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Geotechnical Engineering Report
Proposed Trailhead Improvements
New South Vashon Levy Trailhead
xxx – 131st Avenue SW
King County, Washington
Contract: KC23005-2406

INTRODUCTION

This *Geotechnical Engineering Report* summarizes our site observations, subsurface explorations, laboratory testing and engineering analyses, and provides geotechnical recommendations and design criteria for the trailhead improvements to be constructed at the above referenced parcel on Vashon Island in King County, Washington. The general location of the site is shown on the attached Site Location Map, Figure 1.

Our understanding of the project is based on our discussions with you; a review of the *Preliminary Site Plan* provided by you; our March 4, 2025 site visit and subsurface explorations; our understanding of King County development codes; and our experience in the area. The proposed trailed head improvements will include 7 paved parking spots, including 1 ADA accessible parking spot, the replacement of a culvert along 131st Avenue SW, and a new gate. The preliminary site configuration is shown on the Site & Exploration Plan, Figure 2.

King County (the County) requires a *Soil Report* to assess the feasibility of on-site soils to support infiltration of stormwater runoff from the proposed new hard surfaces. We have prepared this *Geotechnical Engineering Report* to address the stormwater manual, provide an assessment of potential geologic hazards per King County Code (KCC) Title 21A for critical areas, and to address the geotechnical report requirements of the 2021 International Building Code (IBC).

PURPOSE & SCOPE

The purpose of our scope of services was to evaluate the surface and subsurface conditions across the site as a basis for providing geotechnical recommendations and design criteria for the proposed park improvements. Specifically, the scope of services for this project included the following:

1. Reviewing the available geologic and geotechnical data for the site area;
2. Exploring subsurface conditions at the site by drilling two hollow stem auger borings to depths of about 16.5 feet below existing site grades near the proposed improvements;
3. Describing surface and subsurface conditions, including soil type, depth to groundwater, and an estimate high groundwater based on observed subsurface conditions;

4. Providing seismic design parameters, including 2021 IBC site class;
5. Providing recommendations and design criteria for foundation and floor slab support, including conventional spread foundations;
6. Providing recommendations for subgrade walls, including lateral earth pressures and applicable seismic surcharges;
7. Providing our opinion about the feasibility of onsite infiltration in accordance with the *2021 King County Surface Water Design Manual* (2021 KCSWDM), including a preliminary infiltration rate based on grain size test data;
8. Providing a standard duty hot mix asphalt (HMA) pavement section designs based on assumed traffic data;
9. Providing geotechnical recommendations for earthwork and grading activities including site preparation, subgrade preparation, fill placement criteria (including hillside grading), suitability of on-site soils for use as structural fill, and temporary and permanent cut and fill slopes;
10. Providing recommendations for erosion and sediment control during wet weather grading and construction; and
11. Preparing this written *Geotechnical Engineering Report* summarizing our site observations and conclusions, and our geotechnical recommendations and design criteria, along with the supporting data.

SITE CONDITIONS

Surface Conditions

As stated, the site is located at an unaddressed parcel off of 131st Avenue SW on Vashon Island, Washington. According to King County iMap data, the subject parcel is roughly rectangular in shape, measures approximately 335 feet wide (north to south) by approximately 525 to 580 feet wide (east to west) and encompasses approximately 4.58 acres. The site is bounded by undeveloped land to the north and south, existing large lot development to the east, and 131st Avenue SW to the west. The proposed trailhead improvements will occur in the western portion of the parcel.

According to topographic information from King County iMap, the ground surface of the site generally slopes up to the east. From 131st Avenue SW, there is a road cut up to the site that slopes up to the east at approximately 60 to 80 percent over a topographic relief of approximately 6 feet. Above the roadcut, in the area of the proposed trailhead improvements, the ground surface slope up to east at approximately 5 to 20 percent. These slopes continue throughout the area of the proposed improvements. East of the proposed improvements, the ground surface slopes up to the east at approximately 30 to 50 percent over a topographic relief of approximately 55 feet. At the top of the slope, the ground surface is relatively level with small changes in inclination on the order of less than 5 percent. West of the site, on the west side of 131st Avenue SW, the ground surface is relatively level and is a topographically low area. The total topographic relief of the site is on the order of 90 feet. The existing conditions and topography are shown on the Site Vicinity Map, Figure 3.

Vegetation in the area of the proposed trailhead improvements generally consist of a moderate stand of mature coniferous and deciduous trees with sparse understory of native and invasive plants and shrubs along with unmaintained grass. No seeps, springs, or standing water were observed during our site reconnaissance. Some standing water was observed in the topographically lower area west of the site, on the other side of 131st Avenue Southwest. No indications of erosion or slope instability were observed during our site reconnaissance.

Site Soils

The USDA Natural Resource Conservation Service (NRCS) Web Soil Survey maps the surficial soils at the site as Alderwood gravelly sandy loam (AgD) and Everett-Alderwood gravelly sandy loam (EwC). An excerpt from the NRCS soils map for the site area is included as Figure 4. These soils are described below.

- Alderwood gravelly sandy loam (AgB): The Alderwood soils mapped as underlying the eastern portion of the site. These soils are derived from glacial drift and/or glacial outwash, form on slopes of 15 to 30 percent, are considered to have a "severe" erosion hazard when exposed, and are included in hydrologic soils group B.
- Everett-Alderwood gravelly sandy loam (EwC): The Everett soils are mapped as underlying the western portion of the site. These soils are derived from glacial outwash with a component of volcanic ash, form on slopes of 6 to 15 percent, are considered to have a "slight to moderate" erosion hazard when exposed, and are included in hydrologic soils group A.

Site Geology

The draft *Geological Map of the Gig Harbor 7.5-minute Quadrangle, Washington* (*Troost, K.G., Booth, D.B., and Wells, R.E.,* in review) maps the site as being underlain by advance outwash (Qva) with glacial till (Qvt) being mapped within the site vicinity. Recessional outwash (Qvr) can intermittently overly these soils. These glacial soils were generally deposited during the Vashon Stade of the Fraser Glaciation, approximately 12,000 to 15,000 years ago. An excerpt of the above referenced map is included as Figure 5. Detailed descriptions of the mapped geologic units are included below.

- *Recessional outwash (Qvr)*: The recessional outwash typically consists of a well graded, lightly stratified mixture of sand and gravel that may locally contain silt and clay. The recessional outwash was deposited by meltwaters emanating from the retreating ice mass. This soil unit is generally observed to be in a normally-consolidated, and exhibits moderate strength and moderate compressibility characteristics where undisturbed. Stormwater infiltration potential in recessional outwash soils is generally favorable.
- *Vashon till (Qvt):* The glacial till typically consists of a heterogeneous mixture of clay, silt, sand and gravel that was deposited at the base of the continental ice mass and subsequently overridden. Accordingly, it is considered over consolidated, is typically encountered in a dense to very dense condition and exhibits high strength and low compressibility characteristics where undisturbed. The infiltration potential of glacial till deposits is generally limited.
- *Advance outwash deposits (Qva)*: The advance outwash typically consists of a well graded, lightly stratified mixture of sand and gravel that may locally contain silt and clay that was deposited by meltwaters emanating from the advancing ice mass. The advance outwash was overridden by the continental ice mass, and as such is considered over-consolidated, and exhibits high strength and low compressibility characteristics where undisturbed. The infiltration potential of advance outwash deposits is generally favorable.

We reviewed the Washington Geological Survey (WGS) protocol landslide mapping and other compiled landslide mapping groups for the site and surrounding area. The landslide mapping from these sources is shown on the Washington State Department of Natural Resources (WA DNR) Geologic Information Portal. The WGS protocol maps landslide landforms and landslide susceptibility using Lidar based on the criteria provided in the Protocol for Landslide Mapping from Lidar Data in Washington State (Slaughter, et al, 2017) and the Protocol for Shallow-Landslide Susceptibility Mapping (Burns and others, 2012). The other compiled landslide mapping is referenced from published 1:24,000- and 1:100,000-scale geologic maps, landslide hazard zonation studies, watershed analyses, reconnaissance-scale landslide mapping from winter storm landslide events and a lidar-based study of near-shore landforms. Where overlap of sources occurs, the WGS-protocol landslide mapping supersedes the other compiled landslide mapping.

The nearest mapped landslide feature is identified as a high confidence landslide complex of pre-historic age (more than 150 years) that has been field verified, situated about 2,000 feet east of the site on the edge of the glacial upland area. An excerpt of the WA DNR landslide mapping is included as Figure 6.

Subsurface Explorations

On March 4, 2025, we visited the site and monitored the drilling of two hollow-stem borings to depths of approximately 16.5 feet below the existing ground surface using a track-mounted drill rig. While onsite, we logged the subsurface conditions encountered at each boring location and obtained representative soil samples. Table 1, below, summarizes the approximate functional locations, surface elevations, and termination depths of our borings.

TABLE 1:
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS

Boring Number	Functional Location	Surface Elevation[1] (feet)	Termination Depth (feet)	Termination Elevation[1] (feet)
B-1	South side of proposed parking lot	265.0	16.5	248.5
B-2	Northern portion of proposed parking lot	264.0	16.5	247.5

Notes:
[1] = Surface elevations estimated from the *King County iMap (NAVD88)*

During drilling, soil samples were obtained at 2.5 and 5-foot depth intervals in accordance with the standard penetration test (SPT) method outlined by ASTM D1586. The SPT method consists of driving a standard 2 inch-outer diameter split-spoon sampler 18 inches into the soil with a 140-pound hammer. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "SPT blow count". If a total of 50 blows are recorded within any 6-inch interval (refusal), the driving is stopped, and the blow counts are recorded as 50 blows for the actual distance the sampler was driven. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

The specific number, locations, and depths of our explorations were selected based on input from you and our understanding of the configuration of the proposed improvements and were adjusted in the field based on consideration for underground utilities, existing site conditions, site access limitations and encountered stratigraphy. Representative soil samples obtained from the borings were placed in sealed containers and taken to our laboratory for further examination and testing as deemed necessary. When complete, the borings were abandoned in accordance with Washington State law, and the surface restored to the extent possible.

The subsurface explorations completed as part of this evaluation indicate the subsurface conditions at specific locations only, as actual subsurface conditions can vary across the site. Furthermore, the nature and extent of such variation would not become evident until additional explorations are performed or until construction activities have begun.

The numbers and approximate locations of our borings are shown on the attached Site & Exploration Plan, Figure 2. The soils encountered were visually classified in accordance with the Unified Soil Classification System (USCS) and ASTM D2488. The USCS is included in Appendix A as Figure A-1, while the descriptive logs of our borings are included as Figures A-2 through A-3.

Subsurface Conditions

Our exploration locations disclosed subsurface conditions that, in our opinion, generally did not confirm the mapped stratigraphy. The encountered soil layers are described in the following paragraphs.

Topsoil: At the surface at the locations explored, we encountered approximately 0.5 to 1.0 foot topsoil.

Undocumented fill: Underlying the topsoil encountered in boring B-1, we encountered approximately 1.3 feet of brown silty sand in a medium dense, moist condition. We interpret these soils to be undocumented fill.

Relic Topsoil: Underlying the undocumented fill in boring B-1, we encountered approximately 12 inches of relic topsoil.

Weathered Recessional Outwash: Underlying the topsoil in boring B-2, encountered approximately 1.8 feet of brown silty sand with some gravel in a loose, moist condition. We interpret these soils to be weathered recessional outwash.

Recessional Outwash: Underlying the relic topsoil in boring B-1 and the weathered recessional outwash in boring B-2, we encountered tan to grey silty sand with variable amounts of gravel in a medium dense to dense, moist to wet condition. We interpret these soils to be recessional outwash. The recessional outwash soils were encountered to the full depth explored in all explorations.

TABLE 2:

APPROXIMATE THICKNESS, DEPTHS, AND ELEVATION OF SOIL TYPES ENCOUNTERED IN EXPLORATIONS

Boring Number	Thickness of (feet, approximate):			Depth to Recessional Outwash (feet)	Elevation[1] of Recessional Outwash (feet)
	Topsoil	Undocumented Fill	Weathered Recessional Outwash		
B-1	1.0	2.3*	NE	3.3	261.7
B-2	0.5	NE	1.8	2.0	262.0

Notes:

[1] = Surface elevations estimated from the *King County iMap (NAVD88)*

*= includes relic topsoil

NE= Not encountered

Laboratory Testing

Geotechnical laboratory tests were performed on select samples retrieved from the borings to estimate index engineering properties of the soils encountered. Samples were visually classified per ASTM D2488 and ASTM D2487. Laboratory testing included moisture content determinations per ASTM D2216 and grain size analyses per ASTM D6913 standard procedures. Test results summarized below in Table 3 and graphical output results are included in Appendix B.

