SUBMITTED TO:
Sargent Engineers, Inc.
320 Ronlee Lane NW
Olympia, WA 98502

BY:
Shannon & Wilson
400 N. 34th Street, Suite 100
Seattle, WA 98103

(206) 632-8020
www.shannonwilson.com

DRAFT

GEOTECHNICAL ENGINEERING AND ENVIRONMENTAL REPORT

Cascade Mill Parkway, Phase 3

YAKIMA COUNTY, WASHINGTON

SHANNON & WILSON

September 19, 2022

Shannon & Wilson No: 106384-002

Submitted To: Sargent Engineers, Inc.
320 Ronlee Lane NW
Olympia, WA 98502
Attn: Ms. Jessica Soward, PE, SE

Subject: DRAFT GEOTECHNICAL ENGINEERING AND ENVIRONMENTAL REPORT, CASCADE MILL PARKWAY, PHASE 3, YAKIMA COUNTY, WASHINGTON

Shannon & Wilson prepared this report and participated in this project as a subconsultant to Sargent Engineers, Inc. Our scope of services was specified our proposal dated February 12, 2021, and executed via the Professional Services Agreement with Sargent Engineers, Inc., dated March 2, 2021.

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

Sincerely,

SHANNON & WILSON

Oliver T. Hoopes, PE
Associate

MXT:KXM:OTH:RAM/oth

CONTENTS

Exhibits

Figures

Appendices

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
BDM	Bridge Design Manual
bgs	below ground surface
CMP	Cascade Mill Parkway
County	Yakima County
CRBG	Columbia River Basalt Group
CSBC	crushed surfacing base course
Ecology	Washington State Department of Ecology
EFW	equivalent fluid weight
ESAL	equivalent single-axle load
EWC	East-West Corridor
FEE	functional evaluation earthquake
FS	factor of safety
g	standard acceleration of gravity
GRO	gasoline-range organics
GDM	Geotechnical Design Manual
H:V	Horizontal to Vertical
HMA	hot-mix asphalt
I-82	Interstate 82
IDW	investigation-derived waste
ksf	kips per square foot
LRFD	Load and Resistance Factor Design
mg/kg	milligrams per kilogram
mm	millimeter
MSW	municipal solid waste
MTCA	Model Toxics Control Act
pcf	pounds per cubic foot
PIT	Pilot Infiltration Test
psf	pounds per square foot
SEE	safety evaluation earthquake
SMMEW	Stormwater Management Manual for Eastern Washington
SPT	Standard Penetration Test
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
VWP	vibrating wire piezometer
WSDOT	Washington State Department of Transportation
YRB	Yakima River Bridge

1 INTRODUCTION

1.1 General

This report presents the results of our geotechnical engineering and environmental studies for Phase 3 of the Cascade Mill Parkway (CMP) Phase 3 Project (Project) in Yakima County (the County), Washington. The location of the proposed CMP roadway alignment is shown in the Vicinity Map, Figure 1.

1.2 Project Understanding and Description

The CMP Project in Yakima County includes approximately 2.1 miles of a four-lane arterial that will connect the City of Yakima with Terrace Heights, an unincorporated area of the County. The Project is designed to improve traffic flow and includes at-grade and abovegrade roads, sidewalks, a shared bicycle/pedestrian path, undercrossing bridges beneath I-82, and a bridge over the Yakima River and the Roza Canal. Other Project improvements include illumination, sewer and potable water utilities, storm drainage, levee flood protection, floodplain restoration, and wetland/stream mitigation on the Yakima River east bank. The river levee to the east and south of the Yakima River Bridge (YRB) will be removed as a part of this Project. The river levee to the east and north of the bridge will be evaluated by a separate County project.

Phase 3 of the Project includes the proposed CMP alignment from west of North 15th Street. Key proposed Phase 3 elements addressed in this report include:

- The CMP Roadway Alignment, including the roadway prism, sign and luminaire foundations, and proposed buried utilities.
- A proposed roadway embankment supporting the CMP alignment, up to about 10 feet tall, west of the I-82 embankment.
- The YRB over the Yakima River and associated approach embankments and walls.
- YRB scour protection measures.
- A stormwater infiltration and detention pond north of CMP, between Interstate-82 (I-82) and the Yakima River.

Two proposed I-82 undercrossing bridges are also associated with Phase 3 of the CMP Project because they will be designed by the Washington State Department of Transportation (WSDOT) Bridge and Structures Office. Our recommendations for these bridges are presented in a separate report (Shannon & Wilson, in press).

Phases 1 and 2 included the at-grade portions of the alignment east of North 15th Street in Yakima. Geotechnical recommendations for Phases 1 and 2 are presented in our Final Design Geotechnical Engineering and Environmental Report, Stages 1 and 2, East-West Corridor Project, February 14, 2020 (Shannon & Wilson, 2020).

West of the I-82 embankment, the CMP alignment crosses land that was previously used as a lumber mill and then later as a municipal solid waste (MSW) landfill. The extent of this landfill location is indicated in Figure 2 with a dashed yellow line. We understand that as part of the Bravo Company Boulevard extension project the City of Yakima has removed the MSW and wood waste material in that area down to native sand and gravel within the CMP footprint and replaced it with compacted granular fill. Exhibit 1-1 presents a July 2021 aerial image that was taken after the City of Yakima performed this work (Google Earth, 2021).

Exhibit 1-1: Aerial Imagery Showing Recent Site Work West of I-82 (July 2021)

Based on preliminary plans, we understand that in addition to replacing the MSW and wood waste, the City of Yakima also installed a zone of low permeability material around the perimeter of the replacement zone. We understand the purpose of this relatively low permeability zone is to reduce the potential that vapor from the remaining MSW would intrude into the newly placed granular material.

1.3 Scope of Services

Our scope of services included performing subsurface explorations, field and laboratory tests, and geotechnical, hydrogeologic, and hydraulic analyses to advance the Phase 3 portion of the CMP Project to final corridor design configuration. This report updates recommendations from the following reports we performed under previous contracts:

- Draft Geotechnical Engineering and Environmental Report, East-West Corridor Project Stage 3, Yakima County, Washington (January 8, 2020)
- Draft Hydraulics Report, Yakima East-West Corridor Project, FEMA No-Rise Study, Yakima County, Washington (January 2019)

The subsurface explorations and engineering performed incorporates and builds upon those presented in previous reports.

2 SUBSURFACE EXPLORATIONS

Shannon & Wilson performed subsurface exploration programs for the CMP Project in 2014, 2017, and 2021. Approximate locations of these explorations are shown in the Site and Exploration Plan (Figure 2).

Numerous explorations by others were performed in the area west of I-82, primarily to evaluate the depth of the MSW and wood waste within the CMP Project alignment. As noted in Section 1.2, the City of Yakima removed this material within the CMP alignment and replaced it with compacted granular fill. Therefore, we have not included logs of any of these explorations west of the I-82 embankment in this report.

2.1 2021 Explorations

Subsurface explorations completed for the project in 2021 included the following three programs:

- Seven borings by Shannon & Wilson in the I-82 embankment,
- Two test pits performed by the County in the footprint of a proposed stormwater detention pond, and
- One test pit completed by WSDOT in the I-82 embankment side slope.

2.1.1 Shannon & Wilson Borings

Shannon & Wilson performed a subsurface exploration program in 2021 that included seven borings. These borings were completed between March and April 2021. The Site and

Exploration Plan, Figure 2, shows the approximate locations of the borings. Appendix A includes the description of field methods and procedures to perform the borings and detailed logs of the borings.

Six borings were advanced for the two I-82 undercrossing bridges. Four borings were performed at the proposed abutments (B-9-21, B-10-21, B-11P-21, and B-12P-21) and two borings were performed approximately 100 feet away from the abutments to assess conditions at the tieback locations (B-13-21 and B-14-21). The borings were drilled in the interior and exterior shoulders of I-82. We advanced the abutment borings to 100 feet below ground surface (bgs) and the tieback borings to 65 feet bgs. All borings were advanced using sonic core drilling methods. The borings extended through the I-82 embankment fill and into the underlying native soil.

One subsurface boring (B-15P-21) was advanced in the existing U.S. Bureau of Reclamation (USBR) levee. The boring was advanced to 40 feet bgs using sonic core drilling methods, and a well was installed in the borehole.

In situ vibrating wire piezometers (VWPs) and dataloggers were installed in two of the abutment borings, B-11P-21 and B-12P-21, and the USBR boring, B-15P-21. We collected over 12 months of daily groundwater data from the VWPs, from April 2021 to May 2022. The dataloggers were removed from the borings in May 2022. Plots of our groundwater observations are included in Appendix E.

2.1.2 County Test Pits

In 2021, the County performed two test pits within the footprint of the proposed pond, designated North Test Hole and South Test Hole. The locations of these test pits are shown in Figure 2. Our understanding of the depth of the wood as shown in Exhibit 2-1 is based on email correspondence with the County. Shannon & Wilson was not present during the excavation of these test pits. Exhibit 2-1 presents the County's findings at these test pits.

Exhibit 2-1: County Wood Waste Test Pit Findings

Test Pit Name	Depth (feet)	Description
North Test Hole	8	Top of wood waste
	9	Bottom of wood waste / top of river alluvium
	14	Bottom of pit (also in river alluvium)
South Test Hole	1	Top of wood waste
	13	Bottom of wood waste / top of river alluvium / bottom of pit

2.1.3 WSDOT Test Pit

WSDOT performed a test pit in May 2022 to evaluate stand-up time of the I-82 embankment material. Details on the stand-up test pit and a log can be found in Appendix A. The test pit log is shown in Appendix A.

2.2 2017-2018 Explorations

Shannon & Wilson performed three boreholes and one test pit for the East-West Corridor (EWC) Project Stage 3, designated B-1-17, B-2-17, and B-3-18, and TP-P1-17 (see Figure 2). The explorations west of the Yakima River were completed between July and September 2017, and boring B-3-18, located on a gravel bar in the Yakima River, was completed in September 2018. The 2017-2018 explorations are included in the Site and Exploration Plan, Figure 2.

The borings, designated B-1-17, B-2-17, and B-3-18, were advanced using sonic core drilling techniques to depths ranging from 40 to 140 feet bgs.

The test pit, designated TP-P1-17, was excavated to design a drainage facility. The test pit was excavated to 8.5 feet bgs using a backhoe provided by the County and observed by a Shannon & Wilson representative. A Pilot Infiltration Test was performed in TP-P1-17.

Boring and test pit logs and descriptions of field methods and procedures used to perform the borings and test pits are included in Appendix C.

2.3 2014 Explorations

Shannon & Wilson completed four borings, designated EWC-B-01-14 through EWC-B-04-14, along the Stage 3 portion of the EWC alignment between June and July 2014 as a part of the 30% design study. The 2014 explorations are included in the Site and Exploration Plan, Figure 2. The borings for the 30% design were drilled using sonic core drilling techniques to an approximate depth of 100 feet bgs. Boring logs and descriptions of field methods and procedures used to perform the borings are included in Appendix C.

3 GEOTECHNICAL LABORATORY TESTING

We performed geotechnical laboratory testing on select soil samples from the explorations performed by Shannon & Wilson to evaluate index and engineering properties. This laboratory testing included visual soil classification, moisture content determinations, grain-size analysis, and Atterberg Limits. Laboratory tests were performed by Shannon & Wilson in accordance with applicable ASTM standard test procedures. Appendix B provides descriptions of the laboratory test procedures and the laboratory test results. Results are also presented graphically in the boring logs in Appendix A.

Appendix C provides descriptions of the laboratory test procedures and the laboratory test results from 2017-2018 and 2014 explorations.

4 ENVIRONMENTAL LABORATORY TESTING

We performed environmental laboratory testing on samples retrieved from the 2014, 2017, and 2021 explorations. Environmental testing was performed by others in the area west of I-82. However, as noted in Section 1.2, the City of Yakima removed the MSW and wood waste material within the CMP Project footprint in 2021. Therefore, environmental testing results from those explorations are not included or summarized in this report.

4.1 2021 Explorations

Soil samples were collected for environmental laboratory analysis from borings B-09-21, B-10-21, B-11P-21, B-13-21, B-14-21, and B-15P-21. The laboratory analysis was completed to assist in the disposal of investigation-derived waste (IDW) generated during the investigation and to provide environmental characterization of the soils that may be encountered during construction for worker health and safety purposes. The samples were screened for the potential of contamination using a photoionization detector and visual and olfactory observations. Soil samples were collected at depths where field indication identified the potential presence of contamination. In borings where no field indication of contamination was observed, samples were collected near the groundwater-soil interface.

Analytical laboratory test results identified heavy oil-range petroleum hydrocarbons and gasoline-range organics (GRO) similar to mineral spirits present in the soil in one of the borings completed for the Project. Several metals, including arsenic, barium, chromium, lead and selenium, were detected in samples collected from each of the borings. With the exception of the GRO detected, the heavy oil-range hydrocarbons and metals, including arsenic, barium, chromium, lead and selenium, were detected below available Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA) Method A and B criteria (Ecology, 2013). GRO was detected at a concentration of 1,030 milligrams per kilogram (mg/kg) in the 15.5-foot sample collected from boring B-10-21. The detected concentration exceeds the Ecology MTCA Method A soil cleanup level for unrestricted land use of 100 mg/kg. Currently, we are unsure of the source of the contamination encountered in boring B-10-21 at that depth.

Additional information is provided in Appendix D, which includes descriptions of the soil sample screening, methodology, and IDW disposal, along with analytical data results of the samples collected during the 2021 investigation.

4.2 2014 and 2017 Explorations

Environmental laboratory analysis was performed on soil samples collected from borings completed during previous investigations, 30% phase borings EWC-B-01-14 through EWC-B-04-14 (2014) and borings B-1-17 and B-2-17 (2017), located west of the Yakima River. The samples were collected to assist with environmental characterization of the soil that may be encountered during construction of the Project and to assist in the disposal of generated IDW. The samples were screened for the potential of contamination using a photoionization detector and visual and olfactory observations. The soil samples in the 30% borings were collected near the groundwater interface.

Laboratory test results identified gasoline-range petroleum hydrocarbons, toluene, ethylbenzene, xylenes, diesel-range-petroleum hydrocarbons, lube-oil-range petroleum hydrocarbons, arsenic, chromium, lead, and cadmium in the soil sampled along the alignment. The identified contaminants were below the Washington MTCA Method A unrestricted cleanup criteria (Ecology, 2013).

Appendix D provides descriptions of the soil sample screening, methodology, and IDW disposal, along with analytical data results.

5 GROUNDWATER AND SURFACE WATER MEASUREMENTS

We measured groundwater levels in piezometers installed in the 2021, 2017-2018, and 2014 borings. Figures E-1 through E-8 in Appendix E present plots of surface and groundwater monitoring data for the Project. The 2021, 2017-2018, and 2014 borings with VWPs and groundwater monitoring wells are as follows:

- 2021: In situ VWPs and dataloggers were installed in borings B-11P-21 and B-12P-21. A monitoring well with a VWP was installed in boring B-15P-21. Figures E-1 through E-3 present the recorded groundwater elevation versus time, and daily precipitation and relative river level between January 2021 and June 2022. Precipitation data is from a National Oceanic and Atmospheric Administration weather station near downtown Yakima. The relative river levels represent gage heights from the Yakima River, from the U.S. Geological Survey (USGS) river gauge at Union Gap, which is approximately 6 miles downstream from the Project site.

- 2017-2018: A monitoring well was installed in B-2-17. Figure E-4 presents the groundwater elevation versus time from November 2017 through September 2018.
- 2014: Monitoring wells and VWPs were installed in EWC-B-01-14 through EWC-B-04-14. Figures E-5 through E-8 present the recorded groundwater elevation versus time, and the area precipitation between July 1, 2014, and June 16, 2015. Precipitation data is from the Yakima Air Terminal.

The boring logs in Appendix A (2021) and Appendix C (2017-2018, 2014) show the groundwater elevations measured and the corresponding dates of record.

We utilized the VWP groundwater data for the final phase of analysis and design recommendations.

6 GEOLOGY AND SUBSURFACE CONDITIONS

6.1 Geologic Setting

The Project site is located near the western margin of the Columbia Basin geologic province, a lowland occupying the southern-central portion of Washington that is characterized by expansive plateaus, incised canyons, and east-west-oriented ridges.

Bedrock within the Columbia Basin is generally composed of the Miocene Columbia River Basalt Group (CRBG) and Tertiary sedimentary rock (Lasmanis, 1991). Basalt that comprises the CRBG accumulated between about 17 and 6 million years ago. While much of the CRBG is buried by younger sedimentary rock or unconsolidated deposits, it is well exposed in many areas, including near the Project site where the basalt has been relatively uplifted and exposed in roughly east-west-oriented anticlinal folds that comprise the Yakima fold and thrust belt. Presently active deformation in the fold and thrust belt began in the Miocene (McCaffrey and others, 2016).

Cataclysmic floods periodically inundated and scoured much of the Columbia Basin during the last glacial period (Norman and others, 2004; Bjornstad, 2006). Repeated failure of the ice dams resulted in numerous massive floods that flowed across much of eastern Washington and down the Columbia River. The floods eroded channels into bedrock and removed surficial soils in some areas, while leaving extensive deposits of gravel, sand, and silt in others (Norman and others, 2004; Bjornstad, 2006).

Constrictions along the path of glacial floods resulted in the formation of temporary lakes and the accumulation of relatively fine-grained slack-water deposits in some areas (Bjornstad, 1980). The wind-deposited loess and dune deposits covering much of the western Columbia Basin were commonly derived from the reworking of these flood and slack-water deposits. Loess deposits are locally as much as 250 feet thick (Norman and others, 2004). The loess and slack-water deposits are exposed on the higher topography encompassing the east-west ridges near the Project site.

Surficial deposits of the CMP area consist of Holocene alluvium along the active Yakima River channel and Pleistocene terrace deposits at slightly higher elevations along the margins of the channel (Bentley and others, 1993; Schuster, 1994). The terrace deposits may extend to about 30 feet above the modern Yakima River floodplain.

6.2 Subsurface Soil Conditions

This section describes the geologic soil units encountered by boreholes along the CMP alignment. The geologic unit descriptions are described below and are shown in the boring logs presented in Appendices A and C. A generalized subsurface cross section along the CMP roadway alignment is presented in Figure 3, and generalized cross sections oriented approximately orthogonal to the alignment are presented in Figures 4 and 5.

The soil units encountered in the project explorations include Holocene Fill (Hf), Loess Deposits (Ql), and Alluvial Deposits (Qa). Terrace deposits from the Yakima River are undifferentiated from Qa. Descriptions of these units follow:

- Holocene Fill (Hf) – Hf generally consists of anthropogenically placed silty gravel with variable sand content and local cobbles. Where present, subsurface explorations encountered up to 50 feet of Hf with variable angularity, density, moisture, and plasticity. Hf deposits appear to be largely derived from the local native Qa deposits.
- Wood Waste and Municipal Solid Waste (MSW) West of I-82 – Within the former Cascade Mill property, MSW and wood waste were encountered in previous borings from grade to about 14 feet bgs and shown as Hf-Landfill in Figure 3.

  As noted in Section 1.2, the City of Yakima removed the MSW and wood waste within the CMP Project footprint west of the I-82 embankment.

  No MSW and no significant wood waste were encountered within the I-82 embankment in the 2021 explorations; however, trace amounts of wood fragments were observed in several locations.
- Wood Waste East of I-82 – Between I-82 and the Yakima River, wood waste was encountered up to about 13 feet bgs in test pits as measured by the County in 2021.
- Alluvial Deposits (Qa) – Qa generally consists of medium dense to dense, poorly sorted gravel with silt, sand, and cobbles to silty gravel with sand. The relative density interpreted from the Standard Penetration Tests (SPTs) may be overestimated due to the presence of gravel and cobbles. The subsurface explorations encountered Qa at the ground surface and underlying the Hf deposits. The Qa deposits are characterized by the presence of silty interbeds to 1 foot thick, and clay is commonly encountered in the

matrix of gravel deposits. From our experience nearby, we anticipate that the matrix in the gravel and cobbles will vary widely from coarse sand to clayey, silty sand. Boulders are also likely present in the Qa material based on our observations of the surface the Yakima River channel and banks (see Exhibit 6-1).

Exhibit 6-1: Photograph of the Bank of the Yakima River Near the Proposed YRB East Abutment

6.3 Groundwater Conditions

6.3.1 2021 Explorations

Groundwater levels vary with the time of year at the site and depend on the amount of precipitation and irrigation. We recorded groundwater levels via in situ VWPs for B-11P-21, B-12P-21, and B-15P-21.

2009 and 2011 reports from SLR International Corporation described the subsurface conditions at the abandoned Cascade Mill landfill site. In the documents, SLR reports that the groundwater could fluctuate from about 8 feet bgs in the summer months to about 20 feet bgs in the winter months at the landfill site. The Yakima River strongly influences groundwater levels close to the river.

We recorded the following groundwater elevation between April 7, 2021, and May 22, 2022:

- **I-82 Roadway/Embankment:** Approximate elevation 1038 to 1043 feet

A groundwater elevation of 1043 feet was used for I-82 analyses and design recommendations. Plots of the groundwater level readings are included in Appendix E.

6.3.2 2017-2018 Explorations

We recorded groundwater levels via a well transducer in boring B-2-17. We recorded the following groundwater elevations between November 2017 and September 2018:

- **B-2-17:** Approximate elevation 1038 to 1044 feet

A plot of the observation well readings is included in Appendix E.

6.3.3 2014 Explorations

We recorded the following groundwater depths between July 17, 2014, and June 10, 2015:

- **Cascade Mill Site:** Approximately 12 to 19 feet bgs
- **Adjacent to the Yakima River:** Approximately 12 to 15 feet bgs

Plots of the groundwater level readings are included in Appendix E.

7 ENGINEERING STUDIES AND RECOMMENDATIONS

The geotechnical engineering recommendations and conclusions presented in the following sections are for the YRB and part of the CMP Phase 3 Project. We understand that the roadway alignment and bridges will be designed in accordance with the 2022 WSDOT Geotechnical Design Manual (GDM) (WSDOT, 2022b) and the American Association of State Highway and Transportation Officials (AASHTO, 2020) Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 9th Edition. The recommendations and conclusions herein are based on information from field explorations, in situ testing, and laboratory testing performed for this project, and our understanding of the project.

7.1 Seismic Design Parameters and Hazard Evaluation

7.1.1 Ground Motions

We understand that the seismic design of the Project will be in accordance with the WSDOT Bridge Design Manual (BDM) (WSDOT, 2022a). The BDM specifies two design level earthquakes, the functional evaluation earthquake (FEE) and the safety evaluation earthquake (SEE). The FEE seismic design parameters are based on design ground motions with a 30% probability of exceedance in 75 years (210-year return period) and the SEE seismic design parameters are based on design ground motions with a 7% probability of exceedance in 75 years (975-year return period). We understand the proposed YRB is considered a "Normal" structure and, therefore, only the SEE is applicable for design. Seismic design parameters presented in this report are based on the SEE earthquake.

The site soil response factors are based on determination of the site class definitions as presented in the BDM. The Washington Division of Geology and Earth Resources Site Class Map of Yakima County (Palmer and others, 2004) shows that the site could be classified as Site Class C or D. Based on the description of the subsurface conditions encountered in nearby explorations and our understanding of the site geology, we recommend that the site be classified as Site Class D. We note that although the SPT blow counts in the Hf and Qa deposits are typically above 50 blows per foot, they likely are not representative of the soil relative density due to the presence of gravel, cobbles, and boulders.

The design response spectrum corresponding to the design ground motion is shown in Figure 6.

7.1.2 Earthquake-Induced Geologic Hazards

Earthquake-induced geologic hazards that may affect a given site include fault-related ground rupture, liquefaction, and liquefaction-related effects, such as loss of shear strength, bearing capacity failures, loss of lateral support, ground oscillation, and lateral spreading. An associated effect of earthquake shaking is densification of the soil and potential ground surface settlement.

7.1.2.1 Fault-Related Ground Rupture

The USGS U.S. Quaternary Fault Map does not show faults mapped within the CMP site area. The closest known faults are the east-west trending Ahtanum Ridge and Rattlesnake Hills structures, which are approximately 5½ miles south of the proposed alignment. Based on these fault locations, it is our opinion that the risk of fault-related ground rupture at the site is low.

7.1.2.2 Liquefaction

Liquefaction of loose, saturated, and cohesionless soil occurs when excess pore pressure is generated as a result of earthquake shaking. Liquefaction potential has been studied for more than 50 years, resulting in analytical methods based on laboratory and field procedures. The most widely used methods are empirical and based on correlations between SPT measurements (N-value), peak ground acceleration, and earthquake magnitude. Based on our analyses, we consider the potential for liquefaction and the associated effects (e.g., loss of shear strength, bearing capacity failures, loss of lateral support, ground oscillation, and lateral spreading) along the CMP alignment to be low.

7.2 Yakima River Bridges

7.2.1 General

Drilled shafts were selected as the preferred foundation system for the proposed YRB. The locations of these proposed bridges are shown on sheet 2 of the Site and Exploration Plan (Figure 2). The following sections provide our recommendations for scour, axial and lateral resistance of drilled shafts, lateral earth loads on abutment walls, and abutment global stability for the YRB.

We understand the structural design team have selected 6-foot-diameter drilled shafts for the abutment piers (Piers 1 and 5) and 10-foot-diameter drilled shafts for the interior piers (Piers 2 through 4).

7.2.2 Subsurface Conditions

Our interpretation of the subsurface conditions for the two YRBs is presented in sheet 2 of Profile A-A' (Figure 3). We based our interpretation on borings EWC-B-03-14, B-3-18, and EWC-B-04-14. The borings encountered native gravel with sand and cobbles and varying amounts of silt (Qa). Although these three borings did not encounter boulders, abundant cobbles and boulders are visible along the Yakima River channel bottom and banks (see Exhibit 6-1). Therefore, we anticipate the Qa geologic unit in this area likely contains scattered boulders and therefore, the Contractor should be prepared to encounter boulders in the drilled shaft excavations.

The SPT blow counts in the Qa deposit were very high. However, we consider the relative density interpreted from the SPTs to be overstated due to the presence of gravel and cobbles. Therefore, for engineering purposes we consider the Qa deposit to be medium dense to dense, rather than very dense. In our opinion, the Qa deposits will be prone to caving during shaft drilling. Full-depth temporary casing will likely be required to maintain the integrity of the drill holes.

7.2.3 Pier Scour

Based on our hydraulic analyses, we estimate pier scour will occur at YRB Piers 2 through 4. Detailed scour recommendation designs are presented in our Hydraulics Report for the Project (Shannon & Wilson, in press). This section summarizes our scour findings and conclusions from that report.

Pier scour occurs when waters flow into a pier and diverges both up and down, as well as around the sides of the pier. Due to the orientation of the Yakima River side channel and proposed removal of the existing levee west of Pier 1 (the east abutment), Yakima River could scour away the material around and behind the Pier 1 shafts if scour mitigation measures are not implemented there. Therefore, we recommend installing scour protection measures for the east abutment.

Design pier scour configurations for 100- and 500-year flood events are presented in sheet 2 of Profile A-A’ (Figure 3).

To protect the east abutment from scour up to the 100+-year flood event, we recommend installing a launchable riprap blanket around the east abutment in a "U" configuration footprint as shown in Exhibit 7-1. The proposed cross-sectional configuration of the placed and launched configurations of this blanket are shown in Profile A-A' (Figure 3). Gradation and sizing details for the riprap blanket are provided in the Hydraulics Report.

Construction of the riprap blanket will require an excavation of up to about 18 feet deep. The location of this excavation would be west of the proposed abutment but outside of the wetted perimeter of the channel. Temporary shoring may be necessary to complete this excavation. Sections 8.4 and 8.5 provided construction considerations for temporary shoring and excavation recommendations, respectively.

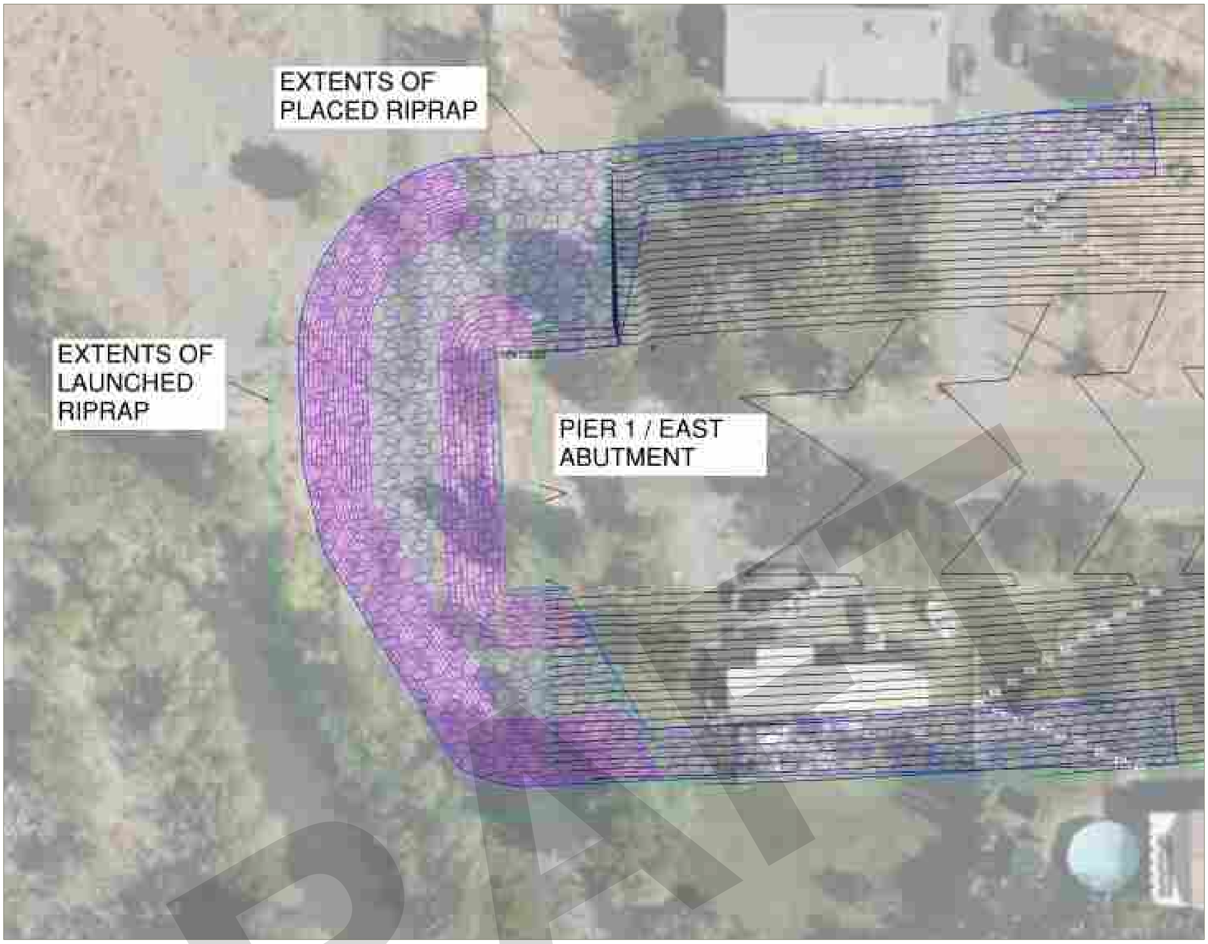


Exhibit 7-1: Approximate Extents of Scour Mitigation Measures

7.2.4 Drilled Shaft Axial Resistance

Drilled shaft axial resistance is a function of shaft diameter, embedment length, subsurface conditions, scour depth, and installation techniques.

Based on discussions with the design team, Piers 1 and 5 will be constructed with 6-foot-diameter drilled shafts, while Piers 2 through 4 will be constructed with 10-foot-diameter drilled shafts. Figures 7 through 14 present the results of our axial resistance analyses for service, strength, and extreme event limit states for 6- and 10-foot-diameter drilled shafts for Piers 1 through 5. The plots present nominal side and base resistance and factored total compressive resistance using the WSDOT GDM (WSDOT, 2022b) guidelines and AASHTO (2020) LRFD resistance factors. The figures show the assumed subsurface conditions based on soil conditions encountered in nearby borings.

7.2.5 Lateral Resistance

The computer program LPILE may be used to generate p-y curves (load-deflection curves) for the lateral resistance analysis of the drilled shafts and to calculate the magnitude of deflection, shear, and moment along the shaft. Figure 18 presents our recommended soil parameters for input into LPILE considering unscoured and scoured conditions.

We recommended a “Soft Clay” soil model with close to zero strength and stiffness for the scour zone for the 100-year flood scour case. Although in reality, soil will not be present in this zone during the scour event, we anticipate the soil below the scour zone will not experience a significant change in overburden stress. The intent of this “zero strength” soil layer is to maintain the same overburden stresses between pre-scour and post-scour cases.

The proposed location of the YRB west abutment (Pier 1) is behind an existing levee. We assume that these levees will be properly maintained and repaired as needed following flood events. We also assume that recommended scour protection measures (as described in Section 7.2.3) will be installed at the east abutment. Under these assumptions, we do not consider the abutments susceptible to pier scour and therefore the lateral resistance analyses for the abutment shafts do not need to consider scour effects.

To account for group effects, the recommended soil parameters in Figure 18 should be adjusted using the P-multipliers summarized in Section 8.13 of the WSDOT Geotechnical Design Manual (2022b) and Sections 10.7.2.4 and 10.8.2.3 of the AASHTO LRFD (2020). These efficiency factors should be used in lateral resistance analyses of deep foundation groups.

7.2.6 Lateral Earth Loads on Abutment Walls

We understand the YRB abutments will include cast-in-place concrete stem walls above the drilled shafts and pile cap. These stem walls will retain the soil behind the abutment and these walls must be designed to resist lateral earth pressures.

Lateral earth pressures against walls are dependent upon many factors, including method of backfill placement and degree of compaction, backfill slope, surcharges, the type of backfill and/or adjacent native soil, drainage provisions, and whether or not the wall or structure can yield or deflect laterally or rotate at the top after or during placement of backfill or during and after excavation. For walls that are capable of deflecting at least 0.001 times the wall height, active lateral earth conditions govern the applied pressures. For walls or structures that are not allowed to move 0.001 times the wall height, at-rest lateral earth pressure conditions govern. Our lateral earth pressure recommendations in the form of

EFW are presented in Exhibit 7-2. These recommendations assume active earth pressure conditions.

Exhibit 7-2: Recommended EFWs for Active Earth Pressure Conditions

Design Condition	EFW (pounds per cubic foot)
Static	34
Seismic	42

Our recommendations for the lateral earth pressures in Exhibit 7-2 include static and seismic lateral earth pressure EFW. These should be applied as triangular pressure distributions. We note that the seismic EFW in Exhibit 7-2 includes both static and seismic components.

The seismic lateral earth pressures provided are consistent with a pseudo-static analysis using the Mononobe-Okabe equation for lateral earth pressures and include a horizontal seismic coefficient of 0.11. In accordance with typical practice, we used a horizontal seismic coefficient equal to one-half of the site design ground acceleration, As, of 0.21g (Figure 6) for the Site Class D SEE ground motion level. One-half the As is used because the full As is experienced only a few times within the record of earthquake shaking, and the actual earthquake ground motion is cyclic in nature, not static.

Lateral earth pressures due to surcharge loads should be added to the recommended lateral earth pressures, where appropriate. Recommended lateral pressures due to surcharge loads are presented in Figure 19. We recommend using the following lateral earth pressure coefficients, K values, in conjunction with Figure 19 (see Exhibit 7-3):

Exhibit 7-3: Lateral Earth Pressure K Values for Surcharge Loads

Design Condition	K Value
Static	0.26
Seismic	0.34

Unless included as a surcharge load on the wall, excavated material, fill embankments, stockpiles, and/or equipment and vehicle traffic should be placed and routed away from the top edge of the wall, no closer than a distance equal to the wall height.

Our lateral earth pressure recommendations assume the walls are backfilled with properly compacted, free-draining aggregate. WSDOT Standard Specifications provide gradation criteria for wall backfill materials. In our opinion, the wall backfill should consist of Gravel Backfill for Walls as specified in Standard Specification Section 9-03.12(2) (WSDOT, 2021).

7.2.7 Abutment Global Stability

We performed global stability analyses for the YRB east and west abutments. Our global stability analysis approach and results are presented in Appendix F. In summary, our analyses indicate that the proposed abutments will achieve an adequate factor of safety (FS) against global instability for both static and seismic cases.

As noted in Section 7.2.3, we recommend a launchable riprap blanket be constructed at the YRB east abutment to mitigate scour. For our global stability analyses, we assumed the fully launched, post-scour condition (see Profile A-A, Figure 3) to represent long-term static conditions for these analyses.

7.3 Roadway Embankments

We understand the following roadway embankments are proposed for the Project that will support the CMP roadway:

- YRB approach embankments leading up to both abutments.
- An approximately 10-foot-tall fill embankment west of the I-82 embankment.

Based on preliminary plans, we understand these embankments will consist of unreinforced soil slopes constructed at 3 Horizontal to 1 Vertical (3H:1V) sideslopes.

As indicated in Profile A-A' (Figure 3), MSW and wood waste were encountered near the ground surface on both sides of I-82. As noted in Section 1.2, we understand the area west of I-82 was a former City of Yakima landfill and before that the entire area west of the Yakima River in the vicinity of the EWC alignment was part of a timber mill (Cascade Mill). However, we understand that in 2021, the City of Yakima, as part of the Bravo Company Boulevard extension project, removed the MSW and wood waste west of the I-82 embankment and replaced it with compacted granular fill.

Based on our review of the preliminary plans for the City of Yakima's MSW and wood waste removal effort and the 60% CMP Project plans, we have assumed the geometric configuration shown in Exhibit 7-4 for our roadway embankment analyses. The as-built plans of the City of Yakima Bravo Company Boulevard extension project should be provided to Shannon & Wilson and reviewed prior to submission of our final report to confirm the materials and depth of excavation on this portion of the EWC alignment as consistent with the assumptions in our analysis.

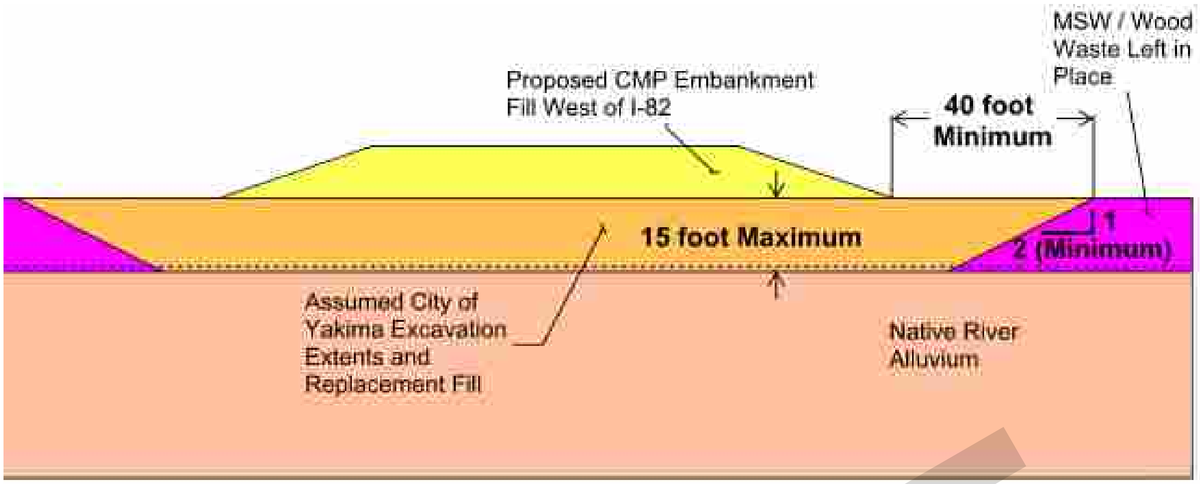


Exhibit 7-4: Assumed MSW and Wood Waste Geometric Parameters for CMP Embankment West of I-82

Between the Yakima River and I-82, we estimate up to about 13 feet of wood waste are present based on the test pits performed by the County (North Test Hole and South Test Hole) and TP-P1-17. We understand that prior to the construction of the YRB approach embankment, the County intends to remove the wood waste within the CMP footprint as well as underneath the proposed stormwater detention pond north of the CMP roadway between I-82 and the Yakima River. Therefore, for our approach embankment analyses we assumed the all the wood waste will be excavated and the resulting subsurface conditions will consist of compacted granular fill underlain by native river alluvium.

7.3.1 Global Stability

We performed global stability analyses for the proposed roadway embankments. Our global stability analysis approach and results are presented in Appendix F. In summary, our analyses indicate that the proposed approach embankments will achieve an adequate FS against global instability for both static and seismic cases.

7.3.2 Settlement

Based on our analyses, we anticipate settlements of the roadway embankments up to about 2 inches may occur. This estimated settlement assumes:

- That the County removes the wood waste within the CMP footprint between I-82 and the Yakima River, and
- The City of Yakima removed and replaced the MSW and wood waste west of the I-82 embankment consistent with the assumptions shown in Exhibit 7-4.

Assuming the foundation soil beneath the proposed approach embankments consists of granular material (sand and gravel), we expect this settlement to occur as the embankment material is placed. We anticipate long-term settlements of the approach embankments will be negligible.

7.4 Stormwater Detention Pond

We understand that a proposed stormwater detention pond will be constructed as part of the Project north of the CMP roadway between I-82 and the Yakima River.

7.4.1 Subsurface Conditions and Recommendations

As noted above and described in Exhibit 2-1, wood waste is present in the area of the proposed pond. In our opinion, wood waste is not suitable for the foundation material or sidewalls of a detention pond and should be removed prior to constructing the pond.

We performed one Pilot Infiltration Test (PIT) in test pit TP-P1-17 in 2017. TP-P1-17 is located about 100 feet east of the proposed pond. The log of TP-P1-1, presented as Figure C-9 in Appendix C, shows that abundant wood debris was encountered in the upper 6 feet of this test pit with material consistent with native alluvium from 6 to 8.5 feet bgs.

In our opinion, the subsurface conditions within TP-P1-17 are similar to those that at the proposed pond area, assuming the wood waste is removed down to the native river alluvium below. We anticipate this will require an excavation of up to about 14 feet deep within the footprint of the pond. Stability of temporary excavations are the responsibility of the Contractor. For planning purposes, we assume that the sideslopes may need to be cut at 2H:1V or shallower. The Contractor may also elect to use temporary shoring. Sections 8.4 and 8.5 provided construction considerations for temporary shoring and excavation recommendations, respectively.

7.4.2 Infiltration Evaluation

We understand the design (fill materials, depth, and bottom elevation, etc.) of the proposed detention pond is still under development. Once the pond design has been finalized, we will need to review the design to determine if our infiltration rate evaluation assumptions and recommendations are still valid.

We estimated long-term design infiltration rates for the proposed stormwater detention pond using the results of the PIT conducted in test pit TP-P1-17. This PIT was performed in a subsurface profile that included wood waste on the sidewalls and native alluvium in a portion of the sidewalls and in the bottom of the PIT excavation.

In addition to the infiltration rate estimated from the PIT, we used empirical correlations to grain-size analysis data for comparison purposes. Both PIT and grain-size analysis-based infiltration rate estimation methods result in short-term rates. We estimated the long-term design infiltration rates by applying correction factors to the short-term infiltration rates.

Appendix C describes the PIT procedure and methods for estimating the long-term design infiltration rates using the results of the PIT and grain-size distributions. The grain-size distribution curves are shown in Appendix C.

Tables C-1 and C-2 provide estimated short-term and long-term design infiltration rates. As indicated in these tables, the PIT infiltration rate results were higher compared to the empirical correlations. Based on the range of infiltration rates we obtained, we recommend using a design infiltration rate of 10 inches per hour for the proposed pond near test pit TP-P1-17. This design value assumes native alluvium material is present at the base of the pond. If new fill is placed at the bottom of the wood waste excavation within the pond footprint to raise the pond's bottom grade, we assume this fill will have a similar gradation and density of the native alluvium. Although lower values were obtained based on several of the empirical grain-size distribution-based infiltration rate estimates (Table C-2) obtained from sand and gravel samples, we consider the PIT to be more representative of the likely infiltration rate behavior at TP-P1-17. Therefore, our design infiltration rate recommendation is weighted toward the PIT-based results.

The long-term design infiltration rates presented in this report meet the requirements for flow control for the Ecology Stormwater Management Manual for Eastern Washington and the Yakima County Regional Stormwater Manual. The design infiltration rates are for flow control only and assume a pretreatment system will be used to meet water quality requirements. Both the SMMEW and the Yakima County Regional Stormwater Manual require a maximum infiltration rate of 2.4 inches per hour for infiltration systems designed to meet treatment standards. The base of the proposed infiltration systems should be a minimum of 5 feet above the seasonally high groundwater level. Based on available data from piezometers installed in the EWC-B-02-14 and B-2-17 boreholes, we estimate the seasonally high groundwater level near the proposed pond to be elevation 1044 feet. See Appendix E for piezometer data.

7.5 Sign Structure and Street Light Foundations

New sign and street light structures may be installed within the CMP alignment. Based on our understanding of the locations of these structures, their foundations will be installed within either engineered YRB approach embankment fill or engineered granular fill installed within the zone where the wood waste will be removed. As such, we recommend designing sign and street light foundations for the Project using WSDOT standard foundations.

Per WSDOT GDM Section 17.2.1 (WSDOT, 2022b), WSDOT standard foundation designs for cantilever signals, strain poles, cantilever signs, sign bridges, and luminaires are based on allowable lateral bearing pressures and soil friction angles developed from correlation. We recommend using an allowable lateral bearing pressure of 3,500 pounds per square foot (psf), and a friction angle of 36 degrees for new, engineered compacted granular borrow fill installed for this project and for the underlying native alluvial sand and gravel.

7.6 Pavement Design

We performed pavement analyses using the AASHTO (1993) method for flexible pavement design. The AASHTO method is a widely used empirical design procedure for the design of pavement structures. It considers strength of the base course materials, traffic stresses, and the strength of the pavement subgrade. We understand design life for the proposed CMP pavement is 50 years.

7.6.1 Traffic Load

Average daily traffic (ADT) counts, including heavy trucks, were provided to us in 2017 for a previous phase of the project. Based on discussions with the design team, we understand the pavement design parameters, including ADT, have not changed.

The ADT is estimated at 11,510 vehicles per day in the eastbound direction and 7,930 vehicles per day in the westbound direction. The Project design team estimated that the passenger cars and other light-duty vehicles make up 98% of the traffic loading, with the remaining 2% being made up of heavy truck traffic. We converted the traffic volumes into equivalent single-axle loads (ESALs) by using equivalent axle load factors provided in the Asphalt Institute manual (Asphalt Institute, 1991) and guidance provided in the AASHTO Design of Pavement Structures (AASHTO, 1993). The Asphalt Institute manual provides percentages of truck types that make up traffic for different function classifications of roads.

The Project design team identified the functional classification for the proposed EWC as Urban Principal. We used Table IV-1 in the Asphalt Institute manual to estimate the distribution of heavy traffic for an Urban Principal roadway. The Project design team also provided growth rates of approximately 2.6% from the design year to 2035 and 1.5% from 2035 to 2067. Based on our analysis of the existing and projected traffic conditions, we estimate that approximately 1.8 million ESALs will be subjected to the roadway over the planned 50-year design life.

7.6.2 Subgrade Conditions

We understand the proposed CMP pavement will be installed on either engineered YRB approach embankment fill, engineered granular fill installed within the zone where the wood waste will be removed, engineered granular fill in the portion that was formerly occupied by the City landfill, or medium dense to dense, native alluvial sand and gravel.

For our pavement design analyses, we assumed embankment fill would consist of WSDOT Common Borrow as specified in Section 9-03.14(3) of the WSDOT Standard Specification (WSDOT, 2020). Placement and compaction of the embankment fill required to raise the grade is discussed in Section 8.3. In areas where the roadway will be constructed on native soils, the area underlying the proposed roadway section should be stripped to remove loose, soft, or disturbed soil, old fill, and organic materials/soils and debris. The subgrade should be graded to its design grade, smoothed, and compacted to 95% of the Modified Proctor maximum dry density (ASTM D1557) and to a dense and unyielding condition.

We recommend proof rolling the pavement subgrades prior to installing the pavement sections. Proof rolling should be observed by a geotechnical engineer and should be performed by rolling over the subgrade with a fully loaded standard dump truck. Loose or soft subgrade soil identified during proof rolling by excessive rutting or pumping should be compacted to a dense, unyielding condition or removed and replaced with at least 2 feet of compacted embankment fill as presented in Section 8.3.

We assumed an average subgrade resilient modulus of 15,000 pounds per square inch for both compacted embankment fill and compacted native granular soils. Drainage should be provided below crushed surfacing base course (CSBC) layers to mitigate saturation of the CSBC and subgrade soils.

7.6.3 Pavement Section Recommendation

The proposed pavement types include hot-mix asphalt (HMA) for the roadway and intersections. We calculated the pavement layer thicknesses using the AASHTO (1993) pavement design method. Based on the analysis results including frost susceptibility conditions described below, we recommend the flexible pavement section consist of a minimum of 6 inches of HMA underlain by 9 inches of CSBC material for a total structural pavement thickness of 15 inches.

7.6.4 Pavement Materials and Construction

The HMA, CSBC, and gravel base layers should be constructed in accordance with current WSDOT Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT, 2021). HMA should conform to Section 5-04 in the WSDOT Standard Specifications.

Aggregate for HMA should meet Section 9-03.8 requirements for HMA subjected to between 0.3 and 3 million ESALs.

7.6.5 Frost Susceptibility

Frost-susceptible soil is regarded as having greater than 3% finer than 0.02 millimeter (mm). Soil with a fines content not exceeding 7% passing the No. 200 sieve, based on the minus ¾-inch fraction, can normally be expected to have 3% or less finer than 0.02 mm. Based on the grain-size analyses presented in Appendices D and E, it is our opinion that the on-site soil is frost susceptible and has near-surface fines content ranging from about 2 to 60%. According to the WSDOT Everseries User's Guide (WSDOT, 2005), the frost depth in the Yakima area is about 30 inches in fine-grained soil and 55 inches in coarse-grained soil. Fine-grained soil is defined as having 50% or more passing the No. 200 sieve. The measured frost depth during the cold winters of 1949 and 1950 was about 25 to 30 inches in the Yakima area. Based on this information, we recommend assuming a frost depth of 30 inches.

Pavement can be designed for frost protection by providing a pavement section that is equal to or thicker than half of the anticipated frost depth in accordance with the WSDOT Pavement Policy (2015). The pavement section includes pavement and non-frost-susceptible granular base materials. In our opinion, the minimum recommended pavement section should provide adequate frost protection.

7.7 Manholes and Vaults

We understand that concrete manholes and vaults will be installed for belowgrade utilities along the alignment. We recommend the unyielding, precast concrete manholes and vaults be designed to resist an at-rest lateral earth pressure using an equivalent fluid weight (EFW) applied as a triangular distribution. The recommended EFWs provided below are based on the assumption that a well-compacted Select Borrow fill will be placed around the concrete structures. Based on the groundwater observations obtained from EWC explorations, we assume that some of structures may extend below the groundwater elevation.

- EFW above groundwater – 54 pounds per cubic foot (pcf)
- EFW below groundwater – 92 pcf (includes hydrostatic pressure)

The EFW below groundwater includes hydrostatic pressure. Unbalanced lateral loads may be resisted through friction along the base of the manholes and vaults. We recommend concrete manholes and vaults be designed using a nominal coefficient of friction of 0.4 for soil against precast concrete. We recommend applying a resistance factor of 0.9 to this nominal coefficient of friction.

7.8 Buried Utilities

Figure 20 presents our geotechnical recommendations regarding loading on rigid buried pipelines caused by overburden soils (Case A and Case B) and H-20 live traffic loads (Case C). The H-20 live traffic loads shown in Case C should be added to the overburden loads for portions of the alignment within proposed or future road right-of-way to obtain the total design load for the pipeline. We recommend using steel plates to distribute temporary loads if construction traffic loads could exceed the H-20 design traffic loads, and/or where the pipeline is not designed for H-20 loading. We recommend using a backfill unit weight of 130 pcf for pipeline overburden load calculations.

We developed recommendations for modulus of soil reaction (E') values for use in the reclamation equation (Howard, 1996) for pipe design. The modulus values are based on the soil encountered in explorations, the trench backfill that we expect to be specified, and recommendations made in Howard (1996). For the buried utility pipelines along the roadway alignment, we recommend using an E' value of 1,500 kips per square foot (ksf) for the embedment material. This value assumes the pipe is embedded in Gravel Backfill for Pipe Zone Bedding as specified in the WSDOT Standard Specification, Section 9.03.12(3) (WSDOT, 2021) and that the material is compacted to at least 95% of its Modified Proctor maximum dry density (ASTM Designation D1557). For the purpose of calculating a composite E' that represents the embedment material and the trench walls, we recommend using an E′ value of 1,500 ksf for the in situ gravel trench walls.

The recommended E' values are based on subsurface conditions in explorations that are several hundred feet apart. Variable subsurface conditions would likely be encountered between these explorations. The pipeline designer should consider this variability when selecting pipe type and properties.

8 CONSTRUCTION CONSIDERATIONS

8.1 General

The applicability of the design recommendations provided in this report is contingent on good construction practice. Poor construction techniques may alter conditions from those on which our recommendations are based, possibly resulting in unfavorable conditions, such as reduced foundation resistance, higher earth pressures, and increased settlement. The following sections present additional construction and material considerations for this Project.

8.2 Site Preparation and Grading

Clearing and grubbing beneath the proposed CMP alignment should be done in accordance with Section 2-01 of the WSDOT Standard Specifications (WSDOT, 2021). The alignment footprint should be cleared of trees, brush, and existing fill or debris. The area should be grubbed of stumps and large roots, and stripped of topsoil and underlying soil, which contains roots or other objectionable debris and organic matter. We recommend that organic-rich soil be removed from the site or stockpiled for reuse in landscape areas.

We assume any wood waste beneath these proposed features will be completely removed and replaced with reinforced, compacted structural fill. The areal and vertical extent of this excavation, as well as environmental considerations, are being prepared by others.

After clearing and grubbing, and prior to any fill placement, the exposed soil surface should be compacted using a heavy vibratory roller (10-ton or heavier static weight). Native subgrade soils should be proof-rolled and, if necessary, compacted to achieve at least 95% of the Modified Proctor maximum dry density (ASTM D1557). The proof-rolling operations should consist of several passes of a fully loaded dump truck to identify potential loose, soft, and/or yielding areas. Loose or soft subgrade should be compacted to a dense, unyielding condition or removed and replaced with at least 2 feet of compacted structural fill. Subgrade surfaces that will receive structural fill, levee fill, or foundations should be dense and unyielding and should be evaluated by a geotechnical engineer prior to placing the fill or constructing the foundations.

8.3 Fill Placement and Compaction

Construction of the proposed CMP Project features will require placement and compaction of:

- Roadway embankment fill,
- Utility trench backfill, and
- Retaining wall backfill.

In our analyses, we assumed the roadway embankment fill and utility trench backfill will be Common Borrow, as specified in Section 9-03.14(3) of the WSDOT Standard Specification (WSDOT, 2021), with the exception that the material shall not contain more than 1% organic material by dry unit weight. Based on the grain-size distributions of the on-site soil samples we tested (see Appendix C), we anticipate the on-site Qa soil along the CMP alignment will meet the requirements of Common Borrow, provided that cobbles and boulders larger than 4 inches are removed prior to or during fill placement. Numerous cobbles and boulders were encountered in the subsurface explorations. Evaluating the cost effectiveness and schedule implications of removing oversized particles should be the Contractor's responsibility.

If fill is to be placed during periods of wet weather or under wet conditions, it should have the added requirement that the percentage of fines (materials passing the No. 200 sieve based on wet-sieving the minus ¾-inch fraction) be limited to 5%. The fines should be nonplastic. See Section 8.8 for additional wet weather construction considerations.

For backfill of utility trenches, pipe zone bedding should extend from the trench bottom to at least 8 to 12 inches above the pipes. Pipe zone bedding should consist of select granular soil free from organic matter meeting the requirements for Gravel Backfill for Pipe Zone Bedding as specified in Standard Specification Section 9-03.12(3) (WSDOT, 2021). The pipe zone bedding below the pipe should be compacted before laying the pipe. After the pipe is installed, heavy vibratory equipment or rollers should not be allowed beside or over the pipe until at least 2 feet of material is placed above the pipe. Fill placed above the Gravel Backfill for Pipe Zone Bedding (8 to 12 inches above the pipes) to the top of the utility trench should be compacted Common Borrow backfill. As discussed above, the on-site coarse-grained (sands and gravels) soils could be used as utility trench backfill above the pipe zone bedding provided cobbles and boulders larger than 4 inches are removed.

Roadway embankment fill, retaining wall backfill, and pipe zone bedding should be placed in horizontal uniform lifts and compacted to a dense and unyielding condition to at least 95% of the Modified Proctor maximum dry density (ASTM D1557) in accordance with Standard Specification Section 2-03.3(14)C, Method C (WSDOT, 2021). Utility trench backfill may be placed and compacted in accordance with Standard Specification Section 2-03.3(14)C, Method B (WSDOT, 2021). The appropriate lift thickness and compaction methods necessary to achieve this compaction criteria should be determined by the Contractor using the Contractor's selected equipment and fill material. In situ soil density of all compacted fill materials must be verified with in situ soil density testing in accordance with WSDOT Standard Specification 2-03.3(14)D (WSDOT, 2021).

8.4 Temporary Shoring

We understand temporary shoring may be needed to facilitate buried utility installation. Temporary shoring may also be deemed necessary by the Contractor for the launchable riprap blanket installation. The design of temporary shoring is the responsibility of the Contractor as they are in control of the means and methods of construction.

Unshored and trench box-protected excavations are generally used where the groundwater is below the base of the excavation and movement of the trench walls is acceptable. Some trench wall movement is commonly acceptable when nearby structures, utilities, and other improvements are a sufficient distance from the excavation, such that they are not impacted by the stress relief and ground movement associated with the excavation. Trench boxes are designed to provide passive protection for workers in the trench and provide poor contact with the trench sidewalls; therefore, movement of the ground adjacent to the trench is likely.

If existing utilities, or settlement-sensitive improvements are too close to the excavation, measures to protect these improvements, temporary or permanent utility relocation, and/or excavation shoring that limits ground movement would be required. We recommend assuming that utilities and other improvements above a plane that extends up and away from the bottom of the excavation at 1.5H:1V could be affected by ground movement associated with unshored or trench box-protected excavations.

8.5 Temporary Excavations

Construction slope angles required for stability and safety depend on careful evaluation of factors that include:

- Contractor means and methods,
- Amount and depth of groundwater seepage,
- Soil and materials exposed in the excavation slope,
- Depth of the excavation,
- Surcharge loads on top of the excavation,
- Geometry of the excavation, and
- Time of construction.

Because of the many factors involved, required slope values can only be estimated prior to construction. For safe working conditions and prevention of ground loss, excavation slopes should be the responsibility of the Contractor, as they will be at the jobsite full time to observe and control the work. All current and applicable safety regulations regarding excavation slopes should be followed.

For planning purposes, we recommend assuming a contractor would make temporary, unsupported, open-cut slopes in sand and gravel Qa soil no steeper than 1.5H:1V. Flatter cut slopes may be required where loose soil is encountered. The above recommendation is for temporary cut slopes in dry conditions. If wet conditions or groundwater inflow is encountered, flatter slopes may be required. Exposed cut slopes may need to be protected with a waterproof covering during periods of wet weather to reduce sloughing and erosion.

Unshored, open-trench techniques might be suitable where the excavation depth is shallow, and the trench sides can be sloped sufficiently to avoid trench side failure. Where the excavation depth exceeds 4 feet, trench side sloping, trench boxes, a trench shoring system, or a combination of the above will be required. All traffic and/or construction equipment loads should be set back from the edge of the cut slopes a minimum of 4 feet. Excavated material, stockpiles, and equipment should not be placed closer to the edge of any excavation than the depth of the excavation, unless the excavation is shored and such materials are accounted for as a surcharge load on the shoring system.

Based on expected temporary excavation depths of up to 6 feet, anticipated subsurface conditions, and space limitations along the proposed alignment, we anticipate that trench excavations could be made using conventional excavating equipment, such as rubber-tired backhoes or tracked hydraulic excavators. If the exposed subgrade is too loose to provide a working surface or a firm foundation for utilities, the subgrade should be improved by compacting at least the upper 12 inches of loose, granular subgrade to a dense and unyielding condition.

8.6 Drilled Shafts

YRB drilled shaft foundations should be constructed in accordance with WSDOT Standard Specifications (2021), Section 6-19.

In our opinion, the Qa deposits will be prone to caving during shaft drilling. Full-depth temporary casing will likely be required to maintain the integrity of the drill holes.

8.7 Obstructions

Based on explorations at the site and our interpretation of the local geologic deposits and field observations of the Yakima River channel and banks (see Exhibit 6-1), we expect the Contractor to encounter cobbles and boulders in shaft excavations. The cobbles and boulders may range in diameter from 3 inches to greater than 24 inches. The Contractor should be prepared to advance excavations and penetrations past such obstructions using suitable means, methods, and equipment.

8.8 Wet Weather Considerations

In the CMP area, wet weather generally begins about mid-October and continues through about May. It would be advisable to schedule earthwork during the drier weather months. However, should wet weather or wet-condition earthwork be unavoidable, the following recommendations are provided:

- The ground surface in and surrounding the construction area should be sloped to promote rapid runoff of precipitation away from the work areas and to prevent the ponding of water.

- Work areas, slopes, and stockpiles should be covered with plastic and appropriate erosion and sediment control measures applied. The use of sloping, ditching, sumps, dewatering, and other measures should be employed as necessary to permit proper completion of the work.
- Earthwork should be accomplished in small sections to minimize exposure to wet conditions. That is, each section should be small enough so that the removal of unsuitable soils and placement and compaction of clean structural fill could be accomplished on the same day.
- To mitigate soil disturbance, the size or type of construction equipment may have to be limited.
- Fill material to be placed should consist of clean, well-graded granular soils, of which not more than 5% by dry weight pass the No. 200 mesh sieve, based on the wet sieving fraction passing the ¾-inch mesh sieve. The fines should be nonplastic.
- No fill soil should be left uncompacted and exposed to moisture. A smooth-drum vibratory roller, or equivalent, should roll the surface to promote rapid runoff of the surface water.
- In-place soil or fill soil that becomes wet and unstable and/or too wet for compaction should be removed and replaced with clean, structural fill material.
- Excavation and placement of structural fill material should be observed on a full-time basis by a geotechnical engineer, experienced in wet weather/wet condition earthwork to determine that the work is being accomplished in accordance with the Project specifications and our recommendations.
- Grading and earthwork should not be performed during periods of heavy, continuous rainfall.

9 LIMITATIONS

This report was prepared for the exclusive use of Sargent Engineers, Yakima County, and other members of the design team for specific application to the design of the CMP Project as it relates to the geotechnical aspects discussed in this report. Our conclusions and recommendations are intended for design of the Stage 3 of the alignment. The final version of report should be provided to a contractor for bidding and constructing the Project. The interpretations, conclusions, and recommendations presented in this report should not be construed as a warranty of surficial or subsurface conditions.

Within the limitations of scope, schedule, and budget, the interpretations, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice in this area at the time this report was prepared. We make no other warranty, either express or implied.

The analyses, conclusions, and recommendations contained in this report are based on site conditions as they existed during our site visits and explorations, and further assume that the explorations are representative of the subsurface conditions throughout the CMP site, i.e., the subsurface conditions everywhere are not significantly different from those disclosed by the explorations. Our conclusions and recommendations are based on our understanding of the Project as described in this report and the site conditions as interpreted from the explorations.

If during construction, subsurface conditions different from those encountered in the explorations are observed or appear to be present, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is substantial lapse of time between submission of this report and the start of work at the site, or if conditions have changed because of natural forces or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of the conclusions and recommendations concerning the changed conditions or time lapse.

Unanticipated soil conditions are commonly encountered and cannot be fully determined by merely taking soil samples from a limited number of subsurface explorations. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed Project. Therefore, some contingency funds are recommended to accommodate such potential extra costs.

The scope of our geotechnical services does not include evaluations regarding the presence or absence of wetlands, hazardous or toxic substances in the soil, surface water, groundwater, or air on, below, or around the site, or for the evaluation or disposal of contaminated soils or groundwater, should any be encountered.

We have prepared the document, "Important Information About Your Geotechnical/ Environmental Report," to assist you and others in understanding the use and limitations of our report.

10 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 1993, AASHTO guide for design of pavement structures: Washington, D.C., AASHTO, 2 v.

American Association of State Highway and Transportation Officials (AASHTO), 2020, AASHTO LRFD bridge design specifications (9th ed.): Washington, D.C., AASHTO, 2 v.

Asphalt Institute, 1991, Thickness design: asphalt pavements for highways & streets (9th ed.): Lexington, Ky., Asphalt Institute, MS-1, 98 p.

Bentley, R.D. and Campbell, N.P., 1983, Geologic map of the Yakima Quadrangle, Washington: Washington State Department of Natural Resources, Division of Geology and Earth Resources, Geologic Map GM-29, 1:62,500.

Bjornstad, B.N., 1980, Sedimentology and depositional environment of the Touchet Beds, Walla Walla River Basin, Washington: Cheney, Wash., Eastern Washington University, Master's Thesis, 119 p.

Bjornstad, B.N., 2006, On the trail of the Ice Age floods: a geological field guide to the mid-Columbia basin: Sandpoint, Idaho, Keokee Books, 307 p.

Geo-Slope International, 2021, SIGMA/W v. 2021.4: Calgary, Alberta, Geo-Slope International.

Google Earth, 2021, Aerial photo of I-82 and Industrial Road, Yakima, Washington: Photo dated July 4, 2021, accessed via Google Earth, September 13, 2022.

Howard, A.K., 1996, Pipeline installation: a manual for construction of buried pipe: Lakewood, Colo., Relativity Pub.

Lasmanis, R., 1991, The geology of Washington: Rocks & Minerals, v. 66, no. 4, p. 262-277.

McCaffrey, Robert; King, R.W.; Wells, R.E.; and others, 2016, Contemporary deformation in the Yakima fold and thrust belt estimated with GPS: Geophysical Journal International, v. 207, no. 1, p. 1-11.

Norman, D.K.; Busacca, A.J.; and Teissere, R.F., 2004, Geology of the Yakima valley wine country—a geologic field trip guide from Stevenson to Zillah, Washington: Olympia, Wash., Washington State Division of Geology and Earth Resources, 96th Annual Meeting of the Association of American State Geologists, Field Trip Guide 1, 13 p.

Palmer, S.P.; Magsino, S.L.; Bilderback, E.L.; and others, 2004, Site class map of Yakima County, Washington, in Liquefaction susceptibility and site class maps of Washington State, by county: Washington State Department of Geology and Earth Resources, Open File Report 2004-20, sheet 39B, scale 1:150,000.

Schuster, J.E., 1994, Geologic map of the east half of the Yakima 1:100,000 quadrangle, Washington: Washington State Department of Natural Resources, Division of Geology and Earth Resources, Open File Report 94-12, 19 p., 1 plate, scale 1:100,000.

Shannon & Wilson, 2020, Final design, geotechnical engineering and environmental report, stages 1 and 2, East-West Corridor Project, Yakima County, Washington: Report prepared by Shannon & Wilson, Inc., Seattle, Wash., 21-1-22425-002, for HW Lochner, Lacey, Wash., February.

Shannon & Wilson, in press, Hydraulics report, Cascade Mill Parkway, Phase 3, Yakima County, Washington: Report prepared by Shannon & Wilson, Inc., Seattle, Wash., 106384-003, for Sargent Engineers, Inc., Olympia, Wash.

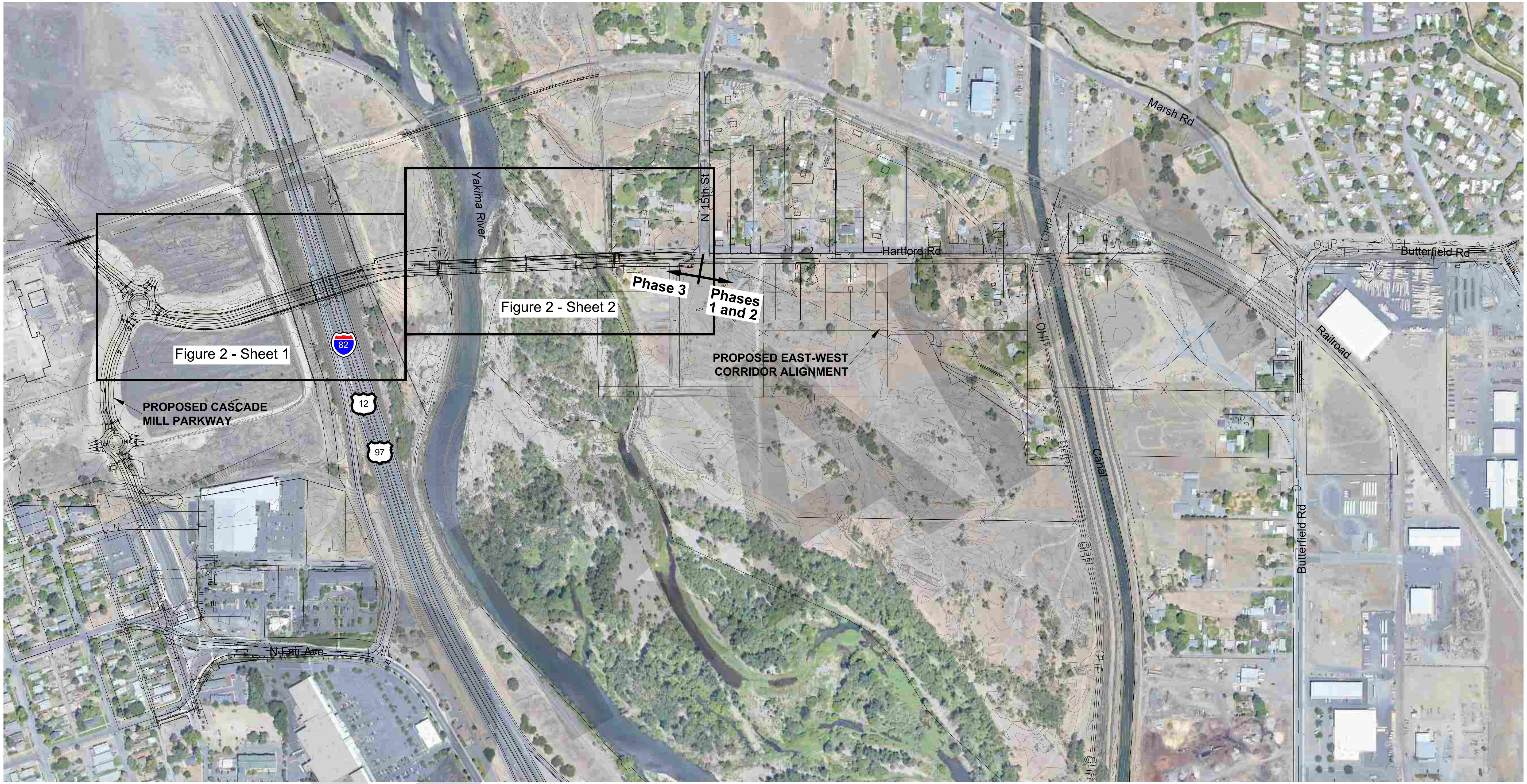
Washington State Department of Ecology, 2013, Model toxics control act regulation and statute: MTCA cleanup regulation, chapter 173-340 WAC; model toxics control act, chapter 70.105D RCW; uniform environmental covenants act, chapter 64.70 RCW (rev.): Olympia, Wash., Washington Dept. of Ecology, Publication no. 94.06, 324 p., available: https://fortress.wa.gov/ecy/publications/summarypages/9406.html.

Washington State Department of Transportation (WSDOT), 2005, Everseries user's guide - pavement analysis computer software and case studies: Olympia, Wash., WSDOT Materials Laboratory, 112 p., available: http://www.wsdot.wa.gov/NR/rdonlyres/0C02BB7B-C345-4958-AA08-089E5E512B96/0/EverseriesUserGuidePart1.pdf.

Washington State Department of Transportation (WSDOT), 2021, Standard specifications for road, bridge, and municipal construction: Olympia, Wash., WSDOT, Manual M 41-10, August, available: https://www.wsdot.wa.gov/Publications/Manuals/M41-10.htm.

Washington State Department of Transportation (WSDOT), 2022a, Bridge design manual LRFD: Olympia, Wash., Manual M 23-50, June, available: https://www.wsdot.wa.gov/Publications/Manuals/M23-50.htm

Washington State Department of Transportation (WSDOT), 2022b, Geotechnical design manual: Olympia, Wash., WSDOT, Manual M 46-03, 1 v., February, available: https://www.wsdot.wa.gov/Publications/Manuals/M46-03.htm.



SOURCE

Figure adapted from files *XR-13179-I82 Survey* received 5-26-20, *and YRB Layout to S&W_050822.dwg* , received 5-9-22.

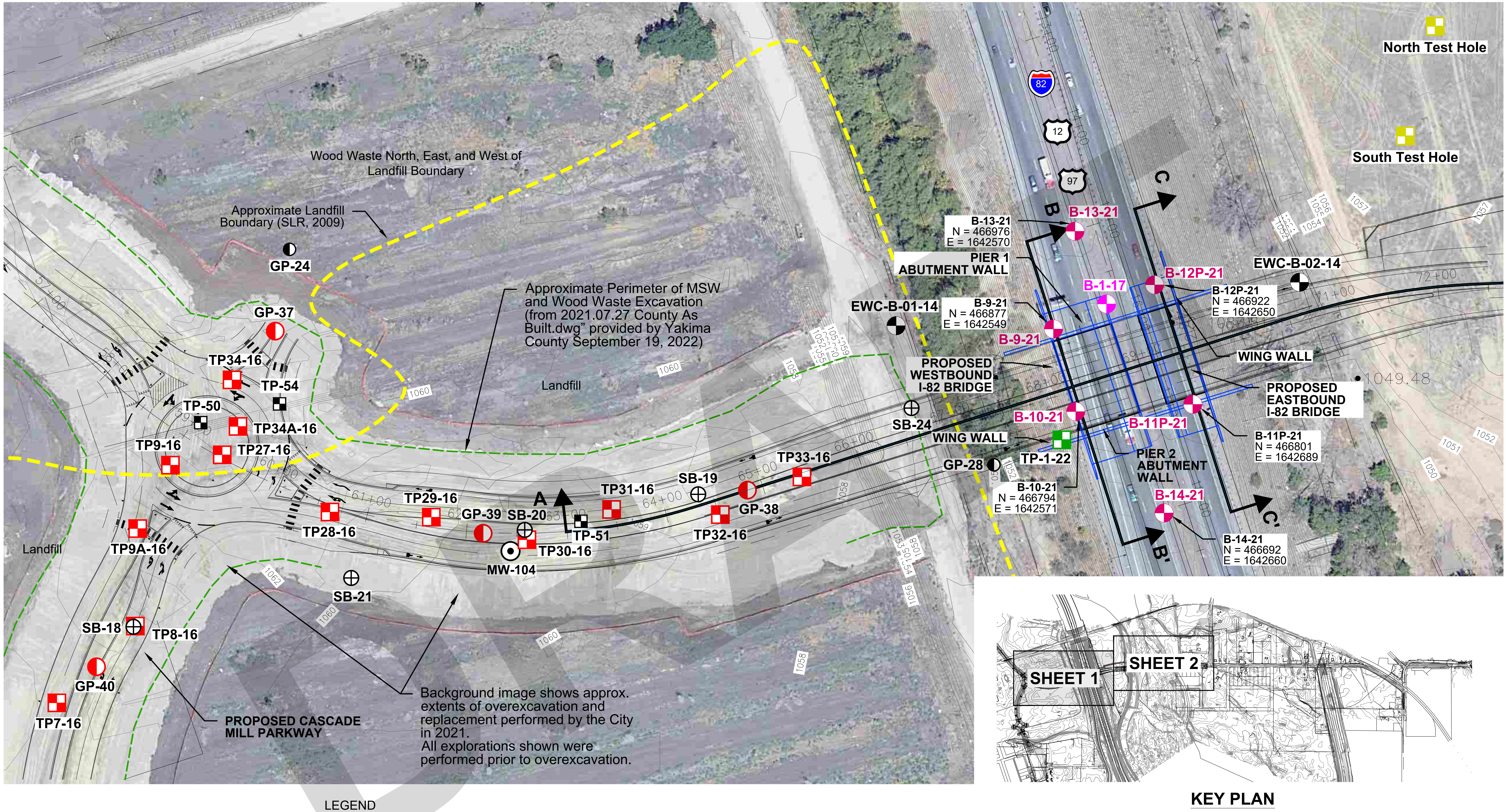
Cascade Mill Parkway Project
Yakima, Washington

VICINITY MAP

September 2022 106384-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1



LEGEND

Designation and Approximate Location

B-9-21	◑	Boring (Shannon & Wilson, 2021)	SB-13	⊕	Boring (SLR, 2009)
B-8-18	◑	Boring (Shannon & Wilson, 2018)	North Test Hole	🟨	Test Pit (Yakima County, 2021)
B-8-17	◑	Boring (Shannon & Wilson, 2017)	TP1-16	🟥	Test Pit (Landau, 2016)
EWC-B-02-14	◑	Boring (Shannon & Wilson, 2015a)	TP-25	▨	Test Pit (SLR, 2009)
TP-1-22	🟩	Test Pit (Shannon & Wilson, 2022)	GP-43	◐	Gas Probe (Landau, 2016)
TP-P1-17	▨	Test Pit (Shannon & Wilson, 2017)	GP-21	◐	Gas Probe (SLR, 2009)
			MW-109	⊙	Monitoring Well (Landau,2014)

NOTES

1. Sonic Core Borings performed by Holt Services Inc. under subcontract for Shannon & Wilson, Inc.
2. Test Pits and PITs excavated by Yakima County and observed by a Shannon & Wilson representative.
3. Horizontal Coordinate System is Washington State Plane, NAD83, South Zone, US Foot.

0 100 200

Scale in Feet

SOURCE

Figure adapted from files *XR-13179-I82 Survey* received 5-26-20, *and YRB Layout to S&W_050822.dwg* , received 5-9-22. Aerial image from Google Earth dated 7-4-2021.

N

Cascade Mill Parkway Project
Yakima, Washington

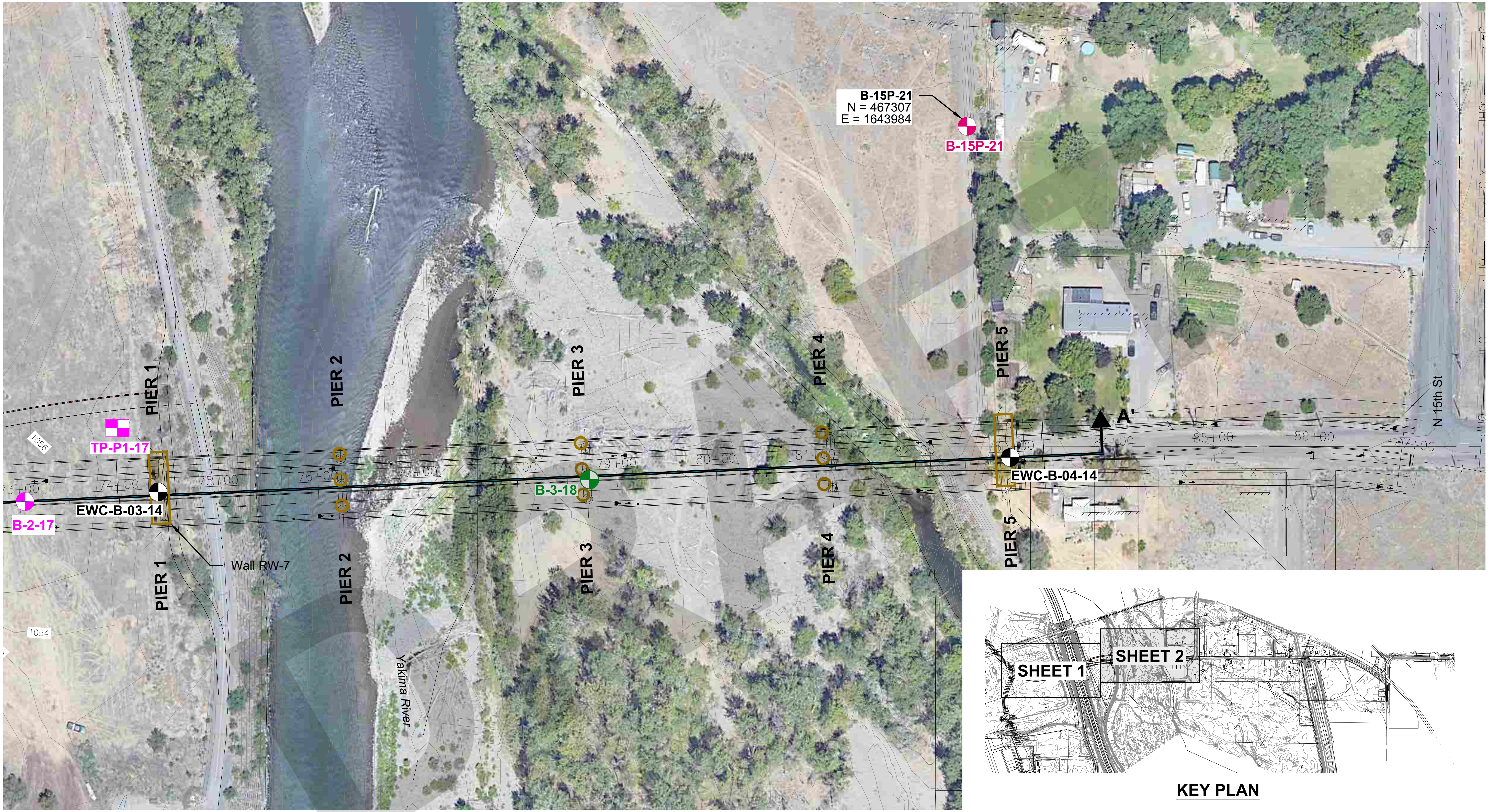
SITE AND EXPLORATION PLAN

September 2022
106384-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 2
Sheet 1 of 2

Filename: C:\Users\jrs\CAD Group Dropbox\J Drive_SEA\106384\002\106384-002 Plan and Profiles.dwg Date: 09-19-2022 Login: JRS



LEGEND

Designation and Approximate Location

B-9-21	⊕	Boring (Shannon & Wilson, 2021)	TP1-16	▚	Test Pit (Landau, 2016)
B-8-18	⊕	Boring (Shannon & Wilson, 2018)	TP-25	▚	Test Pit (SLR, 2009)
B-8-17	⊕	Boring (Shannon & Wilson, 2017)	GP-43	◐	Gas Probe (Landau, 2016)
EWC-B-02-14	⊕	Boring (Shannon & Wilson, 2015a)	GP-21	◐	Gas Probe (SLR, 2009)
TP-P1-17	▚	Test Pit (Shannon & Wilson, 2017)	MW-109	⊙	Monitoring Well (Landau,2014)
SB-13	⊕	Boring (SLR, 2009)			

NOTES

1. Sonic Core Borings performed by Holt Services Inc. under subcontract for Shannon & Wilson, Inc.
2. Test Pits and PITs excavated by Yakima County and observed by a Shannon & Wilson representative.
3. Horizontal Coordinate System is Washington State Plane, NAD83, South Zone, US Foot.

0 100 200

Scale in Feet

SOURCE

Figure adapted from files *XR-13179-I82 Survey* received 5-26-20, *and YRB Layout to S&W_050822.dwg* , received 5-9-22. Aerial image from Google Earth dated 7-4-2021.

N

Cascade Mill Parkway Project
Yakima, Washington

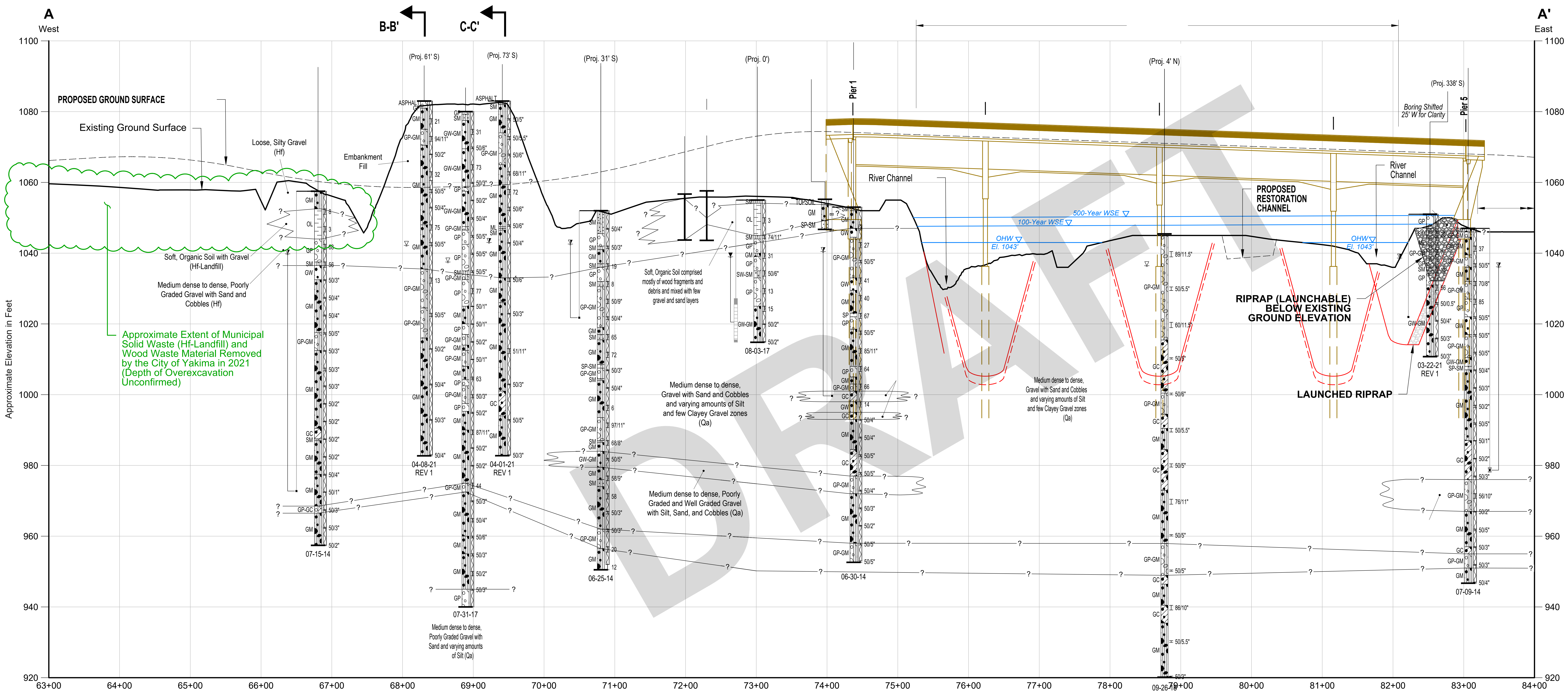
SITE AND EXPLORATION PLAN

September 2022 106384-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 2
Sheet 2 of 2

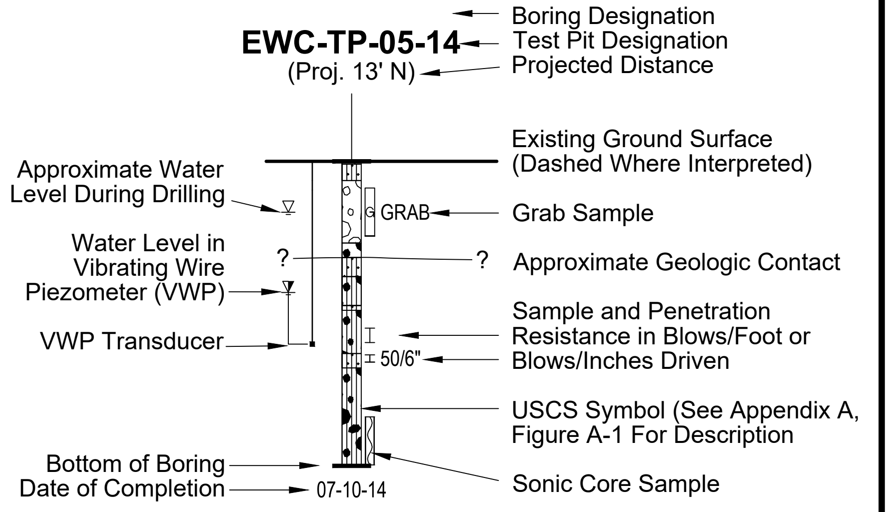
Filename: C:\Users\jrs\CAD Group Dropbox\JDrive_SEA\106384\002\106384-002 Plan and Profiles.dwg Date: 09-15-2022 Login: JRS



NOTES

1. Existing and proposed ground surfaces derived from Sargent file, *YRB Layout to S&W_072221.dwg*
2. Bridge structure and bridge ground surfaces adapted from Sargent, *YRB Layout to S&W_050822.dwg*, received 5-9-2022.
3. This subsurface cross section is generalized from materials observed in soil explorations. Variations may exist between cross section and actual conditions.
4. Some penetration resistance values and densities are artificially high due to the presence of gravel and cobbles, and do not reflect the relative density of the soil unit.

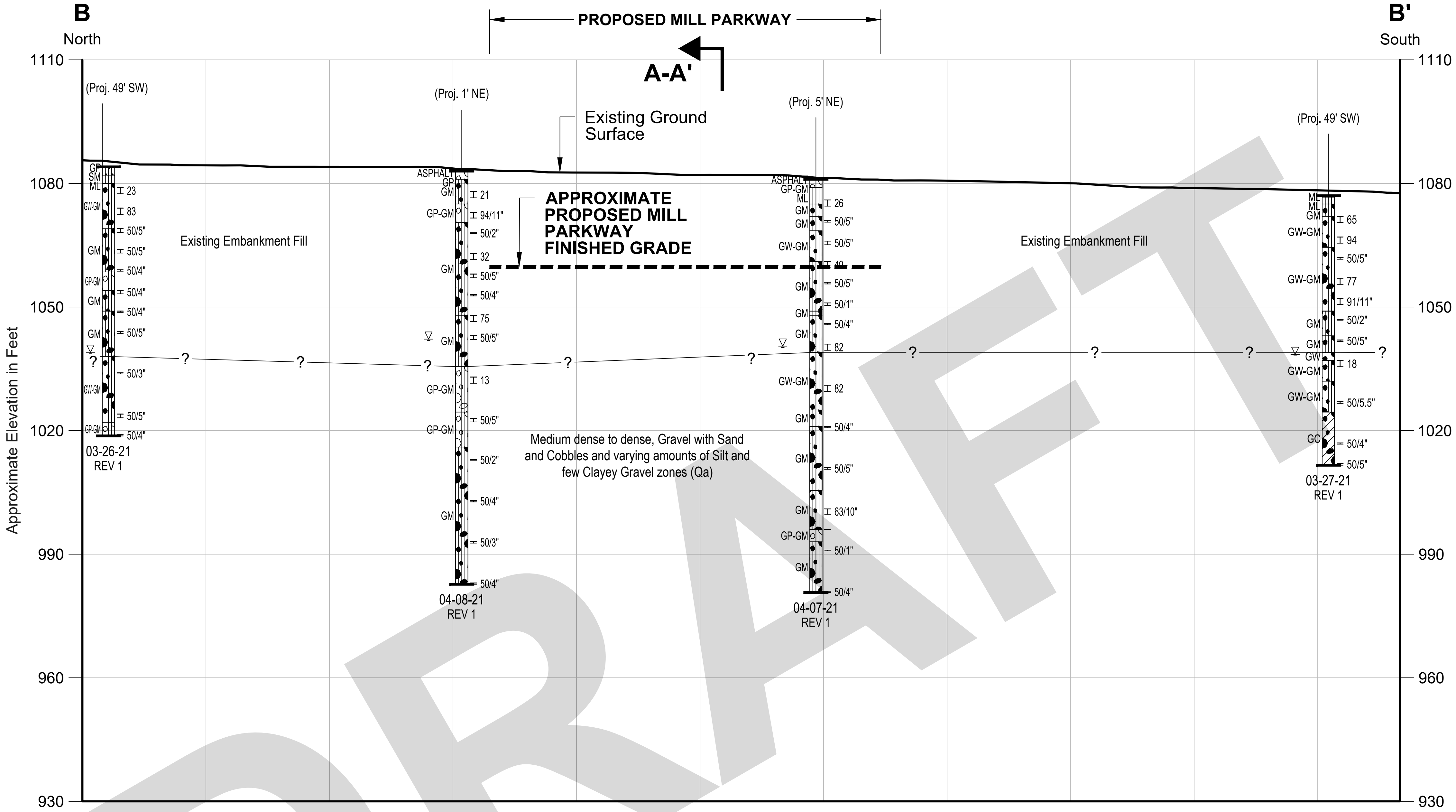
BORING LEGEND



GENERALIZED SUBSURFACE PROFILE A-A'

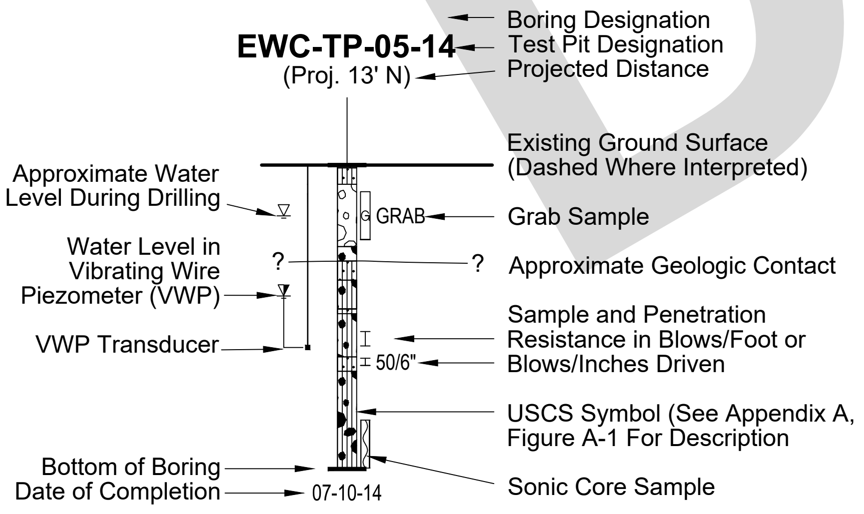
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Filename: C:\Users\jrs\CAD Group Dropbox\UDrive_SEA\106384\002\106384-002 Plan and Profiles.dwg Date: 09-15-2022 Login: JRS



Vertical = Horizontal

BORING LEGEND



NOTES

1. Existing ground surface derived from LiDAR provided by the Puget Sound LiDAR Consortium.
2. This subsurface cross section is generalized from materials observed in soil explorations. Variations may exist between cross section and actual conditions.
3. Some penetration resistance values and densities are artificially high due to the presence of gravel and cobbles, and do not reflect the relative density of the soil unit.

Cascade Mill Parkway Project
Yakima, Washington

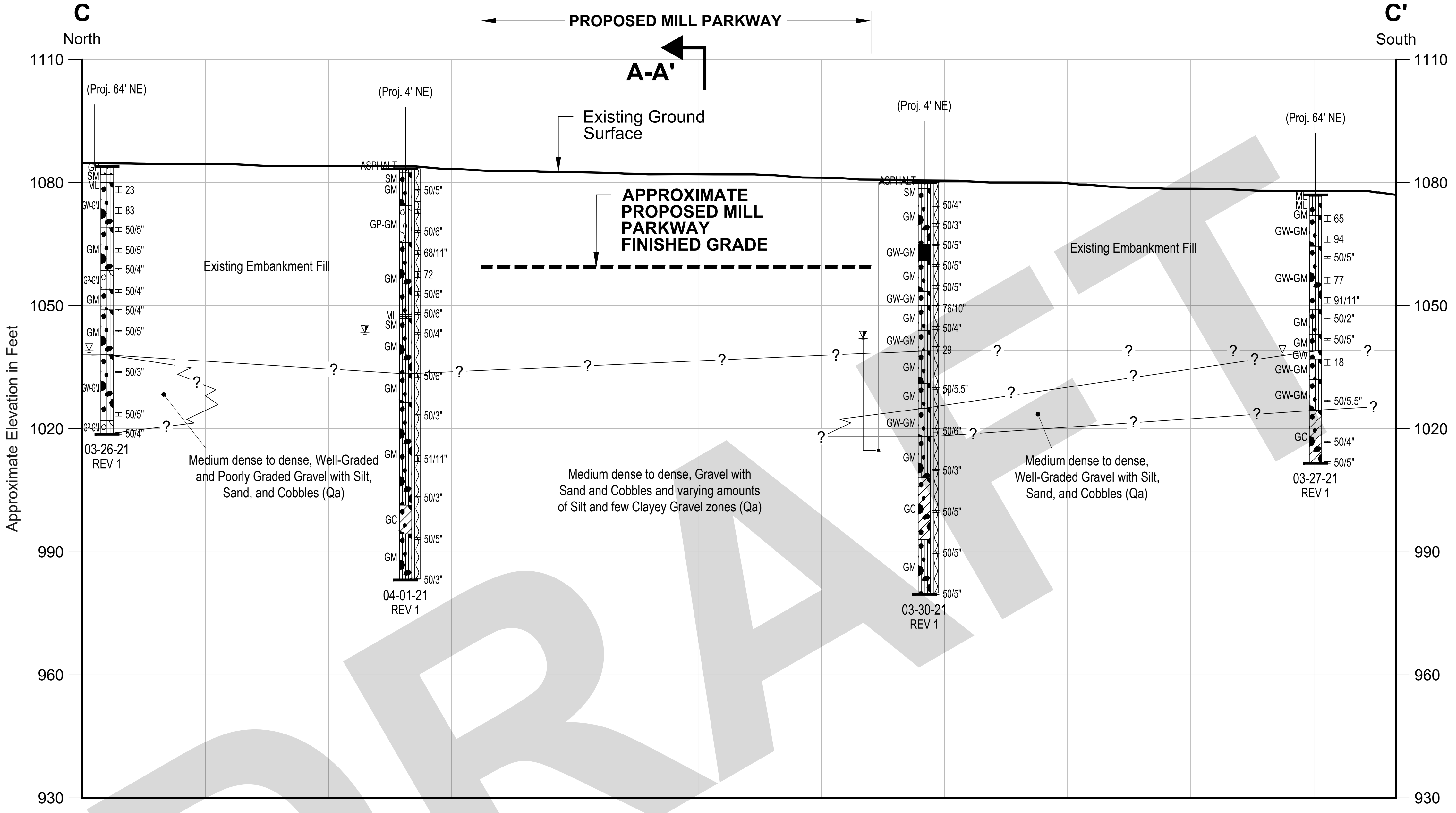
GENERALIZED SUBSURFACE PROFILE B-B'

June 2022
106384-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

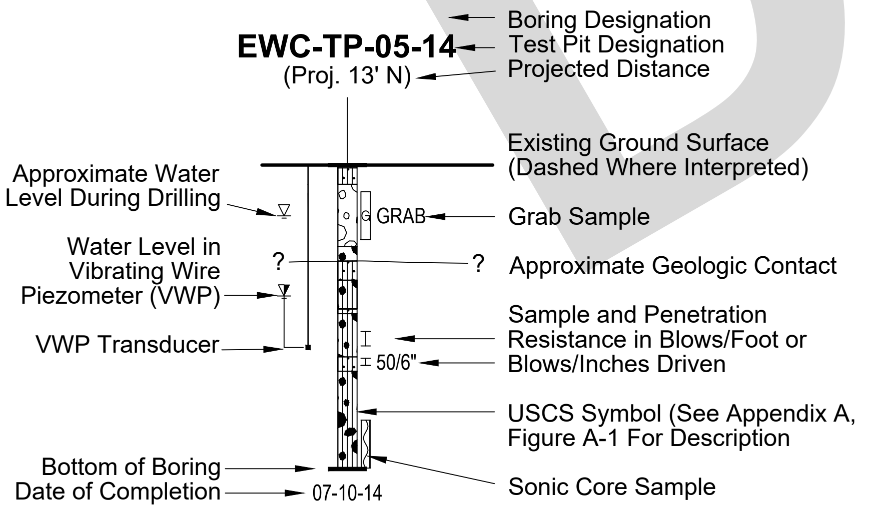
FIG. 4

Filename: C:\Users\jrs\CAD Group Dropbox\JDrive_SEA\106384\002\106384-002 Plan and Profiles.dwg Date: 06-20-2022 Login: JRS



Vertical = Horizontal

BORING LEGEND



NOTES

1. Existing ground surface derived from LiDAR provided by the Puget Sound LiDAR Consortium.
2. This subsurface cross section is generalized from materials observed in soil explorations. Variations may exist between cross section and actual conditions.
3. Some penetration resistance values and densities are artificially high due to the presence of gravel and cobbles, and do not reflect the relative density of the soil unit.

