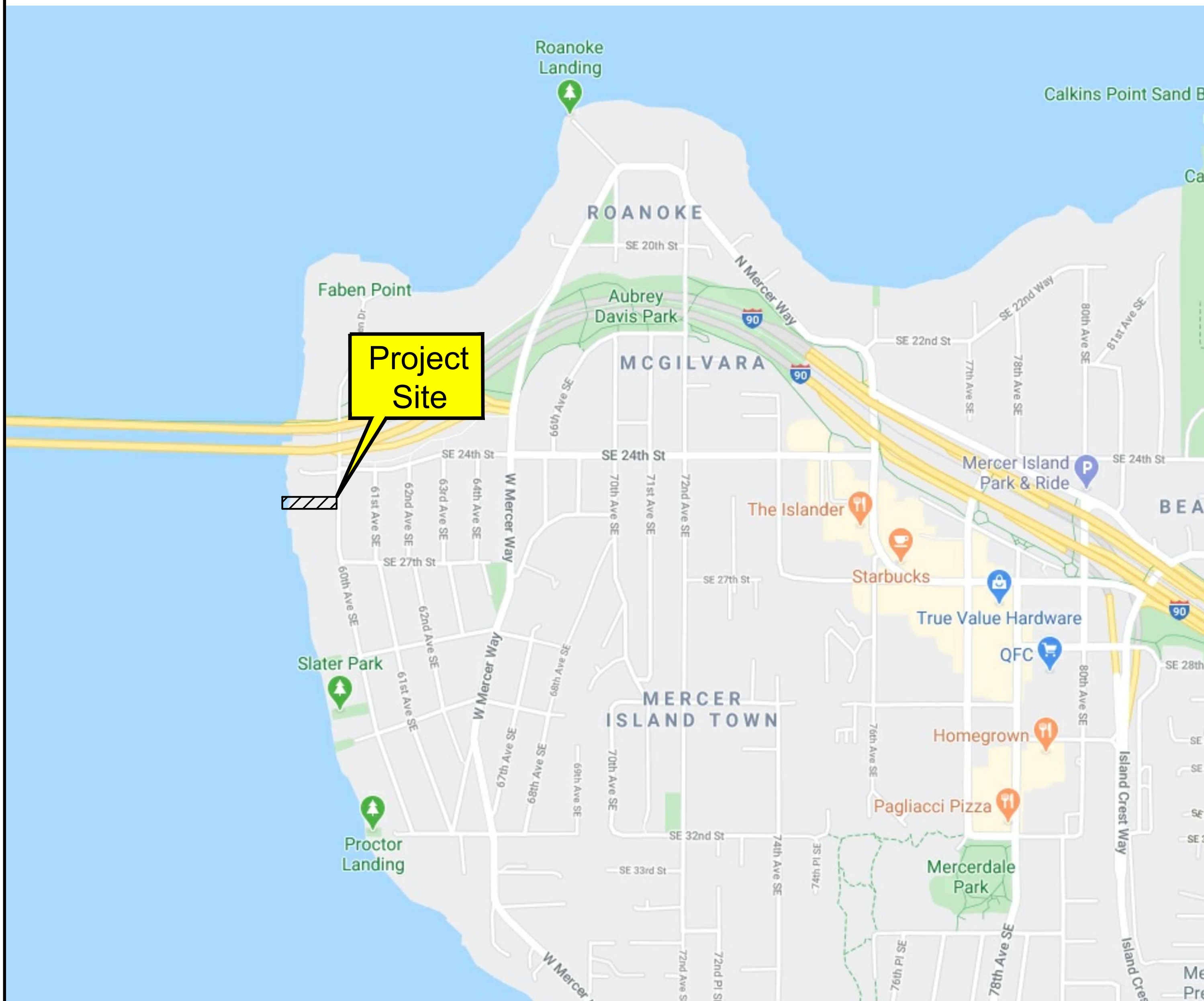

Mercer Island, WA

Project Number 1159920	Petrie Liquefaction Assessment Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 1		Woodinville Office 17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax: 481-2510 www.nelsongeotech.com East Wenatchee Office 5526 Industry Lane, #2 East Wenatchee, WA 98802 (509) 665-7696 / Fax: 665-7692	1	3/4/20	Original	DPN	CTC

