

Geotechnical Engineering Services Report

Ballou Junior High Expansion
Puyallup, Washington

for
Puyallup School District

September 6, 2019



GEOENGINEERS 
Earth Science + Technology

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File No. 2017-007-00

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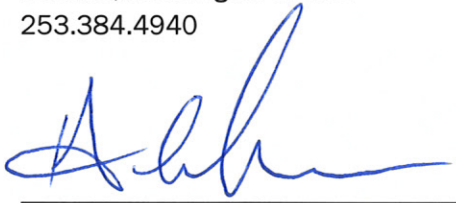
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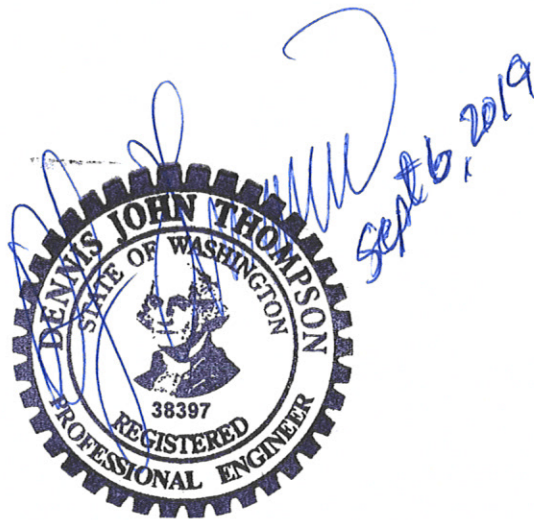


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Table of Contents

1.0 INTRODUCTION AND PROJECT UNDERSTANDING.....	1
2.0 SCOPE OF SERVICES.....	1
3.0 SITE CONDITIONS.....	1
3.1. Surface Conditions.....	1
3.2. Published Literature	2
4.0 SUBSURFACE CONDITIONS	2
4.1. Subsurface Explorations.....	2
4.2. Subsurface Conditions	3
4.2.1. Soil Conditions	3
4.2.2. Groundwater Conditions.....	4
5.0 CONCLUSIONS AND RECOMMENDATIONS.....	4
5.1. General	4
5.2. Seismic Design Considerations.....	5
5.2.1. International Building Code Seismic Design Parameters.....	5
5.2.2. Liquefaction, Lateral Spreading, and Surface Rupture	5
5.3. Site Development and Earthwork	6
5.3.1. General	6
5.3.2. Clearing and Stripping.....	6
5.3.3. Erosion and Sedimentation Control.....	6
5.3.4. Temporary Excavations.....	7
5.3.5. Groundwater Handling Considerations	7
5.3.6. Permanent Cut and Fill Slopes.....	8
5.3.7. Subgrade Preparation and Evaluation.....	8
5.3.8. Subgrade Protection and Wet Weather Considerations.....	8
5.4. Fill Materials.....	9
5.4.1. Structural Fill	9
5.4.2. Select Granular Fill	9
5.4.3. Pipe Bedding	9
5.4.4. Trench Backfill.....	10
5.4.5. Quarry Spalls	10
5.4.6. Recycled Materials.....	10
5.4.7. On-Site Soil.....	10
5.5. Fill Placement and Compaction	10
5.5.1. General	10
5.5.2. Area Fills and Pavement Bases	11
5.5.3. Backfill Behind Retaining Walls	11
5.5.4. Trench Backfill.....	11
5.6. Shallow Foundations	11
5.6.1. General	11
5.6.2. Footing Bearing Surface Preparation	12
5.6.3. Allowable Soil Bearing Pressure	12
5.6.4. Foundation Settlement.....	12

5.6.5.	Lateral Resistance	13
5.6.6.	Foundation Drains	13
5.7.	Slab-on-Grade Floor	13
5.8.	Retaining Walls and Below-Grade Features.....	14
5.8.1.	Design Parameters	14
5.8.2.	Drainage	15
5.9.	Stormwater Infiltration.....	15
5.9.1.	General	15
5.9.2.	PIT Methodology.....	15
5.9.3.	PIT Results.....	16
5.9.4.	Grain-Size Analysis Infiltration Rate Correlations	16
5.9.5.	Discussion and Recommended Design Infiltration Rate.....	17
5.9.6.	Construction Recommendations	18
5.10	Pavement Recommendations.....	19
5.10.1	Conventional Asphalt Concrete Pavements	19
5.10.2	Permeable Pavements	19
6.0	LIMITATIONS	22

LIST OF FIGURES

Figure 1. Vicinity Map

Figure 2. Site Plan

Figures 3 through 5. PIT Results

APPENDICES

Appendix A. Subsurface Explorations

Figure A-1 – Key To Exploratoion Logs

Figures A-2 through A-15 – Logs of Borings and Test Pits

Appendix B. Laboratory Testing

Figures B-1 through B-5 – Sieve/Hydrometer Analysis Results

Appendix C. Report Limitations and Guidelines for Use

1.0 INTRODUCTION AND PROJECT UNDERSTANDING

This report presents the results of our geotechnical engineering services for the Ballou Junior High School Expansion project located at 9916 136th Street East in Puyallup, Washington. The approximate project location is shown on the Vicinity Map, Figure 1. Our understanding of the project is based on our discussions with you and the project team and information provided including a schematic civil site plans dated July 12, 2019.

We understand that proposed site improvements include construction of a new academic building at the approximate location of the existing portable classrooms, an expansion to the existing gymnasium, an expansion to the field areas, improvements to site pavements and hardscaping, relocation or replacement of underground utilities and installation of new stormwater detention and infiltration systems. The full extent and final locations of proposed improvements are still in development. It is our understanding that infiltration facilities at the site will be designed in accordance with the 2015 Pierce County Stormwater Management and Site Development Manual (SMSDM).

2.0 SCOPE OF SERVICES

The purpose of our services is to evaluate subsurface conditions and provide geotechnical and earthwork recommendations to support planning and design of the proposed improvements. Our scope of work included the following tasks. A complete list of our scope of services is summarized in our signed agreement dated June 3, 2019.

- Exploring subsurface conditions within the project area by advancing 10 soil borings. One of our borings was completed as a monitoring well to measure groundwater levels at the site.
- Conducting one large-scale pilot infiltration test (PIT) and three small-scale PITs in areas of proposed infiltration facilities.
- Providing geotechnical seismic design information in accordance with the 2015 International Building Code (IBC) criteria and discuss our opinion on the potential for liquefaction and lateral spreading at the site.
- Providing recommendations for site preparation and earthwork.
- Providing design recommendations for shallow foundations building slabs and retaining walls.
- Providing a discussion of suitability of site soils for stormwater infiltration, including design infiltration rates based on laboratory sieve analysis results and results from the PITs.

3.0 SITE CONDITIONS

3.1. Surface Conditions

The project site related to this study is located on the south side of the Ballou Junior High School Campus. The proposed development area is bound by the existing Ballou Junior High Buildings to the north, the school bus drop-off road and loop to the east, the Firgrove Elementary School Campus to the south, and a

wooded area and existing stormwater pond to the west. We understand that portions of the wooded area are within a 100-year floodplain. The existing stormwater pond appears to be used for overflow detention.

The proposed academic building will be located in an area currently developed with portable classroom buildings, asphalt parking areas and grass landscaping. The ground surface in this area is relatively level. We understand that finished floor elevation of the new academic building will be about 1 to 2 feet above existing grade.

The planned auxiliary gymnasium will be located on the east side of the existing gymnasium building. This area of the site is currently developed with landscaping and parking areas. Existing grade at the south end of the proposed auxiliary gymnasium is about 4 to 5 feet lower than the existing grade on the north end of the expansion. We understand that the south end of the expansion area will be filled to create a level surface for the new auxiliary gymnasium. The finished floor elevation of the new gymnasium will match that of the existing gymnasium.

3.2. Published Literature

We reviewed the *Geologic Map of the Puyallup Quadrangle, Washington* (Troost, *In Review*). The geologic map indicates soils in the project vicinity generally consist of outwash glacial deposits (Qvs) and glacial till (Qvt). The glacial outwash deposits are described in the literature as poorly to well sorted sands and gravels that were deposited during glacial lake outburst floods. Glacial till is typically described as a highly compact mixture of clay, silt, sand and gravel deposited below glacial ice. Glacial till was overridden by glacial ice after deposition. Intact glacial till is typically dense to very dense with low permeability, although the upper few feet of glacial till can be weathered and in a relatively loose condition.

We also reviewed the geotechnical engineering report we prepared for the Firgrove Elementary School project, which is located immediately south of the site and is currently under construction. Soil conditions encountered in the explorations completed for the Firgrove project generally consisted of variable amounts of fill and glacial outwash soils underlain by glacial till. Observed outwash soils generally consisted of silty sand and silt with variable sand content. Observed glacial till soils generally consisted of silty sand with variable gravel content.

Based on our review of the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soil survey map, the project site is underlain primarily by Kitsap silt loam. According to the soil survey, Kitsap silt loam is a glaciolacustrine deposit with moderate capacity for transmitting water. This soil type is in Hydrologic Soil Group C/D.

4.0 SUBSURFACE CONDITIONS

4.1. Subsurface Explorations

We explored subsurface conditions at the site by advancing 10 borings (designated B-1 through B-10) and four test pits (designated as PIT-1 through PIT-4). Approximate locations of completed explorations are shown on the Site Plan, Figure 2. The borings were advanced to depths ranging from about 11.5 feet below ground surface (bgs) to about 26.5 feet bgs. One of our borings, B-9, was completed as a monitoring well after drilling. The test pits were completed to intermediate depths between 2.5 and 4 feet bgs to perform the PITs. After infiltration testing was complete, the test pit explorations were deepened to between about

11.5 and 16 feet bgs. Details regarding our subsurface exploration program are provided in Appendix A. A key to our exploration logs is presented as Figure A-1 and the exploration logs are presented as Figure A-2 through Figure A-15.

Selected samples from our explorations were tested in order to evaluate engineering properties and to confirm or modify field classifications. A description and the results of our laboratory testing program are included in Appendix B.

4.2. Subsurface Conditions

4.2.1. Soil Conditions

We observed what we interpret to be three general geologic units in our explorations, fill or reworked soils (fill), glacial outwash soils, and glacial till.

4.2.1.1. Borings

Borings were advanced within areas covered with sod. Sod thicknesses ranged between approximately 1 and 4 inches. Below the sod, we observed what we interpret to be fill extending to depths ranging from about 1.5 to 9.5 feet bgs. Fill generally consisted of loose to medium dense silty sand and stiff sandy silt. In some of the borings fill material appears to consist of reworked native soils. The fill was generally thickest in borings B-3 and B-4 (located within the footprint of the proposed auxiliary gymnasium) and in B-6. In B-3 and B-4, the observed fill contained debris consisting of plastic and other refuse. Organic matter (roots and charcoal) was occasionally encountered within the fill.

Glacial outwash was observed below the fill in our borings with the exception of B-3 and B-5. Glacial outwash typically consisted of medium stiff to very stiff sandy silt and silt with sand and loose to medium dense silty sand. Glacial outwash deposits appeared to be thickest on the west side of the site near the location of B-1, B-9 and B-10. Borings B-7 and B-10 were terminated within the glacial outwash soils around 11.5 feet bgs. Our interpretation of the glacial outwash observed in the borings generally resembles soil deposited from meltwater streams and lakes within and around glaciers that covered the area about 15,000 years ago and appear to have been placed from a lower depositional energy environment.

Below the glacial outwash soils in B-1, B-2, B-4, B-6, B-8 and B-9 and starting below the fill in B-3 and B-5, we observed what we interpret to be glacial till. Glacial till soils generally consisted of dense to very dense silty sand with variable gravel content. In B-5 and B-9, the upper 2 to 8 feet of the glacial till soils appeared to be weathered and consisted of very stiff sandy silt and medium dense silty sand. All borings, except for B-3 and B-5, were terminated within glacial till soils at depths between 11.5 and 26.5 feet bgs.

4.2.1.2. Test Pits

At the surface of our test pits, we observed approximately 2 to 4 inches of sod. Underlying the sod, we observed what we interpret to be fill extending to depths between about 3.5 and 8 feet bgs. Fill generally consisted of medium dense to very dense sand and gravel with variable silt content to medium stiff to very stiff silt with variable sand and gravel content.

Underlying the fill material in PIT-1, PIT-2 and PIT-4, we encountered what we interpret to be glacial outwash soils extending to depths between about 6.5 to 16 feet bgs. Glacial outwash typically consisted of loose to medium dense silty sand and medium stiff to stiff silt with variable sand content. PIT-1 and PIT-2 were terminated within glacial outwash soils at respective depths of 16 and 14 feet bgs. Underlying the fill in

PIT-3 and the glacial outwash in PIT-4, we encountered very dense silty sand with gravel and occasional cobbles. We interpreted these soils as glacial till. PIT-3 and PIT-4 were terminated within glacial till soils at depths of 13 and 11.5 feet bgs, respectively.

4.2.2. Groundwater Conditions

We did not observe what we interpret to be the regional groundwater table in our borings. However, we did observe what we interpret to be perched groundwater in all of our explorations with the exception of B-5, B-6, B-7, B-10, PIT-2 and PIT-4. Perched groundwater seepage was observed at depths between 5 and 15 bgs during our explorations. The observed groundwater appeared to be perched on top of the relatively low permeability glacial till soils. Boring B-9 was completed as a monitoring well after drilling. We installed a pressure transducer in the well to measure groundwater levels on regular intervals. We returned to the site on August 15th (44 days after well installation) to measure groundwater levels in the well. No groundwater was observed in the well and the data collected from the pressure transducer indicated that no water had collected in the well since installation. We observed relatively wet soils around 15 feet during drilling of B-9. It appears that the perched water observed during drilling is not significant enough to accumulate in the well. We expect that during the winter months some amount of perched groundwater may accumulate in the well. For preliminary design purposes we recommend that groundwater levels be assumed at 15 feet bgs. In our opinion this is conservative. We plan to monitor groundwater levels through the wet season to gather information on seasonal high-water levels.

We anticipate that isolated areas of perched groundwater could be encountered at higher elevations and is most likely to occur at contacts between soils with relatively different permeability such as the contact between fill and glacial outwash deposits or within relatively sandy seams of the glacial till soils. Soil and groundwater conditions observed in our explorations were consistent with the mapped geology of the area and the soil conditions observed in explorations completed for the nearby Firgrove Elementary School project.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1. General

Based on our understanding of the project, the explorations performed for this study and our experience, it is our opinion that the proposed improvements can be constructed generally as envisioned with regard to geotechnical considerations. A summary of the primary geotechnical considerations for the project is provided below and is followed by our detailed recommendations.

- Structures at the site can be adequately supported on conventional shallow foundations. We anticipate that glacial outwash soils of varying densities will be present at the design bottom footing elevations. It is also possible that some fill may be encountered. For reduction of potential differential settlement and to provide uniform bearing surfaces, we recommend that 2 feet of overexcavation be completed below the bottom of footing elevation and the excavations be backfilled to foundation grade using granular structural fill. Additional overexcavation could be required in some areas to remove excessively soft or loose soils.
- A majority of soils encountered in our borings have a relatively high fines (silt and clay-sized particles passing the U.S. Standard No. 200 sieve) content. Soil with a high fines content is more sensitive to

small changes in moisture content and may be difficult to work with and is susceptible to disturbance when wet.

- Infiltrating stormwater at the site appears to be feasible. The design infiltration rate for facilities will likely be controlled by the underlying glacial outwash and glacial till soils. The glacial outwash soils appear to have moderate infiltration potential. In our opinion, the glacial till soils have a low infiltration potential.

