TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

July 29, 1988
Project No. T-744-1

Steven D. Smith Construction
16325 NE 135th Street
Redmond, Washington 98052

Attention: Mr. Steve Smith

Subject: GEOTECHNICAL INVESTIGATION
Proposed Smalley Residence
8448 N. Mercer Way
Mercer Island, Washington

Dear Steve:

Enclosed is the report of our geotechnical investigation performed at the site of the proposed Smalley residence to be located on the lower portion of the lot at 8448 N. Mercer Way.

The results of our investigation indicated that the site is underlain by peat soils but can be improved for support of the proposed structure by proper site preparation procedures. Subsoils encountered in the test boring consisted generally of moderately thick surface deposits of peat and compressible silts underlain by granular soils. Several alternative procedures are provided in this report for migrating the effects of the compressible onsite soils to provide support for the proposed structure.

Thank you for this opportunity to be of continued service. If you have any questions please call the undersigned.

Respectively submitted,

TERRA ASSOCIATES, INC.

James A. Doolittle
Principal Engineer

Dist. 3/addressee

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INTRODUCTION

This report presents the results of our geotechnical investigation performed at the site of the proposed Smalley residence to be located at 8448 N. Mercer Way on Mercer Island, Washington (see Figure 1). The purpose of our investigation was to determine the nature and engineering properties of the subsurface soils and provide geotechnical engineering recommendations for design of foundations, swimming pool walls and site grading.

A site plan prepared by 4D Architects Inc. was used as a reference for our investigation. Locations of our exploratory borings within the site are shown on Figure 2.

It is understood that the residence will be a two story woodframe structure with a swimming pool as shown on Figure 2. The plan footprint of the structure will be irregular but maximum dimensions will be about 85 feet by about 145 feet. Bearing wall loads are expected to be on the order of 2 klf or less. If actual structural loads exceed the above values by more than 25%, this office should be notified.

Site grading will include excavation for the swimming pool and placement of imported fill to raise the site grades by about 3 feet over the entire site area.

SCOPE OF WORK

Our geotechnical investigation included subsurface exploration, soil sampling, laboratory testing, engineering analyses, client consultation, and the preparation of this report. The scope of work included the following specific tasks:

- o Drilled three test borings to depths ranging from 11.5 to 29 feet below the ground surface to provide subsurface data and soil samples for our investigation. Locations of the borings are shown on Figure 2.

- o Continuously logged the subsurface conditions, as encountered in the test borings at the time of drilling. Logs of the borings are presented on the summary sheets of Appendix A.

- o Obtained relatively undisturbed and disturbed samples of the subsurface materials from the borings at frequent intervals for testing in our laboratory.

- o Conducted laboratory tests. Moisture content tests were performed on selected soil samples. Results of the laboratory test are presented on the boring summary sheets of Appendix A.

- o Performed engineering evaluations and analyses and developed appropriate recommendations for foundations systems design, temporary excavations, pool wall design and site grading.

o Prepared this geotechnical investigation report summarizing our findings and recommendations for the proposed site development.

EXISTING SITE CONDITIONS

The proposed residence site is located on the northeast shoreline of Mercer Island as shown on the Vicinity Map of Figure 1. Site topography consists of a relatively flat, gently sloping area within the pre-locks boundary of Lake Washington. We have been told by the previous residents of the site that the old shoreline was located on the south side of the existing cottage (roughly 60 to 100 feet south of the proposed structure). The current shoreline forms the north boundary of the site. At the time of our field investigation, the site was occupied only by the small cottage at the south end of the site. Vegetation on the site consisted of lawn which covers most of the site, miscellaneous shrubs and bushes as well as some mature trees along the east and west property borders.

Subsoils

Our evaluation of the subsurface conditions was based on the exploratory borings, soil samples and laboratory tests. In general the soil profile encountered consisted of sod and topsoil underlain by soft peat soils and soft silt which were in turn underlain by medium dense silty sand and sand soils to the depths of our borings.