TABLE 3:

LABORATORY TEST RESULTS FOR ON-SITE SOILS

Sample	Soil Type	Lab ID	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)	Moisture Content (percent)
B-1, S-1, D: 0ft	SM	105959	19.2	60.5	20.3	17.9
B-1, S-6, D: 15ft	SP-SM	105960	0	91.3	8.3	26.9
B-2, S-1, D: 0ft	SM	105961	28.4	59.2	12.4	16.4
B-2, S-3, D: 5ft	SM	105962	37.0	48.2	14.8	6.7
B-2, S-5, D: 10ft	SM	105963	16.0	71.9	12.1	19.6

Groundwater Conditions

Groundwater was observed in our borings at approximately elevation 250 feet. Based on the wetlands to the west of the site, we interpret the observed groundwater to be an unconfined aquifer that develops seasonally atop a denser, more impermeable soil at depth. We anticipate fluctuations in the local groundwater levels will occur in response to precipitation patterns, off-site construction activities, and site utilization. Accordingly, observations made during drilling may vary significantly from those encountered during construction.

ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our data review, site reconnaissance, subsurface explorations, laboratory testing, and our experience in King County; it is our opinion that the proposed park improvements are feasible from a geotechnical engineering standpoint, provided the conclusions and recommendations presented below are appropriately incorporated into the project plans and specifications.

Erosion Hazard Areas KCC Title 21A.06.415

King County defines an erosion hazard area as an area underlain by soils that are subject to severe erosion when disturbed. These soils include, but are not limited to, those classified as having a severe to very severe erosion hazard according to the USDA NRCS. These soils include any of the following when they occur on slopes inclined at 15 percent or more:

A. Alderwood gravelly sandy loam (AgD)
B. Alderwood and Kitsap soils (AkF)
C. Beausite gravely sandy loam (BeD and BeF)
D. Kitsap silt loam (KpD)
E. Ovall gravely loam (OvD and OvF)
F. Ragnar fine sandy loam (RaD)
G. Ragner-Indianola Association (RdE)

The USDA NRCS maps the soil types at the site as Alderwood gravelly sandy loam (AgD) and Everett-Alderwood gravelly sandy loam (EwC). The Alderwood soils are considered to have a severe erosion hazard when exposed and are mapped east of the project site on slopes steeper than 15 percent. Therefore, these areas meet the criteria of erosion hazard areas. However, based on our understanding of the project scope, these areas will not be disturbed by the proposed trailhead improvements. It is our opinion that if erosion and sediment control Best Management Practices (BMPs) per the 2021 *King County Surface Water Design Manual* are implemented prior to, during, and after construction activities, the potential for erosion to impact the project site or adjacent parcels should be minimal. Further discussion on erosion and sediment control is included in the "**Erosion and Sediment Control**" section of this report. We anticipate a temporary erosion and sediment control plan will be required for this project.

Erosion Hazard Areas Development Standards KCC Title 21A.24.220

The following development standards apply to development proposals and alterations on sites containing erosion hazard areas and should be incorporated into the project plans and specifications:

A. Clearing in an erosion hazard area is allowed only from April 1 to October 1, except that:
    1. Clearing of up to fifteen-thousand square feet within the erosion hazard area may occur at any time on a lot;
    2. Clearing of noxious weeds may occur at any time; and

    3. Forest practices regulated by the department are allowed at any time in accordance with a clearing and grading permit if the harvest is in conformance with chapter 76.09 RCW and Title 222 WAC;
- B. All subdivisions, short subdivisions, binding site plans or urban planned developments on sites with erosion hazard areas shall retain existing vegetation in all erosion hazard areas until building permits are approved for development on individual lots. The department may approve clearing of vegetation on lots if:
  1. The clearing is a necessary part of a large scale grading plan; and
  2. It is not feasible to perform the grading on an individual lot basis;
  - C. If the department determines that erosion from a development site poses a significant risk of damage to downstream wetlands or aquatic areas, based either on the size of the project, the proximity to the receiving water or the sensitivity of the receiving water, the applicant shall provide regular monitoring of surface water discharge from the site. If the project does not meet water quality standards established by law or public rules, the county may suspend further development work on the site until such standards are met. (Ord. 15051 § 160, 2004: Ord. 10870 § 469, 1993).

Landslide Hazard Areas KCC Title 21A.06.680

King County defines a landslide hazard area as an area subject to severe risk of landslide, such as:

- A. An area with a combination of:
  1. Slopes steeper than fifteen percent of inclination;
  2. Impermeable soils, such as silt and clay, frequently interbedded with granular soils, such as sand and gravel; and,
  3. Springs or groundwater seepage;
- B. An area that has shown movement during the Holocene epoch, which is from ten thousand years ago to the present, or that is underlain by mass wastage debris from that epoch;
- C. Any area potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action;
- D. An area that shows evidence of or is at risk from snow avalanches; or
- E. An area located on an alluvial fan, presently or potentially subject to inundation by debris flows or deposition of stream-transported sediments.

Slopes steeper than 15 percent are present at the site. However, we did not observe impermeable soils interbedded within the recessional outwash encountered in our explorations. Additionally, the encountered groundwater within our explorations was at an elevation lower than the base of the slopes. No areas on or within 300 feet of the site are mapped as landslide deposits nor did we observe geomorphic evidence of past landslide activity. The site is not located along a water body. The site is not at risk of snow avalanches. The site is not mapped as being underlain by an alluvial fan. Additionally, we do not interpret the soils encountered in our explorations to be alluvium.

Based on our site observations, it is our opinion that the site does not meet the King County technical definition of a landslide hazard area. In our opinion, no prescriptive buffers or setbacks should be required.

Steep Slope Hazard Areas KCC Title 21A.06.1230

King County defines a steep slope hazard area as an area on a slope of forty percent inclination or more with a vertical elevation change of at least ten feet. For this definition, a slope is delineated by establishing its toe and top and is measured by averaging the inclination over at least ten feet of vertical relief. Also, for the purpose of this definition:

> A. The "toe" of a slope means a distinct topographic break in slope that separates slopes inclined at less than forty percent from slopes inclined at forty percent or more. Where no distinct break exists, the "toe" of a slope is the lower most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of twenty-five feet; and
>
> B. The "top" of a slope is a distinct topographic break in slope that separates slopes inclined at less than forty percent from slopes inclined at forty percent or more. Where no distinct break exists, the "top" of a slope is the upper-most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of twenty-five feet. (Ord. 15051 § 101, 2004: Ord. 10870 § 286, 1993).

The slope east of the proposed parking lot meets the definition of a steep slope hazard area. Additionally, King County iMap confirms this mapping as shown on Figure 7. Accordingly, we recommend a buffer and associated building setback be established from the identified steep slope hazard areas at the site.

Recommended Setback

Buffers and setbacks are typically used to protect critical areas or steep slopes from disturbance and to protect the proposed development from damage due to a critical area. There are steep slope hazard areas within 300 feet of the proposed development location. The following discussions regarding recommended critical area buffers and associated building setbacks are based on the King County Code Section 21A.06.122 and the 2021 International Building Code.

Vegetated Buffers

Buffers typically consist of an undisturbed area of native vegetation, retained, or established, that extend from the edge of the critical area or hazard. The width of the buffer should be a reflection of the potential hazard and associated risks. Buffer widths are generally measured from the edge of the critical area being protected, in this case top of slope.

As described above, slopes steeper than 40 percent are present east of the proposed parking area. As such, we recommend that a 50-foot buffer of native vegetation be established from the base of slopes steeper than 40 percent with 10 or more feet of vertical relief. Based on our understanding of the project scope, the proposed parking lot will be more than 50 feet from the steep slope area.

Building Setbacks

King County requires building setbacks from critical area buffers and building setbacks in accordance with the 2021 International Building Code (IBC). The IBC Section 1808.7 requires a building setback from slopes that are steeper than 3H:1V (Horizontal: Vertical) or 33 percent with more than 10 feet in vertical height, unless evaluated and reduced and/or a structural setback is provided by a licensed geotechnical engineer. The setback distance is calculated based on the vertical height of the slope. The typical 2021 IBC setback from the top of the slope equals one third the height of the slope or 40 feet, whichever is less, while a setback from the toe of the slope equals one half the height of the slope or 15 feet, whichever is less. As such, we recommend that any development occur 15 feet from the identified steep slopes. Based on our understanding of the project scope, the proposed parking lot will be more than 15 feet from the steep slope area.

Seismic Design

The site is located in the Puget Sound region of western Washington, which is seismically active. Seismicity in this region is attributed primarily to the interaction between the Pacific, Juan de Fuca and North American plates. The Juan de Fuca plate is subducting beneath the North American plate at the Cascadia Subduction Zone (CSZ). This produces both intercrustal (between plates) and intracrustal (within a plate) earthquakes. In the following sections we discuss the design criteria and potential hazards associated with the regional seismicity.

Seismic Site Class

Based on our observations and the subsurface units mapped at the site, it is our opinion a seismic Site Class "D" is appropriate per the 2021 IBC documents and American Society of Civil Engineers (ASCE) standard 7-16 Chapter 20 Table 20.2-1. This is based on the anticipated range of SPT (Standard Penetration Test) blow counts for the soils encountered. These conditions are assumed to be representative for the subsurface across the site.

Design parameters

The U.S. Geological Survey (USGS) completed probabilistic seismic hazard analyses (PSHA) for the entire country in November 1996, which were updated and republished in 2002 and 2008. We used the *ASCE Hazard Tool* website to estimate seismic design parameters at the site.

Table 4, below, summarizes the recommended design parameters based on ASCE 7-16. The project structural engineer should confirm the adopted criteria with the jurisdiction having authority.

TABLE 4:

2021 IBC PARAMETERS FOR DESIGN OF SEISMIC STRUCTURES

Spectral Response Acceleration (SRA) and Site Coefficients	ASCE 7-16
Risk Category	II
Mapped SRA	S_S = 1.458g
Site Coefficients (Site Class D)	F_a = 1.000
Maximum Considered Earthquake SRA	S_{MS} = 1.458g
Design SRA	S_{DS} = 0.972g

Peak Ground Acceleration

The mapped modified peak ground acceleration (PGA_M) is 0.679g. In general, estimating seismic earth pressures (k_h) by the Mononobe-Okabe method or for use in slope stability analyses are taken as 33 to 50 percent the PGA_M, or about 0.23g to 0.34g.

Seismic Hazards

Earthquake-induced geologic hazards may include liquefaction, lateral spreading, slope instability, and ground surface fault rupture. Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in pore water pressure in soils. The increase in pore water pressure is induced by seismic vibrations. Liquefaction primary affects geologically recent deposits of loose, uniformly graded, fine-grained sands and granular silts that are below the groundwater table. Based on our review of the *Liquefaction Susceptibility of the Pierce County, Washington* (Palmer, et al, 2003), Figure 8, the site appears to be in an area mapped as having a "very low" to "low" susceptibility to liquefaction. In our opinion, the proposed parking lot will have no greater risk to liquefaction than surrounding infrastructure.

Based on our review of the Department of Natural Resources Geologic Hazards Map (Geologic Information Portal), the site is located about 0.51 miles south of the nearest strand of the Tacoma Fault Zone. No evidence of ground fault rupture was observed in the subsurface explorations or our site reconnaissance. Therefore, in our opinion, the risk for ground fault rupture at the site is low, and the proposed improvements should have no greater risk for seismic hazards than other appropriately designed structures located in the area. An excerpt of the Geologic Information Portal is included as Figure 9.

Exterior Slabs-on-grade

We recommend that slab-on-grade construction is supported by firm native soils or structural fill as described below. Areas of old fill material should be removed Areas of significant organic debris should be removed.

A subgrade modulus of 200 pci (pounds per cubic inch) may be used for floor slab design. We estimate that settlement of the floor slabs designed and constructed as recommended, will be 0.5 inch or less over a span of 50 feet.

Where slabs will be protected from the elements, we recommend they be directly underlain by a capillary break consisting of a minimum 4-inch-thick layer of washed pea gravel (⅜-inch to US No. 8 sieve size) or clean ⅝-inch crushed rock (less than 2 percent passing the US No. 200 sieve). If pea gravel is used, a 2-inch layer of clean crushed rock can be placed over it to provide a firmer working surface on which to place the slab reinforcement.

Temporary Excavations

All job site safety issues and precautions are the responsibility of the contractor providing services/work. The following temporary cut/fill slope guidelines are provided for planning purposes only. Temporary cut slopes will likely be necessary during grading operations or utility installation. Where there is not enough area for sloped excavations, temporary shoring should be provided. If shallow temporary shoring is required, we recommend that it be designed to withstand the lateral earth pressures provided in the basement wall section of this report.

