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May 5, 2022

JN 21024

Upright Construction
18827 – 53rd Avenue Northeast
Lake Forest Park, Washington 98155

Attention: Brian Highberger

Subject: **Transmittal Letter – Geotechnical Engineering Study**
Proposed Residence
3333 Northeast 202nd Street
Lake Forest Park, Washington

Dear Mr. Highberger, *via email:* *brian@uprightconstruction.com*

Attached to this transmittal letter is our geotechnical engineering report for the proposed residence to be constructed in Lake Forest Park. The scope of our services consisted of exploring site surface and subsurface conditions, and then developing this report to provide recommendations for general earthwork and design considerations for foundations, retaining walls, subsurface drainage, and temporary excavations. This work was authorized by your acceptance of our proposal, dated August 13, 2021.

The attached report contains a discussion of the study and our recommendations. Please contact us if there are any questions regarding this report, or for further assistance during the design and construction phases of this project.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

James H. Strange, P.E.
Associate

MKM/JHS:kg

GEOTECHNICAL ENGINEERING STUDY
Proposed Residence
3333 Northeast 202nd Street
Lake Forest Park, Washington

This report presents the findings and recommendations of our geotechnical engineering study for the site of the proposed residence to be located in King County.

Development of the property is in the planning stage, and detailed plans were not available to us at the time of this study. A topographic survey was provided to us, prepared by ALL Land Surveying, dated January 29, 2021. Based on the survey, and conversations with the client, we understand that a new residence is proposed to be constructed in place of the existing house. The new residence will likely be two stories in height and will be set north of the footprint of the existing house.

If the scope of the project changes from what we have described above, we should be provided with revised plans in order to determine if modifications to the recommendations and conclusions of this report are warranted.

SITE CONDITIONS

SURFACE

The Vicinity Map, Plate 1, illustrates the general location of the site in Lake Forest Park. The generally rectangular shaped site has approximate dimensions of 185 to 195.9 feet in the north-south direction, and 119 feet in the east-west direction. The site has frontage along Northeast 202nd Street, and is bordered to the east, south and west by single family parcels.

The grade across the site slopes downward from north to south, with a total elevation change of 36 feet across the site bounds. Initially, the grade slopes downward from the eastern and western sides of the northern edge of the site, into the driveway alignment. The driveway carries out relatively flat, continuing to the footprint of the existing, two-story house, located in the approximate center of the site. The grade continues to drop gently across the house footprint, carrying out gently across a shop building and small shed located south of the house. The grade continues to drop gently past the south side of the shop, and to the east of the residence, before dropping moderately steeply downward to the eastern and southern property lines. While the southwestern portion of this slope within the site bounds is only sloped moderately, the remainder of the southeastern portion of the slope is inclined from approximately 50 to 60 percent over elevation changes of 20 to 34 feet before bottoming out in the adjacent southern and eastern parcels.

While the Lake Forest Park GIS does not map any critical areas on the subject site, some of the site's characteristics would meet the criteria for several critical areas based on the Lake Forest Park Municipal Code. Much of the southern side of the site is sloped in excess of 15 percent and would be classified as an Erosion Hazard Area. In addition, the southern and southeastern slopes are inclined in excess of 40 percent over elevation changes in excess of 10 feet and would meet the criteria for both a Steep Slope Hazard Area and Class III Landslide Hazard Area. These critical area designations carry certain development restrictions and will be discussed later in the report.

The adjacent eastern, southern, and western parcels are all developed with single family residences. The adjacent eastern and western parcels both contain residences located within 10 feet of the property lines and are set at similar elevations to the grade of the subject site. The adjacent southern parcel also contains a residence located near the toe of the moderately to steeply inclined slope.

SUBSURFACE

The subsurface conditions were explored by excavating four test pits and drilling four test borings at the approximate locations shown on the Site Exploration Plan, Plate 2. Our exploration program was based on the proposed construction, anticipated subsurface conditions and those encountered during exploration, and the scope of work outlined in our proposal.

The test pits were excavated on January 7, 2021 and October 14, 2021 with tracked excavators. A geotechnical engineer from our staff observed the excavation process, logged the test pits, and obtained representative samples of the soil encountered. "Grab" samples of selected subsurface soil were collected from the backhoe bucket. The Test Pit Logs are attached to this report as Plates 3 and 4

The test borings were drilled on September 17, 2021 using a track-mounted, hollow-stem auger drill. Samples were taken at approximate 2.5 and 5-foot intervals with a standard penetration sampler. This split-spoon sampler, which has a 2-inch outside diameter, is driven into the soil with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler a given distance is an indication of the soil density or consistency. A geotechnical engineer from our staff observed the drilling process, logged the test borings, and obtained representative samples of the soil encountered. The Test Boring Logs are attached as Plates 4 through 7.

Soil Conditions

Test Pits 2 and 3 as well as Borings 2, 3, and 4 were conducted surrounding the existing house, and encountered similar subsurface conditions. Beneath a thin layer of topsoil, these explorations encountered a layer of loose and medium-dense sand, slightly silty sand, and silty sand ranging in thickness from 2.5 to 6 feet in depth. Dense sand and silty sand were revealed beneath this depth, becoming very dense beneath depths of 2.5 to 10 feet. The very dense soils were observed to be glacially compressed and are geologically referred to as glacial till. The very dense glacial till continued to the base of these explorations at depths of 6.5 to 11 feet.

Test Pits 1 and 4 as well as Test Boring 1 were conducted south of the existing house, near the top of the southeastern steep slope. Beneath the ground surface, loose fill soil generally consisting of silty sand containing concrete rubble and metal debris was encountered. Test Pit 1 and Test Boring 1 met refusal within the rubble fill after several attempts to extend through the fill layer. Test Pit 4 was excavated with a larger excavator, and was able to work through the rubble, encountering the bottom of the fill layer at a depth of 12 feet beneath the existing grade. Native, loose to medium-dense silty sand was revealed beneath the fill, continuing to a depth of 14 feet. Medium-dense to dense sand was revealed beneath a depth of 14 feet continuing to the base of the test pit at a depth of 15 feet, which was the maximum reach of the excavator used.

Obstructions in the form of concrete rubble and metal debris were revealed in Test Pits 1 and 4 as well as Test Boring 1, causing the auger to refuse in the fill soils in the boring and Test Pit 1. Debris, buried utilities, and old foundation and slab elements are commonly encountered on sites that have had previous development.

Although our explorations did not encounter cobbles or boulders, they are often found in soils that have been deposited by glaciers or fast-moving water.

Groundwater Conditions

No groundwater seepage was observed during the excavation of the test pits, nor during the drilling of the borings. However, iron staining and rusting were observed in the native soils, indicating the potential for a seasonal, transient perched groundwater layer to develop with the fluctuating weather. This is a common observance within the Pacific Northwest.

It should be noted that groundwater levels vary seasonally with rainfall and other factors. We anticipate that groundwater could be found between the looser near-surface soil and the underlying glacial till.

The stratification lines on the logs represent the approximate boundaries between soil types at the exploration locations. The actual transition between soil types may be gradual, and subsurface conditions can vary between exploration locations. The logs provide specific subsurface information only at the locations tested. If a transition in soil type occurred between samples in the borings, the depth of the transition was interpreted. The relative densities and moisture descriptions indicated on the test pit and test boring logs are interpretive descriptions based on the conditions observed during excavation and drilling.

The compaction of test pit backfill was not in the scope of our services. The test pits were backfilled with excavated soil that was lightly tamped into place. Loose soil will therefore be found in the area of the test pits. If this presents a problem, the backfill will need to be removed and replaced with structural fill during construction.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

THIS SECTION CONTAINS A SUMMARY OF OUR STUDY AND FINDINGS FOR THE PURPOSES OF A GENERAL OVERVIEW ONLY. MORE SPECIFIC RECOMMENDATIONS AND CONCLUSIONS ARE CONTAINED IN THE REMAINDER OF THIS REPORT. ANY PARTY RELYING ON THIS REPORT SHOULD READ THE ENTIRE DOCUMENT.

The test pits and test borings conducted for this study generally encountered dense, native silty sand, glacial till, and sand at varying depths beneath the ground surface. The underlying glacial till is glacially compressed and is not susceptible to instability due to its high internal shear strength. All foundation loads for the new residence should bear on this competent native soil.

While competent soils were encountered in many of the explorations, based on the findings on Test Pits 1, 4, and Test Boring 1, it is apparent that the area southeast of the existing residence was filled at some time. Based on the condition of the house, it appears that a more recent addition had been constructed off the main footprint of the house, extending east from the old house foundation.

This area was likely filled prior to the construction of this addition and based on the depth of fill encountered in our explorations, this loose fill soil likely extends beneath the southeastern corner of the house. Evidence that this poorly compacted fill soil exists beneath the southeastern corner of the house can be observed in the form of a crack in the perimeter foundation along the eastern side of the addition foundation. It is likely that this soil will undergo slow consolidation over time as the fill layer compresses under its own weight, and from any structural loads placed atop the fill layer. New foundation loads should not bear on this variable, compressible fill soil.

Locating the new house north of the existing house will locate it outside of a majority of the deep fills at the site. Therefore, for much of the residence, the competent bearing soils were encountered at relatively shallow depths, and conventional foundations could be utilized. Overexcavations will likely be necessary in areas due to the varying depth the competent native soils were revealed. It will be important that all exposed bearing surfaces be kept free of any loose soils or debris. We recommend that all final foundation elevations be conducted with either a smooth bucket, grade bar, or flat blade shovel so that the subgrades can be scraped clean. It would also be prudent of the contractor to cover the base of the cleaned footing excavations with a thin layer of clean, angular rock such as ballast rock to protect the prepared subgrades from disturbance due to foot traffic and any perched water that may form during foundation construction. Typically, it is necessary for the project geotechnical engineer to verify that suitable bearing soils have been reached before placing protective rock. Additional recommendations can be found in the ***Conventional Foundations*** section of this report. For the foundations the new house, we recommend that the southern and eastern foundations be lowered to bear directly on the dense glacial till soils. Based on our test holes, this may require extending the stem walls and dropping the footings one the order of 5 feet below the existing grades.

