ICICLECREEK ENGINEERS

Report
Geotechnical Engineering Services
Proposed Lake to Sound Trail – Segment C
SeaTac and Burien, Washington

July 30, 2019
ICE File No. 0105-023

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Prepared For:
Parametrix, Inc.

Prepared By:
Icicle Creek Engineers, Inc.

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July 30, 2019

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We are pleased to submit an electronic copy (pdf) and one original copy of our *Report, Geotechnical Engineering Services, Proposed Lake to Sound Trail – Segment C, SeaTac and Burien, Washington*. Icicle Creek Engineers' services were completed in general accordance with Parametrix Subconsultant Agreement for Professional Services and Amendment Nos. 1 and 2 for Subconsultant Agreement for Professional Services. These contracts were authorized in writing by Roger W. Flint, Chief Operating Officer for Parametrix, on January 19, 2018 and May 29, 2019; and by John Perlic, Senior Vice President for Parametrix, on November 28, 2018.

Our draft report was submitted for review and comment on May 25, 2018 (30% design).

Please contact us if you require additional information or an interpretation of the information presented in this report. We appreciate the opportunity to be of service to you.

Yours very truly,
Icicle Creek Engineers, Inc.

Kathy S. Killman, LEG
Principal Engineering Geologist

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Attachments

cc: Jenny Bailey and Craig Buitrago, Parametrix (email)

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REPORT
GEOTECHNICAL ENGINEERING SERVICES
PROPOSED LAKE TO SOUND TRAIL - SEGMENT C
SEATAC AND BURIEN, WASHINGTON
FOR
PARAMETRIX

1.0 INTRODUCTION

This report presents the results of Icicle Creek Engineers' (ICE's) geotechnical engineering services for design related to the proposed Lake to Sound Trail Segment C (L2ST-Seg C). The L2ST-Seg C is a part of the King County Regional Trails system that extends from the south end of Lake Washington to the shoreline of the Puget Sound in Des Moines. The L2ST-Seg C will connect the southern terminus of Segment B to the Des Moines Creek Trail at South 200th Street roughly following the State Route (SR) 509 extension alignment, crossing through the Cities of SeaTac and Burien.

The general location of the L2ST-Seg C alignment is shown on the Vicinity Map, Figure 1. Plans and profiles of the L2ST-Seg C alignment are shown on the Plans and Profiles, Figures 2 through 28.

2.0 PROJECT DESCRIPTION

Yammie Ho, PE, with Parametrix, the Project Engineer, provided ICE with the following design documents for our use and review:

- Parametrix, July 2018 (60% review submittal), *Lake to Sound Trail, Segment C, Plan and Profile*, sheets AL1 through AL27.

The L2ST-Seg C project includes construction of about 2.2 miles of 10-to 12-foot wide paved trail with gravel shoulders, adjacent to Des Moines Memorial Drive (DMMD) or traversing the open space area within the SR 509 right-of-way (ROW), from South 200th Street to the DMMD/South Normandy Road intersection. The project also includes approximately 782 linear feet of elevated boardwalk, 5,826 feet of porous hot mix asphalt (HMA) pavement (or a bioretention alternative in lieu of porous HMA), 14 driveway crossings, three existing signalized intersections (DMMD/South 192nd Street, DMMD/8th Avenue South, and DMMD/South Normandy Road), one existing midblock (signalized) crossing on South 200th Street, retaining walls up to 15-feet high and various other construction elements such as storm drains, utilities, and landscaping. Types of retaining walls under consideration include structural earth walls (SEWs), a gravity block wall (GBW) referred to as Wall #17 at Stations 202+23 to 206+73, and a soldier pile wall (SPW) as described below.

To obtain trail width, the toe of the SR 509 fill embankment will require a cut varying from about 3- to 10-feet high from about Stations 186+40 to 188+80. The cut will be supported by a SPW referred to as Wall #15. We understand that Wall #15 is semi-permanent; the soldier pile wall may eventually be removed when redevelopment of SR 509 occurs. At this time, the schedule for the SR 509 redevelopment is not confidently known. For this reason, geotechnical design parameters developed for this wall assume a permanent structure.

The proposed boardwalks generally cross wet, soft ground areas from about Stations 165+86 to 167+77, 169+24 to 171+24, and 174+31 to 178+44.

A dispersion trench is proposed at about Station 180+50. Porous HMA (or bioretention) may be used to manage stormwater on the trail surface from about Stations 100+64 to 114+30, 134+94 to 151+53, 154+81 to 165+86, and 195+40 to 212+36. About 1,238 feet of underdrain trench is planned from about Stations 180+51 to 192+89.

3.0 GEOLOGIC SETTING

The surficial geologic units along the L2ST-Seg C were mapped based on published geologic information, field reconnaissance and test borings. The most recent regional geologic mapping in the site area was completed by the US Geological Survey (USGS - Booth, D.B. and Waldron, H.H, 2004, *Geologic Map of the Des Moines 7.5' Quadrangle, King County, Washington*, Scientific Investigations Map 2855, 1:24,000 scale).

The geology and landforms of the site area are the result of recent (within the past 20,000 years) glacial and postglacial events within the Puget Sound area. Older glacial and interglacial deposits and bedrock underlie the entire site area, though at a depth of more than 50 feet below the ground surface. In general, the L2ST-Seg C parallels the longitudinal axis of the Des Moines Creek valley, which is the location of a former glacial meltwater channel.

The most recent glaciation, the Vashon Stade of the Fraser glaciation, covered the entire area with up to 3,000 feet of ice at its maximum extent. The Vashon ice sheet completely melted from the site area approximately 13,000 to 15,000 years ago.

During the Vashon Stade of the Fraser glaciation, Advance Outwash, Glacial Till and Recessional Outwash were deposited across the project site area.

Since the last glaciation, Alluvium was deposited in the current wide valley containing Des Moines Creek. Recent human activities (cuts and fills) have modified the land surface across the entire L2ST-Seg C alignment. The cuts and fill are expected to be less than 10-feet high or deep.

The following is a description of these soil types.

Advance Outwash – Advance Outwash was deposited in front of the advancing ice sheet and consists about 50 feet of stratified (horizontally layered) sand and gravel. Advance Outwash is typically in a dense to very dense condition as a result of being overridden by the glacial ice.

Glacial Till – Glacial Till usually overlies the Advance Outwash and was deposited directly at the base of the overriding ice sheet and consists of up to 30 feet of an unsorted, unstratified mixture (referred to as a diamicton) of silt, sand and gravel with occasional cobbles and boulders. Glacial Till is typically in a dense to very dense condition as a result of being overridden by glacial ice.

Recessional Outwash – Recessional Outwash was deposited in front of retreating (melting) ice sheet in meltwater channels (such as the Des Moines Creek valley) and is usually relatively thin (less than 15-feet thick) and typically consists of medium dense sand with variable amounts of silt and gravel.

Alluvium – Recent deposits of Alluvium were deposited in the (current) Des Moines Creek valley during the past 10,000 years. Alluvium typically consists of loose to medium dense sand and gravel or soft to medium stiff silt. Peat (compressible organic soil) may occur locally within the Alluvium.

Fill – Human activities (grading/Fill) have locally modified the ground surface along the L2ST-Seg C alignment. Fills are more common than cuts because of the relatively level to gently sloping terrain along the L2ST-Seg C alignment. We expect the Fill to be of widely variable quality, thickness (usually less than 10 feet in this area, with the exception of the SR 509 fill embankment) and area distribution.

The interpreted geologic conditions that underlie the L2ST-Seg C are shown on Figures 2 through 28.

4.0 REGIONAL HYDROGEOLOGY

4.1 GENERAL

The L2ST-Seg C alignment generally parallels the longitudinal axis of the Des Moines Creek valley. The Des Moines Creek valley is a wide, low relief feature that was occupied by a former glacial meltwater channel and is underlain by a layered sequence (oldest to youngest) of glacial deposits consisting of Advance Outwash, Glacial Till and Recessional Outwash, with localized surficial deposits of Alluvium and Fill.

4.2 SHALLOW GROUNDWATER SYSTEM

The Alluvium and Recessional Outwash are relatively well-drained, however, are underlain by very low permeability Glacial Till (often called "hardpan") or the less (vertically) permeable Advance Outwash. For this reason, groundwater will "perch" on the less permeable layers resulting in an unconfined shallow groundwater system. Often this shallow, perched groundwater will dry out by the late summer months. The perched groundwater along with undulations in the surface topography including closed depressions will collect water and is exposed at the surface as lakes and wetlands.

4.3 DEEP GROUNDWATER SYSTEM

We expect that a deep groundwater system consisting of layer(s) of groundwater occurs within the more permeable layers of the Advance Outwash. The deep groundwater system may be under pressure (confined aquifer) and typically does not dry out, however, the level may seasonally fluctuate a few feet.

5.0 CRITICAL AREAS

The L2ST-Seg C crosses through the City of SeaTac from about Stations 99+96 (beginning) to 192+88, and the City of Burien from about Stations 194+50 to 214+91 (end). The trail is within shared jurisdiction of SeaTac and Burien from about Stations 193+00 to 194+50.

The City of Burien Municipal Code (BMC) chapter 19.40.280 regulates Critical Areas (Geologically Hazardous Areas - GHAs) including Steep Slope, Landslide, Seismic and Erosion Hazards. The City of SeaTac Municipal Code (SMC) chapter 15.700 regulates Critical Areas (GHAs) including Steep Slope, Landslide, Seismic, Erosion, Coal Mine and Volcanic Hazards.

Other naturally-occurring Critical Areas exist in both jurisdictions including Flood, Wetlands, Streams and Aquifer Recharge Areas and are being addressed by others for this project.

Based on our review of BMC 19.40.280 and SMC 15.700 and respective Critical Areas mapping by each jurisdiction, the L2ST-Seg C does not contain GHAs or associated buffers, where appropriate, within or adjacent to the L2ST-Seg C alignment ROW.

It should be noted that numerous fill embankments, and less frequent cut slopes, that are sloped at 2H:1V (horizontal to vertical - 50 percent grade) are technically a "Steep Slope Hazard" or "Landslide Hazard" in SeaTac or Burien. However, both jurisdictions provide an exemption for this condition if the slope is 1) less than 10-feet high (BMC 19.40.280 and SMC 15.700.015) or 2) created by previous legal grading (BMC 19.40.280 4.A.iii and SMC 15.700.270 E.2.).

As previously described, there are no regionally-mapped Seismic Hazard areas within SeaTac or Burien along or adjacent to the L2ST-Seg C alignment. However, based on our subsurface explorations (soil and groundwater conditions as described later in this report), we encountered "Liquefaction-Prone" soils which are a Seismic Hazard by definition (BMC 19.40.280 2.B. and SMC 15.700.015). The locations of these Liquefaction Prone areas are shown on Figures 9 through 11 and 15 through 22 and are listed by station as follows:

Liquefaction Prone Areas	
Stations	**Length (feet)**
133+55 to 142+75	920
158+35 to 171+75	1,340
174+30 to 186+10	1,180

6.0 SEISMICITY

The Puget Sound region is seismically active. Seismicity in this region is attributed primarily to the interaction between the Pacific, Juan de Fuca and North American plates. The Juan de Fuca plate is subducting beneath the North American plate. It is thought that the resulting deformation and breakup of the Juan de Fuca plate might account for the large-magnitude deep-focus earthquakes in this region.

Thick deposits of glacial and non-glacial sediments occur throughout most of the Puget Sound Basin. Due to the thick sediment cover, little is known regarding the nature of faults in the underlying bedrock. The Seattle Fault, the Southern Whidbey Island Fault and the Tacoma Fault Zones are the only known structural geology features that have indicated ground displacement in the Quaternary age glacial and interglacial sediments in the Puget Sound region. The project site is located about 6 miles northeast of the Tacoma Fault Zone, and about 5 miles south of the Seattle Fault Zone.

An abbreviated listing of major (greater than 5.0 magnitude) earthquake events in the Puget Sound region according to the Pacific Northwest Seismic Network is presented below.

Summary of Major Seismic Events in the Puget Sound Region			
Seismic Event	**Date**	**Location**	**Richter Magnitude**
North Cascades Earthquake	December 15, 1872	Chelan, WA	6.8*
Pickering Passage Earthquake	February 15, 1946	Olympia, WA	5.8
Strait of Georgia Earthquake	June 23, 1946	Courtenay, BC	7.4
Olympia Earthquake	April 13, 1949	Olympia, WA	7.1
Seattle-Tacoma Earthquake	April 29, 1965	SeaTac, WA	6.5
Duvall Earthquake	May 3, 1996	Duvall, WA	5.4
Satsop Earthquake	July 3, 1999	Satsop, WA	5.8
Nisqually Earthquake	February 28, 2001	Olympia, WA	6.8

Source: *Pacific Northwest Seismic Network.*

* Estimated from historical information

7.0 SITE CONDITIONS

7.1 SURFACE CONDITIONS

Surface conditions of the L2ST-Seg C alignment were evaluated based on field reconnaissance as described in Appendix A of this report.

The L2ST-Seg C alignment begins at about Station 99+96 (Elevation 245 feet) by connecting with the existing Des Moines Creek Trail at South 200th Street and gradually grades uphill to the north and west to its crest along DMMD (Elevation 329 feet), descending again to the north to connect with the existing L2ST-Seg B at South Normandy Road (Elevation 268 feet).

The L2ST-Seg C alignment generally follows the low-gradient Des Moines Creek valley by paralleling existing roads, crossing undeveloped areas, occasionally crossing various wetlands and bordering other commercial development. We did not observe evidence of landslides or severe erosion along the L2ST-Seg C alignment. To further describe surface conditions, the L2ST-Seg C alignment was segmented into areas of similar land use and topographic character. Details of the site conditions along the L2ST-Seg C alignment based on site visits between February 7 and April 6, 2018 are described as follows:

Stations 99+96 to 103+50 (South 200th Street)

This east-west segment of the trail parallels the gravel-surfaced north shoulder of South 200th Street. Along this segment the road shoulder has been raised by fill forming a paralleling embankment inclined down at about a 2H:1V slope (50 percent grade) from about 2- to 5-feet high; increasing in height from east to west. A chain-link fence topped with barbed-wire borders the fill embankment to the north. The fill embankment is vegetated with grasses; blackberry vines and scattered deciduous trees vegetate the base of the embankment along the fence line. Utility poles and low overhead utility lines are present within the L2ST-Seg C alignment along this station interval. No surface water was observed along this segment at the time of our site visits.

Stations 103+50 to 114+00 (SR 509 ROW)

This segment of the trail turns northwest following the SR 509 ROW within property maintained by the Port of Seattle. This general area is characterized by gently undulating terrain that was previously occupied by the Tyee Valley Golf Course which reportedly closed in 2014. The ground surface slopes gradually down (less than 5 percent grade) to the east in this area. The area is vegetated with grasses and scattered deciduous and conifer trees. It appears that the Port of Seattle maintains the area by, at a minimum, keeping the grass mowed. Sprinklers and plastic and iron irrigation piping were observed in the area. Several unimproved maintenance roads traverse the area. No surface water was observed along this segment at the time of our site visits.

Stations 114+00 to 135+00 (18th Avenue South and South 196th Street)

This segment of the trail parallels the base of a low hill, turning north, northwest then west within the 18th Avenue South and South 196th Street paved corridors. The ground surface slopes down to the east, northeast then north at about a 10 percent grade along this segment. The road area is a cut and fill slope, with cut slopes up to about 4-feet high along the uphill side and fill slopes up to about 5-feet high along the downhill side. Adjacent to the L2ST-Seg C alignment, the area is vegetated with mature deciduous and conifer trees and an understory of grasses and blackberry vines. Downhill of the L2ST-Seg C alignment, along the base of the fill slope, a chain-link fence topped with barbed-wire parallels the L2ST-Seg C alignment. No surface water was observed along this segment at the time of our site visits.

Stations 135+00 to 142+00 (SR 509 ROW)

This segment of the trail turns northwest following the undeveloped SR 509 ROW and adjacent properties maintained by the Washington State Department of Transportation (WSDOT). The ground surface slopes gradually down (less than five percent grade) to the northeast in this area. Evidence of previous residential development, including modified land (shallow cuts and fills) and patches of asphalt and concrete pavement, was observed in the area. Several demolished and regraded home sites are scattered across the area; as evidenced by historical aerial photographs (Google Earth), some homes appear to have been demolished in 2006 or 2007, and more later in 2010 or 2011. The area is vegetated with grasses, scattered clumps of dense blackberry vines and scotch broom, and scattered mature deciduous and conifer trees. No surface water was observed along this segment at the time of our site visits.

Stations 142+00 to 161+50 (DMMD)
This segment of the trail turns north along DMMD. For approximately 250 feet, the L2ST-Seg C alignment follows the gravel-surfaced east shoulder of DMMD. A 2-foot-high cut slope borders the L2ST-Seg C alignment to the east for approximately 250 feet. For the next 700 feet, the L2ST-Seg C alignment follows a sidewalk and landscaped area (consisting of grass, small trees and streetlights) along the east shoulder of DMMD, bordering an embankment that slopes down to the east at about a 20 percent grade to a warehouse area; this embankment is about 2- to 4-feet high, increasing in height from north to south. The L2ST-Seg C alignment then crosses to the west side of DMMD at a signalized intersection, continuing along the west shoulder at the base of a gently-sloping 1- to 2-foot high embankment. This portion of the segment is surfaced by concrete sidewalk, a landscaped area consisting of grass and small trees and some plastic irrigation piping and sprinklers, and streetlights. No surface water was observed along this segment at the time of our site visits.

Stations 161+50 to 165+30 (DMMD)
This segment of the trail continues along the west shoulder of DMMD. The L2ST-Seg C alignment contains a 2- to 4-foot-high embankment sloping down to the west at about a 30 percent grade. A concrete sidewalk, grass and streetlights cover a portion of the L2ST-Seg C alignment area. At the base of the embankment, a chain-link fence and the Des Moines Creek channel follow the L2ST-Seg C alignment. The creek channel area is vegetated with dense deciduous trees; the channel contained intermittent areas of standing and slowly flowing water at the time of our site visits.

Stations 165+30 to 167+75 (Hertz Realty Corporation Property)
This segment of the trail turns west just north of the SR 509 ROW, within property maintained by the Hertz Realty Corporation. The area slopes to the south at about a 5 percent grade. The L2ST-Seg C alignment area is vegetated with tall grass. Standing water within the Des Moines Creek channel parallels the L2ST-Seg C alignment to the south. The ground surface was moist within the L2ST-Seg C alignment at the time of our site visits.

Stations 167+75 to 169+25 (Stormwater Pond Berm)
This segment of the trail continues west along an east-west-trending stormwater pond berm maintained by Hertz Realty Corporation. The berm is about 10-feet wide at its top and about 4- to 6-feet high, with slopes to the north and south sloping down at about a 50 percent grade. The berm is vegetated with blackberry vines and scattered deciduous trees. Standing water was observed along the southern base of the berm, within the Des Moines Creek channel and adjacent wetland areas at the time of our site visits.

Stations 169+25 to 171+75 (SR 509 ROW)
The ground surface along this segment of the trail descends gently (less than 5 percent grade), then becomes nearly level with slight undulations. This area is vegetated with scattered areas of dense deciduous brush and small trees. Standing water up to about 2-feet deep was present in this area at the time of our site visits.

Stations 171+75 to 174+25 (SR 509 ROW)
This segment of the trail continues west, then turns north within the SR 509 ROW. The ground surface grades down to the northeast at about a 15 percent grade in this area. Between about Stations 172+75 and 174+25, a block wall rises about 30-feet high just west of the L2ST-Seg C alignment. The block wall is

slightly battered from vertical and is faced with 6-inch by 12-inch blocks. The base of the wall is about 20 feet west of the center of the L2ST-Seg C alignment.

An open stormwater manhole was discovered about 30 feet east of the trail corridor at approximately Station 171+80. The opening was approximately 3 feet in diameter and 8-feet deep.

The area around this segment is vegetated with very dense blackberry vines. No surface water was observed along this segment during our site visits.

Stations 174+25 to 178+50 (SR 509 ROW)
This segment of the trail continues generally north through a wetland area within the SR 509 ROW. The ground surface slopes down to the east at about a 10 percent grade in this area. At about Station 176+00, an 8-foot-high rockery parallels the west edge of the L2ST-Seg C alignment. The L2ST-Seg C alignment area is vegetated with scattered areas of dense deciduous brush and deciduous and conifer trees. Local areas of standing water were observed related to the wetlands. The L2ST-Seg C alignment also crosses several channels of flowing water along this segment; the largest was flowing at about 5 gallons per minute at the time of our site visits.

Stations 178+50 to 184+50 (SR 509 ROW)
This segment of the trail continues generally north through a drier area within the SR 509 ROW. The ground surface slopes to the south at about 5 percent grade in this area. The area is vegetated with scattered areas of dense deciduous brush and deciduous and conifer trees. North of approximately Station 181+50, the ground surface is vegetated with very dense blackberry vines. No surface water was observed along this segment during our site visits.

Stations 184+50 to 192+50 (SR 509 ROW)
This segment of the trail turns north-northwest, paralleling the SR 509 southbound off-ramp to southbound DMMD. A chain-link fence intersects the L2ST-Seg C alignment at approximately Station 184+45. The L2ST-Seg C alignment parallels the base of an approximately 20-foot-high fill embankment for the SR 509 off-ramp, sloped at about a 50 percent grade with a 4-foot high rockery at the toe of the embankment.

Just west of the L2ST-Seg C alignment, a chain-link fence and an approximately 3-foot-deep open ditch parallel the L2ST-Seg C alignment, with a parking lot maintained by Park-N-Jet, LLC just beyond. The L2ST-Seg C alignment area is vegetated with grass and scattered areas of dense blackberry vines and other deciduous brush. Localized areas of standing water and saturated soil were observed within the L2ST-Seg C alignment between about Stations 184+65 and 186+00. Standing water was also observed within the ditch-line adjacent to the L2ST-Seg C alignment.

It appears that the embankment toe and rockery encroach (pinch point) into the trail L2ST-Seg C alignment between about Stations 186+40 and 188+80 where Wall #15 (a soldier pile wall) is planned. At this location, the trail crosses between an approximately 22- to 26-foot-high fill embankment sloped at about a 50 percent grade for the SR 509 off-ramp to the east and private property to the west. Presently, the toe of the fill embankment is faced with an approximately 4-foot-high rockery.

Stations 192+50 to 214+91 (DMMD)
This segment of the L2ST-Seg C alignment turns northwest along the asphalt, gravel and grass-surfaced west shoulder of DMMD. The L2ST-Seg C alignment crosses several driveways and a signalized intersection along this segment. Between about Stations 192+50 and 196+00, the ground surface grades

gradually down (less than 5 percent grade) to the southeast. The L2ST-Seg C alignment then reaches a high point and grades down to the northwest at about a 5 percent grade between about Stations 196+00 and 214+91. An open ditch occurs within the L2ST-Seg C alignment between about Stations 200+90 and 205+25. The ditch is up to about 2-feet deep. Several culverts occur at driveway crossings. An embankment rises from the L2ST-Seg C alignment to the southwest and west between about Stations 202+50 and 207+50, and Stations 208+50 and 212+50. A GBW (Redi-Rock® wall system) to retain existing fill is planned from Stations 202+23 to 206+73. The embankment is a maximum of about 4-feet high and inclined at about a 50 percent grade.

Between about Stations 197+00 and 199+50, the L2ST-Seg C alignment is vegetated with landscape hedges and deciduous brush. Between about Stations 199+50 and 212+80, the L2ST-Seg C alignment is vegetated with grass, scattered thickets of dense blackberry vines and deciduous trees. Areas of standing water were observed in the open ditch. No other surface water was observed along this segment at the time of our site visits.

7.2 SUBSURFACE CONDITIONS

7.2.1 General

Subsurface conditions were evaluated based partially on published and unpublished geologic information for the area, including regional geologic mapping by the US Geological Survey (USGS – Booth, D.B. and Waldron, H.H., 2004, *Geologic Map of the Des Moines 7.5' Quadrangle, King County, Washington,* Scientific Investigations Map 2855, 1:24,000 scale) and on our subsurface exploration program completed for this study. In addition, we used soil and groundwater information from four borings completed by Hong West Associates (HWA) for a previous study of the L2ST-Seg C alignment, specifically in the proposed boardwalk areas.

ICE completed 39 subsurface explorations (Borings B-1 to B-20, Infiltration Tests IT-1 to IT-24, and Test Holes TH-1 and TH-2, with some Borings and Infiltration Tests completed as combination explorations) along the L2ST-Seg C alignment and in the area of the proposed SR 509 SPW (Wall #15); the explorations ranged from about 6- to 36.4-feet deep. The locations of the explorations, including four borings completed by HWA (BH-1, BH-2, BH-3 and BH-4) are shown on Figures 2 through 28. Our field exploration program is described in detail in Appendix A, along with our boring, infiltration test and test hole logs. Details of the laboratory testing program, along with the test results, are presented in Appendix B, and in the boring, infiltration test and test hole logs in Appendix A. The previously-referenced boring logs completed by HWA are presented in Appendix C.

In general, our subsurface explorations encountered native soil conditions generally consistent with the regional geologic mapping by the USGS (2004), including Recessional Outwash, Glacial Till, and Advance Outwash. Surficial soils consisting of recent Alluvium and Fill deposits not mapped by the USGS (2004) were also encountered in some of the explorations.

Fill thickness generally varies from about 6 inches to 8 feet in the explorations along the L2ST-Seg C alignment, with the following exception. Up to about 27.5 feet of Fill was encountered in Borings B-16 and B-17 completed on the SR 509 fill embankment in the area of the proposed SR 509 SPW (Wall #15). Fills encountered were generally related to previous road construction and utility installation activities, and therefore are prevalent along the existing roadways and the existing stormwater pond (at about Stations 167+77 to 169+24).

The occurrence of the recent Alluvium also varies along the L2ST-Seg C alignment. In areas where the L2ST-Seg C alignment traverses the lower areas occupied by wetlands and Des Moines Creek, Alluvium was typically encountered.

The interpreted geologic and hydrogeologic conditions based on the subsurface explorations and piezometers are shown on Figures 2 through 28.

7.2.2 Soil Conditions (L2ST-Seg C Alignment)

The following is a summary of the soil conditions encountered in our test borings and infiltration test locations completed along the L2ST-Seg C alignment.

Topsoil – Topsoil was encountered in many explorations mantled by landscaped or natural vegetation. Topsoil was not encountered in explorations occurring in gravel shoulders or pavement areas. Topsoil observed in the explorations consisted of loose silty sand or soft sandy silt with sod and abundant fine roots; the Topsoil observed was between about 2- and 12-inches thick and mantled the ground surface.

Fill – Surficial Fill was encountered in many of the subsurface explorations occurring adjacent to existing man-made facilities, such as roads, general infrastructure and past residential use areas. The Fill encountered in the explorations was typically in a medium dense or medium stiff condition. Borings/Infiltration Tests IT-8, IT-11 and B-7 encountered Fill in a dense condition. Borings/Infiltration Test B-3, IT-10, IT-12, B-4, B-8 and B-13 encountered Fill in a loose or very loose condition. The Fill encountered varied in thickness from about 6 inches to 8 feet, and consisted of a variable mixture of silt, sand, gravel and cobbles. Some of the explorations encountered concrete and asphalt fragments, miscellaneous plastic and metal and organic debris.

Alluvium – Alluvium encountered in the subsurface explorations typically consisted of very loose to medium dense sand with variable amounts of silt, gravel and organic material, or soft to medium stiff silt with variable amounts of sand, gravel and organic material. Borings B-4 encountered Alluvium in a stiff condition. The Alluvium encountered was often stratified/laminated (layered). Layers of peat and/or organic silt up to about 1½-feet thick were encountered within the Alluvium in Borings B-4 and B-8.

Recessional Outwash – Recessional Outwash encountered in the subsurface explorations typically consisted of medium dense to dense sand and gravel with variable amounts of silt and cobbles, or layers of medium stiff to stiff silt with variable amounts of sand and gravel. Borings/Infiltration Tests IT-7, B-3, B-14 and B-15 encountered Recessional Outwash in a very loose or loose condition. Borings B-5, B-6 and B-7 encountered Recessional Outwash in a very dense or very stiff condition. However, the SPT blow counts (and therefore density estimates) may not be representative for samples containing an abundance of gravel.

Glacial Till – Glacial Till encountered in the subsurface explorations typically consisted of an unsorted mixture of dense to very dense silty sand with variable amounts of gravel and cobbles.

Advance Outwash – Advance Outwash encountered in the subsurface explorations typically consisted of dense to very dense sand and gravel with variable amounts of silt and cobbles, or discontinuous layers of stiff to very stiff silt with variable amounts of sand. Boring B-1 encountered Advance Outwash in a medium dense condition.

7.2.3 Soil and Groundwater Conditions (Proposed SR 509 Soldier Pile Wall)

ICE completed field explorations related to the proposed SR 509 SPW (Wall #15) for the L2ST-Seg C alignment from approximate Stations 186+40 to 188+80. The wall generally parallels the toe of a fill embankment of the southbound SR 509 off-ramp in the City of SeaTac. The fill embankment is within WSDOT ROW. The location of the proposed retaining wall is shown on Figure 22.

ICE completed five test borings (Borings B-16 through B-20) and two test holes (Test Holes TH-1 and TH-2) to supplement Boring B-11. The locations of these test borings and test holes relative to the proposed retaining wall are shown on Figures 22 and 23. The boring and test hole logs for the explorations completed in the area of the proposed retaining wall are included in Appendix A.

Borings (B-16 and B-17) and test holes (Test Holes TH-1 and TH-2) that were completed in the SR 509 fill embankment encountered Fill generally consisting of medium dense silty sand with variable amounts of gravel and cobbles. The Fill extended to the base of Test Holes TH-1 and TH-2 at depths of about 6.0 and 8.0 feet, respectively, and to depths of about 27.5 and 27.0 feet in Borings B-16 and B-17, respectively. Alluvium was encountered beneath the Fill in Borings B-16 and B-17, and Recessional Outwash was encountered beneath the Alluvium in Boring B-17.

At the time of drilling, groundwater was not encountered in Boring B-16 and was observed at a depth of about 32 feet in Boring B-17. A thin layer of groundwater seepage was encountered at a depth of about 1 to 2 feet in Test Hole TH-1 and about 3 to 4 feet in Test Hole TH-2. It is likely that this groundwater is seasonal and may occur in discontinuous layers or lenses during the wet season.

Borings B-11, B-18, B-19 and B-20 were completed at the base of the SR 509 embankment and encountered about 5.5 to 9 feet of Alluvium consisting of very soft to stiff silt/clay or very loose to medium dense silty sand with variable amounts of gravel. The Alluvium is underlain by Recessional Outwash to depths of about 10 to 12.5 feet consisting of medium dense sand with variable amounts of gravel. The Recessional Outwash is underlain by Glacial Till consisting of silty sand with variable amounts of gravel and cobbles.

Groundwater at the time of drilling was encountered at depths ranging from about 7.5 to 9 feet in Borings B-11, B-18 and B-20.

7.2.4 Groundwater Conditions

Groundwater, if encountered, was measured at the time of drilling as shown on the boring and infiltration test logs in Appendix A, although this measurement can be much different from the actual groundwater level. Groundwater was subsequently measured in the piezometers that were installed in six of the explorations as shown in the table presented below. Selected groundwater measurements are shown on the logs in Appendix A.

Boring (Piezometer) No.	Station	Date of Measurement	Depth to Groundwater (approximate - feet)
B-1(p)	101+90	04/06/2018	13.91
		09/21/2018	16.61
		12/11/2018	15.42
		03/22/2019	13.10
		07/30/2019	16.49
B-7(p)/IT-16	164+45	04/06/2018	4.46
		09/21/2018	6.01
		12/11/2018	4.91
		03/22/2019	5.14
		07/30/2019	5.36
B-9(p)	173+40	04/06/2018	3.56
		09/21/2018	5.18
		12/11/2018	4.11
		03/22/2019	4.51
		07/30/2019	9.02
B-10(p)	180+25	04/06/2018	0.96
		09/21/2018	6.37
		12/11/2018	1.62
		03/22/2019	1.07
		07/30/2019	4.88
IT-19a(p)	184+90	04/06/2018	0.63
		09/21/2018	Dry
		12/11/2018	0.63
		03/22/2019	1.61
		07/30/2019	Dry
B-19(p)	188+10	03/22/2019	4.18
		07/30/2019	7.34

Groundwater is expected to fluctuate seasonally. Our test borings and infiltration tests along the L2ST-Seg C alignment were completed in early Spring (April) when groundwater levels are expected to be near the seasonal high. Other test borings in the area of the proposed SR 509 SPW were completed in late Fall (December); groundwater levels are expected to be moderate at that time.

We observed wetland areas (identified by Parametrix, Plans and Profiles, July 2018), adjacent to (within about 100 feet of) the L2ST-Seg C alignment at the following approximate Station intervals:

Wetland Identifier	Station
E	102+30 to 103+50
F	Vicinity of 124+40
C	131+75 to 137+30
A	161+50 to 180+25
H	184+45 to 186+40
G	190+35 to 191+75
B	210+45 to 212+75

Based on our field observations, these wetlands have formed in closed depressions underlain by Glacial Till.

8.0 PRELIMINARY INFILTRATION ANALYSIS

8.1 GENERAL

The field (short-term) and design (long-term) infiltration rate characteristics were preliminarily evaluated (screened for planning purposes) based on the results of small-scale infiltration tests for LID BMPs (Low Impact Development Best Management Practices) in general accordance with the 2016 King County Surface Water Design Manual (KCSWDM) Appendix C, Section C.1.3 using the EPA Falling Head Percolation Test Procedure, and, for comparison purposes, the Washington State Department of Ecology's 2014 Stormwater Management Manual for Western Washington (Ecology 2014 SMMWW) (Soil Grain Size Analysis Method – Method 2). Both the City of Burien and the City of SeaTac have adopted the 2016 KCSWDM for surface water management design standards.

8.2 METHOD 1 – EPA FALLING HEAD PERCOLATION TEST PROCEDURE

We completed 24 small-scale falling-head infiltration tests in 6- to 8-inch diameter vacuum- or hand-excavated holes approximately every 500 feet along the proposed trail corridor. Infiltration tests were typically completed about 5 feet from the adjacent subsurface exploration, after the excavation was completed. Infiltration tests were completed at various depths, intending to be set at approximately the base of the proposed porous HMA pavement or infiltration trench section (about 1.5- to 3-feet below proposed finish trail grade based on preliminary plans and profiles provided by Parametrix, dated March 2017). Gregory provided water from tanks on the two support pickups, and on an ATV, as needed.

Infiltration tests were completed in general accordance with the Environmental Protection Agency (EPA) Falling Head Test (FHT) procedure. About 2 to 3 inches of clean, ¾- to 1-inch diameter round rock ("landscape gravel") was added to the base of the holes. A 5-foot long, 4-inch diameter slotted PVC pipe (slotted pipe) was placed vertically within each hole, and the annular space backfilled with at least 12 inches of landscape gravel. The infiltration tests were completed by adding water into the slotted pipe using a hose connected to a water tank on either the support truck or ATV. Typically, two 12-inch FHTs were completed (from about 1.2-feet to 0.2-feet above gravel) to determine if a soak period is necessary. Per the EPA FHT procedure, if the 1-foot FHT took less than 10 minutes, the testing proceeded immediately. If the 1-foot FHT took greater than 10 minutes, a soak period was completed, where the water level was maintained about 8- to 12-inches above the gravel for a minimum of 4 hours before the test was performed. The FHT was then performed between about 6 and 5 inches above the base of the slotted pipe, repeatedly, until results stabilized. Infiltration test holes were backfilled in general accordance with Ecology guidelines.

Two infiltration tests, IT-18a and IT-19a, were abandoned at their intended location due to the presence of shallow groundwater at the testing depth. The tests were relocated (offset by about 40 to 50 feet to locations IT-18b and IT-19b) where the ground surface was higher and the testing depth was above the groundwater level.

The following is a summary of our preliminary field infiltration rate analysis using Method 1 (EPA Falling Head Percolation Test Procedure):

Infiltration Test No. (Station)	Test Depth (feet)	Geologic Unit	Soil Type (USCS)	Field Infiltration Rate (inches per hour – iph)
IT-1 (101+00)	3	Fill	GP-GM	8.0
IT-2 (103+00)	4	Fill	SM	800
B-2/IT-3 (106+00)	1.5	Recessional Outwash	SP	336
IT-4 (111+00)	3	Recessional Outwash	SM	5.6
IT-5 (116+00)	3	Recessional Outwash	SP-SM	133
IT-6 (121+00)	3	Fill	GP-GM	13
IT-7 (126+00)	3	Recessional Outwash	SM	51
IT-8 (131+00)	3	Recessional Outwash	SP	9.5
B-3/IT-9 (136+00)	1.5	Fill	SM	3.9
IT-10 (141+00)	4	Alluvium	SM	0.6
IT-11 (146+00)	2	Fill	GP-GM	0.4
IT-12 (151+00)	1.5	Fill	GP	1,829
B-4/IT-13 (155+90)	2.5	Alluvium	SM	1.6
B-5/IT-14 (158+40)	2	Fill	SM	1.2
B-6/IT-15 (161+90)	2.5	Fill	SP-SM	3.6
B-7/IT-16 (164+45)	1.5	Fill	GP-GM	59
IT-17 (172+90)	2	Alluvium	SP-SM	128
IT-18a (179+90)	1.5	Alluvium	SM	Not tested**
IT-18b (180+40)	1.5	Alluvium	SP-SM	99
IT-19a(p) (184+90)	1.5	Alluvium	SP-SM	Not tested**
IT-19b (185+30)	1.5	Alluvium	SP-SM	16
IT-20 (189+90)	1.5	Alluvium	ML	5.1
B-12/IT-21 (197+85)	1.5	Fill	SP-SM	0.3
IT-22 (203+15)	1.5	Glacial Till	SM	0.1
B-14/IT-23 (205+80)	1.5	Fill	GP	1,281
B-15/IT-24 (210+05)	1.5	Fill	GP-GM	7.3

* infiltration rates greater than 10 iph rounded to the nearest whole number.

** not tested – shallow groundwater at test depth

8.3 METHOD 2 – SOIL GRAIN SIZE ANALYSIS METHOD

Infiltration rates were also evaluated for the 24 Infiltration Tests by using the Ecology 2014 SMMWW, Soil Grain Size Analysis Method, which calculates the saturated hydraulic conductivity (field infiltration rate) based on a soil's particle-size distribution curve using the following formula:

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$

where K_{sat} is the saturated hydraulic conductivity in centimeters per second (converted to iph), D_{10}, D_{60} and D_{90} are the grain sizes in millimeters for which 10, 60 and 90 percent of the sample is finer and f_{fines} is the fraction of the soil (by weight) that passes the US Standard No. 200 sieve.

For this evaluation, we completed grain size analyses of grab samples obtained at the infiltration test depths for the 24 infiltration tests; the results of our grain size analyses are shown in Figures B-1 through B-24. The following is a summary of our infiltration analysis using Method 2 (Soil Grain Size Analysis Method – Ecology 2014 SMMWW).

Infiltration Test No. (Station)	Test Depth (feet)	Geologic Unit	Soil Type (USCS)	K_{sat} (saturated hydraulic conductivity) (iph)
IT-1 (101+00)	3	Fill	GP-GM	16.9
IT-2 (103+00)	4	Fill	SM	7.7
B-2/IT-3 (106+00)	1.5	Recessional Outwash	SP	49.7
IT-4 (111+00)	3	Recessional Outwash	SM	25.6
IT-5 (116+00)	3	Recessional Outwash	SP-SM	30.5
IT-6 (121+00)	3	Fill	GP-GM	10.2
IT-7 (126+00)	3	Recessional Outwash	SM	18.0
IT-8 (131+00)	3	Recessional Outwash	SP	56.9
B-3/IT-9 (136+00)	1.5	Fill	SM	9.0
IT-10 (141+00)	4	Alluvium	SM	3.6
IT-11 (146+00)	2	Fill	GP-GM	61.1
IT-12 (151+00)	1.5	Fill	GP	358.1
B-4/IT-13 (155+90)	2.5	Alluvium	SM	4.1
B-5/IT-14 (158+40)	2	Fill	SM	8.3
B-6/IT-15 (161+90)	2.5	Fill	SP-SM	27.1
B-7/IT-16 (163+45)	1.5	Fill	GP-GM	54.0
IT-17 (172+90)	2	Alluvium	SP-SM	48.7
IT-18a (179+90)	1.5	Alluvium	SM	*Not Tested
IT-18b (180+40)	1.5	Alluvium	SP-SM	30.5
IT-19a(p) (184+90)	1.5	Alluvium	SP-SM	*Not Tested
IT-19b (185+30)	1.5	Alluvium	SP-SM	34.0
IT-20 (189+90)	1.5	Alluvium	ML	2.9
B-12/IT-21 (197+85)	1.5	Fill	SP-SM	22.7
IT-22 (203+15)	1.5	Glacial Till	SM	3.0
B-14/IT-23 (205+80)	1.5	Fill	GP	293.0
B-15/IT-24 (210+05)	1.5	Fill	GP-GM	14.6

* not sampled for grain size analysis – shallow groundwater at test depth

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 GENERAL

Based on our field reconnaissance, explorations, testing and analyses, we conclude that proposed improvements for L2ST-Seg C development related to the geotechnical conditions along the L2ST-Seg C alignment are feasible as planned. The following is a list of surface and subsurface conditions along the L2ST-Seg C that should be further evaluated as the design progresses (stations noted are approximate):

- **Stations 100+50 to 103+50** – Power poles and low-hanging overhead utility lines encroach on the proposed trail corridor along this station interval.
- **Stations 135+00 to 142+00** – Several demolished and regraded home sites are scattered across the area. Historical aerial photograph review indicates that the proposed L2ST-Seg C alignment may intersect several old home sites in this area, specifically at about Stations 136+00, 136+70, 138+00 and 140+00. Concrete foundation elements, abandoned utilities and low-quality, uncontrolled basement fills may be encountered in this area.
- **Stations 147+00 to 163+55** – Existing street lights encroach on the proposed trail corridor along this station interval.
- **Stations 154+75 to 162+25** – About 4- to 6-inches of concrete slab was encountered in explorations at a depth of about 1½-feet deep. Concrete debris was also encountered between about 2-and 4-feet deep in explorations under at least a portion of the L2ST-Seg C alignment along this station interval.

Further evaluation should be made regarding the extent of the weathered concrete slab and impacts of the weathered concrete on the feasibility of pervious pavement in the area.

- **Station 171+80** – An abandoned open (no lid) stormwater manhole was encountered about 30 feet east of the trail centerline in this area. The opening was about 3 feet in diameter and 8-feet deep. The owner of this manhole and other related underground utilities is not known despite several efforts to determine the owner of this open (hazardous) manhole. Further evaluation should be made regarding the presence of other abandoned utilities.
- **Stations 172+75 to 174+25** – A existing modular block wall about 30-feet high is present within about 20 feet of the L2ST-Seg C centerline. This wall should be evaluated for structural integrity.
- **Station 185+70** – The ditch-line west of the trail drains into the L2ST-Seg C alignment, providing surface water and shallow groundwater into the L2ST-Seg C alignment area; methods for remediation should be evaluated.

Some overexcavation of the Topsoil and Fill will likely be required in order to support retaining walls such as Structural Earth Walls and Gravity Block Walls, or other structures on a reasonably firm and uniform soil type. The actual amount of overexcavation should be a field decision depending on the surficial soils encountered. We suggest maintaining site grades as high as practical.

Because most of the near surface soils are "granular" (sand and gravel), it is likely that most of the settlement from new Fill will occur rapidly (within a few weeks) once the Fill is placed. Postponing paving as long as possible is recommended to allow some of this settlement to occur.

Stormwater dispersion, infiltration and use of pervious pavement are encouraged and, based on the results of our field explorations and infiltration testing, should be feasible for this project. Infiltration Trenches and dispersion can be a benefit for wetland recharge.

9.2 CRITICAL AREAS (GEOLOGICALLY HAZARDOUS AREAS)

9.2.1 General

Based on our review of BMC 19.40.280 and SMC 15.700 and respective Critical Areas mapping by each jurisdiction, the L2ST-Seg C does not contain GHAs or associated buffers, where appropriate, within or adjacent to the trail ROW.

9.2.2 Steep Slope and Landslide Hazard Areas

As previously described, numerous fill embankments and less frequent cut slopes that are sloped at 2H:1V (50 percent grade) are technically a "Steep Slope Hazard" or "Landslide Hazard" in SeaTac or Burien. However, both jurisdictions provide an exemption for this condition if the slope is 1) less than 10-feet high (BMC 19.40.280 and SMC 15.700.015) or 2) created by previous legal grading (BMC 19.40.280 4.A.iii and SMC 15.700.270 E.2.).

In our opinion, slopes that are steeper than 40 percent grade that were created by previous legal grading should be exempt from Critical Areas regulation. Often, slope instability is triggered by adverse erosion. Reducing the risk of erosion also serves to reduce the risk of slope instability. Earthwork for the entire L2ST-Seg C project, including areas within or adjacent to exempted slopes that exceed 40 percent grade, should implement the following BMPs to reduce erosion.

- The dryer season (typically late June through early October) is preferred for construction to reduce erosion potential. However, construction may occur during the wetter season (typically late October through early June), but additional materials and labor for increased erosion control installation and monitoring may be required.
- In areas where no access is present and temporary access is necessary, brush should be cut to the

extent that is practical without complete removal or ground disturbance, with construction equipment crossing over the brush. In areas of soft ground conditions, heavy equipment mats should be used to reduce ground disturbance.

- Rock spalls may be needed for surfacing of equipment temporary access areas.
- Construction activities should include appropriate temporary erosion and sediment control BMPs specific to that location under the observation of a qualified representative from ICE.
- Tree cutting and removal, temporary access preparation and the installation of erosion control measures, should be observed by representatives from King County and ICE. A Certified Erosion and Sediment Control Lead (CESCL) should evaluate the effectiveness of design measures, construction activities and erosion control, and provide additional recommendations, if needed.
- Upon construction completion, permanent erosion control measures should be established in accordance with permit requirements, including, but not limited to slope restoration and measures such as permanent slope inclinations and use of straw mulch/haybales.

9.2.3 Seismic Hazard Areas

As previously described, there are no regionally-mapped Seismic Hazard areas within SeaTac or Burien along or adjacent to the L2ST-Seg C alignment. However, based on our subsurface explorations (soils and groundwater conditions), we encountered "liquefaction-prone" soils which are a Seismic Hazard by definition (BMC 19.40.280 2.B. and SMC 15.700.015). Liquefaction-prone soils are described in further detail in section **9.3** of this report.

9.3 SEISMIC CONSIDERATIONS

9.3.1 Seismic Design Criteria

We understand that structures along the L2ST-Seg C alignment, including SEWs, GBWs, reinforced concrete retaining walls, SPWs and the boardwalks will be designed for seismic loading in accordance with the AASHTO LRFD Bridge Design Specifications, 8th Edition (2017). This design specification requires structures to be designed for earthquake ground motions with a 7-percent probability of exceedance in 75 years (approximately 1,000-year return interval).

Based on our review of available geologic information and the subsurface soil conditions encountered in the test borings completed for this project, we interpret the native soil conditions at the site to correspond to Seismic Site Class D, as defined by Table 3.10.3.1-1 in AASHTO 2017. The Seismic Site Class was developed based on the recommended procedure using SPT N-values. Seismic Site Class D pertains to a soil profile with an average Standard Penetration Test (SPT) value of more than 15 and less than 50. Seismic design parameters obtained from the AASHTO 2017 design specification include the following:

Seismic Parameters	
Site Class	D
Peak Ground Acceleration (PGA)$^{(1)}$	0.446g
Site-adjusted PGA (As)$^{(2)}$	0.470g
Short Period Spectral Response Acceleration, $S_S^{(3)}$	0.994g
1-Second Period Spectral Response Acceleration, $S_1^{(3)}$	0.332g
Site Coefficient, $F_a^{(4)}$	1.103
Site Coefficient, $F_v^{(4)}$	1.735
Short Period Design-Level Spectral Response Acceleration, $S_{DS}^{(3)}$	1.096g
1-Second Period Design-Level Spectral Response Acceleration, $S_{D1}^{(3)}$	0.577g

(1) Based on the Seven Percent Probability of Exceedance in 75 Years Horizontal Peak Ground Acceleration Coefficient Map from AASHTO 2017 (Figure 3.10.2.1-1).

(2) PGA adjusted for the Site Coefficient F_{PGA} = 1.054 (AASHTO 2017 Table 3.10.3.2-1).

(3) Based on the Seven Percent Probability of Exceedance in 75 Years Horizontal Response Spectral Acceleration Coefficient Maps from AASHTO 2017 (Figures 3.10.2.1-2 and 3.10.2.1-3), adjusted following AASHTO 2017 Section 3.10.4.

(4) From AASHTO 2017 Tables 3.10.3.2-2 and 3.10.3.2-3.

9.3.2 Soil Liquefaction

9.3.2.1 General

Soil liquefaction is a phenomenon where soils experience a rapid loss of shear strength as pore water pressures increase in response to strong ground shaking. Loss of soil strength and migration of water can result in soils that flow, deform or erupt. Soil liquefaction may cause ground settlement, lateral deformation, excessive ground oscillation, and/or sand boils or soil eruptions, potentially resulting in structural damage.

9.3.2.2 Liquefaction Susceptibility

Liquefaction generally occurs in loose to medium dense sand deposits, though recent studies have shown that gravels, silty sands and non-plastic sandy silts may also be susceptible to liquefaction. Additionally, soil saturation (groundwater) is a necessary component of liquefaction susceptibility.

The potential for liquefaction to initiate is typically quantified by comparing the Cyclic Stress Ratio (CSR – the driving forces which are based on ground shaking amplitude, frequency content and duration) to the Cyclic Resistance Ratio (CRR – the resisting forces which are related to soil strength and grain size distribution). Procedures for determining the CSR and CRR are outlined in Idriss and Boulanger (2004, *Semi-Empirical Procedures for Evaluating Liquefaction Potential During Earthquakes*). To determine the CSR, we used the site-adjusted seven percent in 75-years probability of exceedance PGA of 0.470g, as prescribed by AASHTO 2017, and an earthquake magnitude M_w of 7.2, obtained from the USGS Unified Hazard deaggregation tool. To determine the CRR, we used correlations between Standard Penetration Test (SPT) blow-count (N) value and the CRR, adjusted for the fines content of the soil (based on sample observations and laboratory testing).

Based on our evaluation of subsurface soil and groundwater conditions, and our analysis using Idriss and Boulanger (2004), the approximate location of Liquefaction Prone areas are shown on Figures 9 through 11 and 15 through 22 and are listed by station as follows:

Stations (approximate)	Length (feet)
133+55 to 142+75	920
158+35 to 171+75	1,340
174+30 to 186+10	1,180

Based on our analysis, in the proposed boardwalk area (about Stations 165+86 to 167+77, Stations 169+24 to 171+24, and Stations 174+31 to 178+44), liquefaction may initiate within the upper 5- to 10-feet within loose to medium dense/medium stiff to stiff sand and silt, during ground motions prescribed by AASHTO 2017.

9.3.2.3 Seismically-Induced Settlements

Based on empirical methods described by Tokimatsu and Seed (1987, *Evaluation of settlements in sand due to earthquake shaking*) and Ishihara and Yoshimine (1992, *Evaluation of settlements in sand deposits following liquefaction during earthquakes*) which correlate the SPT N value to expected ground settlements, we estimate that liquefaction-induced ground settlement in the area of the boardwalks may be on the order of 2 to 3 inches during ground motions prescribed by AASTHO 2017. We expect that liquefaction may not be initiated uniformly across the trail alignment and may result in 2 to 3 inches of seismically-induced differential settlement (unmitigated).

Deep foundations extending past the liquefiable zone will help mitigate the risk of seismically-induced total and differential settlements. Seismically-induced settlement may exert downdrag forces on deep foundation elements extending past the liquefiable zone. Recommendations for downdrag forces are provided in section **9.6** of this report.

9.3.2.4 Lateral Spreading

Lateral spreading is the phenomenon wherein the ground surface displaces towards a gentle slope or free face during liquefaction, resulting in large, permanent lateral deformations and often substantial structural damage. In the vicinity of the boardwalks, the ground surface slopes gently (about 2-percent grade) down to the south.

Based on Youd and Bartlett (1994, *Empirical Prediction of Liquefaction-Induced Lateral Spread*) and Youd *et al.* (2002, *Revised Multilinear Regression Equations for Prediction of Lateral Spread Displacement*), the risk of horizontal displacements due to lateral spreading in the area of the boardwalks (approximately Stations 165+86 to 167+77, Stations 169+24 to 171+24, and Stations 174+31 to 178+44) is generally low. The risk of horizontal displacements elsewhere in the vicinity (Stations 158+50 to 165+86 and Stations 178+44 to 186+10) is also generally low.

Between approximately Stations 133+55 and 142+75, the ground surface slopes moderately (about 6-percent grade) down to the east. In this area, based on Youd and Bartlett (1994) and Youd *et al.* (2002), the trail alignment is at moderate risk of excessive horizontal displacement due to lateral spreading. However, it is infeasible to support the trail surface on deep foundation elements extending below the liquefiable zone along the entirety of the alignment.

