September 18, 2023

RB Engineering
91 SW 13th Street
Chehalis, WA 98532

Attention: Mr. Chris Aldrich

Subject: Geotechnical Engineering Report
Jackson Multi-Family Development
2061 Jackson Highway
Chehalis, Washington
SSGC Project No. 23054

Mr. Adrich,

South Sound Geotechnical Consulting (SSGC) has completed a geotechnical assessment for the proposed development on the above addressed property in Chehalis, Washington. Our services have been completed in general conformance with our proposal P23067 (dated August 16, 2023) and authorized per signature of our agreement for services. Our scope of services included completion of four test pits and one infiltration test on the site, laboratory testing, engineering analyses, and preparation of this report.

PROJECT INFORMATION

The site is on the south side of the road. Development plans include ten two-story townhouses with garages. Conventional spread footings will be used to support new structures, with slab-on-grade concrete floors. Conventional asphalt access ways and parking area are anticipated. A stormwater pond is planned in the southern portion of the site.

SITE CONDITIONS

The site is currently vacant, but a removed residence was in the northwestern portion. Most of the site is brush and grass covered with young forest growth in the southern portion. It is gently sloping down to the south with an overall elevation change on the order of about 12 feet (+/-).

SUBSURFACE CONDITIONS

Subsurface conditions were characterized by completing four test pits and one infiltration test on the site on August 23, 2023. Explorations were advanced to depths between 6 and 10 feet below existing ground surface. Approximate locations of the test pits are shown on Figure 1, Exploration Plan. A summary description of observed subgrade conditions is provided below. Logs of the test pits are provided in Appendix A.

Soil Conditions

Fill consisting of silt, sand, gravel and isolated debris on the order of 1-foot thick was observed at the surface in two of the test pits in the northern portion of the site and is related to previous residential development. Topsoil was observed at the surface in the remaining test pits and extended to a depth of about 9 inches.

Native soil was below the topsoil/fill and consisted of typically fine-grained silty sand with clay to clayey silt/silty clay with some fine sand. These soils were in a generally medium stiff condition and extended to the termination depths of the test pits.

Groundwater Conditions

Groundwater was not observed in test pits at the time of excavation. However, soil became soft and wet at about 7 feet in the infiltration test hole in the lower southern portion of the site. We anticipate perched groundwater will occur in soils during the wetter seasons of the year. Groundwater levels will vary throughout the year based on seasonal precipitation and on- and off-site drainage patterns.

Geologic Setting

Native soil on the site is mapped as Lacamas silt loam per the USDA Soil Conservation Service of Lewis County. This soil reportedly formed in alluvium on flood plain terraces. Native soil observed in the test pits appeared to conform to the mapped soil type.

GEOTECHNICAL DESIGN CONSIDERATIONS

Planned development of the site is considered feasible based on observed subsurface conditions in the test holes. Native soils can be used for support of conventional spread footing foundations. Existing topsoil and any fill encountered during construction should be removed from planned building and pavement areas.

Recommendations presented in the following sections should be considered general and may require modifications when earthwork and grading occur. They are based upon the subsurface conditions observed in the test holes and the assumption that finish site grades will be similar to existing grades. It should be noted that subsurface conditions across the site may vary from those depicted on the exploration logs and can change with time. Therefore, proper site preparation will depend upon the weather and soil conditions encountered at the time of construction. We recommend that SSGC review final plans and further assess subgrade conditions at the time of construction, as warranted.

Site Preparation

Site grading and earthwork should include procedures to control surface water runoff. Grading the site without adequate drainage control measures may negatively impact site soils, resulting in increased export of impacted soil and import of fill materials, potentially increasing the cost of the earthwork and subgrade preparation phases of the project.

Site grading should include removal (stripping) of topsoil and any fill in future building and pavement areas. Subgrades should consist of firm native soils following stripping. Stripping depth will be on the order of about 1 foot based on observed soil conditions in the test holes, but may vary across the site. Final stripping depths can only be determined at the time of construction.

