



# Preliminary Geotechnical Engineering Report

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**Port of Kingston Remote Ferry Holding Lot  
Kingston, Washington**

January 20, 2020

Terracon Project No. 81195118

**Prepared for:**

Perteet, Inc.

Seattle, WA

**Prepared by:**

Terracon Consultants, Inc.

Mountlake Terrace, Washington



January 20, 2020



Perteet, Inc.  
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Attn: Patty Buchanan – Senior Project Manager  
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Re: Preliminary Geotechnical Engineering Report  
Port of Kingston Remote Ferry Holding Lot  
State Route 104 and Lindvog Road  
Kingston, Washington  
Terracon Project No. 81195118 – Perteet Project No. 20190109

Dear Ms. Buchanan:

We have completed the Preliminary Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P81195118 dated August 14, 2019, which was incorporated into a Subconsultant Agreement between Perteet and Terracon executed October 10, 2019. This report presents the findings of the subsurface exploration and provides preliminary geotechnical recommendations concerning earthwork, building foundations and floor slabs, design of permanent fill and cut slopes, retaining wall considerations, preliminary infiltration rates, and subgrade design information suitable for subsequent design of pavements for the proposed project.

The site is generally situated atop competent, glacially-consolidated granular sediments which are well-suited for support of the project elements. However, the site subgrade soils are sensitive to changes in moisture content during earthwork activities and will require care during construction to maintain their utility as a source of site-derived fill. While glacial till in the Puget Lowland is typically considered to have negligible infiltrative capacity, till at this site may likely support at least some distributed infiltrative capacity. However, careful consideration must be given to avoid potential negative groundwater impacts to neighboring down-slope properties to the south.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

**Preliminary Geotechnical Engineering Report**

Port of Kingston Remote Ferry Holding Lot ■ Kingston, Washington  
505 Fifth Avenue, Suite 300 ■ Terracon Project No. 81195118



Sincerely,

**Terracon Consultants, Inc.**

Chad T. McMullen, P.E.  
Project Engineer

Dennis R. Stettler  
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**Note:** This report was originally delivered in a web-based format. For more interactive features, please view your project online at [client.terracon.com](http://client.terracon.com).

## ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES  
SITE LOCATION AND EXPLORATION PLANS  
EXPLORATION RESULTS  
SUPPORTING INFORMATION

**Note:** Refer to each individual Attachment for a listing of contents.

# Preliminary Geotechnical Engineering Report

## Port of Kingston Remote Ferry Holding Lot

### State Route 104 and Lindvog Road

#### Kingston, Washington

Terracon Project No. 81195118

January 20, 2020

## INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed remote ferry holding lot, to be located at State Route 104 and Lindvog Road in Kingston, Washington. The primary intent of this development will be to reduce congestion within Kingston due to queuing of vehicle traffic waiting to board east-bound ferries during peak travel periods. The purpose of our geotechnical services is to provide information and preliminary geotechnical engineering recommendations to support project planning and preliminary engineering relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Fill selection criteria
- Foundation design and construction
- Floor slab design and construction
- Seismic considerations and liquefaction
- Permanent slopes and retaining walls
- Lateral earth pressures
- Feasibility of stormwater infiltration
- Preliminary pavement design inputs

The geotechnical engineering scope of services for this project included the advancement of three soil borings and ten test pits to depths ranging from approximately 20.5 to 21.5 and 4 to 10 feet below existing site grades, respectively.

Maps showing the site and exploration locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring and test pit logs and as separate graphs in the **Exploration Results** section of this report.

## SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
<b>Parcel Information</b>	<p>The project site is located in the southwest quadrant of the intersection of State Route 104 and Lindvog Road in Kingston, Washington.</p> <p>Lot Size: Approximately 8.6 acres comprised of several contiguous parcels. The site boundary is irregular in shape.</p> <p>Latitude: 47.803396    Longitude: -122.506834    See <a href="#">Site Location</a></p>
<b>Existing Improvements</b>	<p>None. Existing signaling and highway luminaire power, plus a waterline are present along the southern shoulder of State Route 104.</p>
<b>Current Ground Cover</b>	<p>Mature, widely-spaced douglas fir, hemlock, and cedar, with a sword fern and salmonberry understory. Young to mature alder and maple are also present. Skunk cabbage, horsetail, and other wetland species are present in isolated areas, primarily in southern portions of the project parcels. Several groundwater seeps emerge in the northern portion of the project site and appear to feed into these wetland areas.</p>
<b>Existing Topography</b>	<p>The site ground surface descends to the south, with slopes that are irregular but generally gentle to moderate. At the western and eastern ends of the site the total grade change is about 25 to 30 feet; the central portion of the site (which is narrower) includes a grade change of approximately 15 feet. South of the site, a housing subdivision is present. The subdivision is topographically lower than the existing site grade; this subdivision in this area appears to be cut into the previous topography of the area.</p>
<b>Geology</b>	<p>The subsurface consists of forest litter and topsoil atop dense to very dense glacially overridden glacial till. Glacial till at the site has a lower fines content than is typically observed for the Puget Sound Lowland; these fines are non-plastic.</p> <p>Isolated surface seeps and weak, wet, organic-rich soils are present around delineated wetland areas; shallow groundwater appears to be perched above isolated layers of shallow, impervious soils. Outside of these areas, groundwater was not encountered.</p>

## PROJECT DESCRIPTION

Our understanding of the overall project purpose and concept remains essentially unchanged since the proposal phase, and includes the following elements:

Item	Description
<p><b>Project Description</b></p>	<p>The overall project includes creating a paved holding area for ferry traffic queuing at the project site, signage and lighting of the site, and construction of a ferry customer restroom facility. The layout of these features is preliminary at the time of this proposal. As the project evolves, we understand that retail or restaurant space, landscaping, and other site features may be added. To accommodate the aspects of site development above, substantial earthmoving will be necessary to create a planar parking area and building pad.</p> <p>Beyond the project site, possible reconfiguration of traffic entering/exiting the ferry terminal area (approximately 0.6 miles southeast of the SR 104/Lindvog Road intersection) may occur. Geotechnical evaluation of that reconfiguration (such as an assessment of existing roadway pavements) is not part of this current geotechnical study.</p>
<p><b>Project Layout</b></p>	<p>Building locations, areas of ferry traffic holding pavement, areas of landscaping, and stormwater facility locations have not been determined. As discussed in the Grading/Slopes section below, the site's elevation would be lower than the adjacent SR 104 grade to the north and higher than the neighborhood to the south.</p>
<p><b>Proposed Structures</b></p>	<p>A restroom structure will be located somewhere within the project site. We anticipate that this structure would consist of light metal or wood framing, and be constructed on conventional spread footings and a concrete slab-on-grade floor. We expect loads on the foundation would be relatively light. We expect that retail structures would be of similar construction. Ticketing booths, information kiosks, or other small structures may be incorporated into project design, as may a retail or restaurant building.</p>
<p><b>Building Construction</b></p>	<p>We expect that shelters or buildings located on site would consist of light metal or wood framing and be constructed on conventional spread footings and a concrete slab-on-grade floor. We expect structures would be a single story and that loads on foundations would be relatively light.</p>
<p><b>Grading/Slopes</b></p>	<p>The planned parking area elevation varies throughout the site, and descends gradually in the direction of eastbound SR 104. We expect that the planned finish grade will be between about 5 and 10 feet below adjacent portions of the existing Highway SR 104 grade. For the purpose for pavement drainage, the holding area would likely have a cross-slope of about 1- to 2-percent.</p> <p>The preliminary grading concept includes between 5 and 10 feet of cut alongside SR 104 and up to 12 feet of fill along the southern side of the holding lot pad. We expect that design grades will be selected to maintain relatively balanced cut and fill volumes of soil. Cuts and fills may be supported by permanent retaining walls, or (where space allows) by permanent slopes. Wall types for these purposes have not been selected.</p>

<b>Below-Grade Structures</b>	None anticipated
<b>Stormwater Management</b>	Development of the site as described above would involve the creation of a significant quantity of new paved surface area. Impervious surface areas would generate stormwater flows that will require on-site stormwater management if feasible. Use of pervious pavement at this site appears to be a practical strategy to reduce concentrated stormwater flows. Based upon soil and groundwater observations made during our subsurface investigation activities and the results of grain-size based correlations, infiltration of stormwater generated on-site may be practical to some degree, but a relatively low infiltration rate is likely. The project site's capacity to infiltrate stormwater will need to be verified with pilot infiltration tests (PITs). Special design considerations may be needed to prevent groundwater impacts to the neighboring properties to the south.
<b>Pavements</b>	A considerable portion of the project site will be finished with pavement. Both rigid (concrete) and flexible (asphalt) pavement sections should be considered for the holding area. Design pavement information including traffic volume through the holding lot's entrance and exit, traffic volume/loads by lane distribution, traffic growth estimates, pavement design life, and similar pavement inputs are not available during this preliminary study. Pavement sections cannot be calculated without these data.  In the <b>Pavements</b> section of this report we provide a recommended CBR value for future design of pavements.

## GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project.

Soil and groundwater conditions encountered at each exploration point are indicated on the individual exploration logs, which can be found in the **Exploration Results** section of this report. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site; variation in conditions between these locations should be expected.

### Soil Conditions

Within the depths of our test pit and boring explorations we encountered several inches of forest litter and topsoil atop very dense glacially overridden glacial till. Glacial till typically consists of a variable mixture of silt, sand, and gravel. Occasionally clay, cobbles, and boulders are encountered. Glacial till at the site was relatively uniform at the site and has a lower fines content than is typically observed for glacial tills in the Puget Sound Lowland; fines for all of the samples tested were between 8 and 17 percent, non-plastic, and within a few percentage points of optimum moisture content (as based on laboratory compaction testing).