9.4 RETAINING WALLS

9.4.1 Structural Earth Walls

9.4.1.1 General

SEWs are typically used in fill applications where sufficient space is available for fill placement within the Reinforced Fill Zone. The SEW system consists of a Reinforced Fill Zone, often reinforced with layers of geotextile fabric depending on the wall height, and a concrete block unit (CBU) facing which is usually connected (pinned) with the Reinforced Fill Zone geogrid reinforcement layers. The CBUs are typically supported on a Leveling Course Pad of crushed rock to provide uniform support and to allow for easier installation (leveling).

In cut sections, an SEW application is treated as a slope "facing" (such as a rockery) and is not regarded as a structural solution for cut slope retention. The CBU supplier should be contacted regarding the height of cut that can be faced with CBUs.

9.4.1.2 SEW Design Parameters

SEW internal design (geogrid type, length and spacing, Reinforced Fill Zone soil material and compaction specification, drainage) should be completed by the SEW material supplier. To assist in this design, we recommend the following soil parameters:

Parameter	Reinforced Fill Zone	Retained Soil	Foundation Soil
Unit Weight (pcf)	125	120	125
Phi (degrees)	32	32	34
Cohesion (psf)	0	0	200

pcf = pounds per cubic foot; psf = pounds per square foot

We strongly recommend that the Reinforced Fill Zone consist of free-draining soil such as Gravel Borrow as described in the 2018 WSDOT Standard Specifications for Road, Bridge and Municipal Construction (Standard Specifications), Section 9-03.14(1). The on-site soils contain a relatively high percentage of fines and may not be suitable for use in the Reinforced Fill Zone.

We recommend using an allowable soil bearing capacity of 2,500 psf.

The design heights of SEWs should include the aboveground wall heights as well as the full embedment depths of the walls down to the Leveling Course Pad. The minimum embedment depth is as follows:

Slope in Front of Wall	Minimum Embedment Depth (feet)
Horizontal	H/20 or 1 foot, whichever is greater
3H:1V	H/10 or 1 foot, whichever is greater
2H:1V	H/7 or 1 foot, whichever is greater

H:V = horizontal to vertical H = Wall Height

The minimum embedment depth assumes use of a 6-inch thick, free-draining crushed rock leveling pad. The wall embedment could be further reduced to 0.5 feet if the leveling pad thickness is increased to 1 foot, or if non-frost susceptible soils are observed at wall subgrade at the time of construction.

Depending on the SEW type and height, geogrid reinforcement of the backfill may not be required and should be discussed with the SEW material supplier. For any height of SEW, we recommend the use of free-draining soil for backfill to provide adequate drainage.

SEWs should be designed with minimum factors of safety of 1.5 for sliding and pullout of reinforcing elements and 2.0 for overturning. If proprietary wall systems are used, the wall manufacturer is responsible for evaluating these items. However, we recommend that proprietary wall system designs be reviewed by a qualified geotechnical engineer to evaluate if valid assumptions were used relative to material properties and other factors such as site-specific topography and soil/groundwater conditions.

If SEWs are subject to the influence of traffic loading or nearby retaining walls within a horizontal distance equal to the height of the SEW, the walls should be designed for the additional horizontal pressure using appropriate design methods. A common practice is to assume a surcharge loading equivalent to 2 feet of additional fill to simulate traffic loads.

9.4.1.3 SEW Subgrade Preparation

General

SEW subgrade preparation typically consists of first excavating the Leveling Course Pad for the SEW, followed by additional excavation for the Reinforced Fill Zone. We recommend that the subgrade be evaluated by probing by a representative of our firm. Acceptable Leveling Course Pad and Reinforced Fill Zone subgrade is generally defined by probe penetration of less than 12 inches.

Leveling Course Pad Subgrade Special Conditions

Special Condition 1 – Where subgrade soils cannot be adequately compacted, or where soft, loose or disturbed soil is present, these areas should be excavated to expose competent material or to a maximum depth of 18 inches below subgrade, and replaced with Structural Fill (Structural Fill is described in section **9.9.2** of this report). Alternatively, a geotextile soil reinforcement fabric such as Tencate Mirafi® RS380i or RS580i, or equivalent, may be placed over the soft, loose or disturbed subgrade, rather than overexcavation.

Special Condition 2 – Where subgrade preparation exposes Topsoil or other organic soils (such as peat or organic silt), these organic soils should be removed and replaced with Structural Fill. We expect the thickness of Topsoil or other organic soils will be less than 18 inches. It should be a field decision by the geotechnical engineer to evaluate the appropriate method of subgrade improvement when the Topsoil or other organic soils exceed 18 inches in thickness.

Special Condition 3 – Where groundwater or wet subgrade is encountered at the base of the excavation, quarry spalls as defined by Section 9-13.6 of the 2018 WSDOT Standard Specifications may be used to provide a stable base on which to place Structural Fill. We recommend placing a nonwoven geotextile soil separation fabric such as TenCate Mirafi® 180N, or equivalent, on the subgrade to reduce the loss of this rock material into the underlying soils.

9.4.1.4 Reinforced Fill Zone Subgrade Preparation

Special Conditions 2 and 3 as described above apply to the preparation of subgrade for the Reinforced Fill Zone.

9.4.2 Gravity Block Walls

9.4.2.1 Design Considerations

GBWs are well suited for slope support where a cut is required and there is insufficient space for an open, cut slope. The GBW system relies on mass and weight for providing lateral stability of a cut into a slope.

As previously described, a GBW (Wall #17) up 7.5-feet high (including 1 foot of embedment) is planned as a method to re-support cut area from about Stations 202+23 to 206+73. The location of Wall #17 is shown on Figures 25 and 26. A Redi-Rock® GBW system is being considered for this application.

A GBW is comprised of several components as described below.

Redi-Rock® Blocks – Three block sizes are available including 28-, 41- and 60-inch blocks that are installed with the long dimension perpendicular to the slope. Full blocks are typically 46.5-inches wide and 18-inches high and vary in weight from about 1,750 to 3,420 pounds. Blocks can be installed with a batter of 0.010-inches, 0.375-inches, 1.675-inches and 9.375-inches per block.

Drainage Fill/Drainage Composite – Drainage Fill consists of free-draining aggregate, such as 2018 WSDOT Standard Specifications Section 9-03.9(2) (Permeable Ballast), that is placed behind the Redi-Rock® blocks.

If a Drainage Composite, such as Strata 350, Synteen 55, or equal is used (applicable to UltrablockTM only), we recommend combining the Drainage Fill and Drainage Composite. The Drainage Composite is not a substitute for the Drainage Fill, however, Drainage Fill alone is satisfactory.

Retained Soil – The native soil where cuts are made into existing slopes.

Leveling Pad/Wall Foundation – Compacted and free-draining crushed rock such as the 2018 WSDOT Standard Specifications Section 9-03.9(3) (Top Course) pad upon which the Redi-Rock® blocks are placed.

Embedment – The minimum depth (1 foot) to which the base Redi-Rock® block is embedded into the ground.

Foundation Subgrade – Medium dense or better, existing fill or native soil, or Structural Fill that extends to the competent native soils.

Drain Pipe – 4-inch diameter, smooth-walled perforated plastic pipe placed at the base of the wall that discharges by gravity to a suitable location.

Geotextile Filter Fabric – A non-woven geotextile fabric, such as TenCate Mirafi® 160N or equal, which is placed between the Retained Soil and the Drainage Fill.

Backslope – The ground surface slope behind (uphill from) the wall.

Foreslope – The ground surface slope in front of the wall.

Batter – The horizontal offset between subsequent Redi-Rock® blocks, decreasing the inclination of the wall face.

Details about the wall geometry and interpreted geology at the wall location are given in the table below.

Wall # (1) (Station)	Maximum Wall Height (feet)(2)	Back Slope Inclination(2)	Nearest Test Boring	Soil Type(3)	Surcharge
17 (202+23 to 206+73)	7.5	Level	B-13 / B-14	Fill / Recessional Outwash	250 psf (traffic)

(1) From Parametrix, July 2018, 60% Review Submittal; (2) Includes 1 foot of embedment (6.5 foot exposed face) and 200 psf traffic surcharge; (3) ICE Interpretation

9.4.2.2 Wall Stability Analysis (Internal and External Stability)

Internal and external stability analyses for Wall #17 was completed by ICE using Redi-Rock® design software (Version 2018.29). The Redi-Rock® wall static and seismic analysis output files are included in Appendix D of this report.

The program has the capability of analyzing internal stability related to sliding, bearing and overturning failure of the wall system utilizing Coulomb theory for determination of active earth pressures and Rankine theory for determination of passive earth pressures.

The program also has the capability of analyzing external stability analysis related to a slope failure through (compound stability) or below (global stability) the face of the wall considering the site topography, soil conditions and block geometry. The program utilizes Bishop's Method for internal and external stability analysis.

The following is a summary of the soil strength parameters that were used in our analysis of the Redi-Rock® GBW:

Soil Type	Moist Unit Weight (pcf)	Φ (degrees)	C (psf)
Retained Soil [(1)]	125	34	0
Foundation Subgrade	125	34	0

(1) Soil used to backfill the Redi-Rock® wall should be well-drained consistent with the 2018 WSDOT Standard Specifications Section 9-03.9(2) (Permeable Ballast).

Φ = angle of internal friction

C = cohesion

For the Wall #17 section geometry, we used the following design input parameters:

Setback	1.625 inches
Wall Embedment Depth	1.0 feet
Leveling Pad Thickness	0.5 feet
Foreslope Angle[(1)]	Level (0 degrees)

(1) Foreslope angle refers to the ground surface inclination on the downhill side of the wall.

The Redi-Rock® software has the capability of performing seismic analyses for internal and external stability using the Mononobe-Okabe method for determination of seismic earth pressures, and seismic slope stability using pseudostatic procedures. The following seismic parameters were used for the analyses:

Peak Ground Acceleration[(1)]	0.46g
Horizontal Seismic Coefficient	0.23g

(1) For seismic evaluation, from 2015 International Building Code

The general minimum FOS (static) for gravity wall structures is 1.5 for sliding and overturning, and 2.0 for bearing. The FOS for seismic conditions is typically acceptable at 75 percent of the static FOS.

For seismic stability evaluation, we used a design-level Peak Ground Acceleration (PGA) of two-thirds of the Risk-Targeted Maximum Considered Earthquake (MCE_R) PGA from the from the ASCE 7-16 seismic design maps (Site Coordinates: 47.44116°N, 122.32668°W). The International Building Code (2018) refers to ASCE 7-16 regarding design Peak Ground Acceleration. The design-level site-adjusted PGA used was 0.46g. The horizontal acceleration coefficient k_h was selected as approximately one-half of the design-level site-adjusted PGA (AASHTO LRFD Bridge Design Specifications 2012 Section 11.6.5.2.2); a k_h of 0.23 was used to determine dynamic seismic lateral earth pressures.

The following table summarizes the results of the stability analysis.

Internal and External Factors of Safety		
	Static	Seismic
Sliding	1.92	1.02
Bearing	5.72	2.77
Overturning	2.45	1.12
Global	2.03	1.41

9.4.2.3 Typical Detail – Redi-Rock® Wall

Figure 29 shows a generalized Redi-Rock® wall section. We recommend that the GBW be constructed in accordance with the plans, specifications and installation requirements provided by Redi-Rock®. As wall height decreases, blocks can be removed from the bottom of the diagram.

9.4.2.4 Temporary Cut Slopes

The GBW will require a temporary cut slope for installation. We expect that the temporary cut slope at Wall #17 will be in Fill or Recessional Outwash. For planning purposes, the following table provides guidance on temporary cut slope at Wall #17:

Wall # (1)	Expected Soil Type(2)	Recommended Temporary Cut Slope Inclination
17	Fill / Recessional Outwash	1.5H:1V

(1) From Parametrix, July 2018, 60% Review Submittal

(2) ICE Interpretation

Additional evaluation of the actual soil material will be required at the time of earthwork to establish safe temporary cut slopes. Flatter slopes may be necessary to maintain safe working conditions if instability is observed. Some sloughing and raveling of the temporary cut slopes should be expected. Temporary covering, such as heavy plastic sheeting, should be used to protect these slopes during periods of wet weather. Surface water runoff from above cut slopes should be prevented from flowing over the slope face by using berms, drainage ditches, swales or other appropriate methods.

9.4.3 Soldier Pile Wall (Wall #15)

9.4.3.1 General

A Soldier Pile Wall (SPW – Wall #15) varying from 3- to 10-feet high is planned to support the SR 509 Ramp Embankment between about Stations 186+40 and 188+80. We understand that an SPW was selected as an alternative to a GBW due to space limitations and risks related to stand-up time of a temporary cut slope at this location.

We understand that Wall #15 is considered semi-permanent. The retaining wall may eventually be removed when redevelopment of SR 509 occurs, but the schedule for this work is not confidently known. For this reason, geotechnical recommendations and design parameters assume Wall #15 is a permanent structure.

9.4.3.2 Soldier Pile Wall Design Parameters

Design details (including the Earth Pressure Diagram and parameters to be used with LPILEPLUS) for Wall #15 are included in Appendix E of this report.

9.4.3.3 Soldier Pile Wall Lagging

We recommend timber lagging be sized using the procedures outlined in the Federal Highway Administration's Geotechnical Circular No. 4. The soils at the planned SPW site are considered "competent soils."

The space behind the lagging should be filled with a permeable soil. Lagging should be installed as soon as practical where clean sand or gravel is present and caving conditions are likely. The earth pressure diagram presented in Appendix E can be used to design lagging for the SPWs. However, we recommend applying a moment reduction factor of 0.5 to the bending moments when using the earth pressure diagram.

9.4.3.4 Soldier Pile Wall Drainage

The earth pressure diagram shown in Appendix E assumes drained conditions immediately behind the wall. Therefore, an appropriate drainage system (underdrain) should be included in the design to prevent hydrostatic pressures from developing behind the SPW. Water will tend to drain from gaps between the lagging. We recommend a vertical spacing of 3/8 inches to allow seepage to flow to the face of the lagging.

9.4.3.5 Soldier Pile Wall Constructability

Dense Fill and native soils, which could include cobbles or boulders, may be encountered while drilling the soldier pile shafts. The contractor should be prepared to utilize drilling methods which can penetrate through these materials where encountered.

Some of the Fill soils and underlying native materials are in a loose condition and/or may contain perched groundwater or deeper groundwater zones. This loose and/or wet material could tend to cave into the shaft excavation. The contractor should be prepared to complete the shaft excavation in such a way that caving is prevented (e.g., casing).

Temporary slopes may be necessary during installation of lagging. Temporary cut slopes of 1.5H:1V or flatter may be used provided that no significant groundwater seepage is encountered. Flatter cut slopes are recommended when significant seepage is encountered or if caving is persistent. In any case, it is the sole responsibility of the contractor to follow Washington State Industrial Safety and Health Act (WISHA) regulations for excavations and shoring.

9.5 BOARDWALKS

9.5.1 General

We have considered foundation support for the three Boardwalks and recommend the use of pipe piles. Other foundation options considered include conventional spread footings and helical piles, both of which are not suitable considering the subsurface conditions consist of the surface layer of 15 to 21 feet or soft or loose soil (Alluvium) or dense soil (Glacial Till) that may resist penetration by a helical pile. We also considered the Diamond Pier system, but the surficial soils are too loose or soft.

The soil underlying the soft or loose soil is expected to be firm and unyielding (Recessional Outwash, Glacial Till or Advance Outwash).

Often the tops of the piles are left with several feet of stick-up to serve as the column to support the structure (Boardwalk) and are cut-off as required.

9.5.2 Axial Capacity

For pipe (galvanized) piles, axial capacities include the following:
4-inch diameter; 20 kips allowable
6-inch diameter; 30 kips allowable
8-inch diameter; 60 kips allowable
10-inch diameter; 75 kips allowable
12-inch diameter; 100 kips allowable

These values include a factor of safety of 2.0. Due to the size of installation equipment for larger piles, we strongly recommend limiting pile diameter to 8 inches for the boardwalks.

9.5.3 Refusal Criteria

Piles are evaluated during construction by refusal criteria. Smaller diameter piles (4- to 8-inch-diameter) are driven with a rapid hammer; refusal criteria is typically given in terms of hammering duration per inch. For 4-inch and 6-inch diameter piles refusal criteria is based on a 2,000-pound hammer; 10 seconds for less than 1-inch advance; or 3,000-pound hammer, 6 seconds for less than 1-inch advance. The 8-inch diameter piles use a 3,000-pound hammer with refusal criteria of 10 seconds for less than 1-inch advance.

Larger-diameter piles are driven with slower hammers; refusal criteria is given in terms of blows per inch. The 10- and 12-inch diameter piles have a refusal criteria of 10 blows for less than 1-inch advance.

9.5.4 Downdrag Force

During a design-level earthquake, soil liquefaction may initiate in the upper 5- to 10-feet of soil in the area of the boardwalks. Liquefaction-induced settlements on the order of 2 to 3 inches may occur, potentially imparting downdrag forces on pipe piles extending past the liquefiable zone. Based on AASHTO 2017 (section 3.11.8), downdrag forces are expected when settlement exceeds 0.4 inches. The following liquefaction-induced downdrag forces (unfactored) may be expected during the design earthquake prescribed by AASHTO 2017:

Pile Diameter	Downdrag Force (kips)
4-inch	5
6-inch	8
8-inch	11
10-inch	14
12-inch	17

Due to the transient nature of this loading, and the factor of safety applied to the provided allowable axial capacities for the pipe piles, we do not recommend applying liquefaction-induced downdrag force in the structural design calculations.

9.5.5 Lateral Loading

We understand that the computer program LPILEPLUS may be used to evaluate the lateral resistance of the drilled shafts. We developed soil parameters to be used for lateral loading based on the information presented on the boring logs and our experience with similar soil conditions. The following table presents our recommended soil parameters. Where liquefiable soils are present, we recommend using the listed P-multiplier to reduce the lateral capacity of the soil for the seismic (liquefied) loading condition.

Boardwalk Stations 169+24 to 171+24 - Boring BH-2									
Soil Unit	Depth (feet)	USCS Soil Type	Friction Angle (degrees)	Cohesion C (psf)	P-Y Curve Model	Unit Weight (pcf)	Soil Modulus (k)(pci)(1)	Strain Factor ε_{50}	Liquefaction p-multiplier
Alluvium	0 to 4	OL	-	250	Soft Clay	43	-	0.02	-
Recessional Outwash(2)	4 to 7.5	SM	30	-	Sand	48	40	-	0.2
Recessional Outwash(2)	7.5 to 10	SP	32	-	Sand	53	60	-	-
Recessional Outwash(2)	10 to Depth	SP/SM	36	-	Sand	58	125	-	-

(1) pci = pounds per cubic inch

(2) Recessional Outwash is coarse-grained

Boardwalk Stations 174+31 to 178+44 - Boring BH-3/BH-4									
Soil Unit	**Depth (feet)**	**USCS Soil Type**	**Friction Angle (degrees)**	**Cohesion C (psf)**	**P-Y Curve Model**	**Unit Weight (pcf)**	**Soil Modulus (k) (pci)**	**Strain Factor ε_{50}**	**Liquefaction p-multiplier**
Alluvium	0 to 7	CL		500	Soft Clay	43		0.01	0.1
Recessional Outwash(1)	7 to 18	SM	34	-	Sand	58	90	-	-
Glacial Till	18 to Depth	SM	40	-	Sand	73	125	-	-

(1) Recessional Outwash is coarse-grained

9.6 PAVEMENT DRAINAGE CONSIDERATIONS

9.6.1 General

Porous HMA (or bioretention) may be used to manage stormwater on the trail surface from about Stations 100+64 to 114+30, 134+94 to 151+53, 154+81 to 165+86, 195+40 to 212+36.

9.6.2 Porous HMA Pavement

The proposed L2ST-Seg C alignment crosses an area with a long history of surface modifications (cuts and fills), primarily for transportation (roads). Parts of the L2ST-Seg C alignment cross the low undeveloped area containing Des Moines Creek and are locally wet, especially during the late winter and early spring months because of shallow, perched groundwater conditions.

In our opinion, the use of porous HMA pavement is a satisfactory solution to disposal of stormwater from the surface of the trail that is a best match for pre-trail conditions and allow for similar groundwater recharge to the wetlands and Des Moines Creek. We recommend that the standard section for porous HMA pavement include a (pervious) pavement layer underlain by a subgrade reservoir with an underdrain. The infiltration rate of the porous HMA pavement should be greater than the peak rainfall rate.

Porous HMA pavement should be designed in accordance with the 2016 KCSWDM – Appendix C, Section C.2.7 (Permeable Pavement). The results of the infiltration testing, summarized in section **8.0** of this report, suggest that porous HMA pavement can be used as planned.

We recommend that the design should provide for a subgrade reservoir of drain rock to provide storage for stormwater under the pavement. The drain rock should be specified as described in 2018 WSDOT Standard Specifications 9-03.12(4) referred to as Gravel Backfill for Drains or WSDOT Standard Specification 9-103-9(2) referred to as Permeable Ballast. Gravel Backfill for Drains and Permeable Ballast typically have a porosity (used to calculate available water storage) of about 30 percent.

Permeable Ballast is angular rock and can be easier to install and work on as the Gravel Backfill for Drains tends to shift easy under foot traffic or wheel loading during construction.

The design should also allow for no reservoir if the Recessional Outwash (clean sand and gravel) is encountered at subgrade level. This determination should be a field decision at the time of construction.

9.6.3 Bioretention

At this time, bioretention is currently being considered as an alternative to porous HMA pavement. Bioretention is similar to the porous HMA pavement option, but standard HMA (non-porous) can be used which has the advantages of being a smoother surface, less maintenance and a longer life. With bioretention, the HMA surface is still underlain by a reservoir or permeable ballast, with stormwater runoff entering the reservoir along the edges of the pavement.

9.7 STORMWATER DISPOSAL

9.7.1 Stormwater Infiltration

The preliminary field infiltration rate characteristics of the soils along the L2ST-Seg C alignment are summarized in section **8.0** of this report. To determine preliminary long-term (design) infiltration rates, we recommend that a correction factor of 0.5 be applied to the field infiltration rates summarized in the tables in sections **8.2** and **8.3** of this report.

We expect that additional field infiltration testing may be required when the location of stormwater facilities and BMPs are known. The preliminary infiltration rates provided in section **8.0** of this report are informational for project planning. It is possible that these infiltration rates could be increased (or decreased) depending on the results of field testing by large-scale field infiltration testing.

9.7.2 Stormwater Dispersion

In our opinion, stormwater discharge can be accomplished using “engineered dispersion” or “natural dispersion” in general accordance with methods developed by WSDOT (April 2014, *Highway Runoff Manual, M31-16.04, Stormwater Best Management Practices*, Chapter 5-4.2.2, FC-01 and FC-02).

9.8 CONSTRUCTION CONSIDERATIONS

9.8.1 General

We recommend that the L2ST-Seg C subgrade be evaluated by proofrolling and/or probing by a representative of our firm. Where subgrade soils cannot be adequately compacted, or where soft or disturbed soil is present, these areas should be excavated to expose competent material or to a maximum depth of 2-feet below the final trail grade, and replaced with Structural Fill. Prior to placing new fill, a geotextile fabric, such as Tencate Mirafi® RS380i or RS580i should be placed to provide separation from the underlying soft soils and to provide reinforcement (support) for the overlying fill.

As previously described in section **9.1** of this report, about 4 to 6 inches of concrete slab was encountered in explorations at a depth of about 1½-feet deep in the general area between Stations 154+75 and 162+25.

Earthwork should be scheduled during the normally drier months, unless project delays and extra costs associated with maintaining an adequate trail subgrade for use by heavy construction equipment are acceptable.

9.8.2 Structural Fill

9.8.2.1 General

All new Fill for the L2ST-Seg C should be placed as Structural Fill. Structural Fill material should be free of debris, organic contaminants and rock fragments larger than 6 inches. The suitability of material for use as Structural Fill will depend on the gradation and moisture content of the soil. As the amount of fines (portion of 3/4-inch-minus soil particles passing the US Standard No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve.

9.8.2.2 Unclassified Fill

We recommend that unclassified imported fill consist primarily of granular material with less than 30 percent passing the US Standard No. 200 sieve. Unclassified material will be sensitive to changes in moisture content and compaction will be difficult or impossible to achieve during wet weather. We recommend that unclassified material be used as Structural Fill only during dry weather conditions when proper moisture conditioning can be achieved.

9.8.2.3 Gravel Borrow

We recommend that Structural Fill consist of Gravel Borrow for the Reinforced Fill Zone for SEWs. Gravel Borrow should conform with Section 9-03.14(1) of the 2018 WSDOT Standard Specifications.

9.8.2.4 Reuse of On-Site Materials

The site soils (Fill, Alluvium, Recessional Outwash, Glacial Till and Advance Outwash) may be reused for Structural Fill during periods of extended dry weather, though may be of limited use within the Reinforced Fill Zone (for SEWs) depending on the fines content. Recessional Outwash is typically considered an "all-weather" Fill because of the low silt content and could be used, if suitable, for the SEWs Reinforced Fill Zone.

Soil containing more than 20 percent organic material (roots, forest duff and topsoil) should only be used in landscaping areas or for other purposes where specific compaction criteria is not required.

9.8.2.5 Base and Drainage Layer

At this time, porous HMA pavement is proposed for this project. We recommend that the base and drainage layer material for the pavement section be designed as described in section **9.6.2** of this report.

9.8.2.6 Placement and Compaction

All Structural Fill placed in trail and shoulder areas should be compacted to at least 95 percent of the MDD (ASTM Test Method D 1557). Waste fill in landscaping areas need only be compacted to the extent required for trafficability of construction equipment and erosion control.

As a guideline, we recommend that Structural Fill for the L2ST-Seg C be placed in horizontal lifts which are 10 inches or less in loose thickness. The actual lift thickness will be a function of the fill quality and size of the compaction equipment used. Each lift should be compacted to the required specification before placing subsequent layers.

For placement during wet weather or on wet subgrades, Structural Fill should contain no more than five percent fines. Structural Fill placement over wet ground should commence with an initial lift of about 12 to 18 inches of clean sand and gravel with less than five percent fines, or quarry spalls (Section 9-13.3, 2018 WSDOT Standard Specification). During dry weather, the fines content may be up to about 30 percent, provided that the fill can be moisture-conditioned and compacted to the degree specified below.

We recommend that a representative from our firm observe the preparation for, placement, and compaction of Structural Fill. An adequate number of in-place density tests should be completed in the fill to evaluate if the desired degree of compaction is being achieved.

Nonstructural Fill placed in landscape and waste-fill areas where the existing surface slope is no steeper than 4H:1V needs to be compacted only to the degree required for trafficability of construction equipment and effective surface drainage/erosion control. All Nonstructural Fills should be sloped no steeper than 4H:1V. Nonstructural Fill is very susceptible to erosion, therefore, we recommend that all Nonstructural Fill areas be immediately seeded, planted or otherwise protected from erosion.

9.8.2.7 Fill Settlement

Most of the Structural Fill placed for the L2ST-Seg C will be underlain by loose to dense or soft to stiff soils. Settlement of these underlying soils is expected to range from ½- to 1-inch and should occur rapidly as Structural Fill is placed, assuming that new fill thickness does not exceed 5 feet.

Some settlement will also occur within the Structural Fill itself, especially where the Structural Fill thickness is greater than 5 feet. We estimate that the maximum amount of settlement within the Structural Fill will be no more than one percent of the Structural Fill thickness. Thus, for a 5-foot Structural Fill section, settlements on the order of ½- to 1-inch might occur.

We recommend placing the final L2ST-Seg C pavement at least three weeks after placement of Structural Fill.

9.8.3 Construction Dewatering

It is possible that excavation dewatering may be required in local areas along the L2ST-Seg C alignment. The level and amount of groundwater will depend on when earthwork occurs. In the late Winter and early Spring, groundwater levels would be highest.

Because of the complex layering (discontinuous layers of variably permeable soils), pockets of groundwater seepage will likely be encountered; we expect that pumping from a sump within the trench may be used for small to moderate amounts of groundwater seepage. Well points or pumped wells will be necessary if large amounts of groundwater seepage are encountered. We recommend that the contractor be required to submit a proposed dewatering system design and plan layout to the project engineer for review and comment prior to beginning construction.

9.8.4 Cut and Fill Slopes

9.8.4.1 Cut Slopes

Temporary cuts less than 4 feet in height may be made near-vertical in medium dense or better soil. Temporary cuts greater than 4 feet in height may be made at 1H:1V or flatter.

Permanent cut slopes should be inclined no steeper than 2H:1V. We recommend constructing a bench on all cut slopes for every 15 feet of vertical height of slope face.

Some of the upper portions of cut slopes will expose loose soil that may be several feet thick. The loose soil will be subject to localized raveling and sloughing and must therefore be sloped no steeper than 3H:1V or covered with quarry spalls or a suitable Turf Reinforcement Mat (TRM) consisting of straw, coir (coconut) and jute for the purpose of stabilization.

Where cut benches are required (cut slopes more than 10-feet high), the benches should be sloped downward into the hill to allow for collection of surface water runoff. We recommend that the benches be sloped no steeper than five percent.

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. All excavations more than 4 feet in depth should be sloped in accordance with WAC 296-66401 and WAC 296-155-657 or be shored. Flatter slopes may be required where groundwater seepage occurs and dewatering may be required to lower the groundwater table below the base of the excavation. Alternatively, trench boxes may be used where the excavation is more than 4-feet deep.

9.8.4.2 Fill Slopes

Structural Fill slopes may be sloped at 2H:1V or flatter. All surfaces which will receive Structural Fill should be properly stripped of vegetation and organic material prior to placing Structural Fill. Structural Fill placed on existing slopes which are steeper than 4H:1V should be properly keyed into the native slope surface. This can be accomplished by constructing the Structural Fill slope in a series of 4- to 8-foot-wide horizontal benches cut into the slope. The Structural Fill should be placed in horizontal lifts. We recommend that Structural Fill be placed on the cut benches as soon as possible following construction of the benches.

Steeper (1V to 1.5H:1V) Structural Fill slopes are possible provided that these slopes are covered with quarry spalls or a permanent erosion control mat or blanket such as Tensar® Hydramax™, EroNet™, BioNet® or VMax® products, as appropriate.

9.8.5 Shored Excavations

It may be necessary to support the temporary excavations to maintain the integrity of the surrounding undisturbed soils and to reduce disruption of adjacent areas, as well as to protect the personnel working within the excavation. Because of the diversity of available shoring systems and construction techniques, the design of temporary shoring is most appropriately left up to the contractor proposing to complete the installation. We recommend that the shoring be designed by a licensed Professional Engineer in Washington, and that the PE-stamped shoring plans and calculations be submitted to the Project Engineer for review and comment prior to construction.

The majority of the materials (Fill, Alluvium, Recessional Outwash, Glacial Till and Advance Outwash) can be retained using conventional trench shoring systems such as trench boxes or sheet piles, with lateral restraint, provided that the excavation is dewatered. The design of temporary shoring should allow for lateral pressures exerted by the adjacent soil, and surcharge loads due to traffic, construction equipment, and temporary stockpiles adjacent to the excavation, etc. Lateral load resistance can be mobilized through the use of braces, tiebacks, anchor blocks and passive pressures on members that extend below the bottom of the excavation. Temporary shoring utilized to support trench excavations typically uses internal bracing such as aluminum hydraulic shoring or trench shield bracing.

It should be understood that a "standard" trench box does not usually provide adequate support of the trench excavation slope, but instead only provides safety for workers in the trench. Because the trench box typically is placed after excavation, a significant amount of soil deformation will likely take place. Ground movements can be severe, especially in the presence of groundwater. The contractor should be held responsible for all damages related to ground movements. It should be noted that trench boxes can be modified and fitted with drivable, watertight walls which may be driven below the bottom of the trench excavation in a similar manner as a standard sheet pile wall. Trench boxes can also be placed with excavation of the soil from within the box, coupled with pushing down on the box, or allowing the box to sink under gravity as the soil is excavated from beneath. If trench boxes are proposed by the contractor, it would be advisable to require the contractor to attempt a test section using the proposed equipment and methods.

Temporary trench shoring can be designed using active soil pressures. We recommend that temporary shoring be designed using a lateral pressure equal to an equivalent fluid density of 40 pcf, for conditions with a level ground surface adjacent to the excavation. If the ground within 5 feet of the excavation rises at an inclination of 1H:1V or steeper, the shoring should be designed using an equivalent fluid density of 75 pcf. For adjacent slopes flatter than 1H:1V, soil pressures can be interpolated between this range of values. Other conditions should be evaluated on a case-by-case basis. Internally-braced shoring may be designed using a uniform lateral soil pressure equal to 40H (where H is the distance from the ground surface to the base of the excavation) in soft soils (Alluvium) or 35H for all other soil types.

These lateral soil pressures do not include traffic or construction surcharges that should be added separately, if appropriate. It is typical for shoring to be designed for a traffic influence equal to a uniform lateral pressure of 240 psf acting over a depth of 10 feet from the ground surface. More conservative pressure values should be used if the designer deems them appropriate. These soil pressure recommendations are predicated upon the construction being essentially dewatered; therefore, hydrostatic water pressures are not included.

10.0 USE OF THIS REPORT

We have prepared this report for use by Parametrix and King County in the design of a portion of the project. The data and report should be provided to prospective contractors for bidding or estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

If there are significant changes in the grades, configurations or types of facilities to be constructed, the conclusions and recommendations presented in this report may not be fully applicable. When the design has been finalized, we recommend that we be retained to review those portions of the specifications and drawings which relate to geotechnical considerations to see that our recommendations have been interpreted and implemented as intended.

Variations in subsurface conditions are possible between the locations of the explorations. Variations may also occur with time. Some contingency for unanticipated conditions should be included in the project budget and schedule. Sufficient observation, testing and consultation should be provided by our firm during construction to evaluate whether the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with the contract plans and specifications.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

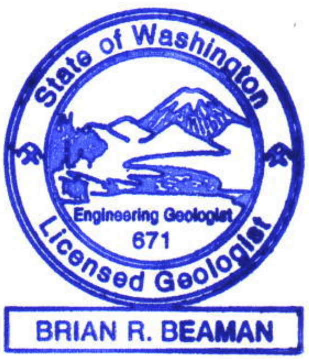
****

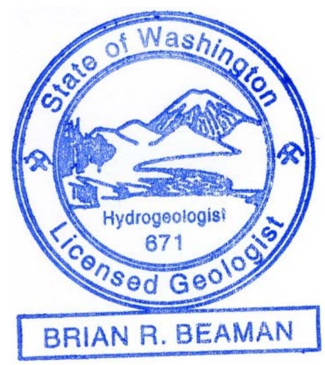
We appreciate the opportunity to be of service to you on this project. If there are any questions concerning this report or if we can provide additional services, please call.

Yours very truly,
Icicle Creek Engineers, Inc.

Kathy S. Killman, LEG
Principal Engineering Geologist

Brian R. Beaman, PE, LEG, LHG
Principal Engineer/Geologist/Hydrogeologist





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FIGURES

Base map obtained from the King County iMap

0 ½ 1

Scale in Miles

King County / Parametrix	VICINITY MAP	ICICLECREEK ENGINEERS	SCALE: As Shown	ICE FILE NO.
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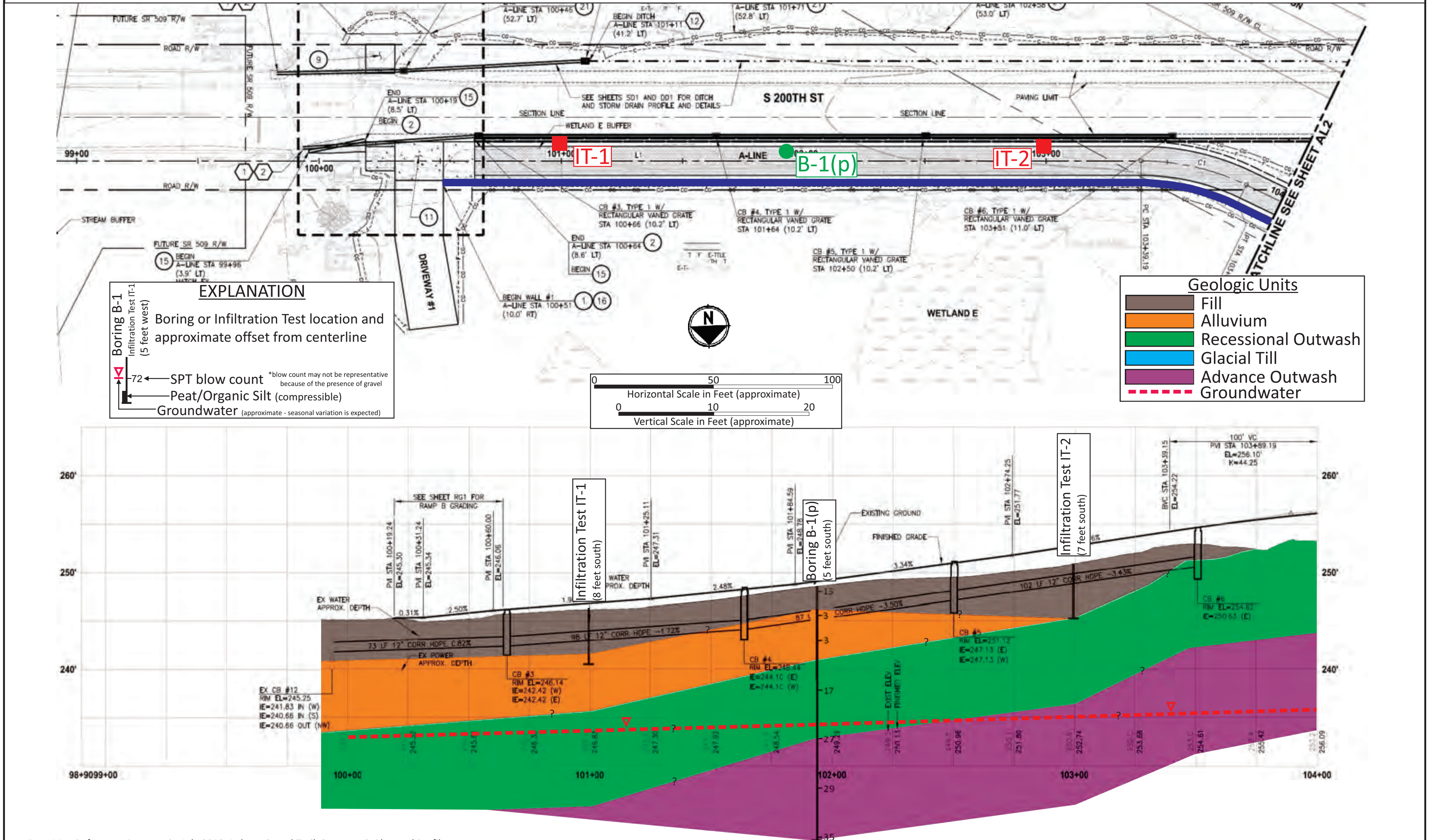
	LAKE TO SOUND TRAIL - SEGMENT C	Carnation, Washington 98014	DRAWN: SJM	Figure
		(425) 333-0093	CHECKED: KSK	1
			DATE: 07/30/19	

EXPLANATION

- B-1 — Test Boring Location
- IT-1 — Infiltration Test Location
- B-2/IT-3 — Test Boring/Infiltration Test Location
- (p) — Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

Notes:
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2) Subsurface conditions shown are along trail centerline and are based on widely-spaced explorations. Actual subsurface conditions may vary significantly especially fill thickness.
3) "?" indicates inferred geologic contact and estimated groundwater level.

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PLAN AND PROFILE

LAKE TO SOUND TRAIL – SEGMENT C

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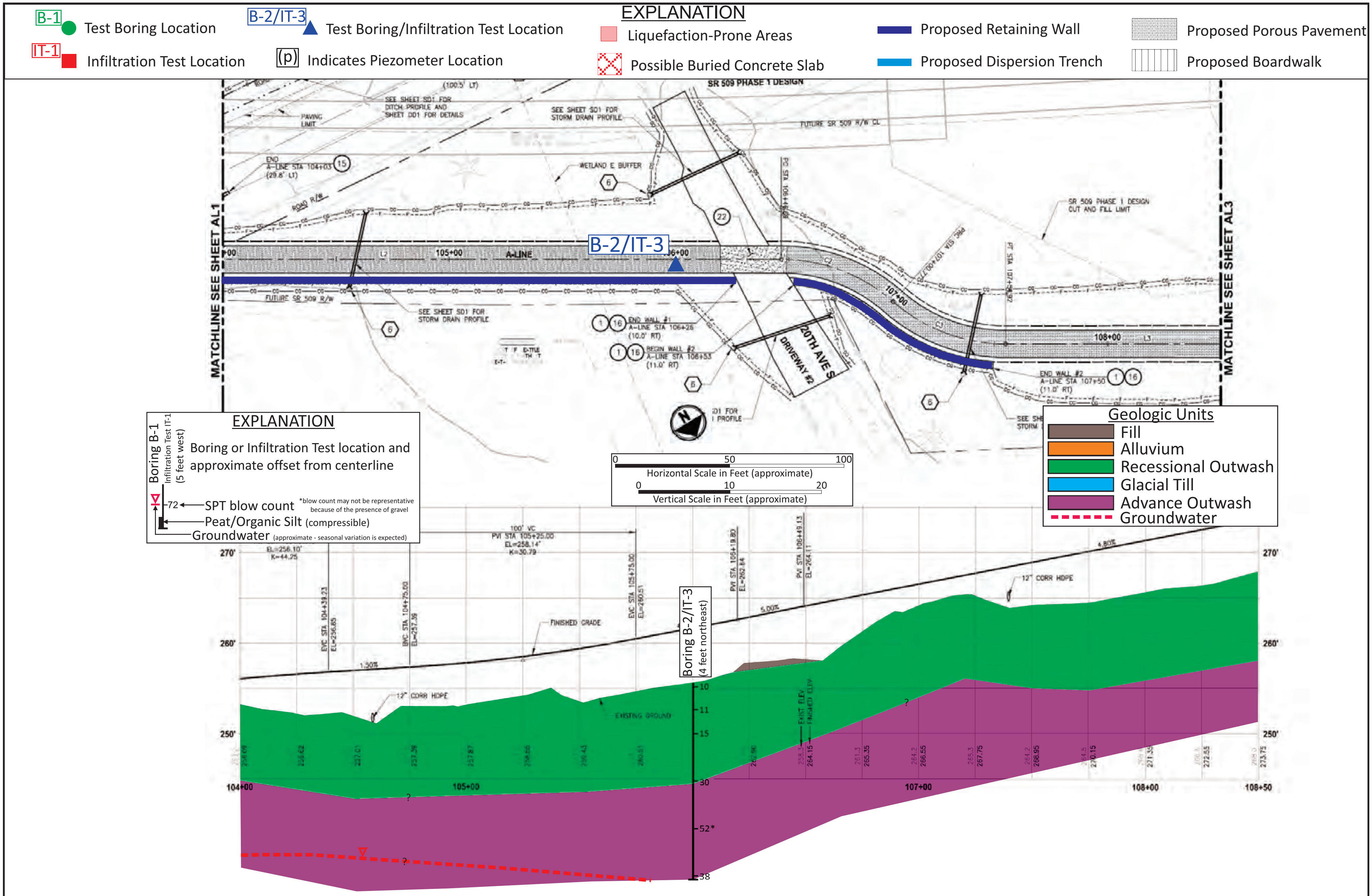

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Figure 3

EXPLANATION

- B-1 ● Test Boring Location
- IT-1 ■ Infiltration Test Location
- B-2/IT-3 ▲ Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk

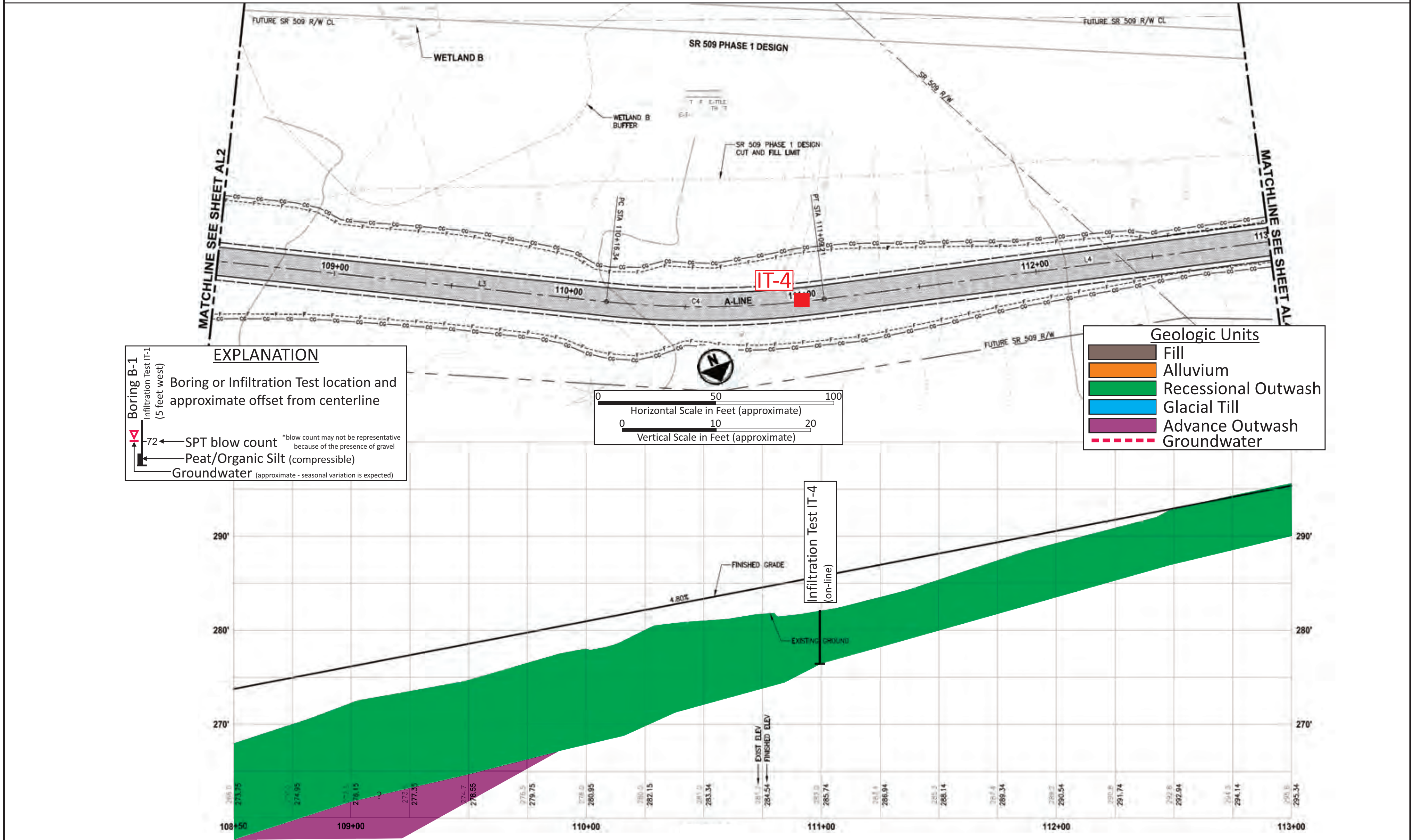

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Figure
4

EXPLANATION

B-1 Test Boring Location
IT-1 Infiltration Test Location
B-2/IT-3 Test Boring/Infiltration Test Location
(p) Indicates Piezometer Location
Liquefaction-Prone Areas
Possible Buried Concrete Slab
Proposed Retaining Wall
Proposed Dispersion Trench
Proposed Porous Pavement
Proposed Boardwalk

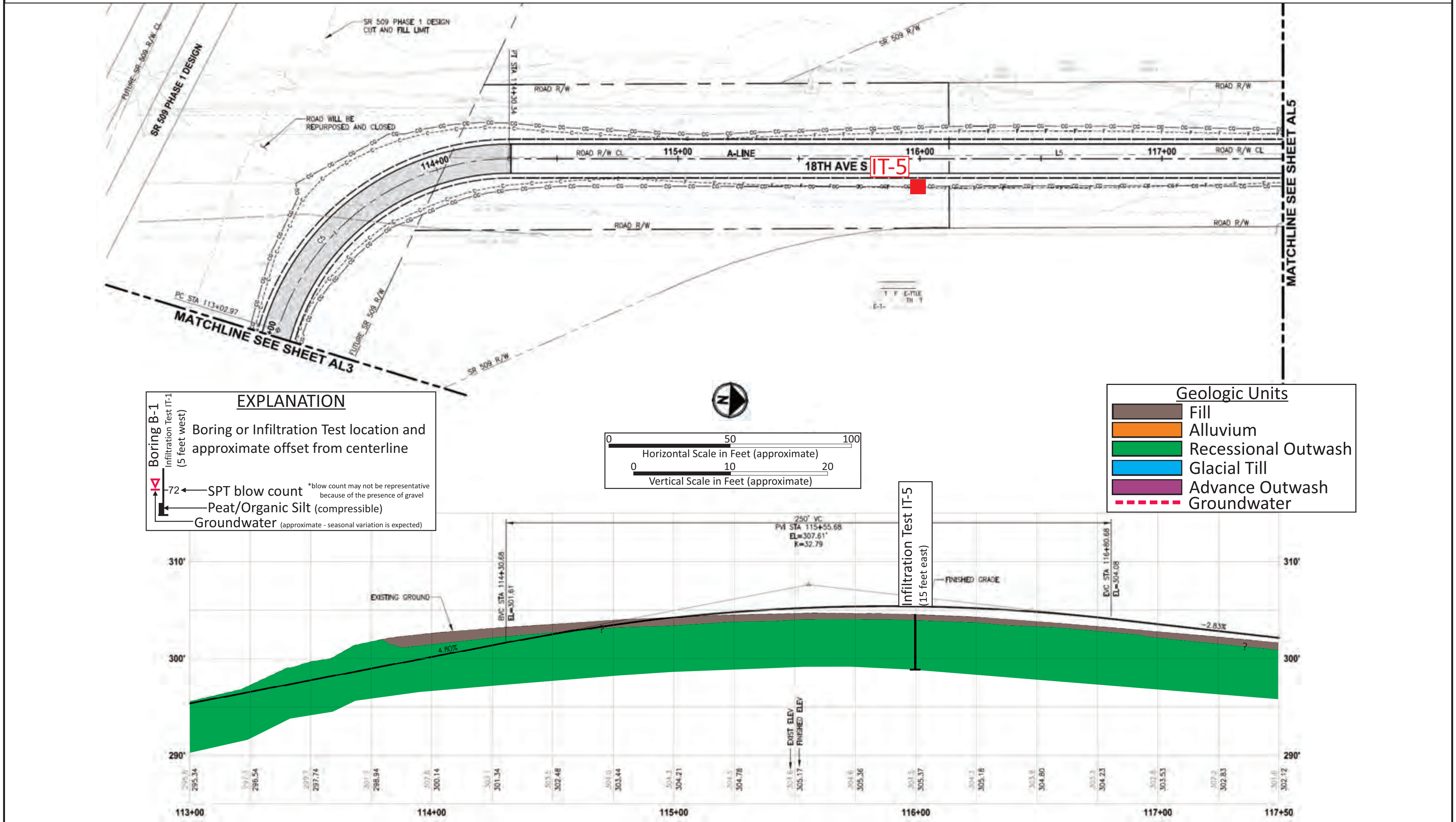

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Figure 5

EXPLANATION

B-1 Test Boring Location
IT-1 Infiltration Test Location
B-2/IT-3 Test Boring/Infiltration Test Location
(p) Indicates Piezometer Location
Liquefaction-Prone Areas
Possible Buried Concrete Slab
Proposed Retaining Wall
Proposed Dispersion Trench
Proposed Porous Pavement
Proposed Boardwalk

