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December 9, 2015

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City of Lake Forest Park

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

Preliminary Geotechnical Engineering Evaluation
Parcel 4019301319 on State Route 522
Lake Forest Park, Washington
NGA Project No. 941815

Dear Mr. Scofield:

NELSON GEOTECHNICAL ASSOCIATES, INC. (NGA) is pleased to submit the attached report titled "Preliminary Geotechnical Engineering Evaluation – Parcel 4019301319 on State Route 522 – Lake Forest Park, Washington." This report summarizes the existing surface and subsurface conditions within the project site, and provides geotechnical recommendations for the design and construction of the planned single family residence and other site improvements. Our services were completed in general accordance with the proposal signed by you on November 12, 2015.

The parcel is situated on a mildly sloped upland bench occupying the northern two-thirds of the site and moderately- to steeply-sloping ground that descends southward to a relatively level bench occupied by State Route 522 (SR 522 and also known as Bothell Way NE). We understand that proposed development plans consist of constructing a new single-family residence on the upland slope within the northwestern portion of the property. We also understand that the site is proposed to be accessed via a driveway that traverses the moderate to steep slope down to SR 522. Stormwater management plans have not been finalized at this time.

We evaluated site conditions and monitored the excavation of three test pits at the site on November 19, 2015. We determined that earthwork, probably performed more than 25 years ago (based on aerial photo

interpretation), had altered site topography, Previous grading has created two relatively level terraces in the northern half of the property and a pioneer road that traverses the slope between the lower terrace and SR 522. Our explorations indicated that the site is generally underlain by competent, native glacial till soils, below the surface topsoil and a layer of fill or loose native soils. At the time of our evaluation, water was perched on the terraces at the loose soil to till interface rendering the loose soils too wet to be re-used as fill. Some of the perched water results from several small diameter stormwater drainage pipes we observed discharging onto the site.

It is our opinion from a geotechnical standpoint that the site is compatible with the planned development provided that our recommendations are incorporated into the design and construction of this project. We have recommended that the new structures be founded on the undisturbed dense or better native soil for bearing capacity and settlement considerations. These soils should be encountered within about 2 feet below the existing ground surface, based on our explorations. However, deeper areas of loose soil and/or undocumented fill could also exist within unexplored areas of the site.

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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Preliminary Geotechnical Engineering Evaluation
Parcel 4019301319 on State Route 522
Lake Forest Park, Washington

INTRODUCTION

This report presents the results of a preliminary geotechnical engineering evaluation conducted by ***NELSON GEOTECHNICAL ASSOCIATES, INC.*** (NGA) to evaluate the feasibility of developing a residential property, parcel number 401930-1319, in Lake Forest Park, King County, Washington. The property fronts Bothell Way NE, which is also State Route 522 (SR 522), near the eastern limit of the city of Lake Forest Park, as shown on the Vicinity Map in Figure 1. The site is located immediately to the northeast of 17749 Bothell Way NE; a street address for the subject parcel has not yet been assigned. It is our understanding a new single-family residence is planned in the upper northern portion 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. Review existing soils and geologic maps of the area.
2. Explore the subsurface soil and groundwater conditions within the site with backhoe/trackhoe excavated test pits. Backhoe was provided by client.
3. Map the conditions on the slope, perform hand-tool excavations, and evaluate current slope stability conditions.
4. Provide recommendations for earthwork, foundation support, and slabs-on-grade.
5. Provide recommendations for temporary and permanent slopes.
6. Provide recommendations for site drainage and erosion control.
7. Document the results of our findings, conclusions, and recommendations in a written geotechnical report.

SITE CONDITIONS

Surface Conditions

The parcel is composed of a roughly square 87-foot by 87-foot lot and a 24-foot by 30-foot rectangular block extending east from the southeast corner of the larger lot, as shown on the Site Plan in Figure 2.

Orientation descriptions are based on "Project North" shown in Figure 2. The general topography in the local area consists of mildly sloping land to the north and moderately- to steeply-sloping ground that descends southward to a relatively level bench occupied by SR 522. The approximate topography is shown in Figure 2.

An initial reconnaissance of the site revealed that the northern two-thirds of the site is composed of two relatively level benches or terraces separated by a 10-foot tall, near-vertical slope. We also observed several 3-inch diameter, black, corrugated plastic pipes at several locations within the terraced area and also down the steep slope to SR 522. These types of pipes are typically used to "tightline" stormwater runoff from roof gutters and surface area drains as well as draining subsurface water from behind retaining walls and perimeter foundations. Water was seen or heard flowing in some of the pipes and some of the pipes were discharging water onto the site. We also observed the end of an estimated 8-inch diameter concrete pipe buried in the soil and discharging water onto the slope near the southeast corner of the site. The flowing water had formed a small gully and we observed two sections of pipe laying horizontally across the slope that may have broken away from the buried pipe. We detected a sewage-like odor in the immediate vicinity of this pipe.