Cascade Mill Parkway Project
Yakima, Washington

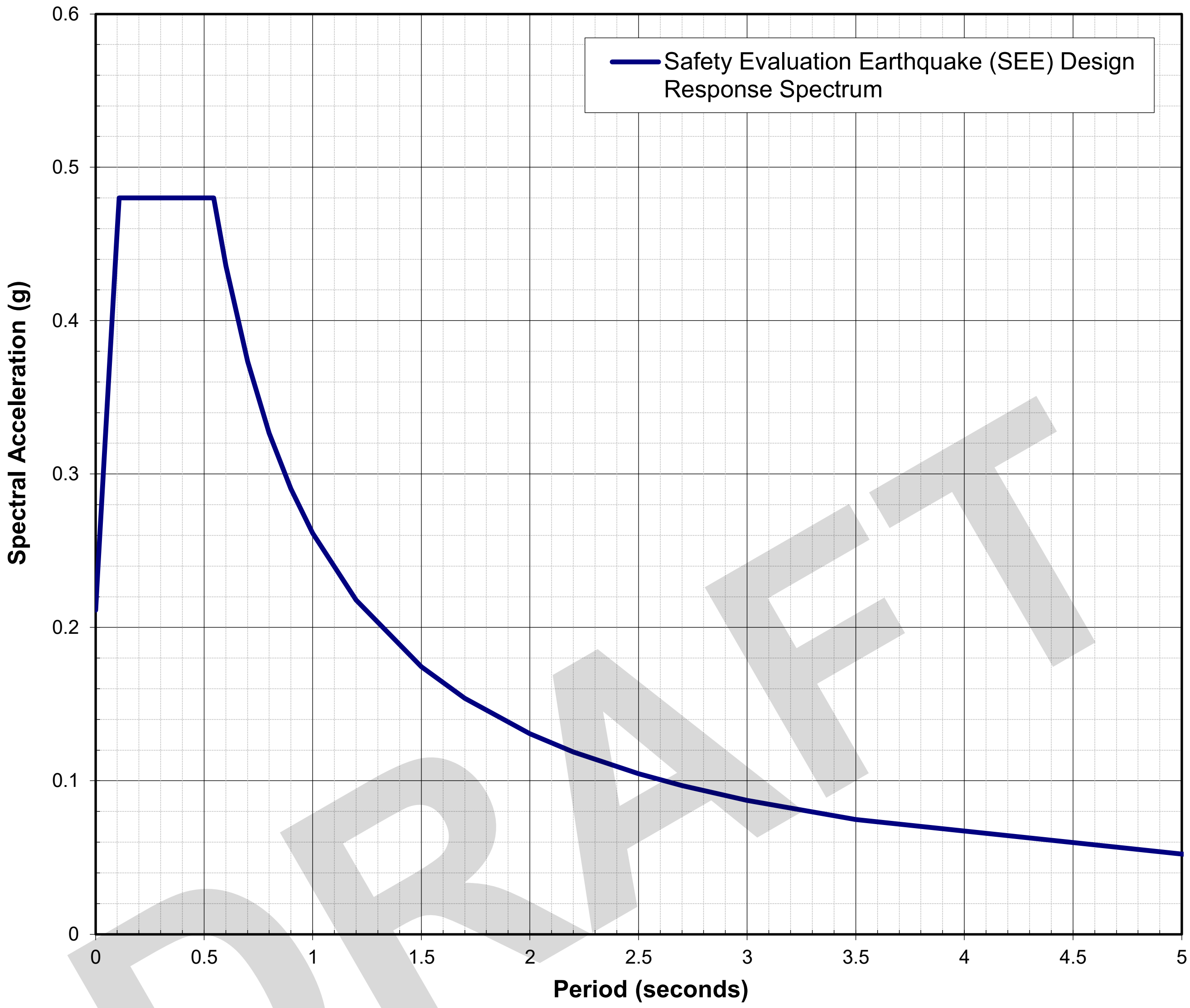
GENERALIZED SUBSURFACE PROFILE C-C'

June 2022 106384-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5

Filename: C:\Users\jrs\CAD Group Dropbox\JDrive_SEA\106384\002\106384-002 Plan and Profiles.dwg Date: 06-20-2022 Login: JRS



Seismic Parameters

PGA = 0.14 g
S_S = 0.31 g
S_1 = 0.11 g
A_s = 0.21 g
S_{DS} = 0.48 g
S_{D1} = 0.26 g
F_{pga} = 1.52
F_a = 1.55
F_v = 2.38
T_0 = 0.11 sec.
T_S = 0.54 sec.

NOTES

1. We developed the design response spectrum based on guidance in WSDOT BDM (2022).
2. The safety evaluation earthquake (SEE) seismic design parameters are based on design ground motions with a 7 percent probability of exceedance in 75 years (975-year return period) for Site Class D.
3. The mapped SRA values are based on a probabilistic seismic hazard analysis performed by the USGS (Petersen and others, 2014).
4. WSDOT BDM = Washington state department of transportation bridge design manual; g = gravitational acceleration; PGA = peak ground acceleration; SRA = spectral response acceleration; USGS = U.S. Geological Survey.
5. Coordinates used for site (NAVD 88):

   Latitude = 46.6135°
   Longitude = -120.4912°

Cascade Mill Parkway Project
Yakima, Washington

SEISMIC DESIGN RESPONSE SPECTRA
SITE CLASS = D

September 2022 106384-002

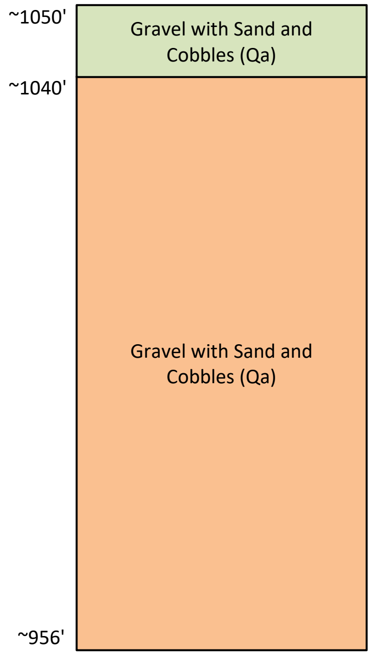
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 6

ASSUMED SUBSURFACE PROFILE

Based on Nearby Explorations:

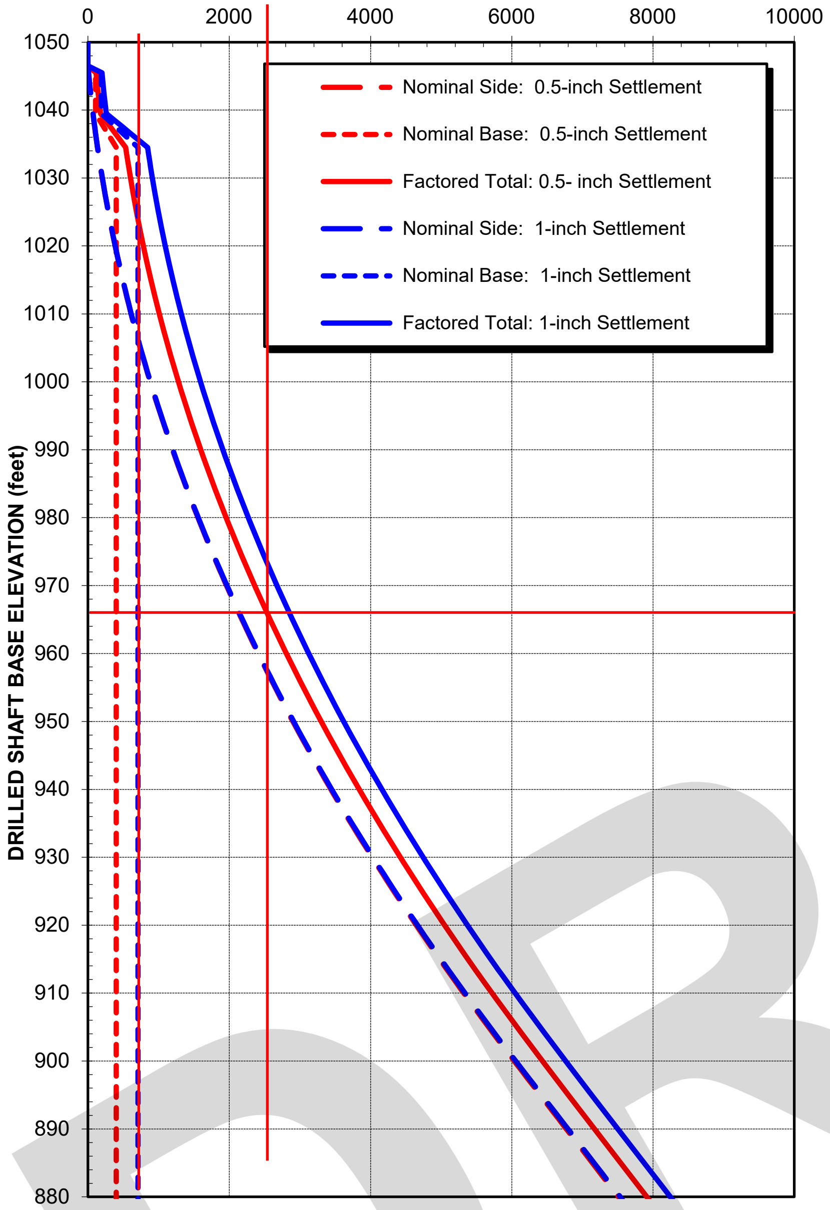
EWC-B-03-14



Bottom of Boring EWC-B-03-14 at Elevation ~956 ft. Boring Extrapolated to 880 ft.

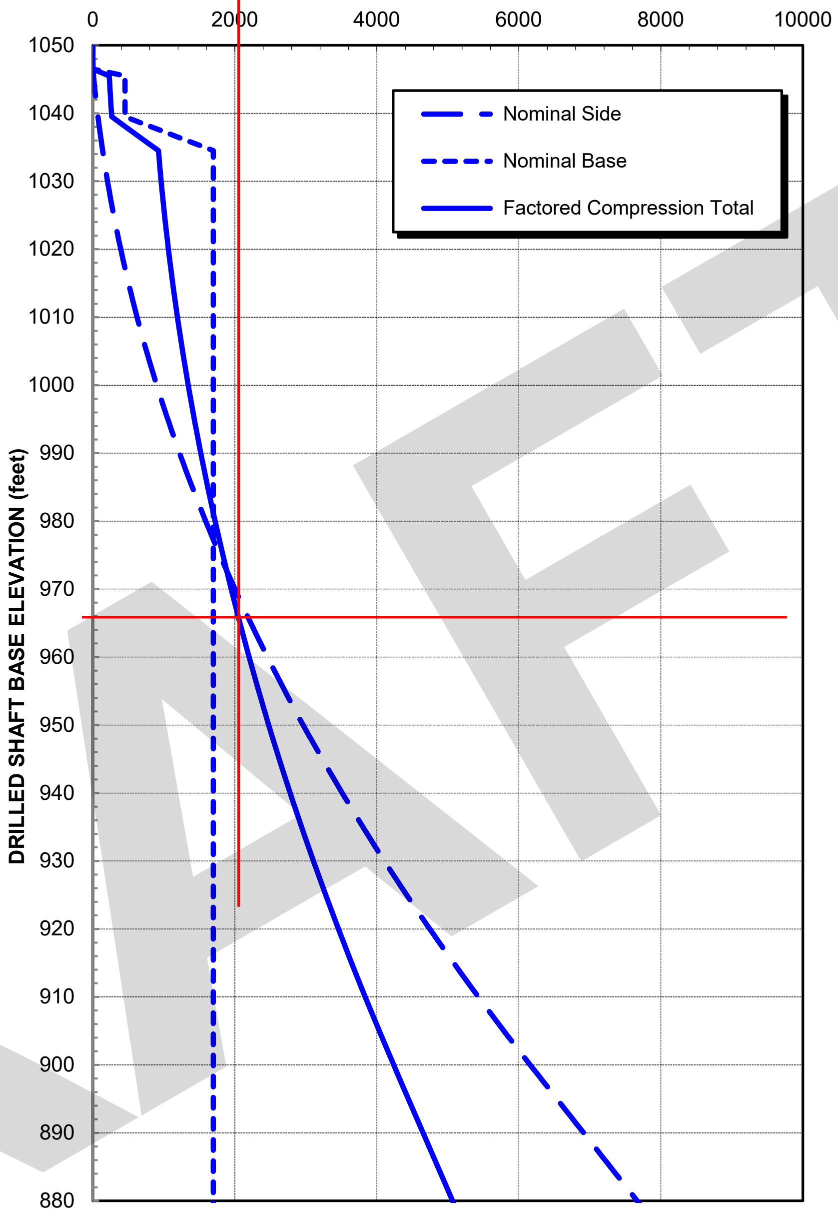
SERVICE LIMIT

NOMINAL RESISTANCE (kips)



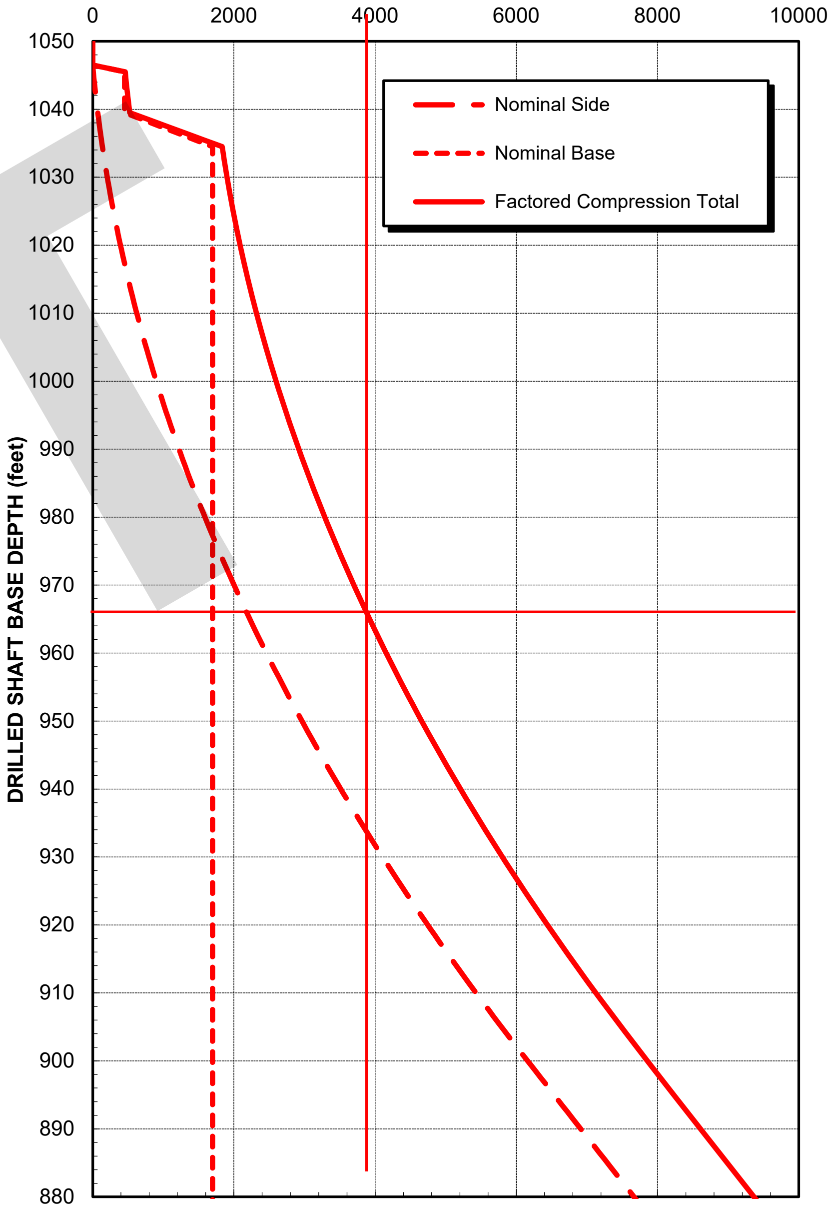
STRENGTH LIMIT

NOMINAL RESISTANCE (kips)



EXTREME EVENT LIMIT

NOMINAL RESISTANCE (kips)



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 1
6 FT DIAMETER

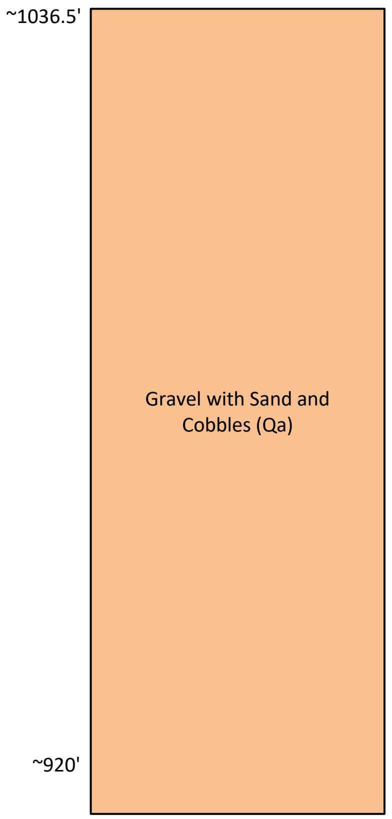
September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 7

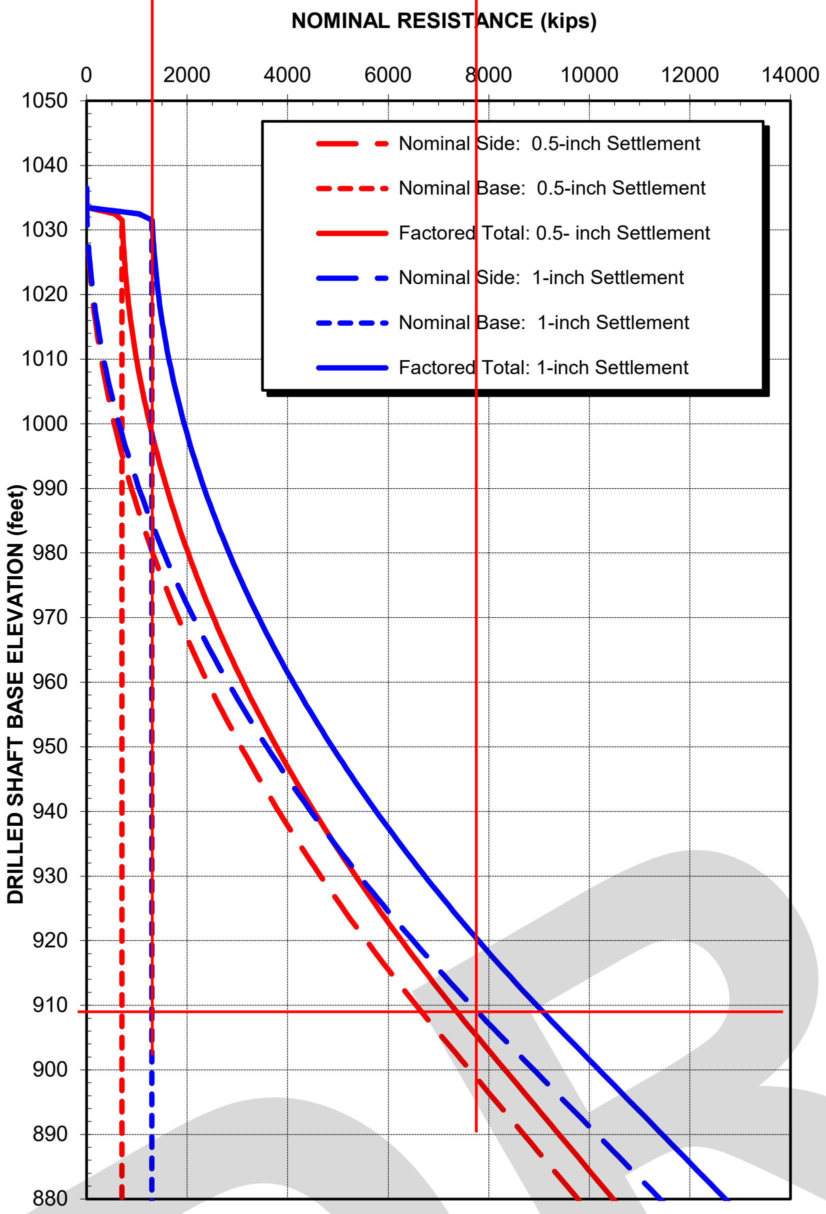
ASSUMED SUBSURFACE PROFILE

Based on Nearby Explorations:
EWC-B-03-14, B-3-18



Bottom of Boring B-3-18 at Elevation ~920 ft. Boring Extrapolated to Elevation 880 ft.

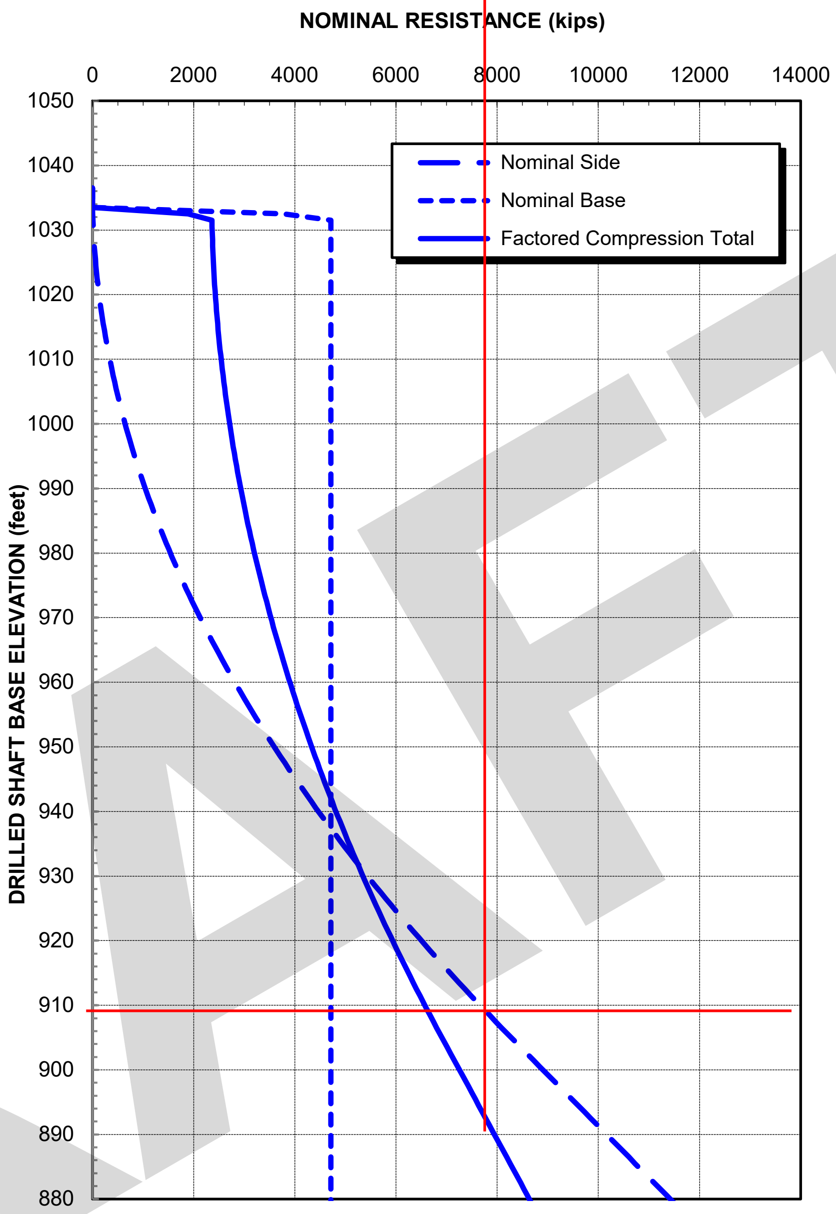
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

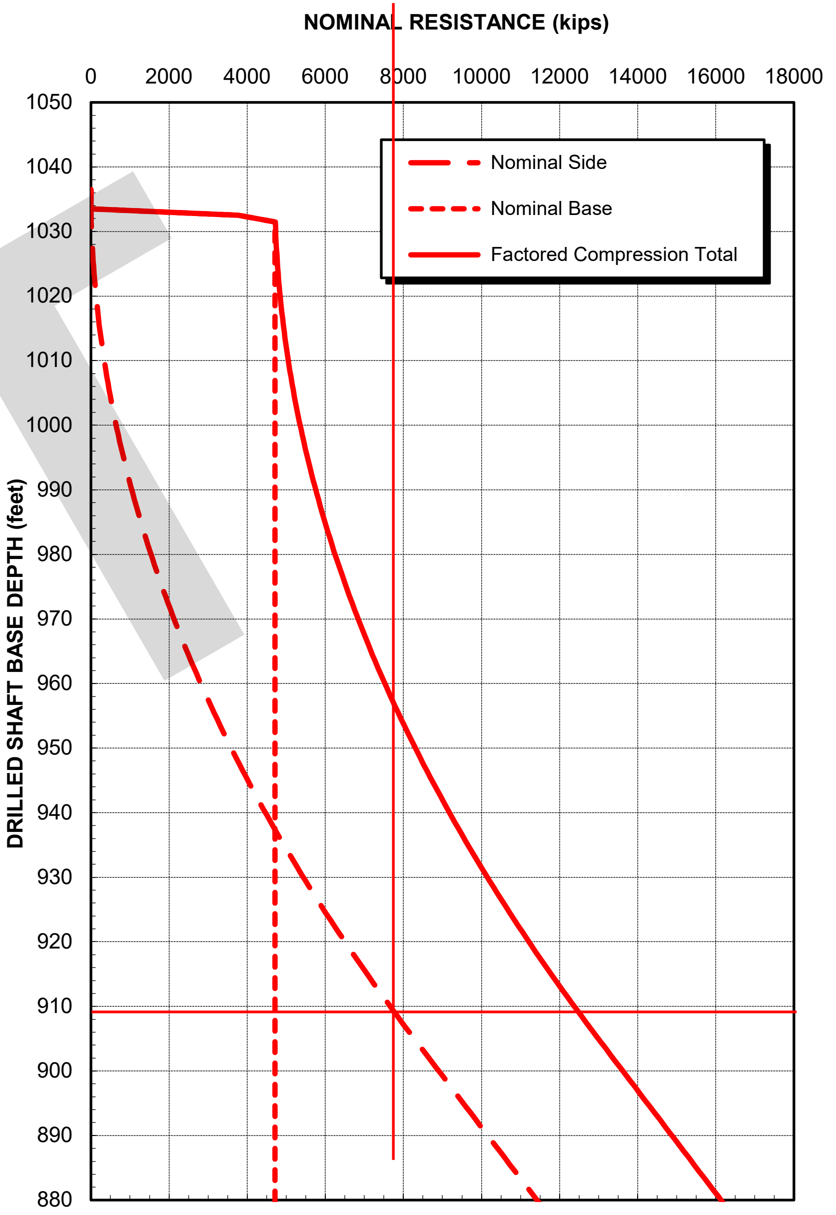
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

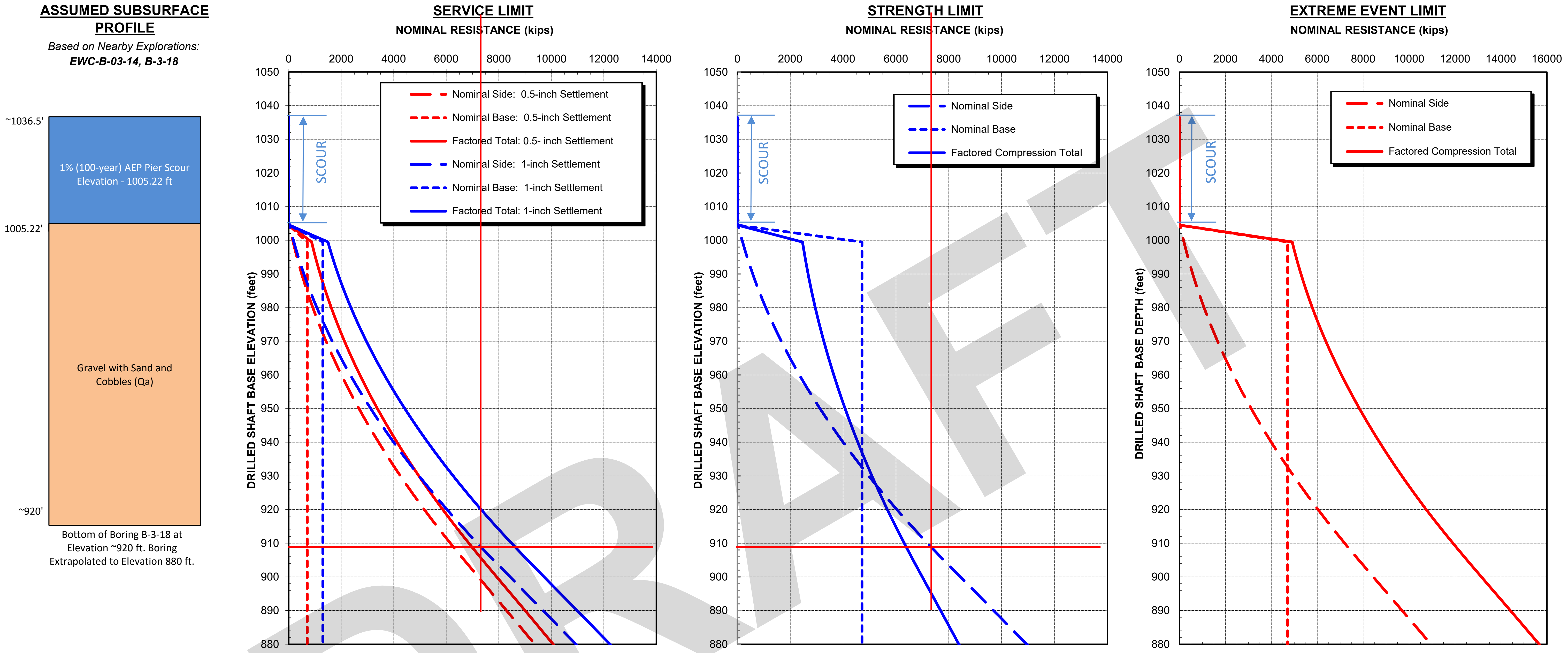
Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 2
10 FT DIAMETER

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 8



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

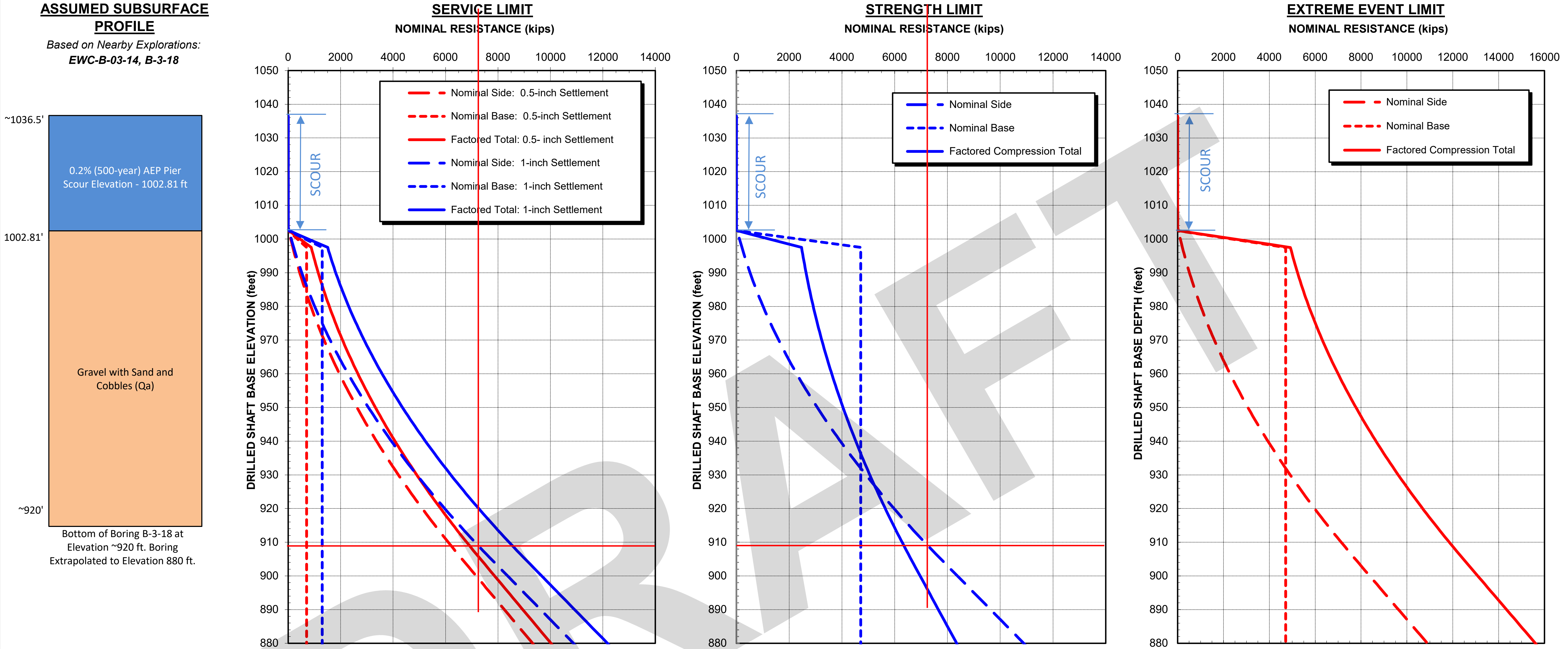
Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 2
10 FT DIAMETER, WITH 100-YR SCOUR

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 9



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

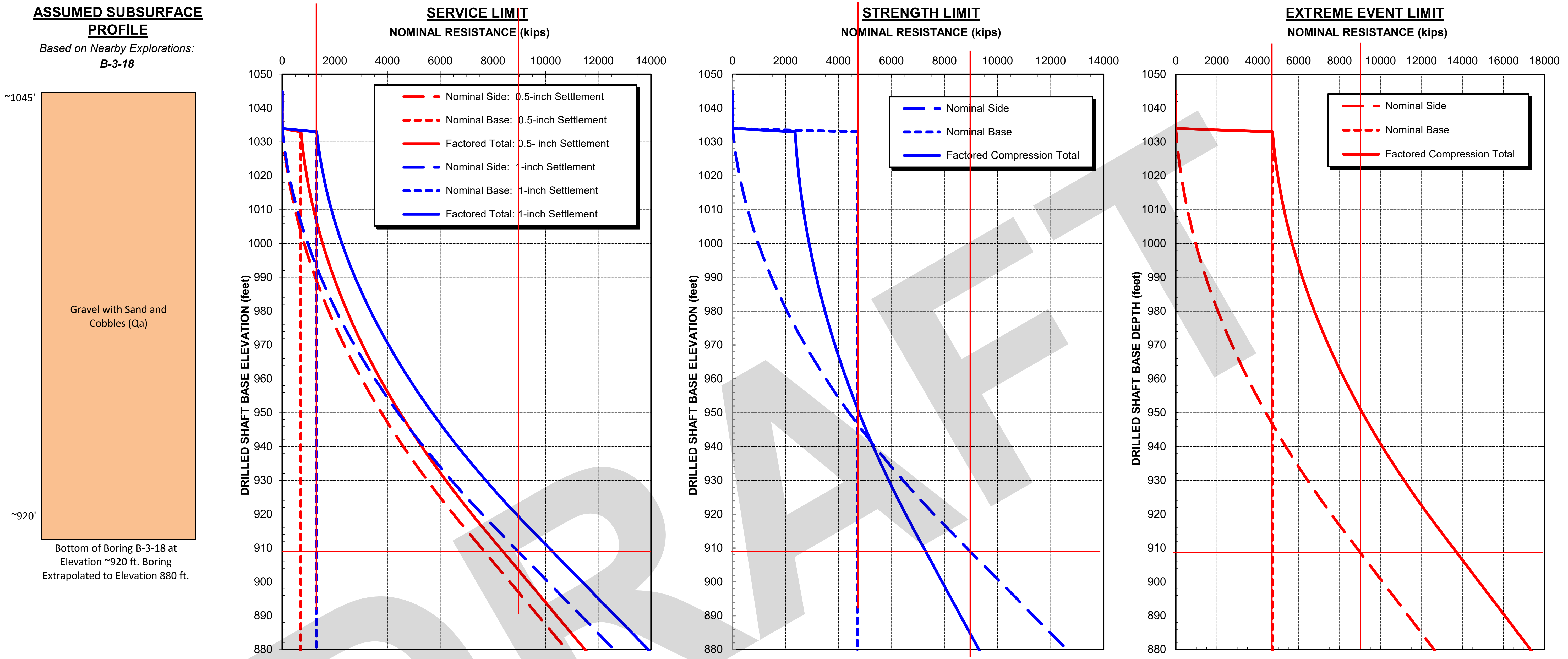
Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 2
10 FT DIAMETER, WITH 500-YR SCOUR

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 10



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 3
10 FT DIAMETER

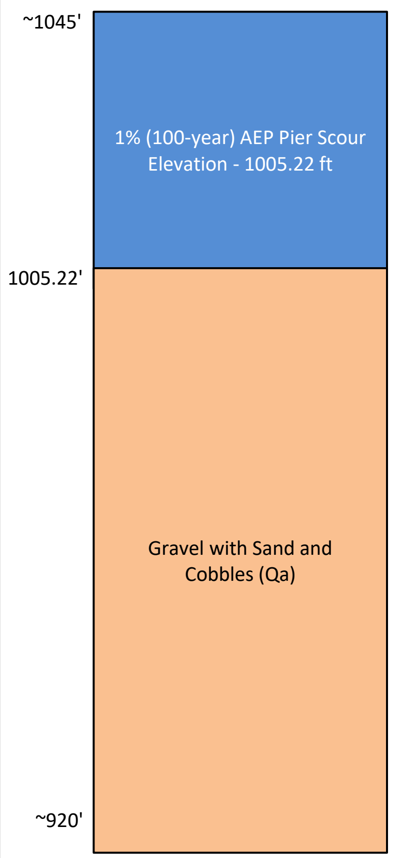
September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 11

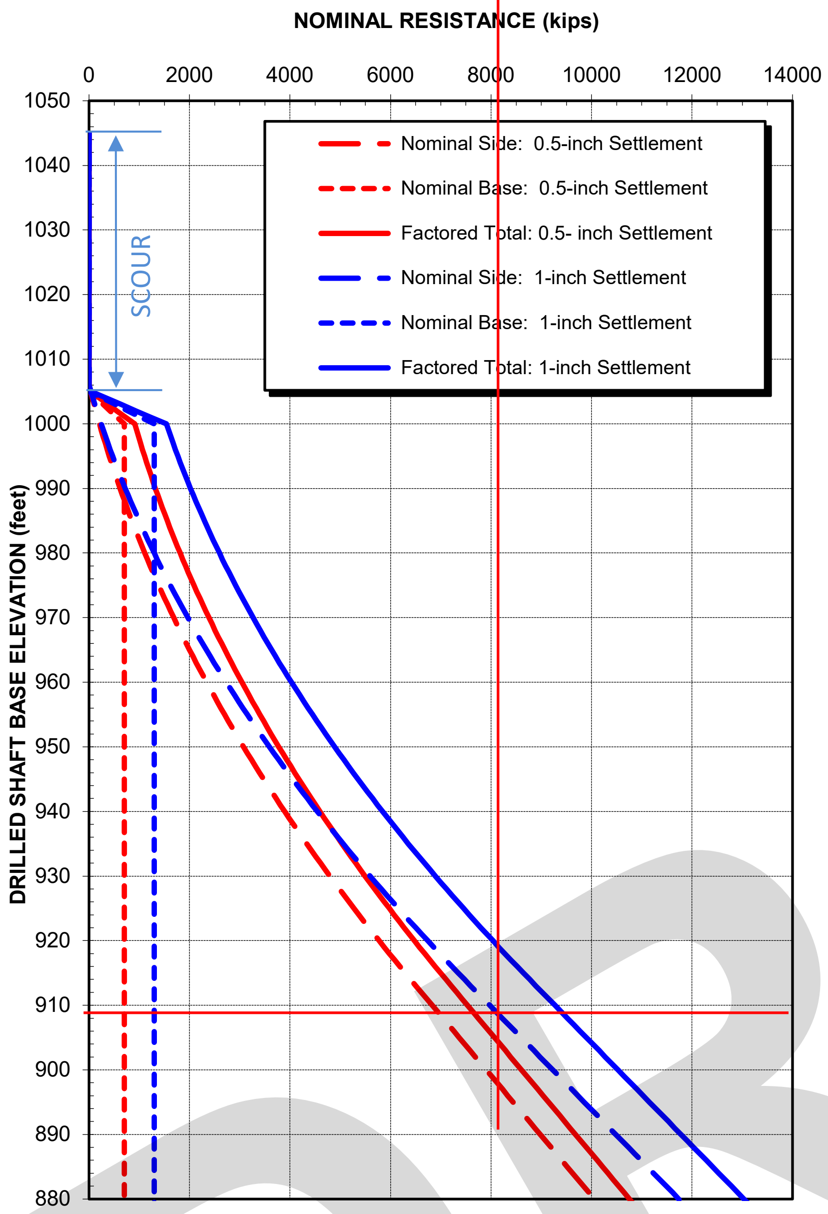
ASSUMED SUBSURFACE PROFILE

Based on Nearby Explorations:
B-3-18



Bottom of Boring B-3-18 at Elevation ~920 ft. Boring Extrapolated to Elevation 880 ft.

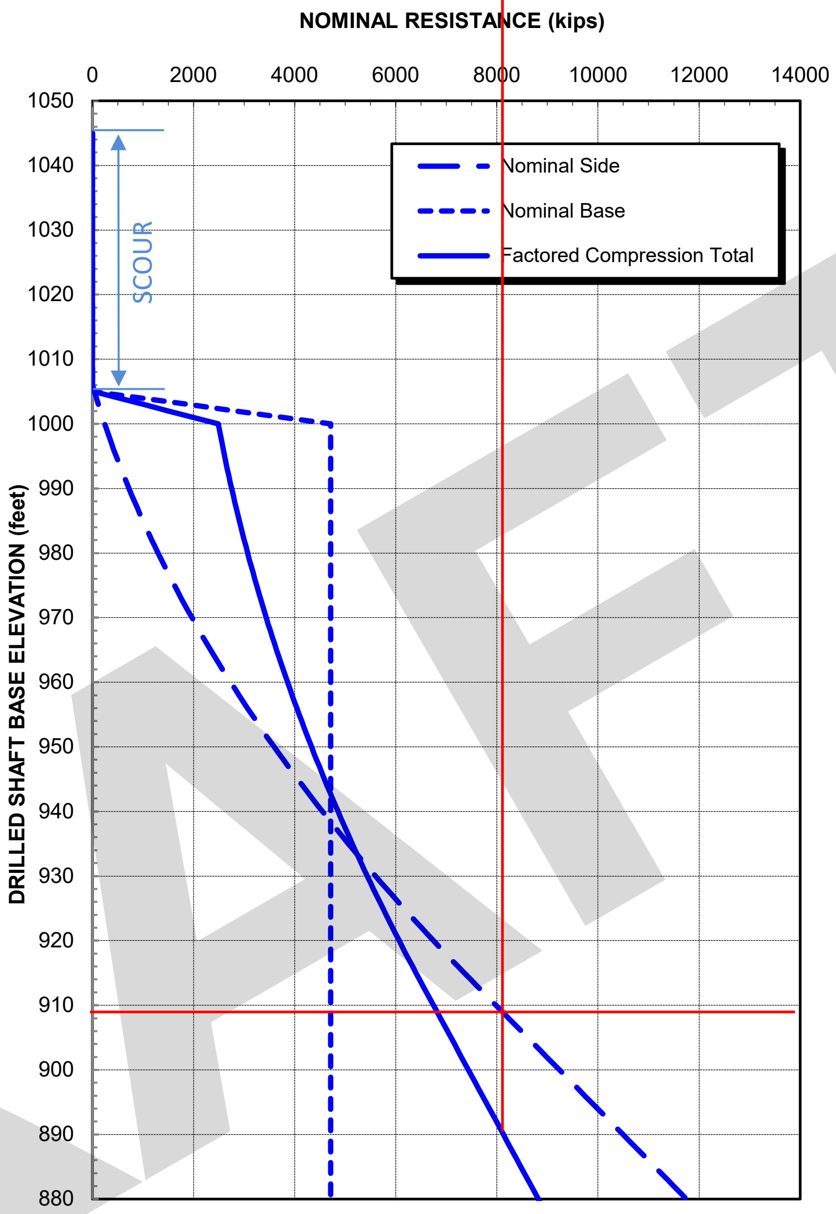
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

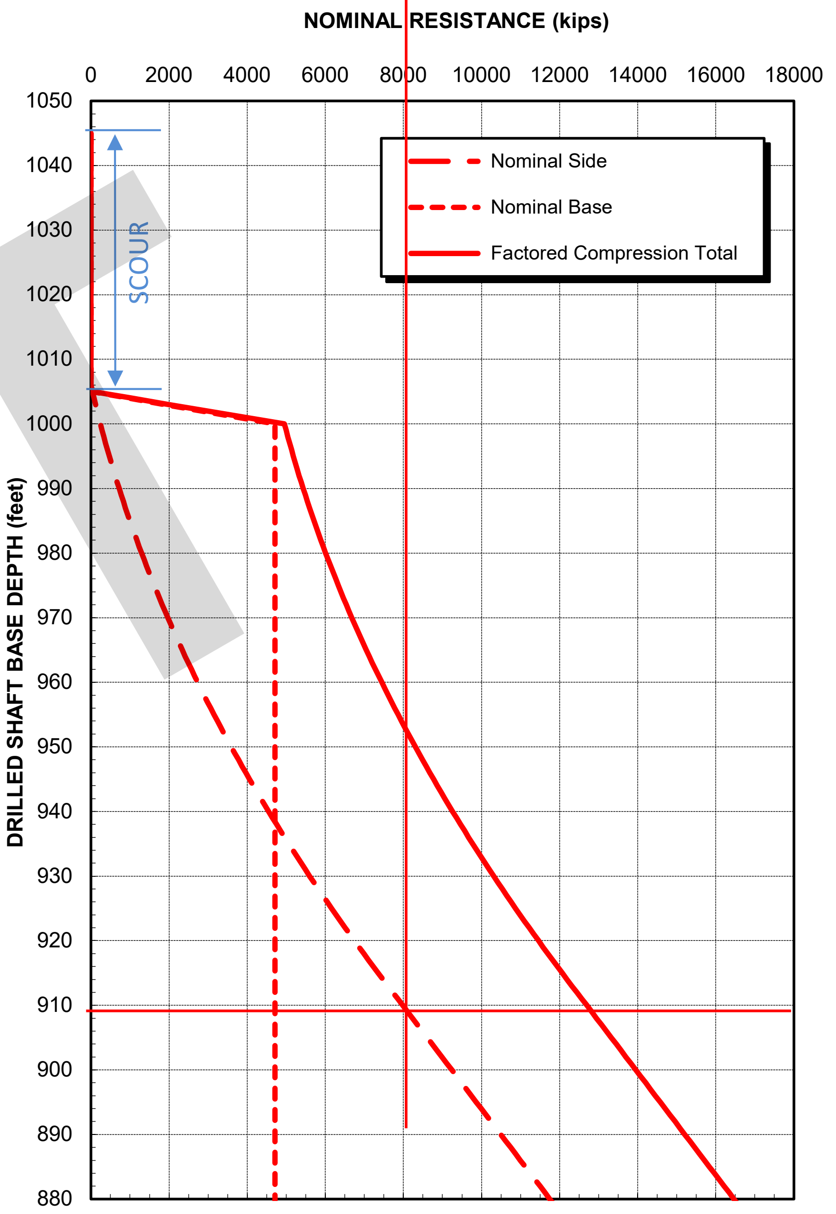
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 3
10 FT DIAMETER, WITH 100-YR SCOUR

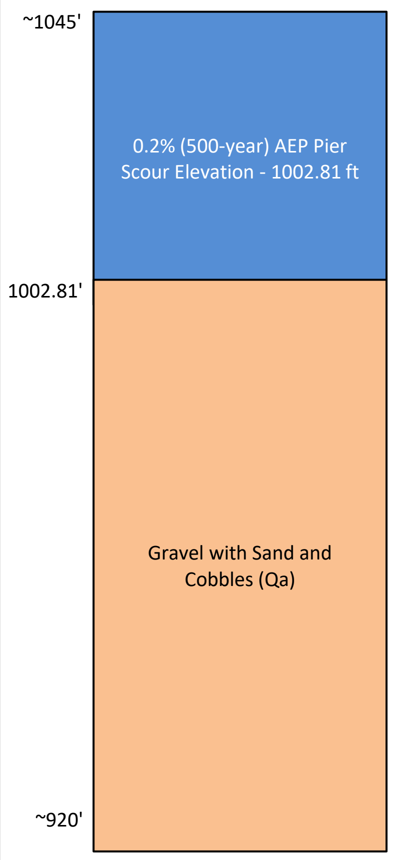
September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 12

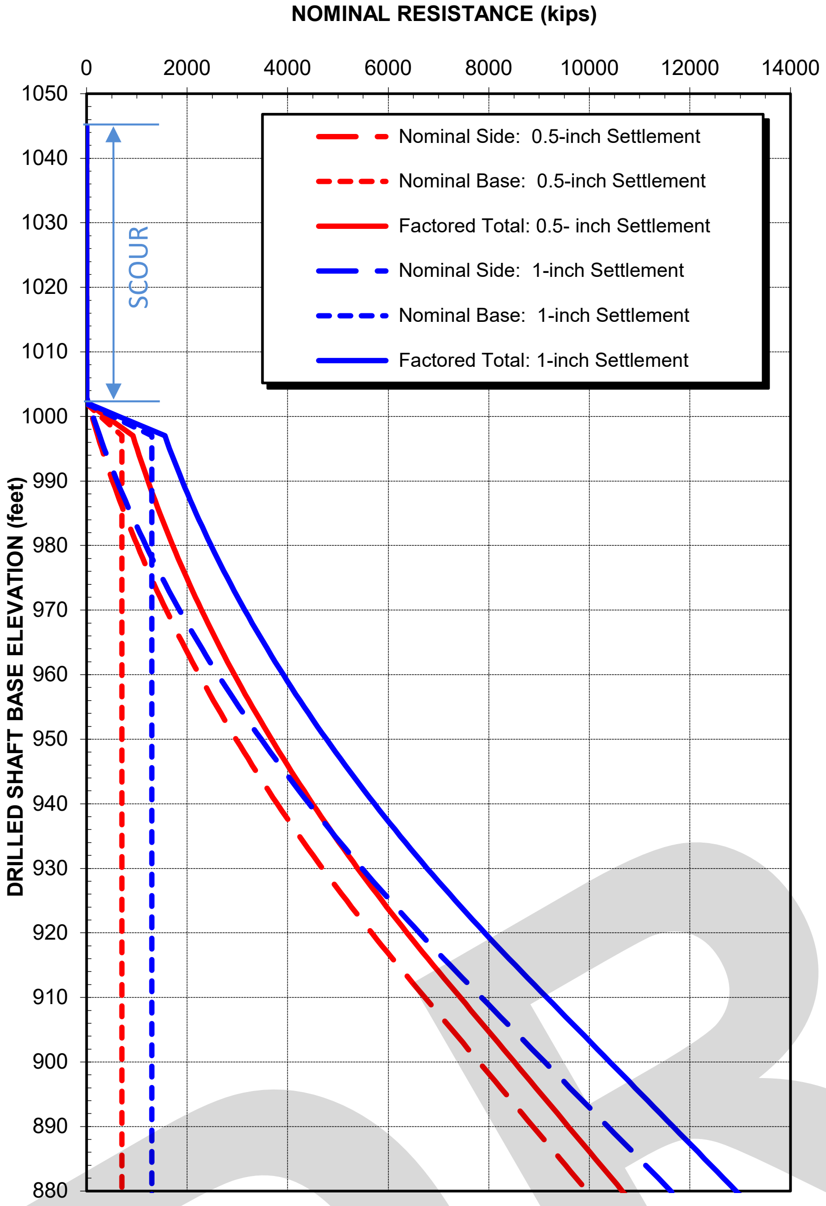
ASSUMED SUBSURFACE PROFILE

Based on Nearby Explorations:
B-3-18

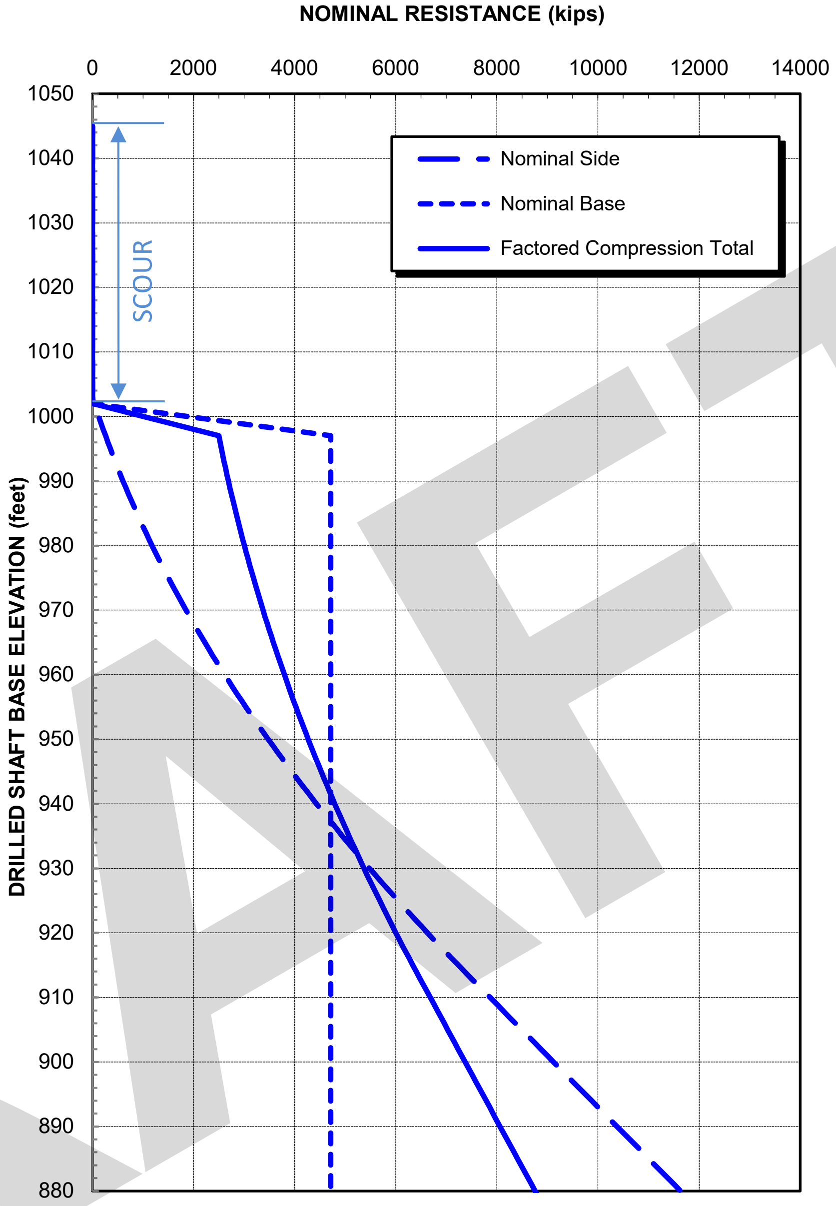


Bottom of Boring B-3-18 at Elevation ~920 ft. Boring Extrapolated to Elevation 880 ft.

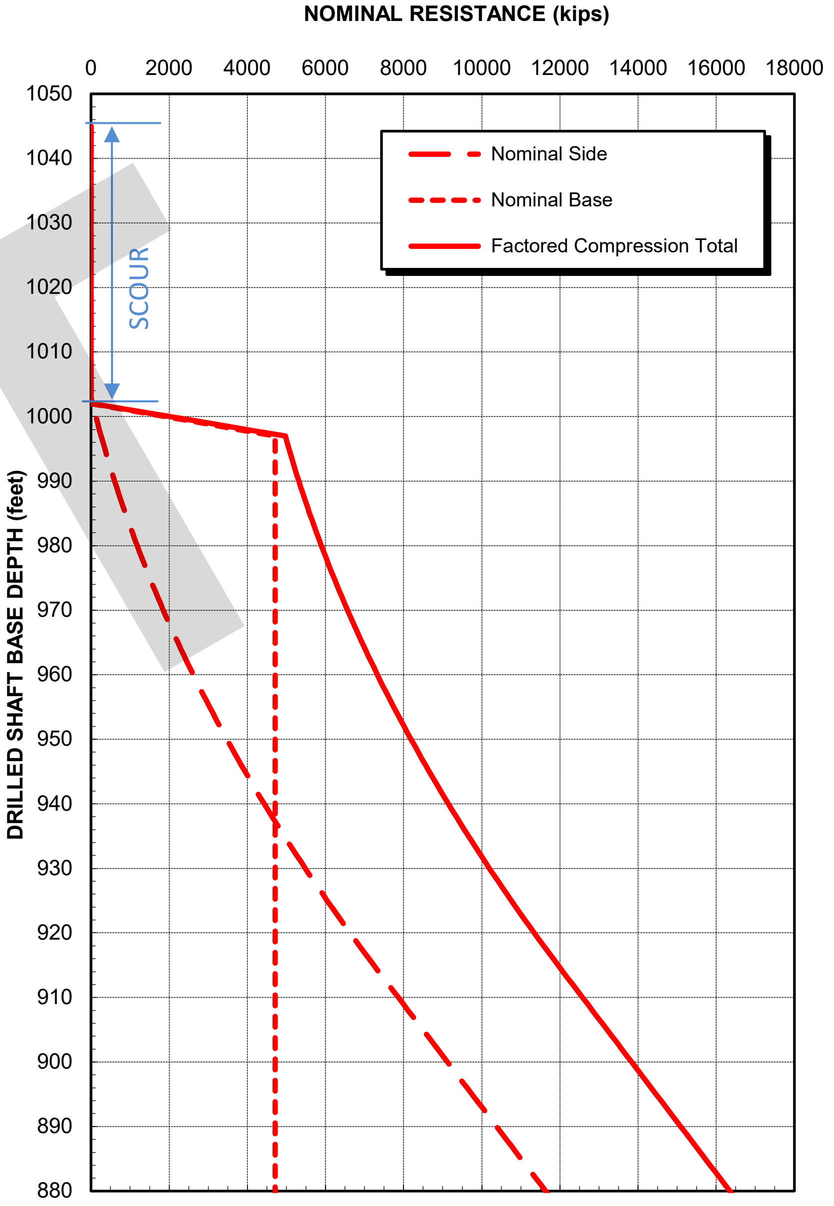
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 3
10 FT DIAMETER, WITH 500-YR SCOUR

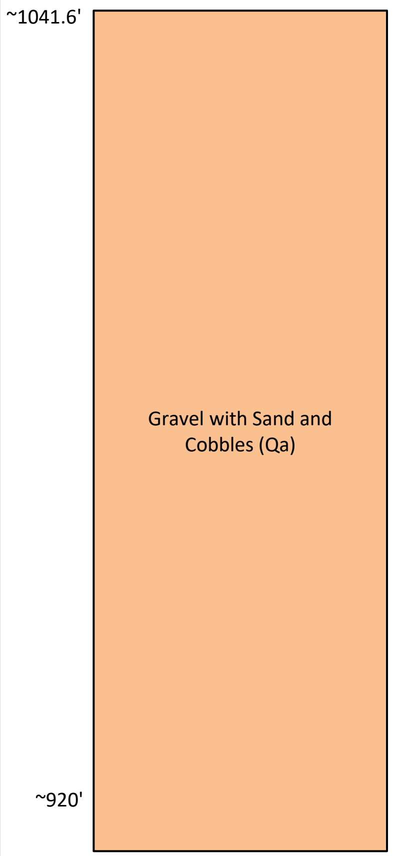
September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 13

ASSUMED SUBSURFACE PROFILE

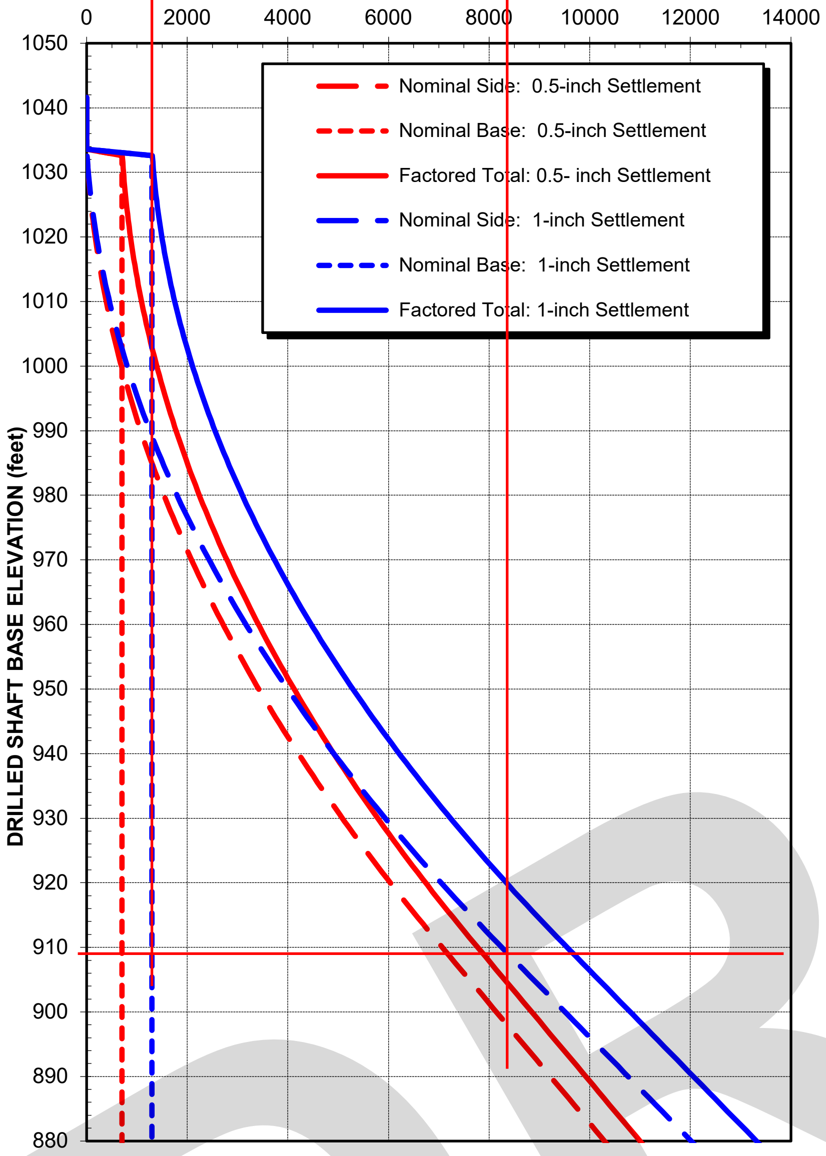
Based on Nearby Explorations:
B-3-18, EWC-B-04-14



Bottom of Boring B-3-18 at Elevation ~920 ft. Boring Extrapolated to Elevation 880 ft.

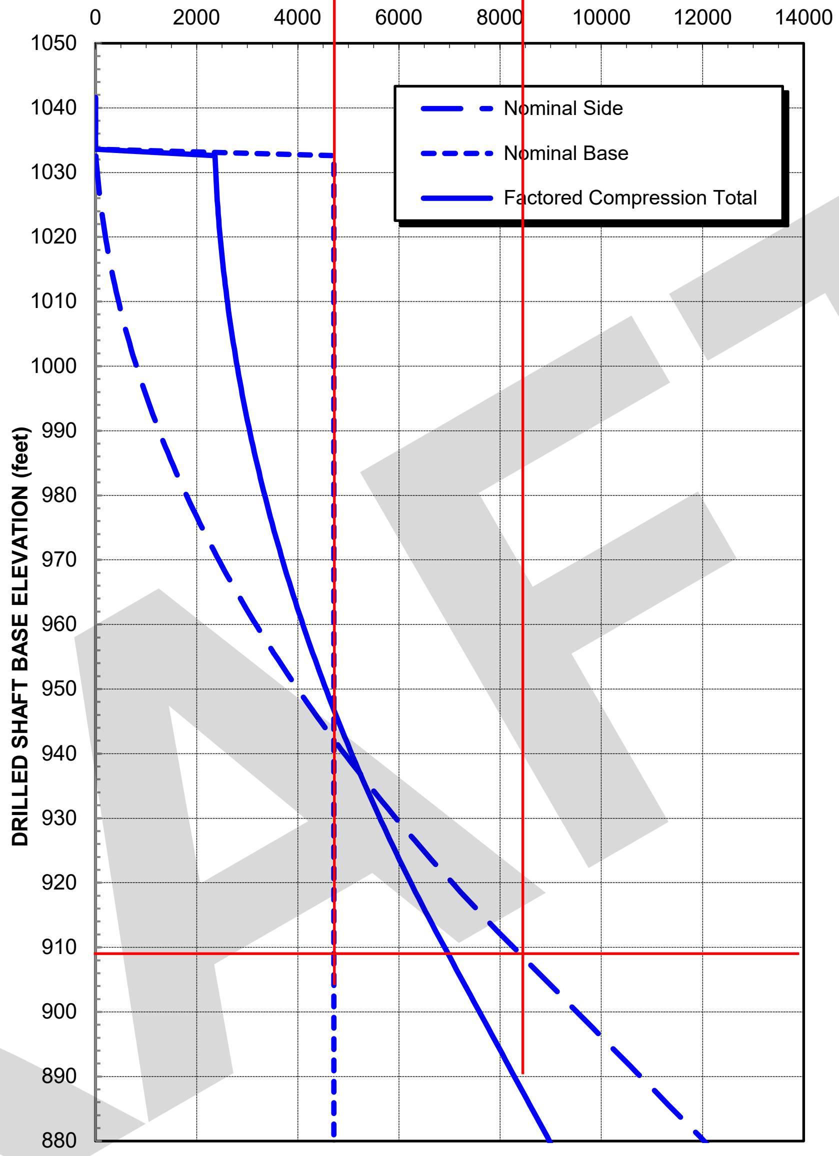
SERVICE LIMIT

NOMINAL RESISTANCE (kips)



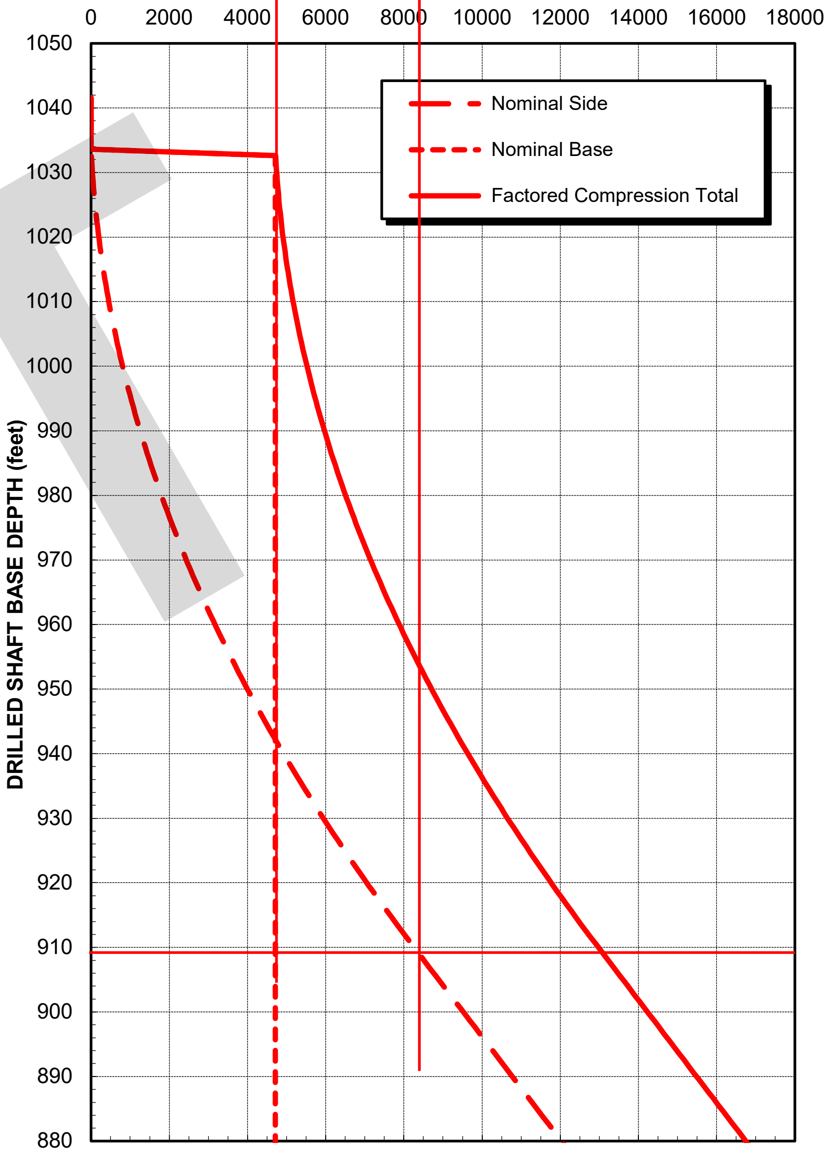
STRENGTH LIMIT

NOMINAL RESISTANCE (kips)



EXTREME EVENT LIMIT

NOMINAL RESISTANCE (kips)



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

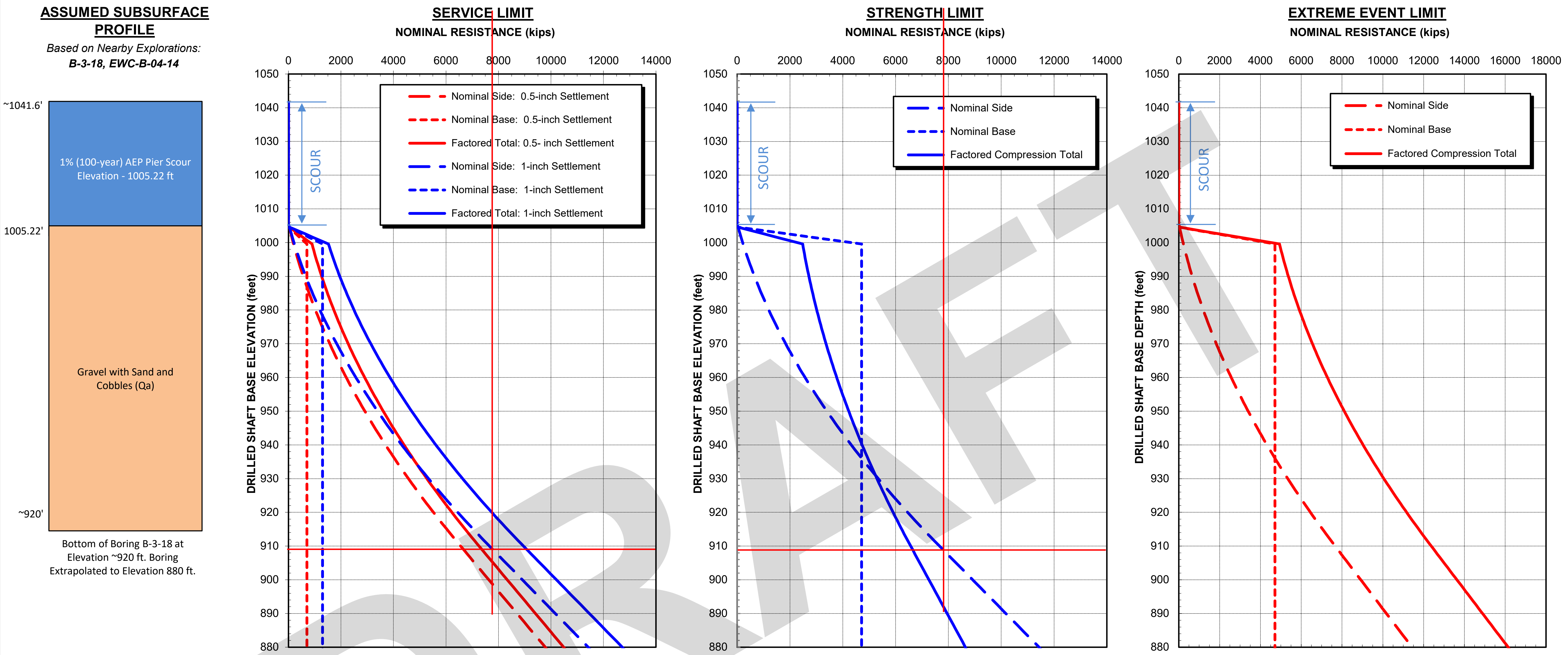
Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 4
10 FT DIAMETER

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 14



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

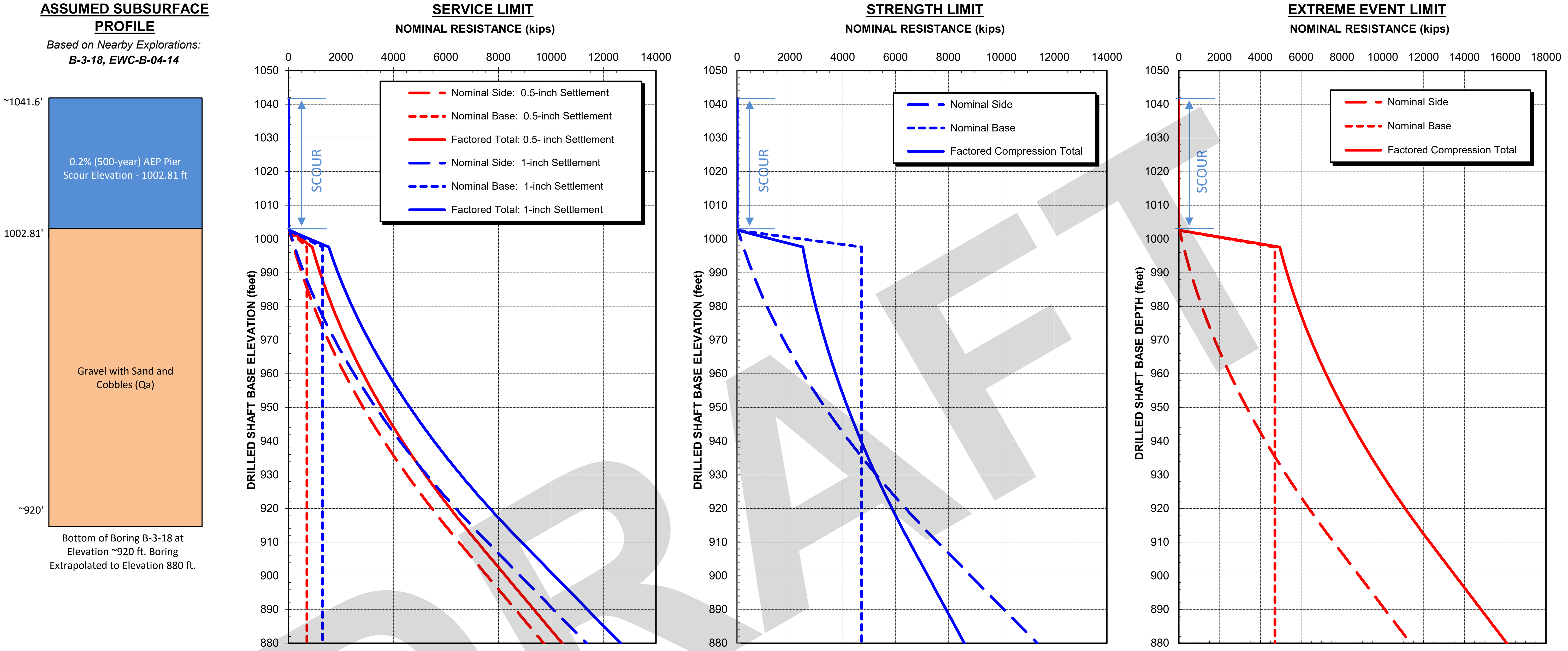
Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 4
10 FT DIAMETER, WITH 100-YR SCOUR

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 15



SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 4
10 FT DIAMETER, WITH 500-YR SCOUR

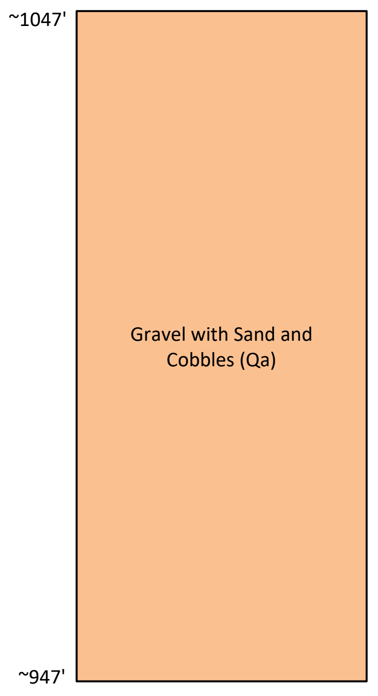
September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 16

ASSUMED SUBSURFACE PROFILE

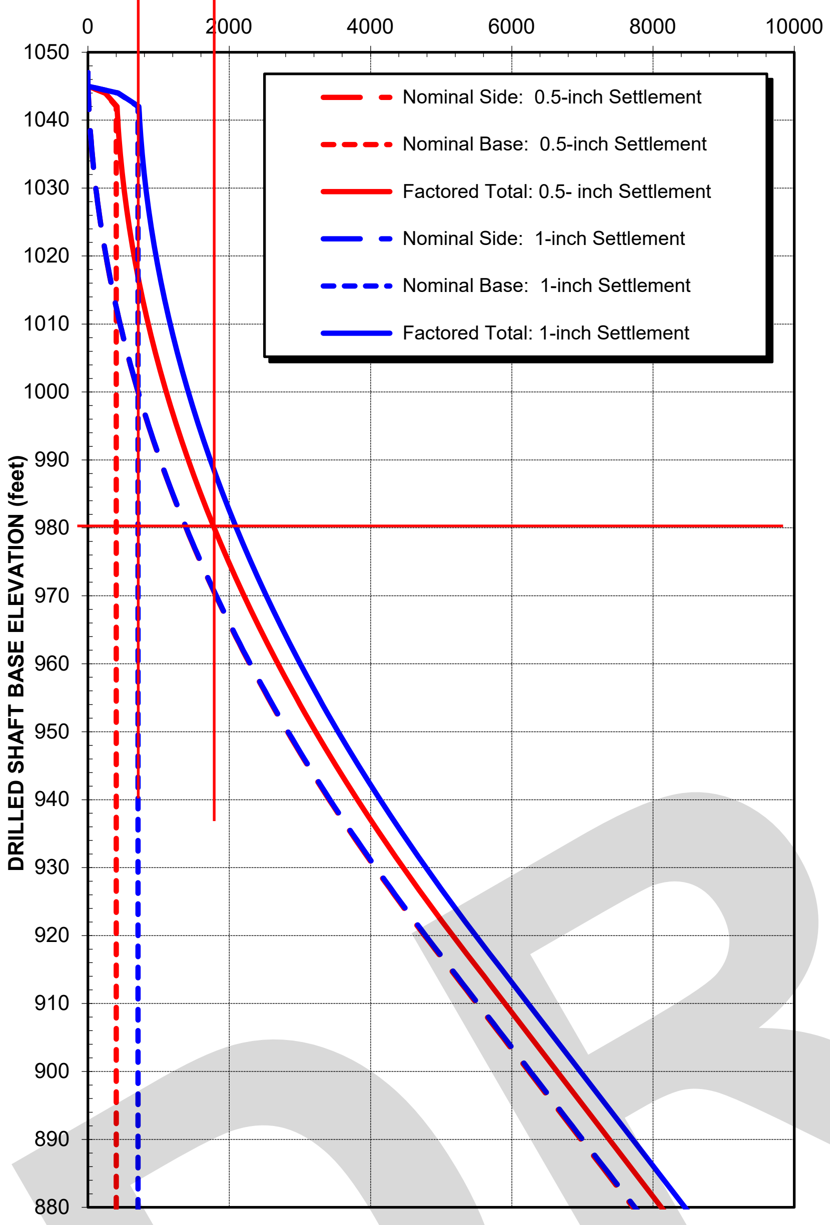
Based on Nearby Explorations:
EWC-B-04-14



Bottom of Boring EWC-B-04-14
at Elevation ~947 ft. Boring
Extrapolated to 880 ft.

SERVICE LIMIT

NOMINAL RESISTANCE (kips)

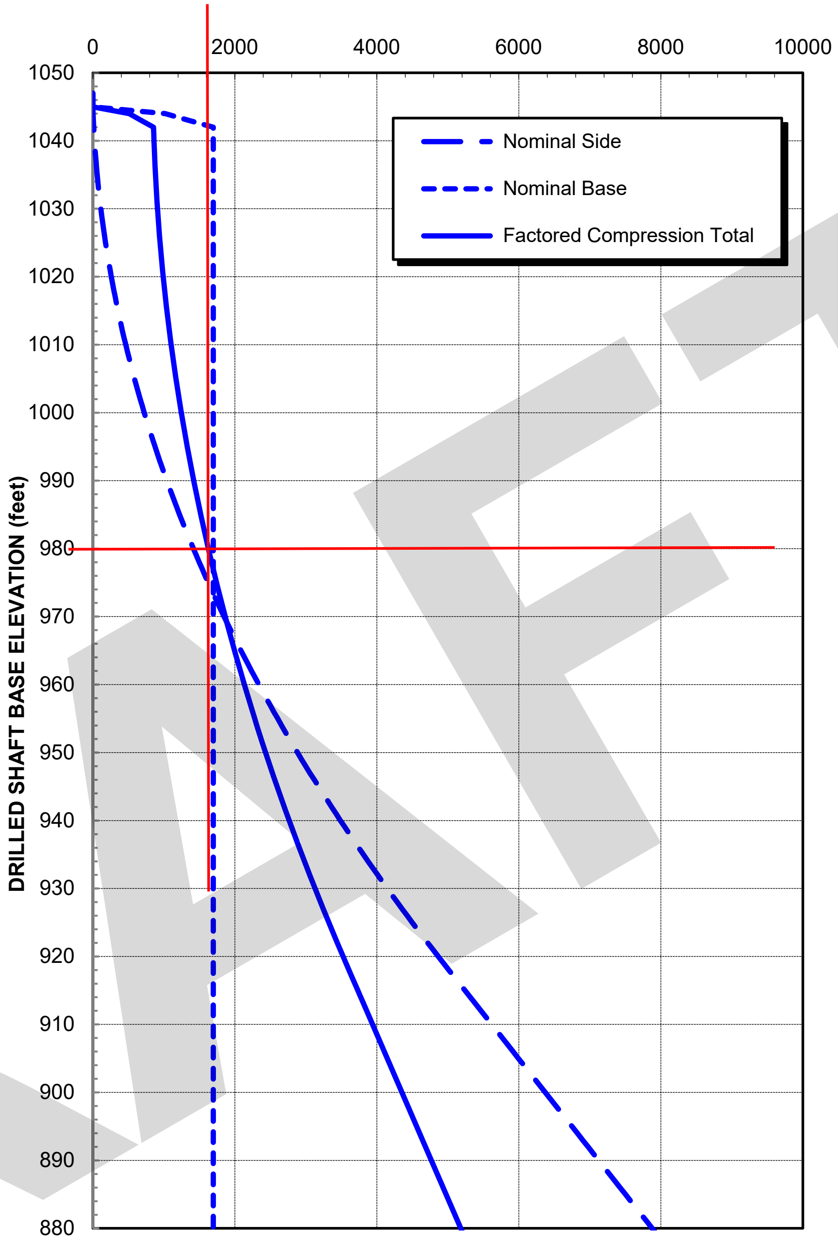


SERVICE LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM are 1.0 for both side and base resistance.
2. Per AASHTO guidelines, a detailed assessment of pile group settlement may be waived because they will be embedded in dense granular soils (AASHTO Section 10.8.2.2.4).

STRENGTH LIMIT

NOMINAL RESISTANCE (kips)

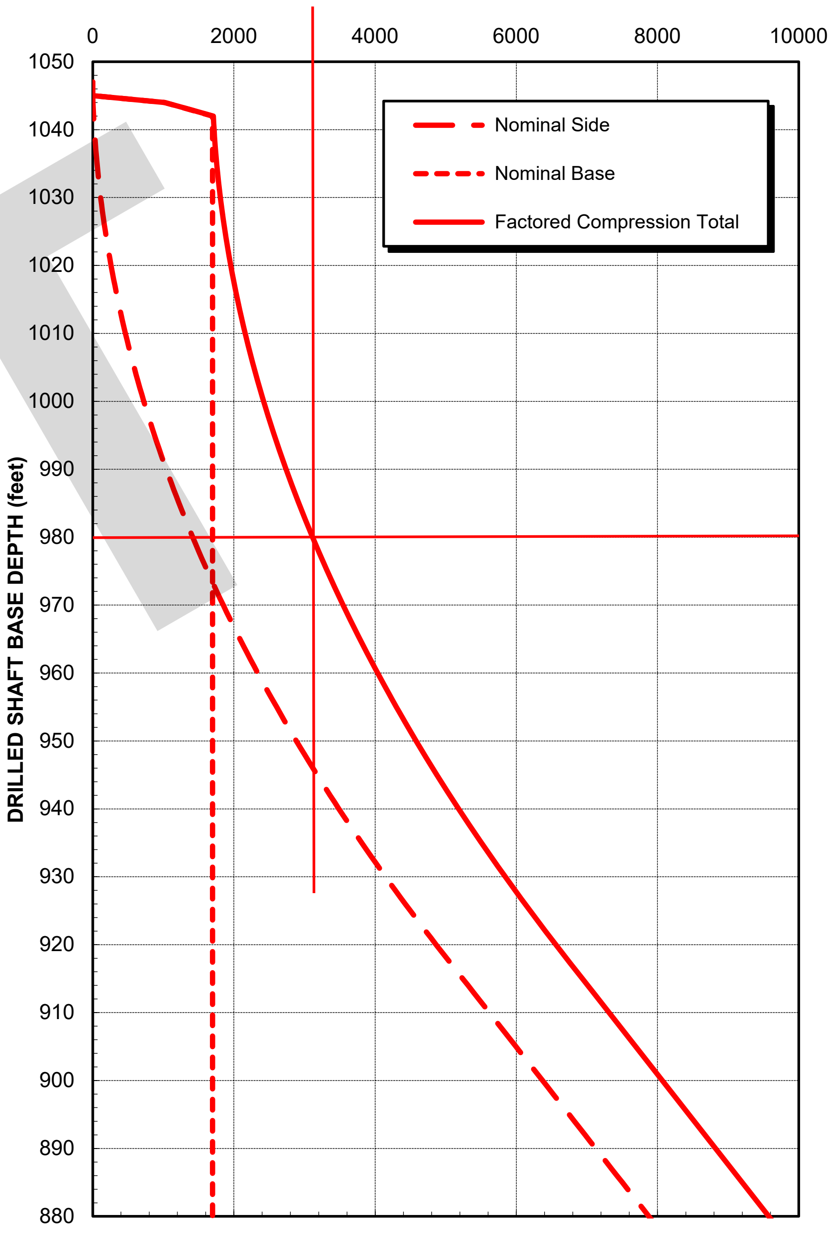


STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors per WSDOT GDM are 0.55 and 0.5 for side and base resistance, respectively.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per WSDOT GDM).

EXTREME EVENT LIMIT

NOMINAL RESISTANCE (kips)



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per WSDOT GDM for both side and base resistance are 1.0 for compression and 0.8 for uplift.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM), AASHTO LRFD Bridge Design Specifications, and local experience. The analyses consider group action of closely spaced shafts (closer than 3 diameters, center to center).
2. Factored total shaft resistance shown on plots is determined by adding its nominal side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Estimated shaft resistance assumes that if casing is used, it will be removed after the shaft installation. If, however, the casing is left in place, grouting should be used to fill all potential voids around the casing and the estimated resistance given above should be re-evaluated.

Cascade Mill Parkway Project
Yakima, Washington

ESTIMATED AXIAL SHAFT RESISTANCE
YAKIMA RIVER BRIDGE PIER 5
6 FT DIAMETER

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 17

Printed: 9-07-22 13:39 File: P:\SEA\106000s\106384 Mill Parkway\Deliverables\Cascade Mill Parkway GER\DRAFT\02 Figures\[Fig 18 - YRB LPILE parameters.xlsx]LPILE-KXM

Table 18-1 - LPILE Parameters by Elevation

			Unscoured Conditions			Scoured Conditions					
Soil Description	Top Elevation of Layer (See Table Below)	Effective Unit Weight (pcf)	LPile Model	Friction Angle, φ (degrees)	Initial Modulus of Subgrade Reaction, k (pci)	LPile Model	Friction Angle, φ (degrees)	Initial Modulus of Subgrade Reaction, k (pci)	Undrained Cohesion, c (psf)	Strain Factor E50	Ground Slope Angle, ß (deg)
Quaternary Alluvium	E	77.6	Sand (Reese)	40	95	Soft Clay (Reese)	--	--	1	1	ß
Quaternary Alluvium	S	77.6	Sand (Reese)	40	95	Sand (Reese)	40	95	--	--	ß

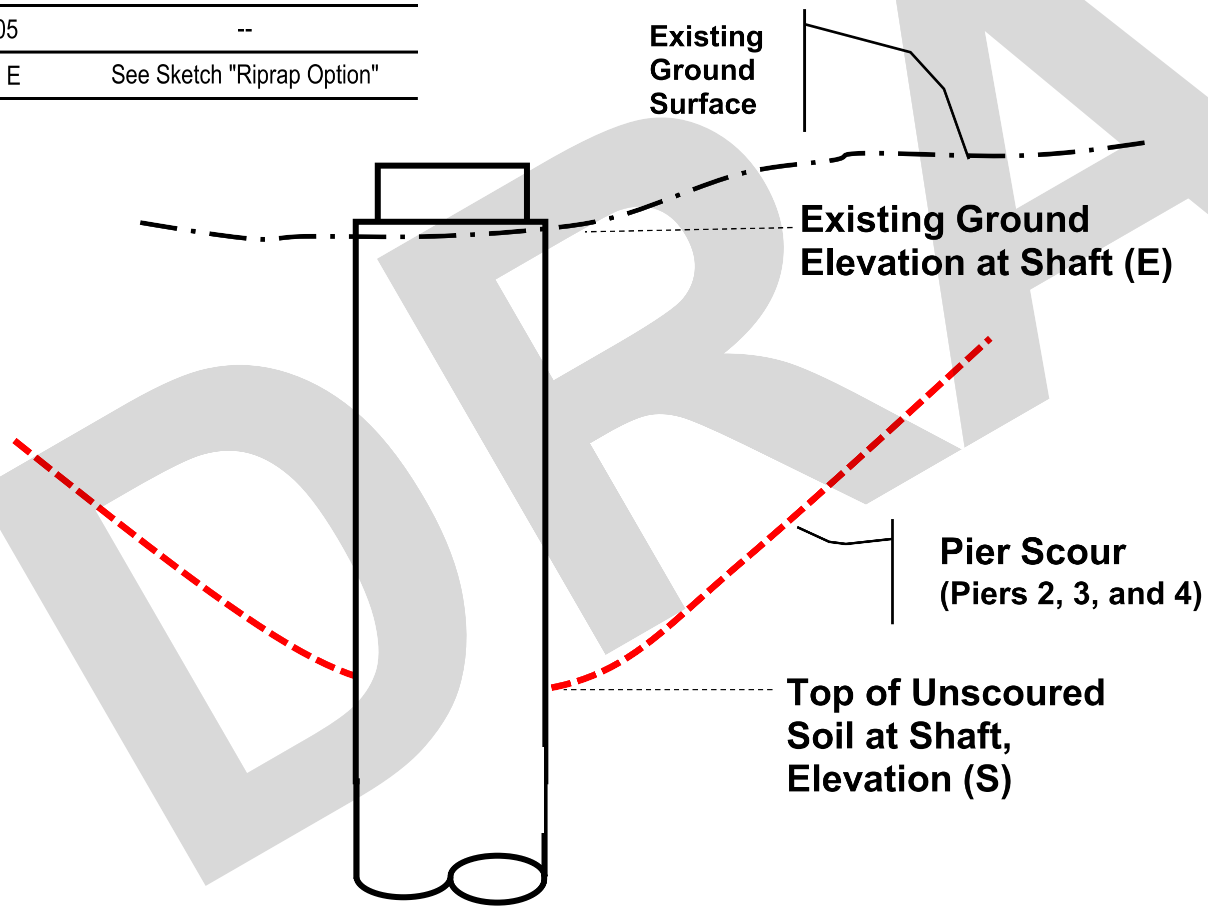
Table 18-2 - Design Elevations

Location	Elevation E (feet)	Elevation S (feet)	Note
Pier 1	See Note 2	S = E	No Scour (See Note 3)
Pier 2	1037	1005	--
Pier 3	1045	1005	--
Pier 4	1042	1005	--
Pier 5 - Riprap Option	See Note 2	S = E	See Sketch "Riprap Option"

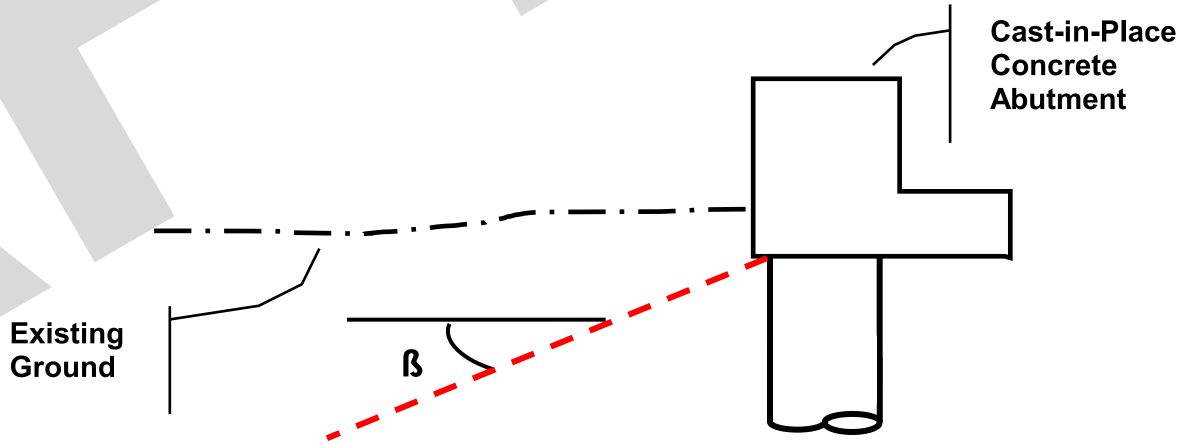
Table 18-3 - Ground Slopes

Location	Ground Slope Angle, ß (deg)
Pier 1	See Note 3
Pier 2	0
Pier 3	0
Pier 4	0
Pier 5 - Riprap Option	26.6

Piers 2, 3, and 4 Geometry Sketch



Pier 5 Geometry Sketch - Riprap Option



NOTES

1. pcf = pounds per cubic foot; pci = pounds per cubic inch; psf = pounds per square foot
2. Top of shaft elevations to be determined by structural engineer.
3. Scour is not anticipated at Pier 1 because it is located behind a levee. We assume the levee will have adequate scour protection during the design flood event. Apply soil parameters from below Elevation S (second row in Table 18-1) to all layers in LPILE model for Pier 1.