## **Groundwater Conditions**

During our site reconnaissance, isolated surface seeps and weak, wet soils were noted around delineated wetland areas (delineated and flagged by others); we speculate that – in these locations -- shallow groundwater is likely perched above isolated layers of shallow, impervious soils. Our explorations were situated outside of delineated wetland areas. With the exception of TP-5, groundwater was not encountered within the depths of test pit excavations. At borings B-2 and B-3 we encountered groundwater during drilling at a depth of approximately 14 feet. We did not observe an obviously groundwater-impervious soil layer within the depths of the test pits nor the borings.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the exploration logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

## **GEOTECHNICAL OVERVIEW**

The dense, strong soils present on the site are favorable for the support of fill, pavement, and building foundations; development of the site is geotechnically feasible. With adequate foundation subgrade preparation the subgrade soils can be expected to support bearing pressure in excess of what is typically required for light-frame single-story construction, and with limited settlement. Recommendations for design of conventional footing is presented in the **Shallow Foundations** section. We include our recommendations for interior at-grade floors and for exterior plazas and sidewalks in the **Floor Slabs** section. With adequate preparation of pavement subgrades, we expect good subgrade performance and economical conventional pavement sections, as discussed in the **Pavements** section. Use of pervious pavement to reduce concentrated stormwater flow is likely feasible, but additional field investigation is necessary and consideration and prevention of groundwater impacts to neighboring properties must be considered.

Earthwork is expected to involve substantial volumes of cut and fill. With proper construction care and favorable weather, glacial till soil excavated during grading can likely be re-used as site-derived fill. However, the native subgrade soil – and fill derived from this soil – will be sensitive to changes in moisture content and will require care during construction. Even small additions of water to this soil – such as moisture additions resulting from poor stockpiling practices or inadequate sloping and sealing of temporary grades – can result in rapid degradation of the soil's engineering performance.

The site generally slopes to the south but is interrupted by several delineated wetlands. The largest of these is within the southeastern portion of the site where grades are lower and flatter than the rest of the site. Other wetlands slope to the south. Where development will occur adjacent to or

within the footprint of wetlands, or where seeps are encountered during site preparation, over-excavation of poor soils – or else their reinforcement via geotextiles – may be necessary. Interceptor drains may also need to be constructed to mitigate groundwater seeps exposed during grading – especially seeps beneath areas to be filled, or in proximity to fill walls on the southern portion of the project site. To the extent that it is practical, avoiding earthwork and development activities within the wetlands will reduce permitting and construction costs and improve long-term performance of foundations, walls, and pavements.

Our recommendations for grading, drainage, fill selection and placement, preparation of subgrade and related topics is included in the **Earthwork** section. In that section we also present our recommendations for temporary and permanent slopes. Where slopes cannot be accommodated due to space or other limitations, temporary or permanent shoring walls may be designed as described in the **Lateral Earth Pressures** and **Excavation Design** sections.

A substantial amount of paved surface area will be created. Impervious pavements and building roofs will generate stormwater which will need to be managed. We present our preliminary estimate of the site's capacity to infiltrate stormwater and additional considerations in the **Stormwater Management** section. Additional field investigation including Pilot Infiltration Tests should be conducted in later phases of design. As an alternative to conventional pavement, pervious pavement could be used to reduce the amount of concentrated flows generated as a result of project development; this reduction would allow for smaller infiltration ponds or galleries.

The **General Comments** section provides an understanding of the report limitations.

## **EARTHWORK**

Earthwork will be preceded by logging of mature second-growth fir, hemlock, cedar, maple, and clearing of understory vegetation, and will include removal of stumps, grubbing of root zones, and complete removal of organic-rich soils. Following these activities, mass grading and subgrade preparation will occur. Mass grading will involve cutting of the ground surface elevation (primarily in northern portions of the site), and placement of fill above a prepared native subgrade (filling will occur primarily in southern portions of the site). The portion of the site along highway SR104 will involve cutting on the order of 5 to 10 feet below the existing adjacent highway grade; to achieve this grading objective, temporary construction slopes and permanent slopes will be necessary and, where space limitations do not allow slopes, cuts will need to be supported by temporary shoring or permanent retaining walls. Fill will likely be retained through some combination of conventional permanent slopes and (where space is limited) with gravity block walls or mechanically stabilized earth walls (MSEWs).

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The following sections provide geotechnical recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria as necessary to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

### Site Preparation

Following logging, stumps should be removed to a depth of at least three feet below the planned finish grade or – in areas to be filled – three feet below the subgrade atop which fill will be placed. Existing vegetation and root mats should be removed, and complete stripping of topsoil and other organic-rich soils should occur in areas to receive fill, and within the footprints of pavements, sidewalks, plazas, and buildings. Excavations created by the removal of stumps, vegetation or topsoil removal, or other site preparation activities should be filled with compacted Common Fill (or better); this fill should be selected, moisture-conditioned, placed, and compacted as described in the **Fill Material Types** and **Fill Compaction Requirements** sections.

Following site preparation, the entire subgrade should be compacted to a dense and unyielding condition with a large, self-propelled, smooth-drum roller, then proof-rolled with an adequately loaded vehicle such as a fully-loaded tandem-axle dump truck. The proof-rolling should be performed under the observation of the Geotechnical Engineer. Areas deflecting excessively under the proof-roll should be delineated and then addressed by the Contractor. Such areas should either be removed and replaced with better material or moisture conditioned (if practical) and then re-compacted.

### Fill Material Types

Fill required to achieve design grade should be classified as structural fill and common fill. Structural fill is material used below, or within 5 horizontal feet of buildings, retaining walls, pavements, and constructed slopes. Common fill is material used to achieve grade outside of these areas. Earthen materials used for structural and common fill should meet the following material property requirements:

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Fill Type	Recommended Materials	Acceptable Location for Placement
Structural Fill	9-03.9(1) <i>Ballast</i> <sup>1</sup> 9-03.9(3) <i>Crushed Surfacing Base Course</i> <sup>1</sup> 9-03.12(1)A <i>Gravel Backfill for Foundations Class A</i> <sup>1</sup> Section 9-03.14(3) <i>Gravel Borrow</i> <sup>1</sup> Suitable On-Site-Native Soils (i.e. Glacial Till) Compacted to Structural Fill Standard <sup>2,3</sup>	Behind footings, within areas of footing overexcavation, within the footprint of buildings and concrete slabs-on-grade.
Common Fill	Section 9-03.14(3) <i>Common Borrow</i> <sup>1</sup> Suitable On-Site Native Soils (i.e. Glacial Till) Compacted to Common Fill Standard <sup>2,3</sup>	General grade filling, utility trench backfill outside of building footprints and appurtenances
Free-Draining Granular Fill	Structural Fill <sup>4</sup> 9-03.9(2) <i>Permeable Ballast</i> <sup>1</sup> 9-03.12(2) <i>Gravel Backfill for Walls</i> <sup>1</sup> 9-03.12(4) <i>Gravel Backfill for Drains</i> <sup>1</sup>	Backfill behind all retaining walls, backfilling in wet weather, drainage layers for walls, sump drains, footing drains <sup>5</sup>

1. WSDOT Standard Specifications
2. Structural and common fill should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
3. May contain local areas of higher fines content that could increase the difficulty of re-using this moisture sensitive material as fill. Particles with a nominal diameter greater than about 3 in. should be removed.
4. To meet “free-draining” requirement, material provided must be specified to be less than 5-percent passing the #200 sieve for the portion of material passing the #4 sieve.
5. Minimum particle size must be greater than drain pipe perforations.

**Fill Compaction Requirements**

Structural and general fill should meet the following compaction requirements.

Item	Structural and Free-Draining Fill	Common Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used <sup>1</sup> 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used <sup>2</sup>	Same as Structural fill

Item	Structural and Free-Draining Fill	Common Fill
<b>Minimum Compaction Requirements<sup>3</sup></b>	95% of max. below foundations and floor slabs and within 2 feet of finished pavement subgrade 92% of max. above foundations and more than 2 feet below finished pavement subgrade	92% of maximum dry density
<b>Water Content Range<sup>3</sup></b>	As required to achieve min. compaction requirements; typically within 2% of optimum	Same as structural fill

1. May be increased up to a maximum of 12 inches if in-place density testing demonstrates that minimum compaction requirements are being met throughout the lift-thickness.
2. Within 4 horizontal feet of retaining walls, only hand-operated equipment should be used to compact wall backfill.
3. Maximum density and optimum water content as determined by the modified Proctor test (ASTM D 1557).

### Utility Trench Backfill

All trenches should be wide enough to allow for compaction around the haunches of the pipe, or material such as pea gravel (provided this is allowed by the pipe manufacturer) should be used below the spring line of pipes to eliminate the need for mechanical compaction in this portion of the trenches. If water is encountered in the excavations, it should be removed prior to fill placement.

Placement and compaction of recommended materials for utility trench backfill should be in accordance with the recommendations presented herein for **Earthwork**. In our opinion, the initial lift thickness should not exceed one foot unless recommended by the manufacturer to protect utilities from damage by compacting equipment. Light, hand-operated compaction equipment in conjunction with thinner fill lift thicknesses may be utilized on backfill placed above utilities if damage resulting from heavier compaction equipment is of concern.

### Grading and Drainage

All grades must provide effective drainage away from retaining walls and building footprints during and after construction and should be maintained throughout the life of the structures. Water retained next to buildings, retaining walls, and similar structures can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable sagging or distortion of retaining wall elements and differential movement of building foundations, slabs, walls, and roofs. Gutters, downspouts, and other sources of concentrated flow should be routed into tightline pipes that discharge into the stormwater system. Splash-blocks should be considered below hose bibs and water spigots. The routing of landscape irrigation pipes and distribution elements should be routed to reduce the potential for damage to buildings and retaining walls due to leaks and pipe breaks.

