PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

February 20, 2017
Project No. 17-054

Mr. Brad Sturman
9 – 103rd Avenue NE, Suite 203
Bellevue, WA 98125

Subject: **Geotechnical Engineering Evaluation**
Platou Residence
8316 Avalon Drive, Mercer Island, Seattle, WA

Dear Mr. Sturman,

As requested, PanGEO Inc. (PanGEO) completed a geotechnical engineering evaluation to assist you for the proposed project located at 8316 Avalon Drive in Mercer Island, Washington. This study was performed in general accordance with verbally discussed scope of work with you. Our service scope included reviewing geology maps in the area, reviewing readily available geotechnical data in the site vicinity, 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 8316 Avalon Drive in Mercer Island, Washington (see Figure 1, Vicinity Map). The subject property is an approximately 18,779 square foot, roughly trapezoidal-shaped lot (see Figure 2). It is bordered to the north by Avalon Drive, to the south by Mercer Island beach club, and to the east and west by existing single-family residences. The site is currently occupied by a two-story house. Based on review of site topographic survey map, the existing site grade slopes down from north to south with an average gradient of about 5 percent.

We understand that the proposed project consists of a complete interior remodel. Based on review the current design plans, we understand the proposed project will also include a second story expansion at the northeast corner of the house off the master bedroom, expansion of the garage, and enclosure of the covered walkway between the garage and house. We anticipate that

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site grading for the proposed new footings will be minor, likely consisting of fills and cuts on the order of 3 feet or less for the new foundation construction.

The conclusions and recommendations outlined in this report are based on our understanding of the proposed improvements, 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 (Troost and Wisher, 2006) mapped the surficial geologic units at the subject site as Lawton Clay (Qvlc) and Pre-Olympia Non-Glaical Deposits (Qpon). Lake Deposits (Ql) is mapped along the lakeshore, to the south and east of the site. Lawton Clay (Qvlc) are described by Troost, et al. as stiff to hard clay, silt, and clayey silt deposited in lowland proglacial lakes. Pre-Olympia Nonglacial deposits (Qpon) typically consist of stiff to hard, laminated to massive, silt and clay with sand interbeds to clean to silty sand and gravel with silt and peat interbeds that had been overridden by Olympia Interglaciation. Lake Deposit (Ql) typically consists of very loose to loose sand to very soft to medium stiff silt and clay with peat and other organic sediments deposited adjacent to Lake Washington.

SURFACE AND SUBSURFACE AND CONDITIONS

The existing house was built in 1969. A site reconnaissance of the subject property was conducted on February 20, 2017. During our site reconnaissance, we did not observe any noticeable cracks on the building foundations and the existing house foundations appear to be in good conditions. We also did not observe any obvious evidence of ground settlement at the subject site. Based on our field observations, the topography at the site and vicinity, and the anticipated subsurface conditions, in our opinion, the subject site appears to be globally stable in its current configuration. Furthermore, it is our opinion that the proposed project as currently planned will not adversely affect the overall stability of the site or adjacent properties, provided it is properly designed and constructed in accordance with the current code.

Our understanding of the site subsurface conditions is inferred from summary logs of test borings completed in the site vicinity. Specifically, three test borings (B-1 through B-3) were previously completed by Geotech Consultant, Inc. (GCI) at 8300 Avalon Drive in 2002, two

parcels to the east of the subject property. The approximate locations of these three test borings and summary test boring logs are included in Appendix A of this report. The 8300 Avalon Drive property is in a similar location with the subject property but more close to the lake. We anticipate that the subject site should have similar representative soil conditions with less lake deposits.

The previous borings generally encountered soft silt and loose silty sand to about 8 to 15 feet below the surface, overlying very stiff to hard, low-plasticity silt, and medium dense to dense non-plasticity silt. Groundwater was observed at about 4 feet below the surface in the boring close near the lake, and about 13 feet deep for the boring in the upper land.

GEOTECHNICAL DESIGN RECOMMENDATIONS

SOIL LIQUEFACTION EVALUATION

The site is mapped within a soil liquefaction geologic hazards area. Soil liquefaction is a condition where saturated cohesionless soils undergo a substantial loss of strength due to the build-up of excess pore water pressures resulting from cyclic stress applications induced by earthquakes. Soils most susceptible to liquefaction are typically cohesionless, predominantly silt and sand sized, must be loose, and be below the groundwater table.