5.2. Seismic Design Considerations

5.2.1. International Building Code Seismic Design Parameters

We used map-based values recommended by the United States Geological Survey (USGS) to determine the seismic design spectrum in accordance with the 2015 IBC. Based on conditions observed in our explorations, our review of geologic maps and our experience in the area, we recommend using a response spectrum for Site Class D. We recommend the parameters provided below be used for design.

TABLE 1. SEISMIC DESIGN CRITERIA

2015 IBC Seismic Design Parameters	
Spectral Response Acceleration at Short Periods (S_s)	1.244g
Spectral Response Acceleration at 1-Second Periods (S_1)	0.478g
Site Class	D
Design Peak Ground Acceleration (PGA_M)	0.506g
Design Spectral Response Acceleration at Short Periods (S_{DS})	0.831g
Design Spectral Response Acceleration at 1-Second Periods (S_{D1})	0.485g

5.2.2. Liquefaction, Lateral Spreading, and Surface Rupture

5.2.2.1. Liquefaction

Liquefaction refers to a condition where vibration or shaking of the ground, usually from earthquake forces, results in development of excess pore pressures and subsequent loss of strength in the affected soil deposit. In general, soils that are susceptible to liquefaction include loose to medium dense “clean” to silty sands below the water table.

We reviewed the *Liquefaction Susceptibility Map of Pierce County, Washington* (Palmer et al. 2004). According to the map, the potential for liquefaction at this site is low. We did not observe what we interpret to be the regional groundwater table in our explorations. During exceptionally wet conditions, perched groundwater could fully saturate isolated areas of the glacial outwash soils and if an earthquake were to occur when these conditions were present, it is possible that discontinuous and relatively thin layers could undergo some type of liquefaction. In our opinion the risk of this occurring is relatively low, and if liquefaction were to occur, we do not expect that it would result in significant surface settlements. Based on the soil conditions observed in our explorations, our interpretation of the regional geology, and the mapped liquefaction potential, it is our opinion the potential for liquefaction at this site is low.

5.2.2.2. Lateral Spreading Potential

Lateral spreading related to seismic activity typically involves lateral displacement of large, surficial blocks of non-liquefied soil when a layer of underlying soil loses strength during seismic shaking. Lateral spreading

usually develops in areas where sloping ground or large grade changes (including retaining walls) are present. Based on our understanding of the proposed improvements, the current site topography and our interpretation of the liquefaction risk at the site, it is our opinion that the risk of lateral spreading is low.

5.2.2.3. Surface Rupture Potential

According to the Washington State Department of Natural Resources (DNR) Interactive Natural Hazards Map (accessed July 8, 2019), the nearest known seismogenic fault or fold is mapped about 8 miles northeast of the project site. Based on the distance of the site to the nearest known seismogenic feature, it is our opinion the risk for seismic surface rupture at the site is low.

5.3. Site Development and Earthwork

5.3.1. General

We anticipate that site development and earthwork will include clearing and stripping vegetated areas, demolition of existing structures and pavements, site grading, establishing subgrades, and placing and compacting fill and backfill materials. We expect that the majority of site grading and earthwork can be accomplished with conventional earthmoving equipment.

The following sections provide recommendations for stripping, erosion and sedimentation control, excavation, temporary and permanent cut slopes, wet weather considerations, fill materials and fill placement and compaction requirements.

5.3.2. Clearing and Stripping

Based on conditions observed in our explorations minimum stripping depths at the site will likely be on the order of 2 to 6 inches. However, greater stripping depths could be required to remove localized zones of loose or organic-rich soil. During clearing and stripping, stumps and primary root systems of shrubs and trees should be completely removed. Voids caused by removal of stumps and/or root systems should be backfilled with compacted structural fill. Stripped material should be transported off site or processed and used as fill in landscape-only areas where surface settlement over time is not a concern.

Foundation systems for the existing structures and existing pavements should be completely removed during demolition. During demolition, excessive disturbance of surficial soils may occur, especially if soils are left exposed to wet conditions. Disturbed soils may require additional remediation during construction and grading.

Cobbles and boulders were not encountered in our explorations; however, in our experience they can be present in the glacial till deposits in the area. The contractor should be prepared for the presence of cobbles or boulders if excavations extend into glacial till. Boulders may be removed from the site or used in landscape areas. Voids caused by boulder removal should be backfilled with structural fill.

5.3.3. Erosion and Sedimentation Control

Erosion and sedimentation rates and quantities can be influenced by construction methods, slope length and gradient, amount of soil exposed and/or disturbed, soil type, construction sequencing and weather. Implementing an erosion and sedimentation control plan will reduce the project impact on erosion-prone areas. The plan should be designed in accordance with applicable city, county and/or state standards. The plan should incorporate basic planning principles, including:

- Scheduling grading and construction to reduce soil exposure;
- Re-vegetating or mulching denuded areas;
- Directing runoff away from exposed soils;
- Reducing the length and steepness of slopes with exposed soils;
- Decreasing runoff velocities;
- Preparing drainage ways and outlets to handle concentrated or increased runoff;
- Confining sediment to the project site;
- Inspecting and maintaining control measures frequently.

Some sloughing and raveling of exposed or disturbed soil on slopes should be expected. We recommend that disturbed soil be restored promptly so that surface runoff does not become channeled.

Temporary erosion protection should be used and maintained in areas with exposed or disturbed soils to help reduce erosion and reduce transport of sediment to adjacent areas and receiving waters. Permanent erosion protection should be provided by paving, structure construction or landscape planting.

Until the permanent erosion protection is established and the site is stabilized, site monitoring may be required by qualified personnel to evaluate the effectiveness of the erosion control measures and to repair and/or modify them as appropriate. Provision for modifications to the erosion control system based on monitoring observations should be included in the erosion and sedimentation control plan.

5.3.4. Temporary Excavations

Excavations deeper than 4 feet should be shored or laid back at a stable slope if workers are required to enter. Shoring and temporary slope inclinations must conform to the provisions of Title 296 Washington Administrative Code (WAC), Part N, "Excavation, Trenching and Shoring." Regardless of the soil type encountered in the excavation, shoring, trench boxes or sloped sidewalls will be required under Washington Industrial Safety and Health Act (WISHA). The contract documents should specify that the contractor is responsible for selecting excavation and dewatering methods, monitoring the excavations for safety and providing shoring, as required, to protect personnel and structures.

In general, temporary cut slopes should be inclined no steeper than about 1½H:1V (horizontal to vertical) in the fill, glacial outwash and weathered glacial till soils. For cuts in dense glacial till, temporary cut slopes as steep as of 1H:1V may be feasible. These conditions should be verified prior to planning for slopes cut this steep. These guidelines assume that all surface loads are kept at a minimum distance of at least one-half the depth of the cut away from the top of the slope and that seepage is not present on the slope face. Flatter cut slopes will be necessary where seepage occurs or if surcharge loads are anticipated. Temporary covering with heavy plastic sheeting should be used to protect these slopes during periods of wet weather.

5.3.5. Groundwater Handling Considerations

Based on our explorations, we do not expect groundwater to be a significant factor during shallow excavations and earthwork. However, some perched groundwater could be present depending on the time of year of construction. Based on our interpretation of the soil conditions and our experience, the interface between the fill material and the native soils and contacts between glacial drift and glacial till are likely

locations for accumulation of perched groundwater. Groundwater handling needs are typically lower during the late summer and early fall months. We anticipate that shallow perched groundwater can typically be handled adequately with sumps, pumps, and/or diversion ditches, as necessary. Ultimately, we recommend that the contractor performing the work be made responsible for controlling and collecting groundwater encountered.

5.3.6. Permanent Cut and Fill Slopes

If permanent slopes are necessary, we recommend they be constructed at a maximum inclination of 2H:1V. Where 2H:1V permanent slopes are not feasible, protective facings and/or retaining structures should be considered.

To achieve uniform compaction, we recommend that fill slopes be overbuilt slightly and subsequently cut back to expose well-compacted fill. Fill placement on slopes steeper than 5H:1V should be benched into the slope face. The configuration of benches depends on the equipment being used. Bench excavations should be level and extend into the slope face.

Exposed areas should be re-vegetated as soon as practical to reduce the surface erosion and sloughing. Temporary protection should be used until permanent protection is established.

5.3.7. Subgrade Preparation and Evaluation

Subgrades that will support slabs-on-grade, parking areas and driveways should be thoroughly compacted to a uniformly firm and unyielding condition on completion of stripping and before placing structural fill. We recommend that subgrades be evaluated to identify areas of yielding or soft soil. Evaluation methods such as probing with a steel probe rod or proof-rolling with a heavy piece of wheeled construction equipment are appropriate methods.

If soft or otherwise unsuitable subgrade areas are revealed during evaluation that cannot be compacted to a stable and uniformly firm condition, we recommend that: (1) the unsuitable soils be scarified (e.g., with a ripper or farmer's disc), aerated and recompacted, if practical; or (2) the unsuitable soils be removed and replaced with compacted structural fill, as needed.

5.3.8. Subgrade Protection and Wet Weather Considerations

The wet weather season generally begins in October and continues through May in western Washington; however, periods of wet weather can occur during any month of the year. The soils encountered in our explorations contain a significant amount of fines. Soil with high fines content is very sensitive to small changes in moisture and is susceptible to disturbance from construction traffic when wet or if earthwork is performed during wet weather. If wet weather earthwork is unavoidable, we recommend that the following steps be taken.

- The ground surface in and around the work area should be sloped so that surface water is directed away from the work area. The ground surface should be graded so that areas of ponded water do not develop. Measures should be taken by the contractor to prevent surface water from collecting in excavations and trenches. Measures should be implemented to remove surface water from the work area.
- Earthwork activities should not take place during periods of heavy precipitation.

- Slopes with exposed soils should be covered with plastic sheeting.
- The contractor should take necessary measures to prevent on-site soils and other soils to be used as fill from becoming wet or unstable. These measures may include the use of plastic sheeting, sumps with pumps and grading. The site soils should not be left uncompacted and exposed to moisture. Sealing the exposed soils by rolling with a smooth-drum roller prior to periods of precipitation will help reduce the extent to which these soils become wet or unstable.
- Construction traffic should be restricted to specific areas of the site, preferably areas that are surfaced with working pad materials not susceptible to wet weather disturbance.
- Construction activities should be scheduled so that the length of time that soils are left exposed to moisture is reduced to the extent practical.
- Protective surfacing such as placing asphalt-treated base (ATB) or haul roads made of quarry spalls or a layer of free-draining material such as well-graded pit-run sand and gravel may be necessary to protect completed areas. Typically, minimum gravel thicknesses on the order of 24 inches are necessary to provide adequate subgrade protection.

5.4. Fill Materials

5.4.1. Structural Fill

The workability of material for use as structural fill will depend on the gradation and moisture content of the soil. We recommend that select granular fill, as described below, be used for structural fill during the rainy season. If prolonged dry weather prevails during the earthwork phase of construction, materials with a somewhat higher fines content may be acceptable. Weather, time of year and site conditions should be considered when determining the type of import fill materials purchased and brought to the site for use as structural fill.

Material used for structural fill should be free of debris, organic contaminants and rock fragments larger than 6 inches. During periods of dry weather, we recommend that structural fill material consist of material similar to “Select Borrow” or “Gravel Borrow” as described in Section 9-03.14 of the Washington State Department of Transportation (WSDOT) Standard Specifications. During periods of wet weather, select granular fill should be considered.

5.4.2. Select Granular Fill

Select granular fill should consist of well-graded sand and gravel or crushed rock with a maximum particle size of 6 inches and less than 5 percent fines by weight based on the minus $\frac{3}{4}$ -inch fraction. Organic matter, debris or other deleterious material should not be present. In our opinion, material with gradation characteristics similar to WSDOT Specification 9-03.9 (Aggregates for Ballast and Crushed Surfacing), or 9-03.14 (Borrow) is suitable for use as select granular fill, provided that the fines content is less than 5 percent (based on the minus $\frac{3}{4}$ -inch fraction) and the maximum particle size is 6 inches.

5.4.3. Pipe Bedding

Trench backfill for the bedding and pipe zone should consist of well-graded granular material similar to “gravel backfill for pipe zone bedding” described in Section 9-03.12(3) of the WSDOT Standard Specifications. The material must be free of roots, debris, organic matter and other deleterious material.

Other materials may be required depending on manufacturer specifications and/or jurisdictional requirements.

5.4.4. Trench Backfill

The use of on-site soil is discussed below. Imported trench backfill material may be required if material generated from the trench excavation is above optimum moisture content and cannot be dried out. We recommend that imported trench backfill material consist of material similar to “Select Borrow” or “Gravel Borrow” as described in Section 9-03.14 of the WSDOT Standard Specifications. During wet weather, select granular fill may be required as a trench backfill. If significant perched groundwater seepage is observed in excavations, alternative trench backfill materials such as a clean ballast or quarry spalls may be required to backfill the trenches within the seepage zone. Pipe manufacturers and jurisdictional requirements should also be considered when choosing trench backfill materials.

5.4.5. Quarry Spalls

We recommend that quarry spalls consist of 2- to 4-inch washed, crushed stone similar to that described in Section 9-13 of the WSDOT Standard Specifications. Alternative stone size ranges, up to about 6 inches, may be considered, depending on the application.

5.4.6. Recycled Materials

Crushed asphalt and Portland cement concrete (PCC) may be considered for use as structural fill provided it meets the gradation criteria for its intended use and the material can be compacted to a uniformly firm and unyielding condition. The maximum particle size must not exceed 6 inches. Recycled materials must not be used below infiltration facilities, below the water table or in drainage applications.

5.4.7. On-Site Soil

The fill, glacial outwash and till soils encountered in our explorations are very moisture sensitive and will be very difficult or impossible to properly compact when wet. In addition, the soil could be at moisture content above optimum when excavated.

Based on our experience at the Firgrove Elementary School project and results of our explorations for this project, it is our opinion that existing site soil should not be considered for use as structural fill below footings. Imported granular material should be used as structural fill below footings.

Existing site soils may be suitable for use in other fill applications such as trench backfill or to raise site grades. Based on our experience, reuse of on-site soils will likely only be feasible if earthwork is being completed during the summer or a prolonged period of dry weather. We expect that it will be very difficult, or impossible, to efficiently dry out native soils at the site if they become saturated or if they are generated at moisture contents above optimum for compaction. We recommend that budgets include provisions for import granular fill, especially if construction is planned during the wet weather season.

5.5. Fill Placement and Compaction

5.5.1. General

To obtain proper compaction, fill soil should be compacted near optimum moisture content and in uniform horizontal lifts. Lift thickness and compaction procedures will depend on the moisture content and

gradation characteristics of the soil and the type of equipment used. The maximum allowable moisture content varies with the soil gradation and should be evaluated during construction. Generally, 12-inch loose lifts are appropriate for steel-drum vibratory roller compaction equipment. Compaction should be achieved by mechanical means. During fill and backfill placement, sufficient testing of in-place density should be conducted to check that adequate compaction is being achieved.

5.5.2. Area Fills and Pavement Bases

Fill placed to raise site grades and materials under pavements and structural areas should be placed on subgrades prepared as previously recommended. Fill material placed below structures and footings should be compacted to at least 95 percent of the theoretical maximum dry density (MDD) per ASTM International (ASTM) D 1557.

Fill material placed less than 2 feet below pavement sections should be compacted to at least 95 percent of the MDD. Fill placed deeper than 2 feet below pavement sections should be compacted to at least 90 percent of the MDD. Fill material placed in landscaping areas should be compacted to a firm condition that will support construction equipment, as necessary, typically around 85 to 90 percent of the MDD.

5.5.3. Backfill Behind Retaining Walls

Backfill behind retaining walls should be compacted to between 90 and 92 percent of the MDD. Overcompaction of fill placed directly behind retaining walls should be avoided. We recommend use of hand-operated compaction equipment and maximum 6-inch loose lift thickness when compacting fill within about 5 feet behind retaining walls.

