Earth Solutions NW LLC

Geotechnical Engineering
Construction Observation/Testing
Environmental Services

GEOTECHNICAL ENGINEERING STUDY
PROPOSED RESIDENTIAL DEVELOPMENT
2430 AND 2436 – 74TH AVENUE SOUTHEAST
MERCER ISLAND, WASHINGTON

ES-8332.01

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PREPARED FOR

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May 2, 2023

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Important Information about This

Geotechnical-Engineering Report

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

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are <u>not</u> final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are <u>Not</u> Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will <u>not</u> of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are <u>not</u> building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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Earth Solutions NW LLC

Geotechnical Engineering, Construction
Observation/Testing and Environmental Services

May 2, 2023
ES-8332.01

BV Homes, LLC
8015 Southeast 60th Street
Mercer Island, Washington 98040

Attention: Mr. Vann Lanz

Greetings, Mr. Lanz:

Earth Solutions NW, LLC (ESNW), is pleased to present this geotechnical report to support the proposed single-family residential development. Based on the results of this study, the proposed construction is feasible from a geotechnical standpoint.

Our field observations indicate the site is underlain by about 15 to 20 feet of disturbed and fractured native silts (USCS: MH) identified as mass wasting deposits. Below the fractured silts, undisturbed native silt deposits were encountered, generally extending to the maximum exploration depth of about 46.5 feet below existing grades. Pervasive groundwater was not observed during the field exploration; however, light groundwater seepage was encountered within two of three borings advanced during the February 2023 subsurface exploration, generally between the depths of 20 to 25 feet bgs. The observed seepage zones did not appear to be associated with distinct changes in stratigraphy.

Based on the relatively soft and disturbed native silt soils encountered near surface, we recommend the project utilize helical piers advanced through the soft soils to bear within the undisturbed native soils for the proposed structures. In addition to providing higher bearing capacity values, the helical piers will transmit new structural loads to more competent soil layers at depth (i.e., at least 15 to 20 feet below existing grades), reducing the driving forces acting on the critical slip plane identified in the slope stability analysis.

The native fine-grained soils generated from site excavations be should not be used as structural fill. Fill placement should not occur along sloping areas of this site. In our opinion, a contingency should be provided in the budget for the export of fine-grained soil cuttings and import of suitable structural fill material, as needed.

Review of the referenced infiltration potential map indicates that infiltrating LID facilities are not permitted at the subject site. In our opinion, based on the disturbed and fine-grained native soil textures, mapped mass wasting deposits, and sloping surface grades, on-site infiltration should be considered infeasible from a geotechnical standpoint.

This report provides preliminary geotechnical analyses and recommendations for the proposed construction. We appreciate the opportunity to be of service to you on this project. If you have any questions about this geotechnical engineering study, please call.

Sincerely,

EARTH SOLUTIONS NW, LLC

Brian C. Snow, G.I.T.
Senior Staff Geologist

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GEOTECHNICAL ENGINEERING STUDY
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MERCER ISLAND, WASHINGTON

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INTRODUCTION

General

This geotechnical engineering study was prepared for the proposed residential development to be located on the east side of 74th Avenue Southeast, just south of the intersection with Southeast 24th Street, in Mercer Island, Washington. The purpose of this study was to provide geotechnical recommendations to support the current development plans, as understood at the time of this study. To complete this study, ESNW performed the following services:

- Subsurface investigation through a series of exploratory borings to characterize the soil and groundwater conditions within accessible areas of the site.
- Laboratory testing of representative soil samples collected at the exploration locations.
- Review of on-site geologically hazardous areas and applicable Mercer Island Code.
- Engineering analyses and recommendations for the proposed construction.
- Preparation of this report.

The following documents and maps were reviewed in preparation of this study:

- Grading & Utilities Plan, prepared by D.R. Strong Consulting Engineers, Project No. 23001, dated February 9, 2023.
- Geotechnical Engineering Services Report, Aegis Mercer Island, prepared by GeoEngineers, Inc., File No. 19811-009-00, dated October 26, 2015.
- Geologic Map of Mercer Island, Washington, compiled by Kathy G. Troost and Aaron P. Wisher, dated October 2006.
- Web Soil Survey (WSS) online resource, maintained by the Natural Resources Conservation Service (NRCS) under the United States Department of Agriculture (USDA).
- Soil Survey of King County Area, Washington, by Snyder, D.E., Gale, P.S., and Pringle, R.F., USDA Soil Conservation Service, issued November 1973.

- Mercer Island Landslide Hazard Assessment, by Troost, K.G. and Wisher, A.P., dated April 2009.

- Mercer Island Seismic Hazard Assessment, by Troost, K.G. and Wisher, A.P., dated April 2009.

- Mercer Island Erosion Hazard Assessment, by Troost, K.G. and Wisher, A.P., dated April 2009.

- Low Impact Development Infiltration Feasibility on Mercer Island (Figure 3), prepared by Herrera, undated.

- Liquefaction Susceptibility of King County, Washington, Map 11-5, prepared by Tetra Tech, Inc. and endorsed by the King County Flood Control District, dated May 2010.

- Mercer Island City Code (MICC).

<u>Project Description</u>

The subject site is located on the east side of 74th Avenue Southeast, approximately 300 to 550 feet south of the intersection with Southeast 24th Street, in Mercer Island, Washington.

Specific grading plans were not available at the time of this report; however, we understand the site will be developed with three new single-family residences and associated improvements. The residences will be located near the 74th Avenue Southeast frontage. Based on conditions observed during the fieldwork, we anticipate new structures will be supported on a system of helical piers, and that site grading will be limited in extent.

At the time of report submission, specific building load values were not available for review; however, we anticipate the proposed structures will consist of relatively lightly loaded wood framing. Based on our experience with similar developments, we estimate perimeter wall loads of about 2 to 3 kips per linear foot and slab-on-grade loading of 150 pounds per square foot (psf) will be incorporated into the final design.

We anticipate site stormwater improvements will tie in to existing stormwater facilities utilizing conventional detention and conveyance methods.

If the above design assumptions either change or are incorrect, ESNW should be contacted to review the recommendations provided in this report. ESNW should review final designs to verify the geotechnical recommendations provided in this report have been incorporated into the plans.

SITE CONDITIONS

Surface

The subject site is located on the east side of 74th Avenue Southeast, approximately 300 to 550 feet south of the intersection with Southeast 24th Street, in Mercer Island, Washington. The approximate site location is depicted on Plate 1 (Vicinity Map). The site is comprised of two adjoining tax parcels (King County Parcel Nos. 5315100-455 & -458) totaling about 0.77 acres of land area. Currently, the property is undeveloped, vacant, and heavily vegetated with mature trees, blackberries, and other low shrubs.

Per the City of Mercer Island GIS Portal, surface topography descends at variable gradients to the east for a total of about 40 feet of vertical relief within the property boundaries. The site is bordered to the north, east, and south by existing single- and multi-family residential development, and to the west by 74th Avenue Southeast.

Subsurface

An ESNW representative observed, logged, and sampled three soil borings advanced at accessible locations within the property boundaries on February 24, 2023, using a tracked drill rig and operators retained by ESNW. The maximum exploration depth was approximately 46.5 feet below the existing ground surface (bgs). Native soils were identified throughout each exploratory boring.

We also reviewed subsurface conditions as described in the referenced geotechnical engineering services report, prepared for the easterly adjacent parcel to gain additional insight into the overall site soil/groundwater conditions.

The approximate locations of the borings are depicted on Plate 2 (Boring Location Plan). Please refer to the boring logs provided in Appendix A for a more detailed description of subsurface conditions. Representative soil samples collected at the exploration locations were analyzed in general accordance with Unified Soil Classification System (USCS) and USDA methods and procedures.

Topsoil and Fill

Topsoil and organic material were observed within the upper 2.5 to 8 feet of existing grades at the boring locations, often containing organic detritus including woody roots, sticks, leaf litter, etc. The topsoil was characterized by its dark brown color, the presence of fine organic material, and small root intrusions.

No indications of fill were observed during the subsurface investigation; however, there is likely fill located along the frontage associated with roadway construction.

Native Soil

Generally, below about 8 feet bgs, native mineral-dominant soils were encountered, identified primarily as silts and clays (USCS: MH, CH) with variable plasticity indices and trace, variable amounts of sand. The native fine-grained soils (predominantly silts and clays) exhibited signs of disturbance and weathering extending to depths between roughly 15 and 20 feet bgs, including fractured/disturbed soil textures and light iron oxide staining. The weathered/disturbed native fine-grained soils shallower than about 20 feet bgs were primarily encountered in a soft to medium stiff (N-values between 8 and 15) and wet condition.

Underlying the weathered/disturbed native soils (i.e., below about 15 to 20 feet bgs), the native fine-grained soils transitioned to a relatively unweathered (gray), massive (no bedding or soil texture), and stiff condition (N-values between 15 and 21). The unweathered silts and clays were observed primarily in a wet condition at the time of exploration, with little variance in moisture content relative to the upper weathered soils. At boring location B-3 within the southern site portion and below about 30.5 feet bgs, the native soils exhibited a sharp transition to dense (N=40) and relatively clean sands with minor silt and gravel. Boring B-3 was terminated 31.5 feet bgs within the relatively clean sands.

Based on the results of the Atterberg limits analysis, in-situ moisture contents of the native silt soils (USCS: MH) encountered at boring locations B-1 and B-2 were generally (one to eight percent) below the plastic limit value calculated for that soil type. Moisture values of the native clay soils (USCS: CH) observed at boring location B-3 were generally (eight to ten percent) above the calculated plastic limit value for that soil.

Geologic Setting

The referenced geologic map identifies Pre-Olympia fine-grained glacial deposits (Qpogf) as the primary geologic unit underlying the subject site. The geologic map also identifies a “scarp” feature within the northeastern site portion, and the entire project site is mapped within the “mass wastage deposits” (Qmw) overlay.

Pre-Olympia fine-grained glacial deposits are characterized primarily as laminated to massive silt and clay deposits with occasional sandy interbeds, localized iron-oxide cemented layers and sandy partings.

The online WSS resource identifies Kitsap silt loam (Map Unit Symbol: KpD) as the primary soil unit underlying the site. Kitsap series soils formed atop glacial lake deposits under a cover of conifer trees and shrubs. Per the referenced soil survey report, runoff over this soil unit is characterized as rapid, with severe erosion hazard and slippage potential.

Based on conditions encountered during the fieldwork, the native soils are generally representative of both disturbed and undisturbed fine-grained glacial sediments, consistent with the geologic mapping resources reviewed in this section.

Groundwater

Light groundwater seepage was encountered within two of three borings advanced during the February 2023 subsurface exploration, generally between the depths of 20 to 25 feet bgs. The observed seepage zones did not appear to be associated with distinct changes in stratigraphy.

In our experience, groundwater seepage is typical of glacially derived deposits and should be expected within site excavations, particularly during the wet season. Groundwater flow rates and elevations may fluctuate depending on many factors, including precipitation duration and intensity, the time of year, and soil conditions. In general, groundwater flow rates are higher during the winter, spring, and early summer months.

GEOLOGICALLY HAZARDOUS AREAS – MICC 19.07.160

We reviewed Mercer Island City Code (MICC) Chapter 19.07.160 – Geologically Hazardous Areas – to evaluate the presence of geologically hazardous areas at the subject site. Per the MICC, geologically hazardous areas within the City of Mercer Island (City) include areas susceptible to erosion, sliding, earthquake, or other geological events based on a combination of slope (gradient or aspect), soils, geologic material, hydrology, vegetation, or alterations, including landslide hazard areas, erosion hazard areas, and seismic hazard areas.

Review of the City's online GIS portal and critical area maps available in the City's online Map Gallery indicates the site contains potential slide areas, seismic hazard areas, and erosion hazard areas. An evaluation of each hazard type is provided below.

Landslide Hazard Areas

Landslide hazard areas are those areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors. The referenced mapping resources indicate the site contains mapped areas of "known landslides," identified landslide locations within roughly 100 to 300 feet of the site on both east and west sides, a scarp feature in the northern portion of the site, and landslide and mass wasting deposits. Slope gradients across the site generally exceed 15 percent, with areas in excess of 40 percent along the eastern site margin.

Based on the landslide hazard definition criteria provided in the MICC and the site conditions outlined above, the site is classified as a landslide hazard area.

Per the MICC, "alteration of landslide hazard areas […] and associated buffers may occur" pending the results of a critical area study. The critical areas study must determine that the project proposal: (a) will not adversely impact other critical areas, (b) will not adversely impact the subject property or adjacent properties, (c) will mitigate impacts to the geologically hazardous area consistent with best available science to the maximum extent reasonably possible such that the site is determined to be save, and (d) includes the landscaping of all disturbed areas outside of building footprints and installation of hardscape prior to final inspection.

MICC section 19.07.160(B)(3) requires a statement of risk from the geotechnical professional in order to allow alteration of landslide hazard areas and associated buffers. In our opinion, based on site conditions observed during the fieldwork and slope stability analyses attached to this report, **"the landslide hazard area will be modified or the development has been designed so that the risk to the site and adjacent property is eliminated or mitigated such that the site is determined to be safe."** Further discussion regarding landslide susceptibility is provided in the *Slope Stability Analysis* section of this report.

Slope Stability Analysis

We evaluated slope stability across the subject site with primary focus on areas likely to be influenced by the proposed modifications. Global slope stability analyses were completed using the 2021 GeoStudio Slope/W modeling program to reflect existing and proposed conditions in both static and seismic scenarios, including foundation loading where applicable. The analyses focused primarily on deep-seated rotational failures and were completed using topographic data provided on the referenced Grading and Utility Plan and King County iMap resourcing for topography outside the subject site. The cross-section line (A-A') is depicted on Plate 2 (Boring Location Plan).

The soil stratigraphy was modeled as two distinct soil units based on conditions observed during the subsurface exploration. We utilized relatively conservative strength parameters in our slope models, outlined in the table below. Additional modeling parameters are attached to this letter report (see Appendix C). Groundwater was not included in the modeling as a pervasive groundwater condition was not observed during the February 2023 subsurface exploration.

Soil Unit	**Density or Consistency**	**Unit Weight (pcf)**	**Cohesion (psf)**	**Internal Friction Angle (deg)**
Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	Soft to medium stiff	110	750	5
Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	Medium stiff to stiff	115	1500	7

Our analyses indicate the proposed site modifications will have minimal impacts to slope stability compared to the existing condition, and that the critical failure plane in all scenarios modeled is located entirely within the zone of disturbed/fractured native soils identified as historic mass wasting deposits. Safety factors for the proposed condition (including new foundation and seismic loading) remain at acceptable levels from a geotechnical standpoint.

It should be noted that foundation loading in the proposed condition was modeled at the existing ground surface. However, we anticipate the project will implement a system of helical piers to effectively transmit new structural loads to more competent soil layers at depth, reducing additional driving forces acting on the identified critical slip plane. The reduction of driving forces imparted on the identified critical slip plane is anticipated to increase factors of safety in the post-construction condition.

Seismic Hazard Areas

Seismic hazard areas are areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction or surface faulting. The referenced mapping resources indicate the site contains mapped areas of known or suspected seismic hazard, which includes a scarp feature in the northern portion of the site and landslide and mass wastage deposits underlying the site. In our opinion, and based on the mapping resources reviewed and the observed site conditions, the primary risk associated with seismic hazard at the subject site relates to seismically induced slope failure. Slope failure and the effects of seismically induced ground shaking on slope stability are addressed in the *Landslide Hazard Areas* and *Slope Stability Analysis* sections of this report.

In our opinion, and consistent with the referenced liquefaction susceptibility map, site susceptibility to liquefaction may be considered very low. The highly cohesive fine-grained soils and lack of a pervasive groundwater condition were the primary bases for this opinion. Furthermore, due to the low risk of liquefaction, seismically induced settlements are likely to be limited in magnitude.

Fault mapping of Mercer Island and the surrounding region indicates the site falls within the Seattle Fault Zone. The Seattle Fault Zone represents the area where several parallel strands of the Seattle fault have either broken the ground surface or caused deformation of geologic materials. In Seattle, evidence for offset along the Seattle fault consists of uplifted beach deposits, down-dropped tidal marshes, offset strata, and deformation such as sheared and tightly folded strata near the leading (northern) edge of the fault. At least two strands of the Seattle fault cross the island in an east-west orientation, the nearest of which is less than one mile south of the subject site.

In the event that a shallow crustal fault associated with the Seattle Fault Zone activates during an earthquake, the subject site will almost certainly experience some degree of ground shaking that is likely to vary depending on the magnitude of the earthquake, as well as the distance from and depth of the rupture zone. However, in our opinion, the hazard to the subject site is no greater than that of the surrounding community, and the risk of surface rupture within the property boundaries is very low.

Per the MICC, "alteration of […] seismic hazard areas and associated buffers may occur" pending the results of a critical area study. The critical areas study must determine that the project proposal: (a) will not adversely impact other critical areas, (b) will not adversely impact the subject property or adjacent properties, (c) will mitigate impacts to the geologically hazardous area consistent with best available science to the maximum extent reasonably possible such that the site is determined to be save, and (d) includes the landscaping of all disturbed areas outside of building footprints and installation of hardscape prior to final inspection.

MICC section 19.07.160(B)(3) requires a statement of risk from the geotechnical professional in order to allow alteration of seismic hazard areas and associated buffers. In our opinion, based on site conditions observed during the fieldwork and slope stability analyses attached to this report, **"[this] evaluation of site-specific subsurface conditions demonstrates that the proposed development is not located in a seismic hazard area."** Further discussion regarding potential seismic impacts to slope stability is provided in the *Slope Stability Analysis* section of this report.

Erosion Hazard Areas

Erosion hazard areas are those areas greater than 15 percent slope and subject to severe risk of erosion due to wind, rain, water, slope, and other natural agents including those soil types and/or areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" or "very severe" rill and inter-rill erosion hazard.

The referenced mapping resources indicate the site contains mapped areas of known or suspected erosion hazard areas, with supplemental data indicating mixed infiltration potential (interbedded or mixed fine and coarse-grained deposits) and estimated slope gradients ranging from 15 to 39 percent.

Infiltration potential can influence erosivity by loosening surface material for removal by erosion. Where sandy soils (with relatively high inferred infiltration rates) are exposed at the surface, the City's Erosion Hazard Assessment map delineates areas of potential erosion hazard. Based on our observations of fine-grained soils, infiltration potential at the surface is considered very low to negligible, and is not expected to contribute to erosion hazard at the subject site.

In any case, surface grades at the subject site generally exceed 15 percent gradient and, as indicated in the *Geologic Setting* section of this report, the native Kitsap silt loam soils are characterized by the USDA with severe erosion hazard. The site is therefore classified as an erosion hazard area.

All development proposals must comply with the requirements of MICC Chapter 15.09 (Storm Water Management). Typical construction stormwater management methods are anticipated to be adequate for mitigating erosion potential during the earthwork and construction phases of the project. At a minimum, silt fencing should be placed along the downslope site margins, and soil stockpiles should be covered with plastic sheeting when not in use. If construction occurs during periods of wet weather, methods to control surface water runoff will be necessary. Construction stormwater should neither be allowed to collected at the top of slope nor flow over steeply sloping areas. Final drainage plans should be designed such that stormwater is collected and diverted away from slopes exceeding 15 percent to an approved discharge location.

DISCUSSION AND RECOMMENDATIONS

General

Based on the results of this study, the proposed construction is feasible from a geotechnical standpoint. Our field observations indicate the site is underlain by about 15 to 20 feet of disturbed and fractured native silts (USCS: MH) identified as mass wasting deposits. Below the fractured silts, undisturbed native silt and clay deposits were encountered, generally extending to the maximum exploration depth of about 46.5 feet below existing grades. Pervasive groundwater was not observed during the field exploration; however, light groundwater seepage was encountered within two of three borings advanced during the February 2023 subsurface exploration, generally between the depths of 20 to 25 feet bgs. The observed seepage zones did not appear to be associated with distinct changes in stratigraphy.

Based on the relatively loose and disturbed native silt soils encountered near surface, we anticipate the project will implement a system of helical piers for the proposed structures. In addition to providing higher bearing capacity values, the helical piers will transmit new structural loads to more competent soil layers at depth (i.e., at least 15 to 20 feet below existing grades), reducing the driving forces acting on the critical slip plane identified in the slope stability analysis.

The native fine-grained soils are not considered “granular soils,” and therefore the fine-grained cuttings generated from site excavations be should not be used as structural fill. Fill placement should not occur along sloping areas of this site. In our opinion, a contingency should be provided in the budget for the export of fine-grained soil cuttings and import of suitable structural fill material, as needed.

Review of the referenced infiltration potential map indicates that infiltrating LID facilities are not permitted at the subject site. In our opinion, based on the disturbed and fine-grained native soil textures, mapped mass wasting deposits, and sloping surface grades, on-site infiltration should be considered infeasible from a geotechnical standpoint.

Site Preparation and Earthwork

Site preparation activities should consist of installing temporary erosion control measures and performing site stripping within the designated clearing limits. Subsequent earthwork activities will likely involve helical pier installation, drainage improvements, and infrastructure and utility installations.

Temporary Erosion Control

The following temporary erosion and sediment control (TESC) BMPs are offered:

- Temporary construction entrances and drive lanes, consisting of at least six inches of quarry spalls, should be considered to both minimize off-site soil tracking and provide stable surfaces at site entrances. Placing geotextile fabric underneath the quarry spalls will provide greater stability, if needed.

- Silt fencing should be placed around appropriate portions of the site perimeter.

- When not in use, soil stockpiles should be covered or otherwise protected to reduce the potential for soil erosion, especially during periods of wet weather.

- Temporary measures for controlling surface water runoff, such as interceptor trenches, sumps, or interceptor swales, should be installed prior to beginning earthwork activities.

- Dry soils disturbed during construction should be wetted to minimize dust and airborne soil erosion.

Additional TESC BMPs, as specified by the project civil engineer and indicated on the plans, should be incorporated into construction activities, as necessary. Temporary erosion control measures must be actively managed and may be modified during construction as site conditions require, as approved by the site erosion control lead to ensure the BMPs are performing as intended.

Given the high fines content of the native soils that may be exposed during temporary grading and the determination that the site is located within an erosion hazard area, enhanced erosion control measures may be required to provide an adequate level of protection for adjacent properties. The contractor must be prepared to employ additional TESC BMPs during construction depending on soil conditions encountered.

Excavations and Slopes

Excavation activities are likely to expose soft to medium stiff native soils within the upper 15 to 20 feet of existing grades, becoming stiff or better at depth. Groundwater seepage should be anticipated within site excavations depending on the time of year.

Based on the soil conditions observed at the subsurface exploration locations, the following maximum allowable temporary slope inclinations may be used. The applicable Federal Occupation Safety and Health Administration and Washington Industrial Safety and Health Act soil classifications are also provided.

- Areas exposing groundwater seepage 1.5H:1V (Type C)
- Loose or previously disturbed soil, fill 1.5H:1V (Type C)
- Medium dense native soil 1H:1V (Type B)
- Very dense native soil 0.75H:1V (Type A)

Permanent slopes should be planted with vegetation to both enhance stability and minimize erosion and should maintain a gradient of 2H:1V or flatter. The presence of perched groundwater may cause localized sloughing of temporary slopes; groundwater seepage should be expected within site excavations, particularly if excavations take place during the wet season. An ESNW representative should observe temporary and permanent slopes to confirm the slope inclinations are suitable for the exposed soil conditions and to provide additional excavation and slope recommendations, as necessary. If the recommended temporary slope inclinations cannot be achieved, temporary shoring may be necessary to support excavations.

In-situ and Imported Soil

The in-situ soils observed at the subject site can be characterized as having very high sensitivity to moisture and are not suitable for use as structural fill. Soils anticipated to be exposed on site will degrade if exposed to wet weather and construction traffic. Fine-grained soils generated from excavations be should be removed from the site and should not be used as structural fill.

In our opinion, a contingency should be provided in the budget for the export of fine-grained soil cuttings and import of suitable structural fill material, as needed.

Imported soil intended for use as structural fill should be evaluated by ESNW during construction. The imported soil must be workable to the optimum moisture content, as determined by the Modified Proctor Method (ASTM D1557), at the time of placement and compaction. During wet weather conditions, imported soil intended for use as structural fill should consist of a well-graded, granular soil with a fines content of 5 percent or less (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction).

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, roadway, permanent slope, retaining wall, and utility trench backfill areas.

The native fine-grained soils are not considered “granular soils,” and therefore the fine-grained cuttings generated from site excavations be should be removed from the site and should not be used as structural fill. Fill placement should not occur along sloping areas of this site.

Structural fill placed and compacted during site grading activities should meet the following specifications and guidelines:

- Structural fill material — Granular soil
- Moisture Content — At or slightly above optimum*
- Relative compaction (minimum) — 95 percent (Modified Proctor)
- Loose lift thickness (maximum) — 12 inches

* *Soil shall not be placed dry of optimum and should be evaluated by ESNW during construction.*

With respect to underground utility installations and backfill, local jurisdictions may dictate the soil type(s) and compaction requirements. Unsuitable material or debris must be removed from structural areas if encountered.

Foundations

Based on the relatively soft fine-grained soils encountered near surface at the exploration locations and historical evidence of ancient slope failures, the new residential structures planned for this site should be supported on a helical pier system. In any case, ESNW should review the proposed grading plans to confirm the recommendations in this report remain applicable or to provide additional or revised recommendations for foundation support.

Given the geologic mapping of mass wastage deposits on site and the presence of sensitive, fine-grained native soils, helical piers are recommended for foundation support at this site. The inclusion of helical pier systems into the project design provides some advantages in terms of long-term slope stability and construction related disturbances.

Helical piers are effective at transmitting structural loads to bearing soil strata at depth. Helical piers installed into relatively dense, undisturbed native soils (i.e., at least 15 to 20 feet below existing grades based on the observed subsurface conditions) will provide higher soil bearing capacities without the need for significant grade cuts to expose suitable foundation soils. Furthermore, the potential for future slope failure is reduced by transmitting new structural loads to the bottom of the helical piers, embedded into undisturbed native soils below the ancient/critical failure planes.

Provided the structures will be supported as described above, the following parameters may be used for preliminary design of the new foundations:

- Shaft Diameter 2.875 inch
- Axial Capacity Tension/Compression 30 kips
- Minimum Depth 20 feet

A one-third increase in the allowable soil bearing capacity can be assumed for short-term wind and seismic loading conditions. With structural loading as expected, total settlement in the range of one inch is anticipated, with differential settlement of about one-half inch. Most of the settlement should occur during construction as dead loads are applied.

Slab-on-Grade Floors

Slab-on-grade floors should be supported on a firm and unyielding subgrade consisting of competent native soil or at least 12 inches of new structural fill. Unstable or yielding areas of the subgrade should be recompacted, or overexcavated and replaced with suitable structural fill, prior to slab construction.

A capillary break consisting of a minimum of four inches of free-draining crushed rock or gravel should be placed below the slab. The free-draining crushed rock or gravel material should have a fines content of 5 percent or less (defined as the percent passing the No. 200 sieve, based on the minus three-quarter-inch fraction). In areas where slab moisture is undesirable, installation of a vapor barrier below the slab should be considered. If used, the vapor barrier should consist of a material specifically designed to function as a vapor barrier and should be installed in accordance with the manufacturer's specifications.

Retaining Walls

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

- Active earth pressure (unrestrained condition) 42 pcf
- At-rest earth pressure (restrained condition) 62 pcf
- Traffic surcharge (passenger vehicles) 70 psf (rectangular distribution)
- Passive earth pressure 200 pcf (level surface for at least 10 feet)
- Coefficient of friction 0.40
- Seismic surcharge 8H psf*

* *Where H equals the retained height (in feet).*

The passive earth pressure and coefficient of friction values include a safety factor of 1.5. Additional surcharge loading from adjacent foundations, sloped backfill, or other loads should be included in the retaining wall design.

Retaining walls should be backfilled with free-draining material that extends along the height of the wall and a distance of at least 18 inches behind the wall. The upper 12 inches of the wall backfill may consist of a less permeable soil, if desired.

Drainage should be provided behind retaining walls such that hydrostatic pressures do not develop. If drainage is not provided, hydrostatic pressures should be included in the wall design. A perforated drainpipe should be placed along the base of the wall and connected to an approved discharge location. A typical retaining wall drainage detail is provided on Plate 3.

Drainage

Groundwater seepage will likely be encountered within site excavations, particularly during the wet season. Temporary measures to control surface water runoff and groundwater during construction would likely involve passive elements such as interceptor trenches, interceptor swales, and sumps. ESNW should be consulted during preliminary grading to identify areas of seepage and provide recommendations to reduce the potential for seepage-related instability.

Finish grades must be designed to direct surface water away from the new structures and/or slopes for a distance of at least 10 feet or as setbacks allow. Water must not be allowed to pond adjacent to the new structures and/or slopes. In our opinion, drainage should be provided along the building perimeter footings. A typical foundation drain detail is provided on Plate 4.

Infiltration Feasibility

Review of the referenced infiltration potential map indicates that infiltrating LID facilities are not permitted at the subject site. In our opinion, based on the disturbed and fine-grained native soil textures, mapped mass wasting deposits, and sloping surface grades, on-site infiltration should be considered infeasible from a geotechnical standpoint.

Utility Support and Trench Backfill

The soils observed at the subsurface exploration locations are generally suitable for support of utilities. However, the use of the native soil as structural backfill in the utility trench excavations is not recommended. Imported granular fill should be used for utility backfill applications.

Utility trench backfill should be placed and compacted to the specifications of structural fill provided in this report or to the applicable requirements of the presiding jurisdiction.

Seismic Design

The 2018 International Building Code (2018 IBC) recognizes the most recent edition of the Minimum Design Loads for Buildings and Other Structures manual (ASCE 7-16) for seismic design, specifically with respect to earthquake loads. Based on our current understanding of the project design and soil conditions encountered at the boring locations, Site Class E should be considered for preliminary design.

The parameters and values provided below are recommended for seismic design per the 2018 IBC.

Parameter	**Value**
Site Class	E*
Mapped short period spectral response acceleration, S_S (g)	1.392
Mapped 1-second period spectral response acceleration, S_1 (g)	0.485
Site modified peak ground acceleration, PGA_M (g)	0.658

* *Based on a standard penetration resistance value less than 15 and observed soil profiles having more than 10 feet of soil with plasticity indices greater than 20 and moisture contents greater than 40 percent.*

In accordance with ASCE 7-16 Section 11.4.8, a ground motion hazard analysis shall be performed for structures on Site Class E sites with S_S greater than or equal to 1.0. Ground motion analyses are not required for structures other than seismically isolated structures and structures with damping systems where structures on Site Class E sites with S_S greater than or equal to 1.0, provided the site coefficient F_a is taken as equal to that of Site Class C.

Further discussion between the project structural engineer, the project owner, and ESNW may be prudent to determine the possible impacts to the structural design due to increased earthquake load requirements under the 2018 IBC. Given the preliminary stage of the project design, and pending further involvement with the project structural engineer, completion of a site-specific seismic hazard analysis and development of site-specific response spectra may be warranted. ESNW would be pleased to provide additional consulting services to aid with seismic design efforts, including supplementary geotechnical and geophysical investigation, upon request.

LIMITATIONS

This study has been prepared for the exclusive use of BV Homes, LLC, and its representatives. No warranty, express or implied, is made. The recommendations and conclusions provided in this study are professional opinions consistent with the level of care and skill that is typical of other members in the profession currently practicing under similar conditions in this area. Variations in the soil and groundwater conditions observed at the test locations may exist and may not become evident until construction. ESNW should reevaluate the conclusions provided in this geotechnical engineering study if variations are encountered.

Additional Services

ESNW should have an opportunity to review final project plans with respect to the geotechnical recommendations provided in this report. The geotechnical recommendations provided in this report are considered preliminary, are intended to support initial feasibility consideration, and should be reviewed and/or updated as project plans develop. ESNW should also be retained to provide testing and consultation services during construction.

Reference:
King County, Washington
OpenStreetMap.org

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

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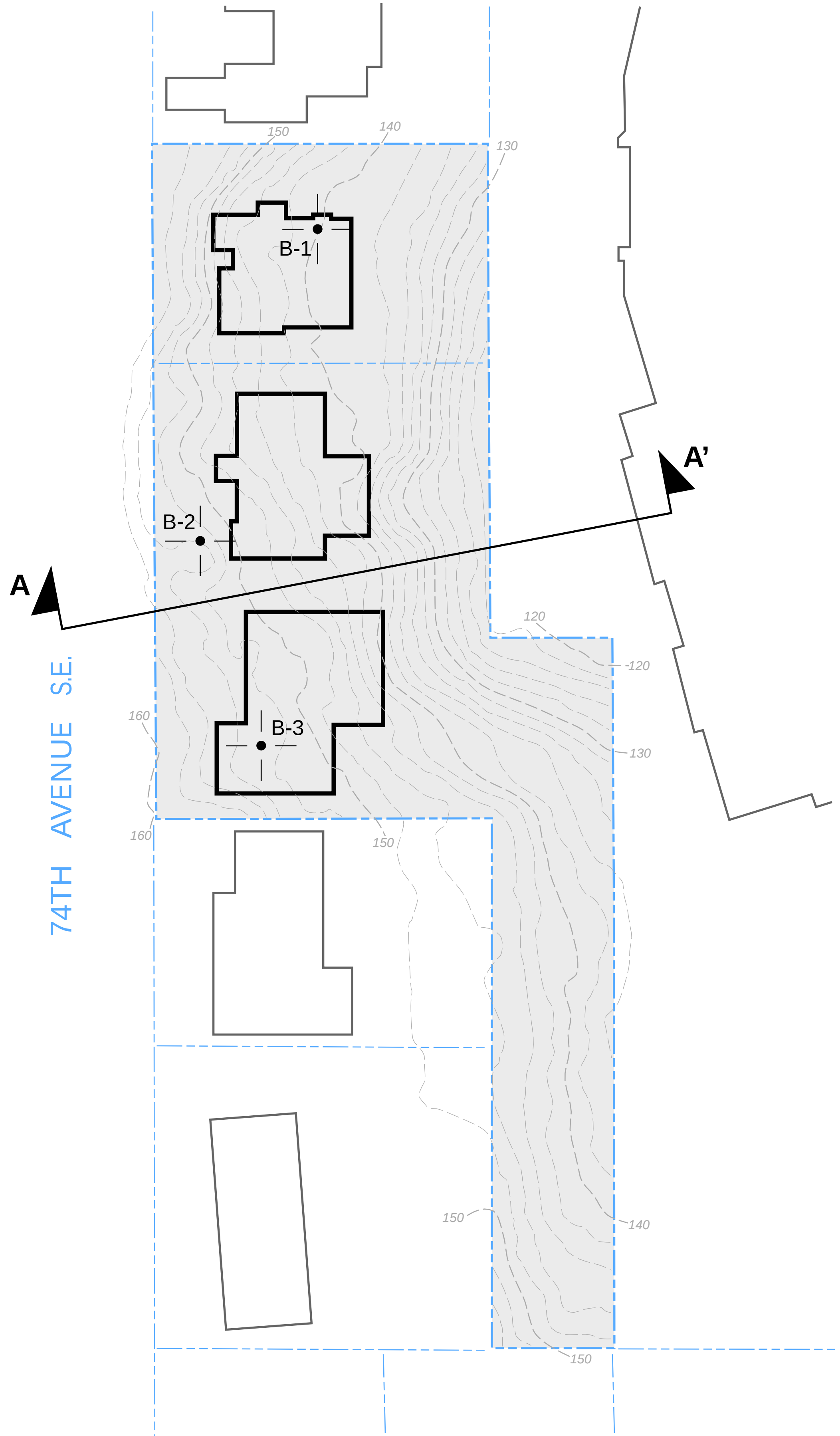
Vicinity Map
74th Avenue S.E. Property
Mercer Island, Washington

Drawn CAM	Date 03/08/2023	Proj. No. 8332.01
Checked BCS	Date Mar. 2023	Plate 1



LEGEND

B-1 — Approximate Location of ESNW Boring, Proj. No. ES-8332.01, Feb. 2023

Subject Site

Proposed Building

Existing Building

Cross Section

NORTH

0 25 50 100

1"=50'

Scale in Feet

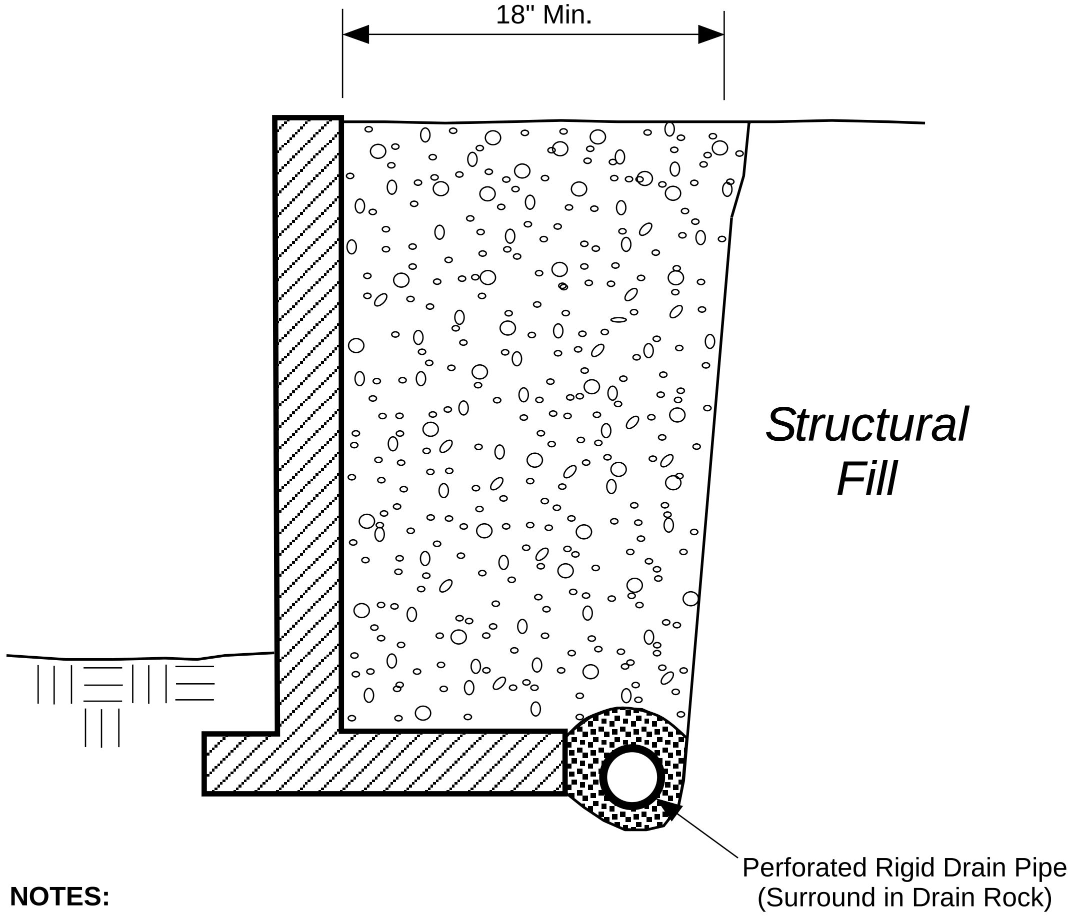
NOTE: The graphics shown on this plate are not intended for design purposes or precise scale measurements, but only to illustrate the approximate test locations relative to the approximate locations of existing and / or proposed site features. The information illustrated is largely based on data provided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

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

Boring Location Plan
74th Avenue S.E. Property
Mercer Island, Washington

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

Drawn	CAM
Checked	BCS
Date	03/23/2023
Proj. No.	8332.01
Plate	2

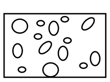


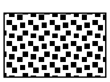
NOTES:

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

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:


Free-draining Structural Backfill


1-inch Drain Rock

Earth Solutions NW LLC
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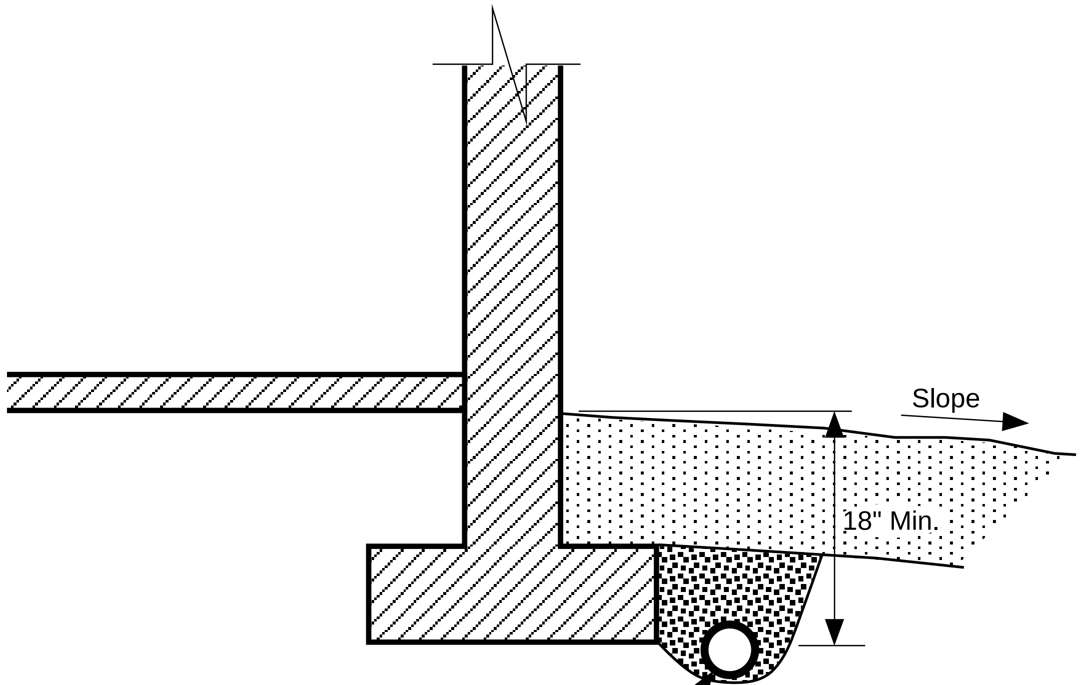
Retaining Wall Drainage Detail
74th Avenue S.E. Property
Mercer Island, Washington

Drawn CAM	Date 03/08/2023	Proj. No. 8332.01
Checked BCS	Date Mar. 2023	Plate 3

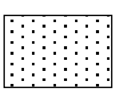


NOTES:

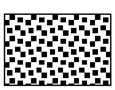
- Do NOT tie roof downspouts to Footing Drain.
- Surface Seal to consist of 12" of less permeable, suitable soil. Slope away from building.

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:



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



1-inch Drain Rock

Earth Solutions NW LLC

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Footing Drain Detail
74th Avenue S.E. Property
Mercer Island, Washington

Drawn CAM	Date 03/08/2023	Proj. No. 8332.01
Checked BCS	Date Mar. 2023	Plate 4

Appendix A

Subsurface Exploration
Boring Logs

ES-8332.01

Subsurface conditions on site were explored on February 24, 2023, by advancing three exploratory borings at accessible locations within the property boundaries using a machine and operators retained by our firm. The approximate locations of the borings are illustrated on Plate 2 of this study. The subsurface exploration logs are provided in this Appendix. The borings were advanced to a maximum depth of about 46.5 feet bgs.

The final logs represent the interpretations of the field logs and the results of laboratory analyses. The stratification lines on the logs represent the approximate boundaries between soil types. In actuality, the transitions may be more gradual.

Major Divisions			Symbol	Description
Coarse-Grained Soils - More Than 50% Retained on No. 200 Sieve	Gravels - More Than 50% of Coarse Fraction Retained on No. 4 Sieve	< 5% Fines	GW	Well-graded gravel with or without sand, little to no fines
			GP	Poorly graded gravel with or without sand, little to no fines
		> 12% Fines	GM	Silty gravel with or without sand
			GC	Clayey gravel with or without sand
	Sands - 50% or More of Coarse Fraction Passes No. 4 Sieve	< 5% Fines	SW	Well-graded sand with or without gravel, little to no fines
			SP	Poorly graded sand with or without gravel, little to no fines
		> 12% Fines	SM	Silty sand with or without gravel
			SC	Clayey sand with or without gravel
Fine-Grained Soils - 50% or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less Than 50		ML	Silt with or without sand or gravel; sandy or gravelly silt
			CL	Clay of low to medium plasticity; lean clay with or without sand or gravel; sandy or gravelly lean clay
			OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		MH	Elastic silt with or without sand or gravel; sandy or gravelly elastic silt
			CH	Clay of high plasticity; fat clay with or without sand or gravel; sandy or gravelly fat clay
			OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils
Fill			FILL	Made Ground

Moisture Content

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

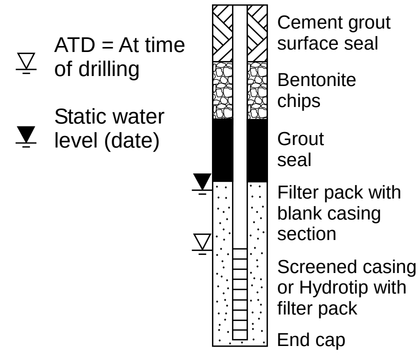
Damp - Perceptible moisture, likely below optimum MC

Moist - Damp but no visible water, likely at/near optimum MC

Wet - Water visible but not free draining, likely above optimum MC

Saturated/Water Bearing - Visible free water, typically below groundwater table

Symbols



Terms Describing Relative Density and Consistency

Coarse-Grained Soils:

Density	SPT blows/foot
Very Loose	< 4
Loose	4 to 9
Medium Dense	10 to 29
Dense	30 to 49
Very Dense	≥ 50

Fine-Grained Soils:

Consistency	SPT blows/foot
Very Soft	< 2
Soft	2 to 3
Medium Stiff	4 to 7
Stiff	8 to 14
Very Stiff	15 to 29
Hard	≥ 30

Test Symbols & Units

Fines = Fines Content (%)

MC = Moisture Content (%)

DD = Dry Density (pcf)

Str = Shear Strength (tsf)

PID = Photoionization Detector (ppm)

OC = Organic Content (%)

CEC = Cation Exchange Capacity (meq/100 g)

LL = Liquid Limit (%)

PL = Plastic Limit (%)

PI = Plasticity Index (%)

Component Definitions

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

Modifier Definitions

Percentage by Weight (Approx.)	Modifier
< 5	Trace (sand, silt, clay, gravel)
5 to 14	Slightly (sandy, silty, clayey, gravelly)
15 to 29	Sandy, silty, clayey, gravelly
≥ 30	Very (sandy, silty, clayey, gravelly)

Classifications of soils in this geotechnical report and as shown on the exploration logs are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates, and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D2487 and D2488 were used as an identification guide for the Unified Soil Classification System.

Earth Solutions NWLLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

EXPLORATION LOG KEY

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-1

PROJECT NUMBER ES-8332.01
PROJECT NAME 74th Avenue S.E. Property
DATE STARTED 2/24/23 **COMPLETED** 2/24/23
GROUND ELEVATION 140 ft
DRILLING CONTRACTOR Boretec1, Inc.
LATITUDE 47.58819 **LONGITUDE** -122.24008
LOGGED BY BCS **CHECKED BY** SSR
GROUND WATER LEVEL:
NOTES
∇ **AT TIME OF DRILLING**
SURFACE CONDITIONS Forest
AFTER DRILLING

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					MH		Brown elastic SILT, medium stiff, wet
	SS	28	3-5-5 (10)	MC = 40.4			-abundant woody organics
							-decreasing organics
5	SS	67	3-4-5 (9)	MC = 39.3			-becomes tan -disturbed/fractured soil texture and light iron oxide staining extending to 15.5'
	SS	100	2-3-5 (8)	MC = 42.2 LL = 82 PL = 50 Fines = 99.9 PI = 32			-strong cohesion
10	SS	100	4-4-5 (9)	MC = 43.9			
15	SS	100	4-5-7 (12)	MC = 38.4			-becomes gray, massive (no bedding)
20							20.0 — 120.0

(Continued Next Page)

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BORING NUMBER B-1

PROJECT NUMBER ES-8332.01
PROJECT NAME 74th Avenue S.E. Property
DATE STARTED 2/24/23 **COMPLETED** 2/24/23
GROUND ELEVATION 140 ft
DRILLING CONTRACTOR Boretec1, Inc.
LATITUDE 47.58819 **LONGITUDE** -122.24008
LOGGED BY BCS **CHECKED BY** SSR
GROUND WATER LEVEL:
NOTES
AT TIME OF DRILLING
SURFACE CONDITIONS Forest
AFTER DRILLING

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	100	5-6-10 (16)	MC = 33.7	MH		Gray elastic SILT, stiff, wet
25	SS	100	4-7-10 (17)	MC = 37.3			
30	SS	100	5-7-9 (16)	MC = 37.9 LL = 74 PL = 41 Fines = 100.0 PI = 33			
35	SS	100	5-8-9 (17)	MC = 34.7			
40							

(Continued Next Page)

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-1

PROJECT NUMBER ES-8332.01
PROJECT NAME 74th Avenue S.E. Property
DATE STARTED 2/24/23 **COMPLETED** 2/24/23
GROUND ELEVATION 140 ft
DRILLING CONTRACTOR Boretec1, Inc.
LATITUDE 47.58819 **LONGITUDE** -122.24008
LOGGED BY BCS **CHECKED BY** SSR
GROUND WATER LEVEL:
NOTES
AT TIME OF DRILLING
SURFACE CONDITIONS Forest
AFTER DRILLING