Site grades should be established such that surface water is directed away from foundation and pavement subgrades to prevent an increase in the water content of the soils. Adequate positive

drainage diverting water from structures, open cuts, and slopes should be established to prevent erosion, ground loss, and instability. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping, final grades should be verified to document effective drainage has been achieved. Where paving or flatwork abuts structures, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

## **Earthwork Construction Considerations**

Site preparation, mass grading, utility installation, foundation excavation, and other earthwork tasks are anticipated to be accomplished with conventional earthwork construction equipment such as excavators, front-end loaders, and dozers, plus on-highway and off-highway haul trucks. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of pavements and floor slabs. Construction traffic over the completed subgrade should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over, or adjacent to, construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted, prior to floor slab construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations. Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

## **Construction Observation and Testing**

The earthwork efforts should be monitored under the observation of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of stumps, vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content. The foundation subgrade for buildings and retaining walls should be evaluated by the Geotechnical Engineer. Backfill placement behind retaining walls should be observed by the Geotechnical Engineer, as should the installation of temporary or permanent shoring walls.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

### **Wet Weather Earthwork**

The near-surface soils include a fines content (silt and clay size particles passing the No. 200 mesh sieve) based on our visual observations and lab testing that indicate they are moisture-sensitive. The soils will exhibit high erosion potential and will be readily transported by running water. Protection of exposed soil through interim grading and sealing to promote drainage to sumps, use of plastic sheeting, temporary seeding, limiting the exposed soils to what can be protected again at the end of each work shift, and suspending earthwork activities during periods of high precipitation should be the primary management tools for sediment and erosion control. The use of silt fences, straw wattles, and other management practices will also be necessary to control erosion and sediment transport during construction, and to prevent impacts to neighboring properties.

If possible, the site-derived sources of fill should remain in place until they are needed; however, if stockpiling of this material is necessary then it should be protected with plastic sheeting to prevent intrusions of moisture. Sheeting will need to be anchored to withstand local wind conditions.

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 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 about 2 percentage points above or below optimum. Optimum moisture content is the moisture content at which the maximum dry density for the material is achieved in the laboratory by the ASTM D1557 test procedure.

If inclement weather or in situ soil moisture content prevents the use of on-site material as structural fill, we recommend use of materials specified in **Fill Material Types** for free-draining granular fill.

## SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

### Design Parameters – Compressive Loads

Description	Spread Footing	Wall Footing
<b>Net allowable bearing pressure</b> <sup>1,2</sup>		
■ <b>Native subgrade soil, or Structural Fill</b>	3,000 psf	3,000 psf
<b>Minimum dimensions</b>	24 inches	18 inches
<b>Minimum embedment below finished grade</b> <sup>3</sup>	18 inches	18 inches
<b>Approximate static total settlement from foundation loads for condition specified</b> <sup>4</sup>	<1 inch	<1 inch
<b>Estimated static differential settlement from foundation loads</b> <sup>4</sup>	About 2/3 of total settlement	
<b>Allowable passive pressure</b> <sup>5,6</sup>		
■ <b>Compacted structural fill</b>	320 pcf (equivalent fluid unit weight)	
<b>Allowable coefficient of sliding friction</b> <sup>7</sup>	0.40	

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Assumes that exterior grades are relatively level adjacent to the structure.
2. Values provided are for maximum loads noted in **Project Description**. Assumes the foundation elevation remains 4 feet above the groundwater table, year-round.
3. For frost protection and to reduce the effects of seasonal moisture variations in the subgrade soils. For perimeter footing and footings beneath unheated areas. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
4. Differential settlements are as measured over a span of 50 feet. We should review the settlement estimates after the foundation plan has been prepared by the structural engineer.
5. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.
6. Passive resistance in the upper foot of the soil profile should be neglected.
7. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.

### Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during

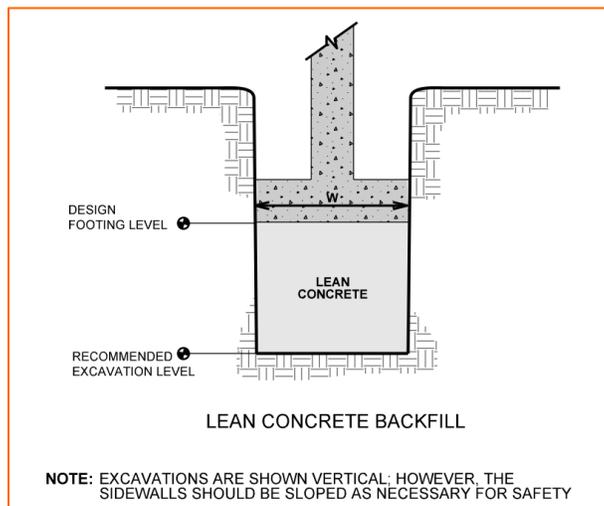
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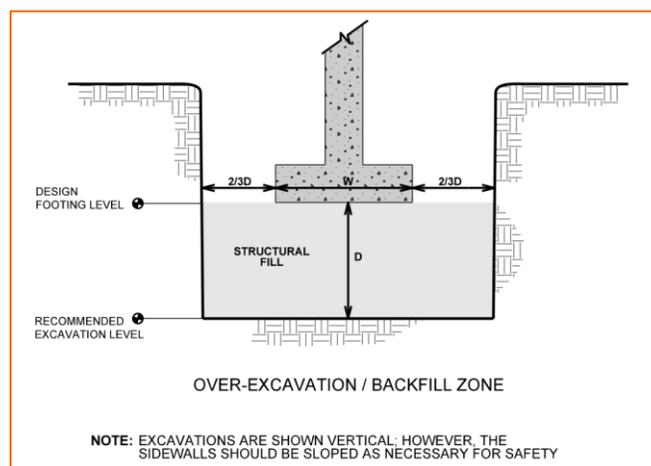
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construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below.



Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with Structural Fill placed as recommended in the **Earthwork** section.



## Foundation Drains

We recommend that buildings constructed on-site be encircled with foundation drains. These drains should consist of a 4-inch diameter perforated pipe within an envelope of washed rock, extending at least 6 inches on all sides of the pipe. The washed rock should conform to WSDOT Section 9-03.12(4), Gravel Backfill for Drains or 9-03.12(5), Gravel Backfill for Drywells. The washed rock envelope should be wrapped with filter fabric (such as Mirafi 140N) to reduce the migration of fines from the surrounding soil. Drain inverts should be installed no more than 8 inches above or below the base of the footings. To avoid inadvertent wetting, the foundation drain should be a system separate from the roof drain system (do not connect foundation and footing drains together). Footing drains should be constructed to discharge into the site storm water system or other appropriate outlet.

## SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on the Seismic Design Category. Site Class is required to determine the Seismic Design Category for a structure. The Site Class is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Chapter 20 of ASCE 7.

Description	Value
<b>IBC Seismic Site Class</b>	C
<b>Site Latitude</b>	47.803396
<b>Site Longitude</b>	-122.506834
<b>S<sub>s</sub> – Short Period Spectral Acceleration, Site Class B <sup>2</sup></b>	1.301 g
<b>S<sub>1</sub> – 1-Second Period Spectral Acceleration, Site Class B <sup>2</sup></b>	0.458 g
<b>F<sub>a</sub> – Short Period Site Coefficient <sup>2</sup></b>	1.2
<b>F<sub>v</sub> – 1-Second Period Site Coefficient <sup>2</sup></b>	1.5
<b>PGA - ASCE 7, Peak Ground Acceleration</b>	0.519 g
<b>F<sub>PGA</sub> – Peak Ground Acceleration Site Coefficient</b>	1.2

1. The IBC requires a site profile extending to a depth of 100 feet for seismic site classification. Borings were extended to a maximum depth of 21½ feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Our recommendation for site class considers that structures on site may be situated atop compacted fill.
2. These values were obtained using online seismic design maps and tools provided by OSHPD (<https://seismicmaps.org/>).

## Surface-Fault Rupture

The hazard of damage from onsite fault rupture appears to be low based on review of the USGS Earthquake Hazards Program Quaternary Faults and Folds Database available online (<https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=5a6038b3a1684561a9b0aadf88412fcf>) accessed on January 14, 2020. The closest mapped fault is a splay of the southern Whidbey Island Fault zone, which lies approximately 3 miles to the east of the project site.

## FLOOR SLABS

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from structures and positive drainage of the aggregate base beneath floor slabs.

### Floor Slab Design Parameters

Item	Description
<b>Floor Slab Support</b> <sup>1</sup>	Minimum 6 inches of capillary break material (see <b>Fill Material Types</b> ) <sup>3</sup> Compacted to at least 95% of maximum dry density (ASTM D 1557)
<b>Estimated Modulus of Subgrade Reaction</b> <sup>2</sup>	<ul style="list-style-type: none"> <li>■ 250 pounds per square inch per inch (psi/in) for point loads</li> <li>■ 100 psi/in for distributed loads</li> </ul>

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder is recommended beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut control joints should be placed in slabs to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the

length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

## **Floor Slab Construction Considerations**

Finished subgrade within and for at least 5 feet beyond floors slab should be protected from traffic, rutting, or other disturbances and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

## **LATERAL EARTH PRESSURES**

### **Design Parameters**

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Active earth pressure is commonly used for design of free-standing cantilever retaining walls such as cast-in-place concrete walls and soldier piles and lagging; these wall type assume that top-of-wall movements are both acceptable and possible (i.e. the structure is free to move at the wall top). The "active" condition is also appropriate for evaluating external stability of MSE walls. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top; this condition may not be applicable for design of structures at the site as we currently understand them to be. The recommended design lateral earth pressures for the "active" and "at-rest" cases do not include a factor of safety and do not accommodate any hydrostatic pressure on the walls. Design of walls at the site must incorporate drainage details that prevent the build-up of hydrostatic pressure.

