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Subsurface Exploration and
Geotechnical Engineering Evaluation

HUNT ELEMENTARY SCHOOL ADDITION

Pierce County, Washington

Prepared For:

PUYALLUP SCHOOL DISTRICT

Project No. TE160563A
December 2, 2016

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Puyallup School District
323 - 12th Street NW
Puyallup, Washington 98371

Attention: Les Gerstmann

Subject: Subsurface Exploration and Geotechnical Engineering Evaluation
Hunt Elementary School Addition
12801 - 144th Street East
Pierce County, Washington

Dear Mr. Gerstmann:

Associated Earth Sciences, Inc. (AESI) is pleased to submit this report describing our subsurface exploration and geotechnical engineering evaluation concerning the planned building addition and related improvements at Hunt Elementary School in Pierce County, Washington. Our services were completed in general accordance with our proposal dated October 24, 2016, and were authorized by your *Agreement for Consulting Services* executed on November 9, 2016, and your Purchase Order No. CP2012 dated November 21, 2016.

We have enjoyed working with you on this study and are confident that the recommendations presented in this report will aid in the successful completion of your project. If you should have any questions, or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Tacoma, Washington

James M. Brisbine, P.E., L.G., L.E.G.
Senior Associate Geotechnical Engineer

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SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING EVALUATION

HUNT ELEMENTARY SCHOOL ADDITION

Pierce County, Washington

Prepared for:
Puyallup School District
323 - 12th Street NW
Puyallup, Washington 98371

Prepared by:
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1.0 PROJECT AND SITE DESCRIPTION

The project site comprises an existing elementary school campus located in the South Hill area of Pierce County, as shown on the attached "Vicinity Map" (Figure 1). This campus is visually delineated by residential properties on the west, by undeveloped grassland on the north, by forested property on the east, and by 144th Street East on the south. It has roughly rectangular shape that measures approximately 600 feet by 800 feet overall and covers about 10 acres. Presently, the campus is occupied by a school building, several portable buildings, playgrounds, parking lots, and playfields. Our attached "Site and Exploration Plan" (Figure 2) illustrates the existing school building and immediately adjacent features.

Improvement plans call for constructing a 12-room addition immediately north of the existing school building. This addition will be a single-story, at-grade structure measuring approximately 100 feet by 200 feet in plan view. We assume that it will utilize either framed or masonry walls that impose low to moderate foundation loads. Other site improvements will include new permeable surfaced playgrounds and walkways in areas to the north, south, and west of the new addition. We understand that some combination of flexible and rigid surface permeable materials will be used, depending on the location and the subsurface conditions. Figure 2 shows the proposed addition footprint and permeable pavement areas. Conventional (impermeable) pavements might also be used in some areas of the site.

2.0 PURPOSE AND SCOPE

Associated Earth Sciences, Inc. (AESI) performed this study to characterize subsurface conditions below the site, such that we can derive geotechnical conclusions and recommendations concerning geologic hazards, site preparation, building foundations, floor slabs, retaining walls, drainage systems, permeable and impermeable pavements, and structural fill. Our scope of work included the following tasks.

- Reviewed topographic maps, geologic maps, site layout drawings, aerial photos, and other available information pertaining to the site vicinity.
- Performed a visual surface reconnaissance of the site and immediate surroundings.
- Advanced five exploration borings (designated EB-1 through EB-5) to a maximum depth of about 26½ feet, at strategic locations across the site.
- Visually classified all soil samples obtained from our explorations.
- Conducted three laboratory grain-size (sieve) tests on representative samples of the near-surface soils.
- Analyzed all research, field, and laboratory data in context with the proposed site development features.

- Prepared this report summarizing our geotechnical findings, conclusions, and recommendations.

Figure 2 shows the locations of all subsurface explorations with respect to existing and proposed site features. Appendix A contains our exploration logs, and Appendix B contains our laboratory testing results.

3.0 FIELD EXPLORATION PROCEDURES

We explored subsurface conditions at the site on November 11, 2016. The number, locations, and depths of our explorations were completed within the constraints of surface access, utility conflicts, and project budgets. Our exploration procedures are described below. The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix A. Soil contact depths shown on the logs should be regarded as only an approximation; the actual changes between sediment types are often gradational and/or undulating.

The conclusions and recommendations presented in this report are based, in part, on conditions encountered by our explorations completed for this study. Due to the nature of subsurface exploratory work, it is necessary to interpolate and extrapolate soil conditions between and beyond the field explorations. Differing subsurface conditions could be present outside the area of the explorations due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of any variations between the field explorations might not become fully evident until construction. If variations are observed at that time, it could be necessary to modify specific conclusions or recommendations in this report.

3.1 Exploration Borings

All exploration borings were performed by Holocene Drilling, Inc., working under subcontract to AESI. Each boring was completed by advancing an 8-inch outside-diameter, hollow-stem auger with a truck-mounted drill rig. During the drilling process, disturbed but representative soil samples were obtained at 2½- or 5-foot-depth intervals using the Standard Penetration Test (SPT) procedure in accordance with the *American Society for Testing and Materials* (ASTM D-1586). Within proposed new pavement areas, soil samples were obtained at 1½-foot-depth intervals using a larger split-spoon for improved sample recovery. After completion of drilling, each borehole was backfilled with bentonite chips, and the surface was patched with concrete.

The SPT testing and sampling procedure consists of driving a standard, 2-inch outside-diameter, split-barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free-falling a distance of 30 inches. The number of blows for each 6-inch interval is recorded, and the number of blows required to drive the sampler the final 12 inches represents the Standard

Penetration Resistance (also known as the "N-value"). If a total of 50 blows is reached within one 6-inch interval, the N-value is recorded as 50 blows for the corresponding number of inches of penetration. The N-value provides a measure of the relative density of granular soils or the relative consistency of cohesive soils. Higher N-values correspond to a denser or stiffer soil. Our measured N-values are plotted on the exploration boring logs presented in Appendix A.

All exploration borings were continuously observed and logged by an AESI geologist. The samples obtained from the split-barrel sampler were classified in the field, and representative portions were placed in watertight containers. The samples were then transported to our laboratory for further visual classification. Soil descriptions shown on our exploration logs are based on N-values, drilling action, field observations, and laboratory classifications.

4.0 SITE CONDITIONS

The following text sections describe current site conditions, including existing site development, regional and local topography, regional geology, local soils, and local ground water. Our sources of information include topographic and geologic maps published by the U.S. Geological Survey (USGS).

4.1 Existing Site Development

Presently, the eastern portion of the campus is occupied by a main school building, several portable buildings, blacktop playgrounds, and a parking lot, whereas the western portion is occupied by grassy playfields. The main school building's foundation appears to be adequately supported; we did not observe any obvious indications of settlement, such as cracking, tilting, or warping in the exterior walls. However, we did observe numerous cracks and irregularities in the paved playground closely northwest of the school building. Apparently, the subgrade in this area has settled several inches since paving was completed.

It should be noted that a large portion of the subgrade below the main school building was overexcavated prior to construction circa 1990. According to an earthwork plan (dated January 4, 1990) prepared by Sitts & Hill Engineers, this overexcavation encompassed all but the easternmost edge of the building footprint, and it extended downward as much as 6 feet below then-existing ground surface (corresponding to a depth of about 10 feet below the building's finished-floor grade). Presumably, the overexcavation was needed to remove unsuitable native soils and replace them with structural fill for bearing purposes. It does not appear that any overexcavation was performed below the proposed building addition footprint or adjacent playground areas.

4.2 Regional and Local Topography

The project site is located near the eastern edge of a broad topographic plateau that abuts the Puyallup River valley. Regional surface grades across this plateau are moderately undulating and hummocky, which is typical for a post-glacial landscape. Local surface grades across the site vicinity are fairly flat, with a gentle slope downward to the northwest. McMillan Reservoir lies about 300 yards northeast of the site. The average ground surface elevation at the site is approximately 580 feet (USGS datum).

4.3 Regional Geology

The 2006 draft *Geologic Map of the Puyallup 7.5-Minute Quadrangle* (1:24,000 scale) indicates that the entire project site vicinity is underlain by a Vashon-age glacial ice-contact deposit. This type of deposit normally comprises a mixture of glacial outwash, lacustrine (lake) sediments, and/or glacial till. Texturally, it tends to contain variable amounts of silt, sand, gravel, and cobbles. Densities are typically moderate, and thicknesses can range from several feet to several tens of feet. Ice-contact deposits are often overlain by recessional outwash and/or underlain by lodgement till.

4.4 Local Soils

Our subsurface explorations confirmed the presence of glacial deposits at the site, as shown on the regional geology map. However, these glacial soils appear to be mantled by fill soils in all locations that we explored. The following paragraphs describe our stratigraphic observations, and the exploration logs contained in Appendix A provide additional subsurface information.

Surficial Fill: All five of our exploration borings disclosed a surficial layer that appeared to be fill soils (possibly reworked native soils). This surficial fill variously consisted of dark brown to gray-brown, silty, fine to medium sands with smaller amounts of gravel and an abundance of rootlets and other organic matter. Densities were generally medium dense, with some zones of loose or dense soils. We observed a total thickness of about 3½ feet to 8 feet in borings EB-1, EB-2, and EB-3, but the fill extended beyond the termination depths of EB-4 and EB-5. This fill layer was likely placed during the original school construction.