The existing wood frame building at the site and in the site vicinity appeared to have performed well during the 2001 Nisqually earthquake. In addition, they were no reported signs of liquefaction such as sand boils in the area during 2001 earthquake. As such, it is our opinion that the proposed wood frame structures will perform reasonably well during future earthquakes with the magnitude similar to 2001 Nisqually earthquake.

For the purpose of soil liquefaction assessment, we assume the site soils will consist of loose to medium dense sandy soils and non-plasticity silt to a maximum depth of approximately 20 feet. We also assume that the groundwater may be as shallow as about 6 to 7 feet, as worst case condition. As such, the soils between about 6 and 20 feet will have a potential for soil liquefaction during a 2,475-year IBC-code level earthquake. As a result of soil liquefaction, ground settlement may likely occur and the ground settlement due to soil liquefaction for this event is estimated to be on the order of about 2 to 3 inches, and the differential foundation settlement is estimated to be about 1 to 1½ inches.

Based on above discussions, it is our opinion that the existing building with the proposed second story addition and the expanded additions may be founded on conventional shallow footings. If liquefaction occurs at the site, it would likely result in differential settlement of the foundations. However, in our opinion, the potential foundation settlement due to a design-level earthquake would not pose a life safety issue for the occupants and would not significantly impede entrance or egress from the structure following an earthquake. If a higher level of performance is desired, use of deep foundations will be required and PanGEO can provide additional input if needed.

Based on the site topography and soil conditions, the potential for seismic-induced landsliding and lateral spreading is considered to be low. And it is our opinion that special design considerations associated with seismic-induced landsliding and lateral spreading are not necessary for this project.

SEISMIC DESIGN PARAMETERS

Table 1 below provides seismic design parameters for the site that are in conformance with the 2012/2015 editions of the International Building Code (IBC), which specifies a design earthquake having a 2% probability of occurrence in 50 years (return interval of 2,475 years), and the 2008 USGS seismic hazard maps. The spectral response accelerations were obtained from the USGS Earthquake Hazards Program Interpolated Probabilistic Ground Motion website (2008 data) for the project latitude and longitude.

Table 1 – 2012/2015 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	1.460	0.555	1.00	1.50	0.973	0.555

BUILDING FOUNDATIONS

New Footings - Based on review of the geologic map and the results of the existing borings nearby, we recommend that an allowable soil bearing pressure of 1,500 psf be used for sizing the new building footings. The recommended bearing pressure should not be increased when design

for seismic conditions. The new footings should have a minimum width of 18 inches. The footings should be placed at a minimum depth of 18 inches below final grade. We recommend that the new footings bear on a minimum of 6 inches compacted structural fill to provide a more uniform support. The structural fill should extend horizontally a minimum of 6 inches beyond the edge of the footing.

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. A higher allowable bearing pressure is used for the existing footings since the existing foundation soil had been consolidated under the existing building loads. The existing footings may be enlarged to account for the added structural loads. The recommended bearing pressure should not be increased when evaluating the seismic conditions.

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 0.35 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 Subgrade Preparation

The footing excavations for the new footings should be trimmed neat and the native subgrade at the bottom of 6-inch structural fill should be properly compacted prior to structural fill placement. The structural fill should also be compacted to a firm, unyielding condition prior to form setting and rebar placement. The adequacy of footing subgrade should be verified by a representative of PanGEO, prior to placing forms or rebar.

Foundation Performance

Settlement for the existing and new footings under static loading conditions is estimated to be less than about 1 inch. Most of the anticipated settlements are likely to occur during

construction as dead loads are applied. Total settlement for footings due to seismic shaking may be as much as 2 to 3 inches during an IBC code-level design earthquake. Differential post-liquefaction foundation settlement is estimated to be on the order of 1 to 1½ inches. As previously indicated, if a higher level of foundation performance is desired, use of deep foundations, such as pin pile foundation, will be required. PanGEO can provide additional design recommendations as requested.

TEMPORARY EXCAVATIONS

As currently planned, temporary excavations for the proposed construction will be less than 3 feet below the existing grade for the new foundations. We anticipate the excavations to mainly encounter loose to medium dense sand and silt. All temporary excavations should be performed in accordance with Part N of WAC (Washington Administrative Code) 296-155. The contractor is responsible for maintaining safe excavation slopes and/or shoring.

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 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 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 Mercer Island, as part of the permitting conditions, may also require geotechnical construction inspection services. PanGEO can provide you a cost estimate for construction monitoring services at a later date.