All excavations at the site associated with confined spaces, such as utility trenches and retaining walls, must be completed in accordance with local, state, or federal requirements including the Washington Administrative Code (WAC) and Washington Industrial Safety and Health Administration (WISHA). Excavation, trenching, and shoring is covered under the WAC 296-155 Part N.

Based on the WAC 296-155-66401, it is our opinion that the fill soils as well as the weathered and undisturbed recessional outwash at the site would be classified as Type C soils. According to WAC

296-155-66403, for temporary excavations of less than 20 feet in depth, the side slopes in Type C soils should be sloped at a maximum inclination of 1½H:1V or flatter from the toe to top of the slope. All exposed slope faces should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation. 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 significant seepage is not present on the slope face. Flatter cut slopes will be necessary where significant raveling or seepage occurs, or if construction materials will be stockpiled along the slope crest.

Where it is not feasible to slope the site soils back at these inclinations, a retaining structure should be considered. Retaining structures greater than 4-feet in height (bottom of footing to top of structure) or that have slopes of greater than 15 percent above them, should be engineered per Washington Administrative Code (WAC 51-16-080 item 5). This information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that GeoResources assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

Permanent Cut and Fill Slopes

Fill slopes constructed on grades that are steeper than 5H:1V should be constructed in accordance with Appendix J of the 2021 IBC and should utilize proper keying and benching methods. A detail of the Appendix J key and bench requirements are attached as Figure 10. The benches should be 1½ times the width of the equipment used for grading and be a maximum of 3 feet in height. Subsurface drainage may be required in areas where significant seepage is encountered during grading. Collected drainage should be directed to an appropriate discharge point. Surface drainage should be directed away from all slope faces.

Permanent cut or fill slopes in soil should be no steeper than 2H:1V. All permanent slopes should be protected from erosion as soon as feasible after grading is completed. Typical erosion control methods per the adopted 2021 *King County Surface Water Design Manual* should be sufficient for proposed site grading activities. Additionally, permanent slopes should be planted with a hardy vegetative groundcover, mulched, or armored with quarry spalls as soon as feasible after grading is completed.

Site Drainage

All ground surfaces, pavements, and sidewalks at the site should be sloped to direct surface water away from the structures, slopes, and property lines. Surface water runoff from the roof areas, driveways, perimeter footing drains, and wall drains should be collected, tightlined, and conveyed to an appropriate discharge point.

Precipitation water from roof downspouts should be collected into tightlines and routed away from the building. Downspout water should not be introduced into the foundation backfill or drains. Surface water should be collected in catch basins and tightlined with the downspout water to an approved discharge point.

Infiltration Recommendations

Based on our subsurface explorations, stormwater infiltration does appear feasible at the site, from a geotechnical standpoint, within the recessional outwash soils. The *2021 King County Surface*

Water Design Manual (KCSWDM), Appendix G provides guidance on testing and analysis to determine a design (long term) infiltration rate.

Infiltration Feasibility

The sieve test results indicate the recessional outwash soils encountered at the site generally range from silty sand with some gravel to poorly graded sand with silt. Accordingly, it is our opinion that stormwater infiltration is feasible within the recessional outwash soils.

Per the 2021 KCSWDM, a minimum vertical separation of 5 feet is required between the bottom of an infiltration facility and the top of an impermeable layer or seasonal high groundwater table. Based on our subsurface explorations, we anticipate that seasonal high groundwater is generally around Elevation 250 feet. This vertical separation can be reduced to 3 feet based on the results of a mounding analysis. We can perform a mounding analysis if requested.

Design Infiltration Rate

Per the 2021 KCSWDM the design infiltration rate is determined by multiplying the measured/calculated rate by correction factors. King County uses the correction factors outlined in Section 5.2.1 of the 2021 KCSWDM. To determine the initial infiltration rate ($I_{measured}$) for this project we used the Soil Grain Size Analysis Method. Three correction factors are then applied to the calculated, measured infiltration rate to account for test method ($F_{testing}$), facility geometry ($F_{geometry}$), and plugging of soils ($F_{plugging}$). The design infiltration rate is determined as follows:

$$I_{design} = I_{measured} * F_{testing} * F_{geometry} * F_{plugging}$$

Where:
I_{design} = Maximum design infiltration rate
$I_{measured}$ = Infiltration rate measured in the field or by grain size analysis
$F_{testing}$ = Accounts for uncertainties in the testing method (0.3 to 0.5)
$F_{geometry}$ = Accounts for the influence of facility geometry on the infiltration rate (0.25 to 1.0)
$F_{plugging}$ = Accounts for reductions in infiltration rates over time due to plugging (0.7 to 1.0)

Based on our field observations and laboratory testing, we used the following correction factors: test method $F_{testing} = 0.3$, geometry $F_{geometry} = 0.5$, and plugging $F_{plugging} = 0.7$. Applying the correction factors listed above to the calculated infiltration rate of 10.5 inches per hour results in a design infiltration rate of about **1.1 inch per hour within the near surface soils**, which is recommended for use in the design of infiltration facilities located in the recessional outwash soils encountered at the site. The project civil engineer should adjust the correction factor for site geometry as needed to fit the proposed design.

Construction Considerations

Suspended solids could clog the underlying soil and reduce the infiltration rate. To reduce potential clogging of the infiltration systems, the infiltration system should not be connected to the stormwater runoff system until after construction is complete and the site area is landscaped, paved or otherwise protected. Additional measures may also be taken during construction to minimize the potential of fines contamination of the proposed infiltration system, such as utilizing an alternative storm water management location during construction. All contractors working on the site should divert sediment laden stormwater away from proposed infiltration facilities during construction and landscaping activities. Washout areas should not be within the vicinity of the proposed infiltration facilities. After construction activities have been completed, periodic sweeping of the paved areas will help extend the life of the infiltration system.

Pavement Sections

We understand that improvements to the existing parking and adjacent roadway may be completed as a component of the proposed project. We have provided recommendations for hot-mix asphalt (HMA) minimum pavement sections based on *King County Road Design and Construction Standards* (2016). We were not provided with traffic data prior to preparation of this analysis.

Pavement Subgrades

Pavement subgrade areas should be prepared by excavating into firm native soils to design subgrade elevation or placing and compacting structural fill soils in appropriate lifts to at least 95 percent of maximum dry density as determined in accordance with ASTM D1557. The prepared subgrade should be performance tested by proof-rolling with a fully-loaded dump truck or equivalent point load equipment. Soft, loose, or wet areas that are identified during performance testing should be recompacted or removed, as appropriate. Over-excavated areas should be backfilled with compacted structural fill.

Pavement Sections

We recommend that the minimum HMA pavement section is in accordance with Table 4-1 of the *King County Road Design and Construction Standards* (2016) for residential roads and streets. Table 5, below, summarizes the recommended minimum pavement section thicknesses.

TABLE 5:
MINIMUM SECTION THICKNESS RECOMMENDATIONS (Inches)

Section	Roadway
	Parking Lot
½-inch Class HMA	2.5
CSBC or CSTC	5.0
Subgrade[1]	12.0

Notes:
CSBC – Crushed Surface Base Course per WSDOT 9-03.9(3)
CSTC – Crushed Surface Top Course per WSDOT 9-03.9(3)
[1] Prepared native soils or structural fill compacted to 95 percent MDD, based on ASTM D1557

Pavement Frost Conditions

Frost-susceptible soil is generally regarded as having greater than 3 percent finer than 0.02 millimeter (mm). Soil with a fines content not exceeding 7 percent passing the No. 200 sieve, based on the minus ¾-inch fraction, can normally be expected to have 3 percent or less finer than 0.02 mm. Based on the soils observed during our construction monitoring, most of the near-surface soils could be considered frost-susceptible. Based on information provided in the WSDOT Pavement

Policy, we recommend assuming the frost depth would be about 15 inches. WSDOT recommends that the total depth of the pavement section be at least 50 percent of the frost depth, or 7.5 inches.

In our opinion, the recommended pavement sections should provide adequate protection against potential frost heave damage.

Pavement Materials and Construction

In general, the aggregate base course, HMA, and PCC should be constructed in accordance with WSDOT Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT Standard Specifications, 2016). HMA should conform to Section 5-04 in the WSDOT Standard Specifications and the PCC should conform to Section 5-05 of the WSDOT Standard Specifications. We recommend that crushed rock used as CSBC in pavement sections consist of material of approximately the same quality as "crushed surfacing (base course)" (or better) described in Section 9-03.9(3) of the WSDOT Standard Specifications. We further recommend that CSBC material be compacted to at least 95 percent of the MDD based on the modified Proctor procedure (ASTM D1557).

EARTHWORK RECOMMENDATIONS

Site Preparation

All structural areas on the site to be graded should be stripped of vegetation, organic surface soils, and other deleterious materials including existing structures, foundations or abandoned utility lines. Organic topsoil is not suitable for use as structural fill, but may be used for limited depths in non-structural areas. Stripping depths ranging from 6 to 12 inches should be expected to remove topsoil and up to 3½ to remove fill soil based on conditions observed at the exploration locations. Areas of thicker topsoil or organic debris may be encountered in areas of heavy vegetation or depressions.

Where placement of fill material is required, the stripped/exposed subgrade areas should be compacted to a firm and unyielding surface prior to placement of any fill. Excavations for debris removal should be backfilled with structural fill compacted to the densities described in the "**Structural Fill**" section of this report.

We recommend that a member of our staff evaluate the exposed subgrade conditions after removal of vegetation and topsoil stripping is completed and prior to placement of structural fill. The exposed subgrade soil should be proof-rolled with heavy rubber-tired equipment during dry weather or probed with a ½ inch diameter steel rod during wet weather conditions.

Soft, loose, or otherwise unsuitable areas delineated during proofrolling or probing should be recompacted, if practical, or over-excavated and replaced with structural fill. The depth and extent of overexcavation should be evaluated by our field representative at the time of construction. The areas of old fill material should be evaluated during grading operations to determine if they need mitigation; recompaction or removal.

Structural Fill

All material placed as fill for the proposed improvements should be placed as structural fill. Material placed as structural fill should be free of debris, organic matter, trash, and cobbles greater than 4-inches in diameter. The moisture content of the fill material should be adjusted as necessary for proper compaction.

Materials

The suitability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines (material passing US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. During wet weather, we recommend use of well-graded sand and gravel with less than 5 percent (by weight) passing the US No. 200 sieve based on that fraction passing the ¾-inch sieve, such as *Gravel Backfill for Walls* (WSDOT 9-03.12(2)). If prolonged dry weather prevails during the wall construction, higher fines content (up to 10 to 12 percent) may be acceptable.

Placement and Compaction

The appropriate lift thickness will depend on the structural fill characteristics and compaction equipment used, but it is typically limited to 4 to 6 inches for hand operated equipment; thicker lifts may be appropriate for larger equipment. For larger equipment such as a hoe-pac or drum roller, we recommend a maximum loose-lift thickness of 10 inches. Structural fill should be compacted to at least 95 percent of the MDD as determined by the Modified Proctor (ASTM D1557), except for within 12 inches of the back of any walls, as described in the "**Wall Drainage**" section of this report. Additionally, the moisture content should be maintained within 3 percent of the optimum moisture content in accordance with ASTM D1557.

Suitability of On-Site Materials as Fill

During dry weather construction, non-organic on-site soil may be considered for use as structural fill; provided it meets the criteria described above in the "**Structural Fill"** section and can be compacted as recommended. If the soil material is over-optimum in moisture content when excavated, it will be necessary to aerate or dry the soil prior to placement as structural fill. We generally did not observe the site soils to be excessively moist at the time of our subsurface exploration program.

The previously placed fill encountered at shallow depths at the site may be suitable for reuse, provided that all organic material is removed prior to placement. The native recessional outwash soils are generally comparable to "common borrow" material and will be suitable for use as structural fill provided the moisture content is maintained within 2 percent of the optimum moisture level.

We recommend that completed graded-areas be restricted from traffic or protected prior to wet weather conditions. The graded areas may be protected by paving, placing asphalt-treated base, a layer of free-draining material such as pit run sand and gravel or clean crushed rock material containing less than 5 percent fines, or some combination of the above.

Erosion and Sediment Control

Weathering, erosion and the resulting surficial sloughing and shallow land sliding are natural processes. These processes are common occurrences on the face of steep slopes. The sediment from any surficial sloughing and shallow land sliding may also cog up existing drainage systems and natural drainage paths. To manage and reduce the potential of these natural processes occurring, we recommend temporary erosion protection and sediment control measures be put in place for the steep slopes at the residence during construction activities. Erosion hazards can be mitigated by applying Best Management Practices (BMP's) outlined in the 2021 *King County Surface Water Design Manual*. To manage and reduce the potential for these natural processes, we recommend the following:

- No drainage of concentrated surface water or significant sheet flow onto slopes greater than 15 percent with more than 10 feet of vertical relief in the eastern portion of the site.
- Any site grading should be limited to surface grades that direct runoff away from the face of slopes to an appropriate discharge location at the toe.
- Existing vegetation should be maintained to the extent feasible during construction activities to reduce the potential for erosion at the site.
- Any areas of exposed soils be covered with mulch, straw, or other approved BMPs for erosion control.

