GEOTECHNICAL REPORT

Stack Short Plat
3807 – 122nd Street Northeast
Marysville, Washington

Project No. T-8719

Terra Associates, Inc.

Prepared for:

Stack Design and Construction, LLC
Marysville, Washington

August 31, 2022

TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

August 31, 2022
Project No. T-8719

Mr. Terry Grooms
Stack Design and Construction, LLC
8825 34th Avenue Northeast
Marysville, Washington 98271

Subject: Geotechnical Report
Stack Short Plat
3807 122nd Street Northeast
Marysville, Washington

Dear Mr. Grooms:

As requested, we have conducted a geotechnical engineering study for the subject project. The attached report presents our findings and recommendations for the geotechnical aspects of project design and construction.

Our field exploration indicates the site is generally underlain by six to nine inches of organic topsoil overlying approximately one and one-half to five feet of loose to medium dense, fine- to coarse-grained silty sand and sand with silt underlain by loose to medium dense, fine- to coarse-grained sand and gravel. Groundwater was encountered in all test pits at depths of approximately three to five feet.

In our opinion, soil and groundwater conditions at the site will be suitable for support of the development as planned, provided recommendations contained herein are incorporated into project design and construction specifications.

We trust the information provided in the attached report is sufficient for your current needs. If you have any questions or need additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Tyler A. Gilsdorf, G.I.T.
Staff Geologist

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Geotechnical Report
Stack Short Plat
3807 – 122nd Street Northeast
Marysville, Washington

1.0 PROJECT DESCRIPTION

The project consists of redeveloping the approximately 1.0-acre parcel with five single-family residential lots along with associated access and utilities. Based on review of a preliminary site plan prepared by LDC, Inc., site grades will be raised by approximately 1.5 to 2.5 feet from elevation 76 feet up to 77.5 to 78.5 feet to establish the residential building lots and roadway elevations. Site stormwater will be handled by permeable pavements and concrete with an emergency over-flow connected to the existing stormwater system.

We expect the residential buildings constructed on the lots will be two- to- three-story, wood-framed buildings constructed over a crawlspace with an attached garage constructed at-grade. Structural loading should be relatively light, with bearing walls carrying loads of 2 to 3 kips per foot and isolated columns carrying maximum loads of 30 to 40 kips.

The recommendations in the following sections of this report are based on our understanding of the preceding design features. We should review design drawings as they become available to verify our recommendations have been properly interpreted and to supplement them, if required.

2.0 SCOPE OF WORK

On February 21, 2022, we explored subsurface conditions at the site by observing soil and groundwater conditions at four test pits excavated to a maximum depth of nine feet below existing site grades. Using the information obtained from the subsurface exploration and laboratory testing, we performed analyses to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

Soil and groundwater conditions.

- Soil and groundwater conditions.
- Seismic Criteria per the current International Building Code (IBC).
- Geologic Hazards per the City of Marysville Municipal Code.
- Site preparation and grading.
- Excavation.
- Foundations.

- Slab-on-grade floors.
- Lateral earth pressures for wall design.
- Infiltration feasibility.
- Utilities.
- Drainage.
- Pavements.

It should be noted, recommendations outlined in this report regarding drainage are associated with soil strength, design earth pressures, erosion, and stability. Design and performance issues with respect to moisture as it relates to the structure environment are beyond Terra Associates, Inc.'s purview. A building envelope specialist or contactor should be consulted to address these issues, as needed.

3.0 SITE CONDITIONS

3.1 Surface

The project site consists of a single residential tax parcel (Snohomish County Parcel #: 30050900202200) totaling approximately 1.00 acre located at 3807-122nd Street Northeast in Marysville, Washington. The approximate site location is shown on Figure 1.

The site is currently developed with a single-family residence, a detached garage, a few outbuildings, and associated access in the eastern half of the site. The remainder of the site is predominately undeveloped and covered with grass as well as scattered small- to medium-sized trees. Site topography is relatively flat with no obvious signs of sloping.

3.2 Subsurface

In general, the soil conditions at the site consist of approximately six to nine inches of organic topsoil overlying approximately one and one-half to five feet of loose to medium dense fine-to coarse-grained sand with varying silt content over loose to medium dense, fine-to course-grained sand and gravel to the termination of the test pits.

The *Geologic Map of the Marysville Quadrangle, Snohomish County, Washington* by J.P. Minard (1985) shows the site as being underlain by the Marysville Sand member of the Vashon Recessional Outwash deposits (Qvrm). This mapped description is consistent with the native soils observed at the test pit locations.

The preceding discussion is intended to be a general review of the soil conditions encountered. For more detailed descriptions, please refer to the Test Pit Logs in Appendix A. The approximate location of the test pits is shown on the Exploration Location Plan, Figure 2.

3.3 Groundwater

We observed groundwater in all the test pits at approximately three to five feet below current site grades. Mottling and oxidation staining was also observed within the upper portion of the outwash deposits in all of the Test Pits. Mottling is typically an indication that shallow groundwater develops within this mottled zone. Additionally, perched groundwater was observed in Test Pit TP-3 at a depth of nine inches to one foot at the contact between the surficial topsoil and a layer of silty sand.

Our observations in the test pits and experience with groundwater conditions in the area indicate observed groundwater levels correspond with the local groundwater table. Groundwater seepage was observed in the late winter following an unseasonably dry February, so the groundwater observed likely is below the typical seasonal high level. Fluctuations in the static groundwater level will occur seasonally. Typically, groundwater will reach maximum levels during the wet winter months. Based on our experience with groundwater conditions in the area, we would expect the seasonal high groundwater level to be approximately one foot below existing site grades.

3.4 Geologic Hazards

Section 22A.020.080 of the City of Marysville Municipal Code (MMC) defines geologic hazards as "lands or areas characterized by geologic, hydrologic and topographic conditions that render them susceptible to potentially significant or severe risk of landslides, erosion, or seismic activity." We have evaluated the site for these hazards in the following sections below.

3.4.1 Erosion Hazard Areas

Chapter 22A.020.060 of the MMC defines Erosion Hazard Areas as "…lands or areas that, based on a combination of slope inclination and the characteristics of the underlying soils, are susceptible to varying degrees of risk of erosion. Erosion hazard areas are classified as low hazard, moderate hazard, and high hazard, based on the following criteria:

(1) Low Hazard. Areas sloping less than 15 percent.

(2) Moderate Hazard. Areas sloping between 15 and 40 percent and underlain by soils that consist predominantly of silt, clay, bedrock, or glacial till.

(3) High Hazard. Areas sloping between 15 and 40 percent that are underlain by soils consisting largely of sand and gravel, and all areas sloping more steeply than 40 percent."