Soil pressure acting on the leading face of the footing plus buried portions of the wall toe may assume a "passive" loading condition, which – along with friction acting of the base of the footing -- is typically employed to resist movement at the wall toe due earth pressures acting behind the wall. These resisting forces are discussed in the design parameters of the **Shallow**

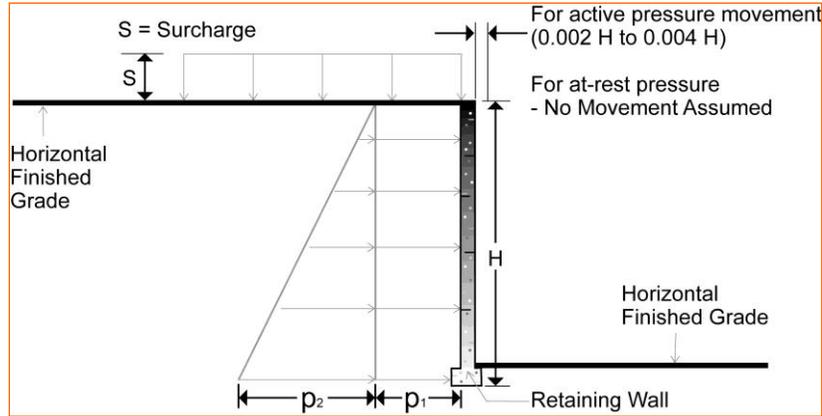
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**Foundations** section. The passive pressure value presented in that section and re-stated in the table below include a factor-of-safety of 1.5.



Lateral Earth Pressure Design Parameters			
Earth Pressure Condition <sup>1</sup>	Coefficient for Structural Fill Backfill <sup>2</sup>	Uniform Pressure <sup>3, 4, 5</sup> p <sub>1</sub> (psf)	Effective Fluid Pressures (psf) <sup>2, 4, ,</sup>
Active (K <sub>a</sub> )	0.27	(0.27)S	(35)H <sup>5</sup>
At-Rest (K <sub>o</sub> )	0.43	(0.43)S	(56)H <sup>5</sup>
Passive (K <sub>p</sub> )	3.7	---	(320)H <sup>6</sup>
Seismic <sup>7</sup>	---	(7)H – Active (12)H – At-Rest	---

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 92 percent of the ASTM D 1557 maximum dry density, rendering a unit weight of approximately 130 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. Effective fluid pressure for passive condition includes a factor-of-safety of 1.5
7. Values are in addition to static earth pressures; “H” is the retained height in feet.

**Subsurface Drainage for Below Grade Walls**

Retaining walls should include foundation drains. These drains should consist of a 4-inch diameter perforated pipe within an envelope of washed rock, extending at least 6 inches on all sides of the pipe. The washed rock should conform to WSDOT Section 9-03.12(4), Gravel Backfill for Drains or 9-03.12(5), Gravel Backfill for Drywells. The washed rock envelope should be wrapped with

filter fabric (such as Mirafi 140N) to reduce the migration of fines from the surrounding soil. Drain inverts should be installed no more than 8 inches above or below the base of the footings, and sloped to drain. The retaining wall foundation drain should be isolated from any other drain systems (such as those installed for building footings or roof drains). Retaining wall drains should be constructed to discharge into the site's storm water system at a discharge point low enough to prevent inadvertent backflow to the retaining wall foundation. Where groundwater seeps are encountered during the preparation of fill-wall subgrade, additional drainage provisions may need to be constructed and routed to the stormwater system.

Retaining walls with impervious facings – such as concrete -- should include weep holes near the wall toe to provide ready drainage from behind the wall and to prevent buildup of hydrostatic pressure. Backfill behind this impervious wall type should include a “curtain” of free-draining granular fill behind the wall, or else a drainage-board product extending to the weep holes and the foundation drain system. Wall types which are pervious -- such as modular blocks often used for gravity block walls or as facing for MSEWs – can omit weep holes but should still include a gravel curtain or drainage board.

## **EXCAVATION DESIGN**

To meet site grading objectives, much of the site adjacent to SR-104 will be lowered below the highway grade. Where space allows, the most cost-effective way to achieve this grading would likely be through the use of permanent cut-slopes descending from the highway to the ferry holding lanes. Permanent slopes no steeper than 2H:1V can be used to meet grading objectives. However, the selected site layout may not allow for the horizontal footprint that permanent slopes would require, and so retaining walls up to about 10 feet in height may be necessary. If construction plans can accommodate the horizontal space required for 1½H:1V temporary slopes, gravity-block walls and MSE walls would likely be the most cost-effective approach for retaining soils along the SR-104 right-of-way; a number of pre-approved designs of this type are included in Appendix 15 of WSDOT's *Geotechnical Design Manual (GDM, WSDOT Publication M46-03.02)*. Cast-in-place concrete “counterfort” walls shown in *WSDOT Standard Plans* may also be a cost-effective means of retaining site soils. Walls types discussed in Appendix 15 of the *GDM* or in the *Standard Plans* may be designed according to the bearing capacity and base friction resistance values presented in the **Shallow Foundations** section.

If project designers opt to construct holding lanes by excavation in proximity to the highway, then either temporary or permanent shoring would be necessary to support vertical cuts. Temporary shoring such as soldier piles and timber lagging are feasible and could allow for construction of more conventional, permanent wall types (gravity-block walls, MSEWs) in front of the shoring. Permanent shoring methods such as a permanent soil nail wall are also feasible. Temporary and permanent shoring require design that is beyond the scope of this preliminary geotechnical report.

Typically, soldier pile-and-lagging shoring is cost effective where there is a limited area to be shored and where the plan layout of the shoring is complex. Shoring through the use of permanent soil nail walls become cost-competitive where greater areas to be retained are involved, and the plan layout is relatively uninterrupted by curves or corners. If a relatively long interval of soil is to be retained along SR-104, a permanent soil nail wall may be a cost-competitive option for supporting a vertical cut permanently.

As site planning continues, Terracon should be included in discussions with the design team regarding design of retaining walls and shoring systems for this project.

## **STORMWATER MANAGEMENT**

Development of the site will include the construction of a significant amount of new paved surfacing. Stormwater generated from conventional (impervious) pavements and building roofs will require on-site stormwater disposal, where feasible. Stormwater facilities such as detention and infiltration ponds, swales, and below-grade galleries are expected to be necessary to accommodate the flow concentrations associated with impervious pavement construction. Where appropriate for soil and groundwater conditions, construction of pervious pavement could reduce the storage volume necessary for pond or gallery sizing.

The relative uniformity of soils encountered across the site, the depth to groundwater, and the results of soil grain-size correlations suggest that infiltration of stormwater at the site is likely a feasible approach to stormwater management; however, the expected infiltration rate is expected to be relatively low (as discussed below). This preliminary conclusion must be confirmed by additional field investigation using Pilot Infiltration Tests (PITs). Beneath pervious pavement, infiltration into both native subgrade and into subgrade comprised of compacted fill may be considered; however, the infiltration rates of these subgrades are likely different and should each be determined.

### **Preliminary Infiltration Rate**

Our scope of services included estimating a preliminary infiltration rate based upon grain-size correlations, as presented in Volume III of the Washington Department of Ecology's *2019 Stormwater Management Manual for Western Washington*. That manual provides a procedure for estimating the short-term infiltration of non-compacted soils using their total fines content and the particle sizes associated with the sample fractions passing at 90 percent, 60 percent, and 10 percent of the total sample mass. For glacially-compacted soils, guidance in the Ecology manual suggests that the infiltration rate is likely to be up to about an order-of-magnitude lower than for non-compacted soils. Using the grain-size distribution plots included in the **Exploration Results** section and considering the glacially-overridden nature of the soils, we estimate a

preliminary short-term infiltration rate of the native subgrade of between 1 and 2 inches per hour:

$$K_{\text{sat, initial}} = 1 \text{ to } 2 \text{ inches per hour.}$$

The short-term infiltration rate must be further reduced according to several correction factors:

$$CF_T = CF_v \times CF_t \times CF_m$$

Per Ecology's manual, we recommend that the variability factor  $CF_v$  be taken as 1.0, the test method factor  $CF_t$  be taken as 0.40, and the maintenance factor  $CF_m$  be taken as 0.90. This last factor should be verified by the design team and the facility owner, as it relates to periodic and ongoing inspection and maintenance of the infiltration facility. Using the partial factors above, a saturated hydraulic conductivity ( $K_{\text{sat, design}}$ ) of about 0.36 to 0.72 inches per hour may be assumed for preliminary design. However, this infiltration value must be confirmed with additional field investigation, as stated in the previous section.

## PAVEMENTS

Provided that the filling and grading activities are carried out as recommended in the **Earthwork** section, and that the finish pavement subgrade surface is prepared and proof-rolled as described in that section, asphaltic concrete (AC) flexible pavement and Portland cement concrete (PCC) rigid pavement are both appropriate as pavement surfacing materials at the project site. If a pervious AC or PCC section is selected to reduce the volume of concentrated stormwater flow, then special care during pavement construction and provision of a separation geotextile at the bottom of the pavement section must be implemented to promote the pavement's lifespan and prevent fines intrusion. A stormwater "storage" course of coarse, open-graded aggregate should be included above the separation geotextile. Additional or more frequent pavement maintenance will be necessary to maintain the pervious nature of the pavement surfacing, including removal of dirt, algae, moss, and other plugging agents.

### Pavement Design Inputs

Pavement design may be completed using the approach presented in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993). This approach uses standard equivalent single-axle load (ESAL) passes as a primary input to characterize the load intensity and frequency of vehicle traffic. Design ESALs have not been determined at this preliminary stage of project design. Additional traffic characterization factors, including lane distribution and projected traffic growth have not been determined, but will be necessary to complete design.