Any erosion and sediment control plan should be in accordance with the 2021 *King County Surface Water Design Manual*.

Wet Weather and Wet Condition Considerations

In the Puget Sound area, wet weather generally begins about mid-October and continues through about May, although rainy periods could occur at any time of year. Therefore, it is strongly encouraged that earthwork be scheduled during the dry weather months of June through September. Most of the soil at the site contains sufficient fines to produce an unstable mixture when wet. Such soil is highly susceptible to changes in water content and tends to become unstable and impossible to compact if the moisture content exceeds the optimum.

In addition, during wet weather months, groundwater levels could increase, resulting in seepage into site excavations. Performing earthwork during dry weather would reduce these problems and costs associated with rainwater, construction traffic, and handling of wet soil. However, should wet weather/wet condition earthwork be unavoidable, the following recommendations are provided:

- The ground surface in and surrounding the construction area should be sloped as much as possible to promote runoff of precipitation away from work areas and to prevent ponding of water.
- Work areas or slopes should be covered with plastic when not being worked. The use of sloping, ditching, sumps, dewatering, and other measures should be employed as necessary to permit proper completion of the work.
- Earthwork should be accomplished in small sections to minimize exposure to wet conditions. That is, each section should be small enough so that the removal of unsuitable soils and placement and compaction of clean structural fill could be accomplished on the same day. The size of construction equipment may have to be limited to prevent soil disturbance. It may be necessary to excavate soils with a backhoe, or equivalent, and locate them so that equipment does not pass over the excavated area. Thus, subgrade disturbance caused by equipment traffic would be minimized.
- Fill material should consist of clean, well-graded, sand and gravel, of which not more than 5 percent fines by dry weight passes the No. 200 mesh sieve, based on wet-sieving the fraction passing the ¾-inch mesh sieve. The gravel content should range from between 20 and 50 percent retained on a No. 4 mesh sieve. The fines should be non-plastic.
- No exposed soil should be left uncompacted and exposed to moisture. A smooth-drum vibratory roller, or equivalent, should roll the surface to seal out as much water as possible.

- In-place soil or fill soil that becomes wet and unstable and/or too wet to suitably compact should be removed and replaced with clean, granular soil (see gradation requirements above).
- Excavation and placement of structural fill material should be observed on a full-time basis by a geotechnical engineer (or representative) experienced in wet weather/wet condition earthwork to determine that all work is being accomplished in accordance with the project specifications and our recommendations.
- Grading and earthwork should not be accomplished during periods of heavy, continuous rainfall.

We recommend that the above requirements for wet weather/wet condition earthwork be incorporated into the contract specifications.

Plan Review and Construction Monitoring

King County will likely require our review of the project plans and specifications and a letter stating that our recommendations in this report have been included and that the development is appropriate. The County may also require us to perform construction monitoring for the project.

LIMITATIONS

We have prepared this report for use by WJA Design Collaborative, King County, and other members of the design team for use in the design of a portion of this project. The data used in preparing this report and this report should be provided to prospective contractors for their bidding or estimating purposes only. Our report, conclusions and interpretations are based on our subsurface explorations, data from others and limited site reconnaissance, and should not be construed as a warranty of the subsurface conditions.

Variations in subsurface conditions are possible between the explorations and may also occur with time. A contingency for unanticipated conditions should be included in the budget and schedule. Sufficient monitoring, testing and consultation should be provided by our firm during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork and foundation installation activities comply with contract plans and specifications.

The scope of our services does not include services related to environmental remediation and construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design.

If there are any changes in the loads, grades, locations, configurations or type of facilities to be constructed, the conclusions and recommendations presented in this report may not be fully applicable. If such changes are made, we should be given the opportunity to review our recommendations and provide written modifications or verifications, as appropriate.

◆ ◆ ◆

We have appreciated the opportunity to be of service to you on this project. If you have any questions or comments, please do not hesitate to call at your earliest convenience.

Respectfully submitted,
GeoResources, LLC

Davis W. Carlsen, LG
Project Geologist

Engineering Geologist
3237
6.12.25
Seth Taylor Mattos

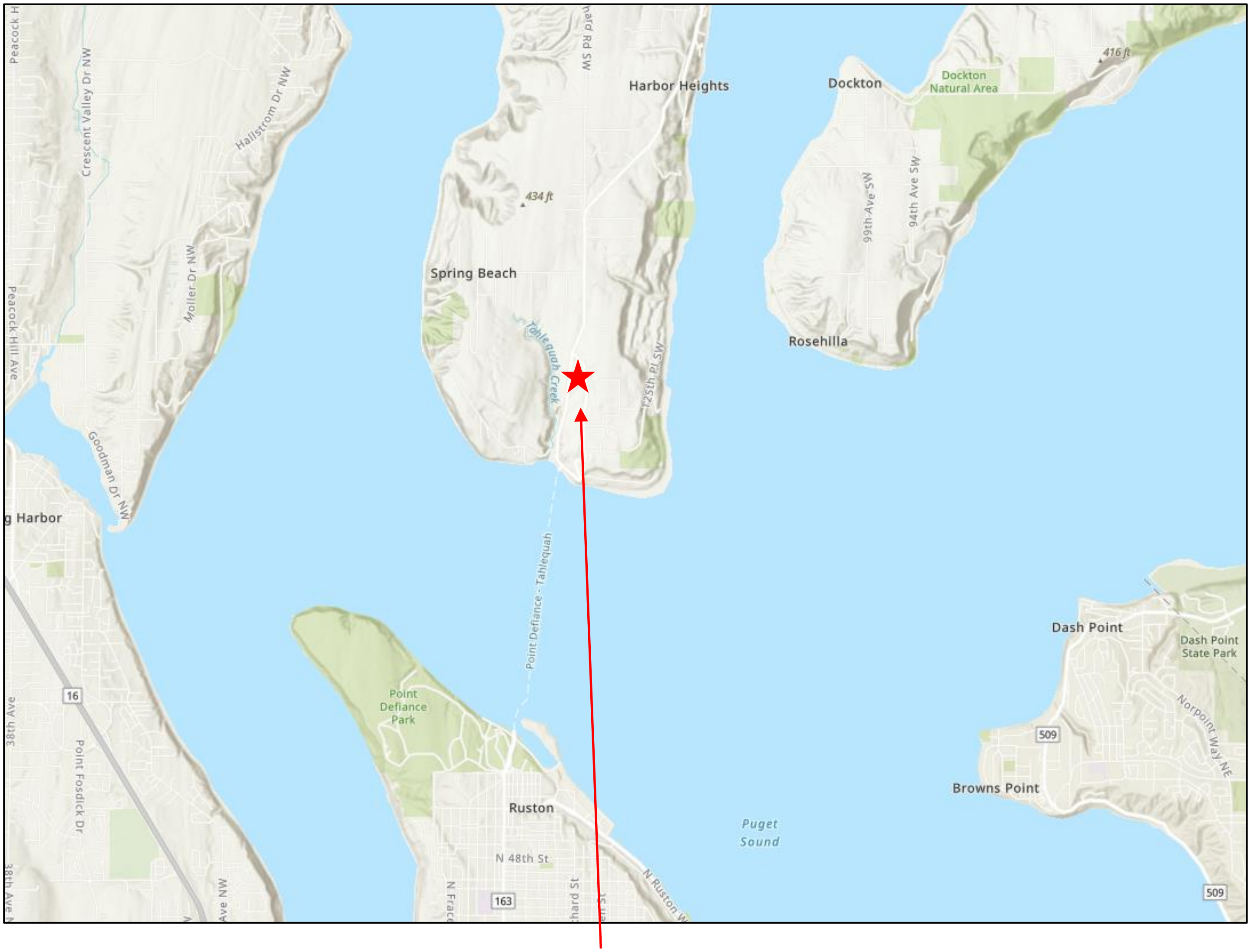
Seth T. Mattos, LEG
Associate

ANDREW EDWARD B SCHNITGER
23020110
6-12-25

Andrew E. Schnitger, PE
Project Geotechnical Engineer

DC:STM:AES/dc
DocID: WJADC.KC.SVashonTrailhead.RG

Attachments:	Figure 1: Site Location Map
	Figure 2: Site & Exploration Plan
	Figure 3: Site Vicinity Map
	Figure 4: NRCS Soils Map
	Figure 5: Geologic Map
	Figure 6: WA DNR Landslide Compilation and LiDAR
	Figure 7: Steep Slope Hazard Map
	Figure 8: Liquefaction Susceptibility Map
	Figure 9: Fault Hazards Map
	Figure 10: IBC Appendix J Detail
	Appendix "A" – Subsurface Explorations
	Appendix "B" – Laboratory Test results



Approximate Site Location

An excerpt from the Washington State Department of Natural Resources Geologic Information Portal
(https://geologyportal.dnr.wa.gov/)

Not to Scale

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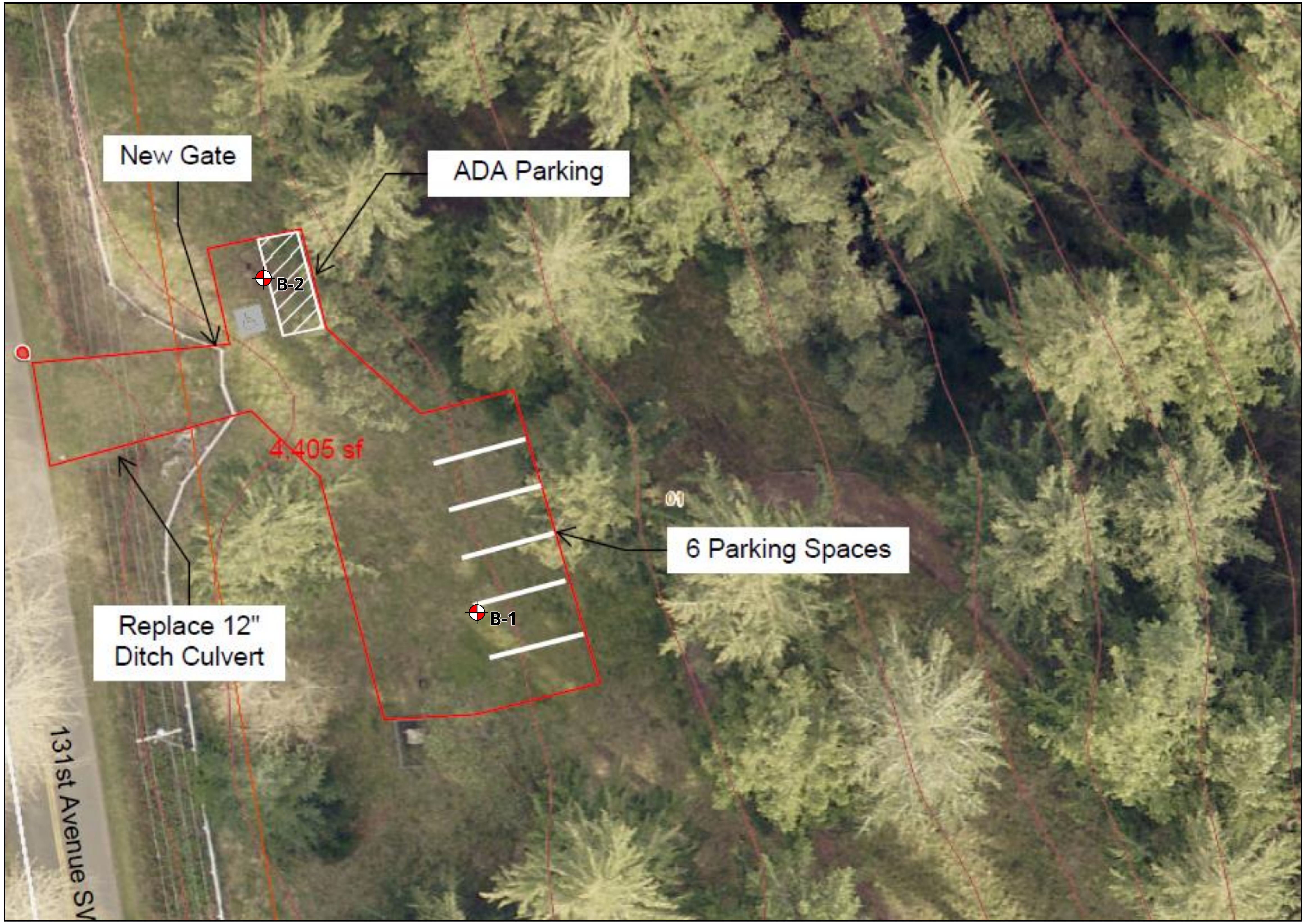
Site Location Map