If the proposed porch and deck do not expose the dense native soils, they may be overexcavated to the glacial till or supported by small diameter pipe piles. These pipe piles would be driven through the deep layer of loose, compressible fill soils, to refusal in the underlying glacially compressed soils. If necessary, we can provide pipe pile recommendations in the future.

The excavations for the new residence will vary depending on the final design. Based on the soils encountered in our explorations, a temporary excavation inclination of no steeper than a 1:1 (Horizontal:Vertical) is appropriate for this project. Vertical excavations should not be conducted near the property lines, or near any settlement sensitive structure. Unshored excavations should not extend beneath a 1.5:1 (H:V) line drawn extending downward from any adjacent foundation. Based on the scope of the project, we anticipate that the residence excavation will be able to be maintained within the property lines without the need for excavation easements or temporary shoring.

The soils that will be excavated for the new residence will consist of weathered, native, fine-grained, silty soil, and uncontrolled, variable fill soil containing rubble and debris. These soils are not free-draining and are exceedingly difficult to compact for use as structural fill. Considering this, we do not recommend that the onsite soils be reused for structural fill. Imported, clean, angular rock such as quarry spalls, ballast rock, or recycled concrete spalls should be used where structural fill is needed beneath the foundations, and free-draining, granular fill should be used where walls are to be backfilled.

Due to the presence of a steep slope south of the site, and the relatively shallow depth to glacial till, which is essentially impermeable, we recommend directing most of the runoff from the house to the north and do not recommend that concentrated infiltration or dispersion of collected stormwater runoff be used within 50 feet of the steep slopes. This appears attainable in the current design.

As stated above, the southern slope meets the criteria for both a Steep Slope Hazard Area and Landslide Hazard Area. The City of Lake Forest Park has certain restrictions regarding development on sites containing these hazards. The dense soils that underlie the site are not susceptible to deep seated instability. However, the looser weathered native soils, and the deep layer of loose fill soils encountered southeast of the existing house are potentially prone to future shallow instabilities, particularly following periods of extended precipitation, or following an earthquake. Per Lake Forest Park's Municipal Code, a buffer from the edges of these critical areas is required and can be reduced provided the stability of the slope is not reduced, and the development area, and adjacent developments are protected. As stated above, we recommend that the new residence foundations bear on a combination system of conventional shallow foundations bearing on the competent glacial till, which is not susceptible to deep-seated instability, and pipe piles driven to refusal in the underlying glacially compressed soils where the deeper fill layer was encountered near the southeastern side of the existing house. As discussed below in the ***Summary of Slope Stability Analysis*** section, there exists the potential for a shallow failure to extend beneath the residence during a theoretical landslide. This theoretical failure depth is measured to be 5 feet deep at the southern edge of the existing house. As stated below, to protect the proposed residence in the event of a future instability, all foundations along the southeastern and eastern building perimeter should be lowered a minimum of 5 feet beneath the existing ground surface, below the depth of the potential failure at this location. In doing this, and supporting all new foundations on the glacial till, a reduced total buffer of 40 feet (25-foot buffer and 15-foot setback) is appropriate from a geotechnical standpoint. This lowering of the southeastern portions of the foundations due to the loose fill soils, will protect the house from impacts from potential slope instability.

It should be noted that these recommendations are only to protect the proposed residence from damage due to future shallow instability. The proposed construction will place all new structural loads atop the glacial till, which is not susceptible to deep seated instability, however, the recommendations in this report will not act to increase the existing stability of the steep slope, and there exists the possibility that future instability on this slope could occur. Predicting the behavior of steep slopes is an inexact science, and a future landslide could affect the proposed residence. The current, and any future property owners should be made well aware that there exists at least some risk associated with owning property containing critical areas.

Even though portions of the site meet the criteria for an Erosion Hazard Area, the erosion potential at the site can be adequately managed with the implementation of a proper temporary erosion control system. The erosion control measures needed during the site development will depend heavily on the weather conditions that are encountered. We anticipate that a silt fence will be needed around the downslope sides of any cleared areas. During construction, existing pavements, ground cover, and landscaping should be left in place wherever possible to minimize the amount of exposed soil. Rocked staging areas and construction access roads should be provided to reduce the amount of soil or mud carried off the property by trucks and equipment. Trucks should not be allowed to drive off of the rock-covered areas. Cut slopes and soil stockpiles should be covered with plastic during wet weather. Following clearing or rough grading, it may be necessary to mulch or hydroseed bare areas that will not be immediately covered with landscaping or an impervious surface. On most construction projects, it is necessary to periodically maintain or modify temporary erosion control measures to address specific site and weather conditions.

The drainage and/or waterproofing recommendations presented in this report are intended only to prevent active seepage from flowing through concrete walls or slabs. Even in the absence of active seepage into and beneath structures, water vapor can migrate through walls, slabs, and floors from the surrounding soil, and can even be transmitted from slabs and foundation walls due to the concrete curing process. Water vapor also results from occupant uses, such as cooking, cleaning, and bathing. Excessive water vapor trapped within structures can result in a variety of undesirable conditions, including, but not limited to, moisture problems with flooring systems, excessively moist air within occupied areas, and the growth of molds, fungi, and other biological organisms that may be harmful to the health of the occupants. The designer or architect must consider the potential vapor sources and likely occupant uses, and provide sufficient ventilation, either passive or mechanical, to prevent a build up of excessive water vapor within the planned structure.

Geotech Consultants, Inc. should be allowed to review the final development plans to verify that the recommendations presented in this report are adequately addressed in the design. Such a plan review would be additional work beyond the current scope of work for this study, and it may include revisions to our recommendations to accommodate site, development, and geotechnical constraints that become more evident during the review process.

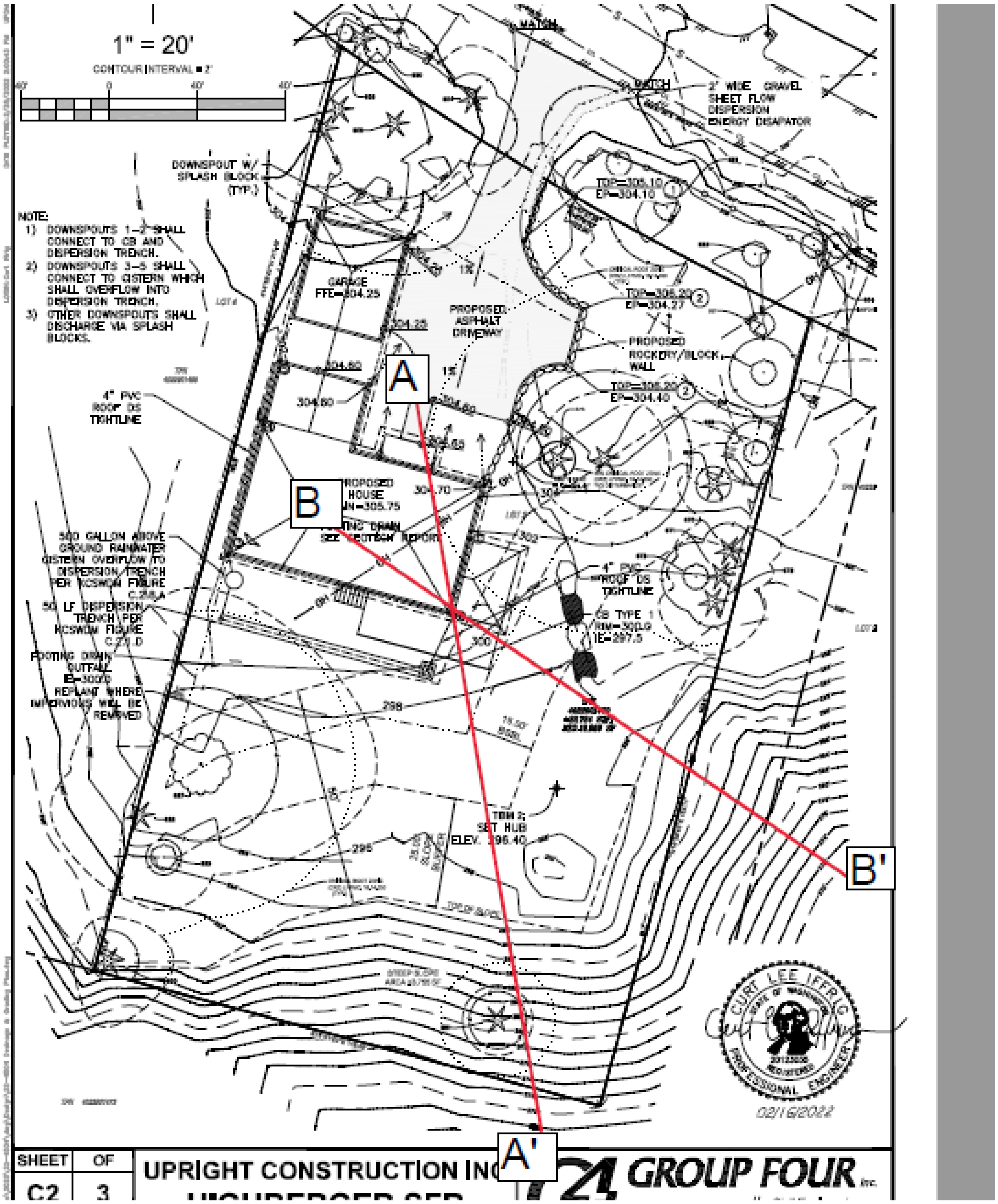
We recommend including this report, in its entirety, in the project contract documents. This report should also be provided to any future property owners so they will be aware of our findings and recommendations.