The sod and topsoil extended to depths of 1 to 1-1/2 feet at the boring locations. Peat soils were encountered to depths of 3 to 8 feet below the surface with generally increasing thickness toward the lake and the greatest thickness encountered at Boring 3 in the northeast corner of the site. Below the peat we encountered a layer of soft sandy to clayey silt 1-1/2 to 2 feet thick in Borings 1 and 3 along the north part of the site. The silt layer was not evident in Boring 2 at the southeast corner of the site. Below the upper peat and silt layers we encountered loose to medium dense and dense sand soils to the depths of our borings. These sands appeared to grade from loose to medium dense silty sands in the upper portion of this strata to cleaner, dense sands in the lower portions of the strata. A deep, thin clay layer was encountered at a depth of about 21 feet in Boring 1, however this strata was not encountered in Boring 3 and therefore is not considered to be continuous.

Groundwater

During drilling of the test borings, groundwater was encountered at depths ranging from 1 to 5 feet below the surface, corresponding approximately to the elevation of the nearby Lake Washington. Laboratory moisture tests indicated high moisture contents (for the various soil types) in all of the samples tested.

Subsurface Variations

Based on our experience, it is our opinion that some variation in the continuity and depth of subsoil deposits and ground water levels should be anticipated. Due to the depositional characteristics of the natural soils and seasonal ground water variations, care should be exercised when interpolating or extrapolating subsurface soils and groundwater conditions between or beyond our test borings.

EVALUATION AND RECOMMENDATIONS

General Site Evaluation

Based on the results of our field and laboratory investigations combined with our own experience and judgement, it is our opinion that the site can be developed as planned provided that appropriate site preparation measures are carried out as recommended in this report.

Results of our investigation indicate that portions of the site are underlain by a varying thickness of soft peat and silt deposits extending to depths of about 3 to 9-1/2 feet at our boring locations. These soils are soft and highly compressible. Underlying the peat and soft silt soils we found loose to medium dense and dense natural sand soils which generally increased in density with depth.

Site grading is expected to include placement of three or more feet of fill to create a pad above the lake level for placement of the house, pool and landscaping areas. In our opinion the existing site is not suitable for direct support of the proposed fill pad and structure. Combined short and long term settlements due to consolidation of the compressible peat and soft silt soils under the load of the new fill and the structure, are expected to be on the order of several inches to more than one foot. The northern portion of the site would be expected to experience greater settlements than the south portion (due to greater peat/silt thickness) and therefore large differential settlements could develop between the north and south areas of the site. A significant amount of the settlement would be expected to be long term settlements occurring over several years following construction.

We discussed three alternative foundation support systems with you. These were the following:

1) Excavation of the organic, compressible materials and replacement with granular structural fill.

2) Constructing the building pad over the existing soils and installation of augercast piles for support of the proposed residence structure.

3) Pre-loading and surcharging the site for an extended period to obtain consolidation magnitudes corresponding to expected long term settlements prior to construction.

Alternative 1 (excavation and replacement of the compressible soils) would, in our opinion, provide a buildable site for which "normal" performance could be expected, i.e., settlements of tolerable magnitude occurring during grading and initial construction loading and little or no long term settlements. This alternative would require the least amount of time for construction and would have the lowest risk from the standpoint of site performance. However it would be difficult to accomplish due to the high ground water condition at the site and the substantial thickness of the compressible soils. A dewatering system would likely be required to lower ground water levels prior to excavation and maintain them below the working level until the excavation was backfilled with the granular structural fill. Disposal of the pumped water from the dewatering system may require de-silting (cleaning) prior to discharge into the lake.

Alternative 2 (pile supported structure) would involve stripping of the sod, placement of geo-fabric, placement of the structural fill pad, monitoring of pad settlements and then installation of pile foundations. This alternative would provide excellent support for the structure, however there would be risk of long term pad settlement under and around the house. Long term settlements of the pad may eventually look unsightly and could potentially cause damage to utilities servicing the house.

Alternative 3 (pre-loading and surcharging) would involve construction of the pad as in alternative 2 but additional surcharge fill would be temporarily placed on the pad to consolidate the compressible soils to a state where long term settlements would be reduced to hopefully tolerable levels. This alternative has the advantage of lower site preparation costs but it could require several weeks to months for the surcharge consolidation to be complete and it has the highest risk from the standpoint of future structure performance due to the fact that the structure will still be supported on the peat soils.

We suggest that consideration also be given to a fourth alternative which would combine the features of alternatives 2 and 3. This would provide excellent support for the structure and greatly reduce the potential for long term settlements of the surrounding pad areas.