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F	Jun 2025	Figure 1



Excerpt of *Preliminary Site Plan* provided by WJA Design Collaborative

North

⊕ B-# Boring number and approximate location (GeoResources 2025)

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Site & Exploration Plan

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F	Jun 2025	Figure 2

Approximate Site Location

An excerpt from the King County GIS Assessor Maps web resource
(https://gismaps.kingcounty.gov/iMap/)

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Site Vicinity Map

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F	Jun 2025	Figure 3

Approximate Site Location

Figure created from the USDA NRCS Web Soil Survey
(http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx)

Soil Type	Soil Name	Parent Material	Slopes (%)	Erosion Hazard (off-road, off-trail)	Hydrologic Soil Group
AgD	Alderwood gravelly sandy loam	Glacial drift and/or glacial outwash	15 to 30	Severe	B
EwC	Everett-Alderwood gravelly sandy loam	Glacial outwash with component of volcanic ash	6 to 15	Slight to Moderate	A

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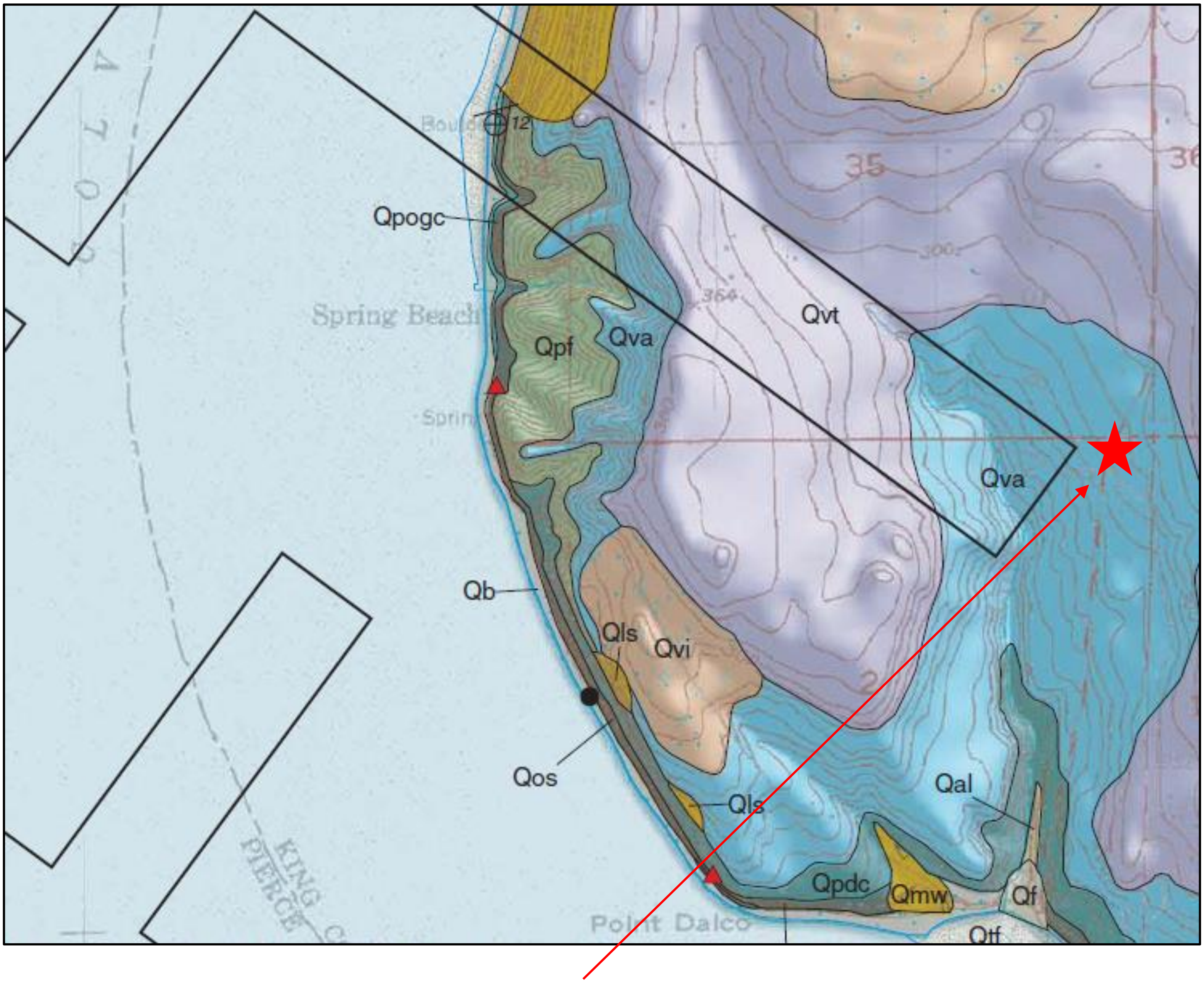
NRCS Soils Map

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, WA

Doc ID: WJADC.KC.SVashonTrailhead.F	Jun 2025	Figure 4



Approximate Site Location

An excerpt from the draft of the *Geologic Map of the Gig Harbor 7.5-minute Quadrangle, Washington*
by Booth, D.B., Troost, K.G., and Wells, R.E. (in review)

Qvt	Glacial till
Qva	Advance outwash deposits

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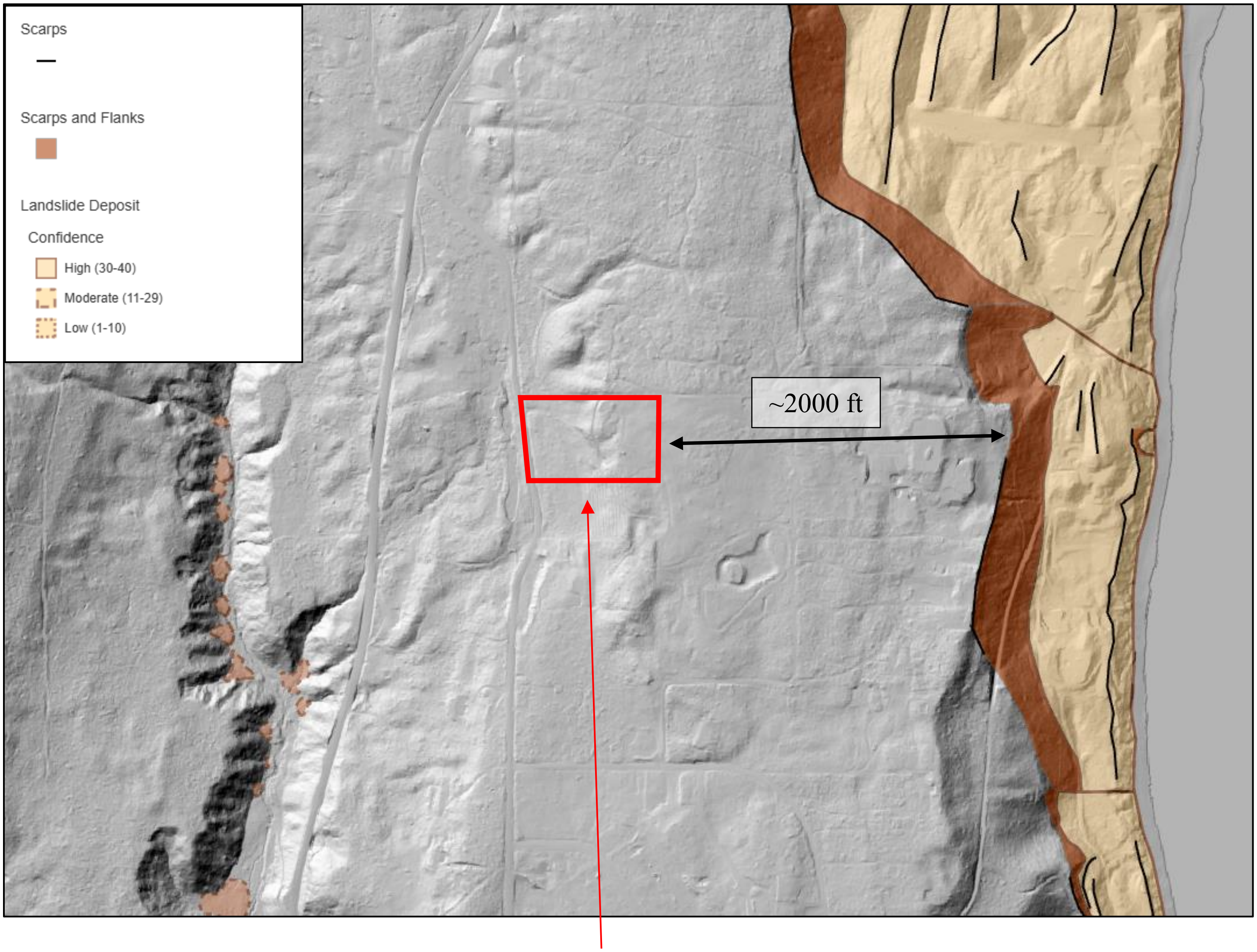
Geologic Map

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F | Jun 2025 | Figure 5



Approximate Site Location

An excerpt from the Washington Department of Natural Resources Landslide Compilation
(https://geologyportal.dnr.wa.gov/)

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DNR Landslide Compilation and LiDAR

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

DocID: WJADC.KC.SVashonTrailhead.F	Feb 2025	Figure 6

Approximate Site Location

An excerpt from the King County GIS Assessor Maps web resource
(https://gismaps.kingcounty.gov/iMap/)

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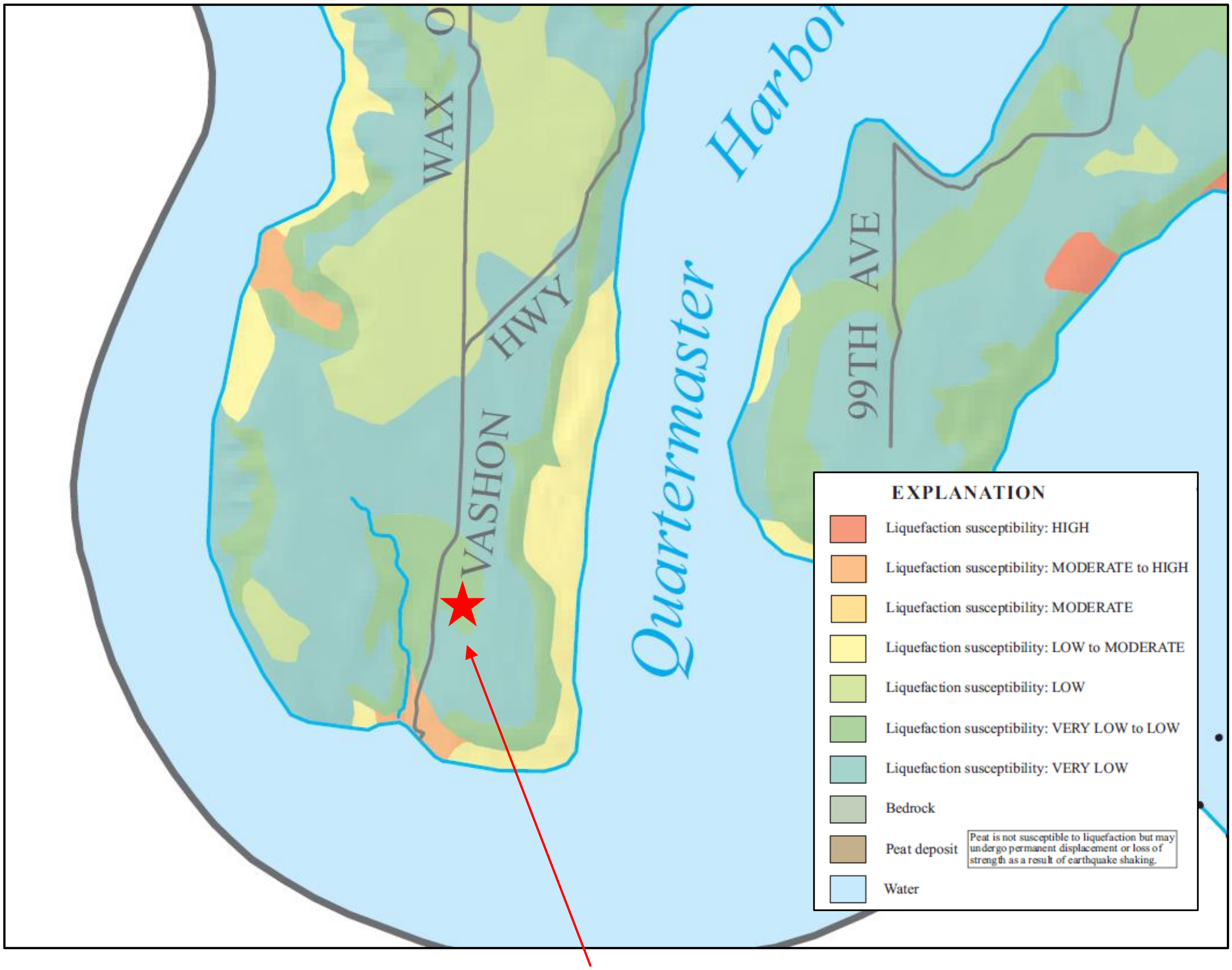
Steep Slope Hazard Map