As part of our subsurface exploration program we completed laboratory compaction testing and California Bearing Ratio (CBR) testing of a test specimen composited from test pit samples across

the project site. The test specimen was composited from samples obtained from depths of 2 to 4 feet below existing grades; we expect these soils to be representative of those that are likely to be used as site-derived fill during mass grading. As presented in **Exploration Results**, the composited sample exhibited a maximum dry density of 126 pounds per cubic foot, an optimum moisture content of 9 percent and, following saturation, a CBR value of approximately 38. We do not recommend use of this relatively high CBR value for design of pavement – especially for pervious pavement, where the subgrade soils are expected to undergo seasonal changes in moisture and experience saturation during the wet season. Instead, we recommend that a CBR value of 20 be assumed for the design of pavement.

Once the traffic volume, lane distributions (both expressed in ESALs), other traffic characteristics, and the pavement's design lifespan have been determined by the project team, the thickness of pavement section components can be determined.

## **GENERAL COMMENTS**

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

## **Preliminary Geotechnical Engineering Report**

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Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

## **ATTACHMENTS**

**Contents:**

Exploration and Testing Procedures

Site Location

Exploration Plan

## EXPLORATION AND TESTING PROCEDURES

### Field Exploration

Exploration Type	Number of Explorations	Exploration Depth (feet) <sup>1</sup>	Locations
Soil Borings	3	20½ to 21½	Vicinity of expected cut-walls
Test Pits	10	4 to 11	Holding lanes, expected fill-walls/fill slopes

1. Below existing ground surface

**Exploration Layout and Elevations:** Unless otherwise noted, Terracon personnel provided the exploration layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±20 feet) and approximate elevations were obtained by interpolation from the Google Earth terrain model. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

**Soil Boring Procedure:** We advanced the borings with a track-mounted drill rig using continuous flight hollow-stem augers. A subcontracted driller was hired to perform this task, under our supervision. Four split-barrel samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. In accordance with Washington State law, all borings were backfilled with bentonite chips after their completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

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**Test Pit Procedures:** Test pits were advanced by a small, tracked excavator outfitted with a toothed bucket. A subcontracted excavation contractor was hired to perform this task, under our supervision. The test pit sidewalls, excavated soils, and groundwater conditions were observed by a Terracon field engineer and recorded in the test pit logs. Excavated soils were stockpiled in the vicinity of the pit for further observation and for convenient backfilling. The density/consistency of the soil was inferred through frequent probing of the base of the excavations for the upper 4 feet. Thereafter, soil density presented on the logs are inferred from probing observations and excavator level of effort during test pit advancement.

Test pits were typically terminated several feet below where dense to very dense/hard soil was first encountered, when further advancement became impractical. Bulk samples were collected for index testing and to evaluate potential reuse of onsite soils.

Our exploration team prepared draft test pit logs in the field (i.e. field logs) as part of standard operations. Field logs included visual classifications of soils encountered during exploration, and our interpretation of subsurface conditions between samples. Final test pit logs, prepared from field logs, represent the geotechnical engineer's interpretation, and include modifications based on observations and laboratory testing results.

## Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the subgrade soils for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soils Using Modified Effort
- ASTM D1883 Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

The laboratory testing program included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

**SITE LOCATION**

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**EXPLORATION PLAN**

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DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

## **EXPLORATION RESULTS**

### **Contents:**

Boring Logs (B-1 through B-3)

Test Pit Logs (TP-1 through TP-10)

Grain Size Distribution (2 pages)

Moisture Density Relationship

California Bearing Ratio Results

Note: All attachments are one page unless noted above.

# BORING LOG NO. B-1

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 81195118 PORT OF KINGSTON - WORKING COPY.GPJ TERRACON.DATATEMPLATE.GDT 1/17/20

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8043° Longitude: -122.5082°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
1.0	<b>FINE SAND WITH SILT (SP-SM)</b> , with gravel, brown, moist, loose to medium dense, scattered fine roots					
	<b>FINE SAND WITH SILT (SP-SM)</b> , with gravel, light gray to gray, moist, very dense, brown mottled with gray in upper few feet					
		5	X		13-21-37 N=58	
			X		40-50	
		10	X		50/4"	
		15	X		40-50/3"	
		20	X		50	
	20.5 -- no recovery <b>Boring Terminated at 20.5 Feet</b>					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:  
Hollow Stem Auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

Abandonment Method:  
Backfilled with bentonite chips

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Boring Started: 12-23-2019

Boring Completed: 12-23-2019

Drill Rig: Mini Track Rig

Driller: Environmental Drilling Inc.

Project No.: 81195118

# BORING LOG NO. B-2

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

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GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8038° Longitude: -122.5067°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
1.0	<b>FINE SAND WITH SILT (SP-SM)</b> , with gravel, brown, moist, loose to medium dense, includes fine roots					
	<b>FINE SAND WITH SILT (SP-SM)</b> , gravelly, gray, moist, very dense					
	-- gravelly/cobbly drill action from 3 to 5 feet	5	X		31-50/3"	
			X		34-30-50/5"	
	-- poor recovery		X		50/2"	
		10			50/0"	
	-- water on sampler rod		▽			
		15	X		0.42/5"	
		20	X		22-50/4"	
	<b>Boring Terminated at 20.8 Feet</b>					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:  
Hollow Stem Auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

Abandonment Method:  
Backfilled with bentonite chips

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

▽ While drilling



Boring Started: 12-23-2019

Boring Completed: 12-23-2019

Drill Rig: Mini Track Rig

Driller: Environmental Drilling Inc.

Project No.: 81195118

# BORING LOG NO. B-3

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Perteet Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

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GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8032° Longitude: -122.5054°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
1.0	<b>SAND WITH SILT TO SILTY SAND (SM)</b> , with gravel, brown, moist, loose to medium dense					
	<b>SAND WITH SILT AND GRAVEL (SP-SM)</b> , gray, moist, dense to very dense, mottled gray-brown in uppermost sample					
	-- no recovery; bouncing on gravel or cobble?	5		X	7-6-40 N=46	
					50/0"	
				X	10-50	
		10		X	50/3"	
	-- water on drill rod		▽			
		15		X	50	
	-- sand component includes fine to coarse sand sizes					
21.5	<b>Boring Terminated at 21.5 Feet</b>				20-20-40 N=60	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:  
Hollow Stem Auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

Abandonment Method:  
Backfilled with bentonite chips

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

▽ While drilling



Boring Started: 12-23-2019

Boring Completed: 12-23-2019

Drill Rig: Mini Track Rig

Driller: Environmental Drilling Inc.

Project No.: 81195118

# TEST PIT LOG NO. TP-1

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

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GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8043° Longitude: -122.5089°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
5.0	<p><b>SILTY SAND (SM)</b>, trace gravel, light brown, moist, loose, abundant roots</p> <p>light gray, medium dense, cemented chunks</p> <p>dense to very dense</p>	5				5
	<b>Test Pit Refusal at 5 Feet</b>					

Stratification lines are approximate. In-situ, the transition may be gradual.

<p><b>Advancement Method:</b> Tracked excavator with 18-inch wide toothed bucket</p>	<p>See <a href="#">Exploration and Testing Procedures</a> for a description of field and laboratory procedures used and additional data (If any).</p> <p>See <a href="#">Supporting Information</a> for explanation of symbols and abbreviations.</p>	<p>Notes:</p>						
<p><b>Abandonment Method:</b> Backfilled with excavation spoils, periodically tamped with bucket during filling</p>								
<b>WATER LEVEL OBSERVATIONS</b>	 <p>21905 64th Ave W, Ste 100 Mountlake Terrace, WA</p>	<table style="width: 100%;"> <tr> <td style="width: 50%;">Test Pit Started: 11-15-2019</td> <td style="width: 50%;">Test Pit Completed: 11-15-2019</td> </tr> <tr> <td>Excavator: Trackhoe</td> <td>Operator: Rick's Truck. &amp; Excav.</td> </tr> <tr> <td>Project No.: 81195118</td> <td></td> </tr> </table>	Test Pit Started: 11-15-2019	Test Pit Completed: 11-15-2019	Excavator: Trackhoe	Operator: Rick's Truck. & Excav.	Project No.: 81195118	
Test Pit Started: 11-15-2019	Test Pit Completed: 11-15-2019							
Excavator: Trackhoe	Operator: Rick's Truck. & Excav.							
Project No.: 81195118								

# TEST PIT LOG NO. TP-2

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Perteet Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

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GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8035° Longitude: -122.5089°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
6.0	<b>SILTY SAND (SM)</b> , trace gravel, dark brown, moist, forest litter and roots  brown to light brown, loose to medium dense  gray, very dense	5				6
	<b>Test Pit Refusal at 6 Feet</b>					

Stratification lines are approximate. In-situ, the transition may be gradual.

**Advancement Method:**  
Tracked excavator with 18-inch wide toothed bucket

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

**Abandonment Method:**  
Backfilled with excavation spoils, periodically tamped with bucket during filling

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Test Pit Started: 11-15-2019

Test Pit Completed: 11-15-2019

Excavator: Trackhoe

Operator: Rick's Truck. & Excav.

Project No.: 81195118

# TEST PIT LOG NO. TP-3

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8031° Longitude: -122.5077°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
	<b>SILTY SAND (SM)</b> , trace gravel, brown to light brown, moist, loose, occasional cobbles					
	gray and brown, dense to very dense			✋		10
	5.0	5				
	<b>Test Pit Refusal at 5 Feet</b>					

Stratification lines are approximate. In-situ, the transition may be gradual.

**Advancement Method:**  
Tracked excavator with 18-inch wide toothed bucket

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

**Abandonment Method:**  
Backfilled with excavation spoils, periodically tamped with bucket during filling

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Test Pit Started: 11-15-2019

Test Pit Completed: 11-15-2019

Excavator: Trackhoe

Operator: Rick's Truck. & Excav.