Outwash and Ice-Contact Deposits: Below the surficial fill layer, exploration borings EB-2 and EB-3 revealed a deposit of loose to medium dense, silty, fine to medium sand with small amounts of gravel, as well as trace amounts of roots and organic matter. These sediments appear to be either recessional outwash or ice-contact material. The layer thickness was observed to be about 8½ feet in EB-2.

Lodgement Till: Our two deepest exploration borings, EB-1 and EB-2, disclosed a deposit of silty sands with some gravel, at depths of about 8 feet and 12½ feet, respectively. We interpret this soil to be glacial lodgement till. Densities were very high, except for an upper layer of medium dense soil that appears to be a weathered zone. The till extended beyond the termination depths of both borings.

4.5 Local Ground Water

None of our exploration borings encountered a true ground water table, but boring EB-2 revealed a perched water atop the lodgement till horizon at a depth of 16 feet. We anticipate that perched water could develop atop this horizon in other site locations later in the wet season. At any time of year, ground water levels could fluctuate due to changes in precipitation patterns, off-site development, and other factors.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on our surface reconnaissance, subsurface explorations, and document research, we conclude that the proposed site improvements are feasible from a geotechnical standpoint, contingent on proper design implementation and construction practices. Our geotechnical conclusions and recommendations concerning general considerations, site preparations, excavations, foundations, slab-on-grade floors, drainage systems, retaining walls, pavement sections, and structural fill are presented herein.

Specification Codes: The following reference documents are cited for specification purposes within subsequent report sections.

- ASTM: Refers to the latest manual published by the *American Society for Testing and Materials* (ASTM).
- WSDOT: Refers to the 2014 edition of *Standard Specifications for Road, Bridge, and Municipal Construction* published by the Washington State Department of Transportation (WSDOT).

5.1 General Considerations

We offer the following comments, conclusions, and recommendations concerning general geotechnical design issues affecting the overall project.

Geological Hazards: Our evaluation did not reveal any geological hazards associated with steep slopes, erosion zones, landslide zones, or abandoned landfills in the site vicinity. In addition, we infer that the dense glacial deposits underlying the site represent a negligible hazard with respect to seismically induced liquefaction. Earthquake activity is obviously a widespread hazard throughout Western Washington, but the risk of associated shaking and ground rupture does not appear to be any higher at this site than elsewhere in the region. Consequently, the proposed site development is not constrained by any prevailing geological hazards, in our opinion.

Foundation Support: Our subsurface explorations encountered loose to medium dense, organic-containing soils (representing a combination of fill and native deposits) mantling the proposed building addition footprint. In our opinion, these soils are not suitable for support of the new addition and are likely associated with the unsuitable soils that were previously overexcavated from the existing school building footprint. Consequently, remedial measures will be needed in order to provide adequate foundation support for the new addition.

Earthwork Scheduling: Our explorations indicate that the on-site soils generally have a moderately high silt content. These existing soils are moisture-sensitive and highly susceptible to disturbance when wet. As such, we expect that most of the on-site soils will be difficult to reuse during periods of wet weather. Earthwork should be scheduled for the dry season in order to maximize the potential for reusing on-site soils. Greater export and import quantities should be expected during the wet season.

Seismic Site Class: The 2015 *International Building Code* (IBC) assigns a seismic Site Class on the basis of geological conditions prevailing within a depth of 100 feet below the local ground surface. Although our subsurface explorations did not extend to such a depth, we infer from shallower soil observations and from available geologic maps that the subsurface conditions correspond to Site Class “C” as defined by the IBC.

Shallow Infiltration Potential: The fill soils mantling the proposed new permeable pavement areas were observed to possess a fairly wide range of densities and textures, and the underlying soils consist of relatively impermeable lodgement till in most areas. Given these shallow conditions, we infer that vertical infiltration of stormwater below the permeable pavements will be restricted and unreliable; any stormwater that does infiltrate into the subgrade soils will tend to migrate laterally through the fill as interflow water. We therefore recommend that all permeable pavement sections be designed for detention purposes, with an adequate thickness of reservoir base rock to provide temporary storage. Collector drains should be installed along the edges of permeable pavements to convey stored water away from building areas and discharge it at suitable locations.

Intermediate-Depth Infiltration Potential: The lodgement till underlying the site typically has a very low permeability due to its high density, low porosity, and high content of fine-grained material. Consequently, the site does not appear suitable for intermediate-depth infiltration systems such as trenches and ponds.

Deep Infiltration Potential: In certain situations, deep Underground Injection Control (UIC) wells can be used to access suitable infiltration receptor soils (typically advance outwash) located below the relatively impervious lodgement till deposit. UIC wells require that an adequate thickness of unsaturated sands or gravels exist below the lodgement till. However, Pierce County currently does not allow the use of UIC wells even when suitable conditions are present.

5.2 Site Preparation

Preparation of the project site will involve tasks such as temporary drainage, stripping, cutting, erosion control, and subgrade compaction. The paragraphs below present our geotechnical comments and recommendations concerning these various site issues.

Temporary Drainage: Any sources of surface or near-surface water that could potentially enter the construction zones should be intercepted and diverted before stripping and excavating activities begin. We tentatively anticipate that a system of temporary swales or berms placed around the construction zone will adequately intercept most off-site surface water runoff. Because the selection of an appropriate drainage system will depend on the water quantity, season, weather conditions, construction sequence, and contractor's methods, final decisions regarding temporary drainage details are best made in the field at the time of construction.

Clearing and Stripping: After surface and near-surface water sources have been controlled, the construction zones should be cleared and stripped of all existing vegetation, sod, topsoil, pavements, and other surface features. Our exploration borings disclosed about 6 to 12 inches of sod and organic topsoil mantling landscaped or undeveloped areas, and about 1½ inches of asphaltic pavement in the blacktop playground. However, the actual thicknesses could vary considerably from one location to another.

Weather Considerations: It should be realized that if the stripping or grading operations proceed during wet weather, greater stripping depths will likely be necessary to remove moisture-sensitive subgrade soil areas that become saturated and disturbed. For this reason, site earthwork should be avoided during periods of wet weather. During the summer months, sprinkling will likely be needed to moisture-condition soils that have become too dry.

Erosion Control Measures: Because stripped surfaces and soil stockpiles are typically a source of runoff sediments, they should be given particular attention. If earthwork occurs during wet weather, we recommend that all stripped surfaces be covered with straw to reduce runoff erosion. Similarly, soil stockpiles and cut slopes should be covered with plastic sheeting for erosion protection. We also recommend that silt fences, berms, and/or swales be maintained around stripped areas and stockpiles in order to capture runoff water and thereby reduce the downslope sediment transport. Stripped areas should be revegetated as soon as possible, also reducing the potential for erosion.

5.3 Building Foundations

The loose to medium dense, organic-containing fill soils underlying the proposed building addition footprint are not well-suited for conventional spread footings, due to the risk of unpredictable and excessive long-term settlements. In our opinion, however, spread footings could be used in conjunction with compacted aggregate piers to provide foundation support. We offer the following comments and recommendations concerning the design and construction of spread footings and aggregate piers.

Footing Depths and Widths: For frost and erosion protection, the bottoms of all exterior footings should bear at least 18 inches below adjacent outside grades, whereas the bottoms of interior footings need bear only 12 inches below the surrounding slab or crawl-space level. To reduce post-construction settlements, continuous (wall) and isolated (column) footings should be at least 18 and 24 inches wide, respectively. It should be noted, however, that greater depths or widths might be needed for other reasons, as determined by the project structural engineer.

Aggregate Piers: We recommend that all new building footings bear on an array of compacted aggregate piers. "Geopier" is a tradename for the most common type of aggregate pier, but other types might be locally available. Regardless of type, we recommend that all aggregate piers extend at least 1 foot into the lodgement till deposit, which we observed at depths of about 8 feet and 12½ feet below the eastern and western ends of the addition footprint, respectively. Due to the proprietary nature of aggregate piers, the specialty contractor should be responsible for determining the spacing, diameters, materials, and other details needed to achieve the allowable bearing capacities stated below for the new footings.

Bearing Capacities: Assuming that aggregate piers are installed as described above, we recommend that all footings be designed for the following maximum allowable bearing capacities. These allowable capacities are stated in pounds per square foot (psf), and they incorporate static and transient (wind or seismic) safety factors of at least 2.0 and 1.5, respectively.

Static Allowable Bearing Capacity:	3,000 psf
Transient Allowable Bearing Capacity:	4,000 psf

Footing Settlements: We estimate that total post-construction settlements of properly designed footings bearing on properly installed aggregate piers will not exceed 1 inch. Differential settlements between new foundation elements over horizontal spans on the order of 50 feet could approach ¾ inch. In all cases, these settlements would be reduced if the actual design bearing pressures are lower than our recommended maximum allowable pressures.

Footing and Stemwall Backfill: To provide erosion protection and lateral load resistance, we recommend that backfill be placed on both sides of the footings and stemwalls after the concrete has cured. Either on-site or imported granular soils can be used for this purpose. All footing and stemwall backfill soil should be compacted to a uniform density of at least 90 percent (based on ASTM D-1557).

Lateral Resistance: Footings and stemwalls that have been properly backfilled as described above will resist lateral loads by means of both passive earth pressure and base friction. We recommend using the following allowable values. These earth pressures are stated in pounds per cubic foot (pcf), and they incorporate static and transient (wind or seismic) safety factors of at least 1.5 and 1.1, respectively. Allowable base friction, which includes a safety factor of 1.5, can be combined with the respective passive pressure to resist static and transient loads.