Subgrade Preparation

Subgrades in building and pavement areas should consist of firm native soil. We recommend exposed subgrades in building and conventional pavement areas are proofrolled using a large roller, loaded dump truck, or other mechanical equipment to assess subgrade conditions following stripping. Proofrolling efforts should result in the upper 1 foot of subgrade soils achieving a firm and unyielding condition. Wet, loose, or soft subgrades that cannot achieve a firm and unyielding condition should be removed (over-excavated) and replaced with structural fill. The depth of over-excavation should be based on soil conditions at the time of construction. A representative of SSGC should be present to assess subgrade conditions during proofrolling.

Grading and Drainage

Positive drainage should be provided during construction and maintained throughout the life of the development. Allowing surface water into cut or fill areas, utility trenches, and building footprints should be prevented.

Structural Fill Materials

The suitability of soil for use as structural fill will depend on the gradation and moisture content of the soil when it is placed. Soils with higher fines content (soil fraction passing the U.S. No. 200 sieve) will become sensitive with higher moisture content. It is often difficult to achieve adequate compaction if soil moisture is outside of optimum ranges for soils that contain more than about 5 percent fines.

> <u>Site Soils:</u> Topsoil and observed fill are not considered suitable for structural fill. Native soils will be difficult to use due to their overall high percentage of fines (silt and clay). They could be considered suitable for use as structural fill provided they can be moisture conditioned to within optimal ranges. Optimum moisture is considered within about +/- 2 percent of the moisture content required to achieve the maximum density per the ASTM D-1557 test method. If moisture

content is higher or lower than optimum, soils would need to be dried or wetted prior to placement as structural fill.

Import Fill Materials: We recommend import structural fill placed during dry weather periods consist of material which meets the specifications for *Gravel Borrow* as described in Section 9-03.14(1) of the Washington State Department of Transportation (WSDOT) Specifications for Road, Bridge, and Municipal Construction (Publication M41-10). Gravel Borrow should be protected from disturbance if exposed to wet conditions after placement.

During wet weather, or for backfill on wet subgrades, import soil suitable for compaction in wetter conditions should be provided. Imported fill for use in wet conditions should generally conform to specifications for *Select Borrow* as described in Section 9-03.14(2), or *Crushed Surfacing* per Section 9-03.9(3) of the WSDOT M41-10 manual, with the modification that a maximum of 5 percent by weight shall pass the U.S. No. 200 sieve.

It should be noted that structural fill placement and compaction is weather-dependent. Delays due to inclement weather are common, even when using select granular fill. We recommend site grading and earthwork be scheduled for the drier months of the year. Structural fill should not consist of frozen material.

Structural Fill Placement

We recommend structural fill is placed in lifts not exceeding about 10 inches in loose measure. It may be necessary to adjust lift thickness based on site and fill conditions during placement and compaction. Finer grained soil used as structural fill and/or lighter weight compaction equipment may require significantly thinner lifts to attain required compaction levels. Granular soil with lower fines contents could potentially be placed in thicker lifts (1 foot maximum) if they can be adequately compacted. Structural fill should be compacted to attain the recommended levels presented in Table 1, Compaction Criteria.

Table 1. Compaction Criteria

Fill Application	Compaction Criteria*
Footing areas (below structures and retaining walls)	95 %
Upper 2 feet in pavement areas, slabs and sidewalks, and utility trenches	95 %
Below 2 feet in pavement areas, slabs and sidewalks, and utility trenches	92 %
Utility trenches or general fill in non-paved or -building areas	90 %

*Per the ASTM D1557 test method.

Trench backfill within about 2 feet of utility lines should not be over-compacted to reduce the risk of damage to the line. In some instances, the top of the utility line may be within 2 feet of the surface. Backfill in these circumstances should be compacted to a firm and unyielding condition.