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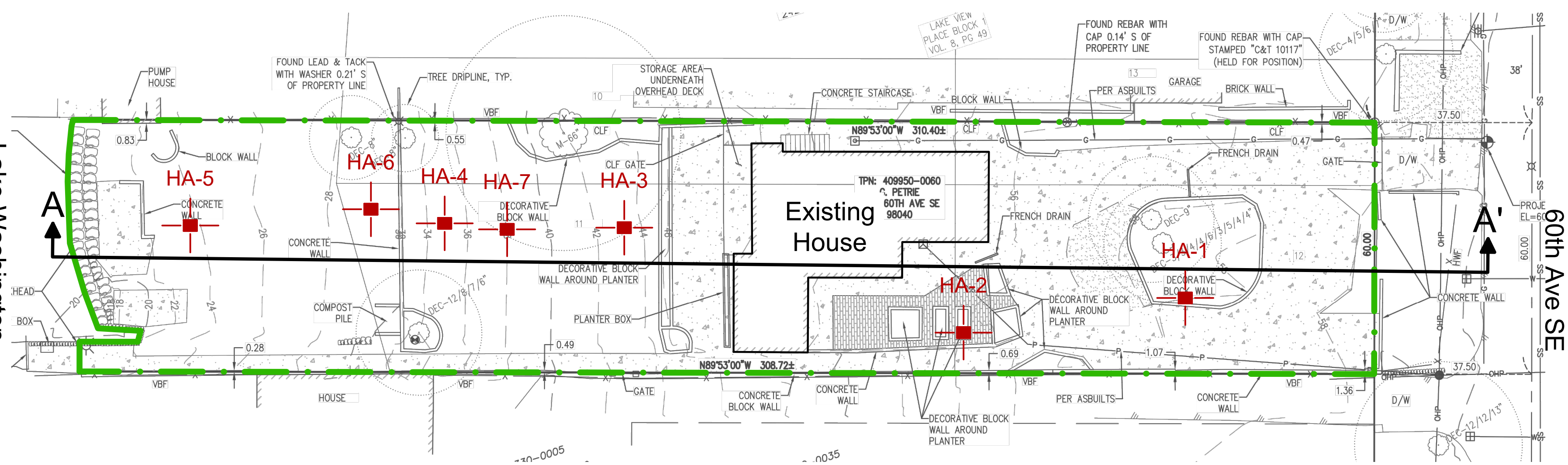
Site Plan



LEGEND

Property line

HA-1 Number and approximate location of hand auger

A — A' Approximate location of cross-section

0 40 80

Scale: 1 inch = 40 feet

Reference: Site plan based on a plan dated November 20, 2019 titled "Boundary and Topographic Survey - Petrie Property," prepared by Core Design.

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Project Number 1159920

Figure 2

Petrie Liquefaction Assessment Site Plan

NELSON GEOTECHNICAL ASSOCIATES, INC.
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No.	Date	Revision	By	CK
1	3/4/20	Original	DPN	CTC

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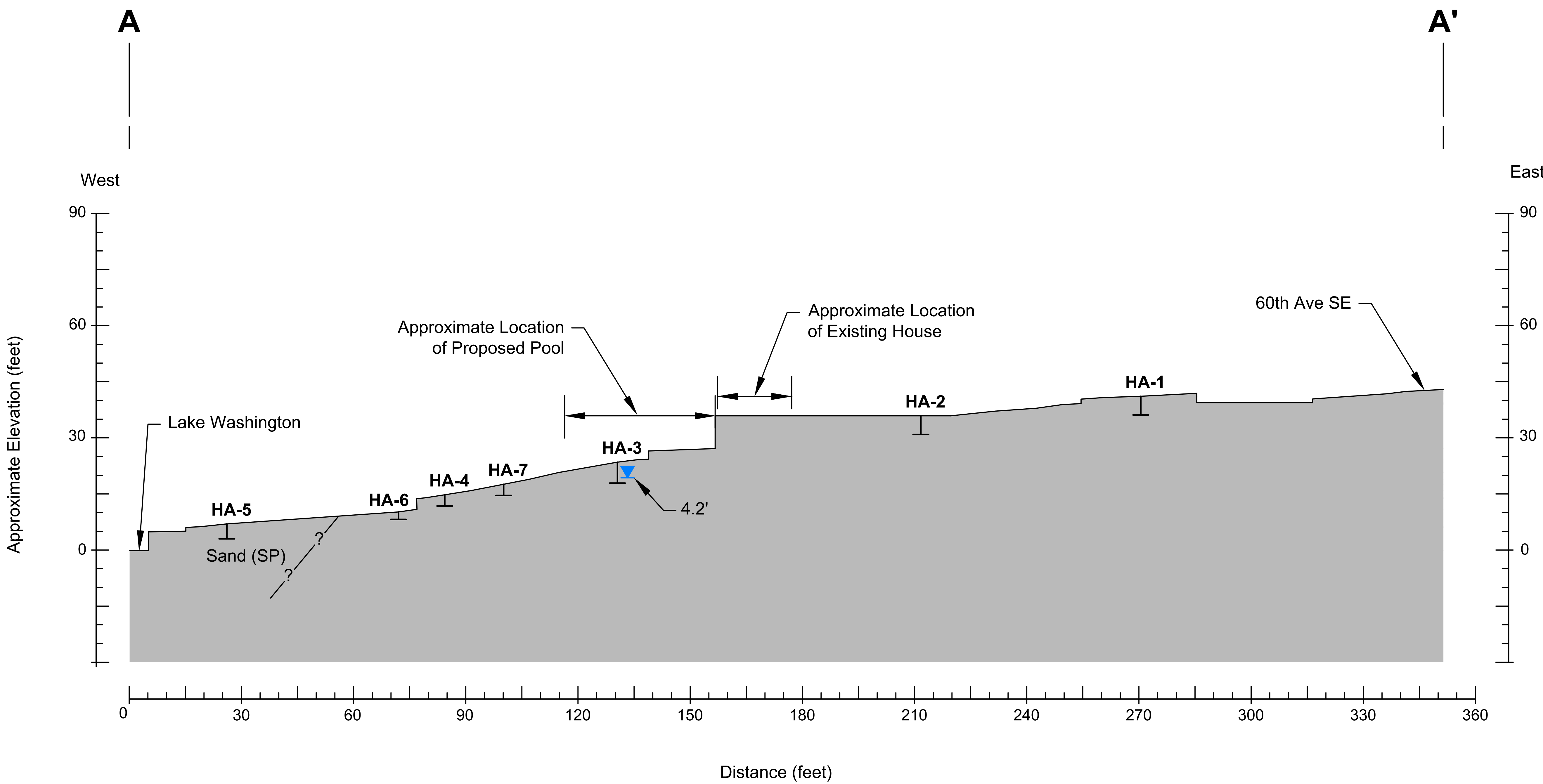

