GEOTECHNICAL ENGINEERING REPORT

PREPARED BY:

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PREPARED FOR:

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RGI PROJECT NO. 2018-144

SAFFOLD RESIDENCE
514 WASHINGTON AVENUE
MUKILTEO, WASHINGTON

JULY 20, 2018

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RILEYGROUP

July 20, 2018

Mr. Hank Saffold
8428 191st Street Southwest
Edmonds, Washington 98026

Subject: **Geotechnical Engineering Report**
Saffold Residence
514 Washington Avenue
Mukilteo, Washington
RGI Project No. 2018-144

Dear Mr. Saffold:

As requested, The Riley Group, Inc. (RGI) has performed a Geotechnical Engineering Report (GER) for the Saffold Residence located at 514 Washington Avenue, Mukilteo, Washington. Our services were completed in accordance with our proposal PRP2018-199 dated May 9, 2018 and authorized by you on June 8, 2018. The information in this GER is based on our understanding of the proposed construction, and the soil and groundwater conditions encountered in the borings completed by RGI at the site on June 13, 2018.

RGI recommends that you submit the project plans and specifications to RGI for a general review so that we may confirm that the recommendations in this GER are interpreted and implemented properly in the construction documents. RGI also recommends that a representative of our firm be present on site during portions of the project construction to confirm that the soil and groundwater conditions are consistent with those that form the basis for the engineering recommendations in this GER.

If you have any questions or require additional information, please contact us.

Respectfully submitted,

THE RILEY GROUP, INC.

State of Washington Licensed Geologist 2698 ERIC L. WOODS
7/20/2018

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Project Geologist

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Executive Summary

This Executive Summary should be used in conjunction with the entire Geotechnical Engineering Report (GER) for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the GER must be read in its entirety for a comprehensive understanding of the items contained herein. Section 7.0 should be read for an understanding of limitations.

RGI's geotechnical scope of work included the advancement of three borings to approximate depths of 14 feet below existing site grades.

Based on the information obtained from our subsurface exploration, the site is suitable for development of the proposed project. The following geotechnical considerations were identified:

Soil Conditions: The soils encountered during field exploration include soft to medium stiff sandy silt and silty clay and medium dense to very dense silty sand with varying amounts of gravel over hard silt and very dense silt sand.

Groundwater: Groundwater was not encountered during our subsurface exploration.

Foundations: Foundations for the proposed building may be supported on conventional spread footings bearing on medium dense to dense native soil or structural fill

Slab-on-grade: Slab-on-grade floors and slabs for the proposed building can be supported on medium dense to dense native soil or structural fill.

1.0 Introduction

This Geotechnical Engineering Report (GER) presents the results of the geotechnical engineering services provided for the Saffold Residence in Mukilteo, Washington. The purpose of this evaluation is to assess subsurface conditions and provide geotechnical recommendations for the construction of a new single family residence. Our scope of services included field explorations, laboratory testing, engineering analyses, and preparation of this GER.

The recommendations in the following sections of this GER are based upon our current understanding of the proposed site development as outlined below. If actual features vary or changes are made, RGI should review them in order to modify our recommendations as required. In addition, RGI requests to review the site grading plan, final design drawings and specifications when available to verify that our project understanding is correct and that our recommendations have been properly interpreted and incorporated into the project design and construction.

2.0 Project description

The project site is located at 514 Washington Avenue in Mukilteo, Washington. The approximate location of the site is shown on Figure 1.

The subject site is occupied by a single family residence. The southern portion of the site contains a steep slope area. The existing residence is to be demolished to make way for a new three-story single family residence.

At the time of preparing this GER, building plans were not available for our review. Based on our experience with similar construction, RGI anticipates that the proposed building will be supported on perimeter walls with bearing loads of two to six kips per linear foot, and a series of columns with a maximum load up to 30 kips. Slab-on-grade floor loading of 250 pounds per square foot (psf) are expected.

3.0 Field Exploration and Laboratory Testing

3.1 Field Exploration

On June 13, 2018, RGI observed the drilling of three borings. The approximate exploration locations are shown on Figure 2.

Field logs of each exploration were prepared by the geologist that continuously observed the drilling. These logs included visual classifications of the materials encountered during drilling as well as our interpretation of the subsurface conditions between samples. The boring logs included in Appendix A represent an interpretation of the field logs and include modifications based on laboratory observation and analysis of the samples.

3.2 Laboratory Testing

During the field exploration, a representative portion of each recovered sample was sealed in containers and transported to our laboratory for further visual and laboratory examination. Selected samples retrieved from the borings were tested for moisture content and grain size analysis to aid in soil classification and provide input for the recommendations provided in this GER. The results and descriptions of the laboratory tests are enclosed in Appendix A.

4.0 Site Conditions

4.1 Surface

The subject site is a rectangular-shaped parcel of land approximately 0.23 acres in size. The site is bound to the north by Washington Avenue, to the east by residential property, to the south by 6th Street, and to the west by residence driveways occupying an undeveloped alignment of Washington Avenue.

The existing site is occupied by a single family residence and an outbuilding. The property is terraced along the south and east sides by concrete and rock walls and stairways. The slope in the southern portion of the site descends from 6th Street to the residence with an elevation change of about 32 feet over a horizontal distance of about 60 feet. Slope gradients in the upper slope along the southern property line and to the south of the site are in the range of 70 to 85 percent.

4.2 Geology

Review of the *Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington,* by James P. Minard (1982) indicates that the soil in the project vicinity is mapped as Transitional Beds (Map Unit Qtb) which is clay silt and fine sand beds deposited in lakes a distance from the ice front, and subsequently overrun by the ice sheet. These descriptions are generally similar to the findings in our field explorations.

4.3 Soils

The soils encountered during field exploration include soft to medium stiff sandy silt and silty clay and medium dense to very dense silty sand with varying amounts of gravel over hard silt and very dense silt sand.

More detailed descriptions of the subsurface conditions encountered are presented in the borings included in Appendix A. Sieve analysis was performed on three selected soil samples. Grain size distribution curves are included in Appendix A.

4.4 GROUNDWATER

Groundwater was not encountered during our subsurface exploration. However, wet soils were encountered that may be indicative of seasonal perched groundwater collecting within some of the sand and silt beds underlying the site.

It should be recognized that fluctuations of the groundwater table will occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the explorations were performed. In addition, perched water can develop within seams and layers contained in fill soils or higher permeability soils overlying less permeable soils following periods of heavy or prolonged precipitation. Therefore, groundwater levels during construction or at other times in the future may be higher or lower than the levels indicated on the logs. Groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.5 SEISMIC CONSIDERATIONS

Based on the 2012/2015 International Building Code (IBC), RGI recommends the follow seismic parameters for design.

Table 1 2012/2015 IBC

Parameter	Value
Site Soil Class[1]	D[2]
Site Latitude	47.94396°N
Site Longitude	122.30427°W
Short Period Spectral Response Acceleration, S_S (g)	1.469
1-Second Period Spectral Response Acceleration, S_1 (g)	0.569
Adjusted Short Period Spectral Response Acceleration, S_{MS} (g)	1.469
Adjusted 1-Second Period Spectral Response Acceleration, S_{M1} (g)	0.853

1. Note: In general accordance with Chapter 20 of ASCE 7-10. The Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile.

2. Note: The 2012/2015 IBC and ASCE 7-10 require a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope of our services does not include the required 100 foot soil profile determination. Borings extended to a maximum depth of 14 feet, and this seismic site class definition considers that similar soil continues below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration.

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in water pressure induced by vibrations from a seismic event. Liquefaction mainly affects geologically recent deposits of fine-grained sands that are below the groundwater table. Soils of this nature derive their strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates this intergranular friction, thus reducing or eliminating the soil's strength.

RGI reviewed the results of the field and laboratory testing and assessed the potential for liquefaction of the site's soil during an earthquake. Since the site is underlain by glacially consolidated deposits and lacks an established groundwater table, RGI considers that the possibility of liquefaction during an earthquake is minimal.

4.6 GEOLOGIC HAZARD AREAS

Regulated geologically hazardous areas include erosion, landslide, earthquake, or other geological hazards. Based on review of Section 17.52A.020 in the Mukilteo Municipal Code (MMC) the site meets the criteria of a geologic sensitive area due to soils mapped by the USDA Natural Resource Conservation Service as a moderate to severe erosion hazard, and forty percent or greater slopes. An erosion and sediment control plan should be implemented as described in Section 5.1.1 of this report to prevent erosion during construction.

A reconnaissance of the slope was completed on June 13, 2018. During the reconnaissance, no seeps or springs were observed. The slope appeared stable with no signs of past instability. The slope appears to have been terraced, with a row of large diameter trees growing along the lower slope. The slope is heavily vegetated, reducing potential for shallow failures and erosion.

Based on review of aerial photographs, 6th street and the existing residence have been in their current configuration since the 1940's. Review of property information shows the existing residence was built in 1905.

Based on observations, the existing slope appears to have been over-steepened due to terracing. Building plans were not available at the time of this report, but we anticipate the building footprint may extend to near the toe of slope near the southern property line. Provided the recommendations in this report are followed, the development will have no adverse effects on the stability of the slope.