Allowable Static Passive Pressure:	300 pcf
Allowable Transient Passive Pressure:	400 pcf
Base Friction Coefficient:	0.35

Subgrade Verification and Construction Monitoring: Footings should never be cast atop loose, soft, organic, or frozen soil, slough, debris, uncontrolled fill, or surfaces covered by standing water. We recommend that the condition of all subgrades be verified by an AESI representative before any concrete is placed. If aggregate piers are used, we should be retained to monitor the installation process.

5.4 Slab-On-Grade Floors

Because floor slabs typically carry a light load in comparison to building foundations, they allow more latitude concerning support options. However, special bearing provisions will be needed to control long-term settlements and reduce the risk of associated warping or cracking. We offer the following comments and recommendations for slab-on-grade floors.

Floor Sections: A conventional slab-on-grade floor section typically comprises a reinforced concrete slab over a vapor retarder over an aggregate base course over a granular subbase course. Assuming that the slab has a conventional thickness on the order of 4 inches and is subjected to typical loads, we recommend the following underslab layers (top to bottom) and minimum thicknesses for floors in the new building addition.

Vapor Retarder:	10 mils
Base Course:	4 inches
Subbase Course:	12 inches

Subgrade Preparation: After the floor footprint has been excavated as needed to accommodate the above-recommended floor section, the exposed subgrade should be compacted to a firm and unyielding condition using a heavy vibratory roller. Any localized zones of soft, organic-rich, or saturated soils revealed during compaction should be overexcavated and replaced with granular structural fill. Next, we recommend that the entire floor subgrade be covered with a woven separation geotextile, such as Mirafi 500X or equivalent.

Subbase Course: A subbase course helps to provide more-uniform structural support for a floor slab, thereby reducing long-term differential settlements. For the subbase, we recommend using a well-graded sand and gravel, such as “Ballast” per WSDOT 9-03.9(1) or “Gravel Borrow” per WSDOT 9-03.14. Other acceptable options include 2-inch-minus angular rock (commonly called “railroad ballast”) and crushed recycled concrete. In all cases, the subbase should be compacted with a vibratory roller to achieve a uniform density equivalent to at least 90 percent of the maximum dry density (based on ASTM D-1557).

Base Course: The base course serves as both a capillary break layer and a leveling layer for the floor slab. Ideally, the base course would consist of clean, uniform, well-rounded gravel, such as $^5/_8$-inch or $^7/_8$-inch washed rock. It would also be acceptable to use a washed, angular gravel or crushed rock for this purpose. In all cases, the base course should be compacted with a vibratory roller or sled to create a firm, smooth surface.

Vapor Retarder: A vapor retarder consists of heavy-duty plastic sheeting that is placed between the base course and floor slab. In our opinion, a vapor retarder provides a significant benefit by reducing the amount of ground moisture that penetrates the floor slab. We recommend that a vapor retarder be installed beneath all floor areas that will be covered by carpet, wood, tile, or any other moisture-sensitive materials. The vapor retarder should be selected on the basis of allowable vapor transmission rates for the planned floor finish materials, and should be installed in strict accordance with the manufacturer’s guidelines.

Floor Settlements: If the subgrade and underslab layers are properly constructed, we estimate that total post-construction static settlements of the slab-on-grade floor will not exceed 1 inch under conventional loading conditions. Differential settlements across the length or width of the floor could approach one-half of the actual total settlement.

Subgrade Verification and Construction Monitoring: Floor slab sections should never be placed atop loose, soft, organic-rich, or frozen soil, slough, debris, or surfaces covered by standing water. We recommend that an AESI representative be allowed to monitor all floor slab construction to verify suitable conditions. Our monitoring services would include probings of subgrade soils, observation and testing of underslab fill layers, and a check of layer thicknesses.

5.5 Drainage Systems

In order to reduce the risk of future moisture problems, the new building addition should be provided with a permanent drainage system. We offer the following recommendations and comments regarding various drainage elements and related features.

Foundation Drains: We recommend that the new addition be encircled with a perimeter foundation drain to collect exterior seepage water. This drain should consist of a 4-inch-diameter, rigid, perforated pipe within an envelope of pea gravel or washed rock, extending at least 6 inches on all sides of the pipe. The gravel envelope should be wrapped with filter fabric (such as Mirafi 140N) to reduce the migration of fines from the surrounding soils. Ideally, the drain invert would be installed no more than 8 inches above or below the base of the perimeter footings.

Subfloor Drains: Based on the soil and ground water conditions observed in our site explorations, we currently do not infer a need for drains beneath the floor slabs if the foundation drains are properly installed. However, the final decision regarding the need for subfloor drains should be made at the time of construction, after the floor subgrade has been exposed and the foundation walls have been cast.

Runoff Water: Roof downspouts, parking lot drains, and drains from any other runoff surfaces should not be tied into the perforated piping system of the foundation drain. Instead, the runoff water collected from such sources should be routed through a separate tightline piping system. Also, final site grades should be sloped so that surface water flows away from the building rather than ponding near the foundation walls.

5.6 Backfilled Retaining Walls

We anticipate that backfilled concrete retaining walls might be used in the new construction. Furthermore, any subsurface vault walls should also be designed as backfilled retaining walls. Our design and construction recommendations for new backfilled retaining walls are presented below.

Wall Foundations: To avoid excessive differential settlement of any new retaining wall, it should be supported on non-organic native soils or on compacted aggregate piers in accordance with our recommendations presented in the "Building Foundations" section of this report. The allowable static and transient bearing capacities presented in that text section would apply to the wall footings.

Static Lateral Earth Pressures: Yielding (cantilever) walls that are allowed to deflect more than 0.005 times the wall height should be designed to withstand an appropriate static *active* lateral earth pressure. Non-yielding (restrained) walls that are allowed to deflect less than 0.005 times the wall height should be designed to withstand an appropriate static *at-rest* lateral earth pressure. These pressures act over the entire back of the wall and vary with the backslope inclination. For retaining walls with a level or 2H:1V backslope and well-drained conditions, we recommend using the following values, which are given in pounds per cubic foot (pcf) of equivalent fluid pressure.

Static Active Earth Pressure with Level Backslope:	35 pcf
Static Active Earth Pressure with 2H:1V Backslope:	50 pcf
Static At-Rest Earth Pressure with Level Backslope:	55 pcf
Static At-Rest Earth Pressure with 2H:1V Backslope:	80 pcf

Static Lateral Surcharge Pressures: Any backslope load located within a 45-degree plane projected upward from the wall base will apply a lateral surcharge on the wall. Possible sources of surcharge loading include parking lots, traffic lanes, and structure footings. These surcharge pressures act over the portion of wall adjacent to the load source. For distributed vertical loads, active and at-rest static lateral surcharge pressures can be approximated by multiplying the vertical pressure "Q" (in psf) by the appropriate coefficient shown below. We recommend using a vertical pressure of 250 psf to model traffic and parking loads behind the wall.

Static Active Surcharge Pressure: 0.30(Q) psf
Static At-Rest Surcharge Pressure: 0.45(Q) psf

Seismic Lateral Surcharge Pressures: The total static pressures acting on a wall should be increased to account for seismic surcharge loadings resulting from lateral earthquake motions. These surcharge pressures act over the entire back of the wall and vary with the backslope inclination, the seismic acceleration, and the wall height. For retaining walls with a level backslope, active and at-rest seismic lateral surcharge pressures can be approximated by multiplying the wall height "H" (in feet) by the appropriate coefficient shown below.

Seismic Active Surcharge Pressure: 8(H) psf
Seismic At-Rest Surcharge Pressure: 12(H) psf

Curtain Drains: A curtain drain is a vertical layer of drainage material placed against the back of a wall to dissipate hydrostatic pressures. We recommend that a curtain of washed gravel be used behind all walls. This curtain drain should extend outward at least 12 inches from the wall and should extend upward nearly to the ground surface. The backslope directly above this drain should be capped with asphalt or concrete or a layer of low-permeability soil.

Heel Drains: A heel drain is a horizontal drainage element placed behind the rearward projection (heel) of a wall foundation to collect water from the curtain drain. We recommend that a heel drain be included behind the subject wall. The heel drain should comprise a 4-inch-diameter perforated pipe surrounded by at least 6 inches of washed gravel, all wrapped with filter fabric (such as Mirafi 140N). The drainpipe should then be connected to a tightline discharge pipe that routes water to an appropriate location.

Backfill Soil: We recommend that all backfill placed behind the curtain drain consist of granular structural fill. Suitable materials include imported, well-graded sand and gravel, such as "Ballast" per WSDOT 9-03.9(1) or "Gravel Borrow" per WSDOT 9-03.14. If the backfill soil contains more than 10 percent fines, a layer of filter fabric (such as Mirafi 140N) should be placed between the curtain drain and backfill.

Backfill Compaction: Because soil compactors place significant lateral pressures on walls, we recommend that only small, hand-operated compaction equipment be used within 3 feet of a wall. Also, the soil within 3 feet should be compacted to a density as close as possible to

90 percent of the maximum dry density (based on ASTM D-1557). A greater degree of compaction closely behind the wall would increase the lateral earth pressure, whereas a lesser degree of compaction might lead to excessive post-construction settlements. Structural backfill placed more than 3 feet behind the wall should be compacted to a density of at least 95 percent.

Construction Monitoring: We recommend that an AESI representative be allowed to monitor all retaining wall construction. Our monitoring services would include verification of foundation systems, observation of drainage components, and testing of backfill compaction.