The soils observed at the site are classified as Custer fine sandy loam by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). Over the site with existing slope gradients, these soils will have a slight potential for erosion when exposed. Therefore, it is our opinion that the site does not present an erosion hazard. Regardless, the site soils would be susceptible to some erosion when exposed during construction. In our opinion, proper implementation and maintenance of Best Management Practices (BMPs) for erosion prevention and sediment control, would adequately mitigate the erosion potential in the planned development area. Erosion protection measures as required by the City of Marysville will need to be in place prior to and during grading activities at the site.

3.4.2 Landslide Hazard Areas

Landslide Hazard Areas are defined in Chapter 22.A.020.130 of the MMC as "…areas that, due to a combination of slope inclination and relative soil permeability, are susceptible to varying degrees of risk of landsliding. Landslide hazard areas are classified as Classes I through IV based on the degree of risk as follows:

(1) Low Hazard. Areas with slopes of less than 15 percent.

(2) Moderate Hazard. Areas with slopes of between 15 and 40 percent and that are underlain by soils that consist largely of sand, gravel, bedrock, or glacial till.

(3) High Hazard. Areas with slopes between 15 percent and 40 percent that are underlain by soils consisting largely of silt and clay, and all areas sloping more steeply than 40 percent.

(4) Very High Hazard. Areas with slopes over 40 percent and areas of known mappable landslide deposits."

The relatively flat site does not meet any of the above conditions. Therefore, the site does not present a landslide hazard as per the MMC in our opinion.

3.4.3 Seismic Hazard Areas

Section 22A.020.200 of the MMC defines seismic hazard areas as "… areas that, due to a combination of soil and ground water conditions, are subject to severe risk of ground shaking, subsidence or liquefaction of soils during earthquakes. These areas are typically underlain by soft or loose saturated soils (such as alluvium), have a shallow ground water table and are typically located on the floors of river valleys. Seismic hazard areas are classified as follows:

(1) Low Hazard. Areas underlain by dense soils or bedrock.

(2) High Hazard. Areas underlain by soft or loose saturated soils."

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. Liquefaction mainly affects geologically recent deposits of fine-grained sands underlying 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, eliminating the soil's strength.

Based on soil and groundwater conditions observed in our subsurface explorations and the above criteria, the seismic hazard of the site is classified as "high hazard." Based on the shallow groundwater levels at the site and the observed density of the native outwash soils, it is our opinion that during a severe seismic event, soil liquefaction has the potential to occur within the saturated sand deposits and cause settlement at the site. If unmitigated, these settlements could result in some building distress and cosmetic damage, but in our opinion, would not structurally impact the proposed buildings.

Once site grading plans become available, further analysis will need to be completed to determine the liquefaction potential at the site.

3.5 Seismic Site Class

As discussed in the previous section, soil and groundwater conditions at the site will be subject to the soil liquefaction phenomenon during a severe seismic event. Because of this condition, per the current International Building Code (IBC), subsurface conditions would be assigned site class "F" which would require performing a site-specific seismic analysis to determine seismic forces for structural design. However, the IBC allows for using code derived seismic values for the soil conditions indicated if the building's fundamental period is equal to or less than 0.5 seconds. If the proposed buildings fall into this category, based on soil conditions encountered and our knowledge of the area geology, site class "D" can be used to determine seismic design forces.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Based on our study, development of the site as proposed is feasible from a geotechnical engineering standpoint. The residential buildings can be supported on conventional spread footings bearing on medium dense or firmer native soils, re-compacted native soils, and/or structural fill placed above suitable native soils. Floor slabs and pavements can be similarly supported.

The upper soils were observed in a loose condition. Depending on the condition of the material at the time of construction the contractor should be prepared to scarify the upper 12 inches of material and re-compact to a firm condition.

Based on our observations during excavation of the test pits and experience with groundwater conditions in the area, utility excavations will likely extend below the groundwater table. Any excavations extending below the groundwater table will likely require dewatering to maintain relatively dry working conditions and to increase the stability of the granular soils encountered onsite. Design and construction of deeper utility structures that may be impacted by groundwater will need to include buoyancy effects and hydrostatic pressures acting on the structure. Dewatering for construction of these structures would also likely be required.

The upper silty sand soils observed at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. Our laboratory results indicate that the soils at the site are several percentage points above optimum moisture content. The ability to use native soils from site excavations as structural fill will depend on its moisture content and the prevailing weather conditions at the time of construction. Drying or treatment of native soils with amendments prior to their use as structural fill will likely be required during grading activities at the site. If grading activities will take place during winter, the owner should be prepared to import clean granular material for use as structural fill and backfill.

Additionally, the soils' high moisture content and inherent moisture sensitivity indicate they have the potential to quickly degrade under construction traffic and stabilization of subgrades may be required prior to and during grading activities at the site.

While not observed, older fill material may be present in areas where we did not explore near the existing residence and outbuildings.

The following sections provide detailed recommendations regarding the preceding issues and other geotechnical design considerations. These recommendations should be incorporated into the final design drawings and construction specifications.

4.2 Site Preparation and Grading

To prepare the site for construction, all vegetation and organic surface soils should be stripped and removed from below building and pavement areas. Surface stripping depths of approximately six to nine inches should be expected to remove the organic surficial soils. In the developed portions of the site, demolition of existing structures should include removal of existing foundations and abandonment of underground septic systems and other buried utilities. Abandoned utility pipes that fall outside of new building areas can be left in place provided they are sealed to prevent intrusion of groundwater seepage and soil. Soil containing organic material will not be suitable for use as structural fill but may be used for limited depths in nonstructural areas.

As noted above, the upper site soils were observed in a loose condition. The contractor should be prepared to scarify the upper 12 inches of soil and re-compact to a firm condition. The lateral extent of the re-compaction should be determined in the field during grading.

Once clearing and stripping operations are complete, cut and fill operations can be initiated to establish desired building grades. Prior to placing fill, all exposed bearing surfaces should be observed by a representative of Terra Associates, Inc. to verify soil conditions are as expected and suitable for support of new fill or building elements. Our representative may request a proofroll using heavy rubber-tired equipment to determine if any isolated soft and yielding areas are present. If excessively yielding areas are observed and they cannot be stabilized in place by compaction, the affected soils should be excavated and removed to firm bearing and grade restored with new structural fill. If the depth of excavation to remove unstable soils is excessive, the use of geotextile fabrics such as, Mirafi 500X or an equivalent fabric can be used in conjunction with clean granular structural fill. Our experience has shown, in general, a minimum of 18 inches of a clean, granular structural fill placed and compacted over the geotextile fabric should establish a stable bearing surface.

