Earth Solutions NW LLC

Geotechnical Engineering
Geology
Environmental Scientists
Construction Monitoring

GEOTECHNICAL ENGINEERING STUDY
PROPOSED CHAIN LAKE PRD
13217 AND 13305 CHAIN LAKE ROAD
MONROE, WASHINGTON

ES-5859

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PREPARED FOR

PROSPECT DEVELOPMENT, LLC

March 8, 2018

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Important Information About Your

Geotechnical Engineering Report

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

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of 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 Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in-this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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Earth Solutions NW LLC

• Geotechnical Engineering
• Construction Monitoring
• Environmental Sciences

March 8, 2018
ES-5859

Prospect Development, LLC
2913 – 5th Avenue Northeast, Suite 201
Puyallup, Washington 98372

Attention: Mr. Mark Holland

Dear Mr. Holland:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled "Geotechnical Engineering Study, Chain Lakes PRD, 13217 and 13305 Chain Lake Road, Monroe, Washington". Based on the results of our investigation, the proposed project is feasible from a geotechnical standpoint. Our study indicates the site is underlain predominately by glacial till deposits. During our subsurface exploration completed on February 2, 2018, groundwater seepage was encountered at shallow depths across much of the site. Mitigation of this groundwater prior to site excavation will be critical during the grading process, and is discussed in greater detail later in this report.

The proposed structures may be constructed on conventional continuous and spread footing foundations bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. In general, competent native soil, suitable for support of the new foundations, will likely be encountered beginning at depths of one to three feet below existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material, will be necessary.

In accordance with the Department of Ecology's Stormwater Management Manual adopted by the City of Monroe, infiltration is not feasible from a geotechnical standpoint. Weakly cemented glacial till deposits were observed roughly two feet below ground surface, as well as heavy groundwater flow at shallow depths. Conceptual plans show a storm detention area in the eastern portion of the site.

We appreciate the opportunity to be of service to you on this project. If you have questions regarding the content of this geotechnical engineering study, please call.

Sincerely,

EARTH SOLUTIONS NW, LLC

Samuel E. Suruda, G.I.T.
Staff Geologist

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GEOTECHNICAL ENGINEERING STUDY
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INTRODUCTION

General

This geotechnical engineering study (study) was prepared for the proposed residential development to be constructed at 13217 and 13305 Chain Lake Road, in Monroe, Washington. The purpose of this study was to provide geotechnical recommendations for currently proposed development plans. Our scope of services for completing this study included the following:

- Excavation, logging, and sampling of test pits for purposes of characterizing site soils;
- Laboratory testing of soil samples collected at the test pit locations;
- Engineering analyses, and;
- Preparation of this report.

The following documents and maps were reviewed as part of our study preparation:

- Chain Lake Road PRD conceptual layout 1, by RM Homes;
- Surficial geologic map of the Skykomish and Snoqualmie Rivers area, Snohomish and King Counties, Washington, prepared by Booth, 1990;
- Online Web Soil Survey (WSS) resource, provided by the United States Department of Agriculture (USDA), Natural Resources Conservation Service.

Project Description

Preliminary site layout indicates the subject site will be developed with 23 single-family residences, a tract road, a stormwater detention area, and associated infrastructure improvements. At the time of this report submission, specific building load and grading plans were not available for review; however, we anticipate the proposed structures will be two to three stories in height and constructed utilizing relatively lightly loaded wood framing supported on a conventional foundation system. Perimeter footing loads will likely be 1 to 2 kips per lineal foot, and slab-on-grade loading is anticipated to be approximately 150 pounds per square foot (psf).

Stormwater will be managed primarily by a detention facility located in the eastern portion of the site. Given the moderate topography and elevation on the site, cuts and fills ranging up to about ten feet are expected.

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

SITE CONDITIONS

Surface

The subject site is located north of Chain Lake Road approximately 300 feet east of the intersection with Brown Road, in Monroe, Washington. The approximate location of the property is illustrated on Plate 1 (Vicinity Map). The property is comprised of two separate tax parcels (Snohomish County Parcel Nos. 2807310020-2500 and -0600) totaling about 5.92 acres. The site is bordered to the north, east, and west by residential houses, and to the south by Chain Lake Road. The site is currently occupied by one single family home and an unoccupied structure. The site topography descends gradually to the east.

Subsurface

A representative of ESNW observed, logged, and sampled five test pits, excavated at accessible locations within the site boundaries, on February 2, 2018 using a mini-trackhoe and operator provided by the client. The explorations were completed for purposes of assessment and classification of site soils as well as characterization of groundwater conditions within areas proposed for new development. The approximate locations of the explorations are depicted on Plate 2 (Test Pit Location Plan). Please refer to the test pit logs provided in Appendix A for a more detailed description of subsurface conditions. Representative soil samples collected at the test pit locations were evaluated in general accordance with Unified Soil Classification System (USCS) and United States Department of Agriculture (USDA) methods and procedures.

Topsoil and Fill

Topsoil was observed extending to depths of about 3 to 12 inches. The topsoil was characterized by the observed dark brown hue, the presence of fine organics, and small root intrusions.

Fill was not encountered at any of the test pit locations. Fill encountered during grading should be evaluated by ESNW during grading activities.

Native Soil

Underlying topsoil, native soils consisted primarily of medium dense to dense silty sand with gravel (USCS: SM). Native soils were primarily encountered in a moist to wet condition. The maximum exploration depth was approximately seven feet below the existing ground surface (bgs).

Geologic Setting

The referenced geologic map resource identifies glacial till (Qvt) deposits as the primary native soil unit underlying the subject site. The till was deposited directly from the glacier as it advanced over bedrock and older Quaternary sediment and is often characterized as a silty sand with gravel. The referenced WSS resource identifies Tokul Medially Gravelly Loam (Map Unit Symbols: 72 and 73) as the primary soil units underlying the subject site. The Tokul was formed in glacial drift settings. Based on our field observations, on-site native soils are generally consistent with glacial till (Qvt) deposits.

Groundwater

During our subsurface exploration completed on February 2, 2018 heavy groundwater seepage was encountered at most locations. Moderate to heavy seepage was encountered from about one to three feet bgs across the site and likely represents interflow where groundwater travels within the shallow weathered zone. Water was observed to be entering excavations from a general northwestern direction, and is likely entering the site from the north side of the 13217 property. It is our opinion the contractor should anticipate and be prepared to respond to perched groundwater seepage during construction, especially within site excavations located within the northern half of the site. Groundwater seepage is common within relatively permeable soil lenses located above more dense to very dense deposits. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches, sumps, and dewatering pumps. It should be noted that seepage rates and elevations 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 wet season (October through April).