We recommend fill procedures include maintaining grades that promote drainage and do not allow ponding of water within the fill area. The contractor should protect compacted fill subgrades from disturbance during wet weather. In the event of rain during structural fill placement, the exposed fill surface should be allowed to dry prior to placement of additional fill. Alternatively, the wet soil can be removed. We recommend consideration be given to protecting haul routes and other high traffic areas with free-draining granular fill material (i.e., sand and gravel containing less than 5 percent fines) or quarry spalls to reduce the potential for disturbance to the subgrade during inclement weather.

Earthwork Procedures

Conventional earthmoving equipment should be suitable for earthwork at this site. Earthwork may be difficult during periods of wet weather or if elevated soil moisture is present due to the amount of fines in native soil. Excavated site soils may not be suitable as structural fill depending on the soil moisture content and weather conditions at the time of earthwork. If soil is stockpiled and wet weather is anticipated, the stockpile should be protected with securely anchored plastic sheeting. If stockpiled soils become unusable, it may become necessary to import clean, granular soils to complete wet weather site work.

Wet or disturbed subgrade soils should be over-excavated to expose firm, non-yielding, non-organic soils and backfilled with compacted structural fill. We recommend the earthwork portion of this project be completed during extended periods of dry weather. If earthwork is completed during the wet season (typically late October through May) it may be necessary to take extra measures to protect subgrade soils.

If earthwork takes place during freezing conditions, we recommend exposed subgrades are allowed to thaw and re-compacted prior to placing subsequent lifts of structural fill. Alternatively, the frozen soil can be removed to unfrozen soil and replaced with structural fill.

The contractor is responsible for designing and constructing stable, temporary excavations (including utility trenches) as required to maintain stability of excavation sides and bottoms. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards. Temporary excavation cuts should be sloped at inclinations of 1H:1.5V (Horizontal:Vertical) or flatter, unless the contractor can demonstrate the safety of steeper inclinations.

Permanent cut and fill slopes should have inclinations of 2H:1V, or flatter.

A geotechnical engineer and accredited testing material laboratory should be retained during the construction phase of the project to observe earthwork operations and perform necessary tests and observations during subgrade preparation, placement and compaction of structural fill, and backfilling of excavations.

Foundations

Foundations should be placed on native subgrade soils (or structural fill over native subgrades) prepared as described in this report. We recommend a working surface of at least 6 inches of clean granular fill for foundations supported on the native soil to limit disturbance during construction. A separation fabric placed between native subgrades and the working surface gravel is recommended. The following recommendations are for conventional spread footing foundations:

Bearing Capacity (net allowable):	1,500 pounds per square foot (psf) for footings supported on firm native soils or structural fill prepared as described in this report.	
Footing Width (Minimum):	16 inches (Strip) 24 inches (Column)	
Embedment Depth (Minimum):	18 inches (Exterior) 12 inches (Interior)	
Settlement:	Total: Differential:	< 1 inch < 1/2 inch (over 30 feet)
Allowable Lateral Passive Resistance:	300 psf/ft* (below 18 inches)	
Allowable Coefficient of Friction:	0.35*	

*These values include a factor of safety of approximately 1.5.

The net allowable bearing pressures presented above may be increased by one-third to resist transient, dynamic loads such as wind or seismic forces. Lateral resistance to footings should be ignored in the upper 12-inches from exterior finish grade.

Foundation Construction Considerations

All foundation subgrades should be free of water and loose soil prior to placing concrete, and should be prepared as recommended in this report. Concrete should be placed soon after excavating and compaction to reduce disturbance to bearing soils. Should soils at foundation level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. We recommend SSGC observe all foundation subgrades prior to placement of concrete.