Some of the site soils could quickly degrade under construction traffic in rainy weather conditions during site clearing and subgrade preparation activities. Where this condition exists, consideration should be given to over-excavating to a depth of one to two feet, placing a geotextile fabric such as Mirafi 500X or equal on the over-excavated subgrade, and replacing with two- to four-inch recycled concrete or quarry spalls. Based on our experience, this will provide a stable surface for areas subject to heavy equipment and construction traffic.

Our study indicates that some of the upper native soils contain a sufficient percentage of fines (silt- and clay-sized particles) that will make them difficult to compact as structural fill if they are too wet or too dry. Accordingly, the ability to use these soils as structural fill will depend on their moisture content and the prevailing weather conditions when site grading activities take place. If wet soils are encountered, the contractor will need to dry the soils by aeration during dry weather conditions. Alternatively, the use of an additive such as Portland cement or lime to stabilize the soil moisture can be considered. If the soil is amended, additional Best Management Practices (BMPs) addressing the potential for elevated pH levels will need to be included in the Stormwater Pollution Prevention Program (SWPPP) prepared with the Temporary Erosion and Sedimentation Control (TESC) plan. The cleaner sand and gravel soils should be suitable for reuse year-round.

If grading activities are planned during the wet winter months, or if they are initiated during the summer and extend into fall and winter, the owner should be prepared to import wet-weather structural fill. For this purpose, we recommend importing a granular soil that meets the following grading requirements:

U.S. Sieve Size	Percent Passing
6 inches	100
No. 4	75 maximum
No. 200	5 maximum*

* Based on the 3/4-inch fraction.

Prior to use, Terra Associates, Inc. should examine and test all materials imported to the site for use as structural fill.

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-1557 (Modified Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas, the degree of compaction can be reduced to 90 percent.

4.3 Excavations

All excavations at the site associated with confined spaces, such as those for utility construction, must be completed in accordance with local, state, or federal requirements. Based on current Washington Industrial Safety and Health Act (WISHA) regulations, soils found on the project site would be classified as Type C soils.

For properly dewatered excavations more than 4 feet, but less than 20 feet in depth, the side slopes should be laid back at an inclination no steeper than 1.5:1 (Horizontal: Vertical). If there is insufficient space to complete the excavations in this manner, or if excavations greater than 20 feet in depth are planned, temporary shoring to support the excavations may be required. Properly designed and installed shoring trench boxes can be used to support utility trench excavations where required.

Based on our study, groundwater should be anticipated within excavations extending below depths of about one to two feet below native surface grades. Excavations extending below this depth will likely encounter groundwater with volumes and flow rates sufficient to require some level of dewatering. Shallow excavations that do not extend more than two to three feet below the groundwater table can likely be dewatered by conventional sump-pumping procedures along with a system of collection trenches. Deeper excavations will require dewatering by well points or isolated deep-pump wells. The utility subcontractor should be prepared to implement excavation dewatering by well point or deep-pump wells, as needed. This will be an especially critical consideration for any deep excavations such for lift stations and sanitary sewer tie-ins.

This information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Terra Associates, Inc. assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

4.4 Foundation Support

The residential buildings may be supported on conventional spread footing foundations bearing on competent native soils or on structural fill placed on a competent native soil subgrade. Foundation subgrades should be prepared as recommended in Section 4.2 of this report. Perimeter foundations exposed to the weather should bear a minimum depth of 1.5 feet below final exterior grades for frost protection. Interior foundations can be constructed at any convenient depth below the floor slab.

Foundations bearing on competent soil, can be dimensioned for a net allowable bearing capacity of 2,000 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used. With the anticipated loads and this bearing stress applied, building settlements should be less than one-inch total and one-half inch differential.

For designing foundations to resist lateral loads, a base friction coefficient of 0.30 can be used. Passive earth pressures acting on the side of the footing and buried portion of the foundation stem wall can also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 300 pcf. We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundations will be constructed neat against competent soil and backfilled with structural fill, as described in Section 4.2 of this report. The recommended values include a safety factor of 1.5.

4.5 Slab-on-Grade Floors

Slab-on-grade floors may be supported on subgrade prepared as recommended in Section 4.2 of this report. Immediately below the floor slab, we recommend placing a four-inch-thick capillary break layer composed of clean, coarse sand or fine gravel that has less than five percent passing the 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. Installation of a capillary break layer will not be necessary where the floor subgrade is composed of the clean native outwash or structural fill comprised of the clean outwash. A representative of Terra Associates should observe the subgrade at the time of construction to verify this condition and determine if an imported capillary break layer is required.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction and to aid in uniform curing of the concrete slab. It should be noted, if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will not be effective in assisting uniform curing of the slab and can actually serve as a water supply for moisture transmission through the slab, potentially affecting floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained. We recommend floor designers and contractors refer to the current American Concrete Institute (ACI) Manual of Concrete Practice for further information regarding vapor barrier installation below slab-on-grade floors.

4.6 Lateral Earth Pressures for Wall Design

The magnitude of earth pressure development on retaining walls will partly depend on the quality and compaction of the wall backfill. We recommend placing and compacting wall backfill as structural fill, as described in Section 4.2. To prevent overstressing the walls during backfilling, heavy construction machinery should not be operated within five feet of the wall. Wall backfill in this zone should be compacted with hand-operated equipment. To prevent hydrostatic pressure development, wall drainage must also be installed. A typical wall drainage detail is shown on Figure 3. All drains should be routed to an approved point of controlled discharge.

With drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 psf should be added to the 35 pcf. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge). For evaluation of wall performance under seismic loading, a uniform pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall should be applied in addition to the static lateral earth pressure. These values assume a horizontal backfill condition and that no other surcharge loading, sloping embankments, or adjacent buildings will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design. 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 4.4.

4.7 Infiltration Feasibility

Based on our study, it is our opinion that the site groundwater conditions will preclude using full infiltration for management of development stormwater runoff due to the lack of adequate separation between the existing site grades and the seasonal-high groundwater level. Based on our experience in the area, the seasonal-high groundwater is expected to be within one foot of the existing site grades. In our opinion, the native soils observed in our test pits below the surficial organic soils would typically be suitable for some degree of limited infiltration using low impact development (LID) natural drainage practices (NDPs) such as permeable pavement.

4.8 Drainage

Surface

Final exterior grades should promote free and positive drainage away from the site at all times. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building areas. We recommend providing a positive drainage gradient away from the building perimeters. If this gradient cannot be provided, surface water should be collected adjacent to the structures and directed to appropriate storm facilities.