Geologically Hazardous Areas

Based on review of geologically hazardous areas in the Monroe Municipal Code 20.05.120, the subject site does not appear to be within, or immediately adjacent to, geologically hazardous areas, with the exception of potentially erodible geology. In our opinion, site susceptibility to erosion hazards may be considered low, provided that groundwater seepage is mitigated appropriately during construction, and temporary erosion control measures are included during grading activities.

DISCUSSION AND RECOMMENDATIONS

General

Based on the results of our investigation, construction of the proposed residential development is feasible from a geotechnical standpoint. The primary geotechnical considerations associated with the proposed development include foundation support, slab-on-grade subgrade support, groundwater drainage, and the suitability of using native soils as structural fill.

The proposed structures may be constructed on conventional continuous and spread footing foundations bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. In general, competent native soil, suitable for support of the new foundations, will likely be encountered beginning at depths of one to three feet below existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material, will be necessary.

Due to the heavy seepage present across most of the subject site, groundwater mitigation should be addressed prior to grading and sitework taking place. In our opinion, an interceptor trench along the upslope margins of the development envelope should be installed prior to the commencement of mass grading.

Glacial till was observed to be in a dense condition and weakly cemented roughly two feet below ground surface. Heavy groundwater flow was observed throughout the site of shallow depths. Given the shallow depths to groundwater and dense, native soils, infiltration is not recommended for this site.

This study has been prepared for the exclusive use of Prospect Development, LLC and their representatives. A warranty is neither expressed nor implied. This study has been prepared in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area.

Site Preparation and Earthwork

Initial site preparation activities will consist of installing temporary erosion control measures, establishing grading limits, performing site clearing and site stripping and installation of interceptor drains. Subsequent earthwork procedures will involve grading and related infrastructure improvements.

Temporary Erosion Control

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 a stable access surface for construction vehicles. Geotextile fabric may be placed below the quarry spalls for greater stability of the temporary construction entrance. Erosion control measures should consist of silt fencing placed around appropriate portions of the site perimeter. Soil stockpiles should be covered or otherwise protected to reduce the potential for soil erosion during periods of wet weather. Temporary approaches for controlling surface water runoff should be established prior to beginning earthwork activities. Additional Best Management Practices (BMPs), as specified by the project civil engineer and indicated on the plans, should be incorporated into construction activities.

Construction Dewatering

Diversion of shallow groundwater should be implemented prior to mass grading and excavations on this site. An interception trench installed along the northern and western site boundaries will help control groundwater and should reduce the effects of on-site seepage. Completion of this trench as early as possible into the project will be key to reducing seepage onsite. The interceptor trench should be installed at a minimum depth of four feet below ground surface within dense, native till. A temporary detention pond, Baker tank, or another means of adequate water treatment and storage will be necessary due to the estimated high volume of groundwater. An ESNW representative should be onsite during trench construction and drainage program to confirm that groundwater is being managed adequately and to provide additional recommendations. A typical interceptor trench detail is provided on Plate 3. We recommend that prior to construction of the trench, ESNW should meet on-site with the client and contractor to finalize trench direction and locations. Additional drainage measures may be necessary on the site depending on the groundwater conditions at the time of construction.

Stripping

Topsoil was encountered within the upper approximately 3 to 12 inches of existing grades at the test pit locations. ESNW should be retained to provide site stripping recommendations at the time of construction. Topsoil and/or organic-rich soil is considered suitable for use neither in structural areas nor as structural fill. If desired, topsoil and/or organic-rich soil may be used in non-structural areas. Based on our field observations, for cost-estimating purposes, an average topsoil and organic-rich soil thickness of six inches should be expected across the site.

Excavations and Slopes

Reduction of groundwater flow will be critical to ensure that overall stability of site excavations remain in good condition while open. Based on the soil conditions observed at the test pit locations, the following allowable temporary slope inclinations, as a function of horizontal to vertical (H:V) inclination, may be used. The applicable Federal Occupation Safety and Health Administration (OSHA) and Washington Industrial Safety and Health Act (WISHA) soil classifications are also provided:

- Loose and medium dense soil or fill — 1.5H:1V (Type C)
- Areas exposing groundwater seepage — 1.5H:1V (Type C)
- Medium dense to dense native soil — 1H:1V (Type B)

Permanent slopes should be planted with vegetation to enhance stability and to minimize erosion and should maintain a gradient of 2H:1V or flatter. The presence of perched groundwater may cause localized sloughing of temporary slopes due to excess seepage forces. 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. This is particularly important where detention vault excavations may be made near property lines.

In-situ and Imported Soils

In-situ soils may not be suitable for use in structural fill applications unless the moisture content of the soil is at (or slightly above) the optimum moisture content at the time of placement and compaction. Successful use of native soils as structural fill will largely be dictated by in-situ moisture contents during construction. A contingency should be added to the budget in the event export of native soil and import of compactible fill is necessary.

Imported soil intended for use as structural fill should consist of a well-graded, granular soil with a moisture content that is at (or slightly above) the optimum level. 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).

Subgrade Preparation

Following site stripping, cuts and fills will be completed to establish proposed subgrade elevations across the site. ESNW should observe the subgrade areas during initial site preparation activities to confirm soil conditions are as anticipated and to provide supplementary recommendations for subgrade preparation. Complete restoration of voids resulting from previous grading activities must be executed as part of overall subgrade and building pad preparation activities. The following guidelines for preparing building subgrade areas should be incorporated into the final design:

- Where voids and grading disturbances extend below planned subgrade elevations, restoration of these areas should be completed. Structural fill should be used to restore voids or unstable areas resulting from previous grading.

- Recompact, or over-excavate and replace, areas of existing fill exposed at building subgrade elevations. Over-excavations should extend into competent native soils and structural fill should be utilized to restore subgrade elevations as necessary.

- ESNW should confirm subgrade conditions, as well as the required level of recompaction and/or over-excavation and replacement, during site preparation activities. ESNW should also evaluate the overall suitability of prepared subgrade areas following site preparation activities.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, and roadway areas. Fill placed to construct permanent slopes and throughout retaining wall and utility trench backfill areas is considered structural fill as well. Soils placed in structural areas, including slab-on-grade, utility trench, and pavement areas, should be placed in loose lifts of 12 inches or less and compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by the Modified Proctor Method (ASTM D1557).