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 Mr. Brad Sturman 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. Please feel free to contact our office with any questions you have regarding our study, this report, or any geotechnical engineering related project issues.

Sincerely,

2/20/2017

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

Attachments:

Figure 1	Vicinity Map
Figure 2	Site and Exploration Plan

Appendix A – Previous Test Boring Logs by Geotech Consultants

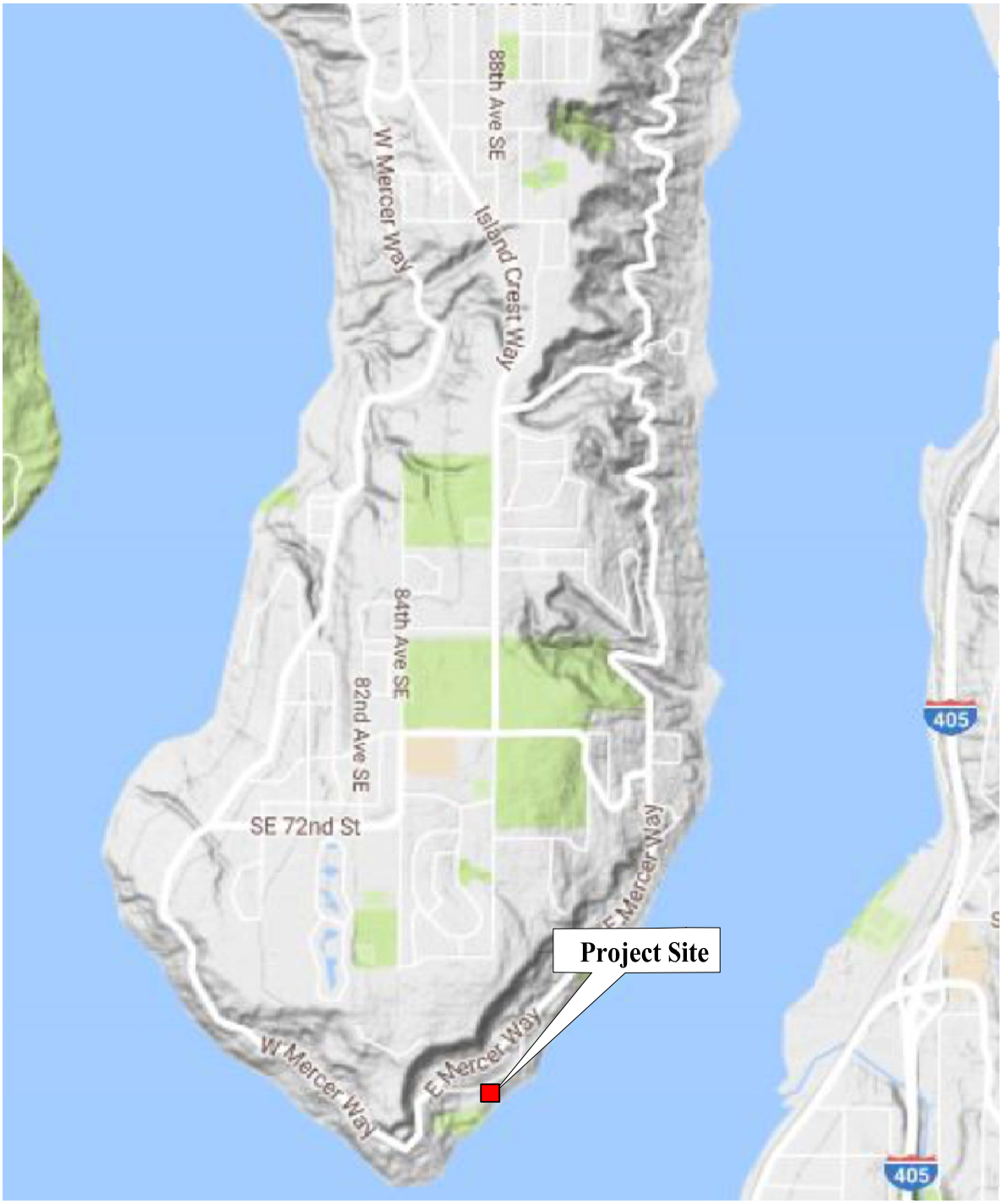
REFERENCES

Geotech Consultants, 2002, *Geotechnical Engineering Study, Proposed Residential Remodel and Additions, 8300 Avalon Drive, Mercer Island, Washington, dated February 28, 2002.*

International Code Council, 2012/2015, *International Building Code.*

Troost, K.G., and Wisher, A. P, 2006. *Geologic Map of Mercer Island, Washington, scale 1:12,000*.