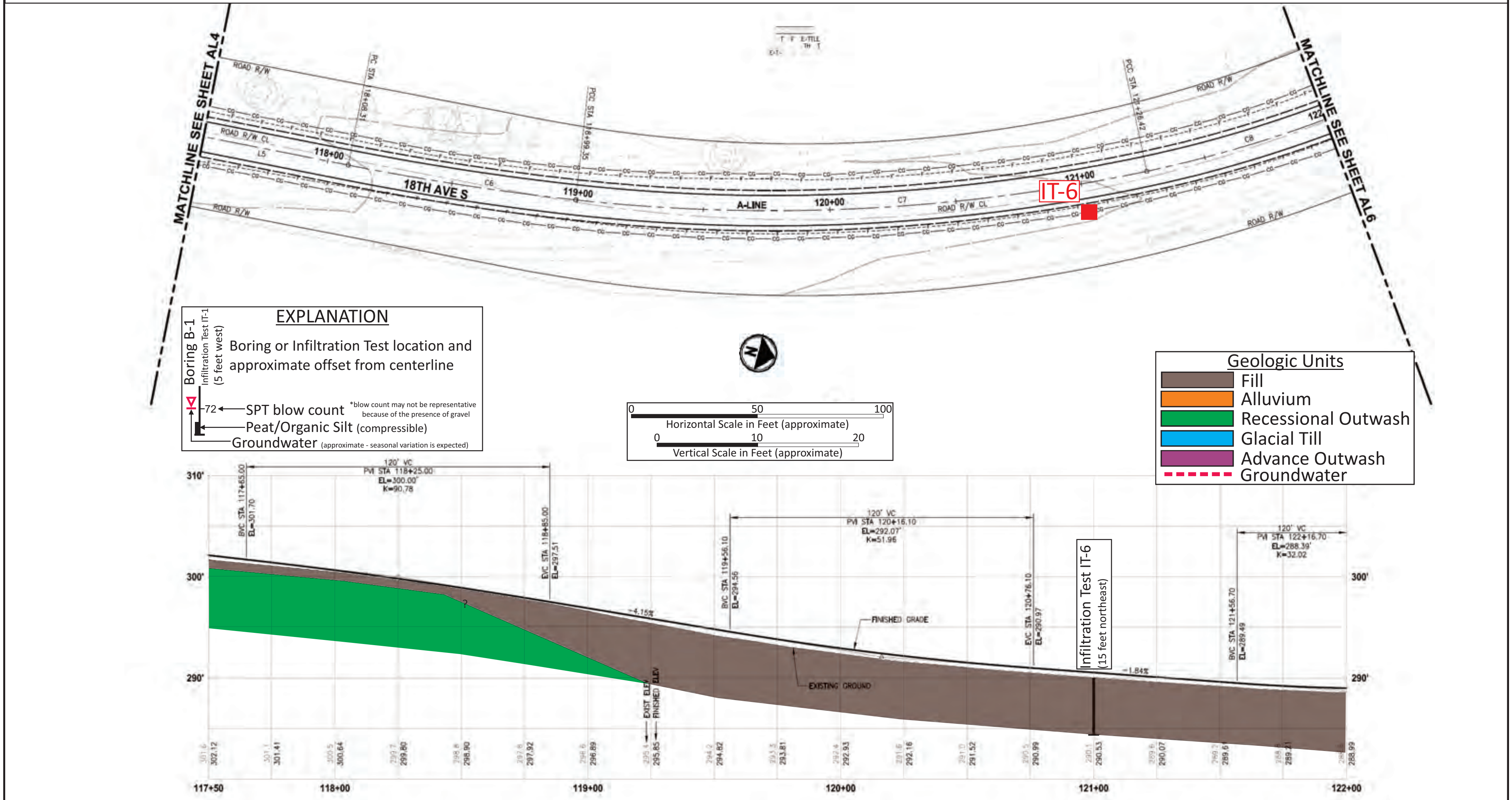

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Figure
6

EXPLANATION

B-1 Test Boring Location

IT-1 Infiltration Test Location

B-2/IT-3 Test Boring/Infiltration Test Location

(p) Indicates Piezometer Location

Liquefaction-Prone Areas

Possible Buried Concrete Slab

Proposed Retaining Wall

Proposed Dispersion Trench

Proposed Porous Pavement

Proposed Boardwalk

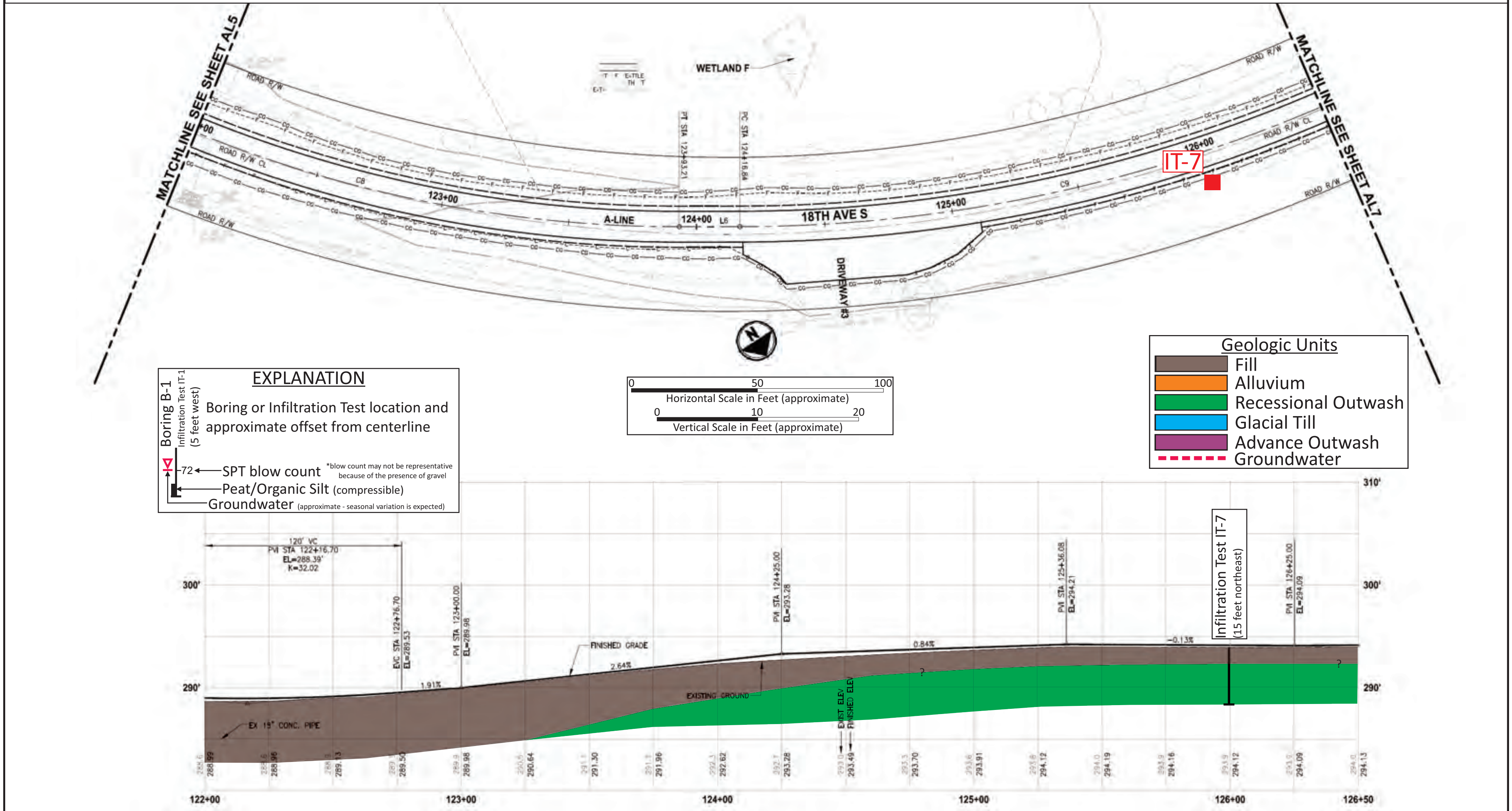

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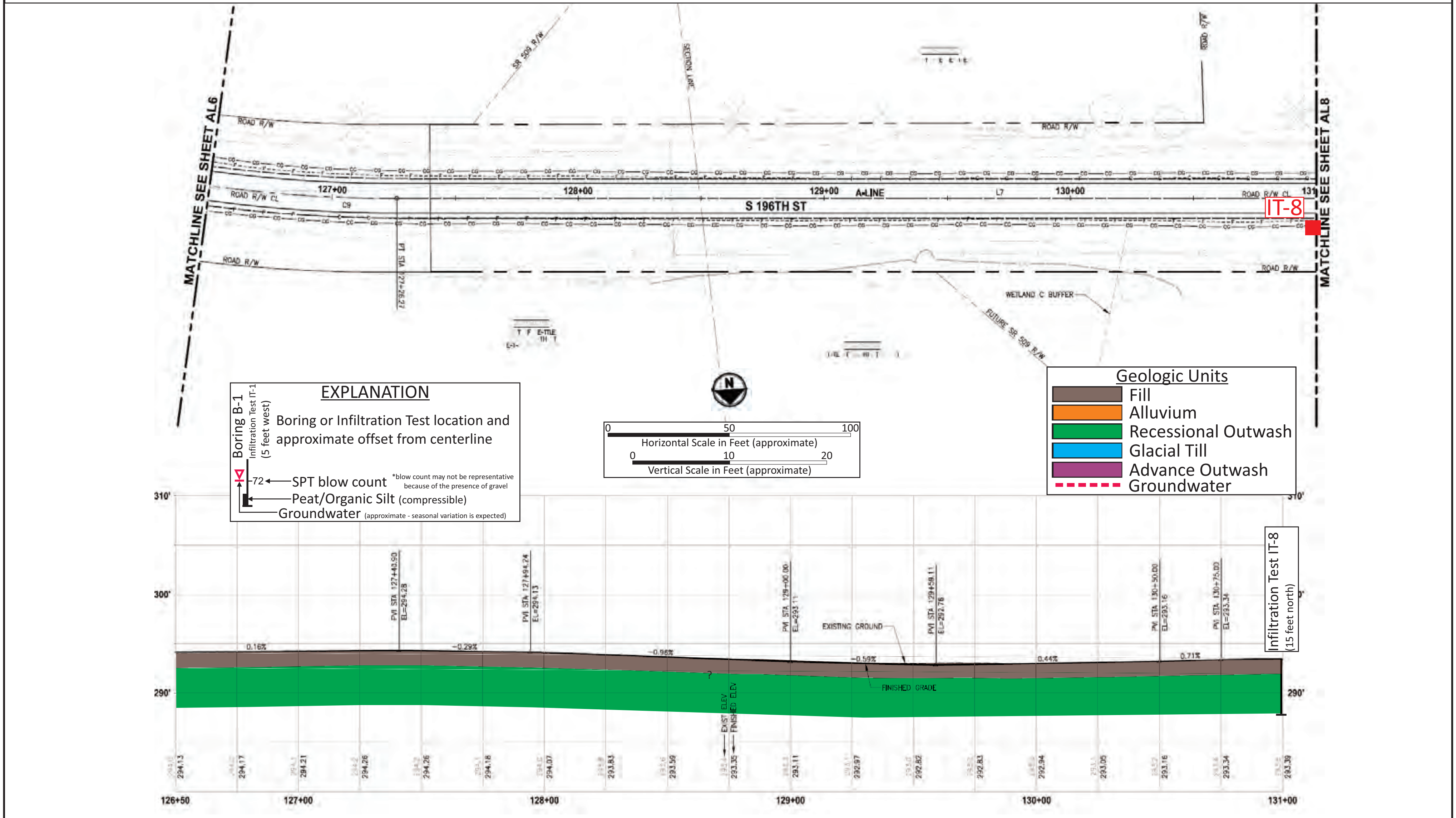
Figure
7

EXPLANATION

- B-1 ● Test Boring Location
- IT-1 ■ Infiltration Test Location
- B-2/IT-3 ▲ Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



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EXPLANATION

B-1 Test Boring Location
B-2/IT-3 Test Boring/Infiltration Test Location
IT-1 Infiltration Test Location
(p) Indicates Piezometer Location
Liquefaction-Prone Areas
Possible Buried Concrete Slab
Proposed Retaining Wall
Proposed Dispersion Trench
Proposed Porous Pavement
Proposed Boardwalk

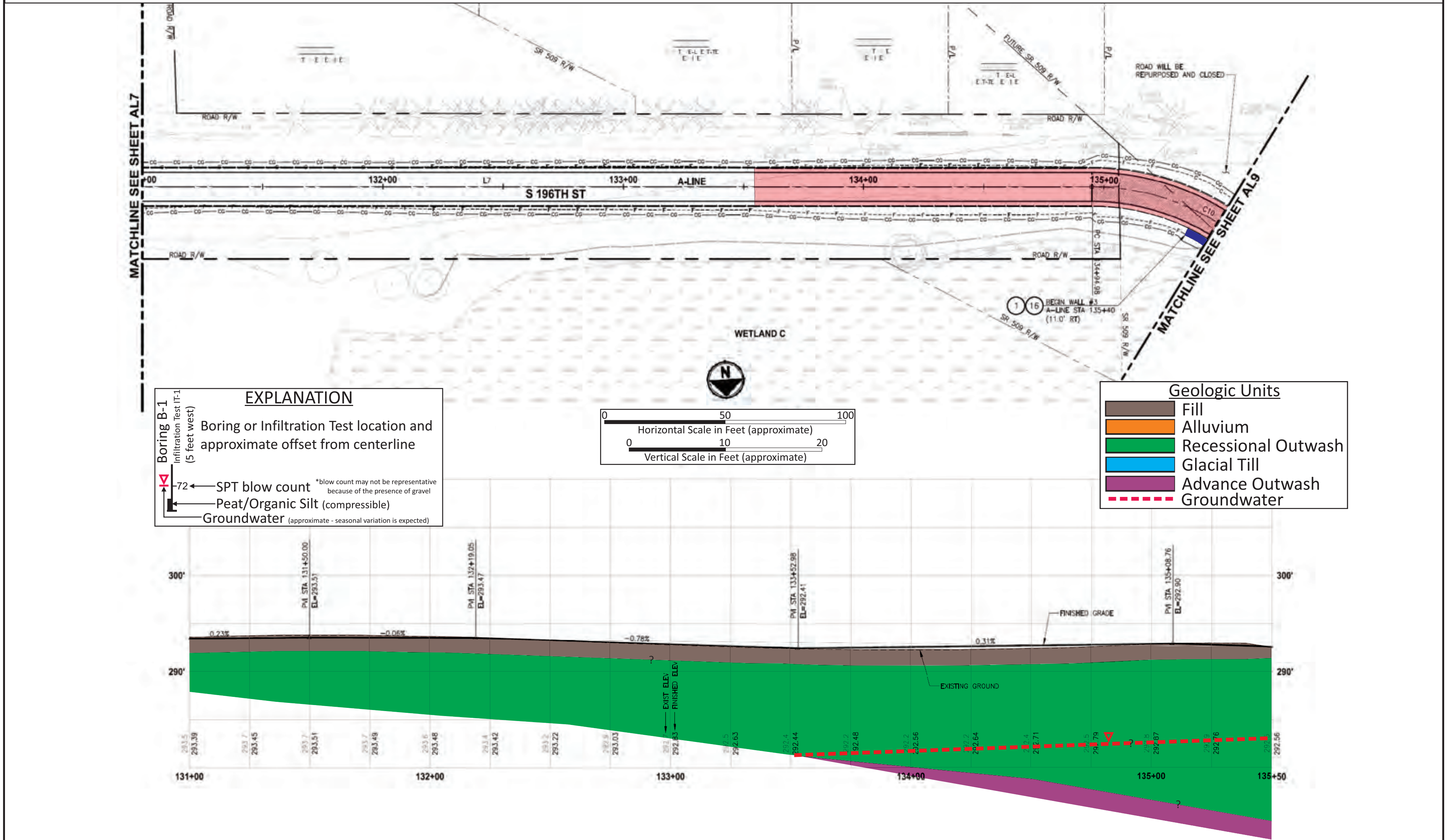

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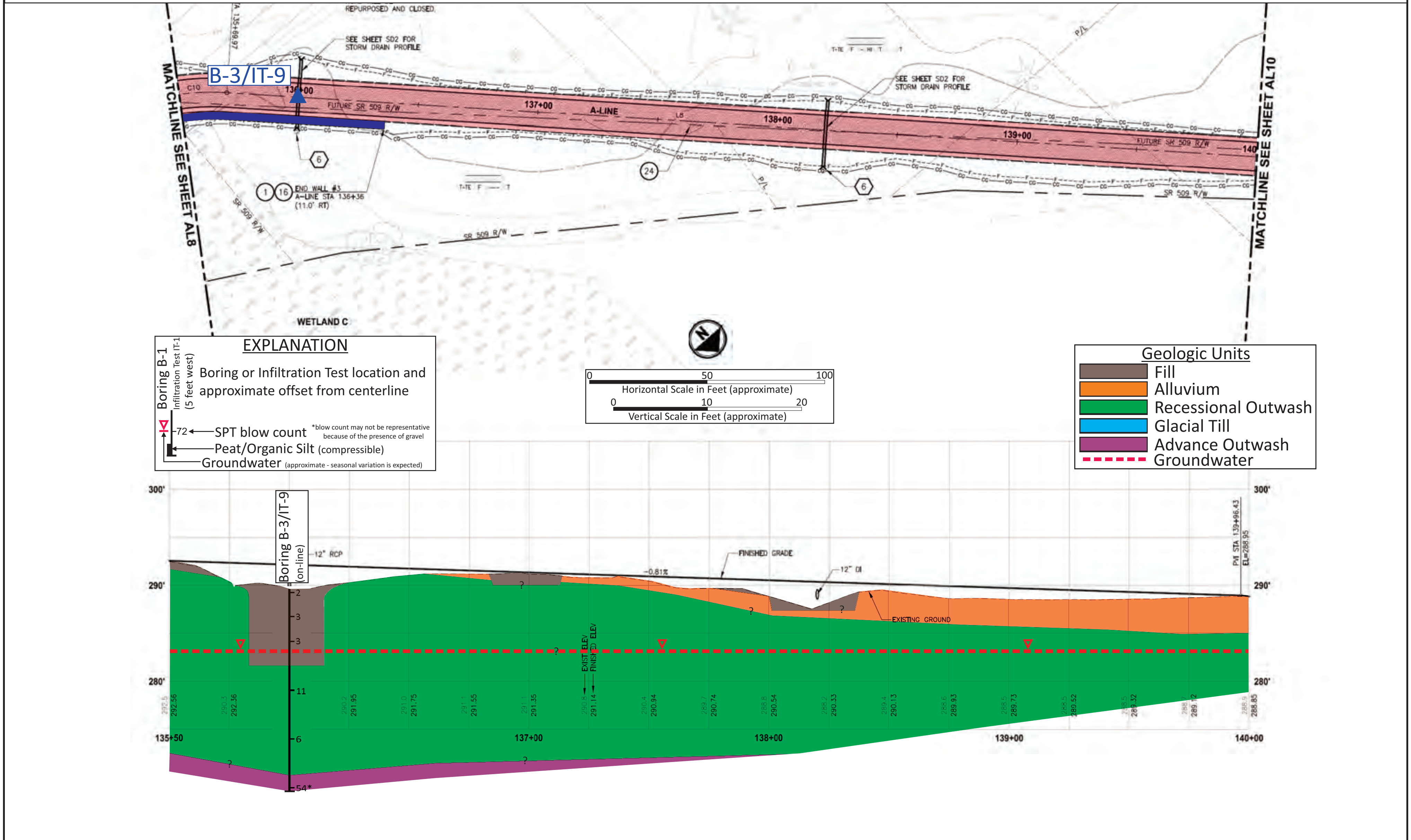
Figure 9

EXPLANATION

- B-1 Test Boring Location
- IT-1 Infiltration Test Location
- B-2/IT-3 Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



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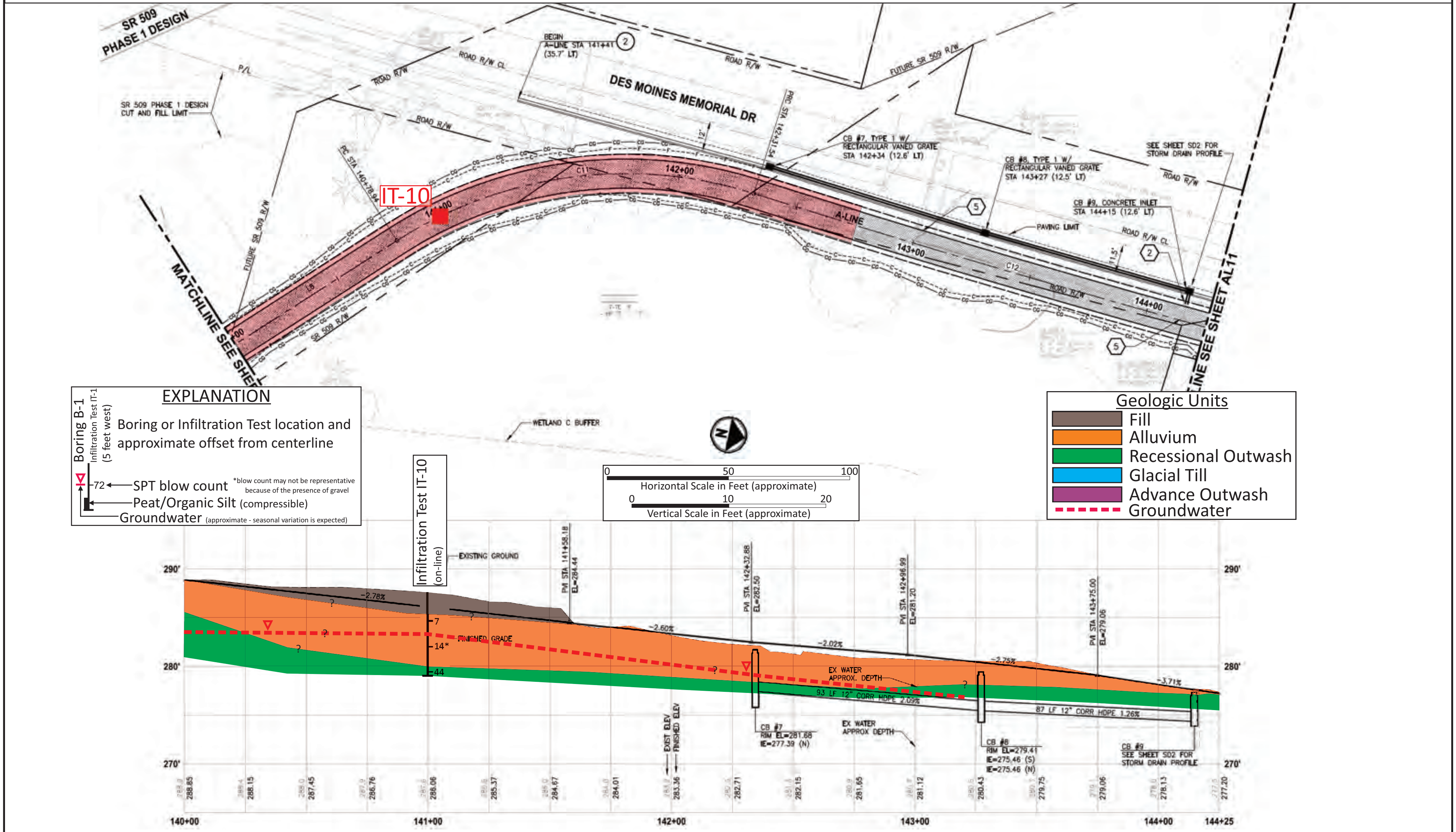
EXPLANATION

- B-1 (green circle) Test Boring Location
- IT-1 (red square) Infiltration Test Location
- B-2/IT-3 (blue triangle) Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



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EXPLANATION

B-1 Test Boring Location
IT-1 Infiltration Test Location
B-2/IT-3 Test Boring/Infiltration Test Location
(p) Indicates Piezometer Location
Liquefaction-Prone Areas
Possible Buried Concrete Slab
Proposed Retaining Wall
Proposed Dispersion Trench
Proposed Porous Pavement
Proposed Boardwalk

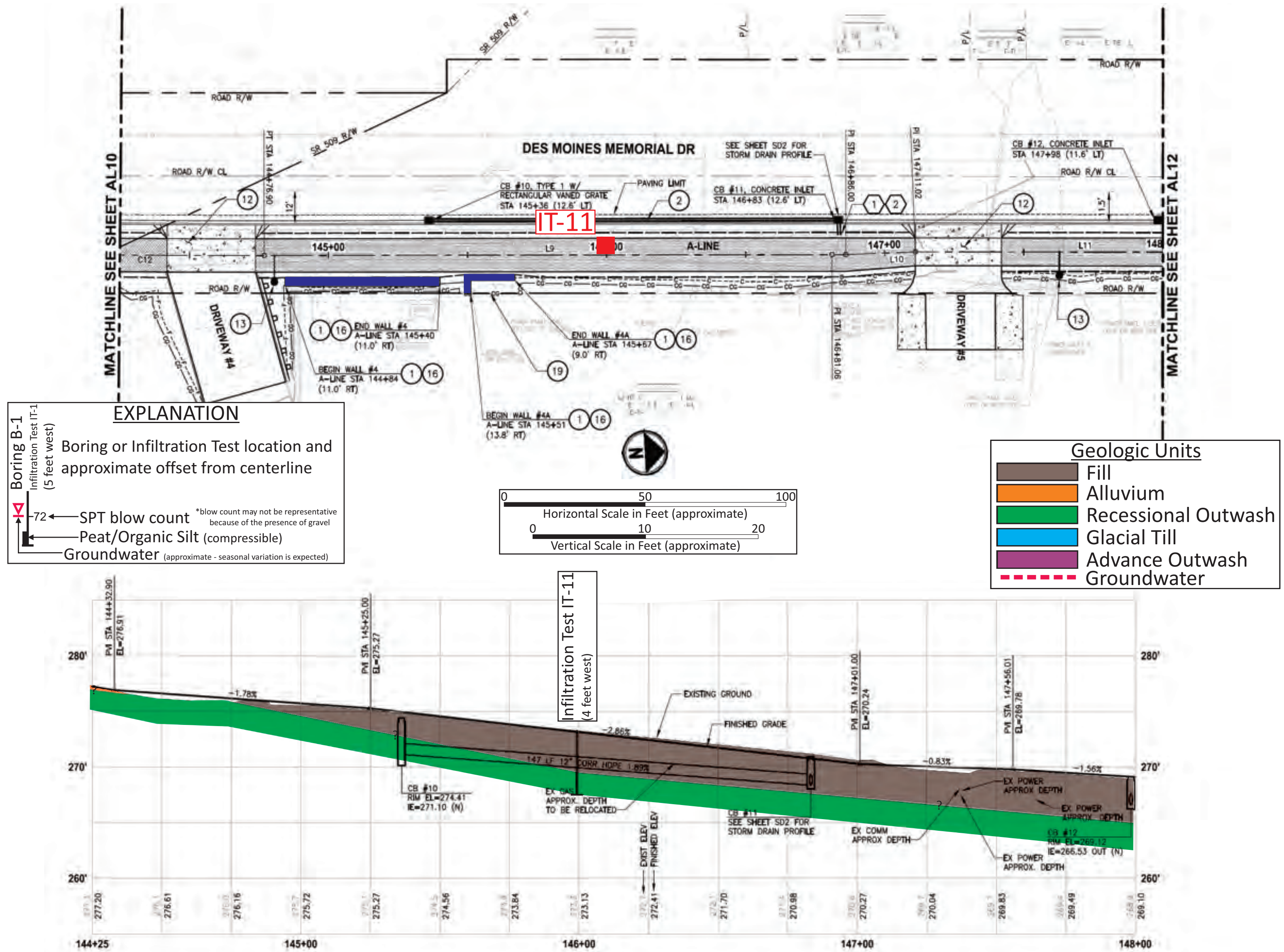

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Figure
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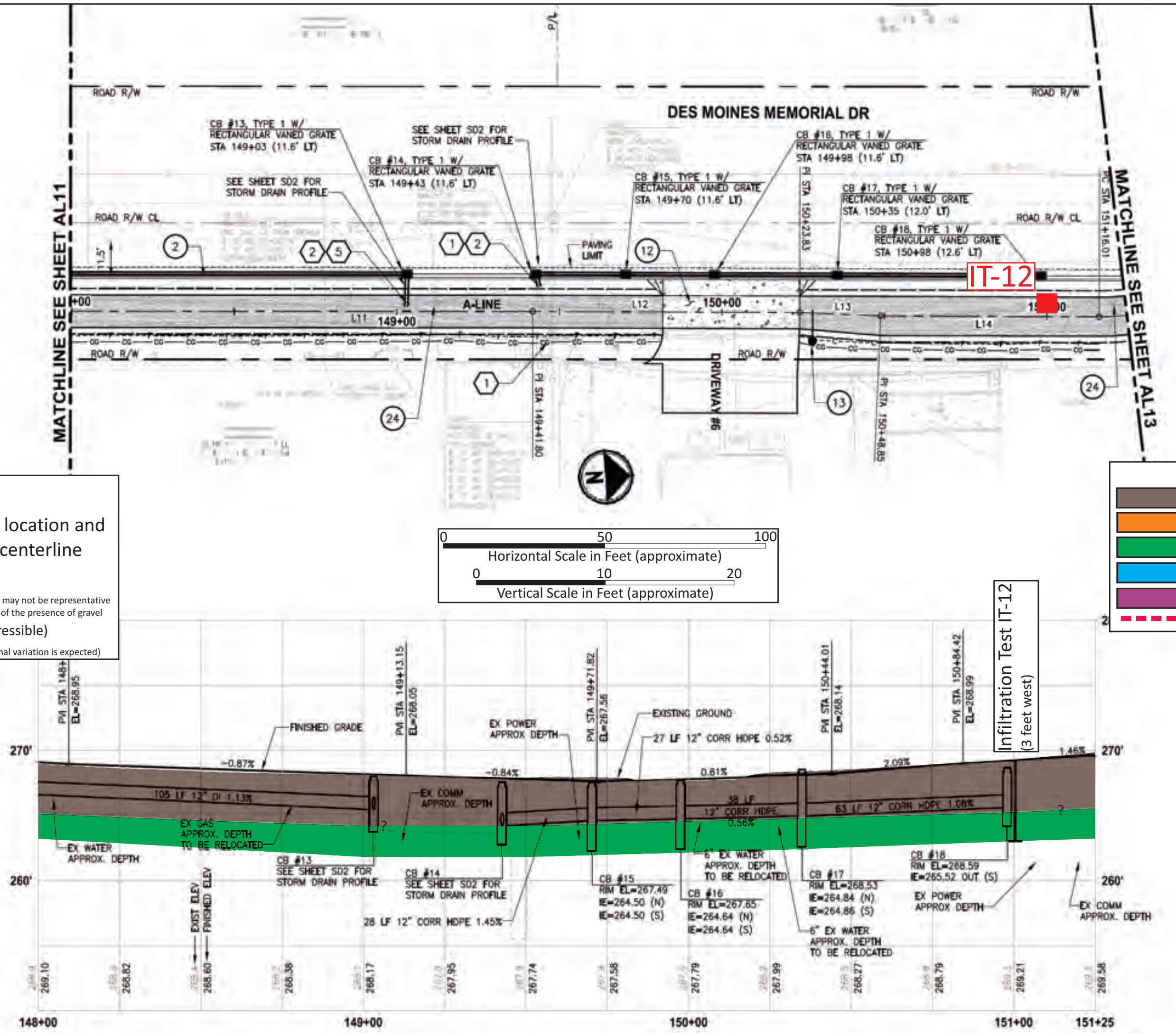
EXPLANATION

- B-1 ● Test Boring Location
- B-2/IT-3 ▲ Test Boring/Infiltration Test Location
- IT-1 ■ Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



EXPLANATION

Boring B-1 / Infiltration Test IT-1 (5 feet west): Boring or Infiltration Test location and approximate offset from centerline

- 72 ← SPT blow count *blow count may not be representative because of the presence of gravel
- Peat/Organic Silt (compressible)
- Groundwater (approximate - seasonal variation is expected)

Horizontal Scale in Feet (approximate): 0 — 50 — 100

Vertical Scale in Feet (approximate): 0 — 10 — 20

Geologic Units

- Fill
- Alluvium
- Recessional Outwash
- Glacial Till
- Advance Outwash
- Groundwater

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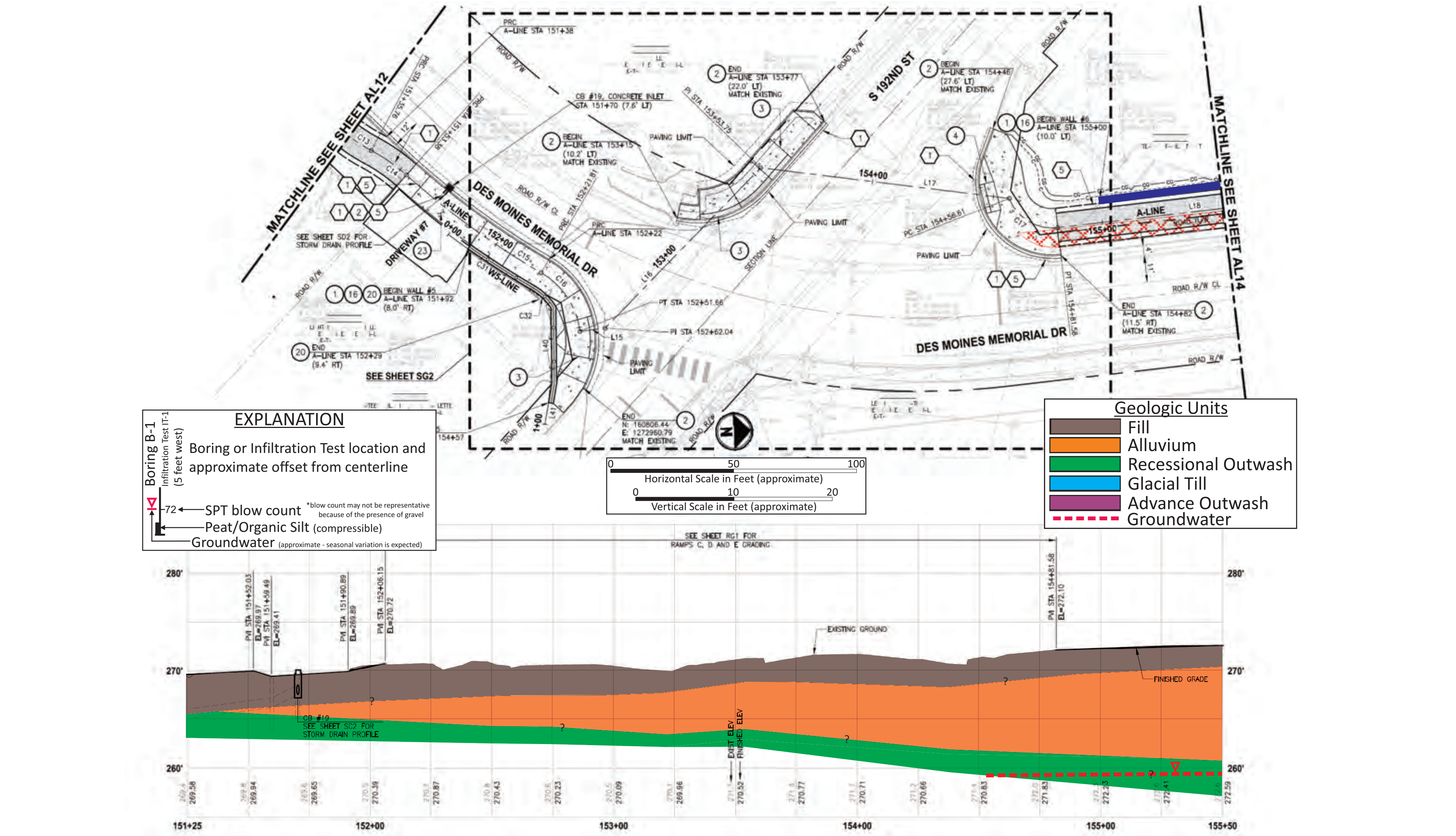
Figure 13

EXPLANATION

B-1 Test Boring Location	B-2/IT-3 Test Boring/Infiltration Test Location	Liquefaction-Prone Areas	Proposed Retaining Wall	Proposed Porous Pavement
IT-1 Infiltration Test Location	(p) Indicates Piezometer Location	Possible Buried Concrete Slab	Proposed Dispersion Trench	Proposed Boardwalk



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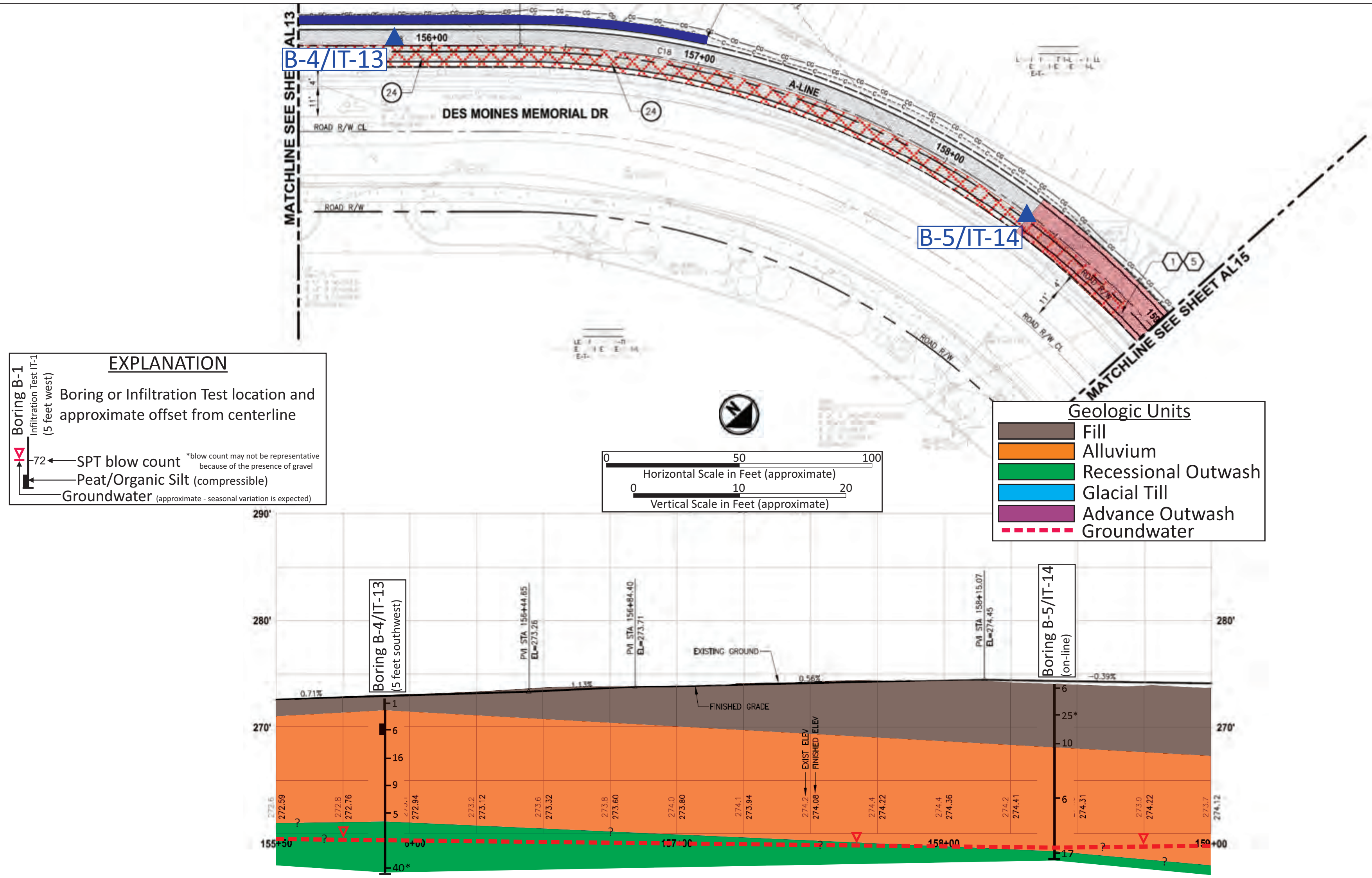
EXPLANATION

- B-1 ● Test Boring Location
- IT-1 ■ Infiltration Test Location
- B-2/IT-3 ▲ Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



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EXPLANATION

B-1 ● Test Boring Location

IT-1 ■ Infiltration Test Location

B-2/IT-3 ▲ Test Boring/Infiltration Test Location

(p) Indicates Piezometer Location

Liquefaction-Prone Areas

Possible Buried Concrete Slab

Proposed Retaining Wall

Proposed Dispersion Trench

Proposed Porous Pavement

Proposed Boardwalk

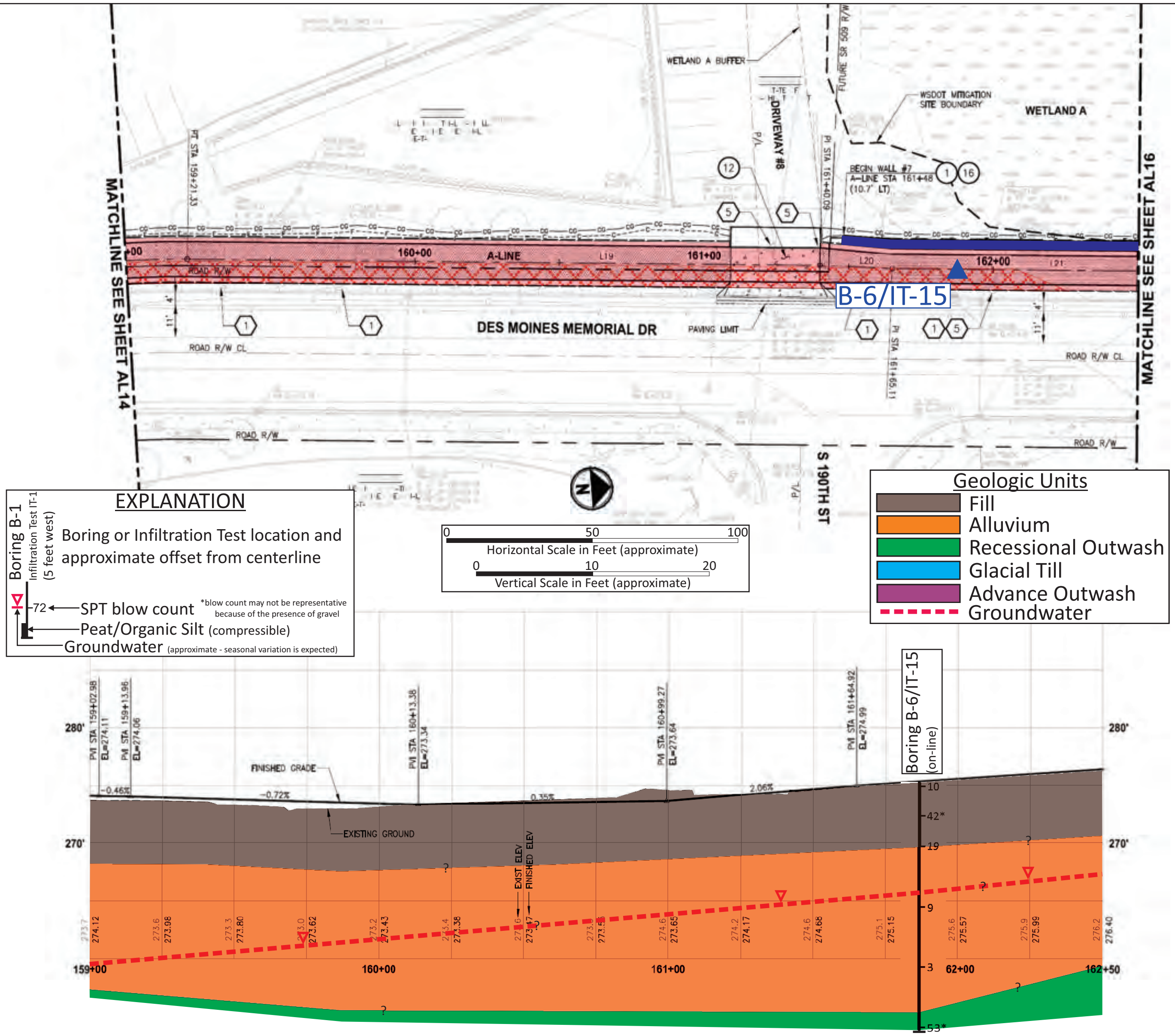

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Figure
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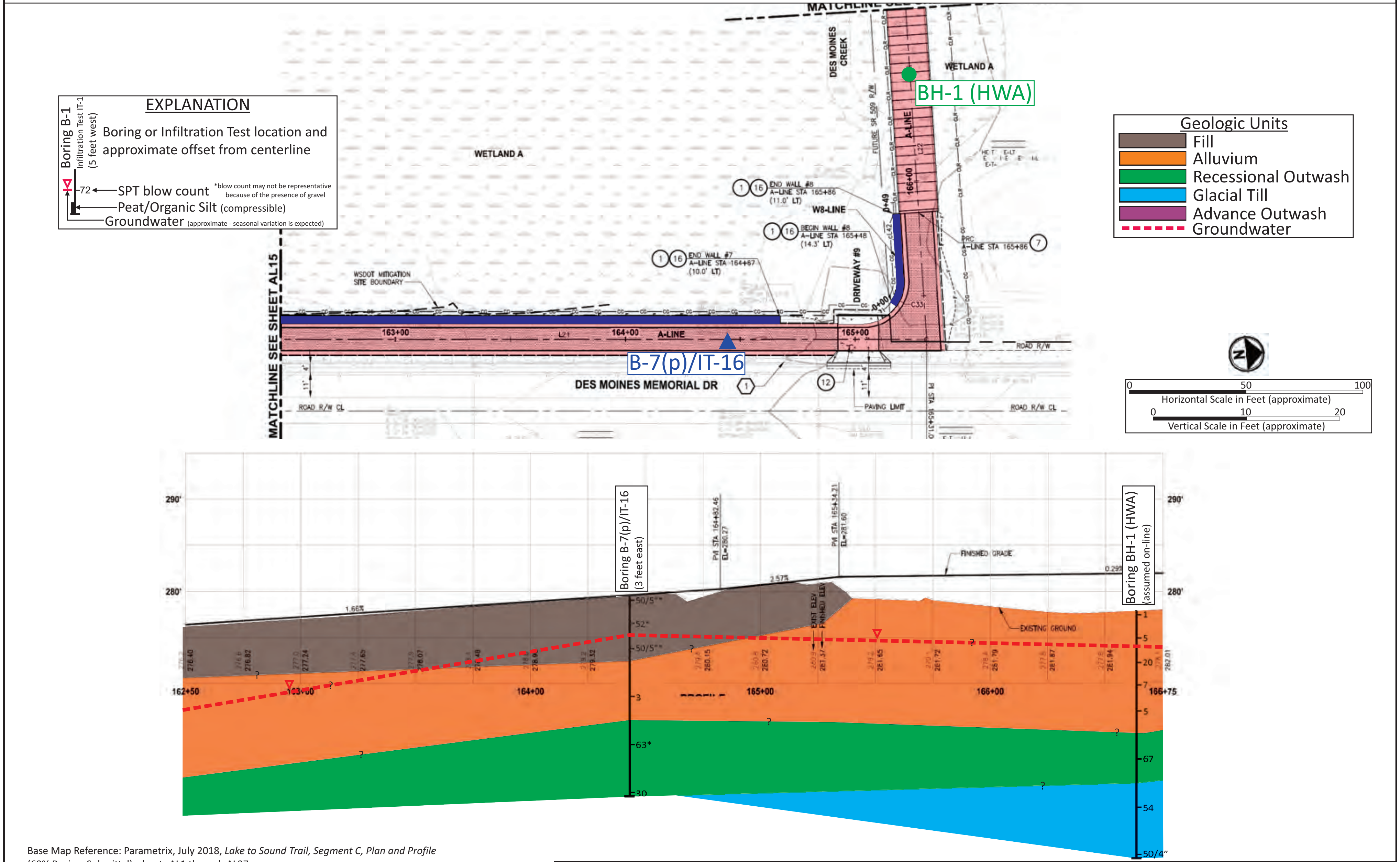
EXPLANATION

- B-1 ● Test Boring Location
- IT-1 ■ Infiltration Test Location
- B-2/IT-3 ▲ Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

Notes:
1) Boring, Infiltration Test and Test Hole logs are included in Appendix A.
2) Subsurface conditions shown are along trail centerline and are based on widely-spaced explorations. Actual subsurface conditions may vary significantly especially fill thickness.
3) "?" indicates inferred geologic contact and estimated groundwater level.