Subsurface

We recommend installing perimeter foundation drains adjacent to shallow foundations. The drains can be laid to grade at an invert elevation equivalent to the bottom of footing grade. The drains can consist of four-inch diameter perforated PVC pipe enveloped in washed pea gravel-sized drainage aggregate. The aggregate should extend six inches above and to the sides of the pipe. Roof and foundation drains should be tightlined separately to the storm drains. All drains should be provided with cleanouts at easily accessible locations.

4.9 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) or City of Marysville specifications. At a minimum, trench backfill should be placed and compacted as structural fill as described in Section 4.2 of this report. The native outwash soils will likely be excavated in a wet condition and would not be suitable for use as trench backfill unless dried back to a moisture content that will facilitate proper compaction. If utility construction takes place during the wet winter months, it will likely be necessary to import suitable wet weather fill for utility trench backfilling.

As noted above, with the shallow groundwater, deep utilities will need to account for buoyancy conditions and implement dewatering methods.

4.10 Pavements

Pavement subgrades should be prepared as described in the Section 4.2 of this report. Regardless of the degree of relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. The subgrade should be proofrolled with heavy rubber-tired construction equipment such as a loaded 10-yard dump truck to verify this condition.

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. For residential access, with traffic consisting mainly of light passenger vehicles with only occasional heavy traffic, and with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of Hot Mix Asphalt (HMA) over four inches of Crushed Rock Base (CRB)

- Three and one-half inches of full depth HMA

The paving materials used should conform to the Washington State Department of Transportation (WSDOT) specifications for half-inch class HMA and CRB.

Long-term pavement performance will depend on surface drainage. A poorly drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability. For optimum pavement performance, we recommend surface drainage gradients of at least two percent. Some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks when they occur.

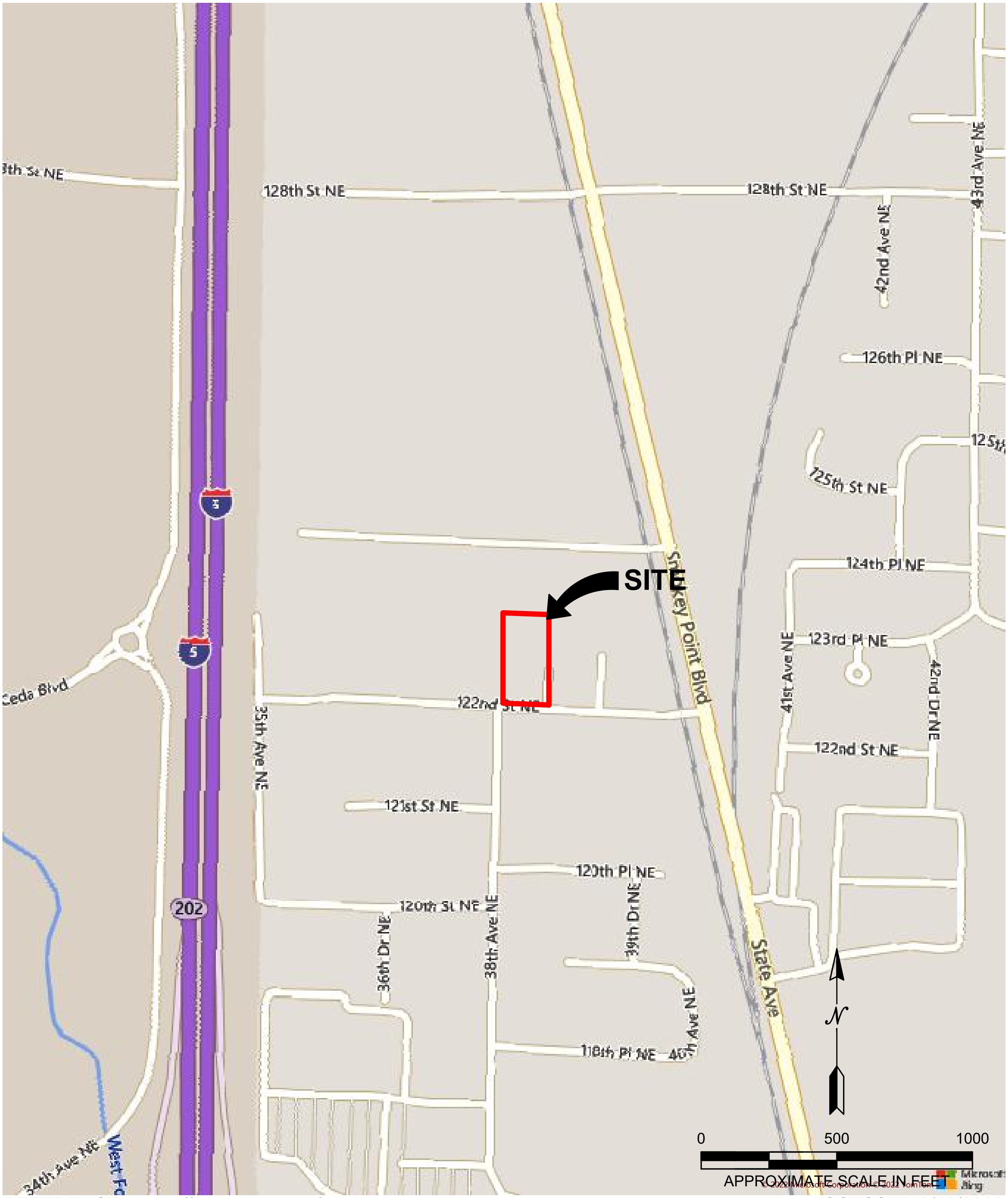
5.0 ADDITIONAL SERVICES

Terra Associates, Inc. should review the final design drawings and specifications in order to verify earthwork and foundation recommendations have been properly interpreted and implemented in project design. We should also provide geotechnical service during construction to observe compliance with our design concepts, specifications, and recommendations. This will allow for design changes if subsurface conditions differ from those anticipated prior to the start of construction.

6.0 LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the Stack Short Plat project in Marysville, Washington. This report is for the exclusive use of Stack Design and Construction, LLC, and their authorized representatives.

The analyses and recommendations presented in this report are based on data obtained from the subsurface explorations completed onsite. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, Terra Associates, Inc. should be requested to reevaluate the recommendations in this report prior to proceeding with construction.