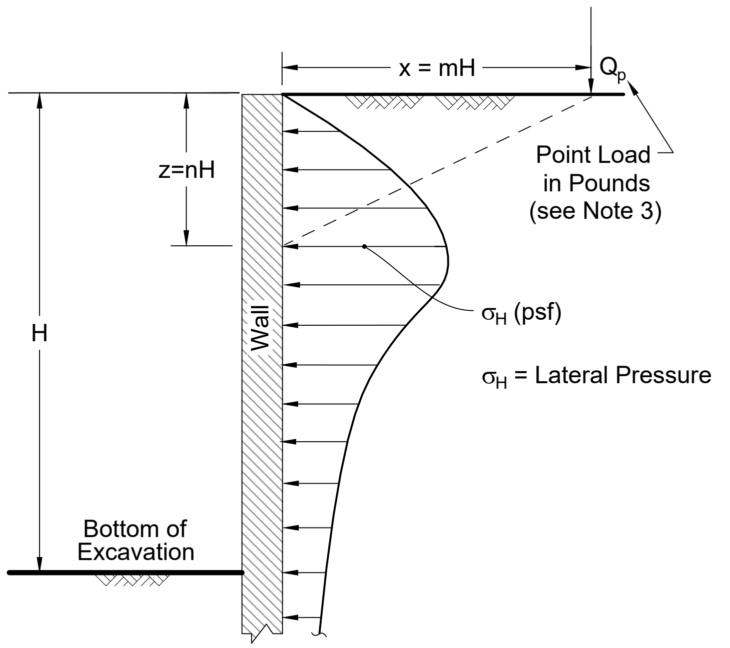
Cascade Mill Parkway
Yakima, Washington

YAKIMA RIVER BRIDGE
LPILE PARAMETERS FOR LATERAL
DEEP FOUNDATION ANALYSIS

September 2022 106384-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

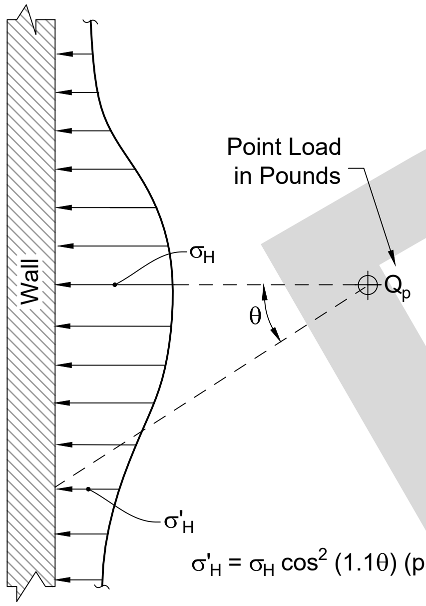
FIG. 18



ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.28 \frac{Q_p}{H^2} \frac{n^2}{(0.16 + n^2)^3}$ (psf) (see Note 3)

For m > 0.4: $\sigma_H = 1.77 \frac{Q_p}{H^2} \frac{m^2n^2}{(m^2 + n^2)^3}$ (psf)

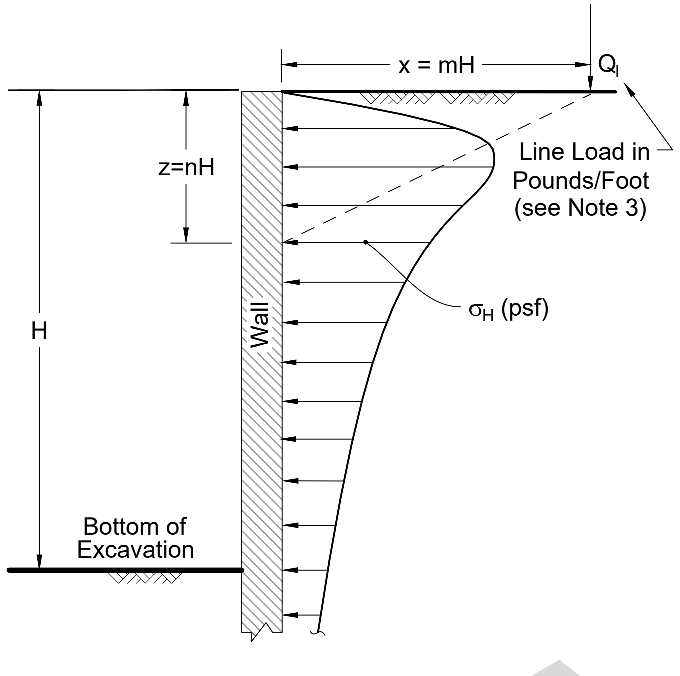


$\sigma'_H = \sigma_H \cos^2(1.1\theta)$ (psf)

PLAN VIEW

A) LATERAL PRESSURE DUE TO POINT LOAD i.e. SMALL ISOLATED FOOTING OR WHEEL LOAD

(NAVFAC DM 7.2, 1986)



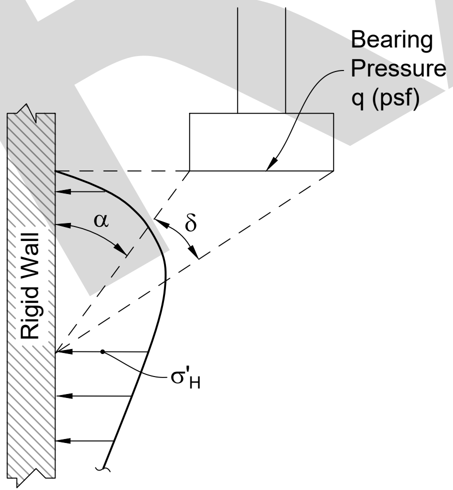
ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.20 \frac{Q_l}{H} \frac{n}{(0.16 + n^2)^2}$ (psf) (see Note 3)

For m > 0.4: $\sigma_H = 1.28 \frac{Q_l}{H} \frac{m^2n}{(m^2 + n^2)^2}$ (psf)

B) LATERAL PRESSURE DUE TO LINE LOAD i.e. NARROW CONTINUOUS FOOTING PARALLEL TO WALL

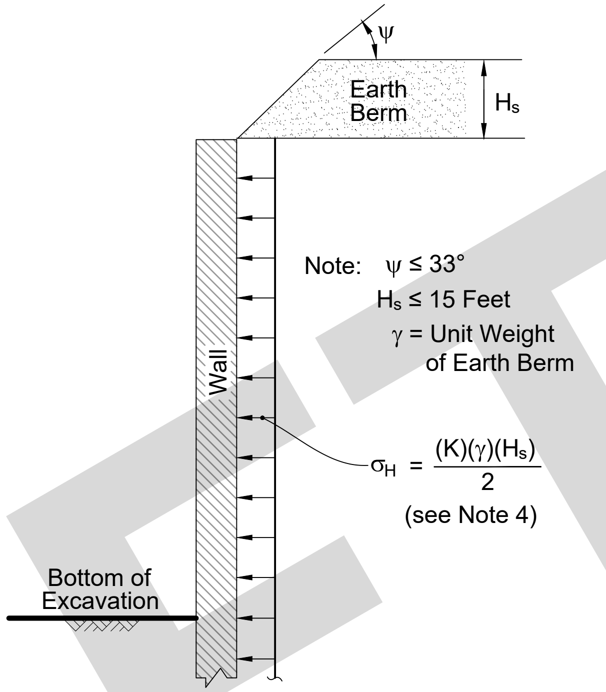
(NAVFAC DM 7.02, 1986)



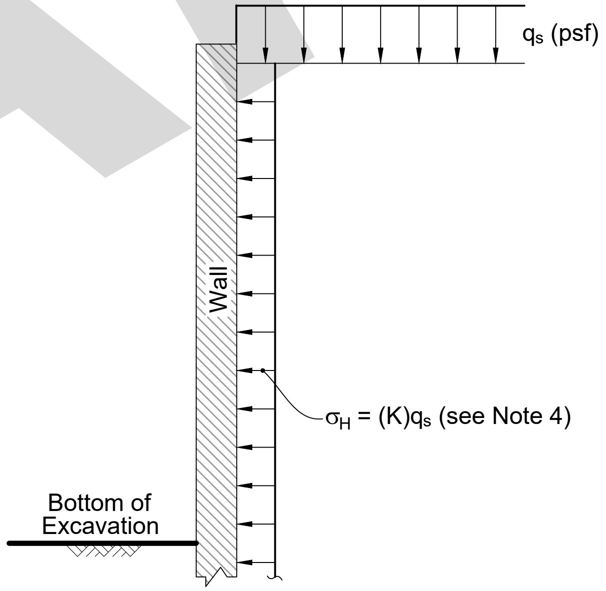
$\sigma_H = \frac{2q}{\pi} [\overset{\text{in radians}}{\delta} - \sin\delta \cos(\delta + 2\alpha)]$ (psf)

C) LATERAL PRESSURE DUE TO STRIP LOAD

(AASHTO LRFD Bridge Design Specifications, 2020)



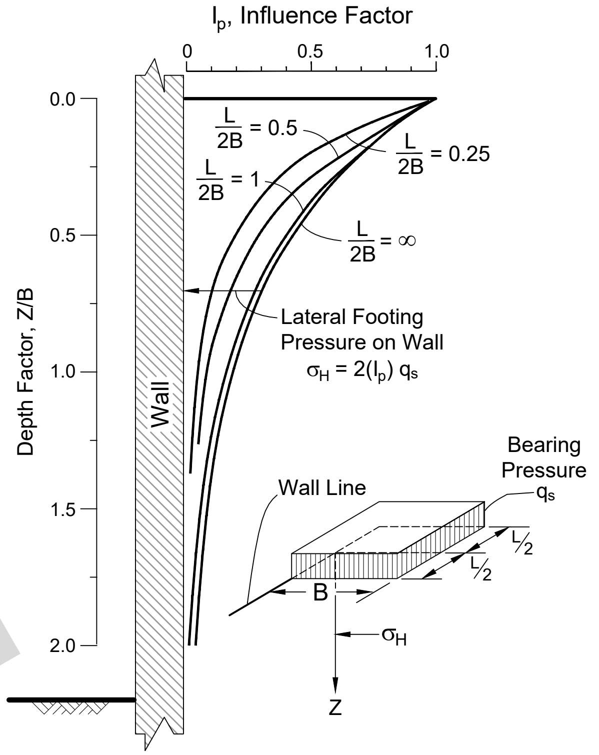
EARTH BERM



UNIFORM SURCHARGE

D) LATERAL PRESSURE DUE TO EARTH BERM OR UNIFORM SURCHARGE

(derived from Poulos and Davis, *Elastic Solutions for Soil and Rock Mechanics*, 1974; and Terzaghi and Peck, *Soil Mechanics in Engineering Practice*, 1967)



E) LATERAL PRESSURE DUE TO ADJACENT FOOTING

(see Notes 5 and 6)

(derived from NAVFAC DM 7.02, 1986; and Sandhu, *Earth Pressure on Walls Due to Surcharge*, 1974)

NOTES

1. Figures are not drawn to scale.
2. Applicable surcharge pressures should be added to appropriate permanent wall lateral earth and water pressure.
3. If point or line loads are close to the back of the wall such that m ≤ 0.4, it may be more appropriate to model the actual load distribution (i.e., Detail E) or use more rigorous analysis methods.
4. See text and lateral load diagram exihibits for recommended K values.
5. The stress is estimated on the back of the wall at the center of the length, L, of loading.
6. The estimated stress is based on a Poisson's ratio of 0.5.

Cascade Mill Parkway Project
Yakima, Washington

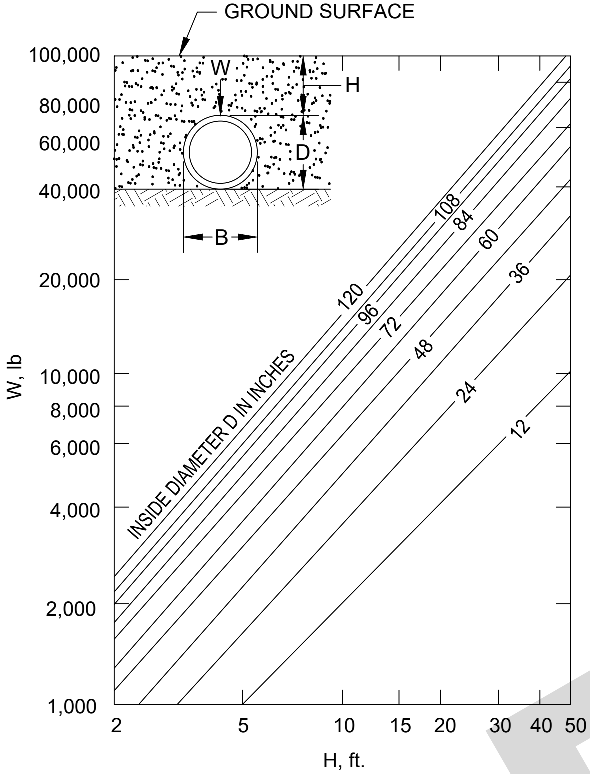
RECOMMENDED SURCHARGE LOADING FOR TEMPORARY AND PERMANENT WALLS

September 2022 106384-002

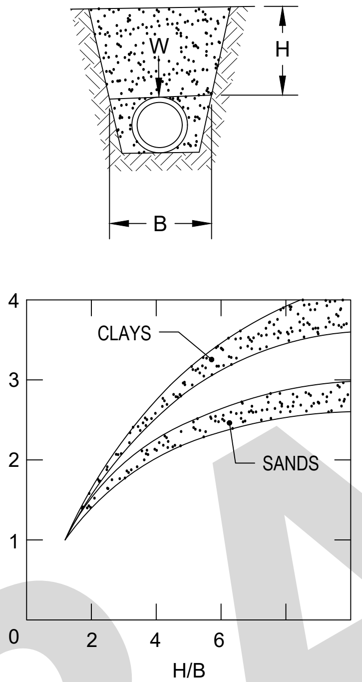
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 19

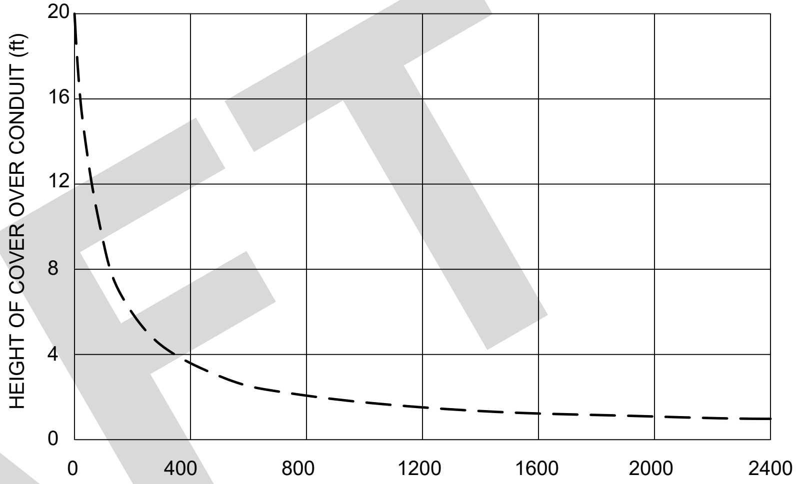
File: C:\Users\jrs\CAD Group Dropbox\JDrive_SEA\106384\002\106384-002 Surcharge Loading.dwg Date: 09-08-2022 Author: JRS



CASE A EMBANKMENT DEAD LOAD W ON A CONDUIT BURIED IN A SOIL EMBANKMENT



CASE B C_w FOR CONDUIT IN A TRENCH



CASE C VERTICAL PRESSURE DUE TO H-20 LIVE LOAD ON CONDUIT (PSF)

NOTES

1. W = total dead load per unit length.

2. Embankment dead loads shown in (a) are based on soil unit weight of 100 pcf. For different soil unit weights, adjust the loads proportionately.

3. For trench backfill shown in (b): $W = C_W (\gamma)(B)^2$

   where: γ = soil unit weight.
   B = trench width at top of pipe level.

   If backfill compacted adequately, a unit weight of 125 pcf is recommended for evaluation.

4. Live loads shown in (c) include effect of impact.

5. This figure was adapted from NAVFAC DM7.

FIG. 18

Cascade Mill Parkway Project
Yakima, Washington

LOADS ON BURIED UTILITIES

September 2022 106384-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 20

Appendix A

Subsurface Explorations

CONTENTS

Exploration Logs

A.1 INTRODUCTION

The subsurface exploration program for Cascade Mill Parkway Phase 3 Project alignment consisted of drilling and sampling seven borings.

We advanced the seven borings, designated B-9-21 through B-15P-21, to depths ranging between 40 to 100 feet. We installed vibrating wire piezometers in B-11P-21, B-12P-21, and B-15P-21.

Approximate locations of the borings and tests pits were recorded in the field using a geographic information system (GIS) application accessed on a cellular phone. The locations of the explorations are shown in Figure 2. The exploration locations and elevations should be considered accurate to the degree implied by the method used.

A.2 SOIL CLASSIFICATION

A representative from Shannon & Wilson was present throughout the field explorations to observe the drilling and sampling operations; retrieve representative soil samples for subsequent laboratory testing; and to prepare descriptive field logs of the explorations. Soil sample classifications were based on ASTM Designation D2487, Standard Practice for Classification of Soils for Engineering Purposes, and ASTM Designation D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). The Unified Soil Classification System, as described in Figure A-1 of this appendix, was used to classify the soil. The exploration logs in the report represent our interpretation of the contents of the field logs.

A.3 SOIL BORINGS

A.3.1 Sonic Core Drilling Procedures

Holt Services Inc. of Edgewood, Washington, drilled the soil borings under subcontract to Shannon & Wilson using a Terra Sonic 150CC track-mounted drill rig, outfitted with an automatic hammer. The sonic core drilling method uses high-frequency vibratory motion applied to the top of the drill column, along with down-pressure and rotation, to obtain nearly continuous core samples in soil and rock.

Soil samples were obtained using a 4-inch-outside-diameter (OD) core barrel. As the drill column was advanced into the ground, soil entered the core barrel. After advancing the core barrel a distance of 5 feet (termed a core "run"), a 6-inch OD temporary casing was vibrated to the bottom of the sample interval. The drill column and core barrel were then removed from the borehole and the soil core was extracted from the core barrel into plastic bags. Soil recovered from each run was described in the field and logged by our field representative. The soil sample bags were then sealed to retain moisture and stored in core boxes for transport. After retrieval of the soil core for a specific interval, the casing was cleared of slough and the drill column and core barrel were advanced, starting at the bottom of the temporary casing.

A.3.2 Split-Spoon Soil Samples

Disturbed soil samples were obtained from the borings by a split-spoon sampler used in conjunction with a Standard Penetration Test (SPT) and the sonic core barrel. To obtain disturbed soil samples from the borings, SPTs were performed in general accordance with the ASTM Designation D1586, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils. The SPTs were performed at 5-foot intervals to a depth of 40 feet, then 10-foot intervals thereafter, in between sonic core runs. The SPT consists of a 2-inch O.D., 1.375-inch-inside-diameter, split-spoon sampler driven 18 inches into the bottom of the borehole with a 140-pound hammer free falling 30 inches. The number of blows required to advance the split-spoon sampler the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). This value is an empirical parameter that provides a means of evaluating the relative density or compactness of cohesionless (granular) soils and the relative consistency (stiffness) of cohesive soils. This value is commonly used in engineering analyses to estimate soil strength and other characteristics. The terminology used to describe the relative density or consistency of the soils is presented in Figure A-1. Generally, when penetration resistances exceed 50 or more blows for 6 inches or less of penetration, the test is terminated, and the number of blows and corresponding penetration recorded. The N-values were recorded by our field representative and are plotted in the boring logs presented as Figures A-2 through A-8.

The split-spoon sampler used during the penetration test recovers a disturbed sample of the soil, which is useful for identification and classification purposes. The samples were classified and recorded in the field by our field representative. The samples were then sealed in jars to retain moisture and returned to our laboratory for testing.

A.3.3 Sonic Core Soil Review

Soil recovered from sonic core drilling was reviewed for identification and classification purposes and photographed in our warehouse. Grab samples were collected during our review and placed in labeled plastic jars and 5-gallon plastic bags, sealed, and transported to our laboratory for further analysis and testing.

A.4 STAND-UP TEST PIT

On May 22, 2022, a test pit, designated TP-1-22, was excavated in the outside shoulder of eastbound Interstate 82. The Washington State Department of Transportation advanced the test pit using a John Deere excavator mounted with a 3-foot-wide bucket. A Shannon & Wilson field representative was onsite to observe the process and log the test pit.

TP-1-22 was excavated at approximately 10 a.m. on Sunday, May 22. The test pit was 4 to 6 feet wide, by 13 feet long, by 9 to 12 feet deep. The test pit remained open for approximately 24 hours. We used a timelapse camera to observe the sidewall conditions during the 24-hour period and also made several visits to the test pit.

Upon arrival at the test pit the next morning, approximately 9 a.m. on Monday, May 23, we observed limited localized sidewall caving and minor erosion of fine sand and silt had occurred during the 24-hour period; however, the volumes were small. The test pit log for TP-1-22 shows overall beginning and ending photographs. The small volumes of erosion can be visualized by comparing the base of the excavation.

We observed that physical disturbance of the sidewalls (e.g., bumping from the excavator bucket or walking too close to the edge of the pit) caused minor sloughing due to the dry nature of the fill. This sloughing occurred immediately at the time of the disturbance.

We observed that the in-place density and compaction of the embankment material at the west, north, and south sidewalls of the test pit was relatively loose with some apparent cohesion in the upper few feet. We attribute this relatively loose layer to the test pit being located on the side slope of the embankment. In contrast, the east sidewall of the test pit, which was beneath the pavement, appeared to be more compact.

SOIL DESCRIPTION AND LOG KEY

Cascade Mill Parkway
Yakima, Washington

Sheet 1 of 2

Shannon & Wilson uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

Structure[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch-thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch-thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

Angularity and Shape[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

Standard Penetration Test (SPT)[3]

Hammer	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diameter cathead 2-1/4 rope turns, > 100 rpm. If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less or 10 blows for 0 inch.

Moisture Content

Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp but no visible water.
Wet	Visible free water, from below water table.

Gradation

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

Cementation[1]

Weak	Crumbles/breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

Plasticity[2]

Nonplastic	Cannot roll a 1/8-in. thread at any water content.	PI < 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 < PI < 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 < PI < 20
Hard	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	PI > 21

Additional Terms

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

Notes:

[1] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

[2] Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

[3] Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

SHANNON & WILSON

SOIL DESCRIPTION AND LOG KEY

Cascade Mill Parkway
Yakima, Washington

Sheet 2 of 2

Unified Soil Classification System (USCS)
Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488

Major Divisions			Symbol		Typical Identifications
Coarse-Grained Soils *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW	●	Well-graded Gravel; Well-graded Gravel with Sand
			GP	○	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM	●	Silty Gravel; Silty Gravel with Sand
			GC	▨	Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW	⁘	Well-graded Sand; Well-graded Sand with Gravel
			SP	⁘	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM	▥	Silty Sand; Silty Sand with Gravel
			SC	▨	Clayey Sand; Clayey Sand with Gravel
Fine-Grained Soils *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	▥	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	▨	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL	▤	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	▥	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH	▨	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH	▨	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor		PT	≋	Peat or other highly organic soils (see ASTM D4427)

Acronyms and Abbreviations

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft	Feet
FeO	Iron Oxide
gal	Gallons
Horiz.	Horizontal
HSA	Hollow-Stem Auger
I.D.	Inside Diameter
in	Inches
lbs	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photoionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt	Weight

Well and Backfill Symbols

▨	Bentonite Cement Grout
▨	Bentonite Grout
▩	Bentonite Chips
⁘	Silica Sand
▤	Perforated or Screened Casing
▩	Surface Cement Seal
■	Asphalt or Cap
▨	Slough
▯	Inclinometer or Non-perforated Casing
▨	Instrumentation Riser or Electrical Lead
▨	Vibrating Wire Piezometer with Designation

Relative Density
Cohesionless Soils

N, SPT, Blows/ft	Relative Density
< 4	Very loose
4 - 10	Loose
10 - 30	Medium dense
30 - 50	Dense
> 50	Very dense

Relative Consistency
Cohesive Soils

N, SPT, Blows/ft	Relative Consistency
< 2	Very soft
2 - 4	Soft
4 - 8	Medium stiff
8 - 15	Stiff
15 - 30	Very stiff
> 30	Hard

Percentages$^{1, 2}$

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

Notes:

Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).

Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

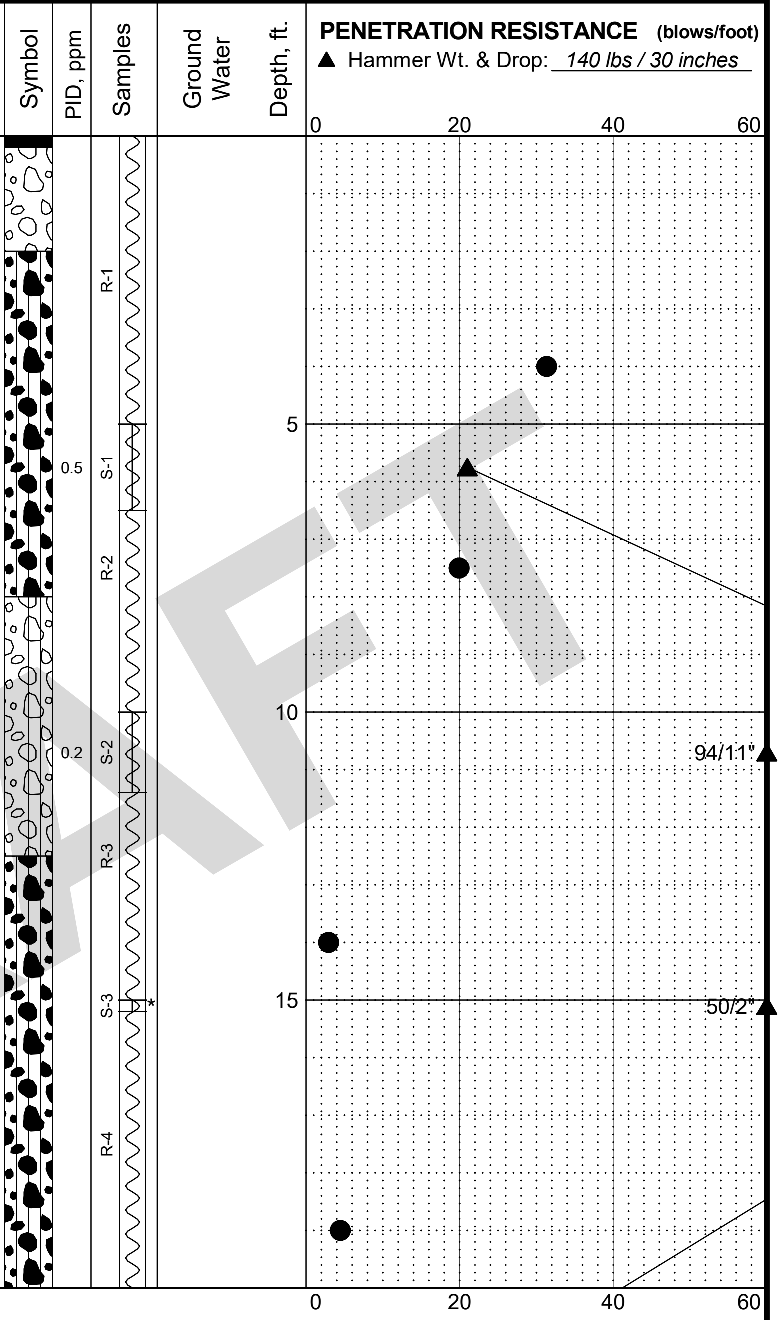
No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

Total Depth: 100.3 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,877 ft.
Easting: ~ 1,642,549 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Asphalt.	0.2
Brown, *Poorly Graded Gravel with Sand (GP)*; moist; fine to coarse, angular to subrounded gravel; fine to coarse sand; trace nonplastic fines. Road Fill (Hf)	2.0
Medium dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity. Embankment Fill (Hf)	8.0
Medium dense to dense, gray-brown, *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; faint iron oxide staining locally. Embankment Fill (Hf)	12.5
Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; sandy gravel layers locally. Embankment Fill (Hf) - 4-inch thick dark brown silt layer with trace wood fragments at about 19 feet.	



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
▨	Soil Core (as in Sonic Core Borings)
I	2.0" O.D. Split Spoon Sample
⊽	Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-09-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 1 of 6

VERSION 1
FINAL

Total Depth: 100.3 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,877 ft.
Easting: ~ 1,642,549 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

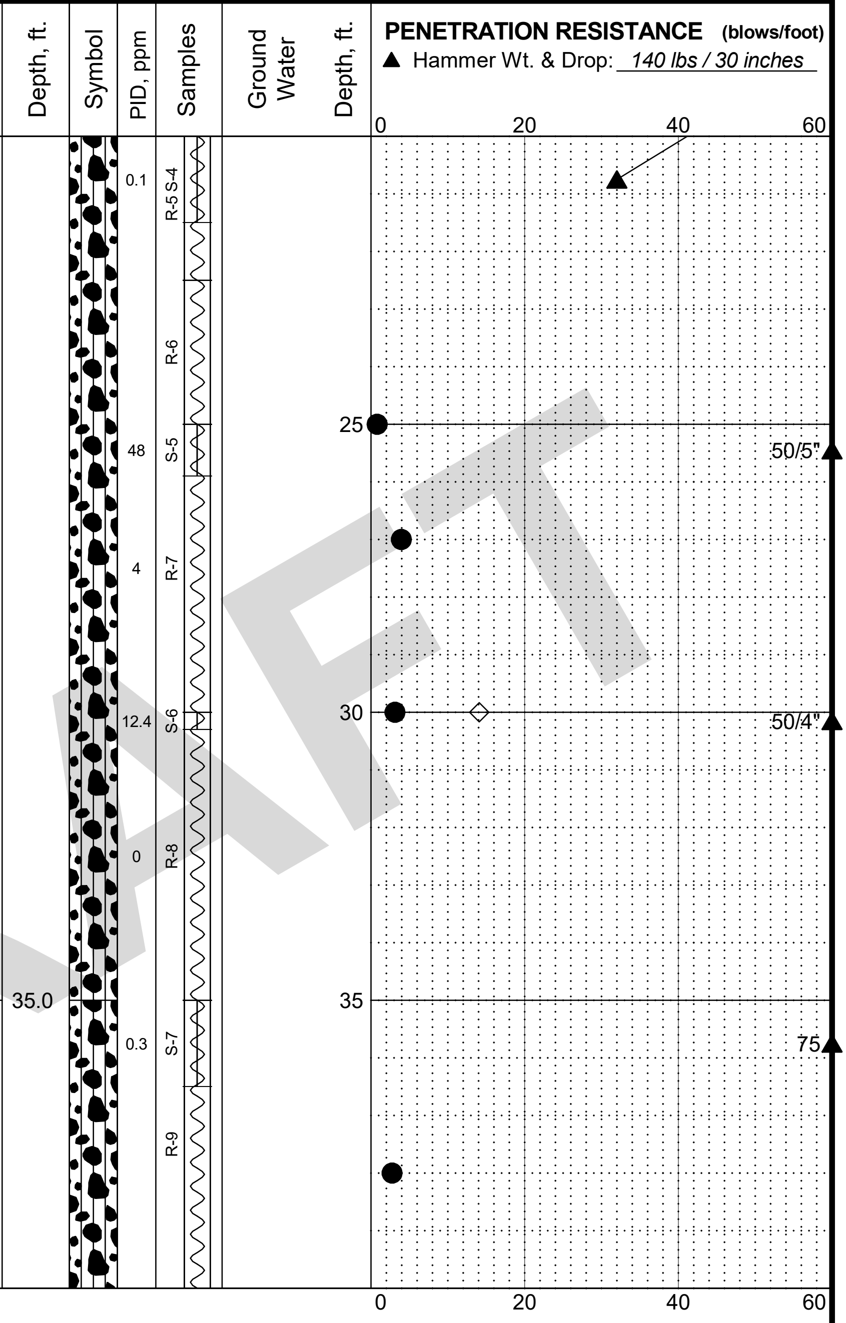
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

- Sandy silt layer or rock flour from drill action from 22.5 to 25 feet.

- Sandy silt with gravel layer or rock flour from drill action from 30 to 31 feet.
- Thin metal wire at about 30 feet.

35.0

Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity.
Embankment Fill (Hf)



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
⊠	Soil Core (as in Sonic Core Borings)
I	2.0" O.D. Split Spoon Sample
⊻	Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-09-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 2 of 6

VERSION 1
FINAL

Total Depth: 100.3 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,877 ft.
Easting: ~ 1,642,549 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

- Sprouted seed at about 42 feet.

- Dark brown organic soil, wood fragments, and slight organic odor from about 42 to 43 feet.

- Trace wood fragments at about 45 feet.

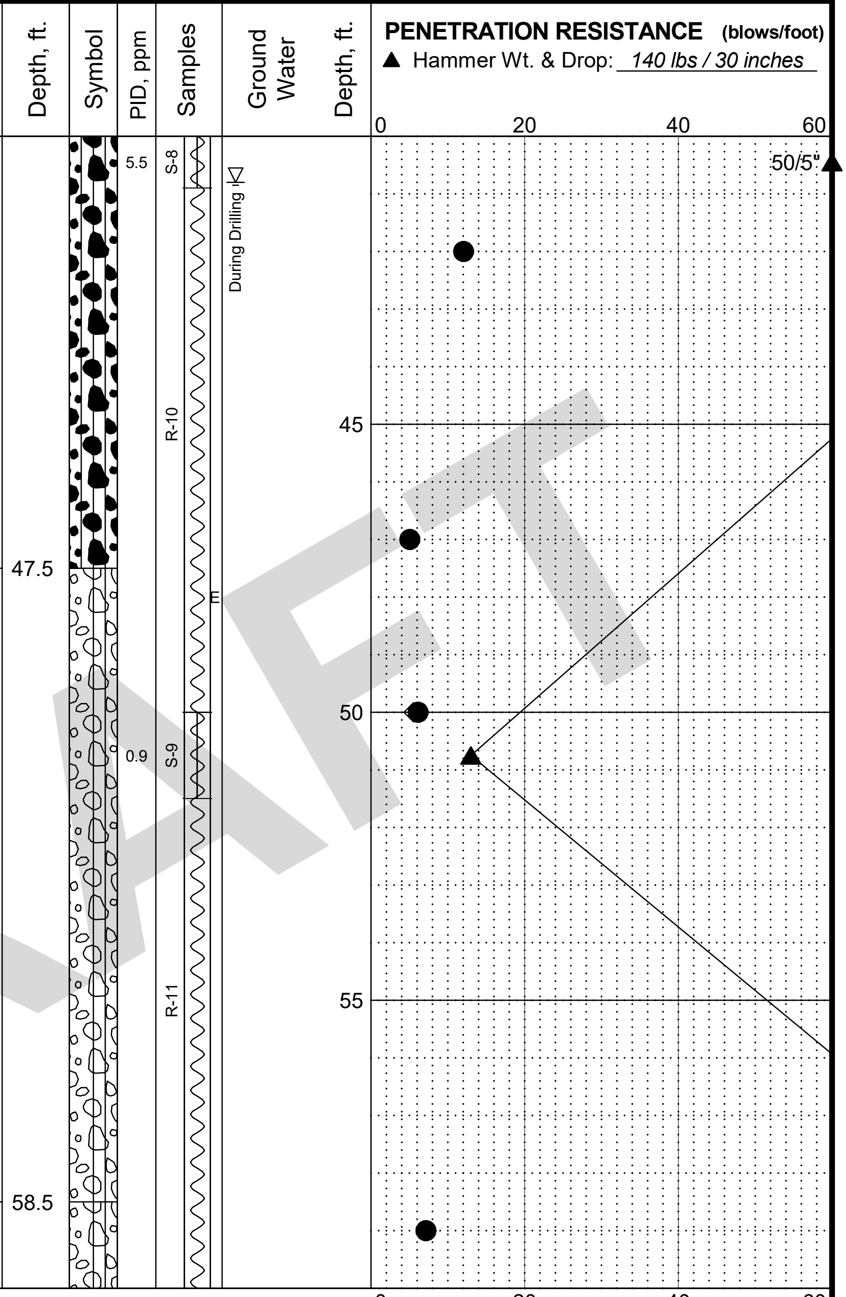
47.5

Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet below about 50 feet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity.
Alluvial Deposits (Qa)
[Environmental sample B-09-21:48 collected at 48 feet.]

58.5

Medium dense to dense, brown to orange-brown, *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)* to

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- ⊠ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-09-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 3 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.3 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,877 ft.
Easting: ~ 1,642,549 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

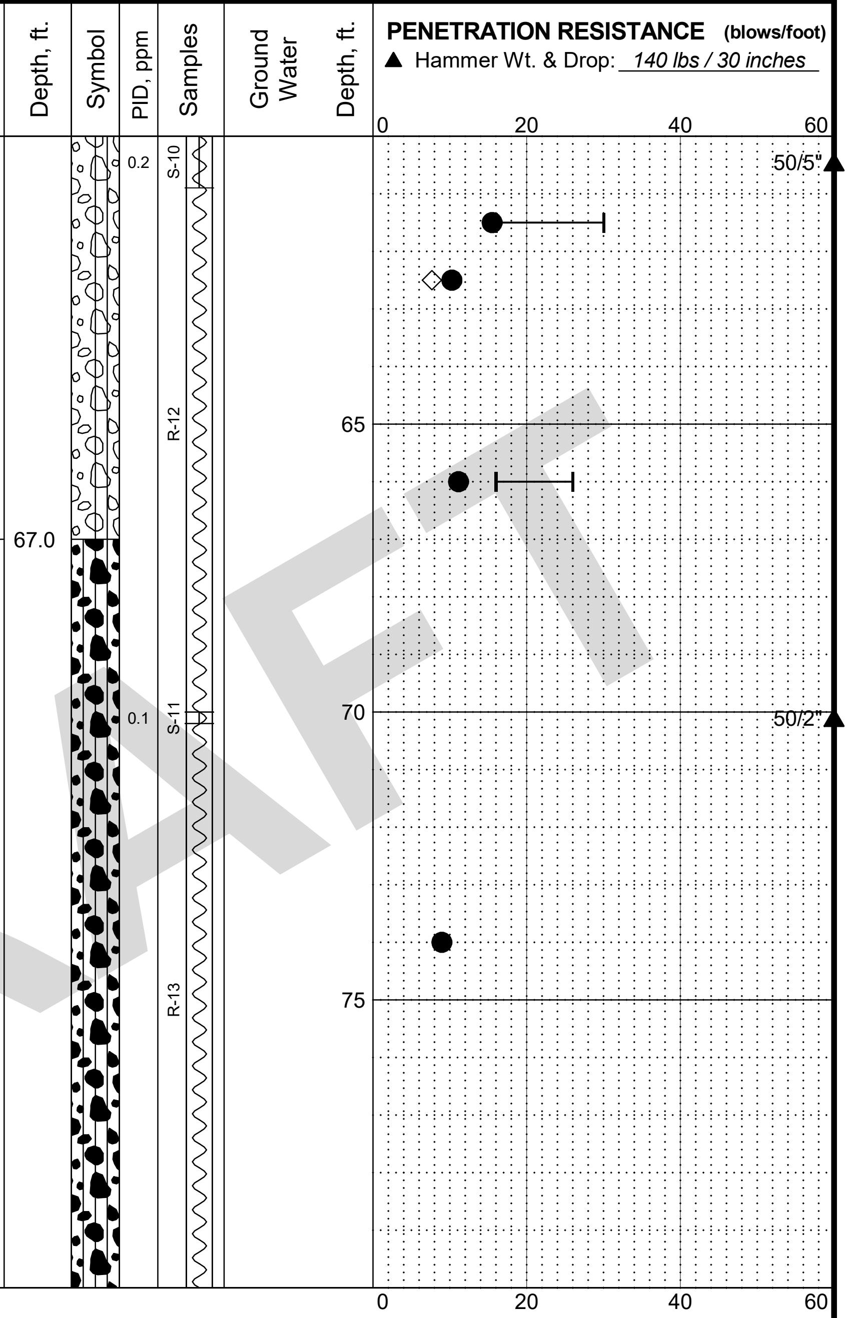
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Poorly Graded Gravel with Clay and Sand and Cobbles (GP-GC); moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron oxide staining locally.
Alluvial Deposits (Qa)
- Sandy Lean Clay (CL) matrix in Gravel at 61.5 feet.
- Clayey Sand (SC) matrix in Gravel at 66 feet.

67.0

Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; few zones of medium plasticity; iron oxide staining locally.
Alluvial Deposits (Qa)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▽ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-09-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

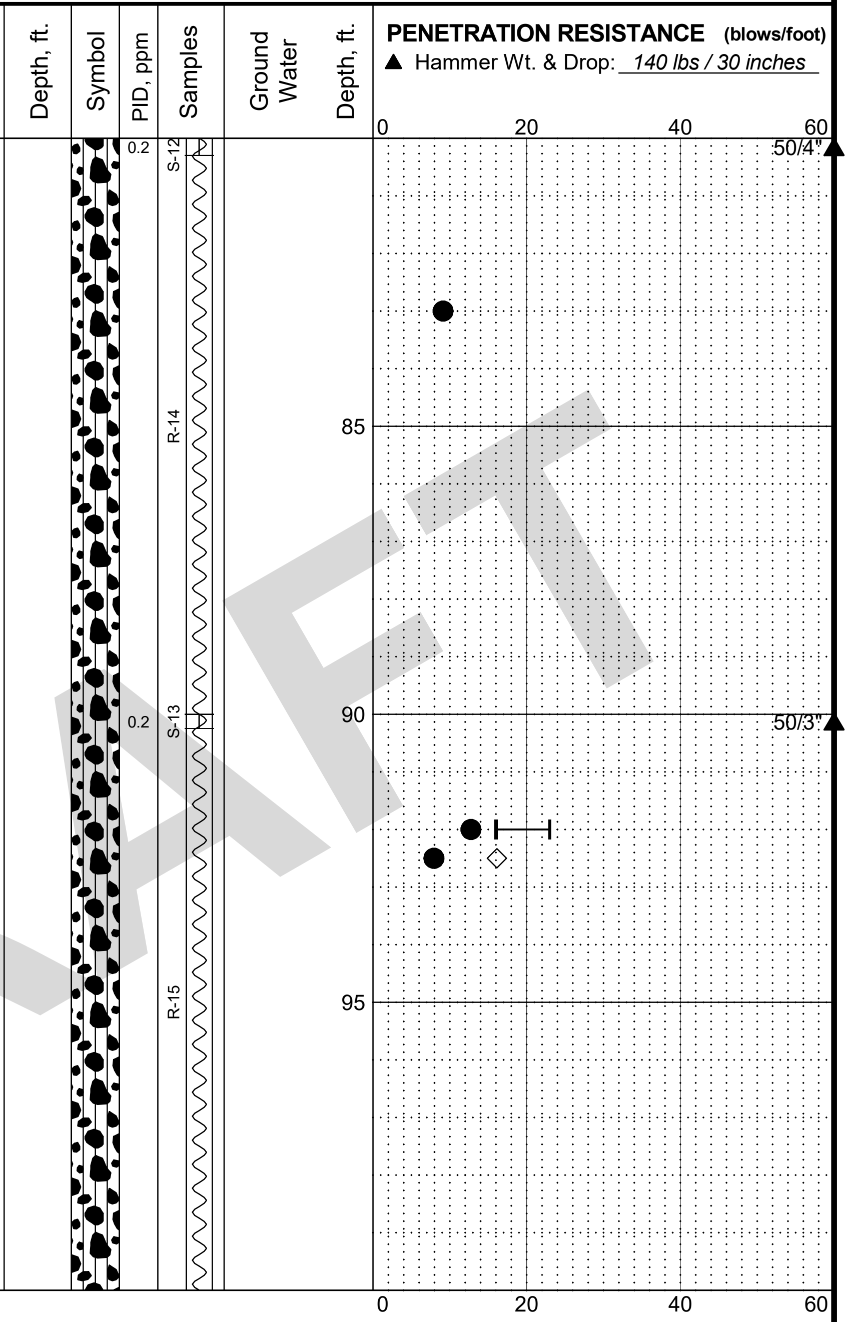
FIG. A-2
Sheet 4 of 6

Total Depth: 100.3 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,877 ft.
Easting: ~ 1,642,549 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

- Silty, Clayey Sand (SC-SM) matrix in Gravel at 92 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-09-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 5 of 6

VERSION 1
FINAL

Total Depth:	*100.3 ft.*	Northing:	*~ 466,877 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*~ 1083 ft.*	Easting:	*~ 1,642,549 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	*NWJ*
Vert. Datum:	*NAVD 88*	Station:	*~*	Drill Rig Equipment:	*Terrasonic 150CC*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	*~*	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

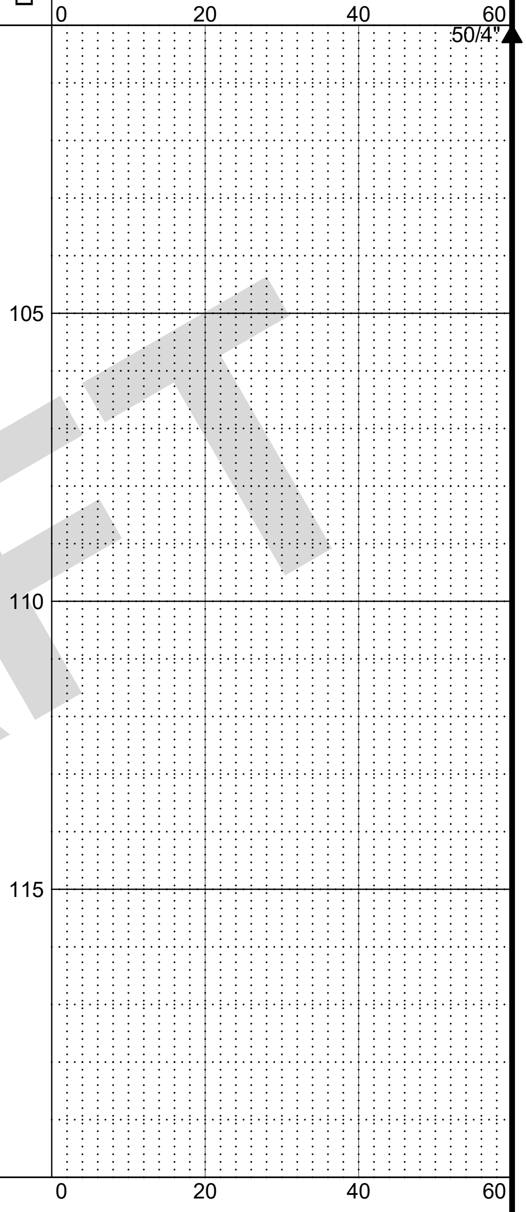
Depth, ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, ft.
100.3			S-14		

BOTTOM OF BORING
COMPLETED 4/8/2021

NOTE: Where gravels exceeding one-half the inside diameter of the split spoon sampler, cobbles, or boulders are present, the SPT blow counts are not reliable indicators of soil density or stiffness per ASTM D1586. The interpreted relative densities for layers that meet these criteria presented in this boring log are based on density of nearby soil zones encountered and interpretation of the geologic depositional environment, instead of the blow count versus relative density relationship presented in Figure A-1.

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
▨	Soil Core (as in Sonic Core Borings)
⌶	2.0" O.D. Split Spoon Sample
⊻	Ground Water Level ATD

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-09-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 6 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

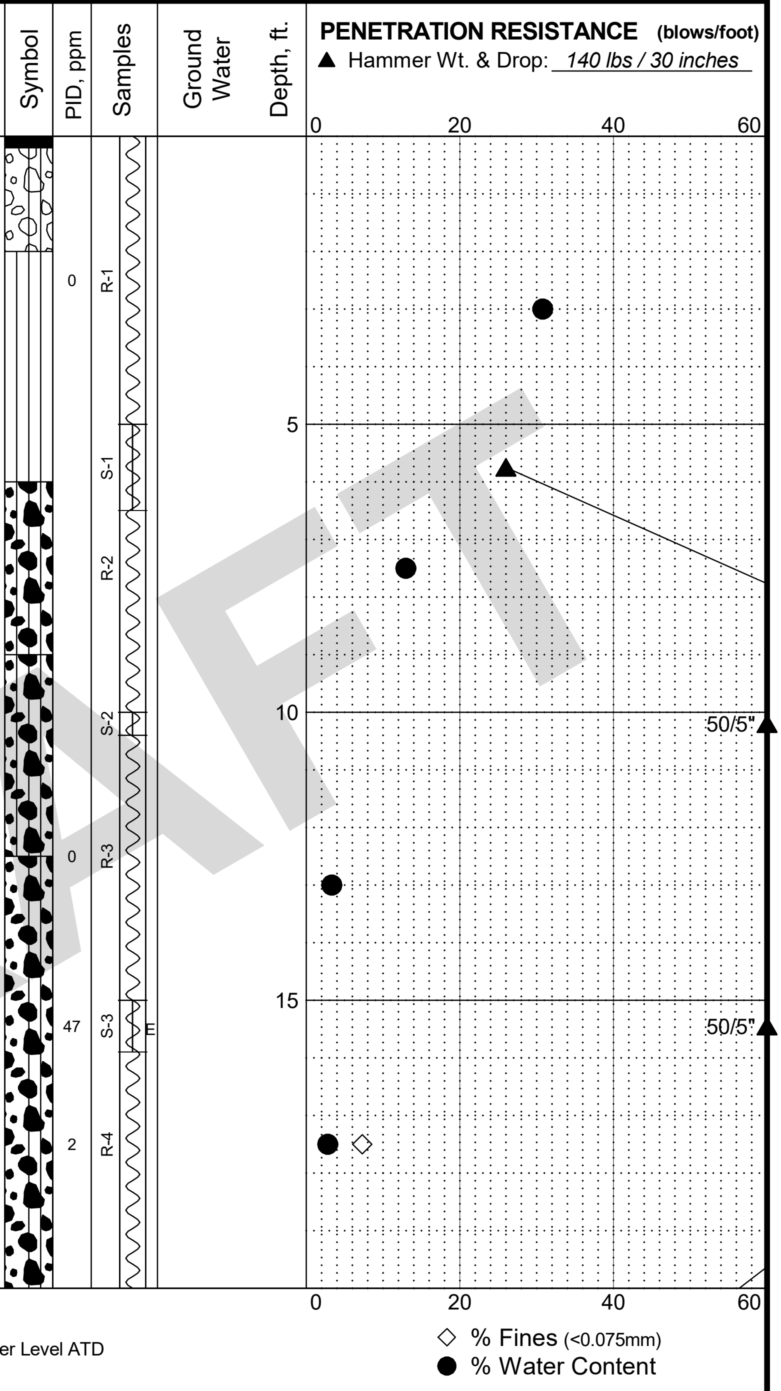
MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth:	*100.3 ft.*	Northing:	*~ 466,794 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*~ 1081 ft.*	Easting:	*~ 1,642,571 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	*NWJ*
Vert. Datum:	*NAVD 88*	Station:	*~*	Drill Rig Equipment:	*Terrasonic 150CC*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	*~*	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Asphalt.	0.2
Brown and gray, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; moist; fine to coarse, angular to subrounded gravel; fine to coarse sand, nonplastic. Road Fill (Hf)	2.0
Medium dense to dense, brown to tan and mottled, *Silt with Gravel (ML)*; moist; fine to coarse, angular to subrounded gravel; few fine to coarse sand; low to medium plasticity; iron oxide staining. Embankment Fill (Hf)	6.0
Medium dense, brown to tan and mottled, *Silty Gravel with Sand and Cobbles (GM)*; moist; subangular to subrounded cobbles; fine to coarse, angular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron oxide staining. Embankment Fill (Hf)	9.0
Medium dense to dense, brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, angular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity. Embankment Fill (Hf)	12.5
Medium dense to dense, brown to gray-brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; few layers of rock flour from drill action. Embankment Fill (Hf) *[Environmental sample B-10-21:15.5 collected at 15.5 feet.]*	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

⊻ Ground Water Level ATD

E Environmental Sample Obtained

⊠ Soil Core (as in Sonic Core Borings)

⌶ 2.0" O.D. Split Spoon Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-10-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 1 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.3 ft.
Top Elevation: ~ 1081 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,794 ft.
Easting: ~ 1,642,571 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

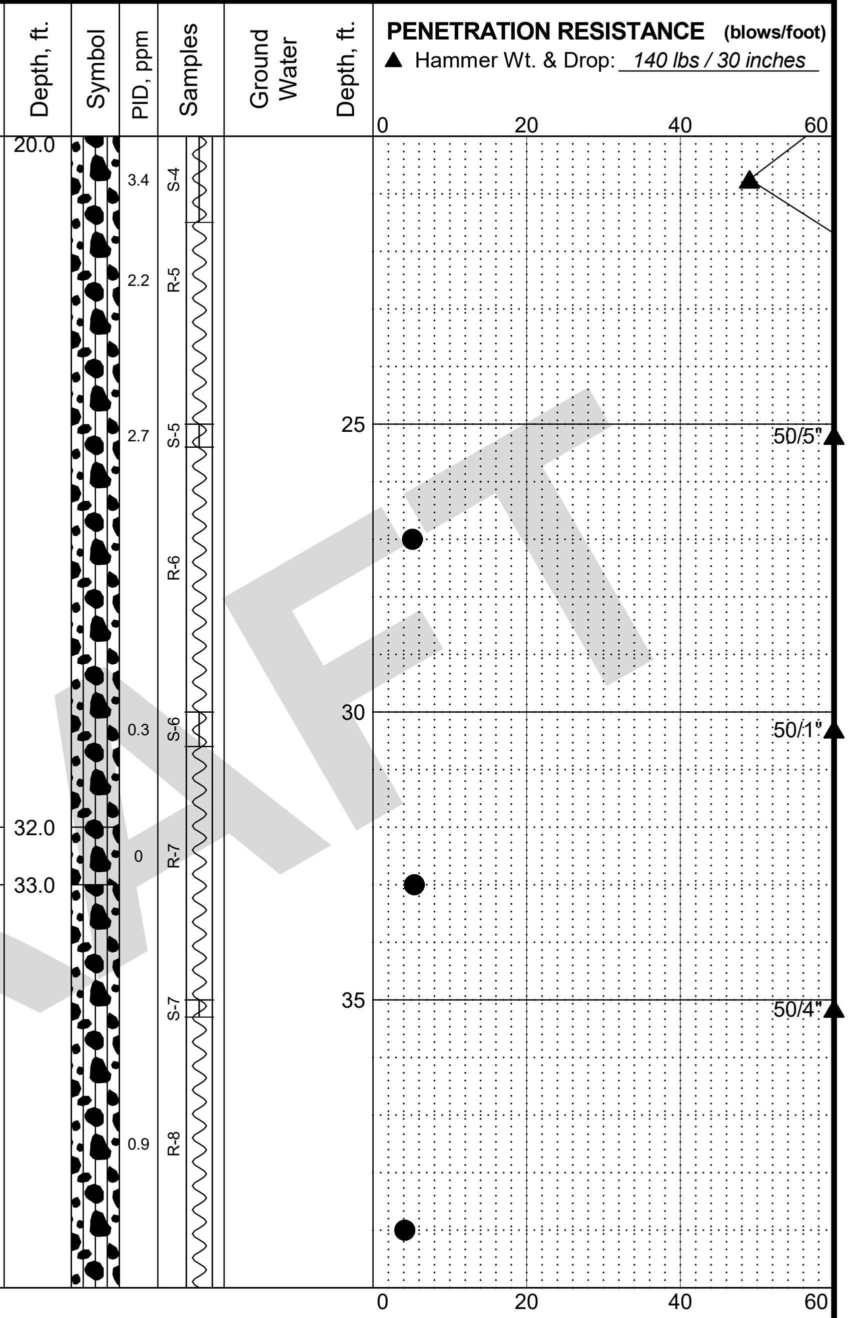
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

20.0 — Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; few sandy gravel layers.
Embankment Fill (Hf)

- Sandy silt with gravel layer or rock flour from drill action from about 25 to 26.5 feet.

32.0 — Medium dense to dense, dark brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; few organics and wood fragments; slight organic odor.
Embankment Fill (Hf)

33.0 — Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity.
Embankment Fill (Hf)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
⊠ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-10-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 2 of 6

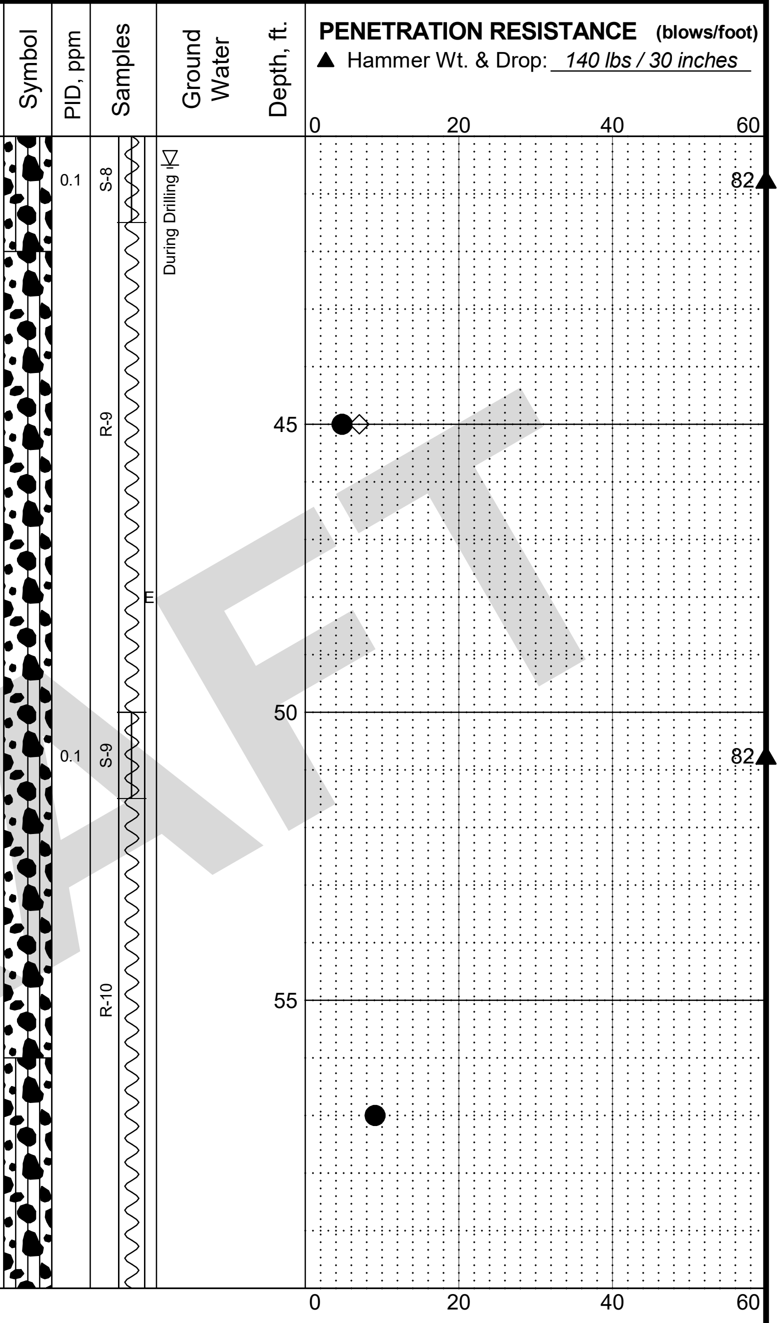
VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.3 ft.
Top Elevation: ~ 1081 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,794 ft.
Easting: ~ 1,642,571 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
- Sandy silt with gravel layer or rock flour from drill action from 35 to 36.5 feet.	
Medium dense to dense, gray-brown to brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)* to *Silty Gravel with Sand and Cobbles (GM)*; moist to wet below about 45 feet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity. Alluvial Deposits (Qa) *[Environmental sample B-10-21:48 collected at 48 feet.]*	42.0
Medium dense to dense, brown to orange-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity, few medium plasticity zones; iron-oxide staining locally.	56.0



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	⊻	Ground Water Level ATD
E	Environmental Sample Obtained		
⍁	Soil Core (as in Sonic Core Borings)		
⌶	2.0" O.D. Split Spoon Sample		

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-10-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 3 of 6

Total Depth: 100.3 ft.
Top Elevation: ~ 1081 ft.
Vert. Datum: NAVD 88
Horiz. Datum:

Northing: ~ 466,794 ft.
Easting: ~ 1,642,571 ft.
Station: ~
Offset: ~

Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:

Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

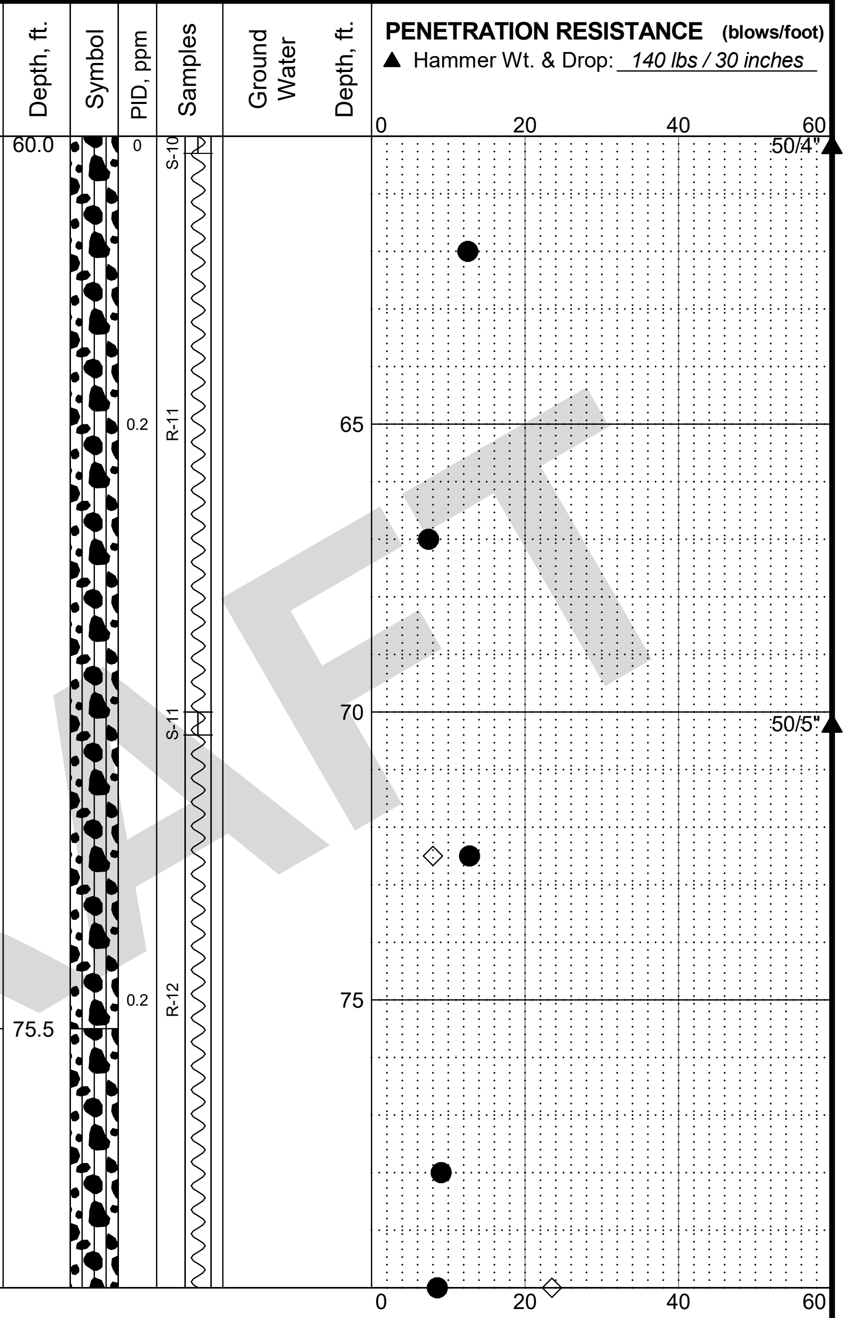
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Alluvium Deposits (Qa)

Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron oxide staining locally.
Alluvial Deposits (Qa)

- Sandy gravel layer from 72.5 to 75 feet.

Medium dense to dense, brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity.
Alluvial Deposits (Qa)



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
⍁ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-10-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 4 of 6

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

VERSION 1
FINAL

Total Depth:	100.3 ft.	Northing:	~ 466,794 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1081 ft.	Easting:	~ 1,642,571 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

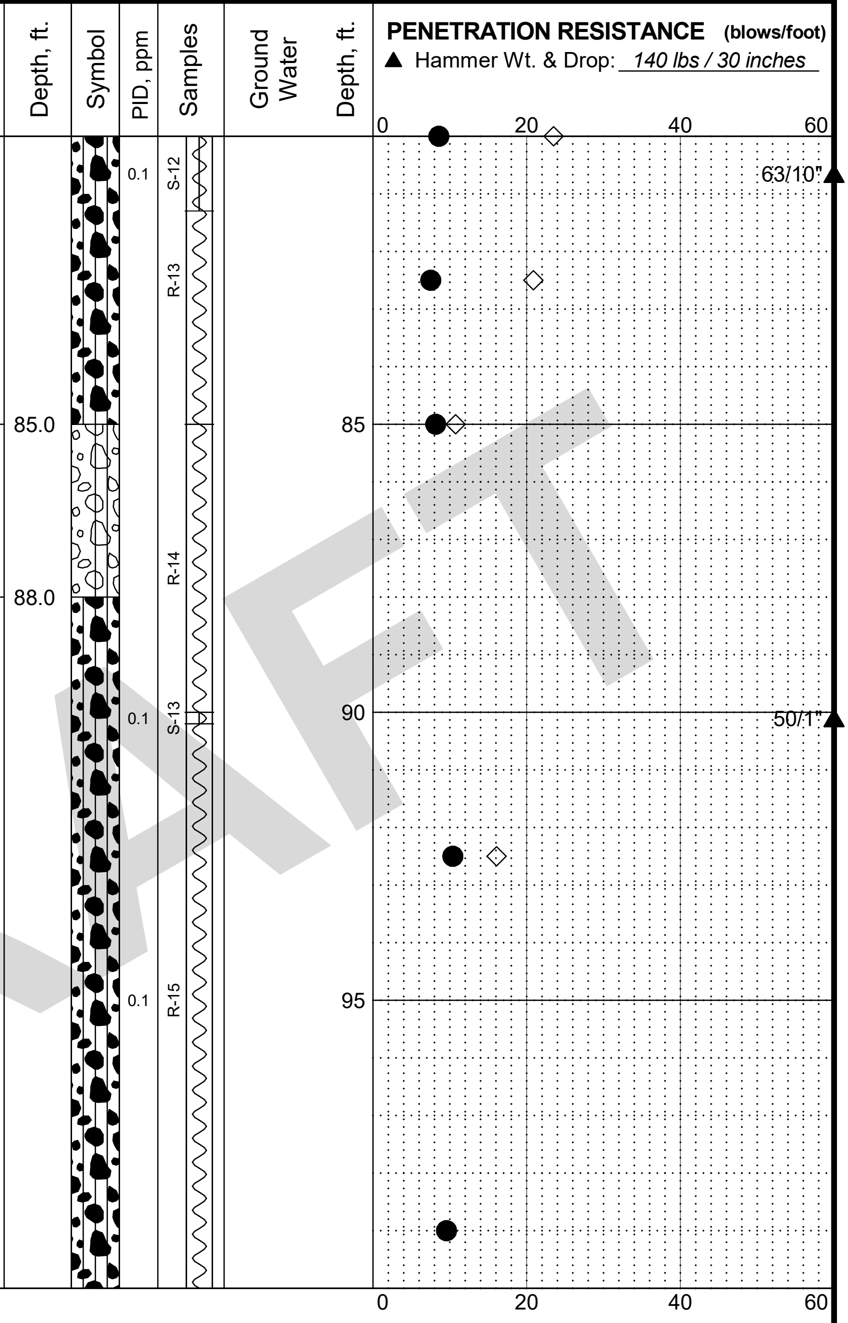
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

85.0

Medium dense to dense, orange-brown to brown, *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; iron oxide staining.
Alluvial Deposits (Qa)

88.0

Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron oxide staining locally.
Alluvium Deposits (Qa)



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- ☒ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊻ Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-10-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 5 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.3 ft.
Top Elevation: ~ 1081 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,794 ft.
Easting: ~ 1,642,571 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

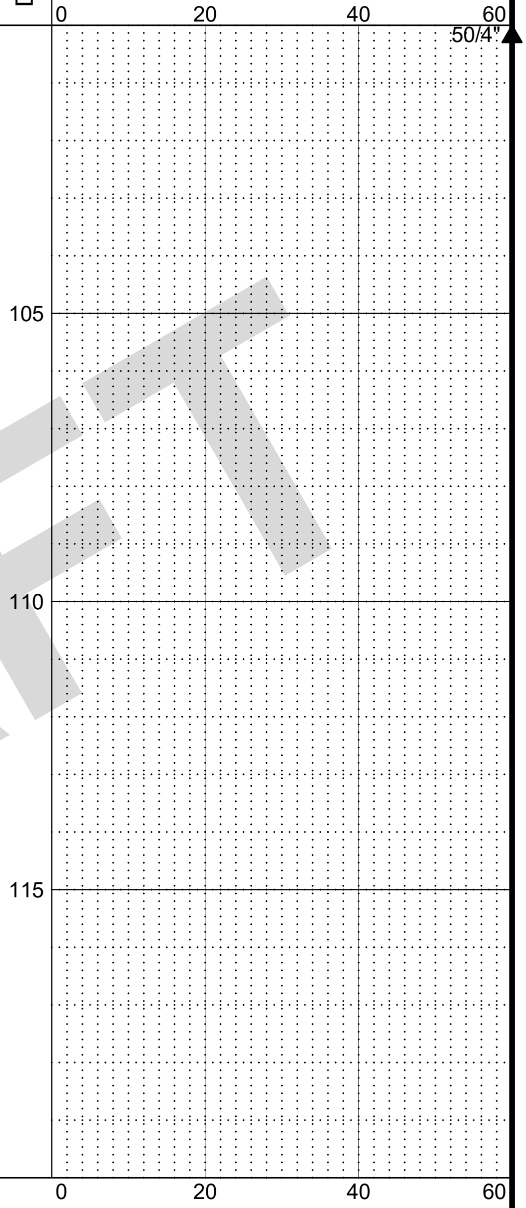
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Symbol	PID, ppm	Samples	Ground Water
100.3			S-14	

BOTTOM OF BORING
COMPLETED 4/7/2021

NOTE: Where gravels exceeding one-half the inside diameter of the split spoon sampler, cobbles, or boulders are present, the SPT blow counts are not reliable indicators of soil density or stiffness per ASTM D1586. The interpreted relative densities for layers that meet these criteria presented in this boring log are based on density of nearby soil zones encountered and interpretation of the geologic depositional environment, instead of the blow count versus relative density relationship presented in Figure A-1.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-10-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 6 of 6

Total Depth:	100.4 ft.	Northing:	~ 466,801 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1080 ft.	Easting:	~ 1,642,689 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Asphalt.

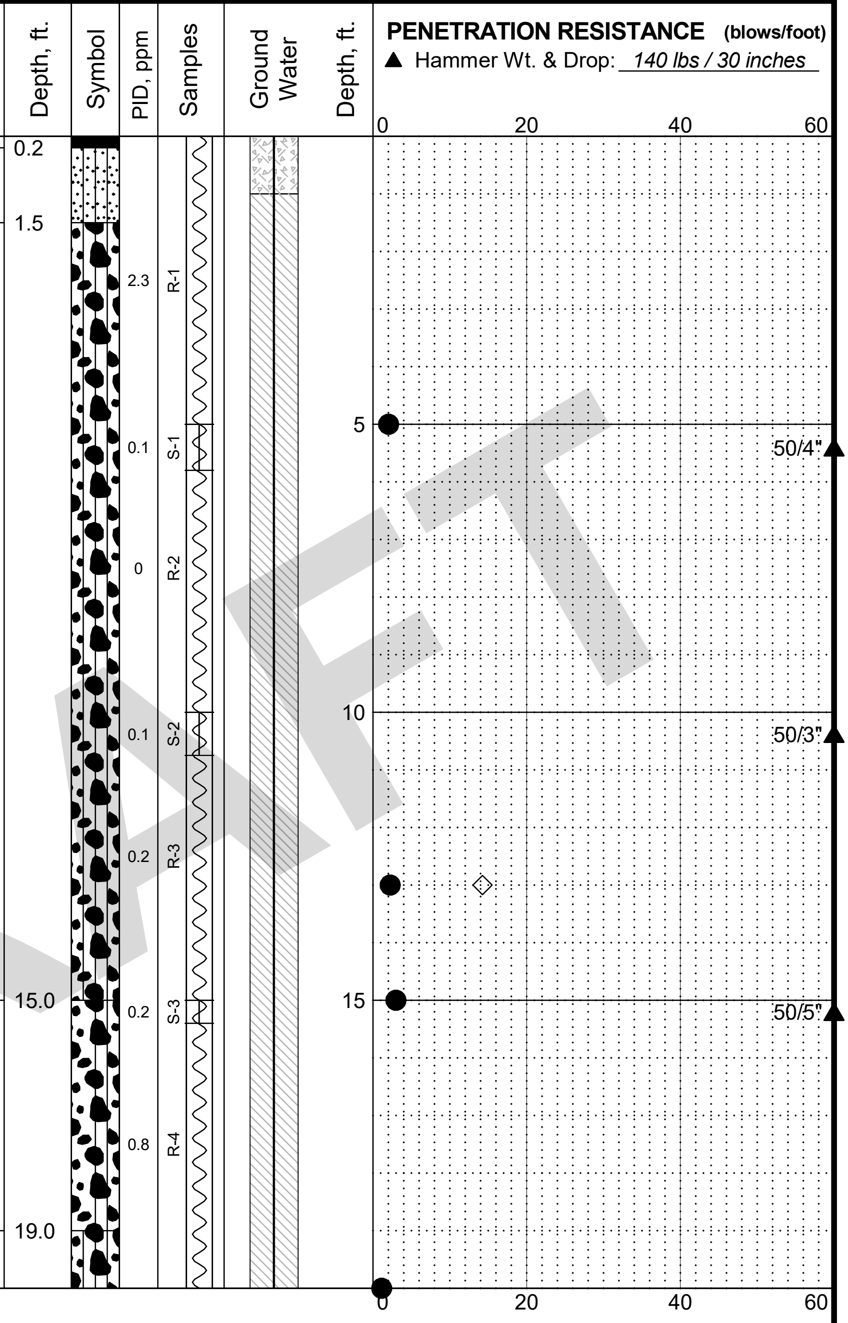
Gray-brown, *Silty Sand with Gravel (SM)*; moist; fine sand; fine to coarse, angular to subrounded gravel; fine to coarse sand, nonplastic.
Road Fill (Hf)

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, angular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity.
Embankment Fill (Hf)

- Sandy gravel layer from 8 to 10 feet.

Medium dense to dense, brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)*; moist; subrounded cobbles; fine to coarse, angular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity.
Embankment Fill (Hf)

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*;



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
▯ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-11P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 1 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.4 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,801 ft.
Easting: ~ 1,642,689 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | PID, ppm | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches

moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity.
Embankment Fill (Hf)

26.5

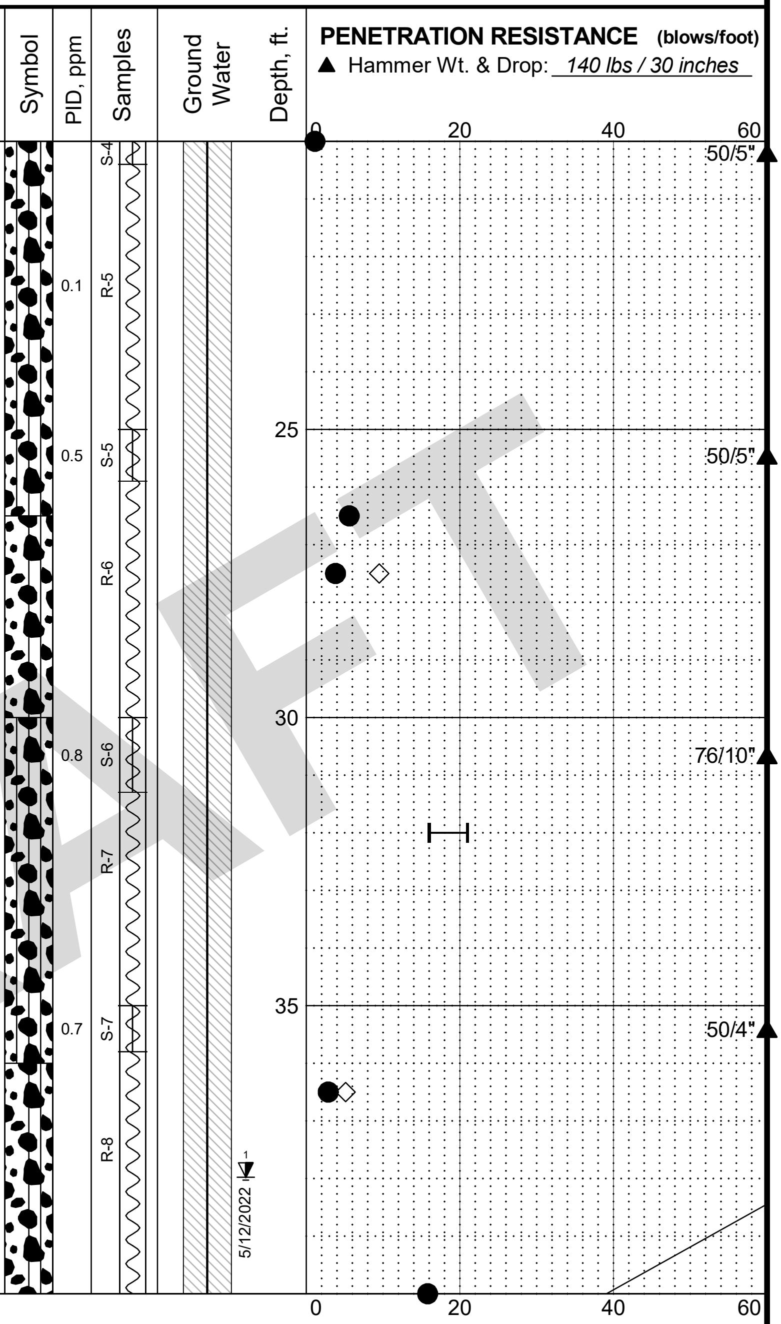
Medium dense to dense, gray-brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)*; moist; subrounded cobbles; fine to coarse, angular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity.
Embankment Fill (Hf)

30.0

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity.
Embankment Fill (Hf)
- Silty, Clayey Sand (SC-SM) matrix in Gravel at 32 feet.
- Rock flour from drill action and cobbles below 33 feet.

36.0

Medium dense, brown to gray-brown, Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM); moist; subangular to subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic.
Embankment Fill (Hf)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
Soil Core (as in Sonic Core Borings)
2.0" O.D. Split Spoon Sample
Well Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout
Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-11P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 2 of 6

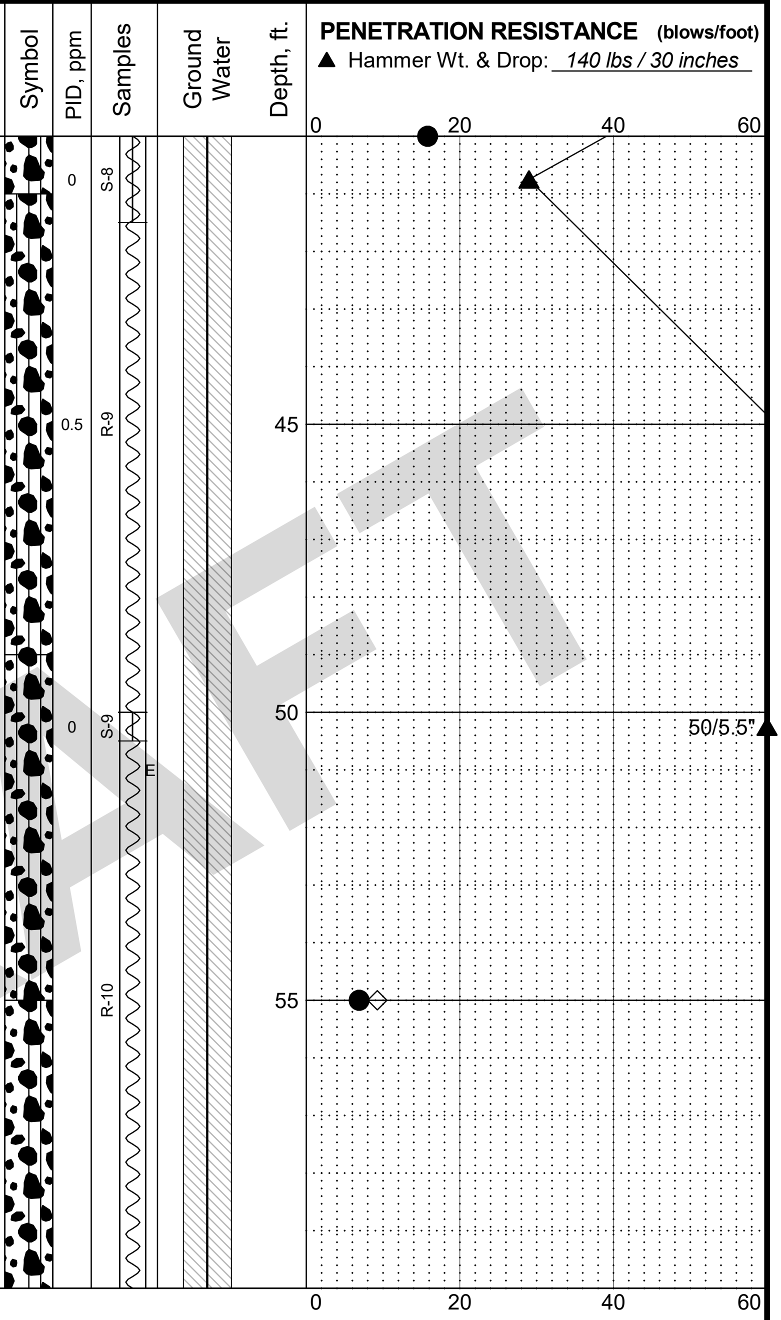
VERSION 1
FINAL

Total Depth:	100.4 ft.	Northing:	~ 466,801 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1080 ft.	Easting:	~ 1,642,689 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
- 2-inch thick white powder layer mixed with soil at about 39.5 feet.	41.0
Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity. Alluvial Deposits (Qa)	49.0
Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; matrix is locally indurated; few layers of rock flour from drill action. Alluvial Deposits (Qa) *[Environmental sample B-11P-21:51 collected at 51 feet.]*	55.0
Medium dense to dense, brown, *Poorly-Graded Gravel with Silt and Sand and Cobbles (GW-GM)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity, few medium plasticity zones; iron-oxide staining locally. Alluvial Deposits (Qa)	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
☐ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample

▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
☒ Bentonite Chips/Pellets
▨ Bentonite Grout

▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-11P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 3 of 6

Total Depth: 100.4 ft. Northing: ~ 466,801 ft. Drilling Method: Sonic Core Hole Diam.: 6 in.
Top Elevation: ~ 1080 ft. Easting: ~ 1,642,689 ft. Drilling Company: Holt Services Rod Diam.: NWJ
Vert. Datum: NAVD 88 Station: ~ Drill Rig Equipment: Terrasonic 150CC Hammer Type: Automatic
Horiz. Datum: Offset: ~ Other Comments:

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

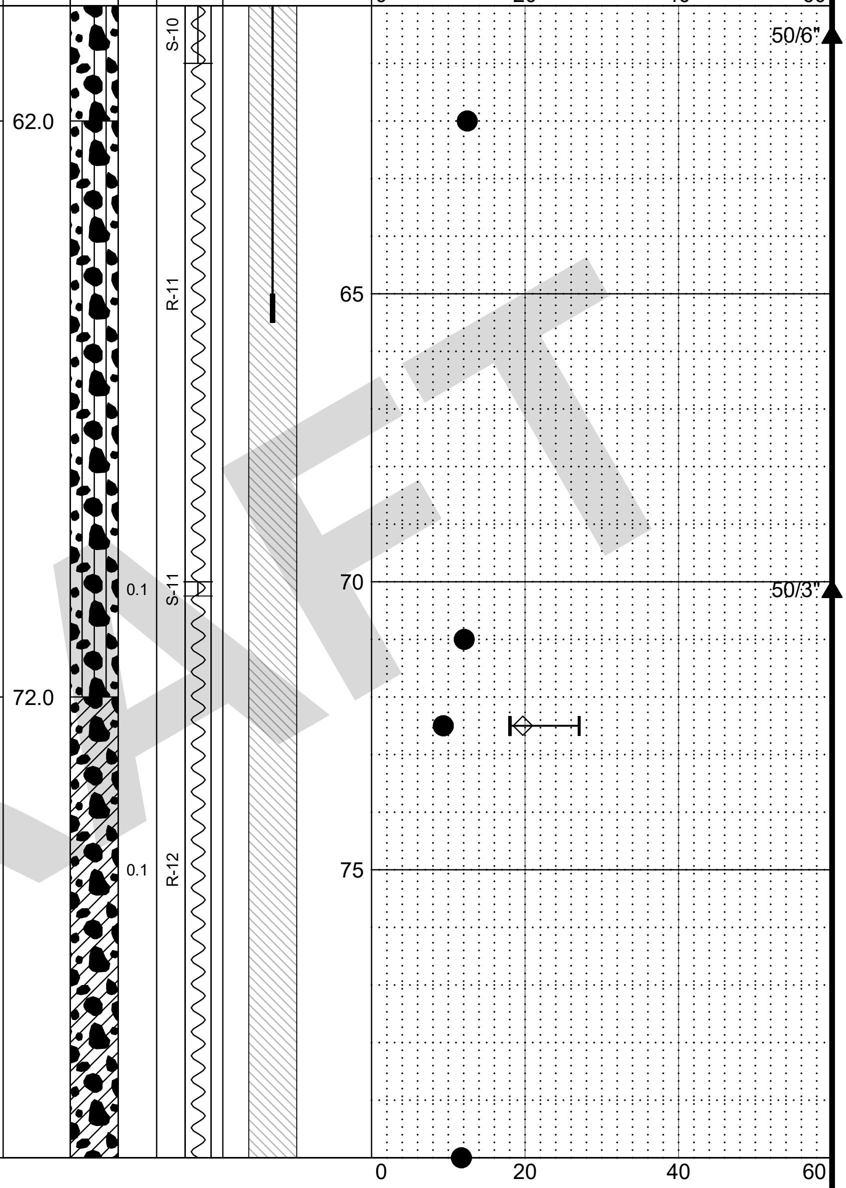
Depth, ft. | Symbol | PID, ppm | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches

62.0 — Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron oxide staining locally.
Alluvial Deposits (Qa)

72.0 — Medium dense to dense, brown, *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron-oxide staining locally.
Alluvial Deposits (Qa)

- 6-inch thick orange-brown, ash or weathered gravel zones at 76 and 83 feet.



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- ⊠ Soil Core (as in Sonic Core Borings)
- I 2.0" O.D. Split Spoon Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-11P-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 4 of 6

Log: KXM Rev: SAW Typ: LKN

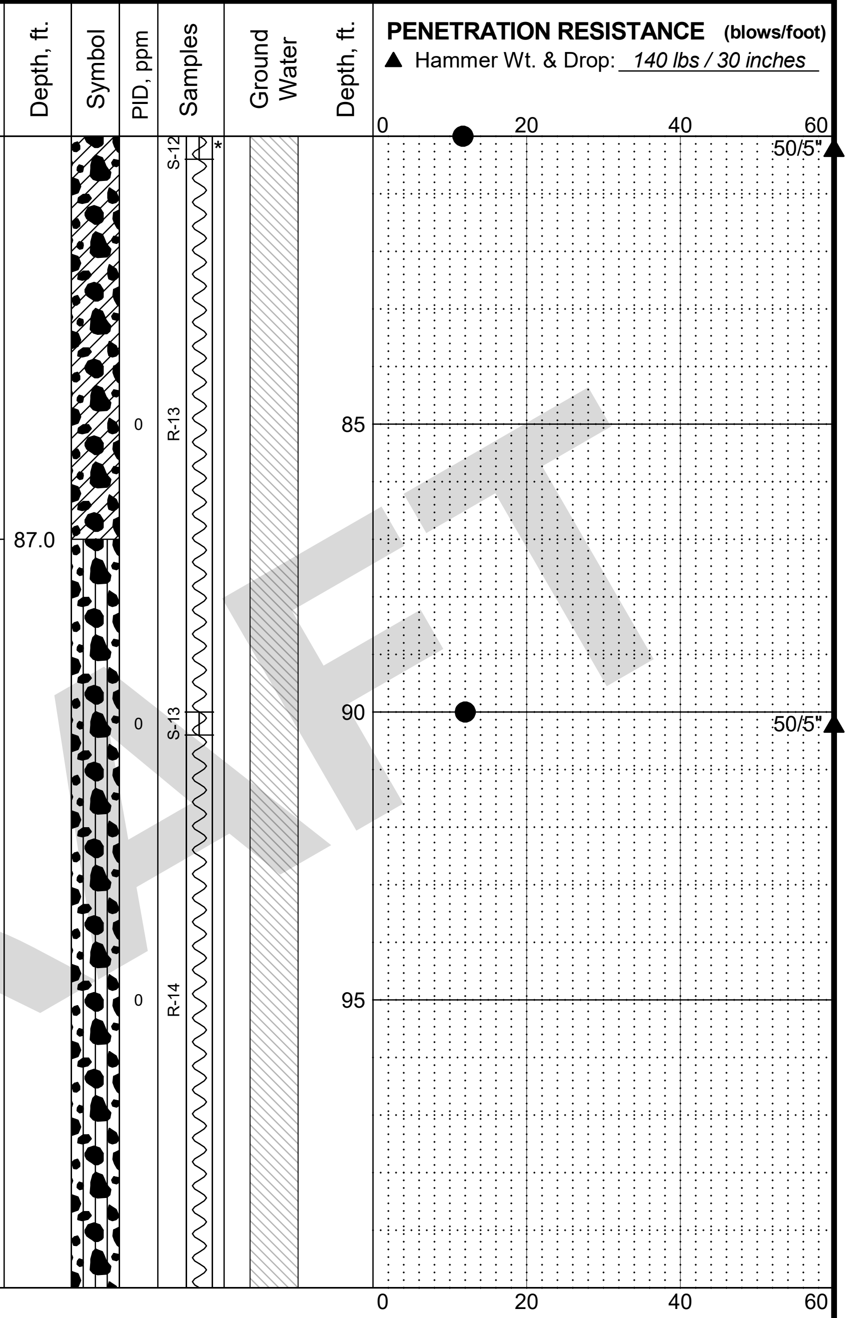
Total Depth: 100.4 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,801 ft.
Easting: ~ 1,642,689 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

87.0

Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron oxide staining locally.
Alluvial Deposits (Qa)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
◪ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-11P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 5 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.4 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,801 ft.
Easting: ~ 1,642,689 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

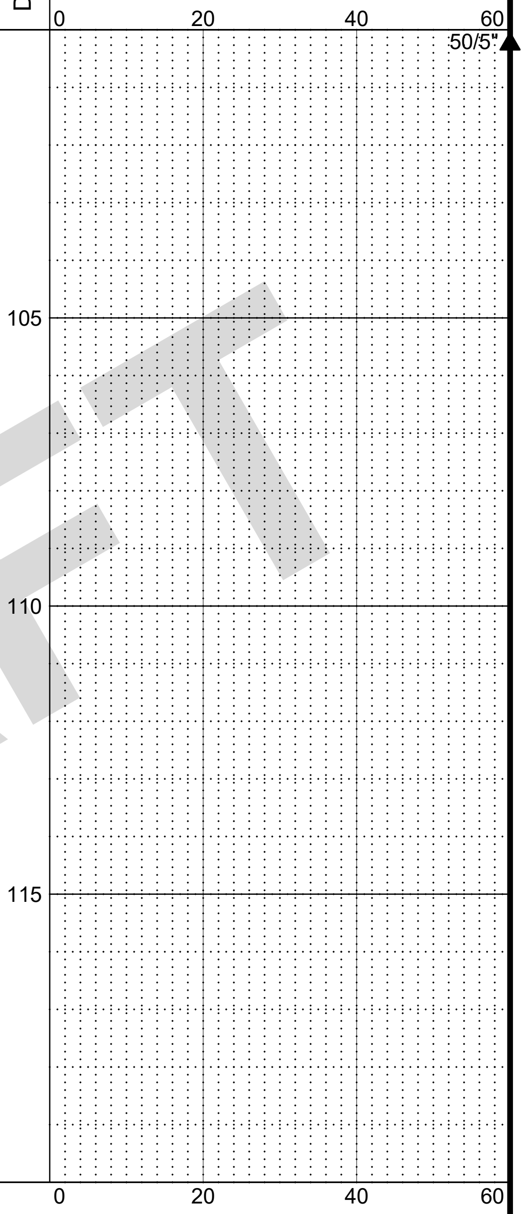
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Symbol	PID, ppm	Samples	Ground Water
100.4		0	S-14	▧

BOTTOM OF BORING
COMPLETED 3/30/2021

NOTE: Where gravels exceeding one-half the inside diameter of the split spoon sampler, cobbles, or boulders are present, the SPT blow counts are not reliable indicators of soil density or stiffness per ASTM D1586. The interpreted relative densities for layers that meet these criteria presented in this boring log are based on density of nearby soil zones encountered and interpretation of the geologic depositional environment, instead of the blow count versus relative density relationship presented in Figure A-1.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
▯	Soil Core (as in Sonic Core Borings)
⌶	2.0" O.D. Split Spoon Sample
▦	Well Screen and Sand Filter
▧	Bentonite-Cement Grout
▩	Bentonite Chips/Pellets
▨	Bentonite Grout
⊻	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-11P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 6 of 6

Total Depth: 100.25 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,922 ft.
Easting: ~ 1,642,650 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

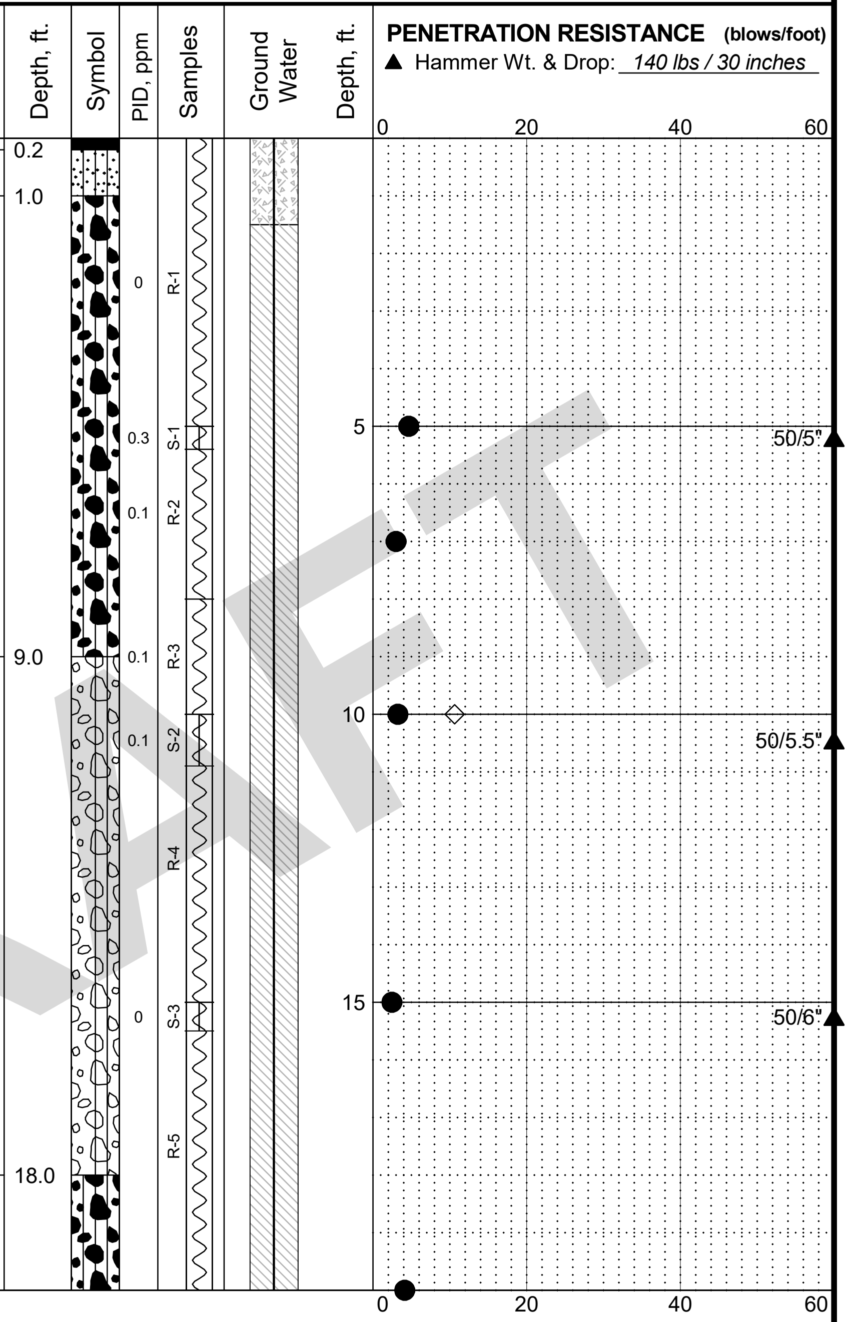
Asphalt.

Brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic. Road Fill (Hf)

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity. Embankment Fill (Hf)

Medium dense to dense, brown, *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; faint iron oxide staining locally. Embankment Fill (Hf)

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse,



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
☐ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▨ Well Screen and Sand Filter
▨ Bentonite-Cement Grout
▨ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-12P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 1 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN
MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.25 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:

Northing: ~ 466,922 ft.
Easting: ~ 1,642,650 ft.
Station: ~
Offset: ~

Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:

Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

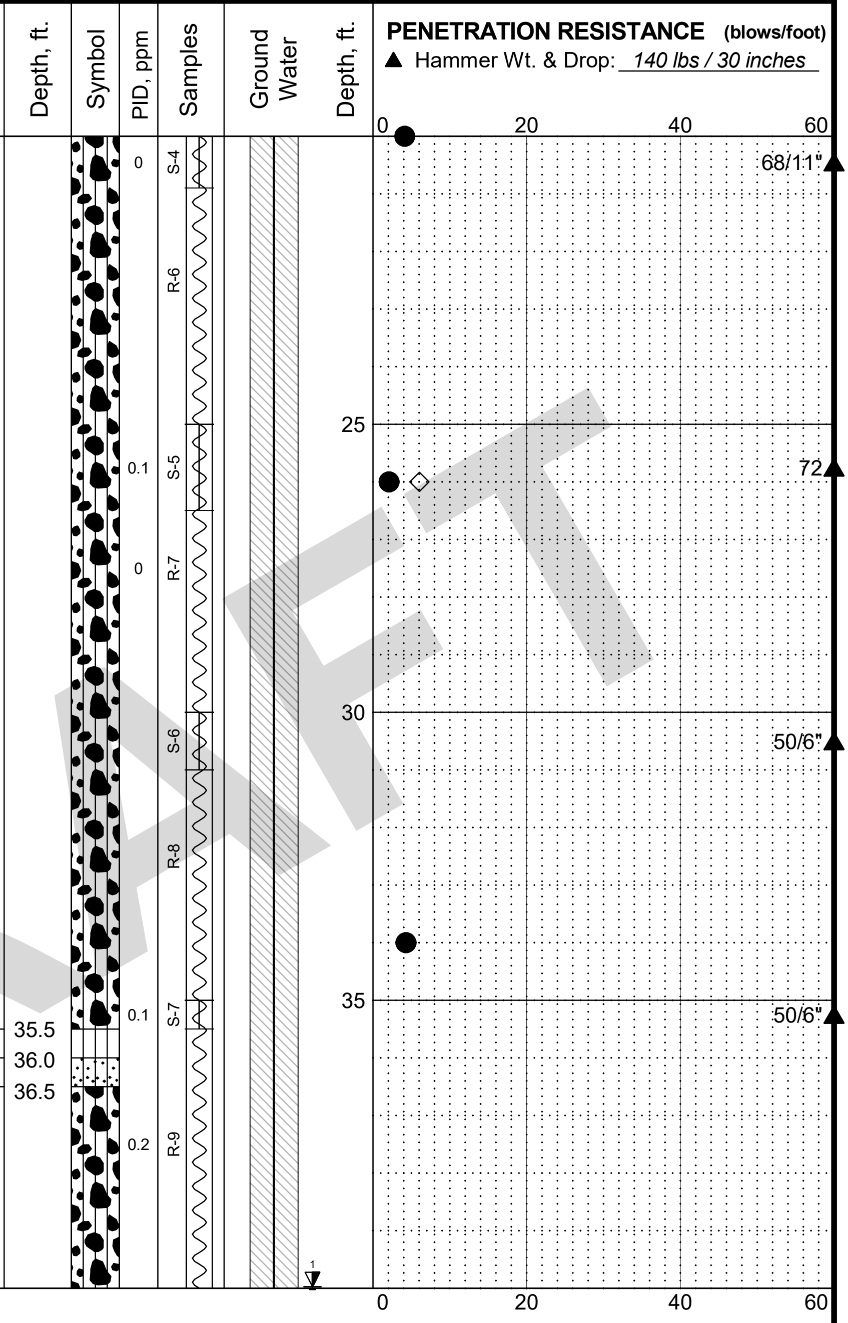
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; sandy gravel layers locally.
Embankment Fill (Hf)

35.5
Dark brown, *Sandy Silt with Gravel (ML)*; moist; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity, organics and wood fragments; slight organic odor.
Embankment Fill (Hf)

36.0
36.5

Medium dense to dense, brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse,



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
▨	Soil Core (as in Sonic Core Borings)
⌶	2.0" O.D. Split Spoon Sample
▨	Well Screen and Sand Filter
▨	Bentonite-Cement Grout
☒	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-12P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 2 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 100.25 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,922 ft.
Easting: ~ 1,642,650 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

subangular to subrounded gravel; fine to coarse sand; nonplastic.
Embankment Fill (Hf)

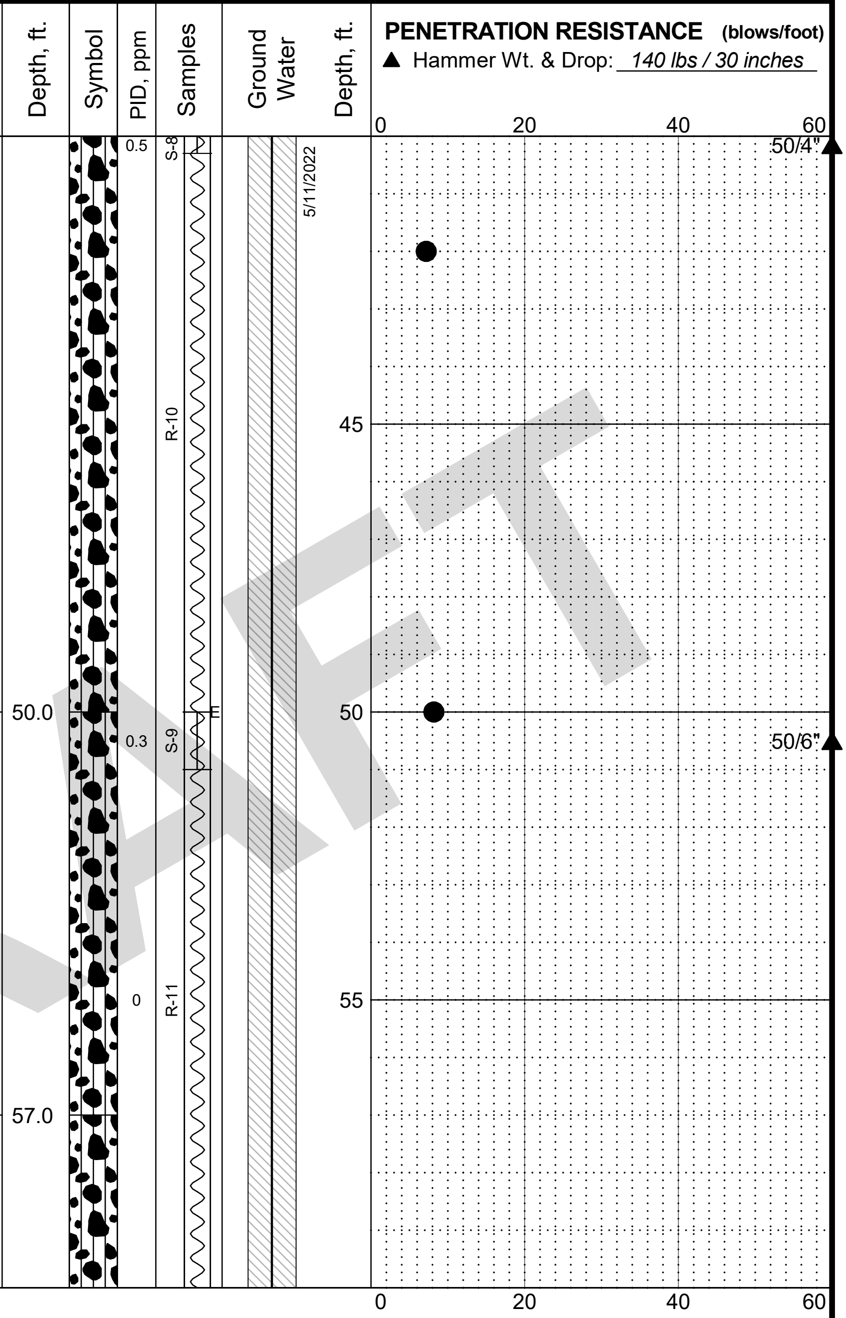
Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity.
Embankment Fill (Hf)

50.0

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity.
Alluvial Deposits (Qa)
[Environmental sample B-12P-21:50 collected at 50 feet.]