5.5.4. Trench Backfill

For utility excavations, we recommend that the initial lift of fill over the pipe be thick enough to reduce the potential for damage during compaction but generally should not be greater than about 18 inches. In addition, rock fragments greater than about 1 inch in maximum dimension should be excluded from this lift.

Trench backfill material placed below structures and footings should be compacted to at least 95 percent of the MDD. In paved areas, trench backfill should be uniformly compacted in horizontal lifts to at least 95 percent of the MDD in the upper 2 feet below subgrade. Fill placed below a depth of 2 feet from subgrade in paved areas must be compacted to at least 90 percent of the MDD. In non-structural areas, trench backfill should be compacted to a firm condition that will support construction equipment as necessary.

5.6. Shallow Foundations

5.6.1. General

Proposed structures can be founded on continuous wall and isolated column footings. Based on the conditions observed in our borings we anticipate that bottom of footing elevations will likely be within fill or glacial outwash soils. The existing fill and glacial outwash soils encountered in our explorations are typically loose to medium dense or medium stiff to stiff and are variable. Due to the potential for excessive differential settlement, we recommend that foundations not bear directly on existing fill or glacial outwash soils. Overexcavation and replacement of existing fill or glacial outwash soils below foundations will be required.

Exterior footings should be established at least 18 inches below the lowest adjacent grade. Interior footings can be founded a minimum of 12 inches below the top of the floor slab. Isolated column and continuous wall footings should have minimum widths of 24 and 18 inches, respectively.

5.6.2. Footing Bearing Surface Preparation

We recommend that existing fill or glacial outwash soils be overexcavated at least 2 feet below bottom of footing elevation and replaced with compacted structural fill. Structural fill should extend 2 feet laterally beyond the edges of the footings. Fill materials are described previously. Structural fill material should comprise select granular fill in periods of wet weather. It is possible that general structural fill will be suitable as foundation bearing surface backfill depending on weather conditions and period of exposure to wet weather conditions.

The base of all footing excavations should be proof compacted to a uniformly firm and unyielding condition as evaluated by a representative from our firm prior to placement of structural fill. Loose or disturbed materials present at the base of footing excavations should be removed or compacted. If soft or otherwise unsuitable areas are observed at the base of the overexcavation that cannot be compacted to a stable and uniformly firm condition the following options may be considered: (1) the exposed soils be moisture conditioned and recompact; or (2) the unsuitable soils be overexcavated and replaced with compacted structural fill, as needed; or (3) it may be possible to push, seat, and compact quarry spalls into the soft soils to stabilize the surface.

It is possible that some portions of bearing surface may expose more dense or stiffer soil conditions. We can assist in evaluating these areas and possibly reduce overexcavation depths. This determination will have to be made in the field and will be based, in part, on weather conditions during time of construction.

During periods of wet weather, concrete should be placed as soon as practical after preparation of the footing excavations. Foundation bearing surfaces should not be exposed to standing water. If water pools in the base of the excavation, it should be removed before placing structural fill or reinforcing steel. If footing excavations are exposed to extended wet weather conditions, a lean concrete mat can be considered for subgrade protection.

5.6.3. Allowable Soil Bearing Pressure

We recommend an allowable soil bearing pressure of 3,500 pounds per square foot (psf) for foundations bearing on 2 feet of compacted structural fill overlying existing fill material or glacial outwash soils. This bearing pressure applies to the total of dead and long-term live loads and may be increased by one-third when considering total loads, including earthquake or wind loads. These are net bearing pressures. The weight of the footing and overlying backfill can be ignored in calculating footing sizes.

5.6.4. Foundation Settlement

Disturbed soil must be removed from the base of footing excavations and the bearing surface should be prepared as recommended. Provided these measures are taken, we estimate the total static settlement of shallow foundations will be on the order of 1 inch or less for the bearing pressures presented above. Differential settlements could be on the order of ¼ to ½ inch between similarly loaded foundations or over a distance of 100 feet of continuous footings. The settlements should occur rapidly, essentially as loads

are applied. Settlements could be greater than estimated if disturbed or saturated soil conditions are present below footings.

5.6.5. Lateral Resistance

The ability of the soil to resist lateral loads is a function of frictional resistance, which can develop on the base of footings and slabs and the passive resistance, which can develop on the face of below-grade elements of the structure as these elements tend to move into the soil. For footings founded in accordance with the recommendations presented above, the allowable frictional resistance on the base of the footing may be computed using a coefficient of friction of 0.40 applied to the vertical dead-load forces. The allowable passive resistance on the face of the footing or other embedded foundation elements may be computed using an equivalent fluid density of 330 pounds per cubic foot (pcf) for undisturbed site soils or structural fill extending out from the face of the foundation element a distance at least equal to two and one-half times the depth of the element. These values include a factor of safety of about 1.5.

The passive earth pressure and friction components may be combined provided that the passive component does not exceed two-thirds of the total. The passive earth pressure value is based on the assumptions that the adjacent grade is level and that groundwater remains below the base of the footing throughout the year. The top foot of soil should be neglected when calculating passive lateral earth pressure unless the area adjacent to the foundation is covered with pavement or a slab-on-grade.

5.6.6. Foundation Drains

We recommend that perimeter foundation footing drains be installed at the base of exterior footings. The perimeter drains should be provided with cleanouts and should consist of at least 4-inch-diameter perforated pipe surrounded on all sides by 6 inches of drain material enclosed in a non-woven geotextile fabric for underground drainage to prevent fine soil from migrating into the drain material. We recommend that the drainpipe consist of either heavy-wall solid pipe or rigid corrugated smooth interior polyethylene pipe. We do not recommend using flexible tubing for footing drainpipes. The drain material should consist of pea gravel or material similar to “Gravel Backfill for Drains” per WSDOT Standard Specifications Section 9-03.12(4). The perimeter drains should be sloped to drain by gravity, if practical, to a suitable discharge point. Water collected in roof downspout lines must not be routed to the perimeter footing drains.

5.7. Slab-on-Grade Floor

The exposed slab subgrade should be evaluated after site grading is complete. The slab subgrades could be variable consisting of existing fill, glacial outwash soil, or newly placed structural fill. In general, the building slab subgrade can be comprised of native soils provided it is prepared as recommended and is in a uniformly firm and unyielding condition. Due to the variability of the site soils, we recommend that overexcavation and replacement of at least 12 inches of native soils below the slab subgrade be included in the project budget. The need to complete the overexcavation should be determined in the field when the existing subgrade soils are exposed. We recommend the slab subgrades be observed by a member of our firm during construction. Disturbed areas should be compacted, if possible, or removed and replaced with compacted structural fill. In all cases, the exposed soil should be firm and unyielding. It may be appropriate to compact the exposed subgrade with a smooth drum vibratory roller to a dense and unyielding condition. Ideally, the subgrade should be compacted to at least 95 percent of the MDD in accordance with ASTM D 1557, or as determined by the field geotechnical engineer.

We recommend slab-on-grade floors be underlain by a minimum 8-inch-thick capillary break consisting of clean sand and gravel, crushed or washed rock with less than 3 percent fines. Provided that loose soil is removed and the subgrade is prepared as recommended, we recommend slabs-on-grade be designed using a modulus of subgrade reaction of 300 pounds per cubic inch (pci).

We estimate that settlement for slabs-on-grade constructed as recommended will be less than $\frac{3}{4}$ inch for a floor load of 500 psf.

For on-grade construction at or within 2 feet of existing grades, it is our opinion that an underslab drain system is not necessary. Based on the conditions observed, isolated areas of perched groundwater could be present. Targeted interceptor drains may be required and should be included as a contingency. We can provide additional recommendations for underslab drains as requested during design and construction.

5.8. Retaining Walls and Below-Grade Features

5.8.1. Design Parameters

We recommend the following lateral earth pressures be used for design of conventional retaining walls and shallow below-grade features that retain 8 feet or less backfill soil. We understand the deep excavations and below-grade shoring are not planned at this time. We should be notified if deep excavations or shoring will be completed to provide appropriate design recommendation. Our design pressures assume that the ground surface around the retaining structures will be level or near level. If drained design parameters are used, drainage systems must be included in the design in accordance with the recommendations presented in the “5.8.2 Drainage” section below.

- Active soil pressure may be estimated using an equivalent fluid density of 32 pcf for the drained condition.
- Active soil pressure may be estimated using an equivalent fluid density of 80 pcf for the undrained condition; this value includes hydrostatic pressures.
- At-rest soil pressure may be estimated using an equivalent fluid density of 52 pcf for the drained condition.
- At-rest soil pressure may be estimated using an equivalent fluid density of 89 pcf for the undrained condition; this value includes hydrostatic pressures.
- For seismic considerations, a uniform lateral pressure of $10H$ psf (where H is the height of the retaining structure or the depth of a structure below ground surface) should be added to the active lateral earth pressure. This assumes walls will be allowed to move laterally during seismic loading.
- An additional 2 feet of fill representing a typical traffic surcharge of 250 psf should be included if vehicles are allowed to operate within $\frac{1}{2}$ the height of the retaining walls. Other surcharge loads should be considered on a case-by-case basis.

The active soil pressure condition assumes the wall is free to move laterally $0.001 H$, where H is the wall height). The at-rest condition is applicable where walls are restrained from movement. The above recommended lateral soil pressures do not include other surcharge loads than described or the effects of sloping backfill surfaces. Overcompaction of fill placed directly behind retaining walls or below-grade structures must be avoided. We recommend use of hand-operated compaction equipment and maximum

6-inch loose lift thickness when compacting fill within about 5 feet of retaining walls and below-grade structures.

Retaining wall foundation bearing surfaces should be prepared following the “5.6.2 Footing Bearing Surface Preparation” section of this report. Provided bearing surfaces are prepared as recommended retaining wall foundations may be designed using the allowable soil bearing values and lateral resistance values presented above. We estimate settlement of retaining structures will be similar to the values previously presented for building foundations.

5.8.2. Drainage

We recommend the drainage system include a zone of free-draining backfill a minimum of 18 inches in width against the back of the wall. The drainage material should consist of coarse sand and gravel containing less than 5 percent fines based on the fraction of material passing the 3/4-inch sieve. Use of drainage boards is also acceptable.

A perforated, rigid, smooth-walled drainpipe with a minimum diameter of 4 inches should be placed along the base of the structure within the free-draining backfill and extend for the entire wall length. The drainpipe should be metal or rigid PVC pipe and be sloped to drain by gravity. Discharge should be routed to appropriate discharge areas and to reduce erosion potential. Cleanouts should be provided to allow routine maintenance. We recommend roof downspouts or other types of drainage systems not be connected to retaining wall drain systems.

5.9. Stormwater Infiltration

5.9.1. General

We evaluated stormwater infiltration rates at the site generally following the methodology presented in the Pierce County SWSDM. We completed one large-scale PIT and three small-scale PITs at the locations shown on the Site Plan. We collected soil samples during excavation of the PITs and completed sieve analyses to compare estimated infiltration rates using published correlations to those measured during PIT testing. The sections below further describe the methods and results of our infiltration testing program.

5.9.2. PIT Methodology

The PITs were completed following GeoEngineers’ standard methodology for stormwater facilities in Western Washington. Our methodology is a synthesis of the standard practices and current local jurisdictional procedures set forth in the SWSDM, Pierce County and the Washington State Department of Ecology. GeoEngineers’ PIT procedure has been developed to provide increased confidence that fully saturated conditions have been achieved and that the infiltration rate measured at the end of the test is representative of the saturated hydraulic conductivity of the soil.

The approximate dimensions of the base of the PIT excavations were 10 feet by 10 feet (large-scale test, PIT-1) and 4 feet by 4 feet (small-scale tests, PIT-2, PIT-3 and PIT-4). Upon reaching the target depth for the PITs (2.5 to 4 feet bgs), a graduated yard stick was driven into the floor of the test pit and a piezoelectric pressure transducer was secured to the bottom of the yard stick to measure water level at 30-second intervals. During the approximately 8-hour long tests, water was added to the excavations and then allowed to drain out in a series of cycles. We attempted to maintain water levels above 12 inches during each cycle. The drain and refill cycle was repeated as many times as practical during the test duration. During each

refill/drain cycle, the infiltration rate was measured manually and using the pressure transducer. Under typical conditions, the measured infiltration rate decreases with each cycle, until a relatively stabilized infiltration rate is observed. This stabilized rate provides the best estimate of a saturated infiltration rate. After the infiltration tests were completed, we continued the excavations to the depth practical to document underlying soil and groundwater conditions.

During PIT-1 water completely drained from the PIT excavation between each refill/drain cycle. This was the result of relatively fast infiltration rates and the need to refill the water source (2,500-gallon water truck) multiple times during testing.

During excavation of PIT-3 after the test was complete, we observed a perforated storm drain pipe a few feet below the test depth. We observed high infiltration rates during testing of PIT-3, which we attribute to the presence of the perforated storm drainpipe. In our opinion the results obtained from PIT-3 are not indicative of the actual soil infiltration rates and, therefore, we have omitted those results from this report.

5.9.3. PIT Results

Recorded water level data from the PITs and plots of the measured (unfactored) infiltration rates determined during each cycle of the PITs are presented in Figures 3 through 5. The SWSDM recommends that correction factors be applied to the unfactored infiltration rates. The correction factors in the SWSDM account for uncertainties in testing procedures, the geometry of the proposed facilities and long-term reductions in permeability due long-term plugging of soils. We applied the following correction factors to the measured infiltration rates determined in the PIT.

- Test Method Correction Factor = 0.5 for small scale PITs and 0.75 for large scale PITs
- Facility Geometry Correction Factor = 0.5 (assumes the ratio of the depth to groundwater [measured from the base of the facility] to the facility width is greater than 0.1)
- Plugging Correction Factor = 0.7

The total correction factor is equal to the product of the partial correction factors above. Table 2 below summarizes the measured and factored infiltration rates for the PITs along with a description of the soil types present at the testing elevation. For final design, we adjusted the factored infiltration rate based on our experience assisting with the design of stormwater infiltration facilities in the area.

TABLE 2. PIT INFILTRATION RATE SUMMARY

Pilot Infiltration Test Number	Test Depth (feet below existing grade)	Geologic Unit	USCS Soil Type	Measured Infiltration Rate (inches/hour)	Estimated Factored Infiltration Rate (inches/hour)
PIT-1	3.5	Fill	SM	5	≤ 1.25
PIT-2	3.5	Fill	GP-GM	9	≤ 1.5
PIT-4	4	Outwash	SM	1.5	≤ 0.25

5.9.4. Grain-Size Analysis Infiltration Rate Correlations

To provide an additional estimate of the infiltration potential of soils observed in our explorations we used the Soil Grain Size Analysis Method presented in the SWSDM. Table 3 below summarizes our results. The factored rates in Table 3 include the recommended reduction factors provided in the SWSDM. For final

design, we adjusted the factored infiltration rate based on our experience assisting with the design of stormwater infiltration facilities in the area.