Excavation for construction of the proposed swimming pool will encounter the same difficulties as discussed above for alternative 1. Dewatering will be required during construction and a subdrain system or hold-down anchors will be required to prevent "floating" of the pool when it is empty.

The following subsections present our geotechnical recommendations for design of spread footing and pile foundations, swimming pool wall design, fill pad surcharge and general site grading. Also included are recommendations for plan review and observations and testing during construction.

Spread Footing Foundations

For foundation alternatives 1 and 3 conventional spread footings may be used for support of the proposed structure. Spread footings should be founded on a zone of properly compacted granular structural fill. The zone of compacted fill should extend vertically at least 2 feet below the footing and horizontally at least one footing width or 5 feet (whichever is greater) beyond the footing edge. Structural fill for support of foundations should be placed and compacted in accordance with the recommendation presented under "Site Grading".

All spread footings should be at least 12 inches wide and founded at least 12 inches below the lowest adjacent final grade. If alternate 1 is used spread footing foundations may be either isolated square footings or continuous wall footings. If alternate 3 is used footings should be limited to continuous type (no isolated footings) to reduce the effects of possible differential settlements. An allowable bearing pressure of 2000 psf may be used for properly constructed footings bearing on compacted granular structural fill.

Estimated differential settlements between footings should be assumed to be 1/2 inch for alternate 1 (replacement) and up to 2 inches for alternate 3 (surcharge).

Resistance to lateral loads can be assumed to be provided by friction acting at the base of the footings and by passive earth pressure. A coefficient of friction of 0.45 may be assume with the dead load forces in contact with granular fill soils. An allowable static passive earth pressure of 250 psf per foot of depth may be used for the sides of footings poured against properly compacted structural fill.

The vertical and lateral bearing values indicated above are for the total dead load plus frequently applied live loads. For short duration dynamic loading caused by seismic or wind forces, the vertical bearing values may be increased by 50 percent and allowable lateral passive pressures may be increased by 33 percent.

Augercast Piles

Recommended allowable single pile static downward capacities for auger-cast piles are presented in Figure 3. Allowable capacities may be used for dead loads plus frequently occurring live loads. Minimum spacing between piles should be at least 2.5 pile diameters center to center. Allowable capacities were based on static calculations using estimated soil strengths from our field investigation. Proper construction to insure that no loose or disturbed material exists at the base of the auger shaft should be verified by close field observations at the time of construction.

Recommended downward pile capacities may be increased by 50% to resist total vertical downward loads which include a transient component such as loads due to wind forces or seismic shaking.

Heaving of the deeper sand soils was encountered during the field explorations, especially between the depths of 15 to 20 feet. The deeper subsoils will be susceptible to heaving during construction of auger-cast piles due to their generally granular nature and submergence. Proper tremie placement of concrete under adequate pressure and optimum design with smaller diameter shafts is recommended to reduce heave potential of the excavations.

If pile foundations are designed in accordance with the recommendations given above, the settlement of a single isolated pile is estimated to be less than 1/4 inch for loads up to 20 kips.

Resistance to lateral loads may be provided by passive soil pressures on the grade beams and pile caps. An allowable passive pressure of 250 psf/ft may be used for surfaces poured against properly compacted structural fill.

Swimming Pool Design

If the pool walls are designed as an unrestrained cantilevered wall, an external lateral soil pressure of 35 psf/ft above the water table and a combined hydrostatic and soil pressure of 85 psf/ft below the water table should be used for design of the "pool empty" condition.

We recommend that a subdrain system be placed around and under the pool to prevent "floating" of the pool structure under "pool empty" conditions due to the high groundwater conditions. The subdrain should consist of drain rock blanket incased in geofabric and should have a gravity connection to a pumped sump. We recommend that the sump system be accessible for maintenance and that it be designed to allow for pump replacement in the event of pump failure or insufficient pumping capacity.

As an alternative, augercast piles could be installed below the pool as "hold down" anchors to prevent floating. Uplift pile capacities for this purpose can be provided upon request.

Surcharge Fill Design

If onsite compressible soils are not removed, the potential for long term settlements of the onsite compressible soils may be reduced by the use of a surcharge fill. The term "surcharge" is defined as the placement of loads in excess of the expected final loads for the purpose of reducing expected secondary (long-term) settlements. Surcharge loads should be placed simultaneously with the permanent load and must remain in place at least until the primary (short-term) settlement of the combined loading has been completed.