Foundations

The proposed structures may be supported on conventional continuous and spread footing foundations bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. In general, competent native soil, suitable for support of the new foundations, will likely be encountered at depths of about two to three feet below existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material, will be necessary. Provided the foundations will be supported as prescribed, the following parameters may be used for design:

- Allowable soil bearing capacity 2,500 psf
- Passive earth pressure 300 pcf (equivalent fluid)
- Coefficient of friction 0.40

A one-third increase in the allowable soil bearing capacity may be assumed for short-term wind and seismic loading conditions. The above passive earth pressure and friction values include a factor-of-safety of 1.5. With structural loading as expected, total settlement in the range of one inch and differential settlement of about one-half inch is anticipated. The majority of the settlements should occur during construction, as dead loads are applied.

Seismic Design

The 2015 International Building Code recognizes the American Society of Civil Engineers (ASCE) for seismic site class definitions. Based on the soil conditions encountered at the test pit locations, in accordance with Table 20.3-1 of the ASCE Minimum Design Loads for Buildings and Other Structures manual, Site Class D should be used for design.

The referenced liquefaction susceptibility map indicates the site maintains a "very low to low" liquefaction susceptibility. Liquefaction is a phenomenon where saturated and loose sandy soils suddenly lose internal strength in response to increased pore water pressures resulting from an earthquake or other intense ground shaking. In our opinion, site susceptibility to liquefaction may be considered low. The relative density and gradation of the site soils is the primary basis for this consideration.

Slab-on-Grade Floors

Slab-on-grade floors for the proposed residential structures should be supported on firm and unyielding subgrades comprised of competent native soil, compacted structural fill, or new structural fill. Unstable or yielding areas of the subgrades should be recompacted, or over-excavated 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 slabs. The free-draining material should have 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). In areas where slab moisture is undesirable, installation of vapor barriers below the slabs should be considered. If a vapor barrier is to be utilized, it should be a material specifically designed for use as a vapor barrier and should be installed in accordance with the specifications of the manufacturer.

Retaining Walls

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

- Active earth pressure (yielding condition) — 35 pcf (equivalent fluid)
- At-rest earth pressure (restrained condition) — 55 pcf
- Traffic surcharge (passenger vehicles) — 70 psf (rectangular distribution)*
- Passive earth pressure — 300 pcf (equivalent fluid)
- Coefficient of friction — 0.40
- Seismic surcharge — 6H psf**

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

The above design parameters are based on a level backfill condition and level grade at the wall toe. Revised design values will be necessary if sloping grades are to be used above or below retaining walls. Additional surcharge loading from adjacent foundations, sloped backfill, or other loads should be included in the retaining wall design, where applicable.

Retaining walls should be backfilled with free-draining material or suitable sheet drain 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 can consist of a less permeable soil, if desired. 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 4. If drainage is not provided, hydrostatic pressures should be included in the wall design.

Drainage

Heavy seepage was observed across the site during our fieldwork, in our opinion, zones of perched groundwater seepage should be anticipated in general site excavations; however, installing an interceptor trench, as described in this report, will help manage the effects of shallow interflow groundwater. Measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches and sumps. ESNW should be consulted during preliminary grading to identify areas of seepage and to provide recommendations to reduce the potential for instability related to seepage effects.

Finish grades must be designed to direct surface water away from the new structures and/or slopes. Water must not be allowed to pond adjacent to the new structure and/or slopes. In our opinion, foundation drains should be installed along the building perimeter footings. A typical foundation drain detail is provided on Plate 5.

Interception trenches built on-site should be considered as permanent installations. Civil engineering designs for the site should account for shallow groundwater conditions.

Infiltration Evaluation

As indicated in the *Subsurface* section of this study, native soils encountered during our fieldwork were characterized primarily as medium dense to dense, glacial till deposits. Given the cemented nature to the glacial till and shallow depths to heavy, pervasive seepage across the site, infiltration is not feasible from a geotechnical standpoint.

Preliminary Detention Vault Recommendations

Final storm detention design plans had not been finalized at the time of writing this report; however, we understand a detention vault will be constructed in the eastern area of the property. Vault foundations should be supported on competent native soil or crushed rock placed atop competent native soil. Final stormwater vault designs must incorporate adequate buffer space from property boundaries such that temporary excavations to construct the vault structure can be successfully completed or shoring will be required. The presence of perched groundwater seepage should be anticipated during excavation activities for the vault.

The following parameters can be used for preliminary stormwater vault design:

- Allowable soil bearing capacity (dense native soil) 5,000 psf
- Active earth pressure 35 pcf
- Active earth pressure (hydrostatic) 80 pcf
- At-rest earth pressure (restrained) 55 pcf
- At-rest earth pressure (restrained, hydrostatic) 100 pcf
- Coefficient of friction 0.40
- Passive earth pressure 300 pcf
- Seismic surcharge 6H*

Where H equals the retained height

Retaining walls should be backfilled with at least 18 inches of free-draining material or suitable sheet drainage that extends along the height of the walls. The upper one foot of the wall backfill can consist of a less permeable soil, if desired. A perforated drain pipe should be placed along the base of the vault wall and connected to an approved discharge location. If the elevation of the vault bottom is such that gravity flow to an outlet is not possible, the portion of the vault below the drain must be designed to include hydrostatic pressure. Design values accounting for hydrostatic pressure are included above.

ESNW should observe grading operations for the vault and the subgrade conditions prior to concrete forming and pouring to confirm conditions are as anticipated, and to provide supplemental recommendations as necessary. Additionally, ESNW should be contacted to review final vault designs to confirm that appropriate geotechnical parameters have been incorporated.

Utility Support and Trench Backfill

In our opinion, native soils will generally be suitable for support of utilities. Organic-rich soils are not considered suitable for direct support of utilities and may require removal at utility grades if encountered. Remedial measures, such as overexcavation and replacement with structural fill and/or installation of geotextile fabric, may be necessary in some areas in order to provide support for utilities. Groundwater will likely be encountered within utility excavations, and caving of trench walls may occur where groundwater is encountered. Temporary construction dewatering, as well as temporary trench shoring, may be necessary during utility excavation and installation as conditions warrant.