Foundation Drainage

Ground surface adjacent foundations should be sloped away from buildings. We recommend footing drains are installed around perimeter footings. Footing drains should include a minimum 4-inch diameter perforated rigid plastic drain line installed at the base of the footing. The perforated drain lines should be connected to a tight line pipe that discharges to an approved storm drain receptor. The drain line should be surrounded by a zone of clean, free-draining granular material having less than 5 percent passing the No. 200 sieve or meeting the requirements of section 9-03.12(2) "Gravel Backfill for Walls" in the WSDOT (M41-10) manual. The free-draining aggregate zone should be at least 12 inches wide and wrapped in filter fabric. The granular fill should extend to within 6 inches of final grade where it should be capped with compacted fill containing sufficient fines to reduce infiltration of surface water into the footing drains. Cleanouts are recommended for maintenance of the drain system.

On-Grade Floor Slabs

On-grade floor slabs should be placed on native soils or structural fill prepared as described in this report. We recommend a modulus subgrade reaction of 150 pounds per square inch per inch (psi/in) for native soil or compacted granular structural fill over native soil.

We recommend a capillary break is provided between the prepared subgrade and bottom of slab. Capillary break material should be a minimum of 4 inches thick and consist of compacted clean, free-draining, well graded coarse sand and gravel. The capillary break material should contain less than 5 percent fines, based on that soil fraction passing the U.S. No. 4 sieve. Alternatively, a clean angular gravel such as No. 7 aggregate per Section 9-03.1(4)C of the WSDOT (M41-10) manual could be used for this purpose.

Seismic Considerations

Seismic parameters and values in Table 3 are recommended based on the International Building Code (IBC).

Table 3. Seismic Parameters

PARAMETER	VALUE
International Building Code (IBC) Site Classification[1]	E
S_s Spectral Acceleration for a Short Period	1.35
S_1 Spectral Acceleration for a 1-Second Period	0.45g

[1] Note: In general accordance with ASCE 7-22 Hazard site for risk categories I,II,III. Site Class is based on the estimated characteristics of the upper 100 feet of the subsurface profile.

Liquefaction

Soil liquefaction is a condition where loose, typically granular soils located below the groundwater surface lose strength during ground shaking, and is often associated with earthquakes. The Lewis County Liquefaction Susceptibility map shows this site as moderate to high risk of liquefaction. Some deformation of underlying soft soils should be expected during a design level earthquake. Although structural failure of properly designed and constructed foundations is not anticipated, some limited structural damage could occur during a design level seismic event.

Infiltration Characteristics

Infiltration facilities are proposed to assist in stormwater control. An assessment of infiltration potential of native soil was completed per the Lewis County stormwater manual. One pilot infiltration test was attempted on the site at a depth of about 4 feet. The hole was filled for the soak period and the water turned off. After a period of one hour, no measurable drop in the water level was observed and the test was abandoned. Due to the impermeable nature of native soil and shallow groundwater, infiltration facilities are not considered suitable on this site.

Conventional Asphalt Pavement Sections

Subgrades for conventional pavement areas should be prepared as described in the "*Subgrade Preparation*" section of this report. Subgrades below pavement sections should be graded or crowned to promote drainage and not allow for ponding of water beneath the section. If drainage is not provided and ponding occurs, subgrade soils could become saturated, lose strength, and result in premature distress or failure of the section. In addition, the pavement surfacing should also be graded to promote drainage and reduce the potential for ponding of water on the pavement surface.

We recommend a separation fabric (such as Mirafi 140N) is placed on new pavement subgrades prior to placement of structural or pavement section fill. The purpose of the fabric is to provide segregation between new granular structural fill and the softer finer grained native soil. Without the fabric, new granular fill will have the tendency to migrate into the looser fine-grained subgrade soil over time, which can compromise the structural integrity of the structural fill zone leading to premature distress of the pavement section.

Minimum recommended pavement sections for conventional asphalt or concrete pavements are presented in Table 4.