5.7 Conventional Pavement Sections

We understand that conventional (impermeable) flexible (asphalt concrete) pavements might be used in new car parking areas and driveways, whereas conventional rigid (cement concrete) pavements might be used for the bus loop and/or certain other locations. The following comments and recommendations are given for conventional pavement design and construction purposes.

Soil Design Values: Soil conditions can be defined by a California Bearing Ratio (CBR), which quantitatively predicts the effects of wheel loads imposed on a saturated subgrade. Although our scope of work did not include a CBR test on the surficial site soils, we infer from our observations and limited textural testing that a CBR value on the order of 5 to 8 would likely be appropriate for pavement design purposes. This value corresponds to a subgrade modulus of about 100 to 200 pounds per cubic inch (pci).

Traffic Design Values: Traffic conditions can be defined by a Traffic Index (TI), which quantifies the combined effects of projected car and truck traffic. Although no specific traffic data was available at the time of our analysis, we estimate that a TI of 3.0 to 4.0 would likely be appropriate for the car parking areas. A higher TI of about 5.0 to 6.0 appears appropriate for driveways and other areas that are occasionally or periodically subjected to school buses, delivery trucks, or similar vehicles.

Flexible Pavement Sections: A flexible pavement section typically comprises an asphalt concrete pavement (ACP) over a crushed aggregate base (CAB) over a granular subbase (GSB). Our recommended minimum thicknesses for flexible pavement sections, which are based on the aforementioned design values and a 20-year lifespan, are shown below.

Car Parking Lots and Playgrounds

Asphalt Concrete Pavement (ACP):	2½ inches
Crushed Aggregate Base Course (CAB):	3 inches
Granular Subbase Course (GSB):	6 inches

Bus Loops and Access Driveways

Asphalt Concrete Pavement (ACP):	4 inches
Crushed Aggregate Base Course (CAB):	4 inches
Granular Subbase Course (GSB):	10 inches

Rigid Pavement Sections: A rigid pavement section typically comprises a cement concrete pavement (CCP) over a CAB over a GSB. We recommend the following minimum thicknesses for a rigid pavement section that is subjected to school buses and occasional delivery trucks. Pavements and slabs that are subjected to frequent truck traffic or to other heavy structural loads would require a special design.

Bus Loops and Access Driveways

Cement Concrete Pavement (CCP):	7 inches
Crushed Aggregate Base Course (CAB):	2 inches
Granular Subbase Course (GSB):	8 inches

Subgrade Preparation: All pavement subgrades should be compacted to a firm and unyielding condition before any pavement layers are placed. We recommend using a heavy vibratory-drum roller for granular (sand and gravel) subgrades. The resulting subgrade condition should then be verified by proof-rolling with a loaded dump truck or other heavy construction vehicle, in the presence of an AESI representative. Any localized zones of soft, organic-rich, or debris-laden soils disclosed during proof-rolling should be overexcavated and replaced with compacted structural fill.

Granular Subbase: A GSB helps to provide more-uniform structural support for a pavement section. For the subject site, we recommend using an imported, well-graded sand and gravel, such as “Ballast” per WSDOT 9-03.9(1) or “Gravel Borrow” per WSDOT 9-03.14. It would also be acceptable to use a crushed recycled concrete, provided that it meets the same general textural criteria as the aforementioned WSDOT materials. In all cases, the GSB should be vibratory-compacted to at least 95 percent based on the modified Proctor maximum dry density (per ASTM D-1557).

Crushed Aggregate Base: We recommend that all CAB material conform to the criteria for “Crushed Surfacing Base Course” or “Crushed Surfacing Top Course” per WSDOT 9-03.9(3). In the interest of using recycled materials from on-site or off-site sources, it would be acceptable to substitute up to 20 percent of the CAB with crushed cement concrete, provided that the final mixture meets the same grain-size criteria as the aforementioned WSDOT material. Regardless of composition, all CAB material should be compacted to at least 95 percent based on the modified Proctor maximum dry density (per ASTM D-1557).

Asphalt Concrete Pavement: We recommend that the ACP aggregate gradation conform to the control points for a ½-inch mix (per WSDOT 9-03.8(6)) and that the binder conform to Performance Grade 64-22 criteria (per WSDOT 9-02.1(4)). We also recommend that the ACP be compacted to a target average density of 92 percent, with no individual locations compacted to less than 90 percent nor more than 96 percent, based on the Rice theoretical maximum density for that material (per ASTM D-2041).

Cement Concrete Pavement: We recommend that the CCP consist of Portland cement concrete with a minimum compressive strength of 4,000 pounds per square inch (psi) and a minimum rupture modulus of 500. We also recommend that the concrete be reinforced with a welded wire mesh, such as W2-6x6, positioned at a one-third depth within the CCP layer.

Pavement Life and Maintenance: It should be realized that conventional asphaltic pavements are not maintenance-free. The foregoing pavement sections represent our minimum recommendations for an average level of performance during a 20-year design life; therefore, an average level of maintenance will likely be required. Furthermore, a 20-year pavement life typically assumes that an overlay will be placed after about 10 years. Thicker asphalt, base, and subbase courses would offer better long-term performance, but would cost more initially; thinner courses would be more susceptible to "alligator" cracking and other failure modes. As such, pavement design can be considered a compromise between a high initial cost and low maintenance costs versus a low initial cost and higher maintenance costs.

5.8 Permeable Pavement Sections

We understand that permeable flexible (asphalt concrete) pavements might be used for new playgrounds and/or parking areas, whereas permeable rigid (cement concrete) pavements might be used for certain other locations. Our geotechnical comments and recommendations concerning permeable pavements are presented in the following paragraphs.

Design Values: For design of permeable flexible and rigid pavement sections, we have assumed the same soil and traffic design values discussed in the "Conventional Pavement Sections" portion of this report. It should be noted that driveways are assumed to be subjected to school buses or delivery trucks, but not garbage trucks.

Permeable Pavement Layers: A permeable pavement section typically comprises a porous asphalt concrete pavement (PACP) or pervious cement concrete pavement (PCCP) over an aggregate drainage base (ADB). In some situations, an aggregate choker base (ACC) is placed between the pavement and base courses, but we regard this as an optional item to be used at the discretion of the civil engineer or paving contractor. Our recommended minimum layer thicknesses for various on-site uses are shown below.

Playgrounds and Car Parking Lots - Flexible Section

Pervious Asphalt Concrete Pavement (PACP):	3 inches
Aggregate Drainage Base (ADB):	8 inches

Car and Truck Driveways - Flexible Section

Pervious Asphalt Concrete Pavement (PACP):	5 inches
Aggregate Drainage Base (ADB):	12 inches

Car and Truck Driveways - Rigid Section
Pervious Cement Concrete Pavement (PCCP): 7 inches
Aggregate Drainage Base (ADB): 10 inches

Subgrade Preparation: All pervious pavement subgrades should be lightly compacted to achieve a firm condition. However, excessive compaction should be avoided because it can reduce the infiltration characteristics of the subgrade soils. After compaction, the surface should be hand-raked or gently scarified to eliminate any “soil skin” that has formed.

Filter Fabric: If the subgrade consists of silt or clay soils, we recommend that a layer of non-woven filter fabric (such as Mirafi 140N) be placed between the prepared subgrade and the ADB layer. This fabric will help prevent migration of native soils into the ADB gravel.

Aggregate Drainage Base: The ADB serves as both a reservoir and discharge layer for storm water. As such, the actual thickness might need to be increased beyond our recommended minimum if greater storage capacity is required. Regardless of thickness, we recommend using an imported, uniform, coarse, angular gravel meeting the specifications of “Permeable Ballast” per WSDOT 9-03.9(2) or “No. 3 Stone” per ASTM C-33. The ADB material should be lightly compacted to achieve a reasonably firm and stable condition, but excessive compaction should be avoided.

Aggregate Choker Course: Because the ADB consists of a moderately large-grained material, some contractors prefer to cover it with a choker course to serve as a leveling layer. Where a choker course is desired, we recommend using 2 inches of imported, uniform, medium-grained, angular gravel meeting the specifications of “No. 57 Stone” per ASTM C-33. The choker course should be lightly compacted to achieve a reasonably firm, smooth, and stable condition, but excessive compaction should be avoided.

Porous Asphalt Concrete Pavement: We recommend that PACP use an aggregate consisting of uniform, small- to medium-grained, crushed gravel meeting the specifications of “No. 8 Stone” per ASTM C-33. The binder should conform to PG 70-22 criteria and should be placed at a ratio of 5.75 to 6.00 percent by weight. We also recommend that the PACP be compacted to a firm condition by means of approximately two passes with a heavy vibratory roller. Excessive compaction should be avoided. Ultimately, the finished PACP should provide a minimum infiltration rate of 200 inches per hour (in/hr).

Pervious Cement Concrete Pavement: We recommend that PCCP use an aggregate consisting of uniform, small- to medium-grained, crushed gravel meeting the specifications of “No. 8 Stone” per ASTM C-33. Typically, the concrete paste is a six-sack mix with a water/cement ratio in the range of 0.27 to 0.35. Ultimately, the finished PCCP should provide a minimum compressive strength of 2,000 psi, and a minimum infiltration rate of 200 in/hr.

Pavement Life and Maintenance: It should be realized that all permeable pavements require routine maintenance to maintain their permeability. The entire surface should be vacuum swept at least once per year under normal conditions; if the pavement is exposed to dirt, excessive traffic, or turbid water, then vacuum sweeping should be performed more frequently. In addition, routine structural maintenance, such as patching, will likely be required over the 20-year pavement life.