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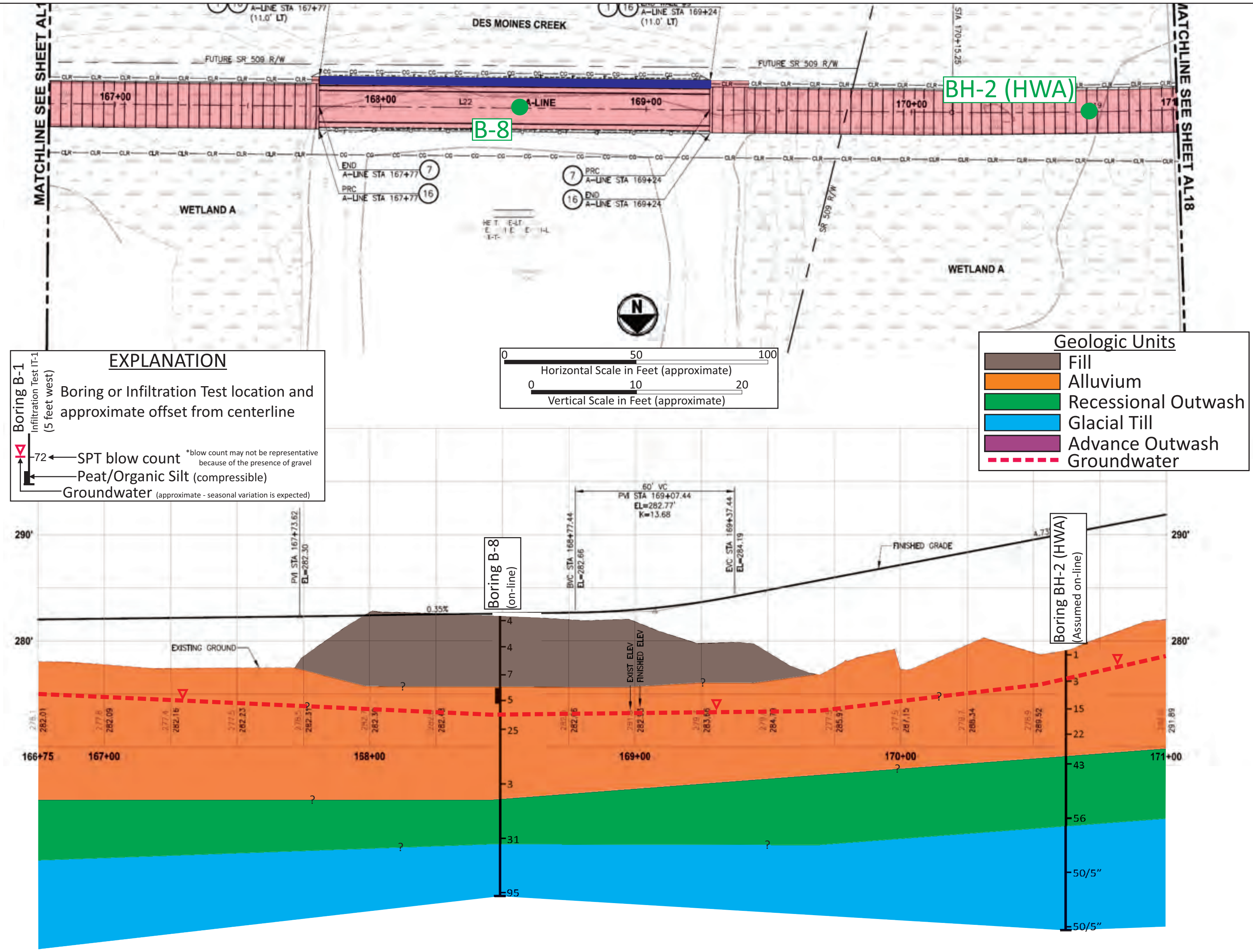
17

EXPLANATION

- B-1 ● Test Boring Location
- IT-1 ■ Infiltration Test Location
- B-2/IT-3 ▲ Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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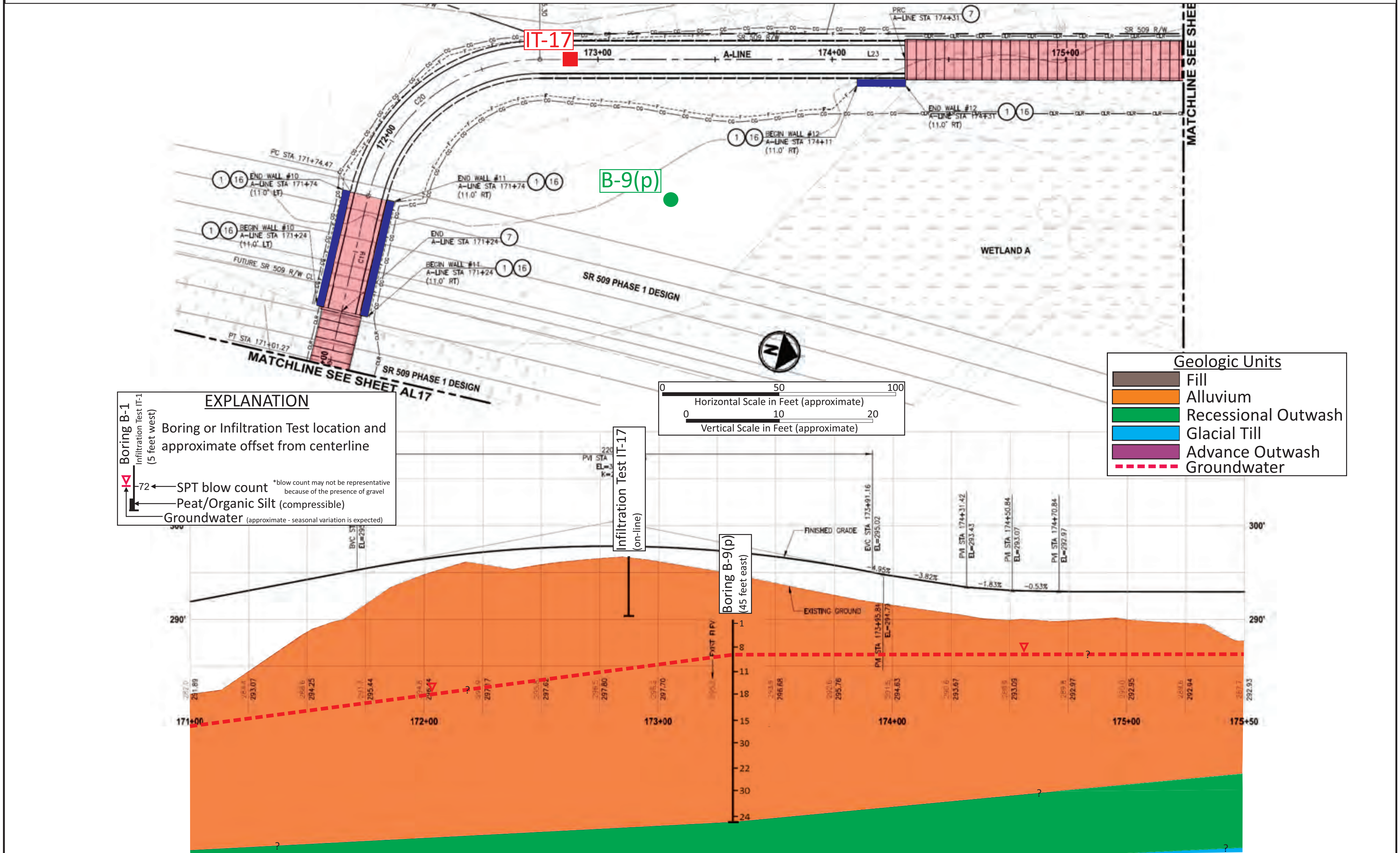
EXPLANATION

- B-1 ● Test Boring Location
- IT-1 ■ Infiltration Test Location
- B-2/IT-3 ▲ Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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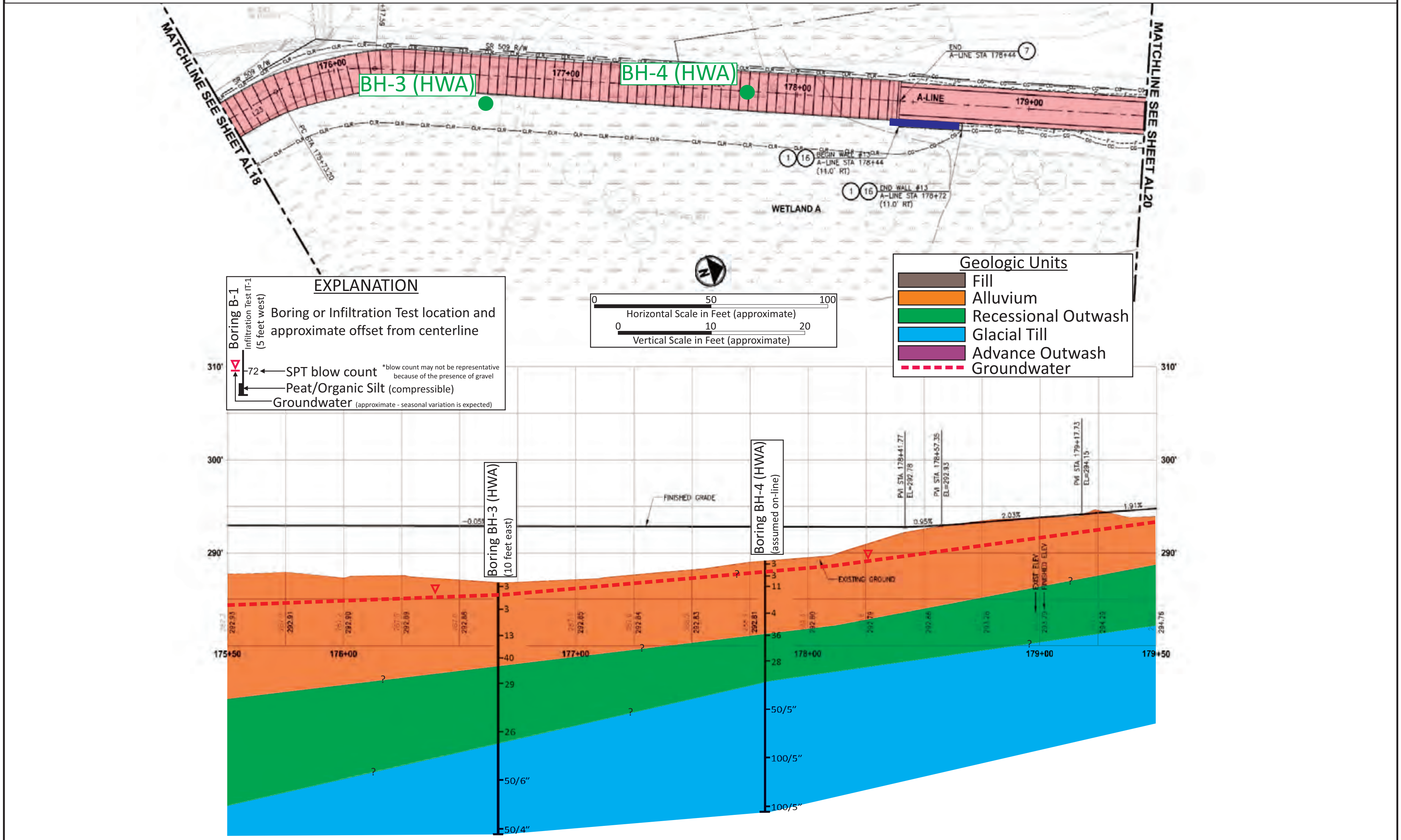
EXPLANATION

- B-1 Test Boring Location
- IT-1 Infiltration Test Location
- B-2/IT-3 Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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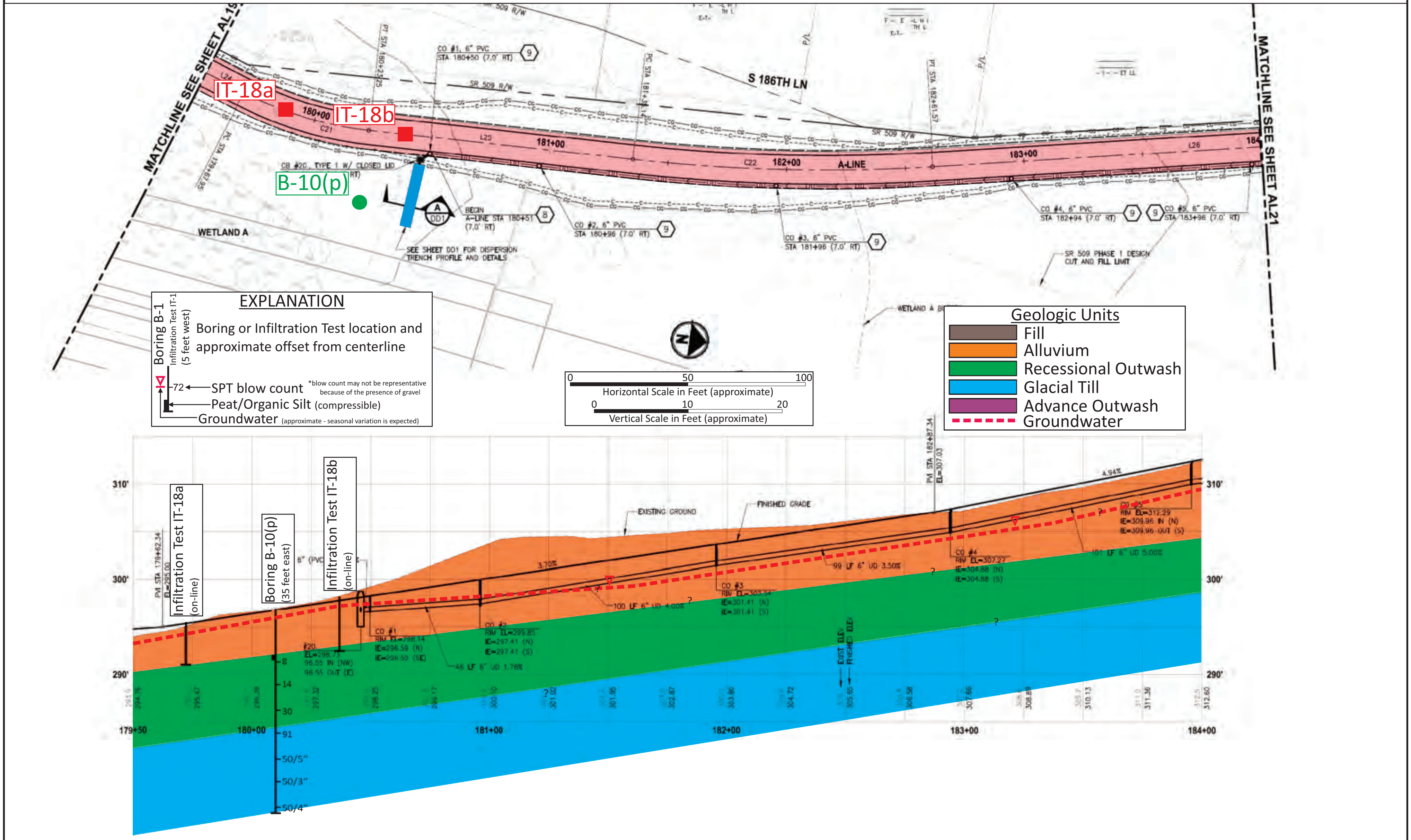
20

EXPLANATION

- B-1 Test Boring Location
- IT-1 Infiltration Test Location
- B-2/IT-3 Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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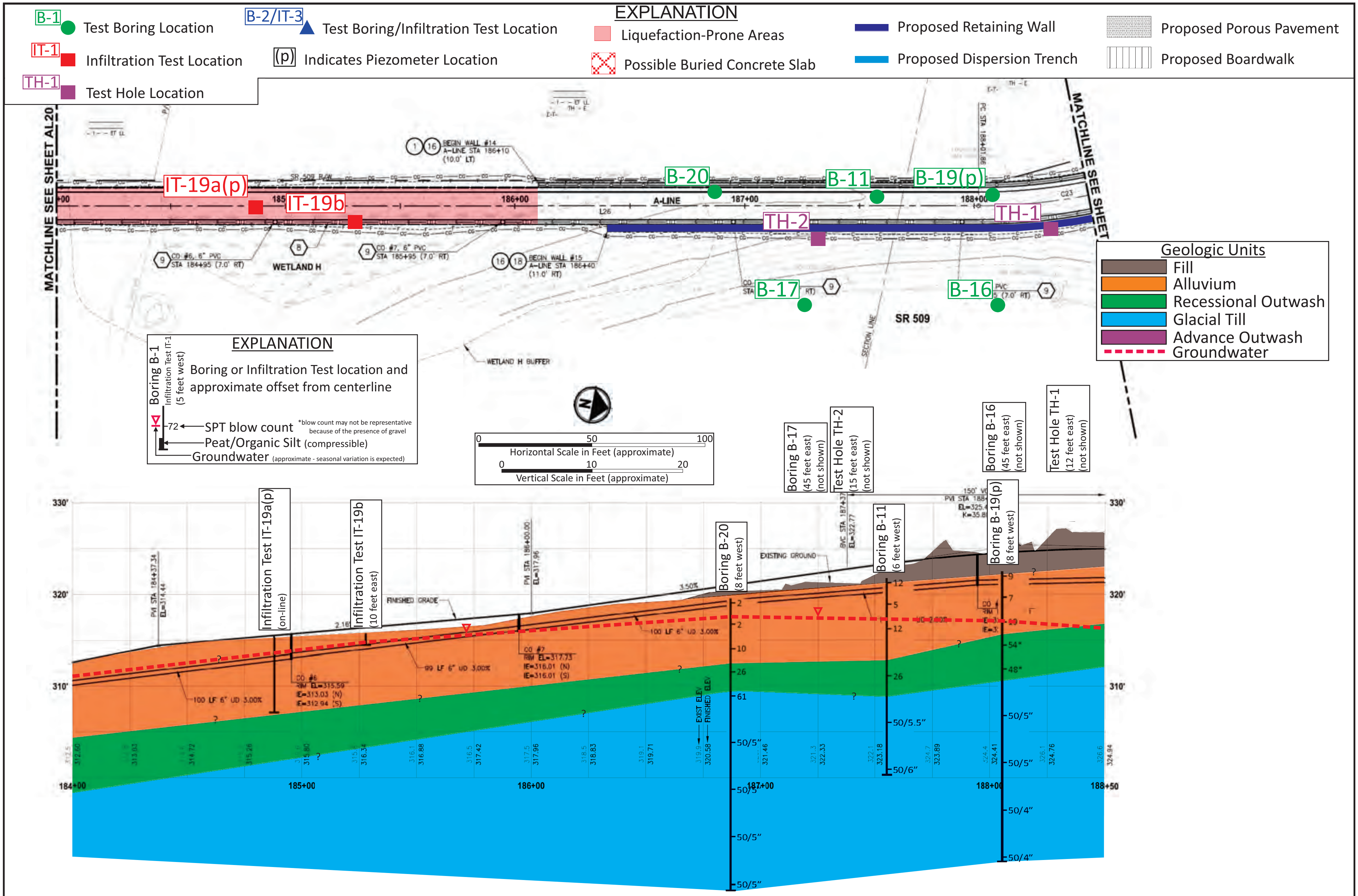

Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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Figure
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EXPLANATION

B-1 ● Test Boring Location

B-2/IT-3 ▲ Test Boring/Infiltration Test Location

IT-1 ■ Infiltration Test Location

(p) Indicates Piezometer Location

Liquefaction-Prone Areas

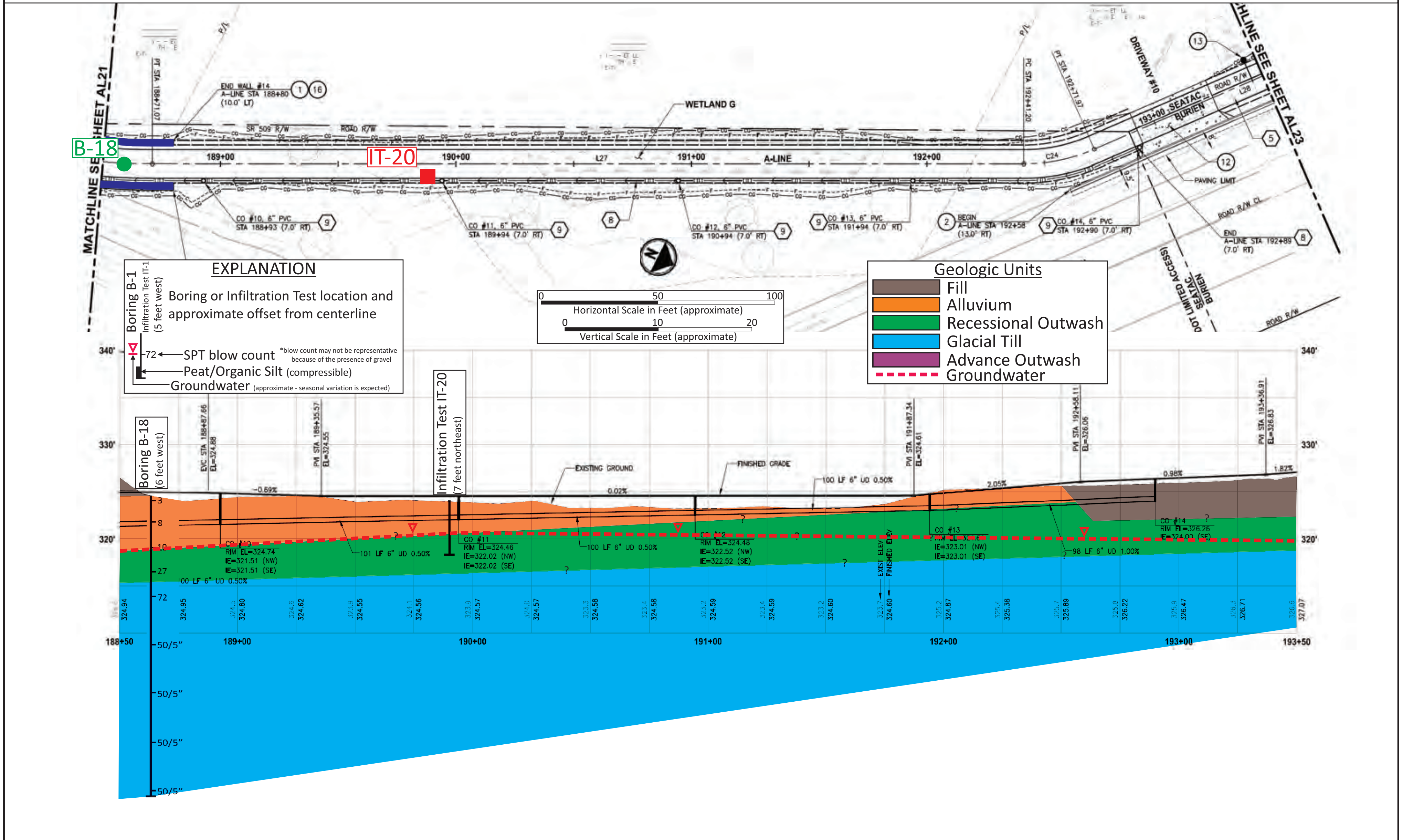
Possible Buried Concrete Slab

Proposed Retaining Wall

Proposed Dispersion Trench

Proposed Porous Pavement

Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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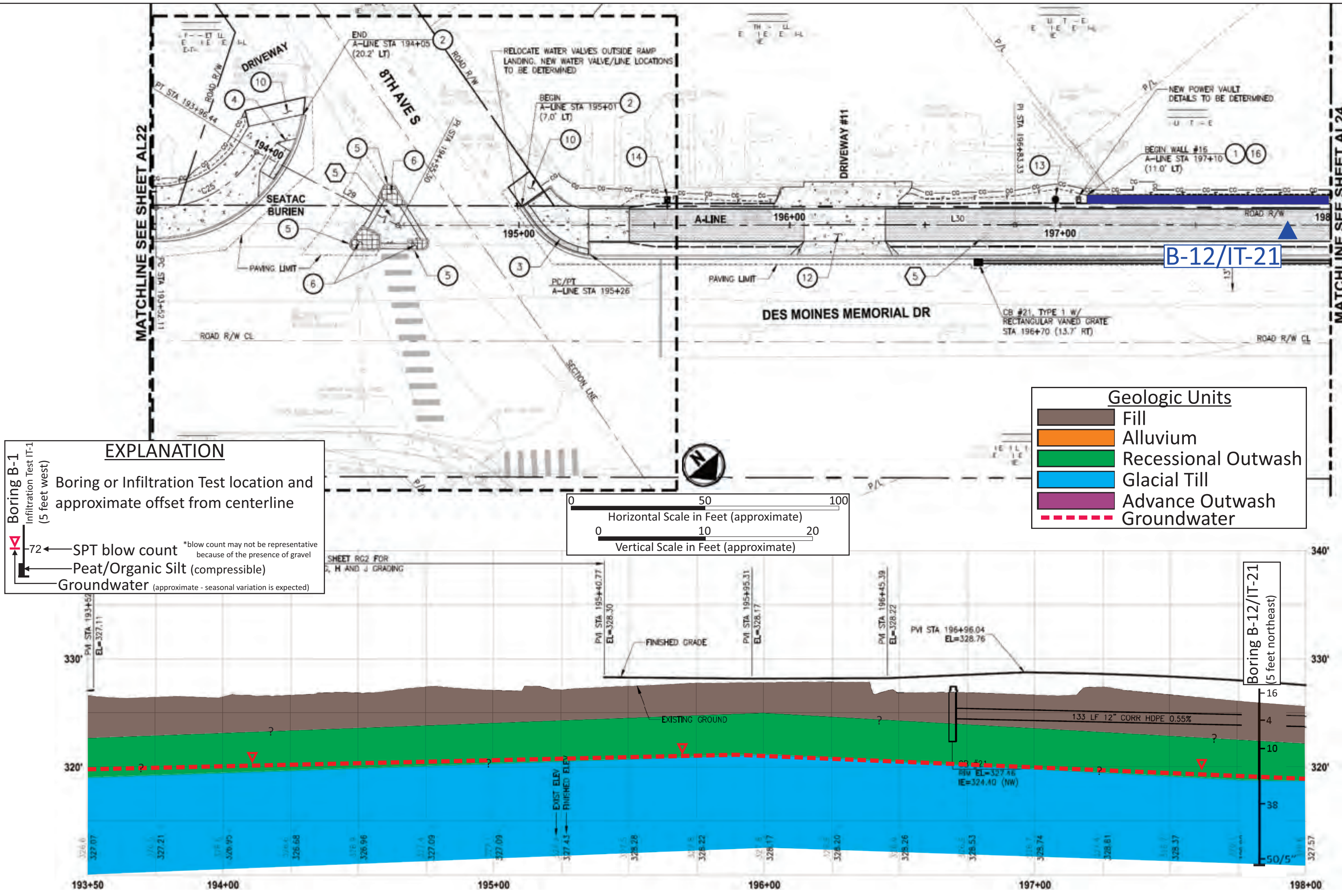
EXPLANATION

- B-1 Test Boring Location
- IT-1 Infiltration Test Location
- B-2/IT-3 Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

Notes:
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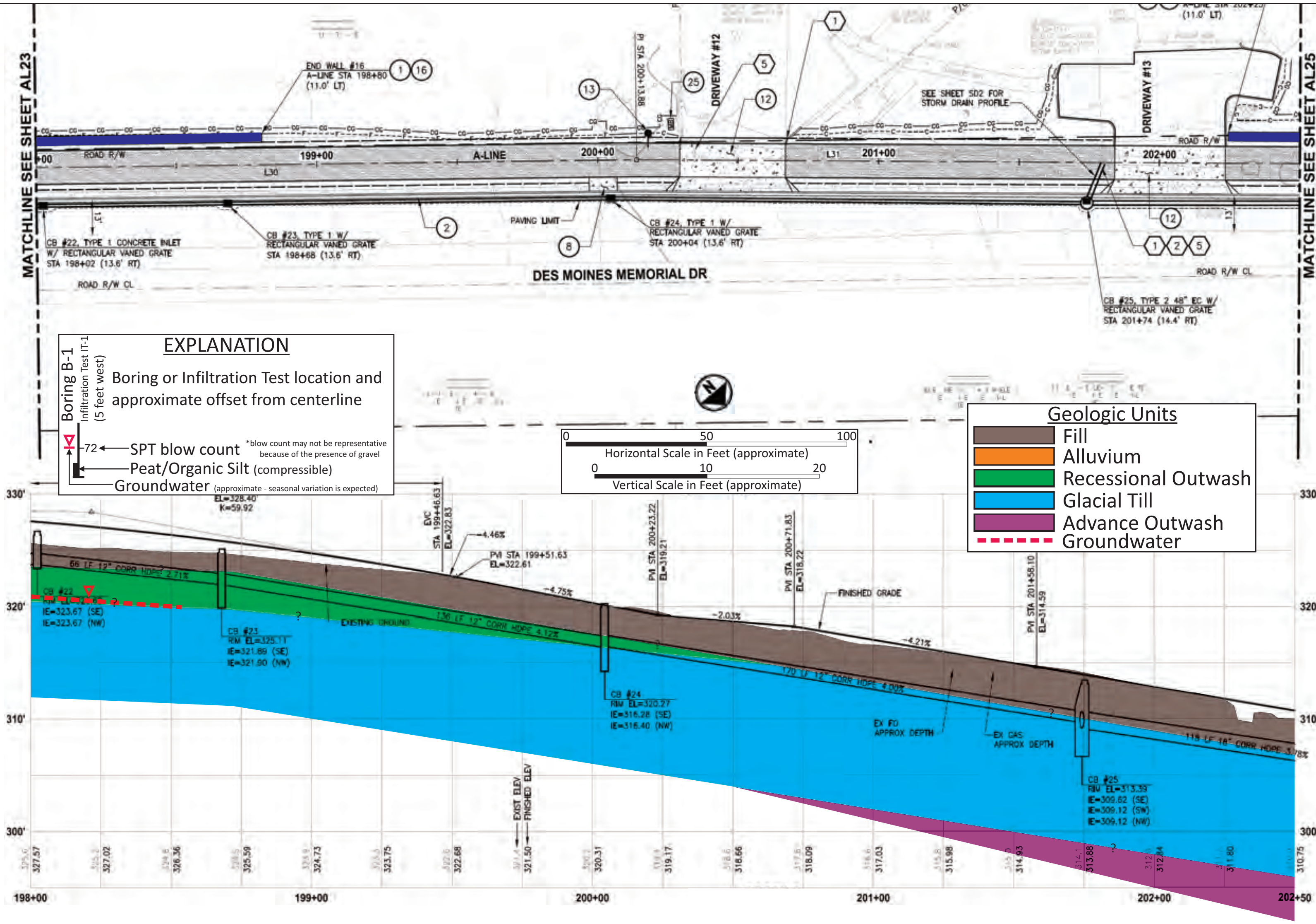
EXPLANATION

- B-1 — Test Boring Location
- IT-1 — Infiltration Test Location
- B-2/IT-3 — Test Boring/Infiltration Test Location
- (p) — Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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Figure 25

EXPLANATION

- B-1 — Test Boring Location
- IT-1 — Infiltration Test Location
- B-2/IT-3 — Test Boring/Infiltration Test Location
- (p) — Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk

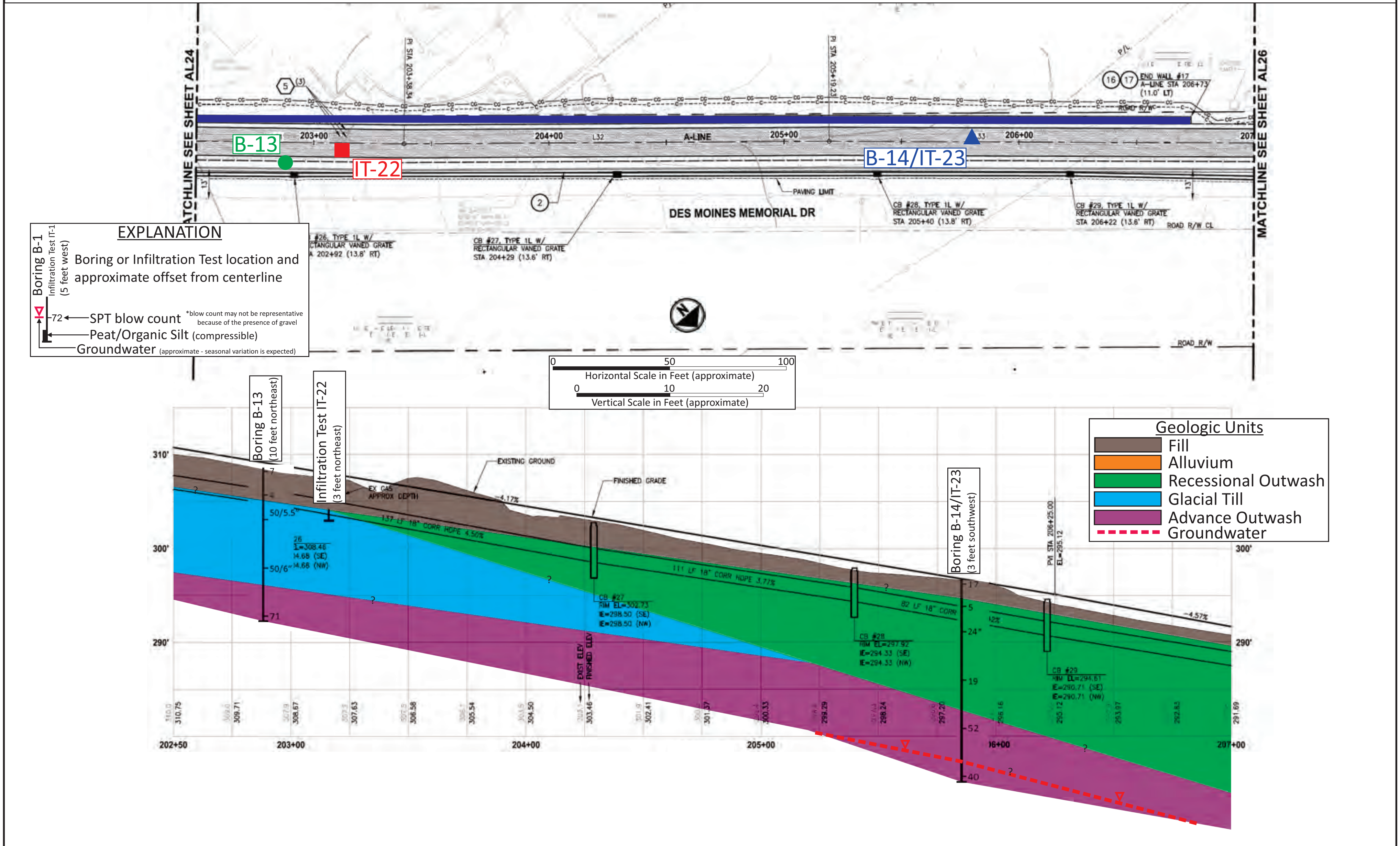

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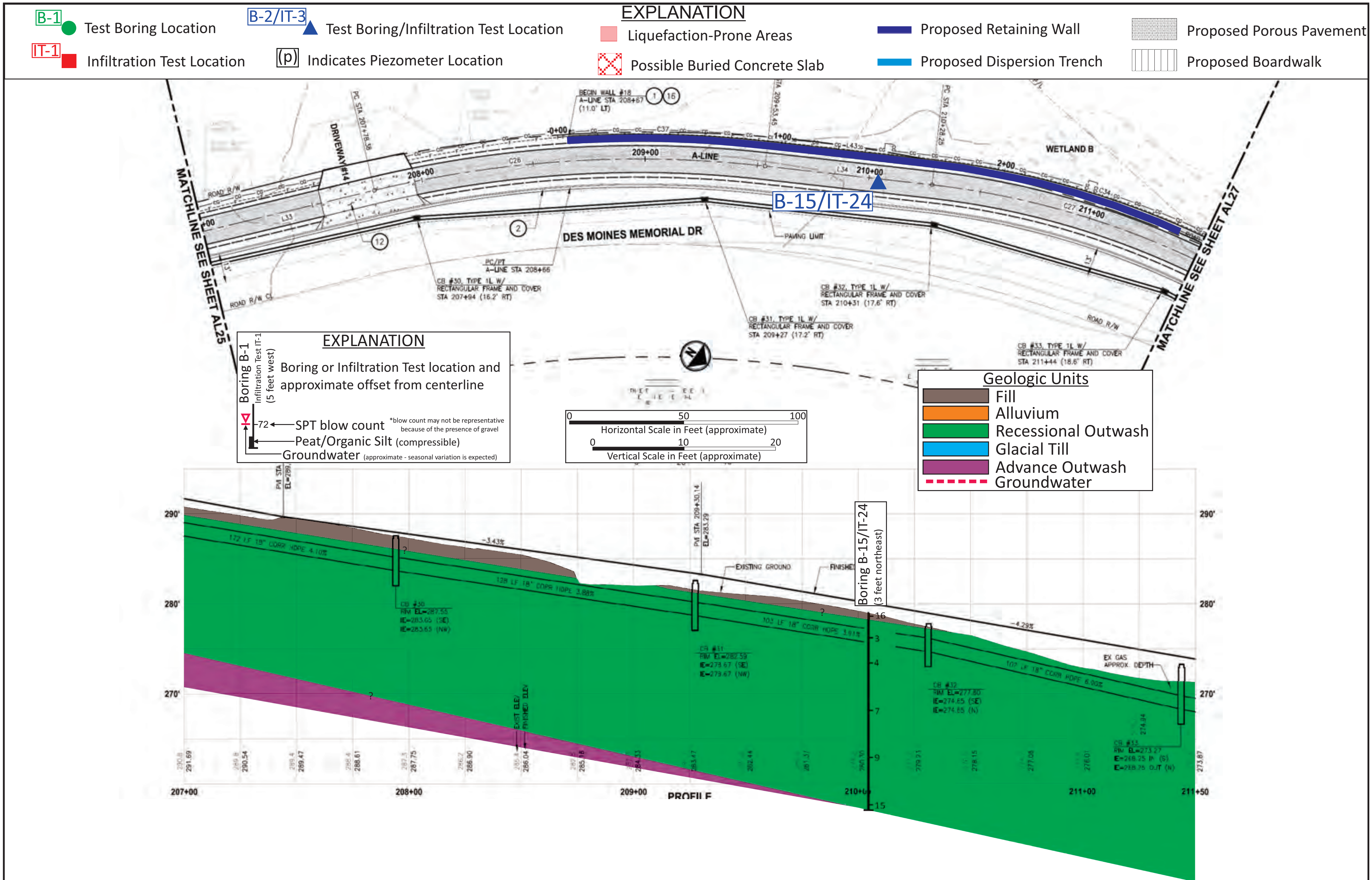
Figure 26



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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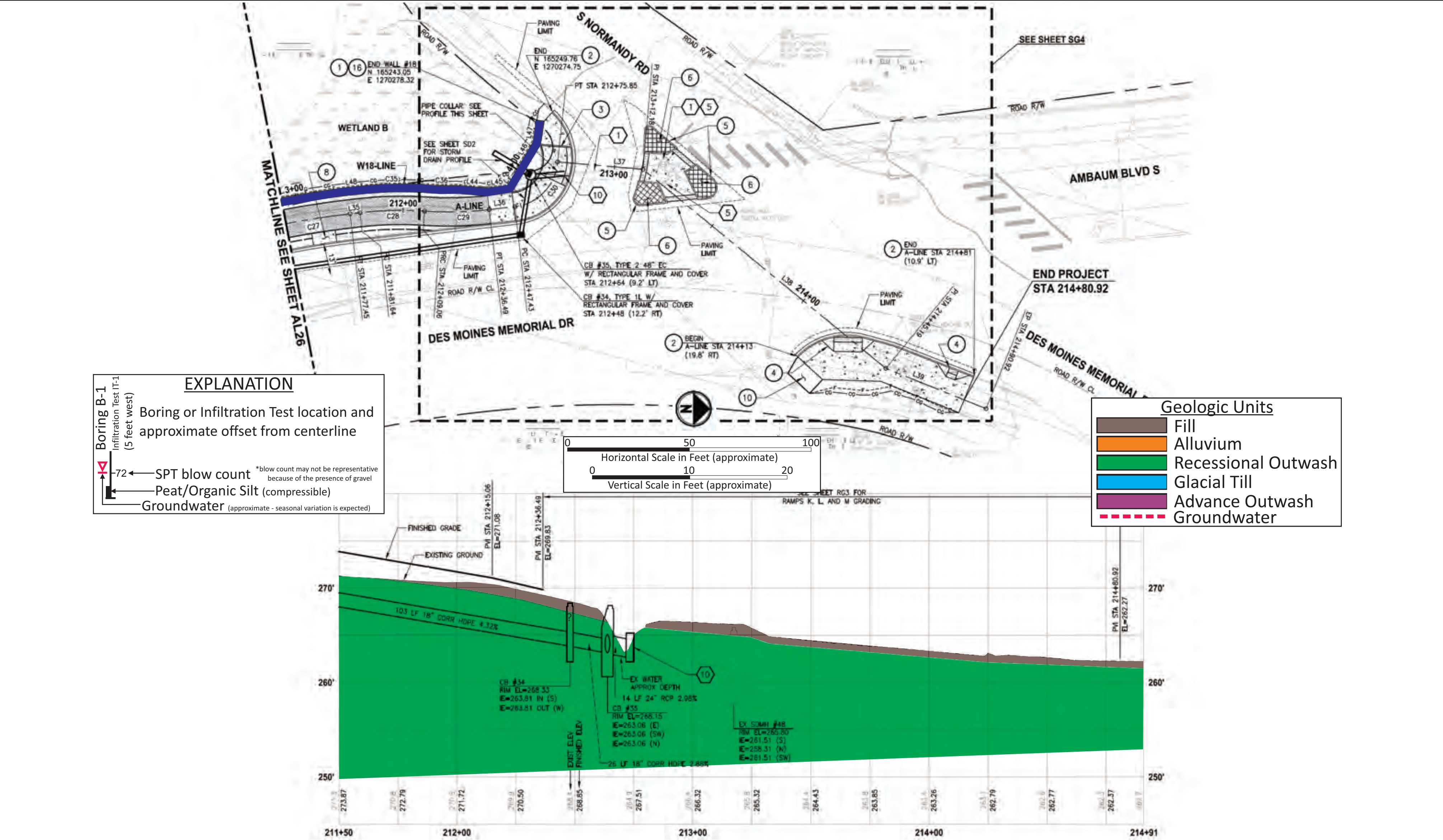
Figure
27

EXPLANATION

- B-1 Test Boring Location
- IT-1 Infiltration Test Location
- B-2/IT-3 Test Boring/Infiltration Test Location
- (p) Indicates Piezometer Location
- Liquefaction-Prone Areas
- Possible Buried Concrete Slab
- Proposed Retaining Wall
- Proposed Dispersion Trench
- Proposed Porous Pavement
- Proposed Boardwalk



Base Map Reference: Parametrix, July 2018, *Lake to Sound Trail, Segment C, Plan and Profile* (60% Review Submittal), sheets AL1 through AL27.

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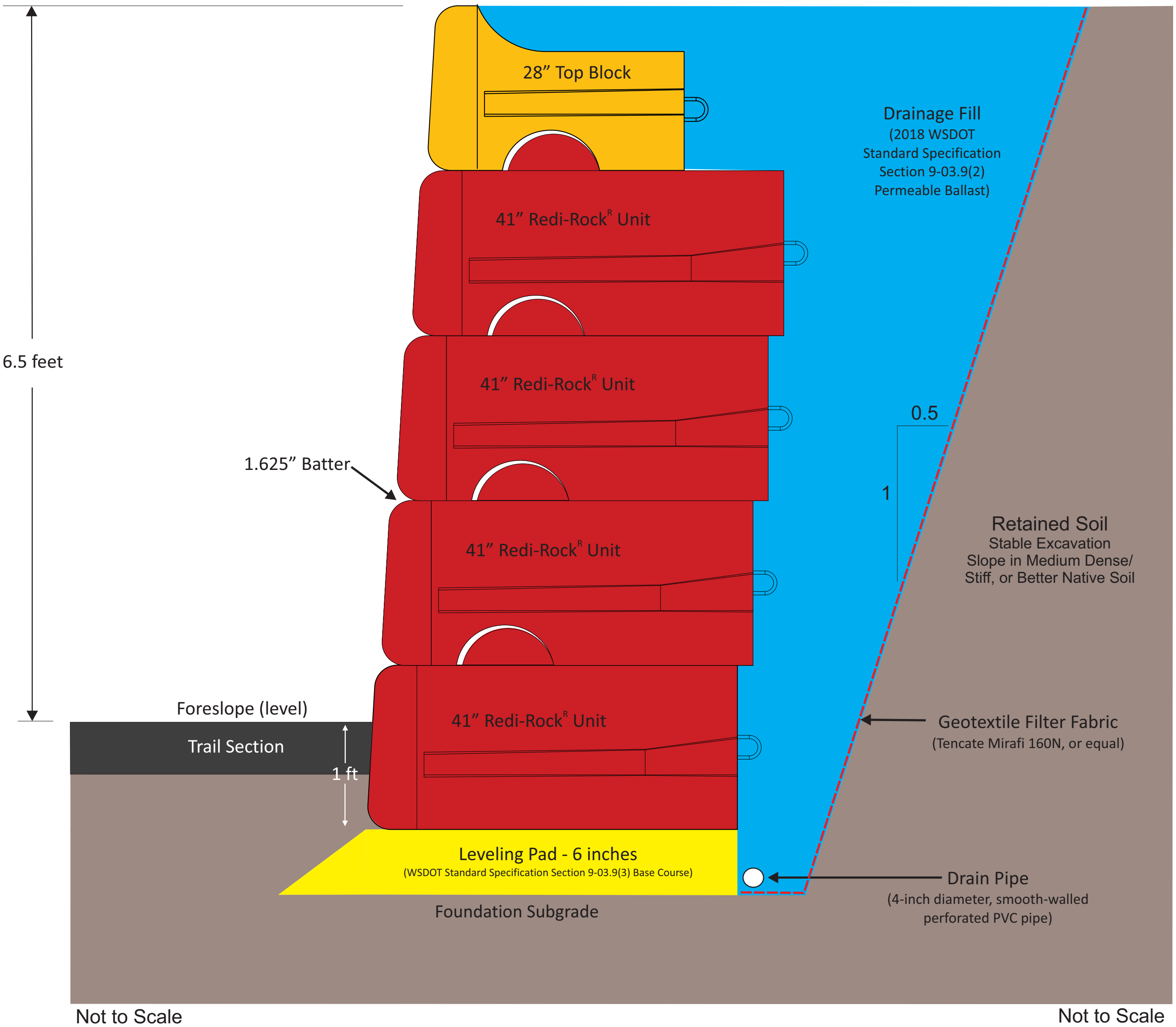


Notes: 1) See report text for additional details.

2) Assumed soil parameters: Φ’ = 34°, γ = 125 pcf, Design PGA = 0.46g (from IBC 2018).

3) Other Redi-Rock® configurations are available for other wall heights. ICE can provide these details on request.

4) Redi-Rock® walls must be installed in accordance with the plans, specifications and installation requirements provided by Redi-Rock®.

5) The Redi-Rock® wall lshould be reviewed by ICE during construction for consistency with the assumed soil parameters, cross-sectional surface conditions and internal/global stability, and revised, as appropriate.

King County / Parametrix	REDI-ROCK® WALL DIAGRAM LAKE TO SOUND TRAIL - SEGMENT C	ICICLECREEK ENGINEERS 29335 NE 20th Street Carnation, Washington 98014 (425) 333-0093	SCALE: None DESIGNED: --- DRAWN: BRB CHECKED: KSK DATE: 07/30/19	ICE FILE NO. 0105-023 Figure 29

APPENDIX A

FIELD EXPLORATION PROGRAM

APPENDIX A

A.0 FIELD EXPLORATION PROGRAM

A.1 GEOLOGICAL RECONNAISSANCE

Surface conditions of the L2ST-Seg C alignment were evaluated based on field reconnaissance completed by ICE personnel (Jeff Schwartz, LEG, LHG and/or Shane Markus, EIT) on February 7 and 26, March 16, 19 through 23, and 26 through 30, and April 4 and 6, June 7, December 1, 11, 12, and 17, 2018. During site visits between about February 7 and March 21, 2018 the weather was unseasonably warm (50s) and dry. The weather during site visits between about March 22 and June 7, 2018 was seasonably cool (March to April - 40s) and wet, to moderate and dry (June – 50s). The weather in December 2018 was seasonably cool with intermittent rain (40s). The reconnaissance and mapping included the following:

- Observation and preliminary evaluation of natural features including slopes, surface water, vegetation character and other surface conditions.
- Observation and preliminary evaluation of man-made features including road embankments (cuts and fills), rockeries, overhead utilities, ditchlines, oversteepened areas, sidewalks and other surface conditions.
- Considerations for construction and drill rig access.
- Staking exploration locations for utility locates.
- Photographic documentation of existing site conditions and subsurface exploration locations.

A.2 SUBSURFACE EXPLORATIONS

ICE completed 32 subsurface explorations (Borings B-1 to B-15 and Infiltration Tests IT-1 through IT-24, with some Borings and Infiltration Tests completed as combination explorations) along the L2ST - Seg C alignment ranging from about 6- to 26½-feet deep. Three of these explorations (Infiltration Tests IT-18a, IT-19b and IT-22) were abandoned at shallow depths due to shallow groundwater (Infiltration Test IT-18a and IT-19b) or a nearby deeper exploration (Infiltration Test IT-22). These subsurface explorations were completed between March 19 and April 6, 2018 by using track-mounted, hollow-stem auger drilling equipment or a Ditch Witch vacuum excavator, owned and operated by Gregory Drilling, Inc. (Gregory), of Redmond, Washington. Infiltration Tests IT-19a and IT-19b were completed using hand tools (digging bar, post-hole digger and hand auger).

Five additional test borings (Borings B-16 to B-20) and two test holes (Test Holes TH-1 and TH-2) were subsequently completed in the SR 509 proposed soldier pile area using the same drilling contractor and equipment described above. Borings B-16 and B-17 were completed on December 11 and 12, 2018, Borings B-18 and B-20 on December 12, 2018 and Boring B-20 on December 17, 2018 to depths ranging from 30.3 to 36.5 feet. Test Holes TH-1 and TH-2 were completed using hand tools (digging bar, post-hole digger and hand auger) to depths of 6 and 8 feet, respectively on December 17, 2018.

The locations of the subsurface explorations are shown on Figures 2 through 28.

Piezometers were installed in six of the subsurface explorations (B-1, B-7, B-9, B-10, B-19 and IT-19). Details of the piezometers are presented in section **A.3** of this appendix.

The subsurface explorations were continuously observed by a geotechnical engineer from ICE who classified the soils, obtained representative soil samples, observed groundwater conditions and prepared a detailed log of each exploration. After completion, the explorations were either backfilled in general accordance with Washington State Department of Ecology (Ecology) guidelines, or piezometers were installed as described in section **A.3** of this appendix. Soil cuttings were hauled off-site by Gregory for explorations B-1, B-4, B-5, B-6, B-7, B-12, B-13, B-14, B-15, B-16, B-17, B-20, IT-1, IT-2, IT-5, IT-6, IT-7, IT-8, IT-11 and IT-12. Soil cuttings were spread on site for explorations B-2, B-3, B-8, B-9, B-10, B-11, B-18, B-19, IT-4, IT-10, IT-17, IT-18, IT-19, and IT-20. For explorations located in landscaped grasses (IT-11 and IT-12), the grass was replaced after backfilling the hole. Borings B-13, B-16 and B-17 were completed within the paved southbound shoulder of DMMD or SR 509. Boring B-13 was backfilled with Perma Plug granular bentonite, about 4 inches of pea gravel, and about 6 inches of Quality Pavement Repair Cold Patch Asphalt, compacted with a hand tamper in 2-inch thick loose lifts. . Borings B-16 and B-17, in the shoulder area of SR 509, were backfilled with Perma Plug granular bentonite, about 7 feet of crushed rock and 3 feet of Quick-Set concrete dyed dark gray to match the surrounding pavement.

In explorations drilled with hollow-stem auger equipment, the soil consistencies noted on the boring logs are based on the conditions observed, our experience and judgement, and blow count data obtained during drilling. Representative samples were obtained from these explorations by collecting soil samples at 2½- or 5-foot depth intervals using a 1.5-inch inner-diameter split barrel (SPT – Standard Penetration Test) sampler. The sampler was driven 18 inches, if possible, by a 140-pound weight falling a minimum vertical distance of 30 inches. The number of blows required to drive the sampler the last 12 inches, or other indicated distance, was recorded on the boring log.

For explorations completed with the Ditch Witch vacuum excavator or by hand auger, soil consistencies noted on the boring logs are based on the conditions observed, our experience and judgement, and penetration depths with a ½-inch diameter steel probe rod. Representative grab samples were obtained at various depth intervals ranging from about 1½ to 4 feet.

Soils encountered were classified in general accordance with the classification system described in Figure A-1. The boring logs and infiltration test logs are presented in Figures A-2 through A-38. The test hole logs are presented in Figures A-39 and A-40. The logs are based on our interpretation of the field and laboratory data and indicate the various types of soil encountered. They also indicate the depths at which the soil characteristics change, although the change might actually be gradual. If the change occurred between samples in the explorations, it was interpreted. The laboratory testing program for soil samples obtained from the explorations is described in Appendix B of this report.

Elevations of the explorations as shown on the logs are based on raw LiDAR data obtained from the Washington State Department of Natural Resources, Washington LiDAR Portal (http://lidarportal.dnr.wa.gov/), processed by ICE for topographic contours.

A.3 GROUNDWATER MONITORING

Groundwater observations as noted on the logs (for explorations where no piezometer was installed) are based on our observations of the soil samples and drilling equipment, or by direct observations or measurement through the auger during drilling, or into the hand-augered or vacuum-excavated hole during excavation.

Piezometers (for measuring groundwater) were installed in six of the explorations including B-1, B-7, B-9, B-10, B-19 and IT-19. Piezometer installation was completed in general accordance with Ecology requirements; installation details are shown on the respective logs in this appendix.

The depth to groundwater was measured in the piezometers using an electric water level indicator (manual readings) on April 6, 2018, September 21, 2018, December 11, 2018, March 22, 2019 and July 30, 2019; these groundwater measurements (high and low water levels) are noted on the boring logs in this appendix. The measured groundwater depths are summarized in section **7.2.4** of this report.

A.4 INFILTRATION TESTING

We completed 24 small-scale falling-head tests (FHTs) in 6- to 8-inch diameter vacuum- or hand-excavated holes approximately every 500 feet along the proposed trail corridor. Infiltration tests were typically completed about 5 feet from the adjacent subsurface exploration after the excavation was completed. Infiltration tests were completed at various depths, intending to be set at approximately the base of the proposed pervious pavement or infiltration trench section (about 1.5- to 3-feet below proposed finish trail grade per the Plan and Profile provided by Parametrix, dated March 2017). Gregory provided water from tanks on the two support pickups, and on an ATV, as needed.

Infiltration tests were completed in general accordance with the Environmental Protection Agency (EPA) Falling Head Test (FHT) procedure. About 2 to 3 inches of clean, ¾- to 1-inch-diameter round rock ("landscape gravel") was added to the base of the holes. A 5-foot-long, 4-inch-diameter slotted PVC pipe (slotted pipe) was placed vertically within each hole, and the annular space backfilled with at least 12 inches of landscape gravel. The infiltration tests were completed by adding water into the slotted pipe using a hose connected to a water tank on either the support truck or ATV. Typically, two 12-inch FHTs were completed (from about 1.2 feet to 0.2 feet above the gravel) to determine if a soak period was necessary. Per the EPA FHT procedure, if the 1-foot FHT took less than 10 minutes, the testing proceeded immediately. If the 1-foot FHT took greater than 10 minutes, a soak period was completed, where the water level was maintained about 8 to 12 inches above the gravel for a minimum of 4 hours before the test was performed. The FHT was then performed between about 6 and 5 inches above the base of the slotted pipe, repeatedly, until results stabilized. Infiltration test holes were backfilled in general accordance with Ecology guidelines.

Representative soil samples obtained from the infiltration test holes at the testing depth were used to complete grain size analysis in general accordance with ASTM Test Method D422 – Standard Test Method for Particle-Size Analysis of Soils; the laboratory testing program for soil samples obtained from the infiltration test holes is described in Appendix B; the test results are presented in Appendix B.

Unified Soil Classification System

MAJOR DIVISIONS			Soil Classification and Generalized Group Description	
Coarse-Grained Soils More than 50% retained on the No. 200 sieve	GRAVEL More than 50% of coarse fraction retained on the No. 4 sieve	CLEAN GRAVEL	GW	Well-graded gravels
			GP	Poorly-graded gravels
		GRAVEL WITH FINES	GM	Gravel and silt mixtures
			GC	Gravel and clay mixtures
	SAND More than 50% of coarse fraction passes the No. 4 sieve	CLEAN SAND	SW	Well-graded sand
			SP	Poorly-graded sand
		SAND WITH FINES	SM	Sand and silt mixtures
			SC	Sand and clay mixtures
Fine-Grained Soils More than 50% passing the No. 200 sieve	SILT AND CLAY Liquid Limit less than 50	INORGANIC	ML	Low-plasticity silts
			CL	Low-plasticity clays
		ORGANIC	OL	Low plasicity organic silts and organic clays
	SILT AND CLAY Liquid Limit greater than 50	INORGANIC	MH	High-plasticity silts
			CH	High-plasticity clays
		ORGANIC	OH	High-plasticity organic silts and organic clays
Highly Organic Soils	Primarily organic material with organic odor		PT	Peat

Notes: 1) Soil classification based on visual classification of soil is based on ASTM D 2488.
2) Soil classification using laboratory tests is based on ASTM D 2487.
3) Description of soil density or consistency is based on interpretation of blow count data and/or test data.