WSDOT, 2016, *Standard Specifications for Road, Bridge and Municipal Construction, M 41-10, Washington State Department of Transportation.*



Reference: Google Terrain Map

Not to Scale

PanGEO INCORPORATED

Platou Residence
8316 Avalon Drive
Mercer Island, Washington

VICINITY MAP

Project No. **17-054**

Figure No. **1**

16-240 Fig 2 Site Exploration Plan.grf 2/20/17 (13:17) BBK

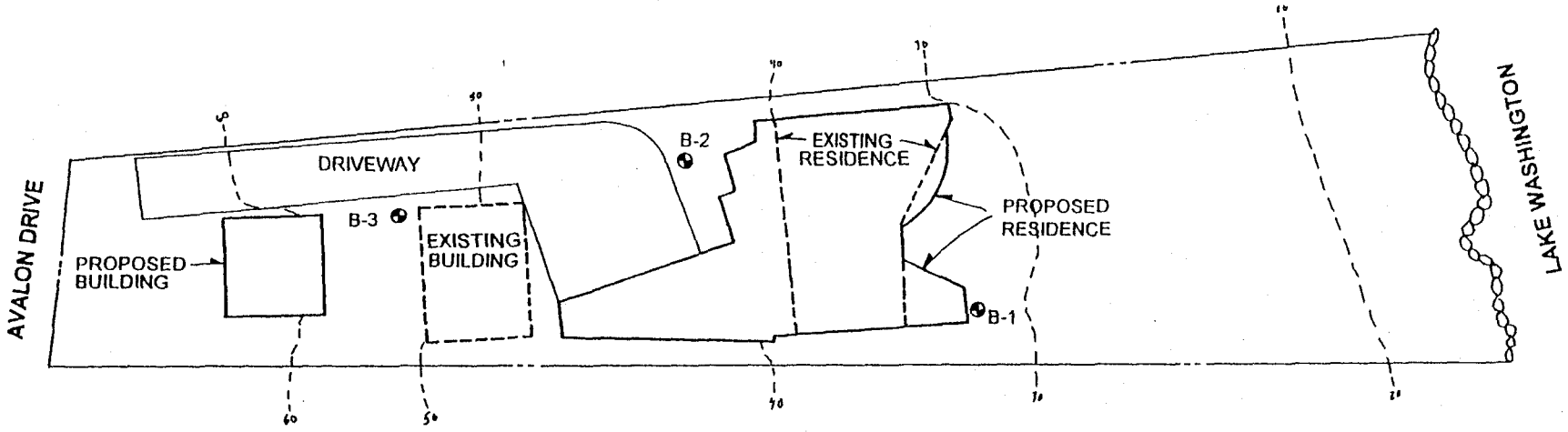
NTS

Note: Basemap modified from King County iMap.

PanGEO INCORPORATED	**Platou Residence** **8316 Avalon Drive** **Mercer Island, Washington**	**SITE AND EXPLORATION PLAN** Project No. **17-054** Figure No. **2**

APPENDIX A

PREVIOUS TEST BORING LOGS (GEOTECH CONSULTANTS)



Source: *Topographic Survey of a Portion of Lot 31, Avalon Park Park Unrecorded;* M.W. Marshall, undated.

LEGEND:

APPROXIMATE BORING LOCATIONS

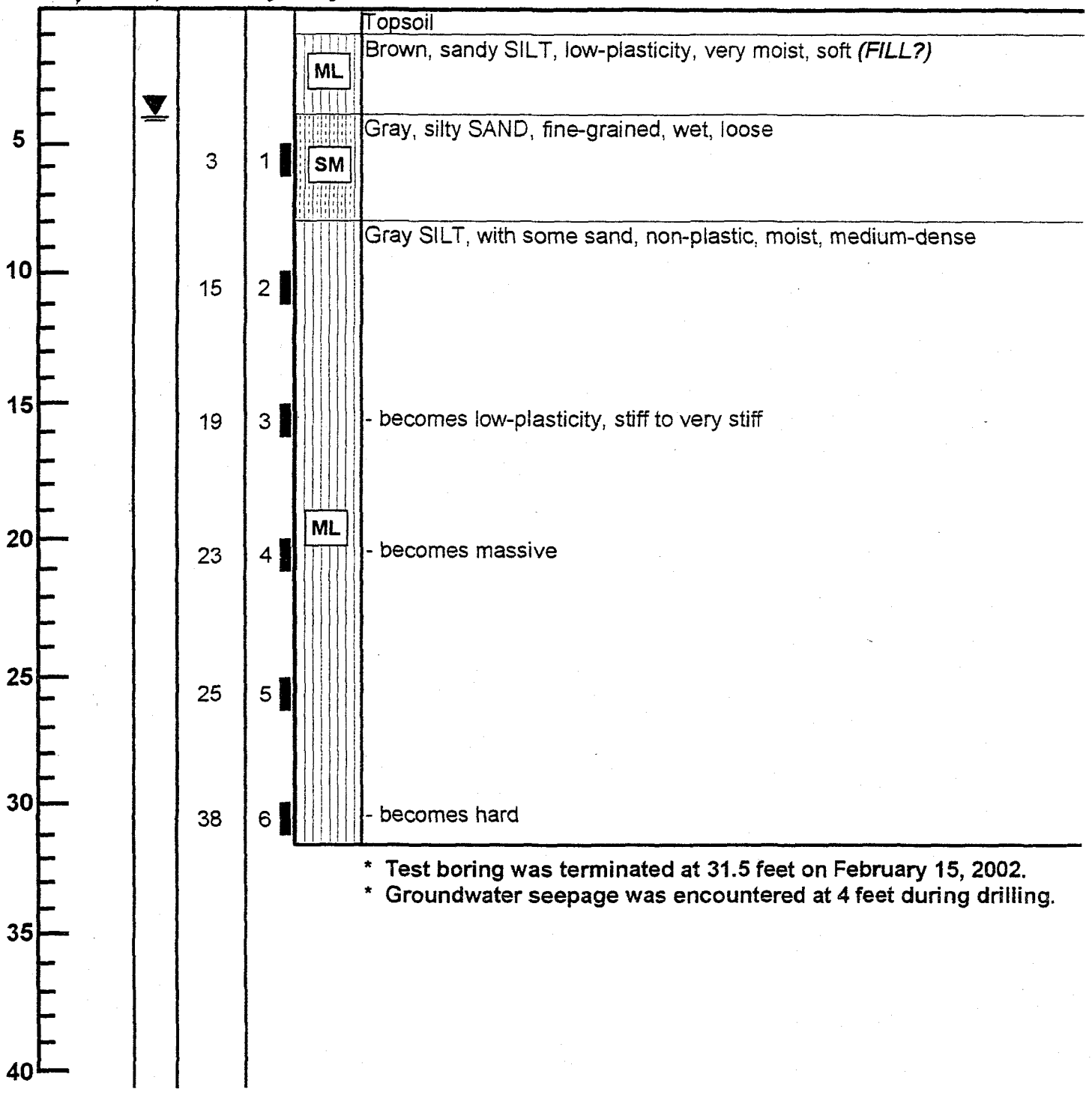
GEOTECH CONSULTANTS

SITE EXPLORATION PLAN

8300 Avalon Drive
Mercer Island, Washington

Job No.:	Date:	Scale:	Plate:
02054	Feb 2002		2

BORING 1



* **Test boring was terminated at 31.5 feet on February 15, 2002.**
* **Groundwater seepage was encountered at 4 feet during drilling.**