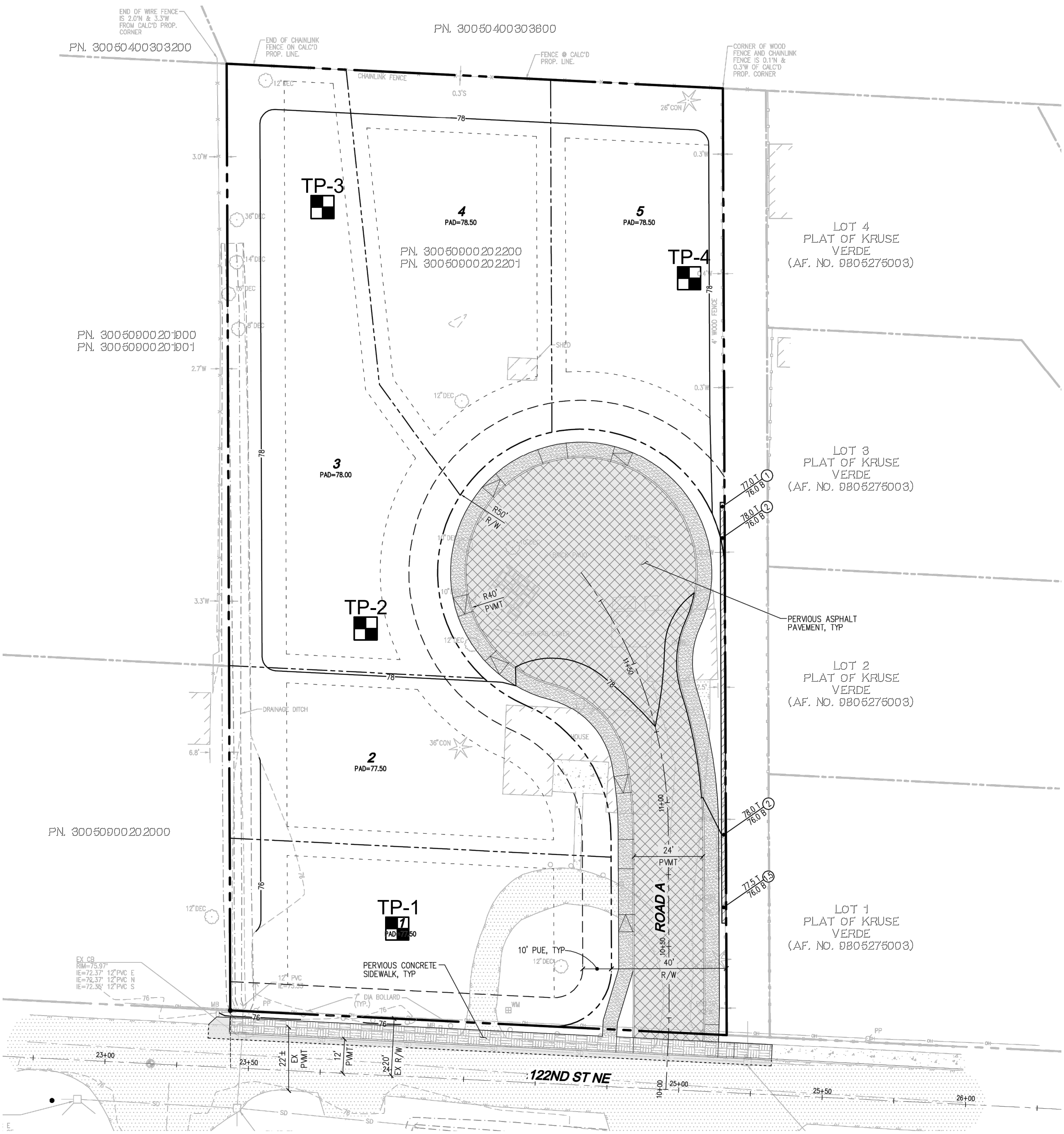
REFERENCE: https://www.bing.com/maps

ACCESSED 8/19/2022

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

VICINITY MAP
STACK SHORT PLAT
MARYSVILLE, WASHINGTON

Proj.No. T-8719	Date: AUG 2022	Figure 1



NOTE:

THIS SITE PLAN IS SCHEMATIC. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE. IT IS INTENDED FOR REFERENCE ONLY AND SHOULD NOT BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

REFERENCE: SITE PLAN PROVIDED BY LDC.

LEGEND:

APPROXIMATE TEST PIT LOCATION

0 50 100

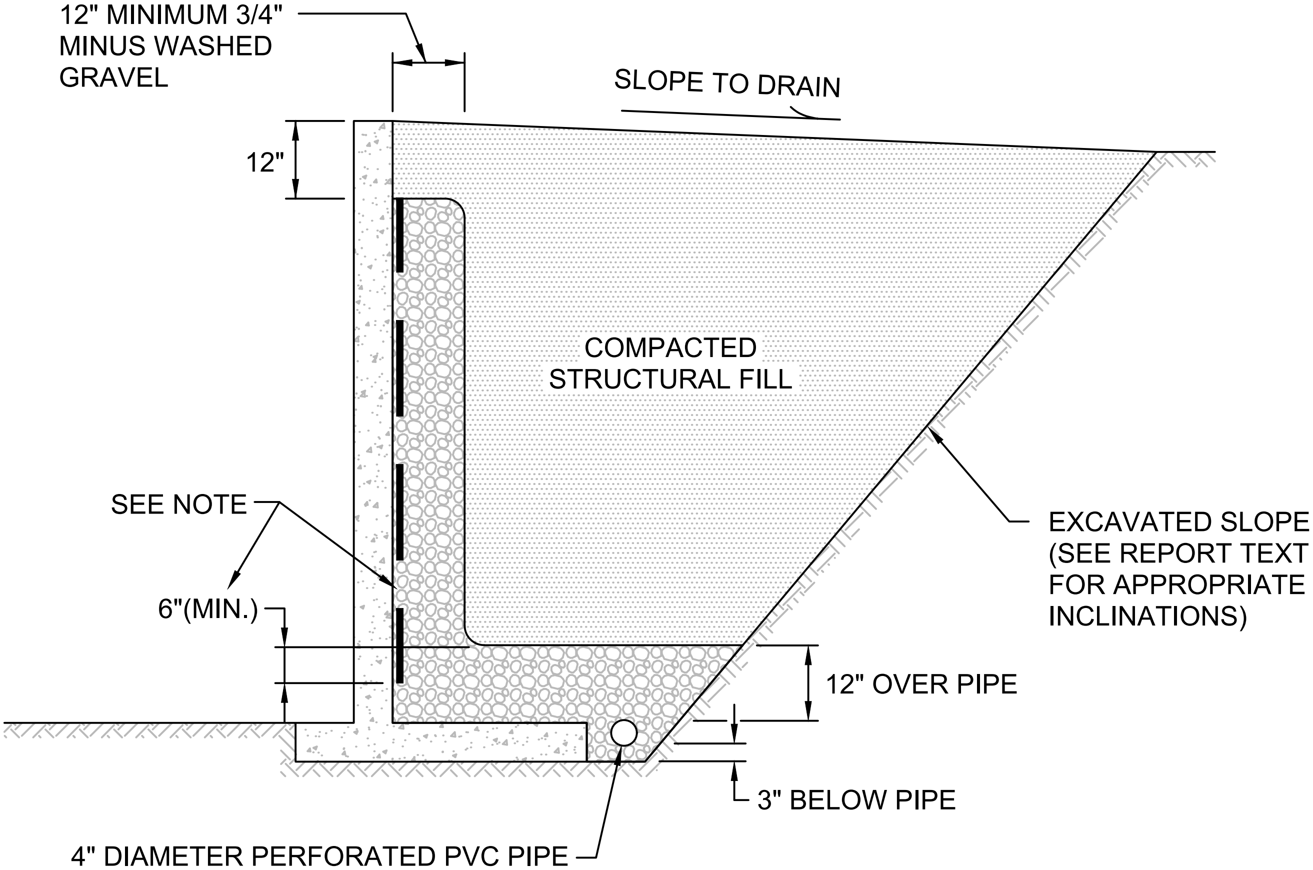
APPROXIMATE SCALE IN FEET

N

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

EXPLORATION LOCATION PLAN
STACK SHORT PLAT
MARYSVILLE, WASHINGTON

Proj.No. T-8719	Date: AUG 2022	Figure 2



NOT TO SCALE

NOTE:

MIRADRAIN G100N PREFABRICATED DRAINAGE PANELS OR SIMILAR PRODUCT CAN BE SUBSTITUTED FOR THE 12-INCH WIDE GRAVEL DRAIN BEHIND WALL. DRAINAGE PANELS SHOULD EXTEND A MINIMUM OF SIX INCHES INTO 12-INCH THICK DRAINAGE GRAVEL LAYER OVER PERFORATED DRAIN PIPE.

Terra Associates, Inc. Consultants in Geotechnical Engineering Geology and Environmental Earth Sciences	TYPICAL WALL DRAINAGE DETAIL STACK SHORT PLAT MARYSVILLE, WASHINGTON		
	Proj.No. T-8719	Date: AUG 2022	Figure 3

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Stack Short Plat
Marysville, Washington

On February 21, 2022, we completed our site exploration by observing soil conditions at four test pits. The test pits were excavated using a track-mounted excavator to a maximum depth of approximately nine feet below existing site grades. Test pit locations were approximately determined in the field using GPS tracking and by pacing and sighting from existing site features. The approximate location of the test pits is shown on the attached Exploration Location Plan, Figure 2. Test Pit Logs are presented on Figures A-2 through A-5.

A geologist from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each test pit, obtained representative soil samples, and recorded water levels observed during excavation. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test pits were placed in sealed plastic bags and taken to our laboratory for further examination and testing. The moisture content of selected samples was measured and is reported on the corresponding Test Pit Logs. Grain size analyses were also performed on select samples. The results are shown on Figures A-6 and A-7.

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS More than 50% material larger than No. 200 sieve size	**GRAVELS** More than 50% of coarse fraction is larger than No. 4 sieve	Clean Gravels (less than 5% 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	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
	SANDS More than 50% of coarse fraction is smaller than No. 4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, sands with gravel, little or no fines.
			SP	Poorly-graded sands, sands with gravel, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines.
			SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS More than 50% material smaller than No. 200 sieve size	**SILTS AND CLAYS** Liquid Limit is less than 50%		ML	Inorganic silts, rock flour, clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity. (Lean clay)
			OL	Organic silts and organic clays of low plasticity.
	SILTS AND CLAYS Liquid Limit is greater than 50%		MH	Inorganic silts, elastic.
			CH	Inorganic clays of high plasticity. (Fat clay)
			OH	Organic clays of high plasticity.
HIGHLY ORGANIC SOILS			PT	Peat.

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

Density	Standard Penetration Resistance in Blows/Foot
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

COHESIVE

Consistancy	Standard Penetration Resistance in Blows/Foot
Very Soft	0-2
Soft	2-4
Medium Stiff	4-8
Stiff	8-16
Very Stiff	16-32
Hard	>32

Symbol	Definition
I	2" OUTSIDE DIAMETER SPILT SPOON SAMPLER
Ⅱ	2.4" INSIDE DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER
▼	WATER LEVEL (Date)
Tr	TORVANE READINGS, tsf
Pp	PENETROMETER READING, tsf
DD	DRY DENSITY, pounds per cubic foot
LL	LIQUID LIMIT, percent
PI	PLASTIC INDEX
N	STANDARD PENETRATION, blows per foot

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UNIFIED SOIL CLASSIFICATION SYSTEM
STACK SHORT PLAT
MARYSVILLE, WASHINGTON

Proj.No. T-8719	Date: AUG 2022	Figure A-1

LOG OF TEST PIT NO. TP-1

FIGURE A-2

PROJECT NAME: Stack Short Plat **PROJ. NO:** T-8719 **LOGGED BY:** TG

LOCATION: Marysville, Washington **SURFACE CONDITIONS:** Grass Sod **APPROX. ELEV:** NA

DATE LOGGED: February 21, 2022 **DEPTH TO GROUNDWATER:** 5' **DEPTH TO CAVING:** 4' - 9'

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(6 inches Grass Sod & Topsoil)		
0.5–3		Reddish Brown, silty SAND, fine to coarse sand, moist to wet, trace gravel, small rootlets to 3', oxidized/mottled throughout (SM) (Marysville Sands)	Loose	22.8
3–5		Brownish Gray to Reddish Brown, SAND with silt and gravel, fine to coarse sand, fine to coarse gravel, wet, heavily mottled (SP-SM) (Marysville Sands)	Loose to Medium Dense	17.0
5–9		Gray, SAND with gravel to SAND with silt and gravel, fine to coarse sand, fine to coarse gravel, saturated, somewhat stratified (SP/SP-SM) (Marysville Sands)	Medium Dense	18.9 30.2
9		Test pit terminated at approximately 9 feet. Groundwater observed at 5 feet. Moderate to severe caving observed at 4 to 9 feet. Could not advance test pit deeper due to caving and groundwater conditions.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-2

FIGURE A-3

PROJECT NAME: Stack Short Plat **PROJ. NO:** T-8719 **LOGGED BY:** TG

LOCATION: Marysville, Washington **SURFACE CONDITIONS:** Grass Sod **APPROX. ELEV:** NA