Native soils will not be suitable for use as structural backfill throughout utility trench excavations, unless the soils are at (or slightly above) the optimum moisture content at the time of placement and compaction. Structural trench backfill should not be placed dry of the optimum moisture content. Each section of the site utility lines must be adequately supported in appropriate bedding material. Utility trench backfill should be placed and compacted to the specifications of structural fill as previously detailed in this report, or to the applicable specifications of the City of Monroe or other responsible jurisdiction or agency.

Preliminary Pavement Sections

The performance of site pavements is largely related to the condition of the underlying subgrade. To ensure adequate pavement performance, the subgrade should be in a firm and unyielding condition when subjected to proof rolling with a loaded dump truck. Structural fill in pavement areas should be compacted to the specifications previously detailed in this report. Soft, wet, or otherwise unsuitable subgrade areas may still exist after base grading activities. Areas containing unsuitable or yielding subgrade conditions will require remedial measures, such as over-excavation and/or placement of thicker crushed rock or structural fill sections, prior to pavement. Cement treatment of the subgrade soil can also be considered for stabilizing pavement subgrade areas if allowed by local jurisdictions.

For lightly loaded pavement areas subjected primarily to passenger vehicles, the following preliminary pavement sections may be considered:

- A minimum of two inches of hot mix asphalt (HMA) placed over four inches of crushed rock base (CRB), or;

- A minimum of two inches of HMA placed over three inches of asphalt treated base (ATB).

Heavier traffic areas generally require thicker pavement sections depending on site usage, pavement life expectancy, and site traffic. For preliminary design purposes, the following pavement sections for occasional truck traffic areas may be considered:

- Three inches of HMA placed over six inches of crushed rock base (CRB), or;

- Three inches of HMA placed over four-and-one-half inches of ATB.

The HMA, ATB and CRB materials should conform to WSDOT specifications. All soil base material should be compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by ASTM D1557. Final pavement design recommendations, including recommendations for heavy traffic areas, access roads, and frontage improvement areas, can be provided once final traffic loading has been determined. Road standards utilized by the City of Monroe may supersede the recommendations provided in this report.

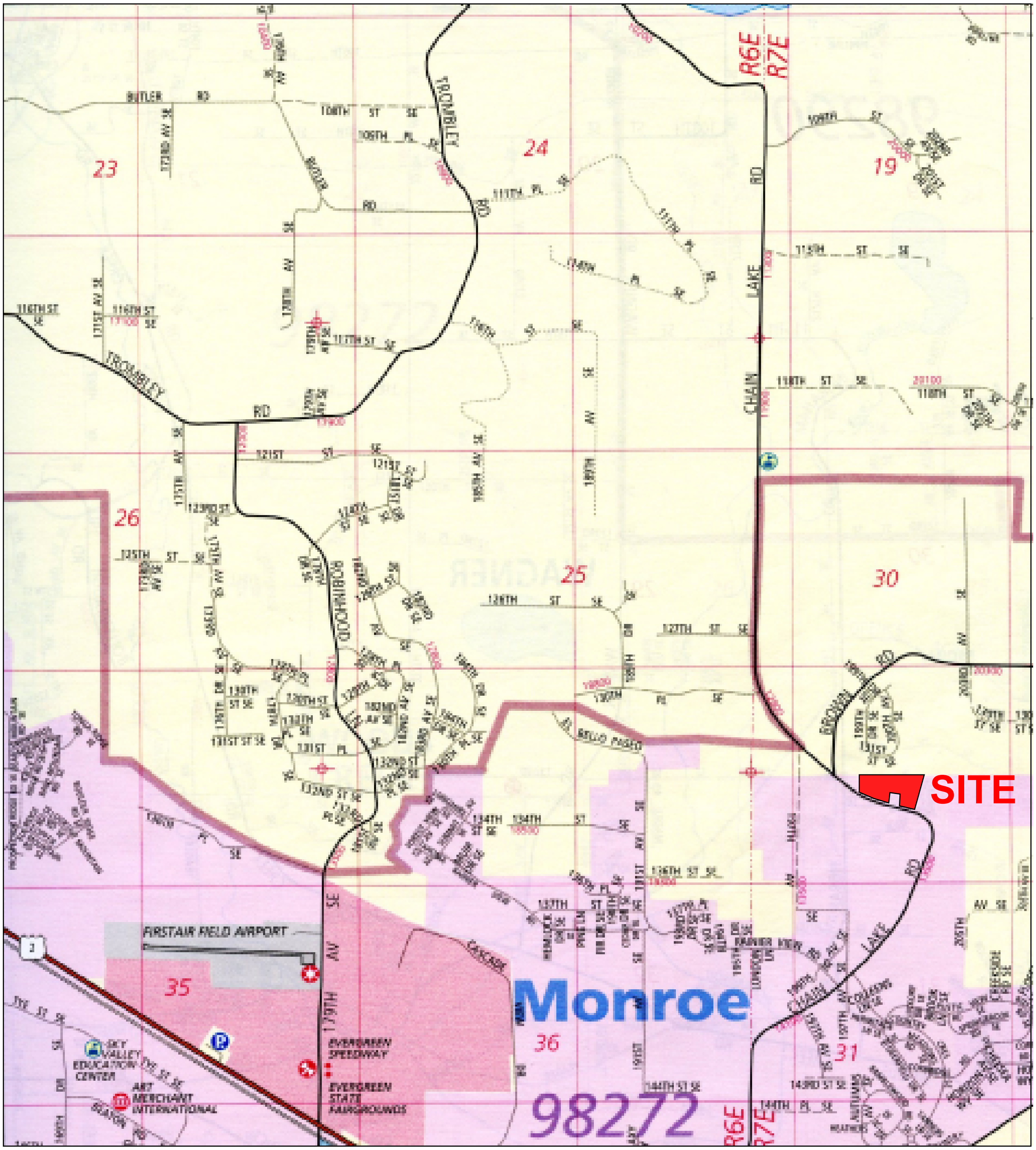
Given the groundwater conditions at site, it may be warranted to install a subgrade drainage system beneath roadways. The need for such a system should be evaluated at the time of construction.

LIMITATIONS

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. A warranty is neither expressed nor implied. Variations in the soil and groundwater conditions observed at the test pit locations may exist and may not become evident until construction. ESNW should reevaluate the conclusions provided in this 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 study. ESNW should also be retained to provide testing and consultation services during construction.