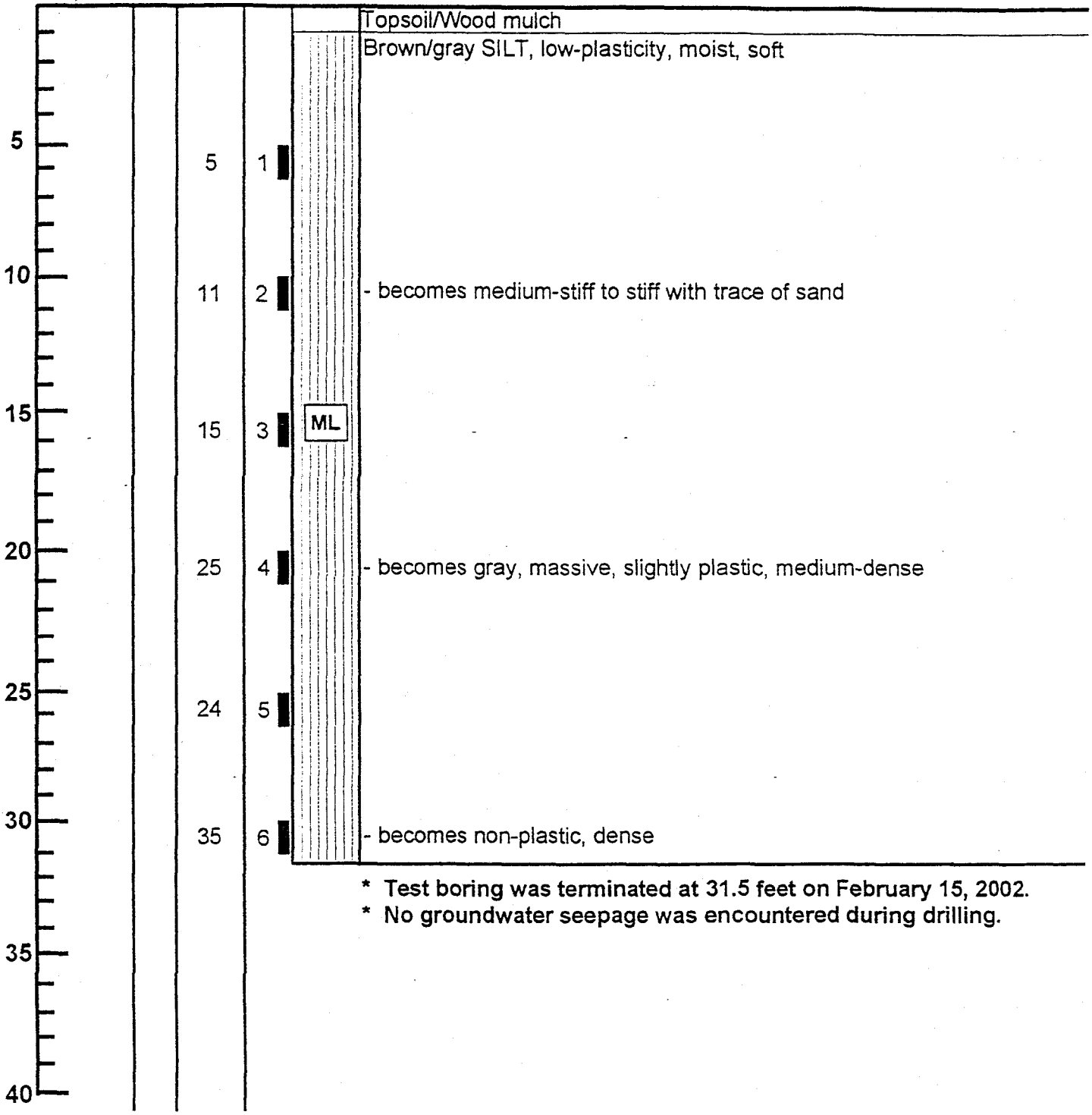
GEOTECH
CONSULTANTS, INC.

BORING LOG

8300 Avalon Drive
Mercer Island, Washington

Job No:	Date:	Logged by:	Plate:
02054	Feb. 2002	GDB	3

BORING 2



* Test boring was terminated at 31.5 feet on February 15, 2002.
* No groundwater seepage was encountered during drilling.

GEOTECH
CONSULTANTS, INC.

BORING LOG
8300 Avalon Drive
Mercer Island, Washington

Job No:	Date:	Logged by:	Plate:
02054	Feb. 2002	GDB	4

BORING 3

Well Design	Water Table	Blows per Foot	Sample	USCS	Description
					Topsoil/Wood mulch
				FILL	Dark gray, silty SAND, fine- to medium-grained, very moist, loose *(FILL)*
5		1	1		
					Old Topsoil
					Gray, silty SAND, fine- to medium-grained, very moist, loose, soft to medium-stiff
10		8	2	SM	- with brown, fine-grained sand lenses
	▼				
					Gray SILT, with some sand, low-plasticity, moist to very moist, soft
15		5	3		
20		15	4		- becomes massive, medium-stiff
25		21	5	ML	- becomes stiff to very stiff
30		27	6		
35		20	7		- with fine-grained sand lenses
40		23	8		
40.5					

* Test boring was terminated at 40.5 feet on February 15, 2002.
* Groundwater seepage was encountered at 13 feet during drilling.

GEOTECH
CONSULTANTS, INC.

BORING LOG
8300 Avalon Drive
Mercer Island, Washington

Job No:	Date:	Logged by:	Plate:
02054	Feb. 2002	GDB	5