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F | Jun 2025 | Figure 7



Approximate Site Location

An excerpt from the *Liquification Susceptibility Map of King County, Washington* by Stephen P. Palmer, Sammantha L. Magsino, Eric L. Bilderback, James L. Poelstra, Derek S. Folger, and Rebecca A. Niggemann (2004)

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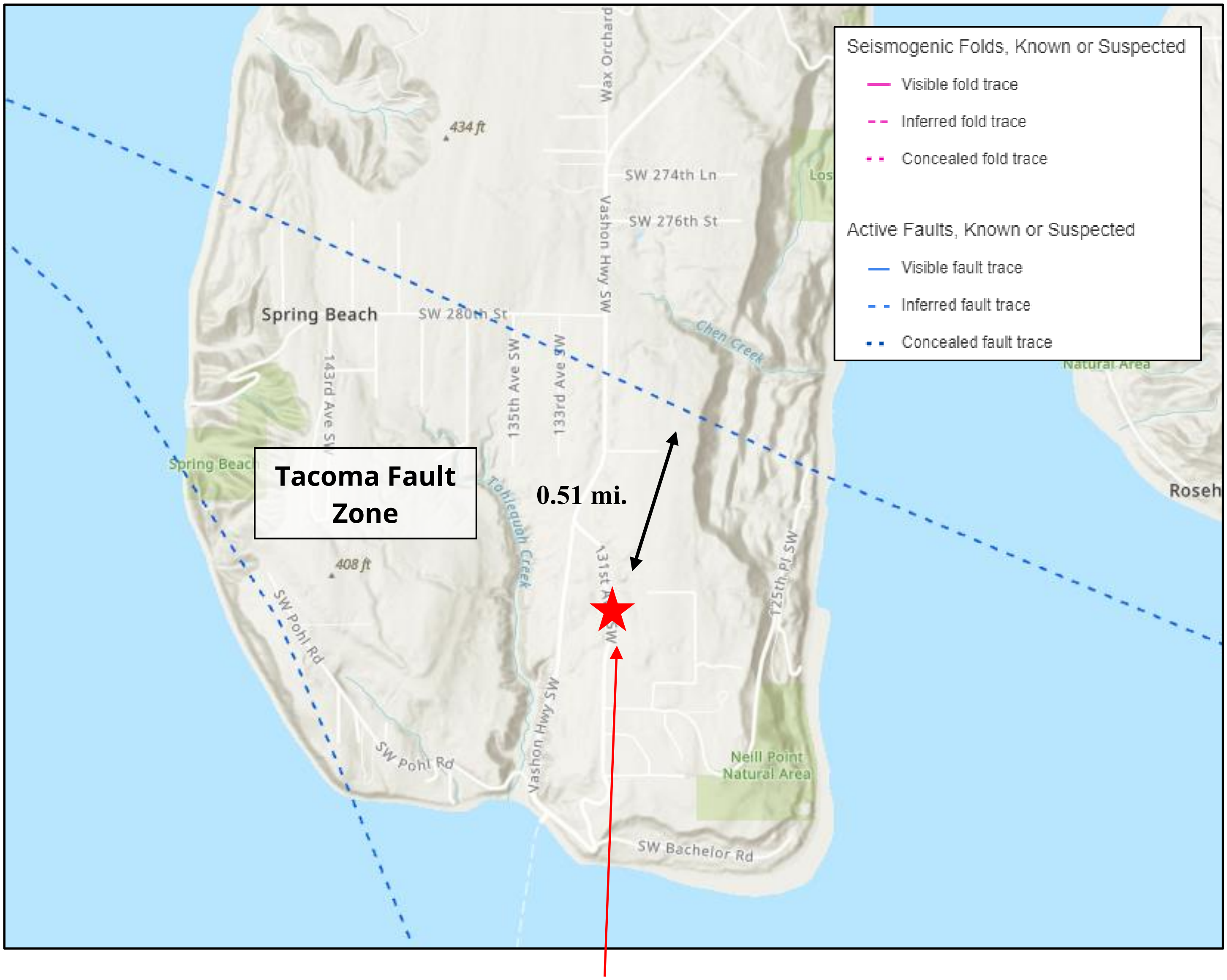
Liquefaction Susceptibility Map
Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F	Jun 2025	Figure 8



Approximate Site Location

An excerpt from the Washington State Department of Natural Resources Geologic Information Portal (https://geologyportal.dnr.wa.gov/)

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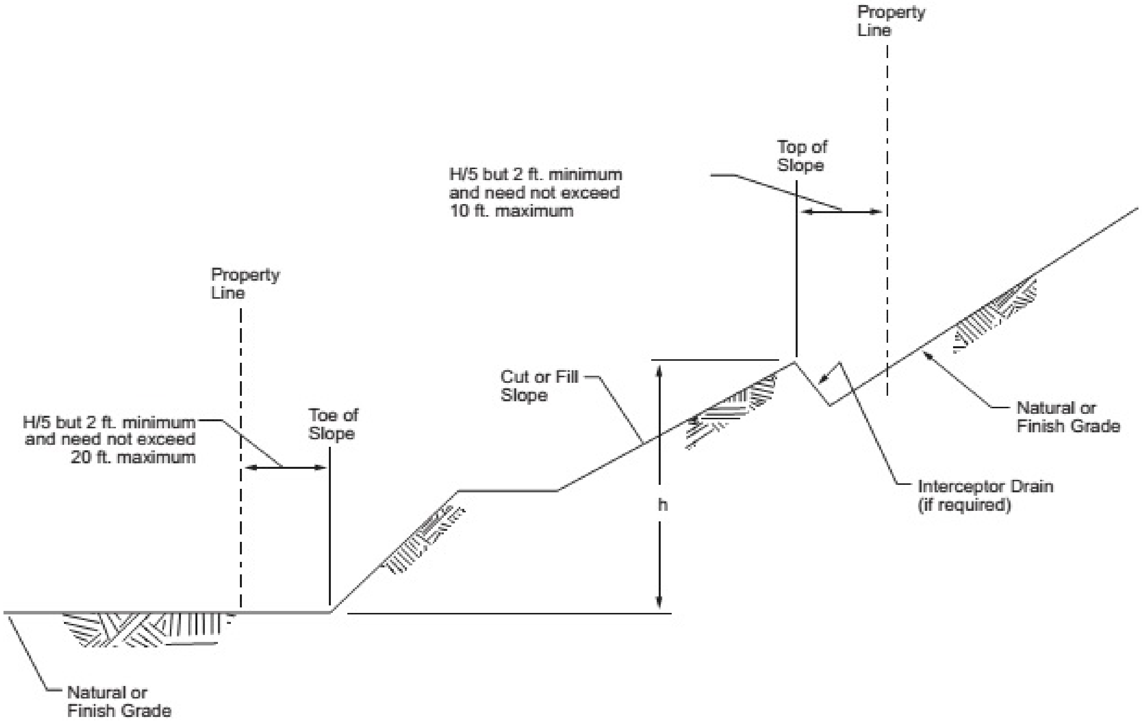
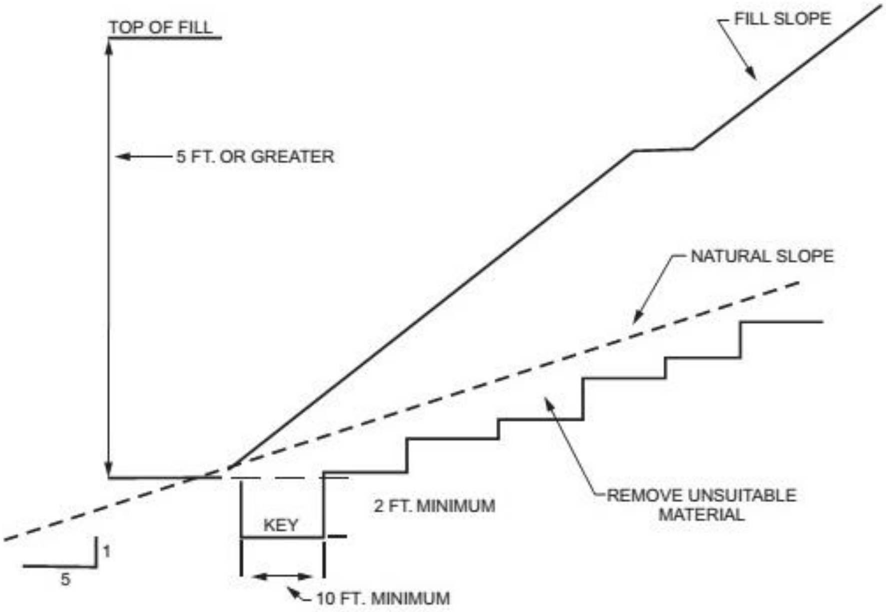
Fault Hazards Map

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F	Jun 2025	Figure 9





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IBC Appendix J Detail

Proposed Trailhead Improvements
New South Vashon Levy Trailhead
Contract: KC23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F | April 2025 | Figure 10

Appendix A

Subsurface Explorations

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More than 50% Retained on No. 200 Sieve	GRAVEL More than 50% Of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More than 50% Of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or more	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D6913.
3. Description of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and or test data.

SOIL MOISTURE MODIFIERS:

Dry-	Absence of moisture, dry to the touch
Moist-	Damp, but no visible water
Wet-	Visible free water or saturated, usually soil is obtained from below water table

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Unified Soils Classification System
Proposed Trailhead Improvements
New South Vashon Levy Trailhead
23005-2406
King County, Washington

Doc ID: WJADC.KC.SVashonTrailhead.F	Jun 2025	Figure A-1

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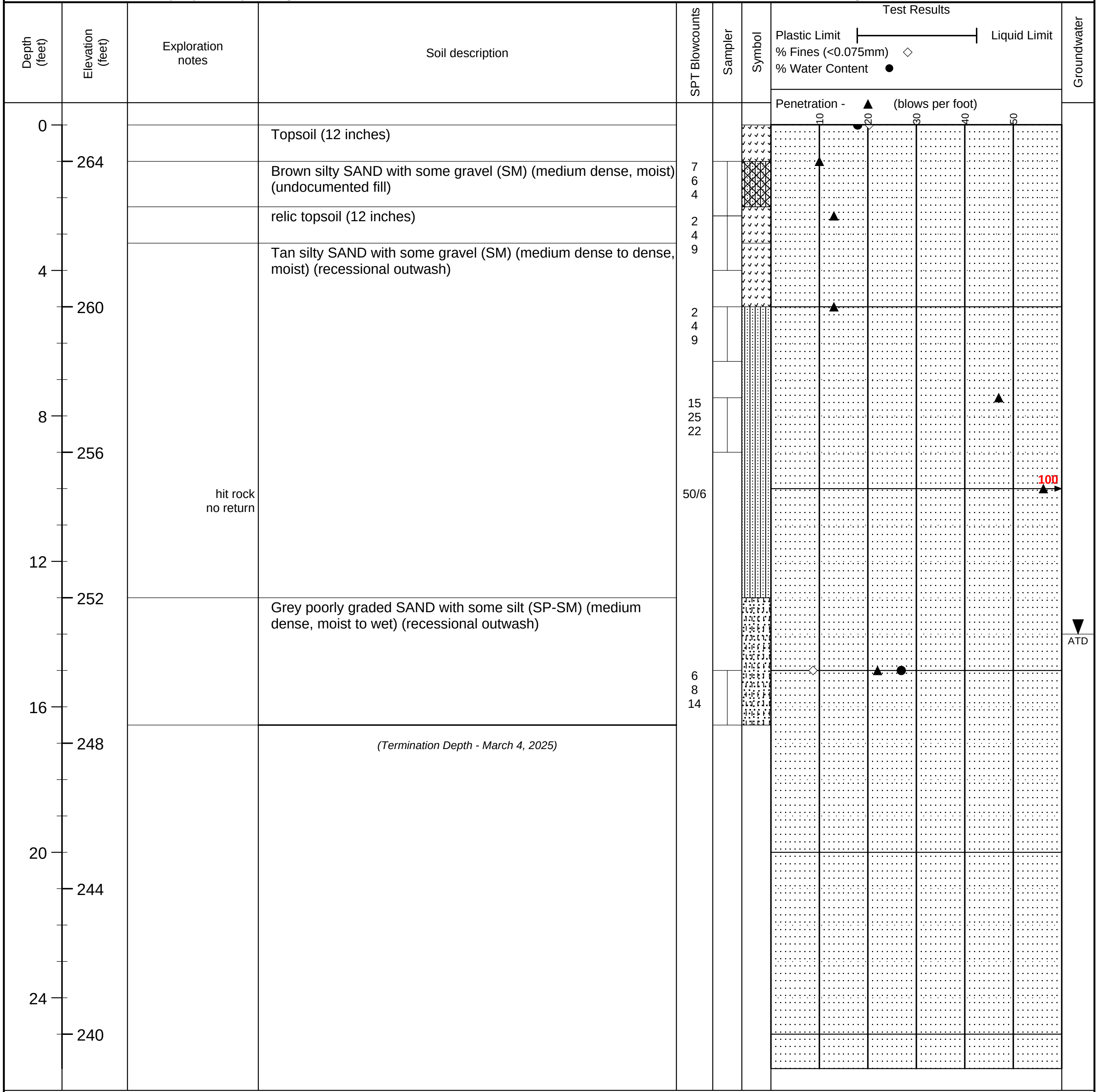
LOG OF BORING B-1