Soil Particle Size Definitions

Component	Size Range
Boulders	Coarser than 12 inch
Cobbles	3 inch to 12 inch
Gravel	3 inch to No. 4 (4.78 mm)
Coarse	3 inch to 3/4 inch
Fine	3/4 inch to No. 4 (4.78 mm)
Sand	No. 4 (4.78 mm) to No. 200 (0.074mm)
Coarse	No. 4 (4.78 mm) to No. 10 (2.0 mm)
Medium	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Finer than No. 200 (0.074 mm)

Soil Moisture Modifiers

Soil Moisture	Description
Dry	Absence of moisture
Moist	Damp, but no visible water
Wet	Visible water

Key to Boring Log Symbols

Sampling Method	Boring Log Symbol	Description
Blows required to drive a 2.4 inch I.D. split-barrel sampler 12-inches or other indicated distance using a 300-pound hammer falling 30 inches.	34	Location of relatively undisturbed sample
	12	Location of disturbed sample
	21	Location of sample attempt with no recovery
Blows required to drive a 1.5-inch I.D. split barrel sampler (SPT - Standard Penetration Test) 12-inches or other indicated distance using a 140-pound hammer falling 30 inches.	14	Location of sample obtained in general accordance with Standard Penetration Test (ASTM D-1586) test procedures.
	30	Location of SPT sampling attempt with no recovery.
Pushed Sampler	P	Sampler pushed with the weight of the hammer or against weight of the drilling rig.
Grab Sample	G	Sample obtained from drill cuttings.

Note: The lines separating soil types on the logs represents approximate boundaries only. The actual boundaries may vary or be gradual.

Laboratory Tests

Test	Symbol
Moisture Content	MC
Density	DN
Grain Size	GS
Percent Fines	PF
Atterberg Limits	AL
Hydrometer Analysis	HA
Consolidation	CN
Compaction	CP
Permeability	PM
Unconfined Compression	UC
Unconsolidated Undrained TX	UU
Consolidated Undrained TX	CU
Consolidated Drained TX	CD
Chemical Analysis	CA

King County Parametrix	EXPLANATION FOR LOGS LAKE TO SOUND TRAIL - SEGMENT C	ICICLECREEK ENGINEERS 29335 NE 20th Street Carnation, Washington 98014 (425) 333-0093	SCALE: None DESIGNED: -- DRAWN: SJM CHECKED: KSK DATE: 07/30/19	ICE FILE NO. 0105-023 Figure A-1

Infiltration Test IT-1

Station 101+00, 8 feet south; 47.42280, -122.30596

Approximate Ground Surface Elevation: 246 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	Light brown fine to coarse GRAVEL with silt and sand (medium dense, moist) (Fill) asphalt fragments at about 1 foot grades to with cobbles at about 1 foot concrete fragments observed at about 3 feet		GP-GM		☒	■	MC/ GS	Bentonite Backfill
5	Light brown silty fine SAND with a trace of gravel (loose, moist) (Alluvium)		SM					
	Boring completed at about 6.5 feet on March 19, 2018 Infiltration testing completed at about 3 feet							No groundwater encountered at the time of drilling
10								
15								
20								
25								

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-1(p)

Station 101+90, 5 feet south; 47.42280, -122.30636

Approximate Ground Surface Elevation: 248 feet

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing
0	5/8-inch-minus crushed rock (dense, moist) (Fill)	GP-GM		
	Light brown silty fine to medium SAND with occasional gravel (medium dense, dry) (Fill)	SM	13	MC
	Light brown silty fine to medium SAND with occasional gravel (loose, moist) (Alluvium)	SM	3	MC
5	Light brown sandy SILT with a trace of gravel (soft, moist) (Alluvium)	ML	3	MC
10	Light brown silty fine to medium SAND (medium dense, moist) (Recessional Outwash)	SM	17	MC
15	grades to light grayish-brown and with a trace of gravel			
	Gray silt (very stiff, moist) (Advance Outwash)	ML	27	MC
20	Light gray silty fine to medium SAND with gravel (medium dense, wet) (Advance Outwash)	SM	29	MC
25				

Penetration Resistance (Blows/foot ●): 20 40 60 80

Moisture Content (Percent ■): 20 40 60 80

Comments/Groundwater Observations:

- Flush Grade Steel Monument
- Concrete Plug
- Bentonite Backfill
- 2-inch PVC Solid Pipe
- Groundwater measured at 13.1 feet (3/22/19)
- Groundwater measured at 16.6 feet (9/21/18)
- 2-inch PVC Slotted Pipe
- Sand Backfill

See Figure A-1 for explanation of symbols

Boring B-1(p)

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)	Laboratory Testing	Comments/ Groundwater Observations
25	Light gray silty fine to medium SAND with occasional gravel (dense, wet) (Advance Outwash)		SM	35		■ ~15; ● ~35	MC	Bentonite Backfill
	Boring completed at about 26.5 feet on March 19, 2018 *Blow count may not be representative because of presence of gravel							
30								
35								
40								
45								
50								

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-2

Station 103+00, 7 feet south; 47.42280, -122.30676

Approximate Ground Surface Elevation: 251 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)	Laboratory Testing	Comments/ Groundwater Observations
0	5/8-inch-minus crushed rock (dense, moist) (Fill)		GP-GM					
	Light brown fine to coarse GRAVEL with silt and sand (medium dense, dry) (Fill)		GP-GM					Bentonite Backfill
	Light brown silty fine to medium SAND with gravel and cobbles (medium dense, moist) (Fill)		SM		☒	■	MC/ GS	
5								
	Boring completed at about 6 feet on March 19, 2018 Infiltration testing completed at about 3.5 feet							No groundwater encountered at the time of drilling
10								
15								
20								
25								

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-2 and Infiltration Test IT-3

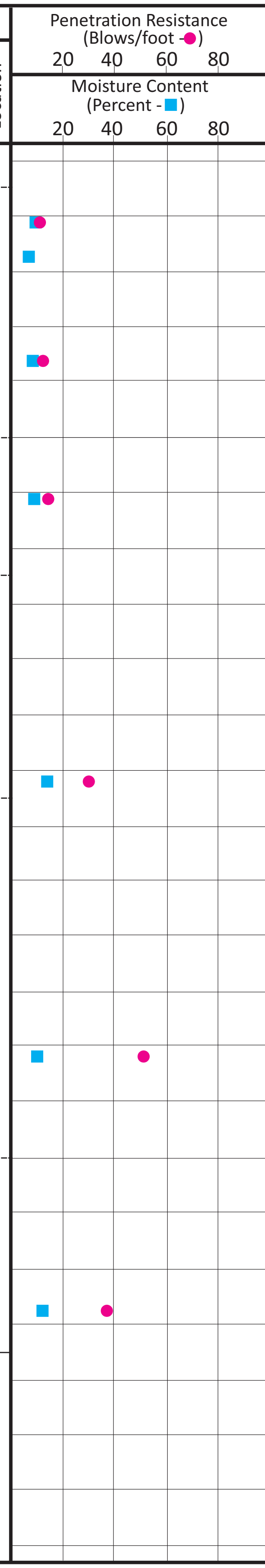
Station 106+00, 4 feet northeast; 47.42310, -122.30787

Approximate Ground Surface Elevation: 256 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Light brown fine to medium SAND with gravel and a trace of silt (medium dense*, moist) (Recessional Outwash)	SP	10	MC	
	grades to with cobbles at about 2 feet	SP		MC/ GS	Bentonite Backfill
		SP	11	MC	
5	Light brown fine to coarse GRAVEL with silt, sand and cobbles (medium dense*, moist) (Recessional Outwash)	GP-GM	15	MC	
	Light brown silty fine to medium SAND with gravel and cobbles (dense*, wet) (Recessional Outwash)				
10		SM	30	MC	
	Light reddish-brown silty fine to coarse GRAVEL with sand and cobbles (very dense*, moist) (Advance Outwash)				
15		GM	52*	MC	
	Light grayish-brown silty fine to medium SAND with occasional gravel and cobbles (dense, moist) (Advance Outwash)				
20		SM	38	MC	
	Boring completed at about 21.5 feet on March 21, 2018				No groundwater encountered at the time of drilling
	Infiltration testing completed at about 1.5 feet				
	*Blow counts may not be representative because of the presence of gravel				
25					



ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-4

Station 111+00, no offset; 47.42378, -122.30959

Approximate Ground Surface Elevation: 283 feet

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0–3	Light brown silty fine SAND with occasional gravel (medium dense, moist) (Recessional Outwash)	SM		☒		MC/ GS	Bentonite Backfill
3–6	Light brown silty fine to coarse GRAVEL with sand and cobbles (medium dense, moist) (Recessional Outwash)	GM		☒		MC	
	Boring completed at about 6 feet on March 21, 2018 Infiltration testing completed at about 3 feet						No groundwater encountered at the time of drilling

See Figure A-1 for explanation of symbols

Icicle Creek Engineers

Boring Log - Figure A-6

Infiltration Test IT-5

Station 116+00, 15 feet east; 47.42460, -122.31070

Approximate Ground Surface Elevation: 304 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	5/8-inch-minus crushed rock (dense, moist) (Fill)							
	Weathered Asphalt (dense, dry) (Fill)							
	Light brown fine to medium SAND with silt and occasional gravel (medium dense, moist) (Recessional Outwash)							Bentonite Backfill
3			SP-SM		☒	■ (moisture, ~10%)	MC/ GS	
5								
6	Boring completed at about 6 feet on March 20, 2018 Infiltration testing completed at about 3 feet							No groundwater encountered at the time of drilling

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-6

Station 121+00, 15 feet northeast; 47.42594, -122.31108

Approximate Ground Surface Elevation: 290 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■) 20 40 60 80	Laboratory Testing	Comments/ Groundwater Observations
0	5/8-inch-minus crushed rock (dense, moist) (Fill)							
	Dark brown silty fine to coarse GRAVEL with sand and cobbles (medium dense, moist) (Fill) asphalt fragments at about 1.7 feet		GM					
	Dark brown fine to coarse GRAVEL with silt, sand and cobbles (medium dense, moist) (Fill)		GP-GM		⊠	■	MC/ GS	Bentonite Backfill
5								
	Boring completed at about 6 feet on March 20, 2018 Infiltration testing completed at about 3 feet							No groundwater encountered at the time of drilling
10								
15								
20								
25								

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-7

Station 126+00, 15 feet northeast; 47.42679, -122.31262

Approximate Ground Surface Elevation: 294 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot - ●) 20 40 60 80 / Moisture Content (Percent - ■) 20 40 60 80	Laboratory Testing	Comments/ Groundwater Observations
0	5/8-inch-minus crushed rock (dense, moist) (Fill)							
	Weathered asphalt (dense, dry) (Fill)							
	Brown silty fine to coarse GRAVEL with sand and cobbles (medium dense, moist) (Fill)		GM					
	Brown silty fine to medium SAND with gravel (loose to medium dense, moist) (Recessional Outwash)		SM		⊠	■	MC/ GS	Bentonite Backfill
5	grades to medium dense to dense, grayish-brown at about 4.5 feet							
	Boring completed at about 6 feet on March 20, 2018 Infiltration testing completed at about 3 feet							No groundwater encountered at the time of drilling
10								
15								
20								
25								

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-8

Station 131+00, 15 feet north; 47.42687, -122.31465

Approximate Ground Surface Elevation: 292 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	5/8-inch-minus crushed rock (dense, moist) (Fill)							Bentonite Backfill
	Light brown fine to coarse GRAVEL with silt, sand and asphalt fragments (dense, moist) (Fill)		GP-GM		☒	■	MC	
	Light brown fine to medium SAND with occasional gravel and a trace of silt (medium dense, moist) (Recessional Outwash)		SP		☒	■	MC/ GS	
5	Light grayish-brown SILT with a trace of sand (stiff, moist) (Advance Outwash)		ML		☒	■	MC	
	Boring completed at about 6 feet on March 21, 2018 Infiltration testing completed at about 1.5 feet							No groundwater encountered at the time of drilling
10								
15								
20								
25								

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-3 and Infiltration Test IT-9

Station 136+00, no offset; 47.42700, -122.31659

Approximate Ground Surface Elevation: 290 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/Groundwater Observations
0	Brown silty fine to medium SAND with gravel, garbage debris, and occasional silt clasts (very loose, moist) (Fill)	SM	2	MC	
		SM		MC/GS	Bentonite Backfill
		SM	3	MC	
5	grades to dark brown with woody debris, charcoal fragments and occasional gravel	SM	3	MC	Groundwater measured at 5.5 feet at the time of drilling
	Light brown silty fine to medium SAND (medium dense, wet) (Recessional Outwash)				
10		SM	11	MC	
	Light brown fine to medium SAND with silt (loose, wet) (Recessional Outwash)				
15		SP-SM	6	MC	
20	Light brown fine to medium SAND with silt and gravel (very dense*, wet) (Advance Outwash)	SP-SM	54	MC	

Boring completed at about 21.5 feet on March 26, 2018

Infiltration testing completed at about 1.5 feet

*Blow counts may not be representative because of the presence of gravel

Penetration Resistance (Blows/foot ●): 20 40 60 80

Moisture Content (Percent ■): 20 40 60 80

See Figure A-1 for explanation of symbols

Infiltration Test IT-10

Station 141+00, no offset; 47.42797, -122.31802

Approximate Ground Surface Elevation: 287 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Brown fine SAND with silt and occasional gravel (loose, moist) (Fill)	SP-SM			Bentonite Backfill
	Grayish-brown and reddish-yellow silty fine to medium SAND with occasional gravel and abundant organic fragments (loose, moist) (Alluvium)	SM	7	MC	
		SM		MC/ GS	
5	grades to with gravel, medium dense*	SM	14*	MC	
	Grayish-brown silty fine to medium SAND with occasional gravel (dense, moist) (Recessional Outwash)	SM	44	MC	No groundwater encountered at the time of drilling

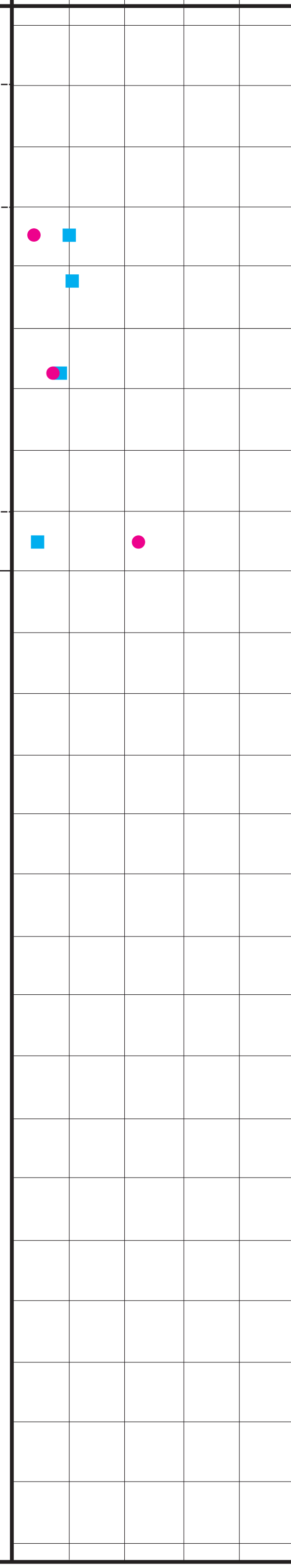
Boring completed at about 9 feet on March 26, 2018

Infiltration testing completed at about 4 feet

*Blow counts may not be representative because of the presence of gravel

Penetration Resistance (Blows/foot ●) 20 40 60 80

Moisture Content (Percent - ■) 20 40 60 80



See Figure A-1 for explanation of symbols

Infiltration Test IT-11

Station 146+00, 4 feet west; 47.42930, -122.31815

Approximate Ground Surface Elevation: 273 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							Bentonite Backfill
	Gray fine to coarse GRAVEL with silt, sand and garbage debris (dense, moist) (Fill)		GP-GM		⊠	■	MC/ GS	
5	Light brown silty fine to coarse GRAVEL with sand and occasional cobbles (dense, moist) (Recessional Outwash)		GM		⊠	■	MC	
	Boring completed at about 6 feet on March 22, 2018							No groundwater encountered at the time of drilling
	Infiltration testing completed at about 1.5 feet							
10								
15								
20								
25								

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-12

Station 151+00, 3 feet west; 47.43067, -122.31808

Approximate Ground Surface Elevation: 270 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent - ■)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							
	Gray fine to coarse GRAVEL with sand and a trace of silt (loose, moist) (Fill)		GP		⊠	■	MC/ GS	Bentonite Backfill
5	Light brown fine to coarse GRAVEL with silt and sand (medium dense, moist) (Recessional Outwash)		GP-GM		⊠	■	MC	
	Boring completed at about 6.5 feet on March 22, 2018 Infiltration testing completed at about 1.5 feet							No groundwater encountered at the time of drilling
10								
15								
20								
25								

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-4 and Infiltration Test IT-13

Station 155+90, 5 feet southwest; 47.43160, -122.31903

Approximate Ground Surface Elevation: 273 feet

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Light brown silty fine to medium SAND with gravel (very loose, moist) (Fill)	SM	1	MC	
	Light grayish-blue silty fine to medium SAND with occasional gravel (loose, moist) (Alluvium)	SM		MC/ GS	
	Dark brown PEAT (medium stiff, moist) (Alluvium)	PT	6	MC	
5	Grayish-blue silty fine to medium SAND with a trace of gravel (medium dense, moist) (Alluvium)	SM	16	MC	
	Grayish-blue sandy SILT with clay, a trace of gravel, and organic fragments (stiff, moist) (Alluvium)	ML	9	MC	Bentonite Backfill
10	grades to clayey, with sand and medium stiff	ML	5	MC	Groundwater measured at 12.9 feet (3/28/18)
15	Blueish-gray silty fine to medium SAND with occasional gravel and cobbles (dense*, wet) (Recessional Outwash)	SM	40*	MC	

Boring completed at about 16.5 feet on March 28, 2018

Infiltration testing completed at about 2 feet

*Blow counts may not be representative because of the presence of gravel

Penetration Resistance (Blows/foot ●): 20 40 60 80

Moisture Content (Percent ■): 20 40 60 80

Depth scale: 0, 5, 10, 15, 20, 25

See Figure A-1 for explanation of symbols

Boring B-5 and Infiltration Test IT-14

Station 158+40, no offset; 47.43216, -122.31956

Approximate Ground Surface Elevation: 275 feet

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Brown SAND with silt and gravel (very loose, moist) (Fill)	SP-SM	P		
	Grayish-brown silty fine to medium SAND with gravel (medium dense, moist) (Fill)	SM	6	MC	
	concrete fragments between about 1.5 and 3.5 feet	SM		MC/ GS	
		SM	25*	MC	
5		SM	10	MC	
	Grayish-blue SILT with sand and organic fragments (medium stiff, moist) (Alluvium)	ML			Bentonite Backfill
10	grades to clayey, with a trace of gravel and sand	ML	6	MC	
	Blueish-gray silty fine to medium SAND with occasional gravel and a trace of cobbles (loose, wet) (Alluvium)	SM			
15	Blueish-gray SILT with sand and a trace of gravel (very stiff, wet) (Recessional Outwash)	ML	17	MC	Groundwater measured at 15.1 feet (3/28/18)
20					
25					

Penetration Resistance (Blows/foot ●) 20 40 60 80

Moisture Content (Percent ■) 20 40 60 80

Boring completed at about 16.5 feet on March 28, 2018

Infiltration testing completed at about 2.5 feet

*Blow counts may not be representative because of the presence of gravel

See Figure A-1 for explanation of symbols

Boring B-6 and Infiltration Test IT-15

Station 161+90, no offset; 47.43312, -122.31951

Approximate Ground Surface Elevation: 275 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Light brown silty fine to medium SAND with gravel (loose, moist) (Fill)	SM			
	Light grayish-brown fine to medium SAND with silt, gravel and occasional organic fragments (medium dense, moist) (Fill)	SP-SM	10	MC	
		SP-SM		MC/ GS	
	concrete and brick fragments between about 1.5 feet and 4 feet	SP-SM	42*	MC	
5		SP-SM	19	MC	
	Grayish-blue clayey SILT with a trace of sand and gravel, and organic fragments (medium stiff, moist) (Alluvium)	ML			Bentonite Backfill
	Grayish-blue fine to medium SAND with silt (loose, wet) (Alluvium)				Groundwater encountered at about 9 feet at the time of drilling
10	buried log at about 10 feet	SP-SM	9	MC	
	grades to with occasional cobbles at about 14 feet				
15	grades to with a trace of gravel	SP-SM			
	Grayish-blue clayey SILT with a trace of sand and gravel (soft, wet) (Alluvium)	ML	3	MC	
20	Light grayish-blue silty fine to medium SAND with occasional gravel (very dense*, wet) (Recessional Outwash)	SM	53*	MC	
	Boring completed at about 21.5 feet on March 28, 2018				
	Infiltration testing completed at about 2.5 feet				
	*Blow counts may not be representative because of the presence of gravel				
25					

Penetration Resistance (Blows/foot - ●) 20 40 60 80

Moisture Content (Percent - ■) 20 40 60 80

See Figure A-1 for explanation of symbols

Boring B-7(p) and Infiltration Test IT-16

Station 164+45, 3 feet east; 47.43382, -122.31944

Approximate Ground Surface Elevation: 279 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

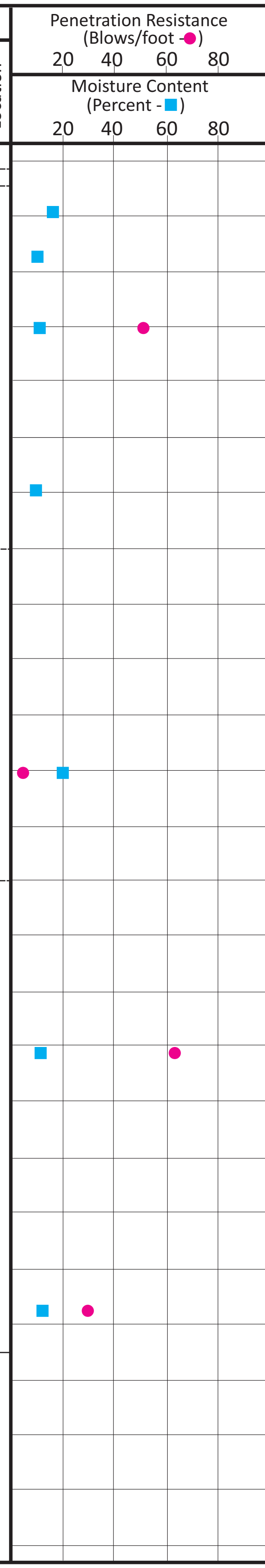
ICE File No. 0105-023

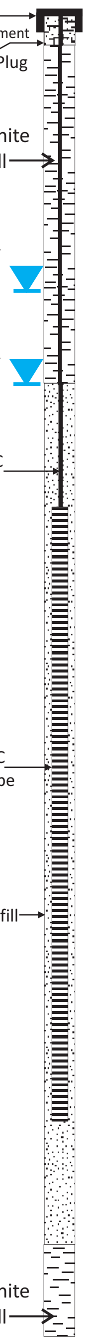
Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing
0	Sod and Topsoil			
	Light brown silty fine SAND with occasional gravel (loose, moist) (Fill)	SM		
	Gray fine to coarse GRAVEL with silt and sand (very dense*, moist) (Fill)	GP-GM	50/5"*	MC
		GP-GM		MC/GS
		GP-GM	52*	MC
		GP-GM	50/5"*	MC
7	Light gray clayey SILT with a trace of sand, gravel and organic fragments (soft, moist) (Alluvium)			
		ML	3	MC
13	Light gray silty fine to medium SAND with occasional gravel (very dense*, moist) (Recessional Outwash)			
		SM	63*	MC
	grades to gray, with a trace of gravel, and medium dense	SM	30	MC

Boring completed at about 21.5 feet on March 23, 2018

Infiltration testing completed at about 1.5 feet

*Blow counts may not be representative because of the presence of gravel





Comments/Groundwater Observations:

- Flush Grade Steel Monument
- Concrete Plug
- Bentonite Backfill
- Groundwater measured at 4.5 feet (4/6/18)
- Groundwater measured at 6.0 feet (9/21/18)
- 2-inch PVC Solid Pipe
- 2-inch PVC Slotted Pipe
- Sand Backfill
- Bentonite Backfill

See Figure A-1 for explanation of symbols

Boring B-8

Station 168+50, no offset; 47.43404, -122.32075

Approximate Ground Surface Elevation: 283 feet

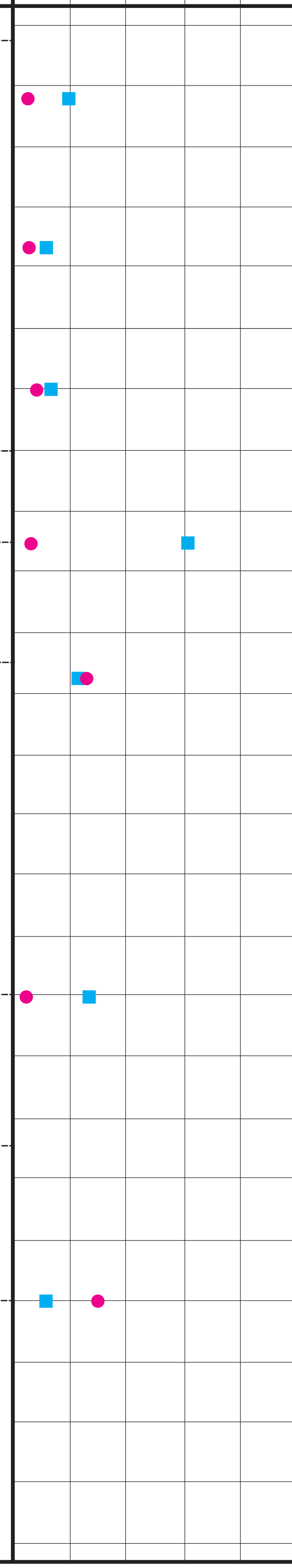
Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Grayish-brown silty fine to medium SAND (loose, moist) (Fill)	SM	4	MC	
	grades to gray, with occasional gravel and organic fragments	SM	4	MC	
5	grades to grayish-brown, with gravel and cobbles	SM	7	MC	
	Dark brown PEAT (medium stiff, moist) (Alluvium)	PT	5		
	Grayish-blue sandy SILT with organic fragments (medium stiff, moist) (Alluvium)	ML			Groundwater encountered at about 9 feet (4/4/18)
10		ML			
	Grayish-blue silty fine to medium SAND with occasional gravel and abundant organic fragments (medium dense, moist to wet) (Alluvium)	SM	25	MC	Bentonite Backfill
15		SM			
	Grayish-blue clayey SILT with sand (soft, wet) (Alluvium)	ML	3	MC	
	Gray silty fine to medium SAND with occasional gravel (medium dense, wet) (Recessional Outwash)	SM	31	MC	
20	Light gray silty fine to medium SAND with gravel (very dense*, moist) (Glacial Till)	SM			
25					

Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)



See Figure A-1 for explanation of symbols

Boring B-8

Depth in Feet	Soil Profile: Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■) 20 40 60 80	Laboratory Testing	Comments/ Groundwater Observations
25	Light gray silty fine to medium SAND with gravel (very dense, moist) (Glacial Till)		SM	95			MC	Bentonite Backfill
	Boring completed at about 26.5 feet on April 4, 2018							
	*Blow count may not be representative because of presence of gravel							
30								
35								
40								
45								
50								

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-17

Station 172+90, no offset; 47.43425, -122.32233

Approximate Ground Surface Elevation: 298 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							
	Brown fine to medium SAND with silt and occasional gravel (loose, moist) (Alluvium)		SP-SM		☒	■	MC/ GS	Bentonite Backfill
	Light brown fine SAND with a trace of silt (loose, moist) (Alluvium)							
5			SP		☒	■	MC	
	grades to with occasional gravel							
	Boring completed at about 7.5 feet on April 4, 2018							No groundwater encountered at the time of drilling
	Infiltration testing completed at about 2 feet							
10								
15								
20								
25								

Penetration Resistance / Moisture Content scale: 20, 40, 60, 80

See Figure A-1 for explanation of symbols

Boring B-9(p)

Station 173+40, 45 feet east; 47.43439, -122.32208

Approximate Ground Surface Elevation: 291 feet

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				Flush Grade Steel Monument; Concrete Plug
	Light brown fine to medium SAND with silt (very loose, moist) (Alluvium)	SP-SM	1	MC	Bentonite Backfill
	Light brownish-gray fine to medium SAND with a trace of silt and gravel (loose, moist) (Alluvium)	SP	8	MC	2-inch PVC Solid Pipe; Groundwater measured at 3.6 feet (4/6/18)
5	Light grayish-brown fine to medium SAND with silt and a trace of wood fragments (medium dense, wet) (Alluvium)	SP-SM	11	MC	2-inch PVC Slotted Pipe
	grades to with a trace of gravel	SP-SM	18	MC	Groundwater measured at 9.0 feet (7/30/19)
10	grades to with occasional gravel	SP-SM	15	MC	Sand Backfill
	Gray silty fine to medium SAND with occasional gravel (medium dense, moist) (Alluvium)	SM			
	Gray sandy SILT with occasional gravel and a trace of organic fragments (very stiff, moist) (Alluvium)	ML	30	MC	
15	grades to with a trace of gravel	ML			
	Light gray silty fine SAND (medium dense, moist) (Alluvium)	SM	22	MC	
	Light brownish-gray sandy SILT with a trace of wood fragments (very stiff, moist) (Alluvium)	ML	30	MC	Bentonite Backfill
	Light gray fine to medium SAND with silt (medium dense, moist) (Alluvium)	SP-SM	24	MC	
20	Boring completed at about 21.5 feet on April 4, 2018				
25					

Penetration Resistance (Blows/foot ●) 20 40 60 80; Moisture Content (Percent ■) 20 40 60 80

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-18a

Station 179+90, no offset; 47.43609, -122.32215

Approximate Ground Surface Elevation: 296 feet

Depth in Feet	Soil Profile: Description	Graphic Log	Sample Data: Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							
	Dark reddish-brown silty fine to medium SAND with occasional gravel (loose, wet) (Alluvium)		SM		⊠	Moisture ~30%	MC	Groundwater measured at 1.5 feet (4/4/18); Bentonite Backfill
	Grayish-brown fine to medium SAND with silt and occasional gravel (loose, wet) (Alluvium)		SP-SM					
5	Boring completed at about 4.5 feet on April 4, 2018 Due to shallow groundwater, infiltration testing was not completed at this location							
10								
15								
20								
25								

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-18b

Station 180+40, no offset; 47.43621, -122.32215

Approximate Ground Surface Elevation: 299 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Sample Location	Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil						
	Light brown fine to medium SAND with silt and gravel (loose, moist to wet) (Alluvium)	SP-SM		☒	■	MC/ GS	Groundwater measured at 3.0 feet (4/4/18)
	grades to grayish-brown at about 3.5 feet						Bentonite Backfill
5	Grayish-brown sandy SILT with a trace of gravel (medium stiff, moist) (Recessional Outwash)	ML		☒	■	MC	
	Boring completed at about 6 feet on April 4, 2018						
	Infiltration testing completed at about 1.5 feet						

Depth scale: 0, 5, 10, 15, 20, 25 feet. Penetration Resistance (Blows/foot ●) and Moisture Content (Percent ■) scales: 20, 40, 60, 80.

See Figure A-1 for explanation of symbols

Boring B-10(p)

Station 180+25, 35 feet east; 47.43619, -122.32200

Approximate Ground Surface Elevation: 295 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				Flush Grade; Steel Monument; Concrete; Plug; Groundwater measured at 1.0 feet (4/6/18)
	Brownish-gray fine to medium SAND with silt and organic fragments (loose, wet) (Alluvium)	SP-SM			2-inch PVC Solid Pipe; 2-inch PVC Slotted Pipe
	Dark brown PEAT (soft, wet) (Alluvium)	PT		MC	
	Grayish-brown sandy SILT with a trace of gravel (medium stiff, moist) (Recessional Outwash)	ML	8		Groundwater measured at 6.4 feet (9/21/18)
	Grayish-brown silty fine to medium SAND with occasional gravel (medium dense, wet) (Recessional Outwash)	SM	14	MC	
10	grades to dense	SM	30*	MC	Sand Backfill
	Gray silty fine to medium SAND with occasional gravel (very dense, moist) (Glacial Till)	SM	91	MC	
15	grades to with gravel	SM	50/5"*	MC	
	grades to with occasional gravel	SM	50/3"	MC	Bentonite Backfill
20		SM	50/4"	MC	
	Boring completed at about 20.3 feet on April 4, 2018				
25	*Blow counts may not be representative because of the presence of gravel				

Penetration Resistance (Blows/foot) and Moisture Content (Percent) scales: 20, 40, 60, 80

See Figure A-1 for explanation of symbols

Infiltration Test IT-19a(p)

Station 184+90, no offset; 47.43744, -122.32240

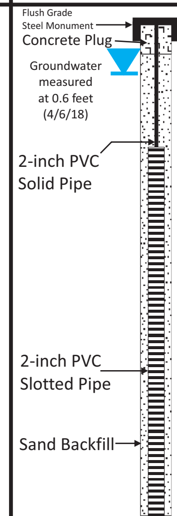
Approximate Ground Surface Elevation: 316 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Soil Profile: Description	Graphic Log	Sample Data: Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent - ■)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							
	Brown fine to medium SAND with silt and a trace of gravel (loose, wet) (Alluvium)		SP-SM					
	Light gray, brown and reddish-yellow sandy SILT with occasional gravel (medium stiff, moist) (Alluvium)							
5			ML		⊠	■ ~20	MC	
	Light gray silty fine to medium SAND with occasional gravel (medium dense, wet) (Alluvium)							
			SM		⊠	■ ~29	MC	
	Boring completed at about 8 feet on April 6, 2018							No groundwater measured (9/21/18)
	Due to shallow groundwater, infiltration testing was not completed at this location							
10								
15								
20								
25								



See Figure A-1 for explanation of symbols

Infiltration Test IT-19b

Station 185+30, 10 feet east; 47.43754, -122.32242

Approximate Ground Surface Elevation: 317 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent) 20 40 60 80	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							Bentonite Backfill
	Brown fine to medium SAND with silt and a trace of gravel (loose, moist) (Alluvium)		SP-SM		☒	■ (~25%)	MC/ GS	
	Boring completed at about 1.5 feet on April 6, 2018							No groundwater encountered at the time of drilling
	Infiltration testing completed at about 1.5 feet							
5								
10								
15								
20								
25								

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-11

Station 187+60, 6 feet west; 47.43816, -122.32264

Approximate Ground Surface Elevation: 323 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Grayish-brown silty fine to medium SAND with occasional gravel (medium dense, moist) (Alluvium)	SM	12	MC	
	Light brownish-gray and yellowish-red SILT with sand, a trace of gravel, and organic fragments (medium stiff, moist) (Alluvium)	ML	5	MC	
5	grades to stiff	ML	12	MC	
	Grayish-brown silty fine to medium SAND with occasional gravel (medium dense, wet) (Recessional Outwash)				Groundwater encountered at about 9 feet (4/6/18)
10		SM	26	MC	Bentonite Backfill
	Brownish-gray silty fine to medium SAND with occasional gravel and cobbles (very dense, moist) (Glacial Till)				
15		SM	50/5.5"	MC	
	grades with gravel and cobbles at about 17.5 feet				
20	grades to gray	SM	50/6"	MC	
	Boring completed at about 20.5 feet on April 6, 2018				
	*Blow count may not be representative because of presence of gravel				
25					

Penetration Resistance (Blows/foot ●) 20 40 60 80; Moisture Content (Percent ■) 20 40 60 80

See Figure A-1 for explanation of symbols

Infiltration Test IT-20

Station 189+90, 7 feet northeast; 47.43874, -122.32298

Approximate Ground Surface Elevation: 324 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							Bentonite Backfill
	Light brown sandy SILT with a trace of gravel (soft, moist) (Alluvium)		ML		☒	■	MC/ GS	Groundwater measured at 3.4 feet (3/30/18)
5	Light brown silty fine to medium SAND with occasional gravel (medium dense, wet) (Recessional Outwash)		SM		☒	■	MC	
	Boring completed at about 6 feet on March 30, 2018 Infiltration testing completed at about 1.5 feet							
10								
15								
20								
25								

Penetration Resistance / Moisture Content scale: 20, 40, 60, 80

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-12 and Infiltration Test IT-21

Station 197+85, 5 feet northeast; 47.44029, -122.32511

Approximate Ground Surface Elevation: 326 feet

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Soil Profile – Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	5/8-inch-minus crushed rock (dense, moist) (Fill)				
	Brown fine to medium SAND with silt, gravel, organic fragments and asphalt fragments (medium dense, moist) (Fill)	SP-SM	16	MC	
		SP-SM		MC/ GS	
	Reddish-brown sandy SILT with gravel, cobbles and organic fragments (medium stiff, moist) (Fill)	ML	4	MC	
5	Light brown sandy SILT with a trace of gravel (stiff, moist) (Recessional Outwash)	ML	10	MC	Bentonite Backfill
	Grayish-brown silty fine to medium SAND with gravel (dense*, moist) (Glacial Till)				Groundwater measured at 8.5 feet (3/30/18)
10		SM	38	MC	
15	grades to gray, very dense	SM	50/5”	MC	
	Boring completed at about 15.4 feet on March 30, 2018				
	Infiltration testing completed at about 1.5 feet				
	*Blow counts may not be representative because of the presence of gravel				
20					
25					

Penetration Resistance (Blows/foot ●): 20 40 60 80

Moisture Content (Percent ■): 20 40 60 80

See Figure A-1 for explanation of symbols

Boring B-13

Station 202+85, 10 feet northeast; 47.44116, -122.32668

Approximate Ground Surface Elevation: 308 feet

Depth in Feet	Description	Group Symbol	Blow Count	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	Asphalt Pavement (6 inches)					
	5/8-inch-minus crushed rock					
	Brown silty fine to medium SAND with gravel and cobbles (loose, moist) (Fill)	SM	7		MC	
	grades to grayish-brown, with a trace of gravel and cobbles boring relocated 4'2" northeast due to utility conflict	SM	4		MC	
5	Grayish-brown silty fine to medium SAND with occasional gravel and cobbles (very dense, moist) (Glacial Till)	SM	50/5.5"		MC	
						Bentonite Backfill
10	grades to light gray	SM	50/6"		MC	
	Grayish-brown silty fine to coarse SAND with gravel (very dense, moist) (Advance Outwash)					
15		SM	71		MC	
	Boring completed at about 16.5 feet on March 30, 2018					No groundwater encountered at the time of drilling
	*Blow counts may not be representative because of the presence of gravel					
20						
25						

Logged by: SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Infiltration Test IT-22

Station 203+15, 3 feet northeast; 47.44120, -122.32678

Approximate Ground Surface Elevation: 306 feet

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot -●) 20 40 60 80 / Moisture Content (Percent -■) 20 40 60 80	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							Bentonite Backfill
	Grayish-brown silty fine to medium SAND with gravel and occasional cobbles (very dense, moist) (Glacial Till)		GP-GM		☒	■	MC/ GS	
	Boring completed at about 1.5 feet on March 30, 2018							No groundwater encountered at the time of drilling
	Infiltration testing completed at about 1.5 feet							
5								
10								
15								
20								
25								

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-14 and Infiltration Test IT-23

Station 205+80, 3 feet southwest; 47.44167, -122.32762

Approximate Ground Surface Elevation: 297 feet

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Grayish-brown fine to coarse GRAVEL with sand, cobbles and a trace of silt (medium dense*, moist) (Fill)	GP	17	MC	
		GP		MC/ GS	
	Light brown fine to medium SAND with silt, gravel and cobbles (loose, moist) (Recessional Outwash)	SP-SM	5	MC	
5	grades to medium dense	SP-SM	24*	MC	
					Bentonite Backfill
10	grades to without gravel and cobbles	SP-SM	19	MC	
	Light brown fine to medium SAND with silt and occasional gravel (very dense, moist to wet) (Advance Outwash)				
15		SP-SM	52	MC	
					Groundwater measured at 19.2 feet (3/30/18)
20	grades to with a trace of gravel, dense	SP-SM	40	MC	
25					

Penetration Resistance (Blows/foot ●) scale: 20, 40, 60, 80

Moisture Content (Percent ■) scale: 20, 40, 60, 80

Boring completed at about 21.5 feet on March 30, 2018

Infiltration testing completed at about 1.5 feet

*Blow counts may not be representative because of the presence of gravel

See Figure A-1 for explanation of symbols

Boring B-15 and Infiltration Test IT-24

Station 210+05, 3 feet northeast; 47.44247, -122.32877

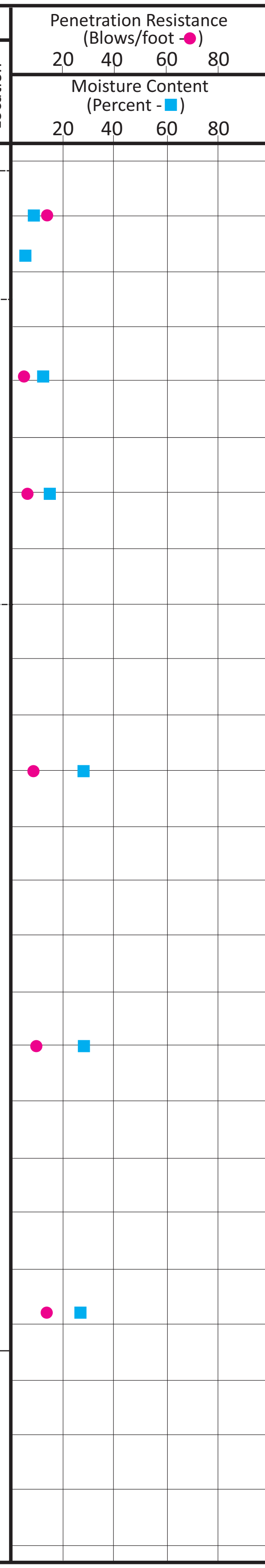
Approximate Ground Surface Elevation: 279 feet

Logged by: SIM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil				
	Dark brown fine to coarse GRAVEL with silt, sand, and cobbles (medium dense*, moist) (Fill)	GP-GM	16	MC	
		GP-GM		MC/ GS	
	Light brown silty fine to medium SAND with gravel (very loose, moist) (Recessional Outwash)	SM	3	MC	
5	grades to gray, loose, with occasional gravel	SM	4	MC	Bentonite Backfill
	Light brown SILT with clay and a trace of sand (medium stiff, moist) (Recessional Outwash)				
10		ML	7	MC	
15	grades to light grayish-brown, sandy, stiff and without clay	ML	9	MC	
20		ML	15	MC	
	Boring completed at about 21.5 feet on March 27, 2018				No groundwater encountered at the time of drilling
	Infiltration testing completed at about 1.5 feet				
25	*Blow counts may not be representative because of the presence of gravel				



See Figure A-1 for explanation of symbols

Boring B-16

Station 188+10, 40 feet east; 47.43832, -122.32251

Approximate Ground Surface Elevation: 347 feet

Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	6 inches of asphalt pavement				Fast-setting Concrete (dyed to match at surface)
	Brown fine to medium SAND with silt and gravel (medium dense, moist) (Fill)	SP-SM			
	Gray silty fine to medium SAND with occasional gravel (medium dense, moist) (Fill)				Crushed Rock Backfill
5		SM	20	MC	
10	grades to with a trace of gravel	SM	16	MC	Bentonite Backfill
15		SM	19	MC	
20	grades to dense	SM	33	MC	
	grades to medium dense	SM	28	MC	
25					

Penetration Resistance (Blows/foot ●) 20 40 60 80; Moisture Content (Percent ■) 20 40 60 80

See Figure A-1 for explanation of symbols

Boring B-16

Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
25	Gray silty fine to medium SAND with occasional gravel (medium dense, moist) (Fill)	SM	21	MC	Bentonite Backfill
	Gray and brown sandy CLAY (medium stiff, moist) (Alluvium)	CL	7	MC	
30	Gray silty fine to medium SAND with a trace of gravel (medium dense, moist) (Alluvium)	SM	27	MC	
	Boring completed at about 31.5 feet on December 11, 2018				No groundwater encountered at the time of drilling

See Figure A-1 for explanation of symbols

Boring B-17

Station 187+25, 40 feet east; 47.43808, -122.32243

Approximate Ground Surface Elevation: 344 feet

Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	6 inches of asphalt pavement				Fast-setting Concrete (dyed to match at surface)
	Brown fine to medium SAND with silt, gravel and occasional cobbles (medium dense, moist) (Fill)	SP-SM			
	Gray silty fine to medium SAND with occasional gravel (medium dense, moist) (Fill)				Crushed Rock Backfill
5		SM	17	MC	
10		SM	21	MC	Bentonite Backfill
15		SM	19	MC	
20	grades to with a trace of gravel	SM	19	MC	
	grades to with occasional gravel	SM	24	MC	
25					

Penetration Resistance (Blows/foot ●): 20 40 60 80
Moisture Content (Percent ■): 20 40 60 80

See Figure A-1 for explanation of symbols

Boring B-17

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)	Laboratory Testing	Comments/ Groundwater Observations
25	Gray silty fine to medium SAND with occasional gravel (medium dense, moist) (Fill)		SM	28			MC	Bentonite Backfill
	Gray CLAY with trace organic fragments (stiff, moist) (Alluvium)		CL	14			MC	
30	Gray silty fine to medium SAND with a trace of gravel (dense, moist to wet) (Recessional Outwash)		SM	35			MC	Groundwater encountered at about 31.9 feet at the time of drilling
35			SM	50/5”			MC	
	Boring completed at about 36.5 feet on December 11, 2018							
40								
45								
50								

Penetration Resistance (Blows/foot ●): 20 40 60 80
Moisture Content (Percent ■): 20 40 60 80

Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-18

Station 188+65, 12 feet west; 47.43842, -122.32278

Approximate Ground Surface Elevation: 323 feet

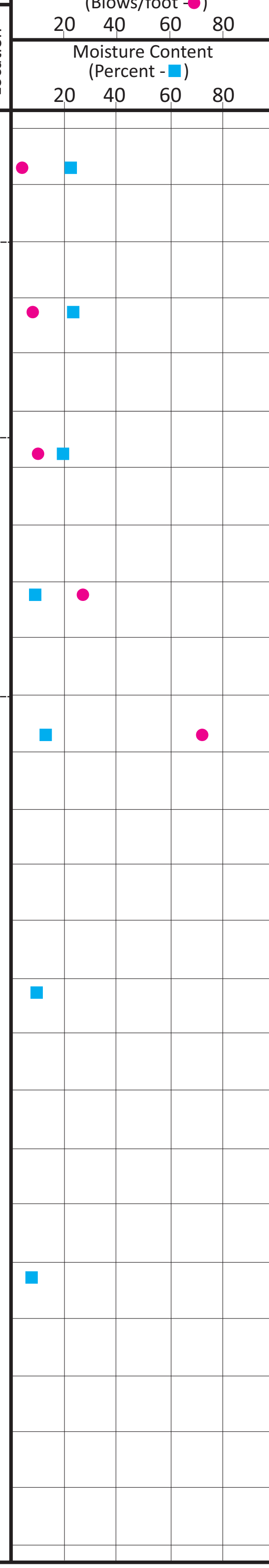
Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Brown and gray silty fine to medium SAND with occasional gravel and organic fragments (very loose, moist) (Alluvium)	SM	3	MC, GS	
	Grayish-brown and reddish-brown CLAY with fine sand (medium stiff to stiff, moist) (Alluvium)	CL	8	MC,AL	
5	Grayish-brown silty fine to medium SAND with occasional fine gravel (loose to medium dense, moist) (Recessional Outwash)	SM	10	MC	
	grades to medium dense and wet	SM	27	MC,GS	Groundwater encountered at about 9 feet at the time of drilling
10	Grayish-brown silty fine to medium SAND with a trace of gravel (very dense, moist) (Glacial Till)	SM	72	MC	Bentonite Backfill
15		SM	50/5”	MC	
20		SM	50/5”	MC	
25					

Penetration Resistance (Blows/foot ●) / Moisture Content (Percent ■)



See Figure A-1 for explanation of symbols

Boring B-18

Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Soil Profile – Description	Group Symbol	Blow Count	Sample Location	Laboratory Testing	Comments/ Groundwater Observations
25	Gray silty fine to medium SAND with occasional gravel (very dense, moist) (Glacial Till)	SM	50/5"	◨	MC	Bentonite Backfill
30	grades to grayish-brown	SM	50/5"	◨	MC	
	Boring completed at about 30.5 feet on December 12, 2018					
35						
40						
45						
50						

Penetration Resistance (Blows/foot ●): 20 40 60 80

Moisture Content (Percent ■): 20 40 60 80

See Figure A-1 for explanation of symbols

Boring B-19(p)

Station 188+10, 10 feet west; 47.43828, -122.32271

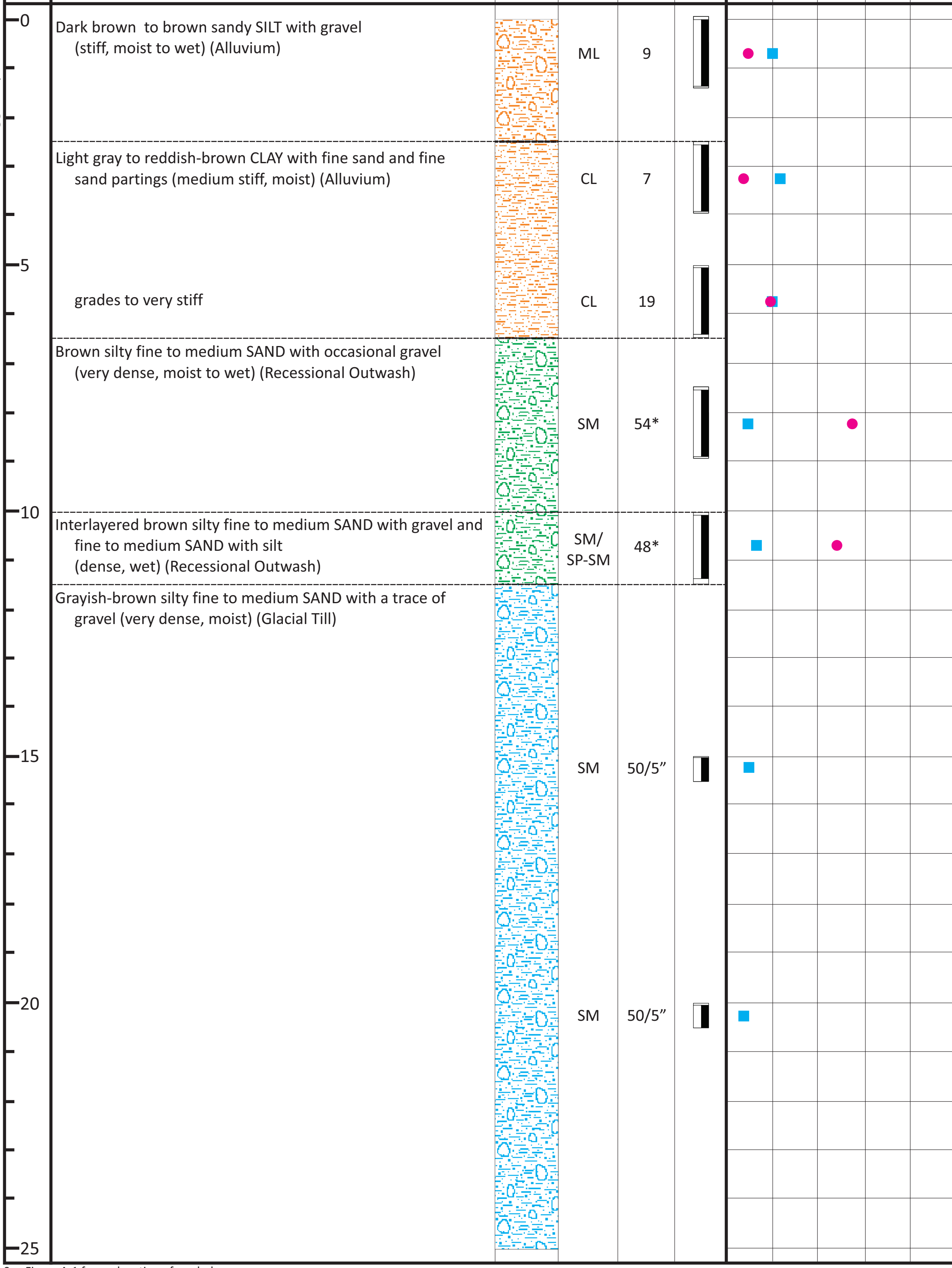
Approximate Ground Surface Elevation: 322 feet

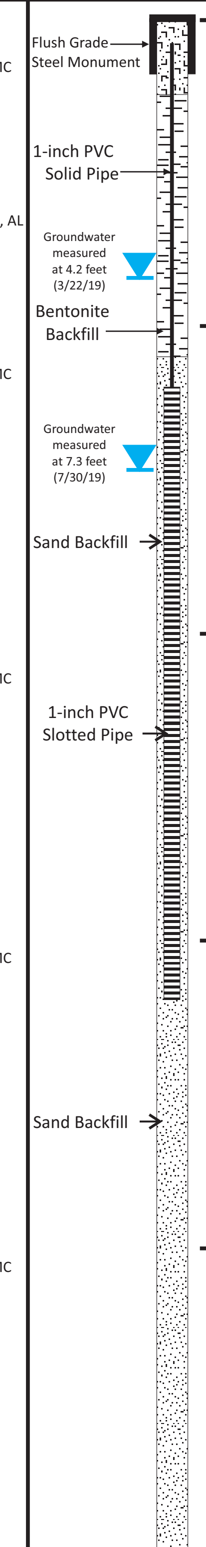
Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Soil Profile – Description	Group Symbol	Blow Count	Laboratory Testing
Dark brown to brown sandy SILT with gravel (stiff, moist to wet) (Alluvium)	ML	9	MC
Light gray to reddish-brown CLAY with fine sand and fine sand partings (medium stiff, moist) (Alluvium)	CL	7	MC, AL
grades to very stiff	CL	19	MC
Brown silty fine to medium SAND with occasional gravel (very dense, moist to wet) (Recessional Outwash)	SM	54*	
Interlayered brown silty fine to medium SAND with gravel and fine to medium SAND with silt (dense, wet) (Recessional Outwash)	SM/ SP-SM	48*	MC
Grayish-brown silty fine to medium SAND with a trace of gravel (very dense, moist) (Glacial Till)	SM	50/5”	MC
	SM	50/5”	MC