5.9 Structural Fill

The term *structural fill* refers to any materials placed under foundations, retaining walls, slab-on-grade floors, sidewalks, pavements, and other such features. Our comments, conclusions, and recommendations concerning structural fill are presented in the following paragraphs.

Soil Moisture Considerations: The suitability of soils used for structural fill depends primarily on their grain-size distribution and moisture content when they are placed. As the fines content (that soil fraction passing the U.S. No. 200 Sieve) increases, soils become more sensitive to small changes in moisture content. Soils containing more than about 5 percent fines (by weight) cannot be consistently compacted to a firm, unyielding condition when the moisture content is more than 2 percentage points above or below optimum.

Structural Fill Materials: For general use, a well-graded mixture of sand and gravel with a low fines content (commonly called "gravel borrow" or "pit-run") provides an economical structural fill material. For specialized applications, it may be necessary to use a highly processed material such as crushed rock, quarry spalls, clean sand, granulithic gravel, pea gravel, drain rock, controlled-density fill (CDF), or lean-mix concrete (LMC). Recycled asphalt or concrete, which are derived from pulverizing the parent materials, are also potentially useful as structural fill in certain applications. Soils used for structural fill should not contain any organic matter, debris, environmental contaminants, or individual particles greater than about 6 inches in diameter.

On-Site Soils: Because only minor grading appears necessary at the site, it is expected that relatively small quantities of on-site native soils will be generated during earthwork activities. Most of these on-site soils will likely consist of silty sands with variable amounts of organic matter. We anticipate that much of the organic-containing soils will not be suitable for reuse as structural fill. Non-organic silty sands can likely be reused as structural fill during the summer months, but these soils will be difficult to reuse during the wet season or during isolated periods of rainy weather.

Fill Placement and Compaction: Structural fill materials should be placed in horizontal lifts not exceeding about 12 inches in loose thickness. Unless stated otherwise in this report, we recommend that each lift then be thoroughly compacted with a mechanical compactor to a uniform density of at least 95 percent, based on the modified Proctor maximum dry density (per ASTM D-1557). Compaction is not necessary for certain structural fill materials, such as pea gravel, drain rock, quarry spalls, CDF, and LMC.

Subgrade Verification and Compaction Testing: Regardless of material or location, all structural fill should be placed over firm, unyielding subgrades prepared in accordance with our various recommendations for site preparation. The condition of all subgrades should be verified by an AESI representative before soil or concrete placement begins. Also, fill soil compaction should be verified by means of in-place density testing, hand-probing, proof-rolling, or other appropriate methods performed during fill placement so that the adequacy of soil compaction efforts may be evaluated as earthwork progresses.

6.0 CLOSURE

AESI has prepared this report for the exclusive use of our client and their agents, for specific application to this project. Within the limitations of scope and schedule, our services have been performed in accordance with generally accepted local geotechnical engineering practices in effect at the time our report was prepared. No other warranty, express or implied, is made.

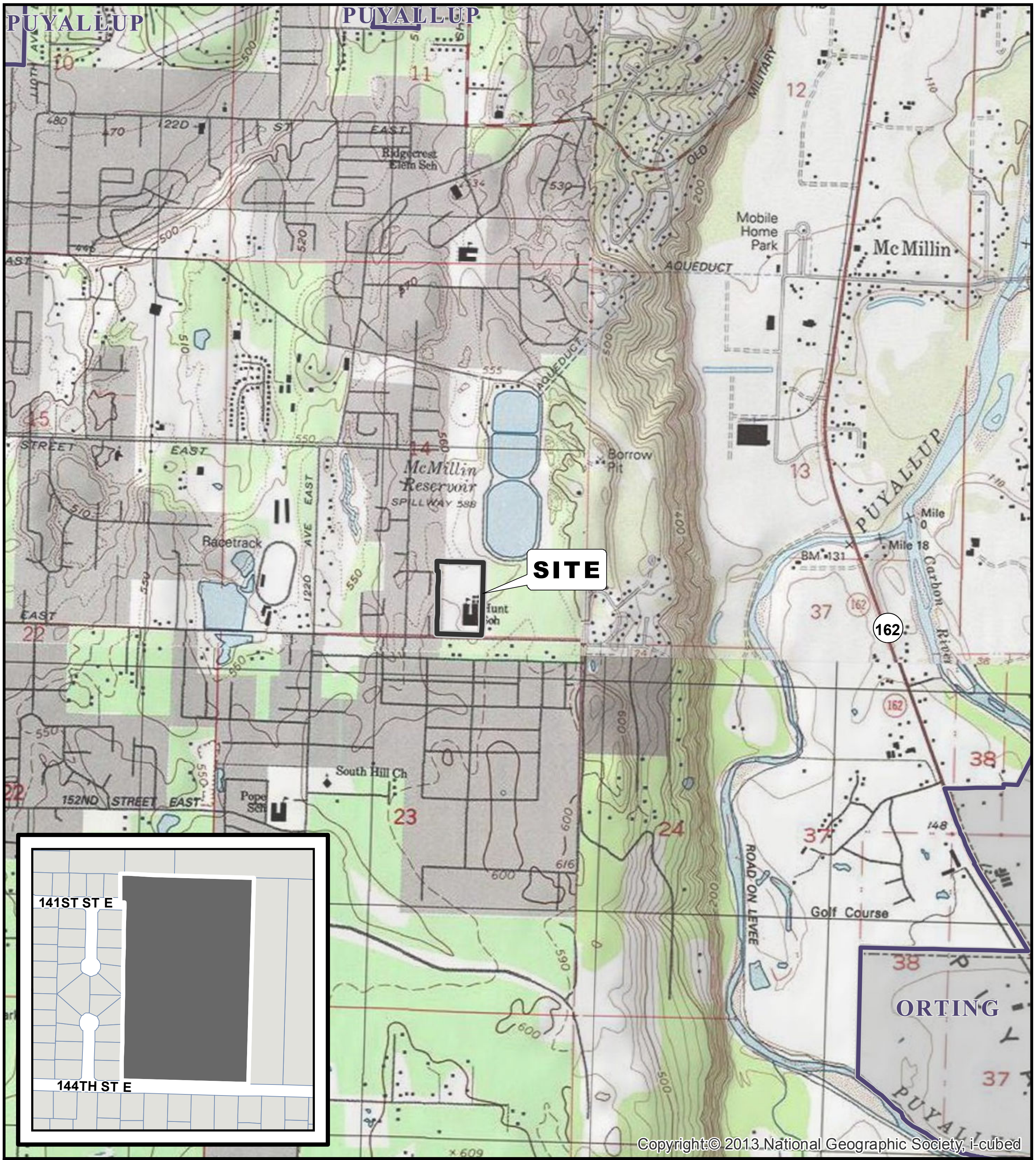
We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this report or other geotechnical aspects of the project, please call us at your earliest convenience.

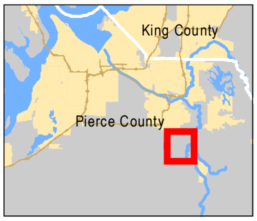
Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Tacoma, Washington

