PRELIMINARY GEOTECHNICAL ENGINEERING EVALUATION SCOFIELD RESIDENTIAL PROPERTY 4900 BLOCK NE 184TH STREET LAKE FOREST PARK, WASHINGTON

PREPARED FOR
ALEX SCOFIELD

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS

Main Office
17311 – 135th Ave NE, A-500
Woodinville, WA 98072
(425) 486-1669 · FAX (425) 481-2510

Engineering-Geology Branch
5526 Industry Lane, #2
East Wenatchee, WA 98802
(509) 665-7696 · FAX (509) 665-7692

June 11, 2015

Mr. Alex Scofield
Yen Design, Inc.
1622 NE 179th Street
Shoreline, WA 98155

Preliminary Geotechnical Engineering Evaluation
Scofield Residential Property
4900 Block NE 184th Street
Lake Forest Park, Washington
NGA Project No. 924515

Dear Mr. Scofield:

NELSON GEOTECHNICAL ASSOCIATES, INC. (NGA) is pleased to submit the attached report titled "Preliminary Geotechnical Engineering Evaluation – Scofield Residential Property – 4900 Block NE 184th Street – Lake Forest Park, Washington." This report summarizes the existing surface and subsurface conditions within the project site, and provides geotechnical recommendations for design and construction of proposed site improvements. Our services were completed in general accordance with the proposal signed by you on May 4, 2015.

We understand that proposed development plans consist of constructing a new single-family residence in the terraced or southern half of the site. You have indicated that you intend to keep modifications to the existing topography to the least extent practical, including supporting the home on a deep foundation system. Specific grading, structural, and utility plans were not available at the time this report was prepared. Stormwater management plans have also not been finalized at this time, but we understand that they will likely include tightlining runoff down to the existing storm drainage system on NE 184th Street. We therefore should be retained to review final development plans prior to applying for a permit.

Based on our site reconnaissance and explorations, we have concluded that development of a single family residence on this site should be feasible, from a geotechnical standpoint. Within the proposed development area we encountered at least 5 feet of loose, wet, random fill in our explorations, and were able to insert a steel probe its full length of 3 feet fairly consistently. The fill soils are not suitable for supporting the house on shallow footings.

Based on the presence of undocumented fill and shallow perched groundwater conditions encountered in our explorations, we recommend supporting the planned residence on a deep foundation system consisting of drilled augercast piles to transfer building loads to the more competent native deposits at depth. Specific recommendations for foundation design and installation are provided in the attached report. In the attached report, we have also provided general recommendations for site grading, slabs-on-grade, structural fill placement, retaining walls, erosion control, and drainage. These recommendations are preliminary in nature, based on our understanding of the proposed project.

We should be retained to review final grading and drainage plans prior to construction. We also recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

We appreciate the opportunity to provide service to you on this project. Please contact us if you have any questions regarding this report or require further information.

Sincerely,
NELSON GEOTECHNICAL ASSOCIATES, INC.

Khaled M. Shawish, PE
Principal

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INTRODUCTION

This report presents the results of our preliminary geotechnical engineering evaluation for the proposed Scofield Residential project. The site is located immediately to the west of 4952 NE 184th Street in Lake Forest Park, Washington, as shown on the Vicinity Map in Figure 1. It is our understanding a new single-family residence is planned in the southern half of the property, although specific designs and plans for the residence were not available at the time of this evaluation. The purpose of this study is to explore and characterize the surface and subsurface conditions at the site and provide general geotechnical recommendations for site development, including evaluating some existing retaining walls.

SCOPE

Based on our understanding of the project, the services provided by NGA included:

1. A review of available soil and geologic maps of the area.
2. Exploring subsurface soil and groundwater conditions within the site with trackhoe test pits.
3. Mapping conditions on the slope, and evaluate current slope stability conditions.
4. Providing our opinion on the condition of the existing retaining walls.
5. Presenting general recommendations for earthwork and foundation support.
6. Providing general recommendations for temporary and permanent slopes.
7. Providing general recommendations for foundation and slab support.
8. Developing general recommendations for retaining walls.
9. Providing general recommendations for site drainage and erosion control.
10. Documenting the results of our findings, conclusions, and recommendations in this written preliminary geotechnical report

SITE CONDITIONS

Surface Conditions

Current site topography is shown approximately on the Site Plan in Figure 2. The southern half of the site contains two relatively level, terraced benches. From NE 184th Street the ground slopes moderately up about 6 to 8 feet to the first terrace that is about 15 feet wide. The ground surface at the northern edge of the terrace slopes upward about 3 feet to another flat terrace that is about 25 to 30 feet wide. An old shed is located at the northeastern corner of the upper bench. The terraced areas are vegetated with overgrown grass and ornamental shrubs. A copse of mature western red cedar trees are located on the slope at the southwest corner of the lot.

The northern half of the site consists of a slope that rises moderately upward for some distance well beyond the property boundary. The upper slope is vegetated primarily with mature Douglas-fir trees, madrone, and blackberry brambles. Three tiered masonry block retaining walls are present at the slope transition west of the shed and extending toward the west property line. These wall are in various stages of distress, including sections that are rotating outward, loose blocks, and broken blocks. We encountered remnants of an apparently older concrete retaining wall located at the west end of the uppermost masonry block wall oriented to the south-southwest. The southern end of this "wing" wall is buried under soil and concrete rubble. We also observed the top of a similar wall extending east of the top block wall behind the shed and curving into the neighboring lot.

Subsurface Conditions

Geology: The geologic units for the site vicinity are shown on the Preliminary Geologic Map of the Edmonds East Quadrangle, Snohomish and King Counties, Washington, by Mackey Smith (USGS, 1975). The site is mapped as Vashon advance outwash (Qva), a Quaternary-age glacial deposit. Advance outwash typically is a thick section of mostly clean, gray, pebbly sand with increasing amounts of gravel higher in the section that was deposited by meltwater flowing from the advancing front of the glacier. Soils observed on the slope were generally consistent with this description.

Explorations: Subsurface conditions within the site were explored on May 8, 2015 by excavating two test pits with a small, rubber-tracked hydraulic excavator to depths of approximately 6½ to 9½ feet below the existing ground surface. The approximate locations of the explorations are shown on the Site Plan in Figure 2. An engineer from NGA was present during the explorations, examined the soils and geologic conditions encountered, obtained samples of the different soil types, and maintained logs of the excavations.

The soils were visually classified in general accordance with the Unified Soil Classification System, presented in Figure 3. The logs of our test pits are attached to this report and are presented as Figure 4. We present a brief summary of the subsurface conditions in the following paragraphs. For a detailed description of the subsurface conditions, the test pit logs should be reviewed.

At the surface of the test pits, we encountered about 3 inches of grass sod overlying brown, mottled with orange, light gray, and light brown silty sand with trace gravel and small roots. In TP-1, this soil extended to a depth of about 1 ¾ feet below ground surface and in TP-2, it extended to a depth of approximately 5 feet. The soil in TP-2 contained pieces of concrete slabs and other debris. In test pit TP-1, the brown silty sand was underlain with about 2½ feet of gray silty fine sand with gravel, and small roots and 1 foot of mottled brown silty sand with gravel and some cobbles. Soils in the upper 5 feet of both test pits was characterized as random fill that varied in relative density from loose to medium dense.

Below the fill, in both test pits we encountered about ½ foot of dark gray to black silty fine sand with woody roots and other organic matter. The buried topsoil layer in TP-1 was underlain by what appears to be intact native soil composed of gray silty sand with gravel that was medium dense to dense. At the east end of the test pit, we observed two black plastic drainage pipes surrounded in large gravel (i.e. drain rock) with flowing water.

The buried topsoil layer in test pit TP-2 was underlain by about 1½ feet of gray to blue-gray silty fine to medium sand that was loose and wet which was underlain by a second 6-inch layer of topsoil composed of black silty sand with roots and other organic matter. Soil beneath the second buried topsoil layer consisted of brown and orange-brown silty fine sand with gravel that was loose becoming medium dense with depth. The test pit was terminated in this material at a depth of about 9 feet, the practical limit of the excavator. As an aid to assessing the relative density of the soils below the bottom of the test pit, the excavator was used to advance a 1½-inch diameter steel pipe into the soil until reaching refusal at about 3 feet.

Surface and near surface soil conditions were also evaluated by probing the soil with a steel rod. Typically, in the terraced areas, the ground was easily penetrated to the full length of the probe (3 feet) unless an obstruction was encountered. Obstructions were interpreted to be cobbles, small boulders, concrete rubble, or other debris rather than an indication of competent undisturbed native soil because further probing around the obstruction did not result in a consistent depth of penetration. On the slope north of the terraces, we observed that much of the surface in open areas is laced with animal burrows that have disturbed and loosened the soils to depths of about 1 to 2 feet. Soils below disturbed areas and below about 6 to 12 inches of weathered surface soils probed medium dense to dense.

Hydrologic Conditions

Groundwater seepage was encountered in both explorations at approximately 4 to 5 feet below the ground surface. However, wet conditions were encountered throughout the upper soil horizons. We interpreted this moisture to be groundwater collecting within sandier/less dense lenses of the subsurface, possibly generated from upslope. It is our opinion that the groundwater observed within our explorations is perched water. Perched water occurs when surface water infiltrates through less dense, more permeable soils and accumulates on top of relatively low permeability materials. The more permeable soils on this site would consist of the sand seams found within the landslide debris. The low permeability soil consists of underlying silt. Perched water does not represent a regional groundwater "table" within the upper soil horizons. Perched water tends to vary spatially and is dependent upon the amount of rainfall. We would expect the amount of perched groundwater to decrease during drier times of the year and increase during wetter periods. However, due to the large area of recharge, there may be areas of seepage and wet soils on this site even in the drier times of the year.

Erosion Hazard

The criteria used for determining the erosion hazard for the site soils includes soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to the vegetative cover and the specific surface soil types, which are related to the underlying geologic soil units. The King County iMap website was reviewed to check for the presence of Sensitive Areas in the vicinity. Our review indicates that the slope adjacent to NE 184th Street is categorized as erosion sensitive; the rest of the property is not within a sensitive area. We believe onsite soils should have a low hazard for erosion in areas that are not disturbed and where the vegetation cover is not removed.

Landslide Hazard/Slope Stability

The criteria used for the evaluation of landslide hazards include soil type, slope gradient, and groundwater conditions. The site slopes gently to moderately down to the south. Groundwater seepage was not observed on the sloping portions of the property above the terraced areas during our site visit.

The site and vicinity have been relatively stable for a very long period of time, and development in the area has taken place in the form of single-family residences, roadways, and underground utilities. Although the likelihood of landsliding in the foreseeable future is very low, localized areas of surface instability and surface sliding can occur on steep slopes, particularly where modified through human activities.

Based on our observations and experience, we believe the distress of the existing masonry block walls is most likely due to a lack of maintenance, specifically failing to trim or remove invasive vegetation, and maintaining proper embedment of wall footings. We speculate that the concrete wall observed at both ends of the block walls pre-dates the block walls by many years. It is possible that the original concrete wall began to fail and that it was replaced or buttressed by earth fill supported by the tiered block walls.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion, from a geotechnical standpoint, that the site should be compatible with the proposed development of a single-family residence, provided that the geotechnical recommendations presented in this report are incorporated into project plans and followed during construction. The southern, terraced portion of the site is blanketed with random, undocumented fill that would not be suitable for supporting typical house structural loads on a shallow foundation. Therefore we recommend that the house, and all other structures be supported on a deep foundation system extending into intact native soils.

With regards to slope stability, the proposed development area appears to be relatively stable under current conditions. To reduce the potential for damage, Lake Forest Park Municipal Code Chapter 16.16 requires a standard buffer of 50 feet from the top, toe, and sides of a steep slope hazard plus an additional 15-foot setback for buildings. The code allows for a 25-foot reduction in the standard buffer when a qualified professional can demonstrated that the proposed development will be adequately protected. Supporting the house and associated appurtenances on a deep foundation system, and assuming the existing soils are left relatively undisturbed, should have no negative impact on slope stability. A byproduct of installing structural elements (piles or piers) through the existing random fill is that some amount of tensile reinforcement is being added, which may actually increase overall stability. Therefore, it is our opinion that the steep slope buffer can safely be reduced to 25 feet, provided our recommendations are incorporated into design and construction, as appropriate.

As stated above, the existing retaining walls at the toe of the upper slope are in distress and not fully supporting retained soils. As a way of creating more useable space, optionally the existing walls could be replaced with a new retaining structure such as a conventional reinforced concrete wall, a gravity wall composed of large concrete blocks, or a reinforced earth slope with modular block facing. However, if development plans change to include removing (and not replacing) soil from the upper terrace we recommend revisiting the need for replacing or rehabilitating these walls. Retaining wall design was beyond the scope of our current services.

To alleviate potential site instability concerns, we recommend that the entire residence be supported on a deep foundation system consisting of augercast piles extending through the undocumented fill and terminating into the competent undisturbed soils at depth. This is further described in the **Deep Foundations** subsection of this report. We should be retained to review the project plans prior to applying for a permit, and to monitor earthwork and foundation system installation during construction

Grading plans were not finalized at the time of this report, but we anticipate that cuts may be needed to allow construction of the residence foundation. If these cuts cannot be sloped back to a safe inclination due to site constraints, we recommend that the cuts be shored with a soldier pile retaining wall or a similar system. The need for a shoring system should be determined during final design. This potential wall could be designed as a permanent wall and incorporated into the residence foundations. We provide recommendations for temporary and permanent cut slopes in the **Temporary and Permanent Slopes** section of this report.

We recommend that if a slab-on-grade is utilized for the proposed residence that the slab be designed as a structural slab and be supported on the deep foundation system. Other hard surfaces, such as paved areas or walkways that are supported on the existing soil have some risk of future settlement, cracking, and the need for maintenance. To reduce this risk, we recommend over-excavating a minimum of two feet of the upper soil from the slab and pavement areas and replacing this material with compacted pit run or crushed rock structural fill. This recommendation is only for hard surfaces to be supported on grade and does not apply for the lower floor structural slab. The lower floor slab should be fully supported on auger-cast piles. Even with the recommended treatment, some settlement of the underlying loose material should be anticipated.

The control of surface and near-surface water is very important for the long-term stability of the site and on the steeper portions of the site slopes. We highly recommend that temporary and final site grading be designed to direct surface water away from the structures and away from the site slopes. Final drainage plans have not been developed at this time, but we understand that all stormwater generated on the site will be collected in tightlines and transported to the bottom of the slope to the west of the property or into an existing stormwater system within the vicinity of the property. No water should be infiltrated or dispersed within the site. We discuss general site drainage in the **Site Drainage** subsection of this report.

The soils encountered within our explorations are considered moisture sensitive and will disturb easily when wet. We recommend that construction take place during extended periods of dry weather if possible. If construction takes place during wet weather, additional expenses and delays should be expected due to the wet conditions. Additional expenses could include the need to export on-site soil, the import of clean, granular soil for fill, and the need to place a blanket of rock spalls or crushed rock in the construction traffic areas and on exposed subgrades prior to placing structural fill or structural elements.

In this report, we have also provided recommendations for drainage, erosion control, and other development considerations intended to reduce the potential impact of development on the site and the site slopes. We should be retained to review final project plans prior to construction. We also recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

Erosion Control and Slope Protection Measures

The erosion hazard for the on-site soils is considered moderate to high, but the actual hazard will be dependent on how the site is graded and how water is allowed to concentrate. Best Management Practices (BMPs) should be used to control erosion. Areas disturbed during construction should be protected from erosion. Erosion control measures may include diverting surface water away from the stripped or disturbed areas. Silt fences and/or slope waddles should be erected to prevent muddy water from leaving the site or flowing over the site slopes. Disturbed areas should be planted as soon as practical and the vegetation should be maintained until it is established. The erosion potential for areas not stripped of vegetation should be low to moderate.

Protection of the site slopes should be performed as required by the City of Lake Forest Park. Specifically, we recommend that the slopes not be disturbed or modified through placement of any fill or future structures outside the planned development areas. No additional material of any kind should be placed on any portion of sloping ground, such as excavation spoils and soil stockpiles. A vegetation cover should be preserved on the slopes. Replacement of vegetation should be performed in accordance with the City of Lake Forest Park code. Under no circumstances should water be allowed to concentrate on the slopes. Any sloping areas disturbed during construction should be planted with vegetation as soon as practical to reduce the potential for erosion.

Site Preparation and Grading

Plans for site grading should be devised such that cuts and fills are kept to a minimum. Site preparation should also include stripping any organic topsoil and/or loose/soft soils in areas that will support foundations, slabs-on-grade, pavement, or structural fill. If the exposed soils are loose/soft, they should be compacted to a non-yielding condition. Areas observed to pump or weave during compaction should be over-excavated and replaced with rock spalls. If significant surface water flow is encountered during construction, this flow should be diverted around areas to be developed and the exposed subgrade maintained in a semi-dry condition. In wet conditions, the exposed subgrade should not be compacted, as compaction of a wet subgrade may result in further disturbance of the soils. A layer of crushed rock may be placed over the prepared areas to protect them from further disturbance.

The site soils are considered moisture sensitive and will disturb easily when wet. We recommend that earthwork construction take place during periods of extended dry weather, and suspended during periods of precipitation if possible. If work is to take place during periods of wet weather, care should be taken during site preparation not to disturb the site soils. This can be accomplished by utilizing large excavators equipped with smooth buckets and wide tracks to complete earthwork, and diverting surface and groundwater flow away from the prepared subgrades. Also, construction traffic should not be allowed on the exposed subgrade. A blanket of rock spalls should be used in construction access areas if wet conditions are prevalent. The thickness of this rock spall layer should be based on subgrade performance at the time of construction. For planning purposes, we recommend a minimum one-foot thick layer of rock spalls.

Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, including the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open and the presence of surface or groundwater. It is exceedingly difficult under these variable conditions to estimate a stable, temporary, cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations since they are continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered.

The following information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Nelson Geotechnical Associates, Inc. assumes responsibility for job site safety. Job site safety is the sole responsibility of the project contractor.

For planning purposes, we recommend that temporary cuts within existing fill or disturbed native soils be no steeper than two units horizontal to one unit vertical (2H:1V). Cuts advanced in intact native soils, such as may be encountered during retaining wall replacement, may be expected to stand at 1H:1V for a limited duration, depending on soil, groundwater, and weather conditions at the time of construction.

If groundwater seepage is encountered, we would expect that flatter inclinations would be necessary. We should be retained to specifically review proposed geometry for significant cuts planned on this site. We recommend that cut slopes be protected from erosion. Erosion control measures may include covering cut slopes with plastic sheeting and diverting surface water runoff away from the top of cut slopes. We do not recommend vertical slopes for cuts deeper than four feet, if worker access is necessary. We recommend that cut slope heights and inclinations conform to appropriate OSHA/WISHA regulations.

Permanent cut and fill slopes should be no steeper than 2H:1V. However, flatter inclinations may be required in areas where loose soils are encountered. Permanent slopes should be covered with erosion control matting and vegetated. The vegetative cover should be maintained until established. We should specifically review all plans for grading on this project. We do not recommend placing irrigation systems near the slopes.

Deep Foundations

Due to the presence of random, undocumented fill soils of varying composition, relative density, and moisture content, we recommend that the entire residence be supported on 14- or 16-inch diameter augercast piles extending a minimum of 5 feet into medium dense to dense native soils. Based on our explorations, we recommend that the piles be a minimum of 16 feet deep below current ground surface to satisfy this requirement. However, depending on the actual depth of fill at the specific pile locations, some of the piles may need to be extended deeper than 16 feet to achieve the minimum five foot embedment into competent native soils. This can be confirmed in the field during pile installation.

Augercast piles are installed with a hollow-stem auger advanced to the desired pile depth. After reaching a minimum recommended penetration into bearing soils, a pressure head is created when grout is pumped into the hollow stem of the auger before starting auger withdrawal. After the grout head is developed, withdrawal of the auger is timed to maintain the grout pressure head and avoid intrusion of loose soil into the sides of the pile excavation or discontinuity or "necking" of the pile. The actual volume of the concrete pumped into each pile is recorded and compared with the theoretical volume of the pile. Piles with a ratio of actual to theoretical great volume less than 1.1 should be re-drilled.

The augercast piles should provide the necessary vertical support for the structure as well as some lateral resistance. The success of this method will depend, in part, on site access for the drill rig and other equipment needed for pile installation. Obstructed piles should be relocated and/or additional piles installed. Some discussion on relocation of piles should be made with your structural engineer prior to start of drilling. It is usually best to make any changes while the drill rig is on site.

For preliminary design, we recommend that the piles extend a minimum of 16 feet below the existing ground surface and penetrate a minimum of 5 feet into the underlying competent native granular soils to provide adequate end bearing and friction capacities. We present design friction, end bearing, and total axial compression capacities for 14- and 16-inch diameter augercast piles, installed as recommended, in the following table. The friction component should be used to resist uplift forces only. The provided values do not include the weight of the piles. If the piles weight will be utilized to resist uplift forces, the buoyant unit weight and adequate safety factors should be used.

Pile Diameter (Inches)	Total Pile Depth (Feet)	Design Friction (Tons) (uplift only)	Design End Bearing (Tons) (pile capacity)
14	16	4.5	10
16	16	5.5	12.5

Lateral resistance on the piers could be calculated based on an equivalent fluid density of 200 pounds per cubic foot (pcf) applied to two pile diameters. The upper 10 feet should be neglected for the purpose of calculating the lateral resistance. If this is not feasible, some of the piles may be battered to provide lateral resistance. Also passive resistance on competent backfill around grade beams could be utilized using the above passive resistance. The upper foot of material should be neglected. We should be retained to review pile design and observe augercast pile installation.

Structural Fill

General: Fill placed beneath foundations, pavements, and other settlement-sensitive structures, or behind retaining walls should be placed as structural fill. Structural fill, by definition, is placed in accordance with prescribed methods and standards and is monitored by an experienced geotechnical professional or soils technician. Field monitoring procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction. The area to receive the fill should be prepared as outlined in the **Site Preparation and Grading** subsection of this report. Sloping areas to receive fill should be benched prior to fill placement. The benches should be level and at least four feet wide.

Materials: Structural fill should consist of a good quality, granular soil, free of organics and other deleterious material and be well graded to a maximum size of about three inches. All-weather fill should contain no more than five-percent fines (soil finer than U.S. No. 200 sieve, based on that fraction passing the U.S. 3/4-inch sieve). We do not anticipate placement of significant volumes of structural fill for this project. The on-site soils consist of moisture-sensitive silty materials and slide debris. We recommend that the on-site material not be used as structural fill. We should be retained to evaluate the suitability of proposed structural fill materials at the time of construction.

Fill Placement: Following subgrade preparation, placement of structural fill may proceed. All filling should be accomplished in uniform lifts up to eight inches thick. Each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill underlying building areas and pavement subgrade should be compacted to a minimum of 95 percent of its maximum dry density. Maximum dry density, in this report, refers to that density as determined by the ASTM D-1557 Compaction Test procedure. The moisture content of the soils to be compacted should be within about two percent of optimum so that a readily compactable condition exists. It may be necessary to over-excavate and remove wet soils in cases where drying to a compactable condition is not feasible. All compaction should be accomplished by equipment of a type and size sufficient to attain the desired degree of compaction.

Retaining Walls

We understand that retaining walls related to creating site access and parking areas may be incorporated into project plans. We recommend that retaining walls be kept as low as possible.

The lateral pressure acting on subsurface retaining walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement which can occur as backfill is placed, wall drainage conditions, the inclination of the backfill, and other possible surcharge loads. For walls that are free to yield at the top at least one thousandth of the height of the wall (active condition), soil pressures will be less than if movement is limited by such factors as wall stiffness or bracing (at-rest condition). We recommend that walls supporting horizontal backfill and not subjected to hydrostatic forces be designed using a triangular earth pressure distribution equivalent to that exerted by a fluid with a density of 40 pcf for yielding (active condition) walls, and 60 pcf for non-yielding (at-rest condition) walls.

These recommended lateral earth pressures are for a drained granular backfill and are based on the assumption of a horizontal ground surface behind the wall for a distance of at least the subsurface height of the wall, and do not account for surcharge loads. Additional lateral earth pressures should be considered for surcharge loads acting adjacent to subsurface walls and within a distance equal to the subsurface height of the wall. This would include the effects of surcharges such as traffic loads, floor slab and foundation loads, slopes, or other surface loads. Also, hydrostatic and buoyant forces should be included if the walls could not be drained. We could consult with the structural engineer regarding additional loads on retaining walls during final design, if needed.

All wall backfill should be well compacted; however, care should be taken to prevent the buildup of excess lateral soil pressures, due to over-compaction of the wall backfill. This can be accomplished by placing wall backfill in thin loose lifts and compacting it with small, hand-operated compactors within a distance behind the wall equal to at least one-half the height of the wall. The thickness of the loose lifts should be reduced to accommodate the lower compactive energy of the hand-operated equipment.

Retaining walls that are part of the residence should be supported on auger-cast piles as described above. Retaining walls associated with driveway grading and other landscaping plan should be kept under four feet in height and should be supported on a minimum of two feet of rock spalls to reduce the potential for differential settlement of the walls. The active pressure on the walls can be resisted by friction on the bottom of the wall footing and passive resistance on the below-grade portion of the footing. We recommend using a design soil bearing pressure of no more than 1,500 pounds per square foot (psf) along with a friction coefficient and passive resistance values of 0.35 and 200 pcf, respectively. The upper one foot of material should be neglected when calculating the passive pressure.

Permanent drainage systems should be installed for retaining walls. Recommendations for these systems are found in the **Subsurface Drainage** subsection of this report. We recommend that we be retained to evaluate the proposed wall drain backfill material and drainage system installation.

Structural Slabs

As mentioned earlier, we recommend that if a lower floor slab is utilized, that this slab be designed as a structural slab fully supported on the deep foundation system. We recommend that slabs be underlain by at least six inches of free-draining gravel with less than three percent by weight passing the Sieve #200 for use as a capillary break. We recommend that the capillary break be hydraulically connected to the footing drain system to allow free drainage from under the slab. A suitable vapor barrier, such as heavy plastic sheeting (6-mil minimum), should be placed over the capillary break material. An additional 2-inch-thick moist sand layer may be used to cover the vapor barrier. This sand layer may be used to protect the vapor barrier membrane and to aid in curing the concrete; however, this sand layer is optional and is intended to protect the vapor barrier membrane during construction. Other slabs and hard surfaces that may be supported on the existing soils should be underlain by a minimum of two feet of railroad ballast in addition to the capillary break and vapor barrier.

Site Drainage

Surface Drainage: The finished ground surface should be graded such that stormwater is directed to an appropriate stormwater collection system. Water should not be allowed to collect in any area where footings, slabs, or retaining walls are to be constructed. Final site grades should allow for drainage away from the structure and away from the site slopes. We suggest that the finished ground be sloped at a minimum gradient of three percent, for a distance of at least 10 feet away from the structure and slopes. Surface water should be collected by permanent catch basins and drain lines, and be discharged into an appropriate discharge system. Under no circumstances should water be allowed to flow uncontrolled over the site slopes or excavation walls.

We recommend that all stormwater generated on the site, including roof downspouts, footing drains, pavement and yard drains, and any water flow from the road, be tightlined to the bottom of the slope to the west or into an approved system within the vicinity of the property. If the stormwater is tightlined to the bottom of the slope, we recommend that the pipe should end with a perforated tee section approximately eight feet long that is capped on both ends and embedded onto a crushed rock pad at the toe of the slope adjacent to NE 184th Street.

Roof drains should also be installed around the structure. Roof drains should consist of gutters and downspouts collecting stormwater runoff from the roof. The downspouts should discharge to catch basins and 4-inch minimum diameter, rigid, PVC tightline pipes. The drains should be directed into catch basins and then into the controlled drainage system. The footing and roof drains should discharge via independent (separate) tightlines into catch basins/cleanouts leading to the stormwater system. Surface water from the driveway and yard areas should also be collected in a catch basin and tightlined separately to the stormwater system.

Subsurface Drainage: If groundwater is encountered during construction, we recommend that the contractor slope the bottom of the excavations and collect water into ditches and small sump pits where the water can be pumped out of the excavations and routed into an appropriate outlet.

We recommend the use of footing drains around the planned structure and behind retaining walls. Footing drains should be installed at least one-foot below planned finished floor elevation. The drains should consist of a minimum four-inch-diameter, rigid, slotted or perforated, PVC pipe surrounded by free-draining material, such as washed rock, wrapped in a filter fabric. We recommend that an 18-inch-wide zone of clean (less than three-percent fines), granular material be placed along the back of the walls above the drain. Washed rock is an acceptable drain material, or drainage composite may be used instead. The free-draining material should extend up the wall to one-foot below the finished surface. The top foot of backfill should consist of low permeability soil placed over plastic sheeting or building paper to minimize the migration of surface water or silt into the footing drain. Footing drains should discharge into tightlines leading to an appropriate collection and discharge point with convenient cleanouts to prolong the useful life of the drains. Roof drains should not be connected to footing drains.

USE OF THIS REPORT

NGA has prepared this preliminary report for Mr. Alex Scofield and his agents, for use in the planning and design of the development planned on this site only. The scope of our work does not include services related to construction safety precautions and our recommendations are not intended to direct the contractors' methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. There are possible variations in subsurface conditions between the explorations and also with time. Our report, conclusions, and interpretations should not be construed as a warranty of subsurface conditions. A contingency for unanticipated conditions should be included in the budget and schedule.

We recommend that we be retained to review final project plans and provide consultation regarding specific structure placement, site grading, foundation support, and drainage. We also recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications. We should be contacted a minimum of one week prior to construction activities and could attend pre-construction meetings if requested.

All people who own or occupy homes on or near hillsides should realize that landslide movements are always a possibility. The landowner should periodically inspect the slope, especially after a winter storm. If distress is evident, a geotechnical engineer should be contacted for advice on remedial/preventative measures as soon as possible. The probability that landsliding will occur is substantially reduced by the proper maintenance of drainage control measures at the site (the runoff from the impervious surfaces should be led to an approved discharge point). Therefore, the homeowner should take responsibility for performing such maintenance.

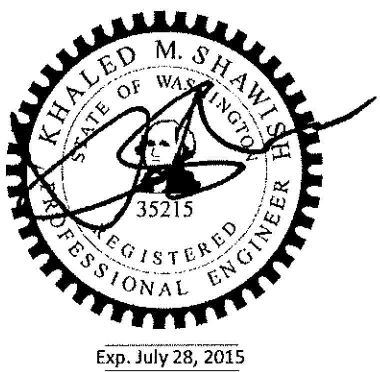
Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this report was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

o-O-o

We appreciate the opportunity to provide service to you on this project. If you have any questions or require further information, please call.

Sincerely,
NELSON GEOTECHNICAL ASSOCIATES, INC.

Timothy D. Huntting, PE
Senior Engineer



Khaled M. Shawish, PE
Principal

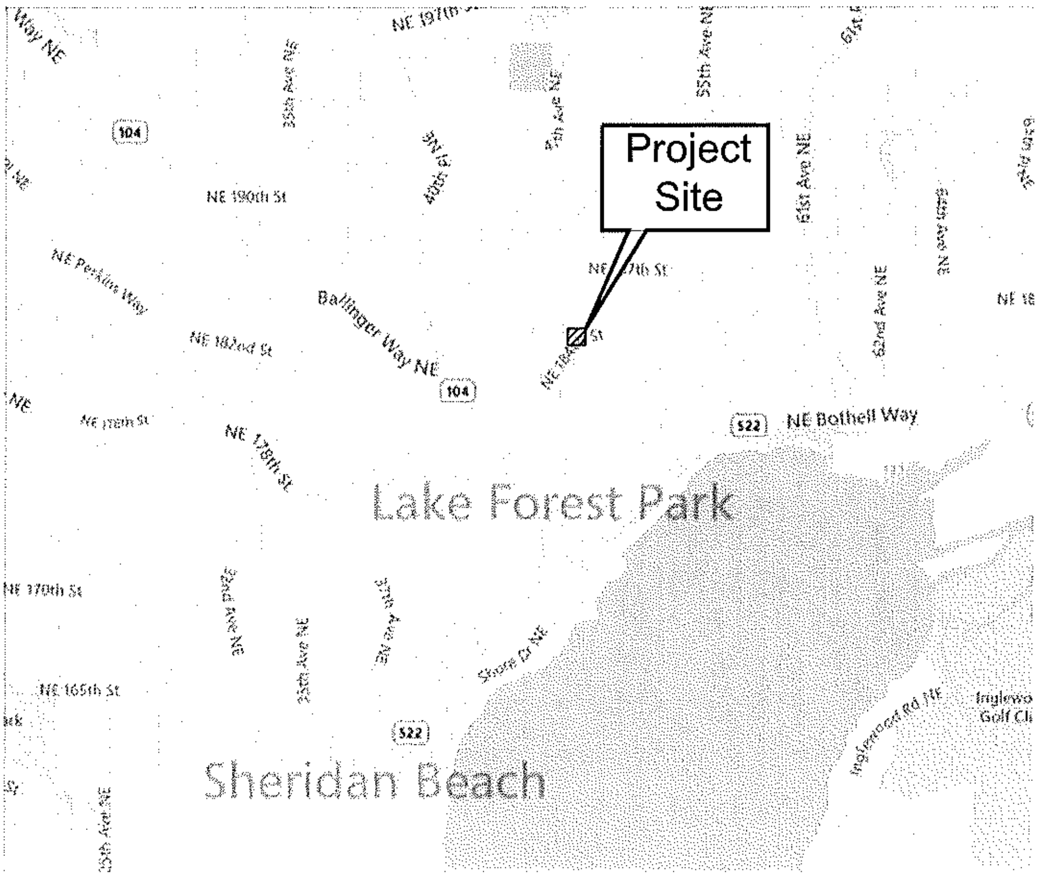
TDH:KMS:cja

Four Figures Attached

VICINITY MAP

Not to Scale

N



King County, Washington

Project Number	Scofield Retaining Wall Lake Forest Park Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
924515			1	5/20/15	Original	TDH	KMS
Figure 1							

17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax 481-2510
Snohomish County (425) 339-1669
Wenatchee/Chelan (509) 665-7696
www.nelsongeotech.com

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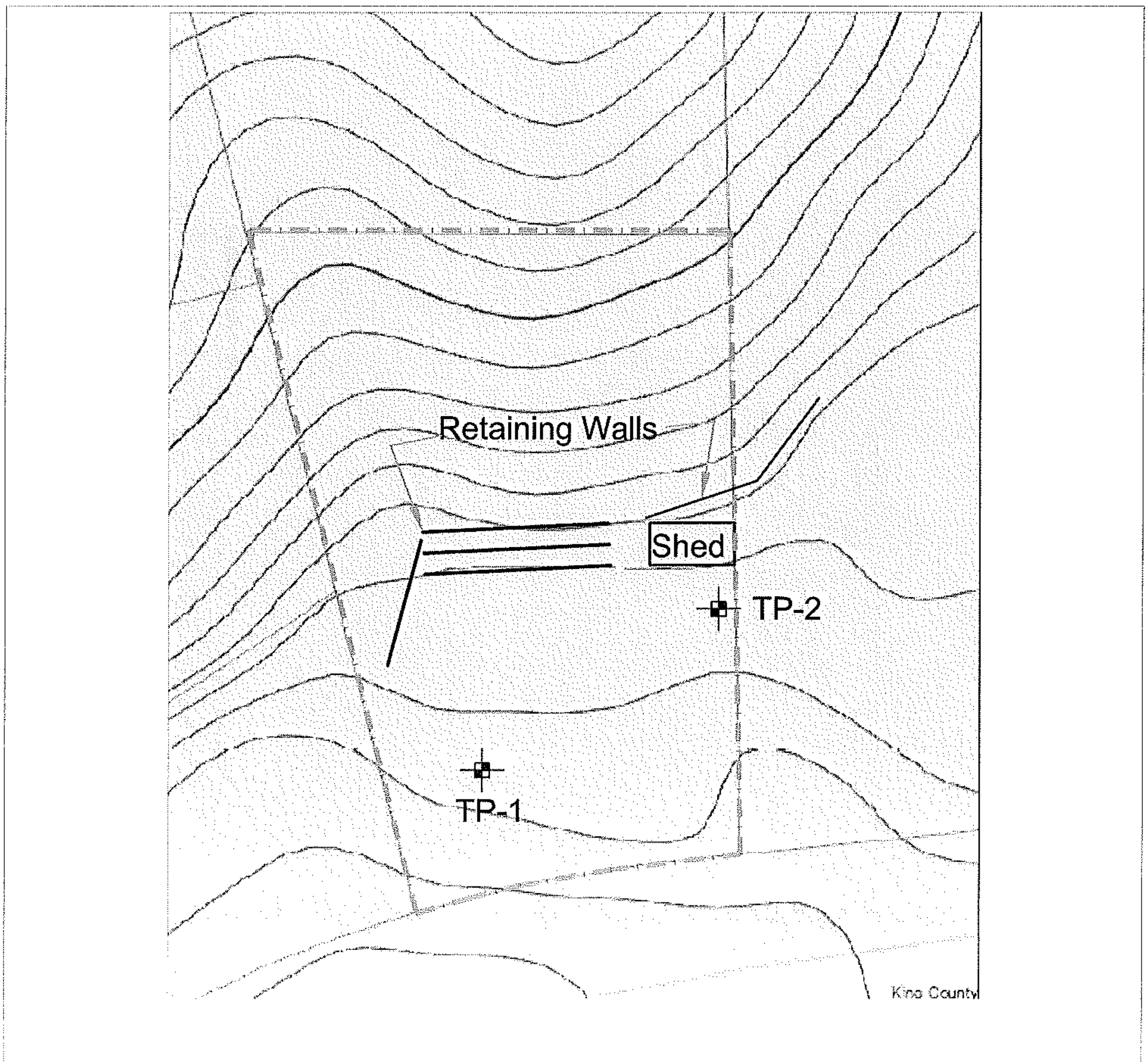
SCHEMATIC SITE PLAN

Not to Scale

N



Property line

TP-1 Number and approximate location of test pit

Project Number	Scofield Retaining Wall Lake Forest Park Schmatic Site Plan	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS 17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 339-1669 Wenatchee/Chelan (509) 665-7696 www.nelsongeotech.com	No.	Date	Revision	By	CK
924515			1	5/20/15	Original	TDH	KMS
Figure 2							

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UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS	GRAVEL MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
MORE THAN 50 % RETAINED ON NO. 200 SIEVE	SAND MORE THAN 50 % OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS	SILT AND CLAY LIQUID LIMIT LESS THAN 50 %	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
MORE THAN 50 % PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT 50 % OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FLAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-93.

2) Soil classification using laboratory tests is based on ASTM D 2488-93.

3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

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

Moist - Damp, but no visible water.

Wet - Visible free water or saturated, usually soil is obtained from below water table

Project Number	Scofield Retaining Wall Lake Forest Park Soil Classification Chart	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS 17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 337-1669 Wenatchee/Chelan (509) 665-7696 www.nelsongeotech.com	No.	Date	Revision	By	CK
924515			1	5/20/15	Original	TDH	KMS
Figure 3							

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Test Pit TP-1

Depth (feet)	USCS	Description	Sample No./Depth (feet)
0 – ¼		Dark gray to black, silty fine SAND with roots and organic matter, loose, wet (**Topsoil Fill**)	
¼ – 1¾		Brown, mottled orange and light gray, silty fine SAND with trace gravel, loose to medium dense, moist to wet (**Fill**)	
1¾ – 4		Gray, silty fine SAND with trace gravel and small cobbles, and woody roots, medium dense, moist to wet (**Fill**)	
4 – 5		Brown mottled with orange and gray, silty fine to medium SAND with gravel, very loose, wet (**Fill**)	
5 – 5½		Black, silty SAND with roots and organic matter, loose, wet (**Topsoil**)	
5½ - 6½	SM	Gray, silty fine SAND with gravel, medium dense to dense, wet	

Test pit completed to a depth of about 6½ feet on May 8, 2015.
Samples were collected at 1.0 and 2.0 feet
Minor groundwater seepage observed at 3 feet. Two perforated black plastic pipes surrounded by gravel with moderate water flow encountered at 5½ feet.
Sidewall caving observed above 5 feet.

Test Pit TP-2

Depth (feet)	USCS	Description	Sample No./Depth (feet)
0 – ¼		Dark brown, silty fine SAND with grass roots and organic matter, loose, moist (**Topsoil Fill**)	
¼ – 5		Brown mottled with tan, silty fine SAND with scattered gravel, roots and charcoal to 1¼ feet, loose to medium dense, moist,(**Fill**)	
5 – 5½		Dark gray to black silty fine SAND with wood and organic matter, loose/soft, wet (**Topsoil Fill**)	
5½ – 7		Gray to blue-gray, silty fine to medium SAND, loose, wet (**Fill**)	
7 – 7½		Dark brown to black silty fine SAND with organic matter loose, wet (**Topsoil Fill**)	
7½ – 8½	SM	Brown, silty fine SAND with gravel, loose, wet	
8½ – 9	SM	Brown and orange-brown, silty SAND with gravel, loose to medium dense, moist to wet	

Test pit completed to a depth of about 9 feet on May 8, 2015.
Samples were collected at 2.0, 8.0, and 9.0 feet
Steel pipe pushed with excavator bucket to a depth of about 12 feet.
No groundwater seepage observed.
No sidewall caving observed.

Project Number 924515	**Logs of Test Pits Scofield Residential Property 4900 Block NE 184th Street Lake Forest Park, Washington**	NGA Nelson Geotechnical Associates, Inc. Geotechnical Engineers & Geologists	No.	Date	Revision	By	CK
Figure 4			1	5/20/15	Original	TDH	KMS