SUMMARY OF SLOPE STABILITY ANALYSES

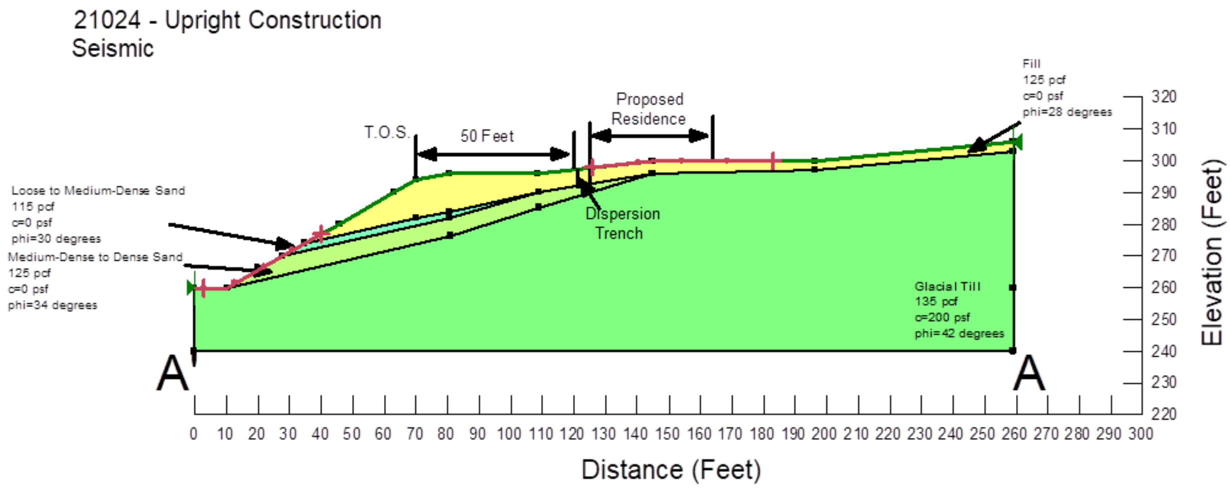
As part of the preparation of this report, we have conducted a slope stability analysis on two cross sections running through the area of the proposed development. Attached to this report are the results of our slope stability analyses using the program Slope/W under both static and seismic loading conditions.

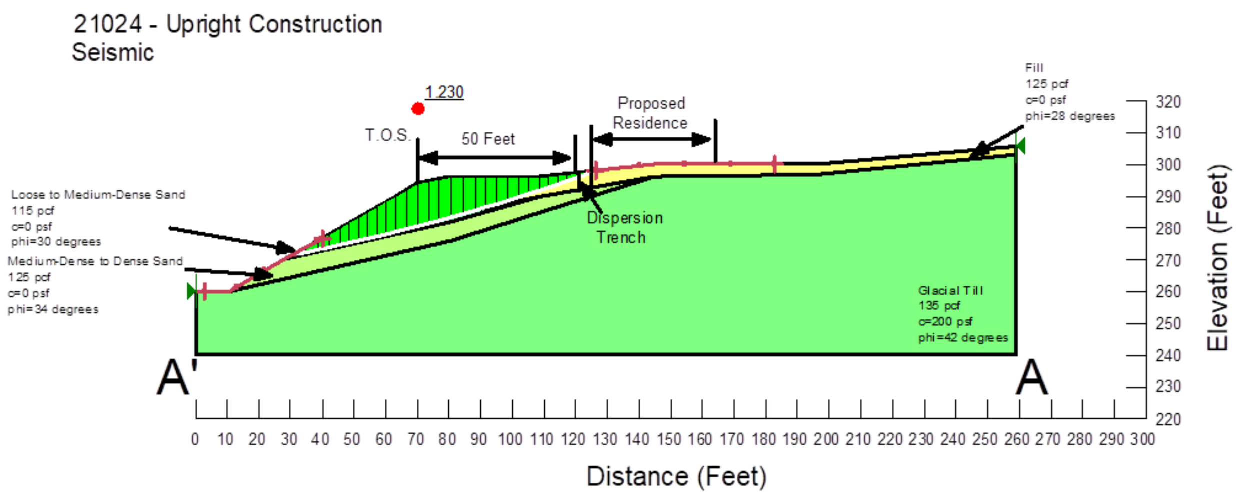
In order to meet the City of Lake Forest Park code minimums for static and dynamic scenarios, a minimum total buffer of 40 feet must be maintained from the top of the southern steep slope, as measured from the edge of the development area. Results of our slope stability analysis yielded factors of safety in excess of 1.9 and 1.2 for static and dynamic scenarios, respectively. These factors of safety exceed the City of Lake Forest Park code minimums (1.5 and 1.2 for static and dynamic scenarios, respectively). However, we still recommend that the southern and eastern perimeter foundation be lowered to bear directly on the dense glacial till soils, that are estimated to be on the order of 4-5 feet beneath the existing site grade. The referenced slope stability cross section locations and graphic results can be found on the following three pages.

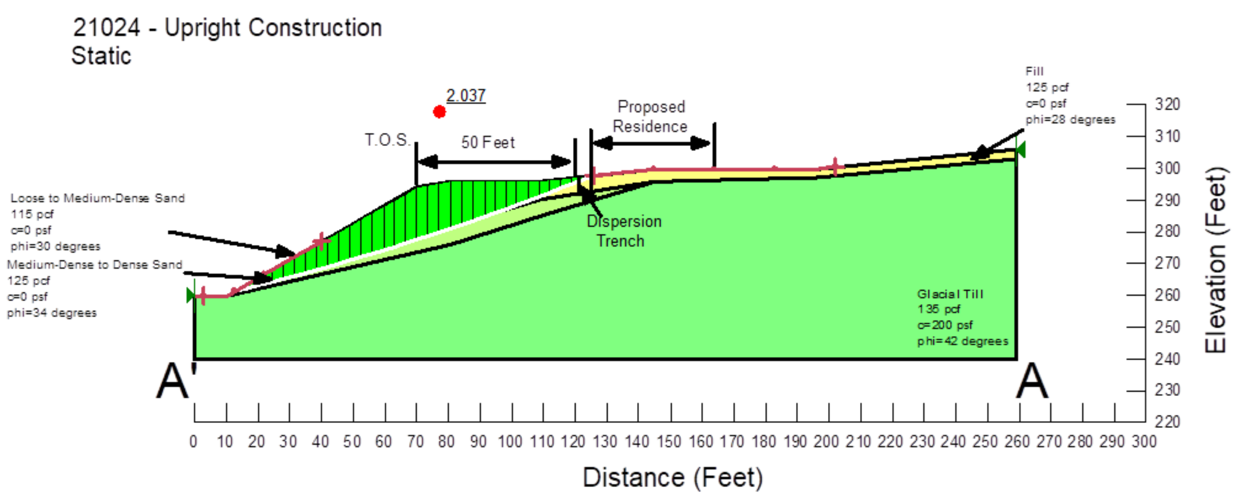
Slope Stability Sections



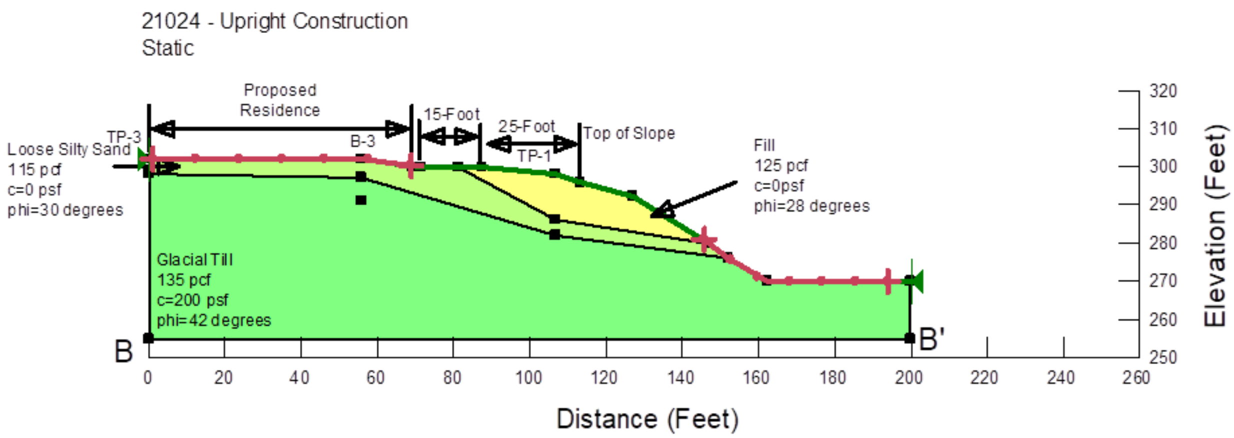
Section A-A'