TABLE 3. ESTIMATED SOIL INFILTRATION RATE FROM GRAIN-SIZE CHARACTERISTICS¹

Exploration	Soil Sample Depth (feet)	Soil Unit	Approximate Percent Fines ²	USCS Soil Classification ³	Estimated Factored Infiltration Rate ⁴ (Inches per Hour)
B-1	2.5	Fill	70	ML	≤ 0.4
B-1	7.5	Glacial Outwash	71	ML	≤ 0.4
B-2	2.5	Glacial Outwash	35	SM	≤ 1.0
B-7	5	Glacial Outwash	69	ML	≤ 0.4
B-8	5	Glacial Outwash	80	ML	≤ 0.2
B-9	5	Glacial Outwash	27	SM	≤ 1.0
B-9	7.5	Glacial Outwash	15	SM	≤ 1.0
B-9	10	Glacial Outwash	42	SM	≤ 1.0
B-9	15	Weathered Glacial Till	68	ML	≤ 0.1
B-10	5	Glacial Outwash	27	SM	≤ 1.0
B-10	7.5	Glacial Outwash	27	SM	≤ 1.0
PIT-1	6	Outwash	24	SM	≤ 1.0
PIT-1	8	Outwash	13	SM	≤ 1.0
PIT-1	10.5	Outwash	84	ML	≤ 0.2
PIT-2	5.5	Outwash	72	ML	≤ 0.2
PIT-2	9	Outwash	35	SM	≤ 1.0
PIT-4	4	Outwash	54	ML	≤ 0.4
PIT-4	6	Outwash	32	SM	≤ 1.0

Notes:

¹ For selected soil samples.

² Fines = Silt and clay-sized particles passing U.S. No. 200 sieve.

³ Unified Soil Classification System (USCS). See Figure A-1 for additional descriptions.

⁴ Based on the Soil Grain Size Analysis Method and correction factors outlined in the Pierce County SWSDM and our experience.

5.9.5. Discussion and Recommended Design Infiltration Rate

5.9.5.1. Infiltration Suitability

It is our opinion that infiltration is feasible at the site. We understand that permeable pavements and concentrated infiltration facilities such as infiltration ponds, bioswales and subsurface galleries are being considered for the site.

Based on the soil types observed in our explorations and our experience designing infiltration facilities for the Firgrove Elementary School project, we expect that the infiltration capacity of facilities will be controlled by the infiltration rate of the glacial outwash and glacial till soils. Accordingly, we do not recommend that infiltration facilities be designed using rates associated with the fill, even if the facility base is located within that soil unit. If glacial till is expected to be present within 5 feet of the base of concentrated infiltration

facilities or within 1 foot of the bottom of permeable pavement sections, the facility should be designed using the glacial till infiltration rate.

Water has not been observed in the B-9 monitoring well since installation and it appears that the perched groundwater observed during drilling is not significant enough to result in water accumulation in the well. Our monitoring program will continue through the Spring of 2020 to monitor for the seasonal high groundwater level. It appears that the perched groundwater observed in our explorations is likely accumulating near the contact with the glacial till soils. In our opinion, provided the base of infiltration facilities are separated more than 5 feet from the top of the glacial till contact, perched groundwater is expected to be slow and intermittent and unlikely to impact performance of the facilities. If the base of infiltration facilities will be located within 5 feet of the glacial till contact, we should be consulted to evaluate if perched groundwater has the potential to impact the infiltration system. This will depend in part on the soil conditions and the facility design (e.g., facility type, size and location). We should review design cross sections and elevations of the infiltration facilities and assist in determining if this is the case.

5.9.5.2. Recommended Design Infiltration Rates

Based on the results of our infiltration tests, conditions observed in our explorations and our experience we recommend that the following infiltration rates be used for design:

- 0.5 inches per hour – Facilities located in the immediate vicinity, and west of, the locations of PIT-1, B-9 and B-10. The base of facilities designed using this infiltration rate must be founded deeper than 2 feet below existing ground surface.
- 0.2 inches per hour – All other locations at the site
- 0.1 inches per hour – Any facility where the base of the facility is located within 5 vertical feet of glacial till soils. The depth to glacial till (where encountered) is shown on the exploration logs.

Due to the variability of soil conditions at the site, we must be notified when a design infiltration rate is selected for a facility so we can confirm that it is appropriate for the location and facility type. Depending on the final facility location it may be necessary to complete additional explorations during design to verify soil conditions below the facility.

5.9.6. Construction Recommendations

During construction, soil conditions at the base of infiltration facilities must be observed by a representative of our firm to verify that the soil conditions present are consistent with the infiltration rate used for design.

After excavation for infiltration facilities is complete, the base of the infiltration facility should be scarified to a depth of approximately 8 inches using the toothed bucket on an excavator. If the soils at the base of infiltration facilities become compacted or otherwise disturbed during construction, the subgrade should be overexcavated to expose undisturbed soils. Construction equipment should not be operated on the subgrade of infiltration facilities.

5.10 Pavement Recommendations

5.10.1 Conventional Asphalt Concrete Pavements

5.10.1.1 General

Based on our experience, we provide recommended conventional asphalt concrete pavement (ACP) sections below. These pavement sections may not be adequate for heavy construction traffic loads such as those imposed by concrete transit mixers, dump trucks or cranes. Additional pavement thickness may be necessary to prevent pavement damage during construction. The recommended sections assume that final improvements surrounding the conventional ACP will be designed and constructed such that stormwater or excess irrigation water from landscape areas does not accumulate below the pavement section or pond on pavement surfaces.

Pavement subgrade should be prepared, placed and observed as previously described. Crushed surfacing base course and subbase should be moisture conditioned to near optimum moisture content and compacted to at least 95 percent of MDD (ASTM D 1577).

Crushed surfacing base course should conform to applicable sections of 4-04 and 9-03.9(3) of the WSDOT Standard Specifications. Hot mix asphalt should conform to applicable sections of 5-04, 9-02 and 9-03 of the WSDOT Standard Specifications.

5.10.1.2 Standard-Duty ACP – Automobile Driveways and Parking Areas

- 2 inches of hot mix asphalt, class ½ inch, PG 58-22.
- 4 inches of crushed surfacing base course.
- 6 inches of subbase consisting of select granular fill to provide uniform grading and pavement support, to maintain drainage, and to provide separation from fine-grained subgrade soil.
- Existing subgrade or structural fill prepared in accordance with the “5.3.7 Subgrade Preparation and Evaluation” section of this report.

5.10.1.3 Heavy-Duty ACP – Areas Subject to Bus or Heavy-Duty Traffic

- 4 inches of hot mix asphalt, class ½ inch, PG 58-22.
- 6 inches of crushed surfacing base course.
- 6 inches of subbase consisting of select granular fill to provide a uniform grading surface and pavement support, to maintain drainage, and to provide separation from fine-grained subgrade soil.
- Existing soil or structural fill on subgrades prepared in accordance with the “5.3.7 Subgrade Preparation and Evaluation” section of this report.

5.10.2 Permeable Pavements

5.10.2.1 General

Our recommendations for permeable pavement design sections are based on information provided in the technical guidance manual for LID (Puget Sound LID manual), completed by the Puget Sound Partnership (December 2012) and our experience designing permeable pavements in the region. The design of permeable pavements for stormwater management should consider storage capacity of the permeable pavement system and infiltration rate of the subgrade soils. Our general recommendations are provided in

the following sections; however, we recommend that final permeable pavement design should be in accordance with the complete recommendations provided in the Puget Sound LID manual.

5.10.2.2 Permeable Pavement Sections

Sections for permeable cement concrete pavement and permeable asphalt pavement are presented below followed by specific recommendations for each layer within the section.

The permeable pavement sections presented below are suitable for use in sidewalk, parking areas and roadways with a low traffic volume and may not be suitable for use on roads that are subjected to regular heavy traffic (such as tractor trailers or ambulances).

In our experience permeable concrete pavements are relatively more durable than permeable asphalt pavements. We recommend that permeable concrete pavements be used if areas will be subjected to heavier vehicle traffic and excessive turning.

5.10.2.3 Permeable Cement Concrete Section for Parking Areas and Low Traffic Roads

- 8 inches of permeable cement concrete.
- 6 inches (minimum) of permeable ballast, more permeable ballast may be required to provide adequate storage capacity for the section.
- 12- to 18-inch treatment layer (if necessary).
- Geotextile separation fabric.
- Subgrade prepared as recommended below.

5.10.2.4 Permeable Cement Concrete Section for Pedestrian Sidewalks

- 4 inches of permeable cement concrete.
- 4 inches (minimum) of permeable ballast, more permeable ballast may be required to provide adequate storage capacity for the section.
- 12- to 18-inch treatment layer (if necessary).
- Geotextile separation fabric.
- Subgrade prepared as recommended below.

5.10.2.5 Permeable Asphalt Concrete Section for Parking Areas and Low Traffic Roads

- 6 inches of permeable hot mix asphalt concrete.
- 6 inches (minimum) of permeable ballast, more permeable ballast may be required to provide adequate storage capacity for the section.
- 12- to 18-inch treatment layer (if necessary).
- Geotextile separation fabric.
- Subgrade prepared as recommended below.

Permeable pavements should be open graded and should have a minimum infiltration rate of at least 100 inches per hour when newly installed. Field infiltration tests should be considered on newly placed permeable pavements to verify the infiltration rate.

5.10.2.6 Permeable Ballast

We recommend a minimum 6-inch-thick permeable ballast layer that meets the specification for American Public Works Association (APWA) General Special Provision (GSP) 9-03.9(2) Option 1. A thicker permeable ballast layer may be necessary to provide sufficient storage capacity for the design infiltration rate. In general, the permeable ballast can be considered to have a porosity of 30 percent. Permeable ballast layers between 6 and 12 inches thick should be placed as a single lift. The ballast should be lightly compacted to a firm unyielding condition. Overcompaction of the ballast can result in reduced permeability. The prepared ballast layer should be observed by the geotechnical engineer to ensure that the ballast has been adequately compacted prior to placement of the permeable pavement. If the permeable ballast layer is thicker than 12 inches, it should be placed and compacted in multiple lifts not exceeding 12 inches in thickness.

5.10.2.7 Treatment Layer

Water quality treatment can be provided by the native soils below the pavement section or by including a treatment layer within the permeable pavement section. In order for native soils to be used for water treatment, they must meet minimum requirements for cation exchange capacity (CEC) and organic content. We plan to complete CEC and organic content testing as part of our additional infiltration study. If native soils do not meet treatment requirements, a treatment layer must be included within the permeable pavement section. Treatment soil should have a minimum organic content of 1 percent and a minimum cation exchange capacity of 5 milliequivalents per 100 grams.

5.10.2.8 Geotextile Separation Fabric

A geotextile separation fabric should be included between the bottom of the pavement section and the prepared subgrade to prevent the underlying subgrade soils from migrating into the permeable ballast or treatment layer. The separation geotextile should be non-woven and meet the requirement of WSDOT Standard Specification 9.33.1 for separation.

5.10.2.9 Subgrade Preparation for Permeable Pavements

Subgrades below permeable pavement sections should be lightly compacted to a firm and unyielding condition before constructing the permeable pavement section; however, overcompaction of the subgrade should be avoided. Prepared subgrades should be protected from construction traffic, standing water or other disturbance. If portions of the subgrade become disturbed or are overcompacted, the subgrade should be scarified to a minimum depth of 8 inches and recompact. The subgrade should be recompact to between 90 and 92 percent of the MDD.

5.10.2.10 Impermeable Liner

We recommend that an impermeable liner be installed at the edges of permeable pavement areas where the permeable pavements abut traditional pavements or where permeable pavements will be within 4 feet of an existing or new foundations or structural elements. The impermeable liner should be installed in order to prevent water from infiltrating through the permeable pavement sections from entering the subgrade area of traditional pavements or foundations. We recommend that the impermeable liner start as close as practical to the top of the pavement section and extend vertically to a depth of 2.5 feet below surrounding grade.

5.10.2.11 Protection, Maintenance and Icing

It is imperative that soils are not tracked onto permeable pavement surfaced areas during construction. Periodic visual inspections should be performed throughout the pavement life to determine if permeable

pavement surfaces are clogged with fine soil or vegetation. Surfaces should be swept with a high-efficiency or vacuum sweeper regularly (typically at least two to four times per year) and washed with a high-pressure hose at least once per year. Failure to maintain permeable pavements on a regular basis will result in poor infiltration performance and could cause premature fatigue of the pavement surface.

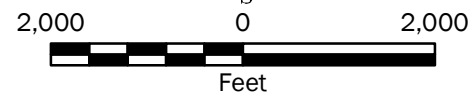
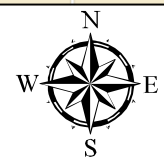
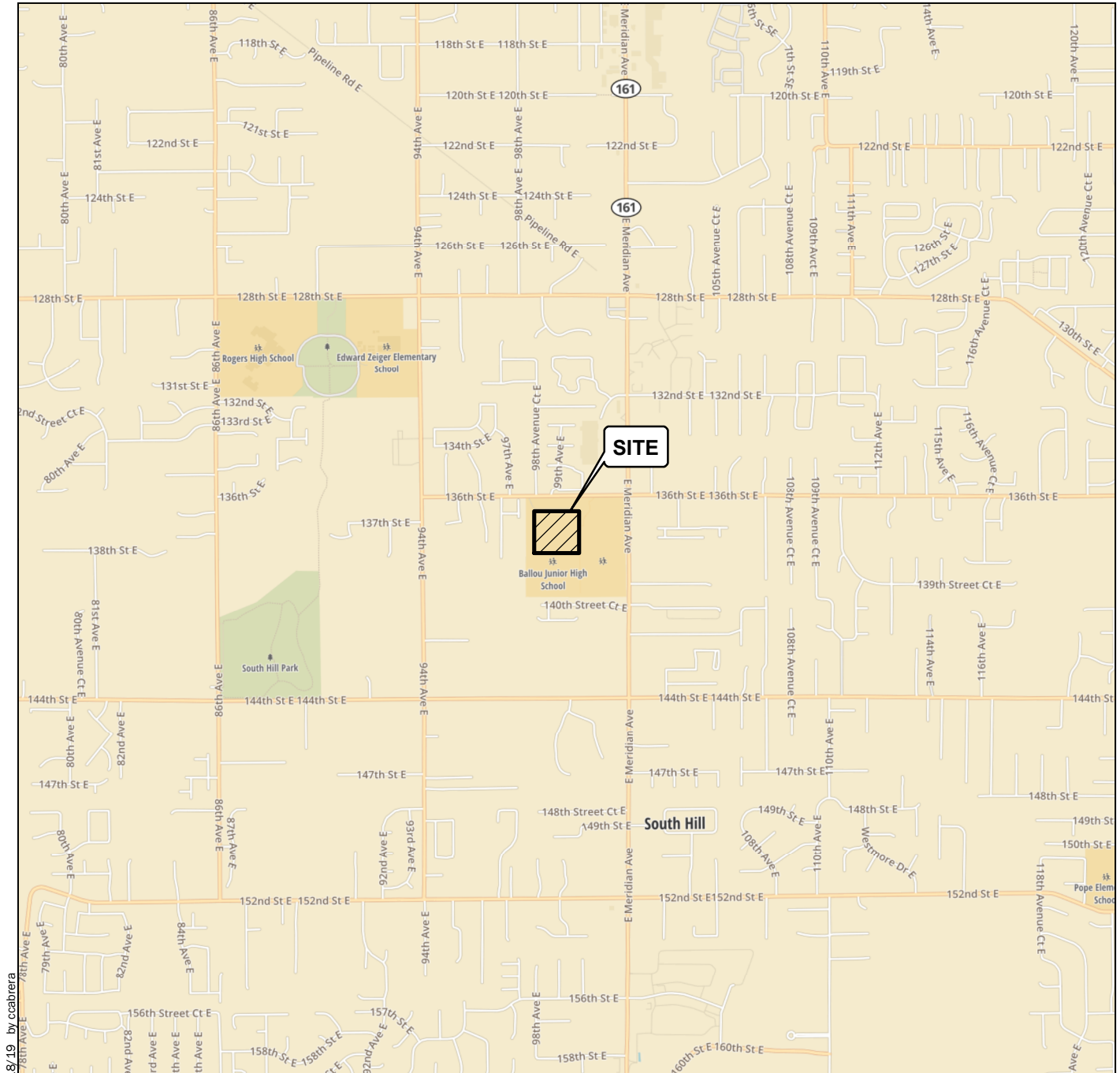
Because the relatively porous base and subbase layers allow some air movement below the pavement, permeable pavement surfaces may become icy more easily than conventional pavement surfaces. This problem is similar to differential icing of bridges and elevated road structures. Users should be made aware of the possibility of differential icing if permeable pavements are used.