Reference:
Snohomish County, Washington
Map 438
By The Thomas Guide
Rand McNally
32nd Edition

NORTH

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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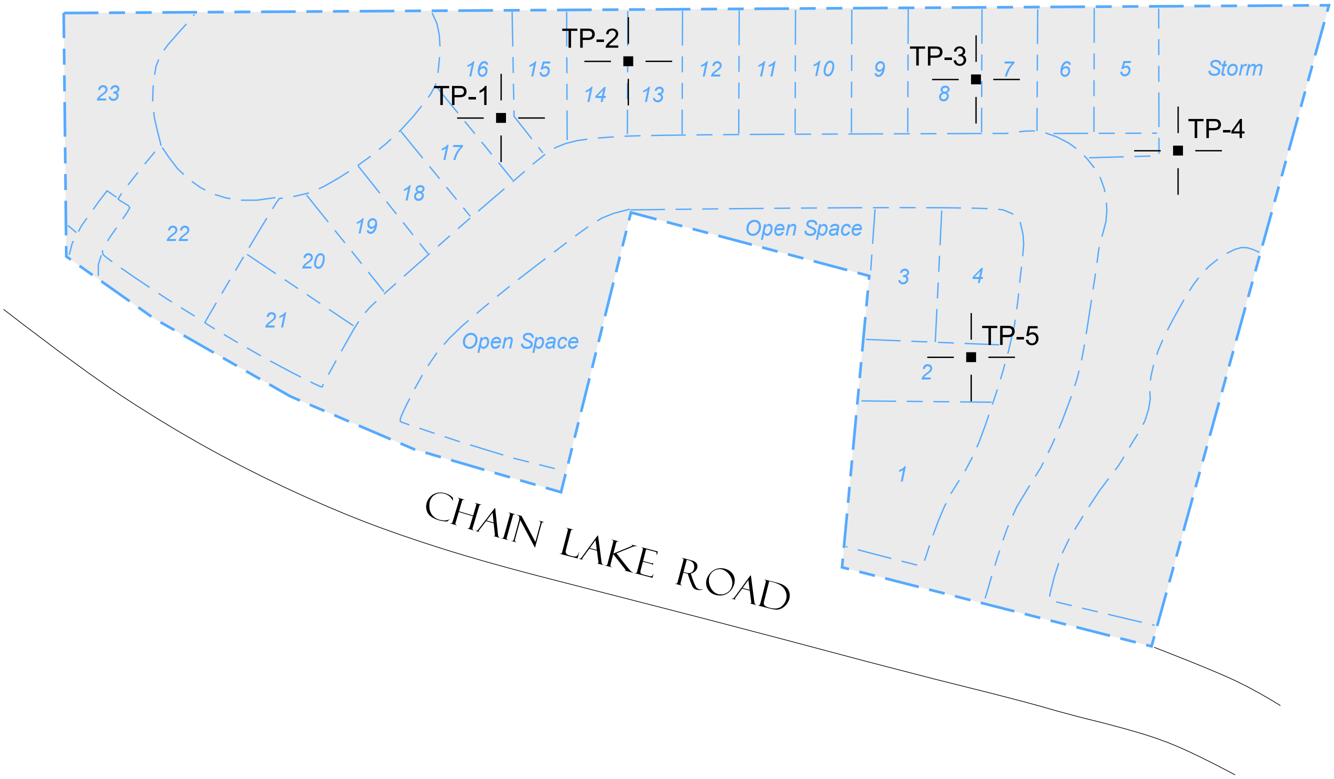
Vicinity Map
Chain Lake PRD
Monroe, Washington

Drwn. CAM	Date 02/26/2018	Proj. No. 5859
Checked SES	Date Feb. 2018	Plate 1



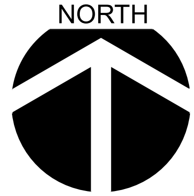
LEGEND

TP-1 — Approximate Location of ESNW Test Pit, Proj. No. ES-5859, Feb. 2018

Subject Site

16 — Proposed Lot Number

NORTH



NOT - TO - SCALE

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.

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Geotechnical Engineering, Construction Monitoring and Environmental Sciences

Test Pit Location Plan
Chain Lake PRD
Monroe, Washington

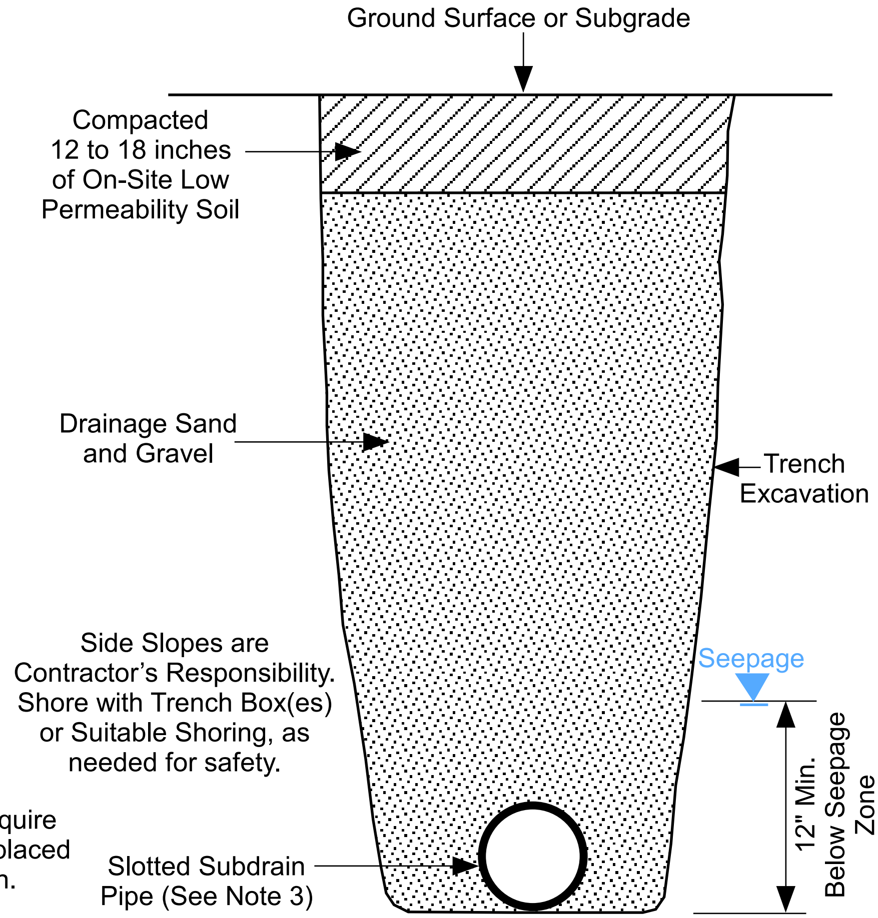
Drwn. CAM	Date 02/26/2018	Proj. No. 5859
Checked SES	Date Feb. 2018	Plate 2

MATERIALS:

Drainage Sand and Gravel should meet the following gradation (Modified City of Seattle Mineral Aggregate Type 26):

Sieve Size	% Passing by Weight
1 - inch	100
3/4 - inch	85 to 95
1/4 - inch	30 to 60
No. 8	20 to 50
No. 50	3 to 12
No. 200	0 to 1
(by wet sieving)	(non-plastic fines)

An alternative to drainage sand and gravel is a 50-50 mixture of washed pea gravel (Mineral Aggregate Type 9) and washed sand (Mineral Aggregate Type 6).



TYPICAL CROSS SECTION

NOT - TO - SCALE

NOTES:

1. Possible caving soil conditions may require that the subdrain pipe and backfill be placed concurrently with the trench excavation.
2. Extend pipe by means of a tightline to a suitable discharge point. Where subdrain pipe changes to a tightline, provide impervious dam (concrete or clay) so as to force all water into the tightline.
3. Slotted subdrain pipe; tight joints; sloped to drain (6"/100' min. slope); provide clean-outs; min. diameter: 6".
4. Slotted pipe to have 1/8" maximum slot width.

Reference: Seattle Landslide Study

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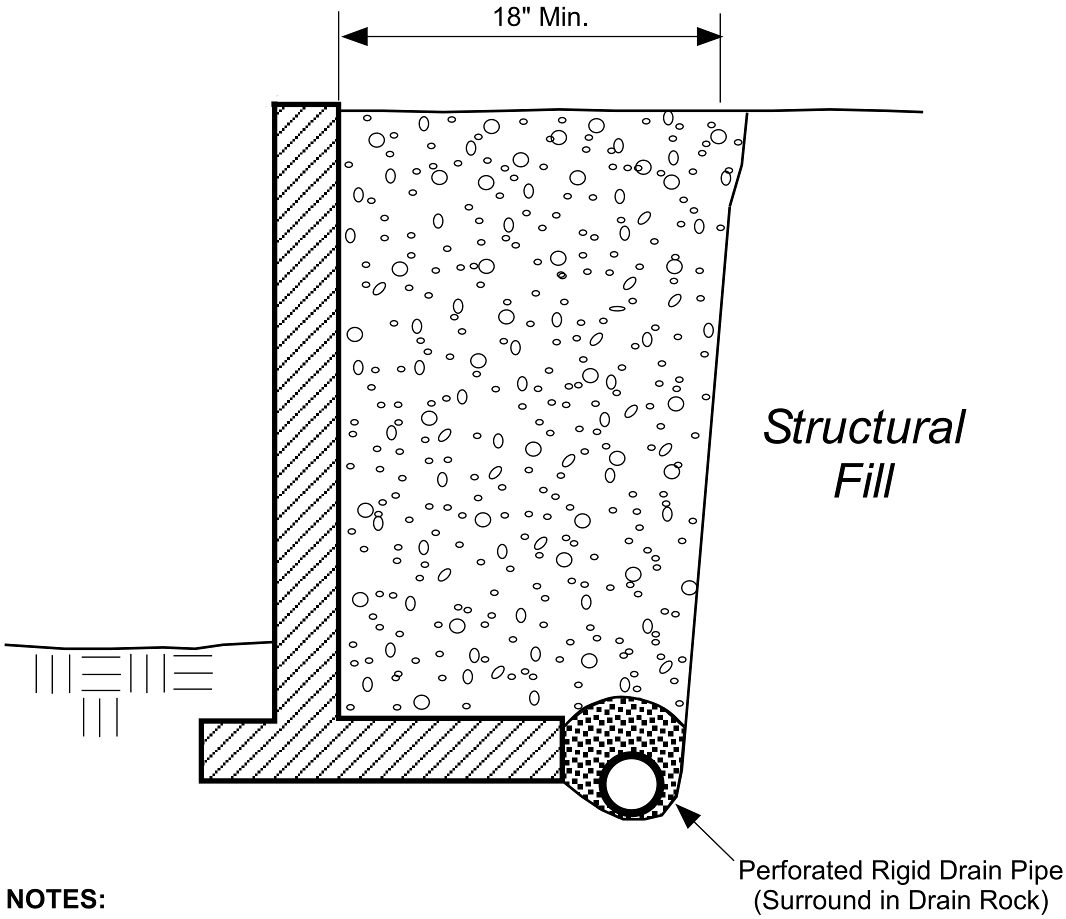
TYPICAL FINGER DRAIN DETAIL
Chain Lake PRD
Monroe, Washington