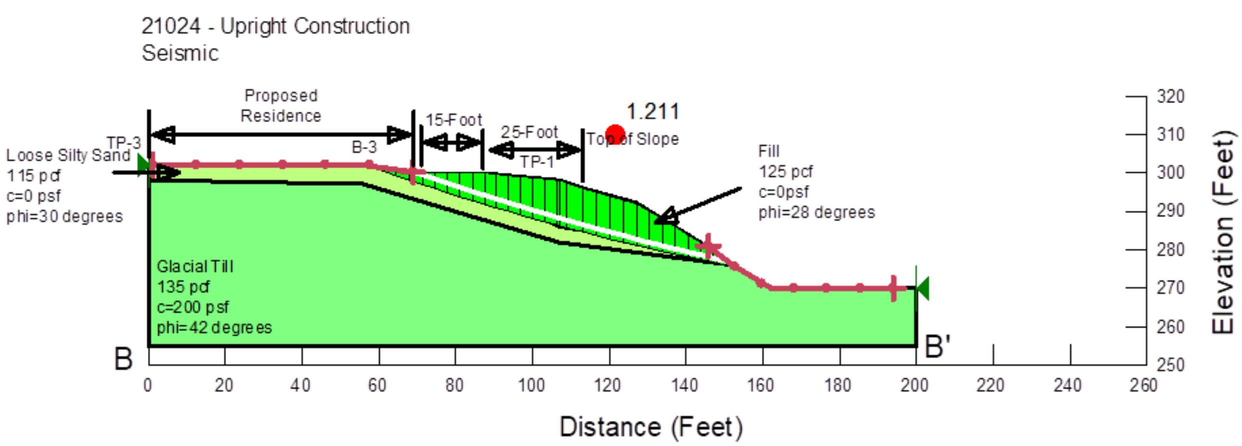

21024 - Upright Construction
Seismic
T.O.S.
50 Feet
Proposed Residence
Dispersion Trench
Loose to Medium-Dense Sand
115 pcf
c=0 psf
phi=30 degrees
Medium-Dense to Dense Sand
125 pcf
c=0 psf
phi=34 degrees
Fill
125 pcf
c=0 psf
phi=28 degrees
Glacial Till
135 pcf
c=200 psf
phi=42 degrees
A'
A
Distance (Feet)
Elevation (Feet)

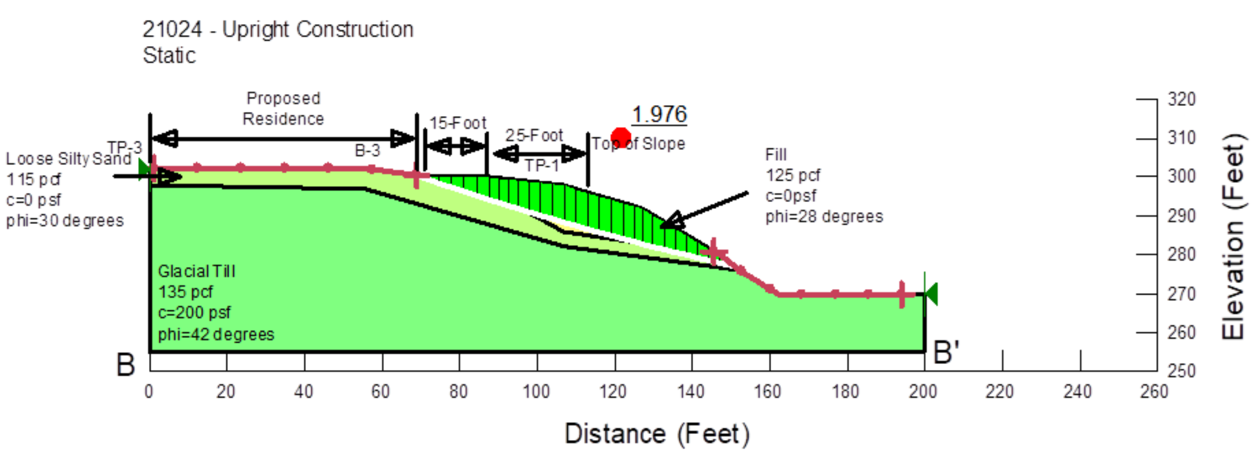

21024 - Upright Construction
Seismic
1.230
T.O.S.
50 Feet
Proposed Residence
Dispersion Trench
Loose to Medium-Dense Sand
115 pcf
c=0 psf
phi=30 degrees
Medium-Dense to Dense Sand
125 pcf
c=0 psf
phi=34 degrees
Fill
125 pcf
c=0 psf
phi=28 degrees
Glacial Till
135 pcf
c=200 psf
phi=42 degrees
A'
A
Distance (Feet)
Elevation (Feet)


21024 - Upright Construction
Static
2.037
T.O.S.
50 Feet
Proposed Residence
Dispersion Trench
Loose to Medium-Dense Sand
115 pcf
c=0 psf
phi=30 degrees
Medium-Dense to Dense Sand
125 pcf
c=0 psf
phi=34 degrees
Fill
125 pcf
c=0 psf
phi=28 degrees
Glacial Till
135 pcf
c=200 psf
phi=42 degrees
A'
A
Distance (Feet)
Elevation (Feet)

Section B-B'


21024 - Upright Construction
Static
Proposed
Residence
15-Foot
25-Foot
Top of Slope
TP-3
B-3
TP-1
Loose Silty Sand
115 pcf
c=0 psf
phi=30 degrees
Fill
125 pcf
c=0psf
phi=28 degrees
Glacial Till
135 pcf
c=200 psf
phi=42 degrees
B
B'
Distance (Feet)
Elevation (Feet)


21024 - Upright Construction
Seismic
1.211
Proposed
Residence
15-Foot
25-Foot
Top of Slope
TP-3
B-3
TP-1
Loose Silty Sand
115 pcf
c=0 psf
phi=30 degrees
Fill
125 pcf
c=0psf
phi=28 degrees
Glacial Till
135 pcf
c=200 psf
phi=42 degrees
B
B'
Distance (Feet)
Elevation (Feet)


21024 - Upright Construction
Static
1.976
Proposed
Residence
15-Foot
25-Foot
Top of Slope
TP-3
B-3
TP-1
Loose Silty Sand
115 pcf
c=0 psf
phi=30 degrees
Fill
125 pcf
c=0psf
phi=28 degrees
Glacial Till
135 pcf
c=200 psf
phi=42 degrees
B
B'
Distance (Feet)
Elevation (Feet)

Lake Forest Park Steep Slope Concerns

In accordance with LFPMC 16.16.040 (G), (J), and (W), - it is our opinion that a **Steep Slope Hazard Area** exists on the southern and eastern edges of the site as shown on the Grading and Drainage Plan (by Group 4 and dated 2/16/22) as the 40 percent steep slopes. The slope is over 10 feet tall and steeper than 40 percent. The site soils are permeable sands, so the slopes would be considered a **Class II Landslide Hazard Area**.

We have recommended a buffer reduction to 25 feet for the steep slope hazard area and landslide hazard areas on the southern and eastern edges of the site. A further recommendation for building setback of 15 feet for structures and 25 feet for dispersion systems is recommended. This recommendation was based on the soils encountered and the inclination and height of the slope. Per 16.16.290 and 16.16.310 it is our professional opinion that as long as the recommendations provided in our Geotechnical Engineering Study and future recommendations are followed, the buffer reduction will adequately protect the proposed development, adjacent developments, and uses and the steep slope and landslide hazard area.

SEISMIC CONSIDERATIONS

In accordance with the International Building Code (IBC), the site class within 100 feet of the ground surface is best represented by Site Class Type D (Stiff Soil). As noted in the USGS website, the mapped spectral acceleration value for a 0.2 second (S_s) and 1.0 second period (S_1) equals 1.26g and 0.49g, respectively.

The IBC and ASCE 7 require that the potential for liquefaction (soil strength loss) during an earthquake be evaluated for the peak ground acceleration of the Maximum Considered Earthquake (MCE), which has a probability of occurring once in 2,475 years (2 percent probability of occurring in a 50-year period). The MCE peak ground acceleration adjusted for site class effects (F_{PGA}) equals 0.51g. The glacially compressed soils beneath the site are not susceptible to seismic liquefaction under the ground motions of the MCE because of their dense nature and the absence of near-surface groundwater.

Sections 1803.5 of the IBC and 11.8 of ASCE 7 require that other seismic-related geotechnical design parameters (seismic surcharge for retaining wall design and slope stability) include the potential effects of the Design Earthquake. The peak ground acceleration for the Design Earthquake is defined in Section 11.2 of ASCE 7 as two-thirds (2/3) of the MCE peak ground acceleration, or 0.34g.

CONVENTIONAL FOUNDATIONS

With respect to the southeastern portion of the residence, the remainder of the proposed structure can be supported on conventional continuous and spread footings bearing on undisturbed, dense, native soil, or on structural fill placed above this competent native soil. See the section entitled ***General Earthwork and Structural Fill*** for recommendations regarding the placement and compaction of structural fill beneath structures. Prior to placing structural fill beneath foundations, the excavation should be observed by the geotechnical engineer to document that adequate bearing soils have been exposed.

We recommend that continuous and individual spread footings have minimum widths of 16 and 24 inches, respectively. Exterior footings should also be bottomed at least 18 inches below the lowest adjacent finish ground surface for protection against frost and erosion. The local building codes should be reviewed to determine if different footing widths or embedment depths are required. Footing subgrades must be cleaned of loose or disturbed soil prior to pouring concrete. Depending upon site and equipment constraints, this may require removing the disturbed soil by hand.

Depending on the final site grades, overexcavation may be required below the footings to expose competent native soil. Unless lean concrete is used to fill an overexcavated hole, the overexcavation must be at least as wide at the bottom as the sum of the depth of the overexcavation and the footing width. For example, an overexcavation extending 2 feet below the bottom of a 2-foot-wide footing must be at least 4 feet wide at the base of the excavation. If lean concrete is used, the overexcavation need only extend 6 inches beyond the edges of the footing. A typical detail for overexcavation beneath footings is attached as Plate 8.

An allowable bearing pressure of 2,500 pounds per square foot (psf) is appropriate for footings supported on competent native soil.

A one-third increase in this design bearing pressure may be used when considering short-term wind or seismic loads. For the above design criteria, it is anticipated that the total post-construction settlement of footings founded on competent native soil, or on structural fill up to 5 feet in thickness, will be about one-half-inch, with differential settlements on the order of one-half-inch in a distance of 20 feet along a continuous footing with a uniform load.