WJA.SouthVashonTrailhead
xxx- 131st Avenue SW
King County, Washington

1. Refer to log key for definition of symbols, abbreviations, and codes
2. USCS disination is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. NE = Not Encountered
5. ATD = At Time of Drilling

Drilling Company:	Holocene	**Logged By:**	DC
Drilling Method:	HSA	**Drilling Date:**	March 4, 2025
Drilling Rig:	D-50	**Datum:**	NAVD88
Sampler Type:	2 inch split spoon	**Elevation:**	265
Hammer Type:	automatic	**Termination Depth:**	16.5
Hammer Weight:	140 lbs	**Latitude:**	
		Longitude:	

Notes: South side of proposed parking lot



Exploration notes	Soil description	SPT Blowcounts
	Topsoil (12 inches)	
	Brown silty SAND with some gravel (SM) (medium dense, moist) (undocumented fill)	7 6 4
	relic topsoil (12 inches)	2 4 9
hit rock no return	Tan silty SAND with some gravel (SM) (medium dense to dense, moist) (recessional outwash)	2 4 9 15 25 22 50/6
	Grey poorly graded SAND with some silt (SP-SM) (medium dense, moist to wet) (recessional outwash)	6 8 14
	(Termination Depth - March 4, 2025)	

▨ Topsoil
▩ Description not given for: "0F"
▥ Silty sand
▦ Poorly graded sand with silt

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LOG OF BORING B-2

WJA.SouthVashonTrailhead
xxx- 131st Avenue SW
King County, Washington

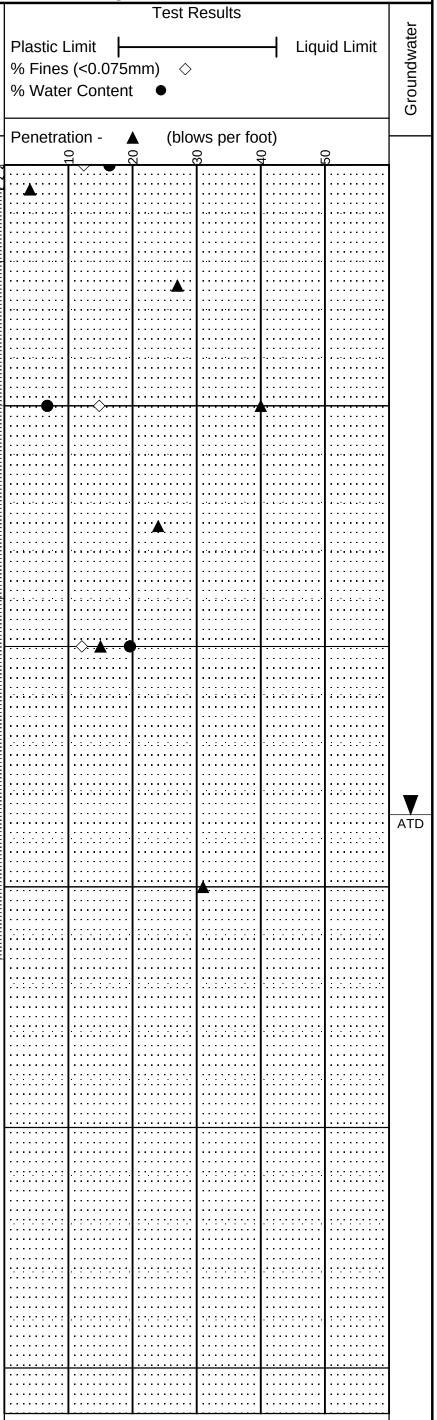
1. Refer to log key for definition of symbols, abbreviations, and codes
2. USCS disination is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. NE = Not Encountered
5. ATD = At Time of Drilling

Drilling Company: Holocene
Drilling Method: HSA
Drilling Rig: D-50
Sampler Type: 2 inch split spoon
Hammer Type: automatic
Hammer Weight: 140 lbs

Logged By: DC
Drilling Date: March 4, 2025
Datum: NAVD88
Elevation: 264
Termination Depth: 16.5
Latitude:
Longitude:

Notes: Northern portion of proposed parking lot

Depth (feet)	Elevation (feet)	Exploration notes	Soil description	SPT Blowcounts	Symbol
0	264		Topsoil (6 inches)		▨
			Brown silty SAND with some gravel (SM) (loose, moist) (weathered recessional outwash)	4 2 2	▥
4	260	no return	Tan silty SAND with some gravel (SM) (medium dense to dense, moist) (recessional outwash)	4 12 15	▥
8	256		Silty SAND with gravel (SM)	14 18 22 8 9 15	▥
12 16	252 248		Grey silty SAND with some gravel (SM) (medium dense to dense, moist to wet) (recessional outwash)	8 6 9 16 12 19	▥
20 24	244 240		*(Termination Depth - March 4, 2025)*		

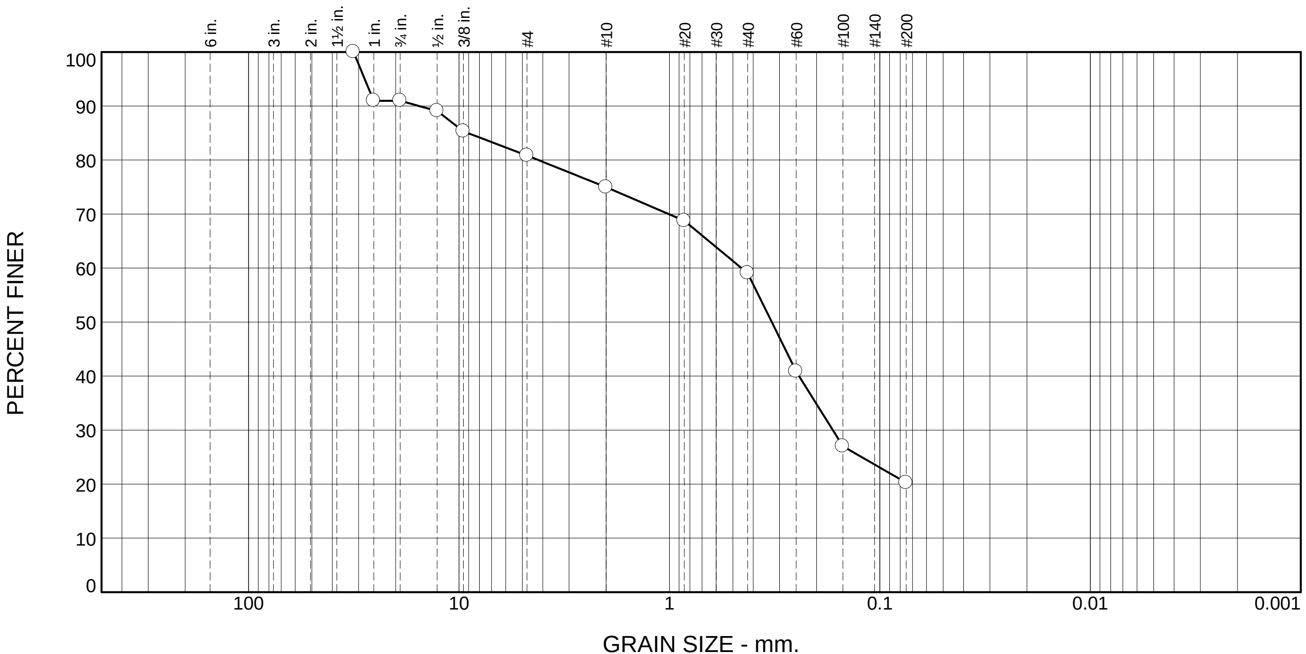


▨ Topsoil ▥ Silty sand

Appendix B

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	9.0	10.2	5.8	15.9	38.8	20.3	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.25	100.0		
1	91.0		
.75	91.0		
.5	89.1		
0.375	85.3		
#4	80.8		
#10	75.0		
#20	68.8		
#40	59.1		
#60	40.9		
#100	27.0		
#200	20.3		

* (no specification provided)

Material Description

Silty SAND with gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}=	15.4626	D_{85}=	9.0960	D_{60}=	0.4547
D_{50}=	0.3263	D_{30}=	0.1674	D_{15}=	
D_{10}=		C_u=		C_c=	

Remarks

Natural Moisture: 17.9%

Date Received: 3/4/25 **Date Tested:** 3/5/25

Tested By: MAW

Checked By: STM

Title: PM

Source of Sample: B-1 **Depth:** 0 **Date Sampled:** 3/4/25

Sample Number: 1

GeoResources, LLC

Fife, WA

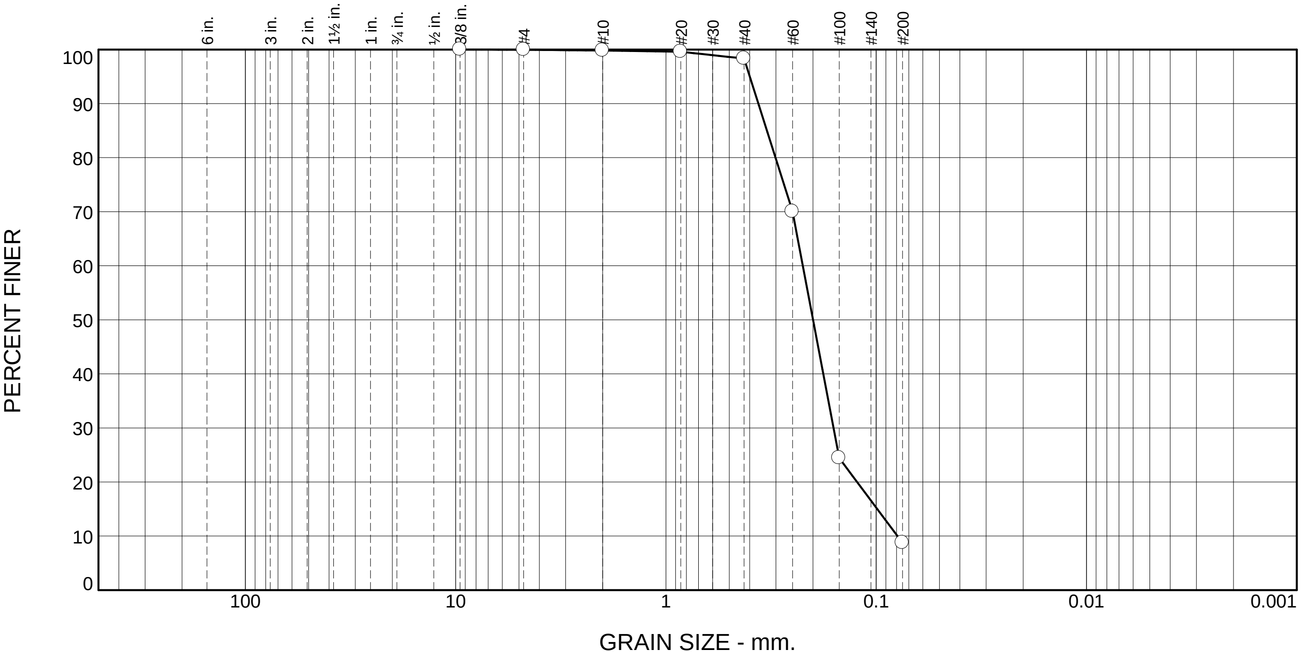
Client: King County Parks

Project: WJA.SouthVashonTrailhead

Project No: WJA.SouthVashonTrailhead **Figure** B-1

Tested By: ______________________ **Checked By:** ______________________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.2	1.5	89.6	8.7	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.375	100.0		
#4	100.0		
#10	99.8		
#20	99.6		
#40	98.3		
#60	70.0		
#100	24.4		
#200	8.7		