57.0

Very dense, brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
◪	Soil Core (as in Sonic Core Borings)
⌶	2.0" O.D. Split Spoon Sample
⬚	Well Screen and Sand Filter
⧅	Bentonite-Cement Grout
⊠	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-12P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 3 of 6

VERSION 1
FINAL

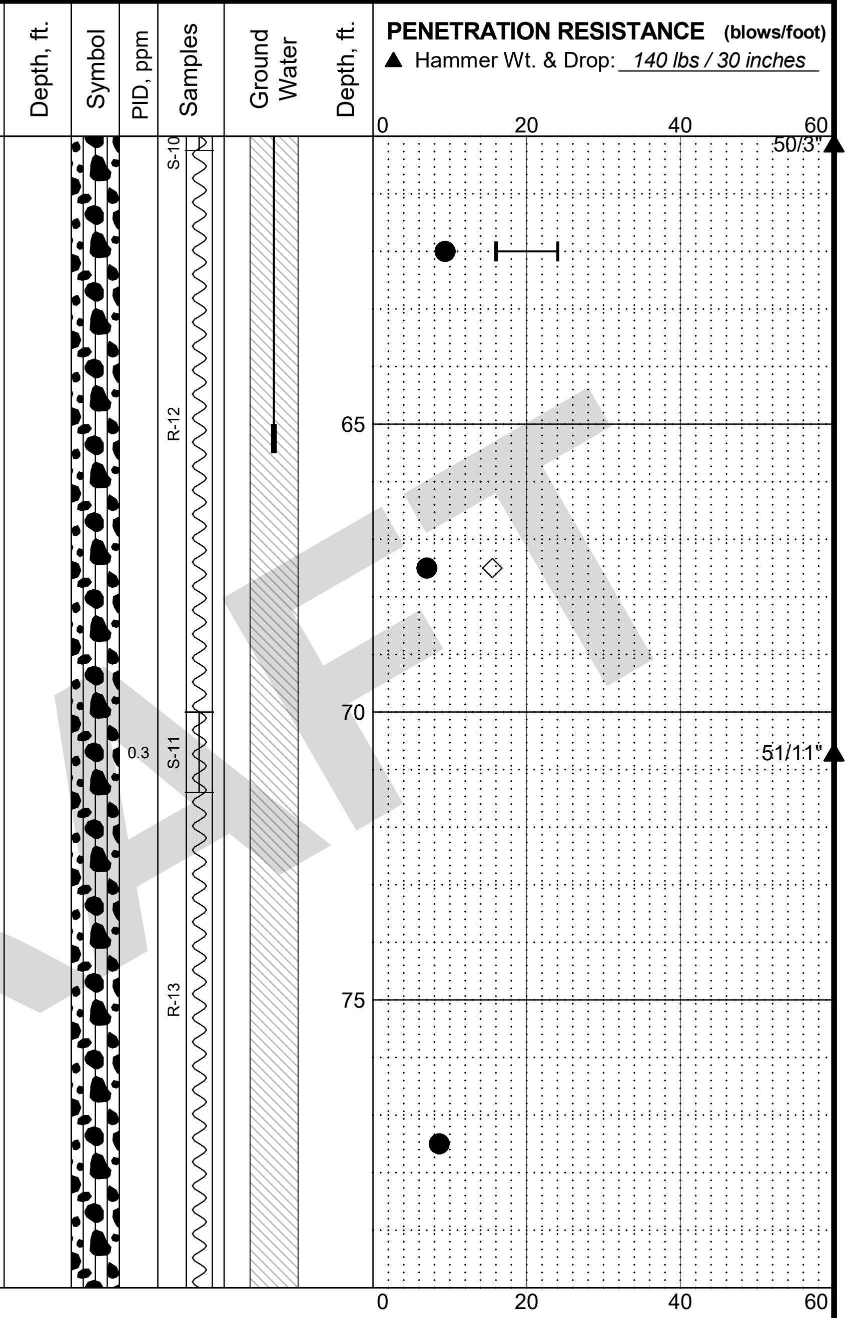
Total Depth:	100.25 ft.	Northing:	~ 466,922 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1083 ft.	Easting:	~ 1,642,650 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

coarse sand; low plasticity; iron oxide staining locally.
Alluvial Deposits (Qa)

- Clayey Sand (SC) matrix in Gravel at 62 feet.



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
▨	Soil Core (as in Sonic Core Borings)
⌶	2.0" O.D. Split Spoon Sample
▤	Well Screen and Sand Filter
▧	Bentonite-Cement Grout
▩	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-12P-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 4 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth:	100.25 ft.	Northing:	~ 466,922 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1083 ft.	Easting:	~ 1,642,650 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

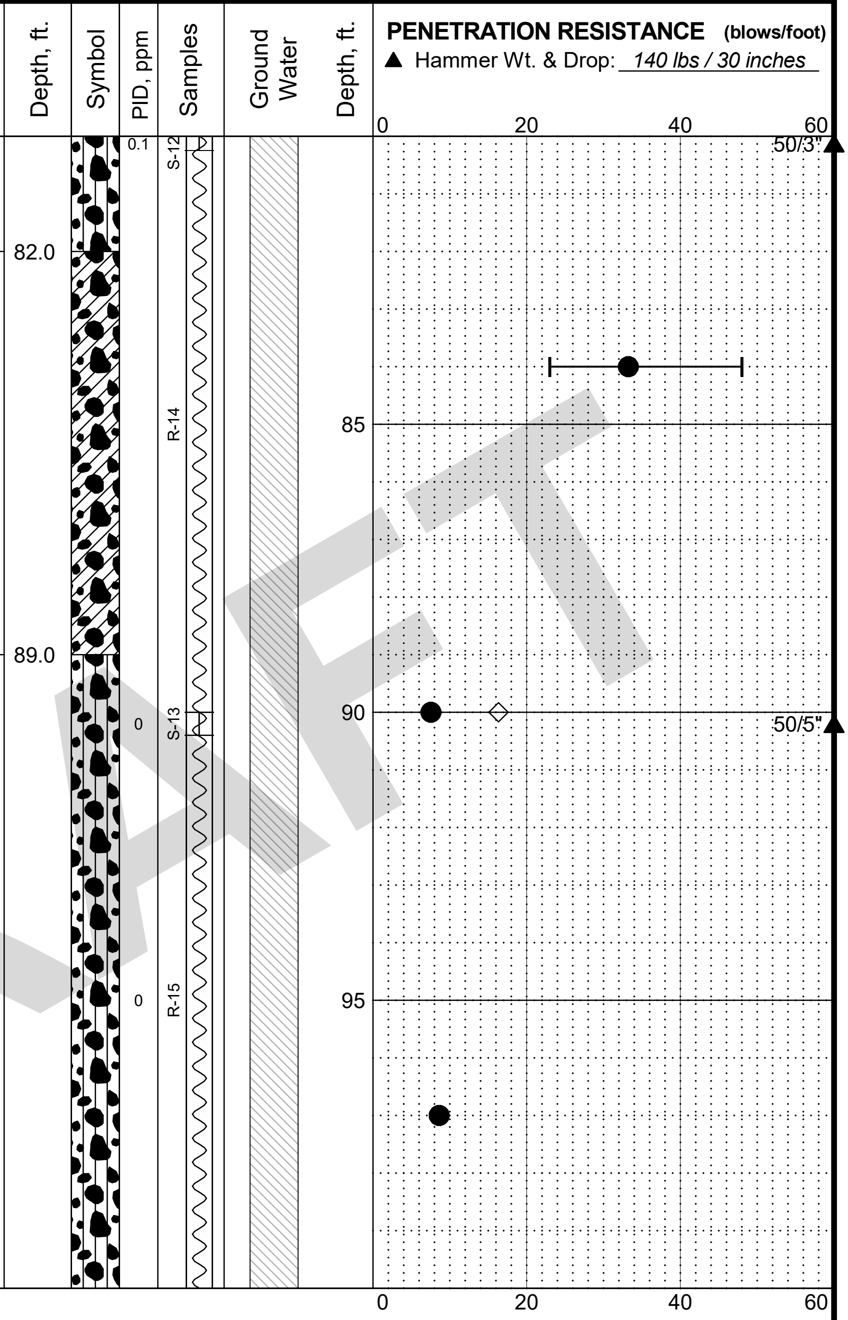
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

82.0

Medium dense to dense, brown, *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low to medium plasticity; iron oxide staining locally.
Alluvial Deposits (Qa)
- 6-inch thick ash or weathered gravel layer at 83.5 feet.
- Lean Clay (CL) matrix in Gravel and Sand at 84 feet.
- Strong iron oxide staining or disintegrated red gravel at 87 feet.

89.0

Medium dense to dense, brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; few zones of medium plasticity.
Alluvial Deposits (Qa)



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	⬚	Well Screen and Sand Filter
E	Environmental Sample Obtained	▧	Bentonite-Cement Grout
⊡	Soil Core (as in Sonic Core Borings)	⊠	Bentonite Chips/Pellets
⌶	2.0" O.D. Split Spoon Sample	▨	Bentonite Grout
		▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-12P-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 5 of 6

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

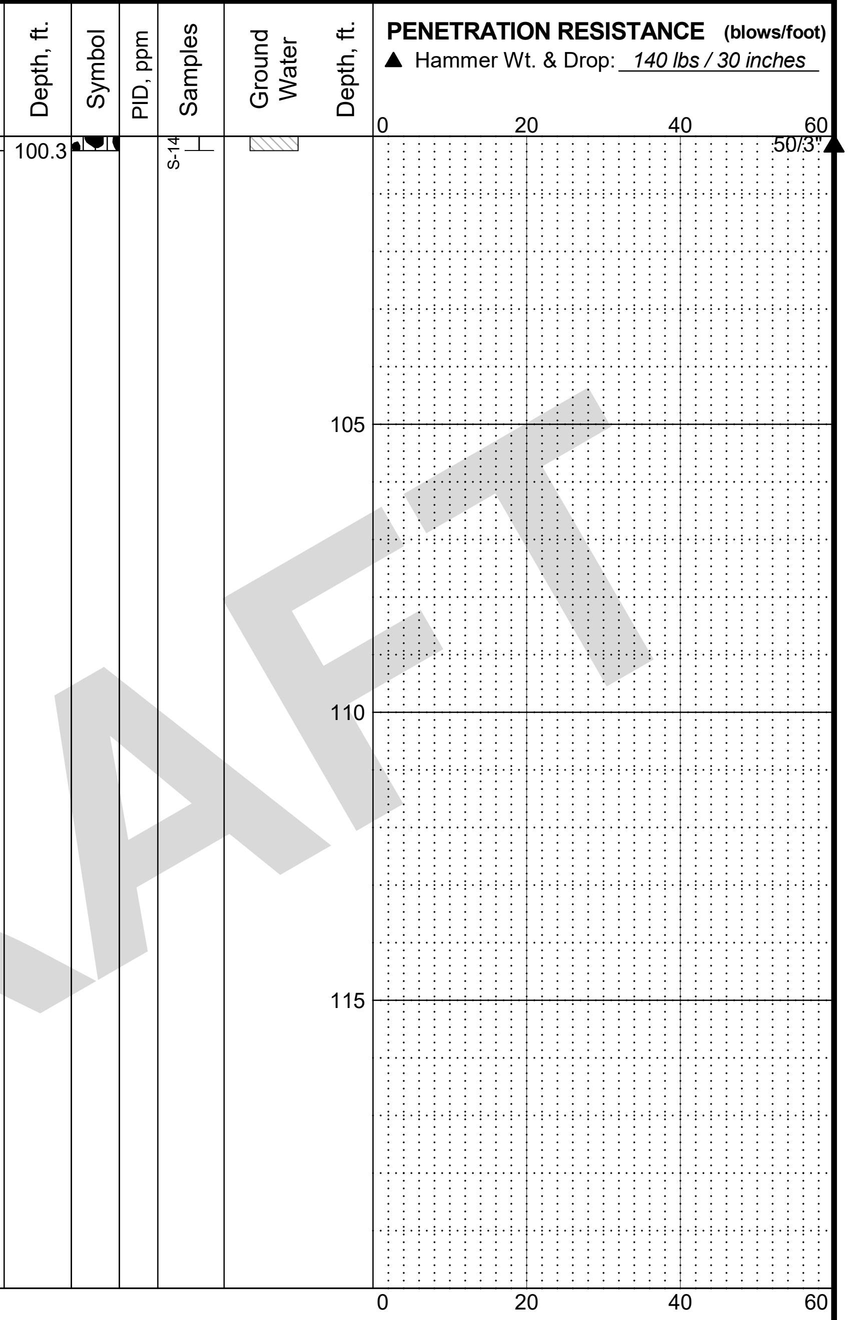
Total Depth: 100.25 ft.
Top Elevation: ~ 1083 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,922 ft.
Easting: ~ 1,642,650 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

BOTTOM OF BORING
COMPLETED 4/1/2021

NOTE: Where gravels exceeding one-half the inside diameter of the split spoon sampler, cobbles, or boulders are present, the SPT blow counts are not reliable indicators of soil density or stiffness per ASTM D1586. The interpreted relative densities for layers that meet these criteria presented in this boring log are based on density of nearby soil zones encountered and interpretation of the geologic depositional environment, instead of the blow count versus relative density relationship presented in Figure A-1.



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

*	Sample Not Recovered	⬚	Well Screen and Sand Filter
E	Environmental Sample Obtained	▧	Bentonite-Cement Grout
⍁	Soil Core (as in Sonic Core Borings)	⊠	Bentonite Chips/Pellets
⌶	2.0" O.D. Split Spoon Sample	▨	Bentonite Grout
		▼	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-12P-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 6 of 6

Total Depth: 65.3 ft.
Top Elevation: ~ 1084 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,976 ft.
Easting: ~ 1,642,570 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

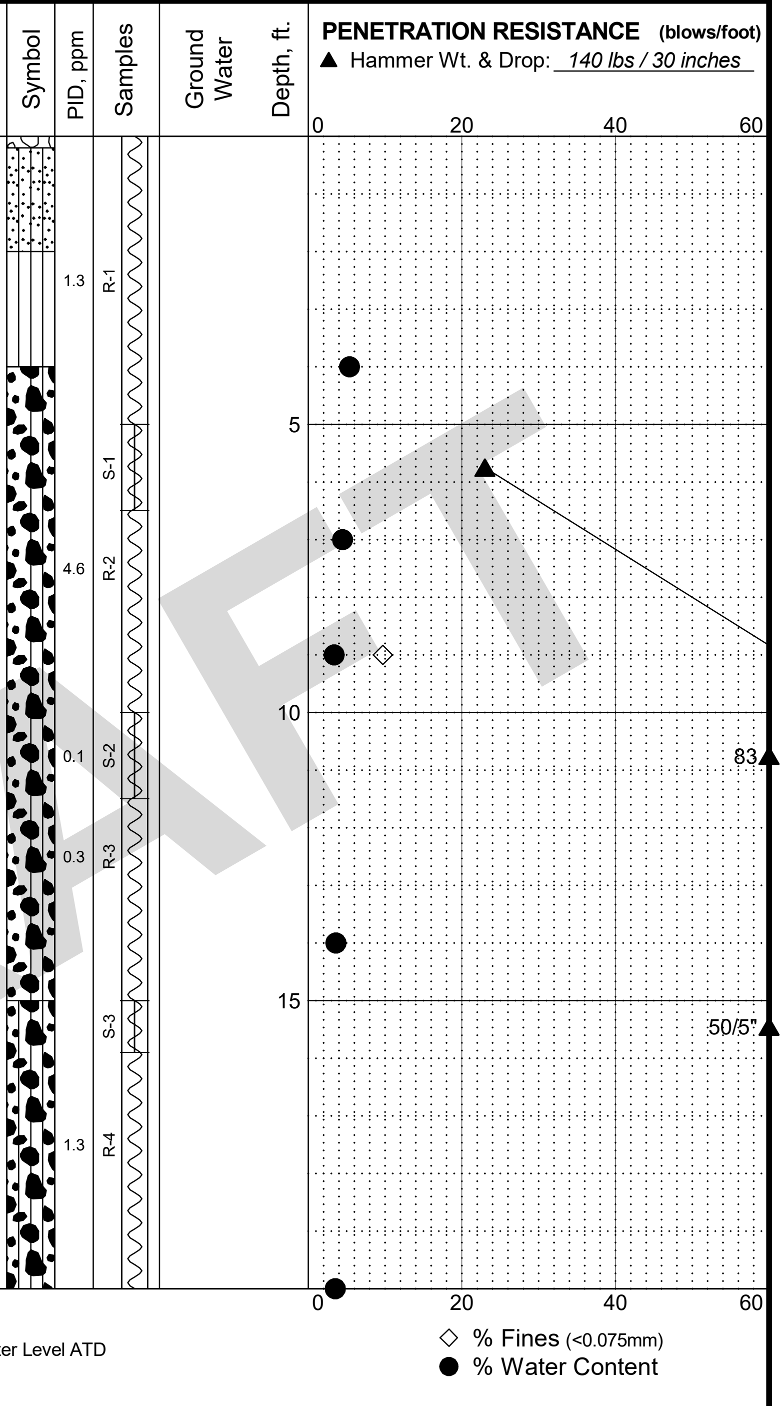
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Gravel.	0.2
Brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic. Embankment Fill (Hf)	2.0
Brown, *Silt with Sand (ML)*; moist; fine to coarse, few fine to coarse, subrounded gravel; fine to coarse sand; low plasticity; few sand seams; dark brown seam at 2 feet. Embankment Fill (Hf)	4.0
Medium dense, brown to gray-brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)*; moist; subrounded cobbles; fine to coarse, subrounded gravel; fine to medium sand; nonplastic to low plasticity; few silty gravel zones. Embankment Fill (Hf)	15.0
Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand; low plasticity; few sandy gravel layers. Embankment Fill (Hf)	

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-13-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 1 of 4

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

VERSION 1
FINAL

Total Depth: 65.3 ft.
Top Elevation: ~ 1084 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,976 ft.
Easting: ~ 1,642,570 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

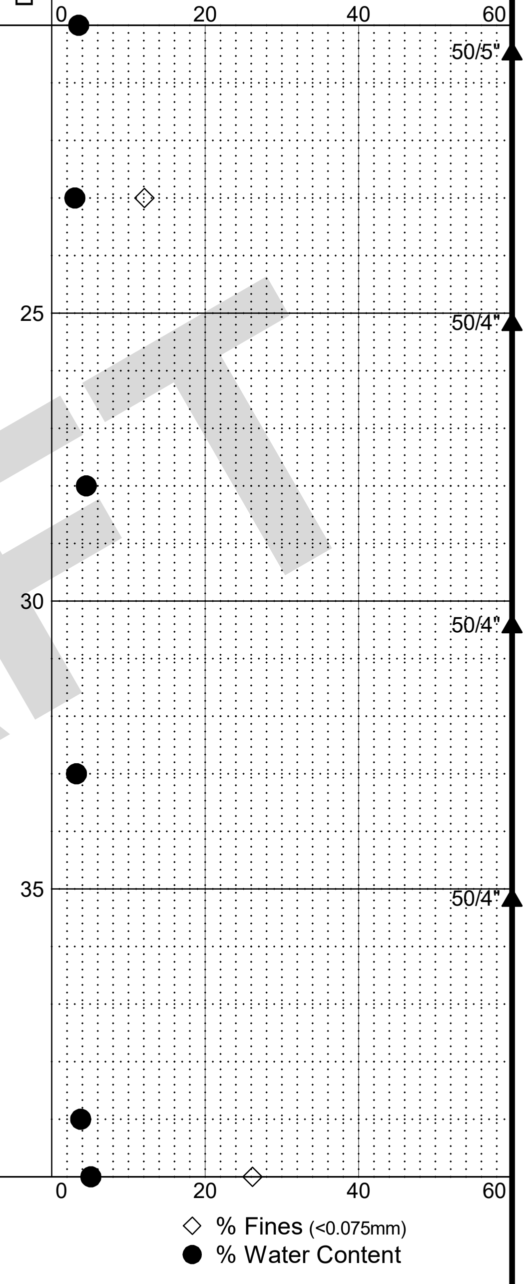
SOIL DESCRIPTION
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
Medium dense to dense, brown, *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic. Embankment Fill (Hf)	25.5
Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand; low plasticity. Embankment Fill (Hf)	30.0
Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)* to *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)*; moist, wet below about 50 feet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity. Embankment Fill (Hf)	35.0

PID, ppm	Samples
0.2	S-4
0.2	R-5
0.2	S-5
0.8	R-6
0.2	S-6
5.7	R-7
2.1	S-7
9.6	R-8

E

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ⊻ Ground Water Level ATD
- E Environmental Sample Obtained
- ◪ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-13-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 2 of 4

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

Total Depth: 65.3 ft.
Top Elevation: ~ 1084 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,976 ft.
Easting: ~ 1,642,570 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

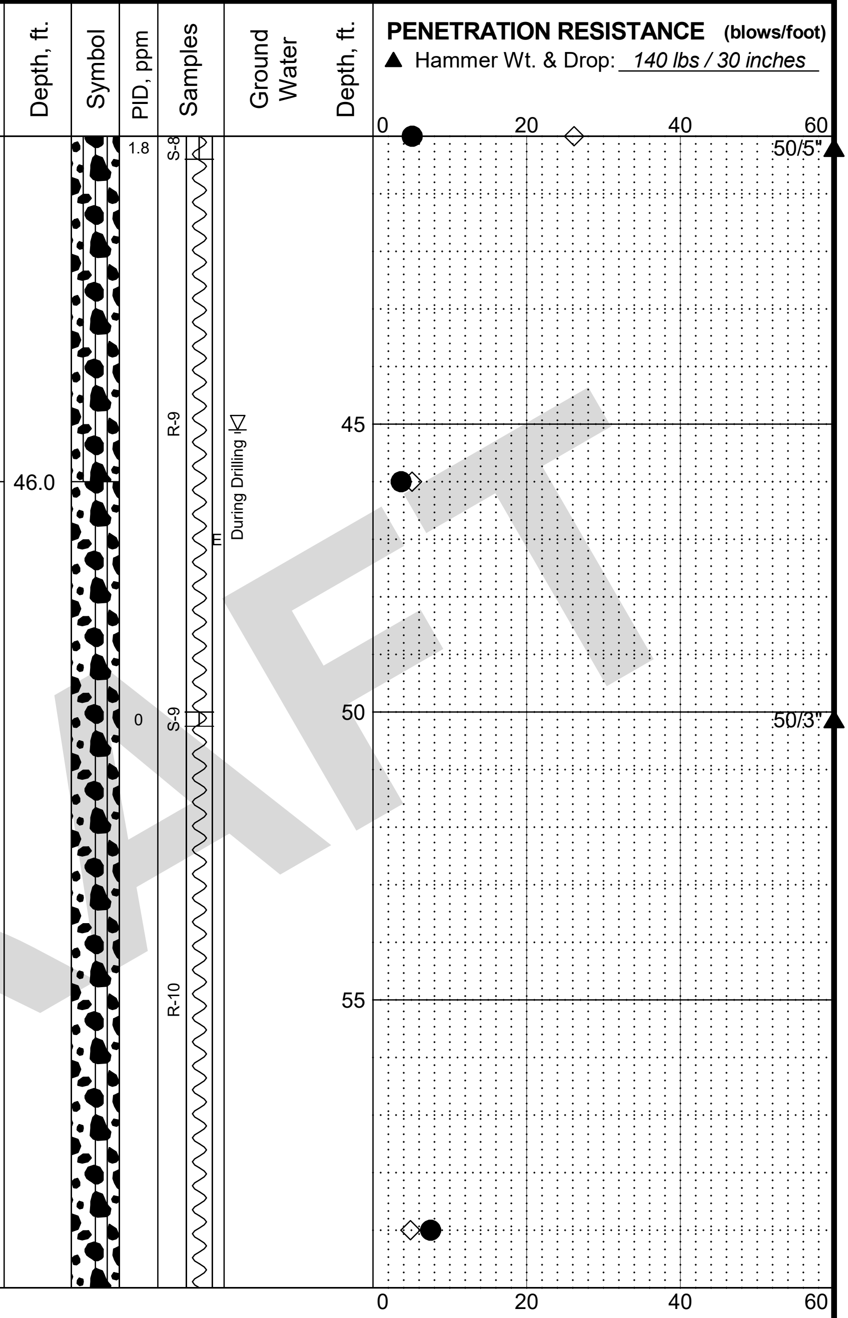
[Environmental sample B-13-21:39 collected at 39 feet.]

- Silty Sand with Gravel layer from about 40 to 42 feet.
- Slight organic odor at about 42 feet.

46.0

Medium dense to dense, gray-brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)* to *Well-Graded Gravel with Sand and Cobbles (GW)*; moist, wet below about 50 feet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity.
Alluvial Deposits (Qa)
[Environmental sample B-13-21:47 collected at 47 feet.]

- Orange-brown sandy gravel layer below about 59 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
Soil Core (as in Sonic Core Borings)
2.0" O.D. Split Spoon Sample
Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-13-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 3 of 4

VERSION 1
FINAL

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

Total Depth: 65.3 ft.
Top Elevation: ~ 1084 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,976 ft.
Easting: ~ 1,642,570 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

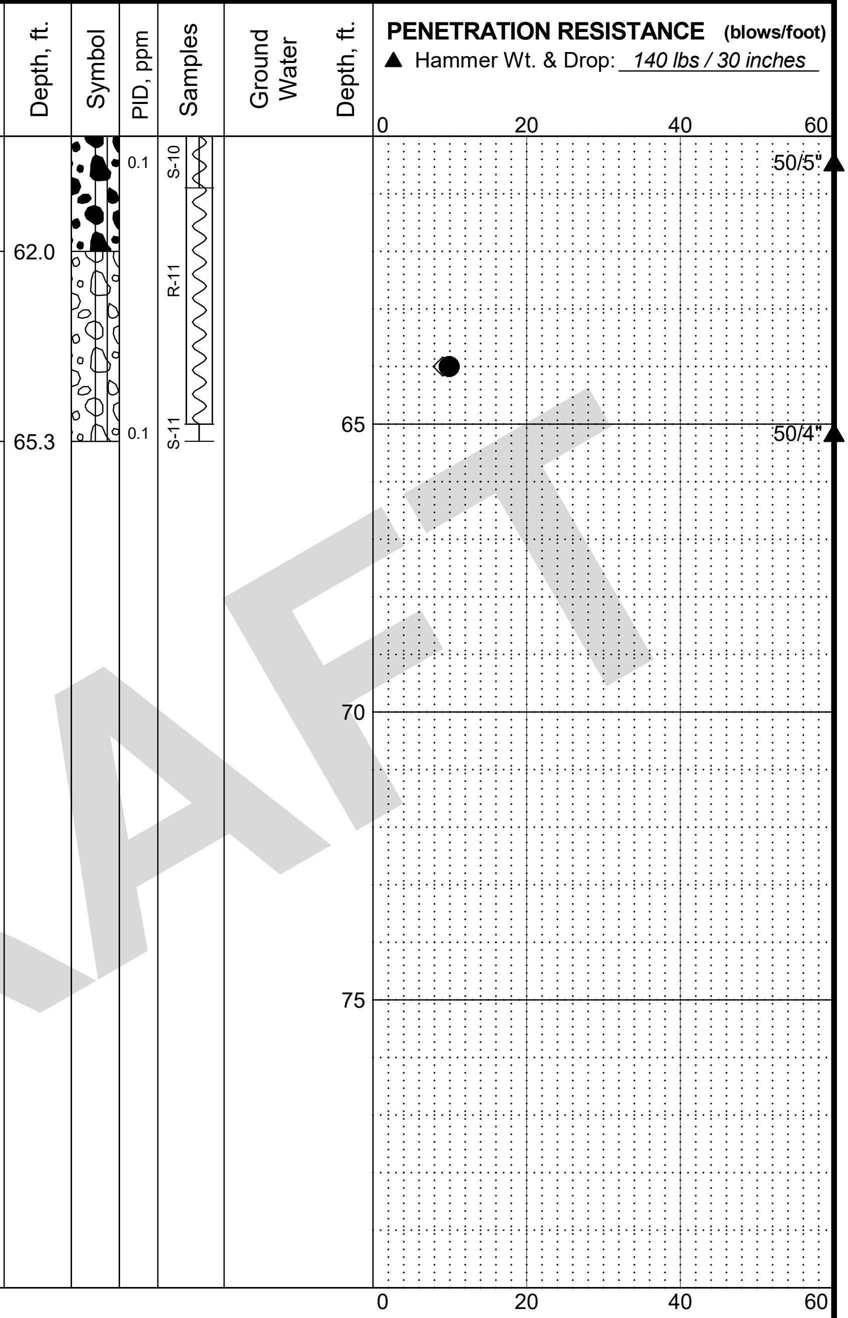
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, brown to orange-brown, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; wet; subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand; low to medium plasticity.
Alluvial Deposits (Qa)

BOTTOM OF BORING
COMPLETED 3/26/2021

NOTE: Where gravels exceeding one-half the inside diameter of the split spoon sampler, cobbles, or boulders are present, the SPT blow counts are not reliable indicators of soil density or stiffness per ASTM D1586. The interpreted relative densities for layers that meet these criteria presented in this boring log are based on density of nearby soil zones encountered and interpretation of the geologic depositional environment, instead of the blow count versus relative density relationship presented in Figure A-1.



LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
▨	Soil Core (as in Sonic Core Borings)
I	2.0" O.D. Split Spoon Sample
▽	Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-13-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 4 of 4

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

VERSION 1
FINAL

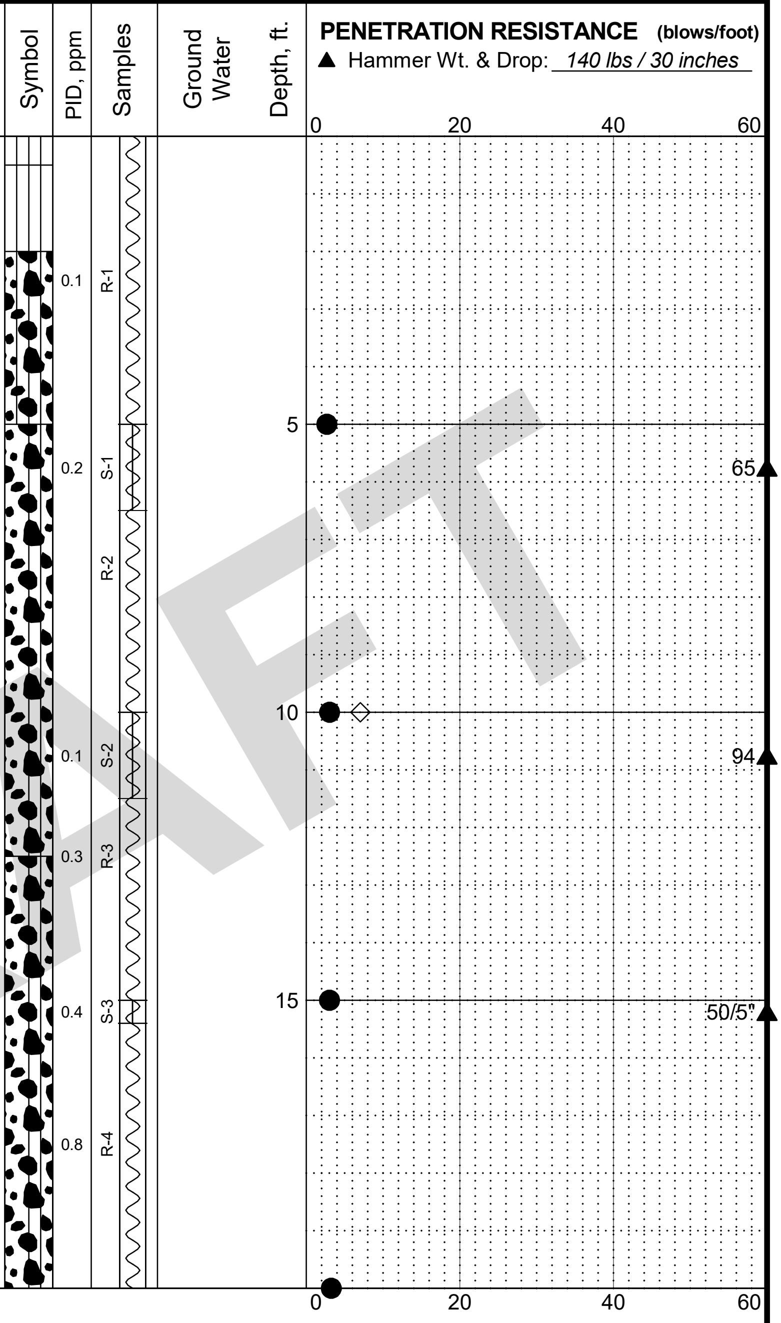
Total Depth: 65.4 ft.
Top Elevation: ~ 1077 ft.
Vert. Datum: NAVD 88
Horiz. Datum:

Northing: ~ 466,692 ft.
Easting: ~ 1,642,660 ft.
Station: ~
Offset: ~

Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:

Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Dark brown, *Silt with Sand (ML)*; wet; fine to medium sand; low plasticity; topsoil.	0.5
Brown, *Sandy Silt (ML)* to *Silty Sand (SM)*; moist; few fine to coarse, subrounded gravel; fine to medium sand; nonplastic to low plasticity; grades coarser into unit below. Embankment Fill (Hf)	2.0
Brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand; nonplastic to low plasticity; grades coarser with depth. Embankment Fill (Hf)	5.0
Medium dense to dense, gray-brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; few sandy gravel zones. Embankment Fill (Hf)	12.5
Medium dense to dense, brown to gray-brown, *Well-Graded Gravel with Silt and Sand and Cobbles (GW-GM)* to *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; iron oxide staining locally. Embankment Fill (Hf)	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- ▨ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-14-21

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 1 of 4

Total Depth:	65.4 ft.	Northing:	~ 466,692 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1077 ft.	Easting:	~ 1,642,660 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

- Iron oxide staining from about 23 to 25.5 feet.

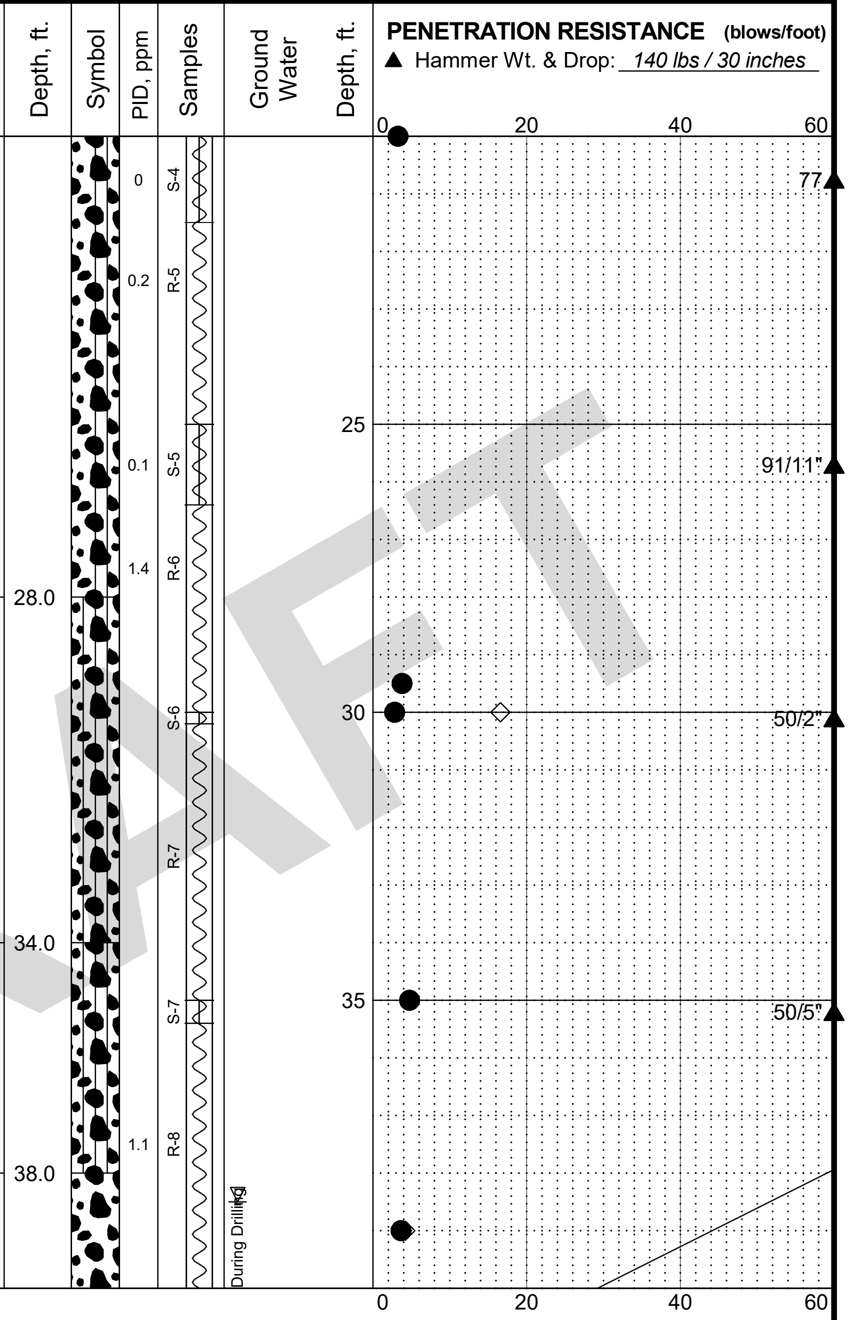
- Nail at 26.5 feet.

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; iron oxide staining at about 27.5 and 33 feet. Embankment Fill (Hf)

Medium dense to dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity; sandy silt layer from 35 to 36.5 feet. Embankment Fill (Hf)

- 2-inch thick white powder layer mixed with soil at about 34.5 feet.

Medium dense to dense, brown to gray-brown, *Well-Graded Gravel with Silt*



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)

● % Water Content

LEGEND

*	Sample Not Recovered	⊻	Ground Water Level ATD
E	Environmental Sample Obtained		
⊠	Soil Core (as in Sonic Core Borings)		
⌶	2.0" O.D. Split Spoon Sample		

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-14-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 2 of 4

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

VERSION 1
FINAL

Total Depth: 65.4 ft.
Top Elevation: ~ 1077 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,692 ft.
Easting: ~ 1,642,660 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

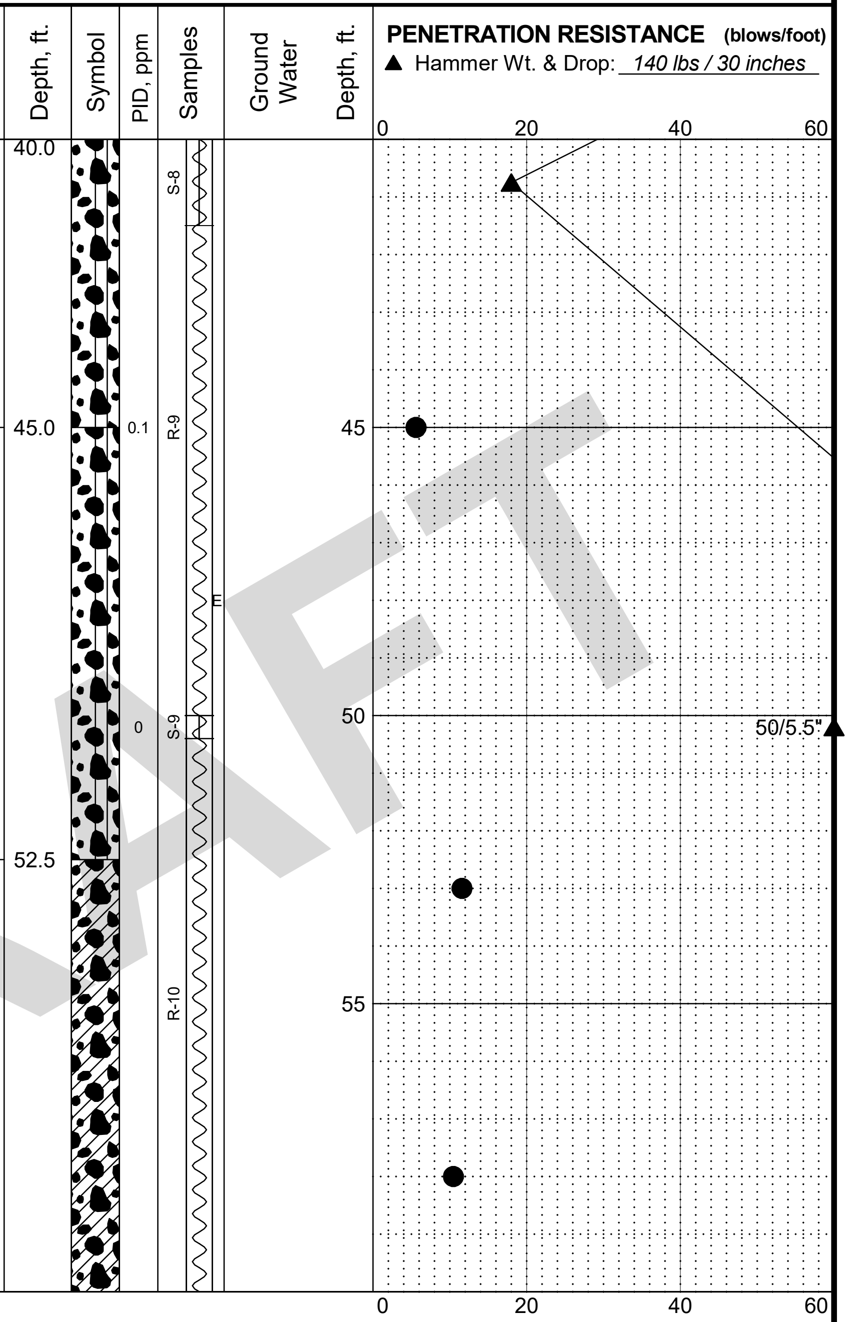
and Sand and Cobbles (GW); moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic.
Alluvial Deposits (Qa)

Medium dense, gray-brown, *Well-Graded Gravel with silt and Sand and Cobbles (GW-GM)*; moist; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity.
Alluvial Deposits (Qa)

Medium dense to dense, gray-brown to brown, *Well-Graded Gravel with Sand and Cobbles (GW-GM)*; moist to wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; few sandy zones.
Alluvial Deposits (Qa)
[Environmental sample B-14-21:48 collected at 48 feet.]

Medium dense to dense, brown to orange-brown, *Clayey Gravel with Sand and Cobbles (GC)*; wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; non plastic to low plasticity; few sandy zones; iron-oxide staining locally.
Alluvial Deposits (Qa)

- Orange-brown, ash or strong iron-oxide staining at about 59 feet.



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
▨	Soil Core (as in Sonic Core Borings)
⌶	2.0" O.D. Split Spoon Sample
⊻	Ground Water Level ATD
◇	% Fines (<0.075mm)
●	% Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-14-21

September 2022
106384-002

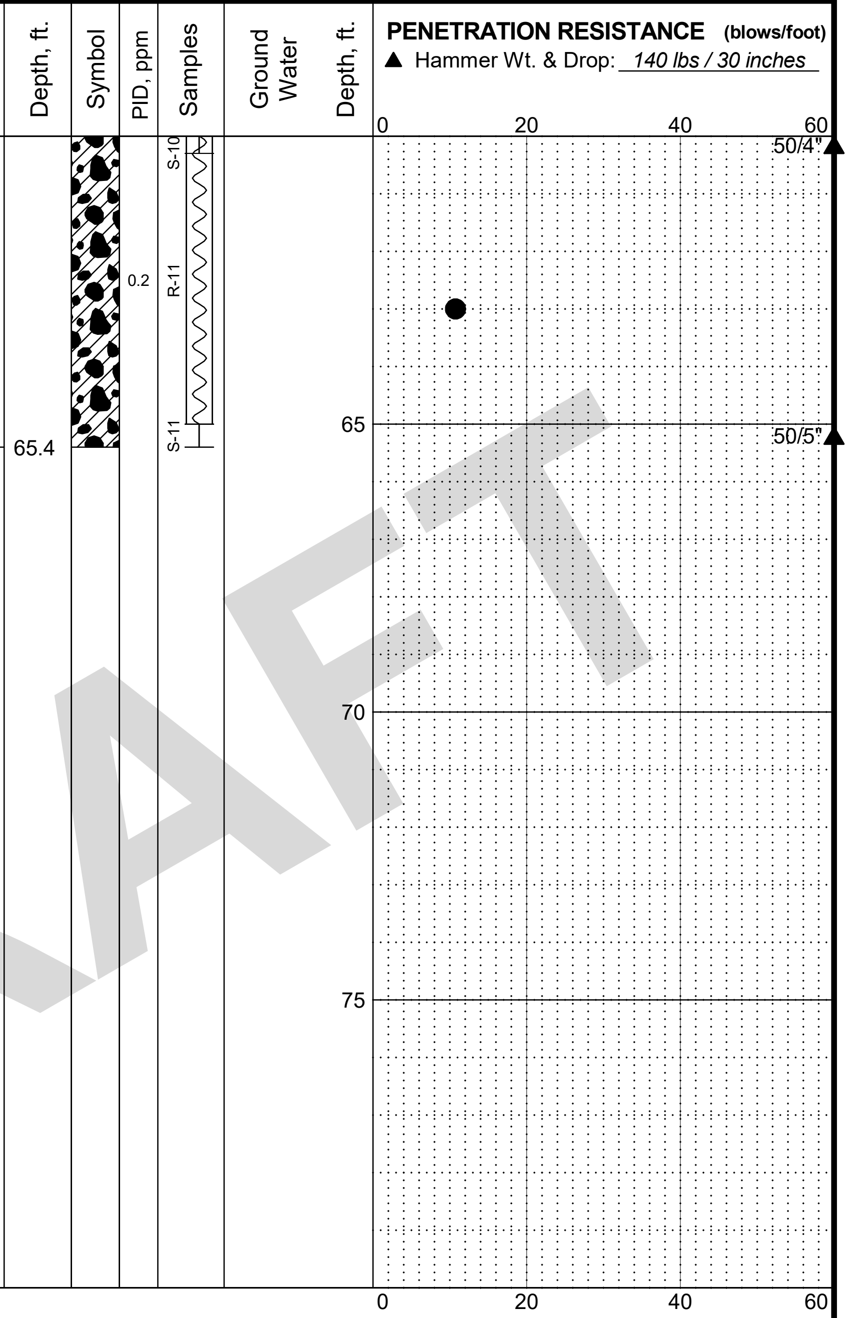
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 3 of 4

Total Depth: 65.4 ft.
Top Elevation: ~ 1077 ft.
Vert. Datum: NAVD 88
Horiz. Datum:
Northing: ~ 466,692 ft.
Easting: ~ 1,642,660 ft.
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.



BOTTOM OF BORING
COMPLETED 3/27/2021

NOTE: Where gravels exceeding one-half the inside diameter of the split spoon sampler, cobbles, or boulders are present, the SPT blow counts are not reliable indicators of soil density or stiffness per ASTM D1586. The interpreted relative densities for layers that meet these criteria presented in this boring log are based on density of nearby soil zones encountered and interpretation of the geologic depositional environment, instead of the blow count versus relative density relationship presented in Figure A-1.

◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
⊠ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊽ Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-14-21

September 2022
106384-002

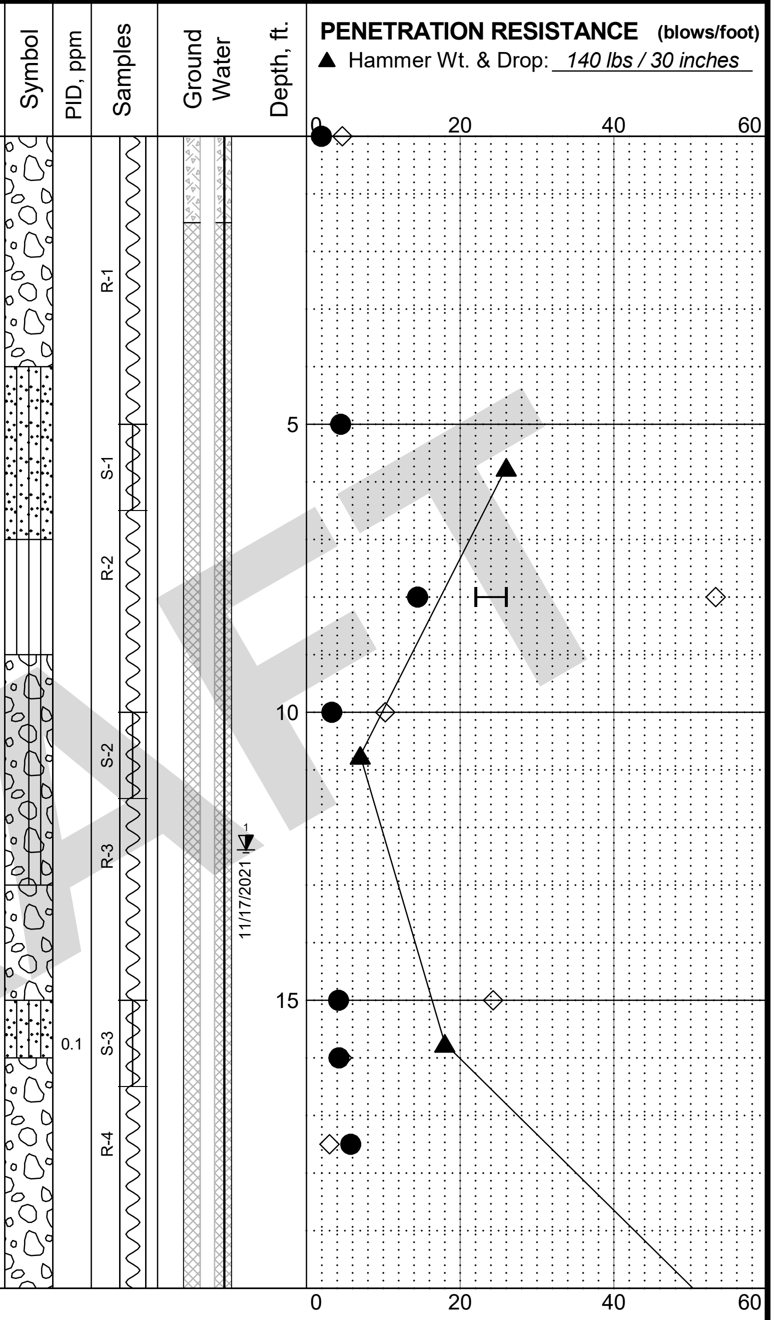
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 4 of 4

VERSION 1
FINAL

Total Depth: 40.25 ft. Northing: ~ 467,307 ft. Drilling Method: Sonic Core Hole Diam.: 6 in.
Top Elevation: ~ 1051 ft. Easting: ~ 1,643,984 ft. Drilling Company: Holt Services Rod Diam.: NWJ
Vert. Datum: NAVD 88 Station: ~ Drill Rig Equipment: Terrasonic 150CC Hammer Type: Automatic
Horiz. Datum: Offset: ~ Other Comments:

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Medium dense, gray-brown, *Poorly Graded Gravel with Sand (GP)*; moist; fine to coarse, angular to subrounded gravel; fine to coarse sand, trace fines; silt and sand layer at about 1 foot. Levee Fill (Hf)	4.0
Loose to medium dense, gray-brown to brown, *Silty Sand with Gravel and Cobbles (SM)*; moist; subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand; low plasticity. Levee Fill (Hf)	7.0
Loose, orange-brown, *Sandy Silt (ML)* to *Silty Sand (SM)*; moist; fine sand; low plasticity. Loess Deposits (Ql)	9.0
Medium dense, orange-brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; moist; few subrounded gravel; fine to medium sand; low plasticity. Alluvial Deposits (Qa)	13.0
Medium dense to dense, brown, *Poorly Graded Gravel with Sand and Cobbles (GP)*; moist; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic; strong iron oxide staining below 14.5 feet. Alluvial Deposits (Qa)	15.0 16.0
Medium dense to dense, brown, *Silty Sand with Gravel (SM)*; moist, wet below 16 feet; fine to coarse, subangular to subrounded gravel; fine to coarse sand; low plasticity. Alluvial Deposits (Qa)	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
E Environmental Sample Obtained
▯ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-15P-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 1 of 3

Log: KXM Rev: SAW Typ: LKN

MASTER_LOG_E 106384.GPJ SHAN_WIL.GDT 6/23/22

VERSION 1
FINAL

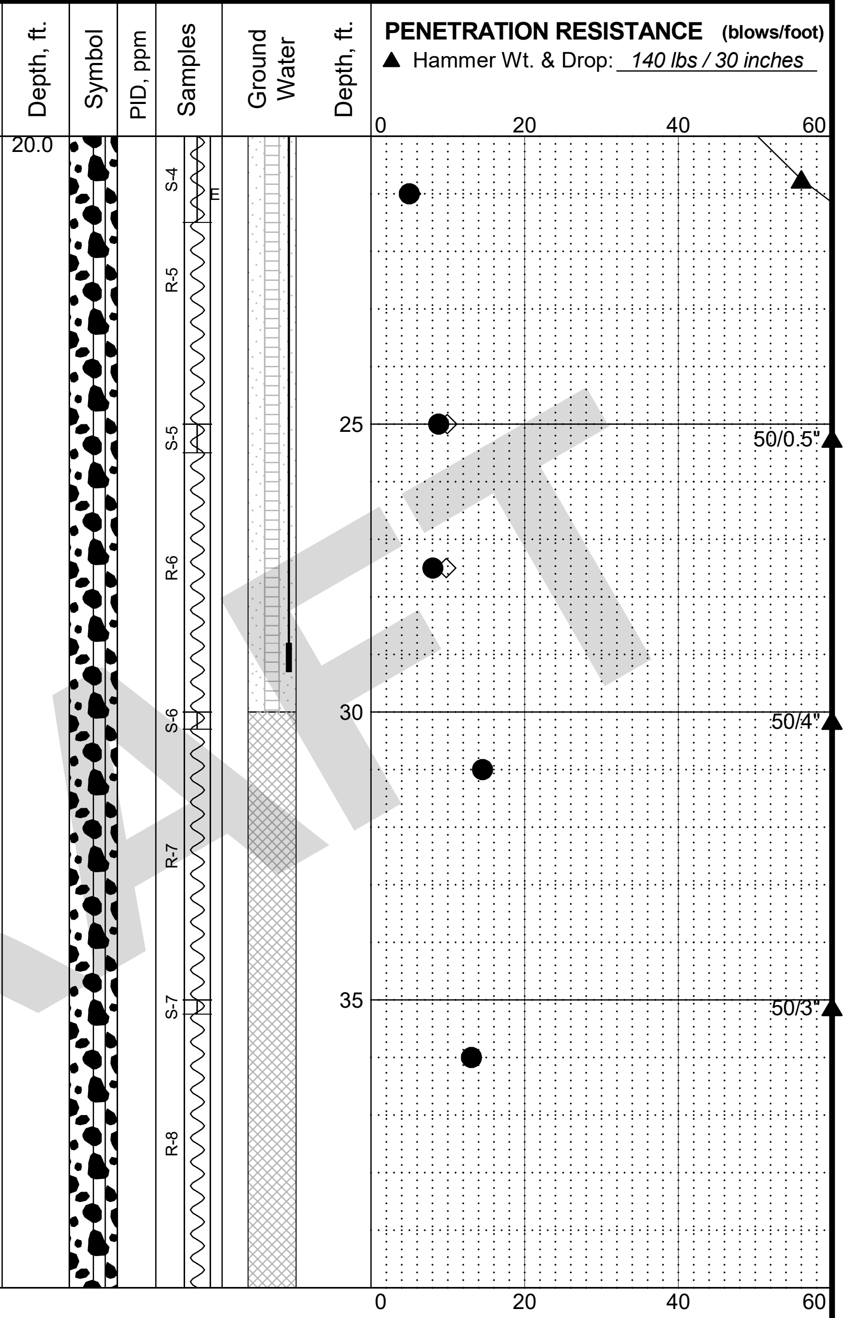
Total Depth:	40.25 ft.	Northing:	~ 467,307 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1051 ft.	Easting:	~ 1,643,984 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, brown, *Poorly Graded Gravel with Sand and Cobbles (GP)*; moist, wet; subrounded cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; zones of well-graded gravel and increased silt content; sand layer at 20 feet may be from drill action; trace organics below 20 feet.
Alluvial Deposits (Qa)

Medium dense to dense, brown, *Well-Graded Gravel with Sand and Cobbles (GW-GM)*; wet; subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand; low plasticity, zones of poorly graded gravel.
Alluvial Deposits (Qa)
[Environmental sample B-15P-21:21 collected at 21 feet.]



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- ☐ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ▤ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ▩ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-15P-21

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 2 of 3

Total Depth:	40.25 ft.	Northing:	~ 467,307 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 1051 ft.	Easting:	~ 1,643,984 ft.	Drilling Company:	Holt Services	Rod Diam.:	NWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Terrasonic 150CC	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | PID, ppm | Samples | Ground Water | Depth, ft.

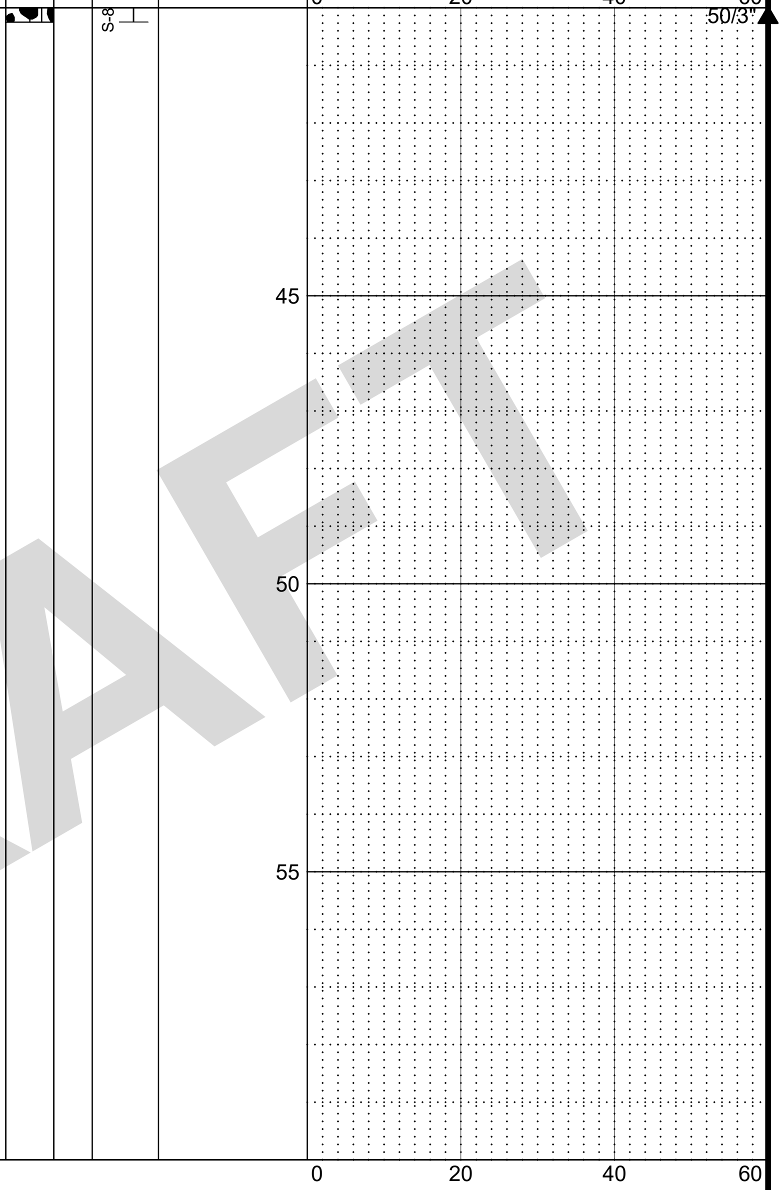
PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

40.3

BOTTOM OF BORING
COMPLETED 3/22/2021

NOTE: Where gravels exceeding one-half the inside diameter of the split spoon sampler, cobbles, or boulders are present, the SPT blow counts are not reliable indicators of soil density or stiffness per ASTM D1586. The interpreted relative densities for layers that meet these criteria presented in this boring log are based on density of nearby soil zones encountered and interpretation of the geologic depositional environment, instead of the blow count versus relative density relationship presented in Figure A-1.



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

*	Sample Not Recovered	⊡	Well Screen and Sand Filter
E	Environmental Sample Obtained	▧	Bentonite-Cement Grout
◫	Soil Core (as in Sonic Core Borings)	⊠	Bentonite Chips/Pellets
I	2.0" O.D. Split Spoon Sample	▨	Bentonite Grout
		▼	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Cascade Mill Parkway
Yakima, Washington

LOG OF BORING B-15P-21

June 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 3 of 3

VERSION 1
FINAL

Cascade Mill Parkway
Yakima, Washington

TP-1-22

Date Completed: *May 23, 2022*
Top Elevation: *~1080 feet*
Vertical Datum:
Northing: *~466,766 feet*
Easting: *~1,642,557 feet*
Horizontal Datum:
Maximum Depth: *12 feet*
TP Top Length: *3 feet*
TP Top Width: *13 feet*
Excavation Company: *WSDOT*
Excavation Equipment: *John Deere*

Approx. Elev. (feet)	Depth (feet)	Material Description
	0	Medium dense to dense, gray-brown, ***SILTY GRAVEL WITH SAND***(GM); moist; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity fines; Embankment Fill (Hf). *-Vegetation and topsoil at ground surface*
1079	1	
1078	2	
1077	3	
1076	4	
1075	5	
1074	6	
1073	7	
1072	8	
1071	9	
1070	10	
1069	11	
1068	12	BOTTOM OF HOLE AT 12 FEET

Symbol

Test Pit Photograph
Southwest Side of Test Pit

Left: Test Pit on Sunday, 5/22/2022 at 11:28 am; Right: Test Pit on Monday, 5/23/2022 at 9:34 am

NOTES:
- Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- ***Excavation was performed adjacent to EB I-82 shoulder, in interstate embankment***
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

FINAL

Logged by:	KXM
Review by:	OTH
Version:	1

Appendix B

Geotechnical Laboratory Test Procedures and Results

CONTENTS

Tables

Tests

B.1 INTRODUCTION

We performed geotechnical laboratory testing on select soil samples retrieved from the borings completed for Cascade Mill Parkway. The laboratory testing program included tests to classify the soil and provide data for engineering studies. We performed visual classification on all retrieved samples. Our laboratory testing program included water content determinations, grain-size distribution analyses, and Atterberg limits tests.

The following sections describe the laboratory test procedures.

B.2 VISUAL CLASSIFICATION

We visually classified soil samples retrieved from the borings using a system based on ASTM D2487-11, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM D2488-09a, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). We summarize our classification system in Appendix A. We assigned a Unified Soil Classification System (USCS) group name and symbol, based on our visual classification of particles finer than 76.2 millimeters (3 inches). We revised visual classifications using results of the index tests discussed below.

B.3 WATER CONTENT DETERMINATION

We tested the water content of selected samples in accordance with ASTM D2216-10, Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. Comparison of the water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. We present water content test results in the Laboratory Test Summary table in this appendix and graphically on Appendix A exploration logs.

B.4 GRAIN-SIZE ANALYSES

Grain-size distribution analyses separate soil particles through mechanical or sedimentation processes. Grain-size distributions are used to classify the granular component of soils and can correlate with soil properties, including frost susceptibility, permeability, shear strength, liquefaction potential, capillary action, and sensitivity to moisture. We plot grain-size distribution analysis results in this appendix. Grain-size distribution plots provide tabular information about each specimen, including USCS group symbol and group name; water content; constituent (i.e., cobble, gravel, sand, and fines) percentages; coefficients of uniformity and curvature, if applicable; personnel initials; ASTM standard designation; and testing remarks. Constituent percentages are presented in the Lab Summary Table in this appendix and fines contents are plotted as data points on Appendix A exploration logs.

B.4.1 Sieve Analysis

We performed mechanical sieve analyses on selected soil specimens to determine the grain-size distribution of coarse-grained soil particles, in accordance with ASTM C136/C136M 14, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

B.4.2 Combined Analysis

We performed combined analyses (mechanical and sedimentation) on selected soil specimens to determine the grain-size distribution of coarse- and fine-grained soil particles, in accordance with ASTM D422-63 2007e2, Standard Test Method for Particle-Size Analysis of Soils. We assumed a specific gravity of 2.7 for hydrometer calculations, unless otherwise indicated on grain-size distribution plots.

B.5 ATTERBERG LIMITS

We performed Atterberg Limits tests on selected fine-grained samples in accordance with ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (www.astm.org). The Atterberg Limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI = LL - PL). These limits can assist soil classification, indicate soil consistency (when compared to natural water content), provide correlation to soil properties, and estimate liquefaction potential. Plasticity charts provide the liquid limit, plastic limit, plasticity index, USCS group symbol, water content, and percent passing the No. 200 sieve (if a grain-size distribution analysis was performed). Soil plasticity test results are also shown graphically on the exploration logs presented in Appendix A.

B.6 CONSIDERATIONS

Drilling and sampling methodologies may affect the outcome of prescribed geotechnical laboratory tests. Refer to the field exploration discussion in this report for a discussion of these potential effects. Instances of limited recovery may have resulted in test samples not meeting specified minimum mass requirements, per ASTM standards. Test plots show which samples do not meet ASTM specified minimum mass requirements.

Table B-1 - Summary of Laboratory Testing

Exploration Designation	Top Depth	Sample Number	Sample Type	SPT Blow Count	USCS	Water Content	Percent Cobbles Removed[1]	Gravel Percent	Sand Percent	Fines Percent	Clay-size Percent	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c	Liquid Limit, LL	Plastic Limit, PL	Soil Description
	(feet)			(bpf)		(%)	(%)	(%)	(%)	(%)	(%)			(%)	(%)	
B-09-21	4	R-1	SCORE			31.3										
B-09-21	7.5	R-2	SCORE			19.9										
B-09-21	14	R-3	SCORE			2.9										
B-09-21	19	R-4	SCORE			4.5										
B-09-21	25	R-7	SCORE			0.8										
B-09-21	25	S-5	SPT	50/5"		0.8										
B-09-21	27	R-7	SCORE			3.9										
B-09-21	30	R-8	SCORE		GM	3.1	12*	44*	40*	16*						Silty Gravel with Sand and Cobbles
B-09-21	30	R-8	SPT	50/4"	GM	3.1										Silty Gravel with Sand and Cobbles
B-09-21	38	R-9	SCORE			2.7										
B-09-21	42	R-10	SCORE			12.1										
B-09-21	47	R-10	SCORE			5.1										
B-09-21	50	R-11	SCORE		GP-GM	6.1		72*	23*	5.5*		125.1	5.1			Poorly Graded Gravel with Silt and Sand
B-09-21	50	R-11	SPT	13	GP-GM	6.1										Poorly Graded Gravel with Silt and Sand
B-09-21	59	R-11	SCORE			7.2										
B-09-21	61.5	R-12	SCORE		CL	15.5								30	16	Sandy Lean Clay with Gravel
B-09-21	62.5	R-12	SCORE		GP-GM	10.3		52*	40*	7.7*		59.8	0.4			Poorly Graded Gravel with Silt and Sand
B-09-21	66	R-12	SCORE		SC	11.1								26	16	Clayey Sand with Gravel
B-09-21	74	R-13	SCORE			9.0										
B-09-21	83	R-14	SCORE			9.1										
B-09-21	92	R-15	SCORE		SC-SM	12.7								23	16	Silty, Clayey Sand with Gravel
B-09-21	92.5	R-15	SCORE		GM	7.9	15*	50*	31*	19*						Silty Gravel with Sand and Cobbles
B-10-21	3	R-1	SCORE			30.8										
B-10-21	7.5	R-2	SCORE			13.0										
B-10-21	13	R-3	SCORE			3.3										
B-10-21	17.5	R-4	SCORE		GW-GM	2.8		63*	29*	7.3*		97.1	1.7			Well-Graded Gravel with Silt and Sand
B-10-21	27	R-6	SCORE			5.1										
B-10-21	33	R-7	SCORE			5.4										
B-10-21	39	R-8	SCORE			4.1										

Table B-1 - Summary of Laboratory Testing

Exploration Designation	Top Depth (feet)	Sample Number	Sample Type	SPT Blow Count (bpf)	USCS	Water Content (%)	Percent Cobbles Removed [1] (%)	Gravel Percent (%)	Sand Percent (%)	Fines Percent (%)	Clay-size Percent (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Soil Description
B-10-21	45	R-9	SCORE		GW-GM	4.8	16*	59*	33*	8.4*		110.4	1.5			Well-Graded Gravel with Silt and Sand and Cobbles
B-10-21	57	R-10	SCORE			9.1										
B-10-21	62	R-11	SCORE			12.5										
B-10-21	67	R-11	SCORE			7.4										
B-10-21	72.5	R-12	SCORE		SP-SM	12.8		35*	57*	8*		8.7	0.9			Poorly Graded Sand with Silt and Gravel
B-10-21	78	R-12	SCORE			9.1										
B-10-21	80	R-13	SCORE		GM	8.6		43*	33*	24*						Silty Gravel with Sand
B-10-21	80	R-13	SPT	63/10"	GM	8.6										Silty Gravel with Sand
B-10-21	82.5	R-13	SCORE		GM	7.5		51	28	21	6					Silty Gravel with Sand
B-10-21	85	R-14	SCORE		GP-GM	8.2	6*	58*	30*	11*		709.2	7.1			Poorly Graded Gravel with Silt and Sand and Cobbles
B-10-21	92.5	R-15	SCORE		GM	10.4		57	27	16	5					Silty Gravel with Sand
B-10-21	99	R-15	SCORE			9.6										
B-11P-21	5	R-2	SCORE			2.0										
B-11P-21	5	S-1	SPT	50/4"		2.0										
B-11P-21	13	R-3	SCORE		GM	2.2	22*	43*	39*	18*						Silty Gravel with Sand and Cobbles
B-11P-21	15	R-4	SCORE			3.0										
B-11P-21	15	S-3	SPT	50/5"		3.0										
B-11P-21	20	R-5	SCORE			1.1										
B-11P-21	20	S-4	SPT	50/5"		1.1										
B-11P-21	26.5	R-6	SCORE			5.6										
B-11P-21	27.5	R-6	SCORE		GW-GM	3.8		62*	28*	9.5*		221.4	1.9			Well-Graded Gravel with Silt and Sand
B-11P-21	32	R-7	SCORE		SC-SM									21	16	Silty, Clayey Sand with Gravel
B-11P-21	36.5	R-8	SCORE		GW-GM	2.9		65*	30*	5.1*		53.9	1.4			Well-Graded Gravel with Silt and Sand
B-11P-21	40	R-9	SCORE			15.8										
B-11P-21	40	S-8	SPT	29		15.8										
B-11P-21	55	R-10	SCORE		GW-GM	6.9		60*	31*	9.3*		147.9	2.3			Well-Graded Gravel with Silt and Sand
B-11P-21	62	R-11	SCORE			12.5										
B-11P-21	71	R-12	SCORE			12.1										
B-11P-21	72.5	R-12	SCORE		GC	9.3		51*	29*	20*				27	18	Clayey Gravel with Sand

Table B-1 - Summary of Laboratory Testing

Exploration Designation	Top Depth (feet)	Sample Number	Sample Type	SPT Blow Count (bpf)	USCS	Water Content (%)	Percent Cobbles Removed ^{1} (%)	Gravel Percent (%)	Sand Percent (%)	Fines Percent (%)	Clay-size Percent (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Soil Description
B-11P-21	80	R-13	SCORE			11.7										
B-11P-21	80	S-12	SPT	50/5"		11.7										
B-11P-21	90	R-14	SCORE			12.0										
B-11P-21	90	S-13	SPT	50/5"		12.0										
B-12P-21	5	R-2	SCORE			4.7										
B-12P-21	5	S-1	SPT	50/5"		4.7										
B-12P-21	7	R-2	SCORE			3.0										
B-12P-21	10	R-4	SCORE		GP-GM	3.2		51*	39*	11*		129.6	4.3			Poorly Graded Gravel with Silt and Sand
B-12P-21	10	R-4	SPT	50/5.5"	GP-GM	3.2										Poorly Graded Gravel with Silt and Sand
B-12P-21	15	R-5	SCORE			2.5										
B-12P-21	15	S-3	SPT	50/6"		2.5										
B-12P-21	20	R-6	SCORE			4.1										
B-12P-21	20	S-4	SPT	68/11"		4.1										
B-12P-21	26	R-7	SCORE		GP-GM	2.1	8*	71*	22*	6.5*		84.4	4.3			Poorly Graded Gravel with Silt and Sand and Cobbles
B-12P-21	26	R-7	SPT	72	GP-GM	2.1										Poorly Graded Gravel with Silt and Sand and Cobbles
B-12P-21	34	R-8	SCORE			4.3										
B-12P-21	42	R-10	SCORE			7.2										
B-12P-21	50	R-11	SCORE		GP-GM	8.2	13*	55*	36*	9.3*		153.2	0.4			Poorly Graded Gravel with Silt and Sand and Cobbles
B-12P-21	50	R-11	SPT	50/6"	GP-GM	8.2										Poorly Graded Gravel with Silt and Sand and Cobbles
B-12P-21	62	R-12	SCORE		SC	9.4								24	16	Clayey Sand with Gravel
B-12P-21	67.5	R-12	SCORE		GM	7.0		55*	29*	16*						Silty Gravel with Sand
B-12P-21	77.5	R-13	SCORE			8.6										
B-12P-21	84	R-14	SCORE		CL	33.2								48	23	Lean Clay
B-12P-21	90	R-15	SCORE		GM	7.5	9*	57*	25*	18*						Silty Gravel with Sand and Cobbles
B-12P-21	90	R-15	SPT	50/5"	GM	7.5										Silty Gravel with Sand and Cobbles
B-12P-21	97	R-15	SCORE			8.6										
B-13-21	4	R-1	SCORE			5.4										
B-13-21	7	R-2	SCORE			4.5										
B-13-21	9	R-2	SCORE		GW-GM	3.4		51*	39*	9.7*		98.3	2.0			Well-Graded Gravel with Silt and Sand

Table B-1 - Summary of Laboratory Testing

Exploration Designation	Top Depth (feet)	Sample Number	Sample Type	SPT Blow Count (bpf)	USCS	Water Content (%)	Percent Cobbles Removed [1] (%)	Gravel Percent (%)	Sand Percent (%)	Fines Percent (%)	Clay-size Percent (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Soil Description
B-13-21	14	R-3	SCORE			3.6										
B-13-21	20	R-5	SCORE			3.5										
B-13-21	20	S-4	SPT	50/5"		3.5										
B-13-21	23	R-5	SCORE		GM	3.0		58*	30*	12*						Silty Gravel with Sand
B-13-21	28	R-6	SCORE			4.5										
B-13-21	33	R-7	SCORE			3.2										
B-13-21	39	R-8	SCORE			3.8										
B-13-21	40	R-9	SCORE		SM	5.1		22*	52*	26*						Silty Sand with Gravel
B-13-21	40	R-9	SPT	50/5"	SM	5.1										Silty Sand with Gravel
B-13-21	46	R-9	SCORE		GP-GM	3.7		75*	20*	5.1*		130.9	8.2			Poorly Graded Gravel with Silt and Sand
B-13-21	59	R-10	SCORE		GW	7.5		60*	36*	4.9*		33.3	2.4			Well-Graded Gravel with Sand
B-13-21	64	R-11	SCORE		GP-GM	9.9		62	29	9.1	3	172.8	0.8			Poorly Graded Gravel with Silt and Sand
B-14-21	5	R-2	SCORE			2.7										
B-14-21	5	S-1	SPT	65		2.7										
B-14-21	10	R-3	SCORE		GW-GM	3.0	9*	63*	29*	7.8*		96.8	2.4			Well-Graded Gravel with Silt and Sand and Cobbles
B-14-21	10	R-3	SPT	94	GW-GM	3.0										Well-Graded Gravel with Silt and Sand and Cobbles
B-14-21	15	R-4	SCORE			3.0										
B-14-21	15	S-3	SPT	50/5"		3.0										
B-14-21	20	R-5	SCORE			3.3										
B-14-21	20	S-4	SPT	77		3.3										
B-14-21	29.5	R-6	SCORE			3.8										
B-14-21	30	R-7	SCORE		GM	2.8	5*	49*	34*	18*						Silty Gravel with Sand and Cobbles
B-14-21	30	R-7	SPT	50/2"	GM	2.8										Silty Gravel with Sand and Cobbles
B-14-21	35	R-8	SCORE			4.8										
B-14-21	35	S-7	SPT	50/5"		4.8										
B-14-21	39	R-8	SCORE		GW	3.6		64*	32*	4.2*		41.9	1.7			Well-Graded Gravel with Sand
B-14-21	45	R-9	SCORE			5.6										
B-14-21	53	R-10	SCORE			11.6										
B-14-21	58	R-10	SCORE			10.5										

Table B-1 - Summary of Laboratory Testing

Exploration Designation	Top Depth (feet)	Sample Number	Sample Type	SPT Blow Count (bpf)	USCS	Water Content (%)	Percent Cobbles Removed [1] (%)	Gravel Percent (%)	Sand Percent (%)	Fines Percent (%)	Clay-size Percent (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Soil Description
B-14-21	63	R-11	SCORE			10.7										
B-15P-21	0	R-1	SCORE		GP	1.9		78*	18*	4.7*		48.9	6.2			Poorly Graded Gravel with Sand
B-15P-21	5	R-2	SCORE			4.5										
B-15P-21	5	S-1	SPT	26		4.5										
B-15P-21	8	R-2	SCORE		ML	14.5		0	47	53	10			26	22	Sandy Silt
B-15P-21	10	R-3	SCORE		GP-GM	3.3		53	37	10	3	211.0	0.2			Poorly Graded Gravel with Silt and Sand
B-15P-21	10	R-3	SPT	7	GP-GM	3.3										Poorly Graded Gravel with Silt and Sand
B-15P-21	15	R-4	SCORE		SM	4.2		20	56	24	7					Silty Sand with Gravel
B-15P-21	15	R-4	SPT	18	SM	4.2										Silty Sand with Gravel
B-15P-21	16	R-4	SCORE		GP-GM	4.2	15	74	20	5.4	1	97.8	5.6			Poorly Graded Gravel with Silt and Sand and Cobbles
B-15P-21	16	R-4	SPT	18	GP-GM	4.2										Poorly Graded Gravel with Silt and Sand and Cobbles
B-15P-21	17.5	R-4	SCORE		GW	5.8		71	26	3.0	1	68.1	2.6			Well-Graded Gravel with Sand
B-15P-21	21	R-5	SCORE		GW-GM	5.0		66	29	5.2	1	45.1	2.4			Well-Graded Gravel with Silt and Sand
B-15P-21	21	R-5	SPT	56	GW-GM	5.0										Well-Graded Gravel with Silt and Sand
B-15P-21	25	R-6	SCORE		GP-GM	8.8	19	47	41	12	3					Poorly Graded Gravel with Silt and Sand and Cobbles
B-15P-21	25	R-6	SPT	50/0.5"	GP-GM	8.8										Poorly Graded Gravel with Silt and Sand and Cobbles
B-15P-21	27.5	R-6	SCORE		GW-GM	8.0	7	55	34	10	3	196.4	1.7			Well-Graded Gravel with Silt and Sand and Cobbles
B-15P-21	31	R-7	SCORE			14.5										
B-15P-21	36	R-8	SCORE			13.1										

NOTES:

* Sample specimen weight did not meet required minimum mass for the test; bpf = blows per foot; SCORE = Soil Core (as in Sonic Core Borings); SPT = 2-inch Outside Diameter Split-Spoon Sample

[1] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel Percent, Sand Percent, Fines Percent, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

Laboratory Terms

Abbreviations, Symbols, and Terms	Descriptions
%	percent
*	Sample specimen weight did not meet required minimum mass for the test method.
"	inch
#	Test not performed by Shannon & Wilson laboratory.
ASTM Std.	ASTM International Standard
C_c	coefficient of curvature
clay-size	Soil particles finer than 0.02 mm.
cm	centimeter
cm^2	square centimeter
coarse-grained	Soil particles coarser than 0.075 mm (cobble-, gravel-, and sand-sized particles).
cobbles	Soil particles finer than 305 mm and coarser than 76.2 mm.
C_u	coefficient of uniformity
CU	consolidated-undrained
ϵ	axial strain
fine-grained	Soil particles finer than 76.2 mm and coarser than 4.75 mm.
ft	feet
ϒm	wet unit weight
gravel	Soil particles finer than 76.2 mm and coarser than 4.75 mm.
G_S	specific gravity of soil solids
H_o	initial height
ΔH	change in height
ΔH_{load}	end of load increment deformation
in	inch
in^3	cubic inch
LL	liquid limit
min	minute
mm	millimeter
μ_m	micrometer
MC	moisture content
MPa	mega-pascal
NP	nonplastic
OC	organic content
p	total stress

Abbreviations, Symbols, and Terms	Descriptions
p'	effective stress
Pa	pascal
pcf	pounds per cubic foot
PI	Plasticity Index
PL	plastic limit
psf	pounds per square foot
psi	pounds per square inch
q	deviatoric stress
Sand	Soil particles finer than 4.75 mm and coarser than 0.075 mm.
sec	second
Silt	Soil particles finer than 0.075 mm and coarser than 0.002 mm.
t_n	time to n% primary consolidation
t_{load}	duration of load increment
tsf	short tons per square foot
USCS	Unified Soil Classification System
UU	unconsolidated-undrained
WC	water content

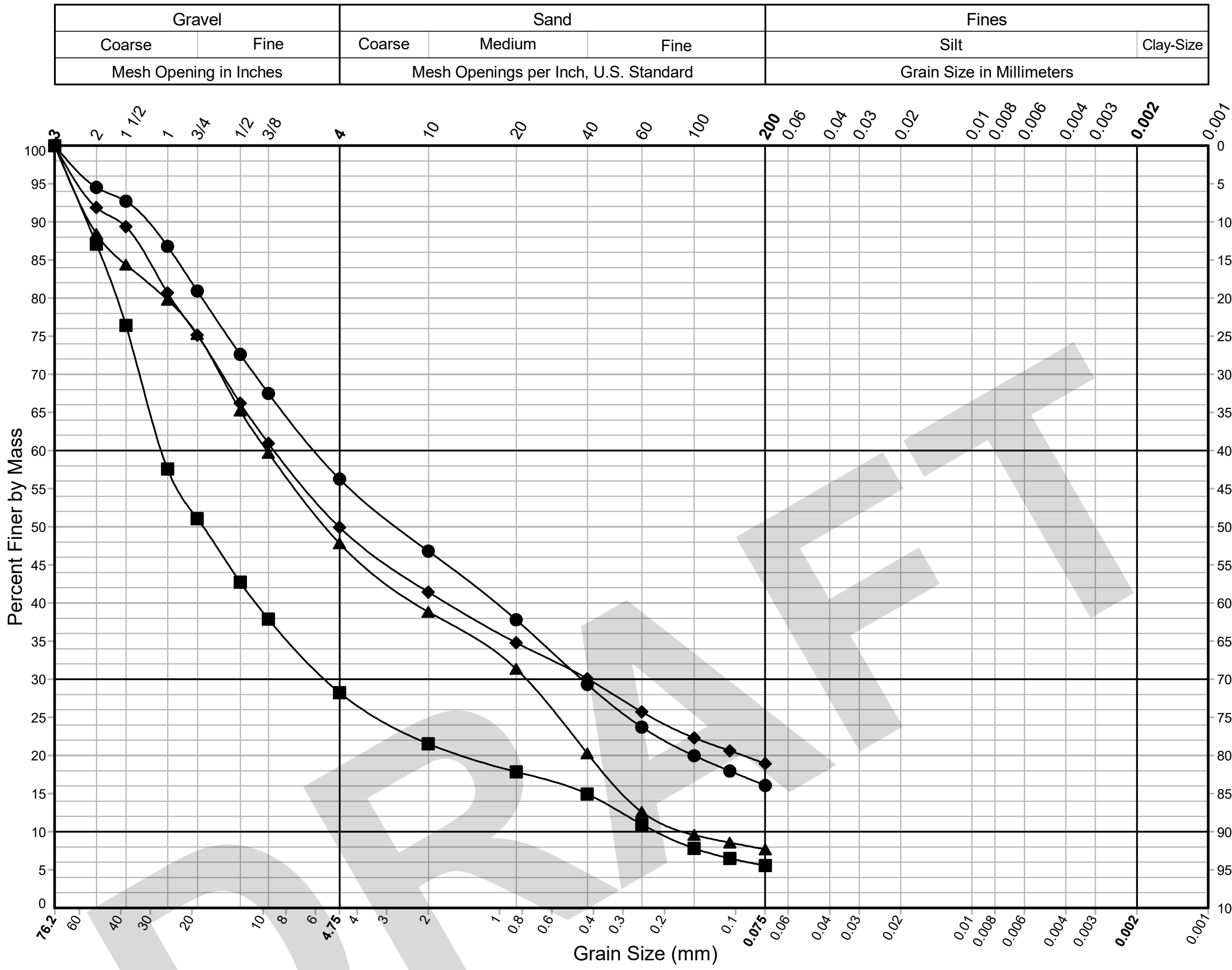
Sample Types

Abbreviations, Symbols, and Terms	Descriptions
2SS	2.5-inch-Outside-Diameter Split-Spoon Sample
2ST	2-inch-Outside-Diameter Thin-Walled Tube
3HSA	3-inch CME Hollow Stem Auger Sampler
3SS	3-inch-Outside-Diameter Split-Spoon Sample
4SS	4-inch-Inside-Diameter Split-Spoon Sample
6SS	6-inch-Inside-Diameter Split-Spoon Sample
CA_MC	Modified California Sampler
CA_SPT	Standard Penetration Test (SPT)
CORE	Rock Core
DM	+3.25-inch-Outside-Diameter Split-Spoon Sampler
DMR	3.25-inch Sampler with Internal Rings
GRAB	Grab Sample
GUS	3-inch-Outside-Diameter Gregory Undisturbed Sampler (GUS) Sample
OSTER	3-inch-Outside-Diameter Osterberg Sample
PITCHER	3-inch-Outside-Diameter Pitcher Sample
PMT	Pressuremeter Test (f=failed)
PO	Porter Penetration Test Sample
PT	2.5-inch-Outside-Diameter Thin-Walled Tube
ROCK	Rock Core Sample
SCORE	Soil Core (as in Sonic Core Borings)
SH1	1-inch Plastic Sheath
SH2	2-inch Plastic Sheath with Soil Recovery
SH3	2-inch Plastic Sheath with no Soil Recovery
SPT	2-inch-Outside-Diameter Split-Spoon Sample
SS	Split-Spoon
ST	3-inch-Outside-Diameter Thin-Walled Tube
STW	3-inch-Outside-Diameter Thin-Walled Tube
TEST	Sample Test Interval
TW	Thin Wall Sample
UNDIST	Undisturbed Sample
VANE	Vane Shear
WATER	Water Sample for Probe Logs
XCORE	Core Sample

GRAIN SIZE DISTRIBUTION PLOT

Cascade Mill Parkway
Yakima, Washington

BORING B-09-21



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %[2]	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-09-21, R-8*	30.0	GM	Silty Gravel with Sand and Cobbles	12	44	40	16			3.1	NJA	AKV	D6913
■ B-09-21, R-11*	50.0	GP-GM	Poorly Graded Gravel with Silt and Sand		72	23	5.5			6.1	NJA	AKV	D6913
▲ B-09-21, R-12*	62.5	GP-GM	Poorly Graded Gravel with Silt and Sand		52	40	7.7			10.3	NJA	AKV	D6913
◆ B-09-21, R-15*	92.5	GM	Silty Gravel with Sand and Cobbles	15	50	31	19			7.9	NJA	AKV	D6913

** Test specimen did not meet minimum mass recommendations.*

[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, and <2um% values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

GRAIN SIZE DISTRIBUTION PLOT

Cascade Mill Parkway
Yakima, Washington

BORING B-10-21

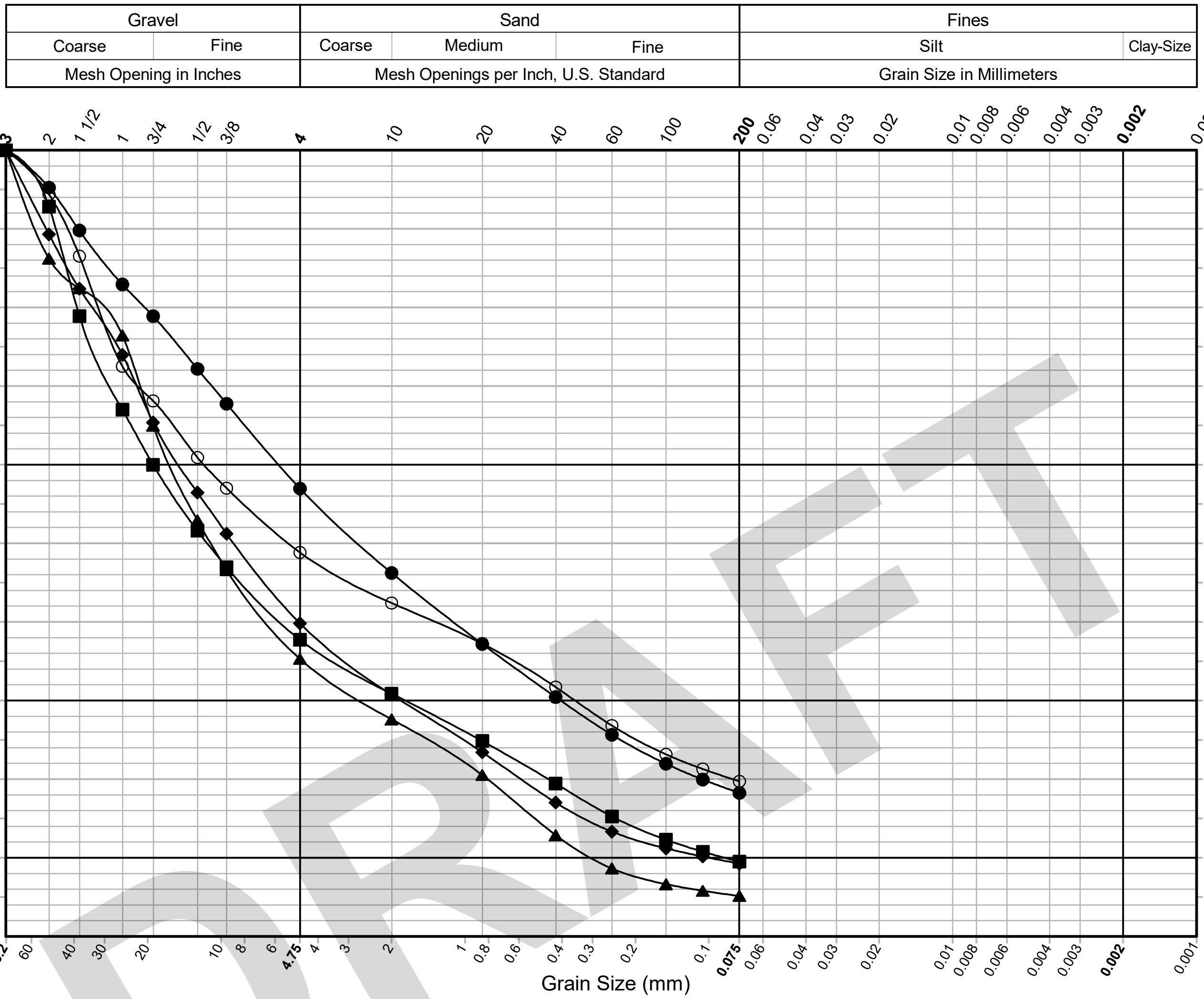
Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %[2]	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-10-21, R-4*	17.5	GW-GM	Well-Graded Gravel with Silt and Sand		63	29	7.3			2.8	SJD	AKV	D6913
■ B-10-21, R-9*	45.0	GW-GM	Well-Graded Gravel with Silt and Sand and Cobbles	16	59	33	8.4			4.8	SJD	AKV	D6913
▲ B-10-21, R-12*	72.5	SP-SM	Poorly Graded Sand with Silt and Gravel		35	57	8.0			12.8	SJD	AKV	D6913
◆ B-10-21, R-13*	80.0	GM	Silty Gravel with Sand		43	33	24			8.6	SJD	AKV	D6913
○ B-10-21, R-13	82.5	GM	Silty Gravel with Sand		51	28	21	16	6	7.5	SJD	AKV	D422
□ B-10-21, R-14*	85.0	GP-GM	Poorly Graded Gravel with Silt and Sand and Cobbles	6	58	30	11			8.2	SJD	AKV	D6913
△ B-10-21, R-15	92.5	GM	Silty Gravel with Sand		57	27	16	12	5	10.4	SJD	AKV	D422

** Test specimen did not meet minimum mass recommendations.*
[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, and <2um% values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

GRAIN SIZE DISTRIBUTION PLOT

Cascade Mill Parkway
Yakima, Washington

BORING B-11P-21



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %^{2}	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-11P-21, R-3*	13.0	GM	Silty Gravel with Sand and Cobbles	22	43	39	18			2.2	NLP	AKV	D6913
■ B-11P-21, R-6*	27.5	GW-GM	Well-Graded Gravel with Silt and Sand		62	28	9.5			3.8	NLP	AKV	D6913
▲ B-11P-21, R-8*	36.5	GW-GM	Well-Graded Gravel with Silt and Sand		65	30	5.1			2.9	NLP	AKV	D6913
◆ B-11P-21, R-10*	55.0	GW-GM	Well-Graded Gravel with Silt and Sand		60	31	9.3			6.9	NLP	AKV	D6913
○ B-11P-21, R-12*	72.5	GC	Clayey Gravel with Sand		51	29	20			9.3	NLP	AKV	D6913

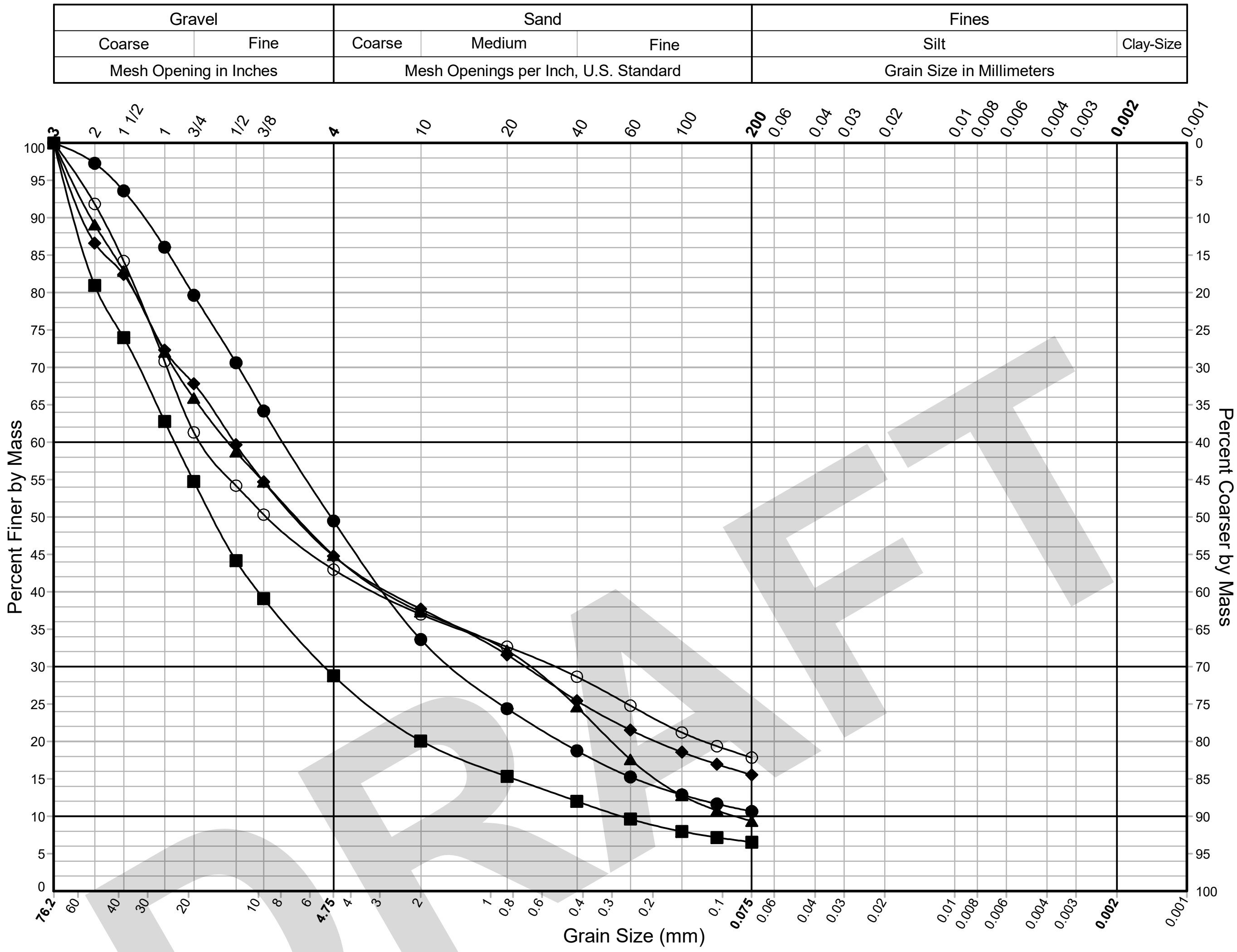
** Test specimen did not meet minimum mass recommendations.*
[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, and <2um% values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

SHANNON & WILSON

GRAIN SIZE DISTRIBUTION PLOT

Cascade Mill Parkway
Yakima, Washington

BORING B-12P-21



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %[2]	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-12P-21, R-4*	10.0	GP-GM	Poorly Graded Gravel with Silt and Sand		51	39	11			3.2	NLP	AKV	D6913
■ B-12P-21, R-7*	26.0	GP-GM	Poorly Graded Gravel with Silt and Sand and Cobbles	8	71	22	6.5			2.1	NLP	AKV	D6913
▲ B-12P-21, R-11*	50.0	GP-GM	Poorly Graded Gravel with Silt and Sand and Cobbles	13	55	36	9.3			8.2	NLP	AKV	D6913
◆ B-12P-21, R-12*	67.5	GM	Silty Gravel with Sand		55	29	16			7.0	NLP	AKV	D6913
○ B-12P-21, R-15*	90.0	GM	Silty Gravel with Sand and Cobbles	9	57	25	18			7.5	NLP	AKV	D6913