5.0 Discussion and Recommendations

5.1 GEOTECHNICAL CONSIDERATIONS

Based on our study, the site is suitable for the proposed construction from a geotechnical standpoint. Foundations for the proposed building can be supported on conventional spread footings bearing on medium dense to dense native soil or structural fill. Slab-on-grade floors can be similarly supported.

Detailed recommendations regarding the above issues and other geotechnical design considerations are provided in the following sections. These recommendations should be incorporated into the final design drawings and construction specifications.

5.1.1 Erosion and Sediment Control

Potential sources or causes of erosion and sedimentation depend on construction methods, slope length and gradient, amount of soil exposed and/or disturbed, soil type, construction sequencing and weather. The impacts on erosion-prone areas can be reduced by implementing an erosion and sedimentation control plan. The plan should be designed in accordance with applicable city and/or county standards.

RGI recommends the following erosion control Best Management Practices (BMPs):

- Scheduling site preparation and grading for the drier summer and early fall months and undertaking activities that expose soil during periods of little or no rainfall
- Retaining existing vegetation whenever feasible
- Establishing a quarry spall construction entrance
- Installing siltation control fencing or anchored straw or coir wattles on the downhill side of work areas
- Covering soil stockpiles with anchored plastic sheeting
- Revegetating or mulching exposed soils with a minimum 3-inch thickness of straw if surfaces will be left undisturbed for more than one day during wet weather or one week in dry weather
- Directing runoff away from exposed soils and slopes
- Minimizing the length and steepness of slopes with exposed soils and cover excavation surfaces with anchored plastic sheeting
- Decreasing runoff velocities with check dams, straw bales or coir wattles
- Confining sediment to the project site
- Inspecting and maintaining erosion and sediment control measures frequently (The contractor should be aware that inspection and maintenance of erosion control BMPs is critical toward their satisfactory performance. Repair and/or replacement of dysfunctional erosion control elements should be anticipated.)

Permanent erosion protection should be provided by reestablishing vegetation using hydroseeding and/or landscape planting. Until the permanent erosion protection is established, site monitoring should be performed by qualified personnel to evaluate the effectiveness of the erosion control measures. Provisions for modifications to the erosion control system based on monitoring observations should be included in the erosion and sedimentation control plan.

5.1.2 STRIPPING AND SUBGRADE PREPARATION

Stripping efforts should include removal of pavements, vegetation, organic materials, and deleterious debris from areas slated for building, pavement, and utility construction. The borings encountered up to 4 inches of topsoil and rootmass. Deeper areas of stripping may be required in forested or heavily vegetated areas of the site.

Subgrade soils that become disturbed due to elevated moisture conditions should be overexcavated to reveal firm, non-yielding, non-organic soils and backfilled with compacted structural fill. In order to maximize utilization of site soils as structural fill, RGI recommends that the earthwork portion of this project be completed during extended periods of warm and dry weather if possible. If earthwork is completed during the wet season (typically November through May) it will be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork will require additional mitigative measures beyond that which would be expected during the drier summer and fall months.

5.1.3 EXCAVATIONS

All temporary cut slopes associated with the site and utility excavations should be adequately inclined to prevent sloughing and collapse. The site soils consist of silty sand, sandy silt, silt, and silty clay.

Accordingly, for excavations more than 4 feet but less than 20 feet in depth, the temporary side slopes should be laid back with a minimum slope inclination of 1H:1V (Horizontal:Vertical). If there is insufficient room to complete the excavations in this manner, or excavations greater than 20 feet in depth are planned, using temporary shoring to support the excavations should be considered. Shoring recommendations are provided in the following section of this GER.

For open cuts at the site, RGI recommends:

- No traffic, construction equipment, stockpiles or building supplies are allowed at the top of cut slopes within a distance of at least five feet from the top of the cut
- Exposed soil along the slope is protected from surface erosion using waterproof tarps and/or plastic sheeting
- Construction activities are scheduled so that the length of time the temporary cut is left open is minimized
- Surface water is diverted away from the excavation
- The general condition of slopes should be observed periodically by a geotechnical engineer to confirm adequate stability and erosion control measures

In all cases, however, appropriate inclinations will depend on the actual soil and groundwater conditions encountered during earthwork. Ultimately, the site contractor must be responsible for maintaining safe excavation slopes that comply with applicable OSHA or WISHA guidelines.

5.2 SHORING RECOMMENDATIONS

Building plans were not available at the time this report was prepared. If excavations will be completed at the toe of the slope, shoring should be provided for excavations exceeding four feet in depth. Our geotechnical comments and recommendations concerning site excavations are presented below.

5.2.1 SOIL AND GROUNDWATER CONDITIONS

Based on our explorations, RGI anticipates that the on-site excavation will encounter primarily dense to very dense silty sand with gravel. These soils can be readily excavated with conventional earthworking equipment but extra effort will be needed in the glacial till. Although our explorations did not reveal rubble within the fill soils or boulders within the native soils, such obstacles could be present at random locations within these deposits.

Our explorations encountered no groundwater below grade at the time of drilling and we do not expect groundwater will impact the proposed shoring. Ideally, the site excavation would be performed in the summer months.

5.2.2 SOLDIER PILE SHORING

In our opinion, soldier piles can be used in a cantilevered configuration for shoring the proposed excavation sidewalls at the site. The following geotechnical comments and recommendations are provided concerning cantilevered soldier piles.

Soldier Pile Embedment

All soldier piles must have sufficient embedment below the final excavation level to provide adequate kick-out resistance to horizontal loads, as calculated by the design engineer. RGI recommends providing a minimum embedment of 10 feet below the excavation base directly in front of each pile. For cantilevered soldier piles, RGI further recommends that the embedment depth not be less than the exposed wall height.

Applied Loads

All soldier piles at the subject site should be designed to resist the various lateral loads applied to them. For a temporary shoring wall, RGI expects that these lateral loads will consist of active or at-rest pressures and possibly traffic surcharge or structural surcharge pressures, depending on the specific wall location. For a shoring wall that has adequate drainage, RGI does not expect that hydrostatic pressures will need to be considered. Our recommended design pressures are presented graphically on Figure 3 and are discussed in the following paragraphs.

- Active Earth Pressures: Cantilevered walls can be designed using active earth pressures modeled as the equivalent fluid densities shown on Figure 3.
- Structural Surcharge Pressures: Lateral earth pressures acting on the soldier piles should be increased to account for any structural loads located within a horizontal distance equal to half the wall height. If existing footings or other structural loads are found to exist within this distance, RGI should be contacted to calculate the appropriate surcharge pressures.
- Traffic Surcharge Pressures: Lateral earth pressures acting on the soldier piles should be increased to account for traffic, construction equipment, material stockpiles, or other temporary loads located within a horizontal distance equal to half the wall height. For light to moderately heavy vehicles, this traffic surcharge can be modeled as a uniform lateral pressure of 75 psf acting over the upper 8 feet of wall; or heavy vehicles, such as concrete trucks, a value of 150 psf would be more appropriate.
- Hydrostatic Pressures: If groundwater is allowed to collect behind the shoring wall, a net hydrostatic pressure of 45 pcf would act against the portion of wall above the foreslope level and below the saturation level. However, if adequate drainage is provided behind the shoring wall, we expect that hydrostatic pressures will not develop.
- Resisting Forces: Lateral resistance can be computed by using an appropriate passive earth pressure acting over the embedded portion of each soldier pile, neglecting the upper 2 feet. This passive pressure should be applied over a lateral distance equal to the pile spacing or twice the pile diameter, whichever is less. For a level foreslope (measured perpendicular to the wall face), RGI recommends using a maximum allowable passive pressure modeled as an equivalent fluid density of 350 pounds per cubic foot (pcf), based on a safety factor of 1.5 or more.
- Pile Deflections: Lateral deflections for a soldier pile can be calculated from the horizontal modulus of subgrade reaction, which generally increases with depth. As a reasonable approximation, however, a uniform modulus of 250 kips per cubic foot (kcf) or 145 pounds per cubic inch (pci) can be used.

Lagging Design and Backfill

RGI recommends that pressure-treated timber lagging be installed between all adjacent soldier piles to reduce the potential for soil caving, backslope subsidence, and hazardous working conditions. Our geotechnical comments and recommendations about lagging are presented below.

Due to soil arching effects, temporary lagging that spans 8 feet or less need be designed for only 50 percent of the lateral earth pressure previously recommended for soldier pile design. Permanent lagging, on the other hand, should be designed for 75 percent of this same lateral earth pressure. In both cases, these values assume that adequate drainage is provided behind the lagging, as discussed below.

RGI recommends that any voids behind the lagging be backfilled with a material sufficiently pervious to allow groundwater flow and prevent a build-up of hydrostatic pressure. For this reason, permeable materials such as granular excavation spoils, clean sand, or pea gravel are suitable as backfill material, whereas silty soils, cement grout, controlled-density fill, or other less-permeable materials are not suitable.