Drwn. CAM	Date 03/05/2018	Proj. No. 5859
Checked SES	Date Mar. 2018	Plate 3



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

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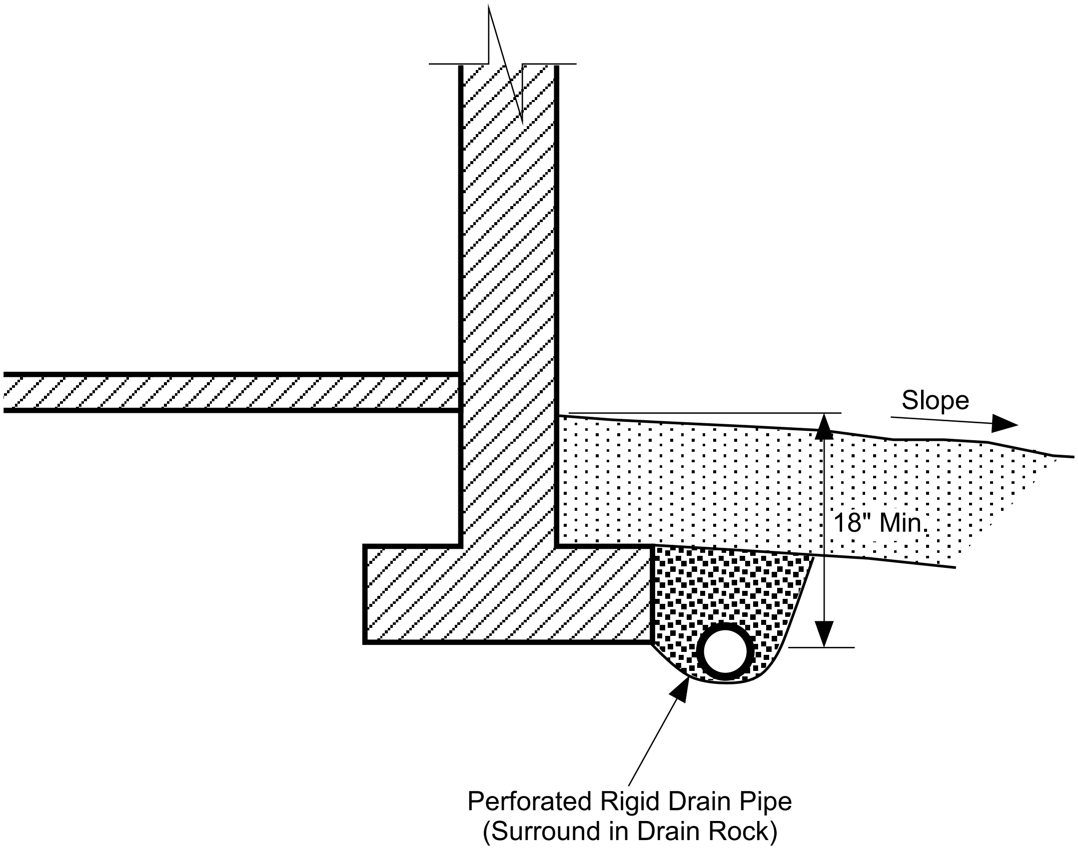
RETAINING WALL DRAINAGE DETAIL
Chain Lake PRD
Monroe, Washington

Drwn. CAM	Date 03/05/2018	Proj. No. 5859
Checked SES	Date Mar. 2018	Plate 4



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

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FOOTING DRAIN DETAIL
Chain Lake PRD
Monroe, Washington

Drwn. CAM	Date 03/05/2018	Proj. No. 5859
Checked SES	Date Mar. 2018	Plate 5

Appendix A

Subsurface Exploration
Test Pit Logs

ES-5859

Subsurface conditions at the subject site were explored on February 2, 2018 by excavating five test pits using a trackhoe and operator retained by the client. The approximate locations of the test pits are illustrated on Plate 2 of this study. The test pit logs are provided in this Appendix. The maximum exploration depth was approximately seven 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.

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SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

DUAL SYMBOLS are used to indicate borderline soil classifications.

The discussion in the text of this report is necessary for a proper understanding of the nature of the material presented in the attached logs.

Earth Solutions NWLLC

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-1

PROJECT NUMBER ES-5859
PROJECT NAME Chain Lake PRD
DATE STARTED 2/2/18 **COMPLETED** 2/2/18
GROUND ELEVATION 390 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR Client Provided
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY SES **CHECKED BY** SSR
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 12": grass, duff
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0			TPSL		Dark brown saturated TOPSOIL	
		MC = 71.50%		1.0		389.0
			SM		Brown silty SAND with gravel, medium dense, wet -heavy groundwater seepage at 1'	
				2.0		388.0
		MC = 37.00% Fines = 72.70%	ML		Brown sandy SILT with gravel, medium dense, wet [USDA Classification: slightly gravelly LOAM]	
5		MC = 29.70%		5.0		385.0
					Test pit terminated at 5.0 feet below existing grade due to heavy seepage. Groundwater seepage encountered at 1.0 foot during excavation. No caving observed. Bottom of test pit at 5.0 feet.	

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TEST PIT NUMBER TP-2

PROJECT NUMBER ES-5859 **PROJECT NAME** Chain Lake PRD

DATE STARTED 2/2/18 **COMPLETED** 2/2/18 **GROUND ELEVATION** 385 ft **TEST PIT SIZE**

EXCAVATION CONTRACTOR Client Provided **GROUND WATER LEVELS:**

EXCAVATION METHOD

AT TIME OF EXCAVATION ---

LOGGED BY SES **CHECKED BY** SSR **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 6": grass **AFTER EXCAVATION** —

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION	
0			TPSL		0.5	Dark brown highly organic TOPSOIL	384.5
		MC = 53.20%	SM			Brown silty SAND with gravel, medium dense, moist	
		MC = 25.20%				-heavy groundwater seepage from 2' to 2.5'	
						-becomes gray, dense, weakly cemented	
5							
		MC = 18.40%			6.0		379.0

Test pit terminated at 6.0 feet below existing grade. Groundwater seepage encountered from 2.0 to 2.5 feet during excavation. No caving observed.

Bottom of test pit at 6.0 feet.

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Earth Solutions NW
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Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-3

PROJECT NUMBER ES-5859 **PROJECT NAME** Chain Lake PRD

DATE STARTED 2/2/18 **COMPLETED** 2/2/18 **GROUND ELEVATION** 385 ft **TEST PIT SIZE**

EXCAVATION CONTRACTOR Client Provided **GROUND WATER LEVELS:**

EXCAVATION METHOD

AT TIME OF EXCAVATION ---

LOGGED BY SES **CHECKED BY** SSR

AT END OF EXCAVATION ---

NOTES Depth of Topsoil & Sod 6": grass

AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0			TPSL		0.5 Dark brown TOPSOIL, root intrusions to 2'	384.5
		MC = 106.10%	SM		Brown silty SAND, medium dense, wet -heavy groundwater seepage at 2' 3.0	382.0
		MC = 23.30%	GM		Brown silty GRAVEL with sand, dense, wet 4.0	381.0

Test pit terminated at 4.0 feet below existing grade due to seepage. Groundwater seepage encountered at 2.0 feet during excavation. No caving observed.
Bottom of test pit at 4.0 feet.

GENERAL BH / TP / WELL 5859.GPJ GINT US.GDT 3/9/18

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-4

PROJECT NUMBER ES-5859
PROJECT NAME Chain Lake PRD
DATE STARTED 2/2/18 **COMPLETED** 2/2/18
GROUND ELEVATION 380 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR Client Provided
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY SES **CHECKED BY** SSR
AT END OF EXCAVATION ---
NOTES Surface Conditions: grass
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION	
0			TPSL		0.5	Dark brown highly organic TOPSOIL	379.5
		MC = 32.90%	SM			Brown silty SAND, medium dense, damp	
						-light groundwater seepage at 3'	
						-becomes gray, dense to very dense, weakly cemented	
		MC = 15.90%					
5							
		MC = 12.60% Fines = 24.00%			7.0	[USDA Classification: very gravelly sandy LOAM]	373.0
						Test pit terminated at 7.0 feet below existing grade. Groundwater seepage encountered at 3.0 feet during excavation. No caving observed.	
						Bottom of test pit at 7.0 feet.	