6.0 LIMITATIONS

We have prepared this report for the Puyallup School District, for Ballou Junior High School. Puyallup School District may distribute copies of this report to owner's authorized agents and regulatory agencies as may be required for the Project.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices for geotechnical engineering services in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty, express or implied, applies to the services or this report.

Please refer to Appendix C titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Mapbox Open Street Map, 2016

Projection: NAD 1983 UTM Zone 10N

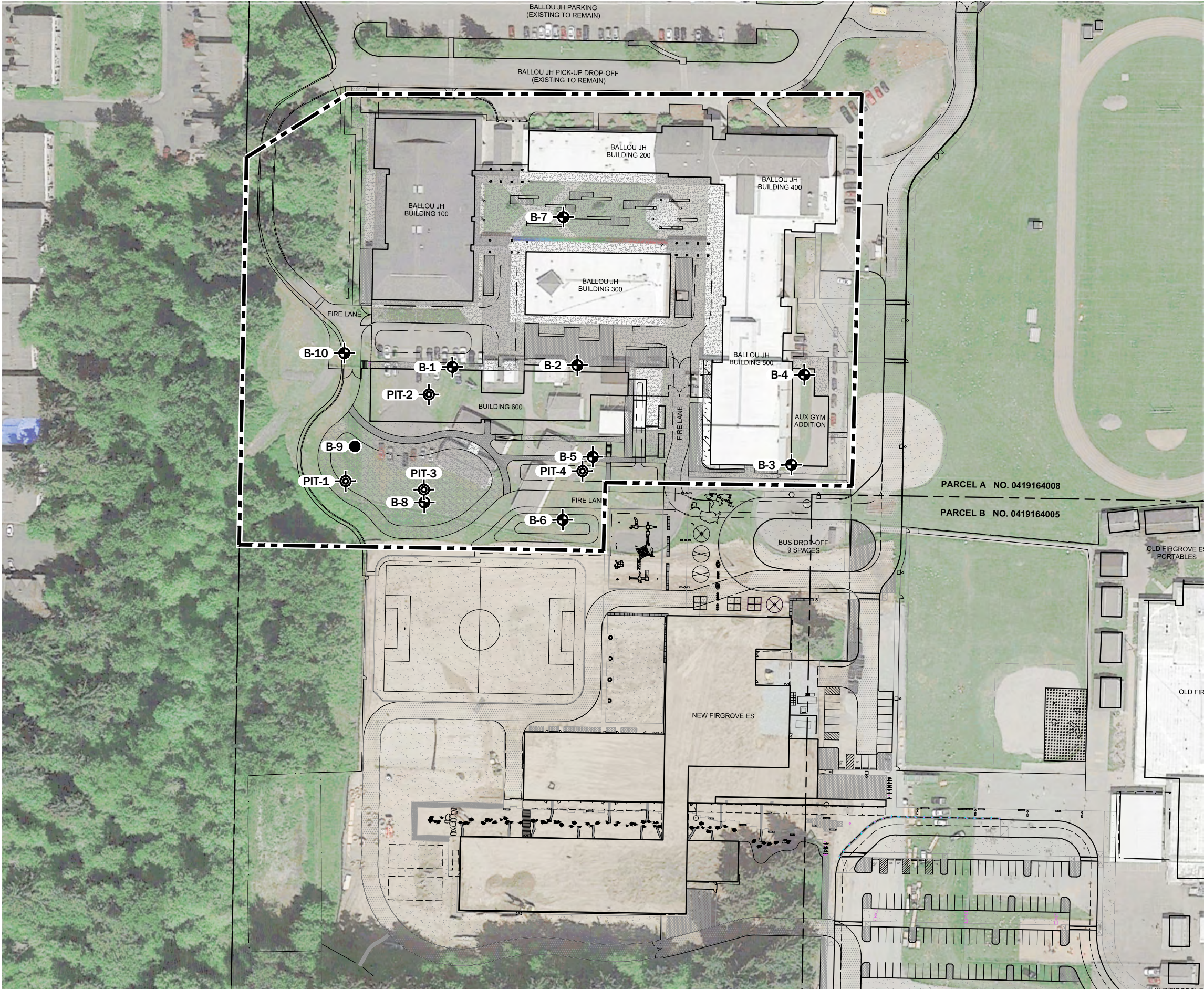
Vicinity Map

**Ballou Junior High Expansion
Puyallup, Washington**



Figure 1

P:\2017007\CAD\00\Geotech\201700700_F02 Site Plan.dwg TAB:F02 Date Exported: 09/05/19 - 12:04 by tmichaud

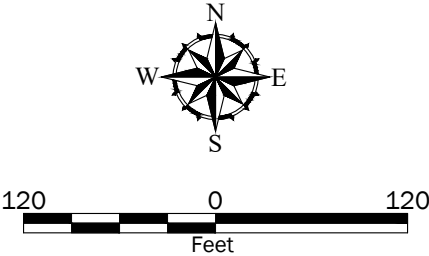


Legend

- Site Boundary
- B-1 Boring by GeoEngineers, Inc., 2019
- B-9 Monitoring Well by GeoEngineers, Inc., 2019
- PIT-1 Pilot Infiltration Test by GeoEngineers, Inc., 2019

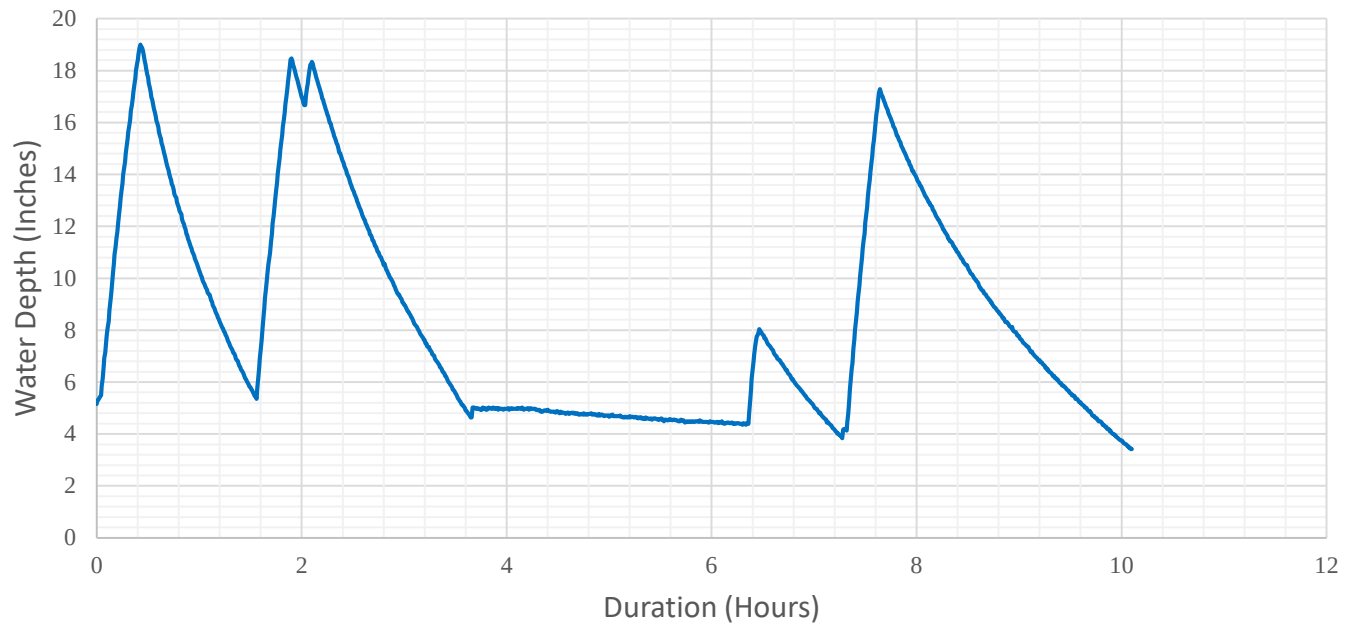
- Notes:**
1. The locations of all features shown are approximate.
 2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from Google Earth captured 07/18/19.
Projection: Washington State Plane, South Zone, NAD83, US Foot