See Figure A-1 for explanation of symbols

Boring B-19(p)

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
25	Grayish-brown silty fine to medium SAND with occasional gravel (very dense, moist) (Glacial Till)		SM	50/4"			MC	Sand Backfill
30			SM	50/4"			MC	
	Boring completed at about 30.3 feet on December 17, 2018							

Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Boring B-20

Station 186+90, 12 feet west; 47.43799, -122.32262

Approximate Ground Surface Elevation: 319 feet

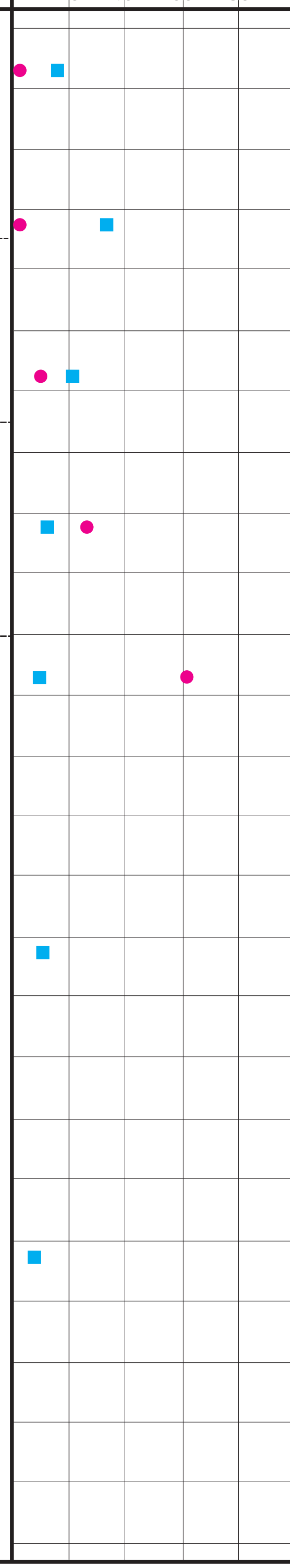
Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Depth in Feet	Description	Group Symbol	Blow Count	Laboratory Testing	Comments/ Groundwater Observations
0	Brown and gray silty fine to medium SAND with occasional gravel and abundant organic fragments (very loose, moist to wet) (Alluvium)	SM	2	MC	Perched groundwater encountered at about 2 feet at the time of drilling
		SM	2	MC	
	Brown and gray CLAY with sand and a trace of fine gravel (very soft to soft, moist) (Alluvium)	CL			
5	grades to grayish-brown to reddish-brown with fine sand partings and stiff	CL	10	MC, AL	Groundwater encountered at about 7.5 feet at the time of drilling
	Grayish-brown silty fine to medium SAND with occasional gravel (medium dense, wet) (Recessional Outwash)	SM	26	MC, GS	
10	Grayish-brown silty fine to medium SAND with a trace of gravel (very dense, moist) (Glacial Till)	SM	61	MC	Bentonite and Sand Backfill
15		SM	50/5”	MC	
20		SM	50/5”	MC	
25					

Penetration Resistance (Blows/foot - ●) 20 40 60 80; Moisture Content (Percent - ■) 20 40 60 80



See Figure A-1 for explanation of symbols

Boring B-20

Depth in Feet	Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot ●) 20 40 60 80 / Moisture Content (Percent ■) 20 40 60 80	Laboratory Testing	Comments/ Groundwater Observations
25	Gray silty fine to medium SAND with gravel (very dense, moist) (Glacial Till)		SM	50/5"			MC	Bentonite Backfill
30	grades to grayish-brown		SM	50/5"			MC	
	Boring completed at about 30.5 feet on December 12, 2018							
35								
40								
45								
50								

Logged by: JMS

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

SJM:12/18/18

Test Hole TH-1

Station 188+35, 10 feet east; 47.43838, -122.32263

Approximate Ground Surface Elevation: 333 feet

Logged by:SJM

Depth in Feet	Soil Profile – Description	Graphic Log	Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	Quarry Spalls							
	Dark gray silty fine to medium SAND with occasional gravel and cobbles (loose, moist) (Fill)		SM		☒	■	MC	
	Light gray silty fine to medium SAND with a trace of gravel (medium dense to dense, wet) (Fill)		SM					
	grades to moist at about 2.0 feet							Native Backfill
	grades to with occasional gravel at about 3.0 feet		SM		☒	■	MC, GS (composite)	
5	grades to with occasional wood fragments at about 5.5 feet		SM		☒	■	MC	
	Boring completed at about 6.0 feet on December 17, 2018 due to practical digging refusal							No groundwater encountered at the time of drilling

Depth scale: 0, 5, 10, 15, 20, 25

Penetration Resistance (Blows/foot ●) scale: 20, 40, 60, 80

Moisture Content (Percent ■) scale: 20, 40, 60, 80

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

See Figure A-1 for explanation of symbols

Test Hole TH-2

Station 187+30, 15 feet east; 47.43818, -122.32261

SJM:12/18/18

Logged by:SJM

Project Name: King County Parks, Lake to Sound Trail, Segment C

ICE File No. 0105-023

Approximate Ground Surface Elevation: 330 feet

Depth in Feet	Soil Profile: Description	Graphic Log	Sample Data: Group Symbol	Blow Count	Sample Location	Penetration Resistance (Blows/foot) / Moisture Content (Percent)	Laboratory Testing	Comments/ Groundwater Observations
0	Sod and Topsoil							
	Dark gray fine to medium SAND with silt and occasional gravel and cobbles (loose, moist) (Fill)		SP-SM		☒	■	MC	
	Light gray silty fine to medium SAND with gravel and cobbles (medium dense, moist) (Fill)		SM		☒	■	MC	Native Backfill
	grades to without cobbles, medium dense to dense, wet at about 3.0 feet		SM		☒	■	MC	
	grades to moist at about 4.0 feet grades to with cobbles at about 4.5 feet							
5							GS (composite)	
			SM		☒	■	MC	
	Boring completed at about 8.0 feet on December 17, 2018 due to practical digging refusal							No groundwater encountered at the time of drilling
10								
15								
20								
25								

Chart scales: 20, 40, 60, 80

See Figure A-1 for explanation of symbols

APPENDIX B

LABORATORY TESTING PROGRAM

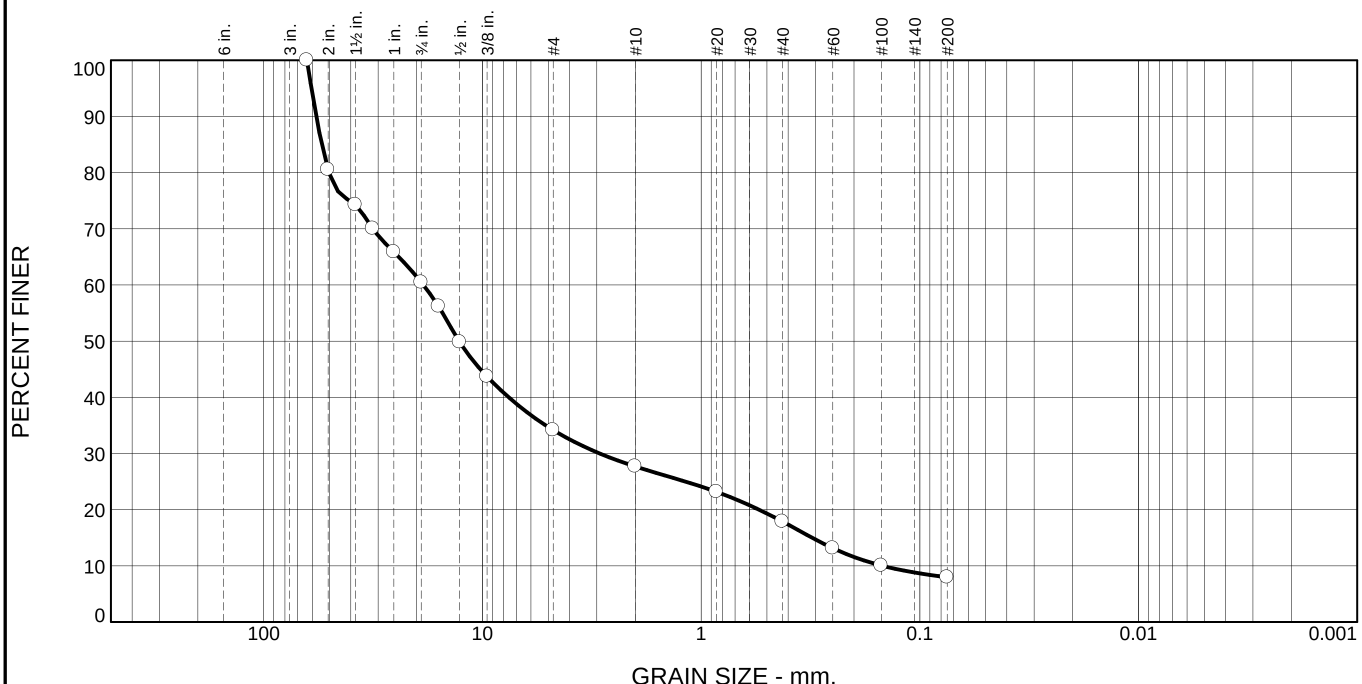
APPENDIX B

B.0 LABORATORY TESTING PROGRAM

The soil samples obtained from the subsurface explorations were returned to ICE's laboratory for further visual examination and laboratory testing. Soil samples were tested to determine moisture content in general accordance with ASTM Test Method D 2216. The results of the moisture content tests are presented on the boring logs, infiltration test logs and test hole logs in Appendix A.

The laboratory testing program included particle size distribution (grain size analysis) by ASTM Test Method D422 on soil samples obtained from the infiltration test locations. The test results are presented on Figures B-1 through B-24 (Particle Size Distribution Reports) in this appendix. The laboratory testing program also included particle size distribution (ASTM Test Method D 422) and Atterberg Limits (ASTM Test Method D 4318) in the vicinity of the proposed Wall #15 at the SR 509 Ramp. These test results are presented on Figures B-25 through B-29 (Particle Size Distribution Reports) and Figure B-30 (Atterberg Limits – Liquid and Plastic Limits Test Report) in this appendix.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	39.5	26.3	6.5	9.8	9.9	8.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2 1/2	100.0		
2	80.5		
1 1/2	74.3		
1 1/4	70.0		
1	65.9		
3/4	60.5		
5/8	56.2		
1/2	49.8		
3/8	43.7		
#4	34.2		
#10	27.7		
#20	23.2		
#40	17.9		
#60	13.1		
#100	10.1		
#200	8.0		

* (no specification provided)

Material Description

Light brown fine to coarse GRAVEL with silt and sand

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= GP-GM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 57.4588 D_{85}= 54.2522 D_{60}= 18.6288
D_{50}= 12.7898 D_{30}= 2.9093 D_{15}= 0.3103
D_{10}= 0.1479 C_u= 125.93 C_c= 3.07

Remarks

Moisture Content 5%. Sampled by SJM.

Date Received: 03/20/2018 **Date Tested:** 03/27/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

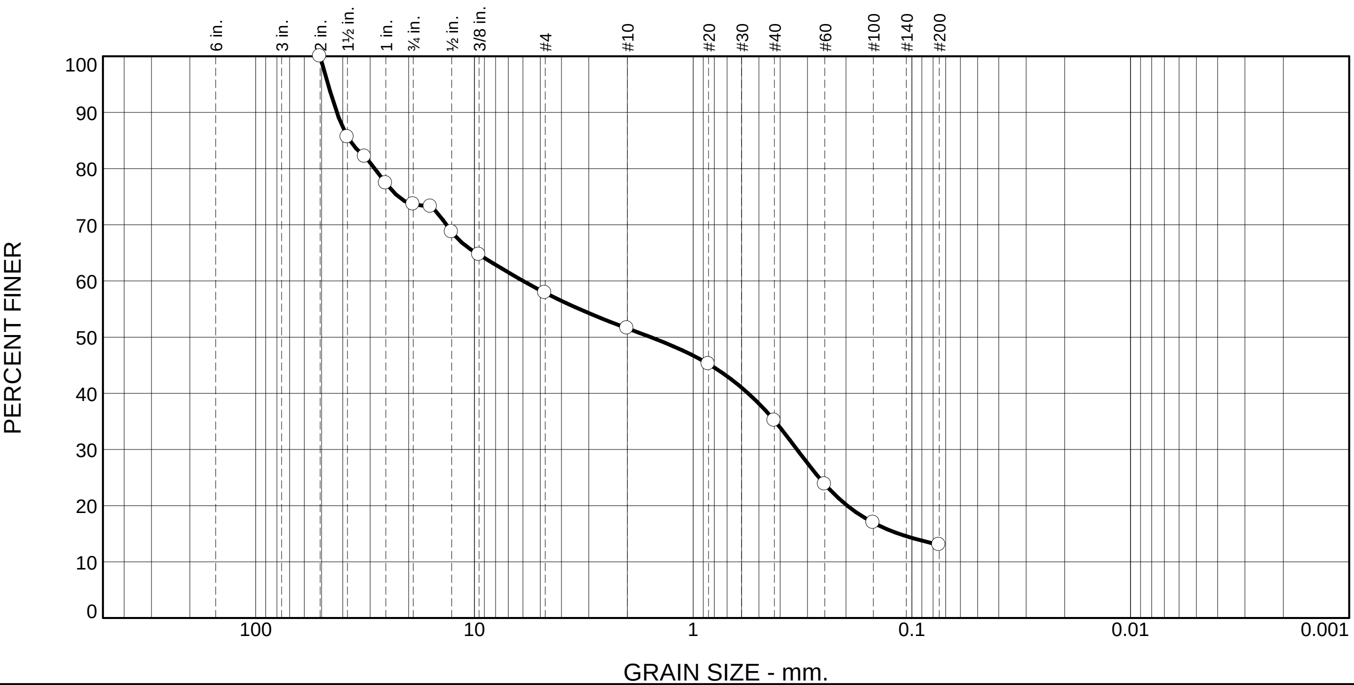
Source of Sample: Infiltration Test **Depth:** 3 feet **Date Sampled:** 03/19/2018
Sample Number: IT-1, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-1

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	26.4	15.7	6.3	16.5	22.1	13.0	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1 1/2	85.6		
1 1/4	82.2		
1	77.4		
3/4	73.6		
5/8	73.2		
1/2	68.7		
3/8	64.7		
#4	57.9		
#10	51.6		
#20	45.2		
#40	35.1		
#60	23.8		
#100	17.0		
#200	13.0		

* (no specification provided)

Material Description

Light brown silty fine to medium SAND with gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 42.5502 D_{85}= 37.2745 D_{60}= 5.9842
D_{50}= 1.5635 D_{30}= 0.3349 D_{15}= 0.1145
D_{10}= C_u= C_c=

Remarks

Moisture Content 10%. Sampled by SJM.

Date Received: 03/20/2018 **Date Tested:** 03/27/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

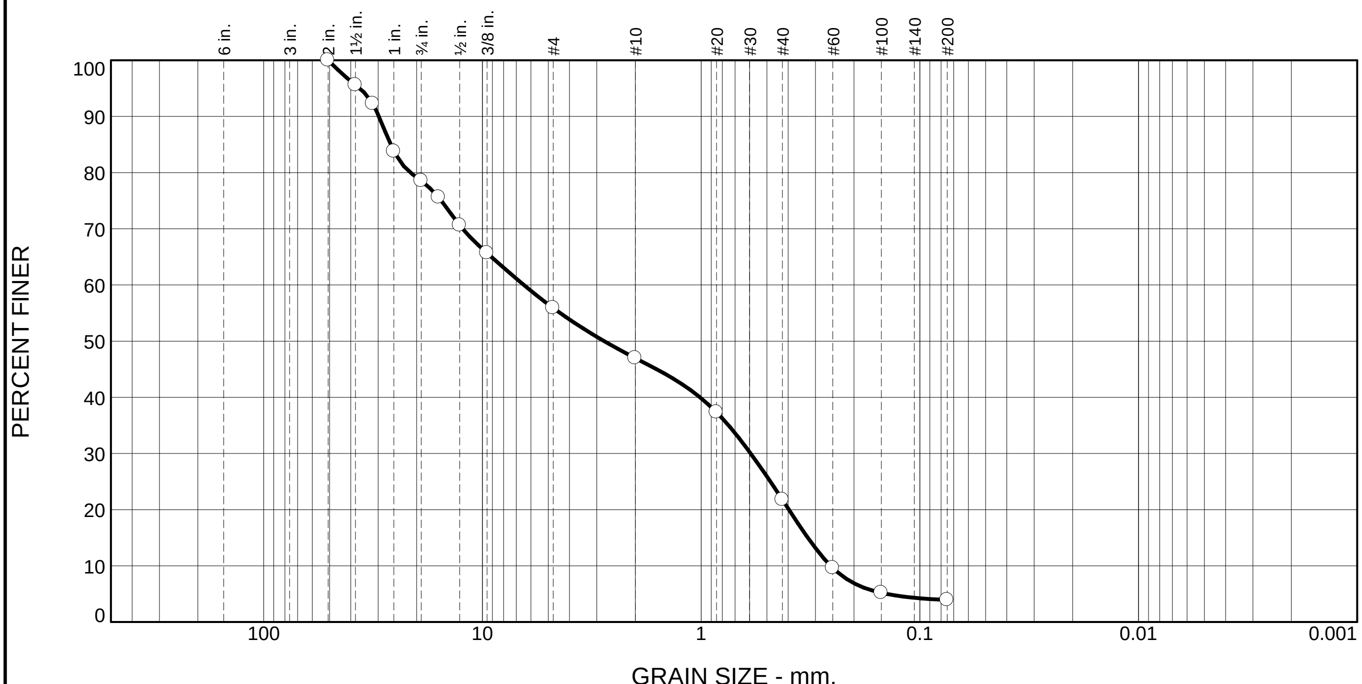
Source of Sample: Infiltration Test **Depth:** 4 feet **Date Sampled:** 03/19/2018
Sample Number: IT-2, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-2

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	21.5	22.6	8.9	25.2	17.9	3.9	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1 1/2	95.6		
1 1/4	92.3		
1	83.8		
3/4	78.5		
5/8	75.6		
1/2	70.6		
3/8	65.7		
#4	55.9		
#10	47.0		
#20	37.3		
#40	21.8		
#60	9.6		
#100	5.2		
#200	3.9		

* (no specification provided)

Material Description

Light brown fine to medium SAND with gravel and a trace of silt

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SP **AASHTO (M 145)=**

Coefficients

D_{90}= 29.7422 D_{85}= 26.2855 D_{60}= 6.4650
D_{50}= 2.7749 D_{30}= 0.5933 D_{15}= 0.3251
D_{10}= 0.2556 C_u= 25.29 C_c= 0.21

Remarks

Moisture Content 6%. Sampled by SJM.

Date Received: 03/27/2018 **Date Tested:** 04/02/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/21/2018
Sample Number: IT-3, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-3

Particle Size Distribution Report

% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.8	4.8	1.2	6.1	71.1	12.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/4	100.0		
1	95.2		
3/4	95.2		
5/8	93.8		
1/2	92.6		
3/8	91.8		
#4	90.4		
#10	89.2		
#20	87.9		
#40	83.1		
#60	53.5		
#100	25.5		
#200	12.0		

* (no specification provided)

Material Description

Light brown silty fine sand with occasional gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 3.2273 D_{85}= 0.5335 D_{60}= 0.2763
D_{50}= 0.2367 D_{30}= 0.1664 D_{15}= 0.0981
D_{10}= C_u= C_c=

Remarks

Moisture Content 25%. Sampled by SJM.

Date Received: 03/27/2018 **Date Tested:** 04/02/2018

Tested By: SED

Checked By: JMS

Title: Project Eng. Geologist

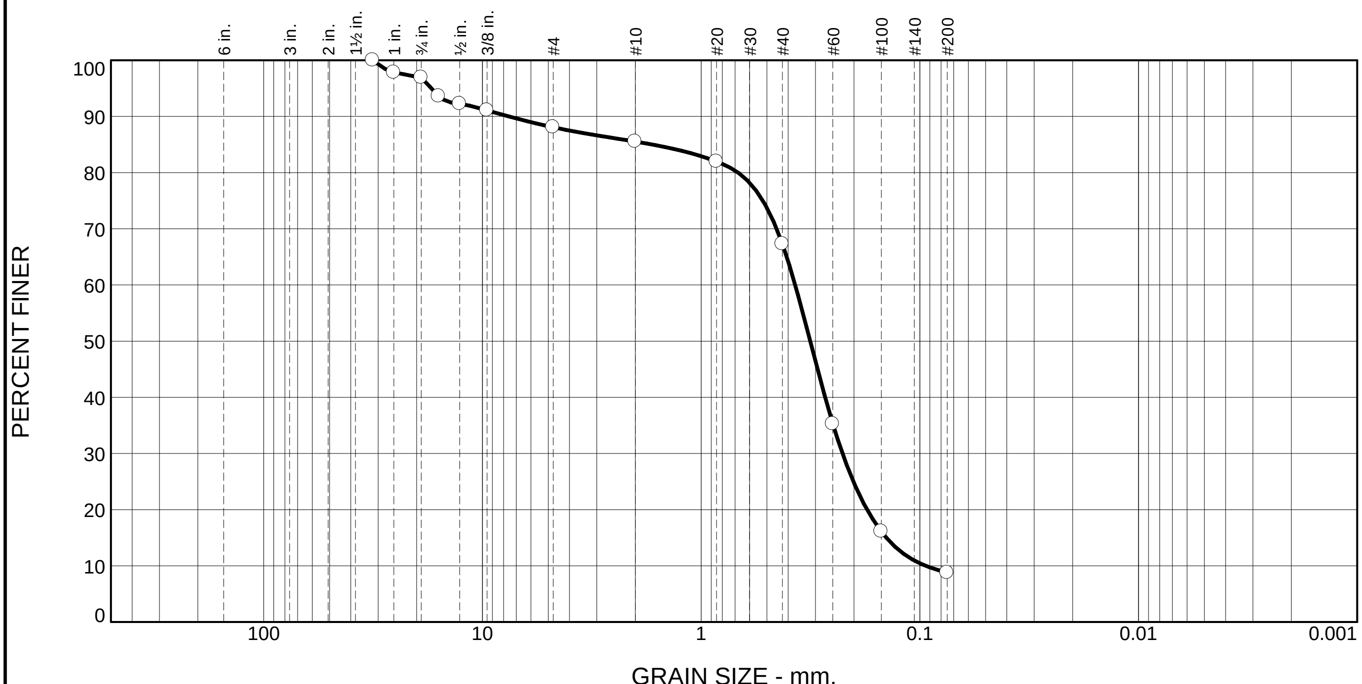
Source of Sample: Infiltration Test **Depth:** 3 feet **Date Sampled:** 03/21/2018
Sample Number: IT-4, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-4

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.1	8.8	2.6	18.2	58.5	8.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/4	100.0		
1	97.8		
3/4	96.9		
5/8	93.6		
1/2	92.2		
3/8	91.1		
#4	88.1		
#10	85.5		
#20	82.0		
#40	67.3		
#60	35.3		
#100	16.1		
#200	8.8		

* (no specification provided)

Material Description

Light brown fine to medium SAND with silt and occasional gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 7.5799 D_{85}= 1.6761 D_{60}= 0.3715
D_{50}= 0.3170 D_{30}= 0.2258 D_{15}= 0.1422
D_{10}= 0.0939 C_u= 3.96 C_c= 1.46

Remarks

Moisture Content 10%. Sampled by SJM.

Date Received: 03/20/2018 **Date Tested:** 03/27/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

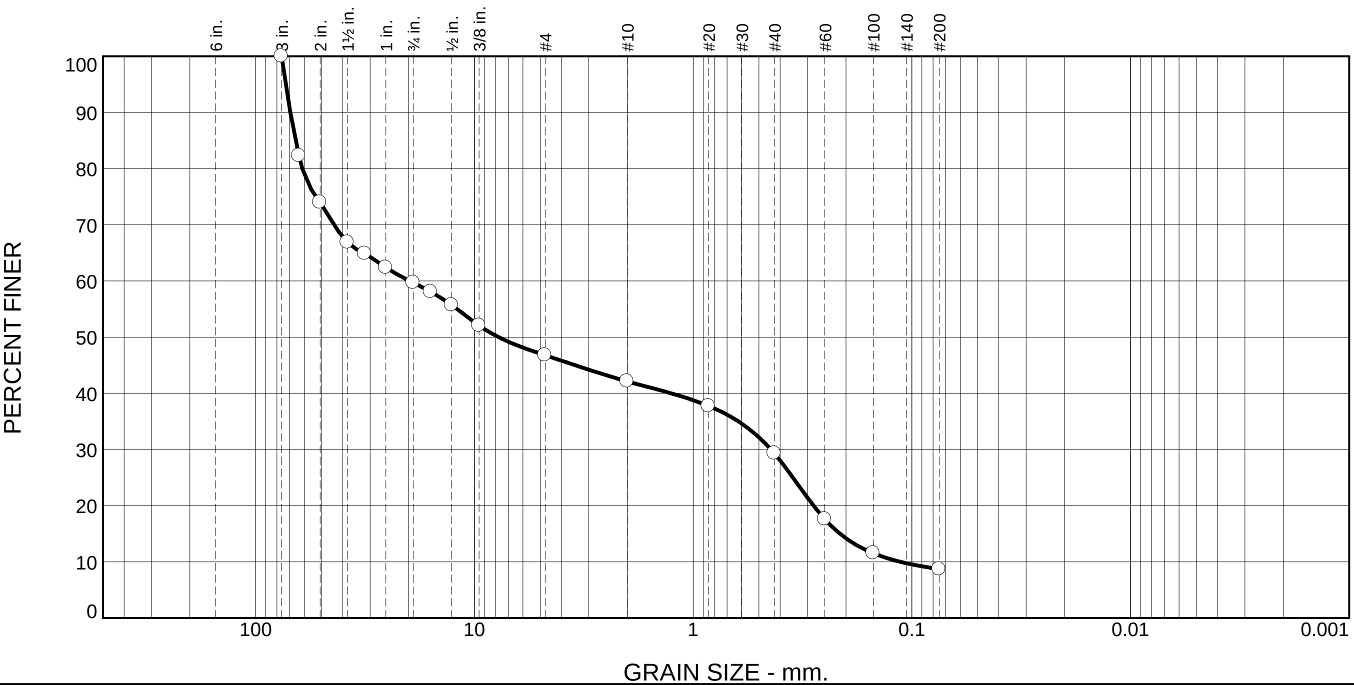
Source of Sample: Infiltration Test **Depth:** 3 feet **Date Sampled:** 03/20/2018
Sample Number: IT-5, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-5

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	40.3	12.9	4.7	12.8	20.6	8.7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3	100.0		
2 1/2	82.3		
2	74.0		
1 1/2	66.9		
1 1/4	64.9		
1	62.4		
3/4	59.7		
5/8	58.1		
1/2	55.7		
3/8	52.1		
#4	46.8		
#10	42.1		
#20	37.7		
#40	29.3		
#60	17.6		
#100	11.5		
#200	8.7		

* (no specification provided)

Material Description

Dark brown fine to coarse GRAVEL with silt and sand

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= GP-GM **AASHTO (M 145)=**

Coefficients

D_{90}= 69.4304 D_{85}= 65.7837 D_{60}= 19.7496
D_{50}= 7.7555 D_{30}= 0.4405 D_{15}= 0.2131
D_{10}= 0.1127 C_u= 175.28 C_c= 0.09

Remarks

Moisture Content 9%. Sampled by SJM.

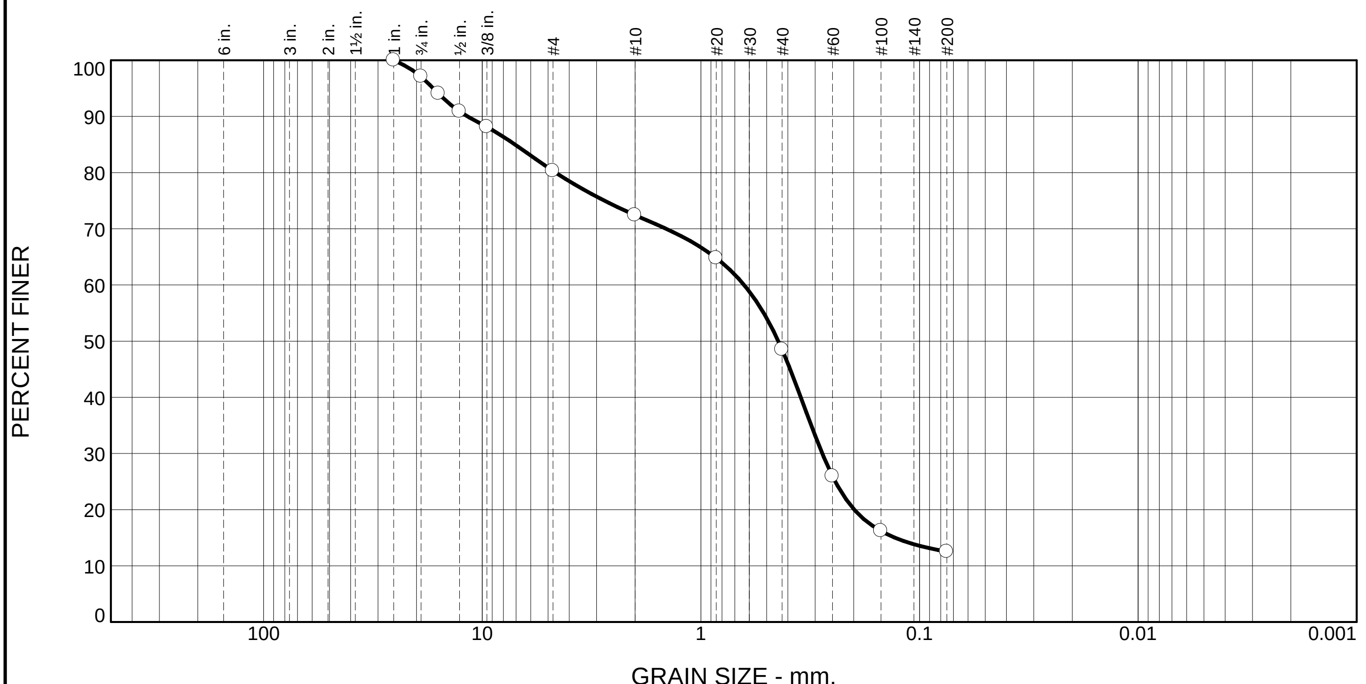
Date Received: 03/20/2018 **Date Tested:** 03/27/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

Source of Sample: Infiltration Test **Depth:** 3 feet **Date Sampled:** 03/20/2018
Sample Number: IT-6, S-1

ICICLE CREEK ENGINEERS, INC.
Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-6

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.9	16.8	7.9	23.9	36.0	12.5	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	97.1		
5/8	94.1		
1/2	90.9		
3/8	88.1		
#4	80.3		
#10	72.4		
#20	64.8		
#40	48.5		
#60	26.0		
#100	16.2		
#200	12.5		

* (no specification provided)

Material Description

Brown silty fine medium SAND with gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 11.6837 D_{85}= 7.0863 D_{60}= 0.6338
D_{50}= 0.4423 D_{30}= 0.2784 D_{15}= 0.1292
D_{10}= C_u= C_c=

Remarks

Moisture Content 18%. Sampled by SJM.

Date Received: 03/20/2018 **Date Tested:** 03/27/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

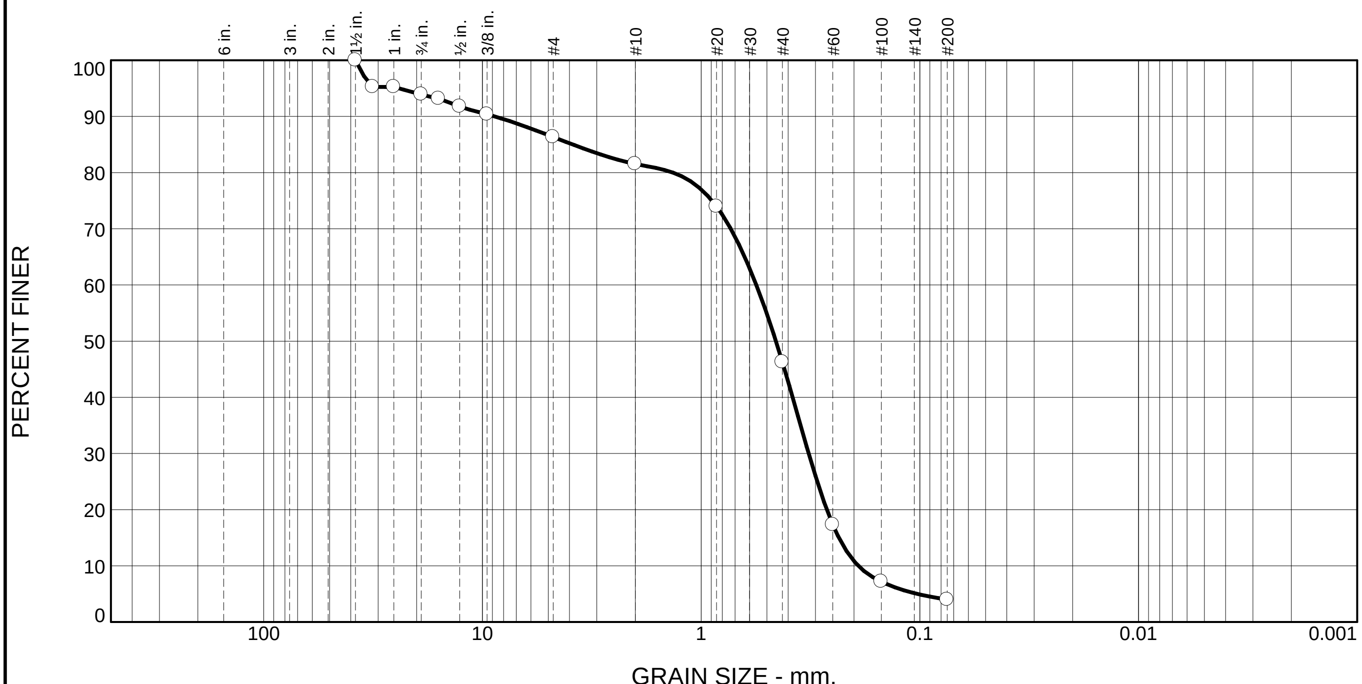
Source of Sample: Infiltration Test **Depth:** 3 feet **Date Sampled:** 03/20/2018
Sample Number: IT-7, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-7

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.1	7.6	4.8	35.2	42.3	4.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/2	100.0		
1 1/4	95.2		
1	95.2		
3/4	93.9		
5/8	93.1		
1/2	91.8		
3/8	90.4		
#4	86.3		
#10	81.5		
#20	74.0		
#40	46.3		
#60	17.3		
#100	7.2		
#200	4.0		

* (no specification provided)

Material Description

Light brown fine to medium SAND with occasional gravel and a trace of silt

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SP **AASHTO (M 145)=**

Coefficients

D_{90}= 8.7914 D_{85}= 3.8588 D_{60}= 0.5592
D_{50}= 0.4550 D_{30}= 0.3222 D_{15}= 0.2346
D_{10}= 0.1910 C_u= 2.93 C_c= 0.97

Remarks

Moisture Content 10%. Sampled by SJM.

Date Received: 03/27/2018 **Date Tested:** 04/02/2018

Tested By: SED

Checked By: JMS

Title: Project Eng. Geologist

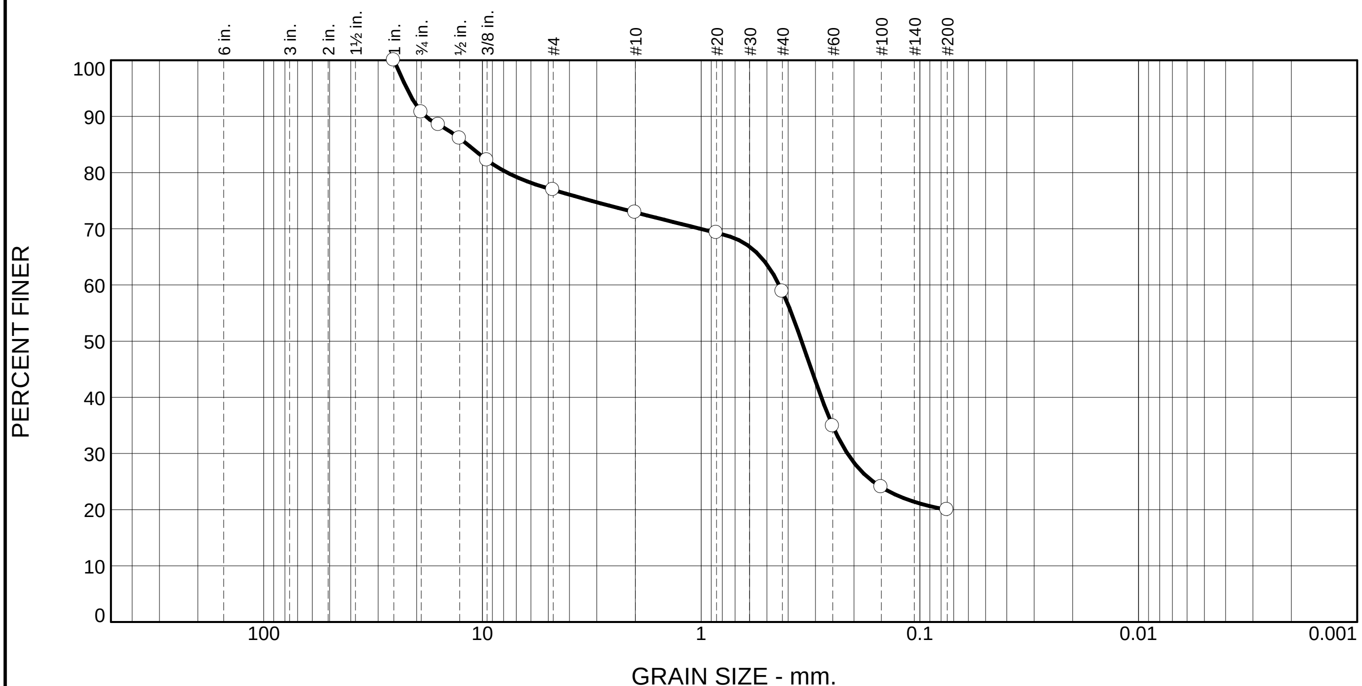
Source of Sample: Infiltration Test **Depth:** 3 feet **Date Sampled:** 03/21/2018
Sample Number: IT-8, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-8

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	9.2	13.9	4.0	14.1	38.9	19.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	90.8		
5/8	88.5		
1/2	86.1		
3/8	82.2		
#4	76.9		
#10	72.9		
#20	69.3		
#40	58.8		
#60	34.9		
#100	24.0		
#200	19.9		

* (no specification provided)

Material Description

Brown silty fine to medium SAND with gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 18.2222 D_{85}= 11.6896 D_{60}= 0.4395
D_{50}= 0.3471 D_{30}= 0.2143 D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture Content 13%. Sampled by SJM.

Date Received: 03/28/2018 **Date Tested:** 04/03/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

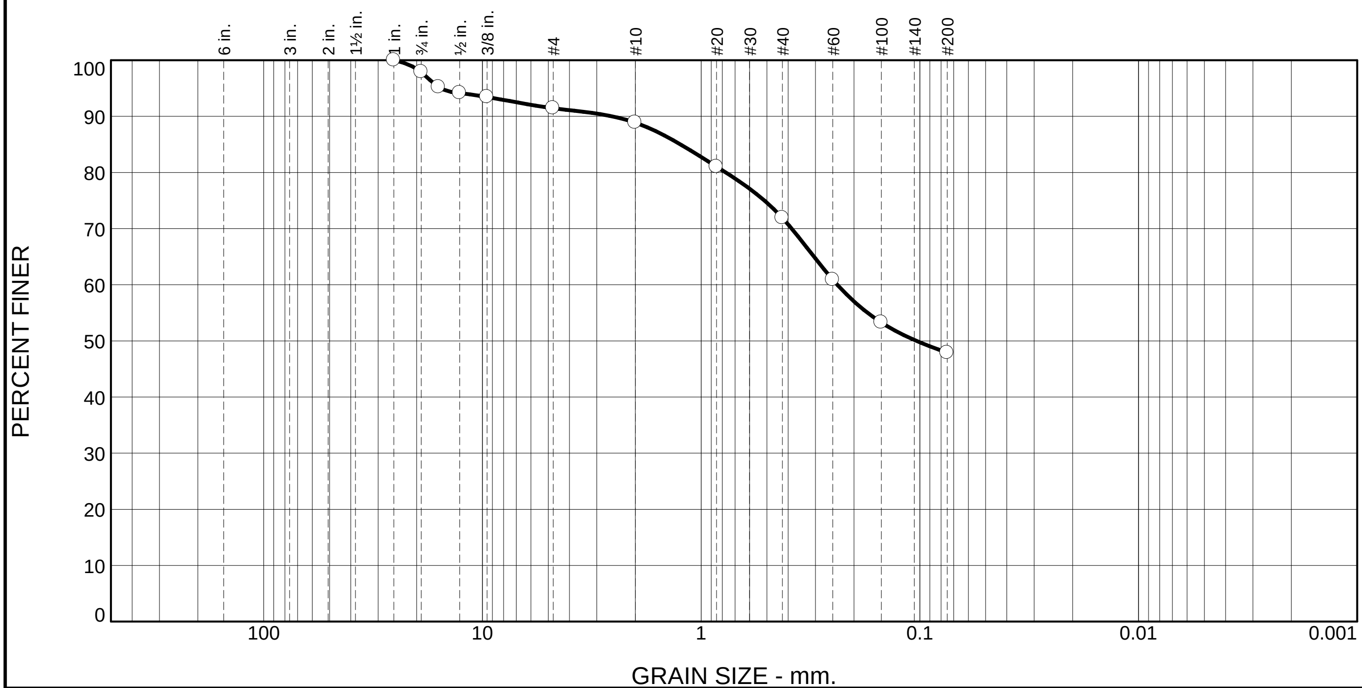
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/26/2018
Sample Number: IT-9, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-9

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.1	6.4	2.6	17.0	24.0	47.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	97.9		
5/8	95.2		
1/2	94.1		
3/8	93.4		
#4	91.5		
#10	88.9		
#20	81.0		
#40	71.9		
#60	60.9		
#100	53.3		
#200	47.9		

* (no specification provided)

Material Description

Light grayish brown silty fine to medium SAND with occasional gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 2.5495 D_{85}= 1.2431 D_{60}= 0.2385
D_{50}= 0.1036 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture Content 22%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/05/2018

Tested By: SED

Checked By: JMS

Title: Project Eng. Geologist

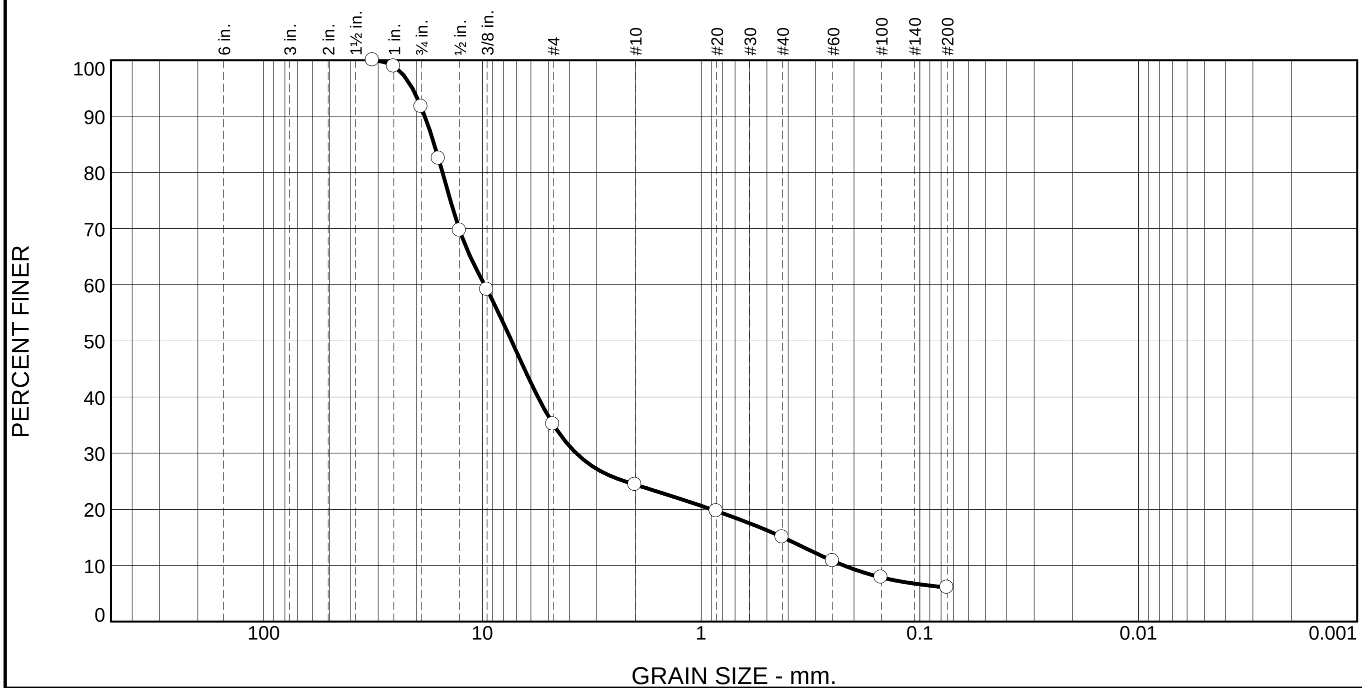
Source of Sample: Infiltration Test **Depth:** 4 feet **Date Sampled:** 03/26/2018
Sample Number: IT-10, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-10

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	8.3	56.5	10.8	9.4	8.9	6.1	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/4	100.0		
1	98.9		
3/4	91.7		
5/8	82.5		
1/2	69.6		
3/8	59.1		
#4	35.2		
#10	24.4		
#20	19.7		
#40	15.0		
#60	10.8		
#100	7.9		
#200	6.1		

* (no specification provided)

Material Description

Gray fine to coarse GRAVEL with silt and sand

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= GP-GM **AASHTO (M 145)=**

Coefficients

D_{90}= 18.3135 D_{85}= 16.5985 D_{60}= 9.7799
D_{50}= 7.3633 D_{30}= 3.7263 D_{15}= 0.4229
D_{10}= 0.2225 C_u= 43.95 C_c= 6.38

Remarks

Moisture Content 5%. Sampled by SJM.

Date Received: 03/23/2018 **Date Tested:** 03/28/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

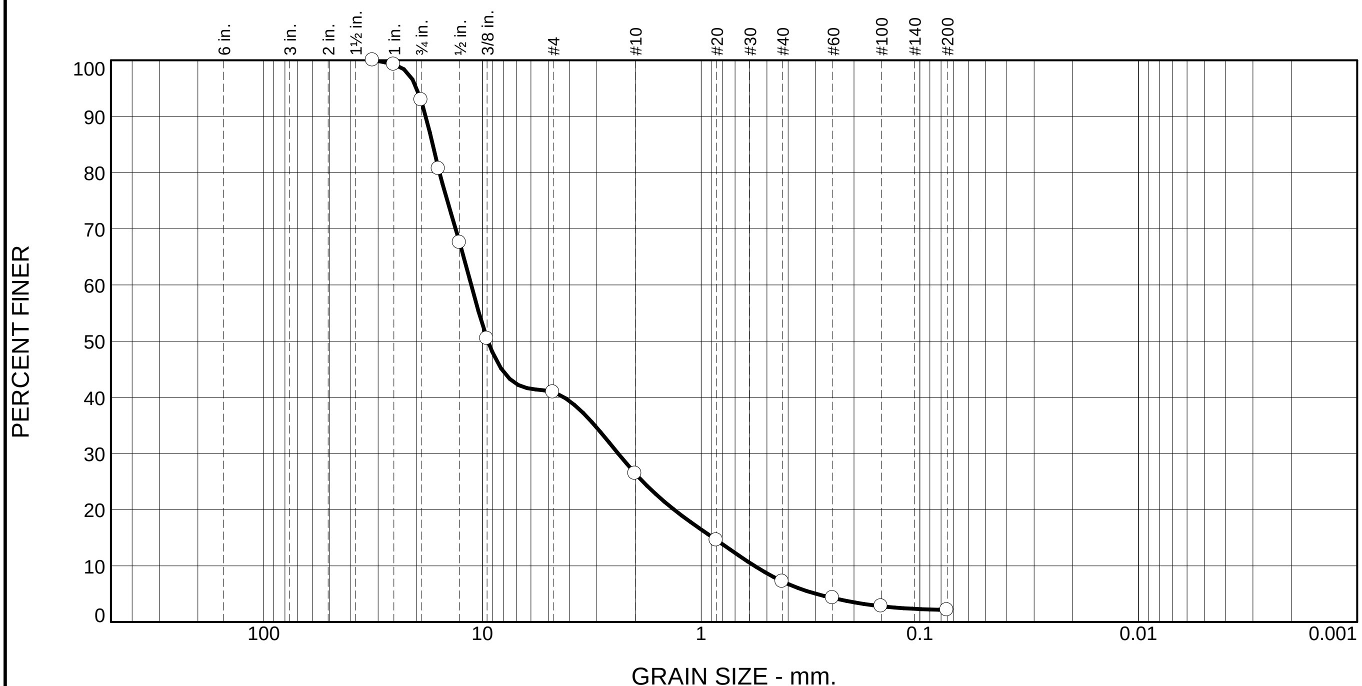
Source of Sample: Infiltration Test **Depth:** 2 feet **Date Sampled:**
Sample Number: IT-11. S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-11

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	7.1	52.0	14.5	19.2	5.1	2.1	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/4	100.0		
1	99.2		
3/4	92.9		
5/8	80.7		
1/2	67.5		
3/8	50.4		
#4	40.9		
#10	26.4		
#20	14.6		
#40	7.2		
#60	4.3		
#100	2.8		
#200	2.1		

* (no specification provided)

Material Description

Gray fine to coarse GRAVEL with sand and a trace of silt

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= GP **AASHTO (M 145)=**

Coefficients

D_{90}= 18.1403 D_{85}= 16.8839 D_{60}= 11.2572
D_{50}= 9.4339 D_{30}= 2.3951 D_{15}= 0.8817
D_{10}= 0.5701 C_u= 19.75 C_c= 0.89

Remarks

Moisture Content 7%. Sampled by SJM.