The upper terrace is covered with ivy and scattered shrubs. South of the upper terrace the remainder of the site is covered with heavy vegetation, primarily blackberry brambles and other tall brush. The excavator onsite to dig test pits cleared a path traversing the steeper slope from the southeast corner of property westward up to the lower terrace and knocked down brush on the terrace to reach test pit locations. After some of the vegetation had been cleared, we determined that the site had been graded some time in the past, probably more than 25 years ago based on aerial photo interpretation. Previous earthwork had created the two terraces and near vertical slope between the two. We were also able to discern that the path cleared by the excavator was located on a pioneer road that was likely used to access the upper portion of the site from SR 522. The approximate locations of steep slopes that appear to have been excavated creating the upper and lower terraces and the pioneer road are shown on Figure 2. A cross-section illustrating the relative positions and elevations of the two terraces, the pioneer road and the steeper slope down to SR 522 is provided in Figure 3.

Subsurface Conditions

Geology: The geologic units for the site vicinity are shown on the Geologic Map of the Edmonds East and Part of the Edmonds West Quadrangles, Washington, by James P. Minard (USGS, 1983). The site is mapped as Vashon Till (Qvt), with Older Alluvium (Qoal) mapped within and southeast of the SR 522

right-of-way. Landslide Deposits (Qls) are mapped within the ravine to the east of the site. The Vashon Till is described as a nonsorted mixture of clay, silt, sand, pebbles, cobbles, and boulders. The Older Alluvium is described as stratified sand and gravel, gray or oxidized to shades of brown, with some sandy, pebbly, organic-rich silt, and the Landslide Deposits are described as clay, silt, sand, and gravel. Our explorations generally encountered surficial topsoil and fill soils underlain by native soils consistent with the description of Vashon Till at depth.

Explorations: Subsurface conditions within the site were explored on November 11, 2015 by excavating three test pits with a small, rubber-tracked hydraulic excavator to a maximum depth of about 2 feet below the existing ground surface on the lower terrace. 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 4. The logs of our test pits are attached to this report and are presented as Figure 5. 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.

We encountered approximately 6 inches of topsoil at the surface at all three test pit locations. Underlying the topsoil in test pit TP-1, we encountered approximately 6 inches of loose to medium dense, gray, silty fine to medium sand with gravel which we interpreted as weathered glacial till soils. Underlying the topsoil in test pits TP-2 and TP-3, we encountered approximately 6 to 9 inches of loose, brown-gray, silty fine sand to sandy silt with gravel and roots. We interpreted these soils as fill soils. Underlying the weathered glacial till soils in test pit TP-1 and the fill soils in test pits TP-2 and TP-3, we encountered dense to very dense, brown to olive-brown, silty fine sand with gravel and scattered roots. We interpreted these soils as glacial till soils.

The excavator encountered practical refusal within approximately 3 to 6 inches of penetration into the undisturbed glacial till. Test pit TP-1 was located on the cut face between the upper and lower terraces resulting in an effective profile depth of about 4¼ feet despite reaching refusal attempting to excavate into the slope. Test pits TP-1, TP-2, and TP-3 were completed within the glacial till soils at respective depths of 4¼, 1¼, and 2 feet below the existing ground surface.

To evaluate subsurface conditions on the upper terrace and at other locations inaccessible to the excavator, the engineer used a T-shaped steel probe to qualitatively assess soil characteristics. The T-probe was inserted into the ground at multiple locations, penetrating the soil until meeting refusal under full body weight. Within the upper terrace, the T-probe penetrated the top 9 to 15 inches under light to moderate pressure with an abrupt contact at refusal. The interpreted soil profile is loose/soft soils as topsoil and disturbed native or fill soils overlying dense to very dense glacial till based on soils encountered in the test pits. Similar conditions were encountered below the lower terrace except the depth to refusal was more variable, ranging from about 3 to 18 inches and averaging about 9 inches. The 18 inches of loose soil was located on the outside shoulder of the pioneer road where it turns northward onto the lower terrace.

Hydrologic Conditions

Ponded water was present within an enclosed depression at the base of the slope at the southeast corner of the site and on the lower terrace. Very wet to saturated soils are present throughout most of the lower terrace, on the upper terrace, and the area surrounding the enclosed depression. All overly wet soils encountered at the site were located in areas that had been previously disturbed and graded to a relatively level condition. Based on our observations, it appears that the primary sources of the ponded water are the several drainage pipes discharging onto the site.

Groundwater seepage that could not be attributed to the drainage pipes was not encountered in our explorations. Based on topography and geologic conditions, we would expect to find groundwater seepage at the interface between glacial till and overlying soils. This water would be interpreted to be perched water. Perched water occurs when surface water infiltrates through less dense, more permeable soils and accumulates on top of a relatively low permeability material. 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.

SENSITIVE AREA EVALUATION

Seismic Hazard

Hazards associated with seismic activity include liquefaction potential and amplification of ground motion by soft deposits. Liquefaction is caused by a rise in pore pressures in a loose, fine sand deposit beneath the groundwater table. The competent glacial soils interpreted to underlie the site have a low potential for liquefaction or amplification of ground motion.