For this site, we recommend that the surcharge fill depth should be twice the permanent fill depth, i.e., total fill depth of three times the permanent fill thickness. This is based on estimated compressibility properties of the onsite soils and a structure life of 30 years. Full depth surcharge fill thickness should extend at least 5 feet beyond the edge of the structure up and to the edges of the pool and any deck or patio areas adjacent to the residence. At this time we do not anticipate the need for surcharge in the areas south (upslope) of the proposed building site.

Settlements for 3 feet of permanent fill plus 6 feet of surcharge are estimated to be in the range of 10 to 20 inches at the north end of the site, diminishing towards the south. After removal of the surcharge fill, theoretically there should not be any significant long-term settlement, however, considering the possible variations in the thickness and compressibility characteristics of the onsite soils, in our opinion, long term settlements of 1 to 2 inches should be anticipated.

Settlement monuments should be established at several locations on the existing site soils prior to fill and surcharge placement. Elevations of these monuments should be monitored during the preload period by this office to provide a basis for evaluating the progress and magnitude of the settlements.

Site Grading

Site development is expected to consist primarily of excavation for the pool and possibly for removal of existing compressible soils, placement of fill to establish final grades for the structure and backfill for retaining walls, footings and utility trenches. Excavation of the on-site peat and silt materials is expected to be difficult due to the high ground water table and should be accomplished in conjunction with site dewatering. Excavated onsite peat and silt soils should be wasted off-site. New fill placement will require the use of imported granular fill soils which can be placed and compacted under wet conditions. Recommended specifications for placement and compaction of fill are presented in Appendix C. Suggested guidelines for site preparation, temporary excavations, structural fill, subgrade preparation and site drainage are presented below.

Site Preparation: Existing vegetation and debris should be stripped from the areas that are to be graded. Stumps, debris and trash, plus rocks and rubble over 6 inches in size, should be removed from the site. Subsoil conditions on the site may vary from those encountered in the borings. Therefore, the soils engineer should observe the prepared areas prior to placement of any new fills.

Temporary Excavations: Sloped temporary construction excavations may be used where planned excavation limits will not undermine existing structures or interfere with other construction. Where there is not enough room for sloped excavations, shoring should be provided. All excavations will likely require dewatering prior to excavating. Groundwater levels should be drawn down to at least 3 feet below the base of the planned excavation and maintained at that level or below until the excavation has been backfilled.

Based on the subsurface conditions encountered in our borings, it is our opinion that dewatered temporary excavations, up to ten feet deep, should be made no steeper than a 1:1 slope ratio, It should be noted that the contractor is responsible for safety and maintenance of construction slopes.

Structural Fill: Imported granular fill soils should be used for all structural fill areas for support of foundations, slabs or pavements and backfill. Mirafi 140 or equivalent geofabric should be placed over the exposed native soils prior to placing fill or backfill. Imported granular fill should be placed and compacted in accordance with the recommended specifications of Appendix C.

Imported granular fill should consist of clean, well-graded sand and gravel materials free of organic debris and other deleterious material and should satisfy the following gradation requirements:

U.S. Standard Sieve Size	Percent Passing by Dry Weight
3 inch	- 100
3/4 inch	50 - 100
No. 4	25 - 65
No. 10	10 - 50
No. 40	0 - 20
No. 200	0 - 5

Where space limitations do not allow for conventional backfill compaction operations, special backfill materials and procedures may be required. Quarry spalls or other select backfill can be used where conditions require special fill procedures. Recommendations for placement and densification of special backfill can be provided during construction.

Subgrade Preparation: Asphalt pavement and concrete slabs-on-grade should be supported by a minimum 6-inch thickness of imported granular compacted fill. Subgrade fill should be placed in accordance with the recommended specifications set forth in Appendix C.

Site Drainage: Adequate positive drainage should be provided away from the structure to prevent water from ponding and to reduce percolation of water into the fill. A desirable slope for surface drainage is 2% in landscaped areas and 1% in paved areas.

<u>**Plan Review**</u>

This report has been prepared to aid in the evaluation of this site and to assist the architect, structural and civil engineers in the design and construction of the project. It is recommended that this office be provided the opportunity to review the final design plans and specifications to determine if the recommendations of this report have been properly implemented and to make any supplemental design recommendations which may be required.