Lateral loads due to wind or seismic forces may be resisted by friction between the foundation and the bearing soil, or by passive earth pressure acting on the vertical, embedded portions of the foundation. For the latter condition, the foundation must be either poured directly against relatively level, undisturbed soil or be surrounded by level, well-compacted fill. We recommend using the following ultimate values for the foundation's resistance to lateral loading:

PARAMETER	ULTIMATE VALUE
Coefficient of Friction	0.40
Passive Earth Pressure	300 pcf

Where: pcf is Pounds per Cubic Foot, and Passive Earth Pressure is computed using the Equivalent Fluid Density.

If the ground in front of a foundation is loose or sloping, the passive earth pressure given above will not be appropriate. The above ultimate values for passive earth pressure and coefficient of friction do not include a safety factor.

FOUNDATION AND RETAINING WALLS

Retaining walls backfilled on only one side should be designed to resist the lateral earth pressures imposed by the soil they retain. The following recommended parameters are for walls that restrain level backfill:

PARAMETER	VALUE
Active Earth Pressure *	35 pcf
Passive Earth Pressure	350 pcf
Coefficient of Friction**	0.50
Soil Unit Weight	135 pcf

Where: pcf is Pounds per Cubic Foot, and Active and Passive Earth Pressures are computed using the Equivalent Fluid Pressures.

*** For a restrained wall that cannot deflect at least 0.002 times its height, a uniform lateral pressure equal to 10 psf times the height of the wall should be added to the above active equivalent fluid pressure. This applies only to walls with level backfill.**

**** Only for use in the design of conventional foundations.**

The design values given above do not include the effects of any hydrostatic pressures behind the walls and assume that no surcharges, such as those caused by slopes, vehicles, or adjacent foundations will be exerted on the walls. If these conditions exist, those pressures should be added to the above lateral soil pressures. Where sloping backfill is desired behind the walls, we will need to be given the wall dimensions and the slope of the backfill in order to provide the appropriate design earth pressures. The surcharge due to traffic loads behind a wall can typically be accounted for by adding a uniform pressure equal to 2 feet multiplied by the above active fluid density. Heavy construction equipment should not be operated behind retaining and foundation walls within a distance equal to the height of a wall, unless the walls are designed for the additional lateral pressures resulting from the equipment.

The values given above are to be used to design only permanent foundation and retaining walls that are to be backfilled, such as conventional walls constructed of reinforced concrete or masonry. It is not appropriate to use the above earth pressures and soil unit weight to back-calculate soil strength parameters for design of other types of retaining walls, such as soldier pile, reinforced earth, modular or soil nail walls. We can assist with design of these types of walls, if desired.

The passive pressure given is appropriate only for a shear key poured directly against undisturbed native soil, or for the depth of level, well-compacted fill placed in front of a retaining or foundation wall. The values for friction and passive resistance are ultimate values and do not include a safety factor. Restrained wall soil parameters should be utilized the wall and reinforcing design for a distance of 1.5 times the wall height from corners or bends in the walls, or from other points of restraint. This is intended to reduce the amount of cracking that can occur where a wall is restrained by a corner.

Wall Pressures Due to Seismic Forces

Per IBC Section 1803.5.12, a seismic surcharge load need only be considered in the design of walls over 6 feet in height. A seismic surcharge load would be imposed by adding a uniform lateral pressure to the above-recommended active pressure. The recommended seismic surcharge pressure for this project is 9**H** pounds per square foot (psf), where **H** is the design retention height of the wall. Using this increased pressure, the safety factor against sliding and overturning can be reduced to 1.2 for the seismic analysis.

Retaining Wall Backfill and Waterproofing

Backfill placed behind retaining or foundation walls should be coarse, free-draining structural fill containing no organics. This backfill should contain no more than 5 percent silt or clay particles and have no gravel greater than 4 inches in diameter. The percentage of particles passing the No. 4 sieve should be between 25 and 70 percent. A minimum 12-inch width of free-draining gravel or drainage composite similar to Miradrain 6000 should be placed against the backfilled retaining walls. The gravel or drainage composites should be hydraulically connected to the foundation drain system. Free draining backfill should be used for the entire width of the backfill where seepage is encountered. The later section entitled ***Drainage Considerations*** should also be reviewed for recommendations related to subsurface drainage behind foundation and retaining walls.

The purpose of these backfill requirements is to ensure that the design criteria for a retaining wall are not exceeded because of a build-up of hydrostatic pressure behind the wall. Also, subsurface drainage systems are not intended to handle large volumes of water from surface runoff. The top 12 to 18 inches of the backfill should consist of a compacted, relatively impermeable soil or topsoil, or the surface should be paved. The ground surface must also slope away from backfilled walls at one to 2 percent to reduce the potential for surface water to percolate into the backfill.

Water percolating through pervious surfaces (pavers, gravel, permeable pavement, etc.) must also be prevented from flowing toward walls or into the backfill zone. Foundation drainage and waterproofing systems are not intended to handle large volumes of infiltrated water. The compacted subgrade below pervious surfaces and any associated drainage layer should therefore be sloped away. Alternatively, a membrane and subsurface collection system could be provided below a pervious surface.

It is critical that the wall backfill be placed in lifts and be properly compacted, in order for the above-recommended design earth pressures to be appropriate. The recommended wall design criteria assume that the backfill will be well-compacted in lifts no thicker than 12 inches. The compaction of backfill near the walls should be accomplished with hand-operated equipment to prevent the walls from being overloaded by the higher soil forces that occur during compaction. The section entitled ***General Earthwork and Structural Fill*** contains additional recommendations regarding the placement and compaction of structural fill behind retaining and foundation walls.

The above recommendations are not intended to waterproof below-grade walls, or to prevent the formation of mold, mildew, or fungi in interior spaces. Over time, the performance of subsurface drainage systems can degrade, subsurface groundwater flow patterns can change, and utilities can break or develop leaks. Therefore, waterproofing should be provided where future seepage through the walls is not acceptable. This typically includes limiting cold-joints and wall penetrations and using bentonite panels or membranes on the outside of the walls. There are a variety of different waterproofing materials and systems, which should be installed by an experienced contractor familiar with the anticipated construction and subsurface conditions. Applying a thin coat of asphalt emulsion to the outside face of a wall is not considered waterproofing and will only help to reduce moisture generated from water vapor or capillary action from seeping through the concrete. As with any project, adequate ventilation of basement and crawl space areas is important to prevent a buildup of water vapor that is commonly transmitted through concrete walls from the surrounding soil, even when seepage is not present. This is appropriate even when waterproofing is applied to the outside of foundation and retaining walls. We recommend that you contact an experienced envelope consultant if detailed recommendations or specifications related to waterproofing design or minimizing the potential for infestations of mold and mildew are desired.

SLABS-ON-GRADE

The building floors can be constructed as slabs-on-grade atop competent native soil, or on structural fill. The subgrade soil must be in a firm, non-yielding condition at the time of slab construction or underslab fill placement. Any soft areas encountered should be excavated and replaced with select, imported structural fill. Alternately, the building floors could be constructed as a framed floor atop a crawlspace.

Even where the exposed soils appear dry, water vapor will tend to naturally migrate upward through the soil to the new constructed space above it. This can affect moisture-sensitive flooring, cause imperfections or damage to the slab, or simply allow excessive water vapor into the space above the slab. All interior slabs-on-grade should be underlain by a capillary break drainage layer consisting of a minimum 4-inch thickness of clean gravel or crushed rock that has a fines content (percent passing the No. 200 sieve) of less than 3 percent and a sand content (percent passing the No. 4 sieve) of no more than 10 percent. Pea gravel or crushed rock are typically used for this layer.

As noted by the American Concrete Institute (ACI) in the *Guides for Concrete Floor and Slab Structures*, proper moisture protection is desirable immediately below any on-grade slab that will be covered by tile, wood, carpet, impermeable floor coverings, or any moisture-sensitive equipment or products. ACI recommends a minimum 10-mil thickness vapor retarder for better durability and long-term performance than is provided by 6-mil plastic sheeting that has historically been used. A vapor retarder is defined as a material with a permeance of less than 0.3 perms, as determined by ASTM E 96. It is possible that concrete admixtures may meet this specification, although the manufacturers of the admixtures should be consulted. Where vapor retarders are used under slabs, their edges should overlap by at least 6 inches and be sealed with adhesive tape. The sheeting should extend to the foundation walls for maximum vapor protection.

If no potential for vapor passage through the slab is desired, a vapor *barrier* should be used. A vapor barrier, as defined by ACI, is a product with a water transmission rate of 0.01 perms when tested in accordance with ASTM E 96. Reinforced membranes having sealed overlaps can meet this requirement.

We recommend that the contractor, the project materials engineer, and the owner discuss these issues and review recent ACI literature and ASTM E-1643 for installation guidelines and guidance on the use of the protection/blotter material.

EXCAVATIONS AND SLOPES

Temporary excavation slopes should not exceed the limits specified in local, state, and national government safety regulations. Also, temporary cuts should be planned to provide a minimum 2 to 3 feet of space for construction of foundations, walls, and drainage. Temporary cuts to a maximum overall depth of about 4 feet may be attempted vertically in unsaturated soil, if there are no indications of slope instability. However, vertical cuts should not be made near property boundaries, near existing utilities and structures, or at the base of sloped cuts. Based upon Washington Administrative Code (WAC) 296, Part N, the soil at the subject site would generally be classified as

Type B. Therefore, temporary cut slopes greater than 4 feet in height should not be excavated at an inclination steeper than 1:1 (Horizontal:Vertical), extending continuously between the top and the bottom of a cut.