Table 4. Minimum Pavement Sections

Traffic Area	Minimum Recommended Pavement Section Thickness (inches)			
	Asphalt Concrete Surface[1]	Portland Cement Concrete[2]	Aggregate Base Course[3,4]	Subbase Aggregate[5]
Heavy Traffic	3	6	4	12
Light Traffic/Parking Areas	2	5	4	12

[1] 1/2 –inch nominal aggregate hot-mix asphalt (HMA) per WSDOT 9-03.8(1)

[2] A 28-day minimum compressive strength of 4,000 psi and an allowable flexural strength of at least 250 psi

[3] Crushed Surfacing Base Course per WSDOT 9-03.9(3)

[4]Although not required for structural support under concrete pavements, a minimum four-inch-thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade “pumping” through joints

[5] 95% compacted native subgrade or Gravel Borrow per WSDOT 9-03.14(1) or Crushed Surfacing Base Course WSDOT 9-03.9(3)

Conventional Pavement Maintenance

The performance and lifespan of pavements can be significantly impacted by future maintenance. The above pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be completed. Proper maintenance will slow the rate of pavement deterioration, and will improve pavement performance and life. Preventive maintenance consists of both localized maintenance (crack and joint sealing and patching) and global maintenance (surface sealing). Added maintenance measures should be anticipated over the lifetime of the pavement section if any fill or topsoil is left in-place beneath pavement sections.

REPORT CONDITIONS

This report has been prepared for the exclusive use of RB Engineering for specific application to the project discussed, and has been prepared in accordance with generally accepted geotechnical engineering practices in the area. No warranties, either express or implied, are intended or made. The analysis and recommendations presented in this report are based on observed soil conditions and test results at the indicated locations, and from other geologic information discussed. This report does not reflect variations that may occur across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

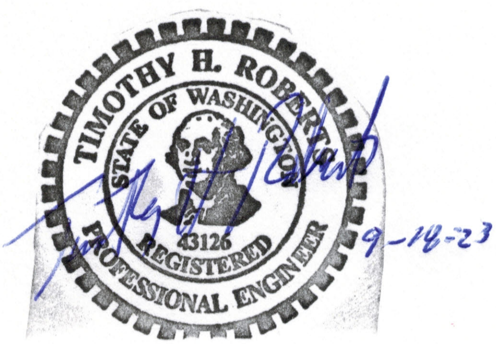
This report was prepared for the planned type of development of the site as discussed herein. It is not valid for third party entities or alternate types of development on the site without the express written consent of SSGC. If development plans change, we should be notified to review those changes and modify our recommendations as necessary.

The scope of services for this project does not include any environmental or biological assessment of the site including identification or prevention of pollutants, hazardous materials, or conditions. Other studies should be completed if the owner is concerned about the potential for contamination or pollution.

We appreciate the opportunity to work with you on this project. Please contact us if additional information is required or we can be of further assistance.