Observations and Testing During Construction

Foundation recommendations given in this report are based on the assumption that all spread footing foundations will be placed on compacted granular fill. All footing excavations should be observed prior to placement of steel and concrete to see that footings are founded on satisfactory bearing materials and that excavations are free of loose and disturbed materials. All structural fill and backfill should be placed and compacted under observation and testing by this office. Pile installations and/or a surcharge program should also be monitored by this office.

CLOSURE

The findings and conclusions of this report were prepared in accordance with generally accepted professional engineering principles and practice. We make no other warranty, either express or implied. Our conclusions and recommendations are based on the results of the field and laboratory investigations, combined with an interpolation or extrapolation of soil conditions between and beyond the boring locations. If conditions encountered during construction appear to be different from those shown by the borings, this office should be notified.

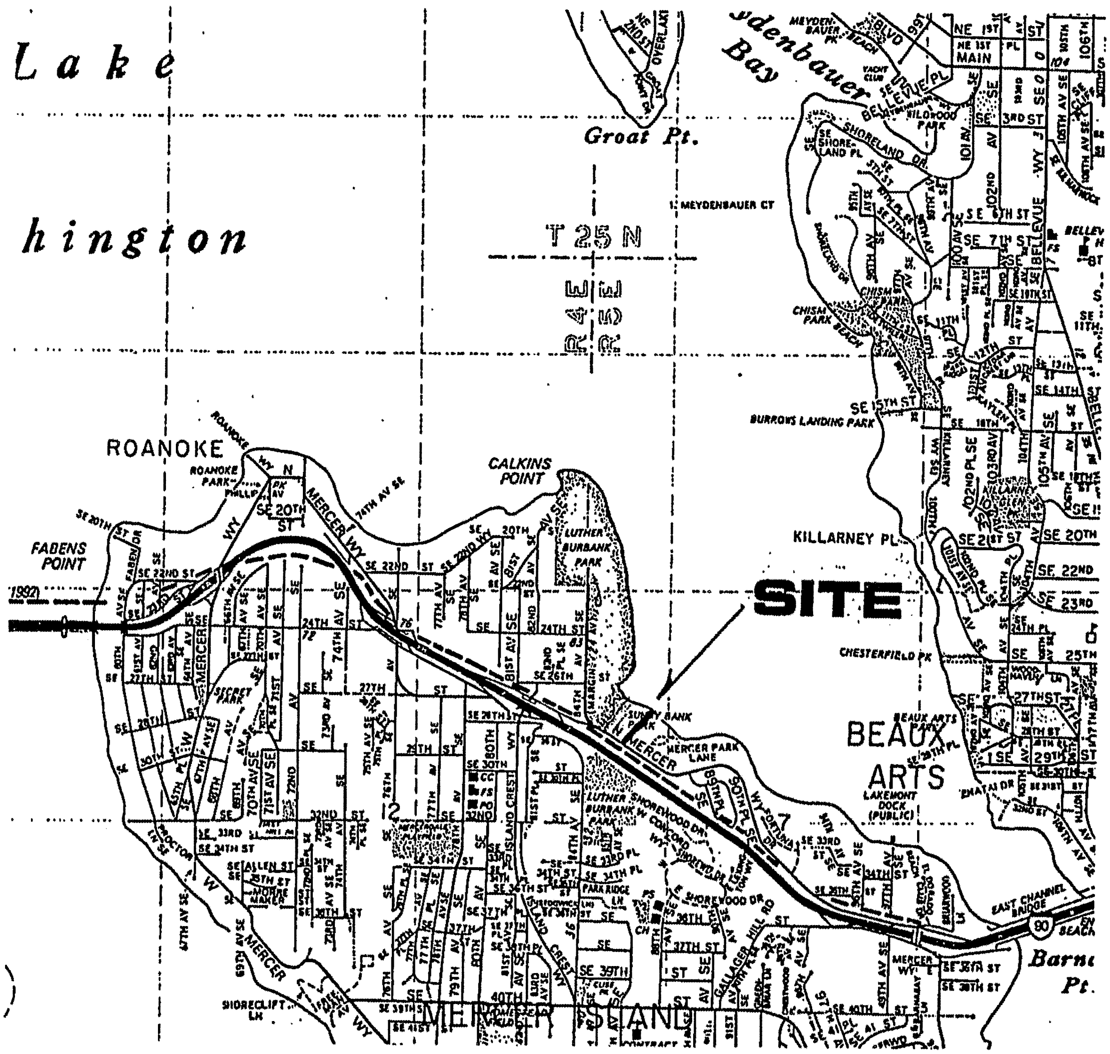
Respectfully submitted,

TERRA ASSOCIATES, INC.