Drainage System

RGI recommends that all lagging backfill material connect to a continuous horizontal drain located in front of the wall. This can be accomplished either by extending gravel under the lagging or by providing gaps between the lagging boards. If concrete or shotcrete walls are to be placed against wooden lagging, prefabricated vertical drainage strips (such as MiraDRAIN 6000®) should be attached to each lagging bay.

5.2.3 Construction and Survey Monitoring

Because shoring requires specialized installation and earthwork techniques to maintain stable conditions during and after construction, RGI strongly recommends that an RGI representative be retained to continuously monitor all construction activities. This would include observation and documentation of installation procedures and construction materials.

A monitoring program must be implemented to verify the performance of the shoring system and possible excavation effects on neighboring properties and streets. The first step in this program should consist of surveying building feature elevations and documenting the condition of the existing properties, streets and adjacent buildings. This documentation should include a photographic record. Monitoring points should be set by a licensed surveyor on the adjacent streets and structures at a maximum of 25 foot intervals with a minimum of two on each side of the excavation.

Monitoring of the shoring system should occur two times per week as the excavation proceeds and then once every two weeks once the excavation is completed. A registered land surveyor should be retained to establish the baseline data and obtain the bi-weekly readings. Monitoring data can be obtained by the project contractor. Monitoring should continue until the permanent new lower walls are adequately braced and should include surveying the vertical and horizontal alignment of the top of every other soldier pile. The project’s structural and geotechnical engineers should review the monitoring data weekly.

5.3 Earthwork

The earthwork is expected to include excavating and backfilling the building foundations and preparing slab subgrades.

5.3.1 STRUCTURAL FILL

RGI recommends fill below the foundation and floor slab, behind retaining walls, and below pavement and hardscape surfaces be placed in accordance with the following recommendations for structural fill. The structural fill should be placed after completion of site preparation procedures as described above.

The suitability of excavated site soils and import soils for compacted structural fill use will depend on the gradation and moisture content of the soil when it is placed. As the amount of fines (that portion passing the U.S. No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve. Soils containing more than about 5 percent fines cannot be consistently compacted to a dense, non-yielding condition when the moisture content is more than 2 percent above or below optimum. Optimum moisture content is that moisture that results in the greatest compacted dry density with a specified compactive effort.

Non-organic site soils are only considered suitable for structural fill provided that their moisture content is within about two percent of the optimum moisture level as determined by ASTM D1557. Excavated site soils may not be suitable for re-use as structural fill depending on the moisture content and weather conditions at the time of construction. If soils are stockpiled for future reuse and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored. Even during dry weather, moisture conditioning (such as, windrowing and drying) of site soils to be reused as structural fill may be required.

The site soils are moisture sensitive and may require moisture conditioning prior to use as structural fill. If on-site soils are or become unusable, it may become necessary to import clean, granular soils to complete site work that meet the grading requirements listed in Table 2 to be used as structural fill.

Table 2 Structural Fill Gradation

U.S. Sieve Size	Percent Passing
4 inches	100
No. 4 sieve	22 to 100
No. 200 sieve	0 to 5*

*Based on minus 3/4 inch fraction.

Prior to use, an RGI representative should observe and test all materials imported to the site for use as structural fill. Structural fill materials should be placed in uniform loose layers not exceeding 12 inches and compacted as specified in Table 3. The soil's maximum density and optimum moisture should be determined by ASTM D1557.

Table 3 Structural Fill Compaction ASTM D1557

Location	Material Type	Minimum Compaction Percentage	Moisture Content Range	
Foundations	On-site granular or approved imported fill soils:	95	+2	-2
Retaining Wall Backfill	On-site granular or approved imported fill soils:	92	+2	-2
Slab-on-grade	On-site granular or approved imported fill soils:	95	+2	-2
General Fill (non-structural areas)	On-site soils or approved imported fill soils:	90	+3	-2

Placement and compaction of structural fill should be observed by RGI. A representative number of in-place density tests should be performed as the fill is being placed to confirm that the recommended level of compaction is achieved.

5.3.2 WET WEATHER CONSTRUCTION CONSIDERATIONS

RGI recommends that preparation for site grading and construction include procedures intended to drain ponded water, control surface water runoff, and to collect shallow subsurface seepage zones in excavations where encountered. It will not be possible to successfully compact the subgrade or utilize on-site soils as structural fill if accumulated water is not drained prior to grading or if drainage is not controlled during construction. Attempting to grade the site without adequate drainage control measures will reduce the amount of on-site soil effectively available for use, increase the amount of select import fill materials required, and ultimately increase the cost of the earthwork phases of the project. Free water should not be allowed to pond on the subgrade soils. RGI anticipates that the use of berms and shallow drainage ditches, with sumps and pumps in utility trenches, will be required for surface water control during wet weather and/or wet site conditions.

5.4 FOUNDATIONS

Following site preparation and grading, the proposed building foundation can be supported on conventional spread footings bearing on dense native soil or structural fill. Loose, organic, or other unsuitable soils may be encountered in the proposed building footprint. If unsuitable soils are encountered, they should be overexcavated and backfilled with structural fill.

Perimeter foundations exposed to weather should be at a minimum depth of 18 inches below final exterior grades. Interior foundations can be constructed at any convenient depth below the floor slab. Finished grade is defined as the lowest adjacent grade within 5 feet of the foundation for perimeter (or exterior) footings and finished floor level for interior footings.

Table 4 Foundation Design

Design Parameter	Value
Allowable Bearing Capacity	2,000 psf[1]
Friction Coefficient	0.30
Passive pressure (equivalent fluid pressure)	250 pcf[2]
Minimum foundation dimensions	Columns: 24 inches Walls: 16 inches

1. psf = pounds per square foot
2. pcf = pounds per cubic foot

The allowable foundation bearing pressures apply to dead loads plus design live load conditions. For short-term loads, such as wind and seismic, a 1/3 increase in this allowable capacity may be used. At perimeter locations, RGI recommends not including the upper 12 inches of soil in the computation of passive pressures because they can be affected by weather or disturbed by future grading activity. The passive pressure value assumes the foundation will be constructed neat against competent soil or backfilled with structural fill as described in Section 5.3.1. The recommended base friction and passive resistance value includes a safety factor of about 1.5.

With spread footing foundations designed in accordance with the recommendations in this section, maximum total and differential post-construction settlements of 1 inch and 1/2 inch, respectively, should be expected.

5.5 RETAINING WALLS

If retaining walls are needed in the building area, RGI recommends cast-in-place concrete walls be used. The magnitude of earth pressure development on retaining walls will partly depend on the quality of the wall backfill. RGI recommends placing and compacting wall backfill as structural fill. Wall drainage will be needed behind the wall face. A typical retaining wall drainage detail is shown in Figure 3.

With wall backfill placed and compacted as recommended, and drainage properly installed, RGI recommends using the values in the following table for design.

Table 5 Retaining Wall Design

Design Parameter	Value
Allowable Bearing Capacity	2,000 psf
Active Earth Pressure (unrestrained walls)	35 pcf
At-rest Earth Pressure (restrained walls)	50 pcf

For seismic design, an additional uniform load of 7 times the wall height (H) for unrestrained walls and 14H in psf for restrained walls should be applied to the wall surface. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 5.4.

5.6 Slab-on-Grade Construction

Once site preparation has been completed as described in Section 5.2, suitable support for slab-on-grade construction should be provided. RGI recommends that the concrete slab be placed on top of medium dense native soil or structural fill. Immediately below the floor slab, RGI recommends placing a four-inch thick capillary break layer of clean, free-draining sand or gravel that has less than five percent passing the U.S. No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab. Where moisture by vapor transmission is undesirable, an 8- to 10-millimeter thick plastic membrane should be placed on a 4-inch thick layer of clean gravel.

For the anticipated floor slab loading, we estimate post-construction floor settlements of 1/4- to 1/2-inch.

5.7 Drainage

5.7.1 Surface

Final exterior grades should promote free and positive drainage away from the building area. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building area. For non-pavement locations, RGI recommends providing a minimum drainage gradient of 3 percent for a minimum distance of 10 feet from the building perimeter. In paved locations, a minimum gradient of 1 percent should be provided unless provisions are included for collection and disposal of surface water adjacent to the structure.

5.7.2 Subsurface

RGI recommends installing perimeter retaining walls and foundation drains as shown on Figures 4, 5 and 6. The foundation drains and roof downspouts should be tightlined separately to an approved discharge facility. Subsurface drains must be laid with a gradient sufficient to promote positive flow to a controlled point of approved discharge.

5.7.3 Infiltration

The site soils are not suitable for infiltration.

5.8 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) specifications. For site utilities located within the right-of-ways, bedding and backfill should be completed in accordance with City of Mukilteo specifications. At a minimum, trench backfill should be placed and compacted as structural fill, as described in Section 5.3.1. Where utilities occur below unimproved areas, the degree of compaction can be reduced to a minimum of 90 percent of the soil's maximum density as determined by the referenced ASTM D1557. As noted, soils excavated on site may not be suitable for use as backfill material. If site soils become over-optimum, imported structural fill meeting the gradation provided in Table 2 should be used for trench backfill.