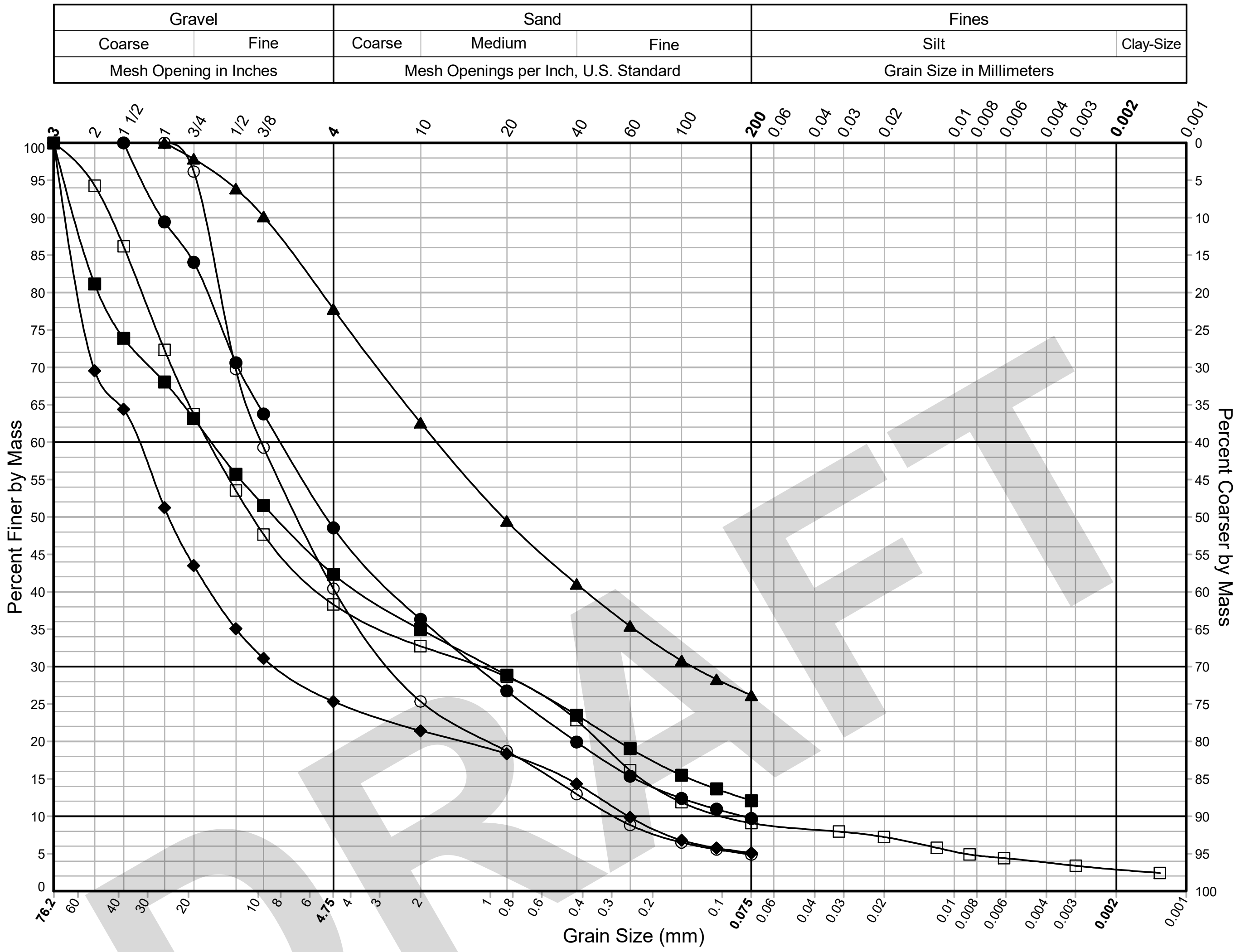
** Test specimen did not meet minimum mass recommendations.*

[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, and <2um% values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

GRAIN SIZE DISTRIBUTION PLOT

Cascade Mill Parkway
Yakima, Washington

BORING B-13-21

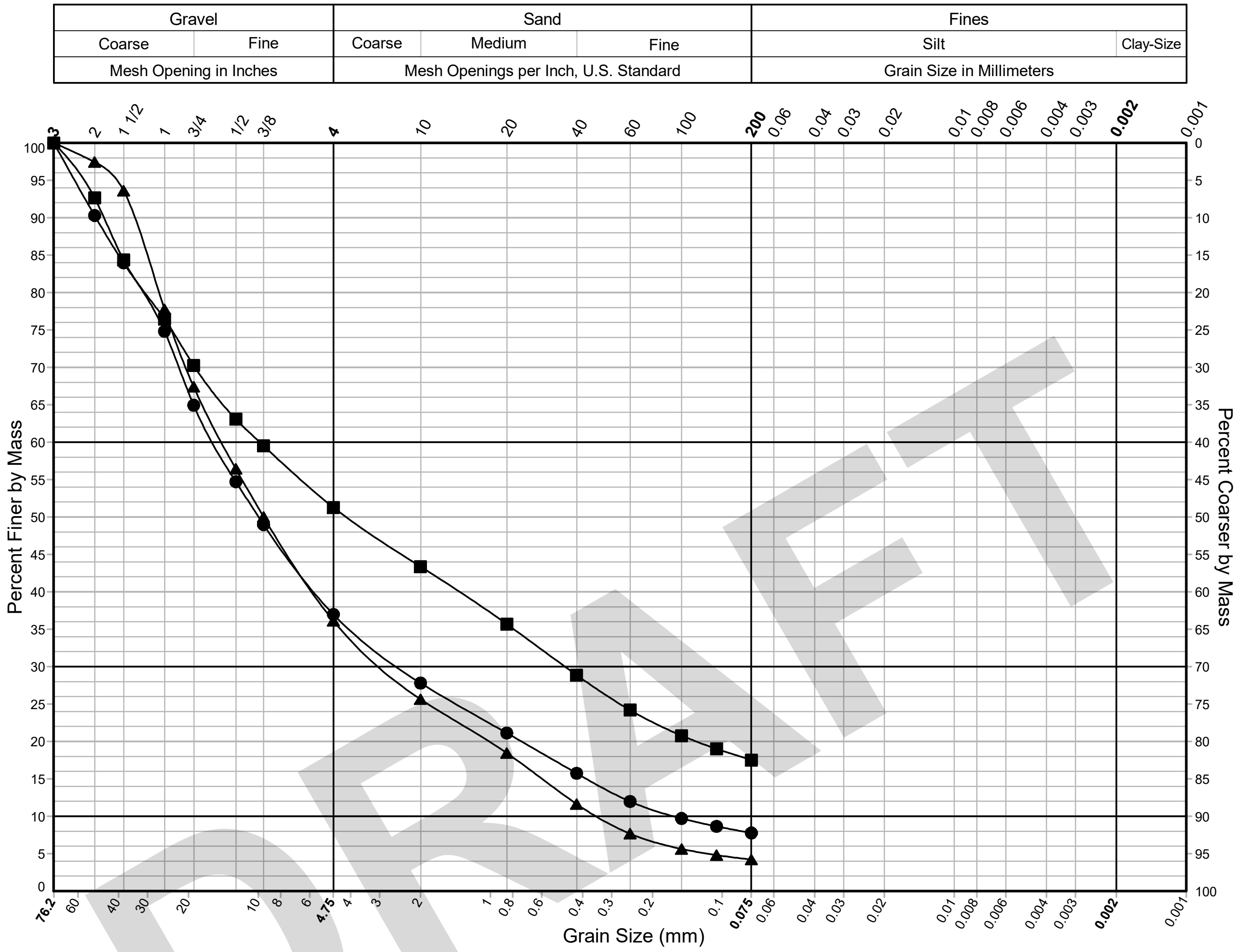


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-13-21, R-2[*]	9.0	GW-GM	Well-Graded Gravel with Silt and Sand	51	39	9.7			3.4	SJD	AKV	D6913
■ B-13-21, R-5[*]	23.0	GM	Silty Gravel with Sand	58	30	12			3.0	SJD	AKV	D6913
▲ B-13-21, R-9[*]	40.0	SM	Silty Sand with Gravel	22	52	26			5.1	SJD	AKV	D6913
◆ B-13-21, R-9[*]	46.0	GP-GM	Poorly Graded Gravel with Silt and Sand	75	20	5.1			3.7	SJD	AKV	D6913
○ B-13-21, R-10[*]	59.0	GW	Well-Graded Gravel with Sand	60	36	4.9			7.5	SJD	AKV	D6913
□ B-13-21, R-11	64.0	GP-GM	Poorly Graded Gravel with Silt and Sand	62	29	9.1	7	3	9.9	SJD	AKV	D422

[*] Test specimen did not meet minimum mass recommendations.
[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, and <2um% values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

Cascade Mill Parkway
Yakima, Washington

BORING B-14-21



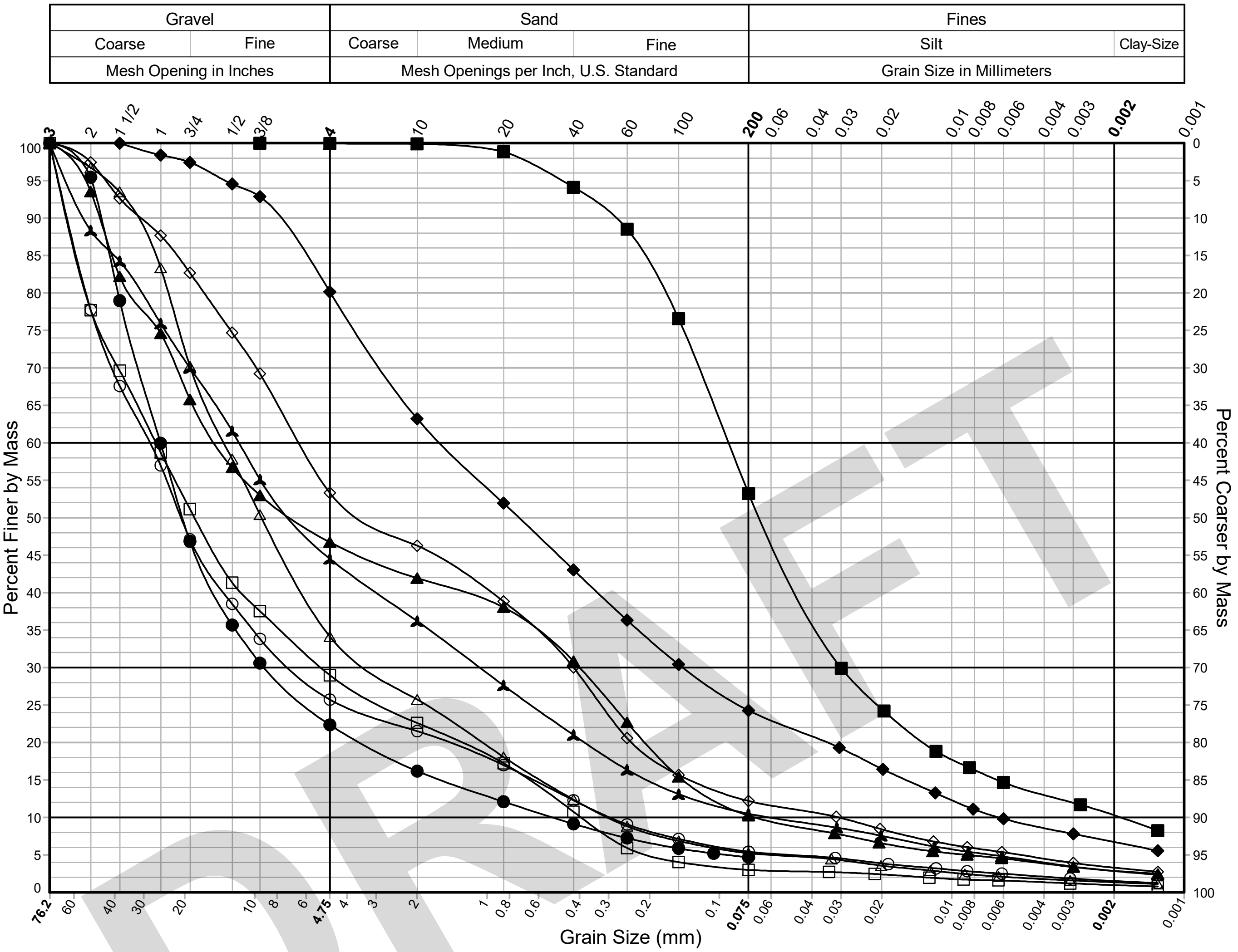
Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %[2]	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-14-21, R-3*	10.0	GW-GM	Well-Graded Gravel with Silt and Sand and Cobbles	9	63	29	7.8			3.0	BXK	AKV	D6913
■ B-14-21, R-7*	30.0	GM	Silty Gravel with Sand and Cobbles	5	49	34	18			2.8	BXK	AKV	D6913
▲ B-14-21, R-8*	39.0	GW	Well-Graded Gravel with Sand		64	32	4.2			3.6	BXK	AKV	D6913

** Test specimen did not meet minimum mass recommendations.*
[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, and <2um% values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

GRAIN SIZE DISTRIBUTION PLOT

Cascade Mill Parkway
Yakima, Washington

BORING B-15P-21



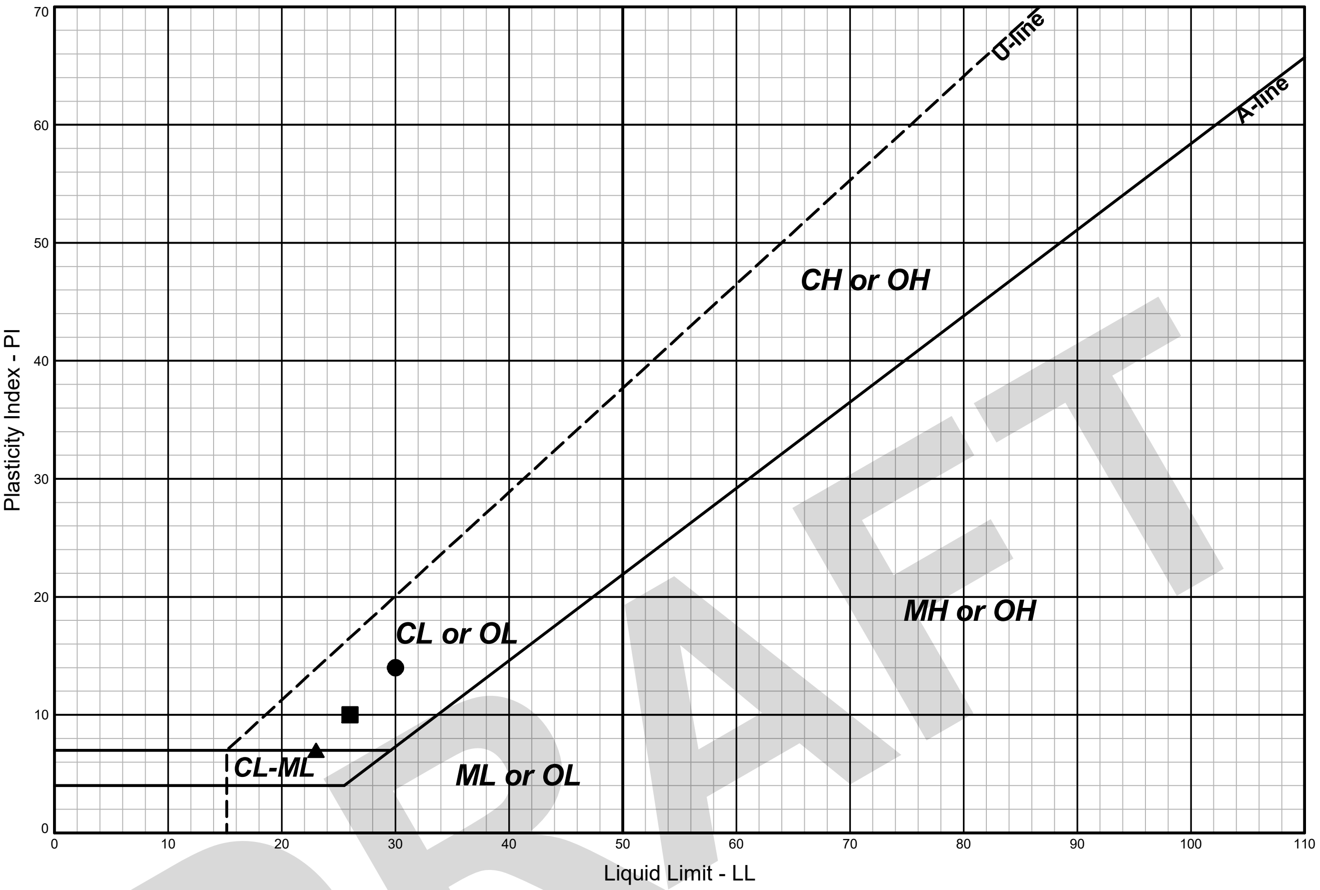
Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %^{2}	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-15P-21, R-1*	0.0	GP	Poorly Graded Gravel with Sand		78	18	4.7			1.9	BXK	AKV	D6913
■ B-15P-21, R-2	8.0	ML	Sandy Silt		0	47	53	24	10	14.5	SJD	AKV	D422
▲ B-15P-21, R-3	10.0	GP-GM	Poorly Graded Gravel with Silt and Sand		53	37	10	7	3	3.3	SJD	AKV	D422
◆ B-15P-21, R-4	15.0	SM	Silty Sand with Gravel		20	56	24	16	7	4.2	SJD	AKV	D422
○ B-15P-21, R-4	16.0	GP-GM	Poorly Graded Gravel with Silt and Sand and Cobbles	15	74	20	5.4	4	2	4.2	SJD	AKV	D422
□ B-15P-21, R-4	17.5	GW	Well-Graded Gravel with Sand		71	26	3.0	2	1	5.8	SJD	AKV	D422
△ B-15P-21, R-5	21.0	GW-GM	Well-Graded Gravel with Silt and Sand		66	29	5.2	4	1	5.0	SJD	AKV	D422
◇ B-15P-21, R-6	25.0	GP-GM	Poorly Graded Gravel with Silt and Sand and Cobbles	19	47	41	12	8	3	8.8	SJD	AKV	D422
⅄ B-15P-21, R-6	27.5	GW-GM	Well-Graded Gravel with Silt and Sand and Cobbles	7	55	34	10	8	3	8.0	SJD	AKV	D422

** Test specimen did not meet minimum mass recommendations.*
[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, and <2um% values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

PLASTICITY CHART

Cascade Mill Parkway
Yakima, Washington

BORING B-09-21

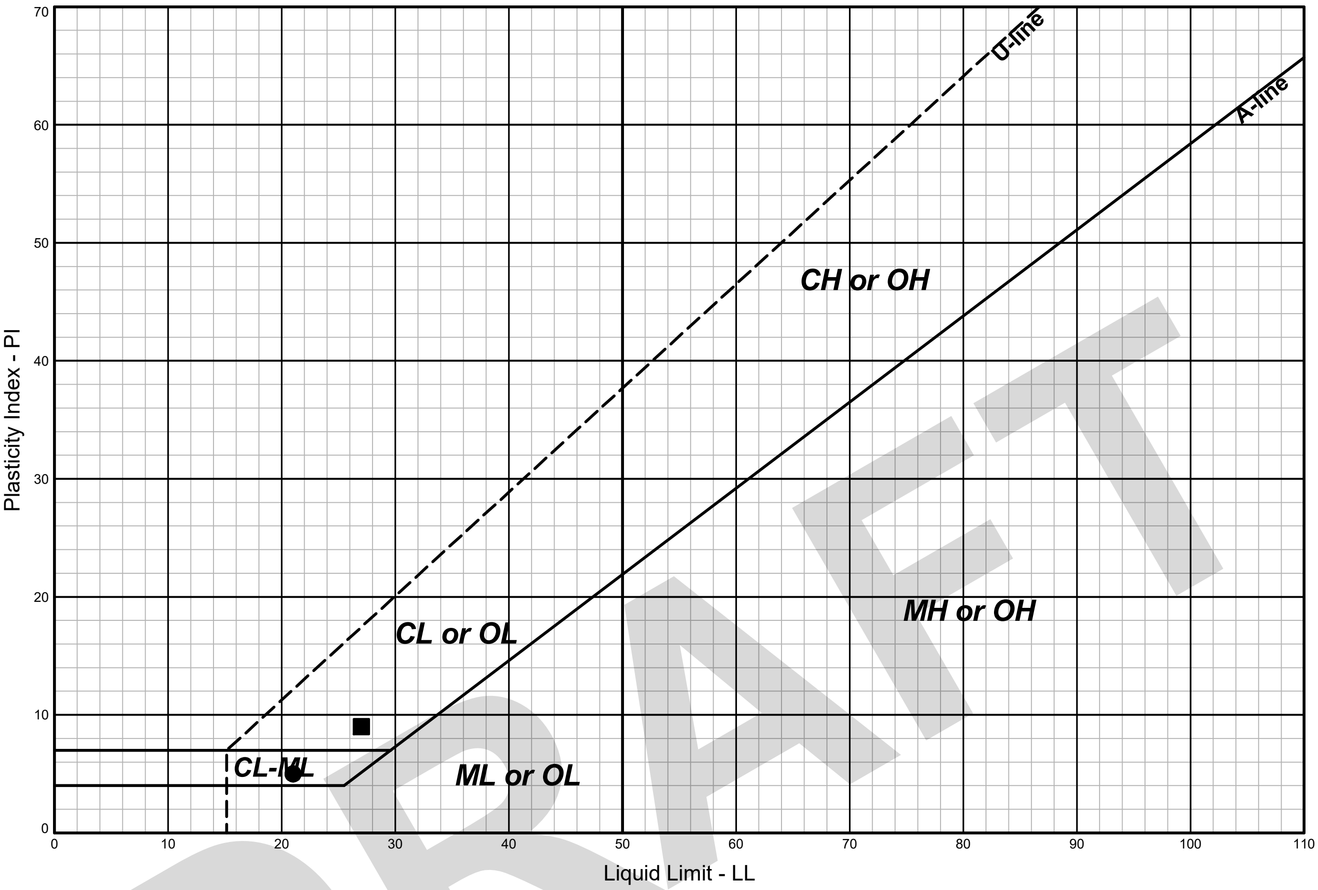


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2μm %	Tested By	Review By	ASTM Std.
● B-09-21, R-12	61.5	CL	Sandy Lean Clay with Gravel	30	16	14	15.5					DES	AKV	D4318
■ B-09-21, R-12	66.0	SC	Clayey Sand with Gravel	26	16	10	11.1					BXK	AKV	D4318
▲ B-09-21, R-15	92.0	SC-SM	Silty, Clayey Sand with Gravel	23	16	7	12.7					MXC	AKV	D4318

PLASTICITY CHART

Cascade Mill Parkway
Yakima, Washington

BORING B-11P-21

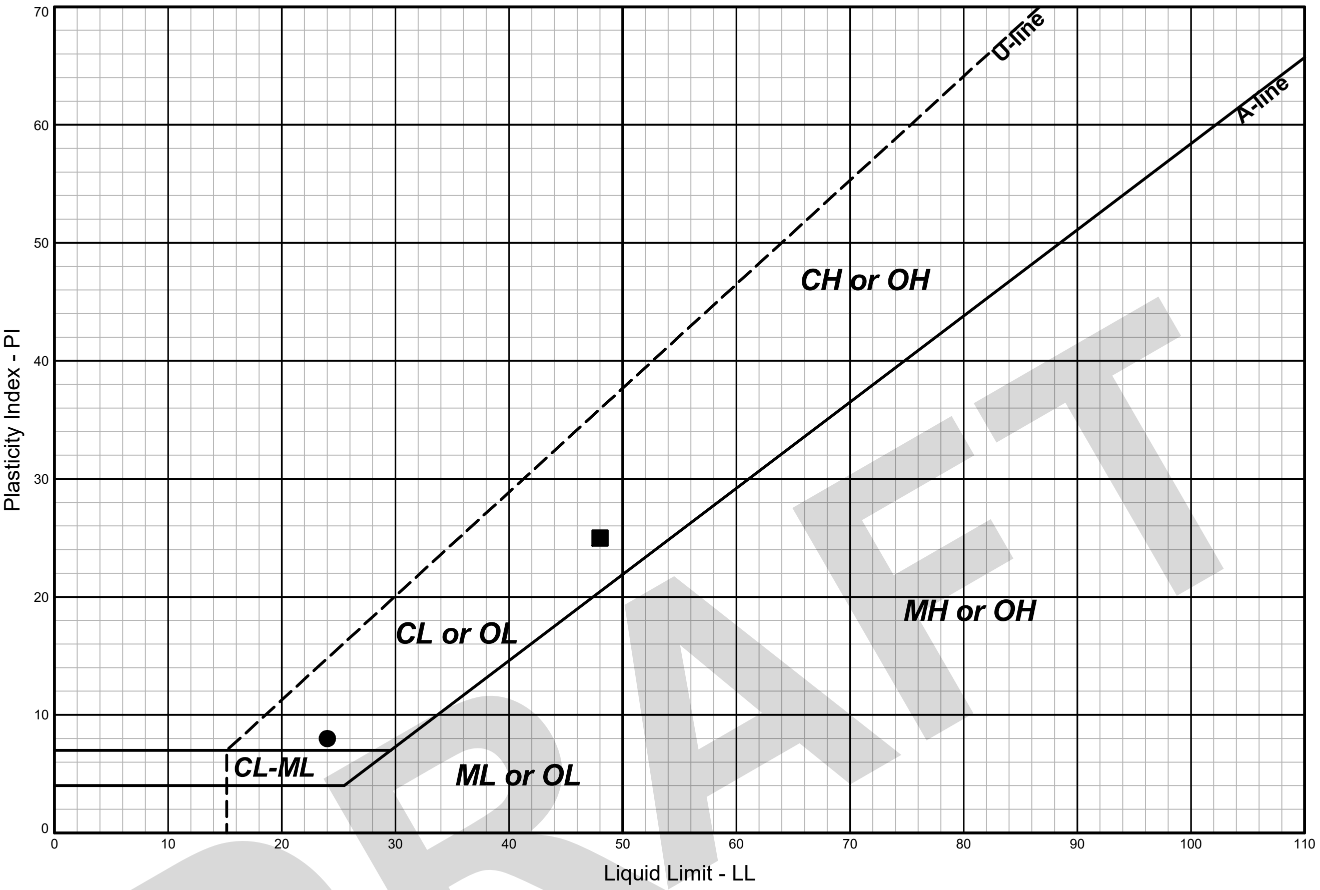


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2µm %	Tested By	Review By	ASTM Std.
● B-11P-21, R-7	32.0	SC-SM	Silty, Clayey Sand with Gravel	21	16	5						BXK	AKV	D4318
■ B-11P-21, R-12	72.5	GC	Clayey Gravel with Sand	27	18	9	9.3	51	29	20		BXK	AKV	D4318

PLASTICITY CHART

Cascade Mill Parkway
Yakima, Washington

BORING B-12P-21

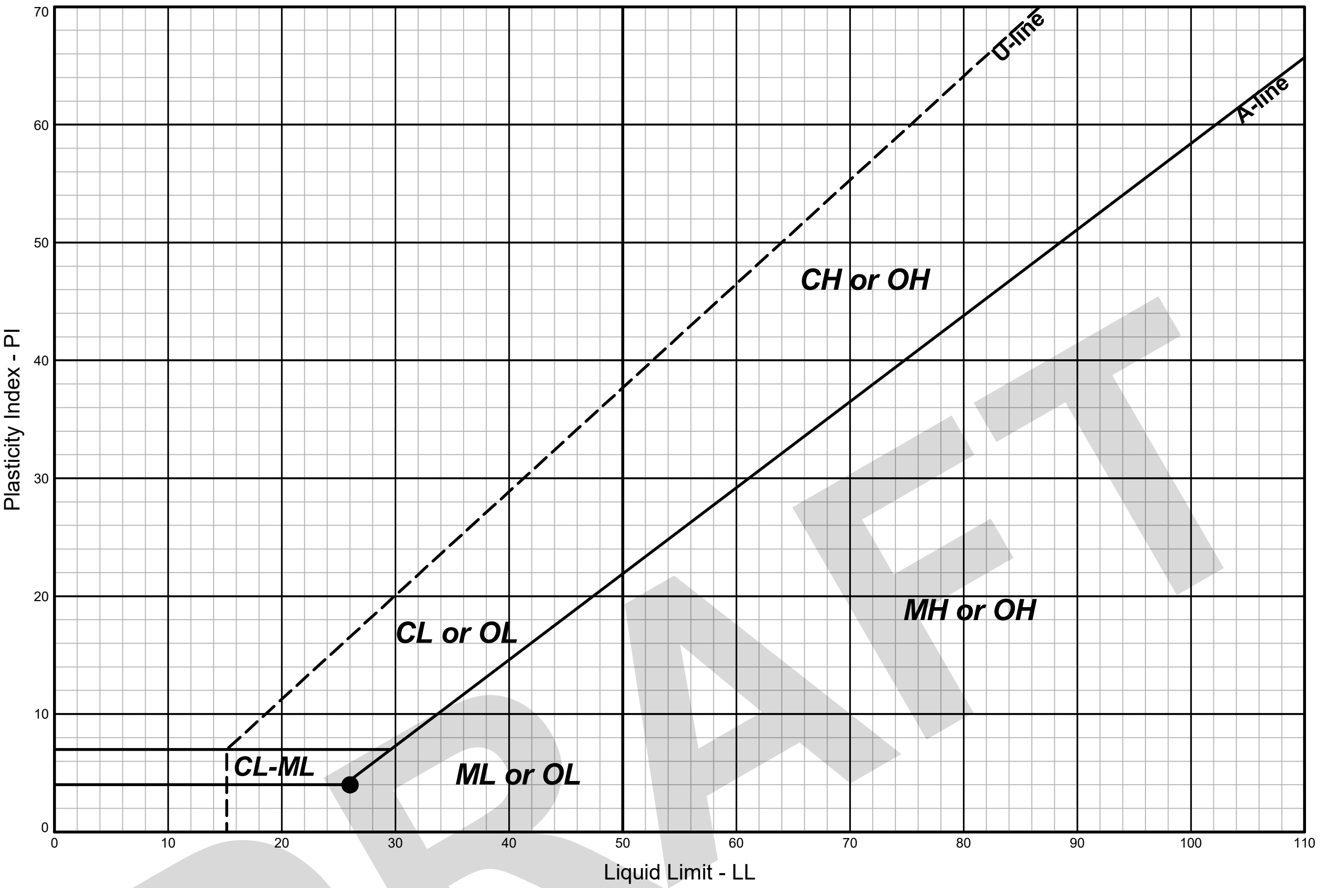


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2µm %	Tested By	Review By	ASTM Std.
● B-12P-21, R-12	62.0	SC	Clayey Sand with Gravel	24	16	8	9.4					BXK	AKV	D4318
■ B-12P-21, R-14	84.0	CL	Lean Clay	48	23	25	33.2					MXC	AKV	D4318

PLASTICITY CHART

Cascade Mill Parkway
Yakima, Washington

BORING B-15P-21



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2µm %	Tested By	Review By	ASTM Std.
● B-15P-21, R-2	8.0	ML	Sandy Silt	26	22	4	14.5	0	47	53	10	BXK	AKV	D4318

Appendix C

2014 and 2017 Subsurface Data

CONTENTS

APPENDIX C: 2014 AND 2017 SUBSURFACE DATA

Figures

Tables

Tests

C.1 SUBSURFACE EXPLORATIONS

C.1.1 Introduction

The subsurface exploration program for the Stage 3 portion of the East-West Corridor (EWC) alignment consisted of drilling and sampling seven borings and excavating and collecting samples in one test pit. Four borings, designated EWC-B-01-14 through EWC-B-04-14 were completed in 2014 during the 30% design phase and the remaining explorations were completed between July and September 2017 and September 2018 (boring B-3-18).

We advanced the seven borings, designated B-1-17, B-2-17, B-3-18, and EWC-B-01-14 through EWC-B-04-14, to depths ranging between 40 to 140 feet. We installed observation wells in B-2-17 and in EWC-B-01-14 through EWC-B-04-14.

We excavated the test pit TP-P1-17 to design drainage facilities to approximately to 8.5 feet below ground surface (bgs). After completion, the test pit was backfilled with the excavation spoils and tamped with the excavator bucket at the ground surface.

Approximate locations of the borings and tests pits were recorded in the field using a hand-held Trimble global positioning system device. The locations of the explorations are shown in Figure 2, after the main text. The exploration locations and elevations should be considered accurate to the degree implied by the method used.

C.1.2 Soil Classification

A representative from Shannon & Wilson was present throughout the field explorations to observe the drilling, test pit, and sampling operations; retrieve representative soil samples for subsequent laboratory testing; and to prepare descriptive field logs of the explorations. Soil sample classifications were based on ASTM Designation D2487, Standard Practice for Classification of Soils for Engineering Purposes, and ASTM Designation D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). The Unified Soil Classification System, as described in Figure A-1 of this appendix, was used to classify the soil. The exploration logs in the report represent our interpretation of the contents of the recent field logs.

C.1.3 Soil Borings

C.1.3.1 Sonic Core Drilling Procedures

Holt Services Inc. of Edgewood, Washington, drilled the soil borings under subcontract to Shannon & Wilson using a Terra Sonic track-mounted drill rig, outfitted with an automatic hammer. The sonic core drilling method uses high-frequency vibratory motion applied to the top of the drill column, along with down-pressure and rotation, to obtain nearly continuous core samples in soil and rock.

Soil samples were obtained using a 4-inch-outside-diameter (OD) core barrel. As the drill column was advanced into the ground, soil entered the core barrel. After advancing the core barrel a distance of 5 feet (termed a core "run"), a 6-inch OD temporary casing was vibrated to the bottom of the sample interval. The drill column and core barrel were then removed from the borehole and the soil core was extracted from the core barrel into plastic bags. Soil recovered from each run was described in the field and logged by our geologist. The soil sample bags were then sealed to retain moisture and stored in core boxes for transport. After retrieval of the soil core for a specific interval, the casing was cleared of slough and the drill column and core barrel were advanced, starting at the bottom of the temporary casing.

C.1.3.2 Split-Spoon Soil Samples

Disturbed soil samples were obtained from the borings by a split-spoon sampler used in conjunction with a Standard Penetration Test (SPT) and the sonic core barrel. To obtain disturbed soil samples from the borings, SPTs were performed in general accordance with the ASTM Designation D1586, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils. The SPTs were generally performed at 5-foot intervals in between sonic core runs. The SPT consists of a 2-inch OD, 1.375-inch-inside-diameter, split-spoon sampler driven 18 inches into the bottom of the borehole with a 140-pound hammer free falling 30 inches. The number of blows required to advance the split-spoon sampler the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). This value is an empirical parameter that provides a means of evaluating the relative density or compactness of cohesionless (granular) soils and the relative consistency (stiffness) of cohesive soils. This value is commonly used in engineering analyses to estimate soil strength and other characteristics. The terminology used to describe the relative density or consistency of the soils is presented in Figure A-1. Generally, when penetration resistances exceed 50 or more blows for 6 inches or less of penetration, the test is terminated, and the number of blows and corresponding penetration recorded. The N-values were recorded by our field representative and are plotted in the boring logs presented as Figures C-2 through C-8.

The split-spoon sampler used during the penetration test recovers a disturbed sample of the soil, which is useful for identification and classification purposes. The samples were classified and recorded in the field by our geologist. The samples were then sealed in jars to retain moisture and returned to our laboratory for testing.

C.1.3.3 Sonic Core Soil Review

Soil recovered from sonic core drilling was reviewed for identification and classification purposes and photographed in our warehouse. Grab samples were collected during our review and placed in labeled plastic jars and 5-gallon plastic bags, sealed, and transported to our laboratory for further analysis and testing.

C.1.4 Test Pit Excavation

C.1.4.1 Test Pit Excavation Procedures

Test pit TP-P1-17 was excavated on September 27, 2017, by Yakima County Maintenance staff using a John Deere 410L rubber-tired backhoe. Test pit depth was approximately 8.5 feet bgs. Yakima County Maintenance staff backfilled the test pits with the excavation spoils in approximately the same order as it was removed from the hole. The surface of the test pit backfill was tamped with the back of the backhoe bucket for compaction.

C.1.4.2 Soil Sampling

Representative disturbed soil samples from the soil layers encountered in the test pits were collected from the backhoe bucket or spoil pile. A Shannon & Wilson representative was present throughout the test pit excavation to collect the grab samples, visually classify the soil, and prepare an exploration log for each test pit. After soil classification, the samples were sealed in jars or 5-gallon bags to retain moisture and returned to our laboratory for analyses.

The intervals where these samples were collected are shown on the test pit log presented in Figure C-9. Figure C-1 presents a soil description and symbology key for the logs.

C.2 GEOTECHNICAL LABORATORY TEST PROCEDURES AND RESULTS

C.2.1 Introduction

We performed geotechnical laboratory testing on select soil samples retrieved from the borings and test pits completed for the final design phase of this project. The laboratory testing program included tests to classify the soil and provide data for engineering studies.

We performed visual classification on all retrieved samples. Our laboratory testing program included water content determinations and grain-size distribution analyses.

The following sections describe the laboratory test procedures.

C.2.2 Visual Classification

We visually classified soil samples retrieved from the borings using a system based on ASTM D2487-11, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM D2488-09a, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). We summarize our classification system in Appendix A. We assigned a Unified Soil Classification System (USCS) group name and symbol, based on our visual classification of particles finer than 76.2 millimeters (3 inches). We revised visual classifications using results of the index tests discussed below.

C.2.3 Water Content Determination

We tested the water content of selected samples in accordance with ASTM D2216-10, Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. Comparison of the water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. We present water content test results in the Laboratory Test Summary table in this appendix, and graphically on Appendix A exploration logs.

C.2.4 Grain-Size Analyses

Grain-size distribution analyses separate soil particles through mechanical or sedimentation processes. Grain-size distributions are used to classify the granular component of soils and can correlate with soil properties, including frost susceptibility, permeability, shear strength, liquefaction potential, capillary action, and sensitivity to moisture. We plot grain-size distribution analysis results in this appendix. Grain-size distribution plots provide tabular information about each specimen, including USCS group symbol and group name; water content; constituent (i.e., cobble, gravel, sand, and fines) percentages; coefficients of uniformity and curvature, if applicable; personnel initials; ASTM standard designation; and testing remarks. Constituent percentages are presented in the Lab Summary Table in this appendix and fines contents are plotted as data points on Appendix A exploration logs.

C.2.4.1 Sieve Analysis

We performed mechanical sieve analyses on selected soil specimens to determine the grain-size distribution of coarse-grained soil particles, in accordance with ASTM C136/C136M-14, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

C.2.4.2 Combined Analysis

We performed combined analyses (mechanical and sedimentation) on selected soil specimens to determine the grain-size distribution of coarse- and fine-grained soil particles, in accordance with ASTM D422-63 2007e2, Standard Test Method for Particle-Size Analysis of Soils. We assumed a specific gravity of 2.7 for hydrometer calculations, unless otherwise indicated on grain-size distribution plots.

C.2.5 Considerations

Drilling and sampling methodologies may affect the outcome of prescribed geotechnical laboratory tests. Refer to the field exploration discussion in this report for a discussion of these potential effects. Instances of limited recovery may have resulted in test samples not meeting specified minimum mass requirements, per ASTM standards. Test plots show which samples do not meet ASTM specified minimum mass requirements.

C.3 PILOT INFILTRATION TEST AND PROCEDURES

C.3.1 Introduction

Shannon & Wilson performed one Pilot Infiltration Test (PIT) within Stage 3 of the East-West Corridor Project on September 27, 2017. The approximate locations of this PIT test pit, designated TP-P1-17, is shown in Figure 2 in the main report.

C.3.2 Infiltration Evaluation

We estimated the long-term design infiltration rates for the proposed infiltration systems along the EWC alignment. The infiltration evaluation was completed according to the 2004 Washington State Department of Ecology (Ecology) Stormwater Management Manual for Eastern Washington (SMMEW) (Ecology, 2004) and the Yakima County Regional Stormwater Manual (Yakima County, 2010). The Ecology 2012 Stormwater Management Manual for Western Washington (Ecology, 2012) was used as a supplement to the SMMEW when limited information was available.

We estimated long-term design infiltration rates for Stage 3 of the EWC using the results of the PIT conducted in test pit TP-P1-17. We also used empirical correlations to grain-size analysis data for comparison purposes. Both PIT and grain-size analysis-based infiltration rate estimation methods result in short-term rates. We estimated the long-term design infiltration rates by applying correction factors to the short-term infiltration rates.

Section C.3.3 describes the PIT procedure and methods for estimating the long-term design infiltration rates using the results of the PIT and grain-size distributions. The grain-size distribution curves are shown at the end of this Appendix.

Tables C-1 and C-2 provide estimated short-term and long-term design infiltration rates. As indicated in these tables, the PIT infiltration rate results were higher compared to the empirical correlations. Based on the range of infiltration rates we obtained, we recommend using a design infiltration rate of 10 inches per hour for the Stage 3 infiltration facility near test pit TP-P1-17. Although lower values were obtained based on several of the empirical grain-size distribution-based infiltration rate estimates (Table 2), we consider the PIT to be more representative of the likely infiltration rate behavior at TP-P1-17. Therefore, our design infiltration rate recommendation is weighted toward the PIT-based results.

The long-term design infiltration rates presented in this report meet the requirements for flow control for the Ecology SMMEW and the Yakima County Regional Stormwater Manual. The design infiltration rates are for flow control only and assume a pretreatment system will be used to meet water quality requirements. Both the SMMEW and the Yakima County Regional Stormwater Manual require a maximum infiltration rate of 2.4 inches per hour for infiltration systems designed to meet treatment standards. The base of the proposed infiltration systems should be a minimum of 5 feet above the seasonally high groundwater level.

C.3.3 Pilot Infiltration Test Procedures

The PIT was performed in accordance with the Ecology 2004 SMMEW (Ecology, 2004). The procedure consisted of excavating a test pit to the proposed depth of the infiltration facility, adding water to the test pit, and measuring the drainage time of the water.

We determined the depth of the infiltration structures at each location using a grading plan provided by H.W. Lochner that described the final grade of the locations where water will be infiltrated. Based on correspondence with Lochner, we assume the maximum depth of the infiltration facility will be about 6 feet bgs. Therefore, the depth for the PIT was targeted at 8.5 feet bgs.

The Yakima County Maintenance staff used a John Deere 410L rubber-tired backhoe to excavate the test pits to the dimensions shown in Table 1 in the main report. Water was conveyed to the test pits from a 3,000-gallon water truck with a 2-inch fire hose and plastic pipe. The flow rate was regulated using a gate valve and measured using a flow meter. A measuring rod was placed in the test pit to measure the depth of the water.

The PIT included a constant rate test and a falling head test. The constant rate test was performed by filling the test pit to a constant level and taking flow rate and water level readings every 15 minutes until the flow rate and water level remained constant, or a minimum of 2 hours had passed. After the constant rate test was complete, a falling head test was performed by turning off the water and recording the rate that water in the test pit drained. Water level measurements were recorded approximately every 15 minutes during the falling head tests.

C.3.4 Short-Term Pilot Infiltration Test Results

The water level was brought up to and maintained at approximately 1 to 2 feet above the bottom of the test pit over the course of 2 hours. As shown in Table 1, the short-term falling head infiltration rate was evaluated to be about 50 inches per hour.

C.3.5 Grain-Size Data Evaluation Procedure

The SMMEW recommends using grain-size data to estimate the infiltration rate of soil; however, it provides limited information on how to estimate the infiltration rate from grain-size data. We used an analytical solution from the Ecology Stormwater Management Manual for Western Washington (SMMWW) (Ecology, 2012) to estimate the infiltration rate of soil using the grain-size data. The analytical solution used to calculate the saturated hydraulic conductivity from the grain-size data is:

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

Ksat = saturated hydraulic conductivity

D10, D60, and D90 = grain size in millimeters for which 10, 60, and 90% of the sample is more fine

ffines = fraction of soil (by weight) that passes the number 200 sieve

C.3.6 Long-Term Design Infiltration Rate Correction Factors

The SMMEW provides limited recommendations for what correction factors to apply to short-term infiltration rates to estimate long-term design infiltration rates. We used the recommended correction factors from the SMMWW to apply to the short-term infiltration rates to obtain long-term design infiltration rates. The correction factors include:

CFv, site variability and number of locations tested. Recommended CFv values range from 0.33 to 0.9.

CFt, uncertainty of test method. Recommended CFt is 0.5 for a small-scale PIT Method and 0.4 for grain-size method.

CFm, degree of influent control to prevent siltation and biological buildup. The CFm value correlates to the percentage of the design infiltration rate that the pond will decrease to before maintenance occurs. For example, if an infiltration pond is cleaned after it infiltrates at 90% of the design infiltration rate, then the CFm correction factor would be 0.9. The 2012 SMMWW does not provide a recommended range of CFm values.

A total correction factor (CFT) is calculated by finding the product of the correction factors for site variability (CFv), uncertainty of test method (CFt), and influent control (CFm). The short-term infiltration rate is multiplied by the CFT to determine the long-term design infiltration rate.

$$\mathrm{CF_T} = \mathrm{CF_v} \text{ x } \mathrm{CF_t} \text{ x } \mathrm{CF_m}$$

$$\mathrm{CF_T} \text{ x Short Term Infiltration Rate} = \text{Long Term Design Infiltration Rate}$$

Our recommended correction factors for the infiltration evaluation are as follows:

CFv = 0.7

CFt = 0.5 for the PIT and 0.4 for the grain-size analysis

CFm = 0.7

Therefore, CFT equals 0.25 for the PIT and 0.20 for the grain-size analysis. Table 1 in the main text provides the long-term design infiltration rate results of the PIT evaluation, and Table 2 in the main text provides the long-term design infiltration rate results of the grain-size analysis.

C.4 REFERENCES

Washington State Department of Ecology (Ecology), 2004, Storm drainage design guideline for site characterization, in stormwater management manual for eastern Washington: Olympia, Wash., Washington State Department of Ecology Water Quality Program, Publication No. 004-10-076, Appendix 6B.

Washington State Department of Ecology (Ecology), 2012, Hydrologic analysis and flow control design/BMPs, in stormwater management in western Washington: Olympia, Wash., Washington State Department of Ecology Water Quality Program, Publication No. 12-10-030, v. III.

Yakima County, Wash., 2010, Yakima County regional stormwater manual: Yakima Wash., Yakima County: Yakima, Wash., Yakima County, January, available: http://www.yakimacounty.us/stormwater/.

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1] All percentages are by weight of total specimen passing a 3-inch sieve.
[2] The order of terms is: *Modifying Major with Minor*.
[3] Determined based on behavior.
[4] Determined based on which constituent comprises a larger percentage.
[5] Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm NOTE: If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND Fine Medium Coarse	 #200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.) #40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.) #10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL Fine Coarse	 #4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.) 3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS

▧	Bentonite Cement Grout	▦	Surface Cement Seal
▨	Bentonite Grout	■	Asphalt or Cap
▩	Bentonite Chips	▨	Slough
░	Silica Sand	▯	Inclinometer or Non-perforated Casing
▤	Perforated or Screened Casing	▮	Vibrating Wire Piezometer

PERCENTAGES TERMS [1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1] Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

East-West Corridor Project
Stage 3
Yakima, Washington

SOIL DESCRIPTION AND LOG KEY

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-1
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW	●	Well-Graded Gravel; Well-Graded Gravel with Sand
			GP	○	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM	●	Silty Gravel; Silty Gravel with Sand
			GC	▨	Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW	⁘	Well-Graded Sand; Well-Graded Sand with Gravel
			SP	⁘	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM	▥	Silty Sand; Silty Sand with Gravel
			SC	▨	Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	▥	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	▨	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL	▤	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	▥	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH	▨	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH	▨	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	≈	Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).
2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

East-West Corridor Project
Stage 3
Yakima, Washington

SOIL DESCRIPTION AND LOG KEY

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-1
Sheet 2 of 3

SOIL_CLASS_KEY_PG2 21-22425.GPJ SHAN_WIL.GDT 8/16/19

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASTICITY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

---

[1] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

[2] Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

East-West Corridor Project
Stage 3
Yakima, Washington

SOIL DESCRIPTION AND LOG KEY

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-1
Sheet 3 of 3

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

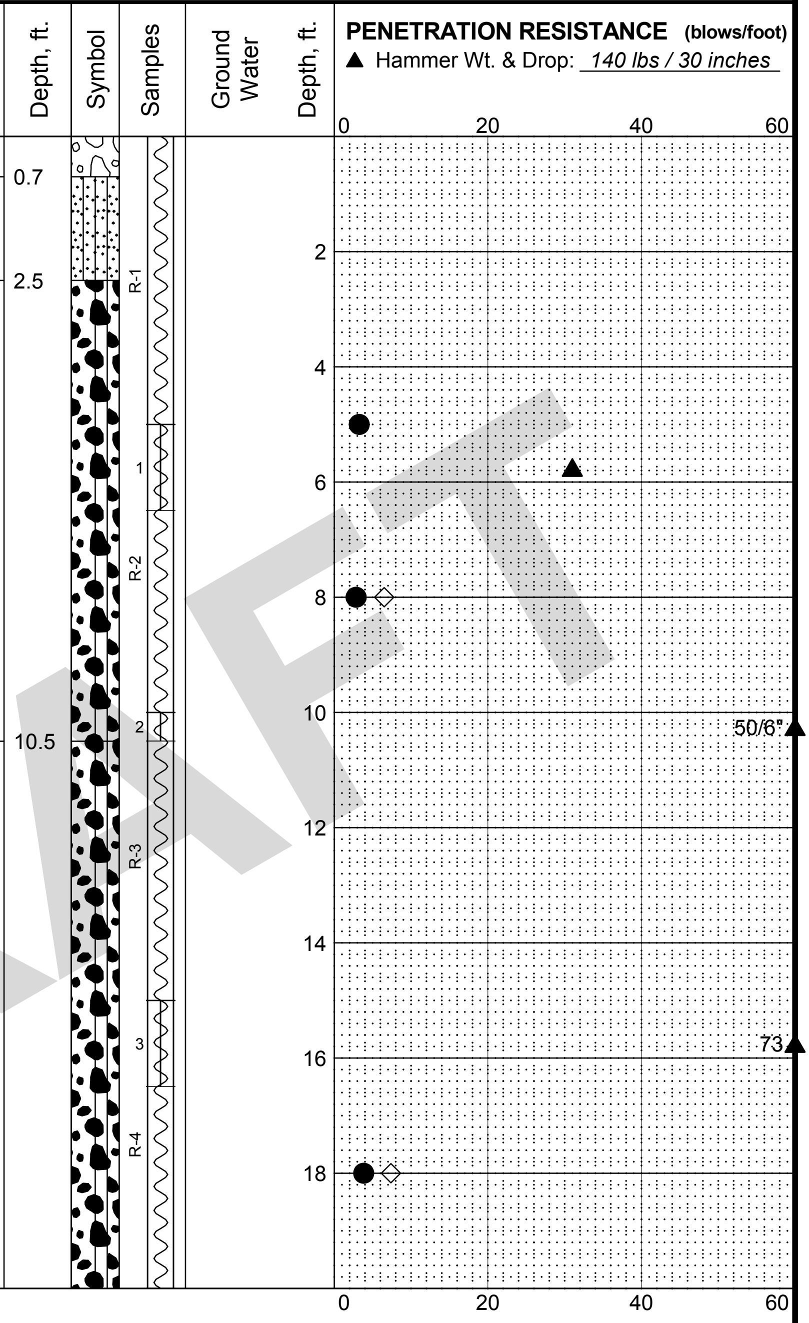
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Dense, gray, *Poorly Graded Gravel with Sand (GP)*; dry; fine to coarse subangular to angular gravel; fine to coarse sand; trace nonplastic fines.
Fill (Hf)

Dense, dark brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subangular to angular gravel; fine to coarse sand; nonplastic fines; trace iron-oxide staining; diamict.
Fill (Hf)
- Layer of poorly graded sand with silt at 2 feet.

Dense to very dense, *Well Graded Gravel with Silt and Sand and Cobbles (GW-GM)* to *Poorly Graded Gravel with Sand and Cobbles (GP)*; moist; few subrounded to subangular cobbles; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic fines; trace seams of silty gravel with sand; trace iron-oxide staining.
Fill (Hf)
- layer of poorly graded sand with gravel from 10 to 10.5 feet.

Very dense, gray, *Well Graded Gravel with Silt and Sand (GW-GM)*; moist; few rounded cobbles; fine to coarse, subangular to subrounded gravel; medium to coarse sand; trace fine sand; trace iron-oxide staining throughout.
Fill (Hf)
- Lenses of drier, sandier gravel from 15.9 to 16 feet and 16.2 to 16.4 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▽ Ground Water Level ATD
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 1 of 8

REV 3 - Approved for Submittal

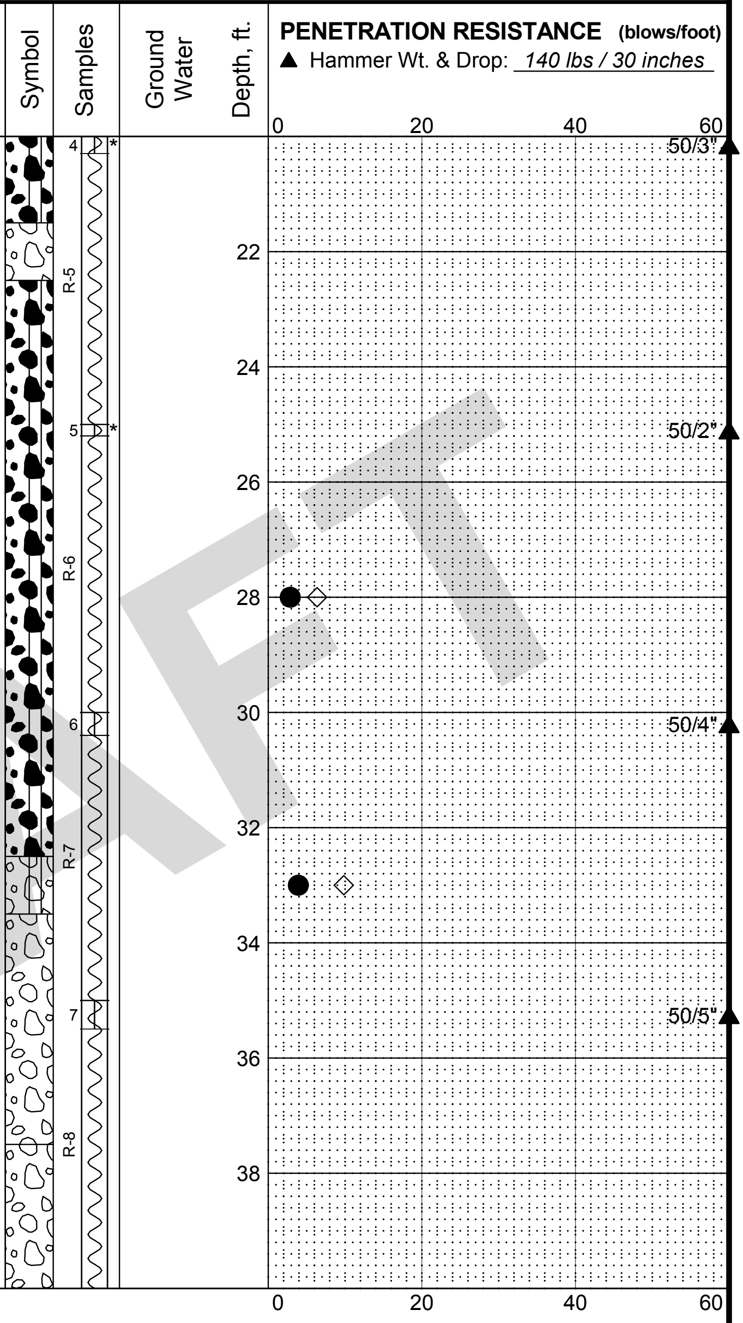
MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19
Log: BMC Rev: EAS Typ: LKN

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
	21.5
Very dense, brown, *Poorly Graded Gravel with Sand (GP)* to *Poorly Graded Sand with Gravel (SP)*; moist; fine to coarse subrounded to subangular gravel; fine to coarse sand; trace nonplastic fines. (Hf)	22.5
Very dense, gray, *Well Graded Gravel with Silt and Sand and Cobbles (GW-GM)*; moist; few subrounded to subangular cobbles; fine to coarse subrounded to subangular gravel; fine to coarse sand; trace nonplastic fines. (Hf) - layer of poorly graded sand with gravel from 25.2 to 25.8 feet. - Little cobbles below 27 feet. - Trace brick fragments at 32 feet.	32.5
Very dense, gray to brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; fine to coarse, subangular to subrounded gravel; fine to coarse sand; nonplastic fines; few wood fragments. Fill (Hf)	33.5
Very dense, gray, *Poorly Graded Gravel (GP)* to *Poorly Graded Gravel with Sand (GP)*; moist to wet; few to little rounded cobbles up to approximately 6-inch-diameter; fine to coarse, subrounded to rounded gravel; fine to coarse sand; trace nonplastic fines; trace organics over 30 feet.	37.5



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⊻ Ground Water Level ATD
⊠ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 2 of 8

Log: BMC Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:

Northing:
Easting:
Station:
Offset:

Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.

Alluvium (Ha)

Very dense, gray-brown, *Poorly Graded Gravel with Sand (GP)*; moist; fine to coarse subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Hf)
- Layer of silty sand with gravel from 40 to 40.5 feet.

45.0

Very dense, gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace metal wire.
(Hf)

46.0

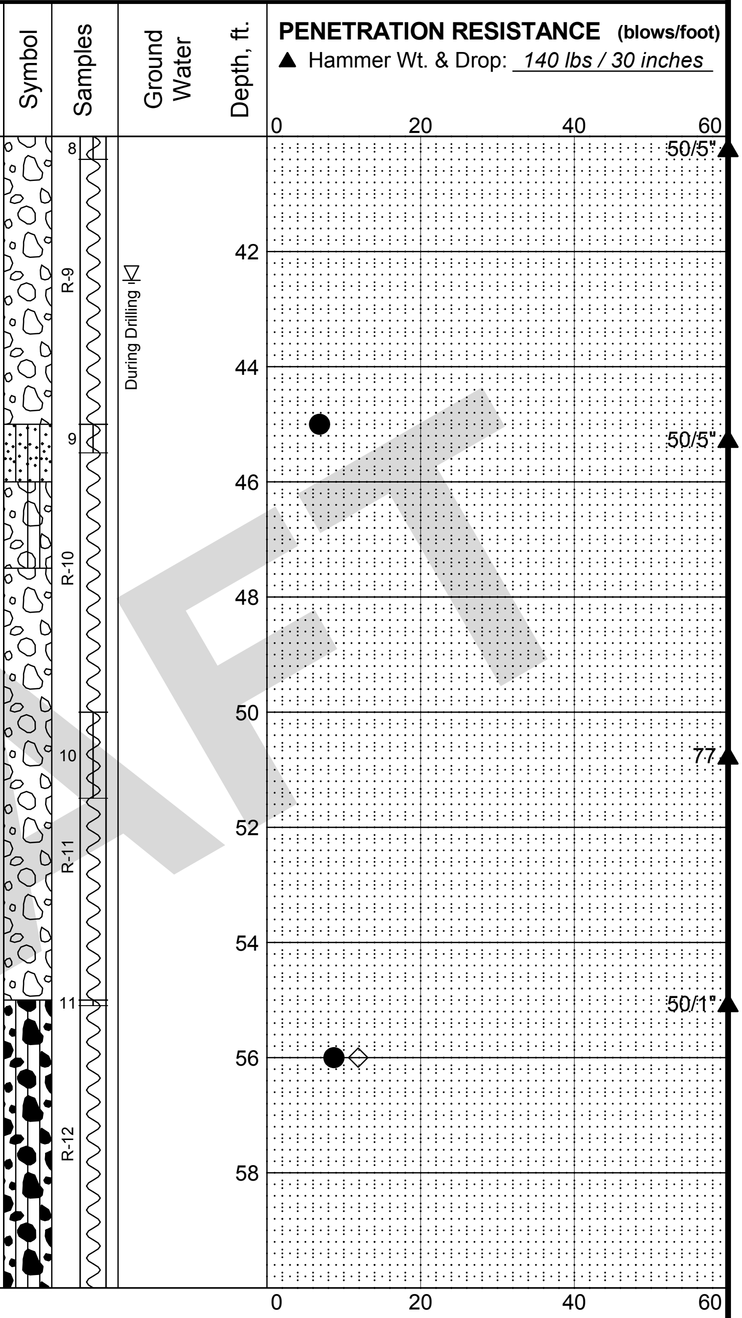
47.5

Very dense, gray-brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; moist; fine to coarse, subrounded to subanguálar gravel; fine to coarse sand; nonplastic fines.
Alluvium (Ha)

Very dense, brown, *Poorly Graded Gravel with Sand and Cobbles (GP)*; wet; few subangular cobbles; fine to coarse, subrounded gravel; fine to coarse sand trace nonplastic fines.
Alluvium (Ha)
- Few silty gravel wit sand pockets below 53 feet.
- Several core runs have approximately 0.4-foot-thick layer of sand to silty sand that fines upwards, looks like slough or other disturbed soils not representative of actual stratigraphy.

55.0

Very dense, brown and gray, *Silty Gravel with Sand and Cobbles (GM)* to *Poorly Graded Gravel with Silt and Sand (GP-GM)*; wet; trace subrounded cobbles; fine to coarse subrounded to rounded gravel; fine to coarse



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
$\underline{\nabla}$ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 3 of 8

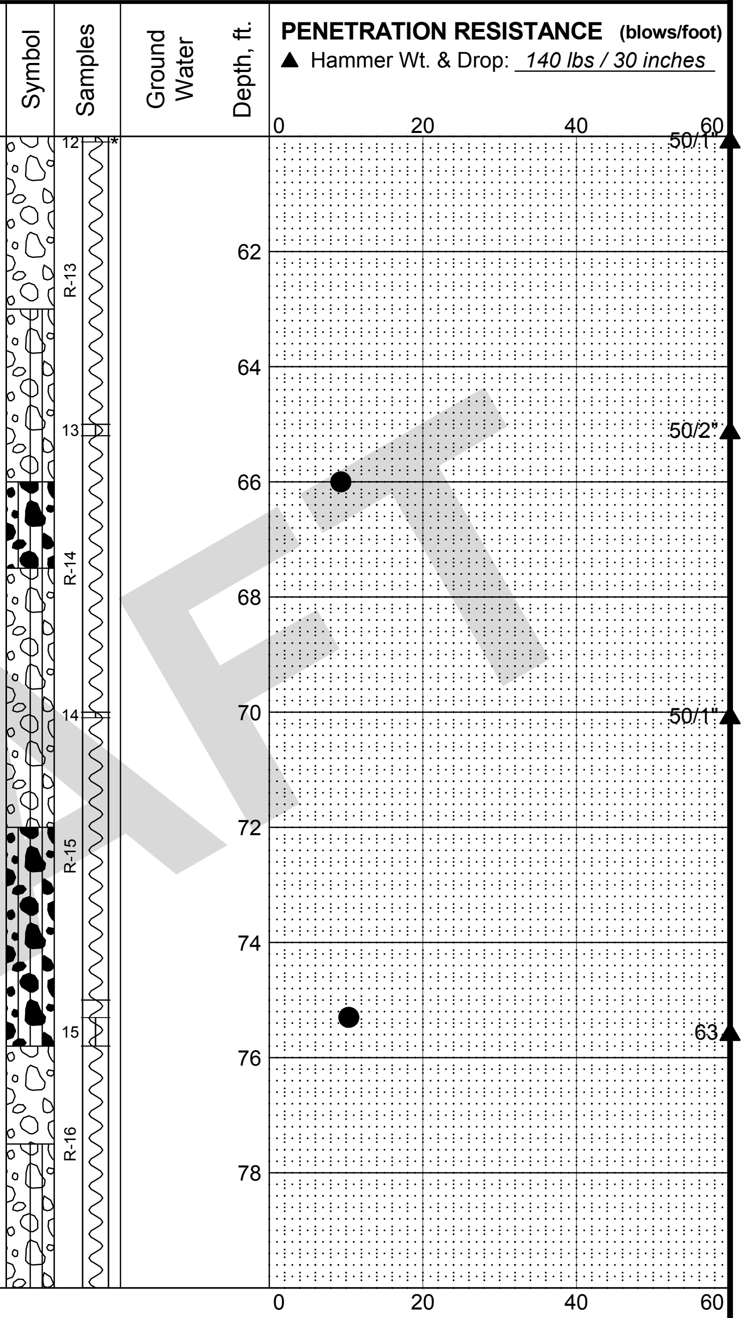
REV 3 - Approved for Submittal

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
sand; nonplastic to low plasticity fines; trace iron-oxide staining. Alluvium (Ha) - Layer of silty gravel with sand from 52.5 to 52.8 feet.	60.0
Very dense, gray *Poorly Graded Gravel (GP)*; wet; fewe subrounded cobbles; fine to coarse subrounded gravel trace sand. Alluvium (Ha)	63.0
Very dense, gray to brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; wet; trace subrounded cobbles; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines. Alluvium (Ha) - Layer of poorly graded gravel from 64 to 64.5 feet.	66.0 67.5
Very dense, gray-brown, *Silty Gravel with Sand (GM)* to *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines. Alluvium (Ha)	72.0
Very dense, gray-brown, *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)* to *Silty Gravel with Sand and Cobbles (GM)*; moist; trace subrounded cobbles; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines. Alluvium (Ha)	75.8
Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)* to *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)*; wet; trace subrounded cobbles; fine to coarse subrounded to subangular gravel; fine to	77.5



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
∇ Ground Water Level ATD
◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 4 of 8

Log: BMC Rev: EAS Typ: LKN

MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

REV 3 - Approved for Submittal

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:

Northing:
Easting:
Station:
Offset:

Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

coarse sand; nonplastic to low plasticity fines.
Alluvium (Ha)

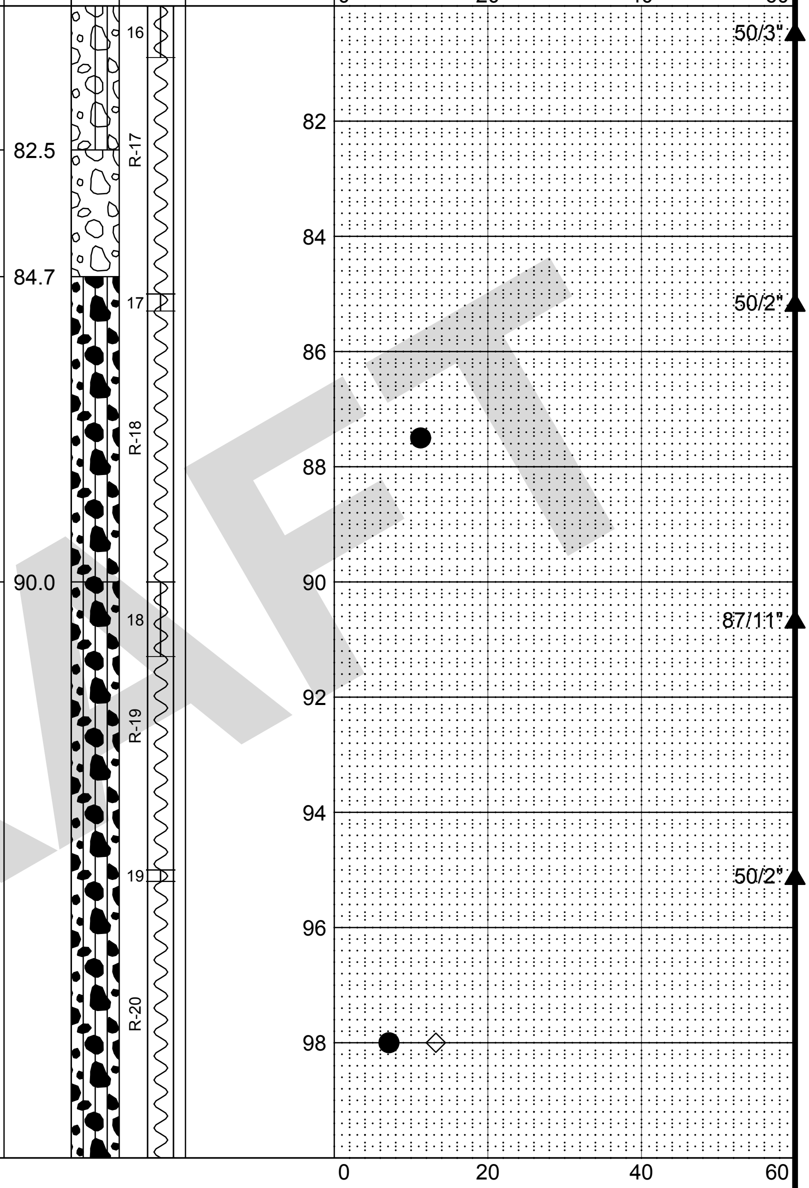
Very dense, brown, *Poorly Graded Gravel (GP)*; wet; fine to coarse, subangular to subrounded gravel; fine to coarse sand; trace low plasticity fines.
Allluvium (Ha)

Very dense, yellow-brown, *Poorly Graded Gravel with Silt and Sand and Cobbles (GP-GM)*; wet; few subrounded to subangular cobbles; fine to coarse subrounded to subangular gravel; fine to coarse sand; low plasticity fines.
Alluvium (Ha)
- Layer of poorly graded sand from 80 to 80.5 feet.

Very dense, yellow-brown, *Poorly Graded Gravel with Sand and Cobbles (GP)* to *Poorly Graded Gravel with Cobbles (GP)*; wet; trace subangular cobbles; fine to coarse, subrounded to subangular gravel; fine to coarse sand; trace nonplastic to low plasticity fines.
Alluvium (Ha)

Very dense, gray, *Silty Gravel with Sand and Cobbles (GM)* to *Silty Sand with Gravel and Cobbles (SM)*; wet; few subrounded cobbles; fine to coarse, subrounded to rounded gravel; fine to coarse sand; nonplastic fines; trace iron-oxide staining.
Alluvium (Ha)
- Lense of poorly graded sand with silt 88.3 to 88.7 feet.

Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; few subrounded cobbles; fine to coarse, subrounded gravel;



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⊠ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 5 of 8

REV 3 - Approved for Submittal

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

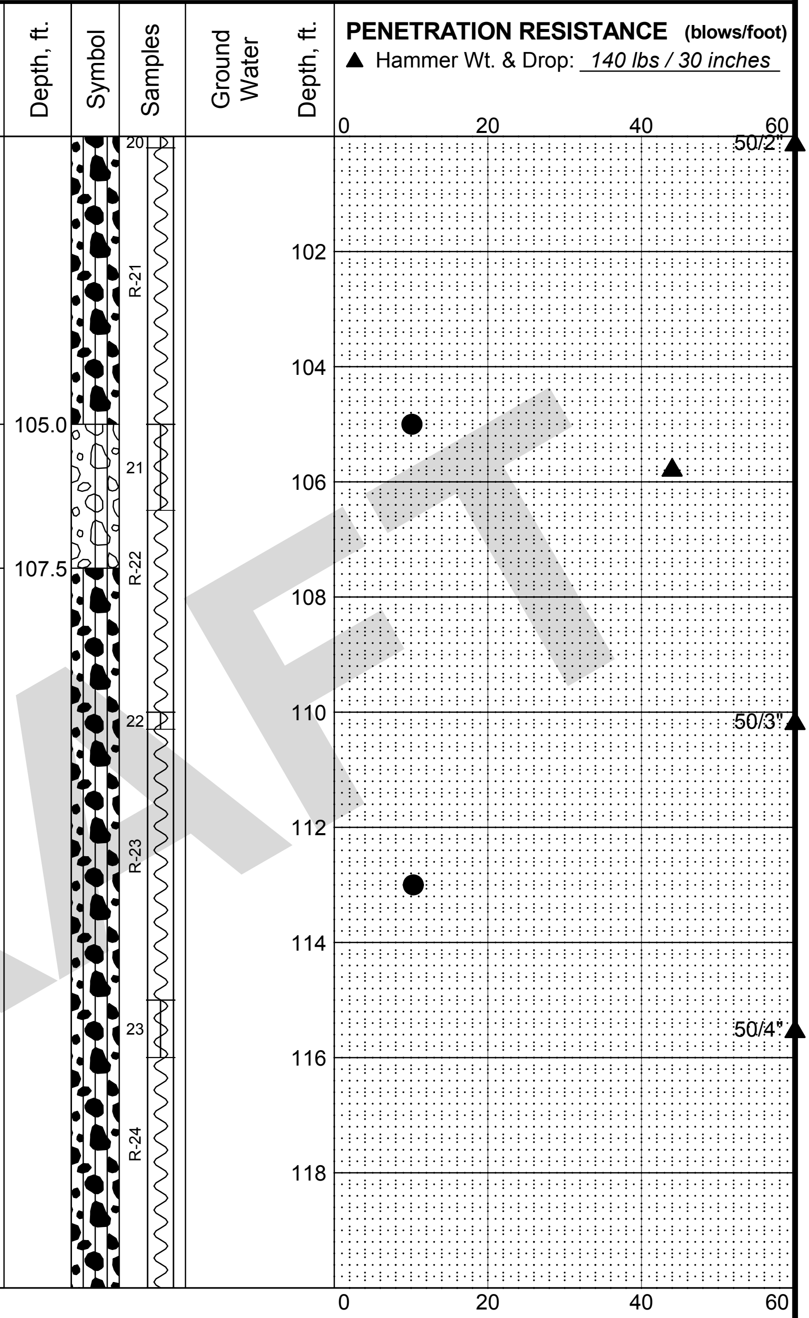
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

fine to coarse sand; low plasticity fines; trace iron-oxide staining; few diamict pockets.
Alluvium (Ha)

Dense, yellow-brown, *Poorly Graded Gravel with Silt and Cobbles (GP-GM)* to *Silty Gravel with Cobbles (GM)*; wet; few subrounded cobbles; fine to coarse, subrounded gravel; few fine to coarse sand; low plasticity fines.
Alluvium (Ha)
- Three 0.2-foot-thick siltier lenses from 107 to 109.2 feet.

Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; few subrounded cobbles; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines.
Alluvium (Ha)
- Layer wet silty sand from 110 to 110.5 feet.
- Pocket of orange-brown silty sand with iron-oxide staining at 116.5 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 6 of 8

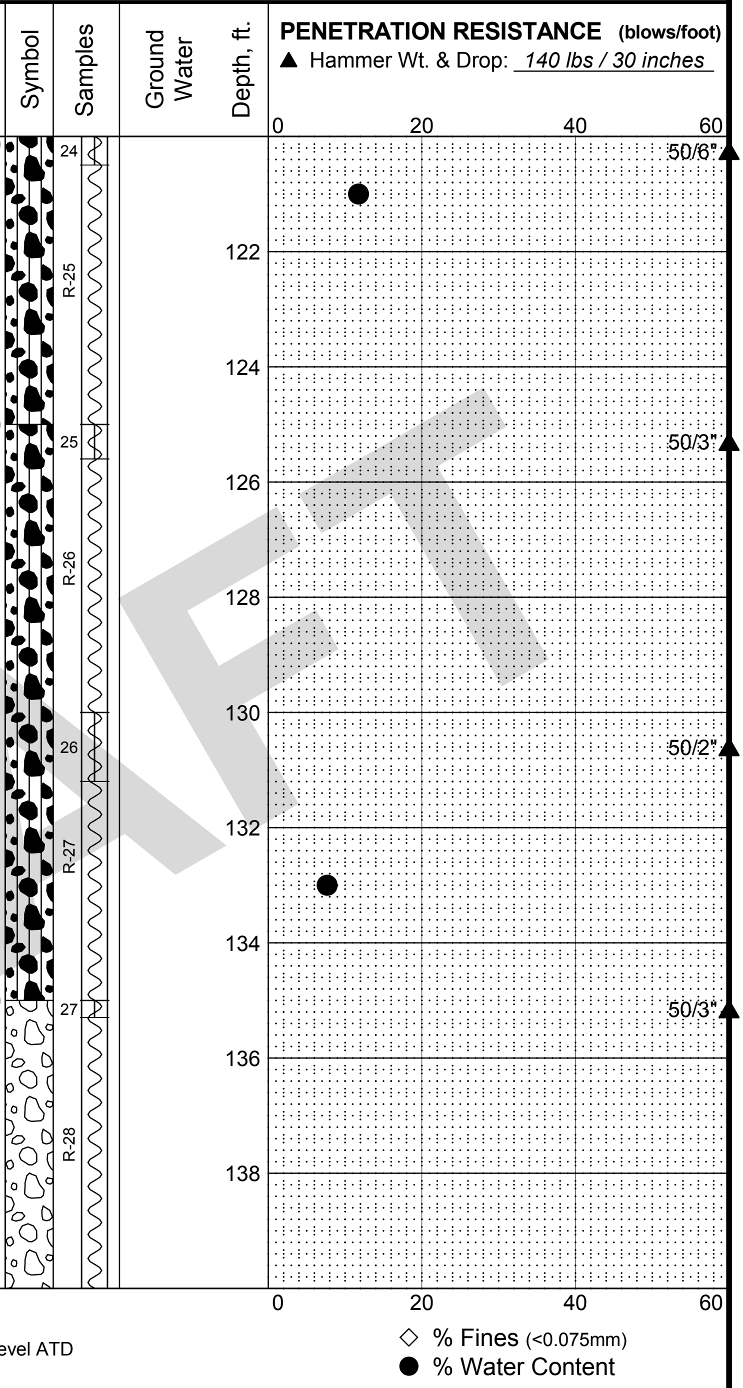
Log: BMC Rev: EAS Typ: LKN

MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

REV 3 - Approved for Submittal

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

Depth, ft.	SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*
120.0	Very dense, gray, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist to wet; few subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand; low to medium plasticity fines. Alluvium (Ha)
125.0	Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; few subrounded cobbles; fine to coarse, subrounded to rounded gravel; fine to coarse sand; nonplastic to low plasticty fines; few diamict pockets. Alluvium (Ha) - Layer of silty sand with gravel from 131.5 to 132 feet.
135.0	Very dense, gray-brown, *Poorly Graded Gravel with Sand (GP)* to *Poorly Graded Gravel with Silt and Sand (GP-GM)*; wet; fine to coase, subrounded to subangular gravel; fine to coarse sand; nonplastic fines. Alluvium (Ha)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▽ Ground Water Level ATD
◪ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 7 of 8

REV 3 - Approved for Submittal

Total Depth: 140 ft.
Top Elevation: ~ 1080 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 8 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

0 20 40 60

BOTTOM OF BORING
COMPLETED 7/31/2017

140.0

142
144
146
148
150
152
154
156
158

0 20 40 60

◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
▽ Ground Water Level ATD
☐ Soil Core (as in Sonic Core Borings)
I 2.0" O.D. Split Spoon Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-1-17

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2
Sheet 8 of 8

Log: BMC Rev: EAS Typ: LKN

MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

REV 3 - Approved for Submittal

Total Depth: 40.2 ft.
Top Elevation: ~ 1055 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Light brown, *Sandy Silt (ML)*; moist; fine sand; nonplastic fines; trace organics and roots.
Fill (Hf)

Dark brown, *Organic Soil (OL)*; moist; few fine to coarse, subrounded to subangular gravel; few fine to coarse sand; nonplastic fines; mostly wood fragments and debris.
Fill (Hf)

- Layer of silty fine sand from 5 to 5.6 feet.

- Layer poorly graded sand from 9.5 to 10 feet.

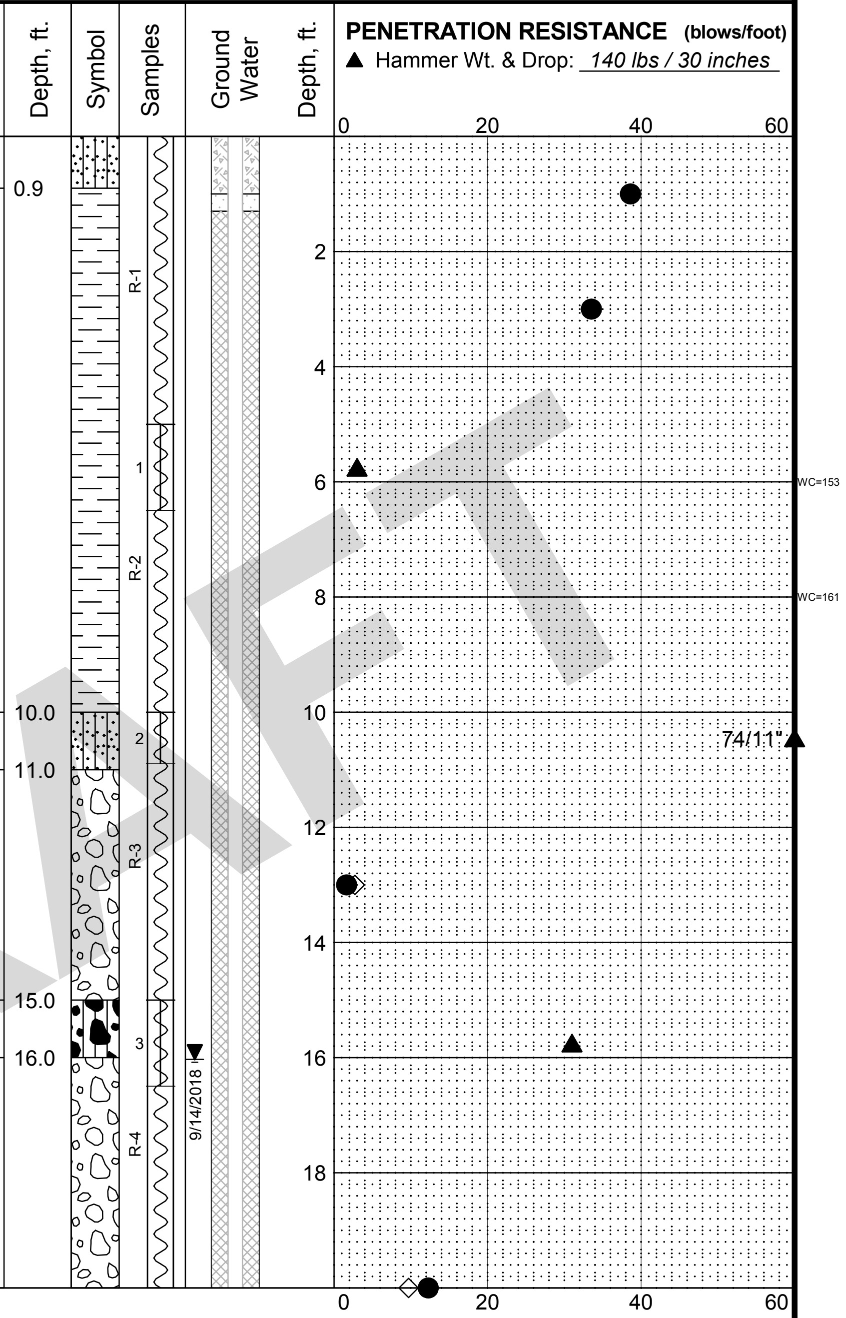
Very dense, gray-brown, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine subrounded to angular gravel; fine to coarse sand; nonplastic to low plasticity fines.
Alluvium (Ha)

Dense to very dense, gray, *Poorly Graded Gravel with Cobbles(GP)*; dry to moist; few subrounded cobbles; fine to coarse, subrounded gravel; few fine to coarse sand; trace nonplastic fines; iron-oxide staining below 13.1 feet.
Alluvium (Ha)

Dense, brown, *Silty Gravel with Sand (GM)*; moist; fine subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
Alluvuim (Ha)

Very dense, gray, *Poorly Graded Gravel with Sand (GP)*; wet; fine to coarse, subrounded

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- ▨ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-2-17

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-3
Sheet 1 of 3

REV 3 - Approved for Submittal

Total Depth: 40.2 ft.
Top Elevation: ~ 1055 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terrasonic 150
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: 3-1/2"
Hammer Type: Automatic

SOIL DESCRIPTION

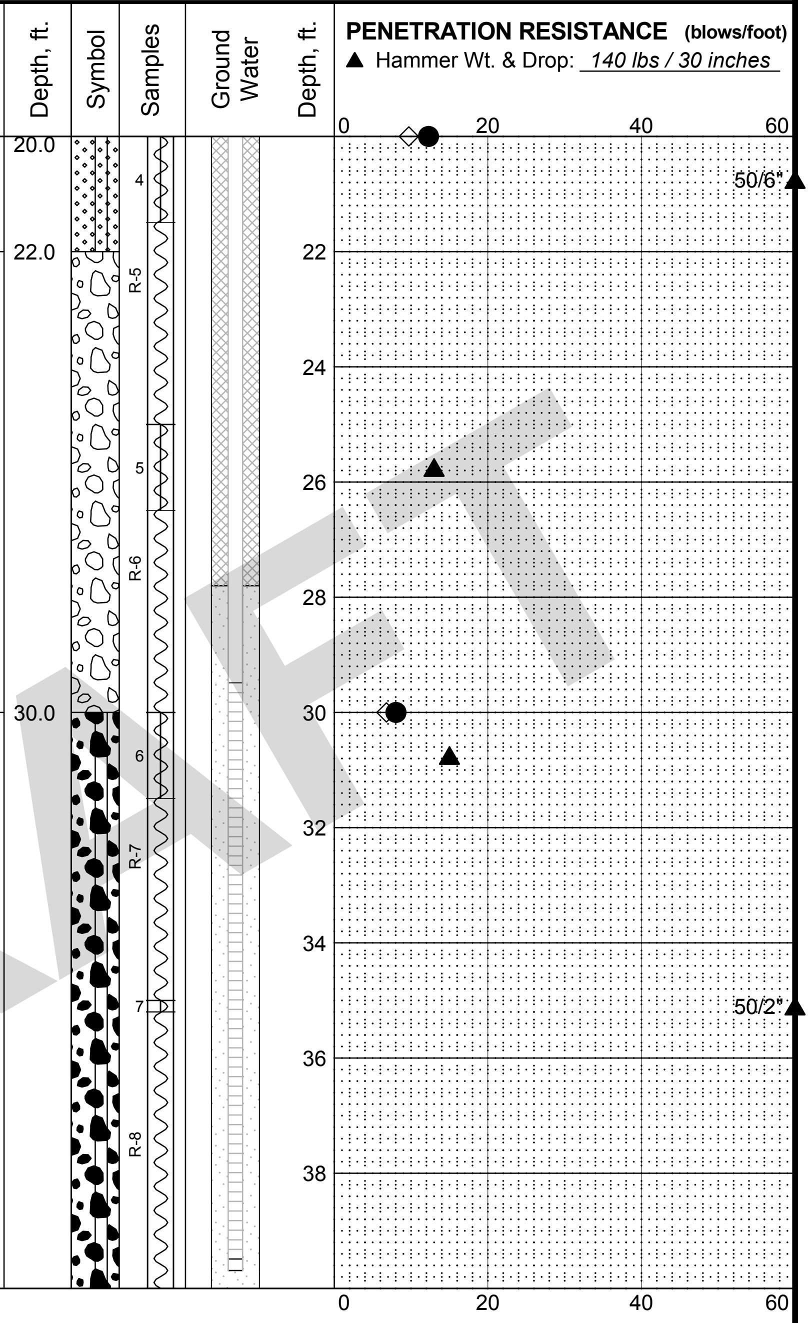
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

gravel; fine coarse sand; trace nonplastic fines. Alluvium (Ha)

Very dense, dark gray, *Well Graded Sand with Silt and Gravel (SW-SM)*; wet; fine, subrounded to subangluar gravel; fine to coarse sand; nonplastic fines. Alluvium (Ha)

Medium dense, gray, *Poorly Graded Gravel with Sand and Cobbles (GP)*; wet; few to little subangular cobbles; fine to coarse, subrounded to subangular gravel; fine to coarse sand; trace nonplastic fines. Alluvium (Ha)

Medium dense to very dense, gray, *Well Graded Gravel with Silt and Sand (GW-GM)* to *Well Graded Gravel with Sand (GW)*; wet; fine to coarse, subrounded gravel; fine to coarse sand; nonpastic fines. Alluvium (Ha)



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ◪ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ▤ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-2-17

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-3
Sheet 2 of 3

REV 3 - Approved for Submittal

Log: BMC Rev: EAS Typ: LKN

MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

Total Depth: *40.2 ft.*
Top Elevation: *~ 1055 ft.*
Vert. Datum: *NAVD88*
Horiz. Datum:

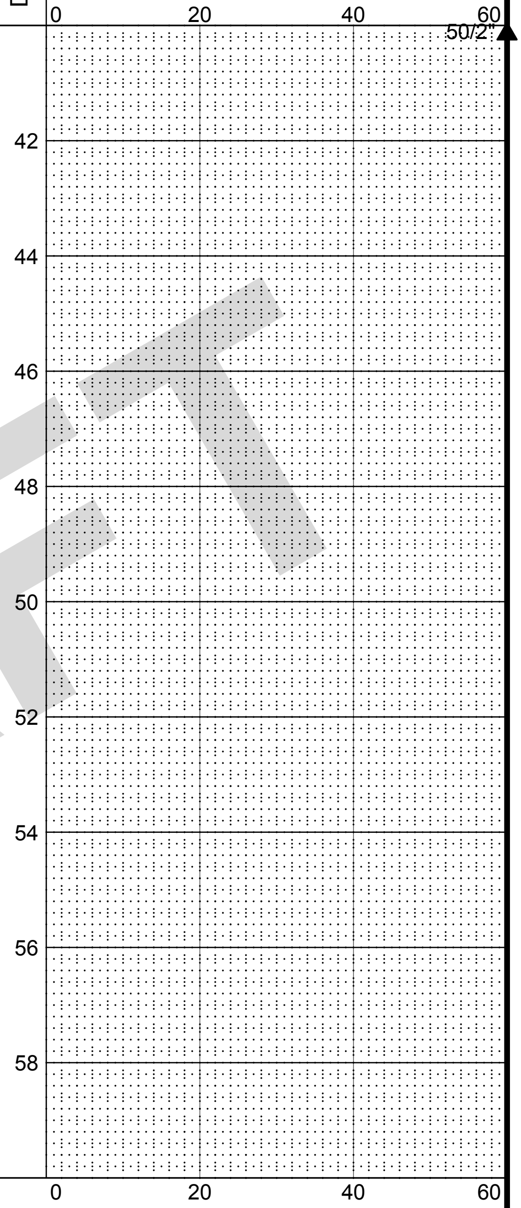
Northing:
Easting:
Station:
Offset:

Drilling Method: *Sonic Core*
Drilling Company: *Holt Services*
Drill Rig Equipment: *Terrasonic 150*
Other Comments:

Hole Diam.: *6 in.*
Rod Diam.: *3-1/2"*
Hammer Type: *Automatic*

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
BOTTOM OF BORING COMPLETED 8/3/2017	40.2		8	

PENETRATION RESISTANCE **(blows/foot)**
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

- * Sample Not Recovered
- ◪ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-2-17

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-3
Sheet 3 of 3

REV 3 - Approved for Submittal

Log: BMC Rev: EAS Typ: LKN

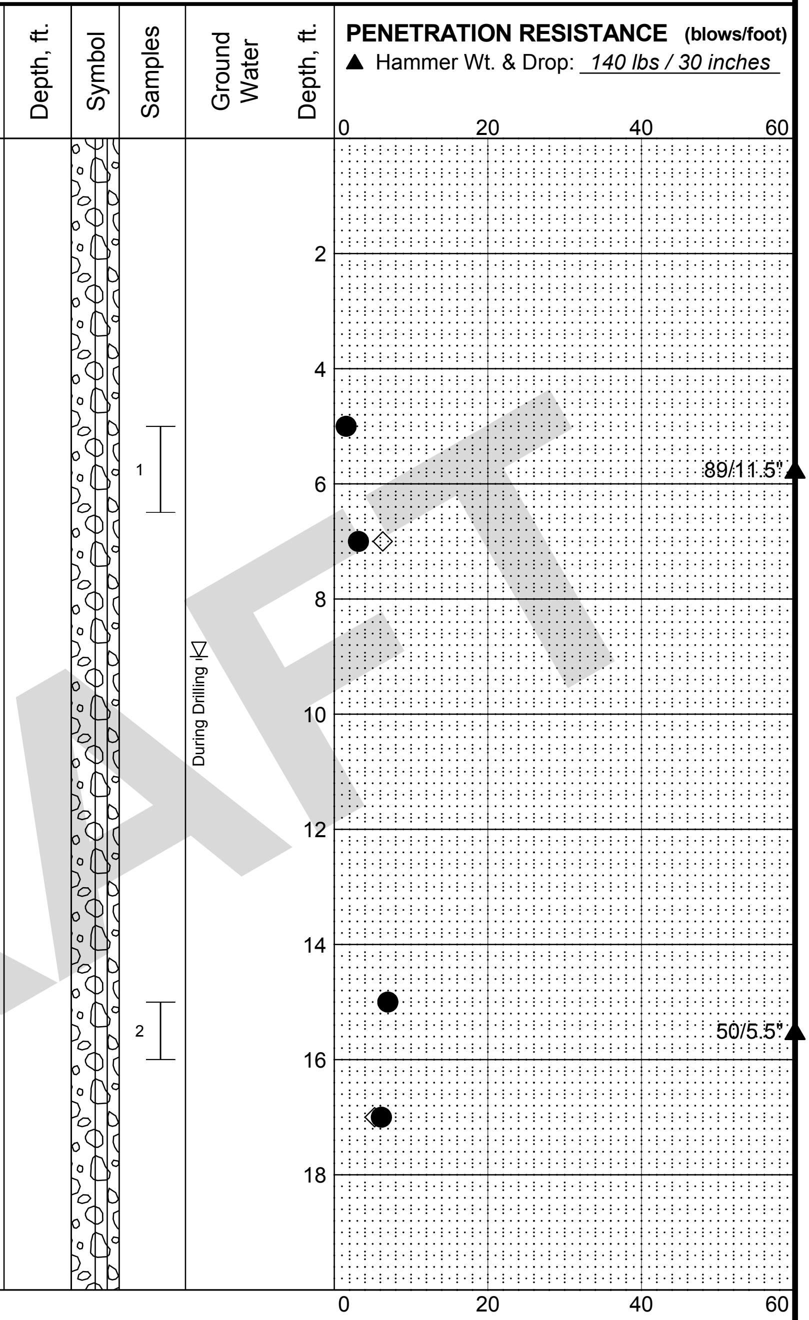
MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

Total Depth: 125.3 ft.
Top Elevation: ~ 1045 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt*
Drill Rig Equipment: *Terrasonic 150 Track*
Other Comments:
Hole Diam.: *7 in.*
Rod Diam.: *6-inch core*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense, brown, *Poorly Graded Gravel with Silt and Cobbles (GP-GM)*; moist to wet; subrounded cobbles up to 6 inches; fine to coarse, subrounded gravel; trace to few medium to coarse sand; nonplastic fines. Alluvium (Ha)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
▽ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-3-18

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4
Sheet 1 of 7

REV 3 - Approved for Submittal

MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

Log: BMC Rev: BMC Typ: LKN

Total Depth: 125.3 ft.
Top Elevation: ~ 1045 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt
Drill Rig Equipment: Terrasonic 150 Track
Other Comments:
Hole Diam.: 7 in.
Rod Diam.: 6-inch core
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

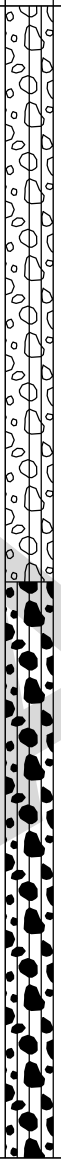
PENETRATION RESISTANCE **(blows/foot)**

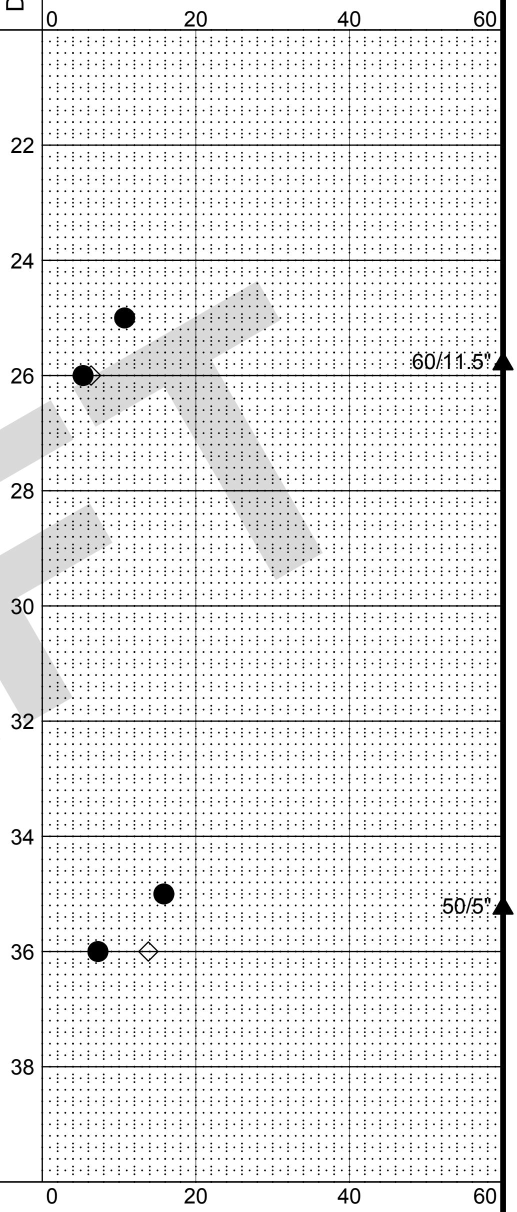
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

- Lens of Silty Gravel with up to 40% sand from 25 to 26 feet.

30.0

Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; few cobbles up to 5 inches; fine to coarse, subrounded gravel; medium to coarse sand; nonplastic to low plasticity fines.
Alluvium (Ha)
- Lens of Silty Gravel with Sand from 32.5 to 33.5 feet.





CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-3-18

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4
Sheet 2 of 7

Log: BMC Rev: BMC Typ: LKN

MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

REV 3 - Approved for Submittal

Total Depth: 125.3 ft.
Top Elevation: ~ 1045 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt
Drill Rig Equipment: Terrasonic 150 Track
Other Comments:
Hole Diam.: 7 in.
Rod Diam.: 6-inch core
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Becomes mostly cobbles and coarse gravel from 43 to 45 feet.