DATE LOGGED: February 21, 2022 **DEPTH TO GROUNDWATER:** 4.5' **DEPTH TO CAVING:** 4' - 7.5'

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(9 inches Grass Sod & Topsoil)		
1		Dark Brown to Reddish Brown, SAND with silt, fine to coarse sand, wet, trace gravel, mottled, small rootlets (SP-SM) (Marysville Sands)	Loose	18.6
2		Brown to Light Reddish Brown, SAND, fine to coarse sand, wet, trace silt, trace gravel, oxidized/mottled throughout, small rootlets to 2' (SP) (Marysville Sands)		
3			Loose to Medium Dense	
4		Brownish Gray to Gray, SAND with gravel, fine to coarse sand, fine to coarse gravel, wet to saturated, trace silt, somewhat stratified (SP) (Marysville Sands)		19.6
5				
6			Medium Dense	27.6
7				
8		Test pit terminated at approximately 7.5 feet. Groundwater observed at 4.5 feet. Moderate to severe caving observed at 4 to 7.5 feet. Could not advance test pit deeper due to caving and groundwater conditions.		
9				
10				
11				
12				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-3

FIGURE A-4

PROJECT NAME: Stack Short Plat **PROJ. NO:** T-8719 **LOGGED BY:** TG

LOCATION: Marysville, Washington **SURFACE CONDITIONS:** Grass Sod **APPROX. ELEV:** NA

DATE LOGGED: February 21, 2022 **DEPTH TO GROUNDWATER:** 3.5' **DEPTH TO CAVING:** 3' - 7.5'

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(9 inches Grass Sod & Topsoil)		
1		Brown to Reddish Brown, silty SAND, fine to coarse sand, wet, saturated at contact with topsoil, trace gravel, heavily mottled, small rootlets to 2' (SM) (Marysville Sands)	Loose	26.8
2				
3		Brownish Gray to Gray, SAND with gravel, fine to coarse sand, fine to coarse gravel, wet to saturated, trace silt, somewhat stratified (SP) (Marysville Sands)		
4				15.8
5			Medium Dense	
6				
7				29.1
8		Test pit terminated at approximately 7.5 feet. Groundwater observed at 3.5 feet. Minor groundwater seepage observed at 9 inches (perched). Moderate to severe caving observed at 3 to 7.5 feet. Could not advance test pit deeper due to caving and groundwater conditions.		
9				
10				
11				
12				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-4

FIGURE A-5

PROJECT NAME: Stack Short Plat **PROJ. NO:** T-8719 **LOGGED BY:** TG

LOCATION: Marysville, Washington **SURFACE CONDITIONS:** Grass Sod **APPROX. ELEV:** NA

DATE LOGGED: February 21, 2022 **DEPTH TO GROUNDWATER:** 3' **DEPTH TO CAVING:** 2.5' - 6.5'

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(6 inches Grass Sod & Topsoil)		
1		Brown to Reddish Brown, SAND with silt, fine to coarse sand, moist to wet, trace gravel, mottled, small rootlets to 2' (SP-SM) (Marysville Sands)	Loose	18.8
2				
3 ▼				
4		Brownish Gray to Gray, SAND with gravel to SAND with silt and gravel, fine to coarse sand, fine gravel, wet to saturated, mottled to 4.5', somewhat stratified (SP/SP-SM) (Marysville Sands)	Medium Dense	17.6
5		Gray, SAND with gravel to GRAVEL with sand, fine to coarse sand, fine to coarse gravel, saturated, trace silt, stratified (SP/GP) (Marysville Sands)		10.4
6				
7		Test pit terminated at approximately 6.5 feet. Groundwater observed at 3 feet. Moderate to severe caving observed at 2.5 to 6.5 feet. Could not advance test pit deeper due to caving and groundwater conditions.		
8				
9				
10				
11				
12				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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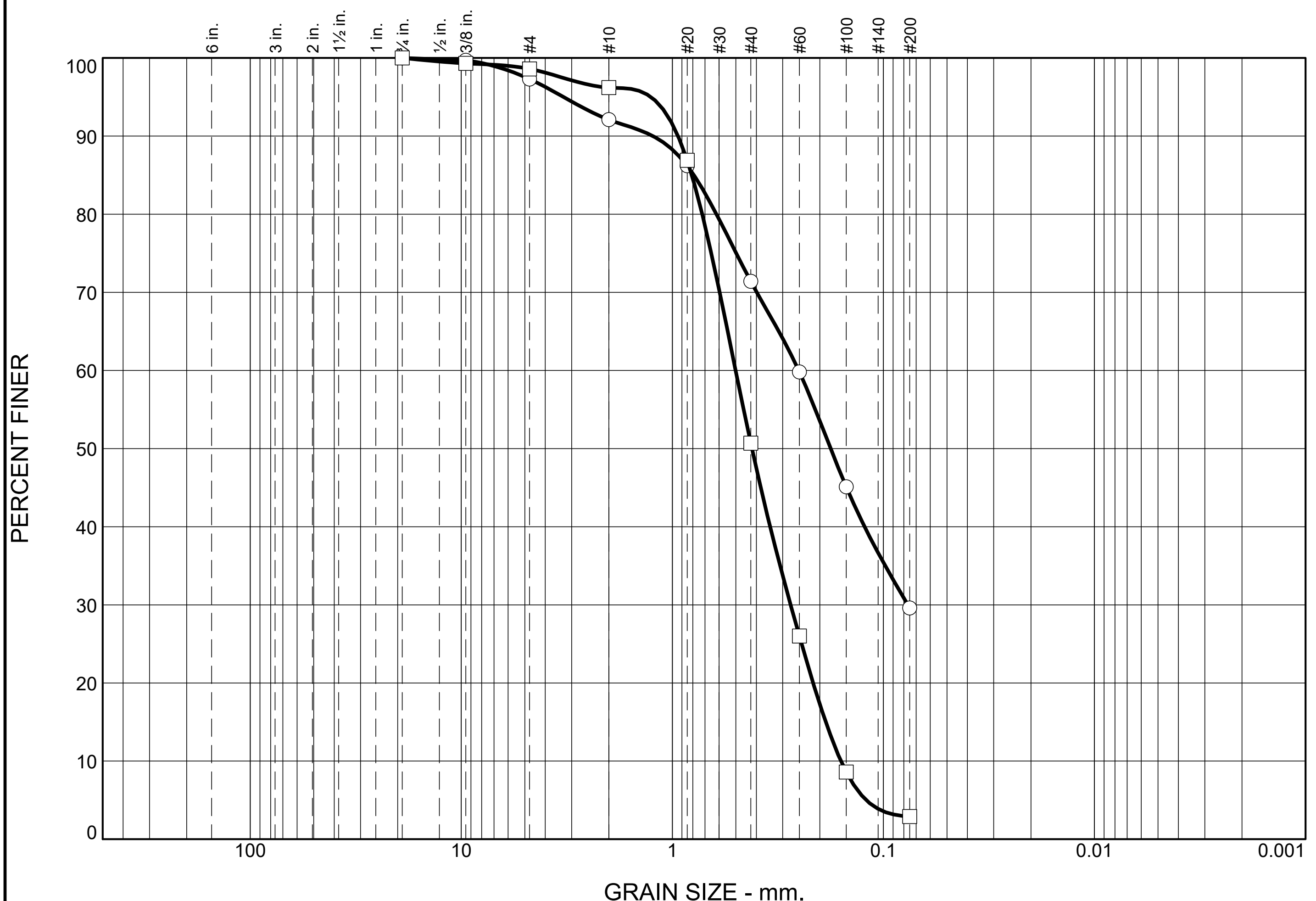
Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.7	5.2	20.7	41.8	29.6	
□	0.0	0.0	1.4	2.4	45.5	47.8	2.9	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.7902	0.2520	0.1777	0.0765				
□			0.8082	0.5012	0.4195	0.2751	0.1875	0.1589	0.95	3.15