30284
12-2-16

James M. Brisbine, P.E., L.G., L.E.G.
Senior Associate Geotechnical Engineer

Matthew A. Miller, P.E.
Principal Engineer





DATA SOURCES / REFERENCES:
USGS: 24K SERIES TOPOGRAPHIC MAPS
PIERCE CO: STREETS, CITY LIMITS, PARCELS 05/16

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 1000 2000
FEET

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

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VICINITY MAP

HUNT ELEMENTARY SCHOOL ADDITION
PIERCE COUNTY, WASHINGTON

PROJ NO.	DATE:	FIGURE:
TE160563A	11/16	1

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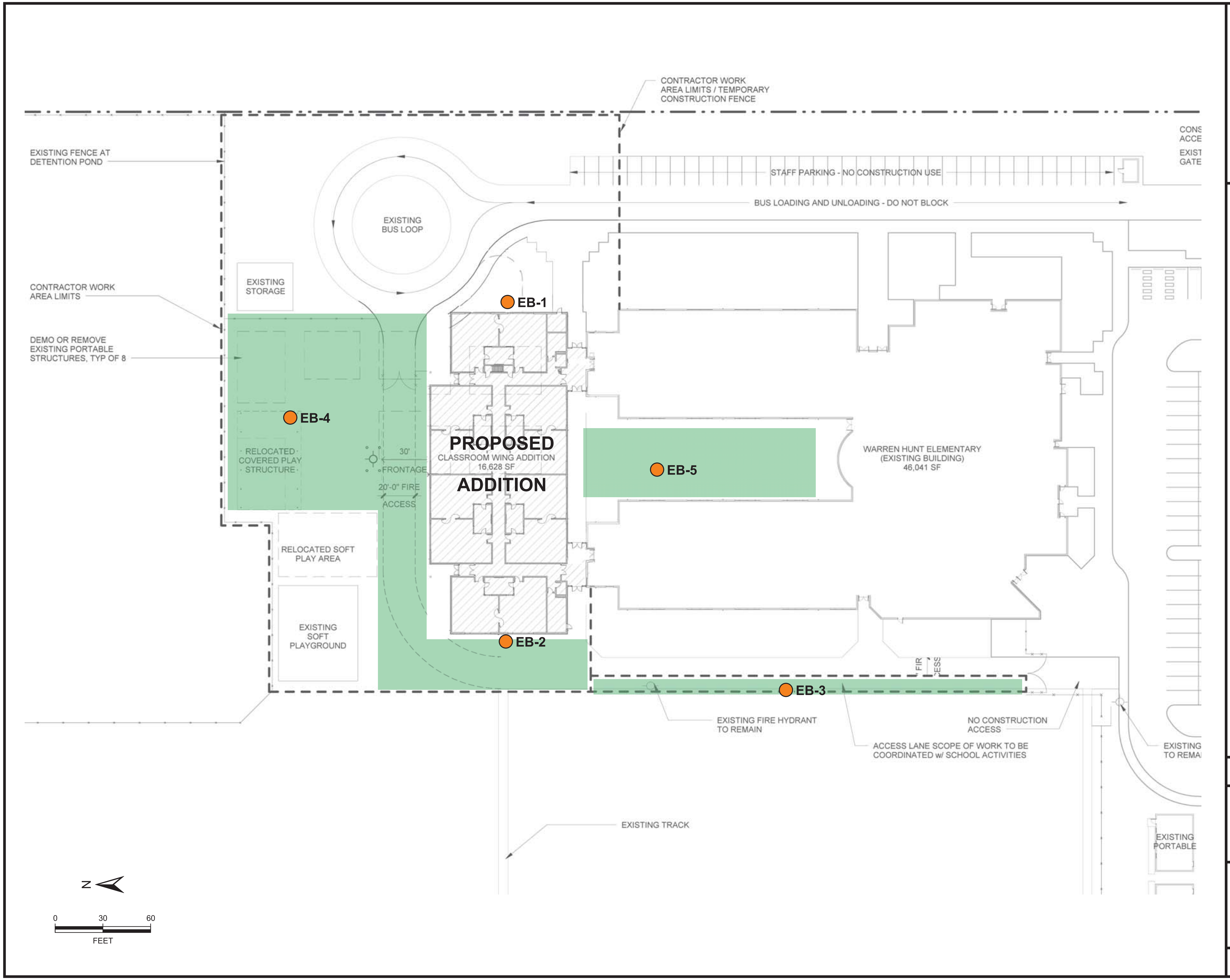

LEGEND:

● EB EXPLORATION BORING

🟩 PROPOSED PERMEABLE PAVEMENT

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:

1. BASE MAP REFERENCE: BCRA, HUNT ELEMENTARY ADDITION, SITE PLAN, SHEET A1.01, 10/15/16.

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SITE AND EXPLORATION PLAN

HUNT ELEMENTARY SCHOOL ADDITION
PIERCE COUNTY, WASHINGTON

PROJ NO.	DATE:	FIGURE:
TE160563A	11/16	2

160563 Hunt Elem \ 160563 F2 Site-Explr.cdr

APPENDIX A

Exploration Logs

Coarse-Grained Soils - More than 50%(1) Retained on No. 200 Sieve	Gravels - More than 50%(1) of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines(5)	▨	**GW**	Well-graded gravel and gravel with sand, little to no fines
			▨	**GP**	Poorly-graded gravel and gravel with sand, little to no fines
		≥12% Fines(5)	▨	**GM**	Silty gravel and silty gravel with sand
			▨	**GC**	Clayey gravel and clayey gravel with sand
	Sands - 50%(1) or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines(5)	▨	**SW**	Well-graded sand and sand with gravel, little to no fines
			▨	**SP**	Poorly-graded sand and sand with gravel, little to no fines
		≥12% Fines(5)	▨	**SM**	Silty sand and silty sand with gravel
			▨	**SC**	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50%(1) or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		▨	**ML**	Silt, sandy silt, gravelly silt, silt with sand or gravel
			▨	**CL**	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			▨	**OL**	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		▨	**MH**	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			▨	**CH**	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			▨	**OH**	Organic clay or silt of medium to high plasticity
Highly Organic Soils			▨	**PT**	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT(2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50

	Consistency	SPT(2) blows/foot
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

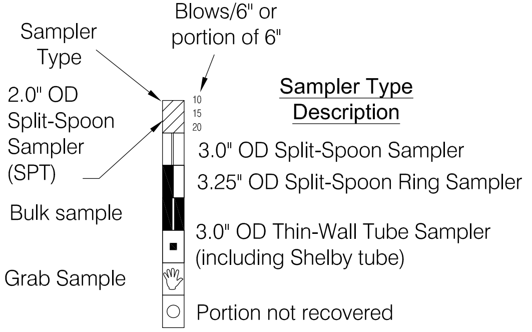
(3) Estimated Percentage

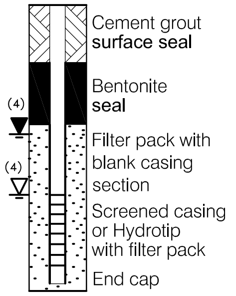
Component	Percentage by Weight
Trace	<5
Some	5 to <12
Modifier (silty, sandy, gravelly)	12 to <30
Very *modifier* (silty, sandy, gravelly)	30 to <50

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of ground water
▼ ATD = At time of drilling
▽ Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 12%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

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EXPLORATION LOG KEY

FIGURE A1

blocks \ dwg \ log_key.dwg LAYOUT: Layout 4 -2014 Qty Chng

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Exploration Log

Project Number	Exploration Number	Sheet
TE160563A	EB-1	1 of 1

Project Name: Hunt Elementary School
Location: Pierce County, WA
Driller/Equipment: Holocene Drilling, Inc. / Truck-Mounted Hollow Stem Auger
Hammer Weight/Drop: 140# / 30"

Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 11/11/16,11/11/16
Hole Diameter (in): 8 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Sod / Fill / Reworked Native					
	✋	S-1		Slightly moist, dark brown to brown, gravelly, fine to medium SAND, some coarse sand, trace silt, some organics/rootlets (SW).					
		S-2		Medium dense, slightly moist, dark brown with orange mottling, very silty, fine to medium SAND, some to trace gravel,; some organics/rootlets; unsorted (SM). Medium dense, slightly moist, gray with orange mottling, very silty, fine to medium SAND, trace gravel; trace organics; unsorted (SM).			7 6 11	▲17	
5		S-3		Medium dense, slightly moist to moist, dark brown with orange mottling, very silty, fine to medium SAND, some to trace gravel, some organics/rootlets; unsorted (SM). Medium dense, slightly moist to moist, gray-brown with orange mottling, silty, fine to medium SAND, some fine to coarse gravel; unsorted (SM).			10 10 10	▲20	
				Vashon Lodgement Till ?					
10		S-4		Medium dense, slightly moist to moist, gray-brown with orange mottling, silty, fine to medium SAND, some fine to coarse gravel; unsorted; poor recovery and blow counts overstated due to gravel content (SM).			18 50/6"	▲68/12"	
15		S-5		Very dense, slightly moist, grayish brown, silty, fine to medium SAND, some fine to coarse gravel; unsorted (SM). First blow count understated due to slough.			7 32 37	▲69	
20		S-6		Very dense, moist, grayish brown, silty, fine to medium SAND, some fine to coarse gravel; unsorted (SM).			15 50/6"	▲75/12"	
				Bottom of exploration boring at 21 feet No ground water encountered. Backfilled with bentonite chips. Sod replaced.					
25									

Sampler Type (ST):

▯ 2" OD Split Spoon Sampler (SPT)
▯ 3" OD Split Spoon Sampler (D & M)
✋ Grab Sample

☐ No Recovery
◧ Ring Sample
▨ Shelby Tube Sample

M - Moisture
▽ Water Level ()
▼ Water Level at time of drilling (ATD)

Logged by: LBK
Approved by: JMB

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Exploration Log

Project Number	Exploration Number	Sheet
TE160563A	EB-2	1 of 1

Project Name: Hunt Elementary School
Location: Pierce County, WA
Driller/Equipment: Holocene Drilling, Inc. / Truck-Mounted Hollow Stem Auger
Hammer Weight/Drop: 140# / 30"
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 11/11/16,11/11/16
Hole Diameter (in): 8 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Asphalt - 1 1/2 inches					
				Fill					
	✋	S-1		Moist, dark brownish gray, very silty, fine to medium SAND, some gravel; unsorted (SM).					
	▯	S-2		Medium dense, slightly moist to moist, dark brownish gray, very silty, fine to medium SAND, trace gravel, some organics, some wood fragments; unsorted (SM).			10 11 9	▲20	
				Vashon Recessional Outwash / Vashon Recessional Lacustrine Deposit					
5	▯	S-3		Loose to medium dense, moist, bluish gray, silty, fine to medium SAND, some to trace gravel; unsorted (SM).			4 5 6	▲11	
				Driller notes formation became softer.					
10	▯	S-4		Loose, very moist to wet, grayish brown, very fine to fine SAND, some silt, trace organics; massive; vague fining upward (SP).			2 3 3	▲6	
				Reworked Native / Weathered Vashon Lodgement Till ?					
15	▯	S-5		Medium dense, moist, grayish brown with heavy orange mottling, very silty, fine to medium SAND, some fine to coarse gravel; unsorted (SM). Perched water at 16 feet.		▼	3 4 10	▲14	
				Vashon Lodgement Till Driller notes formation becomes harder and some water within the softer section.					
20	▯	S-6		Very dense, slightly moist, grayish brown, very silty, fine to medium SAND, some fine gravel; unsorted (SM).			12 26 29	▲55	
25	▯	S-7		Very dense, slightly moist, grayish brown, silty, gravelly, fine to medium SAND; unsorted (SM).			35 26 33	▲59	
				Bottom of exploration boring at 26.5 feet Backfilled with bentonite chips and patched with cold patch asphalt.					

