PanGEO
INCORPORATED
*Geotechnical & Earthquake Engineering Consultants*

December 11, 2017
*Revised on July 7, 2021*
Project No. 17-381

Suzanne Zahr
8110 SE 70th St
Mercer Island, WA 98040

**Subject**: **Geotechnical Engineering Evaluation (Revised)**
**Proposed Addition**
**8110 SE 70th Street, Mercer Island, Washington**

Dear Ms. Zahr,

As requested, PanGEO Inc. (PanGEO) completed a geotechnical engineering evaluation to assist you and the design team for the proposed addition located at 8110 SE 70th Street in the City of Mercer Island, Washington. This study was performed in general accordance with our mutually agreed scope of work outlined in our proposal dated November 14, 2017, and subsequently approved by you on November 15, 2017. Our service scope included reviewing readily available geologic and geotechnical data, excavating two hand borings, conducting a site reconnaissance, performing engineering analysis, and developing the conclusions and recommendations presented in this report.

## SITE AND PROJECT DESCRIPTION

The project site is located at 8110 SE 70th Street in the City of Mercer Island, Washington (see Figure 1, Vicinity Map). The subject property is an approximately 16,738 square foot lot (see Figure 2). The subject property is roughly triangular, and borders SE 70th Street to the southeast and existing single-family residences to the north and west (see Figure 2). The site is currently occupied by a one-story house with a daylight basement (see Plates 1 and 2). Based on a review of the site plan, the site grade slopes down from northeast to southwest with an average gradient of about 15 percent. The northwestern portion of the site is mapped as a steep slope.

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We understand that you plan to construct an addition to the southwest corner of the existing house. Based on a review of the preliminary design plans, the addition will be a two-level structure matching the existing house. We anticipate that site grading for the addition construction will involve cuts and fill on the order of 3 feet.

| | |
|---|---|
|  |  |
| **Plate 1.** View of the southwest side of the house. Looking north. | **Plate 2.** View of the north side of the site. Looking northeast. |

The conclusions and recommendations outlined in this report are based on our understanding of the proposed development, which is in turn based on the project information provided to us. If the above project description is substantially different from your proposed improvements, or if the project scope changes, PanGEO should be consulted to review the recommendations contained in this study and make modifications, if needed.

## SITE GEOLOGY

The Geologic Map of Mercer Island, Washington (Troost, et al., 2006) mapped the surficial geologic unit at the subject site as Advance Outwash Deposits (Qva). Advance Outwash Deposits are described as well-sorted sand and gravel deposited by streams issuing from the advancing ice sheet. This unit is typically dense to very dense.

## SUBSURFACE EXPLORATION AND CONDITIONS

### SUBSURFACE EXPLORATION

Our subsurface exploration for the current study consisted of excavating two hand borings (HB-1 and HB-2) at the site on November 20, 2017, using a hand auger. The approximate hand boring locations were taped in the field from on-site features, and are plotted on Figure 2. Hand boring

HB-1 was excavated to a depth of about 5½ feet and hand boring HB-2 was excavated to a depth of about 5 feet below the existing grade.

The hand borings generally encountered a thin layer of fill overlying sand with gravel. The soils encountered in the hand borings are generally consistent with the mapped geology at the site. The following is a brief description of the soils encountered in the hand borings excavated at the site. Please refer to the summary hand boring logs in Appendix A for additional details.

> ***UNIT 1 – Fill:*** In both hand borings we encountered about 1½ feet of loose, brown to dark brown, fine to medium SAND with silt, rootlets and organics. We interpret this unit as fill.
>
> ***UNIT 2 – Advance Outwash:*** Below the fill, our hand borings generally encountered light brown to gray, medium dense to dense sand to the bottom of each hole. This unit appears to be consistent with the mapped Advance Outwash deposits.

Groundwater seepage was encountered at 4½ feet in HB-1 and 1½ feet in HB-2 at the time of our field exploration. It should be noted that groundwater elevations and seepage rates are likely to vary depending on the season, local subsurface conditions, and other factors. Groundwater levels and seepage rates are normally highest during the winter and early spring (typically October through May).