Exploration

Hand Auger Designation ⟶ **HA-1**

Groundwater Level ⟶
During Exploration

Geologic Contact ⟶ ?— — —?
(approximate)

NOTES:
1) Stratigraphic conditions are interpolated between the explorations. Actual conditions may vary.
2) Elevations are approximate.

Reference: Cross Section is based on field measurements using a hand-held clinometer and 100-ft tape measure.

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Petrie Liquefaction Assessment
Cross-Section A-A'

Project Number
1159920

Figure 3

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50 % RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50 % OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50 % PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50 %	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 % OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-93.

2) Soil classification using laboratory tests is based on ASTM D 2488-93.

3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water.

Wet - Visible free water or saturated, usually soil is obtained from below water table

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Figure 4

Petrie Liquefaction Assessment
Soil Classification Chart

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LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
HAND AUGER 1		
0.0 – 1.0		BROWN, SILTY, FINE TO MEDIUM SAND WITH ORGANIC PARTICULATE AND ROOTS (MOIST, LOOSE) (**UNDOCUMENTED FILL**)
1.0 – 1.8		LIGHT BROWN SILT WITH FINE TO MEDIUM SAND (MOIST, LOOSE-MEDIUM DENSE) (**UNDOCUMENTED FILL**)
1.8 – 5.0	ML	LIGHT GRAY MOTTLED FINE SANDY SILT BECOMING CLAYEY SILT WITH FINE SAND (DRY-MOIST, STIFF-HARD) (**PRE-OLYMPIA FINE-GRAINED DEPOSITS**)
		SAMPLES WERE COLLECTED AT 5.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED CAVING WAS NOT ENCOUNTERED HAND AUGER TEST HOLE TERMINATED AT 5.0 FEET ON 02/19/2020
HAND AUGER 2		
0.0 – 0.5		BROWN, SILTY, FINE TO MEDIUM SAND WITH ORGANIC PARTICULATE AND ROOTS (MOIST, LOOSE) (**UNDOCUMENTED FILL**)
0.5 – 3.0		BROWN SILT WITH FINE TO MEDIUM SAND AND ANTHROPOGENIC DEBRIS (MOIST, LOOSE-MEDIUM DENSE) (**UNDOCUMENTED FILL**)
3.0 – 5.0	SM	LIGHT GRAY SILTY FINE TO MEDIUM SAND WITH IRON OXIDATION STAINING (MOIST-WET, MEDIUM DENSE) (**PRE-OLYMPIA FINE-GRAINED DEPOSITS**)
		SAMPLES WERE COLLECTED AT 4.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED CAVING WAS NOT ENCOUNTERED HAND AUGER TEST HOLE TERMINATED AT 5.0 FEET ON 02/19/2020
HAND AUGER 3		
0.0 – 0.6		BROWN, SILTY, FINE TO MEDIUM SAND WITH ORGANIC PARTICULATE AND ROOTS (MOIST, LOOSE) (**UNDOCUMENTED FILL**)
0.6 – 2.3		BROWN SILTY FINE TO MEDIUM SAND WITH GRAVEL, ORGANIC PARTICULATE, AND IRON OXIDATION STAINING (MOIST, LOOSE-MEDIUM DENSE) (**UNDOCUMENTED FILL**)
2.3 – 3.0	SM	GRAY-BROWN SILTY FINE TO COARSE SAND WITH TRACE FINE GRAVEL (MOIST, MEDIUM DENSE) (**WEATHERED PRE-OLYMPIA NON-GLACIAL DEPOSITS?**)
3.0 – 5.6	SM	LIGHT GRAY SILTY FINE TO COARSE SAND WITH TRACE FINE GRAVEL AND IRON OXIDATION STAINING (MOIST-WET, MEDIUM DENSE) (**PRE- OLYMPIA NON-GLACIAL DEPOSITS?**)
		SAMPLES WERE COLLECTED AT 5.0 FEET MODERATE GROUNDWATER SEEPAGE WAS ENCOUNTERED AT 4.2 FEET SLIGHT CAVING WAS ENCOUNTERED BELOW 3.3 FEET HAND AUGER TEST HOLE TERMINATED AT 5.6 FEET ON 02/19/2020
HAND AUGER 4		
0.0 – 1.5		BROWN, SILTY, FINE TO MEDIUM SAND WITH ORGANIC PARTICULATE AND ROOTS (MOIST, LOOSE) (**UNDOCUMENTED FILL**)
1.5 – 2.0		GRAY, CLEAN, ROUNDED GRAVEL (DRY, LOOSE-MEDIUM DENSE) (**UNDOCUMENTED FILL**)
2.0 – 3.0	SM	LIGHT GRAY, SILTY FINE TO COARSE SAND WITH TRACE FINE GRAVEL AND IRON OXIDATION STAINING (MOIST, MEDIUM DENSE) (**WEATHERED PRE-OLYMPIA GLACIAL TILL?**)
		SAMPLES WERE COLLECTED AT 3.0 FEET NO GROUNDWATER SEEPAGE WAS ENCOUNTERED CAVING WAS NOT ENCOUNTERED HAND AUGER TEST HOLE TERMINATED AT 3.0 FEET ON 02/19/2020