Project No.: 81195118

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# TEST PIT LOG NO. TP-5

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

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GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8022° Longitude: -122.5061°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
5.0	<p><b>SILTY SAND (SM)</b>, brown, wet, loose</p> <p>roots and topsoil</p> <p>gray, moist to wet, dense</p>	5		☞		13
	<p><b>Test Pit Refusal at 5 Feet</b></p>					

Stratification lines are approximate. In-situ, the transition may be gradual.

**Advancement Method:**  
Tracked excavator with 18-inch wide toothed bucket

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

**Abandonment Method:**  
Backfilled with excavation spoils, periodically tamped with bucket during filling

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Test Pit Started: 11-15-2019

Test Pit Completed: 11-15-2019

Excavator: Trackhoe

Operator: Rick's Truck. & Excav.

Project No.: 81195118

# TEST PIT LOG NO. TP-6

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Perteet Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8022° Longitude: -122.5049°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
DEPTH	ELEVATION (Ft.)	5				
	<b>SILTY SAND (SM)</b> , trace gravel, light brown, moist, loose, with cobbles					
	medium dense					
	very dense					
6.0	<b>Test Pit Refusal at 6 Feet</b>					

Stratification lines are approximate. In-situ, the transition may be gradual.

**Advancement Method:**  
Tracked excavator with 18-inch wide toothed bucket

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

**Abandonment Method:**  
Backfilled with excavation spoils, periodically tamped with bucket during filling

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Test Pit Started: 11-15-2019

Test Pit Completed: 11-15-2019

Excavator: Trackhoe

Operator: Rick's Truck. & Excav.

Project No.: 81195118

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# TEST PIT LOG NO. TP-7

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8028° Longitude: -122.5045°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
5.0	<b>SILTY SAND (SM)</b> , gravelly, brown to light brown, moist, loose to medium dense  light gray, very dense	5		☞		9
	<b>Test Pit Refusal at 5 Feet</b>					

Stratification lines are approximate. In-situ, the transition may be gradual.

**Advancement Method:**  
Tracked excavator with 18-inch wide toothed bucket

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

**Abandonment Method:**  
Backfilled with excavation spoils, periodically tamped with bucket during filling

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Test Pit Started: 11-15-2019

Test Pit Completed: 11-15-2019

Excavator: Trackhoe

Operator: Rick's Truck. & Excav.

Project No.: 81195118

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# TEST PIT LOG NO. TP-8

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8038° Longitude: -122.5081°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					
10.0	<b>SAND WITH SILT (SW-SM)</b> , trace gravel, light brown to gray, moist, loose to medium dense	5		☞		5
	dense, occasional cobbles, cemented	10		☞		
<b>Test Pit Terminated at 10 Feet</b>						

Stratification lines are approximate. In-situ, the transition may be gradual.

**Advancement Method:**  
Tracked excavator with 18-inch wide toothed bucket

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

Notes:

**Abandonment Method:**  
Backfilled with excavation spoils, periodically tamped with bucket during filling

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Test Pit Started: 11-15-2019

Test Pit Completed: 11-15-2019

Excavator: Trackhoe

Operator: Rick's Truck. & Excav.

Project No.: 81195118

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# TEST PIT LOG NO. TP-9

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8034° Longitude: -122.507°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					

DEPTH	<b>SILTY SAND (SW-SM)</b> , gravelly, brown to light brown, moist, dense  very dense, occasional cobbles	5				6
-------	--	---	--	--	--	---

6.0 **Test Pit Refusal at 6 Feet**

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method: Tracked excavator with 18-inch wide toothed bucket	See <a href="#">Exploration and Testing Procedures</a> for a description of field and laboratory procedures used and additional data (If any).  See <a href="#">Supporting Information</a> for explanation of symbols and abbreviations.	Notes:
Abandonment Method: Backfilled with excavation spoils, periodically tamped with bucket during filling		
<b>WATER LEVEL OBSERVATIONS</b>	21905 64th Ave W, Ste 100 Mountlake Terrace, WA	Test Pit Started: 11-15-2019 Excavator: Trackhoe Project No.: 81195118
		Test Pit Completed: 11-15-2019 Operator: Rick's Truck. & Excav.

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# TEST PIT LOG NO. TP-10

**PROJECT:** Port of Kingston Remote Ferry Holding Lot

**CLIENT:** Pertect Inc. - project no. 20190109  
Everett, WA

**SITE:** State Route 104 and Lindvog Road  
Kingston, WA

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 47.8027° Longitude: -122.5055°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)
	ELEVATION (Ft.)					

DEPTH	5.0 <b>SILTY SAND (SM)</b> , gravelly, mostly fine to medium sand, light brown, moist, loose to medium dense, scattered plant and brush roots in uppermost 12 inches  -- color change to gray -- becomes dense, then very dense	5				
-------	--	---	--	--	--	--

	<b>Test Pit Refusal at 5 Feet</b>					
--	-----------------------------------	--	--	--	--	--

Stratification lines are approximate. In-situ, the transition may be gradual.

**Advancement Method:**  
Tracked excavator with 18-inch wide toothed bucket

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (if any).

Notes:

**Abandonment Method:**  
Backfilled with excavation spoils, periodically tamped with bucket during filling

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**



Test Pit Started: 11-15-2019

Test Pit Completed: 11-15-2019

Excavator: Trackhoe

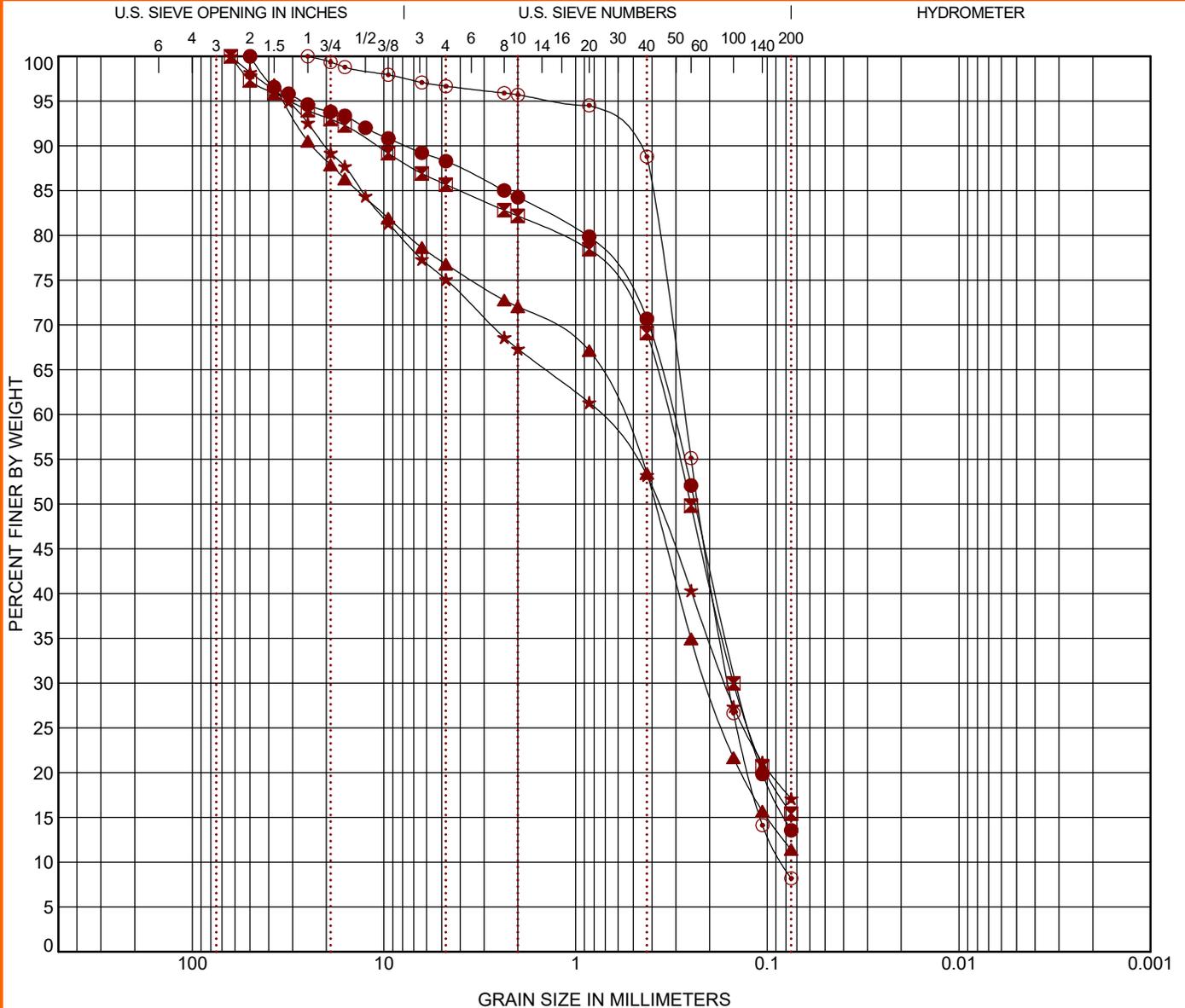
Operator: Rick's Truck. & Excav.