Sampler Type (ST):

- ▯ 2" OD Split Spoon Sampler (SPT)
- ▯ 3" OD Split Spoon Sampler (D & M)
- ✋ Grab Sample
- ☐ No Recovery
- ◧ Ring Sample
- ▨ Shelby Tube Sample
- M - Moisture
- ▽ Water Level ()
- ▼ Water Level at time of drilling (ATD)

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Approved by: JMB

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Exploration Log

Project Number	Exploration Number	Sheet
TE160563A	EB-3	1 of 1

Project Name: Hunt Elementary School
Location: Pierce County, WA
Driller/Equipment: Holocene Drilling, Inc. / Truck-Mounted Hollow Stem Auger
Hammer Weight/Drop: 140# / 30"
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 11/11/16,11/11/16
Hole Diameter (in): 8 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Sod / Fill / Reworked Native					
		S-1		Dense, moist, brown, very silty, fine to medium SAND, some fine to coarse gravel, some organics/rootlets; unsorted (SM).			3 18 24	▲42	
		S-2		Medium dense, slightly moist, brown, very silty, fine to medium SAND, some fine to coarse gravel; unsorted (SM). Becomes brownish gray.			10 10 12	▲22	
				Weathered Vashon Lodgement Till / Vashon Ice-Contact ?					
		S-3		Medium dense, slightly moist, brown, silty, fine to medium SAND, some to trace gravel; unsorted (SM).			8 6 6	▲12	
5				Bottom of exploration boring at 4.5 feet No ground water encountered. Backfilled with bentonite chips. Sod replaced.					
10									
15									
20									
25									

Sampler Type (ST):

- ▯ 2" OD Split Spoon Sampler (SPT)
- ▯ 3" OD Split Spoon Sampler (D & M)
- ☐ Grab Sample
- ☐ No Recovery
- ◧ Ring Sample
- ▨ Shelby Tube Sample
- M - Moisture
- ▽ Water Level ()
- ▼ Water Level at time of drilling (ATD)

Logged by: LBK
Approved by: JMB

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Exploration Log

Project Number	Exploration Number	Sheet
TE160563A	EB-4	1 of 1

Project Name: Hunt Elementary School
Location: Pierce County, WA
Driller/Equipment: Holocene Drilling, Inc. / Truck-Mounted Hollow Stem Auger
Hammer Weight/Drop: 140# / 30"
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 11/11/16,11/11/16
Hole Diameter (in): 8 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Gravel / Fill					
		S-1		Medium dense, slightly moist, grayish brown, silty, fine to medium SAND, some gravel; unsorted (SP). Medium dense, slightly moist, dark brown, very silty, fine SAND, trace gravel; abundant wood fragments; unsorted (SM).			14 8 10	▲18	
		S-2					6 6 8	▲14	
		S-3		Loose, slightly moist, brown, silty, fine to medium SAND, some fine gravel; unsorted; poor recovery (SP).			2 3 3	▲6	
5				Bottom of exploration boring at 4.5 feet No ground water encountered. Backfilled with bentonite chips. Gravel replaced.					
10									
15									
20									
25									

Sampler Type (ST):

▯ 2" OD Split Spoon Sampler (SPT)	☐ No Recovery	M - Moisture
▯ 3" OD Split Spoon Sampler (D & M)	◧ Ring Sample	▽ Water Level ()
Grab Sample	▨ Shelby Tube Sample	▼ Water Level at time of drilling (ATD)

Logged by: LBK
Approved by: JMB

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Exploration Log

Project Number	Exploration Number	Sheet
TE160563A	EB-5	1 of 1

Project Name: Hunt Elementary School
Location: Pierce County, WA
Driller/Equipment: Holocene Drilling, Inc. / Truck-Mounted Hollow Stem Auger
Hammer Weight/Drop: 140# / 30"
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 11/11/16,11/11/16
Hole Diameter (in): 8 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
		S-1		**Sod / Fill** Dense, moist to slightly moist, brown, gravelly, fine to medium SAND, some coarse sand, some silt, some organics/rootlets; poor recovery; blow counts overstated due to gravel content (SP).			5 38 48	83	
		S-2		As above.			19 42 50/4"	92/10"	
		S-3		Dense, slightly moist, grayish brown, very gravelly, fine to coarse SAND, some silt; unsorted; blow counts likely overstated due to gravel content (SW).			21 21 23	44	
5				Bottom of exploration boring at 4.5 feet No ground water encountered. Backfilled with bentonite chips. Sod replaced.					
10									
15									
20									
25									

Sampler Type (ST):

▯ 2" OD Split Spoon Sampler (SPT)
▯ 3" OD Split Spoon Sampler (D & M)
▯ Grab Sample
☐ No Recovery
◧ Ring Sample
▨ Shelby Tube Sample
M - Moisture
▽ Water Level ()
▼ Water Level at time of drilling (ATD)