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
40	SS	100	6-8-10 (18)	MC = 39.6	MH		Gray elastic SILT, stiff, wet *(continued)*
45	SS	100	6-10-11 (21)	MC = 32.5		46.5	93.5

Boring terminated at 46.5 feet below existing grade. No groundwater encountered during drilling. Boring backfilled with bentonite chips.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-2

PROJECT NUMBER ES-8332.01
PROJECT NAME 74th Avenue S.E. Property
DATE STARTED 2/24/23 **COMPLETED** 2/24/23
GROUND ELEVATION 154 ft
DRILLING CONTRACTOR Boretec1, Inc.
LATITUDE 47.58791 **LONGITUDE** -122.24024
LOGGED BY BCS **CHECKED BY** SSR
GROUND WATER LEVEL:
NOTES
AT TIME OF DRILLING
SURFACE CONDITIONS Forest
AFTER DRILLING

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					MH		Dark brown to black elastic SILT, medium stiff, wet
	SS	67	2-3-5 (8)	MC = 30.0			-trace to minor organics
5	SS	67	4-4-4 (8)	MC = 34.6			-leaves, roots, sticks, potential down drag on auger from surface
	SS	78	2-2-3 (5)	MC = 45.5			-becomes soft -becomes tan -disturbed/fractured soil texture and light iron oxide staining extending to roughly 19'
10	SS	100	3-2-4 (6)	MC = 41.5 LL = 64 PL = 42 Fines = 100.0 PI = 22			-becomes medium stiff
15	SS	100	2-4-7 (11)	MC = 45.3			
20						20.0	-becomes gray, massive (no bedding) 134.0

(Continued Next Page)

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-2

PROJECT NUMBER ES-8332.01
PROJECT NAME 74th Avenue S.E. Property
DATE STARTED 2/24/23 **COMPLETED** 2/24/23
GROUND ELEVATION 154 ft
DRILLING CONTRACTOR Boretec1, Inc.
LATITUDE 47.58791 **LONGITUDE** -122.24024
LOGGED BY BCS **CHECKED BY** SSR
GROUND WATER LEVEL:
NOTES
∇ **AT TIME OF DRILLING**
SURFACE CONDITIONS Forest
AFTER DRILLING

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	100	4-6-9 (15)	MC = 41.1	MH		Gray elastic SILT, medium stiff, wet
25	SS	100	4-9-10 (19)	MC = 39.2			-light groundwater seepage -becomes stiff -trace sand
30	SS	17	14-12-9 (21)	MC = 20.3		31.5	-decreasing moisture content -trace sand and gravel 122.5

Boring terminated at 31.5 feet below existing grade. Groundwater seepage encountered at 25.0 feet during drilling. Boring backfilled with bentonite chips.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-3

PROJECT NUMBER ES-8332.01
PROJECT NAME 74th Avenue S.E. Property
DATE STARTED 2/24/23 **COMPLETED** 2/24/23
GROUND ELEVATION 153 ft
DRILLING CONTRACTOR Boretec1, Inc.
LATITUDE 47.58772 **LONGITUDE** -122.24015
LOGGED BY BCS **CHECKED BY** SSR
GROUND WATER LEVEL:
NOTES
∇ **AT TIME OF DRILLING**
SURFACE CONDITIONS Forest
AFTER DRILLING

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					TPSL		Dark brown TOPSOIL, leaves, organics
	SS	11	4-5-5 (10)	MC = 83.6			-limited recovery
4.5							148.5
5					CH		Tan fat CLAY, soft, wet -disturbed/fractured soil texture and light iron oxide staining extending to 20.5'
	SS	28	3-3-3 (6)	MC = 35.5			
	SS	100	3-3-6 (9)	MC = 46.2			-becomes medium stiff
10	SS	100	4-5-8 (13)	MC = 41.4 LL = 61 PL = 31 Fines = 99.9 PI = 30			
15	SS	100	4-5-8 (13)	MC = 44.8			
20							20.0 — 133.0

(Continued Next Page)

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-3

PROJECT NUMBER ES-8332.01
PROJECT NAME 74th Avenue S.E. Property
DATE STARTED 2/24/23 **COMPLETED** 2/24/23
GROUND ELEVATION 153 ft
DRILLING CONTRACTOR Boretec1, Inc.
LATITUDE 47.58772 **LONGITUDE** -122.24015
LOGGED BY BCS **CHECKED BY** SSR
GROUND WATER LEVEL:
NOTES
AT TIME OF DRILLING
SURFACE CONDITIONS Forest
AFTER DRILLING

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
20	SS	100	5-5-9 (14)	MC = 40.9	CH		Tan fat CLAY, medium stiff, wet -becomes gray, massive (no bedding) -groundwater seepage	
25	SS	100	3-4-4 (8)	MC = 39.8 LL = 75 PL = 32 Fines = 92.6 PI = 43				
30	SS	100	14-18-22 (40)	MC = 3.8		30.5	-sharp contact with underlying unit observed in sample spoon	122.5
					SP-SM	31.5	Gray poorly graded SAND with silt and gravel, dense, damp	121.5

Boring terminated at 31.5 feet below existing grade. Groundwater seepage encountered at 21.0 feet during drilling. Boring backfilled with bentonite chips.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Appendix B

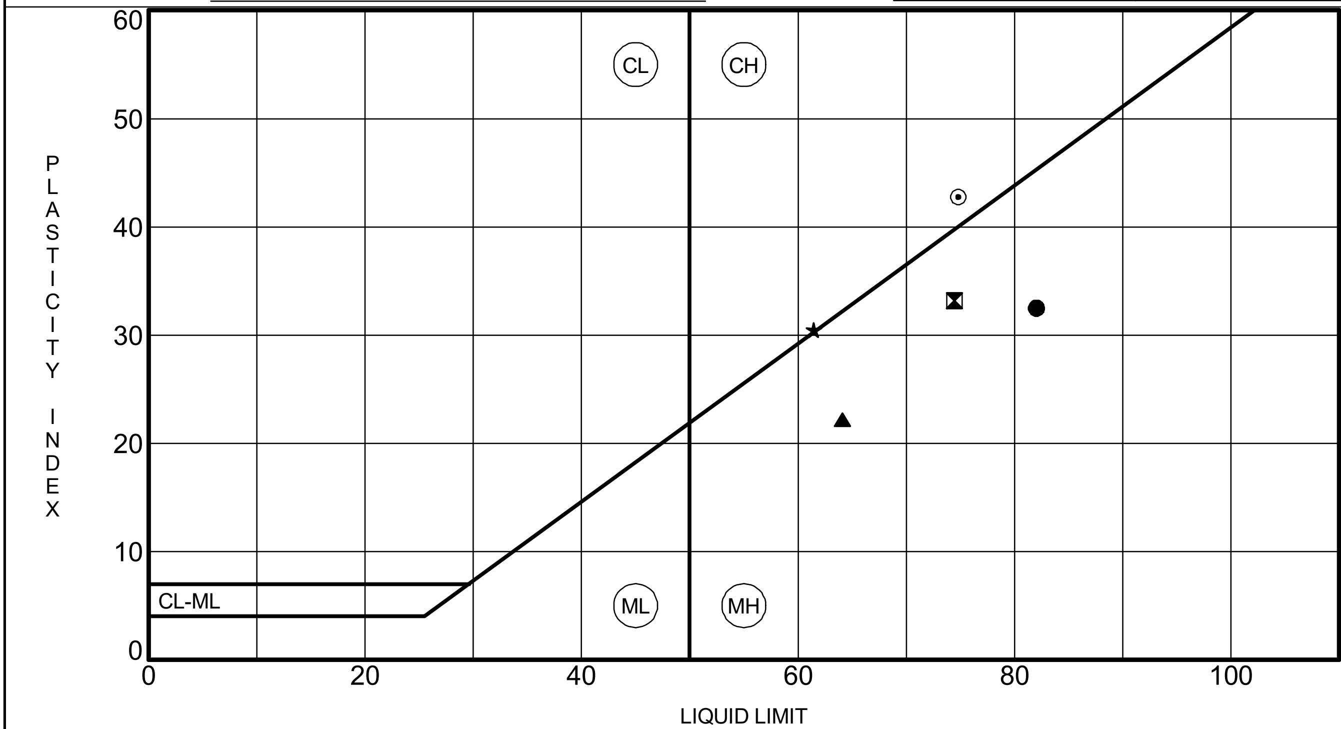
Laboratory Test Results

ES-8332.01

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

ATTERBERG LIMITS' RESULTS

PROJECT NUMBER ES-8332.01 **PROJECT NAME** 74th Avenue S.E. Property



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**B-01**	**7.5**	**82**	**50**	**32**	**99.9**	**Brown Elastic SILT, MH**
⧗	**B-01**	**30.0**	**74**	**41**	**33**	**100.0**	**Gray Elastic SILT, MH**
▲	**B-02**	**10.0**	**64**	**42**	**22**	**100.0**	**Brown Elastic SILT, MH**
★	**B-03**	**10.0**	**61**	**31**	**30**	**99.9**	**Tan Fat CLAY, CH**
⊙	**B-03**	**25.0**	**75**	**32**	**43**	**92.6**	**Gray Fat CLAY, CH**

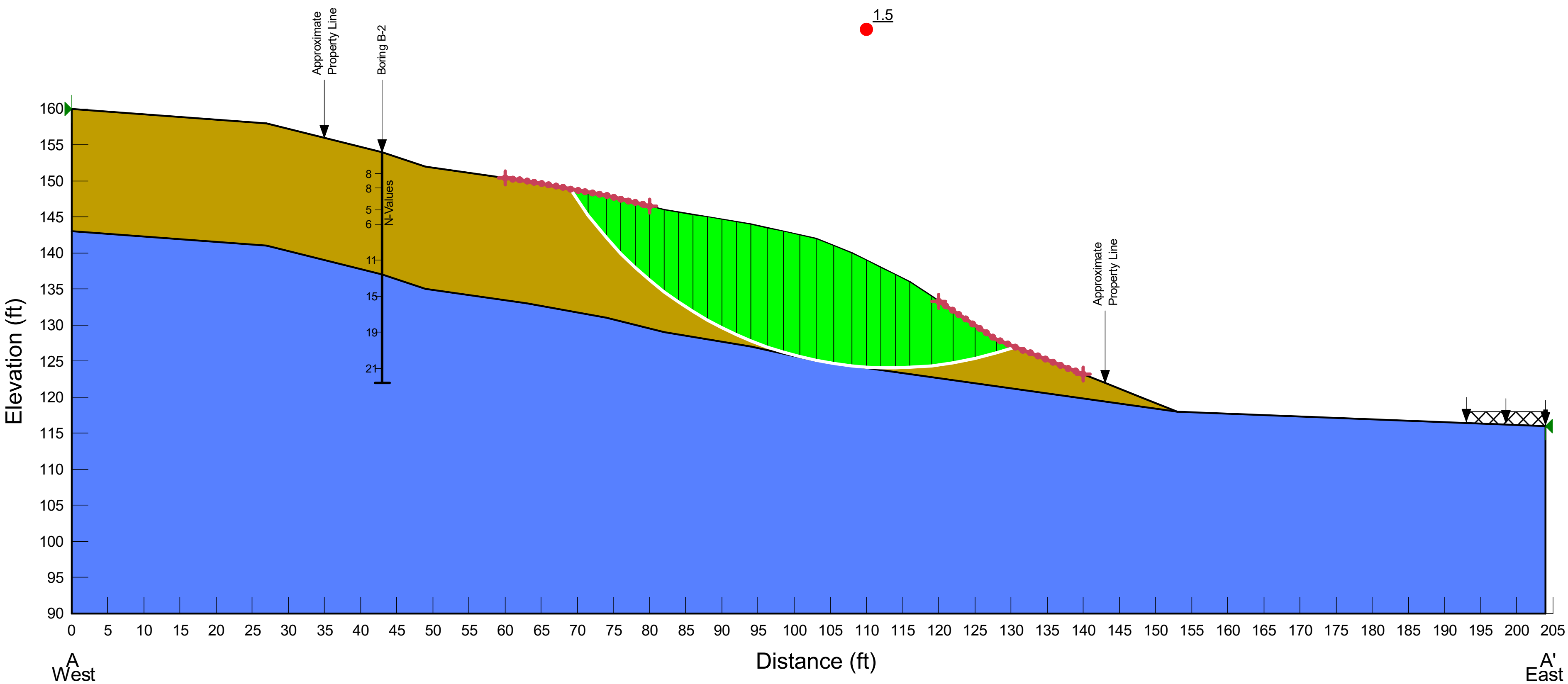
Appendix C

Slope/W Computer Output

ES-8332.01

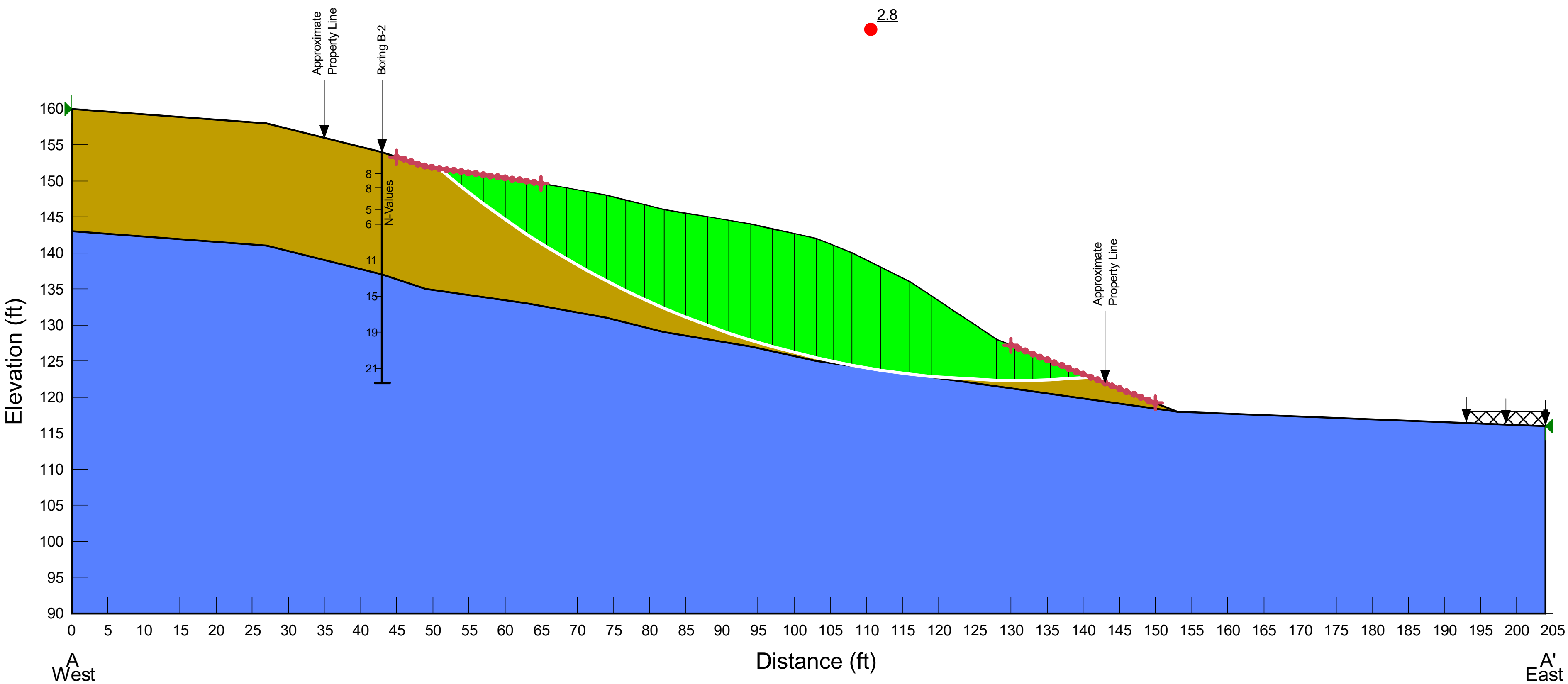
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	110	750	5
	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	115	1,500	7

ES-8332.01
74th Avenue S.E. Property
Existing Geometry
Seismic Condition
Horizontal Acceleration = 0.329



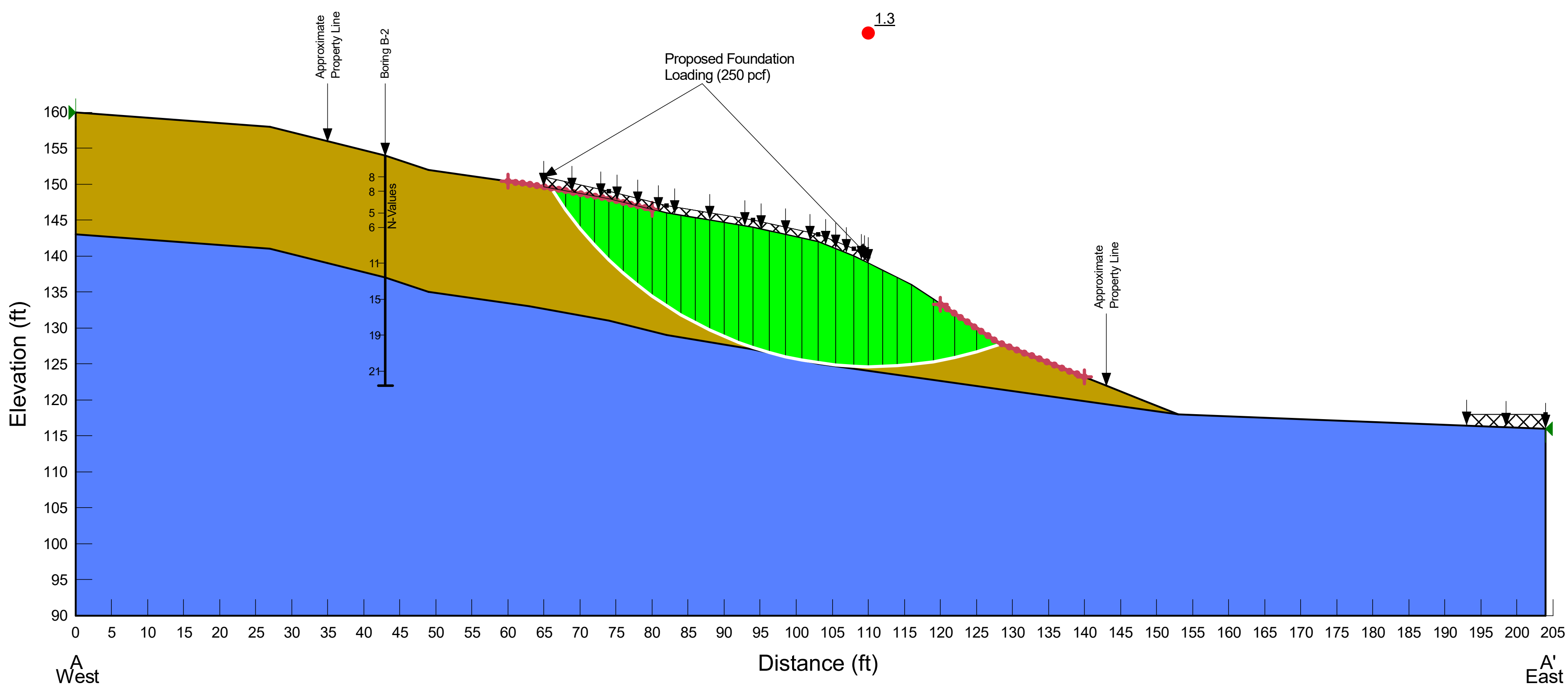
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	110	750	5
	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	115	1,500	7

ES-8332.01
74th Avenue S.E. Property
Existing Geometry
Static Condition



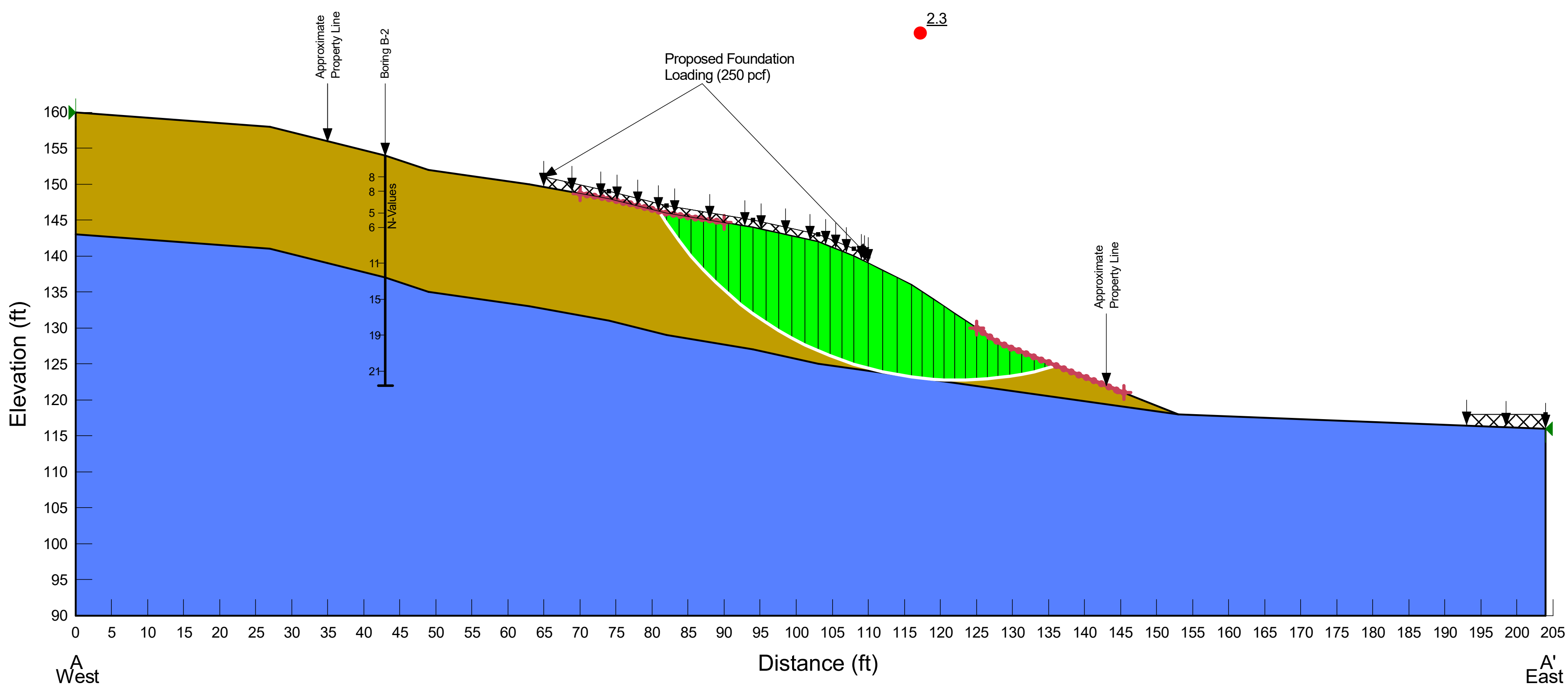
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	110	750	5
	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	115	1,500	7

ES-8332.01
74th Avenue S.E. Property
Proposed Geometry
Seismic Condition
Horizontal Acceleration = 0.329



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	110	750	5
	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	115	1,500	7

ES-8332.01
74th Avenue S.E. Property
Proposed Geometry
Static Condition



Existing, Seismic

File Information

File Version: 11.02
Title: 74th Avenue S.E. Property
Created By: Brian Snow
Last Edited By: Brian Snow
Revision Number: 45
Date: 03/31/2023
Time: 11:03:24 AM
Tool Version: 11.2.0.22838
File Name: 8332.01 Slope Stability.gsz
Directory: G:\# ESNW\# INBOX\00 - Project Files\00 - Geotechnical\8332.01 - (SLOPE) 74th Avenue S.E. Property\SlopeW\
Last Solved Date: 03/31/2023
Last Solved Time: 11:03:35 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Existing, Seismic

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 5 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Under-Relaxation Criteria
- Initial Rate: 1
- Minimum Rate: 0.1
- Rate Reduction Factor: 0.65
- Reduction Frequency (iterations): 50

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 1,500 psf
Effective Friction Angle: 7 °
Phi-B: 0 °

Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 750 psf
Effective Friction Angle: 5 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (60, 150.42857) ft
Left-Zone Right Coordinate: (80, 146.5) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (120, 133.33333) ft
Right-Zone Right Coordinate: (140, 123.2) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 160) ft
Right Coordinate: (204, 116) ft

Seismic Coefficients

Horz Seismic Coef.: 0.329

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	193 ft	118 ft
	204 ft	118 ft

Geometry

Name: Existing Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	160 ft
Point 2	27 ft	158 ft
Point 3	35 ft	156 ft
Point 4	43 ft	154 ft
Point 5	49 ft	152 ft
Point 6	63 ft	150 ft
Point 7	74 ft	148 ft
Point 8	82 ft	146 ft
Point 9	94 ft	144 ft
Point 10	103 ft	142 ft
Point 11	108 ft	140 ft
Point 12	112 ft	138 ft
Point 13	116 ft	136 ft
Point 14	119 ft	134 ft
Point 15	122 ft	132 ft
Point 16	125 ft	130 ft
Point 17	128 ft	128 ft
Point 18	133 ft	126 ft
Point 19	138 ft	124 ft
Point 20	143 ft	122 ft
Point 21	148 ft	120 ft
Point 22	153 ft	118 ft

Point 23	204 ft	116 ft
Point 24	204 ft	90 ft
Point 25	0 ft	90 ft
Point 26	0 ft	143 ft
Point 27	27 ft	141 ft
Point 28	35 ft	139 ft
Point 29	43 ft	137 ft
Point 30	49 ft	135 ft
Point 31	63 ft	133 ft
Point 32	74 ft	131 ft
Point 33	82 ft	129 ft
Point 34	94 ft	127 ft
Point 35	103 ft	125 ft

Regions

	Material	Points	Area
Region 1	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,35,34,33,32,31,30,29,28,27,26	2,144 ft^2
Region 2	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	26,25,24,23,22,35,34,33,32,31,30,29,28,27	7,594 ft^2

Slip Results

Slip Surfaces Analysed: 1896 of 2205 converged

Current Slip Surface

Slip Surface: 1,003
Factor of Safety: 1.5
Volume: 685.60713 ft^3
Weight: 75,416.785 lbf
Resisting Moment: 3,059,739.4 lbf·ft
Activating Moment: 2,097,770 lbf·ft
Resisting Force: 51,705.282 lbf
Activating Force: 35,468.381 lbf
Slip Rank: 1 of 2,205 slip surfaces
Exit: (130.5828, 126.96688) ft
Entry: (69.048338, 148.9003) ft
Radius: 52.077183 ft
Center: (113.43371, 176.13945) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	70.286253 ft	147.0633 ft	0 psf	-430.66839 psf	-37.678602 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 2	72.762084 ft	143.67541 ft	0 psf	35.147506 psf	3.0750083 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 3	75 ft	141.02985 ft	0 psf	291.72716 psf	25.52282 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 4	77 ft	138.95535 ft	0 psf	444.17025 psf	38.859861 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 5	79 ft	137.09365 ft	0 psf	558.42876 psf	48.856186 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 6	81 ft	135.41535 ft	0 psf	648.37942 psf	56.725849 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 7	83 ft	133.89844 ft	0 psf	728.07727 psf	63.698507 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 8	85 ft	132.52602 ft	0 psf	803.09613 psf	70.261807 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 9	87 ft	131.28475 ft	0 psf	872.73248 psf	76.354198 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 10	89 ft	130.16398 ft	0 psf	940.74029 psf	82.304111 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 11	91 ft	129.15506 ft	0 psf	1,010.0829 psf	88.370804 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 12	93 ft	128.25089 ft	0 psf	1,083.1343 psf	94.761972 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 13	95.125 ft	127.40159 ft	0 psf	1,162.9612 psf	101.74592 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 14	97.375 ft	126.61419 ft	0 psf	1,252.3726 psf	109.56841 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 15	99.625 ft	125.93994 ft	0 psf	1,351.0598 psf	118.20242 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 16	101.875 ft	125.37433 ft	0 psf	1,458.5848 psf	127.60963 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice		124.89416	0	1,563.3912	136.77901			Disturbed Pre-Olympia

17	104.25 ft	ft	psf	psf	psf	750 psf	0 psf	Fine-Grained Glacial Deposits (Qpogf)
Slice 18	106.75 ft	124.50834 ft	0 psf	1,659.0011 psf	145.14379 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 19	109 ft	124.26106 ft	0 psf	1,729.5727 psf	151.31801 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 20	111 ft	124.1288 ft	0 psf	1,767.7463 psf	154.65776 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 21	113 ft	124.07368 ft	0 psf	1,783.61 psf	156.04566 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 22	115 ft	124.09545 ft	0 psf	1,769.854 psf	154.84216 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 23	117.5 ft	124.24307 ft	0 psf	1,673.4358 psf	146.40666 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 24	120.5 ft	124.56612 ft	0 psf	1,449.8882 psf	126.84878 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 25	123.5 ft	125.0673 ft	0 psf	1,126.6719 psf	98.571021 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 26	126.5 ft	125.75192 ft	0 psf	722.80863 psf	63.237561 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 27	129.2914 ft	126.55389 ft	0 psf	342.80099 psf	29.9912 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Existing, Static

File Information

File Version: 11.02
Title: 74th Avenue S.E. Property
Created By: Brian Snow
Last Edited By: Brian Snow
Revision Number: 45
Date: 03/31/2023
Time: 11:03:24 AM
Tool Version: 11.2.0.22838
File Name: 8332.01 Slope Stability.gsz
Directory: G:\# ESNW\# INBOX\00 - Project Files\00 - Geotechnical\8332.01 - (SLOPE) 74th Avenue S.E. Property\SlopeW\
Last Solved Date: 03/31/2023
Last Solved Time: 11:03:34 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Existing, Static

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 5 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Under-Relaxation Criteria
- Initial Rate: 1
- Minimum Rate: 0.1
- Rate Reduction Factor: 0.65
- Reduction Frequency (iterations): 50

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 1,500 psf
Effective Friction Angle: 7 °
Phi-B: 0 °

Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 750 psf
Effective Friction Angle: 5 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (45, 153.33333) ft
Left-Zone Right Coordinate: (65, 149.63636) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (130, 127.2) ft
Right-Zone Right Coordinate: (150, 119.2) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 160) ft
Right Coordinate: (204, 116) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	193 ft	118 ft
	204 ft	118 ft

Geometry

Name: Existing Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	160 ft
Point 2	27 ft	158 ft
Point 3	35 ft	156 ft
Point 4	43 ft	154 ft
Point 5	49 ft	152 ft
Point 6	63 ft	150 ft
Point 7	74 ft	148 ft
Point 8	82 ft	146 ft
Point 9	94 ft	144 ft
Point 10	103 ft	142 ft
Point 11	108 ft	140 ft
Point 12	112 ft	138 ft
Point 13	116 ft	136 ft
Point 14	119 ft	134 ft
Point 15	122 ft	132 ft
Point 16	125 ft	130 ft
Point 17	128 ft	128 ft
Point 18	133 ft	126 ft
Point 19	138 ft	124 ft
Point 20	143 ft	122 ft
Point 21	148 ft	120 ft
Point 22	153 ft	118 ft
Point 23	204 ft	116 ft
Point 24	204 ft	90 ft
Point 25	0 ft	90 ft
Point 26	0 ft	143 ft

Point 27	27 ft	141 ft
Point 28	35 ft	139 ft
Point 29	43 ft	137 ft
Point 30	49 ft	135 ft
Point 31	63 ft	133 ft
Point 32	74 ft	131 ft
Point 33	82 ft	129 ft
Point 34	94 ft	127 ft
Point 35	103 ft	125 ft

Regions

	Material	Points	Area
Region 1	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,35,34,33,32,31,30,29,28,27,26	2,144 ft^2
Region 2	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	26,25,24,23,22,35,34,33,32,31,30,29,28,27	7,594 ft^2

Slip Results

Slip Surfaces Analysed: 2155 of 2205 converged

Current Slip Surface

Slip Surface: 687
Factor of Safety: 2.8
Volume: 926.22126 ft^3
Weight: 101,884.34 lbf
Resisting Moment: 10,000,387 lbf·ft
Activating Moment: 3,603,357.8 lbf·ft
Resisting Force: 75,743.065 lbf
Activating Force: 27,292.725 lbf
Slip Rank: 1 of 2,205 slip surfaces
Exit: (141, 122.8) ft
Entry: (50.881913, 151.73116) ft
Radius: 122.73745 ft
Center: (130.55725, 245.0924) ft

Slip Slices

	X	Y	PWP	Base Normal	Frictional Strength	Cohesive Strength	Suction Strength	Base Material

				Stress				
Slice 1	52.396674 ft	150.47979 ft	0 psf	-99.494923 psf	-8.7046778 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 2	55.426196 ft	148.05562 ft	0 psf	134.70046 psf	11.784763 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 3	58.455717 ft	145.78305 ft	0 psf	343.68152 psf	30.068237 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 4	61.485239 ft	143.65187 ft	0 psf	531.37392 psf	46.489194 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 5	64.375 ft	141.73997 ft	0 psf	688.42311 psf	60.229217 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 6	67.125 ft	140.02932 ft	0 psf	818.88173 psf	71.642868 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 7	69.875 ft	138.41699 ft	0 psf	938.46093 psf	82.104692 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 8	72.625 ft	136.89858 ft	0 psf	1,048.5085 psf	91.732606 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 9	75.333333 ft	135.49052 ft	0 psf	1,139.532 psf	99.696136 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 10	78 ft	134.18685 ft	0 psf	1,212.6291 psf	106.0913 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 11	80.666667 ft	132.96175 ft	0 psf	1,279.2463 psf	111.91955 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 12	83.5 ft	131.74577 ft	0 psf	1,355.8094 psf	118.61795 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 13	86.5 ft	130.54609 ft	0 psf	1,442.0244 psf	126.16079 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 14	89.5 ft	129.43666 ft	0 psf	1,521.2564 psf	133.09269 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 15	92.5 ft	128.4149 ft	0 psf	1,593.603 psf	139.4222 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 16	95.5 ft	127.47854 ft	0 psf	1,650.3558 psf	144.38743 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 17	98.5 ft	126.62553 ft	0 psf	1,691.1088 psf	147.95285 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice	101.5 ft	125.85409	0	1,724.0313	150.8332	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial

18		ft	psf	psf	psf			Deposits (Qpogf)
Slice 19	104.25 ft	125.21424 ft	0 psf	1,723.7725 psf	150.81055 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 20	106.75 ft	124.69276 ft	0 psf	1,690.7886 psf	147.92483 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 21	110 ft	124.10576 ft	0 psf	1,614.6804 psf	141.26623 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 22	114 ft	123.49361 ft	0 psf	1,487.9464 psf	130.17844 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 23	117.5 ft	123.06079 ft	0 psf	1,333.6105 psf	116.6758 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 24	120.5 ft	122.77695 ft	0 psf	1,156.0702 psf	101.14304 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 25	123.5 ft	122.56722 ft	0 psf	965.98178 psf	84.512455 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 26	126.5 ft	122.43121 ft	0 psf	763.73446 psf	66.818107 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 27	129.25 ft	122.36828 ft	0 psf	605.23386 psf	52.951101 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 28	131.75 ft	122.36711 ft	0 psf	493.16586 psf	43.146422 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 29	134.25 ft	122.41689 ft	0 psf	374.23118 psf	32.740986 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 30	136.75 ft	122.51767 ft	0 psf	248.87721 psf	21.773935 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 31	139.5 ft	122.69041 ft	0 psf	103.86513 psf	9.0870211 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Proposed, Seismic

File Information

File Version: 11.02
Title: 74th Avenue S.E. Property
Created By: Brian Snow
Last Edited By: Brian Snow
Revision Number: 45
Date: 03/31/2023
Time: 11:03:24 AM
Tool Version: 11.2.0.22838
File Name: 8332.01 Slope Stability.gsz
Directory: G:\# ESNW\# INBOX\00 - Project Files\00 - Geotechnical\8332.01 - (SLOPE) 74th Avenue S.E. Property\SlopeW\
Last Solved Date: 03/31/2023
Last Solved Time: 11:03:36 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Proposed, Seismic

- Kind: SLOPE/W
- Analysis Type: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions from: (none)
  - Unit Weight of Water: 62.430189 pcf
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Optimize Critical Slip Surface Location: No
  - Tension Crack Option: (none)
- Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Geometry Settings
    - Minimum Slip Surface Depth: 5 ft
    - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Under-Relaxation Criteria
- Initial Rate: 1
- Minimum Rate: 0.1
- Rate Reduction Factor: 0.65
- Reduction Frequency (iterations): 50

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 1,500 psf
Effective Friction Angle: 7 °
Phi-B: 0 °

Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 750 psf
Effective Friction Angle: 5 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (60, 150.42857) ft
Left-Zone Right Coordinate: (80, 146.5) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (120, 133.33333) ft
Right-Zone Right Coordinate: (140, 123.2) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 160) ft
Right Coordinate: (204, 116) ft

Seismic Coefficients

Horz Seismic Coef.: 0.329

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	193 ft	118 ft
	204 ft	118 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	65 ft	151 ft
	74 ft	149 ft
	82 ft	147 ft
	94 ft	145 ft
	103 ft	143 ft
	108 ft	141 ft
	110 ft	140 ft

Geometry

Name: Proposed Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	160 ft
Point 2	27 ft	158 ft
Point 3	35 ft	156 ft
Point 4	43 ft	154 ft
Point 5	49 ft	152 ft
Point 6	63 ft	150 ft
Point 7	74 ft	148 ft

Point 8	82 ft	146 ft
Point 9	94 ft	144 ft
Point 10	103 ft	142 ft
Point 11	108 ft	140 ft
Point 12	112 ft	138 ft
Point 13	116 ft	136 ft
Point 14	119 ft	134 ft
Point 15	122 ft	132 ft
Point 16	125 ft	130 ft
Point 17	128 ft	128 ft
Point 18	133 ft	126 ft
Point 19	138 ft	124 ft
Point 20	143 ft	122 ft
Point 21	148 ft	120 ft
Point 22	153 ft	118 ft
Point 23	204 ft	116 ft
Point 24	204 ft	90 ft
Point 25	0 ft	90 ft
Point 26	0 ft	143 ft
Point 27	27 ft	141 ft
Point 28	35 ft	139 ft
Point 29	43 ft	137 ft
Point 30	49 ft	135 ft
Point 31	63 ft	133 ft
Point 32	74 ft	131 ft
Point 33	82 ft	129 ft
Point 34	94 ft	127 ft
Point 35	103 ft	125 ft

Regions

	Material	Points	Area
Region 1	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,35,34,33,32,31,30,29,28,27,26	2,144 ft^2
Region 2	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	26,25,24,23,22,35,34,33,32,31,30,29,28,27	7,594 ft^2

Slip Results

Slip Surfaces Analysed: 1937 of 2205 converged

Current Slip Surface

Slip Surface: 678
Factor of Safety: 1.3
Volume: 715.71506 ft³
Weight: 78,728.657 lbf
Resisting Moment: 3,177,999.6 lbf·ft
Activating Moment: 2,402,315.1 lbf·ft
Resisting Force: 53,557.381 lbf
Activating Force: 40,490.521 lbf
Slip Rank: 1 of 2,205 slip surfaces
Exit: (128.49008, 127.80397) ft
Entry: (66.038367, 149.44757) ft
Radius: 52.310352 ft
Center: (110.54225, 176.93897) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	67.033571 ft	147.95371 ft	0 psf	-285.44827 psf	-24.973488 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 2	69.023979 ft	145.15965 ft	0 psf	86.020426 psf	7.5258121 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 3	71.014388 ft	142.71019 ft	0 psf	334.11688 psf	29.23144 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 4	73.004796 ft	140.53473 ft	0 psf	510.91364 psf	44.699152 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 5	75 ft	138.58193 ft	0 psf	646.32056 psf	56.545722 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 6	77 ft	136.81926 ft	0 psf	756.20851 psf	66.159672 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 7	79 ft	135.22701 ft	0 psf	847.79136 psf	74.172133 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 8	81 ft	133.78622 ft	0 psf	927.93026 psf	81.183379 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 9	83 ft	132.4821 ft	0 psf	1,006.935 psf	88.095395 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 10	85 ft	131.30287 ft	0 psf	1,088.3072 psf	95.21454 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 11	87 ft	130.23906 ft	0 psf	1,169.71 psf	102.33637 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial

								Deposits (Qpogf)
Slice 12	89 ft	129.28291 ft	0 psf	1,253.6878 psf	109.68347 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 13	91 ft	128.42803 ft	0 psf	1,342.151 psf	117.423 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 14	93 ft	127.66914 ft	0 psf	1,436.4521 psf	125.67328 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 15	95.125 ft	126.96602 ft	0 psf	1,539.5842 psf	134.69616 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 16	97.375 ft	126.32627 ft	0 psf	1,652.8755 psf	144.60787 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 17	99.625 ft	125.79346 ft	0 psf	1,773.0405 psf	155.12094 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 18	101.875 ft	125.36426 ft	0 psf	1,897.3822 psf	165.99943 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 19	104.25 ft	125.0237 ft	0 psf	2,010.1031 psf	175.86123 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 20	106.75 ft	124.78131 ft	0 psf	2,100.0658 psf	183.73195 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 21	109 ft	124.66093 ft	0 psf	2,151.7229 psf	188.25136 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 22	111 ft	124.64018 ft	0 psf	1,899.052 psf	166.14552 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 23	113 ft	124.69598 ft	0 psf	1,871.0434 psf	163.69509 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 24	115 ft	124.82856 ft	0 psf	1,806.4951 psf	158.04784 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 25	117.5 ft	125.1155 ft	0 psf	1,639.9574 psf	143.47768 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 26	120.5 ft	125.60787 ft	0 psf	1,334.8549 psf	116.78467 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 27	123.5 ft	126.28255 ft	0 psf	946.83138 psf	82.837012 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 28	126.5 ft	127.14698 ft	0 psf	503.51565 psf	44.051911 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice	128.24504	127.71584	0	242.89666	21.250704	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial

29	ft	ft	psf	psf	psf			Deposits (Qpogf)

Proposed, Static

File Information

File Version: 11.02
Title: 74th Avenue S.E. Property
Created By: Brian Snow
Last Edited By: Brian Snow
Revision Number: 45
Date: 03/31/2023
Time: 11:03:24 AM
Tool Version: 11.2.0.22838
File Name: 8332.01 Slope Stability.gsz
Directory: G:\# ESNW\# INBOX\00 - Project Files\00 - Geotechnical\8332.01 - (SLOPE) 74th Avenue S.E. Property\SlopeW\
Last Solved Date: 03/31/2023
Last Solved Time: 11:03:36 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Proposed, Static

- Kind: SLOPE/W
- Analysis Type: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions from: (none)
  - Unit Weight of Water: 62.430189 pcf
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Optimize Critical Slip Surface Location: No
  - Tension Crack Option: (none)
- Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Geometry Settings
    - Minimum Slip Surface Depth: 5 ft
    - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Under-Relaxation Criteria
- Initial Rate: 1
- Minimum Rate: 0.1
- Rate Reduction Factor: 0.65
- Reduction Frequency (iterations): 50

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 1,500 psf
Effective Friction Angle: 7 °
Phi-B: 0 °

Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 750 psf
Effective Friction Angle: 5 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (70, 148.72727) ft
Left-Zone Right Coordinate: (90, 144.66667) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (125, 130) ft
Right-Zone Right Coordinate: (145.5, 121) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 160) ft
Right Coordinate: (204, 116) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	193 ft	118 ft
	204 ft	118 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	65 ft	151 ft
	74 ft	149 ft
	82 ft	147 ft
	94 ft	145 ft
	103 ft	143 ft
	108 ft	141 ft
	110 ft	140 ft

Geometry

Name: Proposed Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	160 ft
Point 2	27 ft	158 ft
Point 3	35 ft	156 ft
Point 4	43 ft	154 ft
Point 5	49 ft	152 ft
Point 6	63 ft	150 ft
Point 7	74 ft	148 ft
Point 8	82 ft	146 ft
Point 9	94 ft	144 ft
Point 10	103 ft	142 ft
Point 11	108 ft	140 ft
Point 12	112 ft	138 ft

Point 13	116 ft	136 ft
Point 14	119 ft	134 ft
Point 15	122 ft	132 ft
Point 16	125 ft	130 ft
Point 17	128 ft	128 ft
Point 18	133 ft	126 ft
Point 19	138 ft	124 ft
Point 20	143 ft	122 ft
Point 21	148 ft	120 ft
Point 22	153 ft	118 ft
Point 23	204 ft	116 ft
Point 24	204 ft	90 ft
Point 25	0 ft	90 ft
Point 26	0 ft	143 ft
Point 27	27 ft	141 ft
Point 28	35 ft	139 ft
Point 29	43 ft	137 ft
Point 30	49 ft	135 ft
Point 31	63 ft	133 ft
Point 32	74 ft	131 ft
Point 33	82 ft	129 ft
Point 34	94 ft	127 ft
Point 35	103 ft	125 ft

Regions

	Material	Points	Area
Region 1	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,35,34,33,32,31,30,29,28,27,26	2,144 ft^2
Region 2	Undisturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)	26,25,24,23,22,35,34,33,32,31,30,29,28,27	7,594 ft^2

Slip Results

Slip Surfaces Analysed: 2046 of 2205 converged

Current Slip Surface

Slip Surface: 1,213

Factor of Safety: 2.3

Volume: 531.71912 ft^3

Weight: 58,489.104 lbf
Resisting Moment: 2,581,032.7 lbf·ft
Activating Moment: 1,115,033 lbf·ft
Resisting Force: 46,450.693 lbf
Activating Force: 20,062.961 lbf
Slip Rank: 1 of 2,205 slip surfaces
Exit: (136.11855, 124.75258) ft
Entry: (80.952622, 146.26184) ft
Radius: 48.377658 ft
Center: (122.43454, 171.15458) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	81.476311 ft	145.4281 ft	0 psf	-169.08 psf	-14.792584 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 2	82.857143 ft	143.37326 ft	0 psf	75.843338 psf	6.6354323 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 3	84.571429 ft	141.07329 ft	0 psf	330.51087 psf	28.915954 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 4	86.285714 ft	139.0299 ft	0 psf	538.88955 psf	47.146726 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 5	88 ft	137.19622 ft	0 psf	714.91351 psf	62.546828 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 6	89.714286 ft	135.53958 ft	0 psf	867.48456 psf	75.895064 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 7	91.428571 ft	134.03612 ft	0 psf	1,002.6297 psf	87.718735 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 8	93.142857 ft	132.66777 ft	0 psf	1,124.5898 psf	98.388862 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 9	94.9 ft	131.39218 ft	0 psf	1,234.2119 psf	107.97955 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 10	96.7 ft	130.20337 ft	0 psf	1,333.4387 psf	116.66077 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 11	98.5 ft	129.12527 ft	0 psf	1,425.7188 psf	124.73423 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 12	100.3 ft	128.14952 ft	0 psf	1,512.1916 psf	132.29962 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice	102.1 ft	127.26927	0	1,593.5346	139.41621	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial

13		ft	psf	psf	psf			Deposits (Qpogf)
Slice 14	103.83333 ft	126.50508 ft	0 psf	1,652.7951 psf	144.60083 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 15	105.5 ft	125.84644 ft	0 psf	1,689.749 psf	147.83388 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 16	107.16667 ft	125.25776 ft	0 psf	1,721.5978 psf	150.62029 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 17	109 ft	124.6914 ft	0 psf	1,739.4665 psf	152.1836 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 18	111 ft	124.15894 ft	0 psf	1,505.3942 psf	131.70493 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 19	113 ft	123.71675 ft	0 psf	1,491.6152 psf	130.49942 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 20	115 ft	123.36231 ft	0 psf	1,464.6936 psf	128.14409 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 21	116.75 ft	123.118 ft	0 psf	1,416.4245 psf	123.92109 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 22	118.25 ft	122.96412 ft	0 psf	1,349.3273 psf	118.05084 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 23	119.75 ft	122.85731 ft	0 psf	1,272.5417 psf	111.33297 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 24	121.25 ft	122.79725 ft	0 psf	1,185.8191 psf	103.74573 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 25	122.75 ft	122.78377 ft	0 psf	1,089.0738 psf	95.281612 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 26	124.25 ft	122.81683 ft	0 psf	982.40319 psf	85.949142 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 27	125.75 ft	122.89652 ft	0 psf	866.10039 psf	75.773966 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 28	127.25 ft	123.02308 ft	0 psf	740.65838 psf	64.799212 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 29	128.83333 ft	123.20934 ft	0 psf	623.90423 psf	54.584547 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 30	130.5 ft	123.46148 ft	0 psf	515.68211 psf	45.116339 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice	132.16667	123.77358	0	399.03016	34.910616			Disturbed Pre-Olympia

31	ft	ft	psf	psf	psf	750 psf	0 psf	Fine-Grained Glacial Deposits (Qpogf)
Slice 32	133.77964 ft	124.13285 ft	0 psf	279.32927 psf	24.438145 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)
Slice 33	135.33891 ft	124.53677 ft	0 psf	158.16657 psf	13.837782 psf	750 psf	0 psf	Disturbed Pre-Olympia Fine-Grained Glacial Deposits (Qpogf)

Report Distribution

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