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. We expect the erosion hazard for site soils with a vegetative cover to be slight but increases to moderate when the surface is exposed and unprotected. The erosion hazard for exposed soils on steep slopes would be classified as moderate for the dense, undisturbed glacial till soils to severe for the overlying loose soils.

Landslide Hazard/Slope Stability

The criteria used for evaluation of landslide hazards include soil type, slope gradient, and groundwater conditions. The property is generally situated on moderately to steeply sloping ground. The steeper slope within the southern third of the site and in the SR 522 right-of-way is generally south-facing with an approximate average gradient of 40 degrees (84 percent). We did not observe evidence of significant slope instability during our investigation, such as deep-seated landsliding.

Relatively shallow sloughing failures as well as surficial erosion are natural processes and should be expected on the steeper slopes within the property during extreme weather conditions. It is our opinion that while there is potential for erosion, soil creep, and shallow failures within the loose surficial soils on the slope, there is not a significant potential for deep-seated slope failure under current site conditions. Proper site grading, drainage, and foundation placement as recommended in this report should help reduce the impact of such events on the planned improvements.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion that the preliminary planned development within the property is feasible from a geotechnical standpoint. Our explorations generally encountered dense to very dense native glacial soils at shallow depths. The native glacial soils encountered should provide adequate support for foundation and slab loads. We recommend that the new structure be designed utilizing shallow conventional foundations. Footings should extend through any undocumented fill or loose soil, and be founded on the underlying dense to very dense native soil, or structural fill extending to these soils. The dense to very dense soil should typically be encountered approximately 1 to 2 feet below the existing ground surface, based on our explorations. The downhill foundation line, however, should be embedded a minimum of four feet into competent native soils and should be setback at least 15 feet from top of the SR 522 right-of-way.

All grading operations and drainage improvements included as part of this development should be planned and completed in a matter that enhances the stability of the site slopes, not reduces it. We recommend that where the access drive traverses the steeper slope that it be constructed by excavating into the hillside only; placing fill on the slope should be avoided. From our casual observations, the existing pioneer road happens to utilize actual topographic conditions to great advantage. It appears that the amount of earthwork will be kept to near a minimum if the access drive can be located on the same approximate alignment.

Excavation spoils should not be stockpiled near or on sloping ground or be allowed to encroach on the slopes. Also, runoff generated within the site should be collected and routed into a permanent discharge system and not be allowed to flow over the slopes. Future vegetation management on the slopes should be the subject of a specific evaluation and a plan approved by the City of Lake Forest Park. We recommend that the trees on the slope be evaluated by a certified arborist, and hazardous trees on the slope that may endanger the residences be removed prior to residence construction. The slopes should be monitored on an on-going basis, especially during the wet season, for any signs of instability, and corrective actions promptly taken should any signs of instability be observed.

The soils encountered on this site are considered moisture-sensitive and could disturb when wet. To lessen the potential impacts of construction on the slopes and to reduce cost overruns and delays, we recommend that construction take place during the drier summer months. If construction takes place during the rainy months, additional expenses and delays should be expected. Additional expenses could include the need for placing erosion control and temporary drainage measures to protect the slopes, the need for placing a blanket of rock spalls on exposed subgrades, and construction traffic areas prior to placing structural fill, and the need for importing all-weather material for structural fill.

Under no circumstances, should water be allowed to flow over or concentrate on the site slopes, both during construction and after construction has been completed. We recommend that stormwater runoff from the roof and yard drains be collected and tightlined to a suitable discharge point. The slopes should be protected from erosion. We recommend that all disturbed areas be replanted with vegetation to re-establish vegetation cover as soon as possible. Specific recommendations for erosion control are presented in the **Erosion Control and Slope Protection Measures** subsection of this report.

Erosion Control and Slope Protection Measures

The erosion hazard for the on-site soils is listed as slight to moderate, 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 straw bales should be erected to prevent muddy water from leaving the site or flowing over the slopes. Stockpiles should be covered with plastic sheeting during wet weather. 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.

Protection of 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 removal of the existing vegetation. Trees should not be cut down or removed from the slopes unless a mitigation plan is developed, such as the replacement of vegetation for erosion protection. Vegetation should not be removed from the slopes. Replacement of vegetation should be performed in accordance with City of Lake Forest Park code.

Site Preparation and Grading

After erosion control measures are implemented, site preparation should start by removing all unauthorized drainage pipes conveying water onto or across the subject property. Neighboring property owners should take the necessary steps to replace the drain lines and re-route them to appropriate points of discharge. If the schedule allows, NGA recommends that a cutoff or French drain be constructed along the north property line concurrent or shortly following the removal of the surface drain pipes. Ideally the trench should be constructed well in advance of final site grading to provide time for the overly wet soils to drain,. The trench should be located at the base of the slope along the north edge of the upper terrace. The bottom of the trench should penetrate at least 1 foot into the dense glacial till to help drain water off of the upper terrace. If drainage improvements can be made well in advance of full site development, draining the lower terrace should also be included. Improvement to the lower terrace may consist of grading the soils to create open swales sloped to carry water off of the terrace or additional French drains. All collected waters should be routed to one or more drain pipes that are tightlined down the slope to appropriate discharge points.