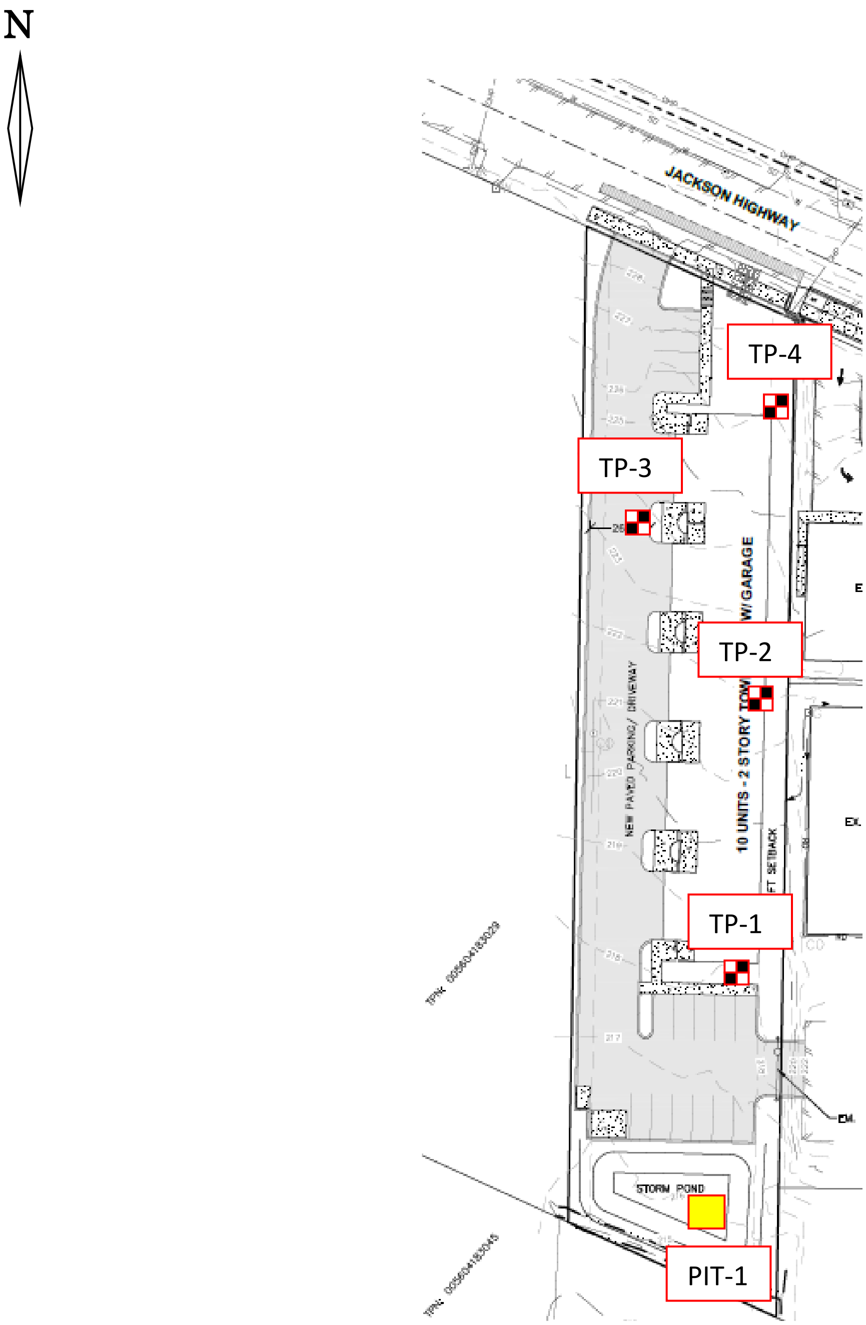
Respectfully,

South Sound Geotechnical Consulting



Timothy H. Roberts, P.E.
Member/Geotechnical Engineer

Attachments: Figure 1 – Exploration Plan
Appendix A – Field Exploration Procedures and Exploration Logs
Appendix B – laboratory Testing and Results
Unified Soil Classification System



Legend

TP - 1

Approximate Test Pit Location

PIT - 1

Approximate Infiltration Test Location

Scale: NTS

Base map from drawing titled Preliminary Site Plan, 2016 Jackson Multi-Family", by RB Engineering, dated 7/14/23.

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Figure 1 – Exploration Plan

Jackson Multi-Family
Chehalis, Washington

SSGC Project #23054

Appendix A

Field Exploration Procedures and Exploration Logs

Field Exploration Procedures

Our field exploration for this project included four test pits and one infiltration test completed on August 23, 2023. Approximate locations of the explorations are shown on Figure 1, Exploration Plan. Exploration locations were determined by pacing from site features. Ground surface elevations referenced on the logs were inferred from client provided topography. Test hole locations and elevations should be considered accurate only to the degree implied by the means and methods used.

A private excavation company dug the test holes. Select soil samples were collected and stored in moisture tight containers for further assessment and laboratory testing. Explorations were backfilled with excavated soils and tamped when completed. Please note that backfill in the explorations may settle with time. Backfill material located in building or pavement areas should be re-excavated and recompacted, or replaced with structural fill.