James A. Doolittle
Principal Engineer

Encl: Figures 1 through 3
Appendices A, B and C

Dist: 3/Addressee



REF: Thomas Brothers Maps, 1987.

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VICINITY MAP

SMALLEY RESIDENCE

MERCER ISLAND, WASHINGTON

Proj. No.744-1	Date July'88	Figure 1

BORING NO. 1

Logged By JJ

Date 7/15/88

ELEV. -6.5'

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
		Dark brown TOPSOIL		I	2	288	
	PT	Peat, saturated below 1½ feet.	2	I			
	ML	Gray sandy SILT with some clay and organics, saturated, very soft.	4	I	1/18"	51	Torvane= 0.2 kg/cm^2
	SM / ML	Tan-gray, iron-stained, very silty SAND to sandy SILT, wet very loose.	6	I	2/18"	35	
			8	II	10	24	
	SM / SW	Tan-gray, silty SAND with interbedded gravelly sand, wet to saturated, loose to medium dense.	10	I	8	23	
			12				
	SP	Light brown SAND, trace silt, saturated, dense.	14	I	28	23	
		Heave.	16				
			18	I	46	18	
		Some gravel at 20'.	20				
	CH	Tan and gray, plastic CLAY, wet, soft.	22	I	10	52	Torvane= 0.1 to 0.2 kg/cm^2
	SM	Gray, silty SAND, very moist to wet, dense. Interbedded silt and clay.	24				
	MH		26				
	SM		28	I	18	NR	

Groundwater encountered below 1½ feet;
II = ring sample;
N.R. = no recovery
Elevation relative to ground surface at NW corner existing house.

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BORING LOG
SMALLEY RESIDENCE
MERCER ISLAND, WASHINGTON

Proj. No. 744-1	Date July'88	Figure A-2

BORING NO. 2

Logged By JJ

Date 7/15/88

ELEV. $-3\frac{1}{2}'$

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
		Dark brown TOPSOIL, moist, very loose.		I	4	36
	SM + PT	Dark brown silt, SAND with peat stringers moist, loose.	2			
	SP/SM	Light brown, slightly silty SAND, wet, loose. Saturated below about 5 feet.	4	I	5	23
			6	I	16	23
			8	I	16	21
			10	I	19	25

Groundwater encountered below about 5 feet;

Elevation relative to ground surface at N.W. corner of existing house.

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BORING LOG

SMALLEY RESIDENCE

MERCER ISLAND, WASHINGTON

Proj. No. 744-1	Date July'88	Figure A-3

BORING NO. 3

Logged By JJ

Date 7/15/88

ELEV. $-7\frac{1}{2}$'

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
		Dark brown TOPSOIL.		I	2/18"	98	
	PT	Peat with some silt beds, saturated below 1 foot.	2	I			
			4		0/18"	478	
			6	I	2	134	
			8	I	2/18"	26	
	MH	Gray, clayey, sandy SILT, wet, soft.					
	SM	Gray to tan, silty SAND with gravelly sections, wet to very moist, medium dense.	10	I			Torvane = 0.1 kg/cm^2
			12		15	16	
	SM / SW	Tan, slightly gravelly, silty SAND, saturated, medium dense to dense.	14	I	13	23	
			16				
			18	I	43	19	
		Heave.	20				
			22				
			24	I	94*	15	
			26				
	SM MH	Brown-gray, silty SAND with interbedded clayey SILT, wet, medium dense to dense.	28	I	56*	21	

Groundwater encountered below about 1 foot;
Elevation relative to groundwater surface at NW corner existing house;
*sample tube driven through heave, inaccurate SPT.

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BORING LOG

SMALLEY RESIDENCE

MERCER ISLAND, WASHINGTON

Proj. No. 744-1	Date July'88	Figure A-4