Logged by: LBK
Approved by: JMB

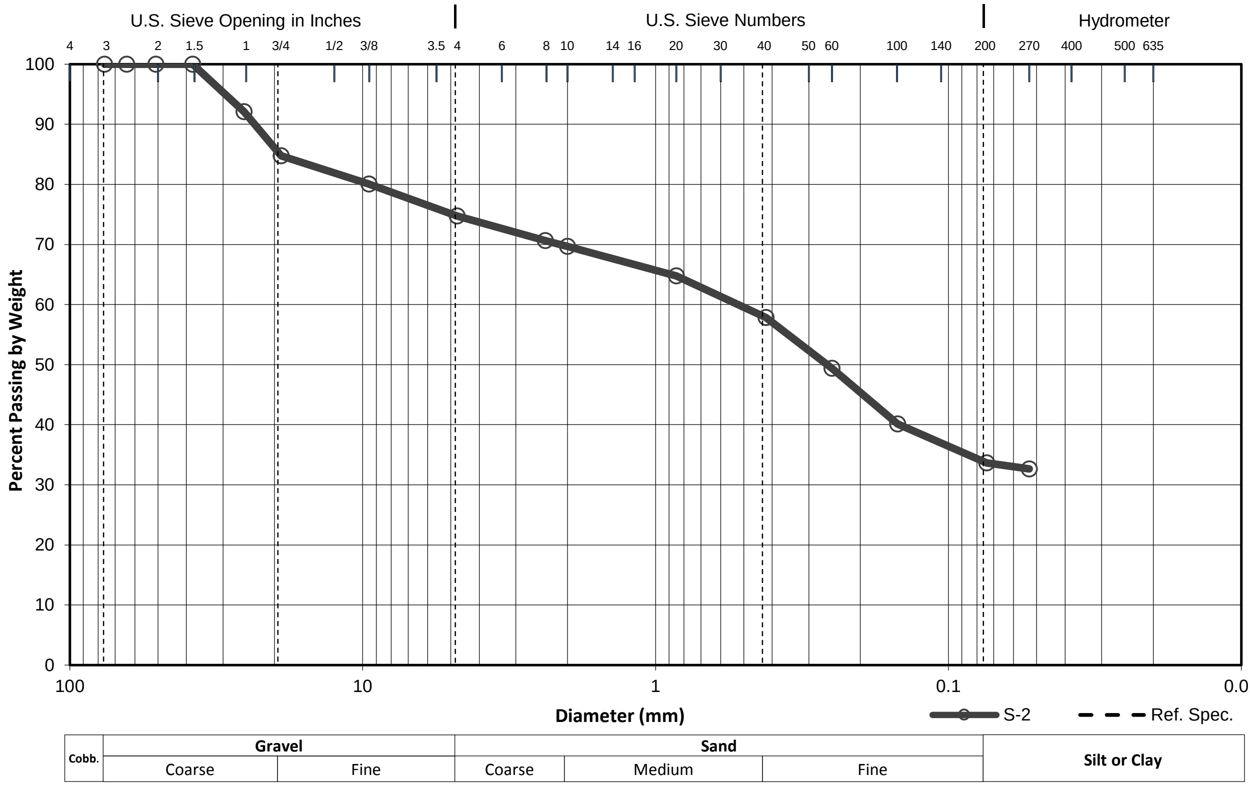
APPENDIX B

Laboratory Testing Results

associated earth sciences incorporated

GRAIN SIZE ANALYSIS - MECHANICAL ASTM D422

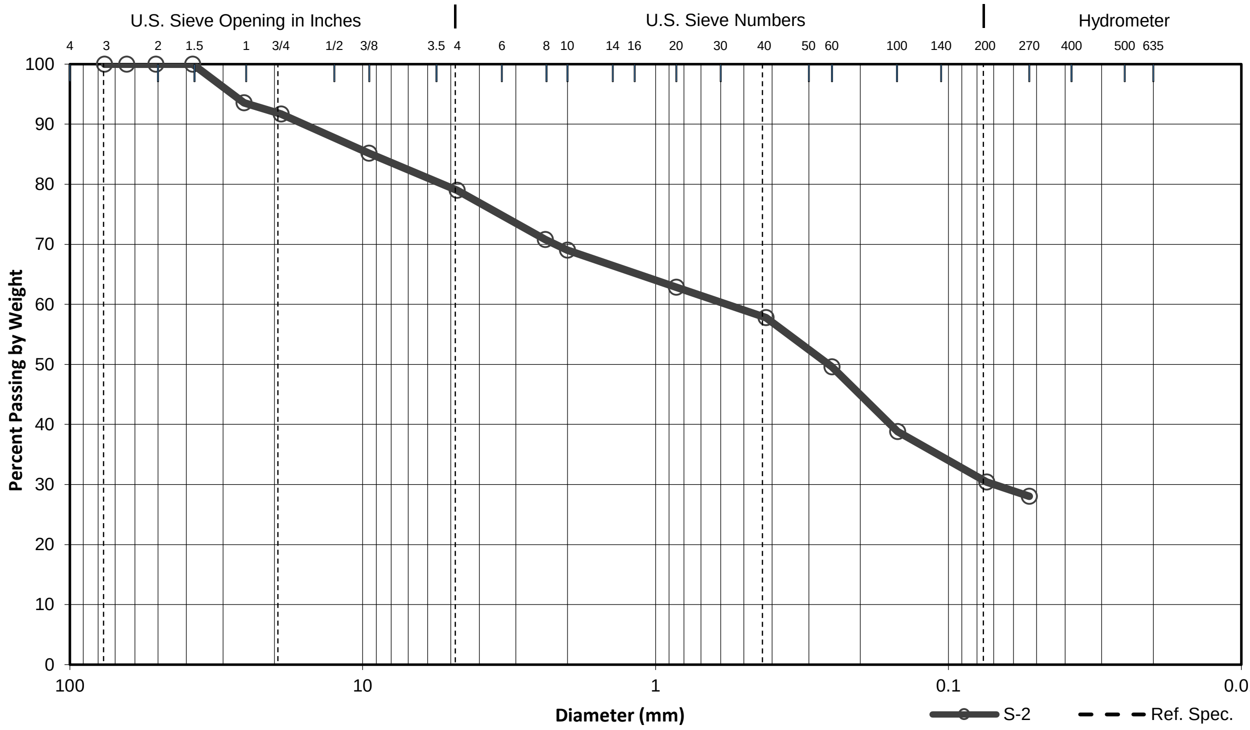
Project Name	Project Number	Date Sampled	Date Tested	Tested By
Hunt Elementary School	**TE160563A**	**11/23/2016**	**11/29/2016**	**BP**
Sample Source	Sample No.	Depth (ft)	Soil Description	
EB-3	**S-2**	**1.5**	**gravelly, very silty SAND (SM)**	
Total Sample Dry Wt. (g)	Moisture Content (%)	D_{10} (mm)	Reference Specification	
905.4	**14**	**<0.01**		



Sieve No.	Diam. (mm)	Cum. Wt. Ret. (g)	% Ret. by Wt.	% Passing by Wt.	% Specs. Pass. by Wt.	
					Min	Max
3	76.1		0.0	100.0		
2.5	64		0.0	100.0		
2	50.8		0.0	100.0		
1.5	38.1		0.0	100.0		
1	25.4	71.7	7.9	92.1		
3/4	19	138.0	15.2	84.8		
3/8	9.51	180.8	20.0	80.0		
#4	4.76	228.5	25.2	74.8		
#8	2.38	265.9	29.4	70.6		
#10	2	274.6	30.3	69.7		
#20	0.85	318.8	35.2	64.8		
#40	0.42	381.6	42.1	57.9		
#60	0.25	458.2	50.6	49.4		
#100	0.149	542.1	59.9	40.1		
#200	0.074	600.9	66.4	33.6		
#270	0.053	609.8	67.3	32.7		

GRAIN SIZE ANALYSIS - MECHANICAL ASTM D422

Project Name	Project Number	Date Sampled	Date Tested	Tested By
Hunt Elementary School	**TE160563A**	**11/23/2016**	**11/29/2016**	**BP**
Sample Source	Sample No.	Depth (ft)	Soil Description	
EB-4	**S-2**	**1.5**	**gravelly, very silty SAND (SM)**	
Total Sample Dry Wt. (g)	Moisture Content (%)	D_{10} (mm)	Reference Specification	
1123.4	**15**	**<0.01**		



Cobb.	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Sieve No.	Diam. (mm)	Cum. Wt. Ret. (g)	% Ret. by Wt.	% Passing by Wt.	% Specs. Pass. by Wt.	
					Min	Max
3	76.1		0.0	100.0		
2.5	64		0.0	100.0		
2	50.8		0.0	100.0		
1.5	38.1		0.0	100.0		
1	25.4	72.5	6.5	93.5		
3/4	19	93.3	8.3	91.7		
3/8	9.51	166.6	14.8	85.2		
#4	4.76	236.3	21.0	79.0		
#8	2.38	327.9	29.2	70.8		
#10	2	348.1	31.0	69.0		
#20	0.85	417.3	37.1	62.9		
#40	0.42	474.1	42.2	57.8		
#60	0.25	566.5	50.4	49.6		
#100	0.149	687.4	61.2	38.8		
#200	0.074	782.1	69.6	30.4		
#270	0.053	808.4	72.0	28.0		

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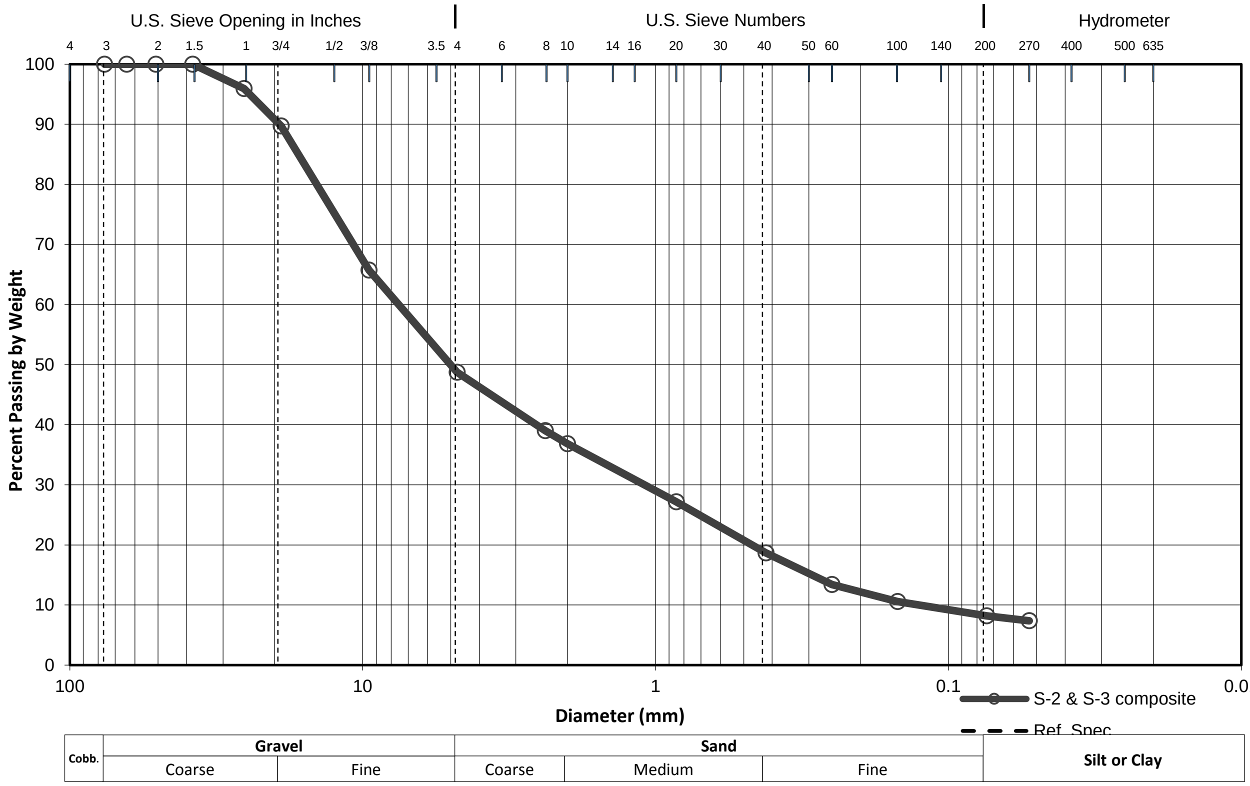
GRAIN SIZE ANALYSIS - MECHANICAL ASTM D422

Project Name	Project Number	Date Sampled	Date Tested	Tested By
Hunt Elementary School	**TE160563A**	**11/23/2016**	**11/29/2016**	**BP**
Sample Source	Sample No.	Depth (ft)	Soil Description	
EB-5	**S-2 & S-3 composite**	**1.5 & 3.0**	**very sandy GRAVEL, some silt (GW-GM)**	
Total Sample Dry Wt. (g)	Moisture Content (%)	D_{10} (mm)	Reference Specification	
637.1	**6**	**0.126**		



Sieve No.	Diam. (mm)	Cum. Wt. Ret. (g)	% Ret. by Wt.	% Passing by Wt.	% Specs. Pass. by Wt.	
					Min	Max
3	76.1		0.0	100.0		
2.5	64		0.0	100.0		
2	50.8		0.0	100.0		
1.5	38.1		0.0	100.0		
1	25.4	25.9	4.1	95.9		
3/4	19	65.7	10.3	89.7		
3/8	9.51	218.3	34.3	65.7		
#4	4.76	326.8	51.3	48.7		
#8	2.38	388.6	61.0	39.0		
#10	2	402.4	63.2	36.8		
#20	0.85	464.0	72.8	27.2		
#40	0.42	518.3	81.3	18.7		
#60	0.25	551.8	86.6	13.4		
#100	0.149	569.9	89.4	10.6		
#200	0.074	585.0	91.8	8.2		
#270	0.053	590.2	92.6	7.4		