6.0 Additional Services

RGI is available to provide further geotechnical consultation throughout the design phase of the project. RGI should review the final design and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and incorporated into project design and construction.

RGI is also available to provide geotechnical engineering and construction monitoring services during construction. The integrity of the earthwork and construction depends on proper site preparation and procedures. In addition, engineering decisions may arise in the field in the event that variations in subsurface conditions become apparent. Construction monitoring services are not part of this scope of work. If these services are desired, please let us know and we will prepare a cost proposal.

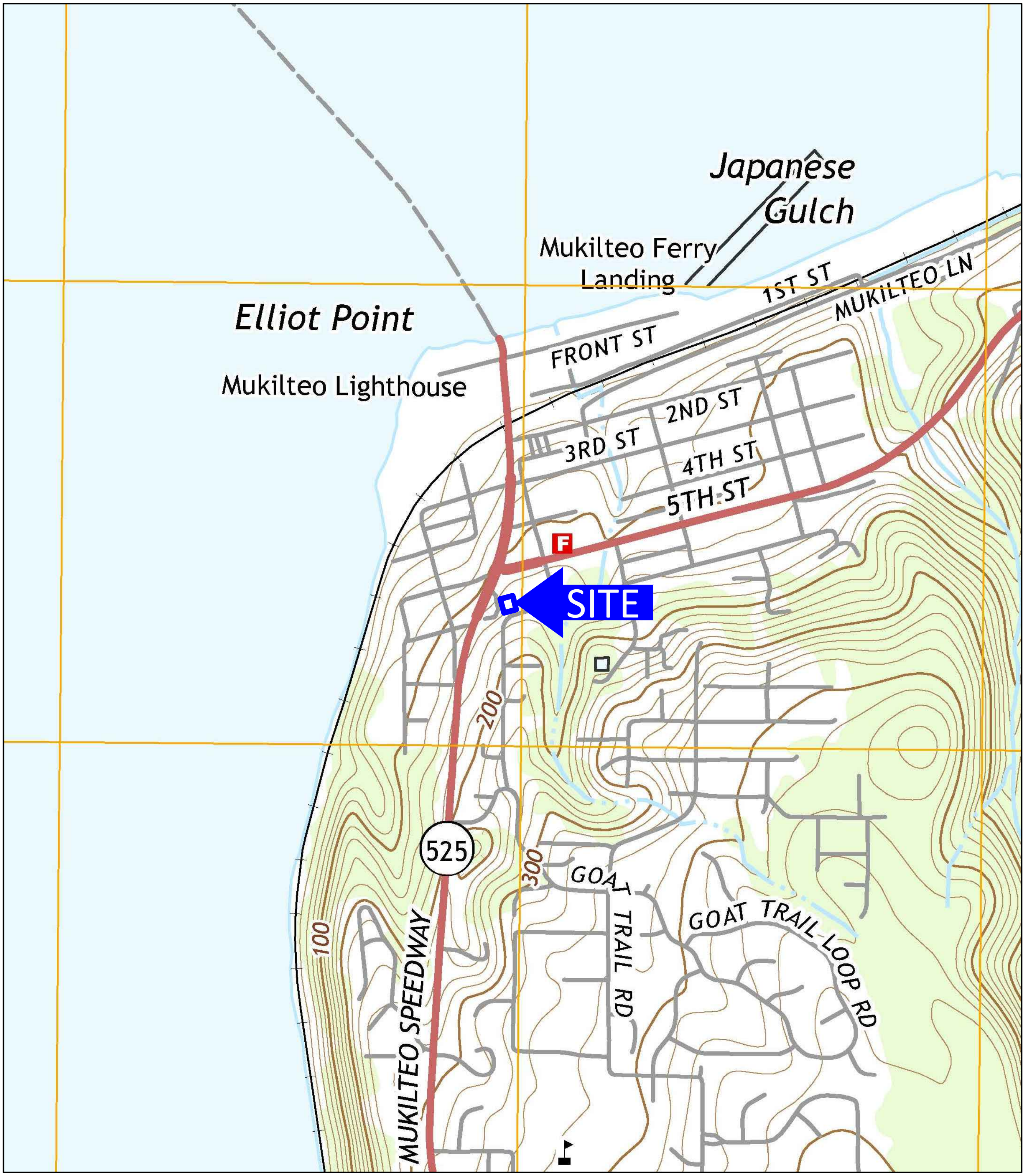
7.0 Limitations

This GER is the property of RGI, Mr. Hank Saffold, and his designated agents. Within the limits of the scope and budget, this GER was prepared in accordance with generally accepted geotechnical engineering practices in the area at the time this GER was issued. This GER is intended for specific application to the Saffold Residence project in Mukilteo, Washington, and for the exclusive use of Mr. Hank Saffold and his authorized representatives. No other warranty, expressed or implied, is made. Site safety, excavation support, and dewatering requirements are the responsibility of others.

The scope of services for this project does not include either specifically or by implication any environmental or biological (for example, mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, we can provide a proposal for these services.

The analyses and recommendations presented in this GER are based upon data obtained from the explorations performed on site. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, RGI should be requested to reevaluate the recommendations in this GER prior to proceeding with construction.

It is the client's responsibility to see that all parties to the project, including the designers, contractors, subcontractors, are made aware of this GER in its entirety. The use of information contained in this GER for bidding purposes should be done at the contractor's option and risk.



USGS, 2014, Mukilteo, Washington
7.5-Minute Quadrangle

Approximate Scale: 1"=1000'

0 500 1000 2000

N

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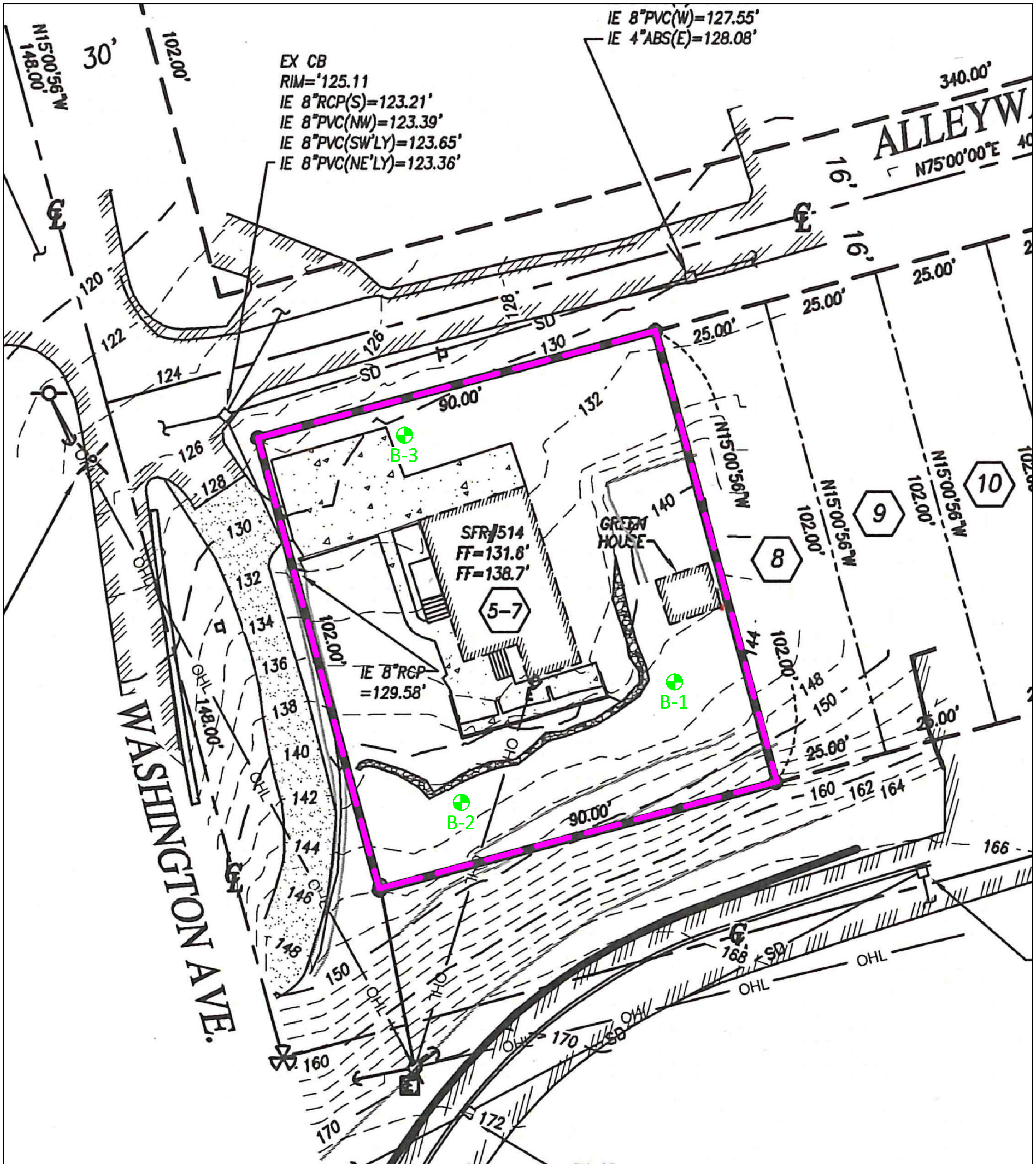
Saffold Residence		Figure 1
RGI Project Number 2018-144	Site Vicinity Map	Date Drawn: 07/2018
Address: 514 Washington Avenue, Mukilteo, Washington 98275		



● = Boring by RGI, 6/13/18

▬ ▬ = Site boundary

Approximate Scale: 1"=30'

0 15 30 60

N

Corporate Office 17522 Bothell Way Northeast Bothell, Washington 98011 Phone: 425.415.0551 Fax: 425.415.0311	Saffold Residence	Figure 2
RGI Project Number 2018-144	Geotechnical Exploration Plan	Date Drawn: 07/2018
	Address: 514 Washington Avenue, Mukilteo, Washington 98275	

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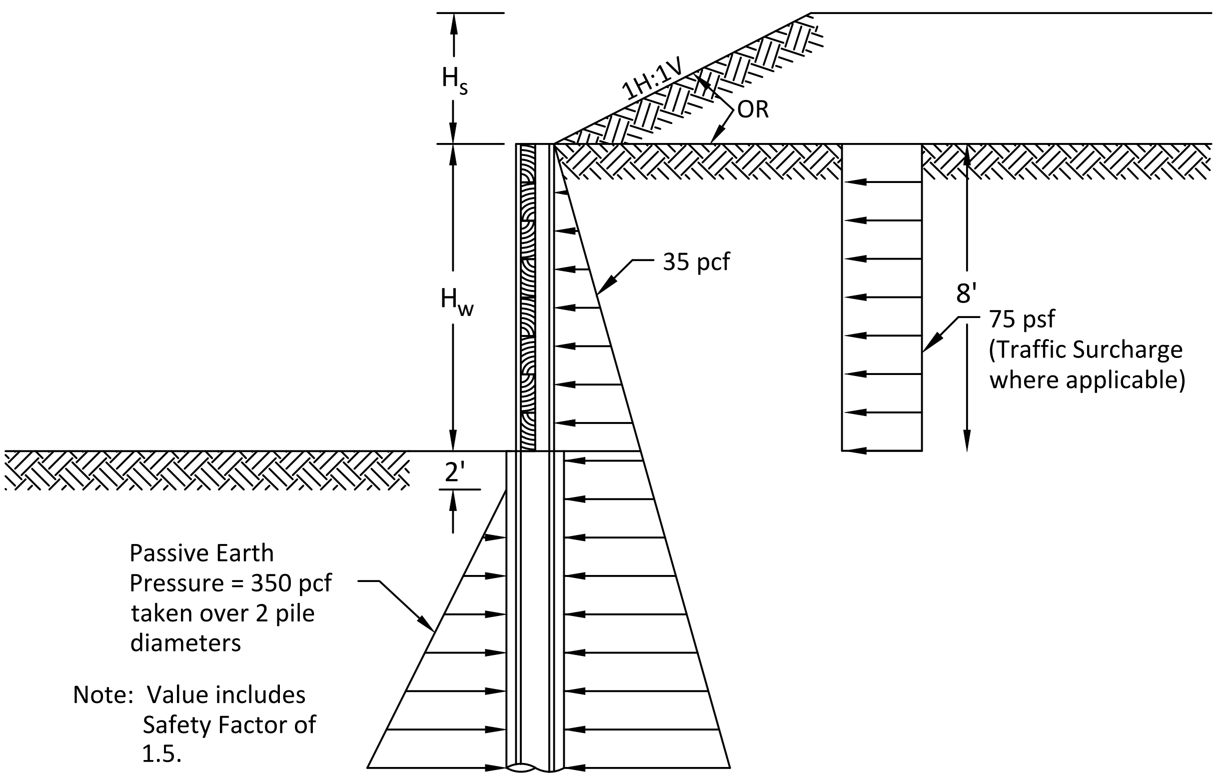

Design Height: $H = H_w + {}^{H_s}\!/_{2}$

Notes:
1. Apparent earth pressure and surcharge act over the pile spacing above the base of the excavation.
2. Passive earth pressure acts over 2 times the concreted diameter of the soldier pile, or the pile spacing whichever is less.
3. Passive pressure includes a factor of safety of 1.5.
4. Additional surcharge from footings of adjacent buildings should be included.
5. This pressure diagram is appropriate for temporary soldier pile walls. If additional surcharge loading (such as from soil stockpiles, excavators, dumptrucks, cranes, or concrete trucks) is anticipated, RGI should be consulted to provide revised surcharge pressures.

Not to Scale

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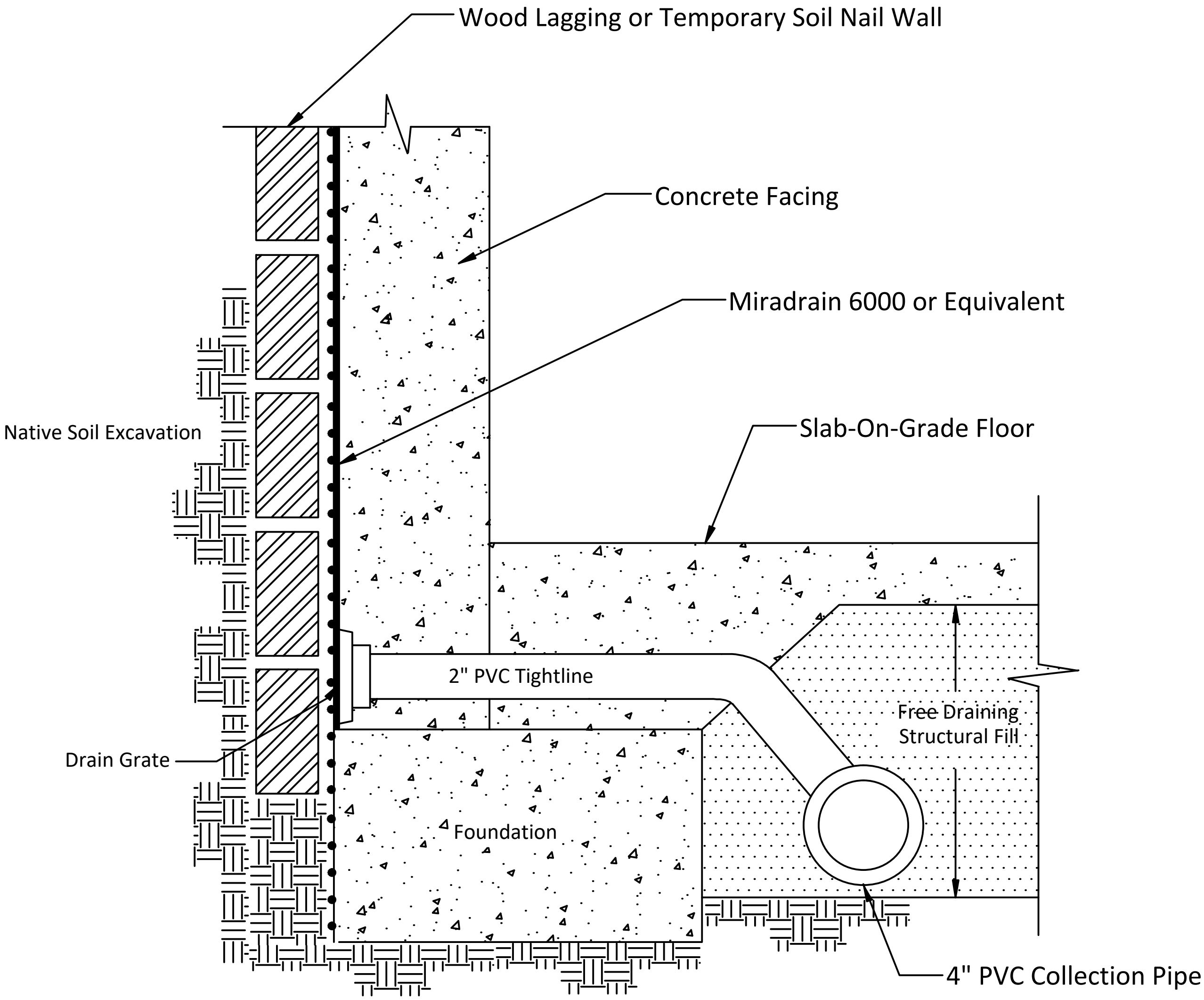
Saffold Residence		Figure 3
RGI Project Number 2018-144	Soldier Pile Pressure Diagram	Date Drawn: 07/2018
Address: 514 Washington Avenue, Mukilteo, Washington 98275		



Note: Drain Though Wall Should be Installed at Middle of Lagging, or at 10 foot intervals in the soil nail wall.

Not to Scale

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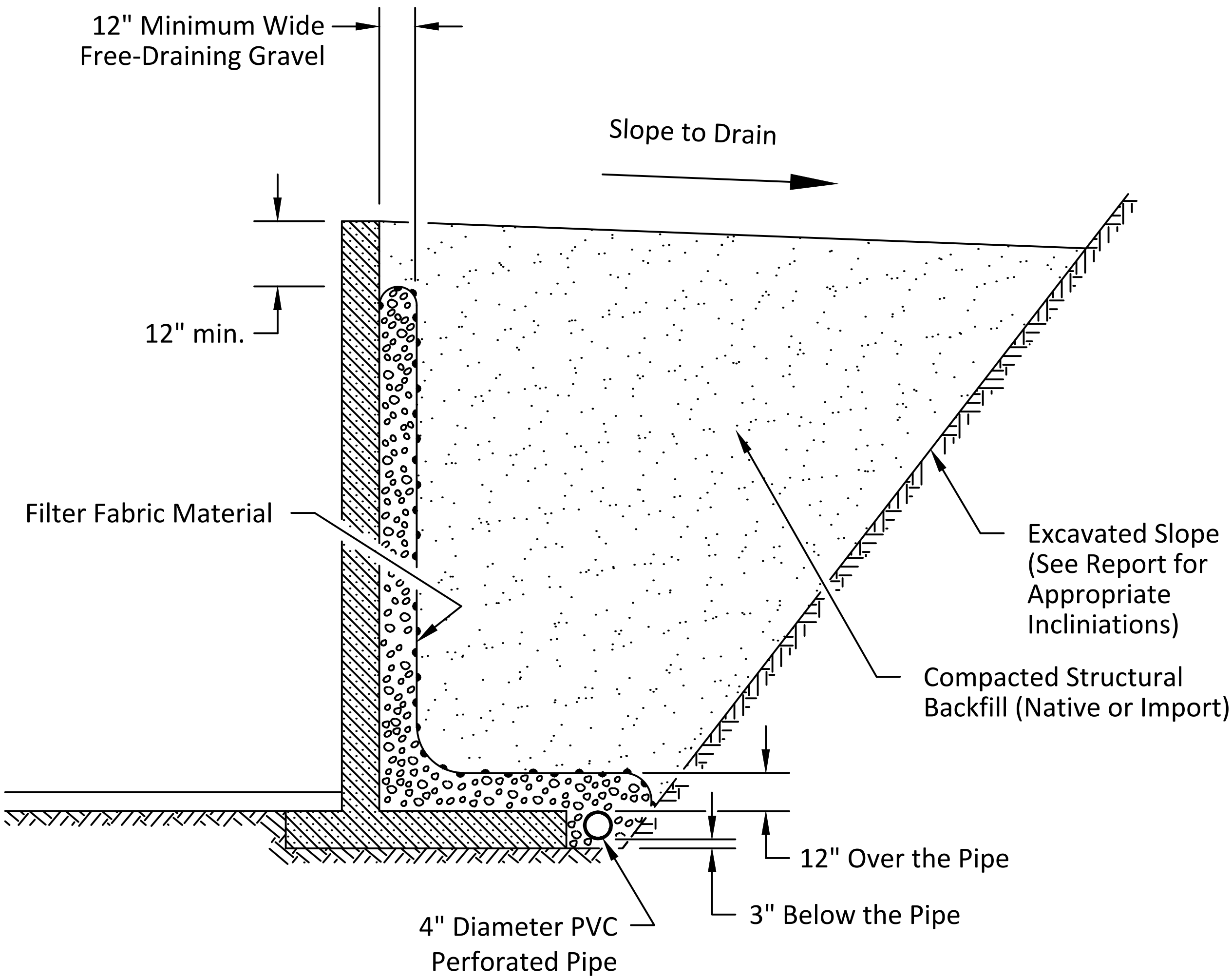
Saffold Residence		Figure 4
RGI Project Number 2018-144	Basement Wall Drainage Detail	Date Drawn: 07/2018
Address: 514 Washington Avenue, Mukilteo, Washington 98275		



Not to Scale

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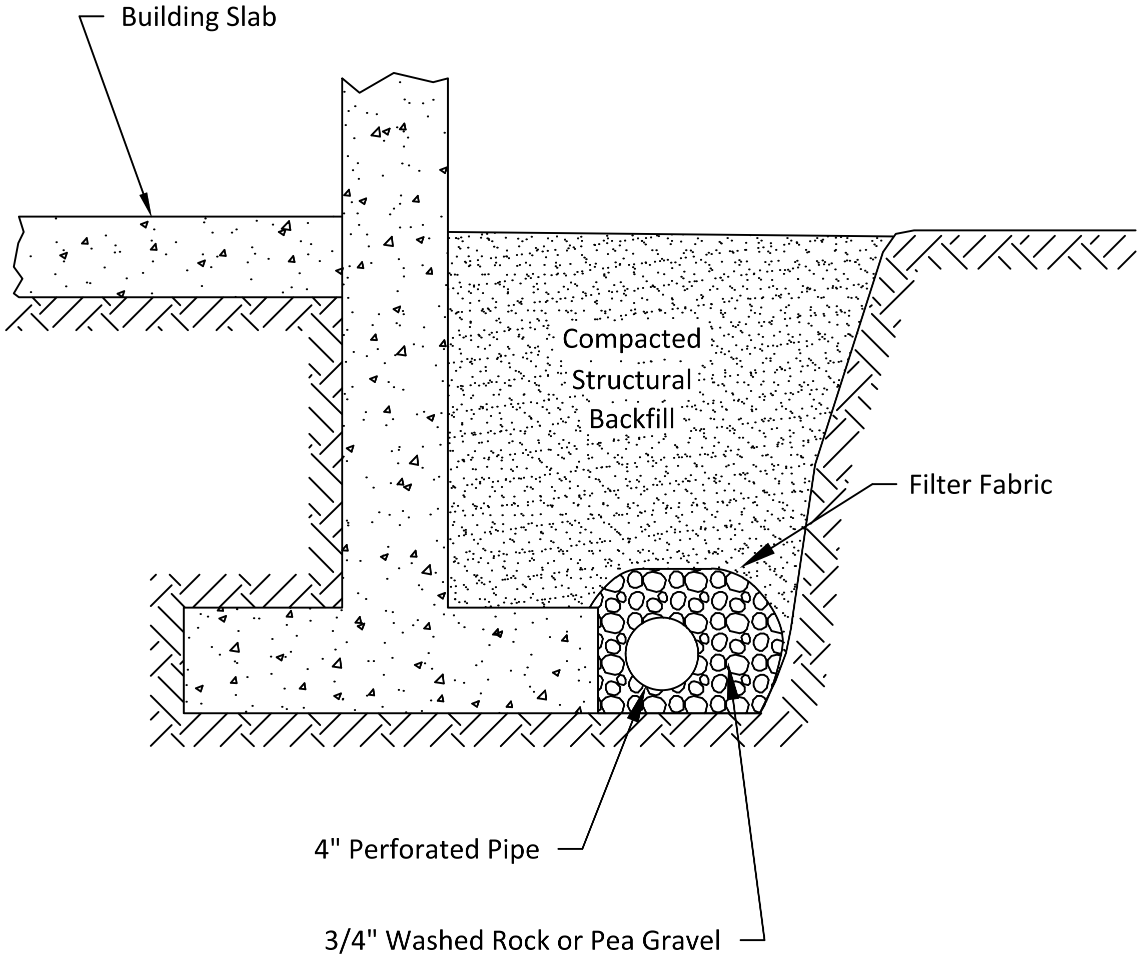
Saffold Residence		Figure 5
RGI Project Number 2018-144	Retaining Wall Drainage Detail	Date Drawn: 07/2018
Address: 514 Washington Avenue, Mukilteo, Washington 98275		



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Saffold Residence		Figure 6
RGI Project Number 2018-144	Typical Footing Drain Detail	Date Drawn: 07/2018
Address: 514 Washington Avenue, Mukilteo, Washington 98275		

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

On June 13, 2018, RGI performed field explorations using a tracked drill rig. We explored subsurface soil conditions at the site by observing the drilling of three borings to a maximum depth of 14 feet below existing grade. The boring locations are shown on Figure 2. The boring locations were approximately determined by measurements from existing property lines and paved roads.

A geologist from our office conducted the field exploration and classified the soil conditions encountered, maintained a log of each test exploration, obtained representative soil samples, and observed pertinent site features. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS).

Representative soil samples obtained from the explorations were placed in closed containers and taken to our laboratory for further examination and testing. As a part of the laboratory testing program, the soil samples were classified in our in house laboratory based on visual observation, texture, plasticity, and the limited laboratory testing described below.

Moisture Content Determinations

Moisture content determinations were performed in accordance with ASTM D2216-10 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (ASTM D2216) on representative samples obtained from the exploration in order to aid in identification and correlation of soil types. The moisture content of typical sample was measured and is reported on the boring logs.

Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses was determined using D6913-04(2009) Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis (ASTM D6913) on three of the samples.

Project Name: **Saffold Residence**	Boring No.: **B-1**
Project Number: **2018-144**	**Sheet 1 of 1**
Client: **Hank Saffold**	RILEYGROUP

Date(s) Drilled: **6/13/2018**	Logged By: **ELW**	Surface Conditions: **Mixed Brush**
Drilling Method(s): **Hollow Stem Auger**	Drill Bit Size/Type: **8" auger**	Total Depth of Borehole: **14 feet bgs**
Drill Rig Type: **Rubber Tracked Excavator**	Drilling Contractor: **Bortec**	Approximate Surface Elevation: **N/A**
Groundwater Level: **Not Encountered**	Sampling Method(s): **SPT**	Hammer Data : **140 lb, 30" drop, rope and cathead**
Borehole Backfill: **Bentonite Chips**	Location: **514 Washington Avenue, Mukilteo, Washington**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	RQD (%)	Recovery (%)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	Moisture (%)
	0					SM		Brown silty SAND with some gravel, medium dense, moist	
		SPT	13						17
						CL-ML		Gray silty CLAY, stiff, moist	39
	5							Becomes very stiff	
		SPT	22						35
								Contains thin silt partings	
		SPT	24						34
	10					ML		Tan SILT, hard, moist to wet 97% fines	
		SPT	36						28
								Becomes gray	
		SPT	31						28
								Becomes brown, iron oxide staining	
								Boring terminated at 14'	31
	15								

Project Name: **Saffold Residence**	Boring No.: **B-2**
Project Number: **2018-144**	**Sheet 1 of 1**
Client: **Hank Saffold**	RILEYGROUP

Date(s) Drilled: **6/13/2018**	Logged By: **ELW**	Surface Conditions: **Mixed Brush**
Drilling Method(s): **Hollow Stem Auger**	Drill Bit Size/Type: **8" auger**	Total Depth of Borehole: **14 feet bgs**
Drill Rig Type: **Rubber Tracked Excavator**	Drilling Contractor: **Bortec**	Approximate Surface Elevation: **N/A**
Groundwater Level: **Not Encountered**	Sampling Method(s): **SPT**	Hammer Data : **140 lb, 30" drop, rope and cathead**
Borehole Backfill: **Bentonite Chips**	Location: **514 Washington Avenue, Mukilteo, Washington**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	RQD (%)	Recovery (%)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	Moisture (%)
	0					SM		Brown silty SAND with some gravel, medium dense, moist	
						SM		Gray silty SAND, very dense, moist	
								40% fines	
								Iron oxide staining	
			52						12
	5							Little recovery	
			67						13
						SM		Gray silty SAND with trace gravel, medium dense, moist to wet	
			21						14
	10					ML		Tan SILT, hard, moist	
			46						26
			53						26
								Boring terminated at 14'	
	15								

Project Name: **Saffold Residence**
Project Number: **2018-144**
Client: **Hank Saffold**

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Boring No.: **B-3**
Sheet 1 of 1

Date(s) Drilled: **6/13/2018**	Logged By: **ELW**	Surface Conditions: **Grass**
Drilling Method(s): **Hollow Stem Auger**	Drill Bit Size/Type: **8" auger**	Total Depth of Borehole: **13.42 feet bgs**
Drill Rig Type: **Rubber Tracked Excavator**	Drilling Contractor: **Bortec**	Approximate Surface Elevation: **N/A**
Groundwater Level: **Not Encountered**	Sampling Method(s): **SPT**	Hammer Data : **140 lb, 30" drop, rope and cathead**
Borehole Backfill: **Bentonite Chips**	Location: **514 Washington Avenue, Mukilteo, Washington**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	RQD (%)	Recovery (%)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	Moisture (%)
	0					TPSL		4" topsoil	
						SM		Brown silty SAND with trace gravel, medium dense, moist	
						ML		Brown sandy SILT, soft, moist to wet	
			6						27
	5					SM		Brown silty SAND with some gravel, medium dense, wet 27% fines	
			18						13
						SM		Gray silty SAND, very dense, moist	
			79/11"						15
	10		50/6"						16
			50/5"						9
								Boring terminated at 13' 5"	
	15								

Project Name: **Saffold Residence**
Project Number: **2018-144**
Client: **Hank Saffold**

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Key to Log of Boring

Sheet 1 of 1

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	RQD (%)	Recovery (%)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	Moisture (%)
1	2	3	4	5	6	7	8	9	10

COLUMN DESCRIPTIONS

1 Elevation (feet): Elevation (MSL, feet).
2 Depth (feet): Depth in feet below the ground surface.
3 Sample Type: Type of soil sample collected at the depth interval shown.
4 Sampling Resistance, blows/ft: Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval using the hammer identified on the boring log.
5 RQD (%): Rock Quality Designation is a relative index of the rock mass quality calculated by comparing the cumulative length of intact pieces of core exceeding 100 mm in length to the cored interval length.
6 Recovery (%): Core Recovery Percentage is determined based on a ratio of the length of core sample recovered compared to the cored interval length.
7 USCS Symbol: USCS symbol of the subsurface material.
8 Graphic Log: Graphic depiction of the subsurface material encountered.
9 MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
10 Moisture (%): Moisture, expressed as a water content.

FIELD AND LABORATORY TEST ABBREVIATIONS

CHEM: Chemical tests to assess corrosivity
COMP: Compaction test
CONS: One-dimensional consolidation test
LL: Liquid Limit, percent
PI: Plasticity Index, percent
SA: Sieve analysis (percent passing No. 200 Sieve)
UC: Unconfined compressive strength test, Qu, in ksf
WA: Wash sieve (percent passing No. 200 Sieve)

MATERIAL GRAPHIC SYMBOLS

SILTY CLAY (CL-ML)
SILT, SILT w/SAND, SANDY SILT (ML)
Silty SAND (SM)
Topsoil

TYPICAL SAMPLER GRAPHIC SYMBOLS

Auger sampler
Bulk Sample
3-inch-OD California w/ brass rings
CME Sampler
Grab Sample
2.5-inch-OD Modified California w/ brass liners
Pitcher Sample
2-inch-OD unlined split spoon (SPT)
Shelby Tube (Thin-walled, fixed head)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)
Water level (after waiting)
Minor change in material properties within a stratum
Inferred/gradational contact between strata
? Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

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GRAIN SIZE ANALYSIS
ASTM D421, D422, D1140, D2487, D6913

PROJECT TITLE	Saffold Residence	SAMPLE ID/TYPE	B-1
PROJECT NO.	2018-144	SAMPLE DEPTH	10'
TECH/TEST DATE	LW 6/14/2018	DATE RECEIVED	6/14/2018

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	355.0
Wt Dry Soil & Tare (gm)	(w2)	281.3
Weight of Tare (gm)	(w3)	15.6
Weight of Water (gm)	(w4=w1-w2)	73.7
Weight of Dry Soil (gm)	(w5=w2-w3)	265.7
Moisture Content (%)	(w4/w5)*100	28

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

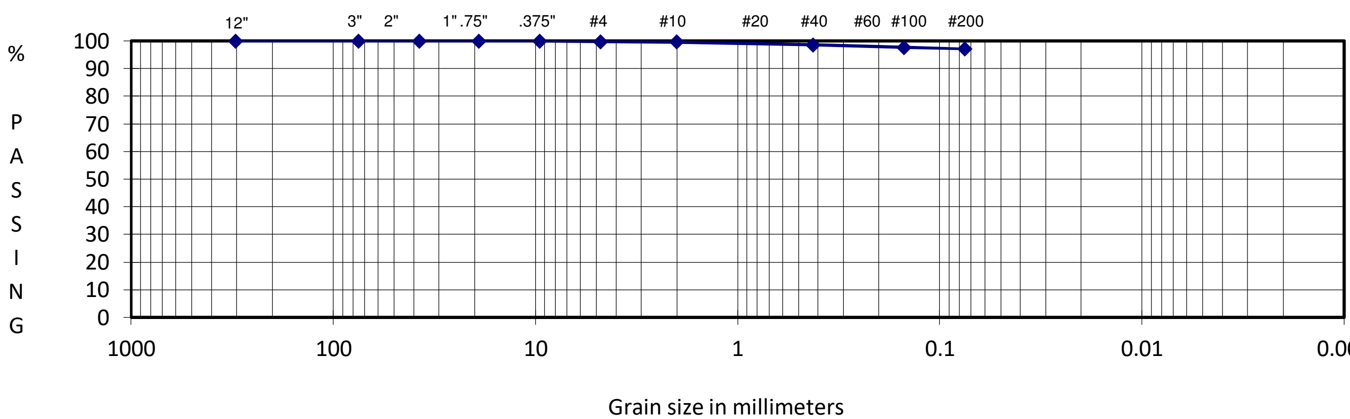
	Weight Of Sample (gm)	281.3
	Tare Weight (gm)	15.6
(W6)	Total Dry Weight (gm)	265.7

% COBBLES	0.0
% C GRAVEL	0.0
% F GRAVEL	0.3
% C SAND	0.1
% M SAND	1.1
% F SAND	1.4
% FINES	97.1
% TOTAL	100.0

D10 (mm)	
D30 (mm)	
D60 (mm)	
Cu	
Cc	

SIEVE ANALYSIS

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	
12.0"	15.6	0.00	0.00	100.00	cobbles
3.0"	15.6	0.00	0.00	100.00	coarse gravel
2.5"					coarse gravel
2.0"					coarse gravel
1.5"	15.6	0.00	0.00	100.00	coarse gravel
1.0"					coarse gravel
0.75"	15.6	0.00	0.00	100.00	fine gravel
0.50"					fine gravel
0.375"	15.6	0.00	0.00	100.00	fine gravel
#4	16.4	0.80	0.30	99.70	coarse sand
#10	16.7	1.10	0.41	99.59	medium sand
#20					medium sand
#40	19.5	3.90	1.47	98.53	fine sand
#60					fine sand
#100	21.8	6.20	2.33	97.67	fine sand
#200	23.2	7.60	2.86	97.14	fines
PAN	281.3	265.70	100.00	0.00	silt/clay



DESCRIPTION	SILT
USCS	ML

Prepared For: *Hank Saffold*

Reviewed By: ELW

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GRAIN SIZE ANALYSIS
ASTM D421, D422, D1140, D2487, D6913

PROJECT TITLE	Saffold Residence	**SAMPLE ID/TYPE**	B-2
PROJECT NO.	2018-144	**SAMPLE DEPTH**	2.5'
TECH/TEST DATE	LW 6/14/2018	**DATE RECEIVED**	6/14/2018

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	475.9
Wt Dry Soil & Tare (gm)	(w2)	426.6
Weight of Tare (gm)	(w3)	15.6
Weight of Water (gm)	(w4=w1-w2)	49.3
Weight of Dry Soil (gm)	(w5=w2-w3)	411.0
Moisture Content (%)	(w4/w5)*100	12

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

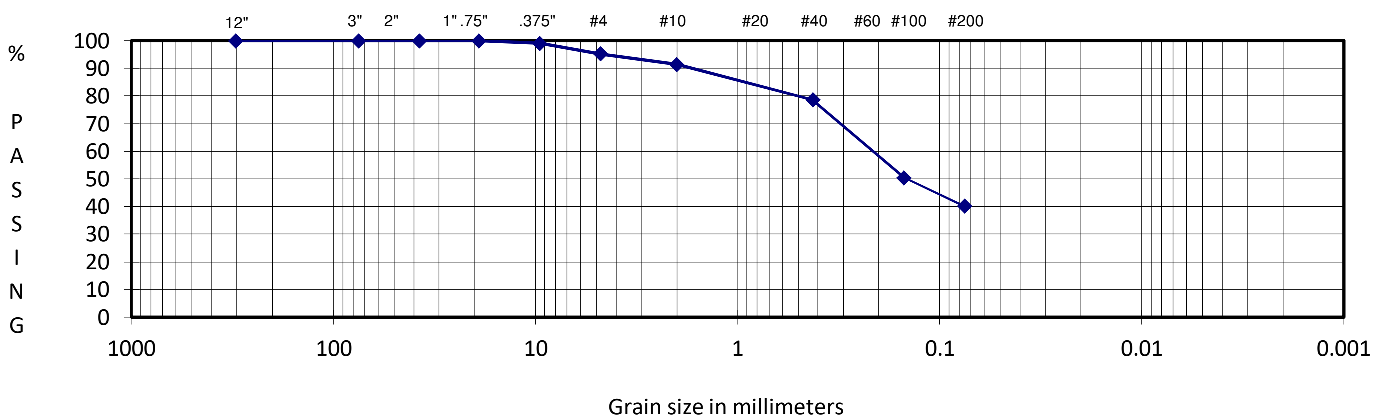
	Weight Of Sample (gm)	426.6
	Tare Weight (gm)	15.6
(W6)	Total Dry Weight (gm)	411.0

% COBBLES	0.0
% C GRAVEL	0.0
% F GRAVEL	4.8
% C SAND	3.8
% M SAND	12.9
% F SAND	38.5
% FINES	40.0
% TOTAL	100.0

D10 (mm)	
D30 (mm)	
D60 (mm)	
Cu	
Cc	

SIEVE ANALYSIS

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	
12.0"	15.6	0.00	0.00	100.00	cobbles
3.0"	15.6	0.00	0.00	100.00	coarse gravel
2.5"					coarse gravel
2.0"					coarse gravel
1.5"	15.6	0.00	0.00	100.00	coarse gravel
1.0"					coarse gravel
0.75"	15.6	0.00	0.00	100.00	fine gravel
0.50"					fine gravel
0.375"	19.7	4.10	1.00	99.00	fine gravel
#4	35.3	19.70	4.79	95.21	coarse sand
#10	50.9	35.30	8.59	91.41	medium sand
#20					medium sand
#40	103.8	88.20	21.46	78.54	fine sand
#60					fine sand
#100	219.2	203.60	49.54	50.46	fine sand
#200	262.0	246.40	59.95	40.05	fines
PAN	426.6	411.00	100.00	0.00	silt/clay



DESCRIPTION	Silty SAND
USCS	SM

Prepared For:
Hank Saffold

Reviewed By:
ELW

RILEYGROUP

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GRAIN SIZE ANALYSIS
ASTM D421, D422, D1140, D2487, D6913

PROJECT TITLE	Saffold Residence	SAMPLE ID/TYPE	B-3
PROJECT NO.	2018-144	SAMPLE DEPTH	5'
TECH/TEST DATE	LW 6/14/2018	DATE RECEIVED	6/14/2018

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	619.9
Wt Dry Soil & Tare (gm)	(w2)	551.4
Weight of Tare (gm)	(w3)	15.7
Weight of Water (gm)	(w4=w1-w2)	68.5
Weight of Dry Soil (gm)	(w5=w2-w3)	535.7
Moisture Content (%)	(w4/w5)*100	13

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

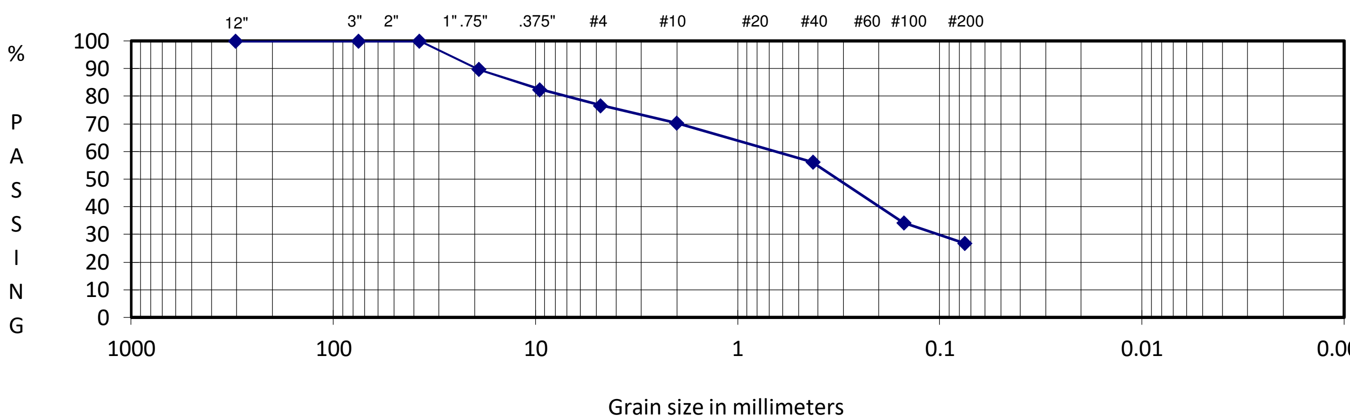
	Weight Of Sample (gm)	551.4
	Tare Weight (gm)	15.7
(W6)	Total Dry Weight (gm)	535.7

% COBBLES	0.0
% C GRAVEL	10.4
% F GRAVEL	13.1
% C SAND	6.4
% M SAND	14.0
% F SAND	29.3
% FINES	26.8
% TOTAL	100.0

D10 (mm)	
D30 (mm)	
D60 (mm)	
Cu	
Cc	

SIEVE ANALYSIS

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	
12.0"	15.7	0.00	0.00	100.00	cobbles
3.0"	15.7	0.00	0.00	100.00	coarse gravel
2.5"					coarse gravel
2.0"					coarse gravel
1.5"	15.7	0.00	0.00	100.00	coarse gravel
1.0"					coarse gravel
0.75"	71.4	55.70	10.40	89.60	fine gravel
0.50"					fine gravel
0.375"	110.1	94.40	17.62	82.38	fine gravel
#4	141.4	125.70	23.46	76.54	coarse sand
#10	175.6	159.90	29.85	70.15	medium sand
#20					medium sand
#40	250.7	235.00	43.87	56.13	fine sand
#60					fine sand
#100	369.0	353.30	65.95	34.05	fine sand
#200	407.8	392.10	73.19	26.81	fines
PAN	551.4	535.70	100.00	0.00	silt/clay



DESCRIPTION Silty SAND with some gravel

USCS SM

Prepared For:
Hank Saffold

Reviewed By:
ELW