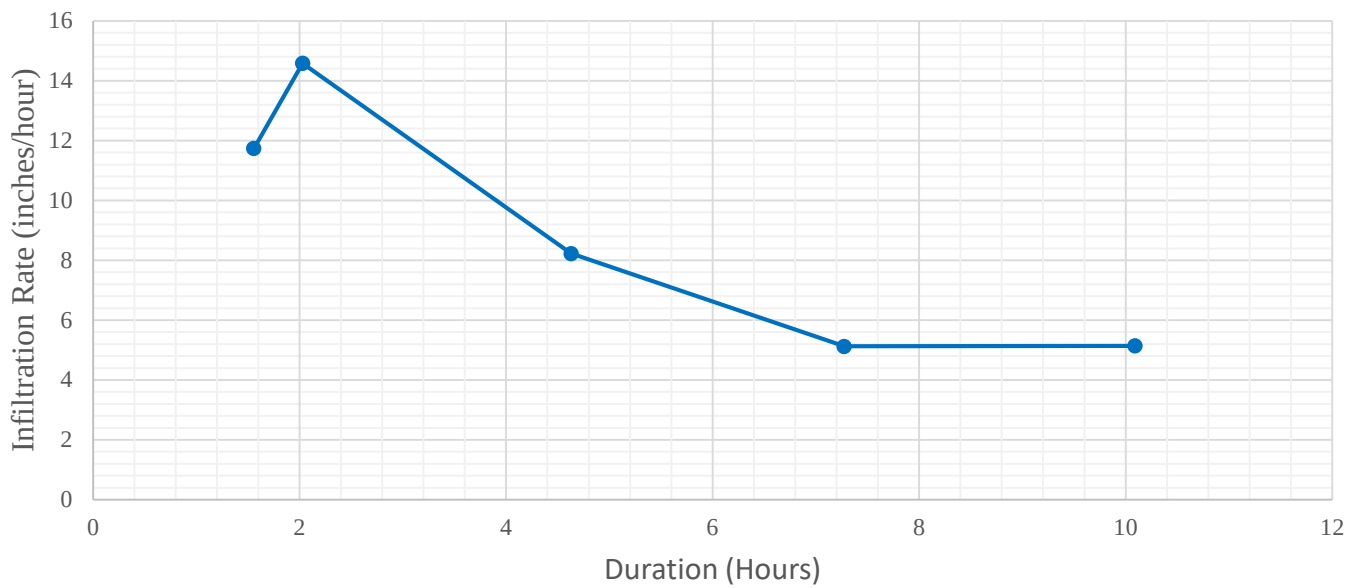


Site Plan	
Ballou Junior High Expansion Puyallup, Washington	
	Figure 2

PIT-1 Measured Water Levels



PIT-1 Measured Infiltration Rate



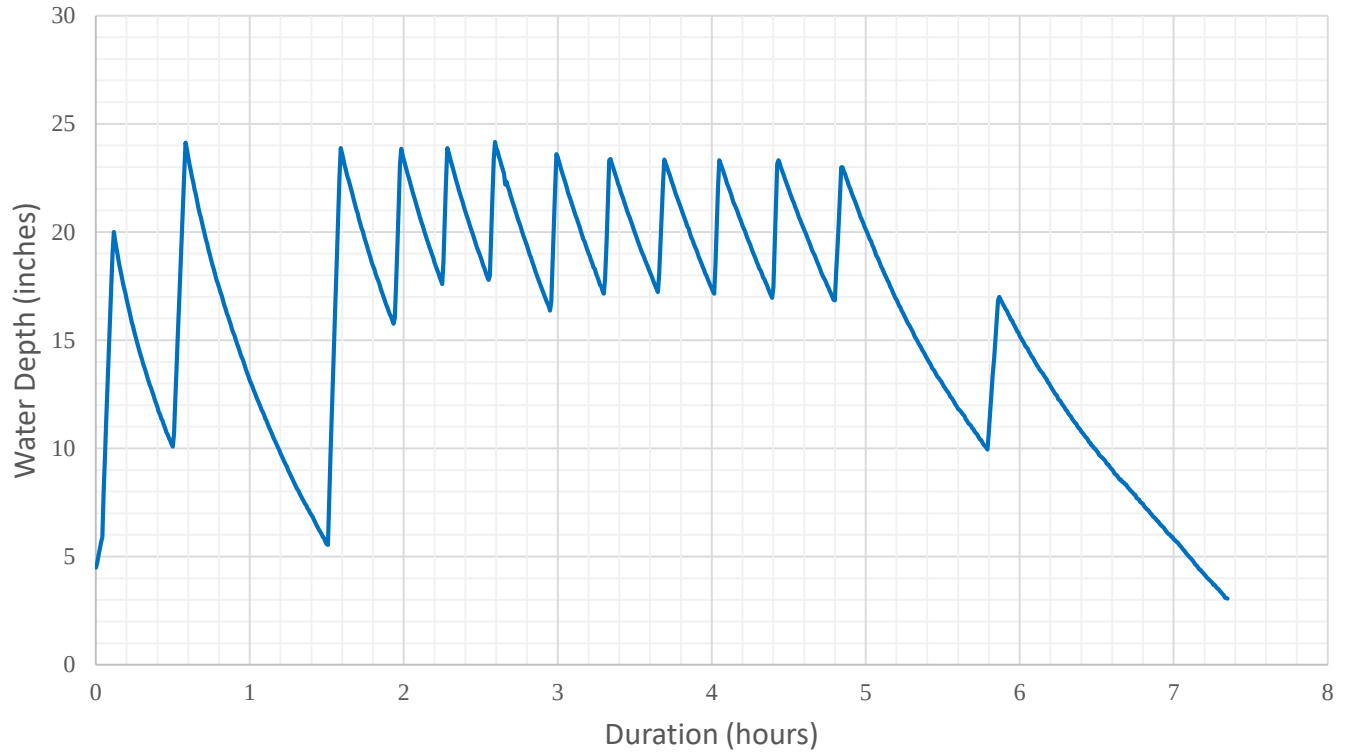
PIT-1 Results

Ballou Junior High Expansion
Puyallup, Washington

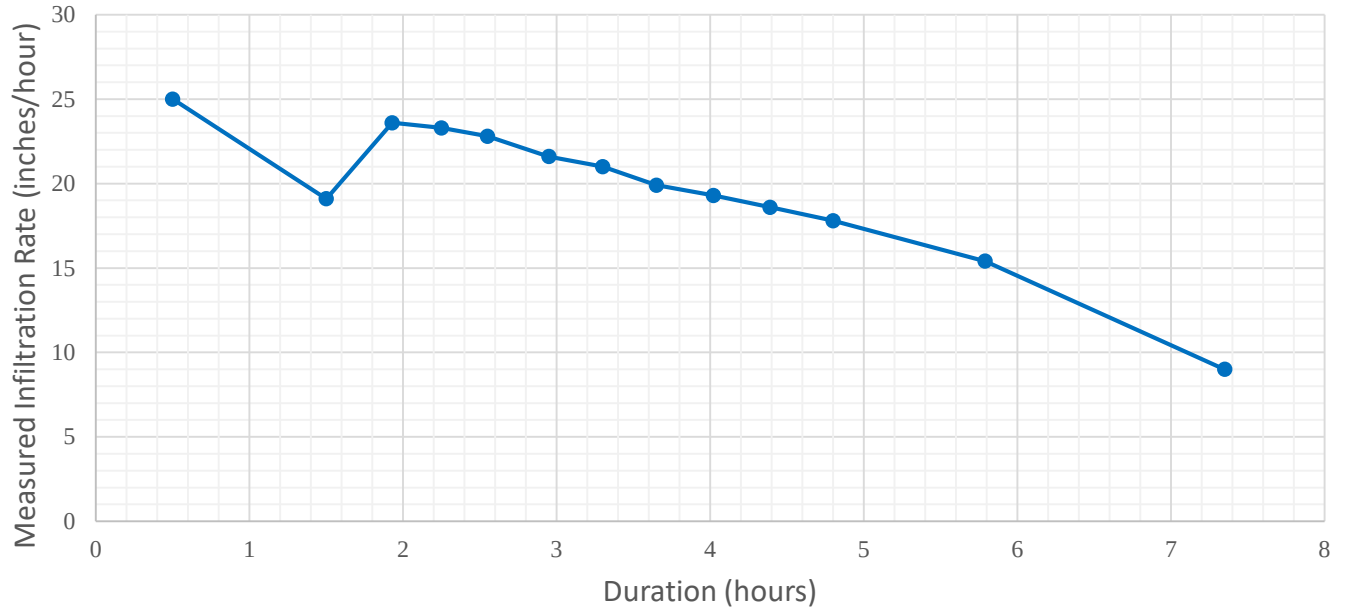


Figure 3

PIT-2 Measured Water Levels



PIT-2 Measured Infiltration Rate



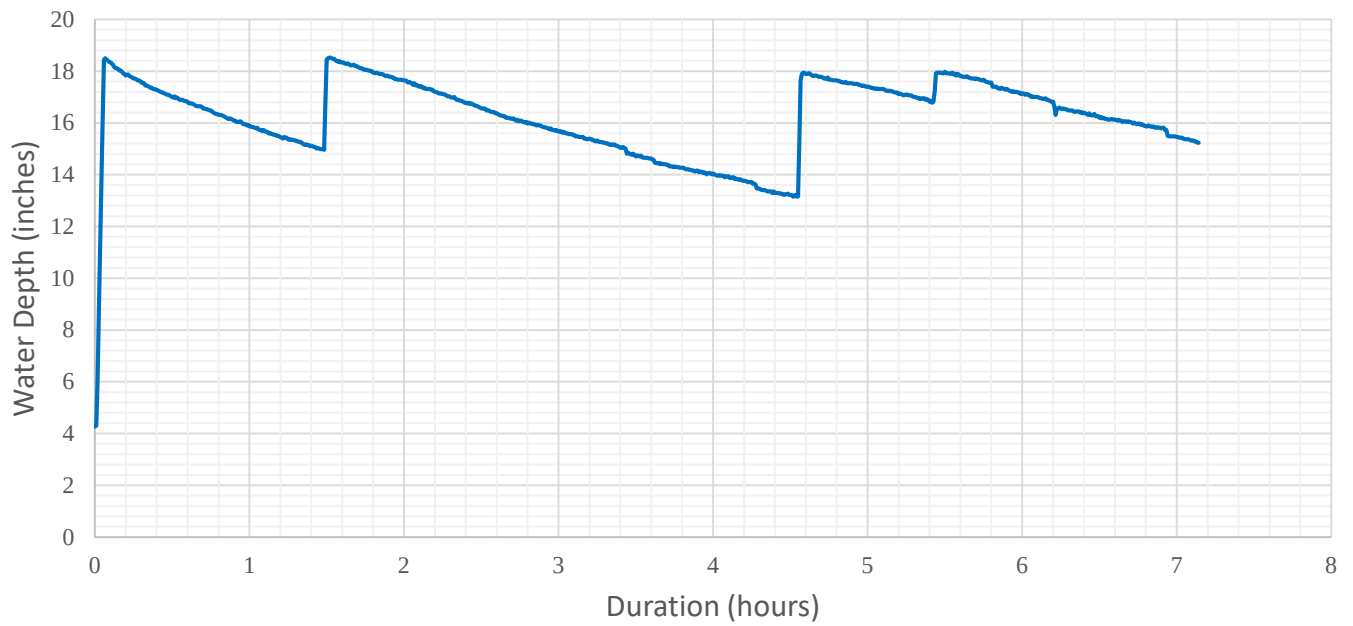
PIT-2 Results

Ballou Junior High Expansion
Puyallup, Washington

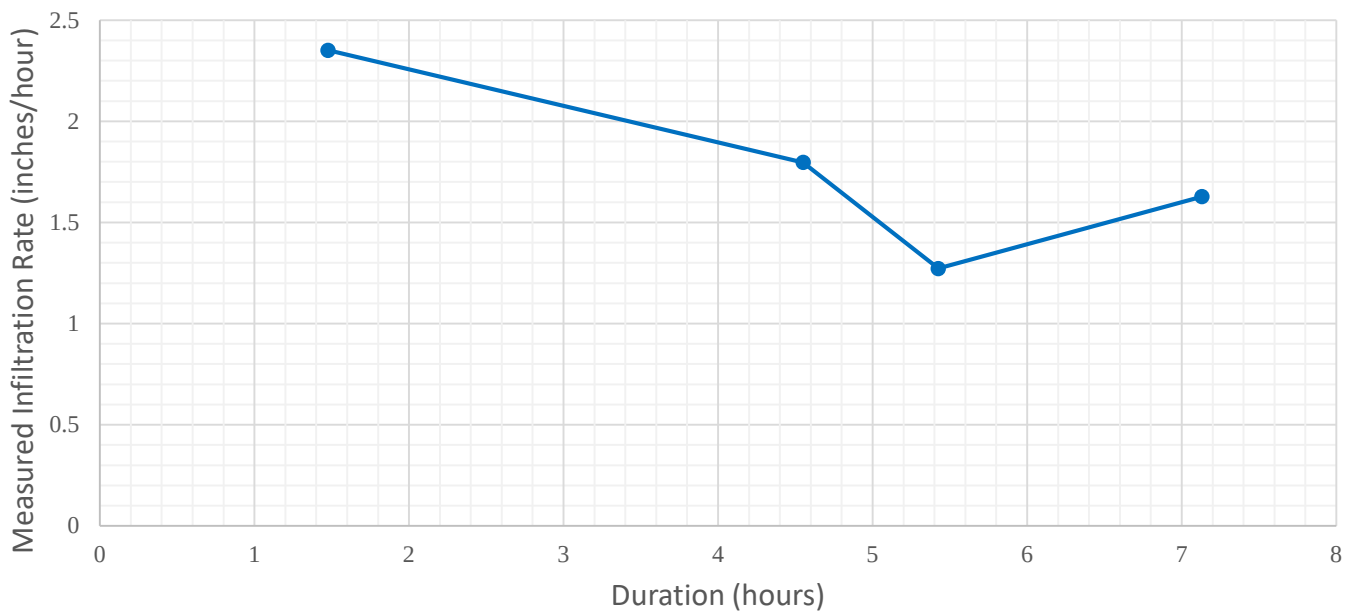


Figure 4

PIT-4 Measured Water Levels



PIT-4 Measured Infiltration Rate



PIT-4 Results

Ballou Junior High Expansion
Puyallup, Washington



Figure 5

APPENDIX A

Subsurface Explorations

APPENDIX A

SUBSURFACE EXPLORATIONS

General

Soil conditions at the project site were explored on July 1 and 2, 2019 by advancing 10 borings and on August 15 and 16, 2019 by excavating four test pits at the approximate locations shown on the Site Plan (Figure 2). The explorations were located in the field using a GPS device. The locations of the explorations shown on the Site Plan should be considered approximate.

Soil Borings

Soil borings were advanced to between 11.5 feet and 26.5 feet below ground surface (bgs) using a track-mounted hollow-stem auger drill rig. The explorations were continuously monitored by a representative from our firm who examined and classified the soil encountered, obtained representative soil samples, and maintained a detailed log of the explorations. Soil encountered in the borings was classified in general accordance with ASTM International (ASTM) D 2488 and the classification chart listed in Key to Exploration Logs, Figure A-1. Logs of the borings are presented in Figures A-2 through A-11. The logs are based on interpretation of the field and laboratory data and indicate the depth at which we interpret subsurface materials or their characteristics to change, although these changes might actually be gradual.

Soil samples were obtained from the borings at approximate 2.5 to 5-foot-depth intervals using either a 2-inch, outside-diameter, standard split-spoon sampler (Standard Penetration Test [SPT]) in general accordance with ASTM D 1586 or using a larger 2.4-inch diameter sampler. The samplers were driven into the soil using a 140-pound automatic hammer, free-falling 30 inches. The number of blows required to drive the samplers each of three, 6-inch increments of penetration were recorded in the field. The sum of the blow counts for the final 12 inches of penetration, unless otherwise noted, is reported on the boring logs.

Boring B-9 was completed as a monitoring well after installation. Other borings were backfilled by Holocene Drilling, Inc. under subcontract to GeoEngineers, Inc.

Test Pits

Test pit explorations were excavated using a rubber tired backhoe at the approximate locations shown on the Site Plan. The excavations were advanced to the intermediate depths shown on the exploration logs where the PITs were completed. After infiltration testing was complete, the excavations were continued to between 11.5 and 16 feet bgs. The explorations were continuously monitored by an engineer from our firm who examined and classified the soil encountered, obtained representative soil samples, and maintained a detailed log of the explorations. Logs of the test pits are presented in Figures A-12 through A-15. Soil generated during excavation was used to backfill the explorations.

SOIL CLASSIFICATION CHART

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

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

Sampler Symbol Descriptions

	2.4-inch I.D. split barrel
	Standard Penetration Test (SPT)
	Shelby tube
	Piston
	Direct-Push
	Bulk or grab
	Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS		TYPICAL DESCRIPTIONS
GRAPH	LETTER	
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/Quarry Spalls
	SOD	Sod/Forest Duff
	TS	Topsoil

Groundwater Contact



Measured groundwater level in exploration, well, or piezometer



Measured free product in well or piezometer

Graphic Log Contact



Distinct contact between soil strata



Approximate contact between soil strata

Material Description Contact



Contact between geologic units



Contact between soil of the same geologic unit

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PL	Point lead test
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

Key to Exploration Logs



Figure A-1

Drilled	Start 7/1/2019	End 7/1/2019	Total Depth (ft)	21.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger		
Surface Elevation (ft) Vertical Datum			470 NAVD88		Hammer Data			140 (lbs) / 30 (in) Drop			Drilling Equipment	D-50 Turbo Track Mounted
Easting (X) Northing (Y)			1193047 660855		System Datum			WA State Plane South NAD83 (feet)			See "Remarks" section for groundwater observed	
Notes:												

Elevation (feet)	Depth (feet)	FIELD DATA				Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
0											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-1

GEOENGINEERS 

Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-2
Sheet 1 of 1

Drilled	Start 7/3/2019	End 7/3/2019	Total Depth (ft)	21.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger
Surface Elevation (ft) Vertical Datum	470 NAVD88			Hammer Data	140 (lbs) / 30 (in) Drop			Drilling Equipment	D-50 Turbo Track Mounted	
Easting (X) Northing (Y)	1193196 660857			System Datum	WA State Plane South NAD83 (feet)			See "Remarks" section for groundwater observed		
Notes:										

Elevation (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
	0	6	15		1		SOD	Approximately 1 inch sod			
							SM	Brown silty fine to medium sand with gravel and organic matter (charcoal fragments) (medium dense, moist) (fill)			
	16	10			2 SA		SM	Brown-gray silty fine sand (medium dense, moist) (glacial outwash)	15	35	Occasional iron oxide staining
465	5	12	9		3			Grades to loose			
								Grades to medium dense, wet			Perched groundwater observed at 7½ feet during drilling
460	10	9	50/6"		5		SM	Gray silty fine to medium sand with gravel (very dense, moist) (glacial till)			Drill chatter 10 feet to bottom of boring
455	15	6	36		6			Grades to dense			
450	20	9	50/4"		7			Grades to very dense			Cobbles/gravel in cuttings

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-2



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-3
Sheet 1 of 1

Date: 7/22/19 Path: P:\2017\007\GINT\201700700.GPJ DBLibrary\Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEB_GEO TECH_STANDARD_%F_NO_GW

Drilled	Start 7/1/2019	End 7/1/2019	Total Depth (ft)	21.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger		
Surface Elevation (ft) Vertical Datum			460 NAVD88		Hammer Data			140 (lbs) / 30 (in) Drop		Drilling Equipment		D-50 Turbo Track Mounted
Easting (X) Northing (Y)			1193450 660739		System Datum			WA State Plane South NAD83 (feet)		See "Remarks" section for groundwater observed		
Notes:												

Elevation (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
	0	14	13		1		SOD	Approximately 4 inches sod			
							SM	Dark brown silty fine to medium sand with gravel (medium dense, moist) (fill)			
	1		2		2			Grades to very loose, wet			Perched water observed at 2½ feet at time of drilling. Debris in cuttings 2½ feet to 7 feet, plastic and duct tape, garbage, pea gravel
455	5	0	17		3			Grades to medium dense			No recovery in SPT. 2.4-inch sampler driven to collect soil sample
450	10	16	47		4		SM	Gray silty fine to medium sand with gravel (dense, dry) (glacial till)			Drill chatter at 7 feet
445	15	0	50/2"		5			Grades to very dense			No recovery
440	20	0	50/3"								No recovery

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-3



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-4
Sheet 1 of 1

Drilled	Start 7/1/2019	End 7/1/2019	Total Depth (ft)	21.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger
Surface Elevation (ft) Vertical Datum	470 NAVD88				Hammer Data	140 (lbs) / 30 (in) Drop			Drilling Equipment	D-50 Turbo Track Mounted
Easting (X) Northing (Y)	1193466 660846				System Datum	WA State Plane South NAD83 (feet)			See "Remarks" section for groundwater observed	
Notes:										

Elevation (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
465	0	14	11		1		SOD	Approximately 3 inches sod			
					2		SM	Dark brown silty fine sand with gravel and trace debris (plastic) (medium dense, moist) (fill)			
					3		SM	Brown silty fine to medium sand with gravel (medium dense, moist)			
460	4	3	3		3			Grades to very loose			
	5	12	2		4		SM	Light brown silty fine to medium sand with occasional gravel (very loose, moist)			
					5			Grades to loose			Pea gravel in cuttings
455	10	18	5		6		ML	Light brown sandy silt (medium stiff, wet) (glacial outwash)			Perched groundwater observed at 10 feet during drilling
					7		ML	Light brown silt with sand (medium stiff, wet)			
							SM	Brown-gray silty fine to medium sand with gravel (very dense, moist) (glacial till)			Drill chatter at approximately 12 feet bgs
450	15	6	57		8						
	20	12	51		9						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-4



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-5
Sheet 1 of 1

Drilled	Start 7/1/2019	End 7/1/2019	Total Depth (ft)	11.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger		
Surface Elevation (ft) Vertical Datum			470 NAVD88		Hammer Data			140 (lbs) / 30 (in) Drop		Drilling Equipment		D-50 Turbo Track Mounted
Easting (X) Northing (Y)			1193214 660748		System Datum			WA State Plane South NAD83 (feet)		Groundwater not observed at time of exploration		
Notes:												

Elevation (feet)	Depth (feet)	FIELD DATA				Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample						
465	0	12	9	1			SOD	Approximately 2 inches sod			Drill chatter at approximately 7 feet
				2			SM	Gray silty fine to coarse sand with gravel (loose, dry) (fill)			
							SM	Brown silty fine sand (loose, moist)			
		7	17	3			SM	Brown silty fine to coarse sand with gravel (medium dense, moist)			
	5	9	26	4			SM	Light brown to gray silty fine to coarse sand with gravel (medium dense, moist) (weathered till)			
		8	60	5			SM	Gray silty fine to medium sand with gravel (very dense, moist) (glacial till)			
460	10	12	57	6							