## GEOLOGY HAZARDS ASSESSMENT

### LANDSLIDE HAZARDS AND STEEP SLOPES

The site is not a steep slope (40% or greater). However, the western edge of the site is mapped within a potential landslide hazard area according to the City of Mercer Island's Geologic Hazards Map. A site reconnaissance of the subject property was conducted on November 20, 2017. During our site reconnaissance, we did not observe obvious evidence of past slope instability or ground movement at the subject site. The existing building foundations appear to have performed well to date. Based on our field observations, the topography at the site and vicinity, and the subsurface conditions encountered in the hand borings, in our opinion, the subject site appears to be globally stable in its current configuration. It is our further opinion that the proposed addition as currently planned will not adversely affect the overall stability of the site or adjacent properties, provided the recommendations outlined herein are followed and the proposed development is properly design and constructed.

### EROSION HAZARDS

The site is mapped within a potential erosion hazard area in accordance with the City of Mercer Island's Geologic Hazards Map. Based on the results of our hand borings, the sandy site soils at the site are anticipated to exhibit moderate erosion potential. In our opinion, the erosion hazards at the site can be effectively mitigated with the best management practice during construction and with properly designed and implemented landscaping for permanent erosion control. During construction, the temporary erosion hazard can be effectively managed with an appropriate erosion and sediment control plan, including but not limited to installing silt fence at the construction perimeter, limiting removal of vegetation to the construction area, placing rocks or hay bales at the disturbed/traffic areas and on the downhill side of the project, covering stockpile soil or cut slopes with plastic sheets, constructing a temporary drainage pond to control surface runoff and sediment trap if needed, placing rocks at the construction entrance, etc. Permanent erosion control measures should include establishing vegetation, landscape plants, and hardscape established at the end of project.

## GEOTECHNICAL DESIGN RECOMMENDATIONS

### SEISMIC DESIGN PARAMETERS

Table 1 provides seismic design parameters for the site that are in conformance with the 2015 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.

**Table 1 – 2015 IBC Seismic Design Parameters**

| 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 | 1.462 | 0.559 | 1.00 | 1.50 | 0.974 | 0.559 |

**BUILDING FOUNDATIONS**

The proposed project consists of a 2-story addition on the southwestern portion of the house. Based on the subsurface conditions encountered at the site, it is our opinion the proposed additions can be supported on continuous footings bearing on the competent native sand. The following sections present our recommendations for evaluating the existing footings and designing the new footings.

***New Footings*** - Based on the results of our hand borings at the site and geologic information in the vicinity, we recommend that an allowable soil bearing pressure of 2,000 psf be used for sizing the new footings. 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 footings should have a minimum width of 18 inches. New footings supporting the proposed additions should be designed to avoid surcharging the existing foundation and wall system.

In designing the footings, the shape of footings will need to be considered with regard to the available space for temporary excavations. Where space may be limited for an unsupported open cut, it may be necessary to use L-shaped perimeter footings in order to conserve space and to allow the temporary excavations to be made within the property limits.

For footings located near the slope, the footings should be embedded lower enough to maintain a minimum horizontal distance of 5 feet between the footings edge and slope face.

***Existing Footings*** – In our opinion, an allowable soil bearing pressure of 2,000 psf may be used to evaluate the adequacy of the existing footings due to the added structural loads. The existing footings may be enlarged to account for the added structural loads. For allowable stress design, the recommended bearing pressure may be increased by one-third for transient loading, such as wind or seismic forces.

Footings designed and constructed in accordance with the above recommendations should experience total settlement of less than one inch and differential settlement of less than ½ inch. Most of the anticipated settlement should occur during construction as dead loads are applied.

### *Lateral Resistance*

Lateral loads acting on the foundations may be resisted by passive earth pressure developed against the embedded portion of the foundation system and by frictional resistance at the bottom of the footings. For footings bearing on the compacted structural fill, a frictional coefficient of 0.4 may be used to evaluate sliding resistance. Passive soil resistance may be calculated using an equivalent fluid unit weight of 250 pcf, assuming properly re-compacted native sandy soil or compacted structural fill will be placed against the footings. The above values include a factor of safety of 1.5. Unless covered by pavements or slabs, the passive resistance in the upper 12 inches of soil should be neglected.

### *Footing Drain*

Footing drains should be installed around the perimeter of the new footings, at or just below the invert of the footings. Under no circumstances should roof downspout drain lines be connected to the footing drain systems. Roof downspouts must be separately tightlined to a suitable discharge point. Cleanouts should be installed at strategic locations to allow for periodic maintenance of the footing drain and downspout tightline systems.

### *Footing Subgrade Preparation*

All footing subgrades should be carefully prepared. We anticipate wet, medium dense sand (advance outwash) to be present at the footing subgrade. However, groundwater seepage is encountered at about 1½ and 4½ feet below the surface. As such, limited over-excavation of foundation soil may be needed to remove wet subgrade soils if present. The footing subgrade should be in firm and unyielding conditions prior to placement of concrete. If the native sand is loose and cannot be compacted to a dense condition, they should be over-excavated 12 inches and the resulting over-excavation should be backfilled with properly compacted structural fill. Footing excavations and subgrade preparation should be observed by a representative of PanGEO, prior to placing forms or rebar, to verify that conditions are as anticipated in this report.

## FLOOR SLABS

Floor slabs may be constructed using conventional concrete slab-on-grade floor construction. The floor slabs may be supported on the recompacted on-site sand soils or on structural fill placed on competent native soils.

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 exposed floor subgrade should be compacted to a dense and unyielding condition before placing the capillary break material.

The capillary break material should meet the gradational requirements provided in Table 2 below.

**Table 2 – Capillary Break Gradation**

| Sieve Size | Percent Passing |
|---|---|
| ¾-inch | 100 |
| No. 4 | 0 – 10 |
| No. 100 | 0 – 5 |
| No. 200 | 0 – 3 |

A minimum 10-mil polyethylene vapor barrier should also be placed directly below the slab. Construction joints should be incorporated into the floor slab to control cracking.

## CONCRETE RETAINING 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.

### *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 7H 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.

***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.

***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 250 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.

***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.

***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 WSDOT Gravel Borrow 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.

### FEASIBLE BUILDING PAD LOCATION

Based on the site condition and our geotechnical evaluation, it is our opinion that a feasible building pad as shown in Figure 3 at the end of this report may be used.

## STATEMENT OF MINIMUM RISKS

We understand that the site is mapped as a geologic hazard area. Per Mercer Island City Code Section 19.07.060.D.2, development within geologic hazard areas and critical slopes may occur if the geotechnical engineer provides a statement of risk with supporting documentation indicating that one of the following conditions can be met:

a. The geologic hazard area will be modified, or the development has been designed so that the risk to the lot and adjacent property is eliminated or mitigated such that the site is determined to be safe; or

b. An evaluation of site specific subsurface conditions demonstrates that the proposed development is not located in a geologic hazard area; or

c. Development practices are proposed for the alteration that would render the development as safe as if it were not located in a geologic hazard area; or

d. The alteration is so minor as not to pose a threat to the public health, safety, and welfare.

It is out opinion that Criterion © can be met through best management practices during construction, including the proper use of silt fence, minimize earthwork activities during periods heavy precipitations, minimized exposed areas in wet season, etc. Permanent erosion control measures including landscape and hardscape installations will effectively mitigate the risk of erosion in the long term.

## CONSTRUCTION CONSIDERATIONS

### SITE PREPARATION

Site preparation for the proposed project includes excavations/fill 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 clearing and 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.

### TEMPORARY EXCAVATIONS

As currently planned, the proposed construction will require excavations of about 3 feet below the existing grade. We anticipate the excavations to mainly encounter medium dense sand. 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.

All temporary excavations deeper than a total of 4 feet should be sloped or shored. Based on the soil 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.

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. 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.

### 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 sand is poorly graded and will be difficult to compact to a dense condition. As such, on-site sand is not suitable to be used as structural fill, but can be used as wall backfill and general fill in the non-structural areas. Structural fill, if needed, should consist of imported, well-graded, granular material, such as City of Seattle Type 2 or 17, WSDOT Gravel Borrow, or approved equivalent. 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 silty soil may 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.

### 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.

### WET WEATHER EARTHWORK

In our opinion, the proposed site construction may be accomplished during wet weather (such as in winter) without adversely affecting the site stability. However, earthwork construction performed during the drier summer months likely will be more economical. Winter construction will require the implementation of best management erosion and sedimentation control practices to reduce the chance of off-site sediment transport. Some of the site soils contain a high percentage of fines and are moisture sensitive. Any footing subgrade soils that become softened either by disturbance or rainfall should be removed and replaced with structural fill, Controlled Density Fill (CDF), or lean-mix concrete. General recommendations relative to earthwork performed in wet conditions are presented below:

- Site stripping, excavation and subgrade preparation should be followed promptly by the placement and compaction of clean structural fill or CDF;
- The size and type of construction equipment used may have to be limited to prevent soil disturbance;
- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water;
- Bales of straw and/or geotextile silt fences should be strategically located to control erosion and the movement of soil;
- Structural fill should consist of less than 5% fines; and
- Excavation slopes should be covered with plastic sheets.

### SURFACE DRAINAGE AND EROSION 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 in conjunction with silt fences to collect runoff and prevent water from entering excavations or to prevent runoff from the construction area from leaving the immediate work site. Temporary erosion control may require the use of hay bales on the downhill side of the project to prevent water from leaving the site and potential storm water detention to trap sand and silt before the water is discharged to a suitable outlet. All collected water should be directed under control to a positive and permanent discharge system.

Permanent control of surface water should be incorporated in the final grading design. Adequate surface gradients and drainage systems should be incorporated into the design such that surface runoff is directed away from structures. Potential problems associated with erosion may also be reduced by establishing vegetation within disturbed areas immediately following grading operations.

## ADDITIONAL SERVICES

To confirm that our recommendations are properly incorporated into the design and construction of the proposed addition, PanGEO should be retained to conduct a review of the final project plans and specifications, and to monitor the construction of geotechnical elements. The City of Seattle DCI, as part of the permitting process, will also require geotechnical construction inspection services. PanGEO can provide you a cost estimate for construction monitoring services at a later date.

We anticipate that the following additional services will be required:

- Review final project plans and specifications;
- Verify implementation of erosion control measures;
- Verify soil bearing;
- Verify the adequacy of subsurface drainage installation;
- Confirm the adequacy of the compaction of structural backfill; 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.

## CLOSURE

We have prepared this report for Ms. Suzanne Zahr and the project design team. Recommendations contained in this report are based on a site reconnaissance, a subsurface exploration program, 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 locations of 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 has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

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.

We appreciate the opportunity to be of service.

Sincerely,

**PanGEO, Inc.**

7/7/2021

John Manke, G.I.T.
Staff Geologist

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

**Attachments:**



**Appendix A – Summary Hand Boring Logs**

## REFERENCES

International Code Council, 2015, *International Building Code.*

Geotech Consultants, 1991, *Geotechnical Engineering Study, Landslide Stabilization, West of Residences, 6739 and 6749 82nd Avenue Southeast, Mercer Island, Washington.*

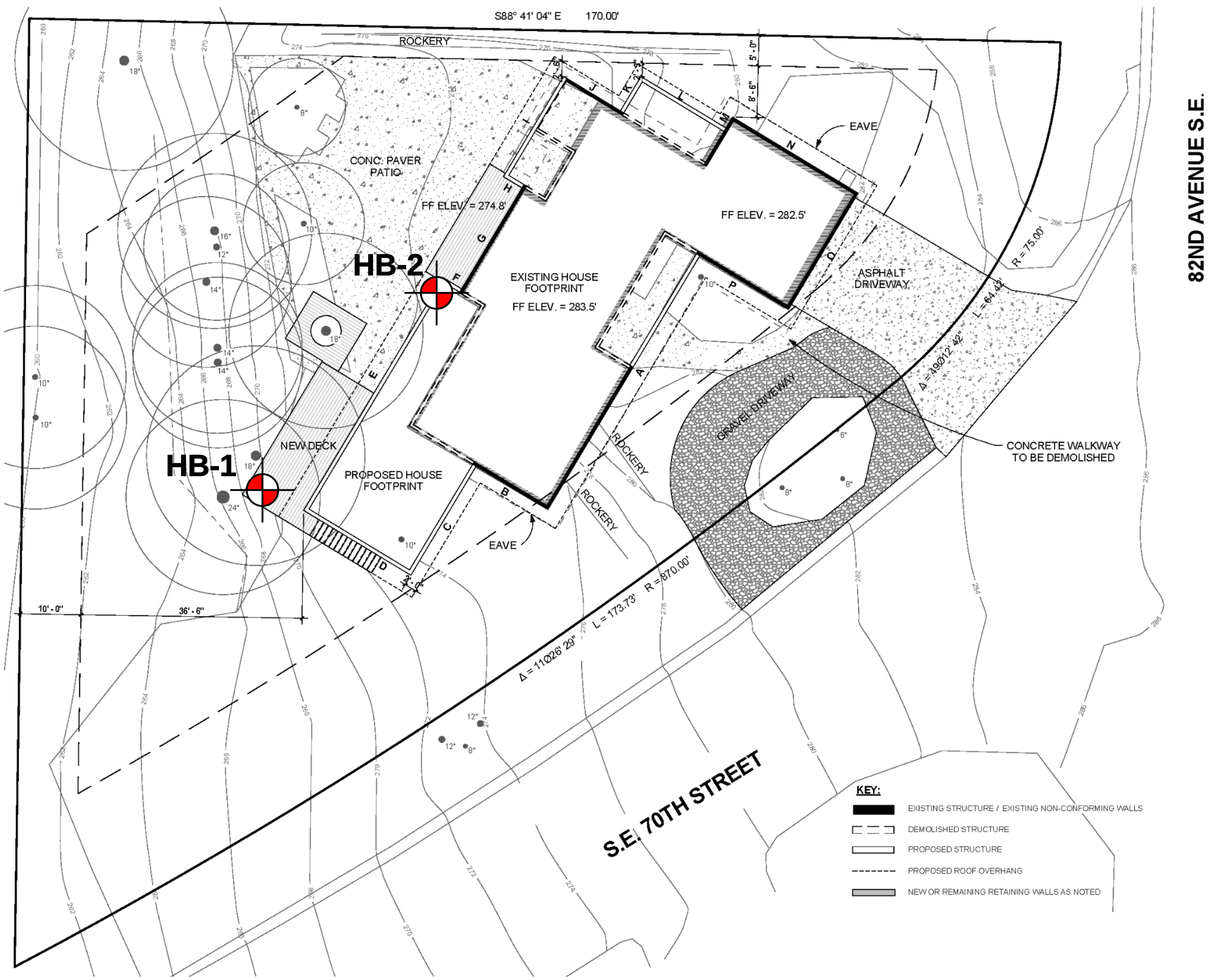
Troost, K.G., Wisher, A. P., 2006, *Geologic Map of Mercer Island, scale 1:24,000.*

WSDOT, 2020, *Standard Specifications for Road, Bridge and Municipal Construction, M 41-10, Washington State Department of Transportation.*


Not to Scale

Reference: Google Terrain Map

| PanGEO INCORPORATED | **Proposed Addition**<br>**8110 SE 70th Street**<br>**Mercer Island, Washington** | **VICINITY MAP** | |
|---|---|---|---|
| | | Project No. **17-381** | Figure No. **1** |




Approx. Scale
1" = 30'

Note: basemap modified from Site Plan by Suzanne Zahr, Inc.

Legend:

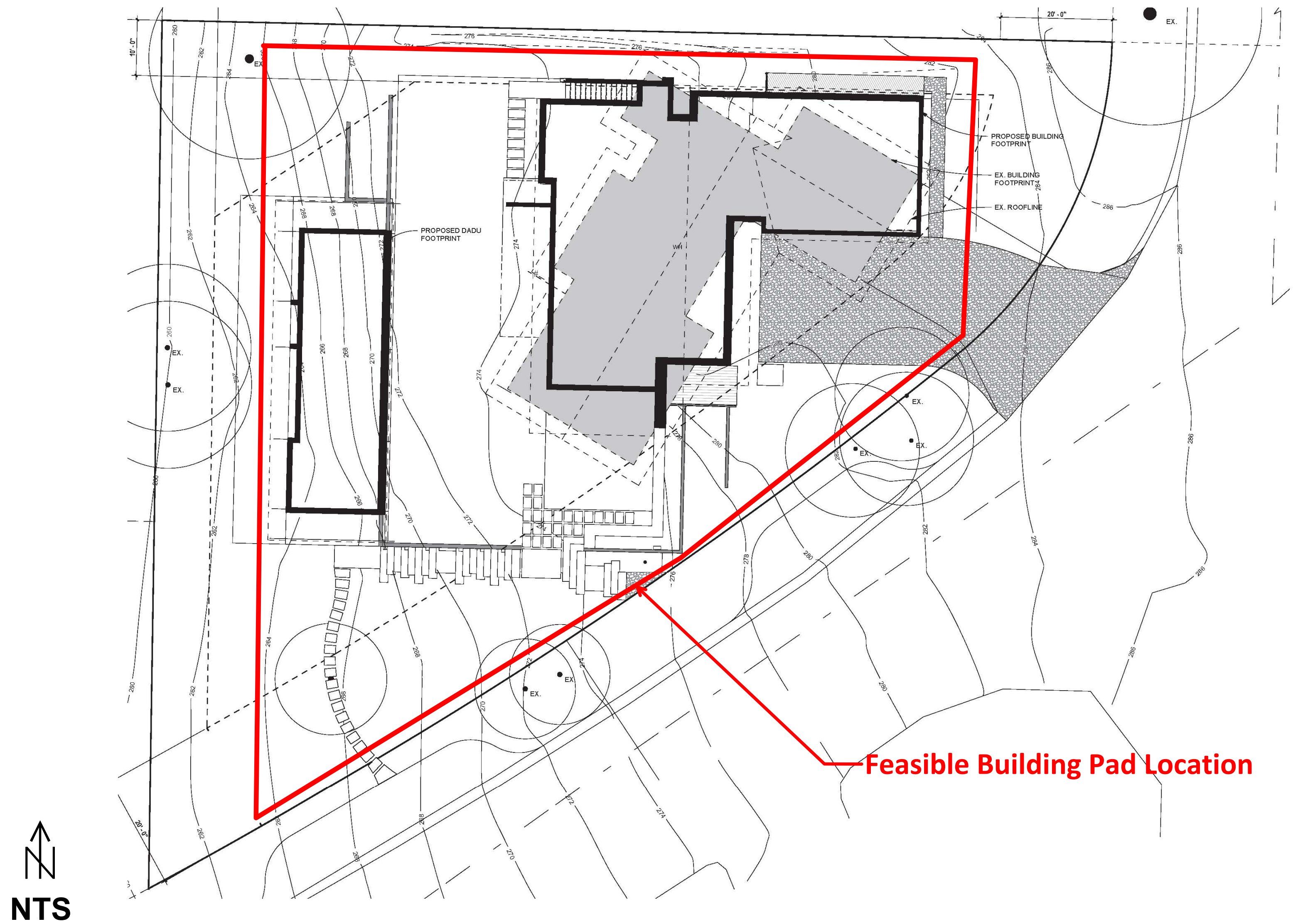
Approx. Test Boring Location

PanGEO INCORPORATED

**Proposed Addition**
**8110 SE 70th Street**
**Mercer Island, Washington**

**SITE AND EXPLORATION PLAN**

| Project No. | 17-381 | Figure No. | 2 |
|---|---|---|---|




Note: basemap modified from Site Plan by Suzanne Zahr, Inc.

| | | |
|---|---|---|
| PanGEO INCORPORATED | **Proposed Addition**<br>**8110 SE 70th Street**<br>**Mercer Island, Washington** | **BUILDING PAD LOCATION** |
| | | Project No. **17-381** / Figure No. **3** |

# APPENDIX A

# SUMMARY 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<br>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<br>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<br>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.

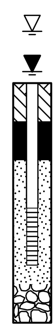
| | |
|---|---|
| ATT | Atterberg Limit Test |
| Comp | Compaction Tests |
| Con | Consolidation |
| DD | Dry Density |
| DS | Direct Shear |
| %F | Fines Content |
| GS | Grain Size |
| Perm | Permeability |
| PP | Pocket Penetrometer |
| R | R-value |
| SG | Specific Gravity |
| TV | Torvane |
| TXC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

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## Terms and Symbols for Boring and Test Pit Logs

**Figure A-1**

**Figure A-2: Summary Log of Hand Boring HB-1**

Approximate ground surface elevation: 270 feet

| Depth (ft) | Material Description |
|---|---|
| 0 – 1½ | **Unit 1:** Loose, brown, fine to medium SAND with silt, roots; moist (Fill) |
| 1½ – 2¾ | **Unit 2:** Medium dense, brown, medium SAND with gravel and trace silt; moist (Weathered Advance Outwash) |
| 2¾ – 5½ | **Unit 3:** Medium dense to dense, brown, medium SAND with trace gravel and silt; moist, minor iron oxide staining (Alluvium)<br>- Becomes wet at 4½ feet<br>- Becomes gray with moderate iron oxide staining at 5 feet |

Notes:
1. HB-1 was terminated at 5½ feet below ground surface.
2. Groundwater was encountered at 4½ feet in the boring.

**Plate 1:** Cuttings from about 3½ feet below surface in HB-1. Moist, light brown, medium SAND with gravel and trace silt.

**Figure A-3: Summary Log of Hand Boring HB-2**

Approximate ground surface elevation: 274 feet

| Depth (ft) | Material Description |
|---|---|
| 0 – 1½ | **Unit 1:** Loose, dark brown, silty SAND with roots and organics; moist (Fill) |
| 1½ – 5½ | **Unit 2:** Medium dense, wet, gray SAND with silt; moist (Advance Outwash)<br>- Becomes dense at 3½ feet |

Notes:

3. HB-1 was terminated at 5 feet below ground surface.
4. Groundwater was observed at about 1½ feet in the boring.

**Plate 1.** Cuttings from about 3 feet below the surface in HB-2. Wet, gray, medium SAND with trace silt.