Earth Solutions NW LLC

Geotechnical Engineering
Construction Observation/Testing
Environmental Services

GEOTECHNICAL ENGINEERING STUDY
YANG RESIDENCE
6660 EAST MERCER WAY
MERCER ISLAND, WASHINGTON

ES-6162

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PREPARED FOR

MR. STEVE AND MRS. SOPHY YANG
C/O RICHARD A. FISHER ARCHITECTS

August 22, 2018

Stephen H. Avril
Project Geologist

8/24/18

Kyle R. Campbell, P.E.
Principal Engineer

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Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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Earth Solutions NW LLC

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Geotechnical Engineering, Construction
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August 22, 2018
ES-6162

Mr. Steve and Mrs. Sophy Yang
c/o Richard A. Fisher Architects
6660 East Mercer Way
Mercer Island, Washington 98040

Dear Mr. and Mrs. Yang:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled "Geotechnical Engineering Study, Yang Residence, 6660 East Mercer Way, Mercer Island, Washington". In general, the site is underlain by non glacial (Qpon) deposits. We performed a liquefaction analysis in preparation of this report to ascertain the amount of earthquake induced settlement. The Liquefy Pro computer software was utilized to provide the estimations of settlement. Based on our analysis up to 9 inches of settlement is possible during a magnitude seven earthquake. In our opinion, the proposed residential building should be pile supported due to the loose soil conditions observed during our subsurface exploration. The risk of lateral spread, where site soils mobilize towards the lake as the result of an earthquake, is significant on the subject site due to the site's proximity to the lake shore. In order to mitigate damage to the proposed structure in the happenstance of lateral spread, batter piles should be considered as part of the project design. In addition to pin pile installation, mat foundations and structural slab construction may be utilized to reduce the impacts of settlement resulting from earthquake induced liquefaction

Groundwater seepage was observed at the boring location at a depth of two feet. Groundwater seepage will be encountered in excavations on this site. Seepage should be expected during grading activities, particularly during winter, and early spring months.

Recommendations for foundation design, site preparation, drainage, and other pertinent recommendations are provided in this study. We appreciate the opportunity to be of service to you on this project. If you have questions regarding the content of this geotechnical engineering study, please call.

Sincerely,

EARTH SOLUTIONS NW, LLC

Stephen H. Avril
Project Geologist

Table of Contents

ES-6162

Table of Contents

Cont'd

ES-6162

GRAPHICS

APPENDICES

GEOTECHNICAL ENGINEERING STUDY
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6660 EAST MERCER WAY
MERCER ISLAND, WASHINGTON

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INTRODUCTION

General

The project area consists of a property located on the east side of East Mercer Way, at the terminus of a shared driveway south of the intersection with Southeast 67th Street in Mercer Island, Washington. Site development plans include the construction of a new single-family residential structure, and associated improvements. The site is roughly rectangular in shape; and is currently developed with a single-family residence. The site is sloped, with topography descending from the driveway on the west side of the building footprint elevation towards the Lake Washington shoreline, with overall slope relief of about 10 feet.

The purpose of this study was to develop geotechnical recommendations for the proposed redevelopment based on our review of the available information gathered during past site exploration. Our scope of services for completing this geotechnical engineering study included the following:

- Review of subsurface data gathered during past site exploration;
- Engineering analyses of data gathered during site exploration, and;
- Preparation of this report.

The following documents/maps were reviewed as part of our report preparation:

- Geologic Map of Washington, Northwest Quadrant, Dragovich, Logan, et al, 2002;
- King County USDA Soil Conservation Survey (SCS).

Project Description

We understand the property will be redeveloped with a single-family residence, and associated improvements following the demolition of the existing structure. Plans for stormwater runoff management were not available at the time of this report production. However, we performed an infiltration evaluation as a part of this report production.

Given the topographic change across the sites, grading activities will likely involve cuts and fills less than five feet to establish the final design grades.

Building construction is anticipated to consist of relatively lightly loaded wood framing and slab-on-grade floors. Perimeter foundation loading is expected to range from approximately one to two kips per foot. Slab-on-grade loading is expected to be on the order of 150 psf.

If the above design assumptions are incorrect or change, ESNW should be contacted to review the recommendations in this report. ESNW should review the final design to confirm that the geotechnical recommendations included in this report have been incorporated into the project plans.

SITE CONDITIONS

Surface

The site is located on the east side of East Mercer Way, at the terminus of a shared driveway south of the intersection with Southeast 67th Street in Mercer Island, Washington. The approximate location of the property is illustrated on Plate 1 (Vicinity Map) included in this study. The site is rectangular in shape and was developed with a single-family residence during our fieldwork (June 27, 2018).

The existing site topography is flat in nature across the building footprint, with an ascending slope on the west side of the residence. The slope ascends approximately 10 feet from the building footprint towards the terminus of the shard driveway which ascends towards East Mercer Way.

Subsurface

ESNW representatives observed, logged and sampled a boring drilled on the site. The approximate location of the boring is depicted on the Boring Location Plan (Plate 2). Please refer to the boring log provided in Appendix A for a more detailed description of the subsurface conditions.

Topsoil

Topsoil was not encountered at the boring location. However, if topsoil is encountered during site grading activities, it is not suitable for use as structural fill nor should it be mixed with material to be used as structural fill. Topsoil or otherwise unsuitable material can be used in landscaping areas if desired.

Fill

Fill was not encountered at the boring location. There is the potential for limited amounts of fill surrounding the residential structure, road alignments, and utility trenches near the site. The fill may be suitable for support of foundations; however a representative of ESNW should be retained during the construction phases of the site development to evaluate the suitability of any on-site soils for use as structural fill or bearing of foundations.

Native Soil

Native soils consisting variable layers of very loose gravel with sand (Unified Soil Classification, GM), very loose silt with sand (ML), very loose poorly graded sand (SP), and medium dense poorly graded sand with silt (SP-SM) were encountered extending to the maximum exploration depth of 36.5 feet below existing grades. The soil density was observed to increase with depth beginning at about 20 feet.

Geologic Setting

The referenced geologic map resource identifies non-glacial (Qpon) deposits across the site and surrounding areas. The referenced SCS soil survey identifies Kitsap silt loam (KpD) series soils across the entirety of the site. Kitsap silt loam soils are typically comprised of lacustrine deposits.

The soil conditions observed at the test pit locations are consistent with lacustrine deposits. We base this opinion on the observations of the silty soils interbedded with poorly graded sand present within the substrate on the subject site.

Groundwater

The groundwater table was observed at the boring location during the fieldwork (June 2018). Seepage should be expected in excavations at this site, particularly during the winter, spring and early summer months. Groundwater seepage rates and elevations fluctuate depending on many factors, including precipitation duration and intensity, the time of year, and soil conditions. In general, groundwater flow rates are higher during the wetter, winter months.

Dewatering utility trenches may be necessary during the construction phase of site redevelopment. Contingencies to manage groundwater seepage in site excavations should be considered prior to ground disturbance on the subject site.

DISCUSSION AND RECOMMENDATIONS

General

In our opinion, construction of the proposed residential structure is feasible from a geotechnical standpoint. The proposed residential building should be pile supported due to the loose soil conditions observed at the boring location. Furthermore, a mat foundation could be utilized to reduce the impact of settlement resulting from earthquake-induced liquefaction.

Slab-on-grade floors should be supported on dense native soil or structural fill. Where loose or unsuitable soil conditions are exposed at slab subgrade elevations, compaction of the soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material will be necessary. Recommendations for foundation design, site preparation, drainage, and other pertinent geotechnical recommendations are provided in the following sections of this study.

This study has been prepared for the exclusive use of Mr. Steve and Mrs. Sophie Yang and their representatives. No warranty, expressed or implied, is made. This study has been prepared in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area.

Site Preparation and Earthwork

Site preparation activities will involve removal of the existing structure, site clearing and stripping, and implementation of temporary erosion control measures. The primary geotechnical considerations associated with site preparation activities include building pad subgrade preparation, pile installation, retaining wall construction, underground utility installations, and preparation of pavement subgrade areas.

Temporary construction entrances and drive lanes, consisting of at least 12 inches of quarry spalls can be considered in order to minimize off-site soil tracking and to provide a stable access entrance surface. Erosion control measures should consist of silt fencing placed along the down gradient side of the site. Soil stockpiles should be covered or otherwise protected to reduce soil erosion. Temporary sedimentation ponds or other approaches for controlling surface water runoff should be in place prior to beginning earthwork activities.

Topsoil and organic-rich soil may be encountered generally within the upper foot of the subgrade. Topsoil and organic-rich soil is not suitable for foundation support, nor is it suitable for use as structural fill. Topsoil or organic-rich soil can be used in non-structural areas if desired. Over-stripping of the site, however, should be avoided. A representative of ESNW should observe the initial stripping operations, to provide recommendations for stripping depths based on the soil conditions exposed during stripping.

Subgrade conditions expected to be exposed throughout the proposed building and pavement areas will likely be comprised of gravelly soil deposits. After the completion of site stripping and rough grading activities the condition of the subgrade should be evaluated by ESNW. It may be necessary to proofroll utilizing a fully loaded solo dump truck in order to determine the suitability of the exposed native soils for support of foundations and roadways. ESNW should be retained during this phase of earthwork to observe the proofroll and other earthwork activities. The soils exposed throughout subgrade areas should be compacted to structural fill specifications prior to constructing the foundation, slab, and pavement elements. The subgrade throughout pavement areas should be compacted as necessary and exhibit a firm and unyielding condition when subjected to the proofrolling with a loaded solo dump truck.

Structural fill soils placed throughout foundation, slab, and pavement areas should be placed over a firm base. Loose or otherwise unsuitable areas of native soil exposed at subgrade elevations should be compacted to structural fill requirements or overexcavated and replaced with a suitable structural fill material. Where structural fill soils are used to construct foundation subgrade areas, the soil should be compacted to the requirements of structural fill described in the following section. Foundation subgrade areas should be protected from disturbance, construction traffic, and excessive moisture. Where instability develops below structural fill areas, use of a woven geotextile below the structural fill areas may be required. A representative of ESNW should observe structural fill placement in foundation, slab, and pavement areas.

Wet Season Grading

Groundwater is present on the subject site. Mass grading should take place during the late summer months when conditions are more favorable. Dewatering utility trenches may be necessary during the construction phase of site redevelopment. Contingencies to manage groundwater seepage in site excavations should be considered prior to ground disturbance on the subject site. ESNW should be retained during construction to provide supplemental recommendations for site stabilization and groundwater management.

If grading takes place during the wetter winter or spring months, a contingency in the project budget should be included to allow for export of native soil and import of structural fill as described below.

In-situ Soils

The gravelly soils encountered at the test sites have a moderate sensitivity to moisture and were generally in a moist condition at the time of the exploration (June 2018). In this respect, the in-situ soils may not be suitable for use as structural fill if the soil moisture content is more than 3 percent above the optimum level at the time of construction. In general, soils encountered during the site excavations that are excessively over the optimum moisture content will require moisture conditioning prior to placement and compaction. Conversely, soils that are below the optimum moisture content will require moisture conditioning through the addition of water prior to use as structural fill. If the in-situ soils are determined to not be suitable for use as structural fill, then use of a suitable imported soil may be necessary. In our opinion, a contingency should be included in the project budget for exporting unsuitable soil and importing structural fill; or moisture conditioning recommendations can be provided upon request based on field observations during the construction phase of on-site work.

Imported Soils

Imported soil intended for use as structural fill should consist of a well graded granular soil with a moisture content that is at or near the optimum level. During wet weather conditions, imported soil intended for use as structural fill should consist of a well graded granular soil with a fines content of 5 percent or less defined as the percent passing the #200 sieve, based on the minus three-quarter inch fraction.

Subgrade Preparation

Following site stripping and removal of existing structure, cuts and fills will be completed to establish the proposed subgrade elevation(s) throughout the site. ESNW should observe the subgrade during initial site preparation activities to confirm soil conditions and to provide supplementary recommendations for subgrade preparation. The process of removing existing structures may produce voids where foundations and/or crawl space areas were present. Complete restoration of voids caused by the removal of existing structural improvements must be executed as part of overall subgrade and building pad preparation activities. The following guidelines for preparing building subgrade areas should be incorporated into the final design:

- Where voids and related demolition disturbances extend below planned subgrade elevations, restoration of these areas should be completed. Structural fill should be used to restore voids or unstable areas resulting from the removal of existing structural improvements.

- Recompact, or overexcavate and replace, areas of existing fill, if present, exposed at building subgrade elevations. ESNW should confirm subgrade conditions and the required level of recompaction, or overexcavation and replacement, during site preparation activities. Overexcavations should extend into competent native soils, and structural fill should be used to restore subgrades areas.

- ESNW should confirm the overall suitability of prepared subgrade areas following site preparation activities.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, and roadway areas. Fills placed to construct permanent slopes and throughout retaining wall and utility trench backfill areas are also considered structural fill. Soils placed in structural areas should be placed in loose lifts of 12 inches or less and compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by the Modified Proctor Method (ASTM D-1557). Additionally, more stringent compaction specifications may be required for utility trench backfill zones, depending on the responsible utility district or jurisdiction.

Foundations

Based on the results of our study (including settlement estimates following computer modeling), the proposed residential structure should be supported on piles if the risk of up to nine inches of settlement is undesirable. Additionally, the risk of lateral spread, where site soils mobilize towards the lake as the result of an earthquake, is significant on the subject site due to the site's proximity to the lake shore. In order to mitigate damage to the proposed structure in the happenstance of lateral spread, batter piles should be considered as part of the project design. In addition to pin pile installation, mat foundations and structural slab construction may be utilized to reduce the impacts of settlement resulting from earthquake induced liquefaction. We have provided pin pile recommendations below.

Pin Piles

The ultimate pile length will be determined by achieving adequate refusal. Therefore, if soil variability is encountered during installation, longer pile lengths may be required to achieve acceptable refusal criteria. We recommend about ten feet of embedment into firm soils.

Three and four-inch diameter pin piles are typically Schedule 40 galvanized steel driven by an 850 pound hammer operating at 900 blows per minute.

Axial Load Capacity

Assuming the pin piles are driven to refusal, the allowable axial load capacities listed below can be used for design:

Pile Diameter	**Load Capacity***	**Refusal Criteria** (seconds/inch)
3 inches	6 tons	10
4 inches	10 tons	10

(* assumes a factor-of-safety of at least 2.0)

Refusal is generally defined as less than six inches of penetration within the above refusal criteria.

With structural loading as expected, total settlement in the range of one inch is anticipated, with differential settlement of approximately 0.75 inches. The majority of the settlements should occur during construction, as dead loads are applied.

An ESNW representative should observe the pin pile installation to verify the refusal criteria during the pile driving operation.

Lateral Load Capacity

In general, lateral load capacity of pin piles is very limited and should be neglected in design. Limited lateral load capacity can be provided by passive resistance developed by grade beams, if utilized. In our opinion, lateral load capacity of the pin piles is negligible and should be assumed to be zero for design. If additional lateral load capacity is required, ESNW can review the pile design and provide batter pile recommendations.

Seismic Design Considerations

The 2012 IBC recognizes the American Society of Civil Engineers (ASCE) for seismic site class definitions. In accordance with Table 20.1-1 of the ASCE Minimum Design Loads for Buildings and Other Structures manual, Site Class E should be used for design.

In our opinion the site has a low susceptibility to liquefaction, given the relative density of the soil underlying the site and the lack of a near-surface groundwater table.

Slab-On-Grade Floors

Slab-on-grade floors for the residential building constructed at this site should be supported on a firm and unyielding subgrade. Where feasible, the existing native soils exposed at the slab-on-grade subgrade level can be compacted in place to the specifications of structural fill. Unstable or yielding areas of the subgrade should be recompacted or overexcavated and replaced with suitable structural fill prior to construction of the slab. A capillary break consisting of a minimum of four inches of free draining crushed rock or gravel should be placed below the slab. The free draining material should have a fines content of 5 percent or less (percent passing the #200 sieve, based on the minus three-quarter inch fraction). In areas where slab moisture is undesirable, installation of a vapor barrier below the slab should be considered. If a vapor barrier is to be utilized it should be a material specifically designed for use as a vapor barrier and should be installed in accordance with the manufacturer's specifications.

Retaining Walls

Retaining walls must be designed to resist earth pressures and applicable surcharge loads. The following parameters can be used for retaining wall design:

- Active earth pressure (yielding condition) — 35 pcf (equivalent fluid)
- At-rest earth pressure (restrained condition) — 55 pcf
- Traffic surcharge for passenger vehicles (where applicable) — 70 psf (rectangular distribution)
- Passive resistance — 300 pcf (equivalent fluid)
- Coefficient of friction — 0.40
- Seismic surcharge (active condition) — 6H (where H equals retained height)

Additional surcharge loading from adjacent foundations, sloped backfill, or other loads should be included in the retaining wall design. Drainage should be provided behind retaining walls such that hydrostatic pressures do not develop. If drainage is not provided, hydrostatic pressures should be included in the wall design.

Retaining walls should be backfilled with free draining material that extends along the height of the wall, and a distance of at least 18 inches behind the wall. The upper one foot of the wall backfill can consist of a less permeable soil, if desired. A perforated drain pipe should be placed along the base of the wall, and connected to an approved discharge location. A typical retaining wall drainage detail is provided on Plate 3.

Drainage

Groundwater seepage should be anticipated in site excavations on the site, particularly during winter, spring, and early summer months. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches and sumps. ESNW should be consulted during preliminary grading to identify areas of seepage and to provide recommendations to reduce the potential for instability related to seepage effects.

Finish grades must slope away from the residence at an inclination of at least 2 percent for a distance of at least ten feet. In addition finish grades must slope away from the top of the steep slope such that surface water does not flow over the top and down the slope.

In our opinion, foundation drains should be installed along building perimeter footings. A typical foundation drain detail is provided as Plate 4.

Excavations and Slopes

The Federal Occupation Safety and Health Administration (OSHA) and the Washington Industrial Safety and Health Act (WISHA) provide soil classification in terms of temporary slope inclinations. Based on the soil conditions encountered at the boring locations, the native soils encountered at the boring locations, and where groundwater seepage is exposed, are classified as Type C by OSHA/WISHA. Temporary slopes over four feet in height in Type C soils must be sloped no steeper than 1.5H:1V (Horizontal:Vertical). The presence of perched groundwater may cause caving of the temporary slopes due to hydrostatic pressure. The undisturbed native soil where groundwater is not observed are classified as Type B. Temporary slopes over four feet in height in Type B soils must be sloped no steeper than 1H:1V. ESNW should observe site excavations to confirm the soil type and allowable slope inclination. If the recommended temporary slope inclination cannot be achieved, temporary shoring may be necessary to support excavations.

Permanent slopes should maintain a gradient of 2H:1V, or flatter, and should be planted with vegetation to enhance stability and to minimize erosion. A representative of ESNW should observe temporary and permanent slopes to confirm the slope inclinations, and to provide additional excavation and slope recommendations, as necessary.

Utility Support and Trench Backfill

In our opinion, the soils anticipated to be exposed in utility excavations should generally be suitable for support of utilities. Organic or highly compressible soils encountered in the trench excavations should not be used for supporting utilities. The native soils are highly moisture sensitive and will therefore be difficult to use as structural trench backfill if the moisture content of the soil is high. Moisture conditioning of the soils will likely be necessary prior to use as structural backfill. Utility trench backfill should be placed and compacted to the specifications of structural fill provided in this report, or to the applicable City of Mercer Island specifications. Seepage should be anticipated within utility trench excavations. Caving of the trench sidewalls due to hydrostatic pressure should be anticipated by the contractor where seepage is encountered.

Pavement Sections

The performance of site pavements is largely related to the condition of the underlying subgrade. To provide adequate pavement performance, the subgrade should be in a firm and unyielding condition when subjected to proofrolling with a loaded dump truck. Structural fill in pavement areas should be compacted as recommended in the "Site Preparation and Earthwork" section of this report. It is possible that soft, wet, or otherwise unsuitable subgrade areas may still exist after base grading activities. Areas of unsuitable or yielding subgrade conditions will require remedial measures such as overexcavation, cement treatment, placement of a geotextile and thicker crushed rock or structural fill sections prior to pavement.

For lightly loaded pavement areas subjected primarily to passenger vehicles, the following preliminary pavement sections can be considered:

- Two inches of hot-mix asphalt (HMA) placed over four inches of crushed rock base (CRB), or;

- Two inches of HMA placed over three inches of asphalt treated base (ATB).

The HMA, ATB and CRB materials should conform to WSDOT specifications. All soil base material should be compacted to at least 95 percent of the maximum dry density.

Given the possible presence of shallow perched groundwater, in our opinion, additional drainage measures should be considered for driveway subgrade areas. Such drainage measures could include crowning the driveway and the installation of drainlines along the sides of the driveway. The drainlines must be hydraulically connected to the crushed rock placed beneath the driveway. If areas of seepage are exposed in roadway excavations, drains should be installed in these areas to allow removal of the water.

LIMITATIONS

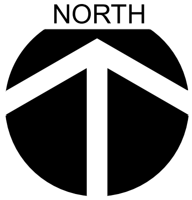
The recommendations and conclusions provided in this geotechnical engineering study are professional opinions consistent with the level of care and skill that is typical of other members in the profession currently practicing under similar conditions in this area. A warranty is not expressed or implied. Variations in the soil and groundwater conditions observed at the test locations may exist, and may not become evident until construction. ESNW should reevaluate the conclusions in this geotechnical engineering study if variations are encountered.

Additional Services

ESNW should have an opportunity to review the final design with respect to the geotechnical recommendations provided in this report. ESNW should also be retained to provide testing and consultation services during construction.

Reference:
King County, Washington
Map 626
By The Thomas Guide
Rand McNally
32nd Edition

NORTH



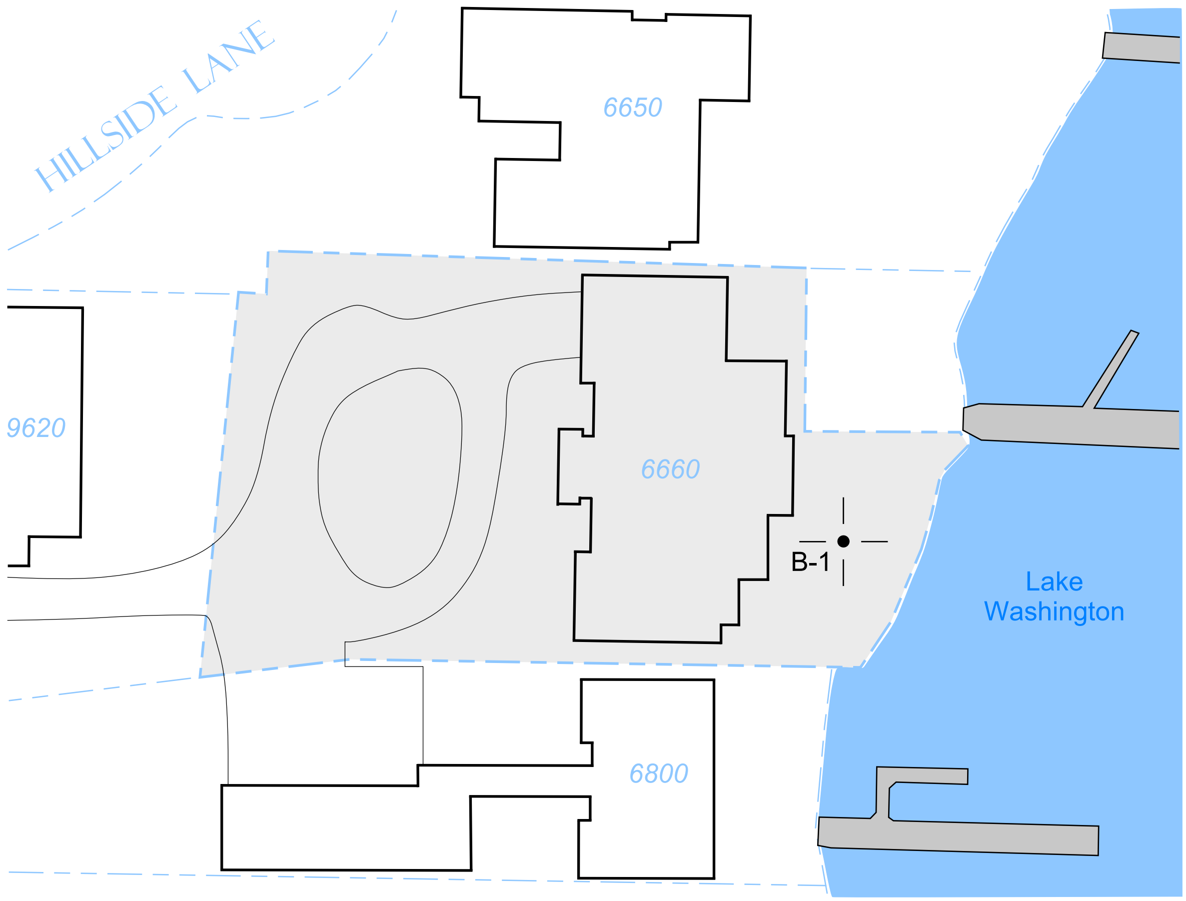
Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Vicinity Map
Yang Residence
Mercer Island, Washington

Drwn. MRS	Date 07/18/2018	Proj. No. 6162
Checked TJD	Date July 2018	Plate 1

NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.