45.0

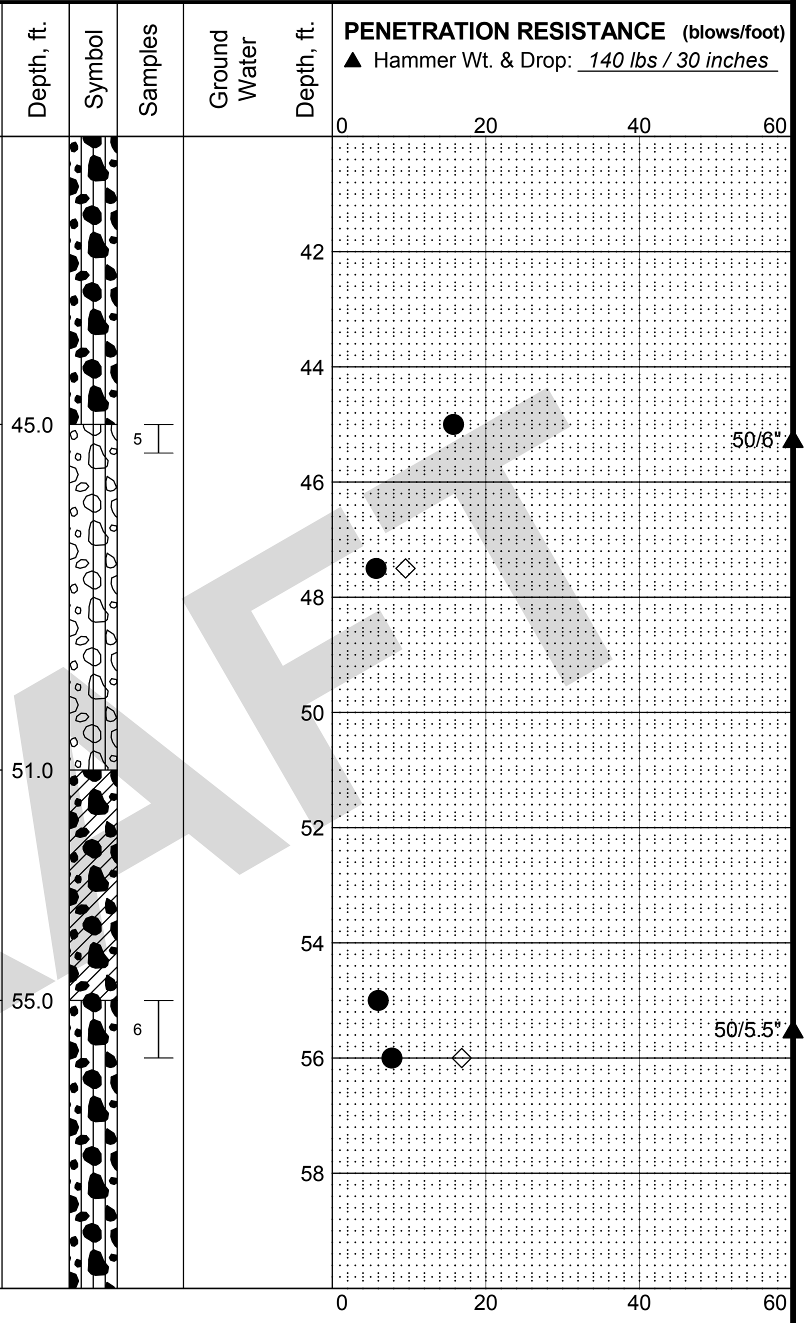
Very dense, brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; wet; fine to coarse, subrounded gravel; fine to coarse sand; nonplastic fines.
Alluvium (Ha)

51.0

Very dense, gray, *Clayey Gravel with Sand and Cobbles (GC)*; wet; few cobbles up to 3 inches; fine to coarse, rounded gravel; medium to coarse sand; low plasticity fines.
Alluvium (Ha)
- Sand content increases from little to some below 52.5 feet.

55.0

Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; few cobbles up to 3 inches; fine to coarse, rounded gravel; medium to coarse sand; nonplastic fines.
Alluvium (Ha)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD
◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-3-18

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4
Sheet 3 of 7

REV 3 - Approved for Submittal

Total Depth: *125.3 ft.*
Top Elevation: *~ 1045 ft.*
Vert. Datum: *NAVD88*
Horiz. Datum:

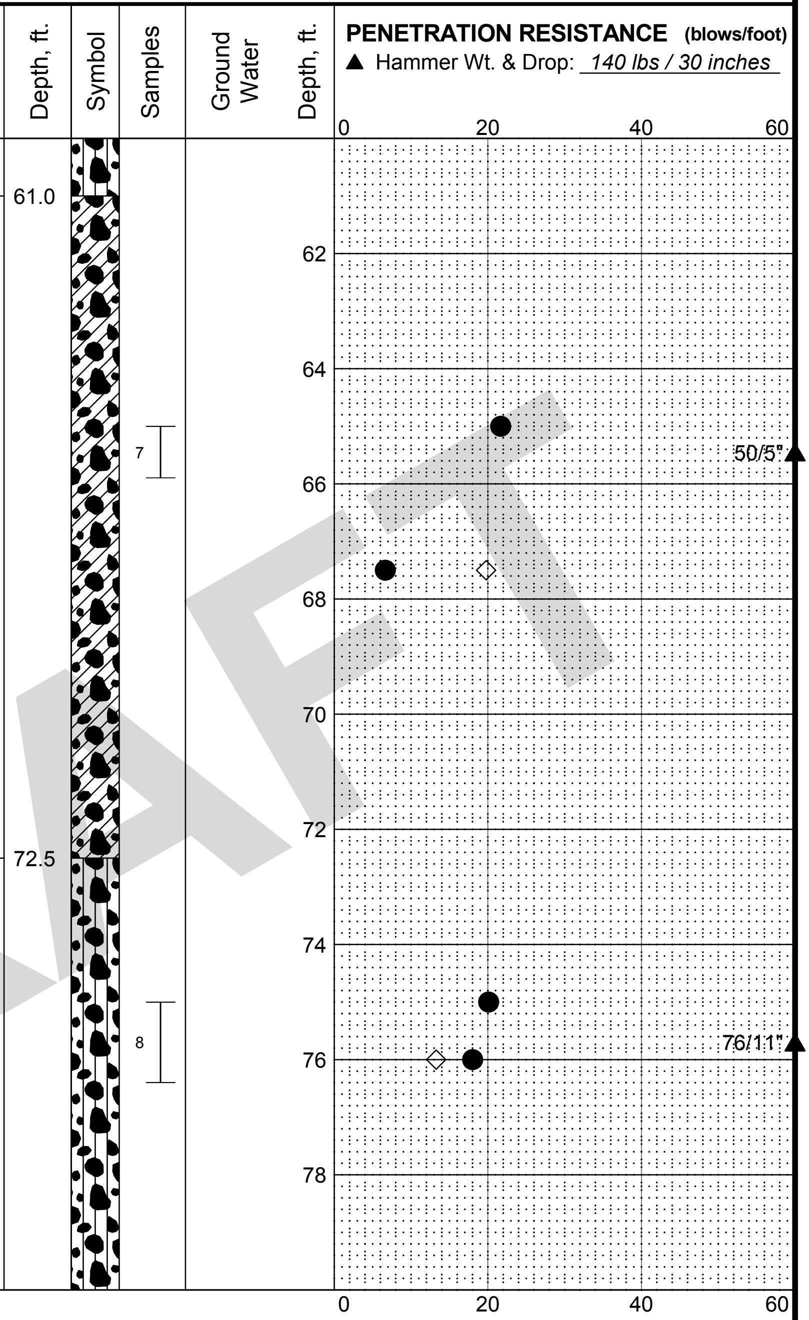
Northing:
Easting:
Station:
Offset:

Drilling Method: *Sonic Core*
Drilling Company: *Holt*
Drill Rig Equipment: *Terrasonic 150 Track*
Other Comments:

Hole Diam.: *7 in.*
Rod Diam.: *6-inch core*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.



61.0 — Very dense, gray-brown, *Clayey Gravel with Sand and Cobbles (GC)*; wet; few cobbles up to 4 inches; fine to coarse, subrounded gravel; fine to coarse sand; low plasticity fines. Alluvium (Ha)

- Maximum cobble size increases to approximately 6 inches from 65 to 82 feet.

72.5 — Very dense, brown, *Silty Gravel with Sand (GM)*; wet; cobbles up to 4 inches; fine to coarse, subrounded gravel; fine to corase sand; nonplastic fines; trace iron oxide staining. Alluvium (Ha)

- Lens of wet, silty sand from 73.5 to 75 feet.

- Increase in fines content from few to little.

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-3-18

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4
Sheet 4 of 7

Log: BMC Rev: BMC Typ: LKN

REV 3 - Approved for Submittal

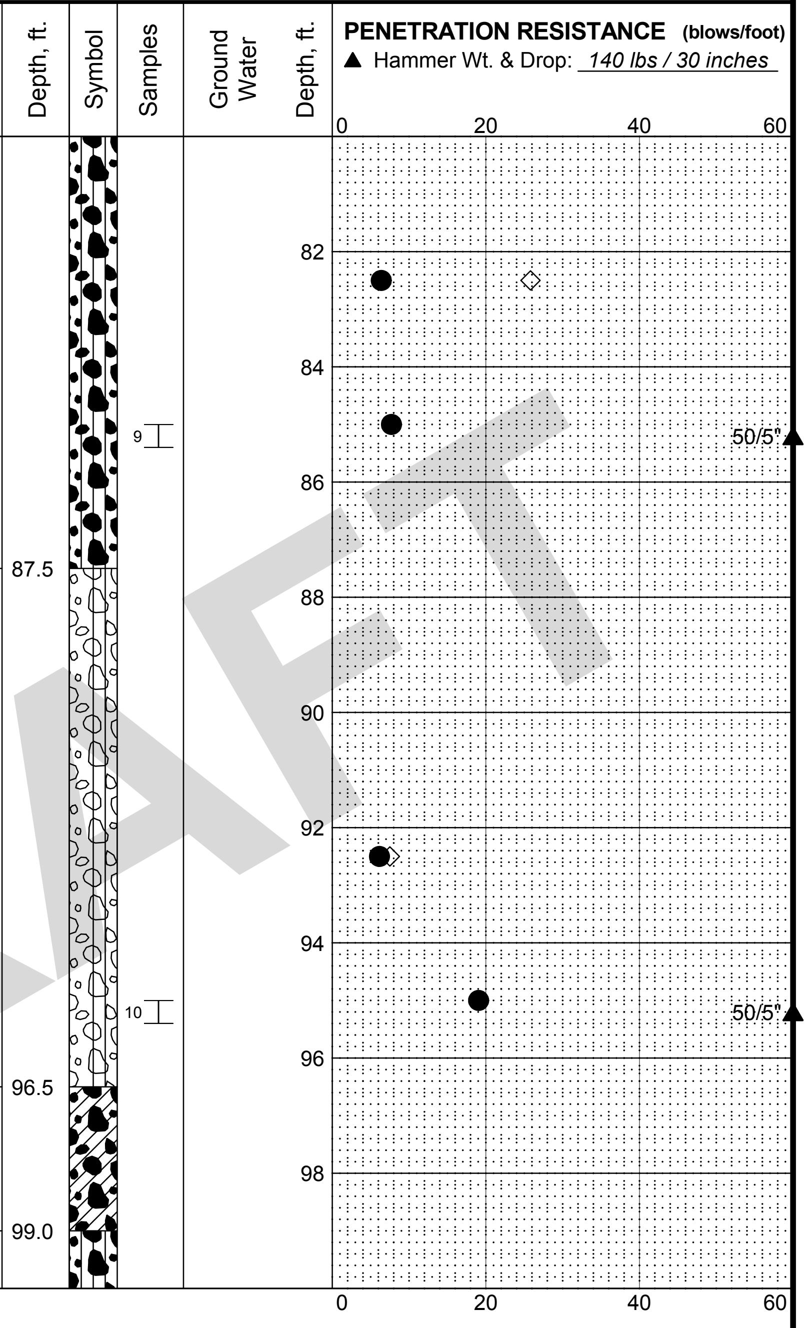
Total Depth: 125.3 ft.
Top Elevation: ~ 1045 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt
Drill Rig Equipment: Terrasonic 150 Track
Other Comments:
Hole Diam.: 7 in.
Rod Diam.: 6-inch core
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense, gray, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist to wet; cobbles up to 5 inches; fine to coarse, subrounded gravel; fine to coarse sand; nonplastic fines; trace iron oxide staining. Alluvium (Ha)

Very dense, gray, *Clayey Gravel with Sand (GC)*; moist; fine to coarse, rounded gravel; fine to coarse sand; low to medium plasticity fines; trace iron oxide staining. Alluvium (Ha)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD
◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-3-18

August 2019
21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4
Sheet 5 of 7

Log: BMC Rev: BMC Typ: LKN

MASTER_LOG_E 21-22425.GPJ SHAN_WIL.GDT 8/16/19

REV 3 - Approved for Submittal

Total Depth:	125.3 ft.	Northing:		Drilling Method:	Sonic Core	Hole Diam.:	7 in.
Top Elevation:	~ 1045 ft.	Easting:		Drilling Company:	Holt	Rod Diam.:	6-inch core
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Terrasonic 150 Track	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; few cobbles up to 3"; fine to coarse, rounded gravel; medium to coarse sand; nonplastic fines.
Alluvium (Ha)

105.0

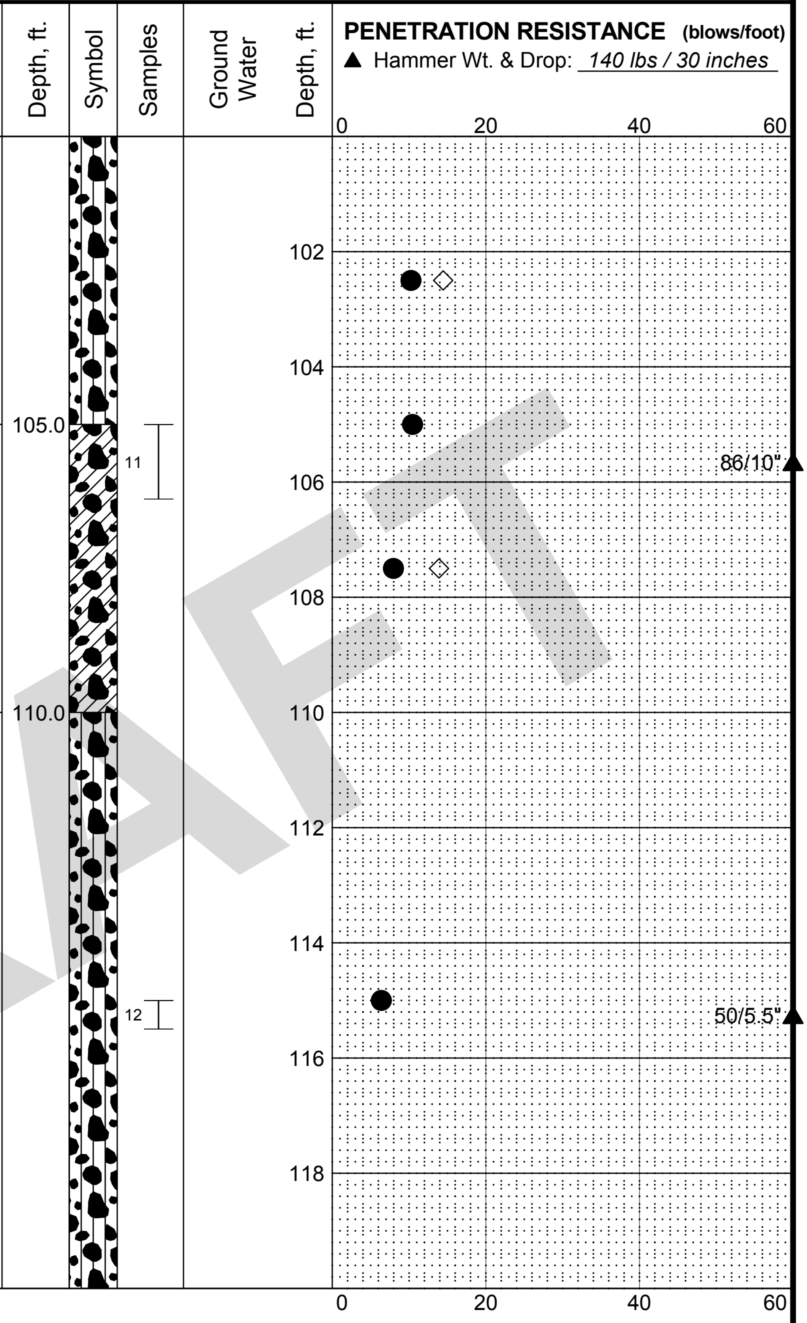
Very dense, gray-brown, *Clayey Gravel with Sand and Cobbles (GC)*; wet; cobbles up to 5"; fine to coarse rounded gravel; medium to coarse sand; low to medium plasticity fines; trace iron oxide staining.
Alluvium (Ha)

- Lens of silty gravel with sand from 108.3 to 109.1 feet.

110.0

Very dense, gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; cobbles up to 8"; fine to coarse rounded gravel; medium to coarse sand; non plastic to low plasticity fines.
Alluvium (Ha)

- Lens of clayey gravel with sand and cobbles from 112.5 to 113.8 feet.
- Lens of relatively dry clayey gravel with trace iron oxide staining from 118.5 to 120 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-3-18

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4
Sheet 6 of 7

REV 3 - Approved for Submittal

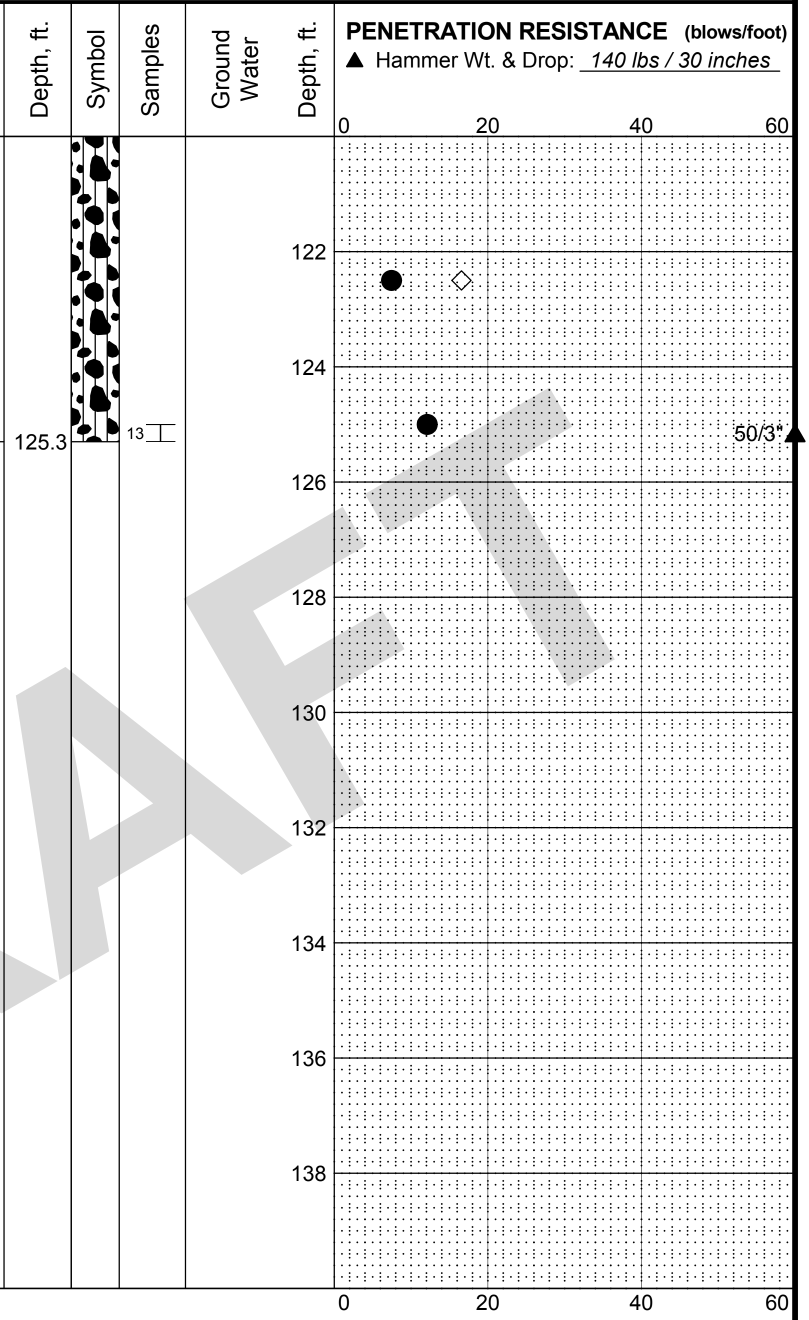
Total Depth: 125.3 ft.
Top Elevation: ~ 1045 ft.
Vert. Datum: NAVD88
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt
Drill Rig Equipment: Terrasonic 150 Track
Other Comments:
Hole Diam.: 7 in.
Rod Diam.: 6-inch core
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Lens of relatively dry clayey gravel from 123.9 to 124.1 feet.

BOTTOM OF BORING
COMPLETED 9/26/2018



LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Stage 3
Yakima, Washington

LOG OF BORING B-3-18

August 2019 21-1-22425-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4
Sheet 7 of 7

REV 3 - Approved for Submittal

Total Depth: *100.1 ft.*
Top Elevation: *~ 1057.5 ft.*
Vert. Datum:
Horiz. Datum:

Northing:
Easting:
Station:
Offset:

Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:

Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION

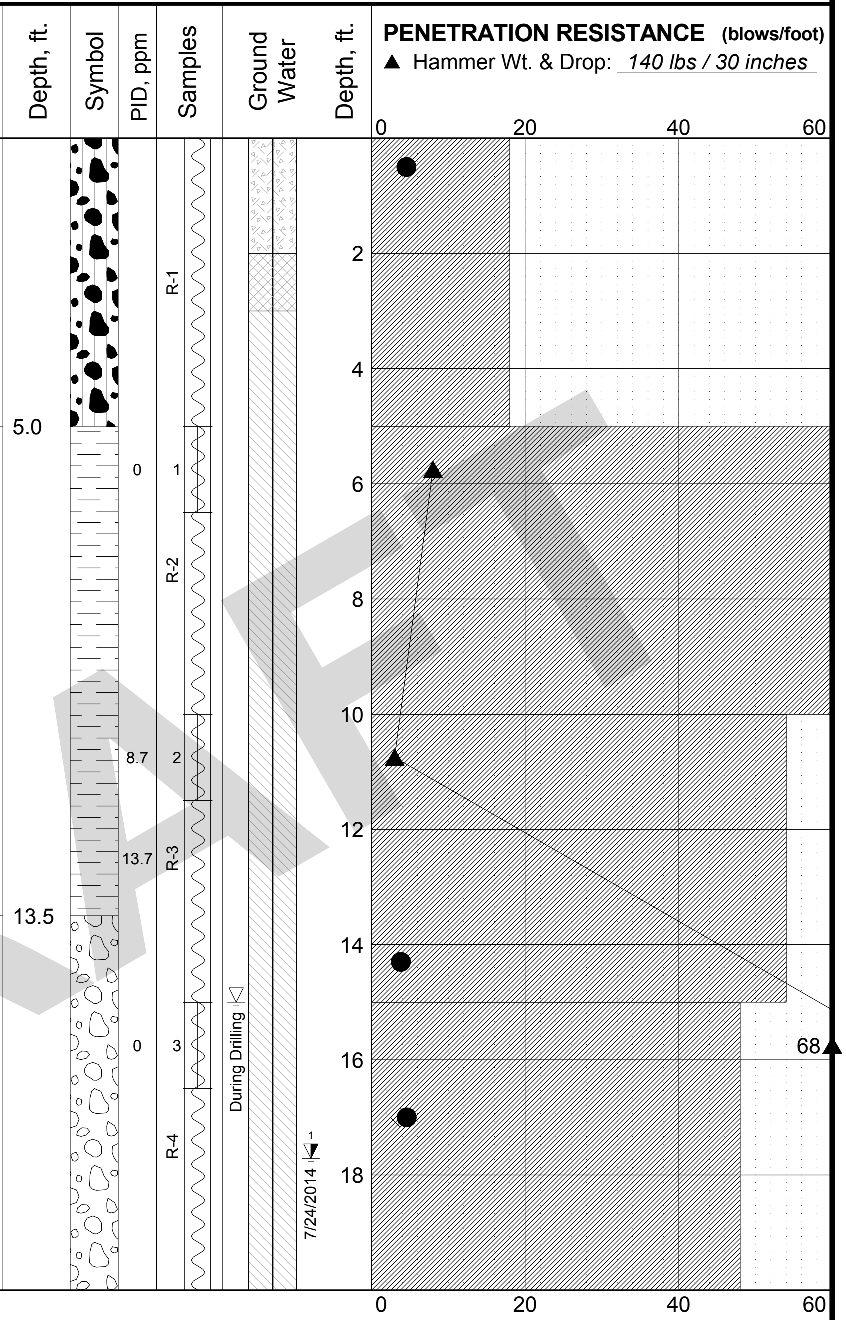
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Loose, brown, *Silty Gravel with Sand and Cobbles (GM)*; dry; angular cobbles in Run 1; some angular to subrounded gravel; few wood fragments.
Fill (Hf)

Soft, dark brown, *Organic Soil with Gravel (OL/OH)*; moist; subangular to subrounded gravel; fine to coarse sand; organic debris, wood, and charcoal; garbage debris including plastic, glass, and foil; slight hydrocarbon odor.
Landfill (Hf)

- Sand and angular gravel with silt between 11 and 11.5 feet.

Medium dense to dense, gray to red-brown, *Poorly Graded Gravel with Sand and Cobbles (GP) to Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist to wet; little cobbles; subangular to rounded gravel.
Fill (Hf)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▯ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▤ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-01-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-5
Sheet 1 of 6

REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth:	*100.1 ft.*	Northing:		Drilling Method:	*Sonic Core*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 1057.5 ft.*	Easting:		Drilling Company:	*Holt Services, Inc.*	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	*Terra Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

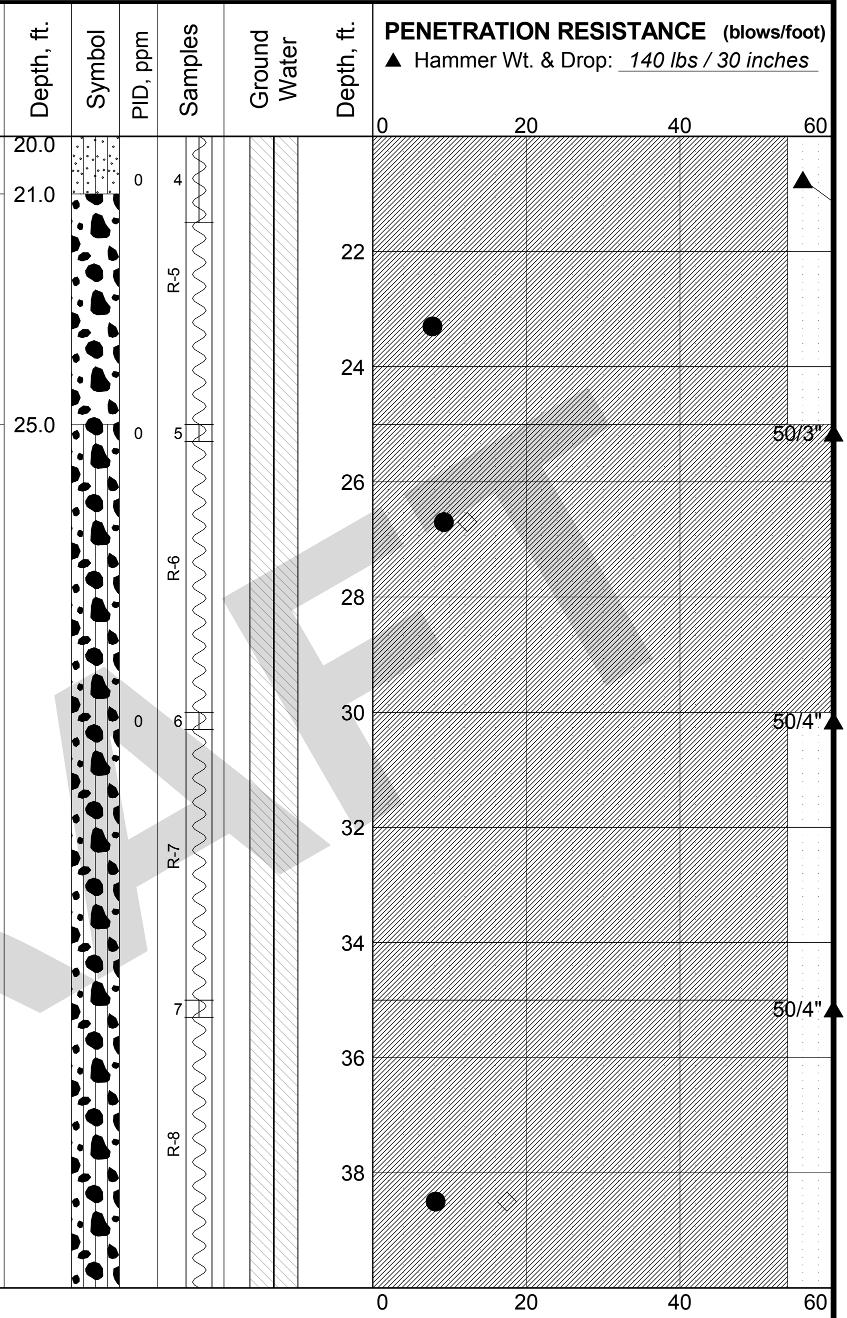
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, dark gray, *Silty Sand with Gravel (SM)*; wet; little organic and garbage debris.
Fill (Hf)

Medium dense to dense, brown mottled with red-brown and dark gray, *Well Graded Gravel with Sand and Cobbles (GW)* grading to *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; wet; subrounded cobbles; angular to subrounded gravel; slight iron-oxide staining.
Alluvium (Qa)
- Siltier below 22 feet.

Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; subangular to rounded gravel; trace clay; trace iron-oxide staining locally.
Alluvium (Qa)
- Iron-oxide staining between 28.5 and 30 feet and below 38.5 feet.
- Cleaner gravel layer from 30.5 to 32 feet.
- Cleaner gravel layer from 35 to 37.5 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
Soil Core (as in Sonic Core Borings)
2.0" O.D. Split Spoon Sample
Well Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout
Ground Water Level ATD
Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-01-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-5
Sheet 2 of 6

REV 3 - Approved for Submittal

Total Depth: 100.1 ft.
Top Elevation: ~ 1057.5 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

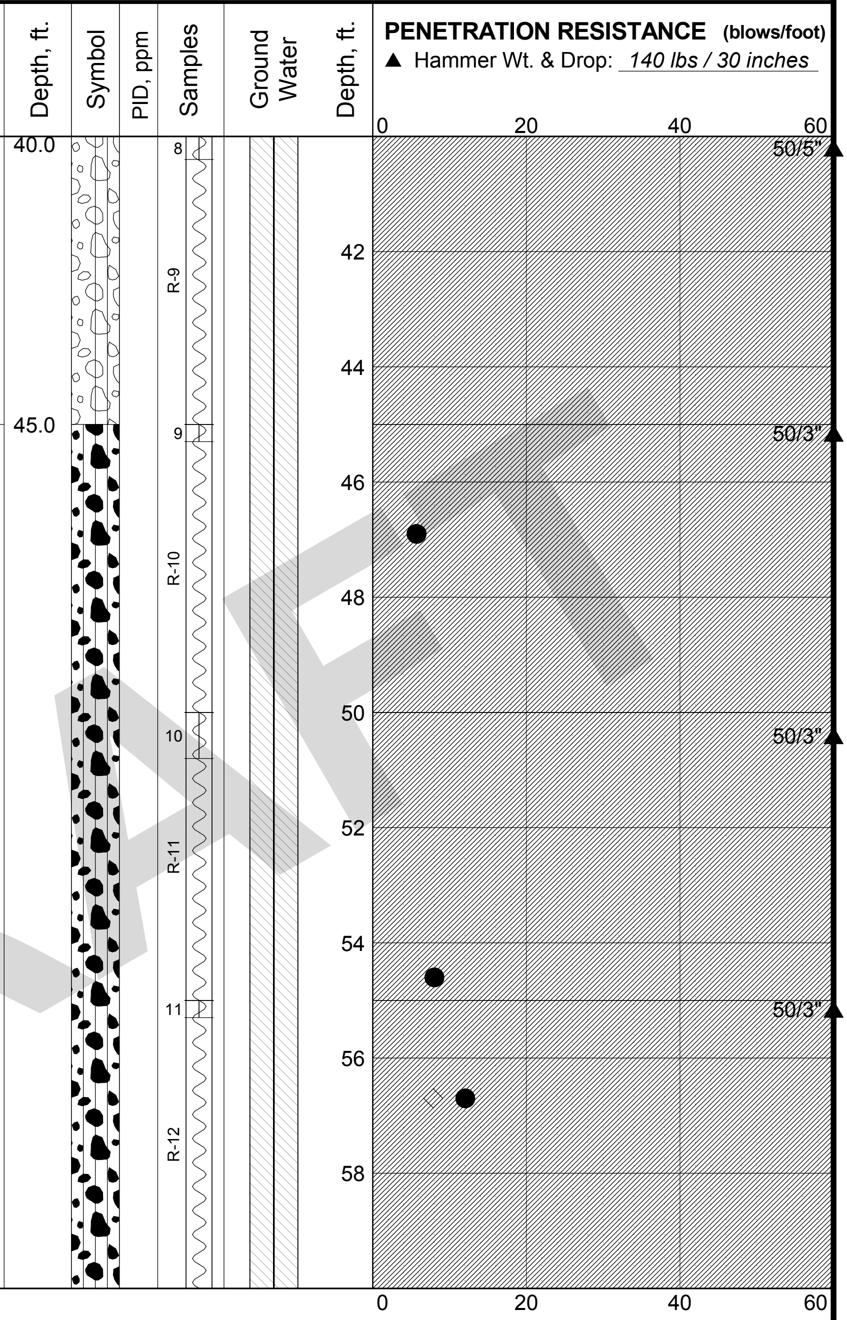
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, light tan to brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; wet, moist below 44 feet; few subangular to subrounded cobbles; subangular to subrounded gravel; trace clay.
Alluvium (Qa)
- Light tan ash layer(?) around 42.5 feet.

Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; subangular to subrounded cobbles; subangular to rounded gravel.
Alluvium (Qa)

- Clayey gravel from 55 to 56.5 feet.
- Poorly Graded Gravel with Sand layer from 56.5 to 57.5 feet.
- Light tan ash layer(?) from 57.5 to 58.5 feet.



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ▯ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊞ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-01-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-5
Sheet 3 of 6

REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth: 100.1 ft.
Top Elevation: ~ 1057.5 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.

- Plastic fines below 60 feet.
- Strong iron-oxide staining below 60 feet.

67.0

Medium dense to dense, brown to gray-brown, *Clayey Gravel with Sand (GC)*; moist; subrounded to subangular gravel; slight iron-oxide staining.
Alluvium (Qa)

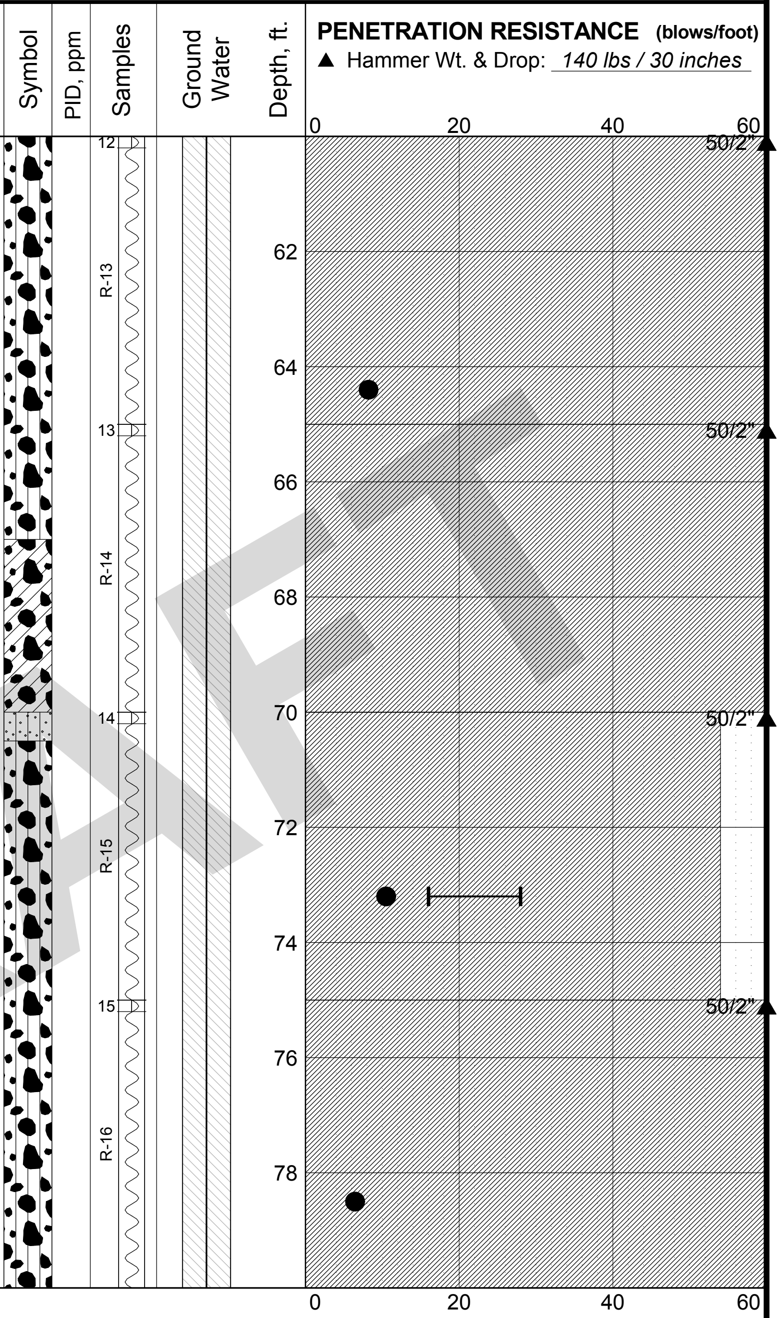
70.0

Medium dense to dense, gray, *Silty Sand (SM)*; wet; trace fine gravel.
Alluvium (Qa)

70.5

Medium dense to dense, brown to gray-brown with red-brown mottling, *Silty Gravel with Sand and Cobbles (GM)* to *Clayey Gravel with Sand and Cobbles (GC)*; moist; subangular to subrounded gravel; trace clay; iron-oxide staining locally.
Alluvium (Qa)

- Iron oxide staining at 78 and 79.5 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▯ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▤ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-01-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-5
Sheet 4 of 6

REV 3 - Approved for Submittal

Total Depth: *100.1 ft.*
Top Elevation: *~ 1057.5 ft.*
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

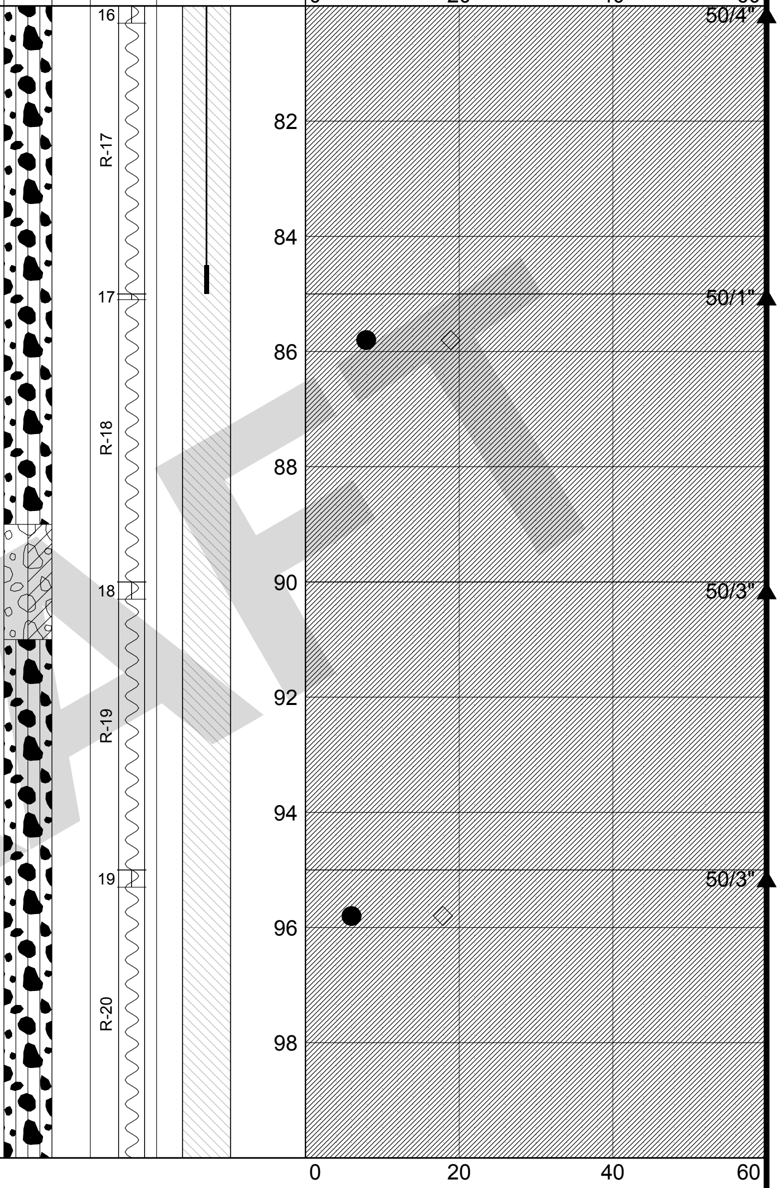
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Soil Description
80.0	Medium dense to dense, brown mottled with red-brown and gray, *Silty Gravel with Sand and Cobbles (GM)*; moist; few subrounded cobbles; subangular to rounded gravel; trace clay. Alluvium (Qa) - Strong iron-oxide staining from 82.5 to 84.5 feet. - Clayey gravel from 83 to 85 feet. - Strong iron-oxide staining between 86.5 and 89 feet.
89.0	Medium dense to dense, brown, *Poorly Graded Gravel with Clay and Cobbles (GP-GC)*; wet; some cobbles; angular to subrounded gravel. Alluvium (Qa)
91.0	Medium dense to dense, brown to gray-brown mottled with red-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; few subangular to subrounded cobbles; subangular to rounded gravel. Alluvium (Qa) - Iron-oxide staining sand from 94 to 94.5 feet.

Symbol | PID, ppm | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▯ Soil Core (as in Sonic Core Borings)
I 2.0" O.D. Split Spoon Sample
▭ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
☒ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-01-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-5
Sheet 5 of 6

REV 3 - Approved for Submittal

Total Depth: *100.1 ft.*
Top Elevation: *~ 1057.5 ft.*
Vert. Datum:
Horiz. Datum:

Northing:
Easting:
Station:
Offset:

Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:

Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, ft.
BOTTOM OF BORING COMPLETED 7/15/2014	100.1			20		
						102
						104
						106
						108
						110
						112
						114
						116
						118

Notes:

a) Some blow counts are high due to the presence of gravel and cobbles, and do not reflect the relative density of the soil unit.

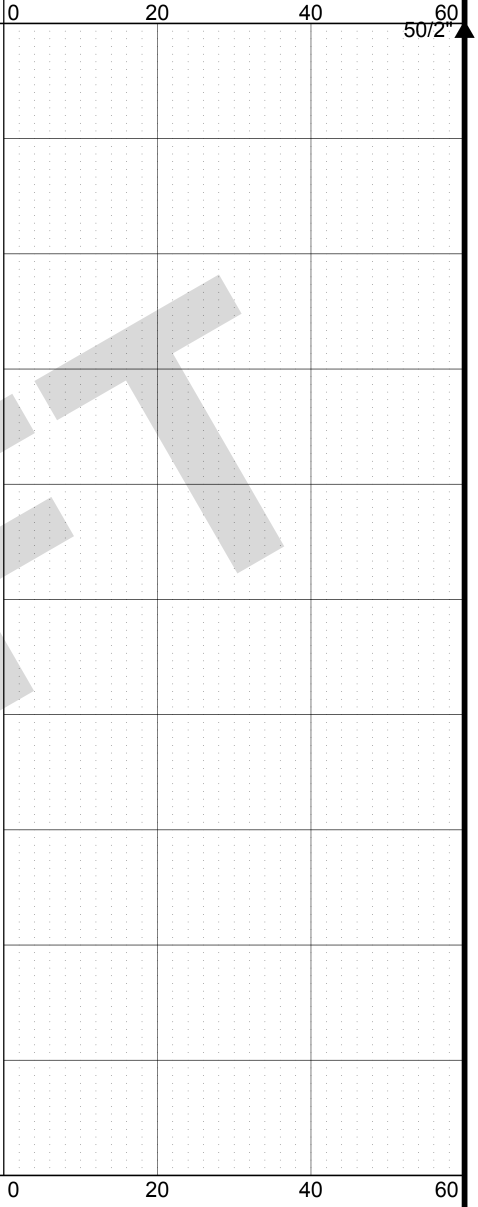
b) Moisture content may be reduced by frictional heating generated during drilling.

c) Boulders may be present in alluvium layers.

d) Drilled using 4- and 6-inch diameter sonic core casings. Recovered 4-inch diameter soil core.

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

Soil Core (as in Sonic Core Borings)

2.0" O.D. Split Spoon Sample

Well Screen and Sand Filter

Bentonite-Cement Grout

Bentonite Chips/Pellets

Bentonite Grout

Ground Water Level ATD

Ground Water Level in VWP

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-01-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-5
Sheet 6 of 6

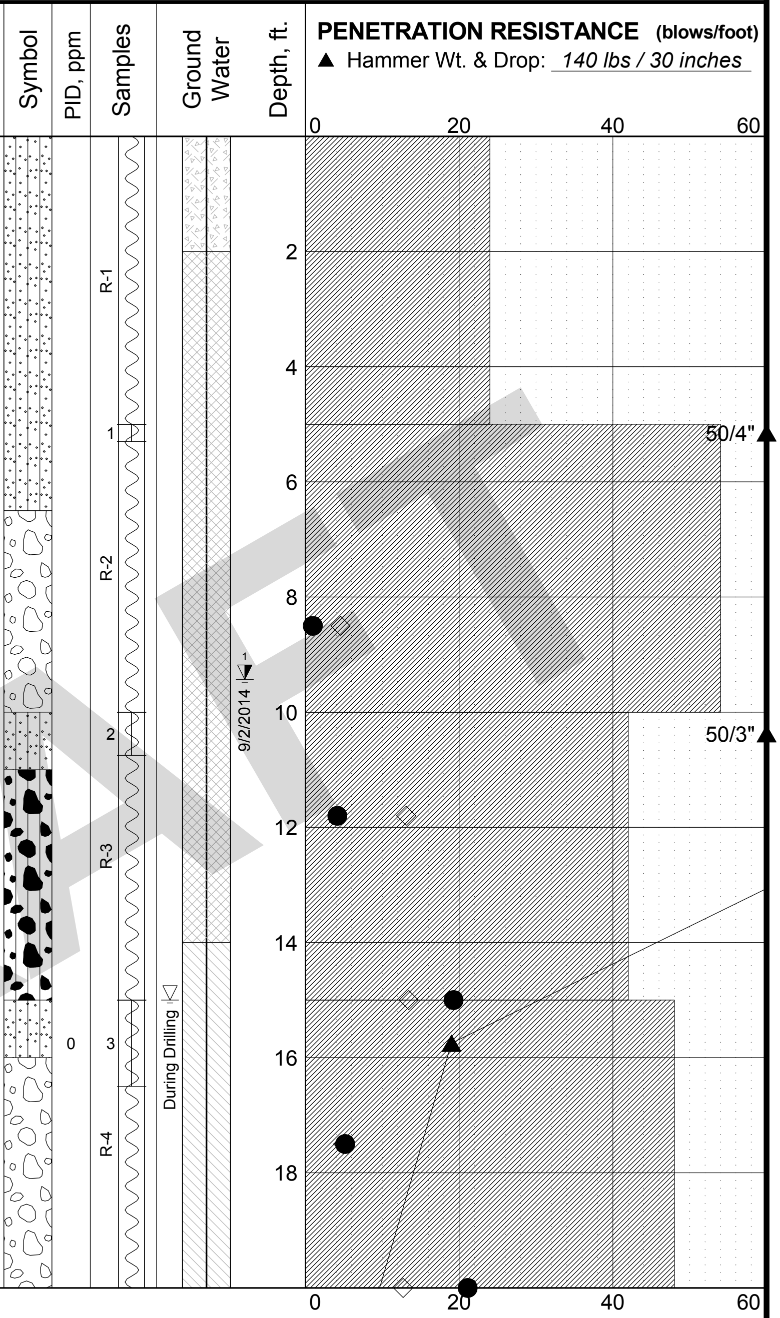
REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth: *101.5 ft.*
Top Elevation: *~ 1052 ft.*
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Medium dense to dense, brown to dark brown, *Silty Sand with Gravel (SM)*; moist; subangular to subrounded and broken gravel; organics including wood chips and grass. Fill (Hf) - Few cobbles below 5 feet.	
Medium dense to dense, gray, *Poorly Graded Gravel with Cobbles (GP)*; moist; few angular to subrounded cobbles; angular to rounded gravel; little sand; trace fines. Fill (Hf)	6.5
Medium dense to dense, brown, *Silty Sand with Gravel (SM)*; moist; angular to subrounded gravel; fine to medium sand; little wood debris; trace organics. Fill (Hf)	10.0
Medium dense to dense, brown, *Silty Gravel with Sand (GM)* to *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist; angular to rounded gravel. Fill (Hf)	11.0
Medium dense, gray to gray-brown, *Silty Sand (SM)*; wet; trace fine gravel; unit fining upward. Alluvium (Qa)	15.0
Medium dense, gray to gray-brown, *Poorly Graded Gravel with Sand (GP)*; wet; subangular to rounded gravel; trace fines. Alluvium (Qa)	16.0



◇ % Fines (<0.075mm)
● % Water Content

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▯ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▥ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-02-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-6
Sheet 1 of 6

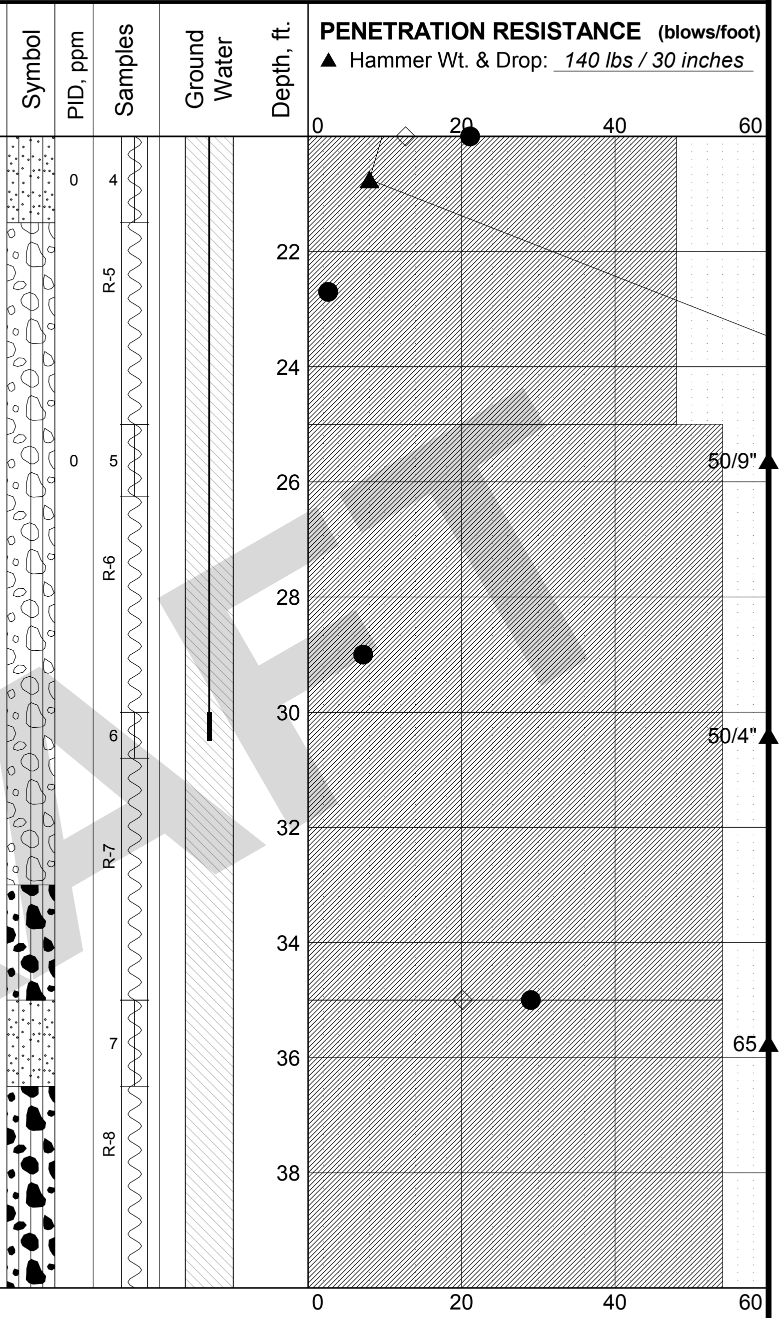
REV 3 - Approved for Submittal

Total Depth:	*101.5 ft.*	Northing:		Drilling Method:	*Sonic Core*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 1052 ft.*	Easting:		Drilling Company:	*Holt Services, Inc.*	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	*Terra Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
- Strong iron-oxide staining and few cobbles below 18.5 feet.	20.0
Loose, brown to gray-brown, *Silty Sand (SM)*; wet; trace fine gravel. Alluvium (Qa)	21.5
Medium dense to dense, gray to gray-brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist to wet; angular to rounded gravel; low plasticity fines. Alluvium (Qa) Note: Blow counts for sample S-4 may be anomalous because sampler was advanced through slough. - Trace clay pockets and slight iron-oxide staining below 26 feet.	
Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; little, subrounded cobbles; subangular to rounded gravel; low plasticity fines. Alluvium (Qa)	33.0
Medium dense to dense, brown, *Silty Sand (SM)*; wet; trace gravel; low plasticity fines. Alluvium (Qa)	35.0
Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; subrounded	36.5



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	▤	Well Screen and Sand Filter
▯	Soil Core (as in Sonic Core Borings)	▧	Bentonite-Cement Grout
⌶	2.0" O.D. Split Spoon Sample	▩	Bentonite Chips/Pellets
		▨	Bentonite Grout
		▽	Ground Water Level ATD
		▼	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-02-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-6
Sheet 2 of 6

REV 3 - Approved for Submittal

Total Depth: 101.5 ft.
Top Elevation: ~ 1052 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

cobbles; subangular to rounded gravel; low plasticity fines.
Alluvium (Qa)
- Light tan ash layer(?) from about 37.5 to 39 feet.
- Light tan ash layer(?) from about 42.5 to 43.5 feet.

Medium dense to dense, gray-brown to brown, *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; subrounded gravel; low plasticity fines.
Alluvium (Qa)

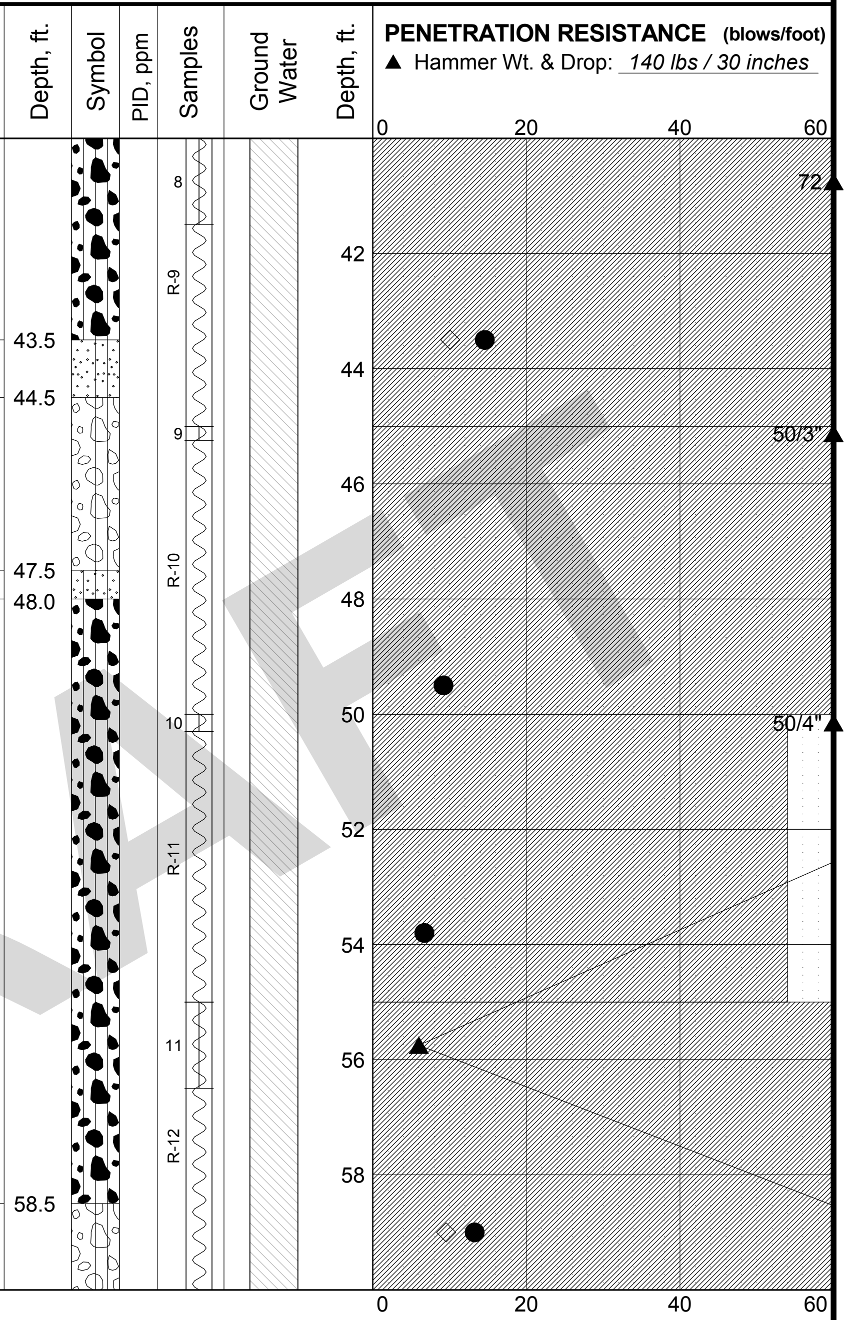
Medium dense to dense, brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist; 3- to 5-inch, subrounded cobbles; subangular to subrounded gravel.
Alluvium (Qa)

Medium dense to dense, brown, *Silty Sand (SM)*; wet; trace fine gravel; fine to medium sand.
Alluvium (Qa)

Loose to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; little subrounded cobbles; subrounded to rounded gravel.
Alluvium (Qa)

- Strong iron-oxide staining at 54.5 feet.

Medium dense to dense, brown to gray-brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist to wet;



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ▯ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ▥ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-02-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-6
Sheet 3 of 6

REV 3 - Approved for Submittal

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17
Log: SAW Rev: JKP Typ: CLP

Total Depth: 101.5 ft.
Top Elevation: ~ 1052 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

angular to rounded gravel; low plasticity fines.
Alluvium (Qa)
- Light tan ash layer(?) from about 60 to 63 feet.
- Gray, Silty Gravel layer from 63 to 63.5 feet.
- Strong iron-oxide staining below 63.5 feet.

65.0

Medium dense to dense, brown, *Silty Sand with Gravel (SM)*; wet; fine, subrounded gravel.
Alluvium (Qa)

65.5

Brown, *Silty Gravel with Sand and Cobbles (GM) to Clayey Gravel with Sand and Cobbles (GC)*; moist; few cobbles; angular to rounded gravel; slight iron-oxide staining in sandy silt matrix.
Alluvium (Qa)

68.0

Medium dense to dense, brown mottled with red-brown and gray, *Well Graded Gravel with Silt and Sand (GW-GM)*; moist; subangular to rounded gravel; trace clay pockets.
Alluvium (Qa)
- Light tan ash layer(?) around 70 feet.

72.5

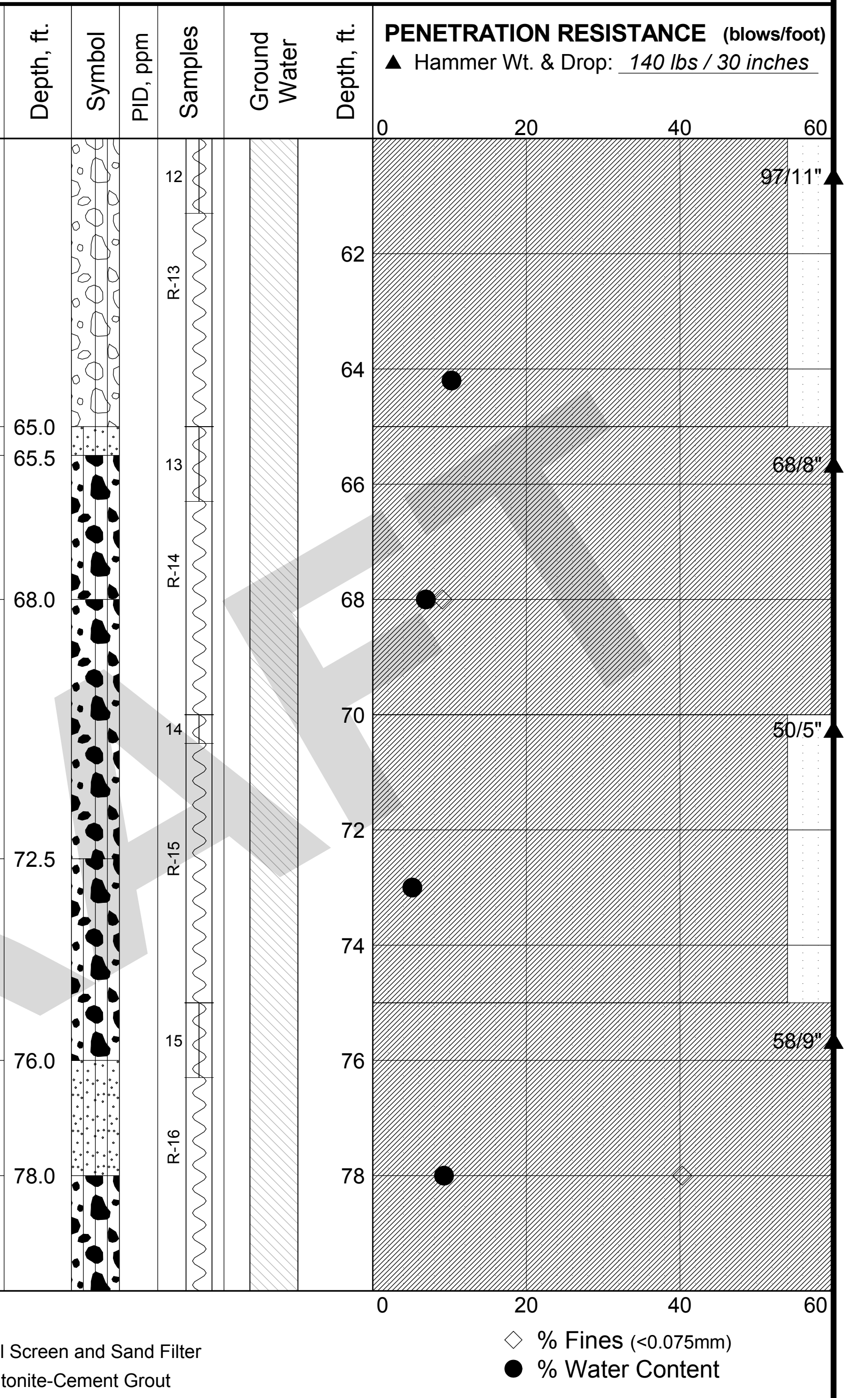
Medium dense to dense, brown mottled with gray and red-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; angular to subrounded gravel; trace clay pockets.
Alluvium (Qa)
- Higher plasticity fines below 74 feet.

76.0

78.0

Medium dense to dense, gray-brown, *Silty Sand with Gravel (SM)*; moist; little subangular to rounded gravel; low to medium plasticity fines.

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- Soil Core (as in Sonic Core Borings)
- 2.0" O.D. Split Spoon Sample
- Well Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-02-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-6
Sheet 4 of 6

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

REV 3 - Approved for Submittal

Total Depth:	101.5 ft.	Northing:		Drilling Method:	Sonic Core	Hole Diam.:	8 in.
Top Elevation:	~ 1052 ft.	Easting:		Drilling Company:	Holt Services, Inc.	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Terra Sonic	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Alluvium (Qa)

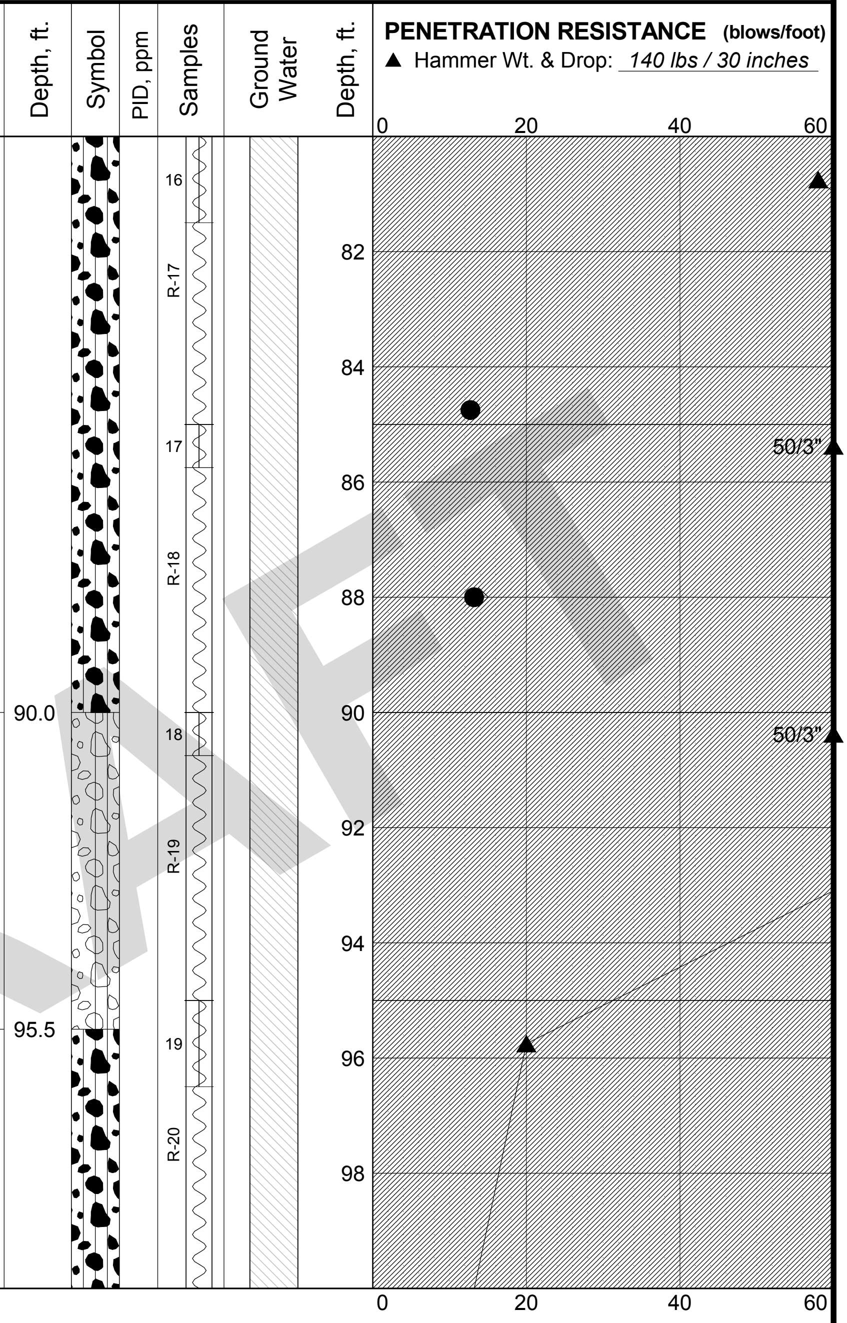
Medium dense to dense, brown, *Silty Gravel with Sand and Cobbles (GM) to Clayey Gravel with Sand and Cobbles (GC)*; moist; few subrounded cobbles; angular to rounded gravel; iron-oxide staining locally.
Alluvium (Qa)

- Baked zone from drill action from 82.5 to 83 feet.
- Clayey gravel from 85 to 88 feet.
- Strong iron-oxide staining from 88.5 to 90 feet.

Brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; wet; subrounded gravel; iron-oxide staining below 93 feet.
Alluvium (Qa)

- Iron-oxide staining below 93.5.

Medium dense, brown to gray-brown with red-brown mottling; *Silty Gravel with Sand and Cobbles (GM)*; moist; subangular to subrounded gravel; interbedded with poorly graded gravel.
Alluvium (Qa)



◇ % Fines (<0.075mm)
● % Water Content

CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	▥	Well Screen and Sand Filter
▯	Soil Core (as in Sonic Core Borings)	▧	Bentonite-Cement Grout
⌶	2.0" O.D. Split Spoon Sample	⊠	Bentonite Chips/Pellets
		▨	Bentonite Grout
		▽	Ground Water Level ATD
		▼	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-02-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-6
Sheet 5 of 6

REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth: 101.5 ft.
Top Elevation: ~ 1052 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

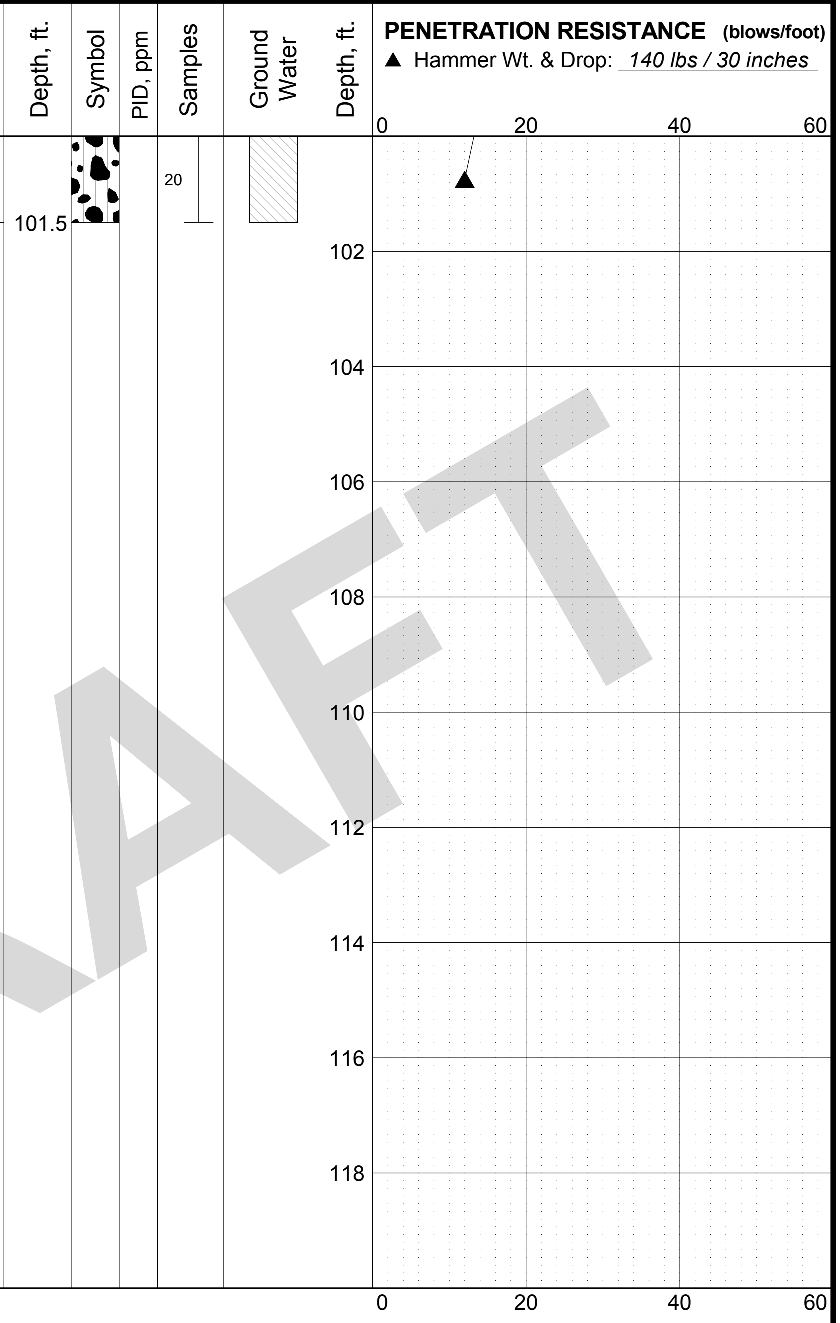
BOTTOM OF BORING
COMPLETED 6/25/2014

Notes:

a) Some blow counts are high due to the presence of gravel and cobbles, and do not reflect the relative density of the soil unit.

b) Moisture content may be reduced by frictional heating generated during drilling.

c) Boulders may be present in alluvium layers.



LEGEND

- * Sample Not Recovered
- ▨ Soil Core (as in Sonic Core Borings)
- I 2.0" O.D. Split Spoon Sample
- ⊞ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ∇ Ground Water Level ATD
- ▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-02-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-6
Sheet 6 of 6

REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth: 100.4 ft.
Top Elevation: ~ 1056.5 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

SOIL DESCRIPTION

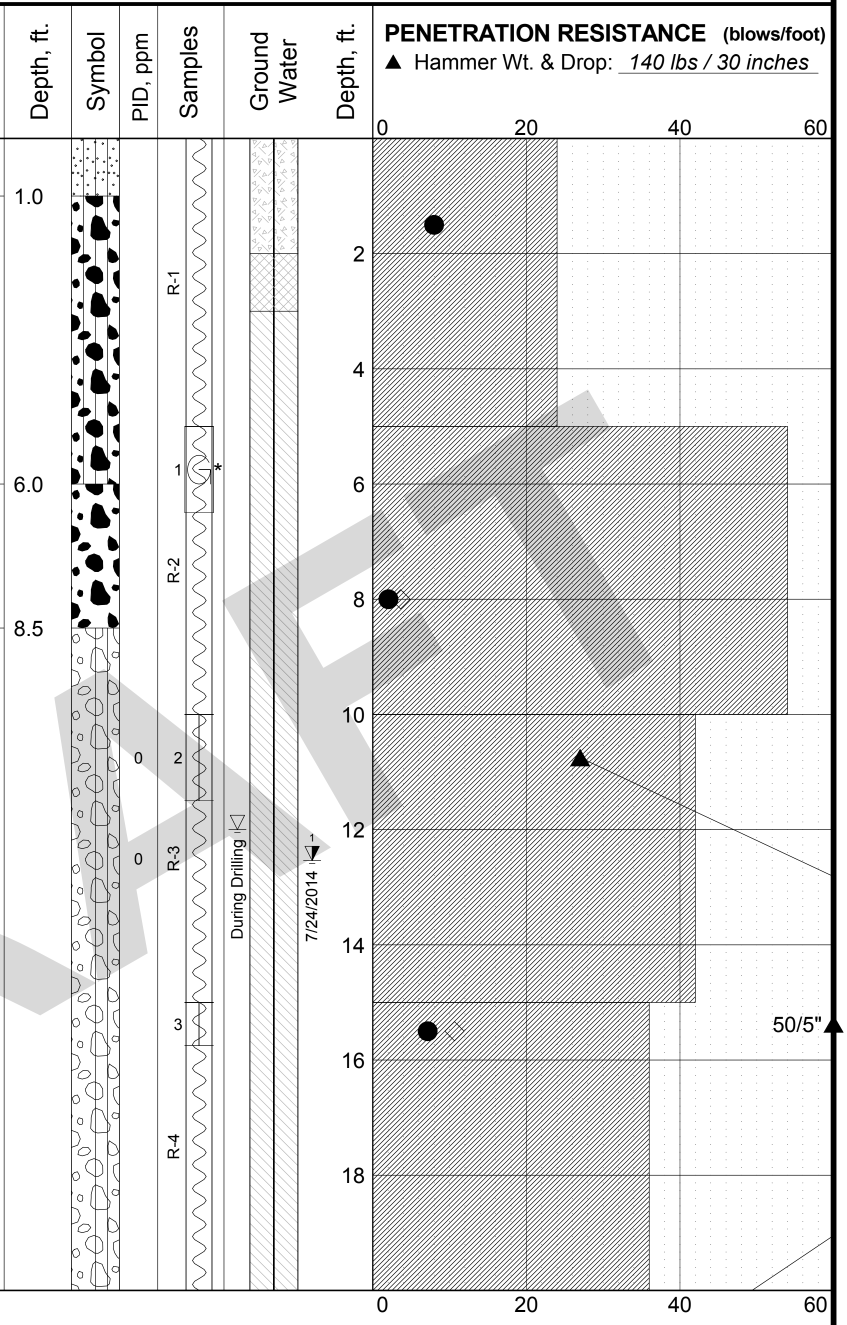
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Brown, *Silty Sand with Gravel (SM)*; moist; angular to subrounded and broken gravel; some wood chips.
Fill (Hf)

Brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; few cobbles; angular to rounded gravel; little wood chips; trace roots.
Fill (Hf)
- Sandy silt with gravel below 5 feet.

Gray-brown, *Well Graded Gravel with Sand and Cobbles (GW)*; moist; subangular to rounded gravel; trace fines.
Alluvium (Qa)

Medium dense, brown to red-brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; wet; subangular to subrounded gravel; slight iron-oxide staining from 11.5 to 13 feet.
Alluvium (Qa)
- Silty gravel with sand from 10 to 12 feet.
- Mostly fine gravel and coarse sand from 15 to 16.5 feet.
- Slight iron-oxide staining below 17 feet.



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	▤	Well Screen and Sand Filter
▯	Soil Core (as in Sonic Core Borings)	▧	Bentonite-Cement Grout
▯	Grab Sample	▩	Bentonite Chips/Pellets
I	2.0" O.D. Split Spoon Sample	▨	Bentonite Grout
		▽	Ground Water Level ATD
		▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-03-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-7
Sheet 1 of 6

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

REV 3 - Approved for Submittal

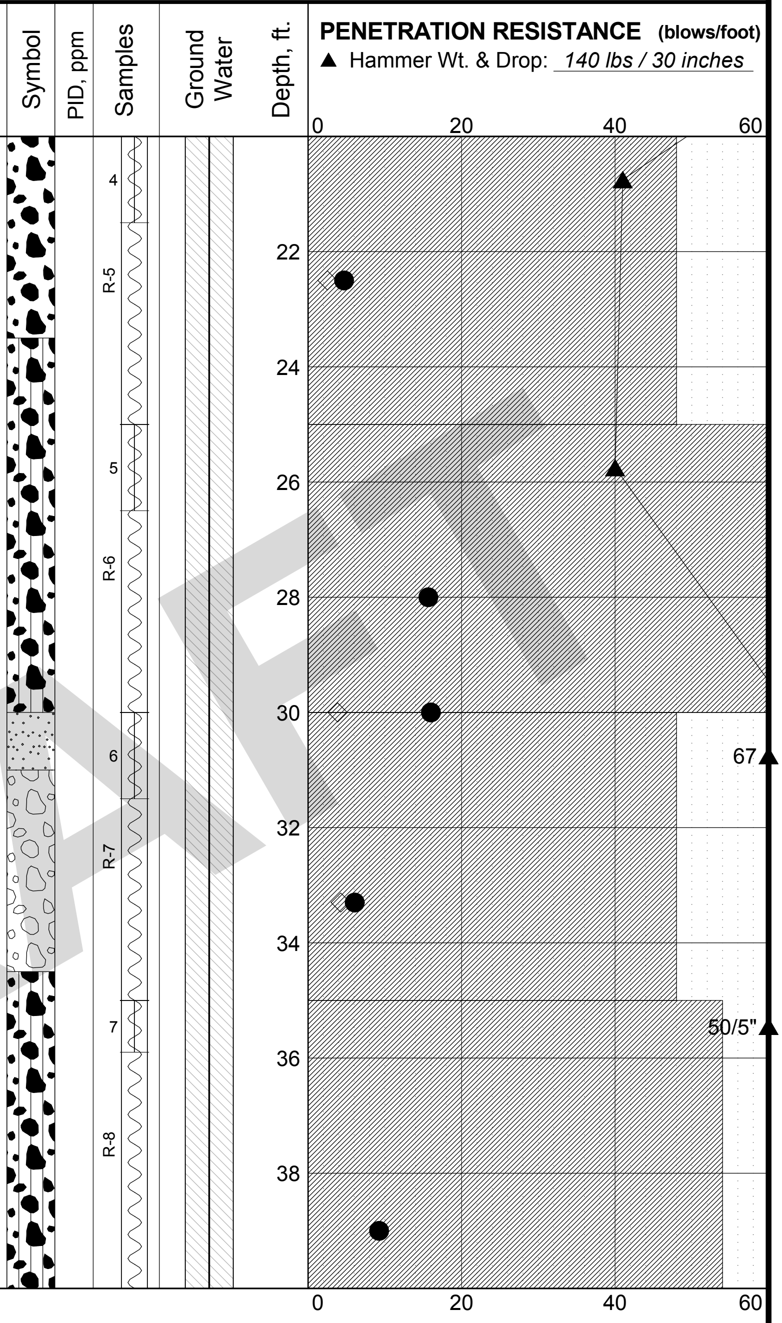
Total Depth:	*100.4 ft.*	Northing:		Drilling Method:	*Sonic Core*
Top Elevation:	*~ 1056.5 ft.*	Easting:		Drilling Company:	*Holt Services, Inc.*
Vert. Datum:		Station:		Drill Rig Equipment:	*Terra Sonic*
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	
20.0	Medium dense to dense, gray to gray-brown, *Well Graded Gravel (GW)*; wet; few cobbles; subangular to subrounded gravel; trace sand and fines. Alluvium (Qa)
23.5	Medium dense to dense, brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; few subrounded cobbles; subangular to subrounded gravel. Alluvium (Qa) - Light tan ash layer(?) from about 26.5 to 27.5 feet.
30.0	Medium dense to dense, gray to gray-brown, *Poorly Graded Sand (SP)*; wet; trace fine gravel. Alluvium (Qa)
31.0	Medium dense to dense, brown, *Poorly Graded Gravel with Sand (GP)*; wet; subangular to rounded gravel; trace fines. Alluvium (Qa) - Siltier below 33.5 feet.
34.5	Medium dense to dense, brown to gray-brown and red-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; subangular to subrounded gravel; trace clay pockets. Alluvium (Qa) - Light tan ash layer(?) from about 36 to 37.5 feet. - Iron-oxide staining below 37.5 feet.



◇ % Fines (<0.075mm)
● % Water Content

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered	Well Screen and Sand Filter
Soil Core (as in Sonic Core Borings)	Bentonite-Cement Grout
Grab Sample	Bentonite Chips/Pellets
2.0" O.D. Split Spoon Sample	Bentonite Grout
	Ground Water Level ATD
	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-03-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-7
Sheet 2 of 6

REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth: 100.4 ft.
Top Elevation: ~ 1056.5 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

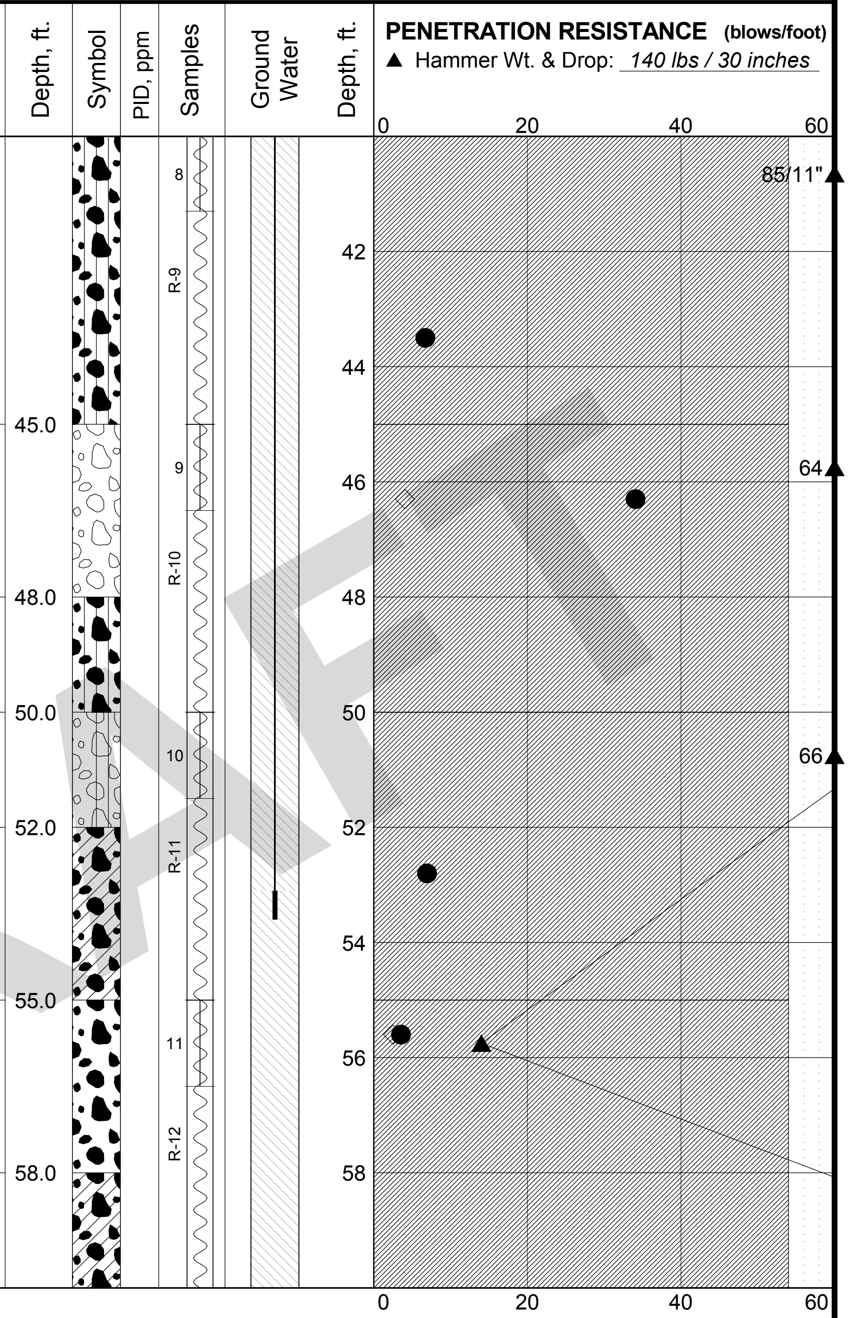
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Soil Description
45.0	Medium dense to dense, brown, *Poorly Graded Gravel with Sand and Cobbles (GP)*; wet; few cobbles; subangular to subrounded gravel; trace fines. Alluvium (Qa)
48.0	Brown to gray-brown mottled with red-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; few cobbles; subangular to rounded gravel. Alluvium (Qa)
50.0	Medium dense to dense, brown to gray-brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist; few cobbles; subangular to subrounded gravel; low plasticity fines. Alluvium (Qa)
52.0	Medium dense to dense, brown, *Clayey Gravel with Sand and Cobbles (GC)*; moist; subrounded to to rounded gravel; fine to medium sand. Alluvium (Qa)
55.0	Medium dense, brown, *Well Graded Gravel with Sand (GW)*; wet; subrounded to rounded gravel; fine to medium sand; trace fines; trace iron-oxide staining. Alluvium (Qa)
58.0	

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
Soil Core (as in Sonic Core Borings)
Grab Sample
2.0" O.D. Split Spoon Sample
Well Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout
Ground Water Level ATD
Ground Water Level in VWP

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-03-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-7
Sheet 3 of 6

REV 3 - Approved for Submittal

Total Depth:	100.4 ft.	Northing:		Drilling Method:	Sonic Core	Hole Diam.:	8 in.
Top Elevation:	~ 1056.5 ft.	Easting:		Drilling Company:	Holt Services, Inc.	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Terra Sonic	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, brown, *Clayey Gravel with Sand and Cobbles (GC)*; moist; subrounded to rounded gravel.
Alluvium (Qa)

Medium dense to dense, gray to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subangular to subrounded gravel; low plasticity fines.
Alluvium (Qa)

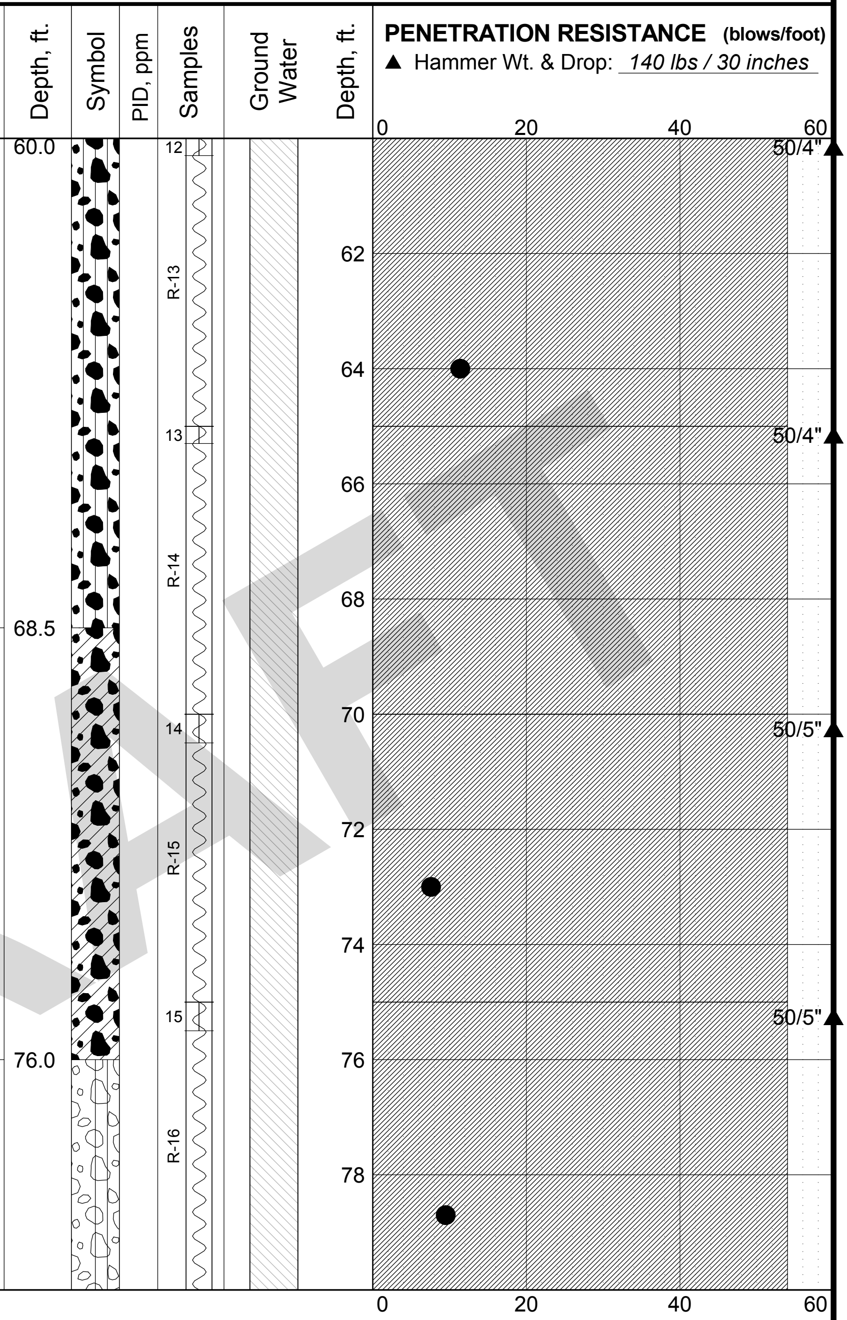
- Baked zone from drilling friction from 67 to 68.5 feet.

Medium dense to dense, brown to red-brown, *Clayey Gravel with Sand and Cobbles (GC)*; moist; subrounded to angular cobbles; angular to rounded gravel.
Alluvium (Qa)

- Slight iron-oxide staining below 70 feet.

Medium dense to dense, brown with red-brown and gray mottling, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist; few cobbles; subangular to subrounded gravel; iron-oxide staining.
Alluvium (Qa)

- Silty gravel from 77 to 79 feet.



◇ % Fines (<0.075mm)
● % Water Content

CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	⊟	Well Screen and Sand Filter
◪	Soil Core (as in Sonic Core Borings)	▧	Bentonite-Cement Grout
Ⓖ	Grab Sample	⊠	Bentonite Chips/Pellets
⌶	2.0" O.D. Split Spoon Sample	▨	Bentonite Grout
		▽	Ground Water Level ATD
		▼	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-03-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-7
Sheet 4 of 6

REV 3 - Approved for Submittal

Total Depth: *100.4 ft.*
Top Elevation: *~ 1056.5 ft.*
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

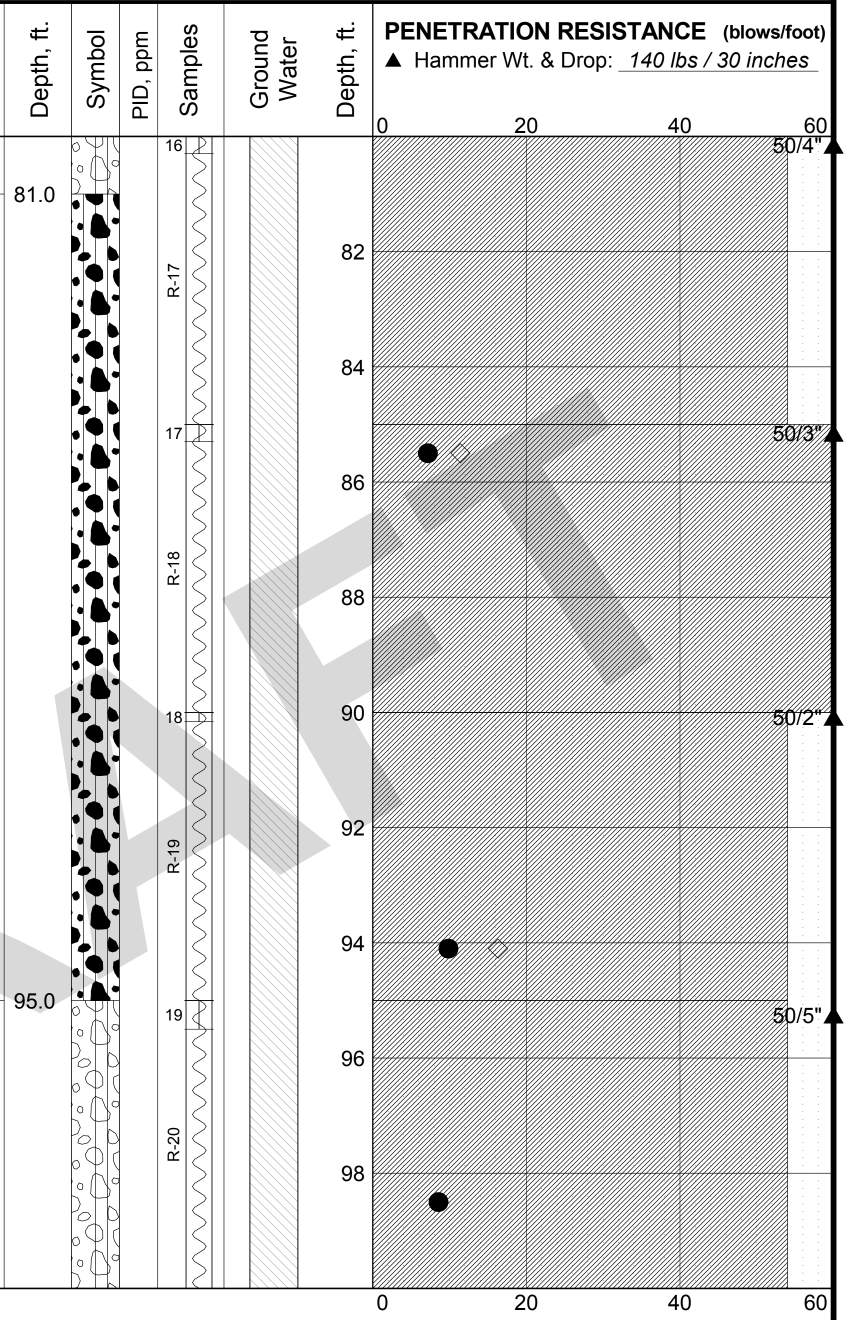
- Iron-oxide staining from 76 to 77 feet and below 79 feet.

Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM) to Clayey Gravel with Sand and Cobbles (GC)*; moist; little, subrounded cobbles; angular to rounded gravel; iron-oxide staining locally.
Alluvium (Qa)

- Slight iron-oxide staining below 84 feet.
- Poorly graded gravel with sand from 85 to 87 feet.

Medium dense to dense, gray-brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; moist; subangular to rounded gravel; low plasticity fines; slight iron-oxide staining.
Alluvium (Qa)

- Silty gravel below 96 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered	▥ Well Screen and Sand Filter
▯ Soil Core (as in Sonic Core Borings)	▧ Bentonite-Cement Grout
G Grab Sample	▩ Bentonite Chips/Pellets
I 2.0" O.D. Split Spoon Sample	▨ Bentonite Grout
	▽ Ground Water Level ATD
	▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-03-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-7
Sheet 5 of 6

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

REV 3 - Approved for Submittal

Total Depth: 100.4 ft.
Top Elevation: ~ 1056.5 ft.
Vert. Datum:
Horiz. Datum:

Northing:
Easting:
Station:
Offset:

Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:

Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	PID, ppm	Samples	Ground Water
BOTTOM OF BORING COMPLETED 6/30/2014	100.4			20	

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

◇ % Fines (<0.075mm)
● % Water Content

Notes:
a) Some blow counts are high due to the presence of gravel and cobbles, and do not reflect the relative density of the soil unit.
b) Moisture content may be reduced by frictional heating generated during drilling.
c) Boulders may be present in alluvium layers.