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
HAND AUGER 5		
0.0 – 0.9		BROWN, SILTY, FINE TO MEDIUM SAND WITH ORGANIC PARTICULATE AND ROOTS (MOIST, LOOSE) (**UNDOCUMENTED FILL**)
0.9 – 3.0	SP	GRAY FINE TO COARSE SAND (MOIST-WET, LOOSE) (**LACUSTRINE DEPOSITS**)
		SAMPLES WERE COLLECTED AT 2.5 FEET NO GROUNDWATER SEEPAGE WAS ENCOUNTERED CAVING WAS NOT ENCOUNTERED HAND AUGER TEST HOLE TERMINATED AT 3.0 FEET ON 02/19/2020
HAND AUGER 6		
0.0 – 0.8		BROWN, SILTY, FINE TO MEDIUM SAND WITH ORGANIC PARTICULATE AND ROOTS (MOIST, LOOSE) (**UNDOCUMENTED FILL**)
0.8 – 2.0	SM	LIGHT GRAY, SILTY FINE TO COARSE SAND WITH TRACE FINE GRAVEL (DRY, MEDIUM DENSE) (**WEATHERED PRE-OLYMPIA GLACIAL TILL?**)
		NO SAMPLES WERE COLLECTED NO GROUNDWATER SEEPAGE WAS ENCOUNTERED CAVING WAS NOT ENCOUNTERED HAND AUGER TEST HOLE TERMINATED AT 2.0 FEET ON 02/19/2020
HAND AUGER 7		
0.0 – 0.8		BROWN, SILTY, FINE TO MEDIUM SAND WITH ORGANIC PARTICULATE AND ROOTS (MOIST, LOOSE) (**UNDOCUMENTED FILL**)
0.8 – 2.0	SM	LIGHT GRAY SILTY FINE TO COARSE SAND WITH TRACE FINE GRAVEL AND IRON OXIDATION STAINING (MOIST-WET, MEDIUM DENSE) (**PRE- OLYMPIA NON-GLACIAL DEPOSITS?**)
2.0 – 3.0	SM	LIGHT GRAY, SILTY FINE TO COARSE SAND WITH TRACE FINE GRAVEL AND IRON OXIDATION STAINING (MOIST, MEDIUM DENSE) (**WEATHERED PRE-OLYMPIA GLACIAL TILL?**)
		NO SAMPLES WERE COLLECTED NO GROUNDWATER SEEPAGE WAS ENCOUNTERED CAVING WAS NOT ENCOUNTERED HAND AUGER TEST HOLE TERMINATED AT 3.0 FEET ON 02/19/2020