The above-recommended temporary slope inclination is based on the conditions exposed in our explorations, and on what has been successful at other sites with similar soil conditions. It is possible that variations in soil and groundwater conditions will require modifications to the inclination at which temporary slopes can stand. Temporary cuts are those that will remain unsupported for a relatively short duration to allow for the construction of foundations, retaining walls, or utilities. Temporary cut slopes should be protected with plastic sheeting during wet weather. It is also important that surface runoff be directed away from the top of temporary slope cuts. Cut slopes should also be backfilled or retained as soon as possible to reduce the potential for instability. Please note that loose soil can cave suddenly and without warning. Excavation, foundation, and utility contractors should be made especially aware of this potential danger. These recommendations may need to be modified if the area near the potential cuts has been disturbed in the past by utility installation, or if settlement-sensitive utilities are located nearby.

All permanent cuts into native soil should be inclined no steeper than 2:1 (H:V). Fill slopes should not be constructed with an inclination greater than 3:1 (H:V). However, no fill should be placed to the south of the new residence, as any additional fill soils would increase the surcharge load atop the slope and could act to decrease the stability of the steep slope. To reduce the potential for shallow sloughing, fill must be compacted to the face of these slopes. This can be accomplished by overbuilding the compacted fill and then trimming it back to its final inclination. Adequate compaction of the slope face is important for long-term stability and is necessary to prevent excessive settlement of patios, slabs, foundations, or other improvements that may be placed near the edge of the slope.

Water should not be allowed to flow uncontrolled over the top of any temporary or permanent slope. All permanently exposed slopes should be seeded with an appropriate species of vegetation to reduce erosion and improve the stability of the surficial layer of soil.

Any disturbance to the existing slope outside of the building limits may reduce the stability of the slope. Damage to the existing vegetation and ground should be minimized, and any disturbed areas should be revegetated as soon as possible. As stated above, soil from the excavation should not be placed on the slope, and this may require the off-site disposal of any surplus soil.

DRAINAGE CONSIDERATIONS

Footing drains should be used where: (1) crawl spaces or basements will be below a structure; (2) a slab is below the outside grade; or, (3) the outside grade does not slope downward from a building. Drains should also be placed at the base of all earth-retaining walls. These drains should be surrounded by at least 6 inches of 1-inch-minus, washed rock that is encircled with non-woven, geotextile filter fabric (Mirafi 140N, Supac 4NP, or similar material). At its highest point, a perforated pipe invert should be at least 6 inches below the bottom of a slab floor or the level of a crawl space. The discharge pipe for subsurface drains should be sloped for flow to the outlet point. Roof and surface water drains must not discharge into the foundation drain system. A typical footing drain detail is attached to this report as Plate 9. For the best long-term performance, perforated PVC pipe is recommended for all subsurface drains. Clean-outs should be provided for potential future flushing or cleaning of footing drains.

Drainage inside the building's footprint should also be provided where (1) a crawl space or slab will slope or be lower than the surrounding ground surface, (2) an excavation encounters significant seepage, or (3) an excavation for a building will be close to the expected high groundwater elevations. We can provide recommendations for interior drains, should they become necessary, during excavation and foundation construction.

As a minimum, a vapor retarder, as defined in the ***Slabs-On-Grade*** section, should be provided in any crawl space area to limit the transmission of water vapor from the underlying soils. Crawl space grades are sometimes left near the elevation of the bottom of the footings. As a result, an outlet drain is recommended for all crawl spaces to prevent an accumulation of any water that may bypass the footing drains. Providing a few inches of free draining gravel underneath the vapor retarder is also prudent to limit the potential for seepage to build up on top of the vapor retarder.

No groundwater was observed during our field work. If seepage is encountered in an excavation, it should be drained from the site by directing it through drainage ditches, perforated pipe, or French drains, or by pumping it from sumps interconnected by shallow connector trenches at the bottom of the excavation.

The excavation and site should be graded so that surface water is directed off the site and away from the tops of slopes. Water should not be allowed to stand in any area where foundations, slabs, or pavements are to be constructed. Final site grading in areas adjacent to the residence should slope away at least one to 2 percent, except where the area is paved. Surface drains should be provided where necessary to prevent ponding of water behind foundation or retaining walls. A discussion of grading and drainage related to pervious surfaces near walls and structures is contained in the ***Foundation and Retaining Walls*** section.

GENERAL EARTHWORK AND STRUCTURAL FILL

All building and pavement areas should be stripped of surface vegetation, topsoil, organic soil, and other deleterious material. It is important that existing foundations be removed before site development. The stripped or removed materials should not be mixed with any materials to be used as structural fill, but they could be used in non-structural areas, such as landscape beds.

Structural fill is defined as any fill, including utility backfill, placed under, or close to, a building, or in other areas where the underlying soil needs to support loads. All structural fill should be placed in horizontal lifts with a moisture content at, or near, the optimum moisture content. The optimum moisture content is that moisture content that results in the greatest compacted dry density. The moisture content of fill is very important and must be closely controlled during the filling and compaction process. As discussed in the ***General*** section, the on-site soils are not suitable for reuse as structural fill, due to their variable, fine-grained, silty nature and the presence of rubble and debris within the onsite fill soils. Imported, clean, angular rock such as quarry spalls, ballast rock, or recycled concrete spalls should be used if structural fill is needed to backfill overexcavations beneath the foundations, and free-draining, granular fill should be used where walls are to be backfilled.

The allowable thickness of the fill lift will depend on the material type selected, the compaction equipment used, and the number of passes made to compact the lift. The loose lift thickness should not exceed 12 inches, but should be thinner if small, hand-operated compactors are used. We recommend testing structural fill as it is placed. If the fill is not sufficiently compacted, it should be recompacted before another lift is placed. This eliminates the need to remove the fill to achieve the required compaction. The following table presents recommended levels of relative compaction for compacted fill:

LOCATION OF FILL PLACEMENT	MINIMUM RELATIVE COMPACTION
Beneath footings, slabs or walkways	95%
Filled slopes and behind retaining walls	90%
Beneath pavements	95% for upper 12 inches of subgrade; 90% below that level

Where: Minimum Relative Compaction is the ratio, expressed in percentages, of the compacted dry density to the maximum dry density, as determined in accordance with ASTM Test Designation D 1557-91 (Modified Proctor).

LIMITATIONS

The conclusions and recommendations contained in this report are based on site conditions as they existed at the time of our exploration and assume that the soil and groundwater conditions encountered in the test pits and test borings are representative of subsurface conditions on the site. If the subsurface conditions encountered during construction are significantly different from those observed in our explorations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. Unanticipated conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking samples in test pits and test borings. Subsurface conditions can also vary between exploration locations. Such unexpected conditions frequently require making additional expenditures to attain a properly constructed project. It is recommended that the owner consider providing a contingency fund to accommodate such potential extra costs and risks. This is a standard recommendation for all projects.

The recommendations presented in this report are directed toward the protection of only the proposed residence from damage due to slope movement. Predicting the future behavior of steep slopes and the potential effects of development on their stability is an inexact and imperfect science that is currently based mostly on the past behavior of slopes with similar characteristics. Landslides and soil movement can occur on steep slopes before, during, or after the development of property. The owner of any property containing or located close to steep slopes must ultimately accept the possibility that some slope movement could occur, resulting in possible loss of ground or damage to the facilities around the proposed residence.

This report has been prepared for the exclusive use of Upright Construction and its representatives, for specific application to this project and site. Our conclusions and recommendations are professional opinions derived in accordance with our understanding of current local standards of practice, and within the scope of our services. No warranty is expressed or implied. The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. Our services also do not include assessing or minimizing the potential for biological hazards, such as mold, bacteria, mildew and fungi in either the existing or proposed site development.

ADDITIONAL SERVICES

In addition to reviewing the final plans, Geotech Consultants, Inc. should be retained to provide geotechnical consultation, testing, and observation services during construction. This is to confirm that subsurface conditions are consistent with those indicated by our exploration, to evaluate whether earthwork and foundation construction activities comply with the general intent of the recommendations presented in this report, and to provide suggestions for design changes in the event subsurface conditions differ from those anticipated prior to the start of construction. However, our work would not include the supervision or direction of the actual work of the contractor and its employees or agents. Also, job and site safety, and dimensional measurements, will be the responsibility of the contractor.

During the construction phase, we will provide geotechnical observation and testing services when requested by you or your representatives. Please be aware that we can only document site work we actually observe. It is still the responsibility of your contractor or on-site construction team to verify that our recommendations are being followed, whether we are present at the site or not.

The scope of our work did not include an environmental assessment, but we can provide this service, if requested.

The following plates are attached to complete this report:

Plate 1	Vicinity Map
Plate 2	Site Exploration Plan
Plates 3 - 7	Test Pit and Test Boring Logs
Plate 8	Typical Footing Overexcavation
Plate 9	Typical Footing Drain Detail

We appreciate the opportunity to be of service on this project. Please contact us if you have any questions, or if we can be of further assistance.