LEGEND

- * Sample Not Recovered
- Soil Core (as in Sonic Core Borings)
- Grab Sample
- 2.0" O.D. Split Spoon Sample
- Well Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in VWP

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-03-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

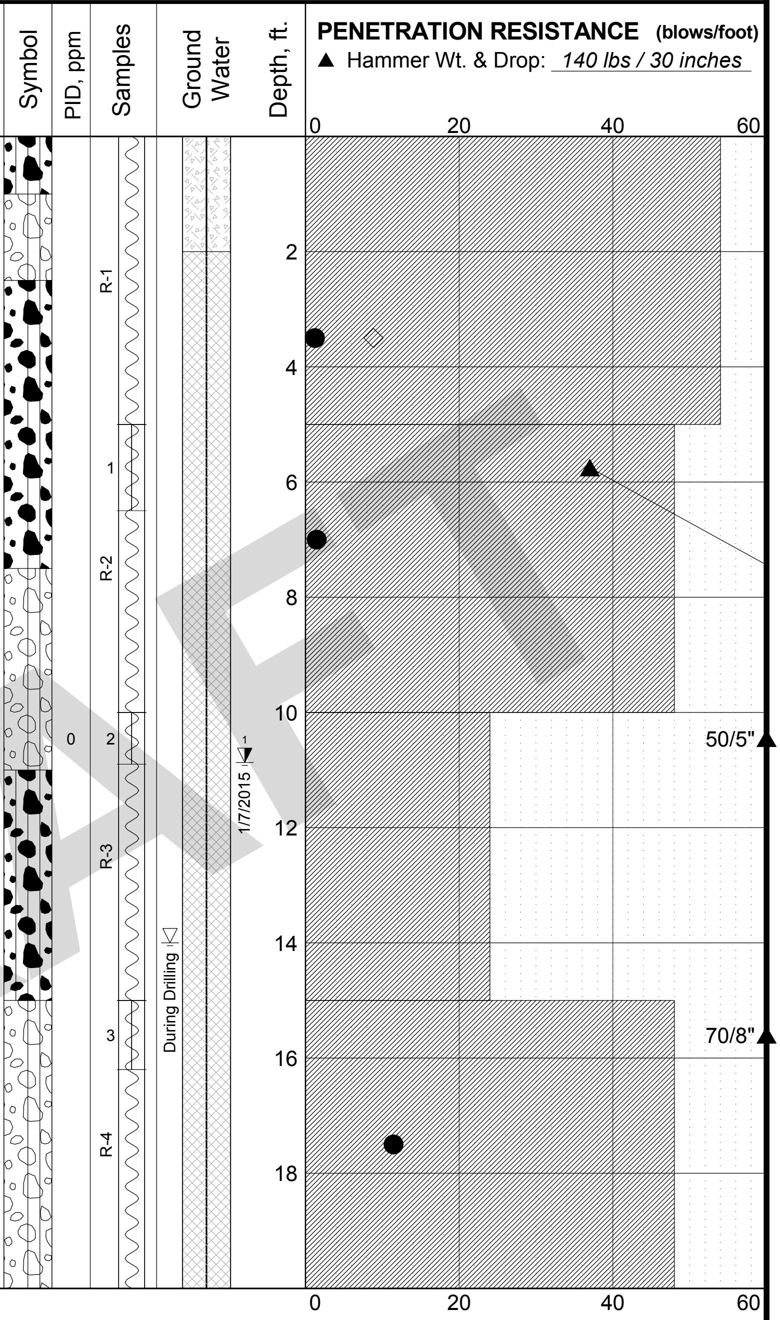
FIG. C-7
Sheet 6 of 6

Log: SAW Rev: JKP Typ: CLP

REV 3 - Approved for Submittal

Total Depth:	*100.3 ft.*	Northing:		Drilling Method:	*Sonic Core*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 1047 ft.*	Easting:		Drilling Company:	*Holt Services, Inc.*	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	*Terra Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded and angular cobbles; angular to rounded gravel. Fill (Hf)	1.0
Red-brown, *Poorly Graded Gravel with Silt and Sand (GP-GM)*; moist; angular to rounded gravel. Alluvium (Qa)	2.5
Dense, gray to brown, *Well Graded Gravel with Silt and Sand (GW-GM)*; moist; angular to rounded gravel. Alluvium (Qa) -- Few subrounded and angular cobbles at 3 feet.	7.5
Dense, brown to gray-brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM) to Silty Gravel with Sand and Cobbles (GM)*; moist; subangular to subrounded gravel. Alluvium (Qa) -- Gradational contact at 11 feet.	11.0
Medium dense to dense, brown, *Silty Gravel with Sand and Cobbles (GM)*; wet; subangular to subrounded gravel. Alluvium (Qa)	15.0
Medium dense to dense, brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; wet; subangular to rounded gravel; low plasticity fines. Alluvium (Qa)	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Soil Core (as in Sonic Core Borings)
- 2.0" O.D. Split Spoon Sample
- Well Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in VWP
- ◇ % Fines (<0.075mm)
- ● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-04-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-8
Sheet 1 of 6

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Log: SAW Rev: JKP Typ: CLP

REV 3 - Approved for Submittal

Total Depth: 100.3 ft.
Top Elevation: ~ 1047 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

20.0 — Medium dense to dense, brown mottled with red-brown, *Poorly Graded Gravel with Sand and Cobbles (GP) to Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; wet; subangular to subrounded gravel.
Alluvium (Qa)

25.0 — Medium dense to dense, brown, *Well Graded Gravel with Sand and Cobbles (GW) to Well Graded Gravel with Silt, Sand, and Cobbles (GW-GM)*; wet; angular to subrounded gravel.
Alluvium (Qa)

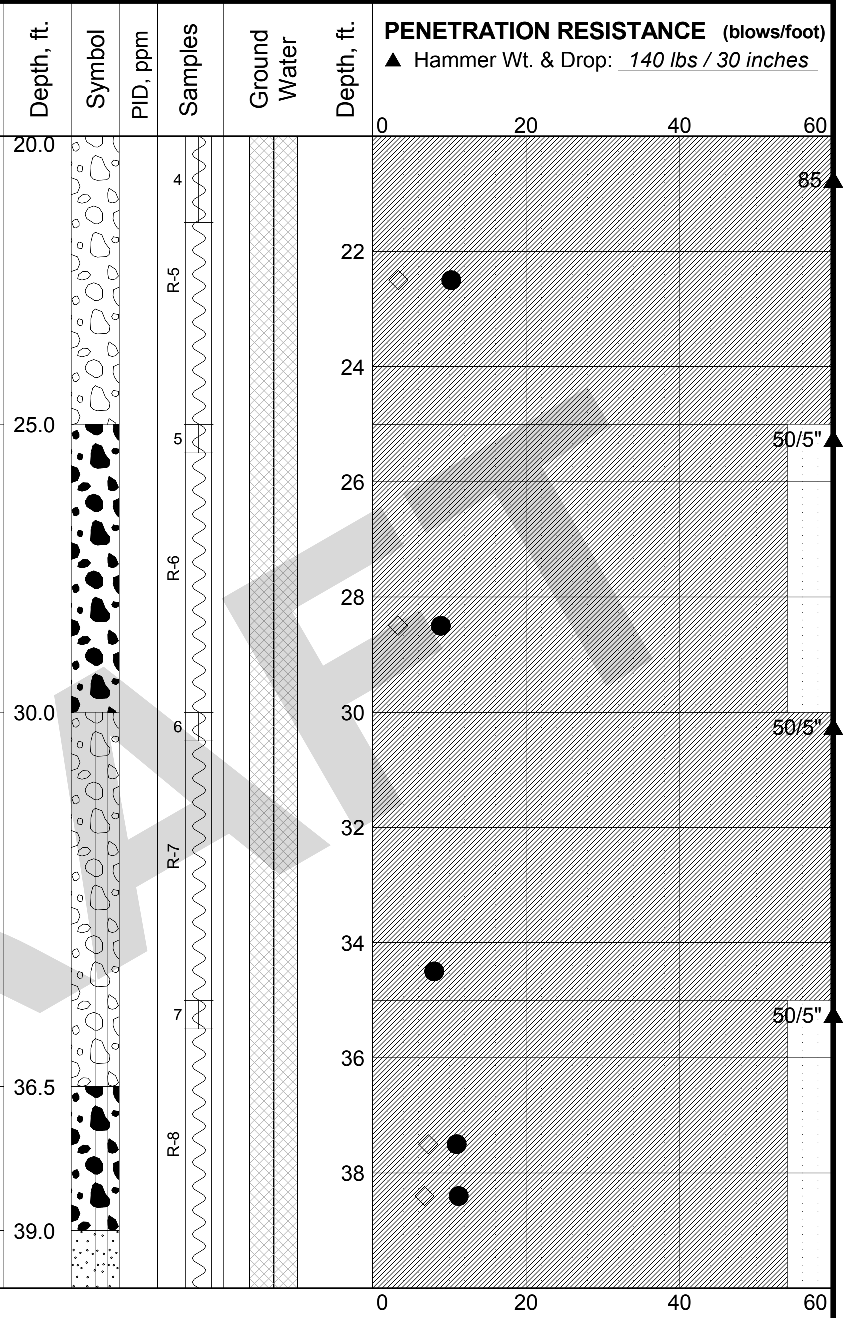
-- Light tan ash layer(?) at about 28 feet.

30.0 — Medium dense to dense, brown to gray, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist; few cobbles; subangular to rounded gravel, mostly fine gravel; low plasticity fines; iron-oxide staining.
Alluvium (Qa)

-- Baked zone from drilling friction from 35 to 36 feet.

36.5 — Medium dense to dense, brown, *Well Graded to Poorly Graded Gravel with Silt, Sand, and Cobbles (GW-GM/GP-GM)*; moist to wet; angular to rounded gravel; slight iron-oxide staining.
Alluvium (Qa)

39.0



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
▯	Soil Core (as in Sonic Core Borings)
I	2.0" O.D. Split Spoon Sample
▤	Well Screen and Sand Filter
▧	Bentonite-Cement Grout
▩	Bentonite Chips/Pellets
▨	Bentonite Grout
▽	Ground Water Level ATD
▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-04-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-8
Sheet 2 of 6

Total Depth: 100.3 ft.
Top Elevation: ~ 1047 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: Sonic Core
Drilling Company: Holt Services, Inc.
Drill Rig Equipment: Terra Sonic
Other Comments:
Hole Diam.: 8 in.
Rod Diam.:
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, gray, *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; subangular to subrounded, fine to coarse gravel.
Alluvium (Qa)

Medium dense to dense, gray-brown to brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; little cobbles; subangular to subrounded gravel; low plasticity fines; iron-oxide staining locally.
Alluvium (Qa)

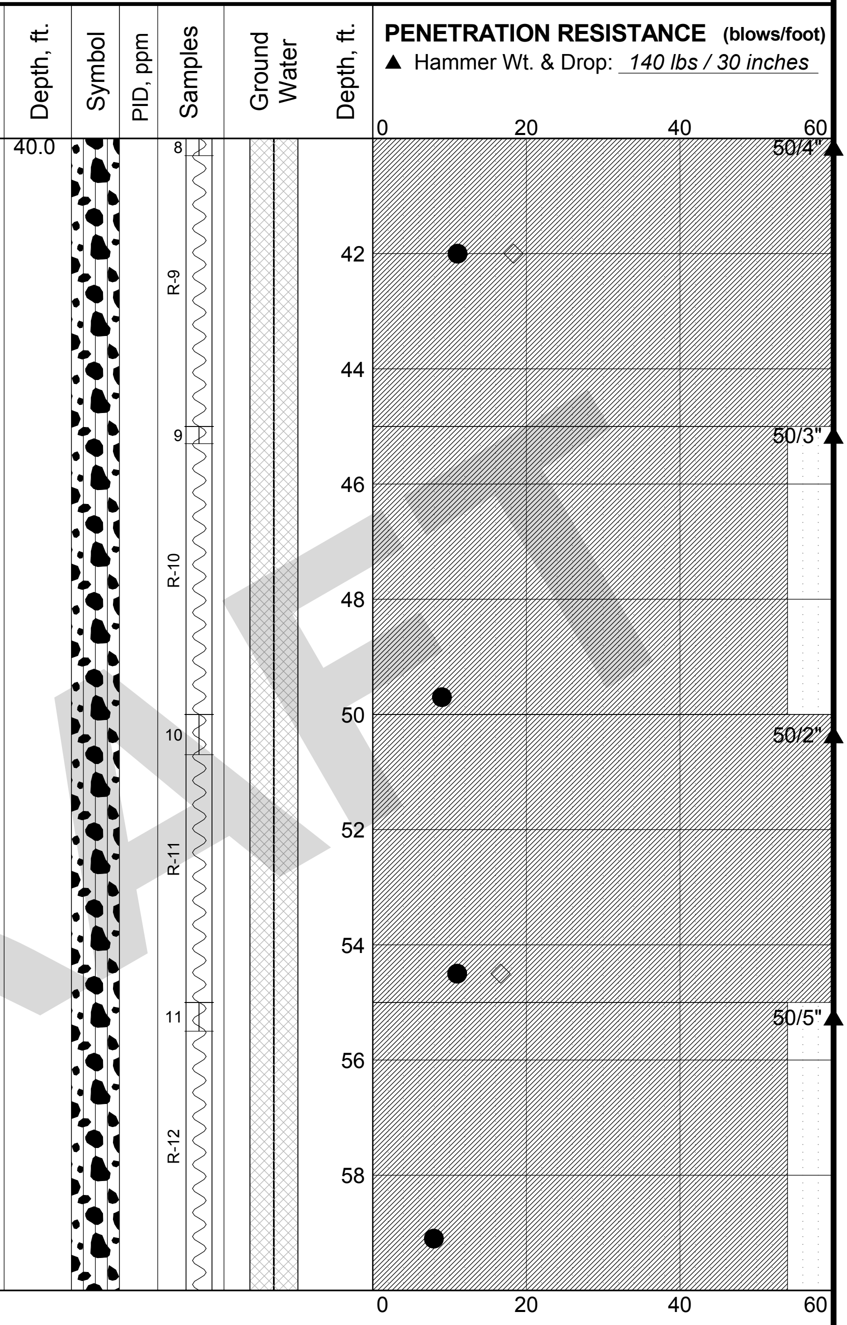
-- Wet below 48 feet.

-- Increasing plasticity below 52.5 feet.

-- Strong iron-oxide staining from 53 to 54.5 feet.

-- Clayey gravel with ash layer(?) from about 55 to 56.5 feet.

-- Poorly graded gravel with silt and sand below 59 feet.



◇ % Fines (<0.075mm)
● % Water Content

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
Soil Core (as in Sonic Core Borings)
2.0" O.D. Split Spoon Sample
Well Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout
Ground Water Level ATD
Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-04-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-8
Sheet 3 of 6

REV 3 - Approved for Submittal

Total Depth: *100.3 ft.*
Top Elevation: *~ 1047 ft.*
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION

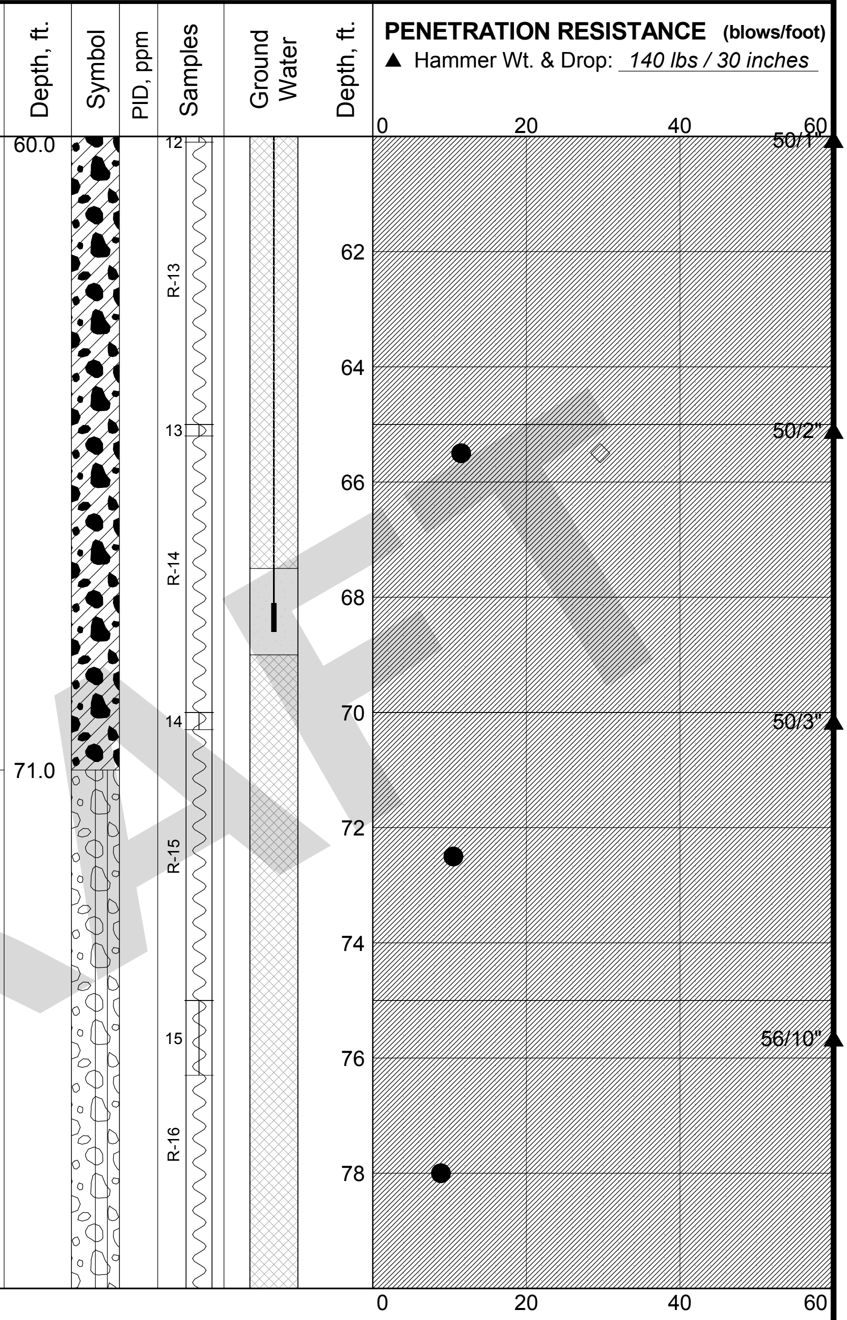
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, gray-brown to brown mottled with red-brown, *Clayey Gravel with Sand and Cobbles (GC)*; moist; few cobbles; angular to rounded gravel. Alluvium (Qa)

-- Strong iron-oxide staining below 66 feet.

Medium dense to dense, brown mottled with red-brown and gray, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; moist; few cobbles; subangular to rounded gravel; low plasticity fines; weathered cobbles and gravel. Alluvium (Qa)

-- Strong iron-oxide staining from 79 to 80 feet.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▯ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▤ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-04-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-8
Sheet 4 of 6

REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP
MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth: 100.3 ft.
Top Elevation: ~ 1047 ft.
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION

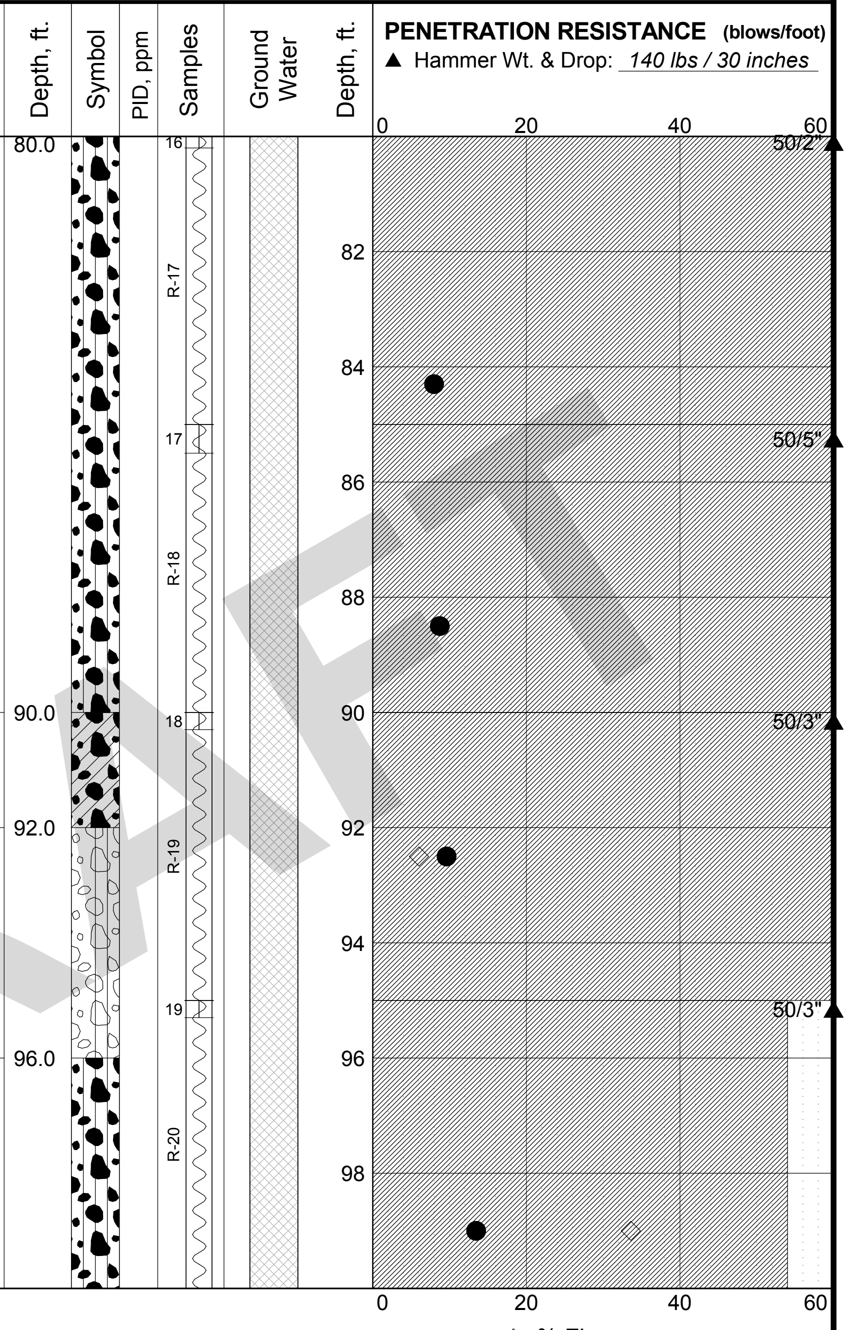
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

80.0 Medium dense to dense, brown to gray-brown mottled with red-brown and dark gray, *Silty Gravel with Sand and Cobbles (GM)*; moist to wet; subangular to subrounded gravel; trace clay pockets; weathered cobbles and gravel.
Alluvium (Qa)

90.0 Medium dense to dense, brown with red-brown, *Clayey Gravel with Sand (GC)* to *Silty Gravel with Sand (GM)*; moist; subangular to subrounded gravel.
Alluvium (Qa)
- Strong iron-oxide staining at 90.5 feet.

92.0 Medium dense to dense, brown to red-brown, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; wet; subangular to rounded gravel; low plasticity fines.
Alluvium (Qa)

96.0 Medium dense to dense, brown to gray-brown, *Silty Gravel with Sand and Cobbles (GM)*; moist; subrounded to rounded gravel; low to medium plasticity fines.
Alluvium (Qa)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▯ Soil Core (as in Sonic Core Borings)
I 2.0" O.D. Split Spoon Sample

▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-04-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-8
Sheet 5 of 6

REV 3 - Approved for Submittal

Log: SAW Rev: JKP Typ: CLP

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Total Depth: *100.3 ft.*
Top Elevation: *~ 1047 ft.*
Vert. Datum:
Horiz. Datum:
Northing:
Easting:
Station:
Offset:
Drilling Method: *Sonic Core*
Drilling Company: *Holt Services, Inc.*
Drill Rig Equipment: *Terra Sonic*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.:
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | PID, ppm | Samples | Ground Water | Depth, ft.

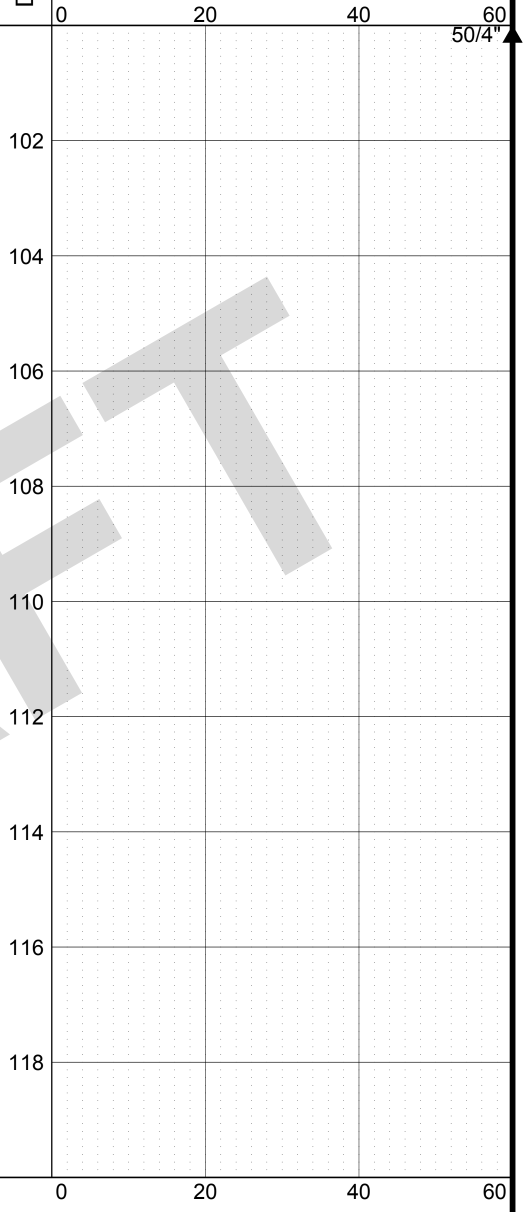
PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

100.3

20

BOTTOM OF BORING
COMPLETED 7/9/2014

Notes:
a) Some blow counts are high due to the presence of gravel and cobbles, and do not reflect the relative density of the soil unit.
b) Moisture content may be reduced by frictional heating generated during drilling.
c) Boulders may be present in alluvium layers.



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

- * Sample Not Recovered
- ▯ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊞ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

East-West Corridor Project
Yakima County, Washington

LOG OF BORING EWC-B-04-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-8
Sheet 6 of 6

MASTER_LOG_E 21-21630.GPJ SHAN_WIL.GDT 11/13/17

Log: SAW Rev: JKP Typ: CLP

REV 3 - Approved for Submittal

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-P1-17

JOB NO: 21-1-22425-002 DATE: 9/27/17 LOCATION: Yakima, WA
PROJECT: Yakima E-W Corridor

Surface: Weeds

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
① Loose-medium dense, brown, Silty Gravel with Sand and Cobbles (GM); dry; SR-R Gravel and Cobbles, maximum dimension 8"; fine to coarse Sand; no fines; trace fine roots; abundant wood debris Topsoil	None Observed			
② Loose to medium dense, light gray-brown, Silty Gravel with Sand and Cobbles (GM); dry; SR-R Gravel and Cobbles, maximum dimension 8"; fine to coarse Sand; no fines; abundant wood debris. Fill			S-1	4
③ Medium dense, gray-brown, poorly-graded Sand with silt and gravel (SP-SM); moist, SR-R Gravels, maximum dimension 3"; fine to coarse Sand; no fines.			S-2	8
Bottom at 8.5'				

Sketch of South Pit Side

Lat/Long: 46.61396134/-120.4892509

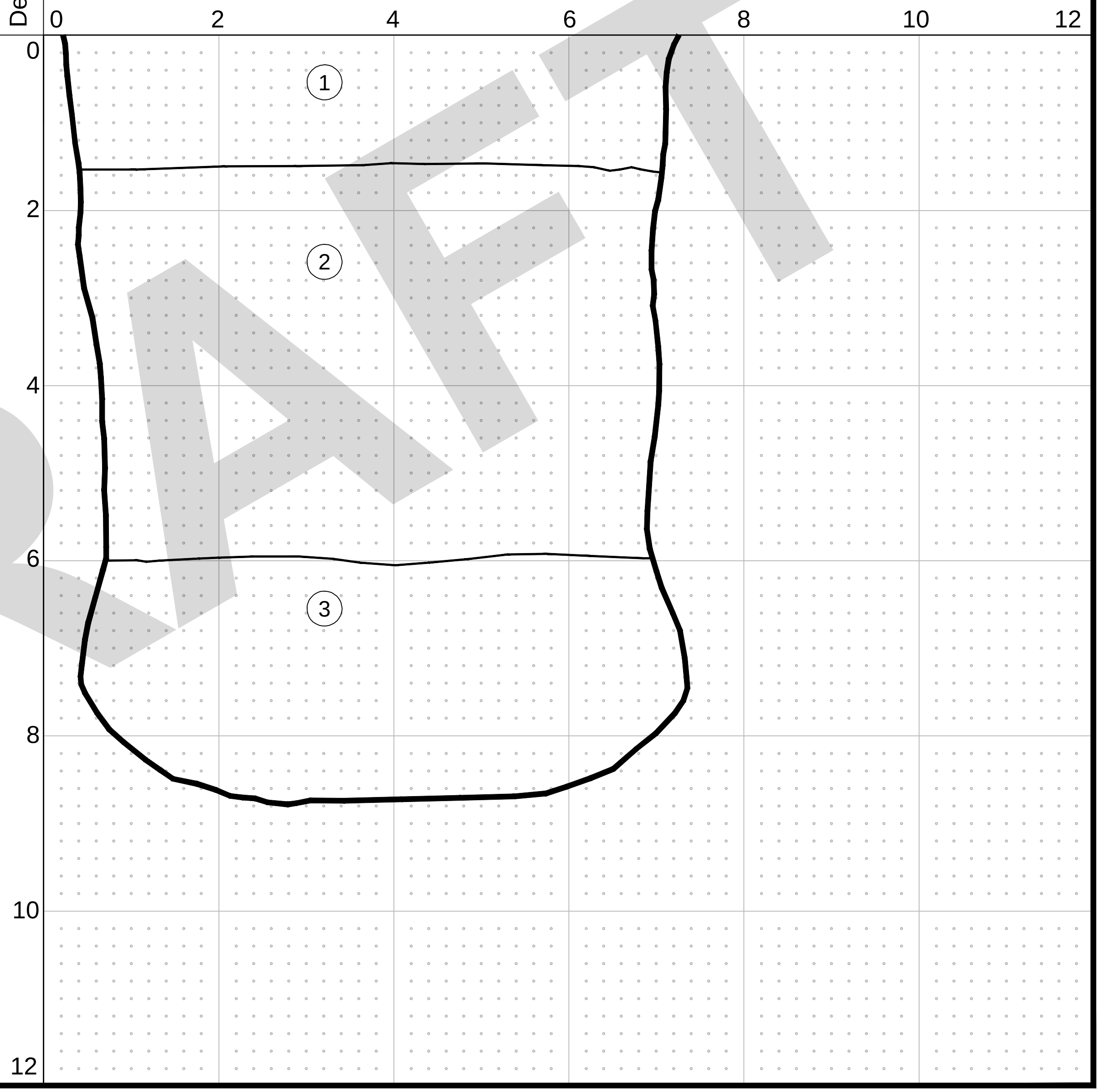


FIG. C-9

Table C-1 - Summary of Pilot Infiltration Test Results

			Test Pit Dimensions (ft)				Short-Term Infiltration (in/hr)			Correction Factors			Total Correction Factors	Long-Term Design Infiltration (in/hr)
Project Stage	PIT ID	Test Date	Length	Width	Depth	Average Flow Rate (gpm)	Constant Head Test	Falling Head Test	Average	CF_v	CF_t	CF_m	$CF_T = CF_v \times CF_t \times CF_m$	Rate = CF_T x Ksat
Stage 3	TP-P1a-17	9/27/2017	5	7	8.5	340	53	50	51	0.7	0.5	0.7	0.25	13

NOTES:

CFv = site variability and number of locations tested; CF_t = uncertainty of test method; CF_m = degree of influent control to prevent siltation and biological buildup; CF_T = total correction factor; ft = feet
gpm = gallons per minute; in/hr = inches per hour; N/A = not applicable; Ksat = saturated hydraulic conductivity; PIT = pilot infiltration tests

Table C-2 - Summary of Grain-Size Analysis Infiltration Correlations

Test Pit Designation and Sample	Depth of Sample (ft bgs)	D_{10} (mm)	D_{60} (mm)	D_{90} (mm)	ffines	(cm/sec)	(in/hr)	Correction Factors			Total Correction Factors	Long-Term Design Infiltration (in/hr)
								CF_v	CF_t	CF_m	$CF_T = CF_v \times CF_t \times CF_m$	Rate = $CF_T \times$ Ksat
TP-P1-17*	4	0.04	0.339	11.53	19.2	9.20E-03	13	0.7	0.4	0.7	0.20	2.5
TP-P1-17	8.5	0.096	0.353	0.757	6.962	2.90E-02	14	0.7	0.4	0.7	0.20	8
TP-P1-17 Average Infiltration Rate												**5**

NOTES:

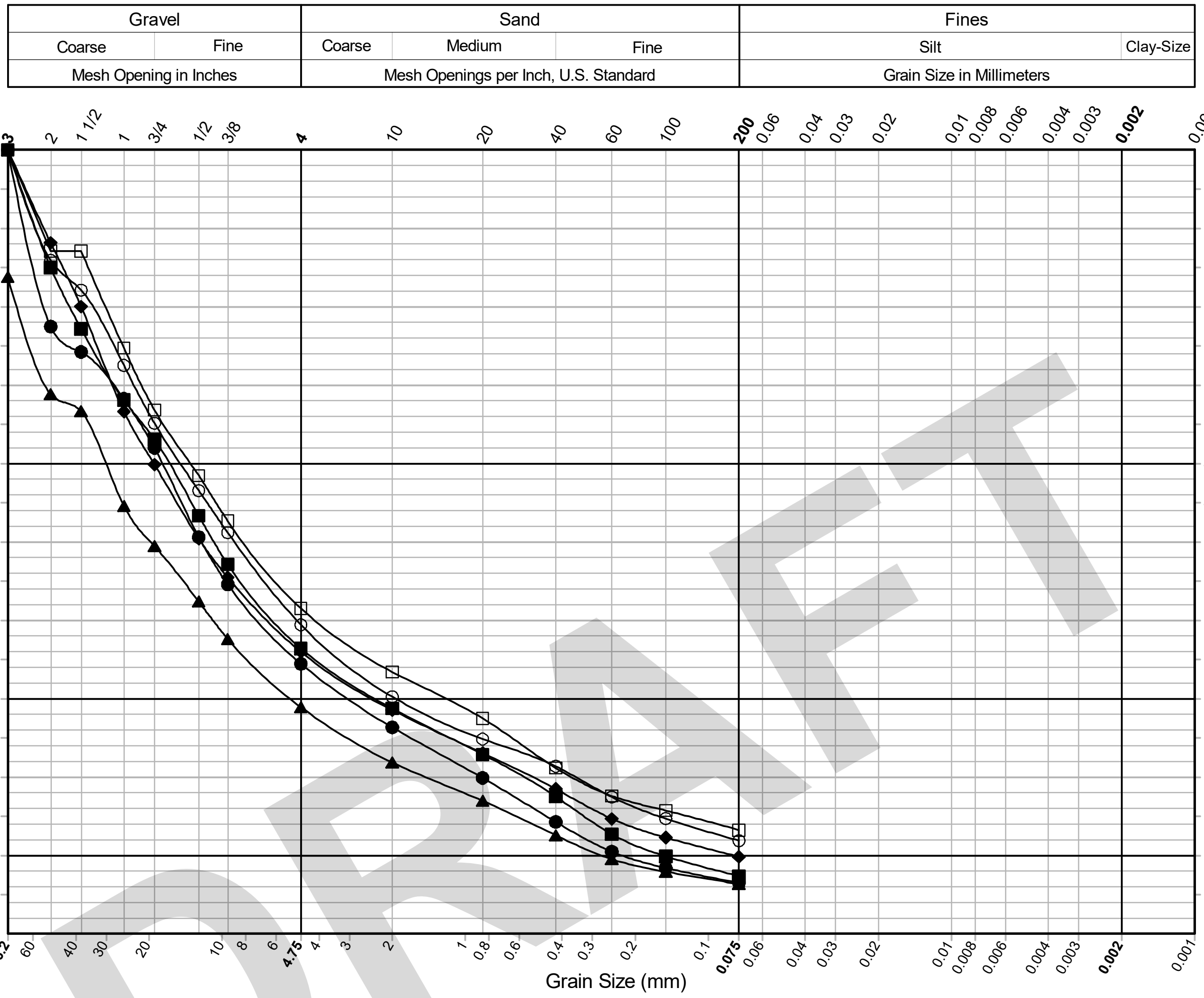
* D10 estimated based on grain-size distribution curve.

CFv = site variability and number of locations tested; CF_t = uncertainty of test method; CF_m = degree of influent control to prevent siltation and biological buildup; CF_T = total correction factor;
cm/sec = centimeters per second; $D_{10,}$ $D_{60,}$ D_{90} = grain size that corresponds to 10, 60, and 90% of the sample that is more fine; ffines = % by weight of fines (materials passing No. 200 sieve);
ft bgs = feet below ground surface; in/hr = inches per hour; Ksat = saturated hydraulic conductivity; mm = millimeter

GRAIN SIZE DISTRIBUTION PLOT

East-West Corridor Project
Stage 3
Yakima, Washington

BORING B-1-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %	Gravel %	Sand %	Fines %	< 20μm %	< 2μm %	WC %	Tested By	Review By	ASTM Std.
● B-1-17, R-2*	8.0	GW-GM	Well-Graded Gravel with Silt and Sand		66	28	6.5			2.8	SAB		C136
■ B-1-17, R-4*	18.0	GW-GM	Well-Graded Gravel with Silt and Sand		64	29	7.4			3.8	SAB		C136
▲ B-1-17, R-6*	28.0	GW-GM	Well-Graded Gravel with Silt and Sand and Cobbles	16	55	23	6.3			2.9	SAB		C136
◆ B-1-17, R-7*	33.0	GP-GM	Poorly Graded Gravel with Silt and Sand		64	26	9.8			3.9	SAB		C136
○ B-1-17, R-12*	56.0	GM	Silty Gravel with Sand		61	28	12			8.7	SAB		C136
□ B-1-17, R-20*	98.0	GM	Silty Gravel with Sand		58	28	13			7.1	SAB		C136

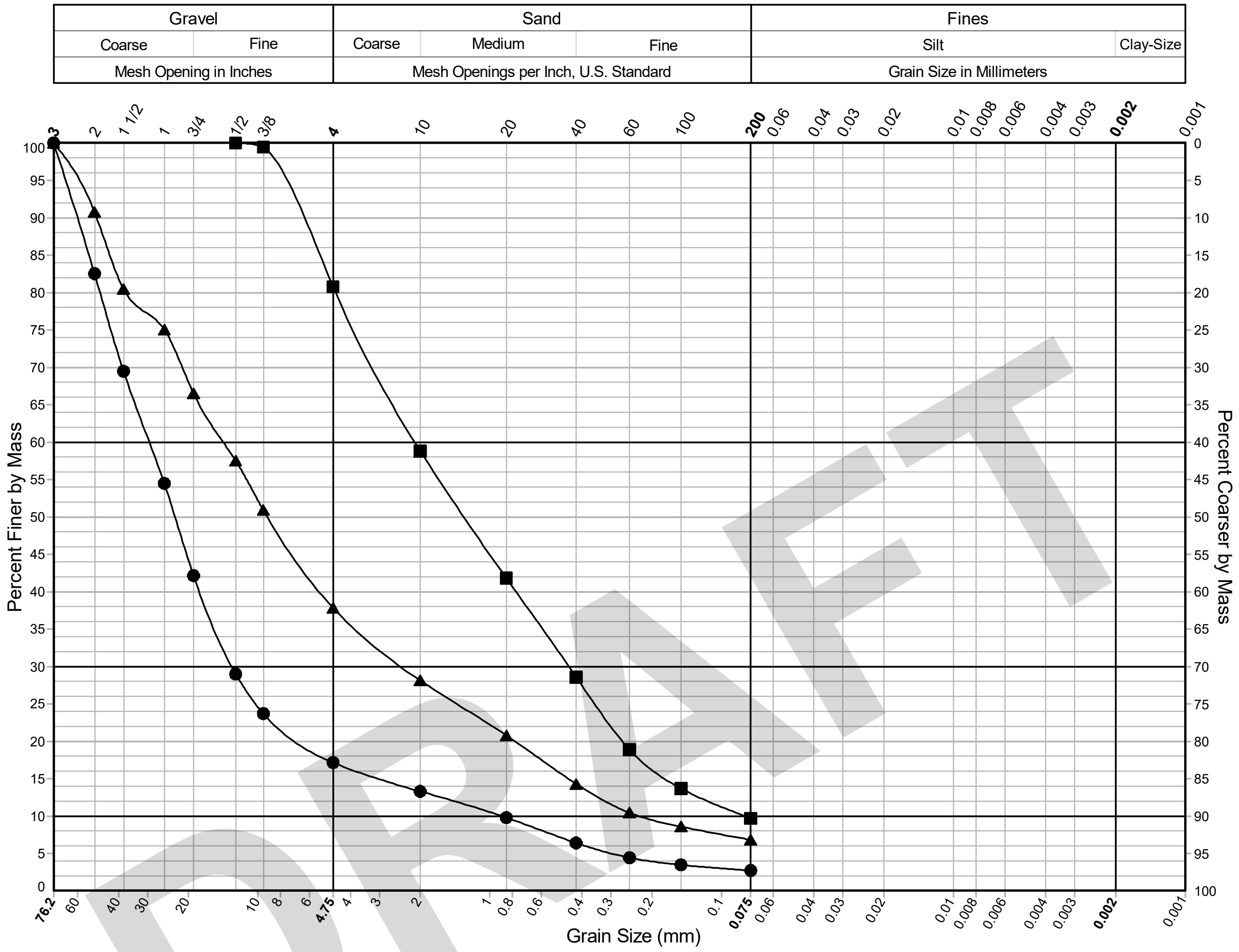
** Test specimen did not meet minimum mass recommendations.*

[2] Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

GRAIN SIZE DISTRIBUTION PLOT

East-West Corridor Project
Stage 3
Yakima, Washington

BORING B-2-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-2-17, R-3*	13.0	GP	Poorly Graded Gravel	83	14	2.7			1.6	SAB		C136
■ B-2-17, R-5*	20.0	SW-SM	Well-Graded Sand with Silt and Gravel	19	71	9.7			12.3	SAB		C136
▲ B-2-17, R-7*	30.0	GW-GM	Well-Graded Gravel with Silt and Sand	62	31	6.8			8.0	SAB		C136

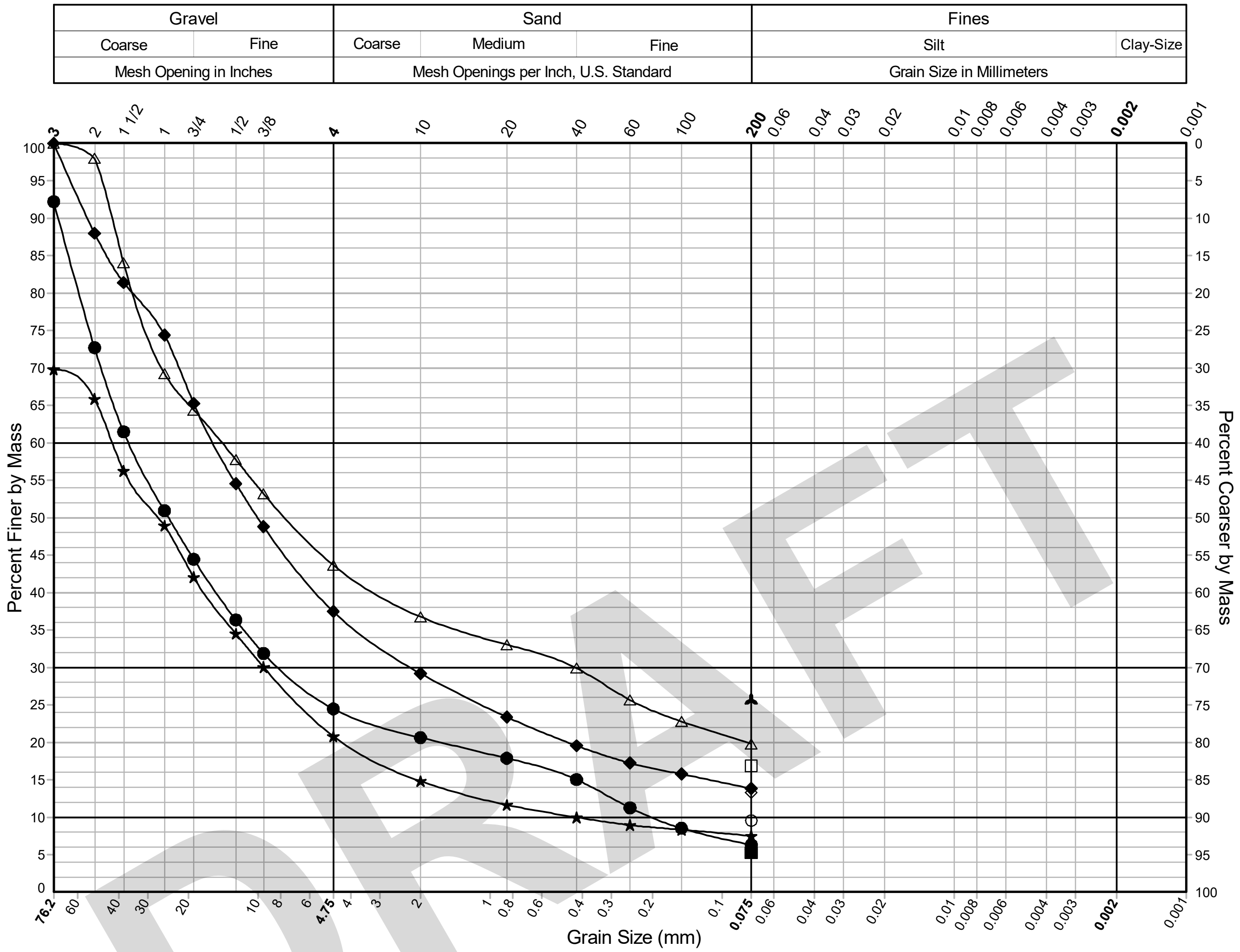
* *Test specimen did not meet minimum mass recommendations.*

GRAIN SIZE DISTRIBUTION PLOT

East-West Corridor Project
Stage 3
Yakima, Washington

BORING B-3-18

Sheet 1 of 2



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-3-18, R-2*	7.0	GP-GM	Poorly Graded Gravel with Silt and Sand and Cobbles	8	68	18	6.3			3.2	AKV	JFL	C136
■ B-3-18, R-4*	17.0	GP-GM	Poorly Graded Gravel with Silt and Sand				5.3			6.1	AKV	JFL	D1140
▲ B-3-18, R-6*	26.0	GP-GM	Poorly Graded Gravel with Silt and Sand				6.3			5.3	AKV	JFL	D1140
◆ B-3-18, R-8*	36.0	GM	Silty Gravel with Sand		63	24	14			7.2	AKV	JFL	C136
○ B-3-18, R-10*	47.5	GP-GM	Poorly Graded Gravel with Silt and Sand				9.5			5.7	AKV	JFL	D1140
□ B-3-18, R-12*	56.0	GM	Silty Gravel with Sand				17			7.8	AKV	JFL	D1140
△ B-3-18, R-14*	67.5	GM	Silty Gravel with Sand		56	24	20			6.6	AKV	JFL	C136
◇ B-3-18, R-16	76.0	SM	Silty Sand with Gravel				13			18.0	AKV	JFL	D1140
⅄ B-3-18, R-17*	82.5	GM	Silty Gravel with Sand				26			6.4	AKV	JFL	D1140
★ B-3-18, R-19*	92.5	GP-GM	Poorly Graded Gravel with Silt and Sand and Cobbles	30	49	13	7.5			6.1	AKV	JFL	C136

* *Test specimen did not meet minimum mass recommendations.*
[2] *Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.*

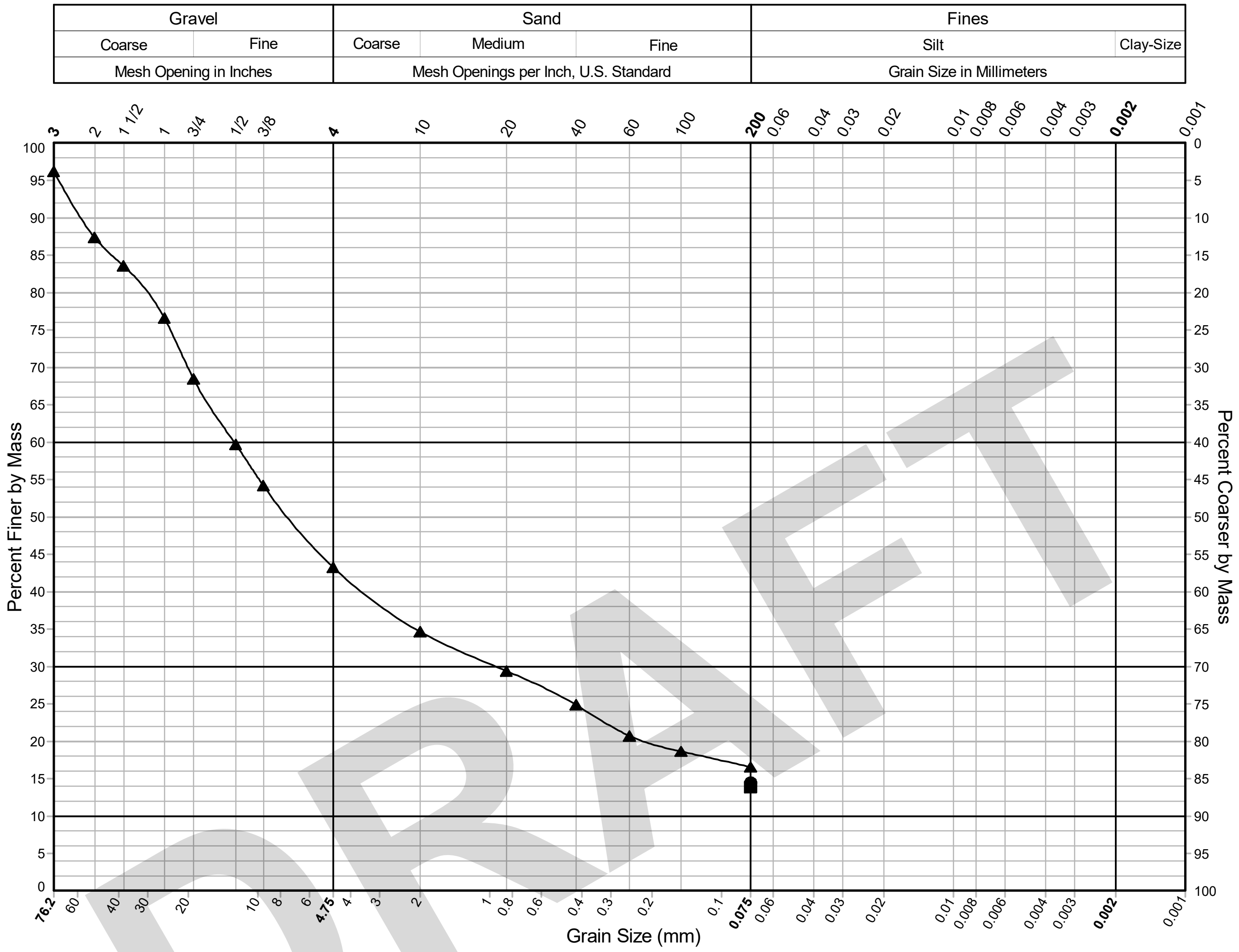
21-1-22425-002

A_GSA_MAIN 21-22425.GPJ SHAN_WIL.GDT 12/10/19

East-West Corridor Project
Stage 3
Yakima, Washington

BORING B-3-18

Sheet 2 of 2



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Cobbles %	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-3-18, R-21[*]	102.5	GM	Silty Gravel with Sand				14			10.2	AKV	JFL	D1140
■ B-3-18, R-22[*]	107.5	GM	Silty Gravel with Sand				14			8.0	AKV	JFL	D1140
▲ B-3-18, R-25[*]	122.5	GM	Silty Gravel with Sand and Cobbles	4	53	27	17			7.5	AKV	JFL	C136

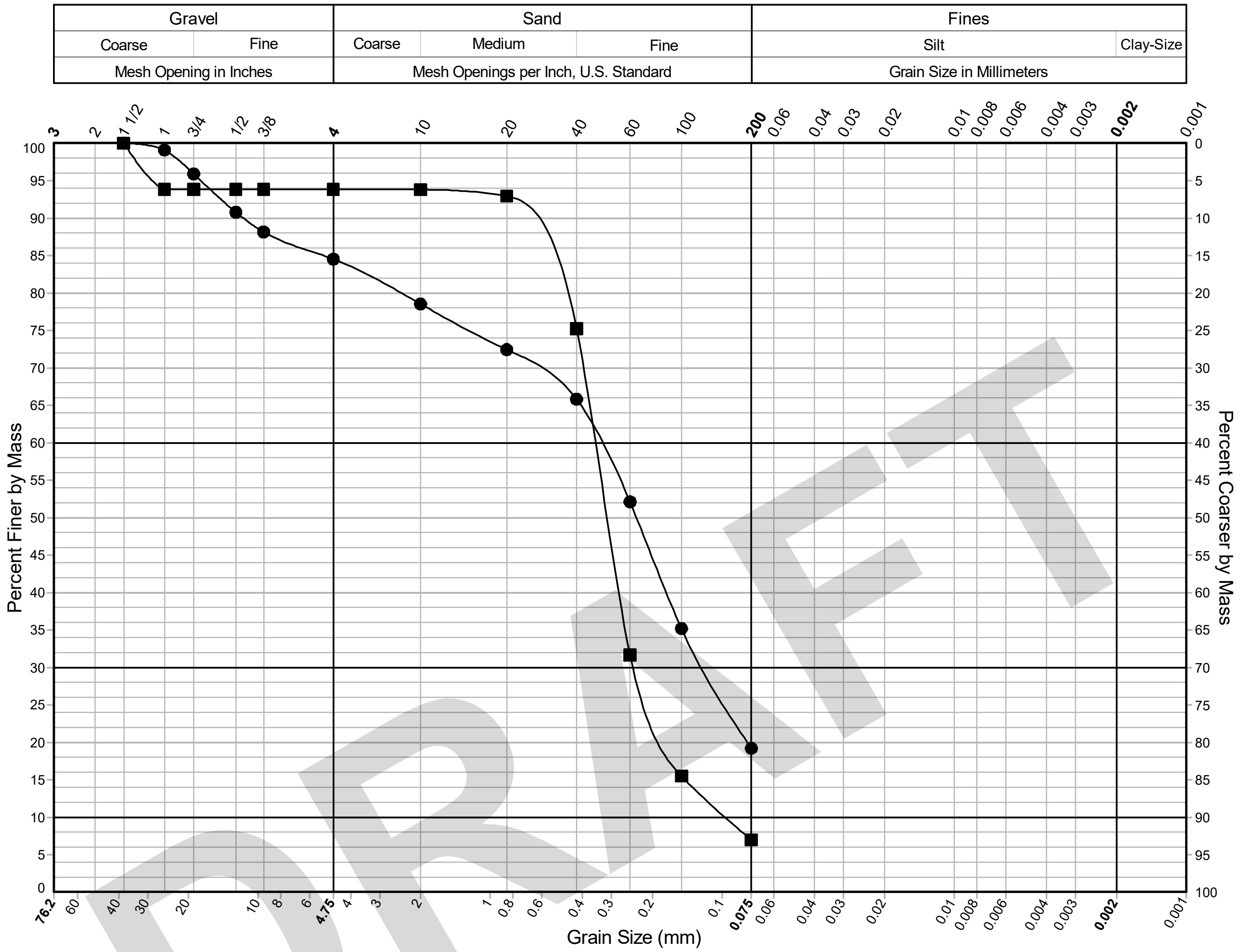
[*] *Test specimen did not meet minimum mass recommendations.*

[2] *Cobble percentages are calculated using the pre-removal, oven-dried mass of the total specimen. USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.*

GRAIN SIZE DISTRIBUTION PLOT

East-West Corridor Project
Stage 3
Yakima, Washington

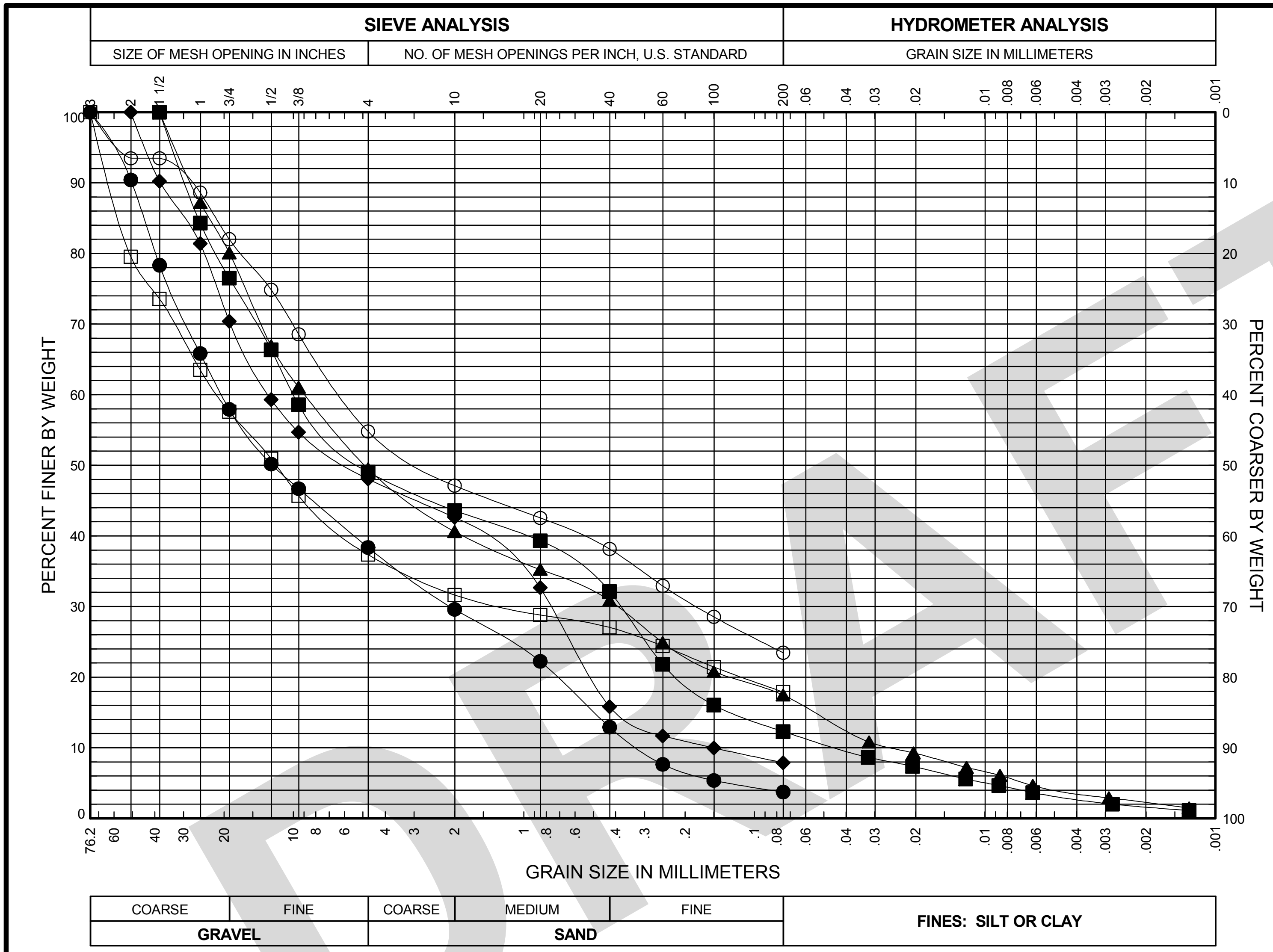
TEST PIT TP-P1-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● TP-P1-17, S-1*	4.0	SM	Silty Sand with Gravel	15	65	19			22.6	SAB		C136
■ TP-P1-17, S-2*	8.5	SP-SM	Poorly Graded Sand with Silt	6	87	7.0			9.5	SAB		C136

* *Test specimen did not meet minimum mass recommendations.*

21-1-22425-002   A_GSA_MAIN 21-22425.GPJ SHAN_WIL.GDT   12/10/19



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

**: Sample specimen weight did not meet required minimum mass for ASTM test method.*

USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● EWC-B-01-14, R-4*	17.0	GP	Poorly Graded Gravel with Sand		62	35	3.7			4.6	64.7	0.7	SXL	JFL	C136
■ EWC-B-01-14, R-6*	26.7	GM	Silty Gravel with Sand		51	37	12	7	2	9.3	204.4	0.3	SXL	JFL	D422
▲ EWC-B-01-14, R-8*	38.5	GM	Silty Gravel with Sand		50	32	17	9	2	8.2			SXL	JFL	D422
◆ EWC-B-01-14, R-12*	56.7	GP-GM	Poorly Graded Gravel with Silt and Sand		52	40	7.9			12.0	84.9	0.3	SXL	JFL	C136
○ EWC-B-01-14, R-18*	85.8	GM	Silty Gravel with Sand and Cobbles	19	45	31	23			7.9			SXL	JFL	C136
□ EWC-B-01-14, R-20*	95.8	GM	Silty Gravel with Sand		63	19	18			6.0			SXL	JFL	C136

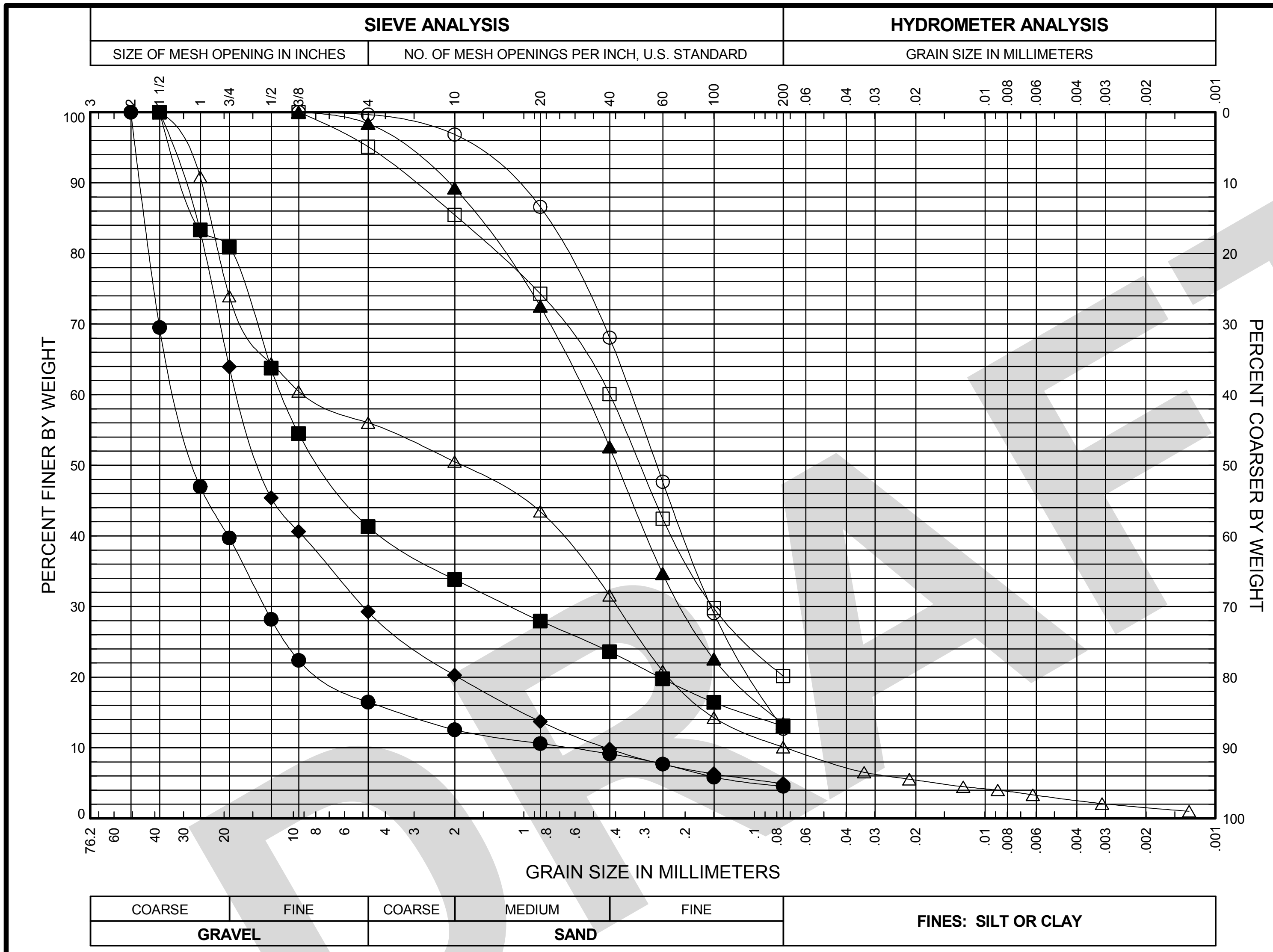
East-West Corridor Project
Yakima County, Washington

GRAIN SIZE DISTRIBUTION
BORING EWC-B-01-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Sheet 1 of 1



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

**: Sample specimen weight did not meet required minimum mass for ASTM test method.*

USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● EWC-B-02-14, R-2*	8.5	GP	Poorly Graded Gravel		84	12	4.6			1.0	50.1	8.7	RXG	JFL	D422
■ EWC-B-02-14, R-3*	11.8	GM	Silty Gravel with Sand		59	28	13			4.1			RXG	JFL	D422
▲ EWC-B-02-14, S-3	15.0	SM	Silty Sand		2	85	13			19.3			RXG	JFL	D422
◆ EWC-B-02-14, R-4*	17.5	GP	Poorly Graded Gravel with Sand		71	24	4.9			5.2	39.5	3.2	RXG	JFL	D422
○ EWC-B-02-14, S-4	20.0	SM	Silty Sand		0	87	13			21.1			RXG	JFL	D422
□ EWC-B-02-14, S-7	35.0	SM	Silty Sand		5	75	20			29.0			RXG	JFL	D422
△ EWC-B-02-14, R-9*	43.5	SP-SM	Poorly Graded Sand with Silt and Gravel		44	46	10	5	2	14.6	119.3	0.2	SXL	JFL	D422

East-West Corridor Project
Yakima County, Washington

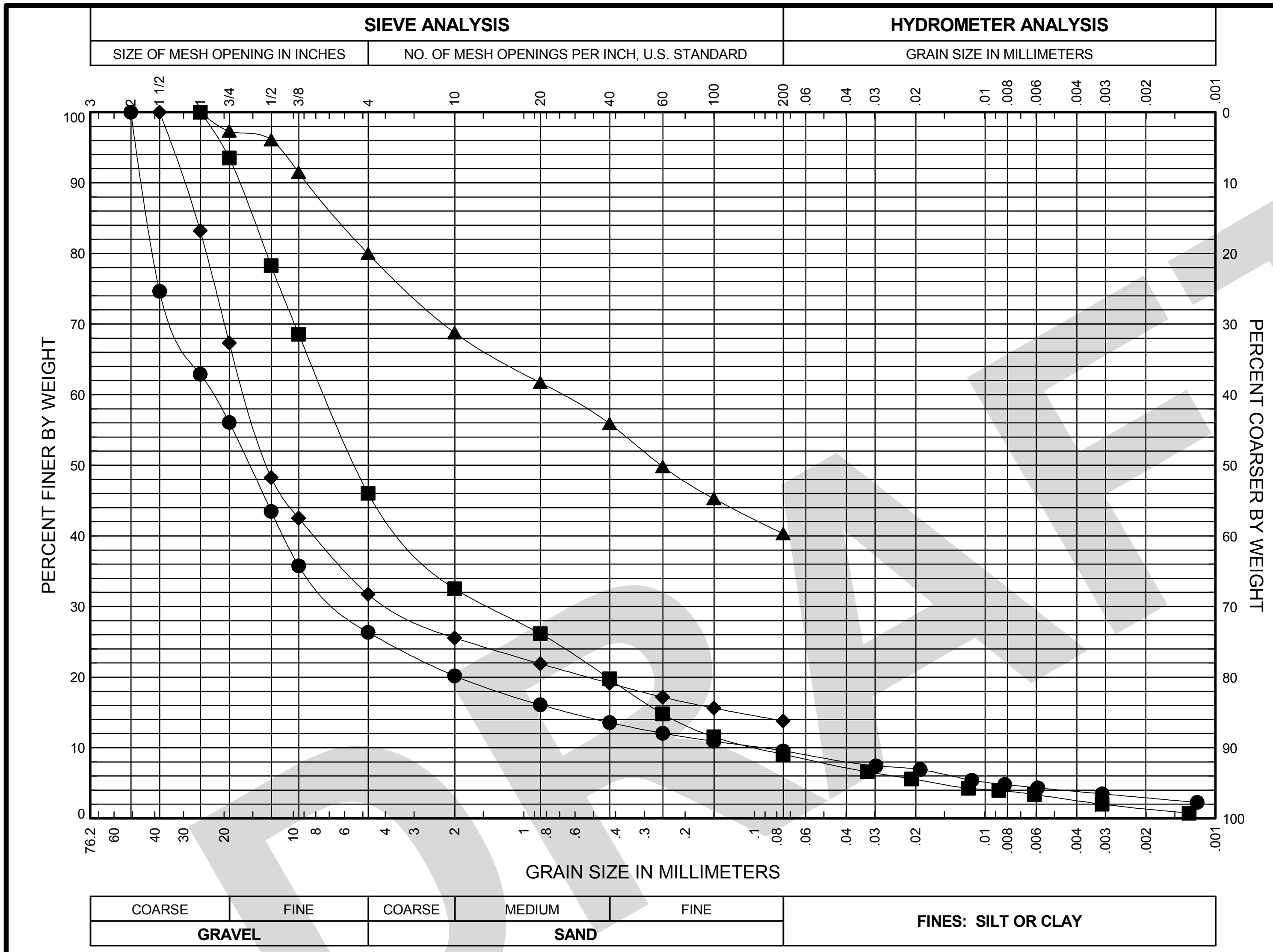
GRAIN SIZE DISTRIBUTION
BORING EWC-B-02-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Sheet 1 of 2

AASHTO GSA TESTA 21-21630.GPJ SHAN WIL.GDT 8/6/15



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

**: Sample specimen weight did not meet required minimum mass for ASTM test method.*

USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

AASHTO GSA TESTA 21-21630.GPJ SHAN WIL.GDT 8/6/15

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● EWC-B-02-14, R-12*	59.0	GP-GM	Poorly Graded Gravel with Silt and Sand		74	17	9.6	7	3	13.3	239.0	18.3	SXL	JFL	D422
■ EWC-B-02-14, R-14*	68.0	GW-GM	Well-Graded Gravel with Silt and Sand		54	37	9.1	6	1	6.9	74.8	2.9	SXL	JFL	D422
▲ EWC-B-02-14, R-16*	78.0	SM	Silty Sand with Gravel		20	40	40			9.3			RXG	JFL	D422
◆ EWC-B-02-14, R-18*	88.0	GM	Silty Gravel with Sand		68	18	14			13.2			RXG	JFL	D422

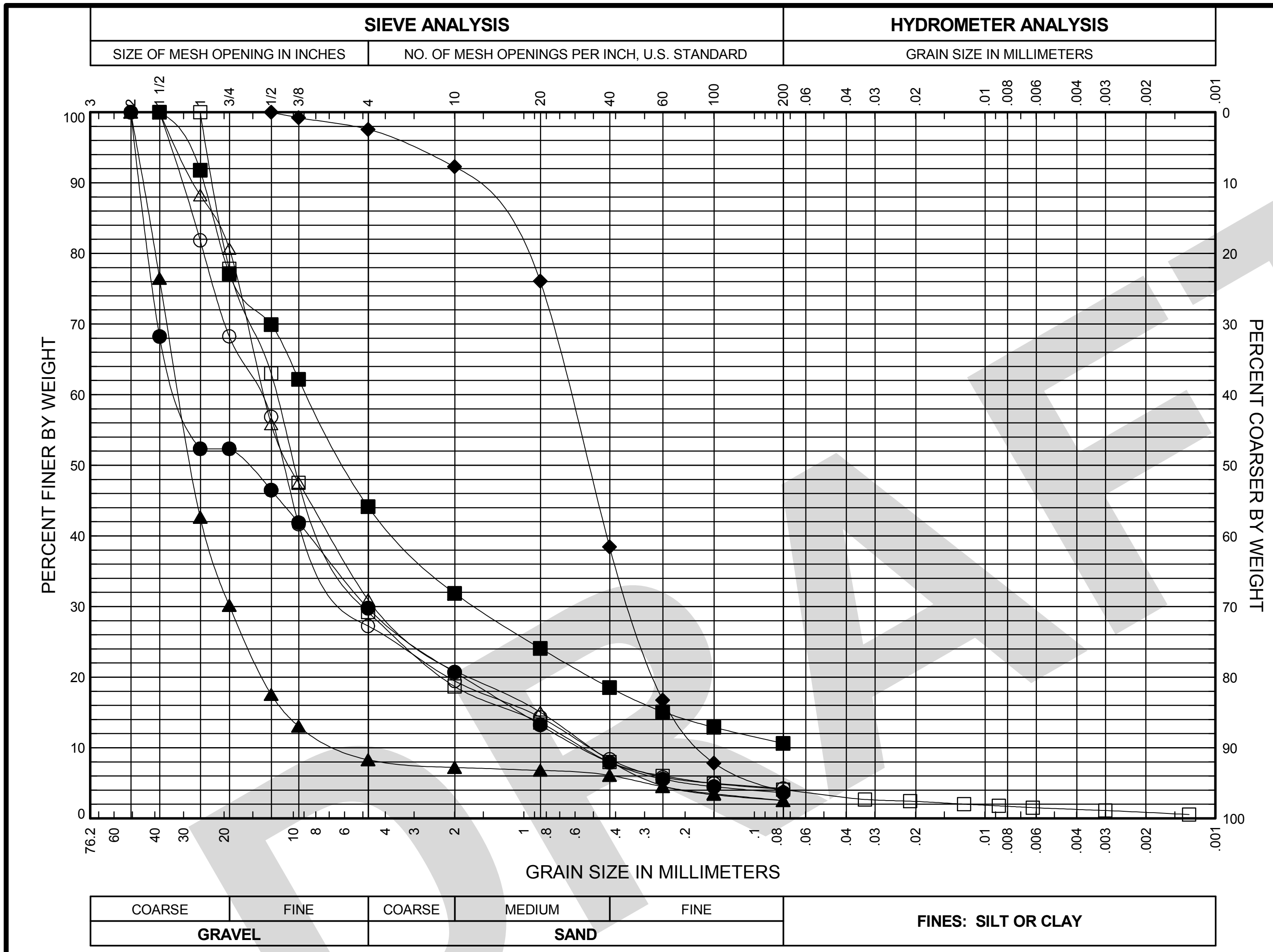
East-West Corridor Project
Yakima County, Washington

GRAIN SIZE DISTRIBUTION
BORING EWC-B-02-14

August 2015
21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Sheet 2 of 2



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

**: Sample specimen weight did not meet required minimum mass for ASTM test method.*

USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● EWC-B-03-14, R-2*	8.0	GW	Well-Graded Gravel with Sand		70	26	3.6			2.0	55.4	1.3	RXG	JFL	D422
■ EWC-B-03-14, S-3*	15.5	GP-GM	Poorly Graded Gravel with Silt and Sand		56	33	11			7.2	141.7	4.9	RXG	JFL	D422
▲ EWC-B-03-14, R-5*	22.5	GW	Well-Graded Gravel		92	6	2.5			4.7	5.1	1.9	RXG	JFL	D422
◆ EWC-B-03-14, S-6*	30.0	SP	Poorly Graded Sand		2	94	3.9			16.0	3.7	1.1	SXL	JFL	D422
○ EWC-B-03-14, R-7*	33.3	GP	Poorly Graded Gravel with Sand		73	23	4.2			6.1	27.3	4.1	RXG	JFL	D422
□ EWC-B-03-14, S-9*	46.3	GP	Poorly Graded Gravel with Sand		71	25	4.1	2	1	34.1	21.7	3.7	SXL	JFL	D422
△ EWC-B-03-14, S-11*	55.6	GW	Well-Graded Gravel with Sand		69	28	2.5			3.5	26.2	2.8	SXL	JFL	D422

East-West Corridor Project
Yakima County, Washington

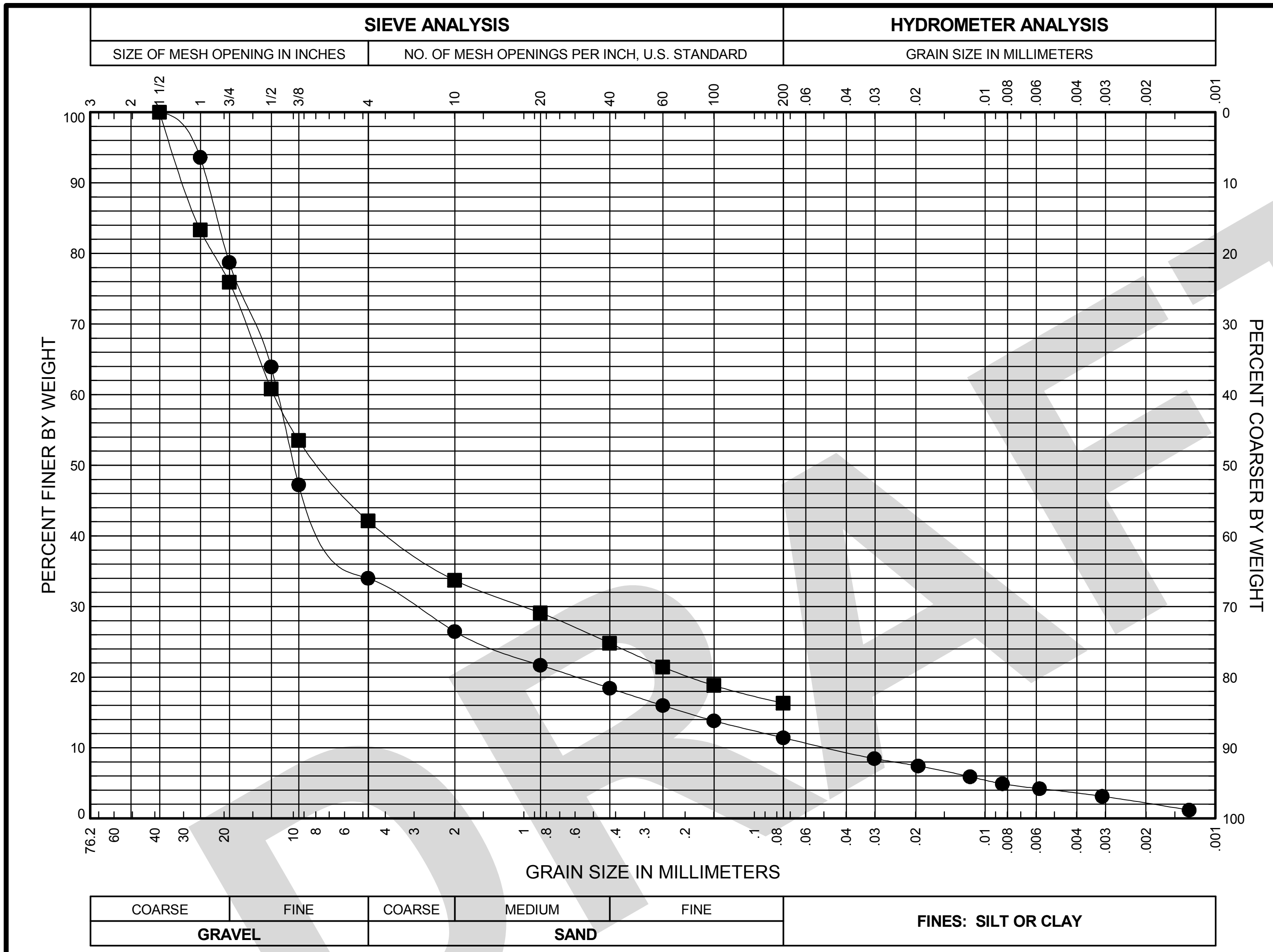
GRAIN SIZE DISTRIBUTION
BORING EWC-B-03-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Sheet 1 of 2

AASHTO GSA TESTA 21-21630.GPJ SHAN WIL.GDT 8/6/15



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

**: Sample specimen weight did not meet required minimum mass for ASTM test method.*

USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● EWC-B-03-14, R-18*	85.5	GP-GM	Poorly Graded Gravel with Silt and Sand		66	23	11	7	2	7.2	235.3	15.4	SXL	JFL	D422
■ EWC-B-03-14, R-19*	94.1	GM	Silty Gravel with Sand		58	26	16			9.8			RXG	JFL	D422

East-West Corridor Project
Yakima County, Washington

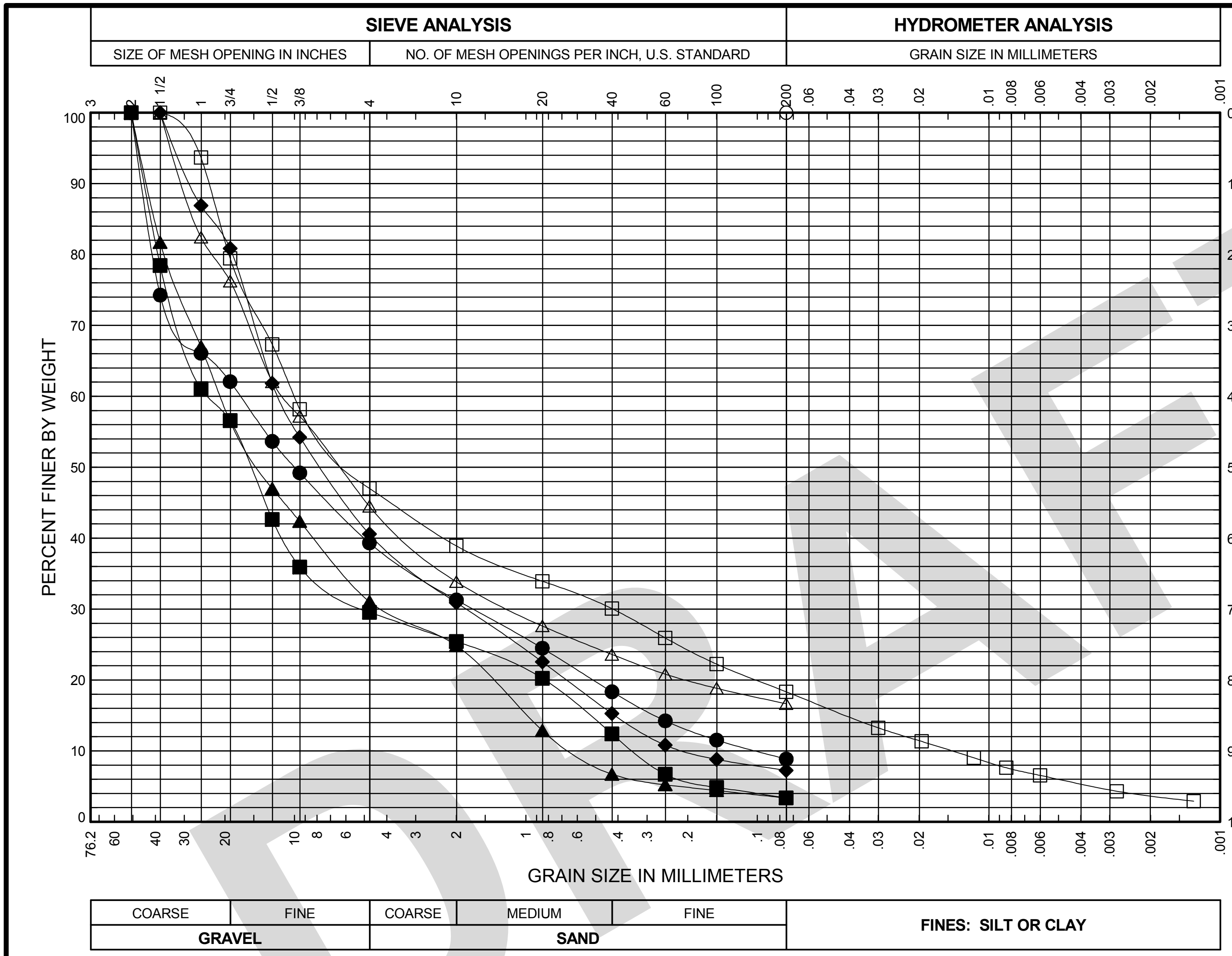
GRAIN SIZE DISTRIBUTION
BORING EWC-B-03-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Sheet 2 of 2

AASHTO GSA TESTA 21-21630.GPJ SHAN WIL.GDT 8/6/15



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

*: *Sample specimen weight did not meet required minimum mass for ASTM test method.*

USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● EWC-B-04-14, R-1*	3.5	GW-GM	Well-Graded Gravel with Silt and Sand		61	30	8.9			1.2	169.7	1.7	AKV	JFL	D422
■ EWC-B-04-14, R-5*	22.5	GP	Poorly Graded Gravel with Sand		70	26	3.4			10.2	69.6	3.1	AKV	JFL	D422
▲ EWC-B-04-14, R-6*	28.5	GW	Well-Graded Gravel with Sand		69	28	3.3			8.9	34.0	1.3	AKV	JFL	D422
◆ EWC-B-04-14, R-8*	37.5	GW-GM	Well-Graded Gravel with Silt and Sand		59	33	7.2			11.0	57.4	1.4	RXG	JFL	D422
○ EWC-B-04-14, R-8*	38.4	GP-GM	Poorly Graded Gravel with Silt and Sand				100			11.2			AKV	JFL	D1140
□ EWC-B-04-14, R-9*	42.0	GM	Silty Gravel with Sand		53	29	18	11	4	11.0			SXL	JFL	D422
△ EWC-B-04-14, R-11*	54.5	GM	Silty Gravel with Sand		56	28	17			11.0			RXG	JFL	D422

East-West Corridor Project
Yakima County, Washington

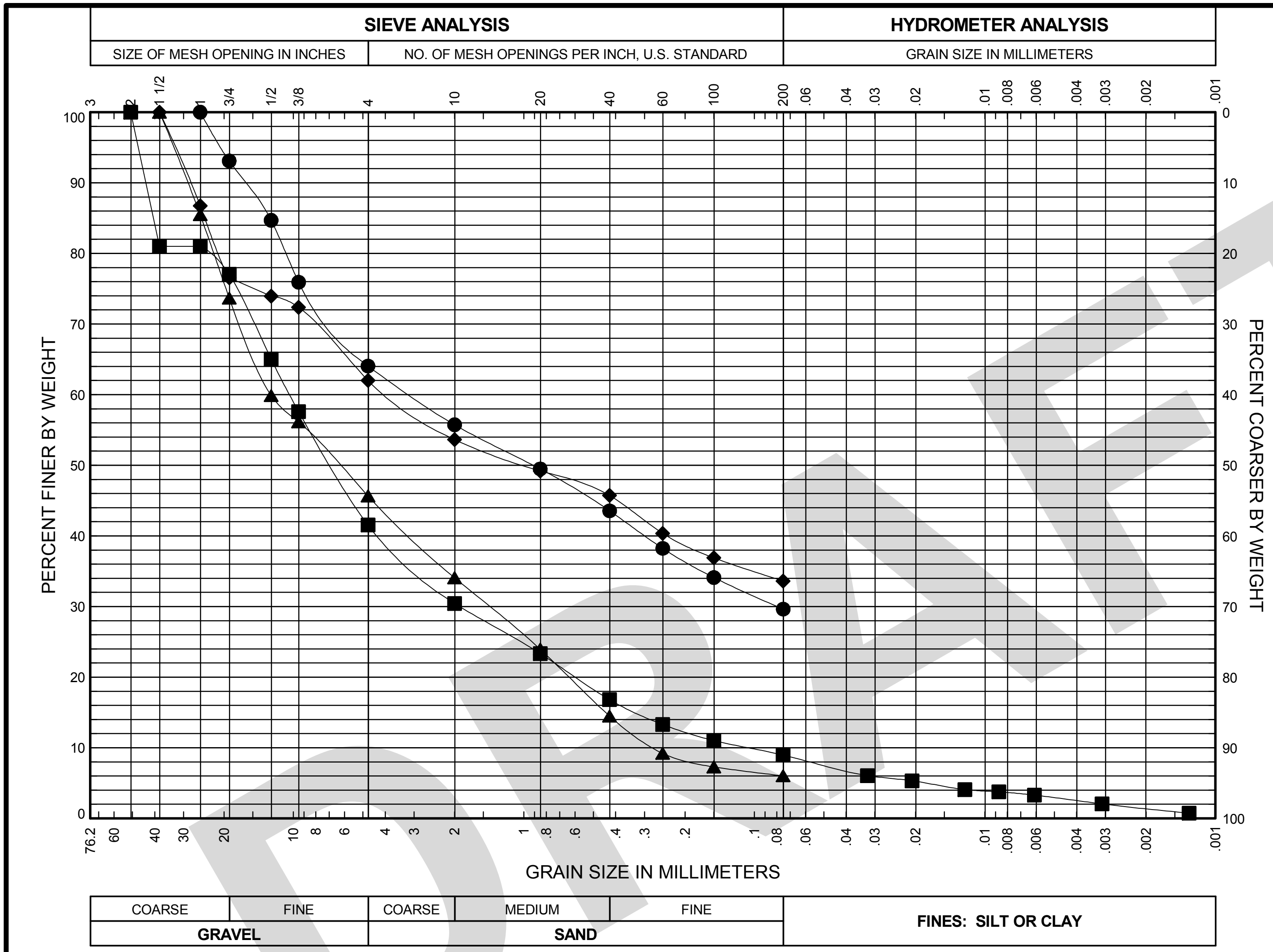
GRAIN SIZE DISTRIBUTION
BORING EWC-B-04-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Sheet 1 of 2

AASHTO GSA TESTA 21-21630.GPJ SHAN WIL.GDT 8/6/15



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

**: Sample specimen weight did not meet required minimum mass for ASTM test method.*

USCS Group Symbol, Soil Classification Group Name, Gravel %, Sand %, Fines %, <0.02mm %, <2um%, Cu, and Cc values are calculated from particles smaller than 76.2mm (3 inches) only, per ASTM D2487.

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● EWC-B-04-14, R-14*	65.5	GC	Clayey Gravel with Sand		36	34	30			11.5			RXG	JFL	D422
■ EWC-B-04-14, R-16*	78.0	GP-GM	Poorly Graded Gravel with Silt and Sand		58	33	9.0	5	1	8.9	97.6	3.3	SXL	JFL	D422
▲ EWC-B-04-14, R-19*	92.5	GP-GM	Poorly Graded Gravel with Silt and Sand		54	40	6.0			9.6	46.3	0.6	RXG	JFL	D422
◆ EWC-B-04-14, R-20*	99.0	GM	Silty Gravel with Sand		38	28	34			13.5			RXG	JFL	D422

East-West Corridor Project
Yakima County, Washington

GRAIN SIZE DISTRIBUTION
BORING EWC-B-04-14

August 2015 21-1-21630-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Sheet 2 of 2

AASHTO GSA TESTA 21-21630.GPJ SHAN WIL.GDT 8/6/15

Appendix D

Environmental Procedures and Testing Results

CONTENTS

Exhibits

Tables

Report Compilation Attachments

D.1 GENERAL

This appendix presents the results of our environmental laboratory testing analyses for the Cascade Mill Parkway Phase 3 project. We also performed two previous sets of environmental testing: one in 2014 for the 30% design study and one in 2017 for the East-West Corridor Stage 3 design study.

D.2 2021 ENVIRONMENTAL TESTING

D.2.1 Soil Sampling Activities

Soil samples were collected from borings B-09-21, B-10-21, B-11P-21, B-13-21, B-14-21, and B-15P-21 for health and safety and waste characterization purposes.

No visual or olfactory signs of contamination were observed during drilling. Wood fragments were noted within borings B-09-21, B-10-21, and B-12-21 at depths of approximately 19, 42, and 45 feet below ground surface (bgs) in B-09-21, 10 feet bgs in B-10-21, and 36 feet bgs in B-12-21.

Soil samples were screened for the potential presence of contamination using a photoionization detector (PID) and visual and olfactory observations. PID readings ranged from 0.3 part per million (ppm) to 5.5 ppm during drilling. Elevated PID readings of 12.4 and 48 ppm were measured in boring B-09-21 and of 47 ppm measured in boring B-10-21. The elevated readings measured in both borings B-09-21 and B-10-21 may have been associated with the presence of rock dust. The dust may have impacted the PID filter and lamp bulb, which potentially could have led to erroneous readings. Field screening results are noted in the boring logs (Appendix A).

Up to two samples were collected from each boring. Samples were collected at depths where field indication potentially identified the presence of contamination. In borings where no field indication of contamination was observed, samples were collected near the groundwater interface.

Soil samples were collected using disposable sampling equipment. The samples were collected by donning a pair of disposable nitrile gloves. Each sample was collected within clean, laboratory-supplied glassware using disposable stainless-steel spoons or laboratory-provided plungers (for U.S. Environmental Protection Agency [EPA] Method 5035). The sample container labels were completed using indelible ink. The sample jars were sealed in plastic bags, and then placed into a cooler with "blue ice." Samples were transported by a

Shannon & Wilson field representative to Fremont Analytical, of Seattle, Washington, under chain-of-custody procedures.

D.2.2 Analytical Methods

Soil samples were submitted to Fremont Analytical for the following analyses:

- Gasoline-range hydrocarbons by Method Northwest Total Petroleum Hydrocarbons – Gasoline
- Diesel- and lube-oil-range hydrocarbons by Method Northwest Total Petroleum Hydrocarbons as Diesel Extended
- Benzene, toluene, ethylbenzene, and xylenes (BTEX) by EPA Method 8260C
- Resource Conservation and Recovery Act metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) by EPA Method 6020A/7471B
- Polycyclic aromatic hydrocarbons (PAHs) by EPA Method 8270DSIM
- Pentachlorophenol (Herbicide) by EPA Method 8151A

Samples were analyzed within specified holding times.

D.2.3 Analytical Results

In April 2022, ten soil samples were collected from the Stage 3 segment geotechnical to support investigation-derived waste (IDW) characterization and provide information for health and safety purposes. The analytical results of the collected samples are summarized in Table D-1. Copies of the analytical laboratory reports are included in this appendix. Dates and reference numbers for these reports are summarized in the following Exhibit D-1:

Exhibit D-1: 2021 Fremont Analytical Reports

Date	Fremont Analytical Laboratory Reference Number	Pages
4/29/2022	2104132	39 pages
4/09/2022	2104041	22 pages
4/07/2022	2103484	25 pages
4/29/2022	2104312	21 pages

No gasoline-range and diesel-range petroleum hydrocarbons were detected above laboratory reporting limits in any of the samples analyzed with the exception of the 15.5-foot sample collected in boring B-10. Gasoline range organics (GRO) with a similar pattern to mineral spirits was detected at a concentration 1,030 milligrams per kilogram (mg/kg). This detected GRO concentration exceeds the Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA) Method A soil cleanup level for unrestricted land use of 100 mg/kg when benzene is not present (Ecology, 2013). Heavy oil-range petroleum hydrocarbons were also detected in the same sample at a concentration of 1,120 mg/kg. The detected concentration does not exceed the MTCA Method A soil cleanup level for unrestricted land use of 2,000 mg/kg. The source of this contamination is unknown.

Several metals, including arsenic, barium, chromium, lead and selenium, were detected in each of the samples analyzed. The detected concentrations are compared to MTCA Method A cleanup levels. Where no Method A level is established, the concentrations are compared to Method B cleanup levels for direct contact. All the metals detected concentrations were below available MTCA cleanup levels. The chromium analysis does not determine if the chromium present is either trivalent or hexavalent chromium. Based on the available site history, hexavalent chromium is not considered likely. The detected concentrations are below cleanup levels for trivalent chromium.

All the detected metals concentrations, with the exception of selenium, were detected within naturally background concentrations for metals in Eastern Washington as identified in the Natural Background Soil Metals Concentrations in Washington State study prepared by Ecology in 1994 (Ecology, 1994). Detected selenium concentrations were present above the established background level of 0.78 mg/kg. It should be noted that the selenium background level established within the study was considered to be an estimate.

No PAHs, BTEX, or pentachlorophenol were detected above laboratory reporting limits within any of the samples collected and analyzed.

D.2.4 Investigation-Derived Waste

IDW generated during these field activities consisted of boring cuttings and drilling mud. IDW was placed in 55-gallon drums and temporarily stored at the Yakima County Equipment Services Yard pending laboratory analyses. Disposable sampling equipment was disposed as solid waste. The IDW was removed from the County Yard by Advanced Chemical Transport of San Jose, California, under subcontract to Shannon & Wilson, on July 13 and 26, 2021. The IDW was disposed at U.S. Ecology Landfill of Grandview, Idaho, on July 26, 2021.

D.3 2017 ENVIRONMENTAL TESTING

D.3.1 Soil Sampling Activities

Soil samples were collected from borings B-1-17 and B-2-17 for environmental characterization. No visual or olfactory signs of contamination were observed. Wood waste was noted within boring B-2-17 from depths of approximately 1 to 10 feet below ground surface. Four samples were taken from each boring. Samples taken from boring B-1-17 were identified as ES-1 through ES-4. Samples taken from boring B-2-17 were identified as ES-5 through ES-8. From each boring, samples included a near-surface sample, a sample from above the groundwater table, a sample from the water table, and a sample from below the water table.

Soil samples were collected using disposable sampling equipment. Soil samples were collected by donning a pair of disposable nitrile gloves. Samples were collected within clean, laboratory-supplied glassware using disposable stainless-steel spoons or laboratory-provided plungers (for EPA Method 5035). The sample container labels were completed using indelible ink. The samples were sealed in plastic bags, and then placed into a cooler with "blue ice." Samples were transported by a Shannon & Wilson field representative to Fremont Analytical, of Seattle, Washington, under chain-of-custody procedures.

D.3.2 Analytical Methods

Soil samples were submitted to Fremont Analytical for the following analyses:

- Gasoline-range hydrocarbons by Method Northwest Total Petroleum Hydrocarbons – Gasoline
- Diesel- and lube-oil-range hydrocarbons by Method Northwest Total Petroleum Hydrocarbons as Diesel Extended
- Volatile organic compounds (VOCs) by EPA Method 8260C
- Resource Conservation and Recovery Act metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) and additional metals (copper, nickel, and zinc) by EPA Method 6020A/7471B
- PAHs by EPA Method 8270DSIM
- Polychlorinated biphenyls (PCBs) by EPA Method 8082
- Organochlorine pesticides by EPA Method 8081A
- Herbicides by EPA Method 8151A

Samples were analyzed within specified holding times.

D.3.3 Analytical Results

Analytical results for the Stage 3 area borings are summarized in Table D-1 and the associated analytical laboratory reports are included in this appendix. Dates and reference numbers for these reports are summarized in the following Exhibit D-2:

Exhibit D-2: 2017 Fremont Analytical Report Reference Numbers

Date	Fremont Analytical Laboratory Reference Number	Pages
8/14/2017	1707301	61 pages
8/14/2017	1708051	66 pages

Gasoline-range and diesel-range petroleum hydrocarbons were not detected above laboratory reporting limits within any of the analyzed samples. One sample (ES-6) contained petroleum hydrocarbons within the lube-oil range at a concentration of 495 mg/kg, below MTCA Method A soil cleanup level for unrestricted land use. The same sample also contained toluene, 1,2,3-trichlorobenzene, and 1,2,4-trichlorobenzene at concentrations below cleanup levels. VOCs were not detected within any of the other samples. It should be noted that sample ES-6 was taken from within the wood waste layer observed within boring B-2-17.

Several metals were detected within the samples. Concentrations were compared to MTCA Method A cleanup levels and Method B cleanup levels for direct contact. Arsenic, barium, lead, copper, nickel, and zinc were detected within all samples at concentrations below cleanup levels. Cadmium was detected within one soil sample, ES-5, at a concentration below the MTCA Method A cleanup level. Selenium was detected within all but one soil sample at concentrations below the cleanup level. Chromium was detected within all samples. Based on the known site history, hexavalent chromium is not considered likely. The detected concentrations are below cleanup levels for trivalent chromium.

With minor exceptions, all metals were detected within background concentrations for Eastern Washington. The copper, nickel, and zinc concentrations detected within sample ES-5 were above typical background concentrations, but below cleanup levels. The nickel concentration measured within sample ES-1 was also above typical background levels, but below cleanup levels. Samples ES-1 and ES-5 were both taken from near-surface depths. Selenium was detected at concentrations above the established background level of 0.78 mg/kg. It should be noted that the selenium background level established within the study was considered to be an estimate. Other sources suggest that selenium concentrations ranging between 0.01 to 2.0 mg/kg are typical of surficial soils.

PAHs, PCBs, organochlorine pesticides, and herbicides were not detected above laboratory reporting limits within any of the analyzed samples.

D.3.4 Investigation-Derived Waste

IDW generated during these field activities was removed from the site by the driller.

D.4 2014 ENVIRONMENTAL TESTING

D.4.1 Soil Sampling Activities

Soil samples were screened for the potential presence of contamination using a PID and visual and olfactory observations. PID readings were recorded at 8.7 and 13.7 ppm in the landfill material encountered in boring EWC-B-01-14. These readings are likely due to the presence of landfill debris consisting of municipal solid waste observed generally in the upper 15 feet. A slight hydrocarbon odor was also observed in the landfill material retrieved from boring EWC-B-01-14. Field screening results are noted in the boring logs (Appendix A).

Soil samples were collected from selected explorations for waste characterization purposes. In borings where no field indication of contamination was observed, samples were collected near the groundwater interface; the samples in the test pits were generally collected at the bottom of the excavation.

Soil samples were collected using disposable sampling equipment. Soil samples were collected by donning a pair of disposable nitrile gloves. At least one laboratory-supplied 8-ounce jar was filled using disposable stainless-steel spoons, and two clean, laboratory-supplied 40-millimeter vials in accordance with EPA Method 5035. The sample container labels were completed using indelible ink. The samples were sealed in plastic bags, and then placed into a cooler and maintained at 4 degrees Celsius (°C) (± 2°C) with “blue ice.” Samples were transported by a Shannon & Wilson field representative to Fremont Analytical of Seattle, Washington, under chain-of-custody procedures.

D.4.2 Analytical Methods

Soil samples were submitted to Fremont Analytical for the following analyses:

- Gasoline-range hydrocarbons by Method Northwest Total Petroleum Hydrocarbons-Gasoline with benzene, toluene, ethylbenzene, and xylenes distinction
- Diesel- and lube-oil-range hydrocarbons by Method Northwest Total Petroleum Hydrocarbons as Diesel Extended with acid/silica gel cleanup
- PAHs EPA Method 8270DSIM
- MTCA metals (arsenic, cadmium, chromium, mercury, and lead) by EPA Method 6020/7471B
- Herbicides by EPA Method 8151A

Samples were analyzed within specified holding times.