Following improvements to surface drainage, further site preparation should consist of stripping vegetation and organic-laden topsoil from areas to be developed and removing fill or loose native soils to expose dense to very dense native soil in foundation, slab-on-grade, and pavement areas. If loose soils are encountered at the finish subgrade elevation, these soils should be removed and replaced with granular structural fill or rock spalls.

Stripped materials should be removed from the site. At the time of our evaluation, the existing fill and loose surficial soils were overly wet and not suitable for re-use. If the soils have dried back to near their

optimum moisture content for compaction at the time they are excavated, they may be stockpiled for later use as landscaping fill. Stockpiles should be kept away from steep slopes and should be covered with plastic during wet weather.

If water is encountered during construction, flows should be diverted around areas to be developed, and the exposed subgrades should be maintained in a semi-dry condition. If site work is conducted during the wetter late fall, winter, and early spring months, exposed subgrades should be covered with a layer of crushed rock as soon as it is exposed to protect the moisture sensitive soils from disturbance by machine or foot traffic during construction.

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 water 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 soil and groundwater conditions encountered, and able to monitor the nature and condition of the cut slopes.

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 in the loose/soft surface soils be no steeper than 2 Horizontal to 1 Vertical (2H:1V). Excavations in undisturbed dense to very dense glacial till soils may be sloped at 1H:1V. We recommend that cut slopes be protected from erosion. The slope protection measures may include covering cut slopes with plastic sheeting and diverting surface runoff away from the top of cut slopes. Shallow excavations for underground utilities that will be open for a short time may be excavated with vertical sidewalls. We do not recommend vertical slopes for cuts deeper than four feet, if worker access is necessary. Cut slope heights and inclinations should conform to appropriate OSHA/WISHA regulations. If these temporary cut slopes are not feasible due to boundary constraints, more elaborate shoring systems should be considered after consultation with NGA.

Permanent cut and fill slopes should be no steeper than 2H:1V. Flatter inclinations may be required in areas where loose soils are encountered. Permanent slopes should be vegetated and the vegetative cover maintained until established. Steeper inclinations cut into glacial till are possible but these slopes should

be protected with rockeries or other surfacing more durable than vegetation. NGA should be consulted for rockery design and we should specifically review all plans for grading near or on steep slopes for this project.

Foundation Support

Conventional shallow spread foundations should be placed on dense to very dense native soils, or be supported on structural fill or rock spalls extending to those soils. We expect dense soils will be encountered approximately 1 to 2 feet below the existing ground surface based on our explorations. Where undocumented fill or less dense soils are encountered at footing bearing elevation, the subgrade should be over-excavated to expose suitable bearing soil. If footings are supported on structural fill, the fill zone should extend outside the edges of the footing a distance equal to one-half of the depth of the over-excavation below the bottom of the footing. The downhill foundations line should be embedded a minimum of four feet into competent soils and setback at least 15 feet from the adjacent right-of-way.

Footings should extend at least 18 inches below the lowest adjacent finished ground surface for frost protection and bearing capacity considerations. Foundations should be designed in accordance with the 2012 IBC. Footing widths should be based on the anticipated loads and allowable soil bearing pressure. Water should not be allowed to accumulate in footing trenches. All loose or disturbed soil should be removed from the foundation excavation prior to placing concrete.

For foundations constructed as outlined above, we recommend an allowable design bearing pressure of not more than 2,000 pounds per square foot (psf) be used for the design of footings founded on dense or better native soils or structural fill extending to the competent native material. The foundation bearing soil should be evaluated by a representative of NGA. We should be consulted if higher bearing pressures are needed. Current IBC guidelines should be used when considering increased allowable bearing pressure for short-term transitory wind or seismic loads. Potential foundation settlement using the recommended allowable bearing pressure is estimated to be less than one-inch total and ½-inch differential between adjacent footings or across a distance of about 20 feet, based on our experience with similar projects.

Lateral loads may be resisted by friction on the base of the footing and passive resistance against the subsurface portions of the foundation. A coefficient of friction of 0.35 may be used to calculate the base friction and should be applied to the vertical dead load only. Passive resistance may be calculated as a triangular equivalent fluid pressure distribution. An equivalent fluid density of 200 pounds per cubic foot (pcf) should be used for passive resistance design for a level ground surface adjacent to the footing. This level surface should extend a distance equal to at least three times the footing depth. These recommended

values incorporate safety factors of 1.5 and 2.0 applied to the estimated ultimate values for frictional and passive resistance, respectively. To achieve this value of passive resistance, the foundations should be poured "neat" against the native medium dense or better soils or compacted fill should be placed against the footing. We recommend that the upper one-foot of soil be neglected when calculating the passive resistance.

Retaining Walls

We anticipate that basement or retaining walls between the upper and lower terraces may be incorporated into the design. 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, and the inclination of the backfill. 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 loads, slopes, or other surface loads. We could consult with the structural engineer regarding additional loads on retaining walls during final design, if needed.

The lateral pressures on walls may be resisted by friction between the foundation and subgrade soil, and by passive resistance acting on the below-grade portion of the foundation. Recommendations for frictional and passive resistance to lateral loads are presented in the **Foundations** subsection of this report.

All wall backfill should be well compacted as outlined in the **Structural Fill** subsection of this report. 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 eight-inch loose lifts and compacting the backfill 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. The recommended level of compaction should still be maintained.

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 observe installation of the drainage systems.

Slab-on-Grade

Slabs-on-grade should be supported on subgrade soils prepared as described in the **Site Preparation and Grading** subsection of this report. We recommend that all floor slabs be underlain by at least six inches of free-draining gravel with less than three percent by weight of the material passing the U.S. No. 200 sieve 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 is optional and is intended to protect the vapor barrier membrane during construction. We have provided additional recommendations regarding this system in the **Subsurface Drainage** subsection of this report.

Pavement

Pavement subgrade preparation and structural fill placement where required, should be completed as recommended in the **Site Preparation and Grading** and **Structural Fill** subsections of this report. The pavement subgrade should be proof-rolled with a heavy, rubber-tired piece of equipment, to identify soft or yielding areas that require repair. We should be retained to observe the proof-rolling and recommend subgrade repairs prior to placement of the asphalt or hard surfaces.

Structural Fill

General: Fill placed beneath foundations, slabs, pavements, or other settlement-sensitive structures 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 suitably prepared as described in the **Site Preparation and Grading** subsection prior to beginning fill placement. Sloping ground to receive fill should be benched to maintain fill stability. The benches should be level and have a minimum width of 6 feet.

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 structural fill should contain no more than 5-percent fines (soil finer than U.S. No. 200 sieve, based on that fraction passing the U.S. 3/4-inch sieve). The use of some of the on-site soils as structural fill may be feasible but will be highly dependent on moisture content of the material at the time construction takes place. We should be retained to evaluate proposed structural fill material prior to placement.

Fill Placement: Following subgrade preparation, placement of structural fill may proceed. All filling should be accomplished in uniform lifts up to 8 inches thick. Each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill 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 2 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.

Site Drainage

Surface Drainage: Final site grades should allow for drainage away from steep slopes and away from the planned residence. 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 building. Runoff generated on this site should be collected and routed into a permanent discharge system. This should include all downspouts and runoff generated on all hard surfaces and yards areas. Under no circumstances should water be allowed to flow uncontrolled over the slopes. Water should not be allowed to collect in any area where footings or slabs are to be constructed.

Subsurface Drainage: If groundwater is encountered during construction, we recommend that the contractor slope the bottom of the excavation and collect the water into ditches and small sump pits where the water can be pumped out of the excavation and routed into a suitable outlet. We recommend that the residence down spouts and footing drains be tightlined to an appropriate discharge location.

We recommend the use of footing drains around structures. Footing drains should be installed at least one foot below planned finished floor elevation. The drains should consist of a minimum 4-inch-diameter, rigid, slotted or perforated, PVC pipe surrounded by free-draining material wrapped in a filter fabric. We recommend that the free-draining material consist of an 18-inch-wide zone of clean (less than 3-percent

fines), granular material placed along the back of walls. Washed rock is an acceptable drain material, or drainage composite may be used instead. The free-draining material should extend up the wall to 1 foot below the finished surface. The top foot of soil 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 wall or footing drains.

CONSTRUCTION MONITORING

We recommend that we be retained to provide construction monitoring services to evaluate conditions encountered in the field with respect to anticipated conditions, to provide recommendations for design changes should the conditions differ from anticipated, and to evaluate whether construction activities comply with contract plans and specifications.

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.

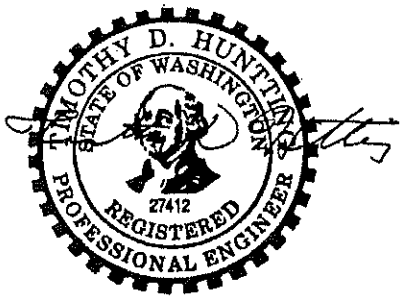
Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this report was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and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

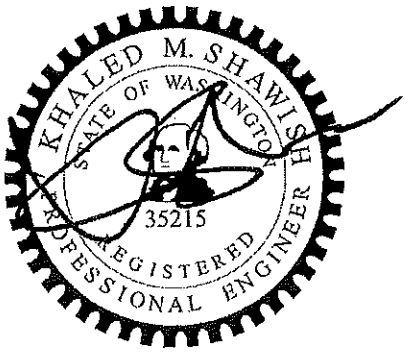
Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.



Exp. March 26, 2017

Timothy D. Huntting, PE
Senior Engineer



Exp. July 28, 2017

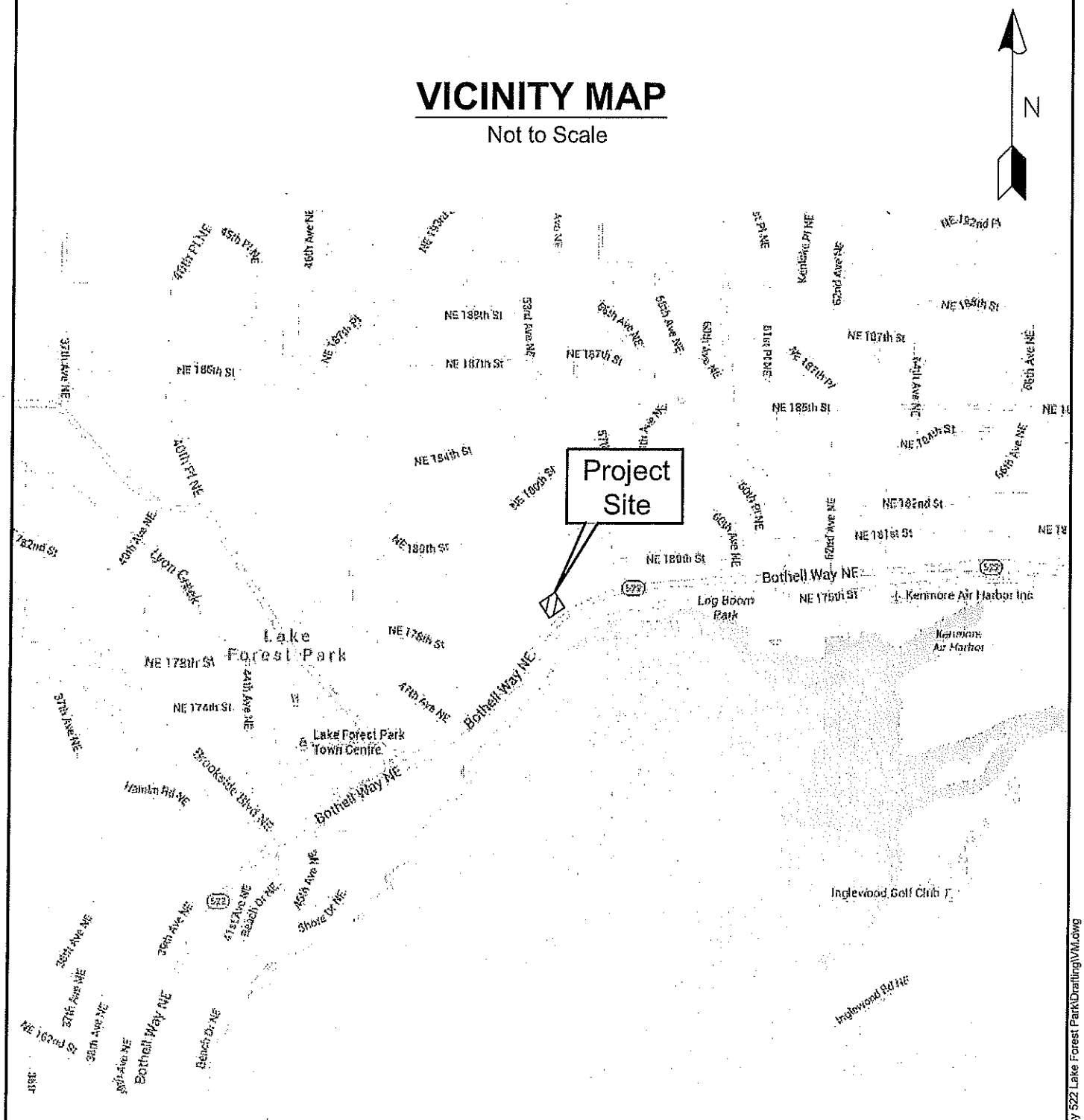
Khaled M. Shawish, PE
Principal

TDH:KMS:dy

Five Figures Attached

VICINITY MAP

Not to Scale



Lake Forest Park, WA

Project Number 941815	SFR SR-522 Lake Forest Park Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
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	1	12/2/15	Original	DPN	TDH