Date Received: 3/22/18 **Date Tested:** 3/28/18
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

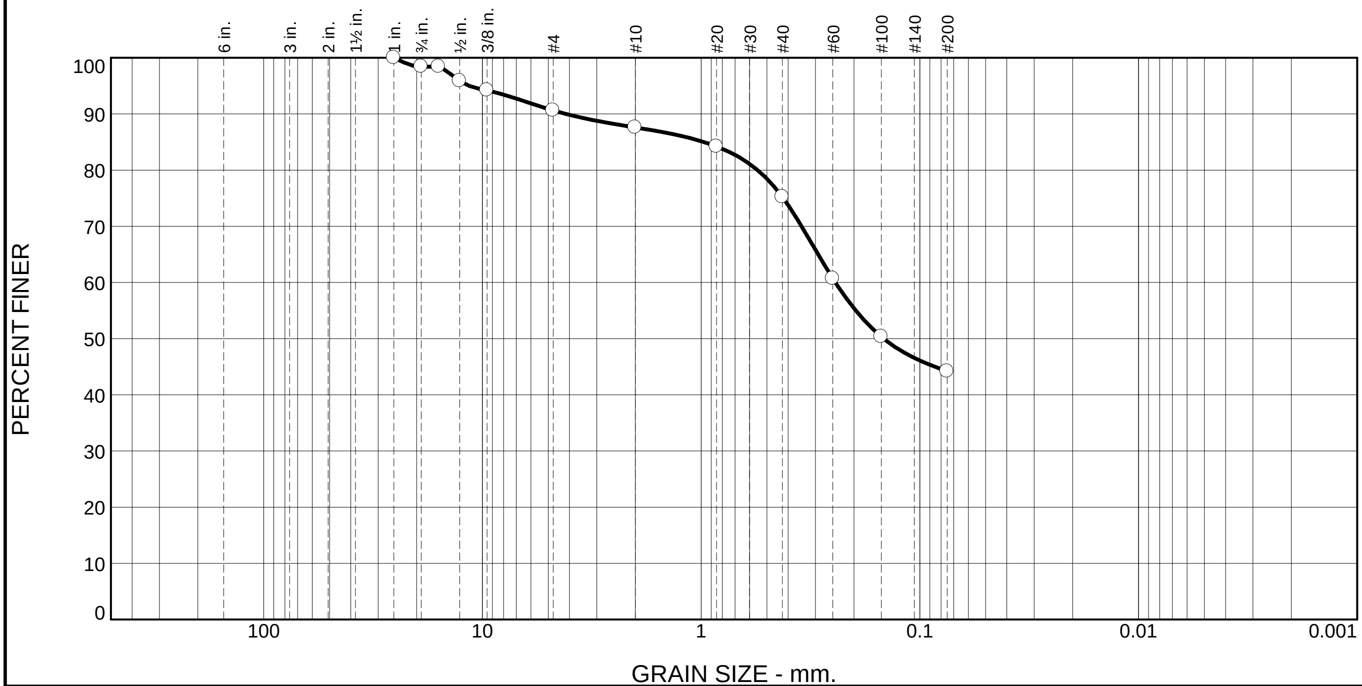
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 3/22/18
Sample Number: IT-12, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-12

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.6	7.8	3.0	12.4	31.0	44.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	98.4		
5/8	98.4		
1/2	95.9		
3/8	94.2		
#4	90.6		
#10	87.6		
#20	84.2		
#40	75.2		
#60	60.7		
#100	50.4		
#200	44.2		

* (no specification provided)

Material Description

Light grayish blue silty fine to medium SAND with occasional gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 4.1522 D_{85}= 0.9734 D_{60}= 0.2434
D_{50}= 0.1463 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture Content 15%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/05/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

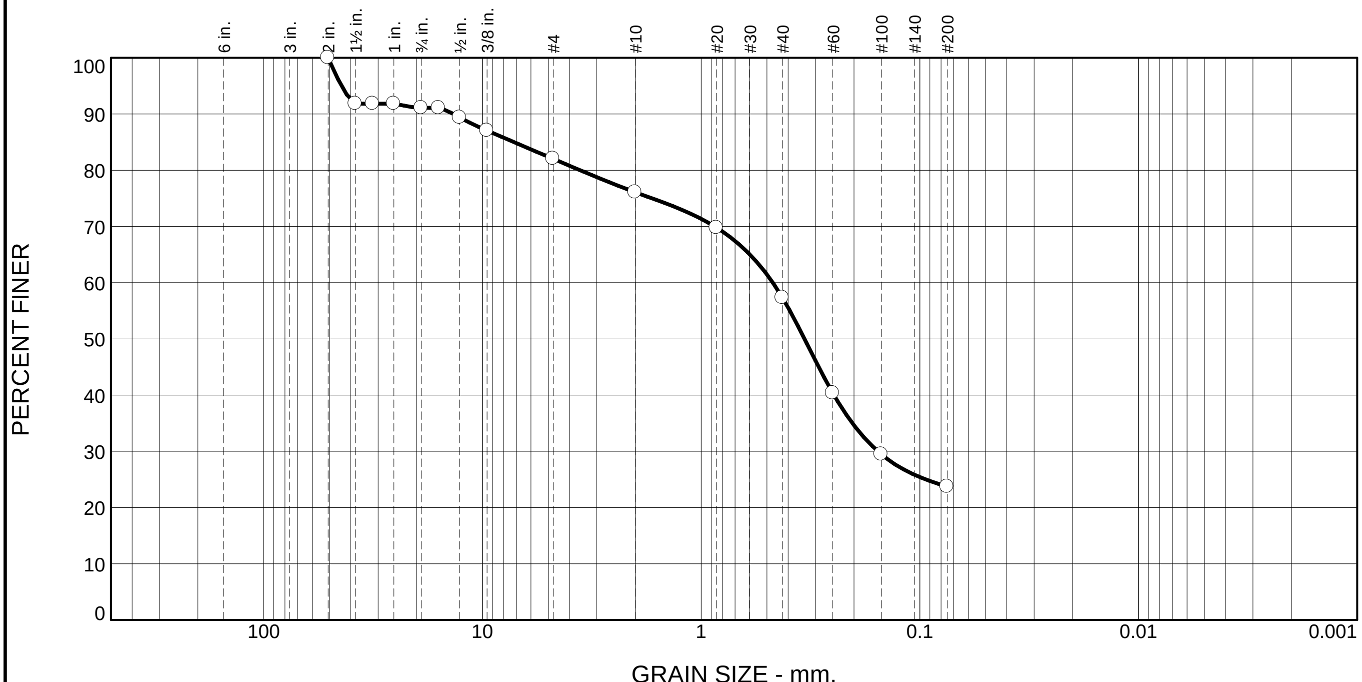
Source of Sample: Infiltration Test **Depth:** 2.5 feet **Date Sampled:** 03/28/2018
Sample Number: IT-13, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-13

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	8.9	9.1	5.9	18.8	33.6	23.7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1 1/2	91.8		
1 1/4	91.8		
1	91.8		
3/4	91.1		
5/8	91.1		
1/2	89.4		
3/8	87.1		
#4	82.0		
#10	76.1		
#20	69.8		
#40	57.3		
#60	40.4		
#100	29.5		
#200	23.7		

* (no specification provided)

Material Description

Grayish brown silty fine to medium SAND with gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 13.5738 D_{85}= 7.1788 D_{60}= 0.4702
D_{50}= 0.3367 D_{30}= 0.1555 D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture Content 14%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/05/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

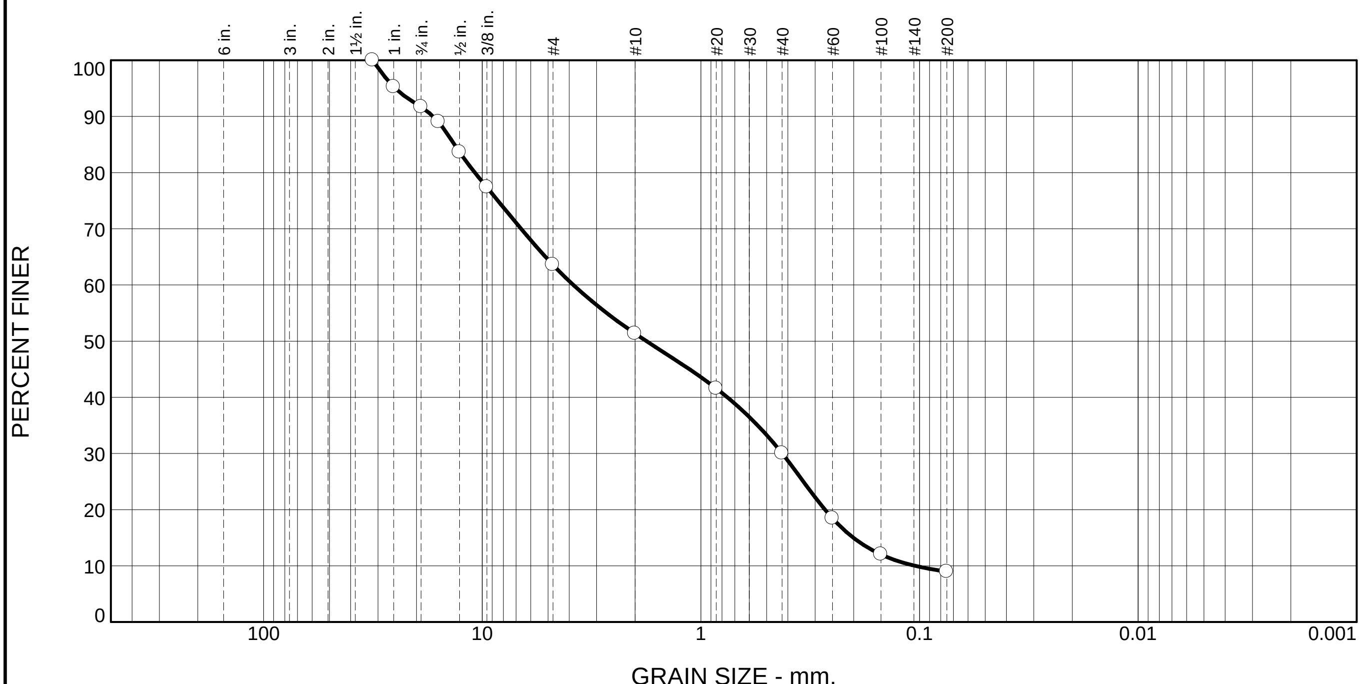
Source of Sample: Infiltration Test **Depth:** 2 feet **Date Sampled:** 03/28/2018
Sample Number: IT-14, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-14

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	8.3	28.1	12.2	21.4	21.0	9.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/4	100.0		
1	95.2		
3/4	91.7		
5/8	89.0		
1/2	83.6		
3/8	77.4		
#4	63.6		
#10	51.4		
#20	41.6		
#40	30.0		
#60	18.5		
#100	12.0		
#200	9.0		

* (no specification provided)

Material Description

Light brown fine to medium SAND with silt and gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 16.7757 D_{85}= 13.4130 D_{60}= 3.8305
D_{50}= 1.7730 D_{30}= 0.4243 D_{15}= 0.2005
D_{10}= 0.1047 C_u= 36.59 C_c= 0.45

Remarks

Moisture Content 11%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/05/2018

Tested By: SED

Checked By: JMS

Title: Project Eng. Geologist

Source of Sample: Infiltration Test **Depth:** 2.5 feet **Date Sampled:** 03/28/2018

Sample Number: IT-15, S-2

ICICLE CREEK ENGINEERS, INC.

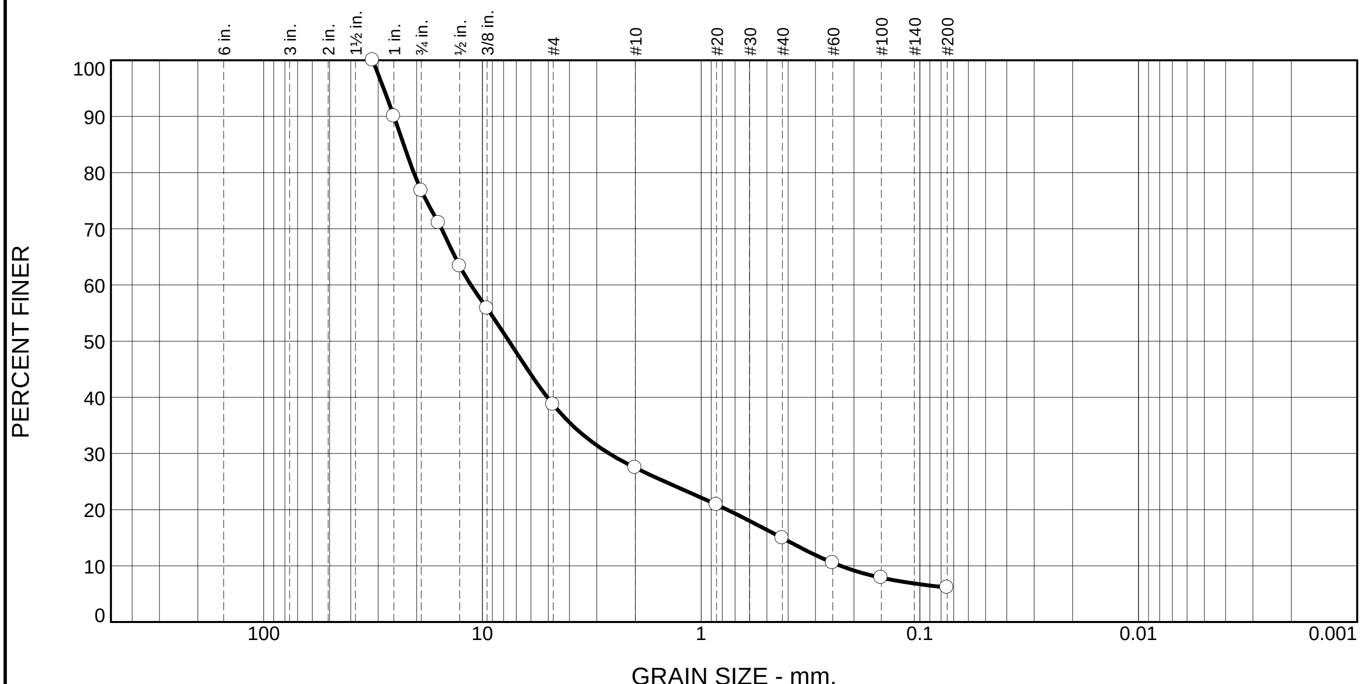
Carnation, WA

Client: Parametrix

Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien

Project No: 0105-023 **Figure** B-15

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	23.2	38.1	11.2	12.6	8.8	6.1	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/4	100.0		
1	90.0		
3/4	76.8		
5/8	71.0		
1/2	63.3		
3/8	55.8		
#4	38.7		
#10	27.5		
#20	20.9		
#40	14.9		
#60	10.5		
#100	7.9		
#200	6.1		

* (no specification provided)

Material Description

Gray fine to coarse GRAVEL with silt and sand

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= GP-GM **AASHTO (M 145)=**

Coefficients

D_{90}= 25.3881 D_{85}= 22.9180 D_{60}= 11.3013
D_{50}= 7.5654 D_{30}= 2.6327 D_{15}= 0.4275
D_{10}= 0.2305 C_u= 49.02 C_c= 2.66

Remarks

Moisture Content 11%. Sampled by SJM.

Date Received: 03/26/2018 **Date Tested:** 03/28/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

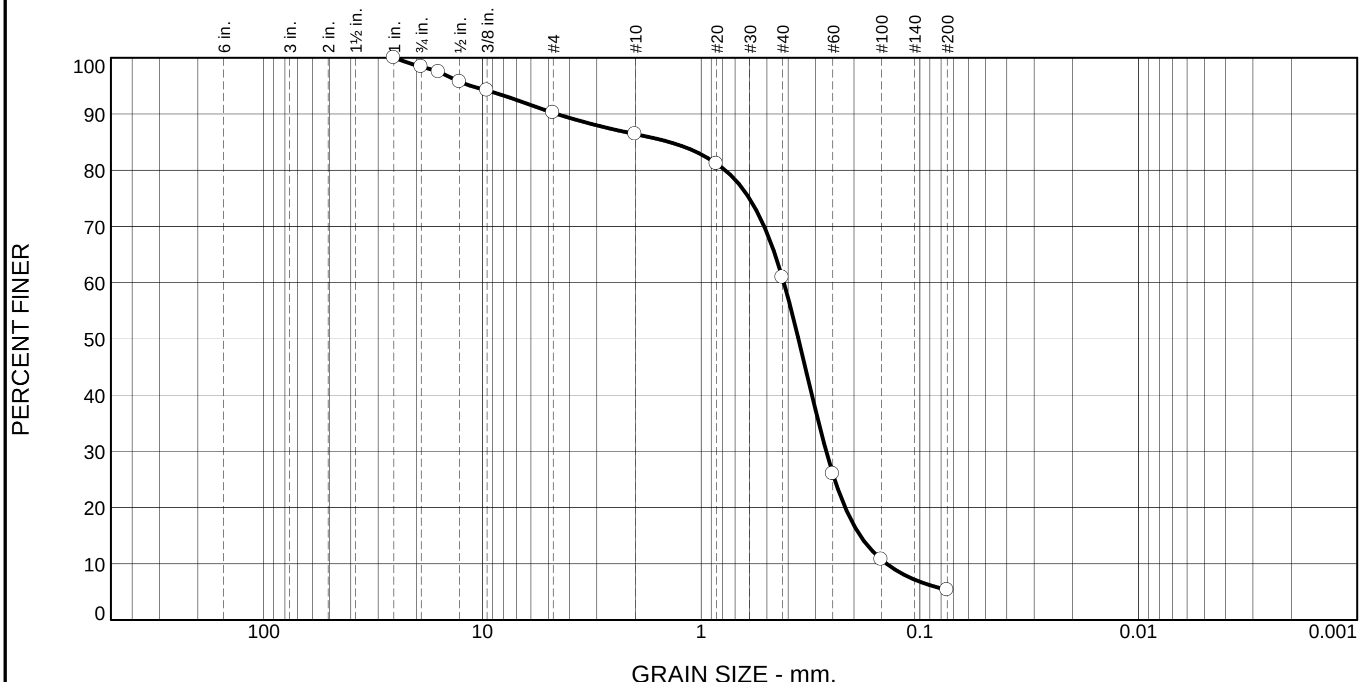
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/23/2018
Sample Number: IT-16, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-16

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.6	8.2	3.8	25.5	55.6	5.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	98.4		
5/8	97.5		
1/2	95.7		
3/8	94.2		
#4	90.2		
#10	86.4		
#20	81.2		
#40	60.9		
#60	26.0		
#100	10.8		
#200	5.3		

* (no specification provided)

Material Description

Brown fine to medium SAND with silt and occasional gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 4.5687 D_{85}= 1.3926 D_{60}= 0.4183
D_{50}= 0.3588 D_{30}= 0.2680 D_{15}= 0.1873
D_{10}= 0.1418 C_u= 2.95 C_c= 1.21

Remarks

Moisture Content 10%. Sampled by SJM.

Date Received: 04/04/2018 **Date Tested:** 04/16/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

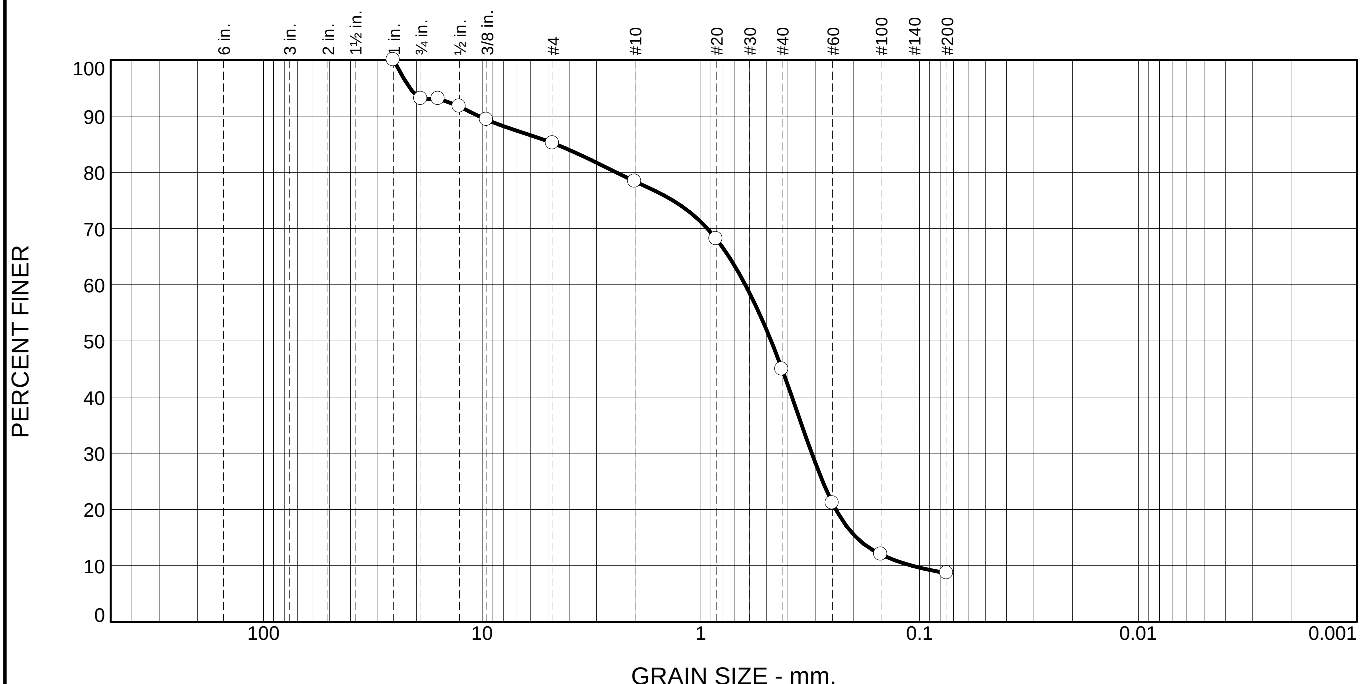
Source of Sample: Infiltration Test **Depth:** 2 feet **Date Sampled:** 04/04/2018
Sample Number: IT-17, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-17

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.9	7.9	6.8	33.5	36.3	8.6	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	93.1		
5/8	93.1		
1/2	91.7		
3/8	89.4		
#4	85.2		
#10	78.4		
#20	68.1		
#40	44.9		
#60	21.1		
#100	12.0		
#200	8.6		

* (no specification provided)

Material Description

Light brown fine to medium SAND with silt and gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 10.3474 D_{85}= 4.6049 D_{60}= 0.6264
D_{50}= 0.4774 D_{30}= 0.3112 D_{15}= 0.1944
D_{10}= 0.1090 C_u= 5.75 C_c= 1.42

Remarks

Moisture Content 17%. Sampled by SJM.

Date Received: 04/04/2018 **Date Tested:** 04/16/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

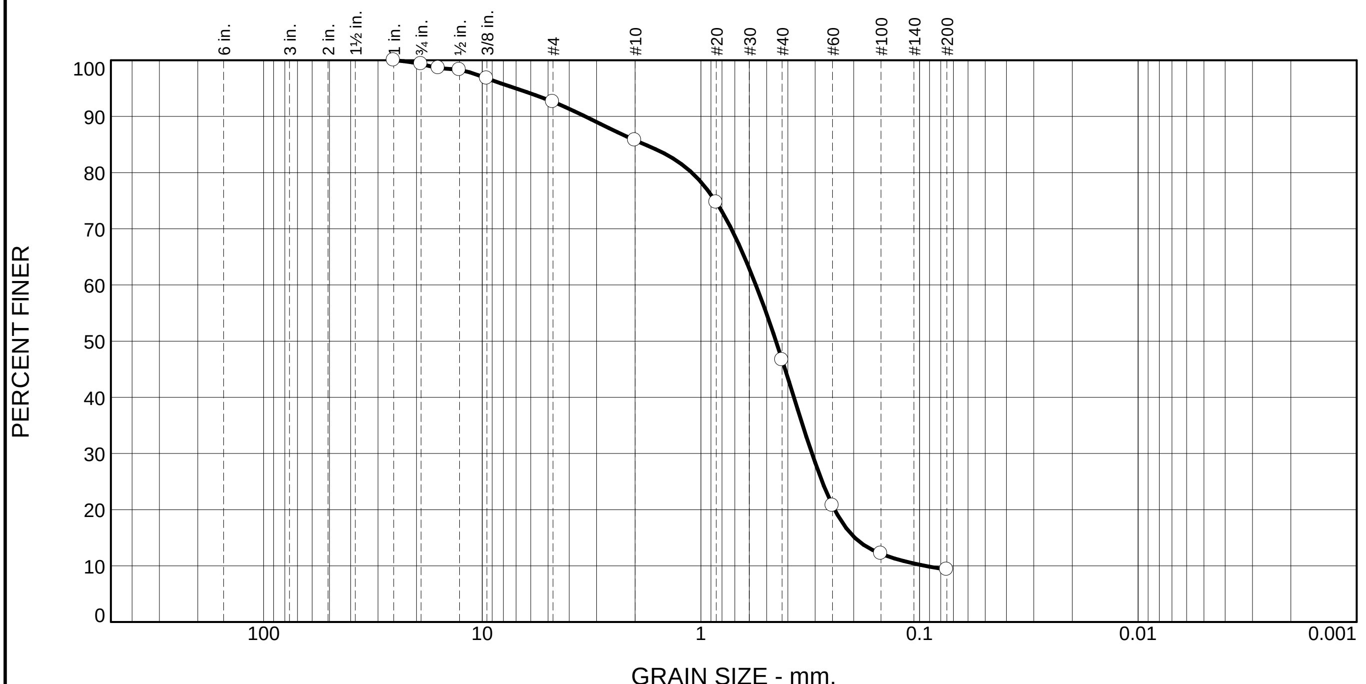
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 04/04/2018
Sample Number: IT-18b, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.7	6.7	6.8	39.1	37.4	9.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	99.3		
5/8	98.6		
1/2	98.3		
3/8	96.8		
#4	92.6		
#10	85.8		
#20	74.7		
#40	46.7		
#60	20.7		
#100	12.2		
#200	9.3		

* (no specification provided)

Material Description

Brown fine to medium SAND with silt and occasional gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 3.3788 D_{85}= 1.8014 D_{60}= 0.5603
D_{50}= 0.4534 D_{30}= 0.3103 D_{15}= 0.1975
D_{10}= 0.0942 C_u= 5.95 C_c= 1.82

Remarks

Moisture Content 25%. Sampled by SJM.

Date Received: 04/06/2018 **Date Tested:** 04/16/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

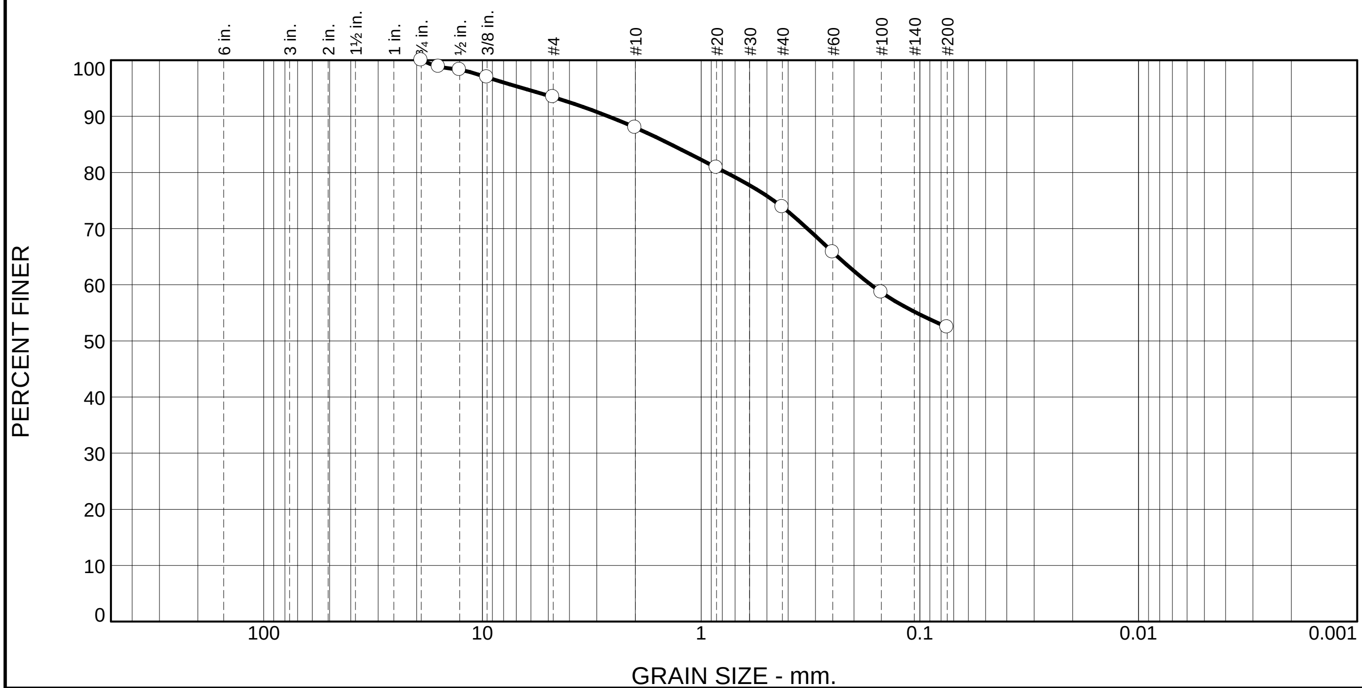
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 04/06/2018
Sample Number: IT-19b, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-19

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	6.6	5.4	14.2	21.4	52.4	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/4	100.0		
5/8	98.9		
1/2	98.3		
3/8	96.9		
#4	93.4		
#10	88.0		
#20	80.9		
#40	73.8		
#60	65.8		
#100	58.7		
#200	52.4		

* (no specification provided)

Material Description

Light brown sandy SILT with a trace of gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= ML **AASHTO (M 145)=**

Coefficients

D_{90}= 2.6559 D_{85}= 1.3746 D_{60}= 0.1673
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture Content 30%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/05/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

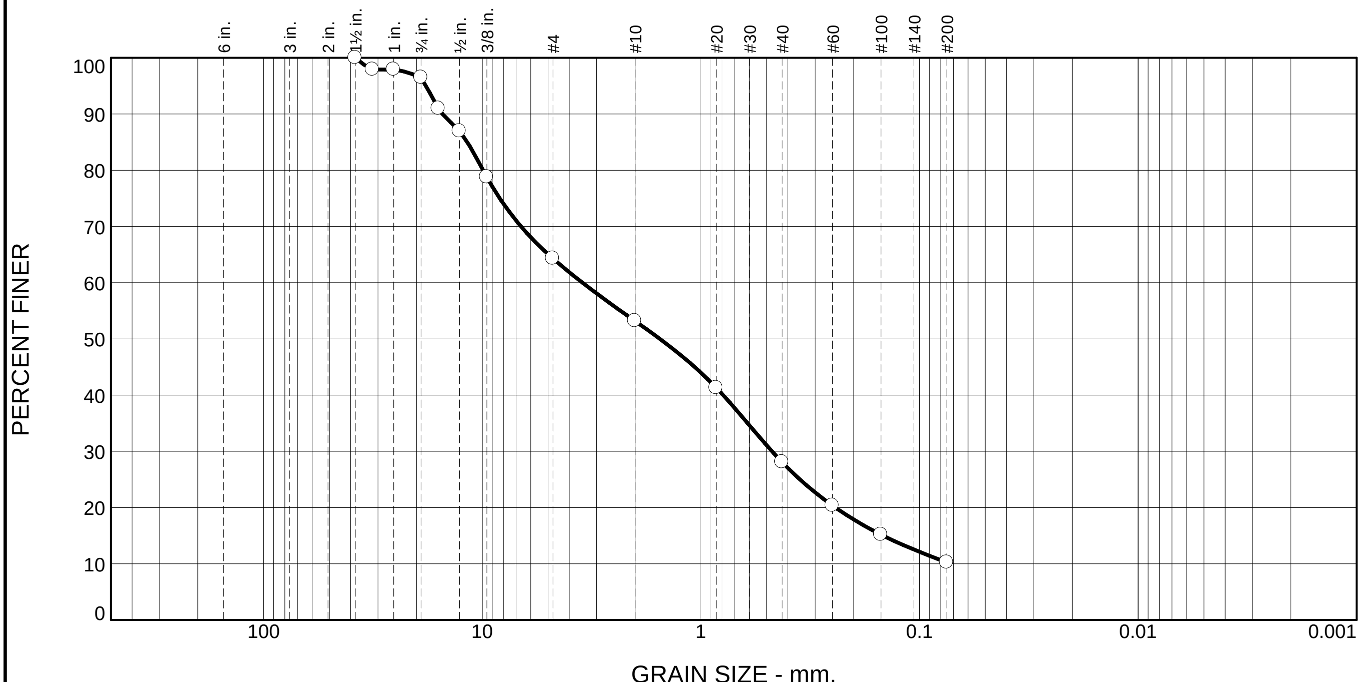
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/27/2018
Sample Number: IT-20, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-20

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.5	32.2	11.1	25.1	17.9	10.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/2	100.0		
1 1/4	97.9		
1	97.9		
3/4	96.5		
5/8	91.0		
1/2	86.9		
3/8	78.8		
#4	64.3		
#10	53.2		
#20	41.3		
#40	28.1		
#60	20.4		
#100	15.2		
#200	10.2		

* (no specification provided)

Material Description

Brown fine to medium SAND with silt and gravel

Atterberg Limits (ASTM D 4318)

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

Classification

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

Coefficients

D_{90}= 15.2070 D_{85}= 11.7034 D_{60}= 3.4836
D_{50}= 1.5401 D_{30}= 0.4727 D_{15}= 0.1467
D_{10}= C_u= C_c=

Remarks

Moisture Content 7%. Sampled by SJM.

Date Received: 03/30/2018 **Date Tested:** 04/09/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

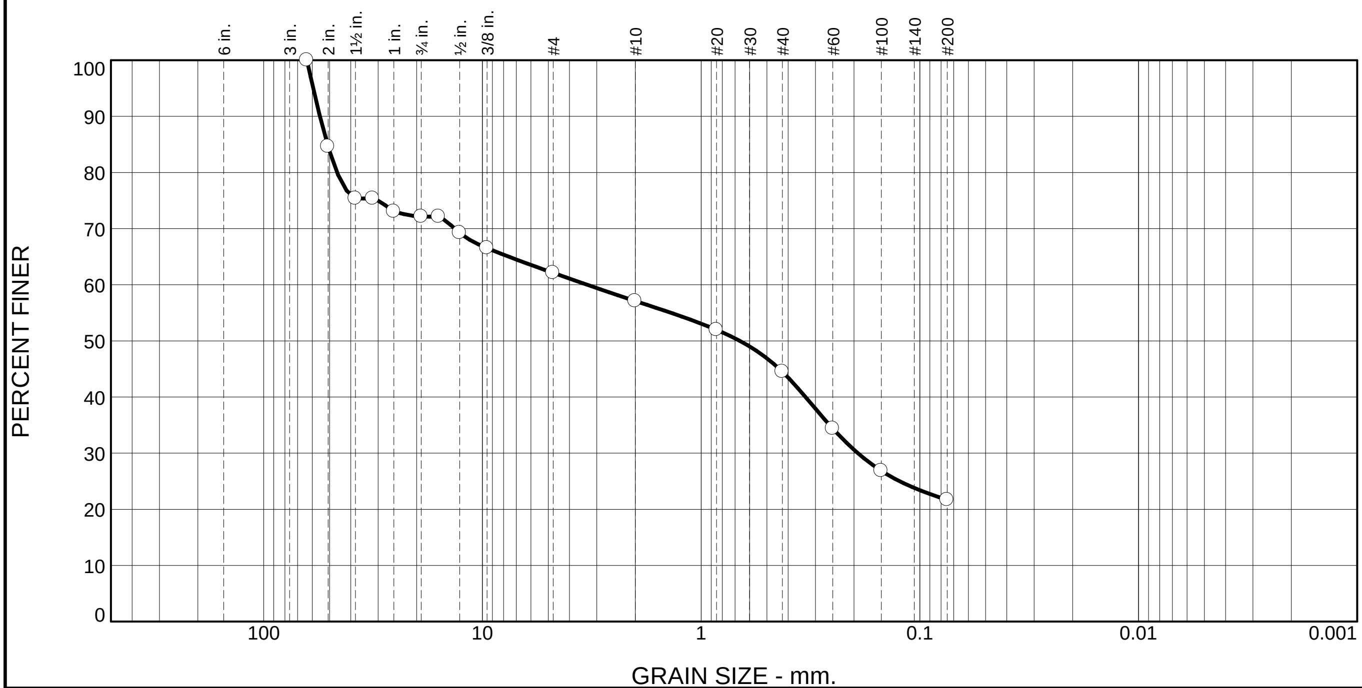
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/30/2018
Sample Number: IT-21, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-21

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	27.9	10.0	5.0	12.6	22.8	21.7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2 1/2	100.0		
2	84.6		
1 1/2	75.4		
1 1/4	75.4		
1	73.0		
3/4	72.1		
5/8	72.1		
1/2	69.2		
3/8	66.5		
#4	62.1		
#10	57.1		
#20	52.0		
#40	44.5		
#60	34.4		
#100	26.9		
#200	21.7		

* (no specification provided)

Material Description

Grayish-brown silty fine to medium SAND with gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 55.3297 D_{85}= 51.1211 D_{60}= 3.3168
D_{50}= 0.6650 D_{30}= 0.1919 D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture Content 8%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/09/2018
Tested By: SED
Checked By: JMS
Title: Project Eng, Geologist

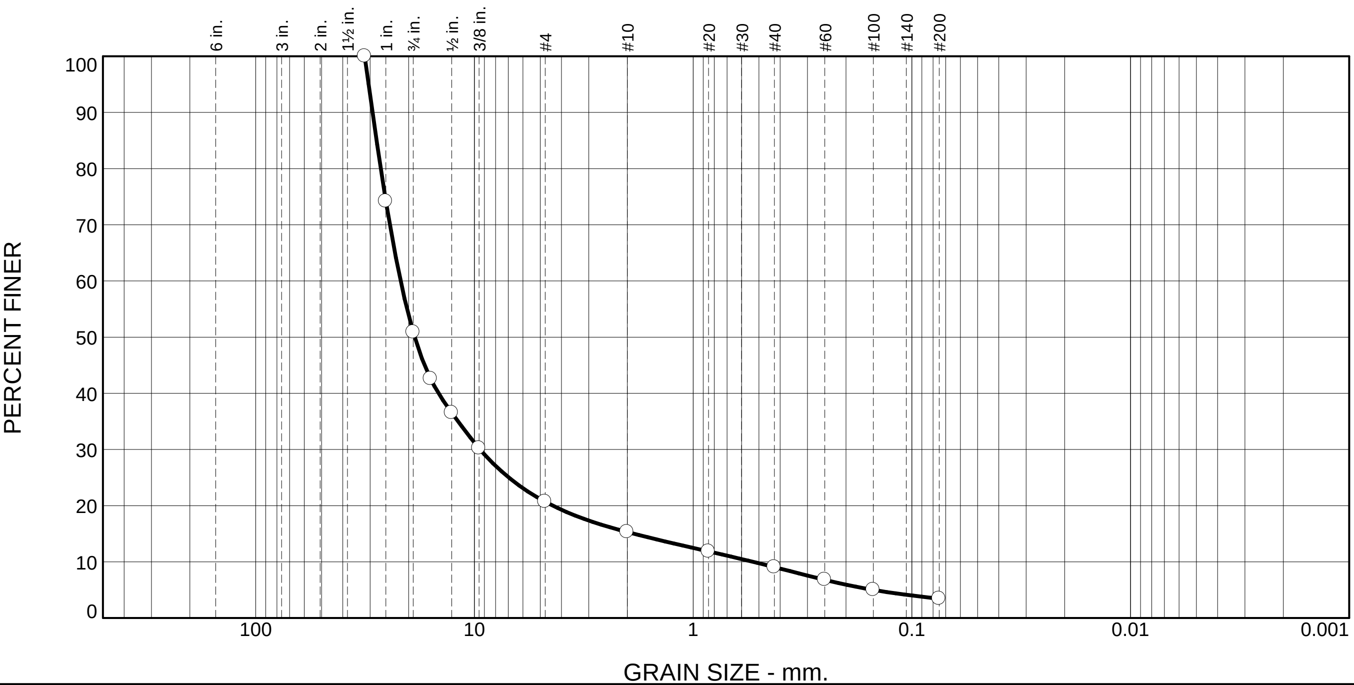
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/29/2018
Sample Number: IT-22, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-22

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	49.1	30.2	5.4	6.2	5.7	3.4	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/4	100.0		
1	74.2		
3/4	50.9		
5/8	42.6		
1/2	36.5		
3/8	30.2		
#4	20.7		
#10	15.3		
#20	11.9		
#40	9.1		
#60	6.8		
#100	5.0		
#200	3.4		

* (no specification provided)

Material Description

Light brown fine to coarse GRAVEL with sand and a trace of silt

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= GP **AASHTO (M 145)=**

Coefficients

D_{90}= 29.2283 D_{85}= 28.0130 D_{60}= 21.7583
D_{50}= 18.7619 D_{30}= 9.4199 D_{15}= 1.8663
D_{10}= 0.5314 C_u= 40.94 C_c= 7.67

Remarks

Moisture Content 3%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/09/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

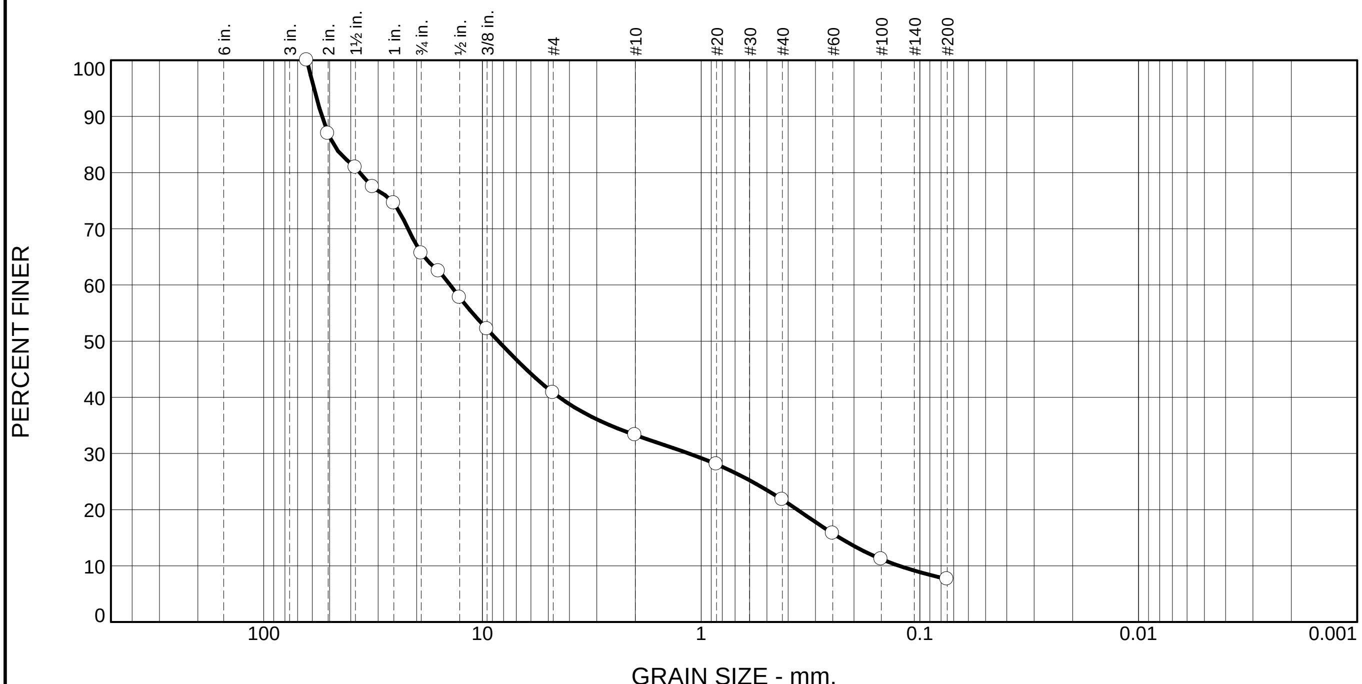
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/29/2018
Sample Number: IT-23, S-2

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-23

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	34.4	24.8	7.5	11.5	14.2	7.6	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2 1/2	100.0		
2	86.9		
1 1/2	80.9		
1 1/4	77.4		
1	74.5		
3/4	65.6		
5/8	62.5		
1/2	57.7		
3/8	52.1		
#4	40.8		
#10	33.3		
#20	28.1		
#40	21.8		
#60	15.8		
#100	11.2		
#200	7.6		

* (no specification provided)

Material Description

Dark brown fine to coarse GRAVEL with silt and sand

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= GP-GM **AASHTO (M 145)=**

Coefficients

D_{90}= 54.1859 D_{85}= 47.9981 D_{60}= 14.0433
D_{50}= 8.4566 D_{30}= 1.1372 D_{15}= 0.2323
D_{10}= 0.1241 C_u= 113.13 C_c= 0.74

Remarks

Moisture Content 5%. Sampled by SJM.

Date Received: 03/29/2018 **Date Tested:** 04/05/2018
Tested By: SED
Checked By: JMS
Title: Project Eng. Geologist

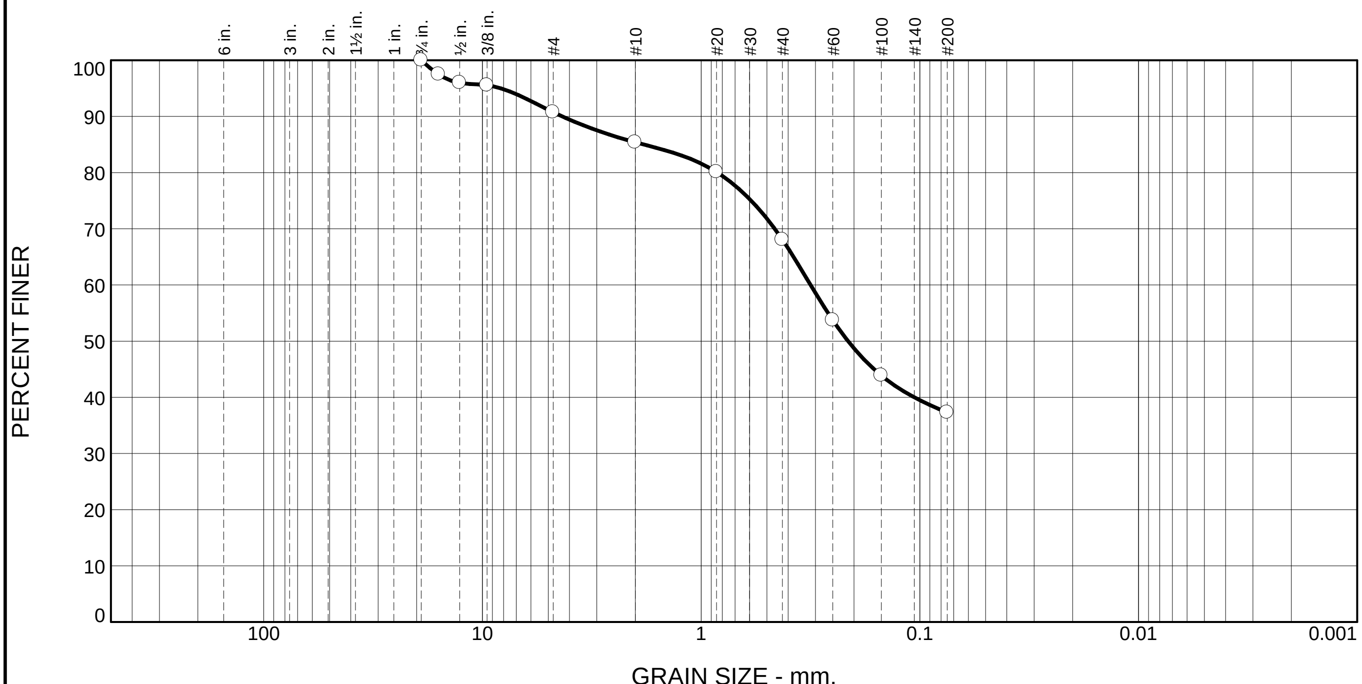
Source of Sample: Infiltration Test **Depth:** 1.5 feet **Date Sampled:** 03/27/2018
Sample Number: IT-24, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-24

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.2	5.4	17.3	30.8	37.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/4	100.0		
5/8	97.5		
1/2	96.0		
3/8	95.5		
#4	90.8		
#10	85.4		
#20	80.1		
#40	68.1		
#60	53.7		
#100	43.9		
#200	37.3		

* (no specification provided)

Material Description

Brown and gray silty fine to medium SAND with occasional gravel and organic fragments

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 4.3180 D_{85}= 1.8298 D_{60}= 0.3157
D_{50}= 0.2128 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Tested by SJM. MC = 22.3%

Date Received: 12/12/2018 **Date Tested:** 1/10/2019
Tested By: SJM
Checked By: JMS
Title: Project Eng. Geologist

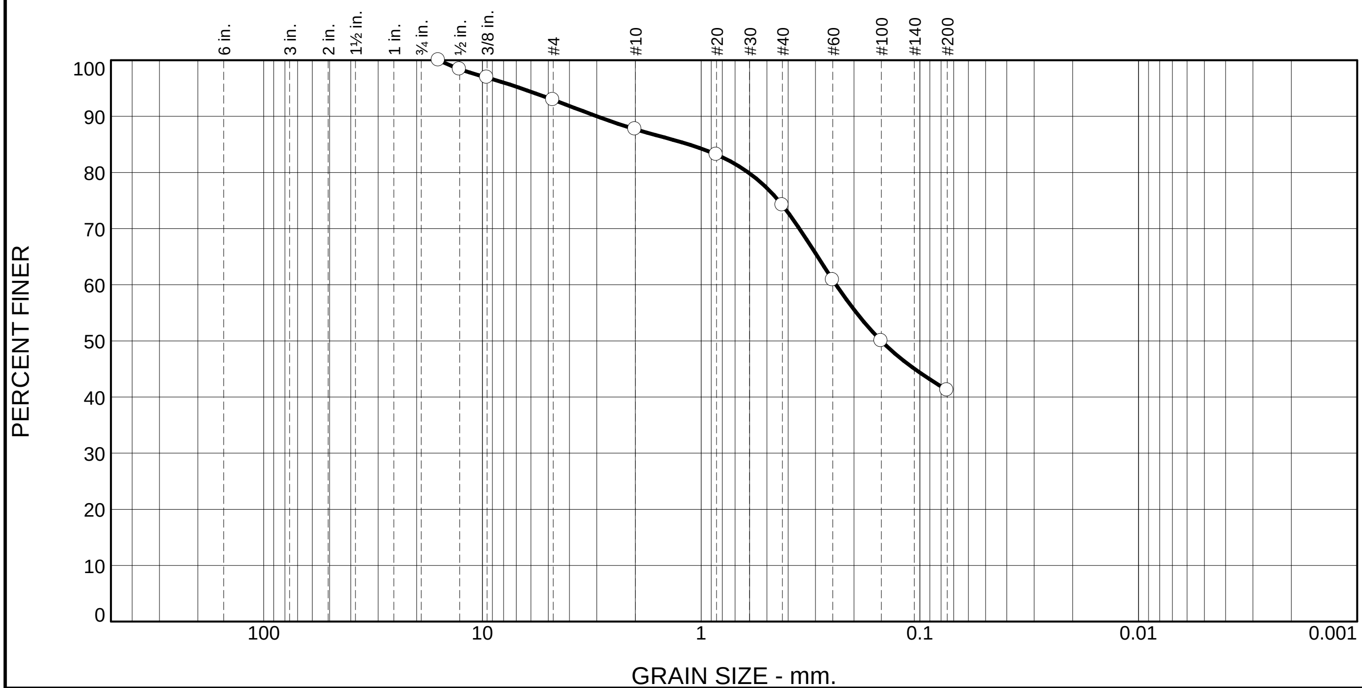
Source of Sample: SR 509 Ramp Test Hole **Depth:** 0.5 feet **Date Sampled:** 12/12/2018
Sample Number: B-18, S-1

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-25

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	7.1	5.2	13.5	33.0	41.2	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
5/8	100.0		
1/2	98.4		
3/8	96.9		
#4	92.9		
#10	87.7		
#20	83.2		
#40	74.2		
#60	60.8		
#100	50.0		
#200	41.2		

* (no specification provided)

Material Description

Grayish-brown silty fine to medium SAND with occasional fine gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 2.9896 D_{85}= 1.1404 D_{60}= 0.2417
D_{50}= 0.1501 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Tested by SJM. MC = 12.5%

Date Received: 12/12/2018 **Date Tested:** 1/10/2019
Tested By: SJM
Checked By: JMS
Title: Project Eng. Geologist

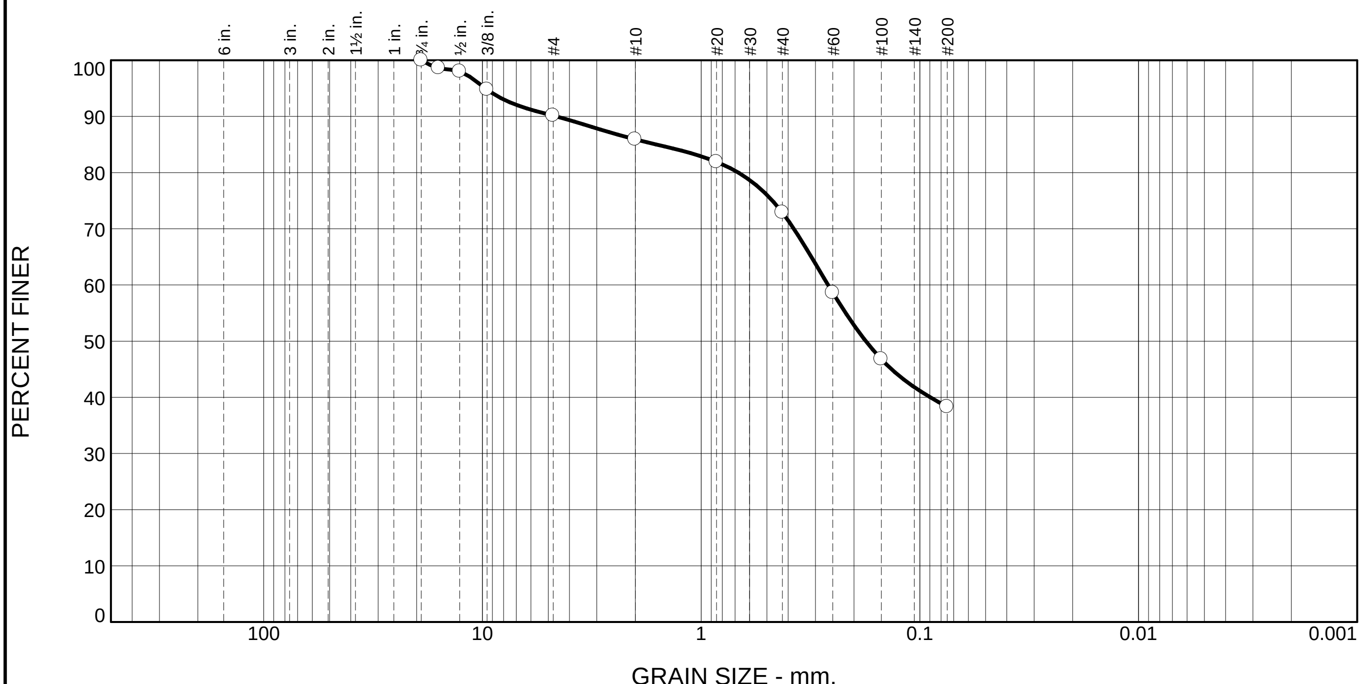
Source of Sample: SR 509 Ramp Boring **Depth:** 7.5 feet **Date Sampled:** 12/12/2018
Sample Number: B-18, S-4