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-5



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-6
Sheet 1 of 1

Drilled	Start 7/1/2019	End 7/1/2019	Total Depth (ft)	11.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger	
Surface Elevation (ft) Vertical Datum	460 NAVD88			Hammer Data				140 (lbs) / 30 (in) Drop		Drilling Equipment	D-50 Turbo Track Mounted
Easting (X) Northing (Y)	1193178 660673			System Datum		WA State Plane South NAD83 (feet)			Groundwater not observed at time of exploration		
Notes:											

Elevation (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
455	0	9	14		1		SOD	Approximately 2 inches sod			Iron oxide staining
							SM	Brown silty fine sand with occasional gravel and organic matter (fine roots) (medium dense, moist) (fill)			
		8	2		2		SM	Brown to dark gray silty fine to coarse sand with occasional gravel (very loose, moist)			
								Grades to loose			
	5	12	5		3						
450							ML	Gray silt with sand (very stiff, moist) (glacial outwash)			
	10	12	44		5		SM	Gray silty fine to medium sand with gravel (dense, moist) (glacial till)			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-6



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-7
Sheet 1 of 1

Drilled	Start 7/1/2019	End 7/1/2019	Total Depth (ft)	11.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger	
Surface Elevation (ft) Vertical Datum	470 NAVD88			Hammer Data				140 (lbs) / 30 (in) Drop		Drilling Equipment	D-50 Turbo Track Mounted
Easting (X) Northing (Y)	1193179 661034			System Datum		WA State Plane South NAD83 (feet)				Groundwater not observed at time of exploration	
Notes:											

Elevation (feet)	FIELD DATA					Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing					
465	0	4	58		1	SOD	Approximately 2 inches sod			
						SM	Gray silty fine to medium sand with gravel (very dense, dry) (fill)			
		10	6		2	ML	Brown with iron oxide staining, sandy silt (medium stiff, moist) (glacial outwash)			
	5	12	6		3 SA, HA			29	69	Occasional 1/4-inch lenses of silty fine sand
		16	14		4	SM	Light brown silty fine sand with occasional gravel (medium dense, moist)			Occasional iron oxide staining
460	10	8	33		5	SM	Brown-gray silty fine sand (dense, moist)			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-7



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-8
Sheet 1 of 1

Drilled	Start 7/2/2019	End 7/2/2019	Total Depth (ft)	11.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger
Surface Elevation (ft) Vertical Datum	460 NAVD88				Hammer Data	140 (lbs) / 30 (in) Drop			Drilling Equipment	D-50 Turbo Track Mounted
Easting (X) Northing (Y)	1193013 660694				System Datum	WA State Plane South NAD83 (feet)			See "Remarks" section for groundwater observed	
Notes:										

Elevation (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
455	0	8	28		1		SOD	Approximately 2 inches sod			
							SM	Brown silty fine to medium sand with gravel, trace organic matter (fine roots and grass) (medium dense, moist) (fill)			
		6	8		2		ML	Brown-gray with orange staining silt with sand and occasional gravel (stiff, moist) (glacial outwash)			
	5	18	9		3 SA ₁₆ HA 4		SM	Brown silty fine to medium sand with gravel (loose, wet) (weathered till)	23	80	
		18	12		5		ML	Gray-brown sandy silt with gravel (stiff, moist)			
450	10	18	38		6		SM	Gray silty fine to coarse sand with gravel (dense, moist) (glacial till)			Occasional iron oxide staining

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

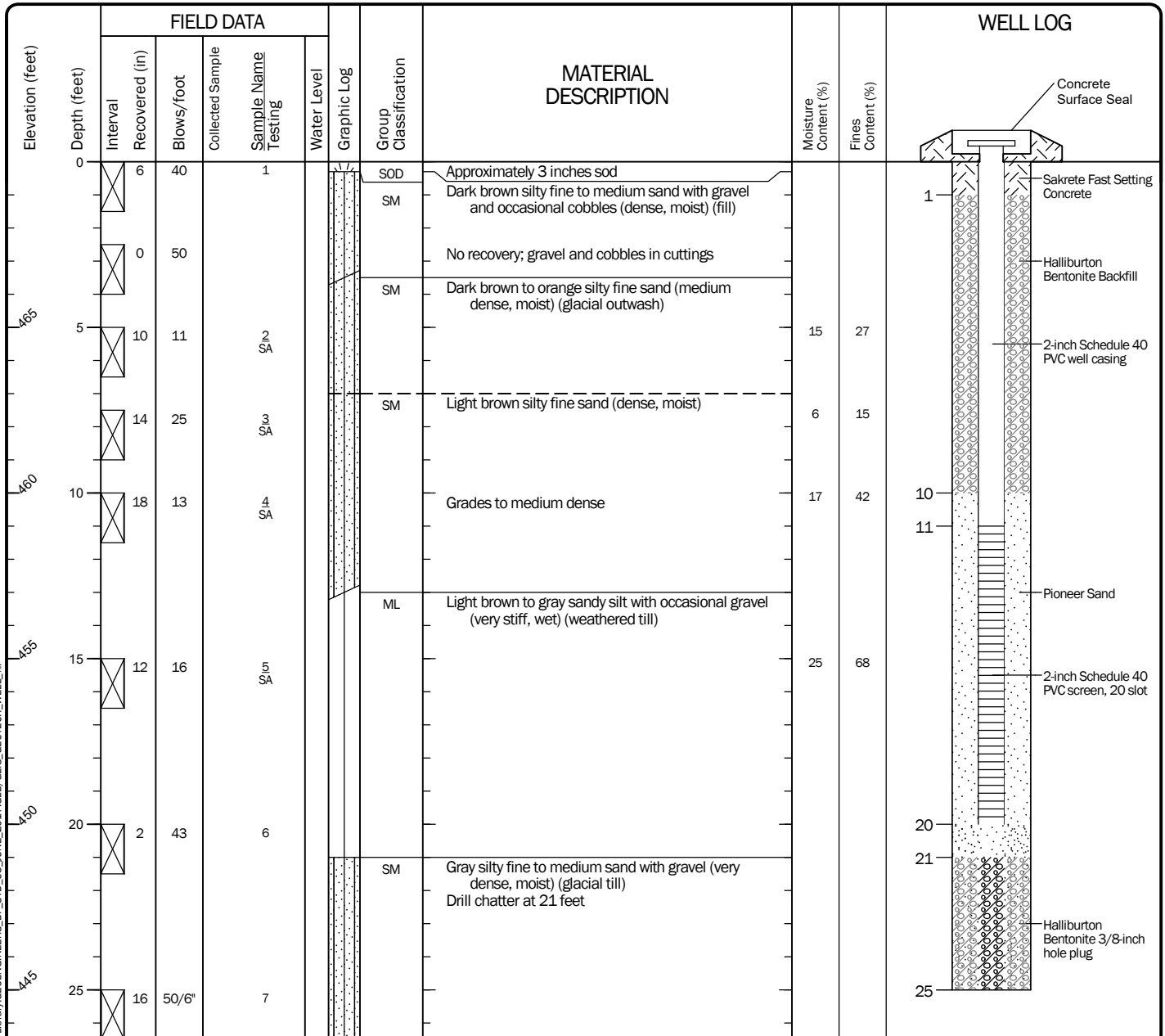
Log of Boring B-8



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-9
Sheet 1 of 1

Drilled	<u>Start</u> 7/2/2019	<u>End</u> 7/2/2019	Total Depth (ft)	26.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger	
Hammer Data	140 (lbs) / 30 (in) Drop				Drilling Equipment	D-50 Turbo Track Mounted		DOE Well I.D.: BLT 804 A 2-in well was installed on 7/2/2019 to a depth of 21 ft. Well was developed on 7/2/2019.			
Surface Elevation (ft) Vertical Datum	470 NAVD88				Top of Casing Elevation (ft)						
Easting (X) Northing (Y)	1192931 660761				Horizontal Datum	WA State Plane South NAD83 (feet)		<u>Groundwater</u> Date Measured	<u>Depth to</u> Water (ft)	<u>Elevation (ft)</u>	
									7/2/2019	15.00	455.00
Notes:											



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Monitoring Well B-9



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-10
Sheet 1 of 1

Drilled	Start 7/2/2019	End 7/2/2019	Total Depth (ft)	11.5	Logged By Checked By	CJL BEL	Driller	Holocene Drilling, Inc	Drilling Method	Hollow-stem Auger	
Surface Elevation (ft) Vertical Datum			470 NAVD88		Hammer Data			140 (lbs) / 30 (in) Drop		Drilling Equipment	D-50 Turbo Track Mounted
Easting (X) Northing (Y)			1192918 660872		System Datum		WA State Plane South NAD83 (feet)		Groundwater not observed at time of exploration		
Notes:											

Elevation (feet)	FIELD DATA					Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing						
465	0	10	25		1		SOD	Approximately 1 inch sod			Drill chatter between 2 and 3 feet Occasional iron oxide staining
							SM	Gray-brown silty fine to medium sand with gravel (medium dense, moist) (fill)			
	0		50/6"								
	5	0	24		2 SA		SM	Gray silty fine sand with gravel (medium dense, moist) (glacial outwash)	8	27	
460	15		9		3 SA; HA			Grades to loose	10	27	
	10	18	6		4						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of Boring B-10



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-11
Sheet 1 of 1

Date Excavated	8/15/2019	Total Depth (ft)	16	Logged By	CJL	Excavator	Kelly's Excavating	See "Remarks" section for groundwater observed Caving not observed	
				Checked By	BEL	Equipment	Komatsu Backhoe		
Surface Elevation (ft)	470	Vertical Datum		Easting (X)		1192920	Coordinate System		WA State Plane South
Vertical Datum	NAVD88			Northing (Y)		660719			

Elevation (feet)	Depth (feet)	SAMPLE		Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Testing Sample	Sample Name Testing						
469	1				SOD	4 inches sod			PIT completed at 3½ feet
468	2	1			SP-SM	Brown fine to coarse sand with silt and gravel and occasional cobbles (medium dense, moist) (fill)			
467	3								
466	4	2							
465	5								PIT completed at 3½ feet
464	6	3			SM	Light brown with orange silty fine sand (medium dense, moist) (outwash)	16	24	
463	7								
462	8	4					6	13	
461	9					Grades to brown			Slow perched groundwater seepage observed at 12½ feet
460	10								
459	11	5			ML	Light brown with orange mottled silt with sand (medium stiff, moist)			
458	12								
457	13	6			SM	Light gray silty fine to medium sand (medium dense, moist)	28	84	Slow perched groundwater seepage observed at 12½ feet
456	14								
455	15								
454	16	7			ML	Brown sandy silt (medium stiff, wet)			

Notes: See Figure A-1 for explanation of symbols.

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to ½ foot.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of PIT PIT-1



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-12
Sheet 1 of 1

Date: 9/5/19 Path: P:\2017007\GINT\2017007000.GPJ DBLibrary\Library\GEOENGINEERS_DF_STD_US_JUNE_2017\GLB\GER_TESTPIT_1P_GEODEC_9F

Date Excavated	8/15/2019	Total Depth (ft)	14	Logged By	CJL	Excavator	Kelly's Excavating	Groundwater not observed
				Checked By	BEL	Equipment	Komatsu Backhoe	Caving not observed
Surface Elevation (ft)	470	Easting (X)	1193013	Coordinate System	WA State Plane South			
Vertical Datum	NAVD88	Northing (Y)	660709	Horizontal Datum	NAD83 (feet)			

Elevation (feet)	Depth (feet)	SAMPLE		Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Testing Sample	Sample Name Testing						
469	1		1		SOD	2 inches sod			PIT completed at 3½ feet
468	2				SM	Brown silty fine sand with gravel and occasional cobbles (dense, dry) (fill)			
467	3				GP-GM	Brown-gray fine to coarse gravel with silt, sand and cobbles (dense, moist)			
466	4								
465	5		2						
464	6		3 SA		ML	Brown silt with sand and gravel (medium stiff, moist)	26	72	
463	7				SM	Brown silty fine sand (medium dense, moist) (outwash)			
462	8								
461	9		4 SA				14	35	
460	10								
459	11								
458	12								
457	13								
456	14		5						

Notes: See Figure A-1 for explanation of symbols.

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to ½ foot.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of PIT PIT-2



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-13
Sheet 1 of 1

Date: 9/5/19 Path: P:\2017007\GINT\2017007000.GPJ DBLibrary\Library\GEOENGINEERS_DF_STD_US_JUNE_2017\GLB\GERB_TESTPIT_1P_GEODEC_9F

Date Excavated	8/16/2019	Total Depth (ft)	13	Logged By	CJL	Excavator	Kelly's Excavating	See "Remarks" section for groundwater observed Caving not observed	
				Checked By	BEL	Equipment	Komatsu Backhoe		
Surface Elevation (ft)	460	Vertical Datum		Easting (X)		1193019	Coordinate System		WA State Plane South
	NAVD88			Northing (Y)		660822			

Elevation (feet)	Depth (feet)	SAMPLE		Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Testing Sample	Sample Name Testing						
459	1	1			SOD	4 inches sod			PIT completed at 2½ feet Concrete 12-inch diameter storm line at 3 feet bgs Moderate groundwater seepage observed at 5 feet
458	2	2			SP-SM	Brown fine to medium sand with silt and gravel (very dense, dry) (fill)			
457	3	3			GP-GM	Gray/brown gravel with sand and silt (very dense, dry)			
456	4	4			ML	Grades to with cobbles Gray silt with sand with iron oxide staining (medium stiff, moist)			
455	5								
454	6	5			SM	Grades to very stiff Gray silty fine to medium sand with gravel (very dense, moist) (glacial till)			
453	7								
452	8								
451	9								
450	10								
449	11								
448	12								
447	13	6							

Notes: See Figure A-1 for explanation of symbols.

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to ½ foot.
 Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of PIT PIT-3



Project: Ballou Junior High Expansion
 Project Location: Puyallup, Washington
 Project Number: 2017-007-00

Figure A-14
 Sheet 1 of 1

Date Excavated	8/16/2019	Total Depth (ft)	11.5	Logged By	CJL	Excavator	Kelly's Excavating	Groundwater not observed
				Checked By	BEL	Equipment	Komatsu Backhoe	Caving not observed
Surface Elevation (ft)	460	Easting (X)	1193202	Coordinate System	WA State Plane South			
Vertical Datum	NAVD88	Northing (Y)	660731	Horizontal Datum	NAD83 (feet)			

Elevation (feet)	Depth (feet)	SAMPLE		Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Testing Sample	Sample Name Testing						
459	1				SOD	4 inches sod			
458	2		1		SM	Light brown silty fine to medium sand with occasional gravel (medium dense, moist) (fill)			
457	3		2						
456	4		3		SM	Brown with orange staining silty fine to medium sand (loose, moist) (outwash)	19	54	PIT completed at 4 feet
455	5		4		SM	Light brown silty fine sand (stiff, moist)			
454	6		5		SM	Gray silty fine to coarse sand with gravel and occasional cobbles (very dense, moist) (glacial till)	41	32	Iron oxide staining
453	7								
452	8								
451	9								
450	10		6						
449	11								

Notes: See Figure A-1 for explanation of symbols.

The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to ½ foot.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Google Earth.