Project No.: 81195118

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# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
● TP-2	3 - 4	Silty SAND with trace gravel (SM)	6					
☒ TP-3	3 - 4	Silty SAND with trace of gravel (SM)	10					
▲ TP-4	3 - 4	Gravelly SAND with silt (SW-SM)	6				1.08	8.85
★ TP-7	4 - 5	Gravelly, silty SAND (SM)	9					
⊙ TP-8	7 - 8	SAND with silt, trace gravel (SW-SM)					1.13	3.24

Boring ID	Depth	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
● TP-2	3 - 4	50	0.313	0.139		0.0	11.7	74.7		13.6	
☒ TP-3	3 - 4	63	0.331	0.15		0.0	14.3	70.2		15.4	
▲ TP-4	3 - 4	37.5	0.593	0.207			20.1	65.4		11.4	
★ TP-7	4 - 5	63	0.759	0.166		0.0	24.9	58.0		17.1	
⊙ TP-8	7 - 8	25	0.27	0.159	0.083	0.0	3.3	88.5		8.2	

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 81195118 PORT OF KINGSTON - WORKING COPY.GPJ TERRACON\_DATATEMPLATE.GDT 1/17/20

PROJECT: Port of Kingston Remote Ferry Holding Lot

SITE: State Route 104 and Lindvog Road  
Kingston, WA



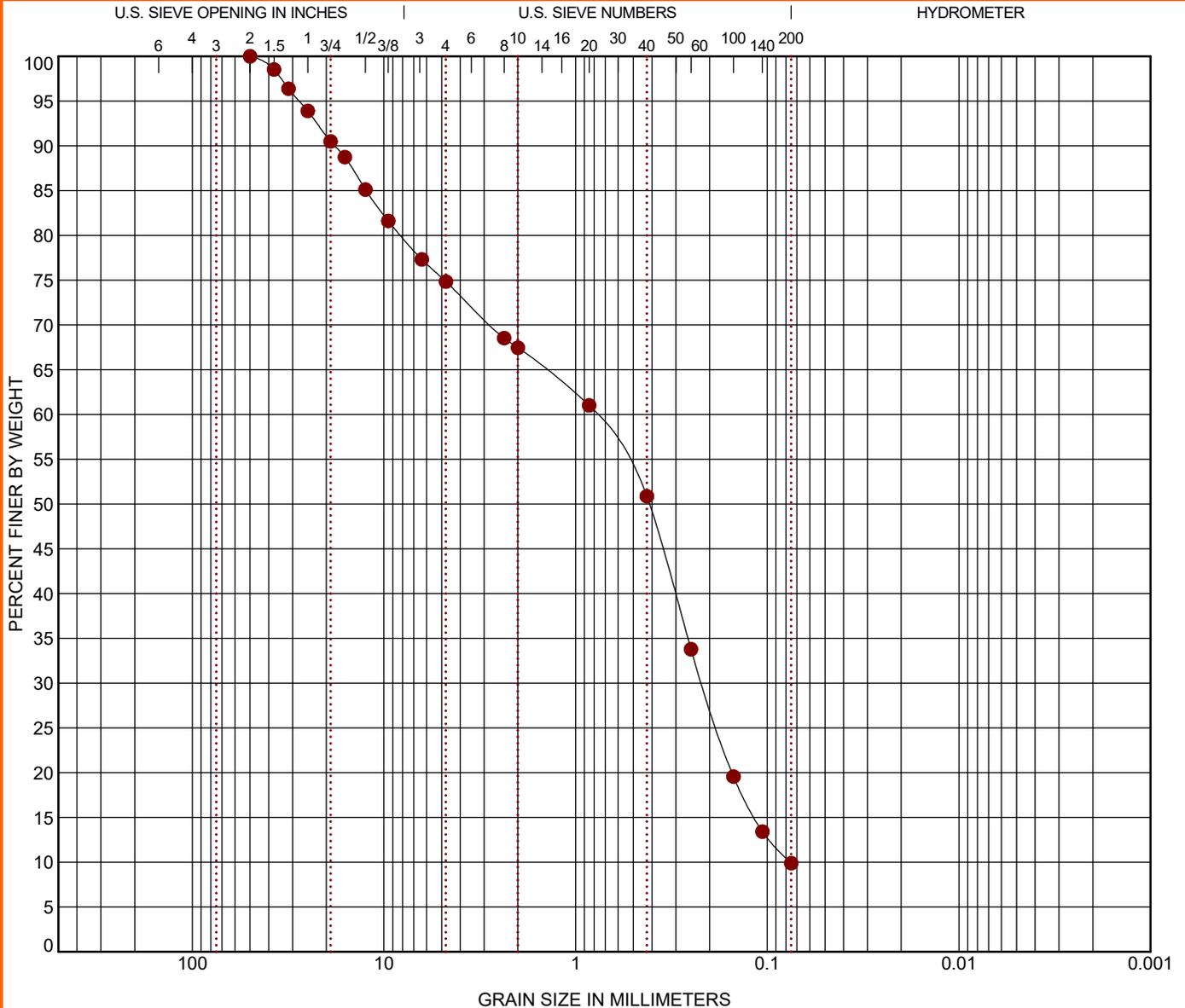
PROJECT NUMBER: 81195118

CLIENT: Pertec Inc. - project no. 20190109  
Everett, WA

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 81195118 PORT OF KINGSTON - WORKING COPY.GPJ TERRACON\_DATATEMPLATE.GDT 1/17/20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
● TP-9	3 - 4	Gravelly SAND with silt (SP-SM)	6				0.79	10.46

Boring ID	Depth	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
● TP-9	3 - 4	50	0.793	0.218	0.076	0.0	25.2	64.9		9.9	

PROJECT: Port of Kingston Remote Ferry Holding Lot

SITE: State Route 104 and Lindvog Road  
Kingston, WA



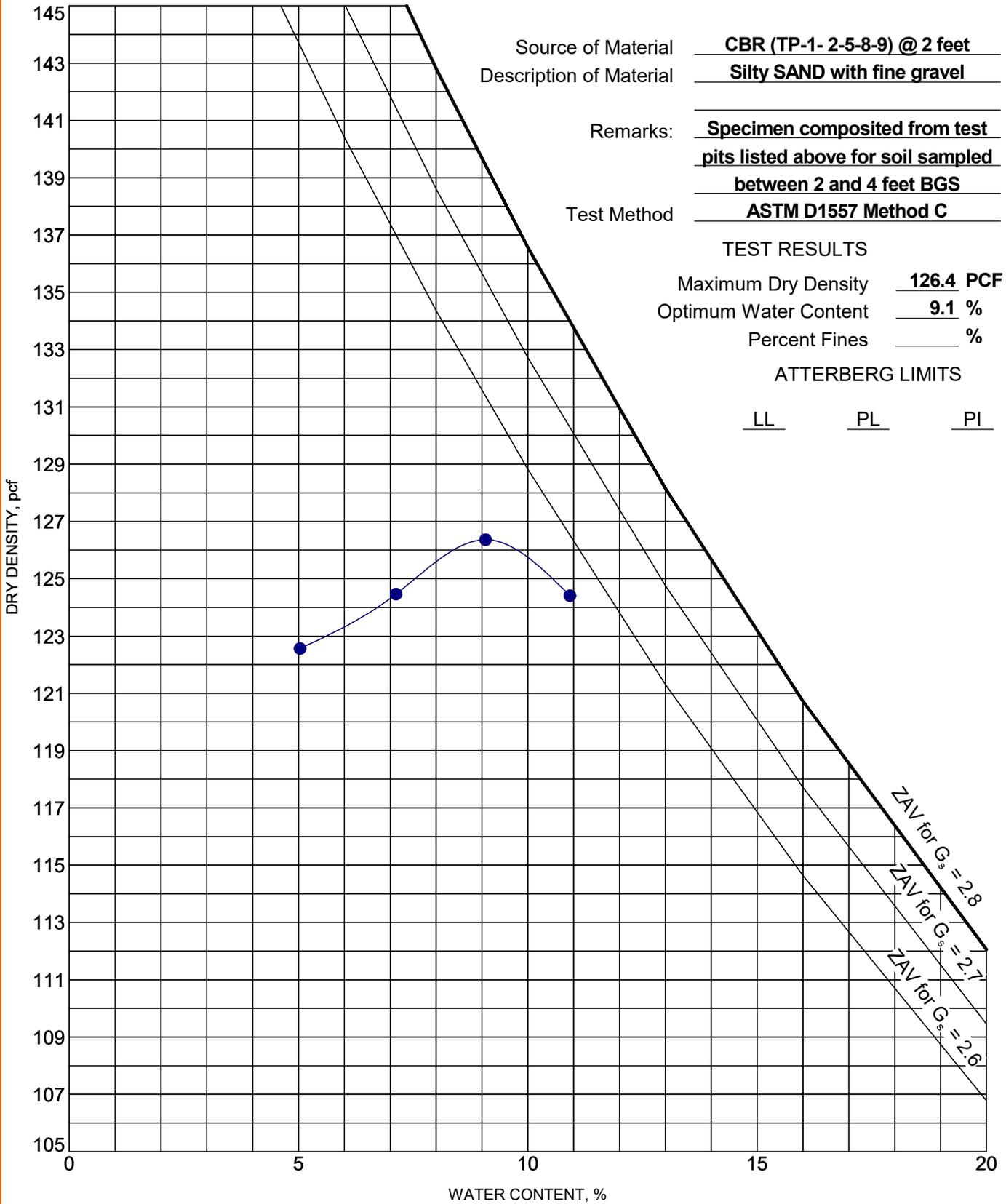
PROJECT NUMBER: 81195118

CLIENT: Pertec Inc. - project no. 20190109  
Everett, WA

# MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V1 81195118 PORT OF KINGSTON - WORKING COPY.GPJ TERRACON\_DATATEMPLATE.GDT 1/17/20



Source of Material CBR (TP-1- 2-5-8-9) @ 2 feet  
 Description of Material Silty SAND with fine gravel

Remarks: Specimen composited from test pits listed above for soil sampled between 2 and 4 feet BGS

Test Method ASTM D1557 Method C

**TEST RESULTS**

Maximum Dry Density 126.4 PCF  
 Optimum Water Content 9.1 %  
 Percent Fines     %  