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-26

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.9	4.2	13.0	34.6	38.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/4	100.0		
5/8	98.6		
1/2	98.0		
3/8	94.8		
#4	90.1		
#10	85.9		
#20	81.9		
#40	72.9		
#60	58.6		
#100	46.8		
#200	38.3		

* (no specification provided)

Material Description

Grayish-brown silty fine to medium SAND with occasional fine gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 4.5977 D_{85}= 1.6010 D_{60}= 0.2628
D_{50}= 0.1765 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Tested by SJM. MC = 12.3%

Date Received: 12/12/2018 **Date Tested:** 1/10/2019
Tested By: SJM
Checked By: JMS
Title: Project Eng. Geologist

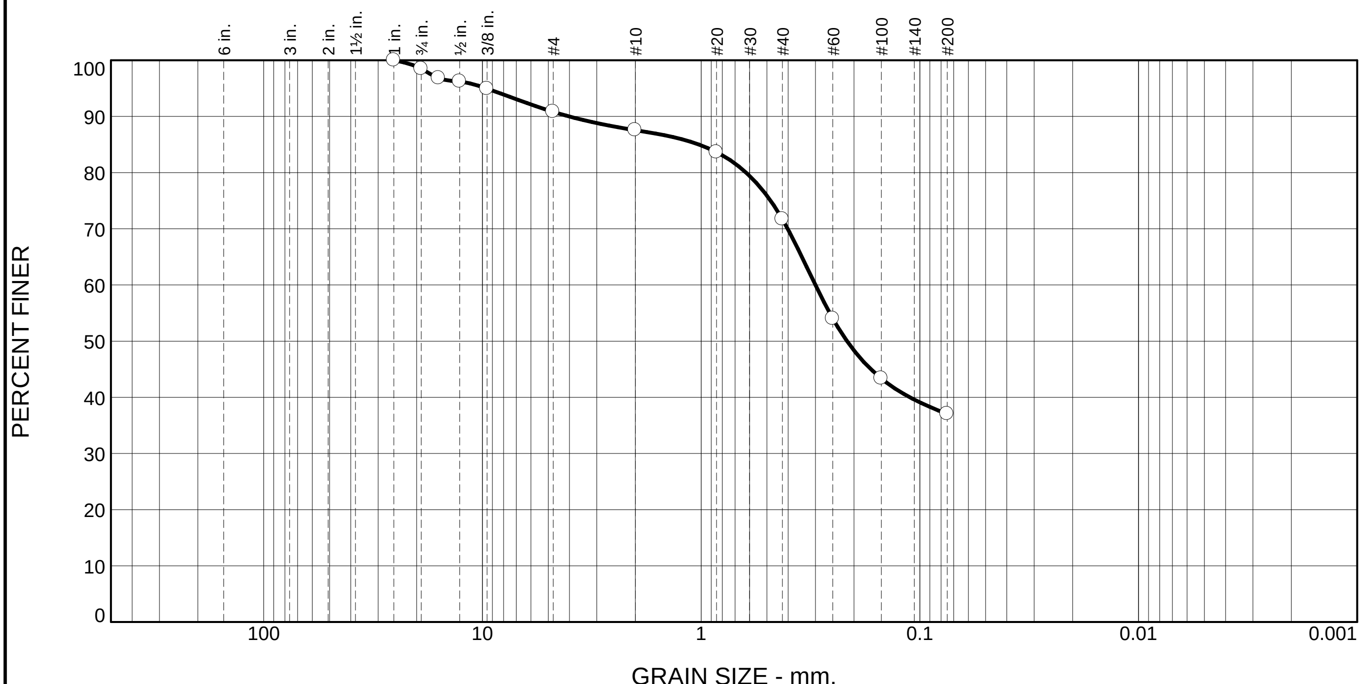
Source of Sample: SR 509 Ramp Boring **Depth:** 7.5 feet **Date Sampled:** 12/12/2018
Sample Number: B-20, S-4

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-27

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.5	7.7	3.3	15.8	34.7	37.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	98.5		
5/8	96.8		
1/2	96.2		
3/8	94.9		
#4	90.8		
#10	87.5		
#20	83.6		
#40	71.7		
#60	54.0		
#100	43.4		
#200	37.0		

* (no specification provided)

Material Description

Light gray silty fine to medium SAND with occasional gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 4.0132 D_{85}= 1.0236 D_{60}= 0.3002
D_{50}= 0.2152 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Tested by SJM. S-2 MC = 7.1%. S-3 MC = 8.1%

Date Received: 12/17/2018 **Date Tested:** 1/10/2019
Tested By: SJM
Checked By: JMS
Title: Project Eng. Geologist

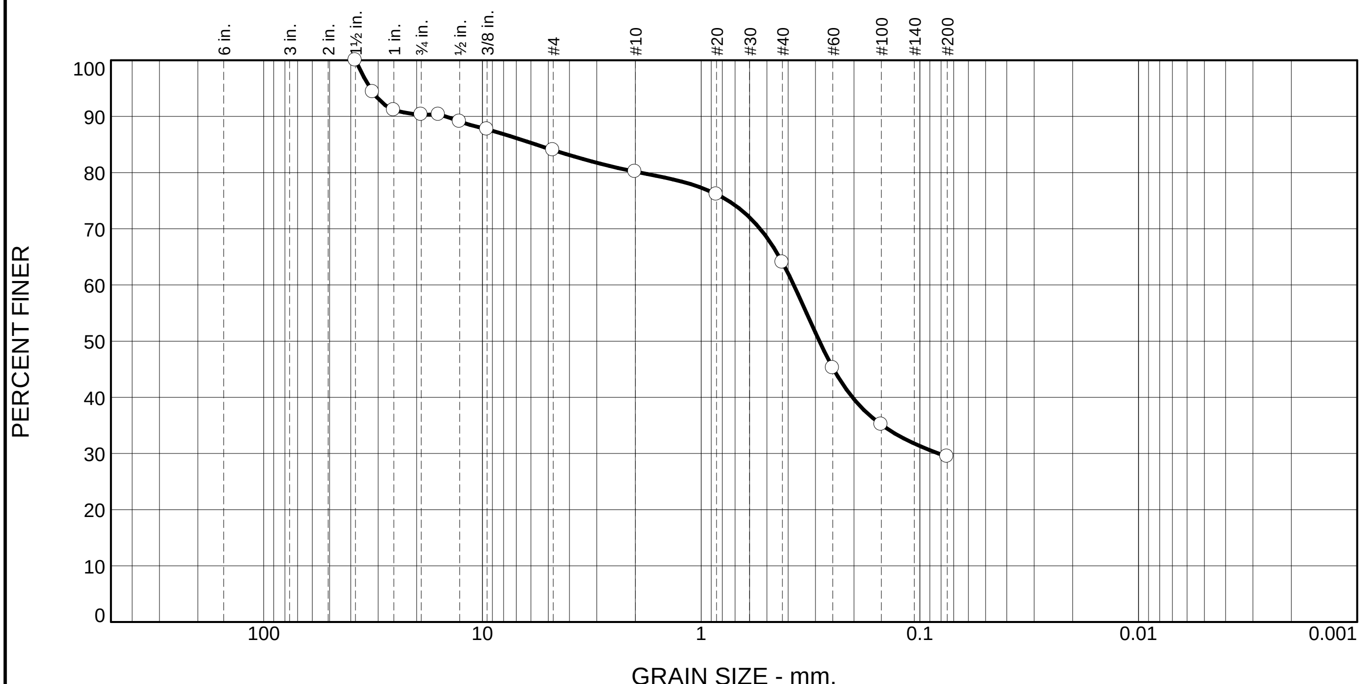
Source of Sample: SR 509 Ramp Test Hole **Depth:** 3.5 feet, 6 feet **Date Sampled:** 12/17/2018
Sample Number: TH-1, S-2 and S-3 Comp

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-28

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	9.7	6.3	3.8	16.2	34.6	29.4	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/2	100.0		
1 1/4	94.4		
1	91.1		
3/4	90.3		
5/8	90.3		
1/2	89.1		
3/8	87.7		
#4	84.0		
#10	80.2		
#20	76.1		
#40	64.0		
#60	45.2		
#100	35.1		
#200	29.4		

* (no specification provided)

Material Description

Light gray silty fine to medium SAND with gravel

Atterberg Limits (ASTM D 4318)

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

Classification

USCS (D 2487)= SM **AASHTO (M 145)=**

Coefficients

D_{90}= 14.6917 D_{85}= 5.6866 D_{60}= 0.3771
D_{50}= 0.2881 D_{30}= 0.0820 D_{15}=
D_{10}= C_u= C_c=

Remarks

Tested by SJM. S-3 MC = 10.8%. S-4 MC = 10.6%

Date Received: 12/17/2018 **Date Tested:** 1/10/2019
Tested By: SJM
Checked By: JMS
Title: Project Eng. Geologist

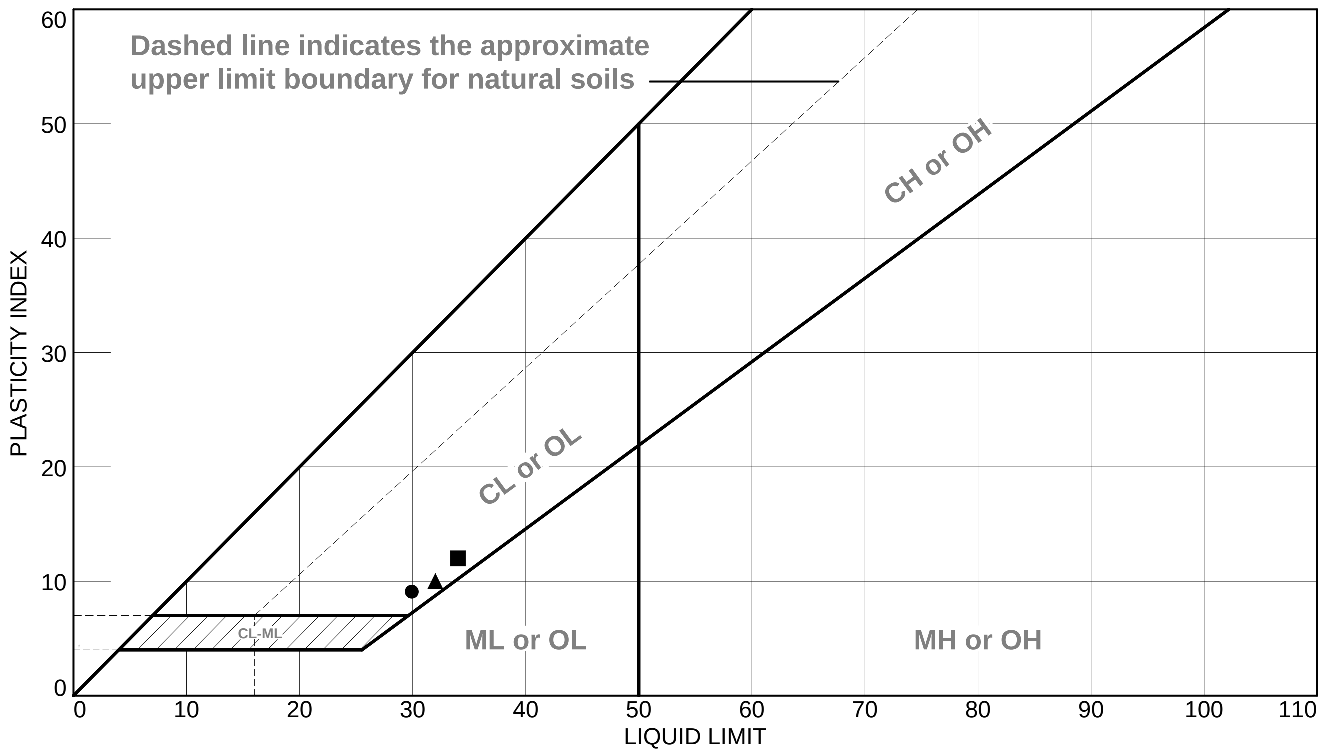
Source of Sample: SR 509 Ramp Test Hole **Depth:** 4 feet, 6.5 feet **Date Sampled:** 12/17/2018
Sample Number: TH-2, S-3 and S-4 Comp

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No: 0105-023 **Figure** B-29

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	SR 509 Ramp Boring	B-19, S-2	2.5'	23.3	21	30	9	CL
■	SR 509 Ramp Boring	B-20, S-3	5'	21.3	22	34	12	CL
▲	SR 509 Ramp Boring	B-18, S-2	2.5'	23.1	22	32	10	CL

ICICLE CREEK ENGINEERS, INC.

Carnation, WA

Client: Parametrix
Project: KC Parametrix Lake to Sound Trail Segment C - SeaTac/Burien
Project No.: 0105-023 **Figure** B-30

Tested By: SJM **Checked By:** JMS

APPENDIX C

HWA BORING LOGS

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS	
Coarse Grained Soils More than 50% Retained on No. 200 Sieve Size	Gravel and Gravelly Soils More than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravel (little or no fines)	GW	Well-graded GRAVEL
			GP	Poorly-graded GRAVEL
		Gravel with Fines (appreciable amount of fines)	GM	Silty GRAVEL
			GC	Clayey GRAVEL
	Sand and Sandy Soils 50% or More of Coarse Fraction Passing No. 4 Sieve	Clean Sand (little or no fines)	SW	Well-graded SAND
			SP	Poorly-graded SAND
		Sand with Fines (appreciable amount of fines)	SM	Silty SAND
			SC	Clayey SAND
Fine Grained Soils 50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit Less than 50%	ML	SILT
			CL	Lean CLAY
			OL	Organic SILT/Organic CLAY
	Silt and Clay	Liquid Limit 50% or More	MH	Elastic SILT
			CH	Fat CLAY
			OH	Organic SILT/Organic CLAY
Highly Organic Soils			PT	PEAT

TEST SYMBOLS

%F	Percent Fines
AL	Atterberg Limits: PL = Plastic Limit, LL = Liquid Limit
CBR	California Bearing Ratio
CN	Consolidation
DD	Dry Density (pcf)
DS	Direct Shear
GS	Grain Size Distribution
K	Permeability
MD	Moisture/Density Relationship (Proctor)
MR	Resilient Modulus
PID	Photoionization Device Reading
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)
SG	Specific Gravity
TC	Triaxial Compression
TV	Torvane Approx. Shear Strength (tsf)
UC	Unconfined Compression

SAMPLE TYPE SYMBOLS

- 2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
- Shelby Tube
- 3-1/4" OD Split Spoon with Brass Rings
- Small Bag Sample
- Large Bag (Bulk) Sample
- Core Run
- Non-standard Penetration Test (3.0" OD split spoon)

GROUNDWATER SYMBOLS

- Groundwater Level (measured at time of drilling)
- Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)

Components are arranged in order of increasing quantities.

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch.
MOIST	Damp but no visible water.
WET	Visible free water, usually soil is below water table.

HWA GEOSCIENCES INC.

LAKE TO SOUND TRAIL
SEGMENT C
SEATAC, WASHINGTON

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

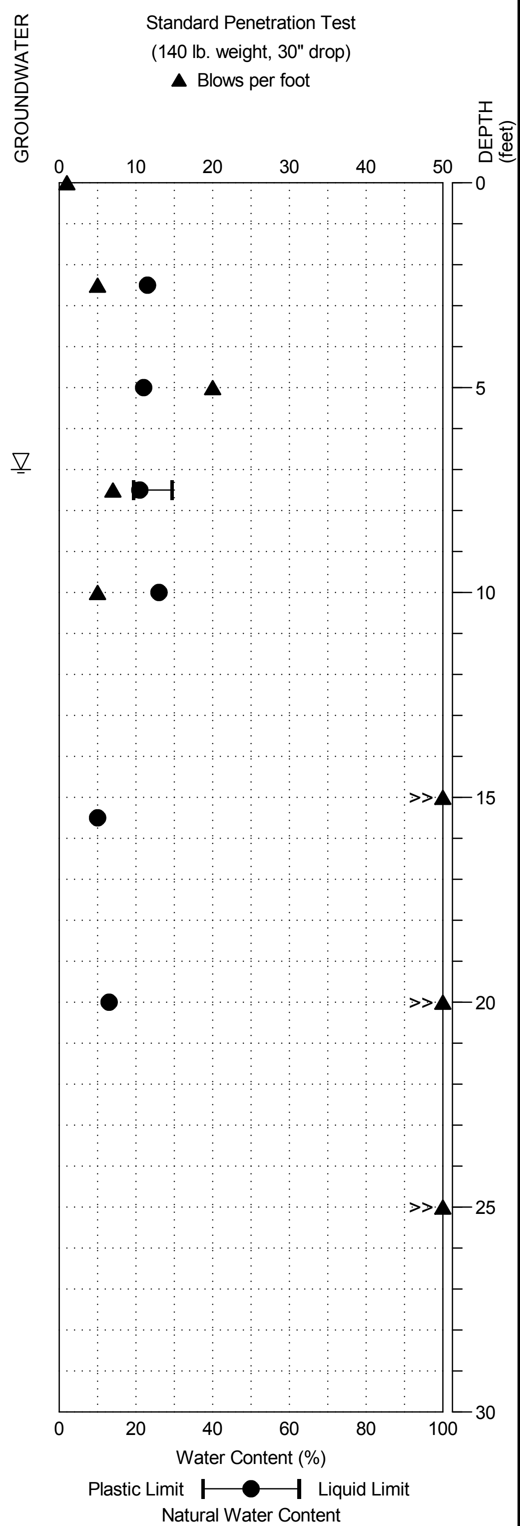
PROJECT NO.: 2010-100 T400 FIGURE: A-1

DRILLING COMPANY: Geologic Drill, Inc.
DRILLING METHOD: Bobcat MT-55 track rig with 4-inch OD HSA
SAMPLING METHOD: SPT w/ cathead
SURFACE ELEVATION: 278.00 ± feet

LOCATION: See Figure 2
DATE STARTED: 10/26/2016
DATE COMPLETED: 10/26/2016
LOGGED BY: B. Salazar

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS
0		Very soft, dark brown, organic SILT, wet. One fine gravel observed in sample. Roots observed. Standing water on surface. **(TOPSOIL)**	S-1	1-0-1	
	SM	Loose, rust-mottled gray, slightly silty, fine to medium SAND, wet. Grades to silty with depth. Lenses of plastic silt observed at 3.5'. **(ALLUVIUM)**	S-2	5-2-3	
5	SP SM	Medium dense, gray, slightly silty, fine to medium SAND, wet. Trace coarse sand observed to 6.0'. Gravels observed at 5.0'	S-3	9-10-10	GS
	CL	Medium stiff, gray, slightly sandy, silty CLAY, moist. Trace fine gravel (dropstones). **(RECESSIONAL GLACIOLACUSTRINE DEPOSITS)**	S-4	4-3-4	AL
10		Becomes olive brown at 10.8'	S-5	3-2-3	
		Drillers note hard drilling at 13.5'			
15	SM	Very dense, olive gray, slightly silty, gravelly, fine to medium SAND, moist. Gravels are subrounded, up to 3/4" in diameter. **(RECESSIONAL OUTWASH)**	S-6A	15-32-35	
	SM	Very dense, olive gray, very silty, fine to medium SAND, moist. Trace fine gravels. **(ICE CONTACT STRATIFIED DRIFT)** Gravelly drilling below 15.6'	S-6B		
20	SM	Very dense, olive gray, very silty, fine to medium SAND with dropstones (fine gravel), moist. Sand lens observed at 20.8' Rust mottling observed at 20.7'.	S-7	18-24-30	GS
25			S-8	50/4"	

Borehole terminated at 25.3'.
Surface water observed at drilling location (wetlands), perched ground water at 7' bgs.
Borehole abandoned with bentonite chips.



For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

LAKE TO SOUND TRAIL
SEGMENT C
SEATAC, WASHINGTON

BORING:
BH-1

PAGE: 1 of 1

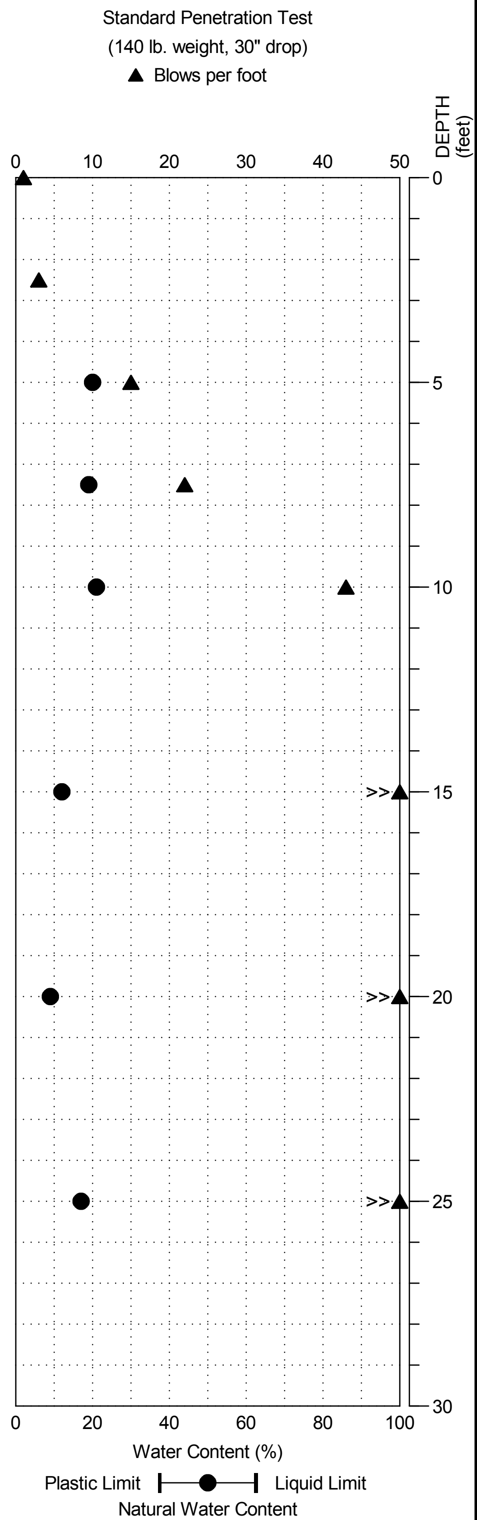
PROJECT NO.: 2010-100 T400 FIGURE: A-2

DRILLING COMPANY: Geologic Drill, Inc.
DRILLING METHOD: Bobcat MT-55 track rig with 4-inch OD HSA
SAMPLING METHOD: SPT w/ cathead
SURFACE ELEVATION: 280.00 ± feet

LOCATION: See Figure 2
DATE STARTED: 10/27/2016
DATE COMPLETED: 10/27/2016
LOGGED BY: B. Salazar

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		Very soft, dark brown, organic SILT with sand and trace fine gravel, wet. Roots present throughout. **(TOPSOIL)**	S-1	1-0-1		
		Brown sand lens observed from 2.6 to 2.7'. No organics or gravel observed. Gray, silty, fine to medium SAND, wet. Trace fine gravel from 2.8 to 2.9'. No organics.	S-2	0-1-2		
5	SM	Medium dense, gray, silty, fine to medium SAND, moist. Silt lens observed at 5.1'. Rust mottling at 5.5'. **(ALLUVIUM)**	S-3	4-8-7	GS	
	SP	Medium dense, olive gray, clean, fine to coarse SAND, wet. Subrounded gravels. **(RECESSIONAL OUTWASH)**	S-4	9-9-13	GS	▽
10	SP	Dense, olive brown, clean, fine to medium SAND, wet. Some rust mottling throughout. Rust band at 11.3'. Blow counts overstated (Driller believes a gravel was pushed by the sampler for the first 12 inches).	S-5	37-30-13		
	SM	Dense, olive gray, silty fine SAND, wet. Finely bedded. Driller notes possible gravel at 12.5'				
15	SM	Very dense, olive gray, very silty, fine SAND, moist. Trace gravel, subrounded, concentrated at 16.0'. Rust mottling at 15.5'. Silt band at 16.3'. Driller notes very hard drilling beginning at 15.0 feet. **(ICE CONTACT STRATIFIED DRIFT)** Driller notes gravelly drilling at 18.0'	S-6	15-26-30	GS	
20		Sand grades to fine to medium. Some rust mottling around gravels observed in sample from 20 to 21.5'. Driller notes smoother drilling at 21.0'.	S-7	30-50/5"		
25	SP	Very dense, olive gray, clean, fine to coarse SAND, wet. Coarse sand increasing in abundance with depth. Driller notes some heave during sampling.	S-8	31-42-50/5"		

Borehole terminated at 26.4'.
Perched ground water inferred at 7.5'.
Borehole abandoned with bentonite chips.



For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

LAKE TO SOUND TRAIL
SEGMENT C
SEATAC, WASHINGTON

BORING:
BH-2

PAGE: 1 of 1

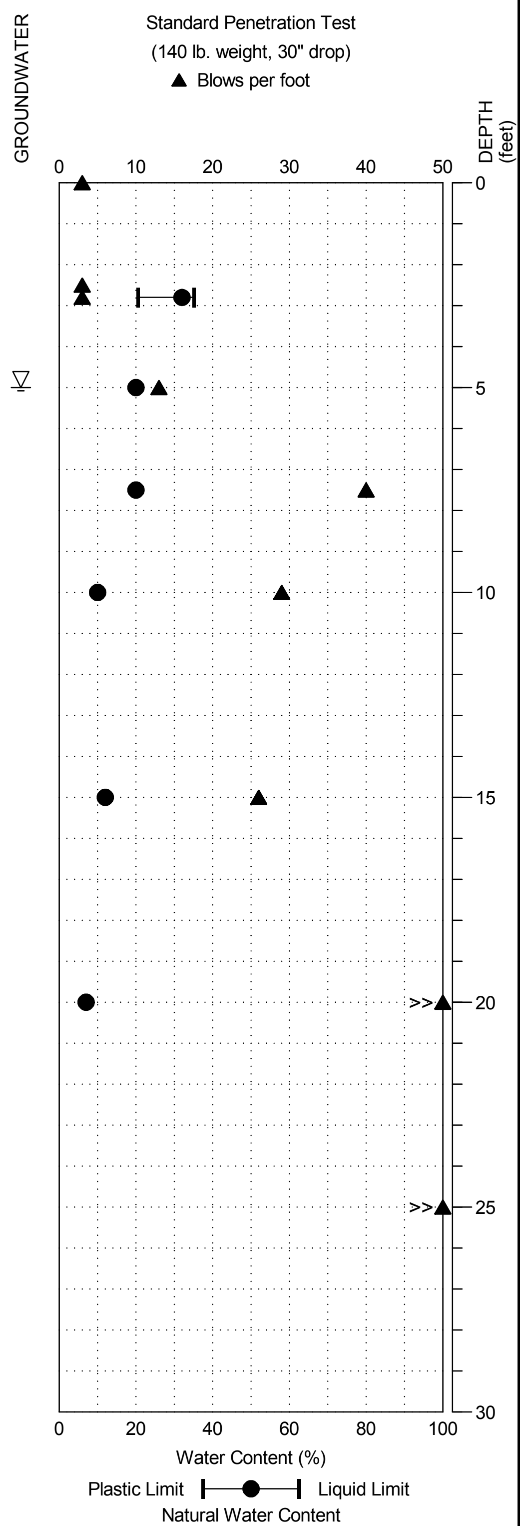
PROJECT NO.: 2010-100 T400 FIGURE: A-3

DRILLING COMPANY: Geologic Drill, Inc.
DRILLING METHOD: Bobcat MT-55 track rig with 4-inch OD HSA
SAMPLING METHOD: SPT w/ cathead
SURFACE ELEVATION: 286.50 ± feet

LOCATION: See Figure 2
DATE STARTED: 10/27/2016
DATE COMPLETED: 10/27/2016
LOGGED BY: B. Salazar

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		Very loose, brown, silty fine to medium SAND with gravel, moist. Gravel is fine, subrounded. Rootlets observed. **(TOPSOIL)**	S-1	2-2-1		
	CL	Soft, dark brown, sandy SILT, moist. Rootlets, charcoal observed.	S-2A	2-1-2	AL	
		Soft, rust-mottled gray, CLAY, moist. Sand lenses observed at 2.8' and 3.1'. **(ALLUVIUM)**	S-2B	2-1-2		
5	SP SM	Medium dense, gray, slightly silty, fine to medium SAND, wet/saturated. Sand includes coarse grains from 5.5 to 6.0'. Rust mottled from 6.0 to 6.5'. **(RECESSIONAL OUTWASH)**	S-3	6-7-6	GS	▽ (5')
	SM	Dense, gray, very silty fine to medium SAND, moist. Rust mottling observed from 7.5 to 8.0'. Becomes less silty, with trace gravels, from 8.5 to 9.0'.	S-4	2-16-24		
10	SM	Medium dense, gray, slightly gravelly, very silty, fine to medium SAND, moist. More abundant gravel observed at 11.1'.	S-5	10-13-16	GS	
15	SM	Medium dense, gray, slightly fine gravelly to gravelly, very silty, fine to medium SAND, moist. With thin, clean sand lenses.	S-6	11-13-13	GS	
20	SM	Very dense, gray, gravelly, silty, fine to medium SAND, moist. Gravel is fine, subrounded. **(GLACIAL TILL)**	S-7	50/6"	GS	
25			S-8	50/4"		

Borehole terminated at 25.3'.
Ground water inferred at 5' bgs.
Borehole abandoned with bentonite chips.



For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

LAKE TO SOUND TRAIL
SEGMENT C
SEATAC, WASHINGTON

BORING:
BH-3

PAGE: 1 of 1

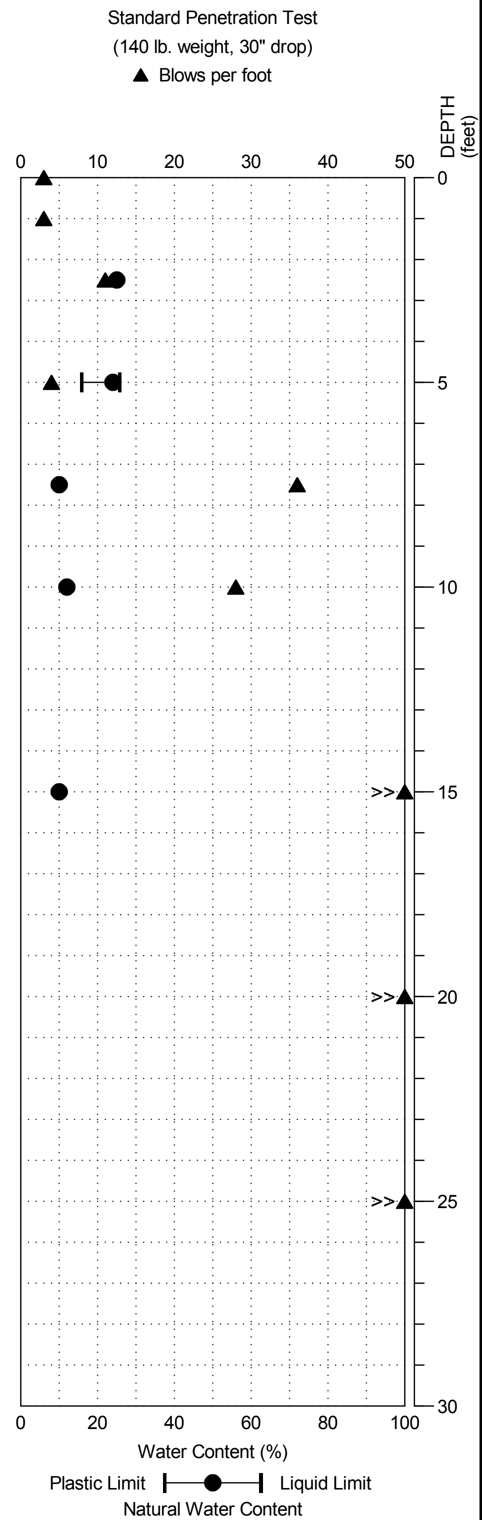
PROJECT NO.: 2010-100 T400 FIGURE: A-4

DRILLING COMPANY: Geologic Drill, Inc.
DRILLING METHOD: Bobcat MT-55 track rig with 4-inch OD HSA
SAMPLING METHOD: SPT w/ cathead
SURFACE ELEVATION: 290.00 ± feet

LOCATION: See Figure 2
DATE STARTED: 10/28/2016
DATE COMPLETED: 10/28/2016
LOGGED BY: B. Salazar

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0	ML	Soft, dark brown sandy organic SILT, wet. Roots, trace fine gravels observed. **(TOPSOIL)**	S-1A	1-1-2		
			S-1B	1-1-2		
	ML SM	Soft, olive gray, fine sandy SILT, moist. Rust mottling observed.	S-2	3-4-7	GS	
		Stiff, gray, sandy SILT, moist. Scattered sand lenses and roots throughout. **(ALLUVIUM)**				
5	CL	Medium stiff, rust-mottled gray, silty CLAY, moist. With scattered fine gravel dropstones.	S-3	3-2-2	AL	
	SM	Dense, gray, slightly fine gravelly, very silty, fine to medium SAND, moist. **(RECESSIONAL OUTWASH)**	S-4	13-15-21	GS	
10	SM	Medium dense, gray, very silty, fine to medium SAND, with trace fine gravel, wet.	S-5	8-12-16		∇
15	SP SM	Very dense, gray, gravelly, very silty fine to medium SAND, moist. Water in sampler tube. **(GLACIAL TILL)** Driller notes very gravelly drilling beginning at 16.0'.	S-6	50/5"	GS	
20		Increased gravel in sample at 20.0'.	S-7	100/5"		
25		Sample is more dry, friable.	S-8	100/5"		

Borehole terminated at 25.4'.
Surface water in area (wetlands).
Perched ground water observed above 15 feet.
Borehole abandoned with bentonite chips.



For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

LAKE TO SOUND TRAIL
SEGMENT C
SEATAC, WASHINGTON

BORING:
BH-4

PAGE: 1 of 1

PROJECT NO.: 2010-100 T400 FIGURE: A-5

APPENDIX D

REDI-ROCK® WALL STATIC AND SEISMIC ANALYSIS OUTPUT FILES

Analysis of Redi Rock wall STATIC ANALYSIS OUTPUT FILE

Input data

Project

Date : 7/9/2019

Settings

(input for current task)

Wall analysis

Active earth pressure calculation :	Coulomb
Passive earth pressure calculation :	Mazindrani (Rankine)
Earthquake analysis :	Mononobe-Okabe
Shape of earth wedge :	Calculate as skew
Allowable eccentricity :	0.333
Internal stability :	Standard - straight slip surface
Reduction coeff. of contact first block - base :	1.00
Verification methodology :	Safety factors (ASD)

Geometry

No. group	Description	Count	Setback s [in]
1	Block 41	4	1.62
2	Top block 28	1	-

Soil parameters

Retained

Unit weight :	γ	=	125.0 pcf
Stress-state :	effective		
Angle of internal friction :	φ_{ef}	=	34.00 °
Cohesion of soil :	c_{ef}	=	0.0 psf
Angle of friction struc.-soil :	δ	=	27.00 °
Saturated unit weight :	γ_{sat}	=	125.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft^2]	Mag.2 [lbf/ft^2]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Traffic Load

Settings of the stage of construction

Design situation : permanent

Verification No. 1

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 16747.3 lbfft/ft

Overturning moment M_{ovr} = 4496.5 lbfft/ft

Safety factor = 3.72 > 1.50

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 3419.88 lbf/ft
Active horizontal force H_{act} = 1325.57 lbf/ft

Safety factor = 2.58 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Verification of block No. 1

Check for overturning stability

Resisting moment M_{res} = 7899.6 lbfft/ft
Overturning moment M_{ovr} = 3230.6 lbfft/ft

Safety factor = 2.45 > 1.50
Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 2076.15 lbf/ft
Active horizontal force H_{act} = 1081.31 lbf/ft

Safety factor = 1.92 > 1.50
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force e = 0.017
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom σ = 1049.2 psf
Bearing capacity of foundation soil R_d = 6000.0 psf

Safety factor = 5.72 > 2.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Slope stability analysis

Input data

Earthquake

Earthquake not included.

Results (Stage of construction 1)

Analysis 1

Slope stability verification (Bishop)

Sum of active forces :	F_a =	4712.7	lbf/ft
Sum of passive forces :	F_p =	9559.8	lbf/ft
Sliding moment :	M_a =	56740.5	lbfft/ft
Resisting moment :	M_p =	115099.6	lbfft/ft

Factor of safety = 2.03 > 1.50

Slope stability ACCEPTABLE

Analysis of Redi Rock wall SEISMIC ANALYSIS OUTPUT FILE

Input data

Project

Date : 7/9/2019

Settings

(input for current task)

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Geometry

No. group	Description	Count	Setback s [in]
1	Block 41	4	1.62
2	Top block 28	1	-

Soil parameters

Retained

Unit weight : γ = 125.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 34.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 27.00 °
Saturated unit weight : γ_{sat} = 125.0 pcf

Input surface surcharges

No.	Surcharge		Action	Mag.1 [lbf/ft2]	Mag.2 [lbf/ft2]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
	new	change						
1	Yes		variable	200.0				on terrain

No.	Name
1	Traffic Load

Earthquake

Factor of horizontal acceleration K_h = 0.2300
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is restricted.

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 20374.2 lbfft/ft
Overturning moment M_{ovr} = 12397.9 lbfft/ft

Safety factor = 1.64 > 1.00
Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 3967.62 lbf/ft
Active horizontal force H_{act} = 2974.08 lbf/ft

Safety factor = 1.33 > 1.00
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Verification of block No. 1

Check for overturning stability

Resisting moment M_{res} = 10047.4 lbfft/ft
Overturning moment M_{ovr} = 8946.8 lbfft/ft

Safety factor = 1.12 > 1.00
Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 2437.19 lbf/ft
Active horizontal force H_{act} = 2401.14 lbf/ft

Safety factor = 1.02 > 1.00
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force e = 0.229
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom σ = 2169.0 psf
Bearing capacity of foundation soil R_d = 6000.0 psf

Safety factor = 2.77 > 1.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Slope stability analysis

Input data

Earthquake

Horizontal seismic coefficient : K_h = 0.23
Vertical seismic coefficient : K_v = 0.00

Results (Stage of construction 1)

Analysis 1

Slope stability verification (Bishop)
Sum of active forces : F_a = 7368.6 lbf/ft
Sum of passive forces : F_p = 10366.9 lbf/ft

Sliding moment : M_a = 118192.9 lbfft/ft
Resisting moment : M_p = 166284.5 lbfft/ft
Factor of safety = 1.41 > 1.00
Slope stability ACCEPTABLE

APPENDIX E

SHANNON & WILSON WALL #15 LETTER DATED JULY 2, 2019

July 2, 2019

Mr. Brian R. Beaman, PE, LEG, LHG
Icicle Creek Engineers, Inc.
29335 NE 20th Street
Carnation, WA 98014

RE: GEOTECHNICAL ANALYSES FOR PROPOSED STATE ROUTE 509 RETAINING WALL #15, LAKE TO SOUND TRAIL SEGMENT C PROJECT, SEATAC, WASHINGTON

Dear Mr. Beaman:

This letter presents our recommendations regarding our evaluation of the proposed retaining wall #15 at the Lake to Sound Trail Project, located in SeaTac, Washington. This letter addresses our review of design plans and geotechnical data provided by Icicle Creek Engineers (ICE); our site visit and reconnaissance on April 3; and our recommendation on LPILE parameters, seismic parameters, and the lateral earth pressure (LEP) for the structural design of the soldier pile wall. Our services were performed in accordance with our Proposal Letter dated November 20, 2018, and ICE's Task Order No. 009. We based the conclusions in this letter on our recent site visit and on the subsurface data provided by ICE.

PROJECT DESCRIPTION

We understand that the proposed Lake to Sound Trail Segment C Project (LSTP) includes widening segments of the trail. The trail crosses a "pinch point" between an approximately 22- to 26-foot-high fill embankment for the State Route (SR) 509 off-ramp to the east and private property to the west. To obtain trail width, the toe of the fill embankment will require a cut varying from about 3 to 10 feet high. ICE recommended use of a soldier pile wall to support the excavated areas, and we concur. Wall #15 will be up to 11 feet high and constructed into a steep (about a 50 percent grade) slope on the west side of the trail between Stations 186+40 and 188+80. We understand that the retaining wall is semi-permanent and the wall may eventually be removed when realignment of SR 509 occurs sometime in the future.

SITE VISIT AND SUBSURFACE CONDITIONS

Two Shannon & Wilson representatives (Martin Page, PE, LEG, and Adnan Khan) visited the project site on April 3, 2019, to observe surface features and correlate them with subsurface information collected by ICE. We did not perform any additional subsurface explorations. During our site visit, we observed the presence of a 3- to 4-foot-high rockery at the toe of the steep embankment. We saw a number of trees on the slope and all of the trees have straight trunks that typically indicates no surficial soil creep is occurring. The slope appeared to be relatively stable. From our visual inspection, we did not see any loss of soils from the slope surface and no bulging of soil at the proposed wall location.

Based on our site visit and our review of borings B-16, B-17, B-18, B-19(P) and B-20, performed by ICE, there are three types of soils underlying the embankment. Most of the soil comprising the embankment can be described as medium dense sand fill. Underneath the fill soil there is a stiff clay layer that overlies recessional outwash with glacial till. From the boring logs we can see the presence of groundwater at elevation between 312 to 314 feet (8 to 10 feet below trail level). Perched water was also found at boring B-20 at 317 feet elevation. Groundwater elevation is likely variable depending on season and will likely be encountered during soldier pile installation. Perched water may also affect soldier pile construction.

GEOTECHNICAL RECOMMENDATIONS

Based on our observations during our site visit and our review of ICE subsurface data, we have prepared recommendations for LEP, seismic design, and LPILE soil parameters to be used in design of the soldier piles.

Seismic Design Parameters

Table 1 provides the site design ground motions and the risk targeted Maximum Considered Earthquake (MCE_R) ground motion parameters from which the design ground motions were derived. The MCE_R ground motion parameters correspond to a target risk of 7 percent probability in exceedance in 75 years of structural collapse. The seismological inputs are the MCE_R short-period and 1-second period spectral accelerations, S_s and S_1, respectively.

The site soil response factors are based on determination of the Site Classification. The site Classification is determined from characterization of the soil and rock within approximately 32 feet of the ground surface. The seismological inputs S_s, S_1, and peak ground acceleration (PGA) are scaled by the site soil coefficients F_a, F_v, and F_{PGA}, respectively, that are determined based on the Site Classification and the magnitude of S_s, S_1, and PGA values. For the AASHTO (2015) Site Class criteria, the site corresponds to Site Class D.

SHANNON & WILSON

Table 1 – Recommended Seismic Design Parameters

Seismic Parameter	Value
Site Class	D
Mapped Peak Ground Acceleration, PGA	0.44g
Mapped Short Period Spectral Acceleration, S_S	1.032g
Mapped 1-Second Period Spectral Acceleration, S_1	0.294g
Peak Ground Acceleration Site Coefficient, F_{PGA}	1.16
Short Period Site Coefficient, F_a	1.087
1-Second Period Site Coefficient, F_v	2.012
Design Peak Ground Acceleration, A_S	0.511g
Short Period Design Spectral Acceleration, S_{DS}	1.122g
1-Second Period Design Spectral Acceleration, S_{D1}	0.592g

Lateral Earth Pressure (LEP)

Recommended apparent LEPs for design of a cantilevered soldier pile wall are presented in Figure 1. These pressures were developed based on assumptions that this is a single-face, vertical wall with a backslope inclined at an angle of 26 degrees. The earth pressures were developed based on the procedures described in Geotechnical Engineering Circular #4, Ground Anchors and Anchored Systems prepared by the Federal Highway Administration (Sabatini and others, 1999[1]; American Association of State Highway and Transportation Officials [AASHTO], 2015[2]; Anderson and others, 2008[3]). Active earth pressure and the seismic earth pressure (acting from 333- to 322-foot elevation) were calculated using general limit equilibrium method. The active and passive earth pressure from 322 feet elevation to the bottom of the wall was calculated using our in-house spreadsheet. Recommended earth pressures showed in Figure 1 are for static (i.e., active and passive) and seismic conditions.

[1] Sabatini, P. J.; Pass, D. G.; and Bachus, R. C., 1999, Geotechnical engineering circular no. 4: Ground anchors and anchored systems. No. FHWA-IF-99-015.
[2] American Association of State Highway and Transportation Officials (AASHTO), 2015, AASHTO LRFD bridge design specifications: customary U.S. nits (7th ed.): Washington, D.C., AASHTO, 2 v.
[3] Anderson, D. G.; Martin, G. R.; Lam, I. P.; and Wang, J. N., 2008, Seismic analysis and design of retaining walls, slopes and embankments, and buried structures: NCHRP Report 611 National Cooperative Highway Research Program, Transportation Research Board, National Research Council, Washington, DC.

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Soldier Piles LPILE Estimates

We understand that the structural engineer will use the computer program LPILE to generate load-deflection (P-Y) curves for the lateral resistance analysis of deep foundations, and to calculate the magnitude of deflection, shear, and moment along the shafts. The following Table 2 presents our recommended geotechnical parameters for lateral resistance analysis for the proposed retaining wall. Liquefaction potential is considered low at this site; therefore, the values provided below are applicable for both static and seismic conditions.

Table 2 – Recommended Parameters for Lateral Resistance Analysis Using LPILE

Wall	Elevation (ft)		USCS	Groundwater Elevation (feet)	LPILELpil Model	Friction Angle, ϕ (deg.)	Cohesion (psf)	Effective Unit Weight, γ' (pcf)	Subgrade Modulus, k (pci)	Strain Factor, ε_{50}
	Top	Bottom								
Wall #15	333	319.5	SM	312	Sand (Reese)	32	100	130	70	-
	319.5	314.5	CL		Stiff Clay without Free Water	-	850	110	200	0.0095
	314.50	312	SM		Sand (Reese)	34	-	130	110	-
	312	307	SM		Sand (Reese)	34	-	68	70	-

NOTE:

deg. = degree; pcf = pounds per cubic foot; pi = pounds per cubic inch; psf = pounds per square foot; USCS = Unified Soil Classification System

CLOSURE AND LIMITATIONS

This letter was prepared for the exclusive use of ICE for the design retaining wall #15 at the LSTP. The conclusions and recommendations contained in this letter are based on surface conditions observed during our review of the subsurface information referenced in this letter.

Within the limitations of the scope, schedule, and budget, the conclusions and recommendations presented in this letter were prepared in accordance with generally accepted professional geotechnical engineering principles and practices in the area at the time this letter was prepared. We make no other warranty, either express or implied.

SHANNON & WILSON

Shannon & Wilson, Inc. has prepared the enclosed "Important Information About Your Geotechnical/Environmental Report" to assist you and others in understanding the use and limitations of this report.

Sincerely,

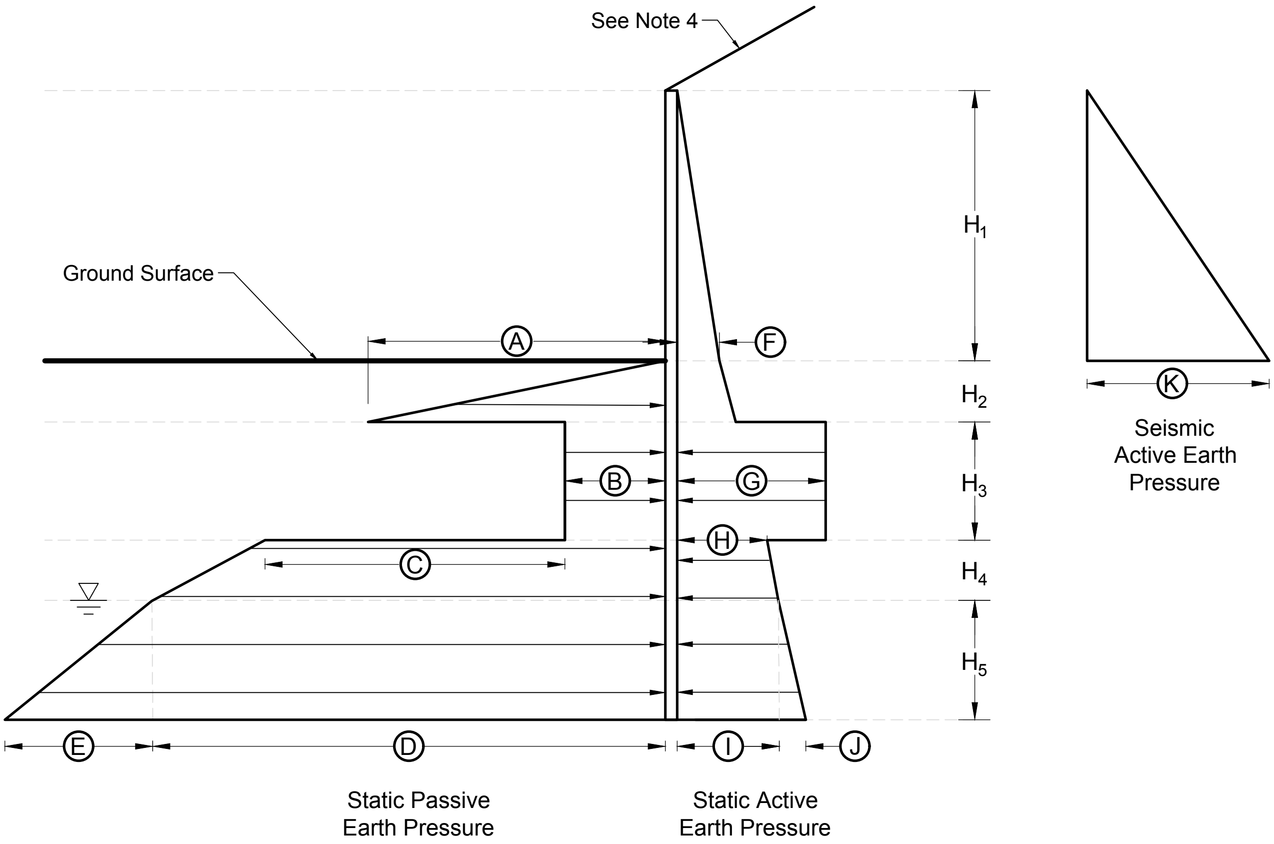
SHANNON & WILSON

Md Adnan Khan, PhD
Geotechnical Engineer

Martin W. Page, PE, LEG
Vice President
Geotechnical Engineer

MAK:MWP/mak

Enc. Figure 1 – Lateral Earth Pressure Diagram for Wall #15
Important Information About Your Geotechnical/Environmental Report



Not to Scale

Recommended Lateral Earth Pressure										
A	B	C	D	E	F	G	H	I	J	K
2,200	600	7,000	9,600	$540H_5$	$29H_1$	2,020	576	660	$17H_5$	$82H_1$

NOTES

1. The lateral earth pressures shown are applicable to cantilever walls and walls with one level of anchors. The pressure units are in pounds per square foot (psf).
2. Active earth pressures assume the wall is allowed to move more than 0.001 x H.
3. Embedment should consider kickout resistance and should be determined to satisfy horizontal static equilibrium and moment equilibrium.
4. Earth pressures assume backslope inclined at an angle of 26°.
5. The provided passive pressures are unfactored. Use a factor of safety of 1.5.
6. Ignore passive resistance in upper 2 ft. (typ.).
7. Seismic and Active Earth Pressure should not be combined.
8. Seismic active earth pressure was calculated using 0.5 PGA_M

Depth (FT.)	
H_2	2.5
H_3	5
H_4	2.5

LEGEND

▽ = Groundwater Level

H = Exposed Wall Height

Lake to Sound Trail - Retaining Wall #15
SeaTac, Washington

LATERAL EARTH PRESSURE DIAGRAM FOR WALL #15

April 2019 102245-001

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1

File: J:_SEA\102245\001\102245-001 Fig 1 - LEP for Wall.dwg Date: 04-05-2019 Author: sac

SHANNON & WILSON
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Attachment to and part of Report:	102245-001
Date:	July 2, 2019
To:	Mr. Brian R. Beaman, PE, LEG, LHG
	Icicle Creek Engineers, Inc.

Important Information About Your Geotechnical/Environmental Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland