Subsurface Exploration, Geologic Hazard,
and Geotechnical Engineering Report

PAEK RESIDENCE
Mercer Island, Washington

Prepared For:
TIMOTHY AND ELLEN PAEK

Project No. 180540E001
December 6, 2018

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December 6, 2018
Project No. 180540E001

Timothy and Ellen Paek
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Attention: Mr. Kevin Sutton, MZA Architecture

Subject: Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report
Paek Residence
Mercer Island, Washington

Dear Mr. Sutton:

We are pleased to present the enclosed copies of the above-referenced report. This report summarizes the results of our subsurface exploration, geologic hazard, and geotechnical engineering studies, and offers recommendations for the design and development of the proposed project. Our recommendations are preliminary in that construction details have not been finalized at the time of this report.

We have enjoyed working with you on this study and are confident the recommendations presented in this report will aid in the successful completion of your project. If you should have any questions, or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

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Bruce L. Blyton, P.E.
Senior Principal Engineer

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I. PROJECT AND SITE CONDITIONS

1.0 INTRODUCTION

This report presents the results of our subsurface exploration, geologic hazard, and geotechnical engineering study for the subject project. Our recommendations are preliminary in that construction details have not been finalized at the time of this report. The location of the subject site is shown on the "Vicinity Map," Figure 1. The approximate location of the /'exploration accomplished for this study is presented on the "Site and Exploration Plan," Figure 2. In the event that any changes in the nature or design of the proposed project are planned, the conclusions and recommendations contained in this report should be reviewed and modified, or verified, as necessary.

1.1 Purpose and Scope

The purpose of this study was to provide subsurface data to be used in the design and development of the subject project. Our study included reviewing available geologic literature, drilling one exploration boring, and performing geologic studies to assess the type, thickness, distribution, and physical properties of the subsurface sediments and shallow groundwater conditions. Geotechnical engineering studies were also conducted to assess the type of suitable foundation, allowable foundation soil bearing pressures, anticipated foundation settlements, basement/retaining wall lateral pressures, floor support recommendations, drainage considerations, and to provide an engineered design for the proposed tiered modular block retaining wall system. This report summarizes our current fieldwork and development recommendations based on our present understanding of the project.

1.2 Authorization

Authorization to proceed with this study was granted by Mr. Timothy Paek. Our study was accomplished in general accordance with our scope of work letter, dated October 29, 2018. This report has been prepared for the exclusive use of Timothy and Ellen Paek, and their agents, for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering and engineering geology practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

2.0 PROJECT AND SITE DESCRIPTION

The subject site is the existing single-family residential property located at 2215 80th Avenue SE in Mercer Island, Washington (King County Parcel No. 5452302145). Site topography is generally flat-lying to gently sloping up to the west of the subject site. Vegetation at the site consists chiefly of grass lawn areas, landscaping shrubbery, and small- to medium-sized trees. We understand that the current plan includes a substantial remodel of, and additions to, the existing residence. A tiered modular block retaining wall system is planned along the northern property line to create a level front yard area. The subject site lies within a Seismic Hazard Area, as delineated in the City of Mercer Island "Geological Hazard Maps." Therefore, the City of Mercer Island has required a geotechnical study for the proposed project.

3.0 SITE EXPLORATION

The site exploration was conducted on November 20, 2018, and consisted of one exploration boring and a geologic and geologic hazard reconnaissance to gain information about the site. The various types of materials and sediments encountered in the exploration, as well as the depths where characteristics of these materials changed, are indicated on the exploration boring log presented in the Appendix. The depths indicated on the log where conditions changed may represent gradational variations between sediment types in the field. If changes occurred between sample intervals in our boring, they were interpreted. The location of the exploration boring is shown on the "Site and Exploration Plan," Figure 2. The conclusions and recommendations presented in this report are based on the exploration boring completed for this study. The number, location, and depth of the exploration were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, extrapolation of subsurface conditions beyond the field exploration is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of any variations beyond the field exploration may not become fully evident until construction. If variations are observed at that time, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

3.1 Exploration Boring

The exploration boring was completed on the property using a hand-portable drill rig advancing a 3.75-inch inside-diameter, hollow-stem auger. During the drilling process, samples were obtained at generally 2.5-foot intervals. The boring was continuously observed and logged by a geologist from our firm. The exploration log presented in the Appendix is based on the field log, drilling action, and observation of the samples secured.

Disturbed but representative samples were obtained by using the Standard Penetration Test (SPT) procedure in accordance with *American Society for Testing and Materials* (ASTM) D-1586. This test and sampling method consists of driving a standard, 2-inch outside-diameter, split-barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free-falling a distance of 30 inches. The number of blows for each 6-inch interval is recorded, and the number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance ("N") or blow count. If a total of 50 blows are recorded at or before the end of one 6-inch interval, the blow count is recorded as the number of blows for the corresponding number of inches of penetration. The resistance, or N-value, provides a measure of the relative density of granular soils or the relative consistency of cohesive soils. These values are plotted on the attached boring log.

The samples obtained from the split-barrel sampler were classified in the field and representative portions placed in watertight containers. The samples were then transported to our laboratory for further visual classification and geotechnical laboratory testing, as necessary.

The various types of soil and groundwater elevations, as well as the depths where soil and groundwater characteristics changed, are indicated on the exploration boring log presented in the Appendix of this report. Our exploration and reconnaissance were approximately located by measuring from known site features.

4.0 SUBSURFACE CONDITIONS

Subsurface conditions at the project site were inferred from the field exploration accomplished for this study, visual reconnaissance of the site, and review of applicable geologic literature. As shown on the field log, the exploration boring generally encountered fill overlying Vashon recessional lake deposits and pre-Olympia-age deposits. The following section presents more detailed subsurface information organized from the youngest to the oldest sediment types.

4.1 Stratigraphy

Grass/Fill

Exploration boring EB-1 encountered grass sod at the surface overlying a fill layer that extended to roughly 2.5 feet below the ground surface. The fill encountered generally consisted of stiff to very stiff silt with sand, organics and a trace amount of fine gravel. Fill is also expected in unexplored areas of the site, such as the area surrounding and under the existing structure foundations, in existing utility trenches, and at previously graded landscaped areas. Due to their variable density and content, the existing fill soils are not suitable for foundation support.

Vashon Recessional Lacustrine Deposits

Sediments interpreted to be representative of Vashon recessional lacustrine deposits were encountered below the fill to a depth of approximately 4.5 feet. The recessional deposits were generally loose to medium dense, moist, fine sand with varying amounts of silt, including thin silt beds, and trace gravel. The Vashon recessional lacustrine deposits were deposited during the receding glacial ice during the Vashon Stade of the Fraser Glaciation which formed temporary lakes that occupied the Lake Washington and Puget Sound basins. Sands and silts were deposited along the glacial lake shore and within the glacial lake. The recessional lake deposit soils are typically suitable for light to moderate foundation loads, when properly compacted and prepared as discussed in this report.

Pre-Olympia Fine-Grained Deposits

Below the Vashon recessional lacustrine deposits, exploration boring EB-1 encountered hard sandy silt, with trace amounts of gravel and occasional dropstones, which extended below the maximum depth explored of 11.5 feet below the ground surface. This deposit was interpreted to represent fine-grained sediments placed prior to the Olympia interglaciation and subsequently compacted by the weight of the overlying glacial ice. This hard material is generally considered suitable for support of light to heavily loaded foundations when in an intact, undisturbed condition.

4.2 Geologic Mapping

Review of the regional geologic map titled *Geologic Map of Mercer Island, Washington* (2006) by Kathy G. Troost and Aaron P. Wisher, indicates that the site is expected to be underlain at shallow depths by Vashon recessional lacustrine deposits (Qvrl) and fine-grained pre-Olympia-age deposits (Qpof). Our interpretation of the sediments encountered at the subject site is in general agreement with the regional geologic map.

4.3 Hydrology

Groundwater was not encountered within exploration boring EB-1. We expect shallow groundwater seepage across much of the site to be limited to interflow. Interflow occurs when surface water percolates down through the surficial weathered or higher permeability sediments and becomes perched atop underlying, lower permeability sediments. It should be noted that the occurrence and level of groundwater seepage at the site may vary in response to such factors as changes in season, amount of precipitation, and site use.

II. GEOLOGIC HAZARDS AND MITIGATIONS

The following discussion of potential geologic hazards is based on the geologic, slope, and shallow groundwater conditions, as observed and discussed herein.

5.0 SLOPE STABILITY ASSESSMENT

It is our opinion that the risk of damage to the proposed structure by landsliding is low due to gentle slope inclinations and the presence of hard soils observed at relatively shallow depths beneath the surface of the site. No detailed slope stability analyses were completed as part of this study, and none are warranted, in our opinion. Based on our review of the *Mercer Island Landslide Hazard Assessment Map*, it does not appear that the site contains areas that are considered to be governed by regulations associated with Landslide Hazard Areas.

6.0 SEISMIC HAZARDS AND MITIGATION

Earthquakes occur in the Puget Lowland with great regularity. The vast majority of these events are small, and are usually not felt by people. However, large earthquakes do occur, as evidenced by the 1949, 7.2-magnitude event; the 1965, 6.5-magnitude event; and the 2001, 6.8-magnitude event. The 1949 earthquake appears to have been the largest in this region during recorded history and was centered in the Olympia area. Evaluation of earthquake return rates indicates that an earthquake of the magnitude between 5.5 and 6.0 is likely within a given 20- to 40-year period.

Generally, there are four types of potential geologic hazards associated with large seismic events: 1) surficial ground rupture, 2) seismically induced landslides, 3) liquefaction, and 4) ground motion. The potential for each of these hazards to adversely impact the proposed project is discussed below.

6.1 Surficial Ground Rupture

The subject site is located within the mapped limits of the Seattle Fault Zone. Recent studies by the U.S. Geological Survey (USGS) (e.g., Johnson et al., 1994, *Origin and Evolution of the Seattle Fault and Seattle Basin, Washington*, Geology, v. 22, p.71-74; and Johnson et al., 1999, *Active Tectonics of the Seattle Fault and Central Puget Sound Washington - Implications for Earthquake Hazards,* Geological Society of America Bulletin, July 1999, v. 111, n. 7, p. 1042–1053) have provided evidence of surficial ground rupture along a northern splay of the Seattle Fault. The recognition of this fault is relatively new, and data pertaining to it are limited, with the studies still ongoing. According to the USGS studies, the latest movement of this fault was about 1,100 years ago when about 20 feet of surficial displacement took place. This displacement can presently be seen in the form of raised, wave-cut beach terraces along Alki Point in West Seattle and Restoration Point at the south end of Bainbridge Island. The recurrence interval of movement along this fault system is still unknown, although it is hypothesized to be in excess of several thousand years. Due to the suspected long recurrence interval, the potential for surficial ground rupture is considered to be low during the expected life of the structure, and no mitigation efforts beyond complying with the current (2015) *International Building Code* (IBC) are recommended.

6.2 Seismically Induced Landslides

Based on the gently sloping site topography and the medium dense soils encountered in our explorations at relatively shallow depths, it is our opinion that the risk of damage to the proposed project by landsliding under either static or seismic conditions is low.

6.3 Liquefaction

Liquefaction is a condition where loose, saturated, typically sandy soils lose shear strength when subjected to high-intensity cyclic loads, such as those which occur during earthquakes. The resulting reduction in strength can cause differential foundation settlements and slope failures. Loose, saturated, fine-grained sands that cannot dissipate the buildup of pore water pressure are the predominant type of sediments subject to liquefaction. It is our opinion that the encountered stratigraphy has a low potential for liquefaction due to its density, fine-grained texture and lack of significant groundwater.

6.4 Ground Motion

Structural design should follow 2015 IBC standards using Site Class "C" as defined in Table 20.3-1 of *American Society of Civil Engineers* (ASCE) *7 – Minimum Design Loads for Buildings and Other Structures*.

7.0 EROSION HAZARDS AND MITIGATION

A properly developed, constructed, and maintained erosion control plan consistent with local standards and best management erosion control practices will be required for this project. It will be necessary to make adjustments and provide additional measures to the Temporary Erosion and Sedimentation Control (TESC) plan in order to improve its effectiveness. Ultimately, the success of the TESC plan depends on a proactive approach to project planning and contractor implementation and maintenance.

The erosion hazard of the site soils is low to moderate, depending primarily on slope and runoff velocity. Maintaining cover measures atop disturbed ground provides significant reduction to the potential generation of turbid runoff and sediment transport. During the local wet season (typically October through April), exposed soil should not remain uncovered for more than 2 days, unless it is actively being worked. Ground-cover measures can include erosion control matting, plastic sheeting, straw mulch, crushed rock or recycled concrete, or mature hydroseed.

7.1 Erosion Hazard Mitigation

To mitigate the erosion hazards and potential for off-site sediment transport, we recommend the following:

1. All TESC measures for the work area should be installed prior to any activity.

2. Construction access points should be surfaced to mitigate sediment track out onto adjacent streets. If practical, existing paved surfaces may be used. Any sediment that is tracked onto adjacent streets should be promptly swept up.

3. During the wetter months of the year (typically October through April), or when large storm events are predicted during the summer months, the work area should be stabilized so that if showers occur, the work area can receive the rainfall without excessive erosion or sediment transport.

4. All disturbed areas should be revegetated as soon as possible. If it is outside of the growing season, the disturbed areas should be covered with mulch.

5. Under no circumstances should concentrated discharges be allowed to flow over the top of steep slopes.

6. Soils that are to be reused around the site should be stored in such a manner as to reduce erosion from the stockpile. Protective measures may include, but are not limited to, covering with plastic sheeting, the use of low stockpiles in flat areas, or the use of straw bales/silt fences around pile perimeters.

8.0 STATEMENT OF RISK

For Section 19.07.060(D) of the Mercer Island Unified Land Development Code (ULDC), the City of Mercer Island requires a statement of risk by the geotechnical engineer. It is the opinion of Associated Earth Sciences, Inc. (AESI) that the development practices proposed for the alteration would render the proposed addition as safe as if it were not located in a geologic hazard area provided the recommendations in this report are followed.

III. DESIGN RECOMMENDATIONS

9.0 INTRODUCTION

It is our opinion that, from a geotechnical standpoint, the property is suitable for the proposed development provided the recommendations contained herein are properly followed. The site is underlain by medium dense/stiff to hard natural sediments. Conventional spread footing foundations bearing on either the medium dense/stiff to hard natural sediments or on structural fill placed over these sediments are capable of providing suitable building support.

10.0 SITE PREPARATION

10.1 Clearing and Stripping

Site preparation of the planned building area should include removal of all trees, brush, debris, and any other deleterious materials. These unsuitable materials should be properly disposed of off-site. Additionally, any areas of organic topsoil should be removed and the remaining roots grubbed. Areas where loose surficial soils exist due to grubbing operations should be considered as fill to the depth of disturbance and treated as subsequently recommended for structural fill placement. Any buried utilities should be removed or relocated if they are under building areas. The resulting depressions should be backfilled with structural fill, as discussed under the "Structural Fill" section of this report.

10.2 Temporary and Permanent Cut Slopes

In our opinion, stable, temporary construction slopes should be the responsibility of the contractor and should be determined during construction. For estimating purposes, we anticipate that temporary, unsupported cut slopes, or utility trenches greater than 4 feet in height or depth, completed within the unsaturated, existing medium dense recessional lacustrine soils can be planned at a maximum slope of 1.5H:1V (Horizontal:Vertical). Temporary, unsupported cut slopes in undisturbed hard, pre-Olympia-age sediments can be planned at a maximum slope of 1H:1V. As is typical with earthwork operations, some sloughing and raveling may occur, and cut slopes may have to be adjusted in the field. In addition, WISHA/OSHA regulations should be followed at all times. In the presence of groundwater seepage, flatter slopes or shoring may be required. Permanent cut and structural fill slopes should not exceed an inclination of 2H:1V. Permanent non-structural landscape fill should not exceed a 3H:1V inclination.

10.3 Site Disturbance

The existing fill and natural sediments contain a high percentage of fine-grained material that makes them moisture-sensitive and subject to disturbance when wet. The contractor must use care during site preparation and excavation operations so that the underlying soils are not softened. If disturbance occurs, the softened soils should be removed and the area brought to grade with structural fill.

Consideration should be given to protecting access and staging areas with an appropriate section of crushed rock or asphalt treated base (ATB). If crushed rock is considered for the access and staging areas, it should be underlain by engineering stabilization fabric to reduce the potential of fine-grained materials pumping up through the rock during wet weather and turning the area to mud. The fabric will also aid in supporting construction equipment, thus reducing the amount of crushed rock required. We recommend that at least 10 inches of rock be placed over the fabric.

11.0 STRUCTURAL FILL

Structural fill may be necessary to establish desired grades or to backfill around foundations and utilities. All references to structural fill in this report refer to subgrade preparation, fill type, placement, and compaction of materials, as discussed in this section. If a percentage of compaction is specified under another section of this report, the value given in that section should be used.

After overexcavation/stripping has been performed to the satisfaction of the geotechnical engineer/engineering geologist, the upper 12 inches of exposed ground should be recompacted to a firm and unyielding condition. If the subgrade contains too much moisture, adequate recompaction may be difficult or impossible to obtain and should probably not be attempted. In lieu of recompaction, the area to receive fill should be blanketed with washed rock or quarry spalls to act as a capillary break between the new fill and the wet subgrade. Where the exposed ground remains soft and further overexcavation is impractical, placement of an engineering stabilization fabric may be necessary to prevent contamination of the free-draining layer by silt migration from below.

After stripping and subgrade preparation of the exposed ground is approved, or a free-draining rock course is laid, structural fill may be placed to attain desired grades. Structural fill is defined as non-organic soil, acceptable to the geotechnical engineer, placed in maximum 8-inch loose lifts, with each lift being compacted to 95 percent of the modified Proctor maximum density using ASTM D-1557 as the standard.

The contractor should note that any proposed fill soils must be evaluated by AESI prior to their use in fills. This would require that we have a sample of the material at least 3 business days in advance to perform a Proctor test and determine its field compaction standard. Soils in which the amount of fine-grained material (smaller than the No. 200 sieve) is greater than approximately 5 percent (measured on the minus No. 4 sieve size) should be considered moisture-sensitive. Use of moisture-sensitive soils in structural fills should be limited to favorable dry weather conditions. The on-site soils are predominantly fine-grained and are considered moisture-sensitive, and we expect that this material may be difficult to compact to structural fill specifications, particularly during and following wet weather. Therefore, we recommend that a select, import material consisting of a clean, free-draining gravel and/or sand be used. Free-draining fill consists of non-organic soil with the amount of fine-grained material limited to 5 percent by weight when measured on the minus No. 4 sieve fraction.

A representative from our firm should observe the stripped subgrade and be present during placement of structural fill to observe the work and perform a representative number of in-place density tests. In this way, the adequacy of the earthwork may be evaluated as filling progresses and any problem areas may be corrected at that time. It is important to understand that taking random compaction tests on a part-time basis will not assure uniformity or acceptable performance of a fill. As such, we are available to aid the owner in developing a suitable monitoring and testing frequency.

12.0 FOUNDATIONS

12.1 Allowable Soil Bearing Pressure

Spread footings may be used for building support when founded either directly on the medium dense/stiff to hard, natural glacial sediments, or on structural fill placed over these materials. Sediments suitable for foundation support in the area of the proposed project were encountered in our exploration at a depth of approximately 2.5 feet, but may be locally deeper, particularly adjacent to existing structures and site improvements. For footings founded either directly upon the medium dense/stiff to hard glacial sediments, or on structural fill as described above, we recommend that an allowable bearing pressure of 2,500 pounds per square foot (psf) be used for design purposes, including both dead and live loads. We recommend that the footing subgrade be recompacted to a firm and unyielding condition prior to footing placement. An increase in the allowable bearing pressure of one-third may be used for short-term wind or seismic loading. If structural fill is placed below footing areas, the structural fill should extend horizontally beyond the footing edges a distance equal to or greater than the thickness of the fill.

12.2 Footing Depths

Perimeter footings for the residence should be buried a minimum of 18 inches into the surrounding soil for frost protection. No minimum burial depth is required for interior footings; however, all footings must penetrate to the prescribed stratum, and no footings should be founded in or above loose, organic, or existing fill soils.

12.3 Footings Adjacent to Cuts

The area bounded by lines extending downward at 1H:1V from any footing must not intersect another footing or intersect a filled area that has not been compacted to at least 95 percent of ASTM D-1557. In addition, a 1.5H:1V line extending down from any footing must not daylight because sloughing or raveling may eventually undermine the footing. Thus, footings should not be placed near the edges of steps or cuts in the bearing soils.

12.4 Footing Settlement

Anticipated settlement of footings founded as described above should be on the order of 1 inch or less. However, disturbed soil not removed from footing excavations prior to footing placement could result in increased settlements.

12.5 Footing Subgrade Bearing Verification

All footing areas should be observed by AESI prior to placing concrete to verify that the exposed soils can support the design foundation bearing capacity and that construction conforms with the recommendations in this report. Foundation bearing verification may also be required by the governing municipality.

12.6 Foundation Drainage

Perimeter footing drains should be provided as discussed under the “Drainage Considerations” section of this report.

13.0 LATERAL WALL PRESSURES

All backfill behind retaining walls or around foundation units should be placed as per our recommendations for structural fill and as described in this section of the report. Horizontally backfilled retaining walls that are free to yield laterally at least 0.1 percent of their height may be designed using an equivalent fluid equal to 35 pounds per cubic foot (pcf). Fully restrained, horizontally backfilled, rigid walls that cannot yield should be designed for an equivalent fluid of 50 pcf. If roadways, parking areas, or other areas subject to vehicular traffic are adjacent to retaining walls, a surcharge equivalent to 2 feet of soil should be added to the wall height in determining lateral design forces. Retaining walls that retain sloping backfill at a maximum angle of 2H:1V should be designed using an equivalent fluid pressure of 55 pcf for yielding conditions or 75 pcf for fully restrained conditions.

In accordance with the 2015 IBC, retaining wall design should include seismic design parameters. Based on the site soils and assumed wall backfill materials, we recommend a seismic surcharge pressure in addition to the equivalent fluid pressures presented above. A rectangular pressure distribution of 5H and 10H psf (where H is the height of the wall in feet) should be included in design for "active" and "at-rest" loading conditions, respectively. The resultant of the rectangular seismic surcharge should be applied at the midpoint of the walls.

The lateral pressures presented above are based on the conditions of a uniform horizontal backfill consisting of the on-site, natural, glacial sediments or imported sand and gravel compacted to 90 percent of ASTM D-1557. A higher degree of compaction is not recommended, as this will increase the pressure acting on the wall.

Footing drains must be provided for all retaining walls, as discussed under the "Drainage Considerations" section of this report. It is imperative that proper drainage be provided so that hydrostatic pressures do not develop against the walls. This would involve installation of a minimum, 1-foot-wide blanket drain to within 1 foot of the ground surface using imported, washed gravel against the walls placed to be continuous with the footing drain.

13.1 Passive Resistance and Friction Factors

Lateral loads can be resisted by friction between the foundation and the competent natural sediments or supporting structural fill soils, and/or by passive earth pressure acting on the buried portions of the foundations. The foundations must be backfilled with compacted structural fill to achieve the passive resistance provided below. We recommend the following allowable design parameters.

- Passive equivalent fluid = 300 pcf
- Coefficient of friction = 0.35

13.2 Segmental Block Walls

Figure 3 includes a design and detail addressing the tiered walls planned for the north side of the subject site. The walls were designed using the MSEW Software (version 3.0) developed by ADAMA Engineering, Inc. and licensed to AESI. The design values are based on the following parameters:

1. Keystone Standard blocks are assumed in the design. Use of other blocks may affect the stability and must be approved by AESI prior to construction.

2. Design is based on backfill in the retained zone consisting of compacted structural fill that is primarily granular (i.e., sandy) with a nominal unit density of 125 pcf and a soil friction angle (N) of at least 34 degrees. The fine-grained site soils encountered in our exploration may not meet these criteria, potentially necessitating the import of a clean, free-draining gravel and/or sand to be placed as properly compacted structural fill. In-place density testing should confirm the minimum moist density during construction. Minimum compaction within the foundation and backfill zone is 95 percent of the modified Proctor maximum dry density, as determined by ASTM D-1557.

3. A 6-inch-thick (minimum), compacted crushed rock leveling pad is assumed below the blocks.

4. A minimum 1-foot-wide blanket of clean crushed rock or approved equal drainage fill is assumed at the back face of the wall, as well as filling the facing unit voids. A 4-inch-diameter, perforated drainpipe should be placed at the base of the drainage fill and routed by gravity to a suitable discharge.

5. A 4-inch-high cap block is optional at the top of the wall. The cap or top block should be bonded to the underlying facing units to prevent vandalism.

6. Minimum toe embedment is measured at the wall face.

AESI should observe foundation conditions, drainage installation, and fill compaction to confirm that construction of the wall is in general accordance with the recommendations presented herein and in Figure 3.

14.0 FLOOR SUPPORT

Slab-on-grade floors may be constructed either directly on the medium dense/stiff to hard natural sediments, or on structural fill placed over these materials. Areas of the slab subgrade that are disturbed (loosened) during construction should be recompacted to an unyielding condition prior to placing the pea gravel, as described below.

If moisture intrusion through slab-on-grade floors is to be limited, the floors should be constructed atop a capillary break consisting of a minimum thickness of 4 inches of washed pea gravel or washed crushed rock. The pea gravel/crushed rock should be overlain by a 10-mil (minimum thickness) plastic vapor retarder.

15.0 DRAINAGE CONSIDERATIONS

All retaining and perimeter foundation walls should be provided with a drain at the base of the footing elevation. Drains should consist of rigid, perforated, polyvinyl chloride (PVC) pipe surrounded by washed pea gravel. The level of the perforations in the pipe should be set at or slightly below the bottom of the footing grade beam, and the drains should be constructed with sufficient gradient to allow gravity discharge away from the building. In addition, all retaining walls should be lined with a minimum, 12-inch-thick, washed gravel blanket that extends to within 1 foot of the surface and is continuous with the foundation drain. Roof and surface runoff should not discharge into the foundation drain system, but should be handled by a separate, rigid, tightline drain. In planning, exterior grades adjacent to walls should be sloped downward away from the structure to achieve surface drainage. All collected runoff must be tightlined to a City-approved location.

16.0 PROJECT DESIGN AND CONSTRUCTION MONITORING

Our recommendations are preliminary in that definite building locations and construction details have not been finalized at the time of this report. We are available to provide additional geotechnical consultation as the project design develops and possibly changes from that upon which this report is based. If significant changes in grading are made, we recommend that AESI perform a geotechnical review of the plans prior to final design completion. In this way, our earthwork and foundation recommendations may be properly interpreted and implemented in the design.

We are also available to provide geotechnical engineering and monitoring services during construction. The integrity of the foundations depends on proper site preparation and construction procedures. In addition, engineering decisions may have to be made in the field in the event that variations in subsurface conditions become apparent. Construction monitoring services are not part of this current scope of work. If these services are desired, please let us know, and we will prepare a proposal.

We have enjoyed working with you on this study and are confident these recommendations will aid in the successful completion of your project. If you should have any questions or require further assistance, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

12/6/18

Jeffrey P. Laub, L.G., L.E.G.
Senior Engineering Geologist

Bruce L. Blyton, P.E.
Senior Principal Engineer

Attachments:	Figure 1:	Vicinity Map
	Figure 2:	Site and Exploration Plan
	Figure 3:	Segmental Block Wall Design
	Appendix:	Exploration Log

DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
KING CO: STREETS, CITY LIMITS 1/18, PARCELS 8/18

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

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0 1000 2000

FEET

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

VICINITY MAP

PAEK RESIDENCE
MERCER ISLAND, WASHINGTON

PROJ NO.	DATE:	FIGURE:
180540E001	11/18	1

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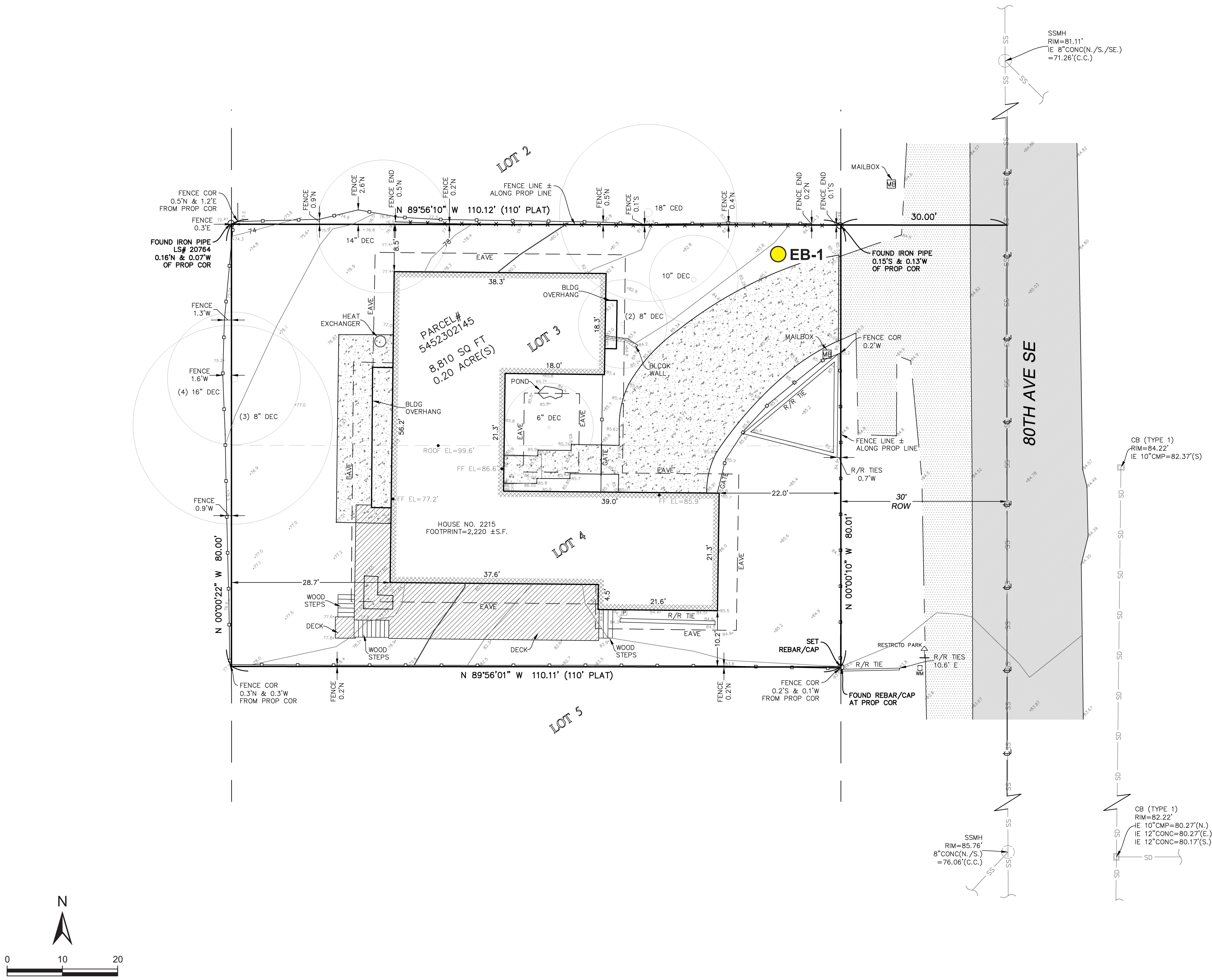

LEGEND:

EB EXPLORATION BORING

CONTOUR INTERVAL = 2'

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: TERRANE, PAEK RESIDENCE, TOPOGRAPHIC AND BOUNDARY SURVEY, 3/22/18

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION.

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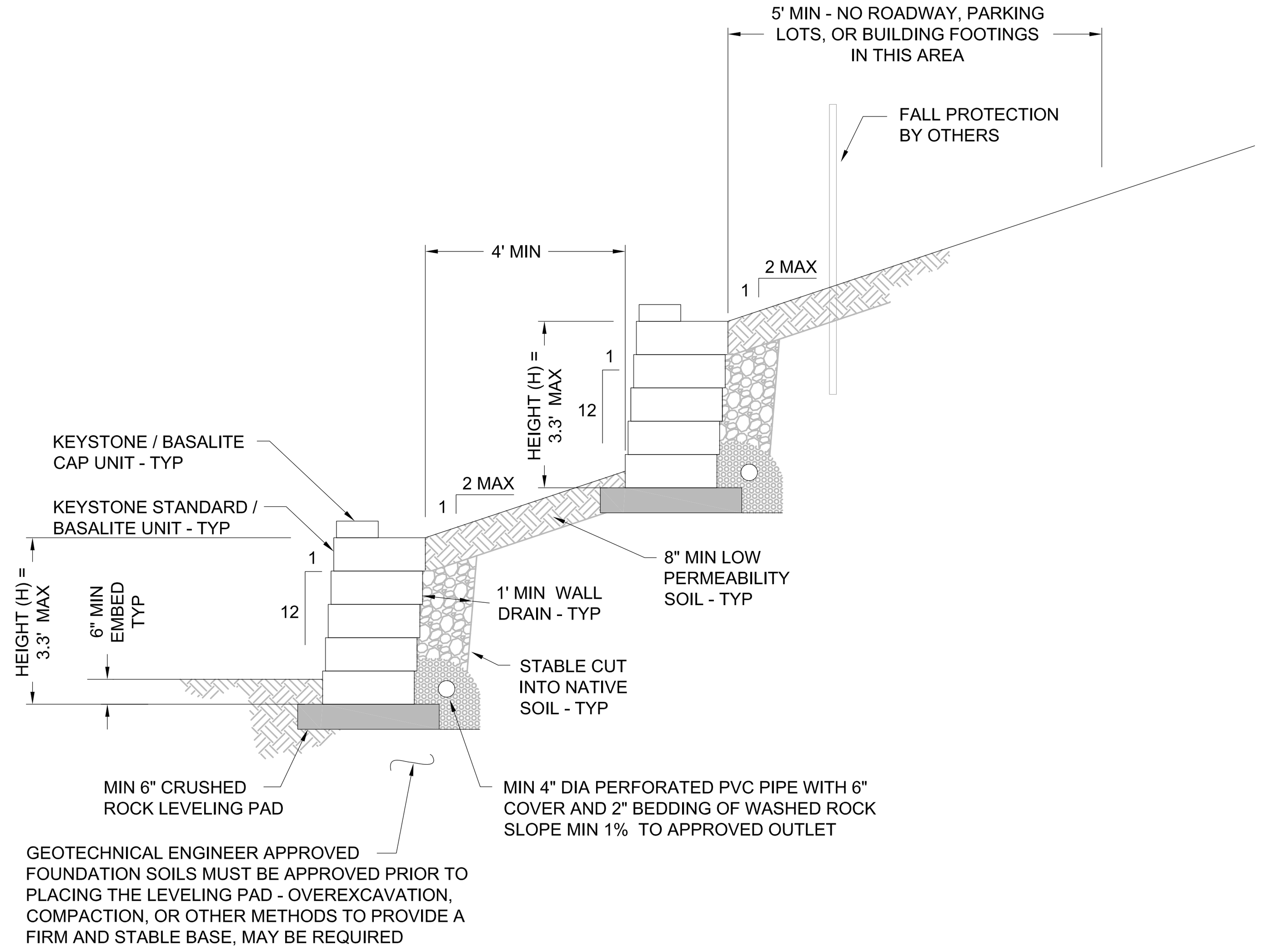
SITE AND EXPLORATION PLAN

PAEK RESIDENCE
MERCER ISLAND, WASHINGTON

PROJ NO.	DATE:	FIGURE:
180540E001	11/18	2

180540 Paek \ 180540E001 F2 S-E.cdr



TYPICAL TIERED GRAVITY WALL SECTION
KEYSTONE BLOCKS OR APPROVED EQUAL
NO SCALE

WALL NOTES - KEYSTONE BLOCKS OR APPROVED EQUAL:

1. DESIGN OF THE SEGMENTAL RETAINING WALL IS BASED ON MSEW VERSION 3.0, USING THE FOLLOWING DESIGN VALUES:
   INTERNAL ANGLE OF FRICTION FOR REINFORCED SOIL = 34 DEGREES
   UNIT WEIGHT OF SOIL = 125 LB/CU FT
   MAXIMUM WALL HEIGHT = AS SHOWN
   BATTER OF WALL = 1H:12V
   BACKFILL SLOPE = 2H:1V MAX
   EMBEDMENT - AS SHOWN

2. CONTRACTOR TO VERIFY ALL LOCATIONS, ELEVATIONS, AND DIMENSIONS.

3. FOR BIDDING PURPOSES, THE DESIGN WALL HEIGHT SHALL INCLUDE BOTH THE ABOVE GRADE DIMENSIONS SHOWN ON THE CIVIL PLANS AND THE BELOW GRADE EMBEDDED PORTION OF THE WALLS INDICATED HEREIN.

GENERAL NOTES - KEYSTONE BLOCKS OR APPROVED EQUAL:

SEGMENTAL RETAINING WALL (SRW) UNITS
1. SRW UNITS SHALL BE MACHINE-FORMED CONCRETE BLOCKS SPECIFICALLY DESIGNED FOR RETAINING WALL APPLICATIONS.

2. SRW UNITS SHALL MEET THE FOLLOWING STRUCTURAL REQUIREMENTS:
   A. CONCRETE USED TO MANUFACTURE SRW UNITS SHALL HAVE A MINIMUM 28-DAY COMPRESSIVE STRENGTH OF 3000 PSI IN ACCORDANCE WITH ASTM C90. THE CONCRETE SHALL HAVE ADEQUATE FREEZE/THAW PROTECTION WITH A MAXIMUM MOISTURE ABSORPTION RATE, BY WEIGHT OF 6%.

   B. UNITS SHALL BE POSITIVELY INTERLOCKED TO PROVIDE A MINIMUM SHEAR CAPACITY OF 1500 PLF AT 2 PSI NORMAL PRESSURE.

   C. UNITS SHALL PROVIDE A MINIMUM CONNECTION STRENGTH BETWEEN IT AND THE GEOSYNTHETIC REINFORCEMENT OF 1000 PLF AT 2 PSI NORMAL FORCE.

   D. SRW UNITS MOLDED DIMENSIONS SHALL NOT DIFFER MORE THAN ± 1/8 INCH FROM THAT SPECIFIED, EXCEPT HEIGHT WHICH SHALL BE ± 1/16 INCH.

3. SRW UNITS SHALL MEET THE FOLLOWING CONSTRUCTABILITY AND GEOMETRIC REQUIREMENTS:
   A. UNITS SHALL BE CAPABLE OF ATTAINING CONCAVE AND CONVEX CURVES.

   B. UNITS SHALL BE POSITIVELY ENGAGED TO THE UNIT BELOW SO AS TO PROVIDE A MINIMUM 1/16-INCH HORIZONTAL SETBACK PER VERTICAL FOOT OF WALL HEIGHT.

4. SRW UNIT COLOR AND FACE FINISH SHALL BE SELECTED BY PROJECT ARCHITECT OR OWNER.

LEVELING PAD AND UNIT FILL FILL MATERIAL
1. MATERIAL FOR LEVELING PAD SHALL CONSIST OF COMPACTED GRAVEL OR UNREINFORCED CONCRETE AND SHALL BE A MINIMUM OF 6 INCHES IN DEPTH.

2. FILL FOR UNITS SHALL BE THE FREE-DRAINING GRAVEL OR DRAINAGE FILL.

3. DO NOT RUN MECHANICAL VIBRATING PLATE COMPACTORS ON TOP OF THE UNITS. COMPACT UNIT FILL BY RUNNING HAND-OPERATED COMPACTION EQUIPMENT JUST BEHIND UNIT. COMPACT TO MINIMUM 95% OF MODIFIED PROCTOR (ASTM D-1557).

DRAINAGE AGGREGATE
1. DRAINAGE LAYER FOR WALL DRAINAGE MATERIALS, INCLUDING THE CHIMNEY DRAIN, SHALL BE 2-INCH WASHED CRUSH ROCK MATERIAL AND FREE OF ORGANICS, WITH LESS THAN 5% FINES (SILT AND CLAY PARTICLES PASSING THE #200 SIEVE MEASURED ON THE MINUS #4 SIEVE SIZE).

INFILL SOIL - (REINFORCED SOIL ZONE)
1. THE INFILL SOIL MATERIAL SHALL BE FREE OF DEBRIS AND CONSIST OF INORGANIC IMPORTED SOIL PLACED AND COMPACTED TO A FIRM AND UNYIELDING CONDITON IN ACCORDANCE WITH THE STRUCTURAL FILL REQUIREMENTS. THE MAXIMUM PARTICLE SIZE SHALL BE 4 INCHES. THERE SHALL BE LESS THAN 20% BY WEIGHT OF PARTICLES GREATER THAN 1-1/2 INCHES AT LEAST 25% RETAINED ON THE NO. 4 SIEVE.

2. THE INFILL SOIL SHALL BE PLACED IN MAXIMUM 8-INCH LIFTS AND COMPACTED TO AT LEAST 95% OF THE MODIFIED PROCTOR MAXIMUM DENSITY AS DEFINED BY ASTM D-1557.

COMMON BACKFILL (RETAINED SOIL)
1. SOIL PLACED BEHIND THE INFILL (REINFORCED SOIL ZONE) SHALL BE INORGANIC ON-SITE STRUCTURAL FILL WITH PLASTICITY INDEX <20, OR AS DIRECTED BY THE SOILS ENGINEER. COMMON BACKFILL SHOULD BE PLACED IN ACCORDANCE WITH THE RECOMMENDATIONS FOR STRUCTURAL FILL PRESENTED IN GEOTECHNICAL REPORT.

2. BACKFILL SHALL BE COMPACTED TO A MINIMUM 95% OF THE MODIFIED PROCTOR, MAXIMUM DENSITY AS DEFINED BY ASTM D:1557.

LEVELING PAD CONSTRUCTION
1. LEVELING PAD SHALL BE PLACED AS SHOWN ON THE CONSTRUCTION DETAILS WITH A MINIMUM THICKNESS OF 6 INCHES.

2. FOUNDATION SOIL SHALL BE COMPACTED TO AT LEAST 95% OF MODIFIED PROCTOR. OVEREXCAVATION (OR OTHER METHODS) AT THE DIRECTION OF THE GEOTECHNICAL ENGINEER MAY BE REQUIRED TO PROVIDE A SUITABLE BASE FOR LEVELING PAD CONSTRUCTION. OVEREXCAVATED AREAS SHALL BE BACKFILLED WITH AN APPROVED STRUCTURAL FILL COMPACTED TO AT LEAST 95% OF THE MODIFIED PROCTOR.

3. LEVELING PAD MATERIAL SHALL BE COMPACTED TO PROVIDE A LEVEL HARD SURFACE ON WHICH TO PLACE THE FIRST COURSE OF UNITS. COMPACTION WILL BE BY MECHANICAL PLATE COMPACTORS TO AT LEAST 95% OF MODIFIED PROCTOR DENSITY.

4. LEVELING PAD SHALL BE PREPARED TO PROVIDE INTIMATE CONTACT OF RETAINING WALL UNIT WITH PAD.

SEGMENTAL UNIT INSTALLATION
1. FIRST COURSE OF SRW UNITS SHALL BE PLACED ON THE LEVELING PAD. THE UNITS SHALL BE CHECKED FOR LEVEL AND ALIGNMENT. THE FIRST COURSE IS THE MOST IMPORTANT TO ENSURE ACCURATE AND ACCEPTABLE RESULTS.

2. ENSURE THAT UNITS ARE IN FULL CONTACT WITH BASE.

3. UNITS ARE PLACED SIDE BY SIDE FOR FULL LENGTH OF STRAIGHT WALL ALIGNMENT. ALIGNMENT MAY BE DONE BY MEANS OF A STRING LINE OR OFFSET FROM BASE LINE TO A MOLDED FINISHED FACE OF THE SRW UNIT. ADJUST UNIT SPACING FOR CURVED SECTIONS ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.

4. INSTALL SHEAR CONNECTORS.

5. PLACE UNIT FILL. TAMP OR ROD UNIT FILLS TO ENSURE ALL VOIDS ARE COMPLETELY FILLED.

6. PLACE AND COMPACT FILL BEHIND AND WITHIN UNITS.

7. CLEAN ALL EXCESS DEBRIS FROM TOP OF UNITS AND INSTALL NEXT COURSE. ENSURE EACH COURSE IS COMPLETELY FILLED PRIOR TO PROCEEDING TO NEXT COURSE.

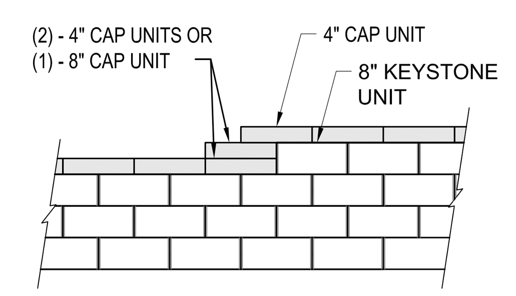
8. LAY EACH SUCCESSIVE COURSE ENSURING THAT SHEAR CONNECTORS ARE ENGAGED.

9. MAXIMUM STACKED VERTICAL HEIGHT OF WALL UNITS, PRIOR TO UNIT FILL AND BACKFILL PLACEMENT AND COMPACTION, SHALL NOT EXCEED TWO COURSES.

10. REPEAT PROCEDURES TO THE EXTENT OF THE WALL HEIGHT.

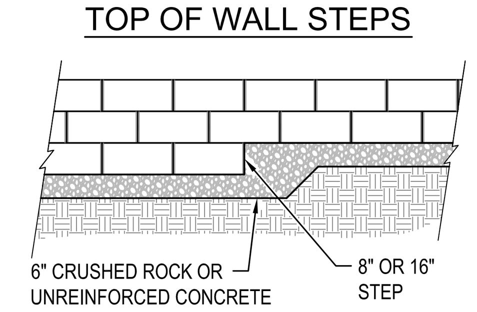
11. UPPERMOST ROW OF SRW OR CAPS SHALL BE GLUED TO UNDERLYING UNITS WITH AN ADHESIVE, AS RECOMMENDED BY THE MANUFACTURER.

CONSTRUCTION MONITORING
1. FULL-TIME OBSERVATION OF THE WALL CONSTRUCTION, INCLUDING FOUNDATION SOIL, LEVELING PAD CONSTRUCTION, DRAINAGE, AND BACKFILL, BY THE GEOTECHNICAL ENGINEER IS REQUIRED.



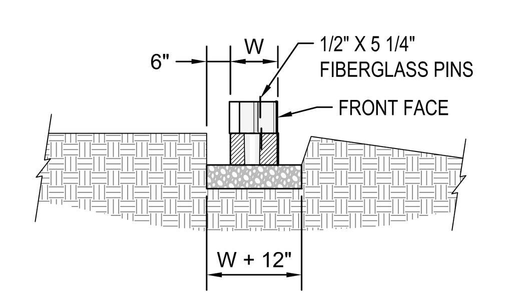
NOTE:
1. SECURE ALL CAP UNITS WITH KEYSTONE KAPSEAL OR EQUAL.

TOP OF WALL STEPS



ELEVATION

NOTE:
1. THE LEVELING PAD IS TO BE CONSTRUCTED OF CRUSHED STONE OR 2000 PSI ± REINFORCED CONCRETE.



SECTION

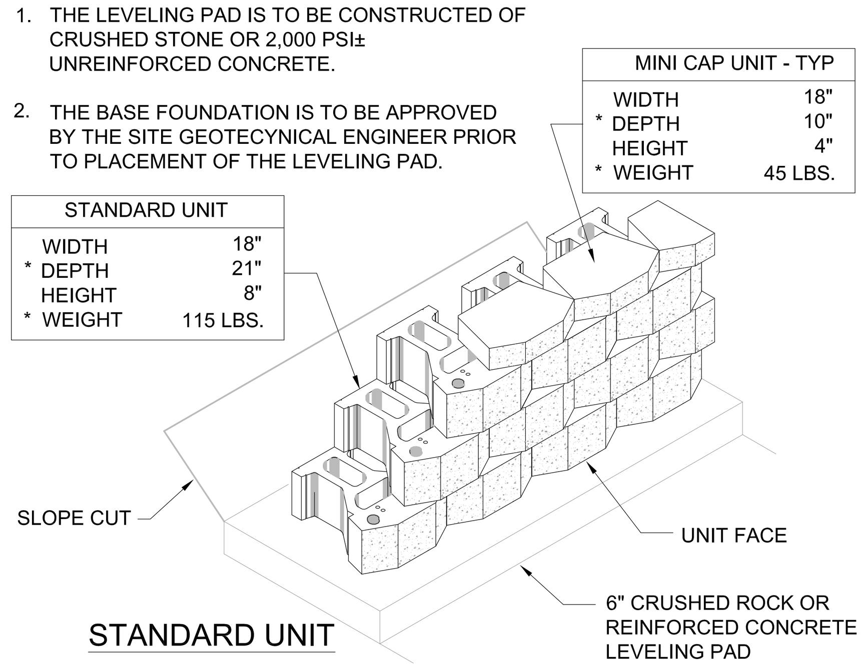
LEVELING PAD DETAIL
KEYSTONE BLOCKS OR APPROVED EQUAL

BASE LEVELING PAD NOTES:
KEYSTONE BLOCKS OR APPROVED EQUAL

1. THE LEVELING PAD IS TO BE CONSTRUCTED OF CRUSHED STONE OR 2,000 PSI± UNREINFORCED CONCRETE.
2. THE BASE FOUNDATION IS TO BE APPROVED BY THE SITE GEOTECYNICAL ENGINEER PRIOR TO PLACEMENT OF THE LEVELING PAD.

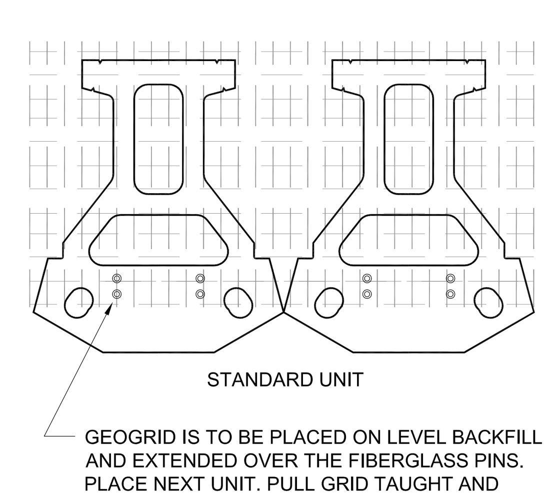
MINI CAP UNIT - TYP	
WIDTH	18"
* DEPTH	10"
HEIGHT	4"
* WEIGHT	45 LBS.

STANDARD UNIT	
WIDTH	18"
* DEPTH	21"
HEIGHT	8"
* WEIGHT	115 LBS.



STANDARD UNIT

BASE PAD ISOMETRIC VIEWS
NO SCALE



GRID AND PIN CONNECTION
KEYSTONE BLOCKS OR APPROVED EQUAL
NO SCALE

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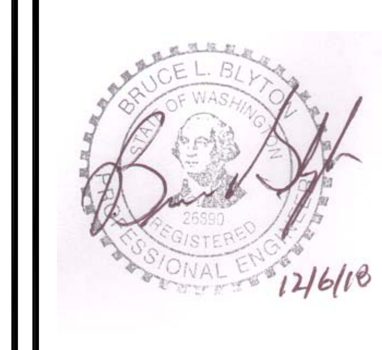


SEGMENTAL BLOCK WALL DESIGN
PAEK RESIDENCE
MERCER ISLAND, WASHINGTON

DRAWN BY:	EIN
CHECKED BY:	JPL
DATE	12/18
PROJECT NO.	180540E001
FIGURE	3

180540 Paek \ 180540 Walls.dwg LAYOUT: E001 F3 Tiered

APPENDIX

Coarse-Grained Soils - More than 50% [1] Retained on No. 200 Sieve	Gravels - More than 50% [1] of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines [5]	**GW**	Well-graded gravel and gravel with sand, little to no fines
			GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥12% Fines [5]	**GM**	Silty gravel and silty gravel with sand
			GC	Clayey gravel and clayey gravel with sand
	Sands - 50% [1] or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines [5]	**SW**	Well-graded sand and sand with gravel, little to no fines
			SP	Poorly-graded sand and sand with gravel, little to no fines
		≥12% Fines [5]	**SM**	Silty sand and silty sand with gravel
			SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50% [1] or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		**ML**	Silt, sandy silt, gravelly silt, silt with sand or gravel
			CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		**MH**	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			**PT**	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT [2] blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50

	Consistency	SPT [2] blows/foot
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

[3] Estimated Percentage

Component	Percentage by Weight
Trace	<5
Some	5 to <12
Modifier (silty, sandy, gravelly)	12 to <30
Very *modifier* (silty, sandy, gravelly)	30 to <50

Moisture Content

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

Slightly Moist - Perceptible moisture

Moist - Damp but no visible water

Very Moist - Water visible but not free draining

Wet - Visible free water, usually from below water table

Symbols

Sampler Type

Blows/6" or portion of 6"

2.0" OD Split-Spoon Sampler (SPT)

Bulk sample

Grab Sample

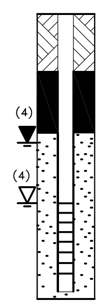
Sampler Type Description

3.0" OD Split-Spoon Sampler

3.25" OD Split-Spoon Ring Sampler

3.0" OD Thin-Wall Tube Sampler (including Shelby tube)

Portion not recovered



Cement grout surface seal

Bentonite seal

Filter pack with blank casing section

Screened casing or Hydrotip with filter pack

End cap

(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of ground water
- ATD = At time of drilling
- Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 12%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

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EXPLORATION LOG KEY

FIGURE A1

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Exploration Log

Project Number	Exploration Number	Sheet
180540E001	EB-1	1 of 1

Project Name	Paek Residence	Ground Surface Elevation (ft)	84
Location	Mercer Island, WA	Datum	N/A
Driller/Equipment	CN Drilling / Acker	Date Start/Finish	11/20/18,11/20/18
Hammer Weight/Drop	140# / 30"	Hole Diameter (in)	6 inches

Depth (ft)	Samples	DESCRIPTION	Blows/6"	Blows/Foot
		Grass / Fill		
	S-1	Moist, oxidized dark to light brown at depth, SILT, some fine sand, trace gravel; abundant rootlets; fine organic debris; grayish brown sandy silt in sampler head (ML). Rock at 1.5 feet. Driller added water at 2 feet to assist in drilling.	4 7 12	19
		Vashon Recessional Lacustrine Deposit		
	S-2	Moist, grayish orangish brown with bands of oxidation, silty, fine SAND to fine SAND, some silt, trace gravel; occasional rootlets and fine organics; frequent thin beds and clasts of purplish pink, clayey, silt to clay; stratified (SM).	5 5 8	13
		Pre-Olympia Fine-Grained Deposits		
5	S-3	Moist to very moist, grayish brown, sandy, SILT, trace gravel; unsorted; high angle joint of fine sand; occasional decimated organics (ML).	15 25 39	64
	S-4	Moist, grayish brown, sandy, SILT, trace gravel; unsorted; slightly stratified; joints of slight oxidation; baked; occasional decimated organics; occasional dropstones (ML). Difficult drilling at 8 feet, driller added water to aid in drilling action.	11 26 38	64
10	S-5	Moist, gray, sandy, SILT, trace gravel; unsorted to massive; slightly laminated; reacts weakly with hydrochloric acid; occasional dropstones (ML).	28 50/3.5"	50/3.5"
		Bottom of exploration boring at 11.5 feet No groundwater encountered.		
15				

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: CRC
Approved by: JHS