GENERAL BH / TP / WELL 5859.GPJ GINT US.GDT 3/9/18

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-5

PROJECT NUMBER ES-5859
PROJECT NAME Chain Lake PRD
DATE STARTED 2/2/18 **COMPLETED** 2/2/18
GROUND ELEVATION 385 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR Client Provided
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY SES **CHECKED BY** SSR
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 3": grass
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION	
0			TPSL		0.3	Dark brown highly organic TOPSOIL	384.7
		MC = 36.90%	SM			Brown silty SAND, medium dense, wet -heavy groundwater seepage at 2'	
		MC = 15.20% Fines = 33.70%			4.0	-becomes gray, dense, unweathered [USDA Classification: gravelly fine sandy LOAM]	381.0

Test pit terminated at 4.0 feet below existing grade. Groundwater seepage encountered at 2.0 feet during excavation. No caving observed.

Bottom of test pit at 4.0 feet.

Appendix B

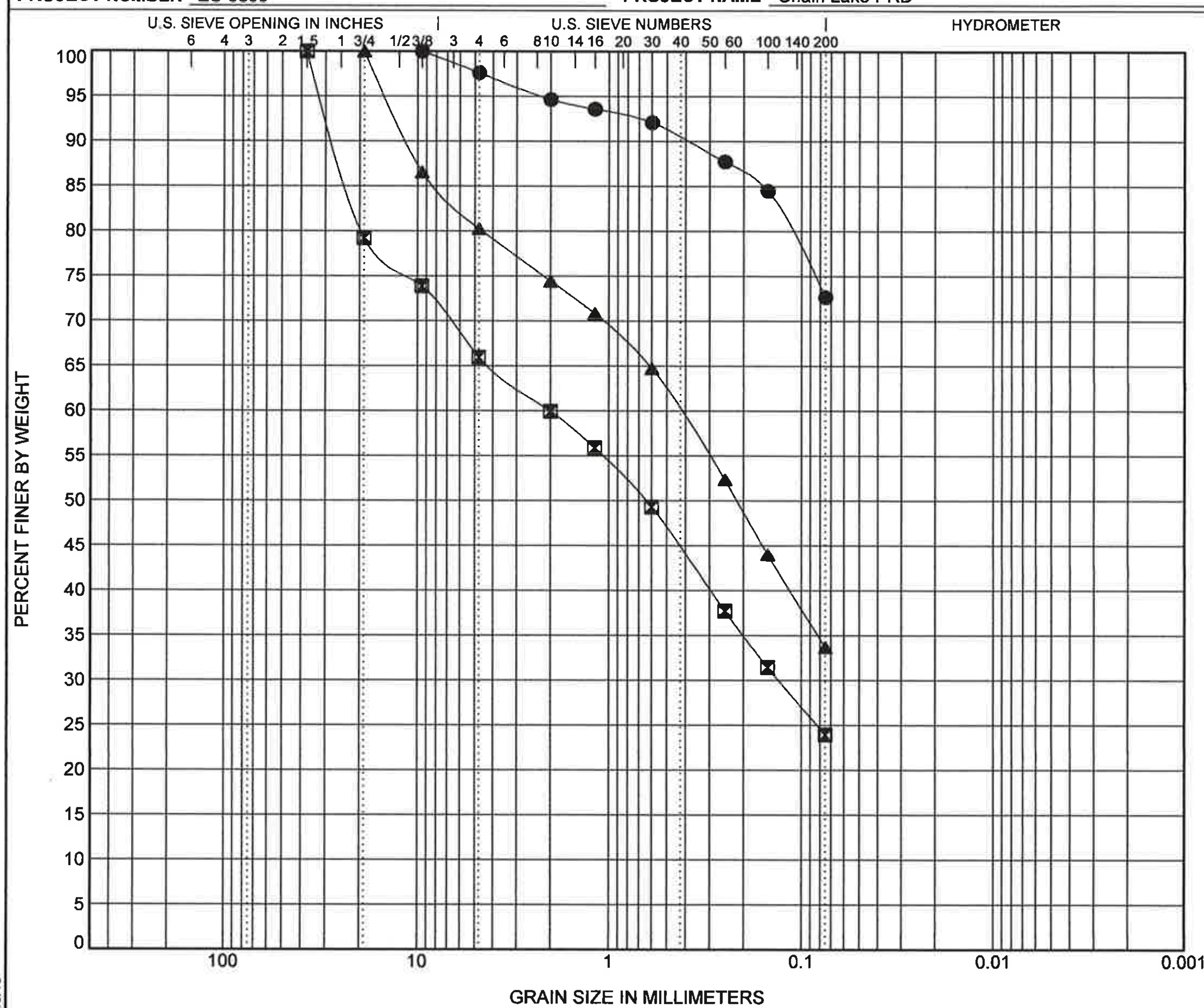
Laboratory Test Results

ES-5859

Earth Solutions NW, LLC
1805 - 136th PL N.E., Suite 201
Bellevue, WA 98005
Telephone: 425-449-4704
Fax: 425-449-4711

GRAIN SIZE DISTRIBUTION

PROJECT NUMBER ES-5859 **PROJECT NAME** Chain Lake PRD



Specimen Identification			Classification	Cc	Cu
●	TP-1	3.00ft.	USDA: Brown Slightly Gravelly Loam. USCS: ML with Sand.		
⊠	TP-4	7.00ft.	USDA: Gray Very Gravelly Sandy Loam. USCS: SM with Gravel.		
▲	TP-5	4.00ft.	USDA: Gray Gravelly Fine Sandy Loam. USCS: SM with Gravel.		

Specimen Identification			D100	D60	D30	D10	LL	PL	PI	%Silt	%Clay
●	TP-1	3.0ft.	9.5							72.7	
⊠	TP-4	7.0ft.	37.5	2.018	0.131					24.0	
▲	TP-5	4.0ft.	19	0.429						33.7	

Report Distribution

ES-5859

<u>EMAIL ONLY</u>

Prospect Development, LLC
2913 – 5th Avenue Northeast, Suite 201
Puyallup, Washington 98372

Attention: Mr. Mark Holland