* (no specification provided)

Material Description

Poorly graded SAND with silt (SP-SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.3635	D_{85}= 0.3310	D_{60}= 0.2234
D_{50}= 0.1997	D_{30}= 0.1596	D_{15}= 0.0989
D_{10}= 0.0793	C_u= 2.82	C_c= 1.44

Remarks

Natural Moisture: 26.9%

Date Received: 3/4/25 **Date Tested:** 3/5/25

Tested By: MAW

Checked By: STM

Title: PM

Source of Sample: B-1 **Depth:** 15 **Date Sampled:** 3/4/25

Sample Number: 6

GeoResources, LLC

Fife, WA

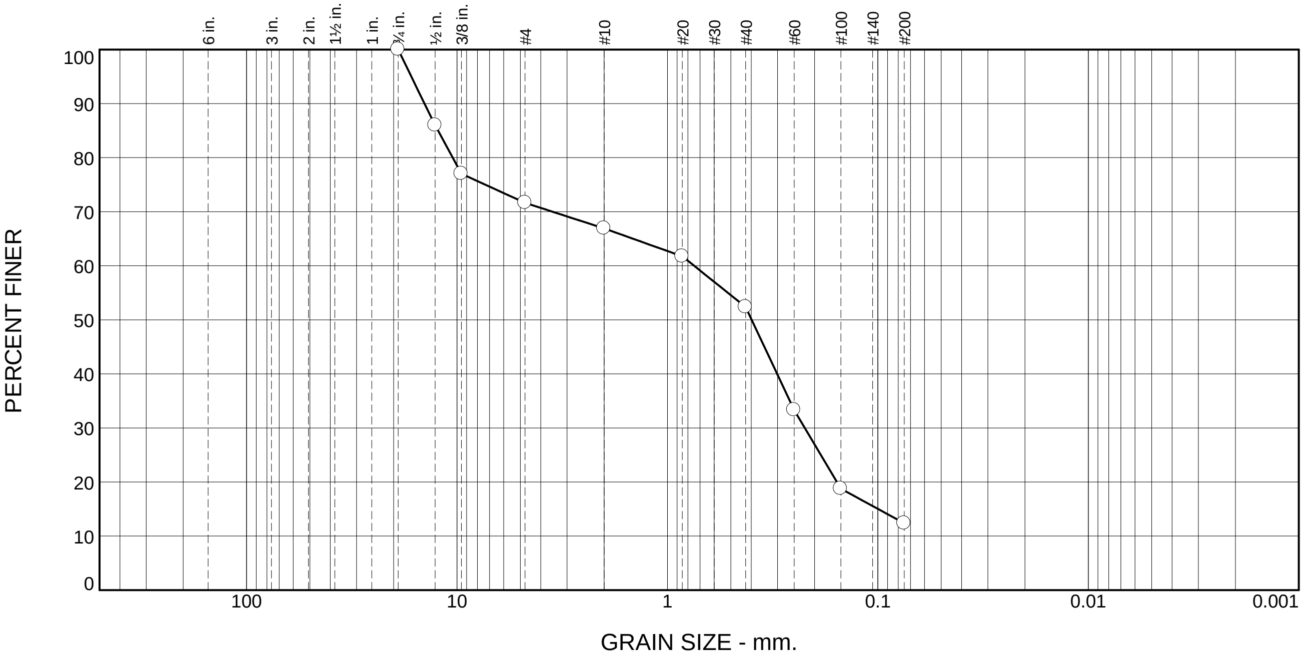
Client: King County Parks

Project: WJA.SouthVashonTrailhead

Project No: WJA.SouthVashonTrailhead **Figure** B-2

Tested By: ____________________ **Checked By:** ____________________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	28.4	4.7	14.5	40.0	12.4	

Test Results (ASTM D 6913 & ASTM D 1140)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.5	86.0		
0.375	77.0		
#4	71.6		
#10	66.9		
#20	61.8		
#40	52.4		
#60	33.3		
#100	18.8		
#200	12.4		

* (no specification provided)

Material Description

Silty SAND with gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}=	14.2659	D_{85}=	12.3072	D_{60}=	0.7468
D_{50}=	0.3979	D_{30}=	0.2226	D_{15}=	0.0997
D_{10}=		C_u=		C_c=	

Remarks

Natural Moisture: 16.4%

Date Received: 3/4/25 **Date Tested:** 3/5/25

Tested By: MAW

Checked By: STM

Title: PM

Source of Sample: B-2 **Depth:** 0 **Date Sampled:** 3/4/25

Sample Number: 1

GeoResources, LLC

Fife, WA

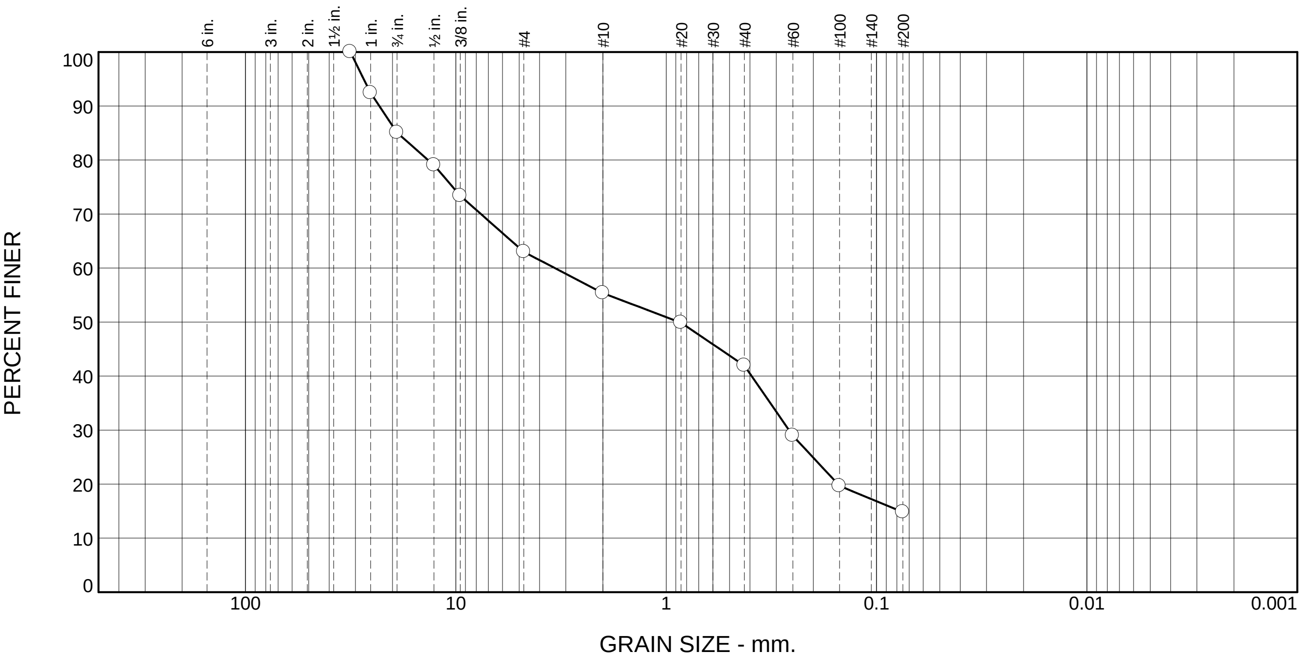
Client: King County Parks

Project: WJA.SouthVashonTrailhead

Project No: WJA.SouthVashonTrailhead **Figure** B-3

Tested By: ______________________ **Checked By:** ______________________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	14.9	22.1	7.6	13.5	27.1	14.8	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.25	100.0		
1	92.4		
.75	85.1		
.5	79.1		
0.375	73.4		
#4	63.0		
#10	55.4		
#20	49.9		
#40	41.9		
#60	29.0		
#100	19.7		
#200	14.8		

* (no specification provided)

Material Description

Silty SAND with gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}=	23.1078	D_{85}=	18.9664	D_{60}=	3.3834
D_{50}=	0.8666	D_{30}=	0.2608	D_{15}=	0.0770
D_{10}=		C_u=		C_c=	

Remarks

Natural Moisture: 6.7%

Date Received: 3/4/25 **Date Tested:** 3/5/25

Tested By: MAW

Checked By: STM

Title: PM

Source of Sample: B-2 **Depth:** 5 **Date Sampled:** 3/4/25

Sample Number: 3

GeoResources, LLC

Fife, WA

Client: King County Parks

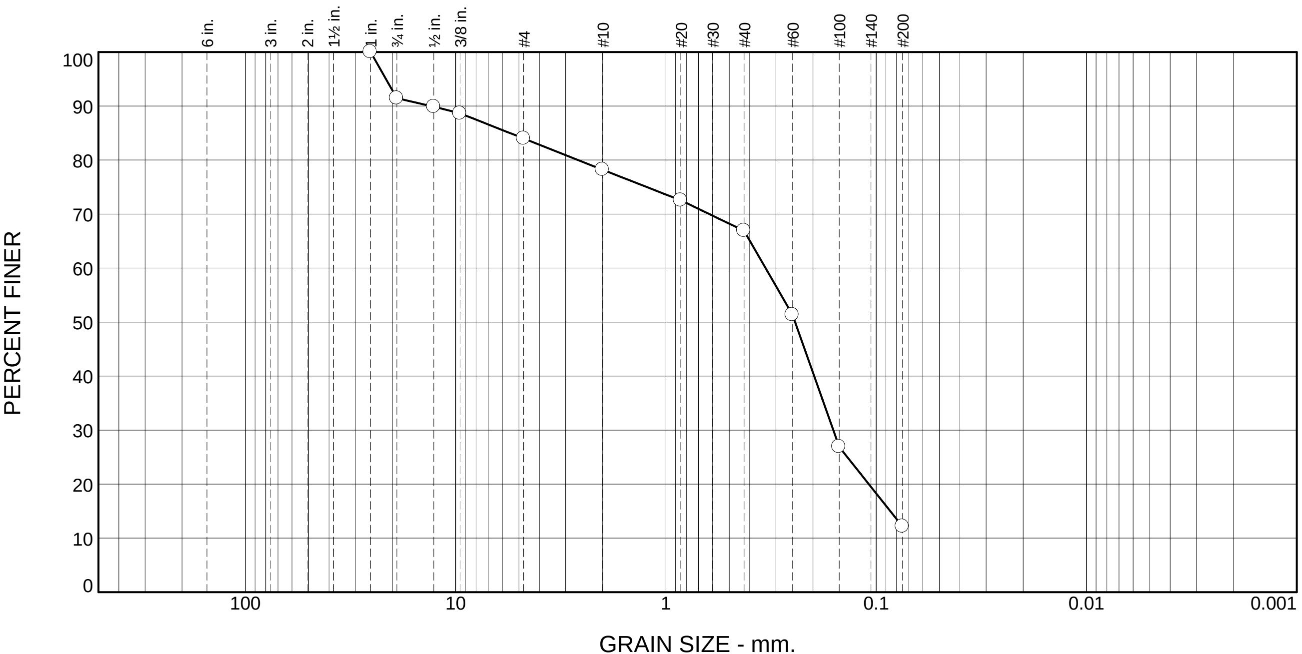
Project: WJA.SouthVashonTrailhead

Project No: WJA.SouthVashonTrailhead **Figure** B-4

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Tested By: ____________________ **Checked By:** ____________________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	8.6	7.4	5.8	11.3	54.8	12.1	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	91.4		
.5	89.9		
0.375	88.6		
#4	84.0		
#10	78.2		
#20	72.5		
#40	66.9		
#60	51.3		
#100	26.9		
#200	12.1		

* (no specification provided)

Material Description

Silty SAND with gravel (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}=	13.1312	D_{85}=	5.5177	D_{60}=	0.3360
D_{50}=	0.2432	D_{30}=	0.1600	D_{15}=	0.0858
D_{10}=		C_u=		C_c=	

Remarks

Natural Moisture: 19.6%

Date Received: 3/4/25 **Date Tested:** 3/5/25

Tested By: MAW

Checked By: STM

Title: PM

Source of Sample: B-2 **Depth:** 10 **Date Sampled:** 3/4/25

Sample Number: 5

GeoResources, LLC

Fife, WA

Client: King County Parks

Project: WJA.SouthVashonTrailhead

Project No: WJA.SouthVashonTrailhead **Figure** B-5

Tested By: ____________________ **Checked By:** ____________________