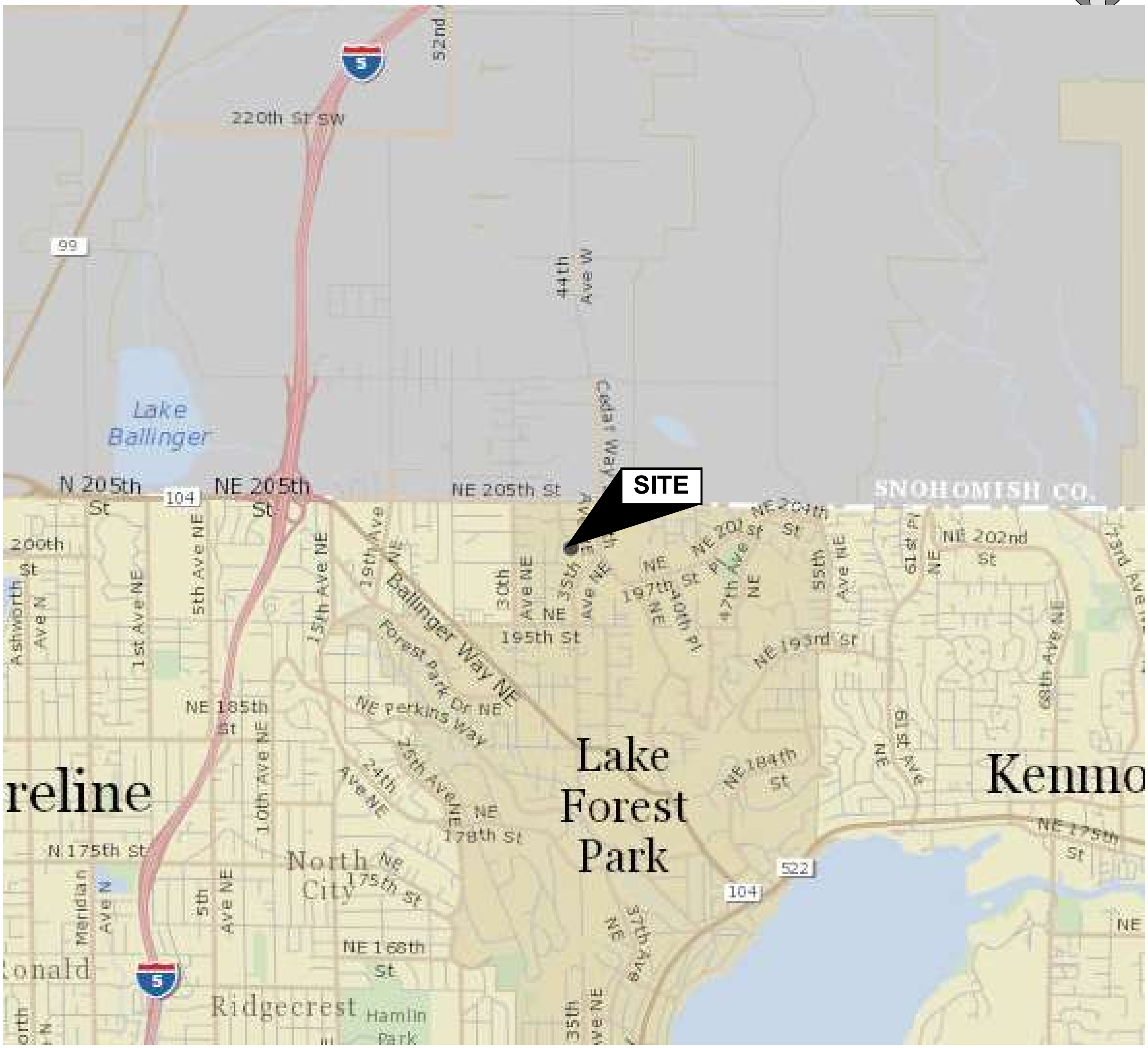
Respectfully submitted,

GEOTECH CONSULTANTS, INC.

5/3/22
James H. Strange, Jr., P.E.
Associate

MKM/JHS:kg

NORTH



(Source: King County iMap)

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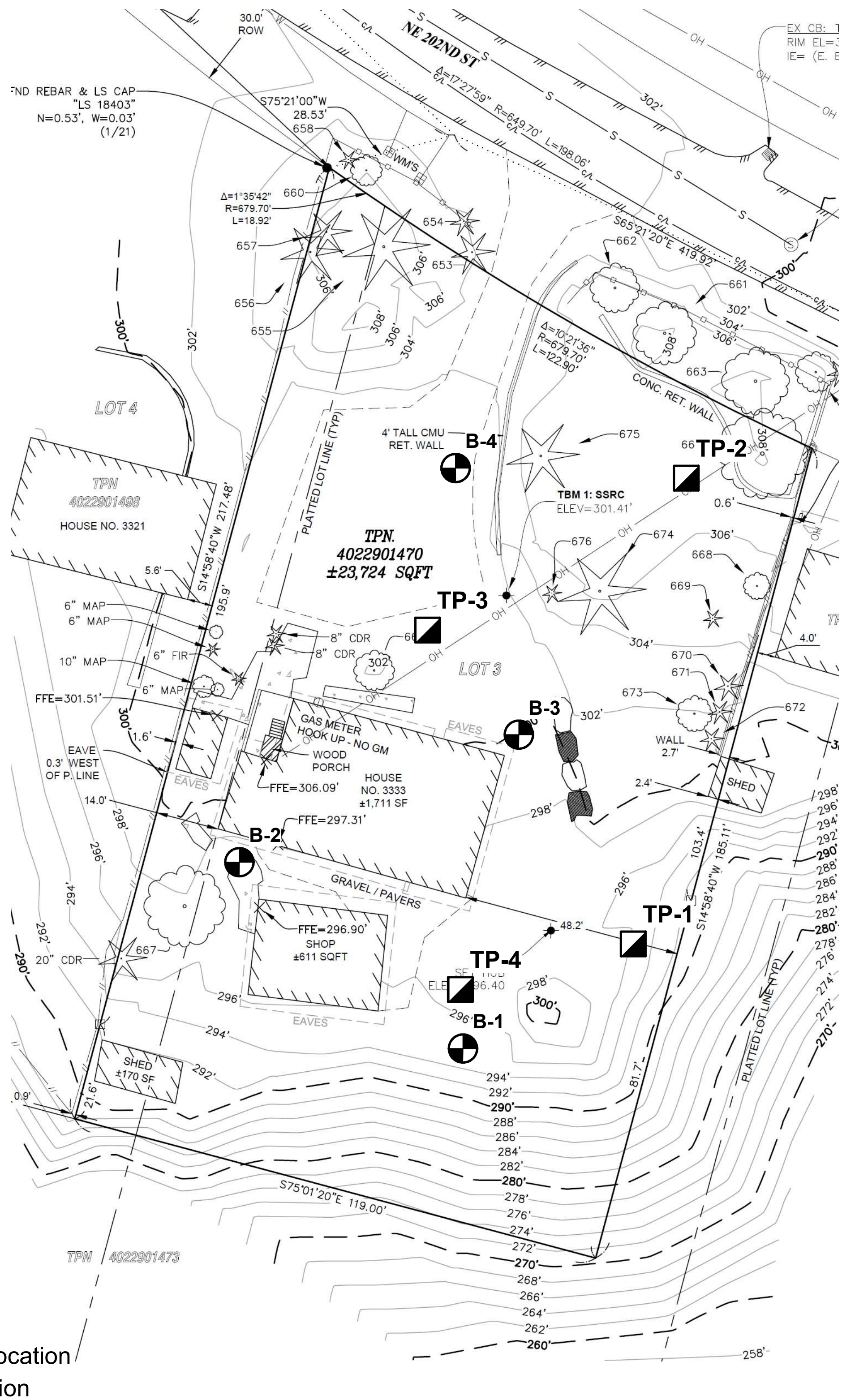
VICINITY MAP

3333 Northeast 202nd Street
Lake Forest Park, Washington

Job No:	Date:		Plate:
21024	Nov. 2021		1

NORTH



Legend:

- Test Boring Location
- Test Pit Location

X-X' Slope Stability Cross Section Location

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SITE EXPLORATION PLAN

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TEST PIT 1

Depth (feet)	Soil Description
0.0 – 6.5	Brown silty SAND with concrete rubble, fine-grained, moist, loose **[FILL]**

Test Pit was terminated at 6.5 feet on January 7, 2021 due to refusal on concrete rubble.
No groundwater seepage was encountered in the test pit.
No caving observed during excavation.

TEST PIT 2

Depth (feet)	Soil Description
0.0 – 1.0	Topsoil
1.0 – 3.5	Brown slightly silty SAND with iron stains, fine-grained, moist, loose **[SP/SM]**
3.5 – 7.5	Gray-brown silty SAND with gravel, fine-grained, moist, medium-dense **[SM]** -6', becomes sandy, dense **(Sandy Glacial Till)**

Test Pit was terminated at 7.5 feet on January 7, 2021.
No groundwater seepage was encountered in the test pit.
No caving observed during excavation.

TEST PIT 3

Depth (feet)	Soil Description
0.0 – 1.0	Topsoil
1.0 – 6.5	Brown slightly silty SAND with iron stains, fine-grained, moist, loose **[SM]** - 3.5', becomes gray, dense **(Glacial Till)**

Test Pit was terminated at 4.0 feet on October 11, 2021.
No groundwater seepage was encountered in the test pit.
No caving observed during excavation.

TEST PIT 4

Depth (feet)	Soil Description
0.0 – 12.0	Brown silty SAND with concrete rubble and metal debris, fine-grained, moist, loose **[FILL]**
12.0 – 14.0	Brown silty SAND, fine-grained, moist, loose to medium-dense **[SM]**
14.0 – 15.0	Gray-brown SAND, fine-grained, moist, medium-dense to dense **[SP]**

Test Pit was terminated at 15.0 feet on October 11, 2021.
No groundwater seepage was encountered in the test pit.
No caving observed during excavation.