Material Description	USCS	AASHTO
○ Silty SAND	SM	
□ Poorly graded SAND	SP	

Project No. T-8719 **Client:** Stack Design and Construction, LLC

Project: Stack Short Plat

Marysville, Washington

○ **Location:** Test Pit TP-1 **Depth:** -1 foot **Sample Number:** 1

□ **Location:** Test Pit TP-2 **Depth:** -1.5 feet **Sample Number:** 1

Remarks:

○ Tested on March 3, 2022

□ Tested on March 3, 2022

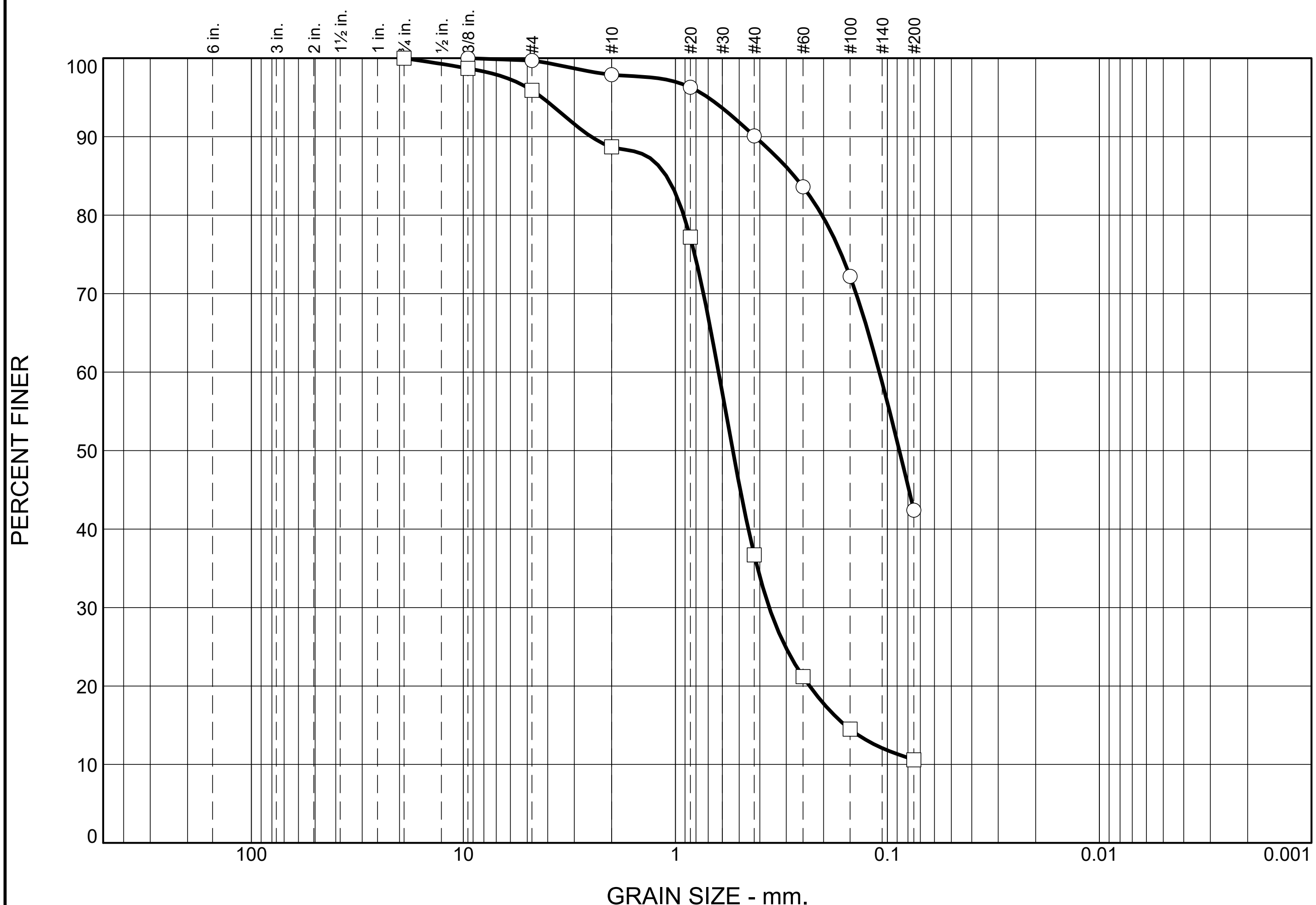
Terra Associates, Inc.

Kirkland, WA

Figure A-6

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.3	1.8	7.8	47.7	42.4	
□	0.0	0.0	4.1	7.2	52.0	26.1	10.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.2753	0.1092	0.0878					
□			1.1031	0.6257	0.5357	0.3610	0.1581			

Material Description	USCS	AASHTO
○ Silty SAND	SM	
□ Poorly graded SAND with silt	SP-SM	

Project No. T-8719 **Client:** Stack Design and Construction, LLC
Project: Stack Short Plat
Marysville, Washington
○ **Location:** Test Pit TP-3 **Depth:** -1 foot **Sample Number:** 1
□ **Location:** Test Pit TP-4 **Depth:** -1 foot **Sample Number:** 1

Remarks:
○ Tested on March 3, 2022
□ Tested on March 3, 2022

Terra Associates, Inc.

Kirkland, WA

Figure A-7

Tested By: FQ