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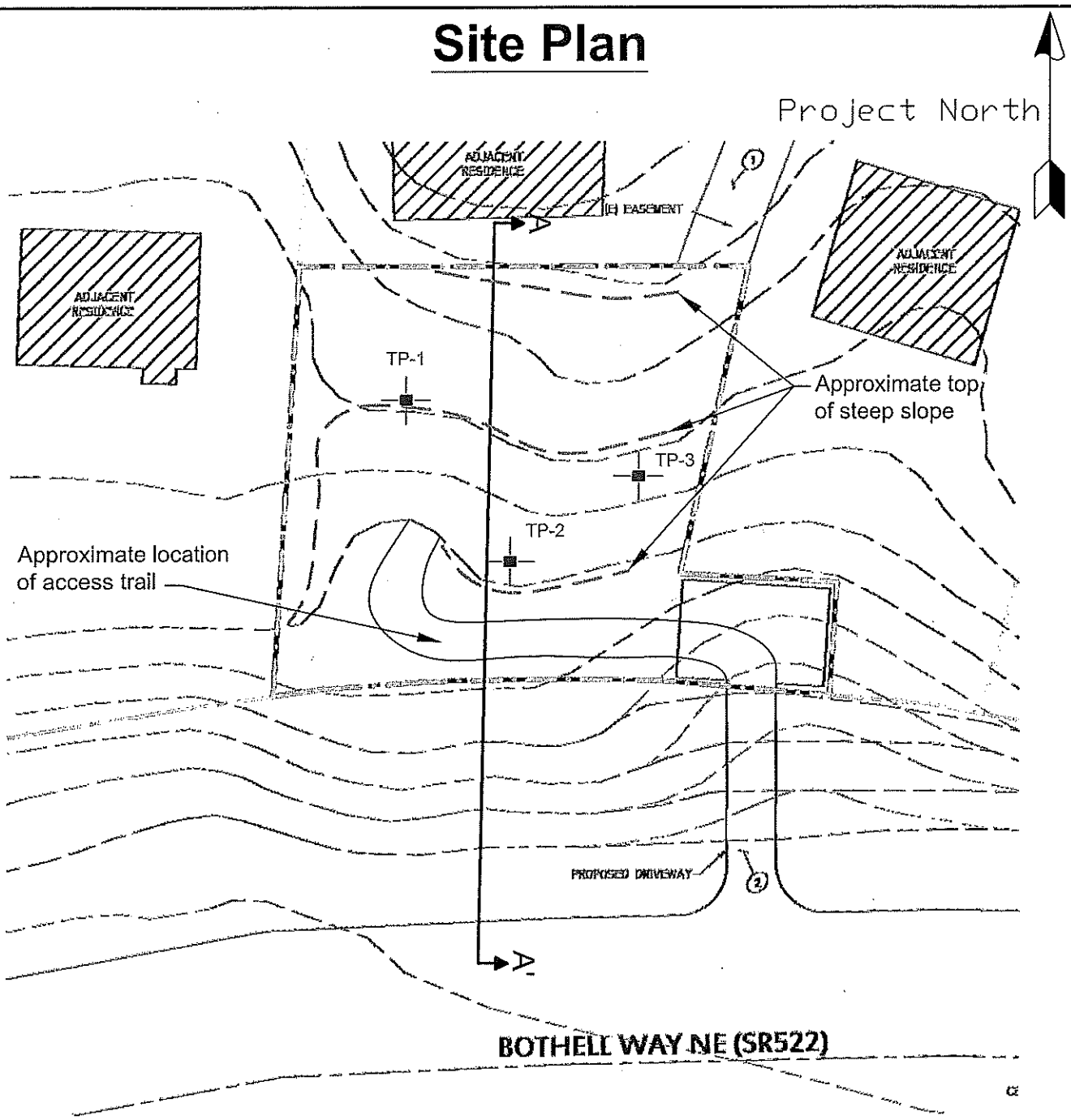
Site Plan



LEGEND

Property line

TP-1

Number and approximate location of test pit

A A'

Approximate location of cross-section

0 30 60

Scale: 1 inch = 30 feet

Reference: Site Plan based on plan dated August 5, 2015 titled "A New Single Family Residence," prepared by Yen Design, Inc.

Project Number 941815	Single Family Residence SR-522 - Lake Forest Park Site Plan	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 2		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	1	12/2/15	Original	DPN	TDH

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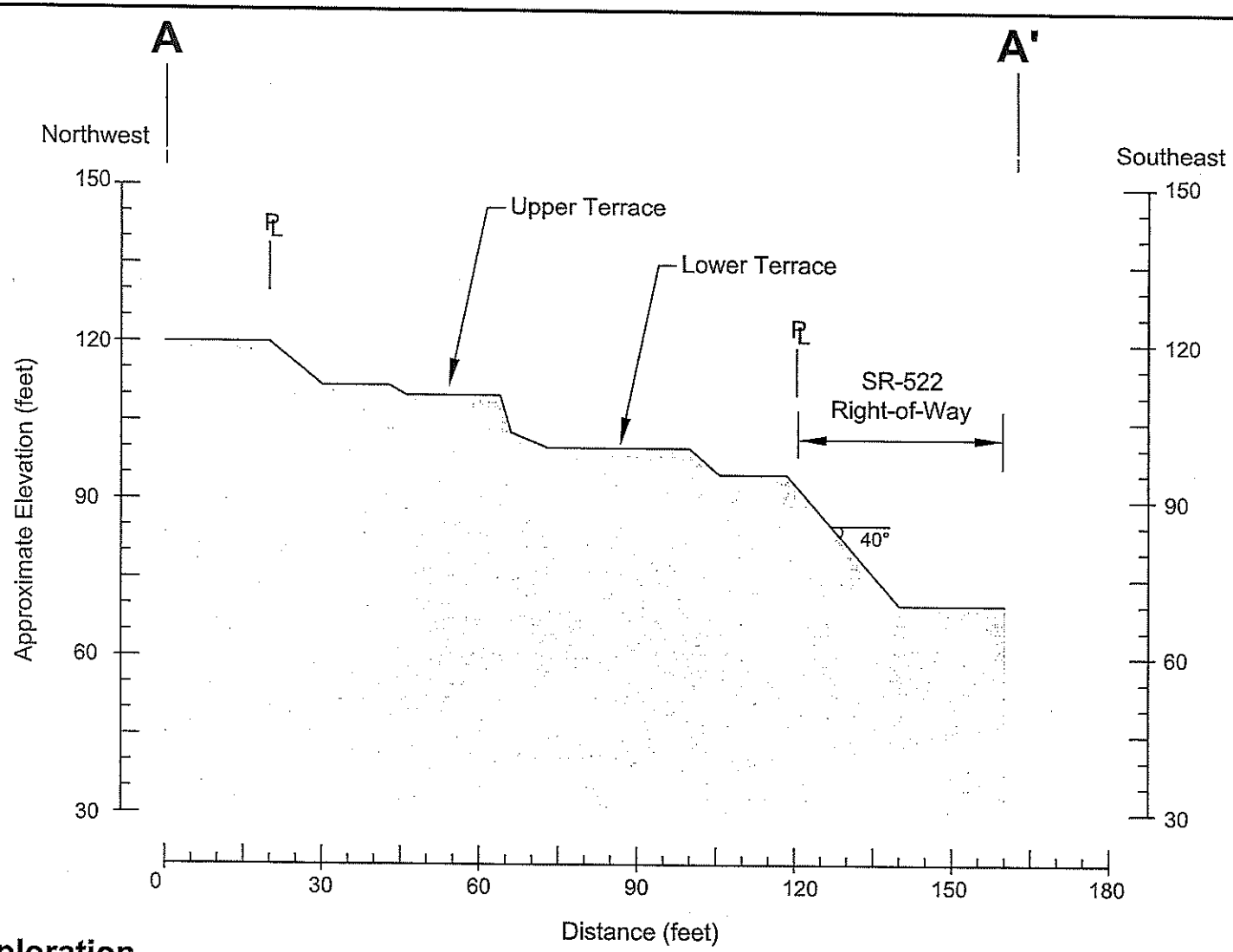

Exploration

Hand Auger Designation → HA-1

Groundwater Level During Exploration →

Geologic Contact (approximate) → ? — — ?

NOTES:
1) Stratigraphic conditions are interpolated between the explorations. Actual conditions may vary.
2) Elevations are approximate.

Reference: Cross Section is based on field measurements using a hand-held clinometer and 100-ft tape measure.

Project Number 941815

Figure 3

Single Family Residence
SR-522 - Lake Forest Park
Cross-Section A-A'

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
17311-135th Ave. NE, A-300
Woodinville, WA 98072
(425) 485-1586 / Fax 481-2510
437 East Penny Road
Wenatchee, WA 98801
(509) 665-7696

No.	Date	Revision	By	CK
1	12/2/15	Original	DPN	TDH

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UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50 % RETAINED ON NO. 200 SIEVE	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
	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 MORE THAN 50 % PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50 %	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	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 941815	Single Family Residence SR-522 - Lake Forest Park Soil Classification Chart	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 4		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	1	12/2/15	Original	DPN	TDH

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Test Pit TP-1

Depth (feet)	USCS	Description	Sample No./Depth (feet)
0 – ½		Gray-brown, sandy SILT with roots and organic matter (soft, wet) (**Topsoil**)	
½ – 1	SM	Gray, silty fine to medium SAND with gravel (loose, moist to wet)	1 / ½
1 – 4¼	SM	Olive-brown, silty fine SAND with gravel and scattered roots (dense to very dense, moist) (**Glacial Till**)	2 / 2½

Test pit terminated at a depth of about 4¼ feet on 11/19/15 due to practical refusal on dense, compact soil.
No groundwater seepage observed.
No sidewall caving observed.

Test Pit TP-2

Depth (feet)	USCS	Description	Sample No./Depth (feet)
0 – ½		Dark gray-brown, silty fine SAND to sandy SILT with gravel, roots and organic matter (loose/soft, wet) (**Topsoil**)	
½ – 1	SM	Brown-gray, silty fine SAND with gravel (loose, wet) (**Fill**)	1 / ¾
1 – 1¼	SM	Olive-brown, silty fine SAND with gravel (very dense, moist) (**Glacial Till**)	

Test pit terminated at a depth of about 1¼ feet on 11/19/15 due to practical refusal on dense, compact soil.
Minor groundwater seepage observed at about 1 foot.
No sidewall caving observed.

Test Pit TP-3

Depth (feet)	USCS	Description	Sample No./Depth (feet)
0 – ½		Black to dark gray-brown, silty fine SAND with roots and organic matter (very soft/very loose, wet) (**Topsoil**)	
½ - 1¼	SM/ML	Brown-gray, silty fine SAND to sandy SILT with gravel and roots (soft/loose, wet) (**Fill**)	1 / 1
1¼ - 2	SM	Brown, silty fine SAND with gravel (dense to very dense, moist) (**Glacial Till**)	2 / 2

Test pit terminated at a depth of about 2 feet on 11/19/15 due to practical refusal on dense, compact soil.
Minor groundwater seepage observed from ½ foot to 1¼ feet.
Minimal sidewall caving observed within topsoil.