**ATTERBERG LIMITS**

     LL           PL           PI

ZAV for  $G_s = 2.8$   
 ZAV for  $G_s = 2.7$   
 ZAV for  $G_s = 2.6$

PROJECT: Port of Kingston Remote Ferry Holding Lot

SITE: State Route 104 and Lindvog Road Kingston, WA

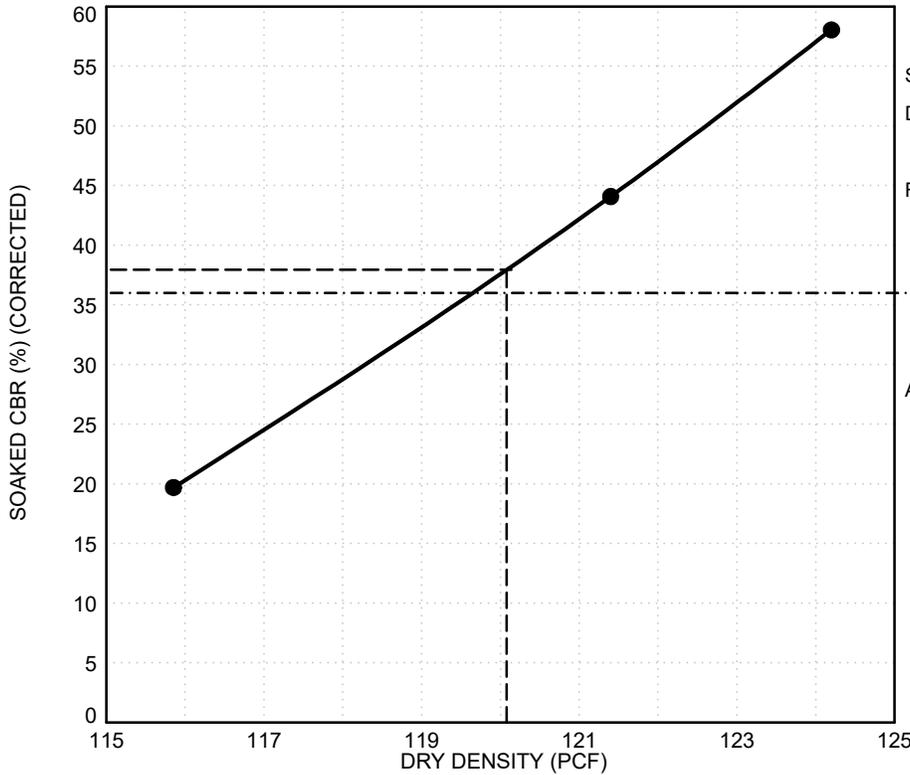


PROJECT NUMBER: 81195118

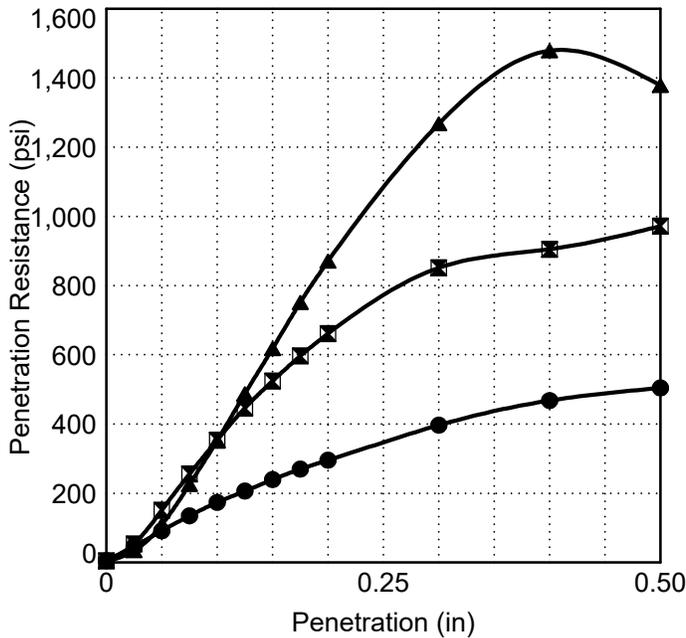
CLIENT: Perteet Inc. - project no. 20190109 Everett, WA

# CALIFORNIA BEARING RATIO

ASTM D1883-07<sup>2</sup>



Source of Material CBR (TP-1- 2-5-8-9) 2.0  
 Description of Material Silty SAND with fine gravel  
 Remarks: Specimen composited from test pits listed above for soil sampled between 2 and 4 feet BGS  
 Percent Fines \_\_\_\_\_ %  
 Atterberg Limits LL PL PI



Sample No.	1	2	3
Sample Condition	Soaked		
Compaction Method	ASTM 1557C		
Maximum Dry Density, (pcf)	126.4	126.4	126.4
Optimum Moisture Content, (%)	9.1	9.1	9.1
Dry Density before Soaking, (pcf)	115.85	121.40	124.20
Moisture Content, (%)			
After Compaction	9.5	9.8	9.5
Top 1" After Soaking	12.8	10.2	9.4
Surcharge, (lbs)	10.00	10.00	10.00
Swell, (%)	-0.04	0.04	-0.10
Bearing Ratio, (%)	19.7	44.1	58.0

Dry Density @ 90% 113.8 pcf  
 Dry Density @ 95% 120.1 pcf  
 Dry Density @ 100% 126.4 pcf

CBR @ 90% Density \_\_\_\_\_  
 CBR @ 95% Density 37.9  
 CBR @ 100% Density \_\_\_\_\_

PROJECT: Port of Kingston Remote Ferry Holding Lot

SITE: State Route 104 and Lindvog Road Kingston, WA



PROJECT NUMBER: 81195118

CLIENT: Perteet Inc. - project no. 20190109 Everett, WA

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## **SUPPORTING INFORMATION**

### **Contents:**

General Notes

Unified Soil Classification System

Note: All attachments are one page unless noted above.

# GENERAL NOTES

## DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Port of Kingston Remote Ferry Holding Lot ■ Kingston, WA  
 January 20, 2020 ■ Terracon Project No. 81195118

SAMPLING	WATER LEVEL	FIELD TESTS
 Grab Sample  Standard Penetration Test	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered <p>Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.</p>	N Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer UC Unconfined Compressive Strength (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer

### DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

### LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See [Exploration and Testing Procedures](#) in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

### STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength Qu, (tsf)	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

### RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests <sup>A</sup>				Soil Classification		
				Group Symbol	Group Name <sup>B</sup>	
<b>Coarse-Grained Soils:</b> More than 50% retained on No. 200 sieve	<b>Gravels:</b> More than 50% of coarse fraction retained on No. 4 sieve	<b>Clean Gravels:</b> Less than 5% fines <sup>C</sup>	$Cu \geq 4$ and $1 \leq Cc \leq 3$ <sup>E</sup>	GW	Well-graded gravel <sup>F</sup>	
			$Cu < 4$ and/or $[Cc < 1$ or $Cc > 3.0]$ <sup>E</sup>	GP	Poorly graded gravel <sup>F</sup>	
		<b>Gravels with Fines:</b> More than 12% fines <sup>C</sup>	Fines classify as ML or MH	GM	Silty gravel <sup>F, G, H</sup>	
			Fines classify as CL or CH	GC	Clayey gravel <sup>F, G, H</sup>	
	<b>Sands:</b> 50% or more of coarse fraction passes No. 4 sieve	<b>Clean Sands:</b> Less than 5% fines <sup>D</sup>	$Cu \geq 6$ and $1 \leq Cc \leq 3$ <sup>E</sup>	SW	Well-graded sand <sup>I</sup>	
			$Cu < 6$ and/or $[Cc < 1$ or $Cc > 3.0]$ <sup>E</sup>	SP	Poorly graded sand <sup>I</sup>	
		<b>Sands with Fines:</b> More than 12% fines <sup>D</sup>	Fines classify as ML or MH	SM	Silty sand <sup>G, H, I</sup>	
			Fines classify as CL or CH	SC	Clayey sand <sup>G, H, I</sup>	
<b>Fine-Grained Soils:</b> 50% or more passes the No. 200 sieve	<b>Silts and Clays:</b> Liquid limit less than 50	<b>Inorganic:</b>	$PI > 7$ and plots on or above "A"	CL	Lean clay <sup>K, L, M</sup>	
			$PI < 4$ or plots below "A" line <sup>J</sup>	ML	Silt <sup>K, L, M</sup>	
		<b>Organic:</b>	Liquid limit - oven dried	< 0.75	OL	Organic clay <sup>K, L, M, N</sup>
			Liquid limit - not dried			Organic silt <sup>K, L, M, O</sup>
	<b>Silts and Clays:</b> Liquid limit 50 or more	<b>Inorganic:</b>	$PI$ plots on or above "A" line	CH	Fat clay <sup>K, L, M</sup>	
			$PI$ plots below "A" line	MH	Elastic Silt <sup>K, L, M</sup>	
		<b>Organic:</b>	Liquid limit - oven dried	< 0.75	OH	Organic clay <sup>K, L, M, P</sup>
			Liquid limit - not dried			Organic silt <sup>K, L, M, Q</sup>
	<b>Highly organic soils:</b>	Primarily organic matter, dark in color, and organic odor			PT	Peat

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve.

<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

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

<sup>D</sup> Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

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

<sup>F</sup> If soil contains  $\geq 15\%$  sand, add "with sand" to group name.

<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.

<sup>I</sup> If soil contains  $\geq 15\%$  gravel, add "with gravel" to group name.

<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>L</sup> If soil contains  $\geq 30\%$  plus No. 200 predominantly sand, add "sandy" to group name.

<sup>M</sup> If soil contains  $\geq 30\%$  plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>N</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>O</sup>  $PI < 4$  or plots below "A" line.

<sup>P</sup>  $PI$  plots on or above "A" line.

<sup>Q</sup>  $PI$  plots below "A" line.