Log of PIT PIT-4



Project: Ballou Junior High Expansion
Project Location: Puyallup, Washington
Project Number: 2017-007-00

Figure A-15
Sheet 1 of 1

APPENDIX B

Laboratory Testing

APPENDIX B

LABORATORY TESTING

General

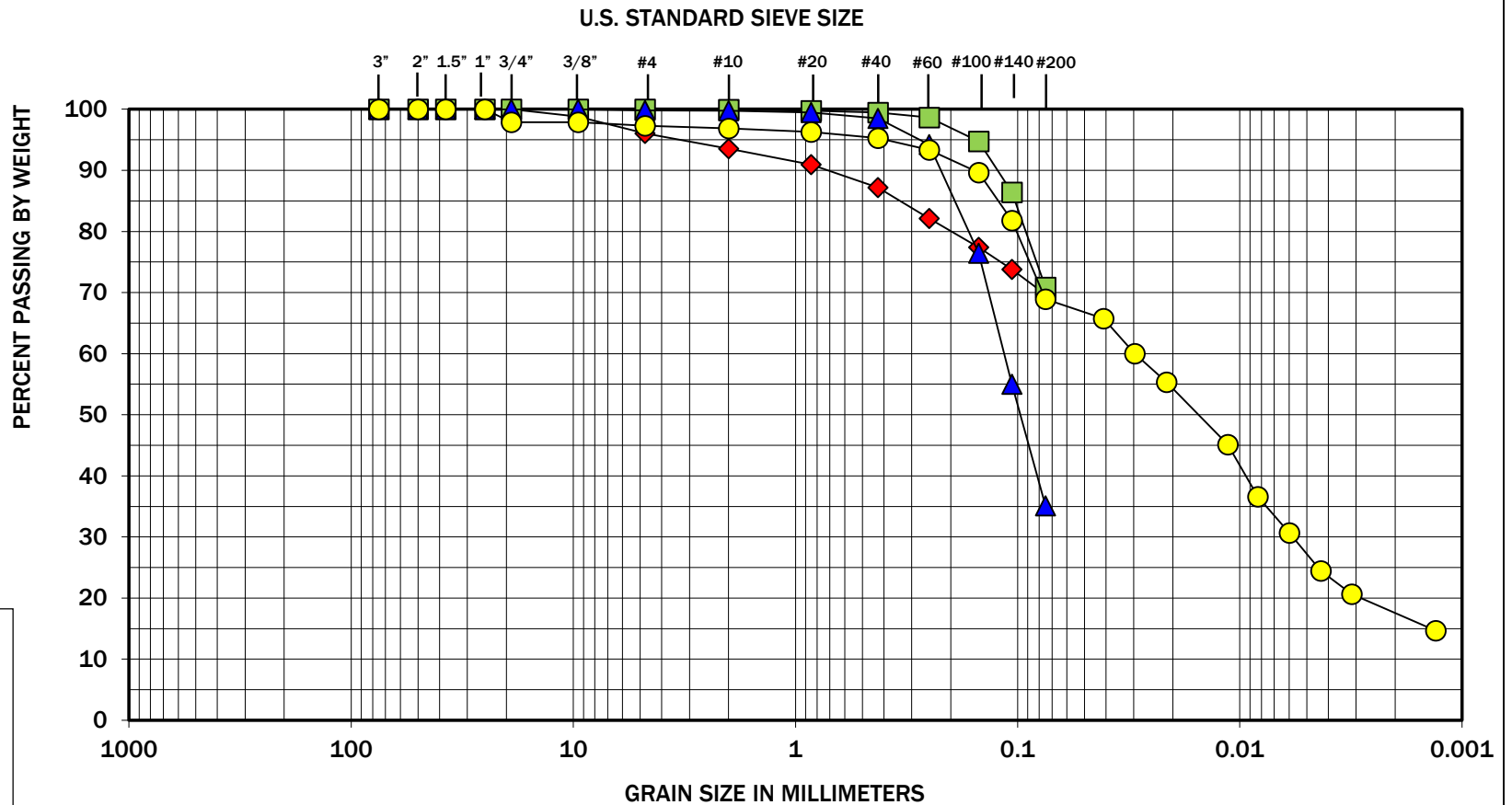
Soil samples obtained from the borings were returned to our laboratory for further examination and testing. Our laboratory testing program consisted of grain-size distribution analyses and hydrometer analyses.

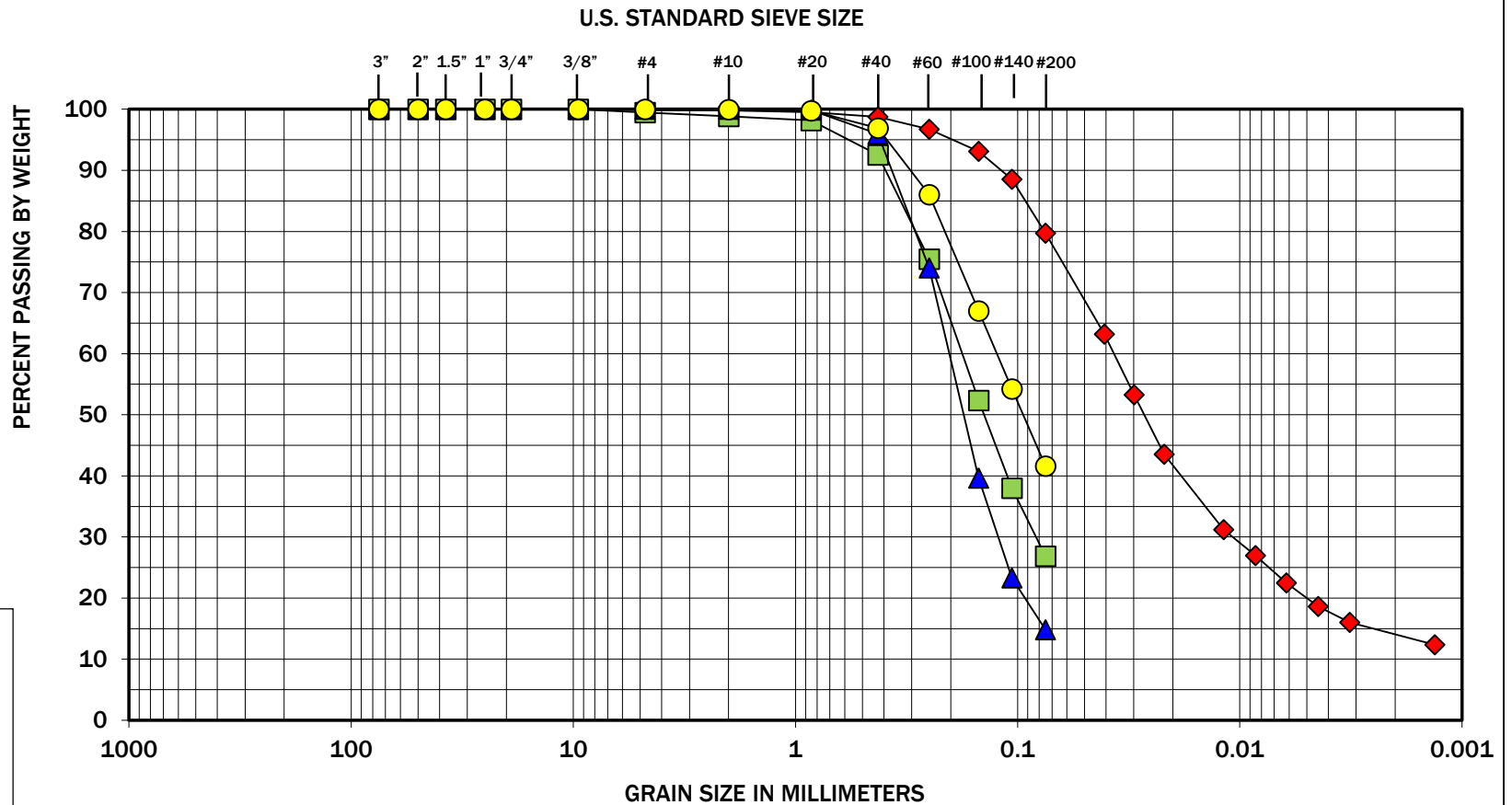
Grain-Size Analysis

Grain-size analyses were performed on selected soil samples in general accordance with ASTM Test Method D 6913. This test provides a quantitative determination of the distribution of particle sizes in soils. Figures B-1 through B-5 present the results of the grain-size analyses.

Hydrometer Analysis (HA)

Hydrometer analyses were performed on selected samples in general accordance with ASTM Test Method D 7928. This test method covers the quantitative determination of the distribution of particle sizes in soils. Typically, the distribution of particle sizes smaller than 75 μm is determined by a sedimentation process using a hydrometer. The hydrometer analysis alone determines the distribution of particle sizes smaller than 2 millimeters (mm). Figures B-1 through B-5 present the results of the hydrometer analyses.





COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Laboratory Soil Description
◆	B8	5	23	Silt with sand (ML)
■	B9	5	15	Silty fine sand (SM)
▲	B9	7.5	6	Silty fine sand (SM)
●	B9	10	17	Silty fine sand (SM)



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The grain size analysis results were obtained in general accordance with ASTM D 6913 and ASTM D 7928. GeoEngineers 17425 NE Union Hill Road Ste 250, Redmond, WA 98052

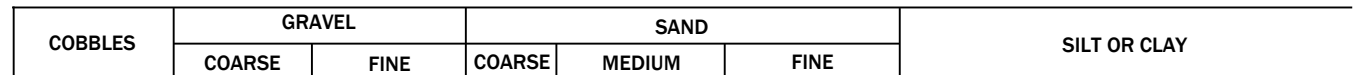
GEOENGINEERS



Figure B-2

Ballou Junior High Expansion
Puyallup, Washington

Sieve/Hydrometer Analysis Results

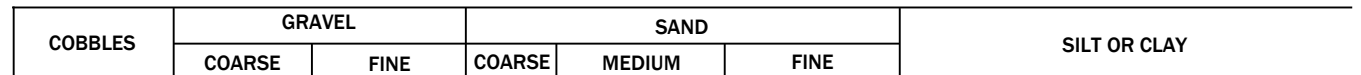


Symbol	Boring Number	Depth (feet)	Moisture (%)	Laboratory Soil Description
◆	B9	15	25	Sandy silt with occasional gravel (ML)
■	B10	5	8	Silty fine sand with gravel (SM)
▲	B10	7.5	10	Silty fine sand (SM)



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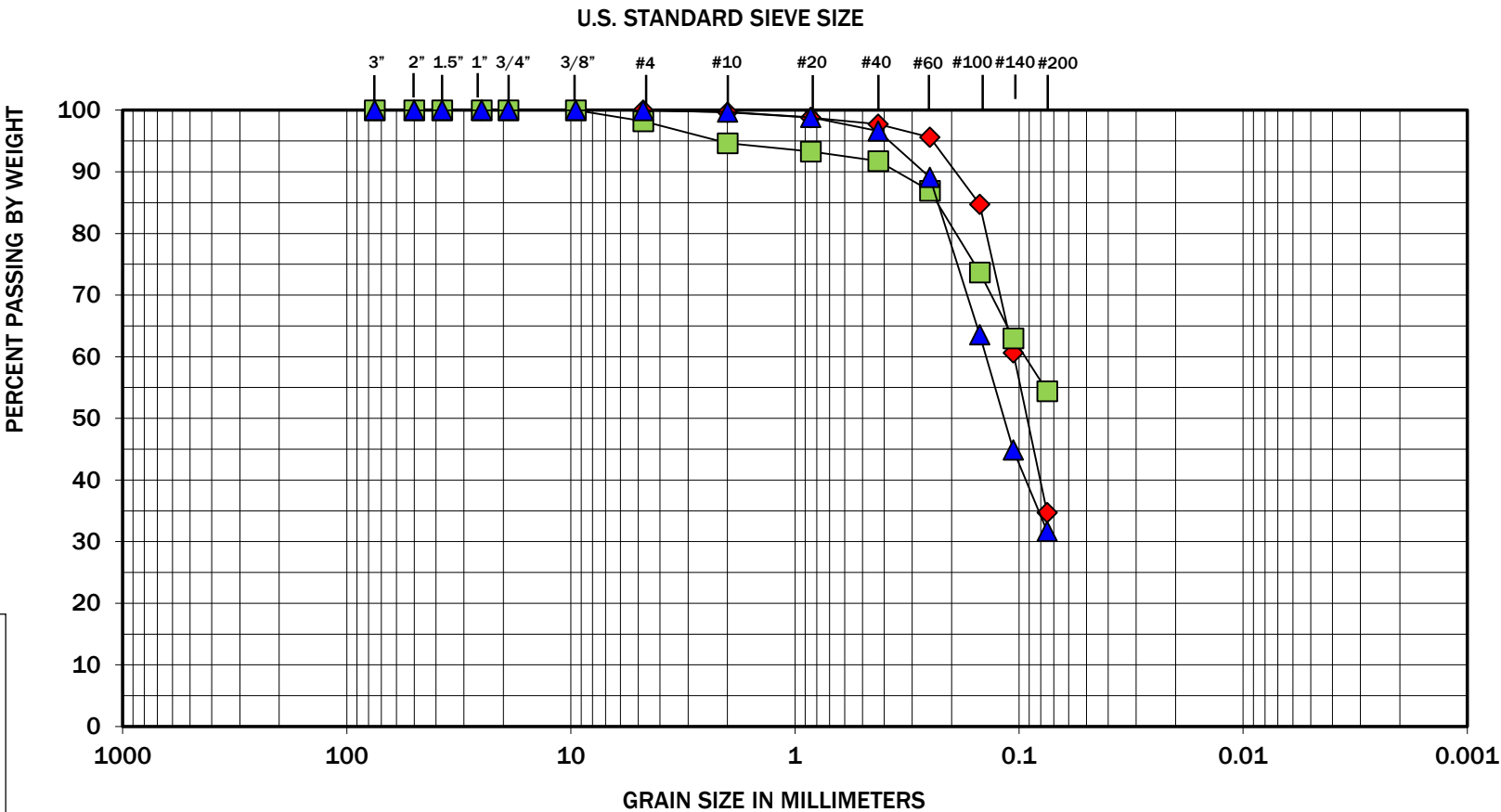
The grain size analysis results were obtained in general accordance with ASTM D 6913 and ASTM D 7928. GeoEngineers 17425 NE Union Hill Road Ste 250, Redmond, WA 98052



Symbol	PIT Number	Depth (feet)	Moisture (%)	Laboratory Soil Description
	PIT-1	6	16	Silty fine sand (SM)
	PIT-1	8	6	Silty fine sand (SM)
	PIT-1	10.5	28	Silt with sand (ML)
	PIT-2	5.5	26	Silt with sand (ML)

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The grain size analysis results were obtained in general accordance with ASTM D 6913 and ASTM D 7928. GeoEngineers 17425 NE Union Hill Road Ste 250, Redmond, WA 98052



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	PIT Number	Depth (feet)	Moisture (%)	Laboratory Soil Description
◆	PIT-2	9	14	Silty fine sand (SM)
■	PIT-4	4	19	Sandy silt (ML)
▲	PIT-4	6	23	Silty fine sand (SM)

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The grain size analysis results were obtained in general accordance with ASTM D 6913 and ASTM D 7928. GeoEngineers 17425 NE Union Hill Road Ste 250, Redmond, WA 98052



APPENDIX C

Report Limitations and Guidelines for Use

APPENDIX C

REPORT LIMITATIONS AND GUIDELINES FOR USE¹

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory “limitations” provisions in its reports. Please confer with GeoEngineers if you need to know more how these “Report Limitations and Guidelines for Use” apply to your project or site.

Geotechnical Services are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the Puyallup School District and for the Project(s) specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with the Puyallup School District dated June 3, 2019 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is based on a Unique Set of Project-Specific Factors

This report has been prepared for Ballou Junior High School in Puyallup, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

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

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;

¹ Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

- composition of the design team; or
- project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Environmental Concerns are Not Covered

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

Information Provided by Others

GeoEngineers has relied upon certain data or information provided or compiled by others in the performance of our services. Although we use sources that we reasonably believe to be trustworthy, GeoEngineers cannot warrant or guarantee the accuracy or completeness of information provided or compiled by others.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations are Not Final

We have developed the following recommendations based on data gathered from subsurface investigation(s). These investigations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be

finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.