***NOTE** – Letters in brackets **[ ]** denote the USCS soil classification.

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TEST PIT LOGS

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Lake Forest Park, Washington

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BORING 1

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
						Grass over;
			13	1		Dark-brown silty SAND with decayed organics, fine-grained, moist, jumbled, loose **(FILL)**
5			**	2	FILL	-with small pieces of concrete (auger bouncing on rubble)
			**	3		-with small pieces of brick
10			**	4		
15						
20						

*** Test boring was terminated at 12 feet on September 17, 2021 due to refusal on large concrete rubble.**

*** No groundwater was encountered during drilling.**

**** Blow counts not representative of drilling action - samplers bouncing on concrete rubble.**

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TEST BORING LOG

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Lake Forest Park, Washington

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BORING 2

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
			26	1	SP	No recovery
5			41	2		Brown very gravelly SAND, fine to medium-grained, moist to dry, dense
			50/5”	3	SM	Minimal recovery - Gray slightly gravelly, silty SAND, fine-grained, moist, dense
10			50/5”	4		-becomes very dense **(Glacial Till) [Faint Hydrocarbon Odor Noted]**
15						
20						

* **Test boring was terminated at 11 feet on September 17, 2021.**
* **No groundwater was encountered during drilling.**

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TEST BORING LOG

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Lake Forest Park, Washington

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BORING 3

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
					SM	Crushed rock over;
			50/4"	1		No recovery
5			57	2		Gray gravelly, silty SAND, fine-grained, damp, cemented, very dense **(Glacial Till)**
			87/11"	3		Topsoil
10						
15						
20						

*** Test boring was terminated at 9 feet on September 17, 2021 due to auger refusal.**

*** No groundwater was encountered during drilling.**

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TEST BORING LOG

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BORING 4

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
					SM	Crushed rock over;
						Brown with rusting, slightly gravelly, silty SAND, fine-grained, dry, loose
			41	1		-becomes gray, gravelly, cemented, dense **(Glacial Till)**
5			69	2		-becomes very dense
10						
15						
20						

*** Test boring was terminated at 6.5 feet on September 17, 2021.**
*** No groundwater was encountered during drilling.**

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TEST BORING LOG

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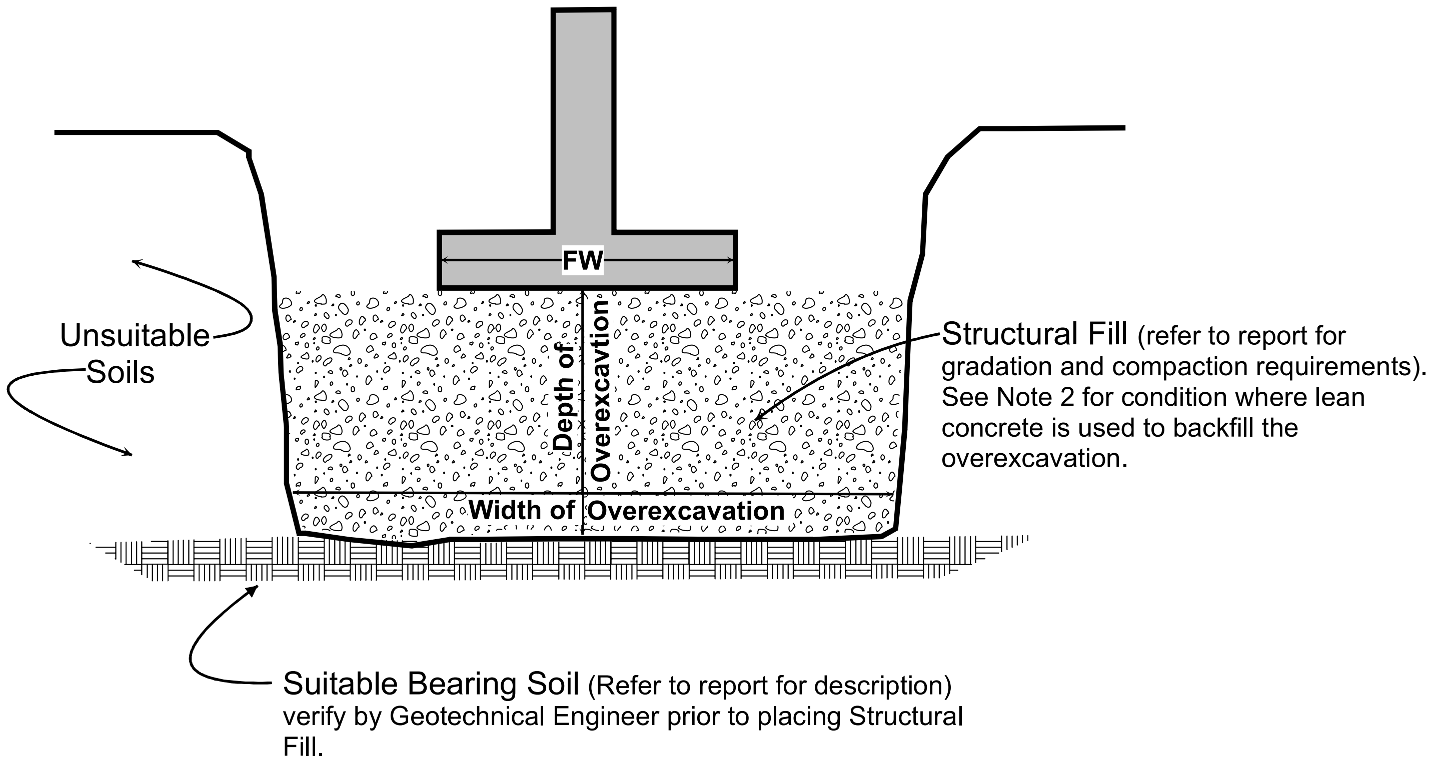
Job	*Date:*	*Logged by:*	*Plate:*
21024	Nov. 2021	MKM	7



Width of Overexcavation = Footing Width (FW) + Depth of Overexcavation

NOTES:

1. Refer to report text for additional overexcavation, foundation, and structural fill considerations.
2. Where lean concrete (minimum 1-1/2 sacks of cement per cubic yard) is used to backfill the overexcavation, the overexcavation must extend only 6 inches beyond the edges of the footing.

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TYPICAL FOOTING OVEREXCAVATION

3333 Northeast 202nd Street
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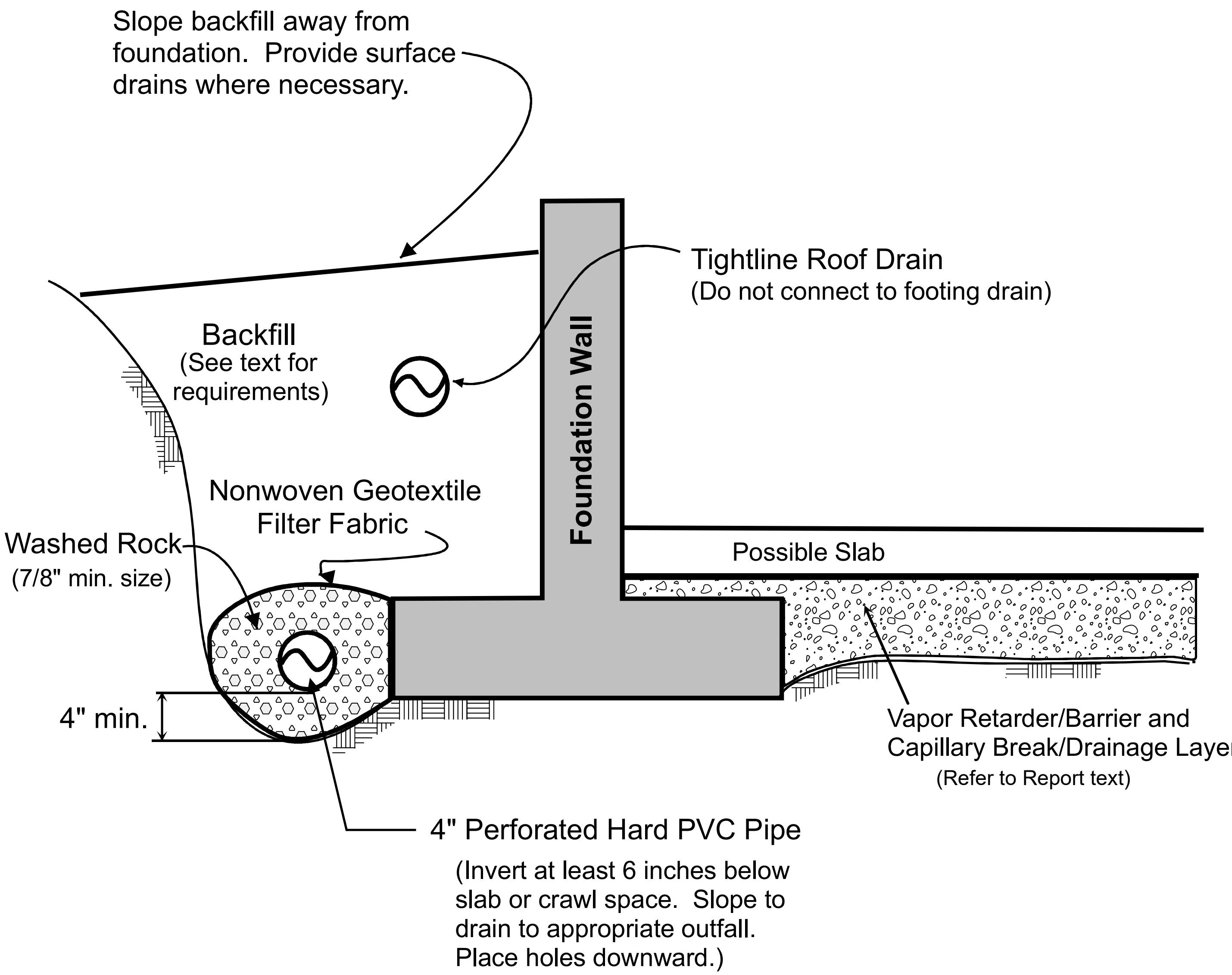

NOTES:

(1) In crawl spaces, provide an outlet drain to prevent buildup of water that bypasses the perimeter footing drains.

(2) Refer to report text for additional drainage, waterproofing, and slab considerations.

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FOOTING DRAIN DETAIL

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