The following logs indicate the observed lithology of soils and other materials observed in the explorations at the time of excavation. Where a soil contact was observed to be gradational, our log indicates the average contact depth. Our logs also indicate the approximate depth to groundwater (where observed at the time of excavation), along with sample numbers and approximate sample depths. Soil descriptions on the logs are based on the Unified Soil Classification System.

Test Pit TP-1

Depth (feet)	Material Description
0 – 0.75	**Topsoil**
0.75 – 3.5	Fine Sandy SILT with some clay: Medium stiff, damp, brownish gray. (ML)
3.5 – 8	Clayey SILT/Silty CLAY with some fine sand: Stiff, moist, gray to brown. (ML/CL)
	Test pit completed at approximately 8 feet on 8/23/23. Groundwater not observed at time of excavation. Approximate surface elevation: 218 feet

Test Pit TP-2

Depth (feet)	Material Description
0 – 0.75	**Topsoil**
0.75 – 8	Fine Sandy SILT with some clay: Medium stiff, damp, brownish gray. (ML)
	Clayey SILT/Silty CLAY with some fine sand: Stiff, moist, gray to brown. (ML/CL)
	Test pit completed at approximately 8 feet on 8/23/23. Groundwater not observed at time of excavation. Approximate surface elevation: 222 feet

Test Pit TP-3

Depth (feet)	Material Description
0 – 1	**Fill:** Silt, sand, some debris (plastic)
1 – 7	Fine Sandy SILT with some clay: Medium stiff, damp, brown. (ML)
7 – 8	Clayey SILT/Silty CLAY with some fine sand: Stiff, moist, gray. (ML/CL)
	Test pit completed at approximately 8 feet on 8/23/23. Groundwater not observed at time of excavation. Approximate surface elevation: 224 feet

Test Pit TP-4

Depth (feet)	Material Description
0 – 1.0	**Fill:** Sand and gravel
1.0 – 4	Fine Sandy SILT with some clay: Medium stiff, damp, brownish gray. (ML)
4 – 6	Clayey SILT/Silty CLAY with some fine sand: Stiff, moist, gray to brown. (ML/CL)

Test pit completed at approximately 6 feet on 8/23/23.
Groundwater not observed at time of excavation.
Approximate surface elevation: 218 feet

Infiltration Test PIT-1

Depth (feet)	Material Description
0 – 0.75	**Topsoil**
0.75 – 3	Fine Sandy SILT with some clay: Medium stiff, damp, brownish gray. (ML)
3 – 10	Clayey SILT/Silty CLAY with some fine sand: Stiff, moist, gray to brown – Grading soft, wet at about 7 feet. (ML/CL)(Sample S-1 @ 4 feet)

Test hole completed at approximately 10 feet on 8/23/23.
Infiltration test completed at 4 feet.
Groundwater not observed at time of excavation.
Approximate surface elevation: 226 feet
Piezometer set in test hole.

Appendix B

Laboratory Testing and Results

Laboratory Testing

Select soil samples were tested for organic content and cation exchange capacity (CEC) by Northwest Agricultural Consultants of Kennewick, Washington. Results of the laboratory testing are included in this appendix.

Northwest Agricultural Consultants

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Kennewick, WA 99336
509.783.7450
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lab@nwag.com

PAP-Accredited

NAPT

South Sound Geotechnical Consulting
PO Box 39500
Lakewood, WA 98496

Report: 65234-1-1
Date: September 2, 2023
Project No:
Project Name: JACKSON

Sample ID	Organic Matter	Cation Exchange Capacity
PIT-1, S-1	5.23%	26.2 meq/100g
Method	**ASTM D2974**	**EPA 9081**

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines Classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above “A” line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below “A” line[J]	ML	Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay[K,L,M,N]
					Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above “A” line	CH	Fat clay[K,L,M]
			PI plots below “A” line	MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ≥ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ≥ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.