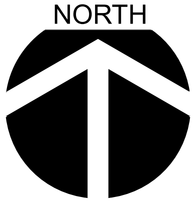
LEGEND

B-1 — Approximate Location of ESNW Boring, Proj. No. ES-6162, June 2018

Subject Site

Existing Building

6800 — Tax Parcel Number



NOT - TO - SCALE

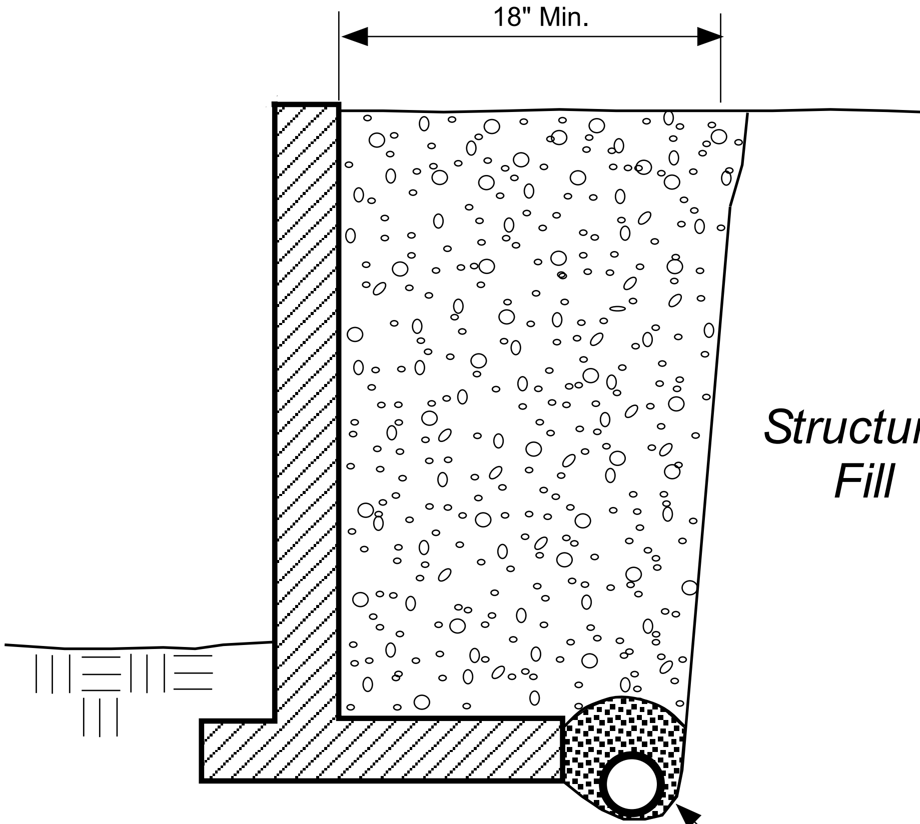
NOTE: The graphics shown on this plate are not intended for design purposes or precise scale measurements, but only to illustrate the approximate test locations relative to the approximate locations of existing and / or proposed site features. The information illustrated is largely based on data provided by the client at the time of our study. ESNW cannot be responsible for subsequent design changes or interpretation of the data by others.

NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC
Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Boring Location Plan
Yang Residence
Mercer Island, Washington

Drwn. MRS	Date 07/19/2018	Proj. No. 6162
Checked TJD	Date July 2018	Plate 2

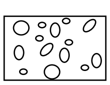


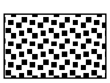
NOTES:

- Free-draining Backfill should consist of soil having less than 5 percent fines. Percent passing No. 4 sieve should be 25 to 75 percent.
- Sheet Drain may be feasible in lieu of Free-draining Backfill, per ESNW recommendations.
- Drain Pipe should consist of perforated, rigid PVC Pipe surrounded with 1-inch Drain Rock.

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:

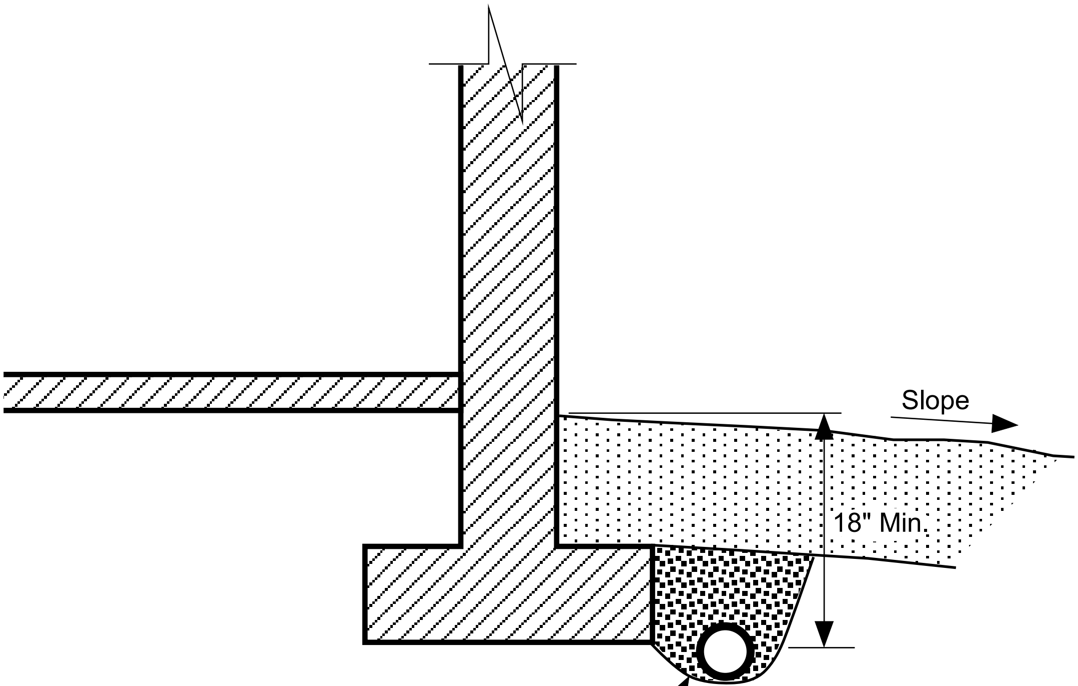

Free-draining Structural Backfill


1-inch Drain Rock

Earth Solutions NW LLC
Geotechnical Engineering Construction Observation/Testing and Environmental Services

Retaining Wall Drainage Detail
Yang Residence
Mercer Island, Washington

Drwn. MRS	Date 07/19/2018	Proj. No. 6162
Checked TJD	Date July 2018	Plate 3

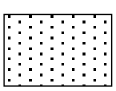


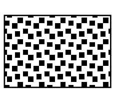
NOTES:

- Do NOT tie roof downspouts to Footing Drain.
- Surface Seal to consist of 12" of less permeable, suitable soil. Slope away from building.

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:


Surface Seal: native soil or other low-permeability material.


1-inch Drain Rock

Earth Solutions NW LLC
Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Footing Drain Detail
Yang Residence
Mercer Island, Washington

Drwn. MRS	Date 07/19/2018	Proj. No. 6162
Checked TJD	Date July 2018	Plate 4

Appendix A

Subsurface Exploration
Boring Log

ES-6162

The subsurface conditions at the site were explored by excavating a boring in accessible portions of the property. The subsurface exploration was completed in June of 2018. The approximate boring location is illustrated on Plate 2 of this report. Logs of the boring is provided in this Appendix. The boring was excavated to a maximum depth of 31.5 feet below existing grades.

Earth Solutions NW LLC

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

DUAL SYMBOLS are used to indicate borderline soil classifications.

The discussion in the text of this report is necessary for a proper understanding of the nature of the material presented in the attached logs.

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BORING NUMBER B-1

PROJECT NUMBER ES-6162 **PROJECT NAME** Yang Residence

DATE STARTED 6/27/18 **COMPLETED** 6/27/18 **GROUND ELEVATION** **HOLE SIZE**

DRILLING CONTRACTOR Geologic Drill Partners **GROUND WATER LEVELS:**

DRILLING METHOD HSA ∇ **AT TIME OF DRILLING** 2.0 ft

LOGGED BY TJD **CHECKED BY** SHA **AT END OF DRILLING** ---

NOTES Surface Conditions: gravel **AFTER DRILLING** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					GM		Brownish-gray silty GRAVEL with sand, very loose, saturated
							∇ -groundwater table
	SS	0	0-2-2 (4)				-no recovery
5	SS	100	2-2-1 (3)	MC = 50.40% Fines = 44.80%			[USDA Classification: gravelly LOAM]
	SS	100	2-2-1 (3)	MC = 31.20%			-becomes gray, increased sand content -wood debris
10						10.5	
	SS	67	2-1-1 (2)	MC = 42.30% Fines = 94.70%	ML		Bluish-gray SILT with sand, very loose, saturated [USDA Classification: slightly gravelly LOAM]
15						15.0	
	SS	100	2-2-1 (3)	MC = 12.40%	SP		Gray poorly graded SAND with gravel, very loose, saturated
						17.0	
					SP-SM		Gray poorly graded SAND with silt, loose to medium dense, saturated
20							

(Continued Next Page)

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BORING NUMBER B-1

PROJECT NUMBER ES-6162 **PROJECT NAME** Yang Residence

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	100	4-3-7 (10)	MC = 22.70% MC = 25.40%	SP-SM		Gray poorly graded SAND with silt, loose to medium dense, saturated *(continued)* -becomes medium dense
25	SS	67	9-9-7 (16)	MC = 24.20% MC = 11.20%			-poorly graded sand lens
30	SS	100	5-14-12 (26)	MC = 20.70% MC = 18.20%		31.5	
							Boring terminated at 31.5 feet below existing grade. Groundwater table encountered at 2.0 feet during drilling. Boring backfilled with bentonite chips. Bottom of hole at 31.5 feet.

Appendix B

Laboratory Test Results

ES-6162

Earth Solutions NW, LLC
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Bellevue, WA 98005
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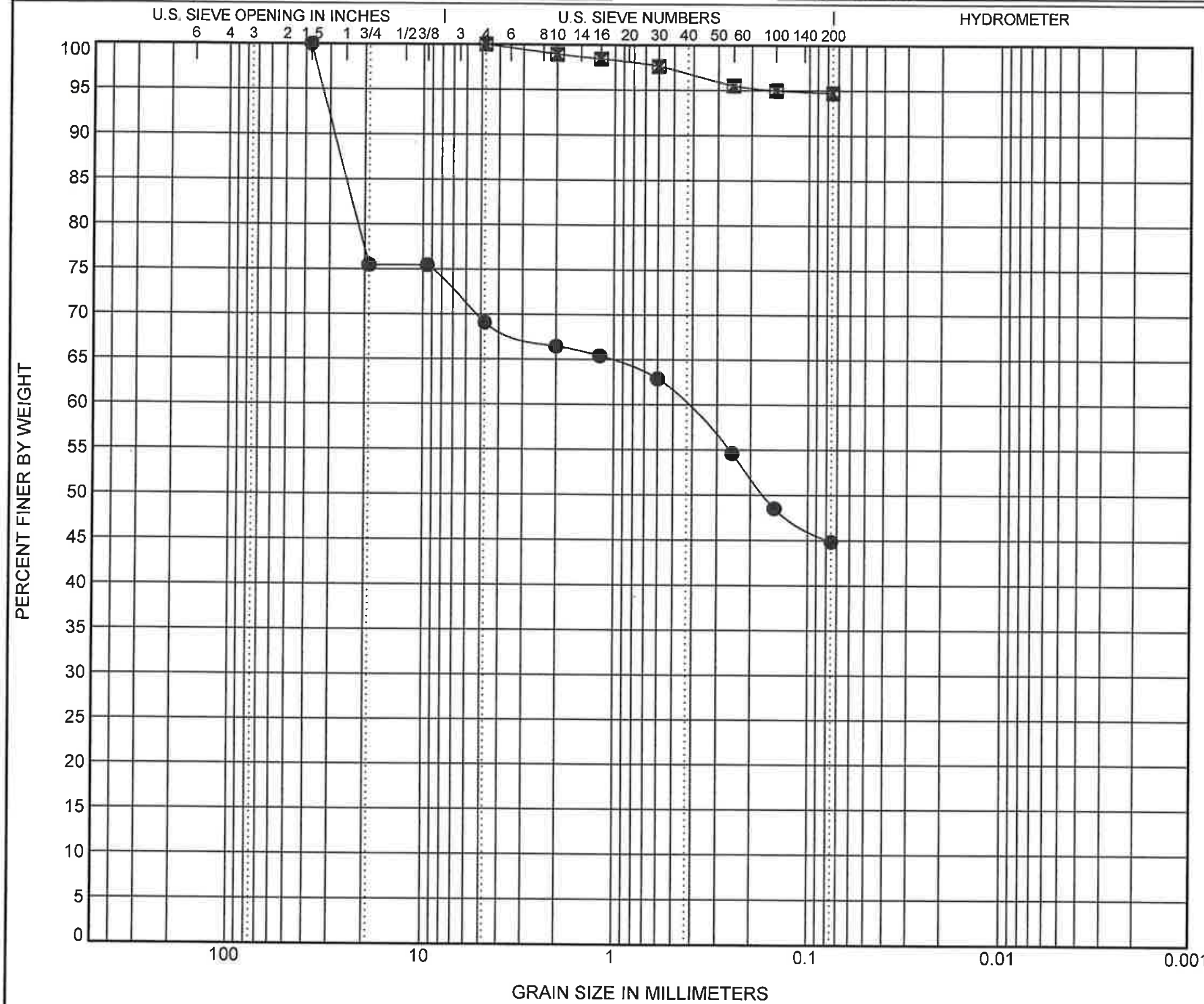
Fax: 425-449-4711

GRAIN SIZE DISTRIBUTION

PROJECT NUMBER ES-6162 **PROJECT NAME** Yang Residence



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	Cc	Cu
● B-01	5.00ft.	USDA: Gray-Brown Gravelly Loam. USCS: GM with Sand.		
⊠ B-01	11.00ft.	USDA: Gray Slightly Gravelly Loam. USCS: ML.		

Specimen Identification		D100	D60	D30	D10	LL	PL	PI	%Silt / %Clay
● B-01	5.0ft.	37.5	0.443						44.8
⊠ B-01	11.0ft.	4.75							94.7

Report Distribution

ES-6162

EMAIL ONLY

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Attention: Mr. Richard Fisher