D.4.3 Analytical Results

In July 2014, five soil samples were collected from the Stage 3 segment geotechnical explorations to support IDW characterization. Analytical results are summarized in Table D-2 and the analytical laboratory reports are included in this appendix. Dates and reference numbers for these reports are summarized in the following Exhibit D-3:

Exhibit D-3: 2014 Fremont Analytical Reports

Date	Fremont Analytical Laboratory Reference Number	Pages
7/10/2014	1406291	19 pages
7/11/2014	1407039	22 pages
7/21/2014	1407120	21 pages
7/25/2014	1407187	21 pages

Lube-oil-range petroleum hydrocarbons were detected in soil samples EWC-B-01-14:10.0 and EWC-B-01-14:15.0 below the cleanup criteria.

Arsenic, chromium, and lead were detected below the MTCA Method A cleanup levels in the soil samples analyzed. Cadmium was also detected below the cleanup level in samples EWC-B-01-14:10.0 and EWC-B-01-14:15.0.

Table D-3 provides a toxicity equivalence factor (TEF) analysis of the individual carcinogenic PAH (cPAH) constituents. The TEF method is used to adjust the concentrations of each cPAH such that they are relative to benzo(a)pyrene, which is the most carcinogenic of the PAHs. The individual cPAH concentrations are then added together for comparison with the MTCA cleanup level for benzo(a)pyrene. Based on the TEF analysis, sample EWC-B-01-14:15.0 has adjusted cPAH concentrations that exceed the MTCA Method A unrestricted cleanup criterion.

Herbicides were detected in soil samples analyzed with the exception of EWC-B-01-14:15.0.

D.4.4 Investigation-Derived Waste

IDW generated during these field activities consisted of boring cuttings and drilling mud. IDW was placed in 55-gallon drums and temporarily stored on site pending laboratory analyses. Disposable sampling equipment was disposed as solid waste. The IDW was removed from the site by Tri-Valley Construction, Inc. of Yakima, Washington, under subcontract to Shannon & Wilson, on January 23, 2015. The IDW was disposed at the Terrace Heights Landfill of Yakima, Washington, on January 23, 2015.

D.5 REFERENCES

Washington State Department of Ecology (Ecology), Toxics Cleanup Program, 1994, Natural background soil metals concentrations in Washington State, Publication No. 94-115, October.

Washington State Department of Ecology (Ecology), 2013, Model Toxics Control Act regulation and statue, Chapter 173-340 WAC: Ecology Toxics Cleanup Program, Olympia, Wash., publication no. 94-06.

Table D-1: Summary of 2021 Analytical Testing Data

Boring:		B-9-21	B-10-21		B-11P-21	B-12P-21	B-13-21		B-14-21	B-15P-21	MTCA Soil Cleanup Levels		
Sample Identification:		B-9-21/R-10@48'	B-10-21/S-3@15.5'	B-10-21/a9@48'	B-11P-21/R-10@51'	B-12P-21/R-11@50'	B-13-21/R-8@39'	B-13-21/R-9@47'	B-14-21/R-9@48'	B-15P-21/S-5@21'			Natural Background Soil Metals Concentration [2]
Sample Depth (feet below ground surface):		48	15.5	48	51	50	39	47	48	21	MTCA Method A Unrestricted Land Use (mg/kg)	MTCA Method B (mg/kg)	
Sample Date:		4/29/2022	4/29/2022	4/29/2022	4/9/2022	4/9/2022	4/7/2022	4/7/2022	4/29/2022	4/29/2022			
Sample Delivery Group:		2104132	2104132	2104132	2104041	2104041	2103484	2103484	2104312	2104312			
Analyte	Method												
Petroleum Hydrocarbons (mg/kg)													
Gasoline	NWTPH-Gx	5.37 U	131 U, H	5.46 U	4.44 U	5.88 U	15.4 U	5.41 U	7.33 U	5.46 U	100 [3]	100 [3]	*
Gasoline Range Organics[1]	NWTPH-Gx	--	**1,030** DH	--	--	--	--	--	--	--	100 [3]	100 [3]	*
Diesel (Fuel Oil)	NWTPH-Dx	52.0 U	52.1 U, H	53.2 U	46.8 U	47.4 U	50.2 U	51.4 U	47.4 U	52.6 U	2,000	2,000	*
Heavy Oil	NWTPH-Dx	104 U	**1,120** DH	106 U	93.6 U	94.7 U	100 U	103 U	94.9 U	105 U	2,000	2,000	*
Volatile Organic Compounds (mg/kg)													
Benzene	SW8260D	0.0215 U	0.0263 U, H	0.0218 U	0.0178 U	0.0235 U	0.0615 U	0.0216 U	0.0293 U	0.0218 U	0.03	0.03	*
Toluene	SW8260D	0.0699 U	0.0854 U, H	0.071 U	0.0577 U	0.0765 U	0.2 U	0.0703 U	0.0953 U	0.071 U	7	7	*
Ethylbenzene	SW8260D	0.0269 U	0.0328 U, H	0.0273 U	0.0222 U	0.0294 U	0.0769 U	0.027 U	0.0366 U	0.0273 U	6	6	*
m, p-Xylene	SW8260D	0.0537 U	0.0657 U, H	0.0546 U	0.0444 U	0.0588 U	0.154 U	0.0541 U	0.0733 U	0.0546 U	9	9	*
o-Xylene	SW8260D	0.0269 U	0.0328 U, H	0.0273 U	0.0222 U	0.0294 U	0.0769 U	0.027 U	0.0366 U	0.0273 U			*
MTCA 5 Metals (mg/kg)													
Arsenic	SW6020B	**2.41** D	**2.58** D	**2** D	**2.25** D	**1.99** D	**2.48** D	**2.46** D	**3.45** D	**2.77** D	20	24	5
Barium	SW6020B	**52.7** D	**70.2** D	**50.5** D	**68.6** D	**68.1** D	**64.8** D	**67.2** D	**63.9** D	**50.5** D	*	16000	255
Cadmium	SW6020B	0.167 U	0.168 U	0.17 U	0.173 U	0.175 U	0.17 U	0.169 U	0.168 U	0.169 U	2	80	1
Chromium	SW6020B	**15.8** D	**29.7** D	**14.2** D	**14.7** D	**17.1** D	**20.6** D	**16.6** D	**18.8** D	**15.7** D	19/2,000 [4]	120,000	38
Lead	SW6020B	**1.97** D	**3.06** D	**1.96** D	**2.04** D	**2.15** D	**4.45** D	**2.49** D	**5.54** D	**2.15** D	250	*	11
Mercury	SW7471	0.238 U	0.235 U	0.245 U	0.247 U	0.248 U	0.26 U	0.263 U	0.251 U	0.273 U	2	*	0.05
Selenium	SW6020B	**2.4** D	**1.52** D	**2.25** D	**2.47** D	**1.68** D	**1.54** D	**1.72** D	**1.85** D	**2.19** D	*	400	0.78
Silver	SW6020B	0.125 U	0.126 U	0.127 U	0.13 U	0.131 U	0.127 U	0.127 U	0.126 U	0.127 U	*	400	0.61
Polynuclear Aromatic Hydrocarbons (PAHs) (mg/kg)													
Naphthalene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.0181 U	0.0206 U	5	5	*
2-Methylnaphthalene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.0181 U	0.0206 U	*	*	*
1-Methylnaphthalene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.0181 U	0.0206 U	*	*	*
Acenaphthylene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.0181 U	0.0206 U	*	*	*
Acenaphthene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.0181 U	0.0206 U	*	*	*
Fluorene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.0181 U	0.0206 U	*	*	*
Phenanthrene	SW8270SIM	0.0426 U	0.0383 U, H	0.0404 U	0.0379 U	0.0437 U	0.0369 U	0.039 U	0.0363 U	0.0411 U	*	*	*
Anthracene	SW8270SIM	0.0426 U	0.0383 U, H	0.0404 U	0.0379 U	0.0437 U	0.0369 U	0.039 U	0.0363 U	0.0411 U	*	*	*
Fluoranthene	SW8270SIM	0.0426 U	0.0383 U, H	0.0404 U	0.0379 U	0.0437 U	0.0369 U	0.039 U	0.0363 U	0.0411 U	*	*	*
Pyrene	SW8270SIM	0.0426 U	0.0383 U, H	0.0404 U	0.0379 U	0.0437 U	0.0369 U	0.039 U	0.0363 U	0.0411 U	*	*	*
Benz[a]anthracene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.0181 U	0.0206 U	*	*	*
Chrysene	SW8270SIM	0.0426 U	0.0383 U, H	0.0404 U	0.0379 U	0.0437 U	0.0369 U	0.039 U	0.0363 U	0.0411 U	*	*	*
Benzo(k)fluoranthene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.018 U	0.0206 U	*	*	*
Benzo(b)fluoranthene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.018 U	0.0206 U	*	*	*
Benzo(ghi)perylene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.018 U	0.0206 U	*	*	*
Benzo(a)pyrene	SW8270SIM	0.0213 U	0.0191 U, H	0.0202 U	0.019 U	0.0219 U	0.0185 U	0.0195 U	0.018 U	0.0206 U	0.1	2	*
Indeno(1,2,3-cd)pyrene	SW8270SIM	0.0426 U	0.0383 U, H	0.0404 U	0.0379 U	0.0437 U	0.0369 U	0.039 U	0.0363 U	0.0411 U	*	*	*
Dibenzo(a,h)anthracene	SW8270SIM	0.0426 U	0.0383 U, H	0.0404 U	0.0379 U	0.0437 U	0.0369 U	0.039 U	0.0363 U	0.0411 U	*	*	*
TEF-adjusted cPAHs (see Table D-3)		0.025	0.02	0.023	0.022	0.0254	0.0214	0.0226	0.021	0.02	0.1	2	*
Detected Herbicides (mg/kg)													
Pentachlorophenol	SW8151A	0.0852 U	0.076 U, H	0.0809 U	0.0759 U	0.0875 U	0.0739 U	0.078 U	0.0725 U	0.0823 U	*	*	*

NOTES:

1 Unresolved gasoline range organics (C6-C12) were detected in this sample (1,030 mg/kg). The beginning pattern matches mineral spirits but the end pattern is a different product.

2 Natural background soil metals concentrations shown are for Yakima Basin with the exception of Barium (value from Spokane Basin), silver (statewide value), and selenium (statewide value).

3 Criteria for gasoline-range petroleum in soil are 100 mg/kg when benzene is not present.

4 Criteria for chromium are for hexavalent chromium/trivalent chromium.

* No MTCA Method A values have been established for this analyte.

Bold values indicate a detection.

Criteria for gasoline-range petroleum in soil are 30 mg/kg when benzene is present and 100 mg/kg when benzene is not present.

All samples were submitted for benzene, toluene, ethylbenzene, and xylenes analysis; no analytes were detected above reporting limits.

NA = Not applicable.

Shaded values indicate a MTCA Method A exceedance.

cPAHs = carcinogenic polycyclic aromatic hydrocarbons; D= dilution was required; H = holding times for preparation or analysis exceeded; mg/kg = milligram per kilogram; MTCA = Model Toxics Control Act; NWTPH-Dx = Northwest Total Petroleum Hydrocarbons-Diesel Extended; NWTPH-Gx = Northwest Total Petroleum Hydrocarbons-Gasoline Extended;

TCLP = Toxicity Characteristic Leaching Procedure; TEF = toxicity equivalency factor; U = the analyte was not detected above the laboratory reporting limit shown

Table D-2: Summary of 2017 Analytical Testing Data

Boring:		*B-1-17*					*B-2-17*			MTCA Soil Cleanup Levels		Natural Background Soil Metals Concentration[1]
Sample Identification:		ES-1	ES-2	ES-3	ES-4	ES-5	ES-6	ES-7	ES-8	Method A Unrestricted Land Use	Method B Direct Contact Noncancer	
Sample Depth (feet below ground surface):		0.4	41.5	43.5	53.9	0.2	8.8	15.8	21.2			
Sample Date:		07/25/17	07/26/17	07/26/17	07/27/17	08/03/17	08/03/17	08/03/17	08/03/17			
Sample Delivery Group:		1707301	1707301	1707301	1707301	1708051	1708051	1708051	1708051			
Analyte	**Method**											
Petroleum Hydrocarbons (mg/kg)												
Gasoline	NWTPH-Gx	NA	4.4 U	5.2 U	5.4 U	NA	25.8 U	4.5 U	4.7 U	100[2]	*	*
#2 Diesel	NWTPH-Dx	NA	18.3 U	20.2 U	18.8 U	NA	19.2 U	18.9 U	20.4 U	2,000	*	*
Lube Oil	NWTPH-Dx	NA	45.8 U	50.5 U	47.0 U	NA	**495**	47.3 U	51.0 U	2,000	*	*
Volatile Organic Compounds (mg/kg)[3]												
Toluene	SW8260C	NA	0.0175 U	0.0207 U	0.0218 U	NA	**0.177**	0.0181 U	0.0186 U	7	6,400	*
1,2,3-Trichlorobenzene	SW8260C	NA	0.0175 U	0.0207 U	0.0218 U	NA	**0.27**	0.0181 U	0.0186 U	*	*	*
1,2,4-Trichlorobenzene	SW8260C	NA	0.0218 U	0.0259 U	0.0272 U	NA	**0.27**	0.0226 U	0.0233 U	*	800	*
RCRA 8 Metals (mg/kg)												
Arsenic	SW6020A	**3.24**	**2.32**	**1.98**	**1.79**	**4.19**	**2.92**	**2.07**	**2.1**	20	24	5
Barium	SW6020A	**71**	**57.5**	**51.9**	**89.9**	**162**	**72.5**	**54.2**	**63.6**	*	16000	255
Cadmium	SW6020A	0.153 U	0.149 U	0.17 U	0.161 U	**0.175**	0.473 U	0.17 U	0.172 U	2	80	1
Chromium	SW6020A	**38.1**	**18.1**	**13.2**	**15.7**	**36.7**	**5.51**	**23**	**23.2**	19/2,000[4]	240/120,000	38
Lead	SW6020A	**3.24**	**2.29**	**1.58**	**2.05**	**7.1**	**14.2**	**2.65**	**2.29**	250	*	11
Mercury	SW7471B	0.208 U	0.196 U	0.208 U	0.211 U	0.251 U	0.702 U	0.253 U	0.288 U	2	*	0.05
Selenium	SW6020A	**1.95**	**1.5**	**1.97**	**1.77**	**2.16**	1.18 U	**1.63**	**1.53**	*	400	0.78
Silver	SW6020A	0.078 U	0.082 U	0.082 U	0.083 U	0.081 U	0.224 U	0.08 U	0.094 U	*	400	0.61
Additional Metals (mg/kg)												
Copper	SW6020A	**20.1**	**14.2**	**16**	**16.6**	**48.8**	**12**	**14.7**	**18.7**	*	3,200	26
Nickel	SW6020A	**62**	**19.3**	**17.9**	**16.2**	**69.1**	**5.56**	**25**	**19.5**	*	1,600	46
Zinc	SW6020A	**69.2**	**40.8**	**40.3**	**45.3**	**82.7**	**56.5**	**43.7**	**42.2**	*	24,000	79
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg)												
1-Methylnaphthalene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
2-Methylnaphthalene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Acenaphthene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Acenaphthylene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Anthracene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Benz[a]anthracene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Benzo(a)pyrene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Benzo(b)fluoranthene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Benzo(ghi)perylene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Benzo(k)fluoranthene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Chrysene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Dibenzo(a,h)anthracene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Fluoranthene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Fluorene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Indeno(1,2,3-cd)pyrene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Naphthalene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Phenanthrene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Pyrene	SW8270DSIM	NA	0.0415 U	0.0396 U	0.0442 U	NA	0.1190 U	0.0371 U	0.0455 U	--		*
Polychlorinated Biphenyls (PCBs) (mg/kg)												
PCB-aroclor 1016	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1221	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1232	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1242	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1248	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1254	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1260	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1262	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB-aroclor 1268	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*
PCB, Sum of Aroclors	SW8082	NA	0.0889 U	0.105 U	0.106 U	NA	0.295 U	0.103 U	0.118 U	--		*

Boring:		B-1-17				B-2-17				MTCA Soil Cleanup Levels		
Sample Identification:		ES-1	ES-2	ES-3	ES-4	ES-5	ES-6	ES-7	ES-8	Method A Unrestricted Land Use	Method B Direct Contact Noncancer	Natural Background Soil Metals Concentration^{1}
Sample Depth (feet below ground surface):		0.4	41.5	43.5	53.9	0.2	8.8	15.8	21.2			
Sample Date:		07/25/17	07/26/17	07/26/17	07/27/17	08/03/17	08/03/17	08/03/17	08/03/17			
Sample Delivery Group:		1707301	1707301	1707301	1707301	1708051	1708051	1708051	1708051			
Analyte	**Method**											
Organochlorine Pesticides (mg/kg)												
4,4'-DDD	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
4,4'-DDE	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
4,4'-DDT	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Aldrin	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
alpha-BHC	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
beta-BHC	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
cis-Chlordane	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
delta-BHC	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Dieldrin	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Endosulfan I	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Endosulfan II	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Endosulfan Sulfate	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Endrin	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Endrin Aldehyde	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Endrin Ketone	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
gamma-Chlordane	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Heptachlor	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Heptachlor Epoxide	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Lindane	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Methoxychlor	SW8081A	0.009 U	NA	NA	NA	0.011 U	NA	NA	NA	--		*
Toxaphene	SW8081A	0.090 U	NA	NA	NA	0.106 U	NA	NA	NA	--		*
Herbicides (mg/kg)												
2,4,5-T	SW8151A	0.0485 U	NA	NA	NA	0.0516 U	NA	NA	NA	--		*
2,4-D	SW8151A	0.0291 U	NA	NA	NA	0.0309 U	NA	NA	NA	--		*
2,4-DB	SW8151A	0.0242 U	NA	NA	NA	0.0258 U	NA	NA	NA	--		*
3,5-Dichlorobenzoic Acid	SW8151A	0.0388 U	NA	NA	NA	0.0413 U	NA	NA	NA	--		*
4-Nitrophenol	SW8151A	0.0291 U	NA	NA	NA	0.0309 U	NA	NA	NA	--		*
Acifluorfen	SW8151A	0.0776 U	NA	NA	NA	0.0825 U	NA	NA	NA	--		*
Bentazon	SW8151A	0.0339 U	NA	NA	NA	0.0361 U	NA	NA	NA	--		*
Chloramben	SW8151A	0.0194 U	NA	NA	NA	0.0206 U	NA	NA	NA	--		*
Chlorthal-dimethyl	SW8151A	0.0291 U	NA	NA	NA	0.0309 U	NA	NA	NA	--		*
Dalapon	SW8151A	0.1940 U	NA	NA	NA	0.2060 U	NA	NA	NA	--		*
Dicamba	SW8151A	0.0339 U	NA	NA	NA	0.0361 U	NA	NA	NA	--		*
Dichlorprop	SW8151A	0.0242 U	NA	NA	NA	0.0258 U	NA	NA	NA	--		*
Dinoseb	SW8151A	0.0291 U	NA	NA	NA	0.0309 U	NA	NA	NA	--		*
MCPA	SW8151A	2.7200 U	NA	NA	NA	2.8900 U	NA	NA	NA	--		*
Mecoprop	SW8151A	4.2700 U	NA	NA	NA	4.5400 U	NA	NA	NA	--		*
Picloram	SW8151A	0.0485 U	NA	NA	NA	0.0516 U	NA	NA	NA	--		*
Silvex	SW8151A	0.0194 U	NA	NA	NA	0.0206 U	NA	NA	NA	--		*

NOTES:

Bold values indicate a detection.

Concentrations are in milligrams per kilogram (mg/kg)

1 Natural background soil metals concentrations shown are for Yakima Basin with the exception of Barium (value from Spokane Basin), silver (statewide value), and selenium (statewide value).

2 Criteria for gasoline-range petroleum in soil is 100 mg/kg when benzene is not present.

3 Only VOCs that were detected within one or more sample are shown in the table. All other VOCs were not detected above laboratory reporting limits.

4 Criteria for chromium are for hexavalent chromium/trivalent chromium.

* = criteria not established for this analyte

-- = not shown, no detections occurred within analytical group

mg/kg = milligram per kilogram; MTCA = Model Toxics Control Act; NA = not analyzed; MTCA = Model Toxics Control Act; NWTPH-Dx = Northwest Total Petroleum Hydrocarbons-Diesel Extended; NWTPH-Gx = Northwest Total Petroleum Hydrocarbons-Gasoline Extended; RCRA = Resource Conservation and Recovery Act;

U = the analyte was not detected above the indicated laboratory reporting limit

Boring		***EWC-B-01-14***		***EWC-B-02-14***	***EWC-B-03-14***	***EWC-B-04-14***	**MTCA Method A Unrestricted Land Use (mg/kg)**	**MTCA Method A Industrial Land Use (mg/kg)**
Sample Identification		**EWC-B-01-14:10.0**	**EWC-B-01-14:15.0**	**EWC-B-02-14:12.25**	**EWC-B-03-14:12.0**	**EWC-B-04-14:10.0**		
Analyte	**Method**							
Petroleum Hydrocarbons (mg/kg)								
Gasoline Range Organics	NWTPH-Gx	8.3 U	11 U	5.1 U	4.5 U	2.8 U	30/100	30/100
Diesel Range Organics	NWTPH-Dx	32 U	42 U	18 U	18 U	20 U	2,000	2,000
Lube Oil	NWTPH-Dx	**147**	**1540**	46 U	46 U	50 U	2,000	2,000
Volatile Organic Compounds (mg/kg)								
Benzene	SW8260C	0.033 U	0.042 U	0.020 U	0.018 U	0.011 U	0.03	0.03
Toluene	SW8260C	0.033 U	0.042 U	0.020 U	0.018 U	0.011 U	7	7
Ethylbenzene	SW8260C	0.050 U	0.064 U	0.030 U	0.027 U	0.017 U	6	6
m, p-Xylene	SW8260C	0.033 U	0.042 U	0.020 U	0.018 U	0.011 U	9	9
o-Xylene	SW8260C	0.033 U	0.042 U	0.020 U	0.018 U	0.011 U		
MTCA 5 Metals (mg/kg)								
Arsenic	SW6010C	**2.5**	**6.1**	**2.2**	**2.0**	**2.8**	20	20
Cadmium	SW6010C	**0.53**	**0.87**	0.17 U	0.16 U	0.18 U	2	2
Chromium	SW6010C	**13**	**18**	**14**	**11**	**25**	2,000	2,000
Lead	SW6010C	**21**	**36**	**2.9**	**1.9**	**2.5**	250	1,000
Mercury	SW7471B	0.41 U	0.50 U	0.29 U	0.26 U	0.29 U	2	2
Polynuclear Aromatic Hydrocarbons (PAHs) (mg/kg)								
Naphthalene	SW8270DSIM	0.083 U	**0.241**	0.053 U	0.049 U	0.058 U	5	5
2-Methylnaphthalene	SW8270DSIM	0.083 U	0.0997 U	0.053 U	0.049 U	0.058 U	*	*
1-Methylnaphthalene	SW8270DSIM	0.083 U	0.0997 U	0.053 U	0.049 U	0.058 U	*	*
Acenaphthylene	SW8270DSIM	0.083 U	0.0997 U	0.053 U	0.049 U	0.058 U	*	*
Acenaphthene	SW8270DSIM	0.083 U	**0.126**	0.053 U	0.049 U	0.058 U	*	*
Fluorene	SW8270DSIM	0.083 U	**0.178**	0.053 U	0.049 U	0.058 U	*	*
Phenanthrene	SW8270DSIM	0.083 U	**1.07**	0.053 U	0.049 U	0.058 U	*	*
Anthracene	SW8270DSIM	0.083 U	**0.289**	0.053 U	0.049 U	0.058 U	*	*
Fluoranthene	SW8270DSIM	**0.12**	**1.09**	0.053 U	0.049 U	0.058 U	*	*
Pyrene	SW8270DSIM	0.083 U	**0.839**	0.053 U	0.049 U	0.058 U	*	*
Benz[a]anthracene	SW8270DSIM	0.083 U	**0.46**	0.053 U	0.049 U	0.058 U	*	*
Chrysene	SW8270DSIM	0.083 U	**0.25**	0.053 U	0.049 U	0.058 U	*	*
Benzo(k)fluoranthene	SW8270DSIM	0.083 U	**0.20**	0.053 U	0.049 U	0.058 U	*	*
Benzo(b)fluoranthene	SW8270DSIM	0.083 U	**0.51**	0.053 U	0.049 U	0.058 U	*	*
Benzo(ghi)perylene	SW8270DSIM	0.083 U	**0.25**	0.053 U	0.049 U	0.058 U	*	*
Benzo(a)pyrene	SW8270DSIM	0.083 U	**0.38**	0.053 U	0.049 U	0.058 U	0.1	2
Indeno(1,2,3-cd)pyrene	SW8270DSIM	0.083 U	**0.23**	0.053 U	0.049 U	0.058 U	*	*
Dibenzo(a,h)anthracene	SW8270DSIM	0.083 U	**0.13**	0.053 U	0.049 U	0.058 U	*	*
Benzo(ghi)perylene	SW8270DSIM	0.083 U	**0.25**	0.053 U	0.049 U	0.058 U	*	*
TEF-adjusted cPAHs (see Table D-4)		0.0020 U	**0.58**	0.0010 U	0.0010 U	0.0012 U	0.1	2

Boring		*EWC-B-01-14*		*EWC-B-02-14*	*EWC-B-03-14*	*EWC-B-04-14*	MTCA Method A Unrestricted Land Use (mg/kg)	MTCA Method A Industrial Land Use (mg/kg)
Sample Identification		EWC-B-01-14:10.0	EWC-B-01-14:15.0	EWC-B-02-14:12.25	EWC-B-03-14:12.0	EWC-B-04-14:10.0		
Analyte	**Method**							
Detected Herbicides (ug/kg)								
Pentachlorophenol	SW8151A	**0.35**	0.036 U	**0.043**	**0.051**	**0.15**	*	*

NOTES:

* No MTCA Method A values have been established for this analyte.

Bold values indicate a detection.

Criteria for gasoline-range petroleum in soil are 30 mg/kg when benzene is present and 100 mg/kg when benzene is not present.

Shaded values indicate a MTCA Method A exceedance.

cPAHs = carcinogenic polycyclic aromatic hydrocarbons; EWC = East-West Corridor; mg/kg = milligram per kilogram; MTCA = Model Toxics Control Act; NWTPH-Dx = Northwest Total Petroleum Hydrocarbons-Diesel Extended; NWTPH-Gx = Northwest Total Petroleum Hydrocarbons-Gasoline Extended; TEF = toxicity equivalent factor; U = the analyte was not detected above the laboratory reporting limit shown; ug/kg = microgram per kilogram

Table D-4: Summary of Adjusted Toxicity Equivalence Factor Concentrations

Soil Sample	Analyte	Sample Result (mg/kg)	Method Detection Limit (mg/kg)	Toxic Equivalency Factor (TEF)	Adjusted Concentration[1] (mg/kg)
B-9-21/R-10@48'	Benzo(a)anthracene	ND	0.0213	0.1	0.001065
	Chrysene	ND	0.0426	0.01	0.000213
	Benzo(b)fluoranthene	ND	0.0213	0.1	0.001065
	Benzo(k)fluoranthene	ND	0.0213	0.1	0.001065
	Benzo(a)pyrene	ND	0.0213	1	0.01065
	Indeno(1,2,3-c,d)pyrene	ND	0.0426	0.1	0.00213
	Dibenzo(a,h)anthracene	ND	0.0426	0.4	0.0085
	Sum[2]				0.025
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
B-10-21/S-3@15.5'	Benzo(a)anthracene	ND	0.0191	0.1	0.000955
	Chrysene	ND	0.0383	0.01	0.0001915
	Benzo(b)fluoranthene	ND	0.0191	0.1	0.000955
	Benzo(k)fluoranthene	ND	0.0191	0.1	0.000955
	Benzo(a)pyrene	ND	0.0191	1	0.00955
	Indeno(1,2,3-c,d)pyrene	ND	0.0383	0.1	0.001915
	Dibenzo(a,h)anthracene	ND	0.0383	0.4	0.0077
	Sum[2]				0.02
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
B-10-21/a9@48'	Benzo(a)anthracene	ND	0.0202	0.1	0.00101
	Chrysene	ND	0.0404	0.01	0.000202
	Benzo(b)fluoranthene	ND	0.0202	0.1	0.00101
	Benzo(k)fluoranthene	ND	0.0202	0.1	0.00101
	Benzo(a)pyrene	ND	0.0202	1	0.0101
	Indeno(1,2,3-c,d)pyrene	ND	0.0404	0.1	0.00202
	Dibenzo(a,h)anthracene	ND	0.0404	0.4	0.00808
	Sum[2]				0.023
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0

Soil Sample	Analyte	Sample Result (mg/kg)	Method Detection Limit (mg/kg)	Toxic Equivalency Factor (TEF)	Adjusted Concentration[1] (mg/kg)
B-11P-21/R-10@51'	Benzo(a)anthracene	ND	0.0190	0.1	0.00095
	Chrysene	ND	0.0379	0.01	0.0001895
	Benzo(b)fluoranthene	ND	0.0190	0.1	0.00095
	Benzo(k)fluoranthene	ND	0.0190	0.1	0.00095
	Benzo(a)pyrene	ND	0.0190	1	0.0095
	Indeno(1,2,3-c,d)pyrene	ND	0.0379	0.1	0.001895
	Dibenzo(a,h)anthracene	ND	0.0379	0.4	0.00758
	Sum[2]				0.0220
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
B-12P-21/R-11@50'	Benzo(a)anthracene	ND	0.0219	0.1	0.001095
	Chrysene	ND	0.0437	0.01	0.0002185
	Benzo(b)fluoranthene	ND	0.0219	0.1	0.001095
	Benzo(k)fluoranthene	ND	0.0219	0.1	0.001095
	Benzo(a)pyrene	ND	0.0219	1	0.01095
	Indeno(1,2,3-c,d)pyrene	ND	0.0437	0.1	0.002185
	Dibenzo(a,h)anthracene	ND	0.0437	0.4	0.00874
	Sum[2]				0.0254
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
B-13-21/R-8@39'	Benzo(a)anthracene	ND	0.0185	0.1	0.000925
	Chrysene	ND	0.0369	0.01	0.0001845
	Benzo(b)fluoranthene	ND	0.0185	0.1	0.000925
	Benzo(k)fluoranthene	ND	0.0185	0.1	0.000925
	Benzo(a)pyrene	ND	0.0185	1	0.00925
	Indeno(1,2,3-c,d)pyrene	ND	0.0369	0.1	0.001845
	Dibenzo(a,h)anthracene	ND	0.0369	0.4	0.00738
	Sum[2]				0.0214
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0

Soil Sample	Analyte	Sample Result (mg/kg)	Method Detection Limit (mg/kg)	Toxic Equivalency Factor (TEF)	Adjusted Concentration[1] (mg/kg)
B-13-21/R-9@47'	Benzo(a)anthracene	ND	0.0195	0.1	0.000975
	Chrysene	ND	0.0390	0.01	0.000195
	Benzo(b)fluoranthene	ND	0.0195	0.1	0.000975
	Benzo(k)fluoranthene	ND	0.0195	0.1	0.000975
	Benzo(a)pyrene	ND	0.0195	1	0.00975
	Indeno(1,2,3-c,d)pyrene	ND	0.0390	0.1	0.00195
	Dibenzo(a,h)anthracene	ND	0.0390	0.4	0.0078
	Sum[2]				0.0226
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
B-14-21/R-9@48'	Benzo(a)anthracene	ND	0.0181	0.1	0.000905
	Chrysene	ND	0.0363	0.01	0.0001815
	Benzo(b)fluoranthene	ND	0.0181	0.1	0.000905
	Benzo(k)fluoranthene	ND	0.0181	0.1	0.000905
	Benzo(a)pyrene	ND	0.0181	1	0.00905
	Indeno(1,2,3-c,d)pyrene	ND	0.0363	0.1	0.001815
	Dibenzo(a,h)anthracene	ND	0.0363	0.4	0.00726
	Sum[2]				0.0210
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
B-15P-21/S-5@21'	Benzo(a)anthracene	ND	0.0206	0.1	0.00103
	Chrysene	ND	0.0411	0.01	0.0002055
	Benzo(b)fluoranthene	ND	0.0206	0.1	0.00103
	Benzo(k)fluoranthene	ND	0.0206	0.1	0.00103
	Benzo(a)pyrene	ND	0.0206	1	0.0103
	Indeno(1,2,3-c,d)pyrene	ND	0.0411	0.1	0.002055
	Dibenzo(a,h)anthracene	ND	0.0411	0.4	0.0082
	Sum[2]				0.02
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0

Soil Sample	Analyte	Sample Result (mg/kg)	Method Detection Limit (mg/kg)	Toxic Equivalency Factor (TEF)	Adjusted Concentration[1] (mg/kg)
EWC-B-01-14:10.0	Benzo(a)anthracene	ND	0.0015	0.1	0.000075
	Chrysene	ND	0.0017	0.01	0.00000845
	Benzo(b)fluoranthene	ND	0.0019	0.1	0.0000965
	Benzo(k)fluoranthene	ND	0.0015	0.1	0.000077
	Benzo(a)pyrene	ND	0.0019	1	0.000965
	Indeno(1,2,3-c,d)pyrene	ND	0.0021	0.1	0.000106
	Dibenzo(a,h)anthracene	ND	0.0019	0.4	0.0004
	Sum[2]				0.002
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
EWC-B-01-14:15.0	Benzo(a)anthracene	**0.46**	0.0019	0.1	0.0462
	Chrysene	**0.25**	0.0020	0.01	0.00248
	Benzo(b)fluoranthene	**0.51**	0.0023	0.1	0.0507
	Benzo(k)fluoranthene	**0.20**	0.0018	0.1	0.0203
	Benzo(a)pyrene	**0.38**	0.0023	1	0.382
	Indeno(1,2,3-c,d)pyrene	**0.23**	0.0025	0.1	0.0231
	Dibenzo(a,h)anthracene	**0.13**	0.0022	0.4	0.0536
	Sum[2]				**0.58**
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
EWC-B-02-14:12.25	Benzo(a)anthracene	ND	0.0010	0.1	0.00005
	Chrysene	ND	0.0011	0.01	0.00000545
	Benzo(b)fluoranthene	ND	0.0013	0.1	0.0000625
	Benzo(k)fluoranthene	ND	0.0009	0.1	0.000045
	Benzo(a)pyrene	ND	0.0013	1	0.000625
	Indeno(1,2,3-c,d)pyrene	ND	0.0013	0.1	0.000065
	Dibenzo(a,h)anthracene	ND	0.0012	0.4	0.00024
	Sum[2]				0.001
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0

Soil Sample	Analyte	Sample Result (mg/kg)	Method Detection Limit (mg/kg)	Toxic Equivalency Factor (TEF)	Adjusted Concentration[1] (mg/kg)
EWC-B-03-14:12.0	Benzo(a)anthracene	ND	0.0009	0.1	0.000045
	Chrysene	ND	0.0010	0.01	0.000005
	Benzo(b)fluoranthene	ND	0.0011	0.1	0.000055
	Benzo(k)fluoranthene	ND	0.0009	0.1	0.000045
	Benzo(a)pyrene	ND	0.0011	1	0.00055
	Indeno(1,2,3-c,d)pyrene	ND	0.0012	0.1	0.00006
	Dibenzo(a,h)anthracene	ND	0.0011	0.4	0.00022
	Sum[2]				0.0010
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
EWC-B-04-14:10.0	Benzo(a)anthracene	ND	0.0011	0.1	0.000055
	Chrysene	ND	0.0011	0.01	0.0000055
	Benzo(b)fluoranthene	ND	0.0013	0.1	0.000065
	Benzo(k)fluoranthene	ND	0.0010	0.1	0.00005
	Benzo(a)pyrene	ND	0.0013	1	0.00065
	Indeno(1,2,3-c,d)pyrene	ND	0.0014	0.1	0.00007
	Dibenzo(a,h)anthracene	ND	0.0013	0.4	0.00026
	Sum[2]				0.0012
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
EWC-TP-03-14:12	Benzo(a)anthracene	0.086	0.0500	0.1	0.0086
	Chrysene	0.082	0.0500	0.01	0.00082
	Benzo(b)fluoranthene	ND	0.0500	0.1	0.0025
	Benzo(k)fluoranthene	ND	0.0500	0.1	0.0025
	Benzo(a)pyrene	**ND**	0.0500	1	0.025
	Indeno(1,2,3-c,d)pyrene	ND	0.0500	0.1	0.0025
	Dibenzo(a,h)anthracene	ND	0.0500	0.4	0.0100
	Sum[2]				**0.052**
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0

Soil Sample	Analyte	Sample Result (mg/kg)	Method Detection Limit (mg/kg)	Toxic Equivalency Factor (TEF)	Adjusted Concentration^1 (mg/kg)
EWC-TP-04-14:11	Benzo(a)anthracene	**0.086**	0.0100	0.1	0.0086
	Chrysene	**0.070**	0.0100	0.01	0.0007
	Benzo(b)fluoranthene	**0.033**	0.0100	0.1	0.0033
	Benzo(k)fluoranthene	**0.012**	0.0100	0.1	0.0012
	Benzo(a)pyrene	**0.024**	0.0100	1	0.024
	Indeno(1,2,3-c,d)pyrene	**ND**	0.0100	0.1	0.0005
	Dibenzo(a,h)anthracene	**ND**	0.0100	0.4	0.0020
	Sum^2				**0.04**
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0
EWC-TP-05-14:11.0	Benzo(a)anthracene	ND	0.0009	0.1	0.000045
	Chrysene	ND	0.0009	0.01	0.0000045
	Benzo(b)fluoranthene	ND	0.0011	0.1	0.000055
	Benzo(k)fluoranthene	ND	0.0008	0.1	0.00004
	Benzo(a)pyrene	ND	0.0011	1	0.00055
	Indeno(1,2,3-c,d)pyrene	ND	0.0012	0.1	0.00006
	Dibenzo(a,h)anthracene	ND	0.0011	0.4	0.00022
	Sum^2				0.0010
	MTCA Method A Cleanup Level for Unrestricted Land Use				0.10
	MTCA Method A Cleanup Level for Industrial Land Use				2.0

NOTES:

1 Calculated as the detected concentration times the TEF, or as half the method detection limit (if analyte is not detected) times the TEF.

2 Sum of the TEF for each cPAH.

Bold values indicated a detection.

Shaded values indicate an MTCA Method A exceedance.

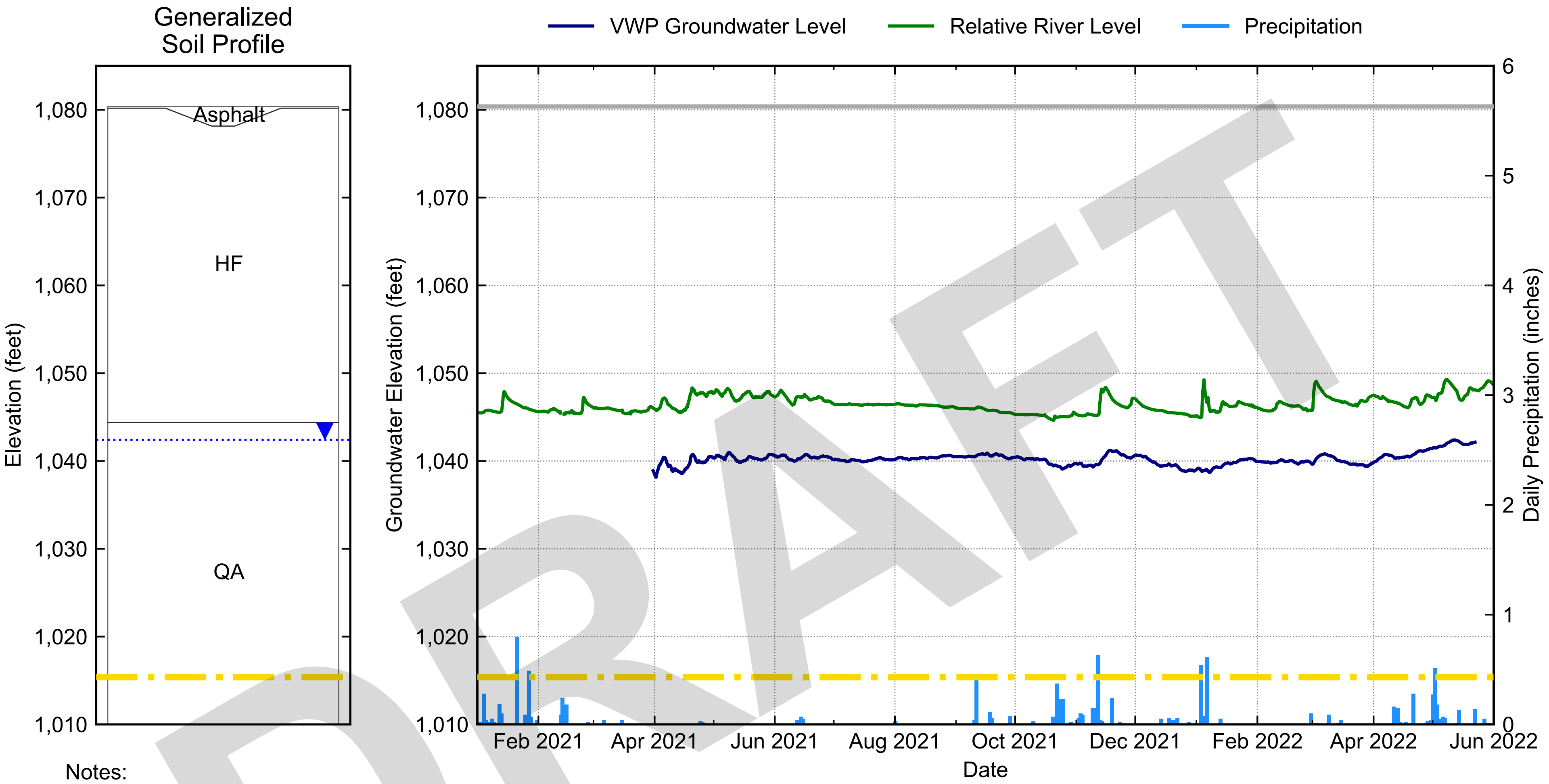
cPAH = carcinogenic polycyclic aromatic hydrocarbon; mg/kg = milligrams per kilogram; MTCA = Washington Model Toxics Control Act; ND = not detected

Appendix E

Groundwater Observations

CONTENTS

ver:0.16.0-beta.2, by:oth



Notes:
1. Groundwater data recorded hourly using a vibrating wire piezometer.
2. Daily Precipitation data from the following NOAA weather station:
   Name = YAKIMA 0.9 WNW, WA US; ID = US1WAYK0024
   (available: ftp://ftp.ncdc.noaa.gov/pub/data/ghcn/daily/)
3. Relative river levels shown represent gage heights from a USGS river gage upstream of the boring location at a different elevation. Levels shown have been shifted such that the lowest gage height aligns with the bottom of the Levee Fill layer. Relative river levels are therefore not actual elevations of the river at the boring locations. Gage height data was retrieved from the following USGS gage site:
   Site Name = YAKIMA RIVER ABOVE AHTANUM CREEK AT UNION GAP, WA (No. 12500450)
   (Available: https://waterservices.usgs.gov/rest/IV-Test-Tool.html)

Cascade Mill Parkway Project
Yakima County, Washington

GROUNDWATER LEVEL READINGS
BORING B-11P-21

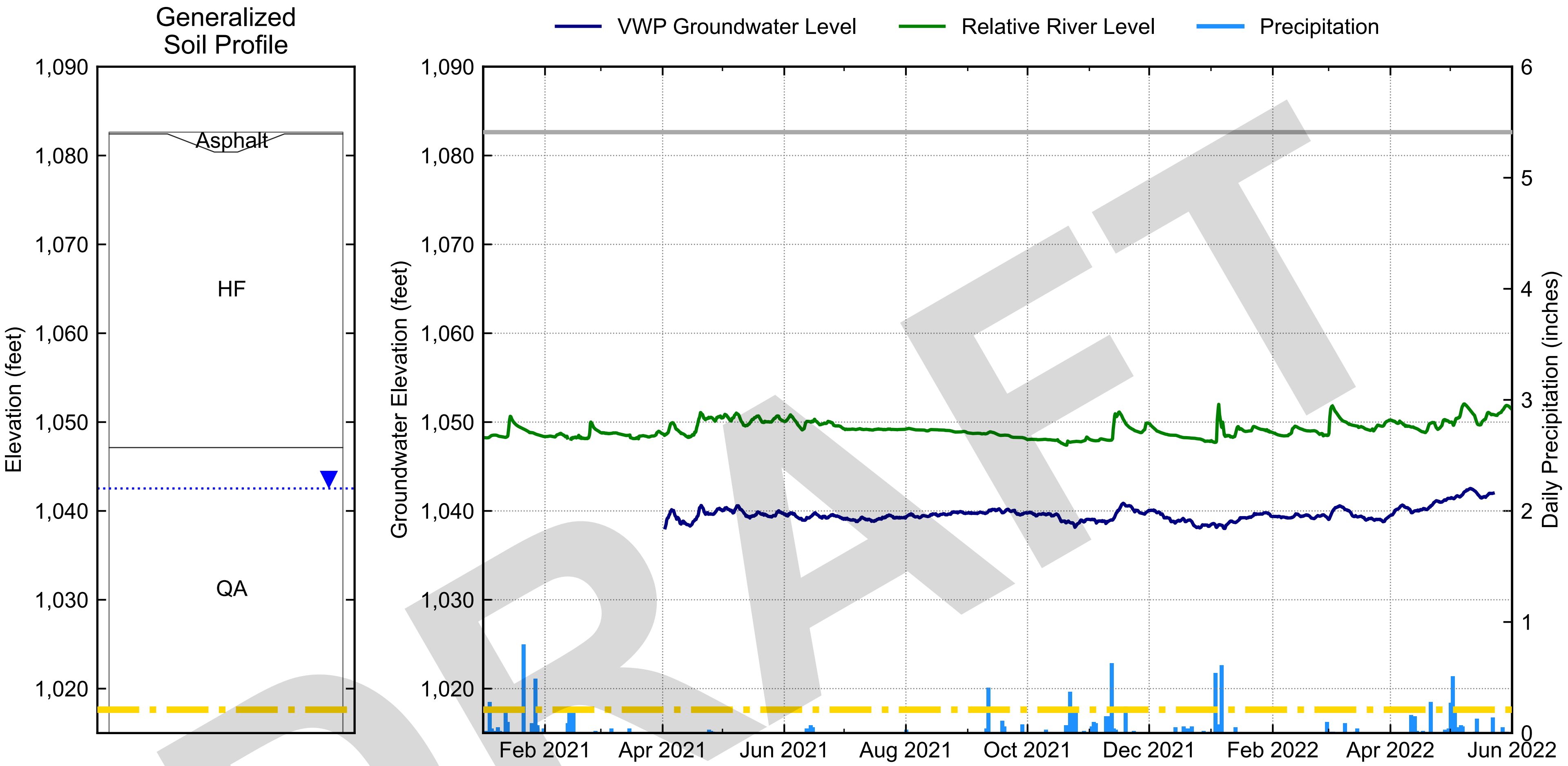
September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-1

\\Sea-fs1\vol1\EF\SEA\106000s\106384 Mill Parkway\Field Explorations\VWP's\Python VWP plots

FIG. E-1



Notes:
1. Groundwater data recorded hourly using a vibrating wire piezometer.
2. Daily Precipitation data from the following NOAA weather station:
   Name = YAKIMA 0.9 WNW, WA US; ID = US1WAYK0024
   (available: ftp://ftp.ncdc.noaa.gov/pub/data/ghcn/daily/)
3. Relative river levels shown represent gage heights from a USGS river gage upstream of the boring location at a different elevation. Levels shown have been shifted such that the lowest gage height aligns with the bottom of the Levee Fill layer. Relative river levels are therefore not actual elevations of the river at the boring locations. Gage height data was retrieved from the following USGS gage site:
   Site Name = YAKIMA RIVER ABOVE AHTANUM CREEK AT UNION GAP, WA (No. 12500450)
   (Available: https://waterservices.usgs.gov/rest/IV-Test-Tool.html)

Cascade Mill Parkway Project
Yakima County, Washington

GROUNDWATER LEVEL READINGS
BORING B-12P-21

September 2022 106384-002

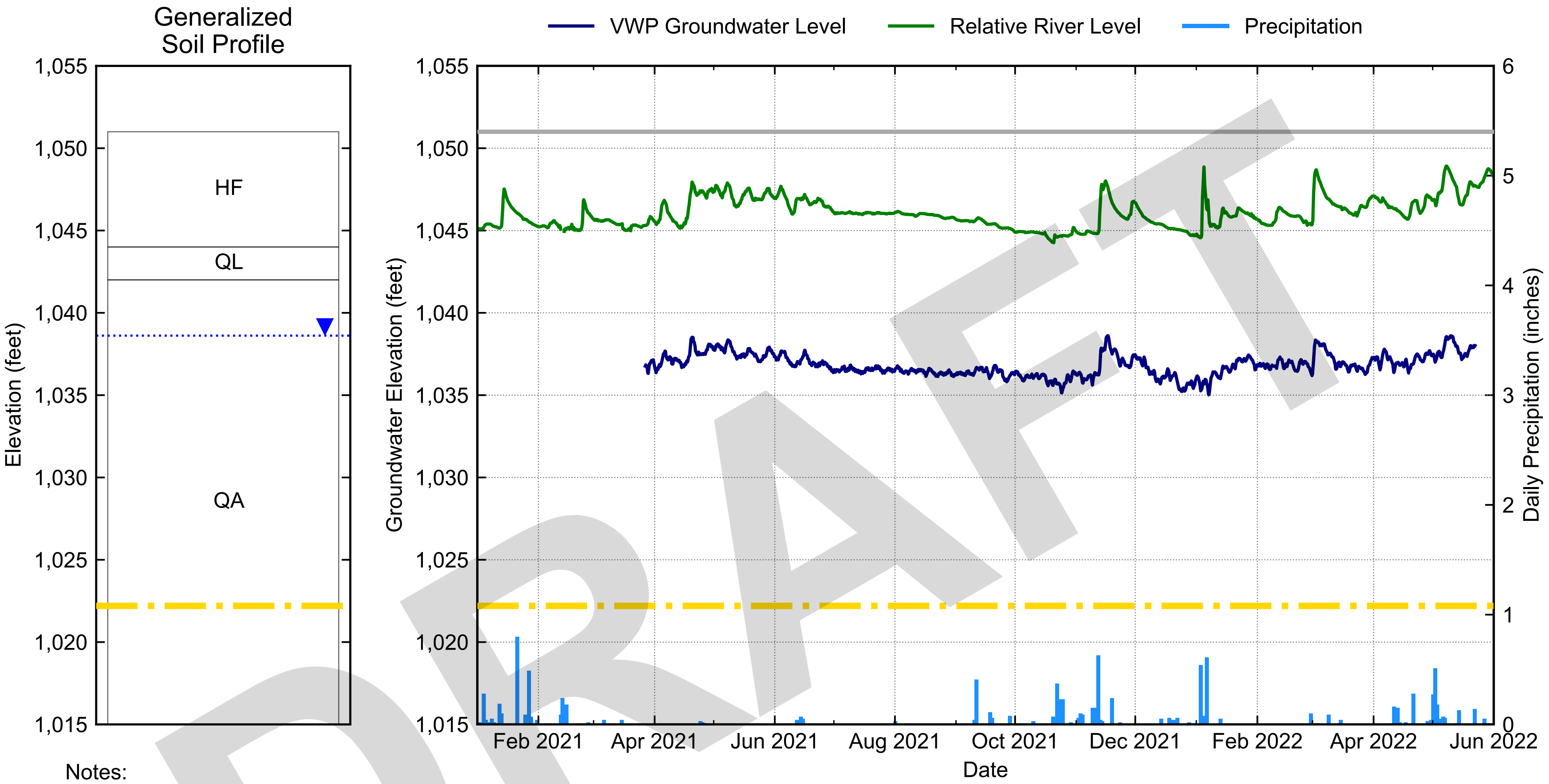
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-2

FIG. E-2

\\Sea-fs1\vol1\EF\SEA\106000s\106384 Mill Parkway\Field Explorations\VWP's\Python VWP plots

ver:0.16.0-beta.2, by:oth



Notes:
1. Groundwater data recorded hourly using a vibrating wire piezometer.
2. Daily Precipitation data from the following NOAA weather station:
   Name = YAKIMA 0.9 WNW, WA US; ID = US1WAYK0024
   (available: ftp://ftp.ncdc.noaa.gov/pub/data/ghcn/daily/)
3. Relative river levels shown represent gage heights from a USGS river gage upstream of the boring location at a different elevation. Levels shown have been shifted such that the lowest gage height aligns with the bottom of the Levee Fill layer. Relative river levels are therefore not actual elevations of the river at the boring locations. Gage height data was retrieved from the following USGS gage site:
   Site Name = YAKIMA RIVER ABOVE AHTANUM CREEK AT UNION GAP, WA (No. 12500450)
   (Available: https://waterservices.usgs.gov/rest/IV-Test-Tool.html)

Cascade Mill Parkway Project
Yakima County, Washington

GROUNDWATER LEVEL READINGS
BORING B-15P-21

September 2022 106384-002

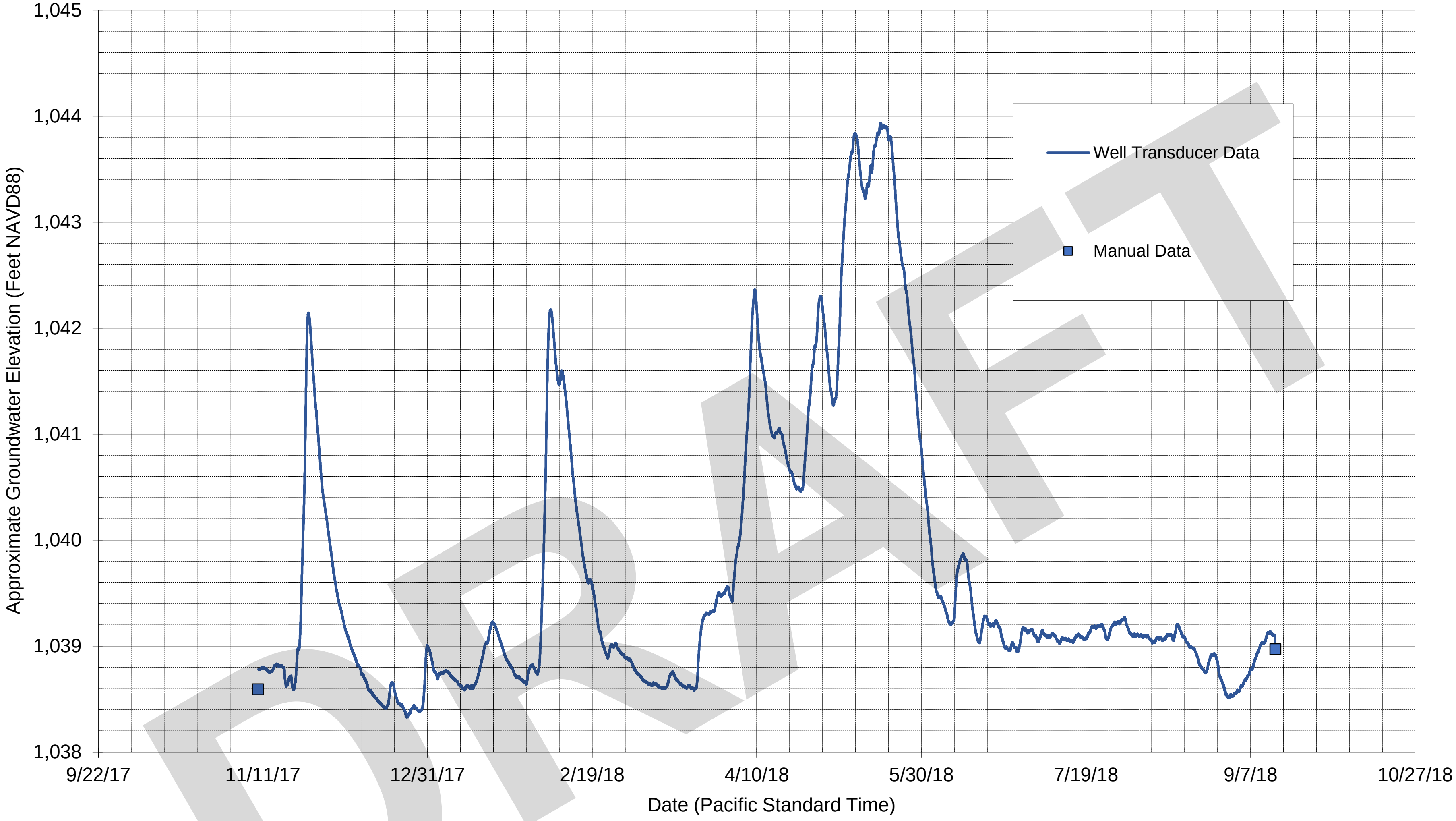
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-3

ver:0.16.0-beta.2, by:oth

\\Sea-fs1\vol1\EF\SEA\106000s\106384 Mill Parkway\Field Explorations\VWP's\Python VWP plots

FIG. E-3



NOTES

1. The screen in observation well B-2-17 is approximately 29.5 to 39.5 feet below ground surface (approximately elevation 1,025.5 to 1,015.5 feet (NAVD88)).
2. Grade elevation at B-2-17 is approximately 1,055 feet NAVD88.
3. Black and white reproduction of this color original may lead to incorrect interpretation.

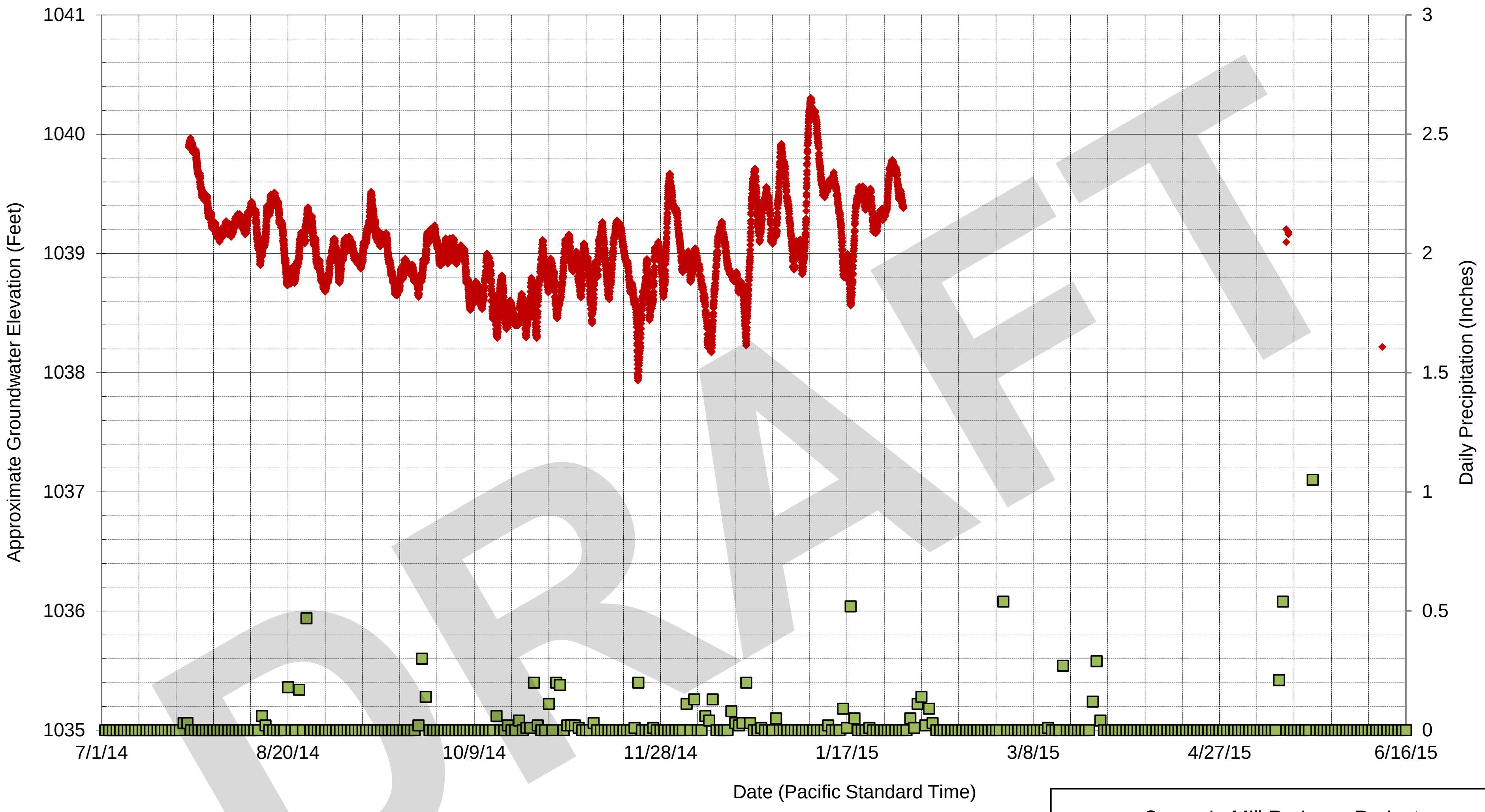
Cascade Mill Parkway Project
Yakima County, Washington

**OBSERVATION WELL B-2-17
HYDROGRAPH**

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-4



LEGEND

- ◆ EWC-B-01-14 Vibrating Wire Piezometer 1 (84.5 feet deep)
- 🟩 Daily Total Precipitation

NOTES

1. EWC-B-01-14 grade elevation is approximately 1057.5 feet.
2. Precipitation data were downloaded for the Yakima Air Terminal (24243).
3. Data logger failed sporadically starting 2/1/15.

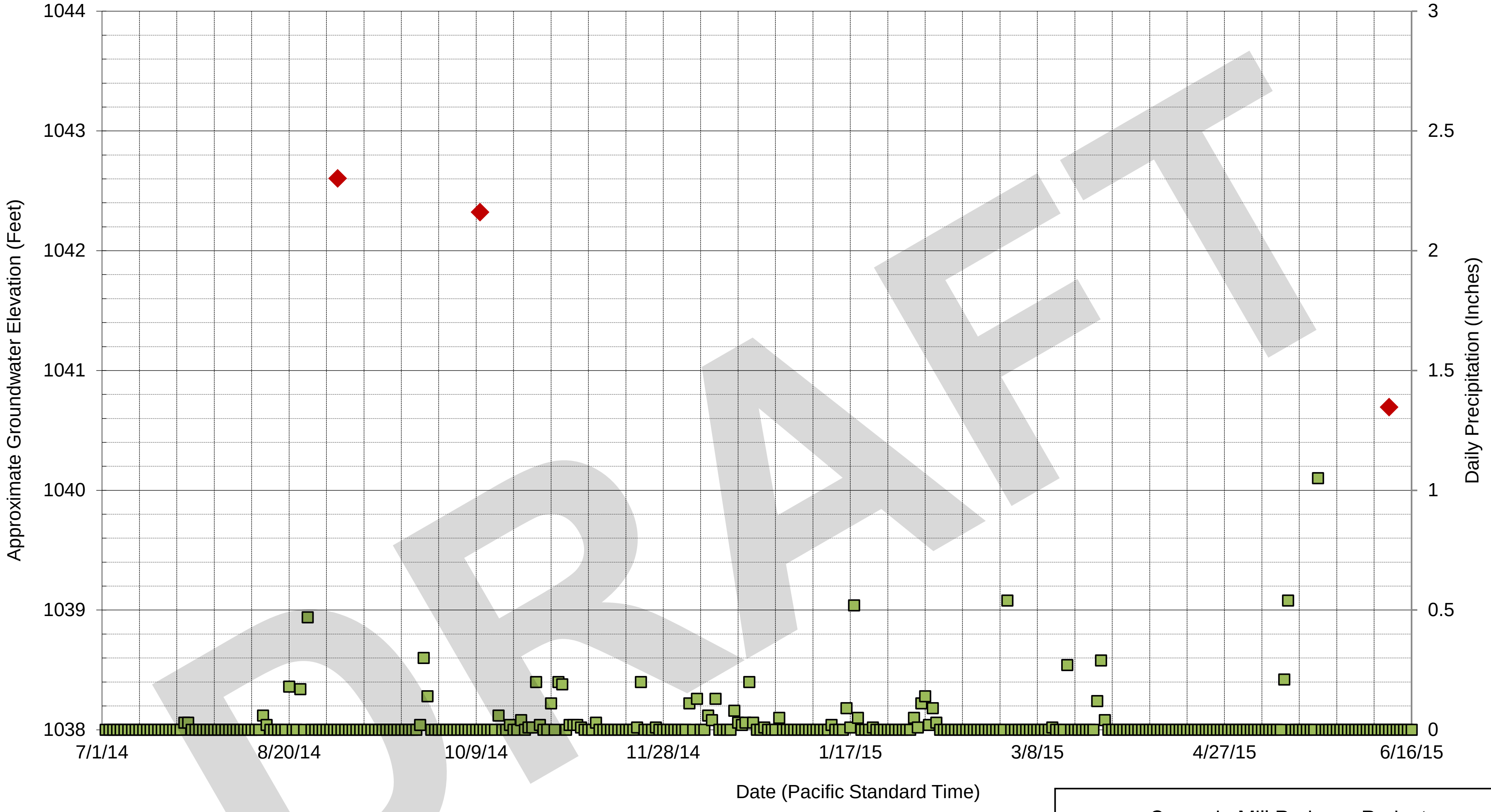
Cascade Mill Parkway Project
Yakima County, Washington

GROUNDWATER LEVEL VS PRECIPITATION
BORING EWC-B-01-14

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-5



LEGEND

◆ EWC-B-02-14 Vibrating Wire Piezometer 1 (30.0 feet deep)

🟩 Daily Total Precipitation

NOTES

1. EWC-B-02-14 grade elevation is approximately 1052 feet.
2. Precipitation data were downloaded for the Yakima Air Terminal (24243).

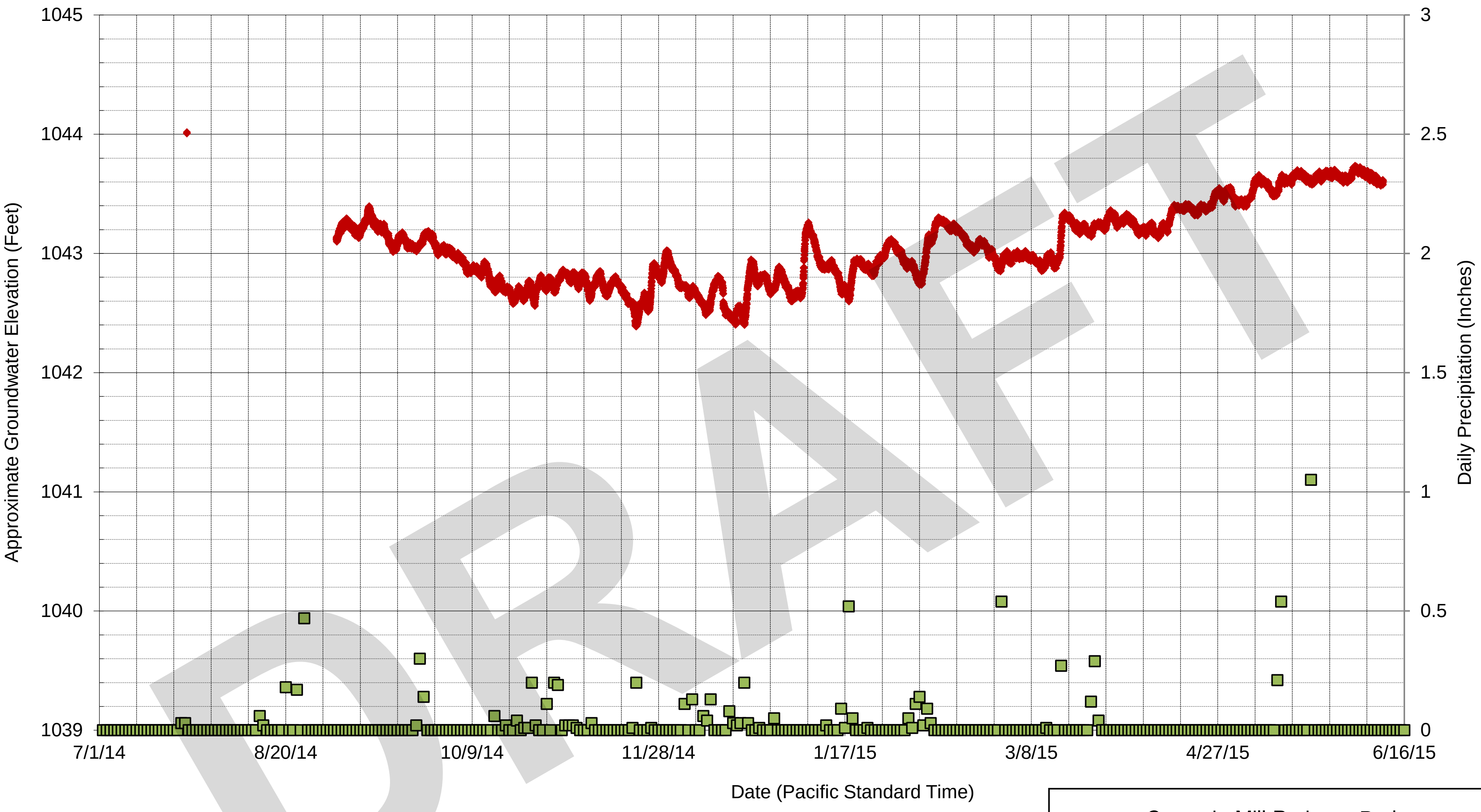
Cascade Mill Parkway Project
Yakima County, Washington

GROUNDWATER LEVEL VS PRECIPITATION BORING EWC-B-02-14

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-6



LEGEND

◆ EWC-B-03-14 Vibrating Wire Piezometer 1 (53.1 feet deep)

🟩 Daily Total Precipitation

NOTES

1. EWC-B-03-14 grade elevation is approximately 1056.5 feet.
2. Precipitation data were downloaded for the Yakima Air Terminal (24243).

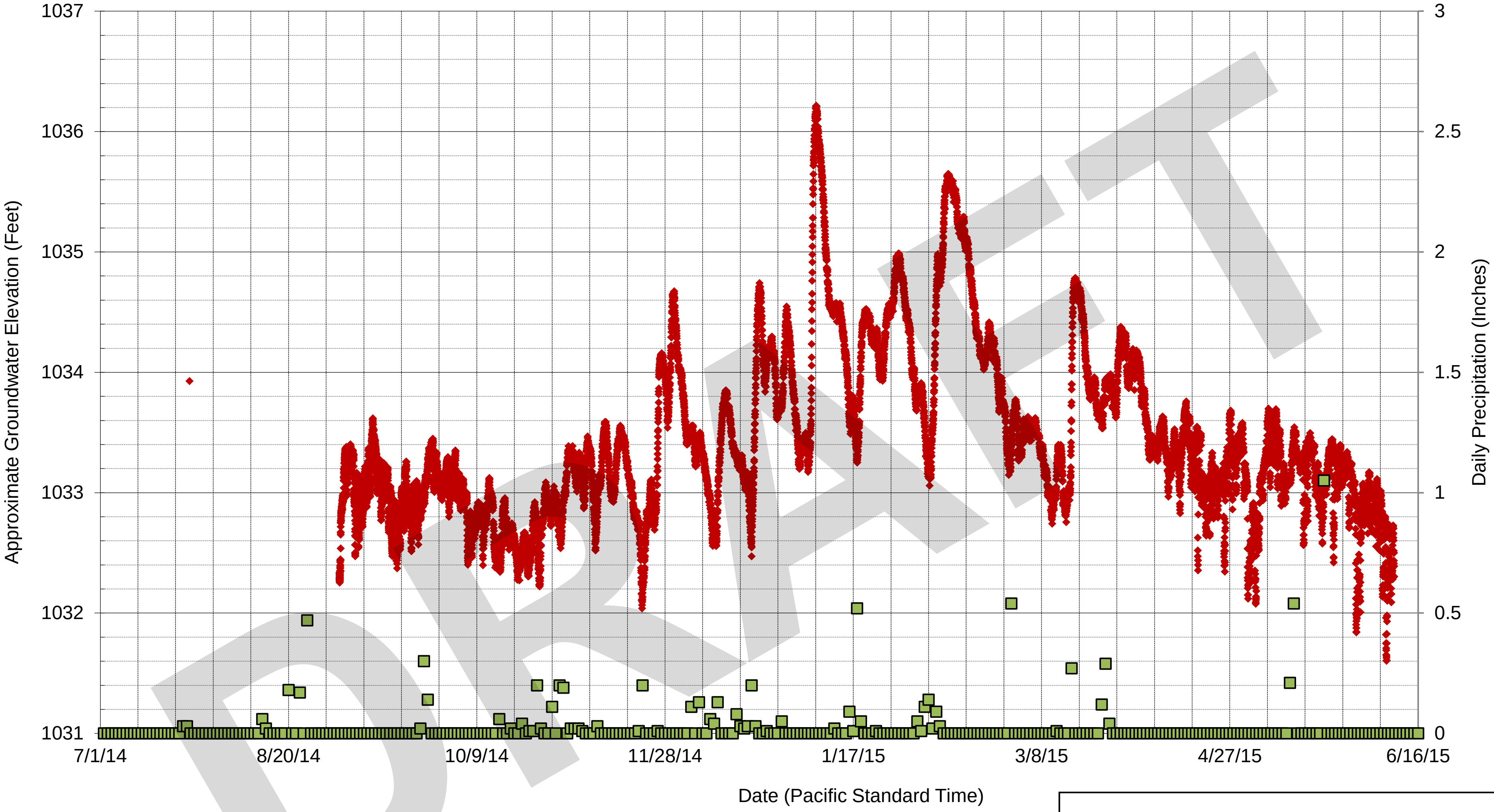
Cascade Mill Parkway Project
Yakima County, Washington

GROUNDWATER LEVEL VS PRECIPITATION
BORING EWC-B-03-14

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-7



LEGEND

♦ EWC-B-04-14 Vibrating Wire Piezometer 1 (68.1 feet deep)

🟩 Daily Total Precipitation

NOTES

1. EWC-B-04-14 grade elevation is approximately 1047 feet.
2. Precipitation data were downloaded for the Yakima Air Terminal (24243).

Cascade Mill Parkway Project
Yakima County, Washington

GROUNDWATER LEVEL VS PRECIPITATION BORING EWC-B-04-14

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-8

EWC_VWP_Data_Plots_Rev_8-5-15.xlsx-EWC-B-04-14Plot-8/10/2015-pvh

Appendix F

Global Stability Analyses

CONTENTS

Exhibits

Tables

Figures

F.1 INTRODUCTION

This appendix presents global stability modeling performed for the Cascade Mill Parkway (CMP) project in Yakima County. This appendix describes the analysis methods, soil parameters, and other assumptions made in the analyses.

F.2 ANALYSIS LOCATIONS AND GEOMETRIES

We evaluated global stability at three locations. Details for each location are provided in the following sections.

F.2.1 Yakima River Bridge East Abutment and Approach Embankment

We evaluated global stability for the longitudinal (east-west) and transverse (north-south) directions at the proposed Yakima River Bridge (YRB) east abutment. Locations of these analyses are indicated in Exhibit F-1. Figures F-1 through F-4 show our geometric assumptions for these analyses.

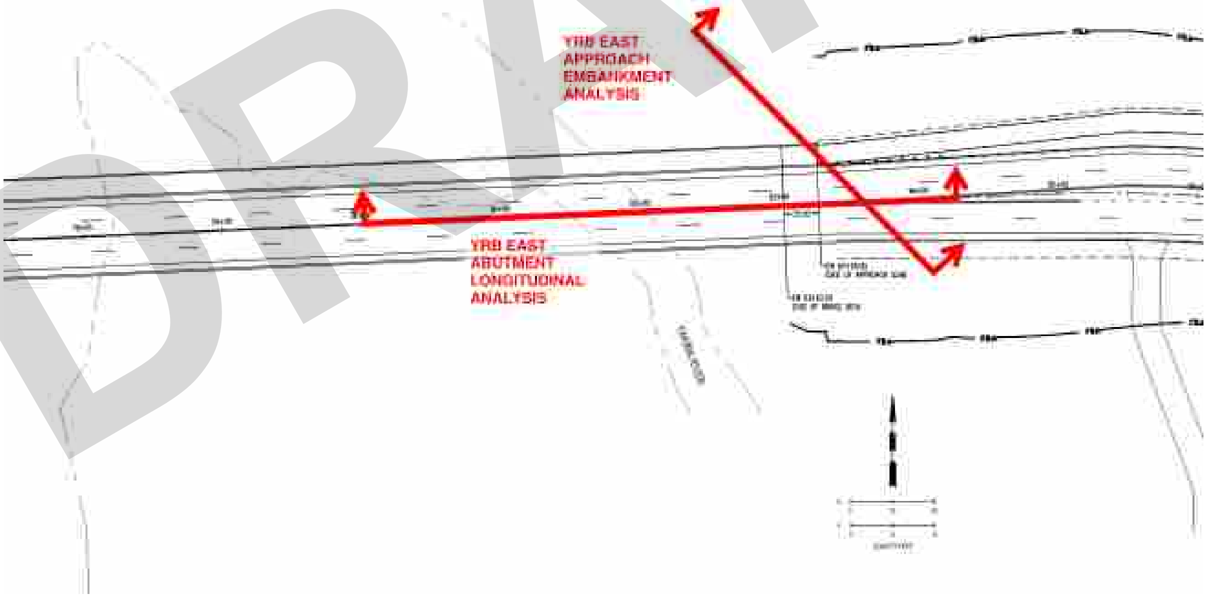


Exhibit F-1: Location of YRB East Abutment Global Stability Analyses

For the approach embankment analysis, we considered a skewed transverse analysis to account for the influence of river scour. Both abutment and approach embankment analyses assume post-scoured conditions for static and seismic conditions.

F.2.2 YRB West Abutment and Approach Embankment

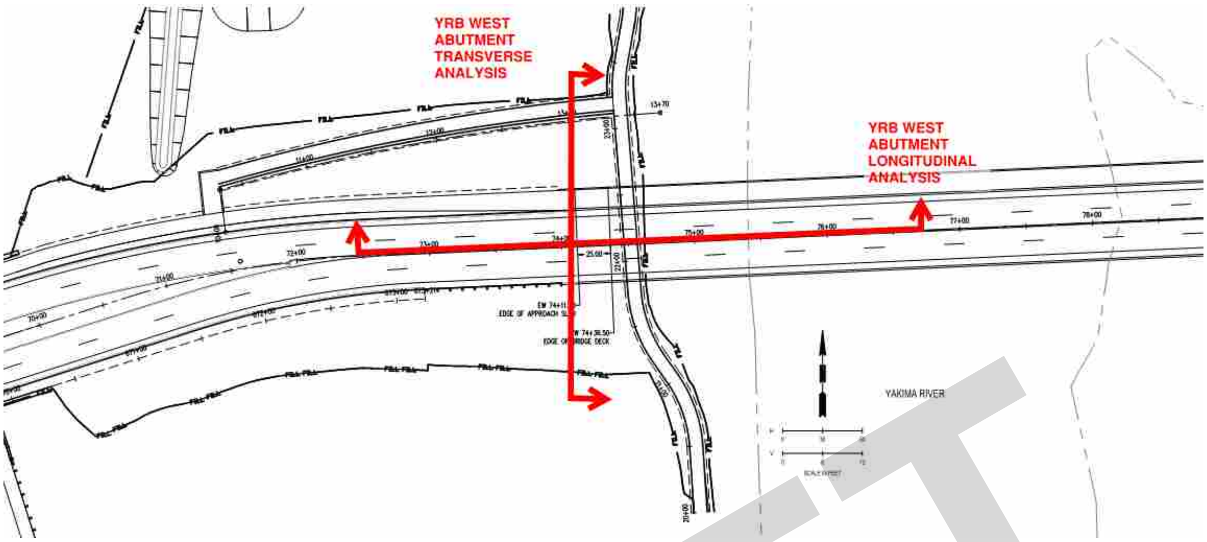


Exhibit F-2: Location of YRB West Abutment Global Stability Analyses

We evaluated global stability for the longitudinal (east-west) and transverse (north-south) directions at the proposed YRB west abutment. Locations of these analyses are indicated in Exhibit F-2. Figures F-5 through F-8 show our geometric assumptions for these analyses.

We assume the post-scour conditions for the longitudinal west abutment analysis. We did not consider scour for the west approach embankment (transverse) analysis due to the presence of the existing levee along the west bank of the Yakima River. See main text for more details on scour.

F.2.3 Fill Embankment West of I-82

We evaluated global stability in the transverse (north-south) direction of the proposed fill embankment west of I-82. The location of this analysis is shown in Exhibit F-3. Figures F-9 and F-10 show our geometric assumptions for this analysis.

This analysis is in an area formerly used as a municipal solid waste (MSW) and wood waste storage site. We understand the City of Yakima removed the MSW and wood waste within the CMP Project footprint. Based on preliminary plans, the City of Yakima had a 50-foot temporary easement outside of the CMP right-of-way and excavated into the MSW and wood waste material at a 2 Horizontal to 1 Vertical (2H:1V) cut slope (see Figures 9 and 10). Based on the City of Yakima preliminary plans, we understand the excavations were backfilled with material consistent with Washington State Department of Transportation (WSDOT) Common Borrow.

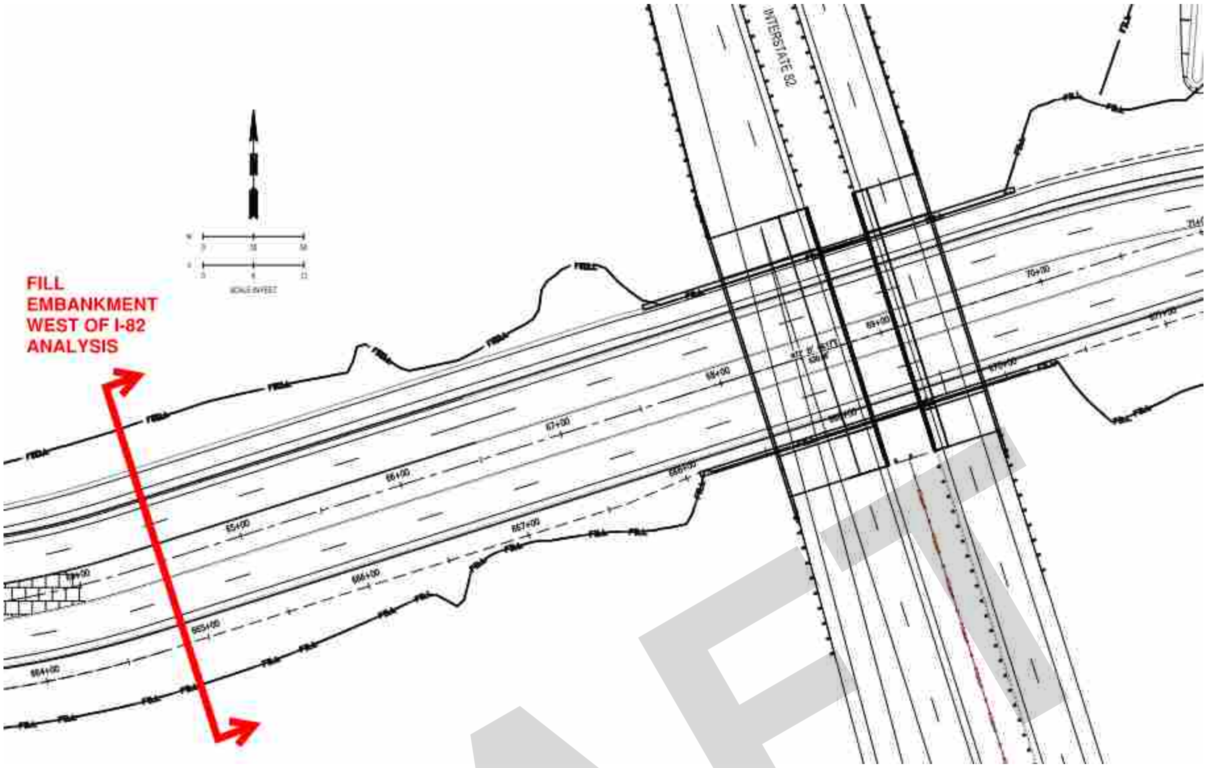


Exhibit F-3: Location of Fill Embankment West of I-82 Global Stability Analysis

F.3 REQUIREMENTS

The slope stability factor of safety (FS) is the ratio of forces resisting sliding to forces driving sliding. If the FS is less than 1.0, then the driving forces are greater than the resisting forces, and the slope is in a state of failure. If the FS is greater than 1.0, the resisting forces are greater than the driving forces, and the slope is in a stable state.

The WSDOT Geotechnical Design Manual (GDM) (WSDOT, 2022) requires the following minimum FS values:

- 1.3 for static loading of slopes adjacent to but not directly supporting structures,
- 1.5 for static loading of slopes directly supporting structures, and
- 1.1 for seismic and post-seismic loading of slopes adjacent to or supporting structures.

F.4 METHODOLOGY

F.4.1 Limit Equilibrium Analyses

We evaluated the slope stability FS using limit equilibrium analyses. Limit equilibrium analyses treat the slide mass as a rigid body, subdivide the mass into slices, and calculate the forces acting on each slice. We used the Morgenstern-Price limit equilibrium method (Morgenstern and Price, 1965), which:

- Includes both normal and shear interslice forces,
- Satisfies both moment and force equilibrium, and
- Allows for variable distributions of interslice forces.

We used the computer program SLOPE/W (GeoStudio International, 2021) to perform the Morgenstern-Price analyses. We used SLOPE/W to specify the potential limits of a slide mass and to calculate the FS of potential slip surfaces in the slide mass. The critical slip surface is the slip surface with the lowest FS.

For our static analyses, we included surcharge loads as specified in the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design Bridge Design Specifications (AASHTO, 2020).

In accordance with WSDOT (2022), we analyzed seismic slope stability using a pseudo-static approach. We modeled the earthquake loading by applying a horizontal seismic coefficient, k_h, of one-half the site peak ground acceleration (PGA). The horizontal seismic coefficient is less than the PGA because:

- The PGA occurs only once during an earthquake record, while k_h is applied as a static force;
- Wave scattering effects tend to reduce the acceleration in the slide mass; and
- The slide mass is allowed to displace a small amount.

F.4.2 Soil Parameters

We selected soil parameters for the model based on laboratory and field testing performed for I-82 and other projects, our experience, and judgment.

We estimated the soil parameters by reviewing:

- The generalized subsurface profiles (see main text Figures 3 through 5) and boring logs (see Appendices A and C), and
- The results of laboratory and field testing (see Appendices B and C).

Input properties for soil layers include unit weight, cohesion, and friction angle. The soil properties are shown in Figures F-1 through F-10 and are summarized in Table F-1.

Table F-1: Materials

Material Name	Color in Figures	Unit Weight (pcf)	Effective Stress Friction Angle (degrees)	Effective Stress Cohesion Intercept (psf)	Description / Note
Concrete Abutment	⬜	150	n/a	n/a	Cast-in-place concrete for YRB abutment stem wall and cap beam – assumed impenetrable in our analyses.
Embankment Fill	🟨	125	32	0	Proposed CMP Project embankment fill.
Wall Backfill	🟦	135	38	0	Proposed CMP Project gravel backfill for retaining walls.
MSW and/or Wood Waste	🟪	50	18	0	Assumed MSW and/or wood waste material west of the I-82 embankment not removed by the City of Yakima.
City Replacement Fill	🟧	125	32	0	Assumed fill material placed by City of Yakima in 2021 to replace MSW and Wood Waste material within CMP footprint west of I-82 embankment.
Loose Silty Gravel (GM) with Wood Waste	🟫	120	24	0	Assumed material containing abundant wood waste between the I-82 embankment and the Yakima River.
County Replacement Fill	🟩	125	32	0	Assumed fill material to be placed for the CMP Project to replace wood waste material within CMP footprint between the I-82 embankment and the Yakima River.
Riprap	⬛	115	45	0	Proposed launchable riprap blanket scour protection at YRB east abutment.

MSW = municipal solid waste; n/a = not applicable; pcf = pounds per cubic foot; psf = pounds per square foot

F.4.3 Design Loads

We applied a factored traffic surcharge of 250 pounds per square foot above abutments and embankments at the CMP roadway grade.

Surcharge loads associated with the bridge superstructure or live traffic loading are not included in our analyses because these loads will be resisted by the drilled shafts.

Drilled shaft foundations are shown our global stability output figures for reference purposes only. We did not account for the lateral resistance of the shafts in our global stability analyses.

F.5 ANALYSIS DETAILS AND RESULTS

Our global stability analyses are presented as Figures F-1 through F-10. As shown in the figures, we confirmed that the geometry of the selected cross sections will meet the WSDOT GDM FS criteria for both static and seismic conditions.

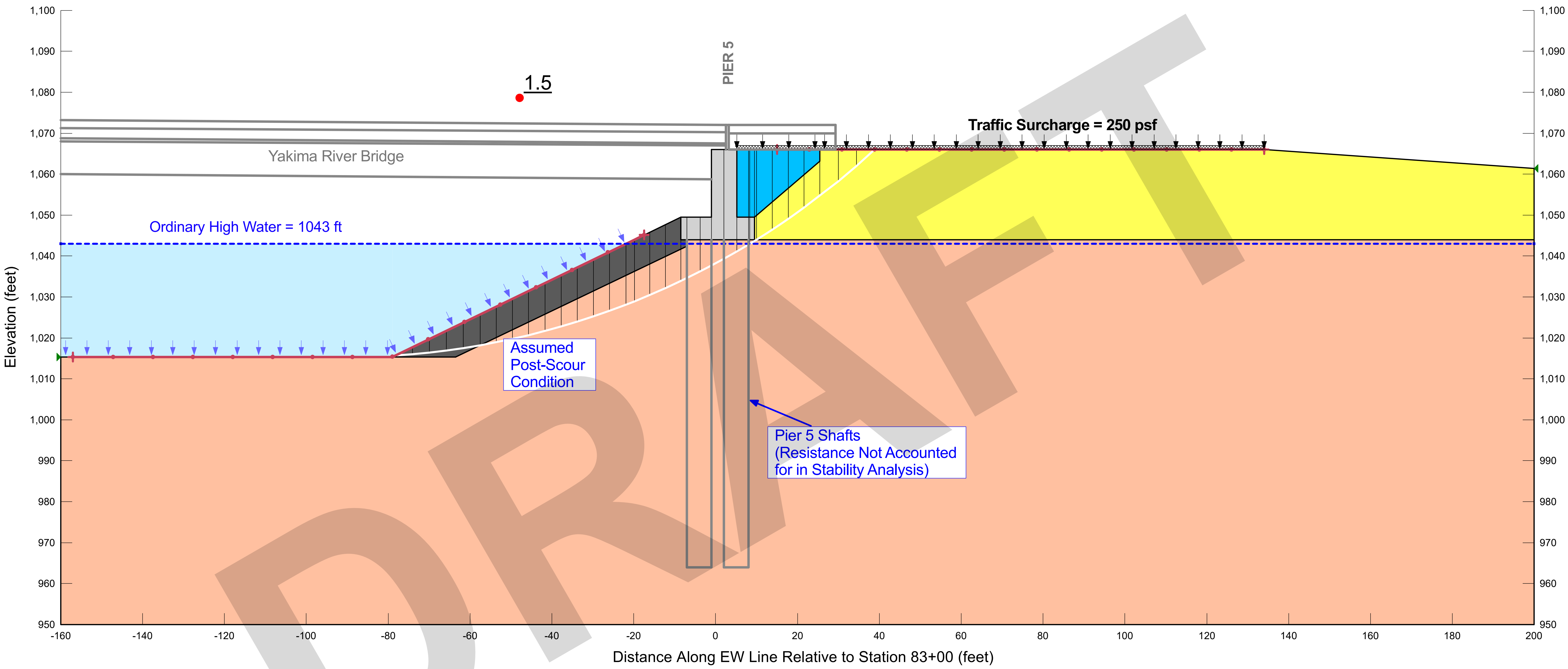
F.6 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 2020, AASHTO LRFD bridge design specifications (9th ed.): Washington, D.C., AASHTO, 2 v.

Geo-Slope International, 2021, SLOPE/W v. 2021.4: Calgary, Alberta, Geo-Slope International.

Morgenstern, N.R. and Price, V.E., 1965, The analysis of the stability of general slip surfaces: Geotechnique, v. 15. no. 1, p. 79-93.

Washington State Department of Transportation (WSDOT), 2022, Geotechnical design Manual: Olympia, Wash., WSDOT, Manual M 46-03, 1 v., February, available: https://www.wsdot.wa.gov/Publications/Manuals/M46-03.htm.



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
⬜	Concrete Abutment	150		
🟨	Embankment Fill	125	0	32
🟧	Quaternary Alluvium	140	0	40
⬛	Riprap	115	0	45
🟦	Wall Backfill	135	0	38

Cascade Mill Parkway Project
Yakima County, Washington

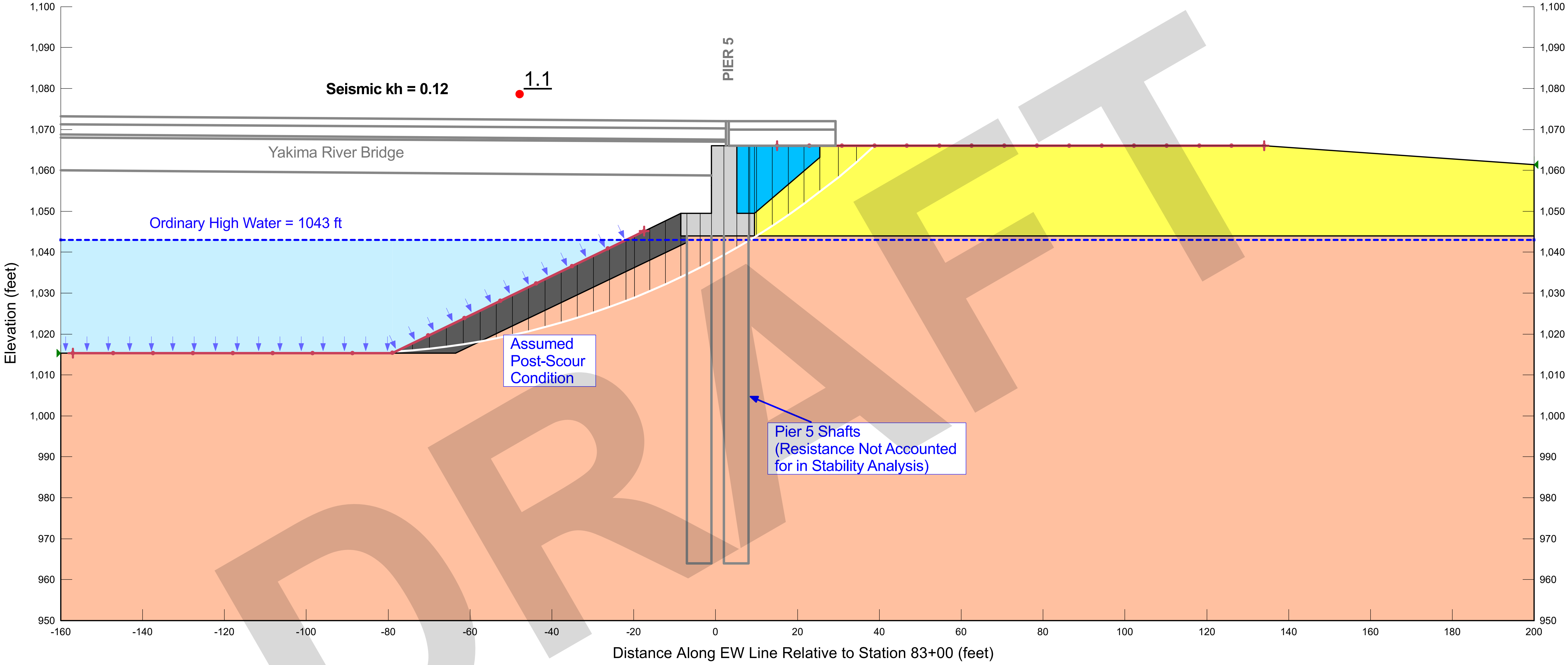
GLOBAL STABILITY ANALYSIS
YRB EAST ABUTMENT
STATIC CASE

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-1

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
⬜	Concrete Abutment	150		
🟨	Embankment Fill	125	0	32
🟧	Quaternary Alluvium	140	0	40
⬛	Riprap	115	0	45
🟦	Wall Backfill	135	0	38

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

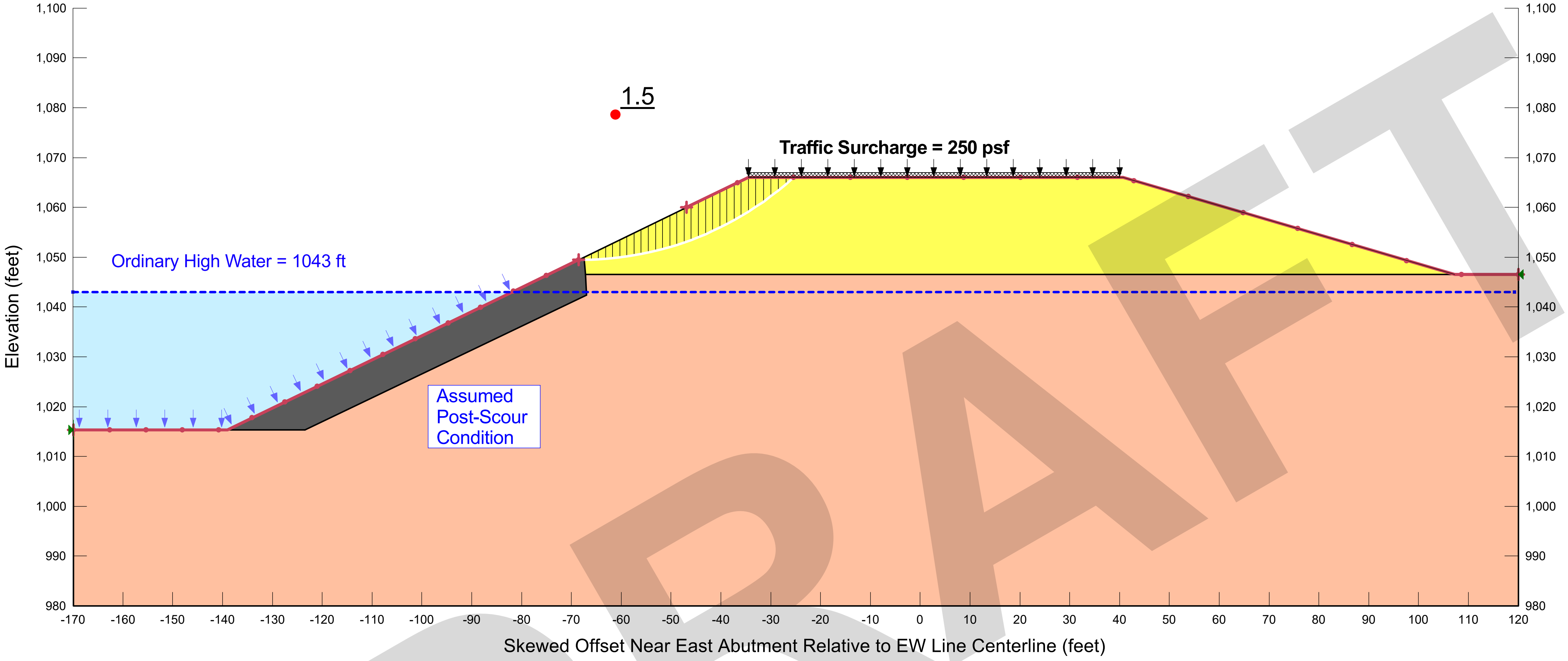
Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
YRB EAST ABUTMENT
SEISMIC CASE

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-2



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	Embankment Fill	125	0	32
🟧	Quaternary Alluvium	140	0	40
⬛	Riprap	115	0	45

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

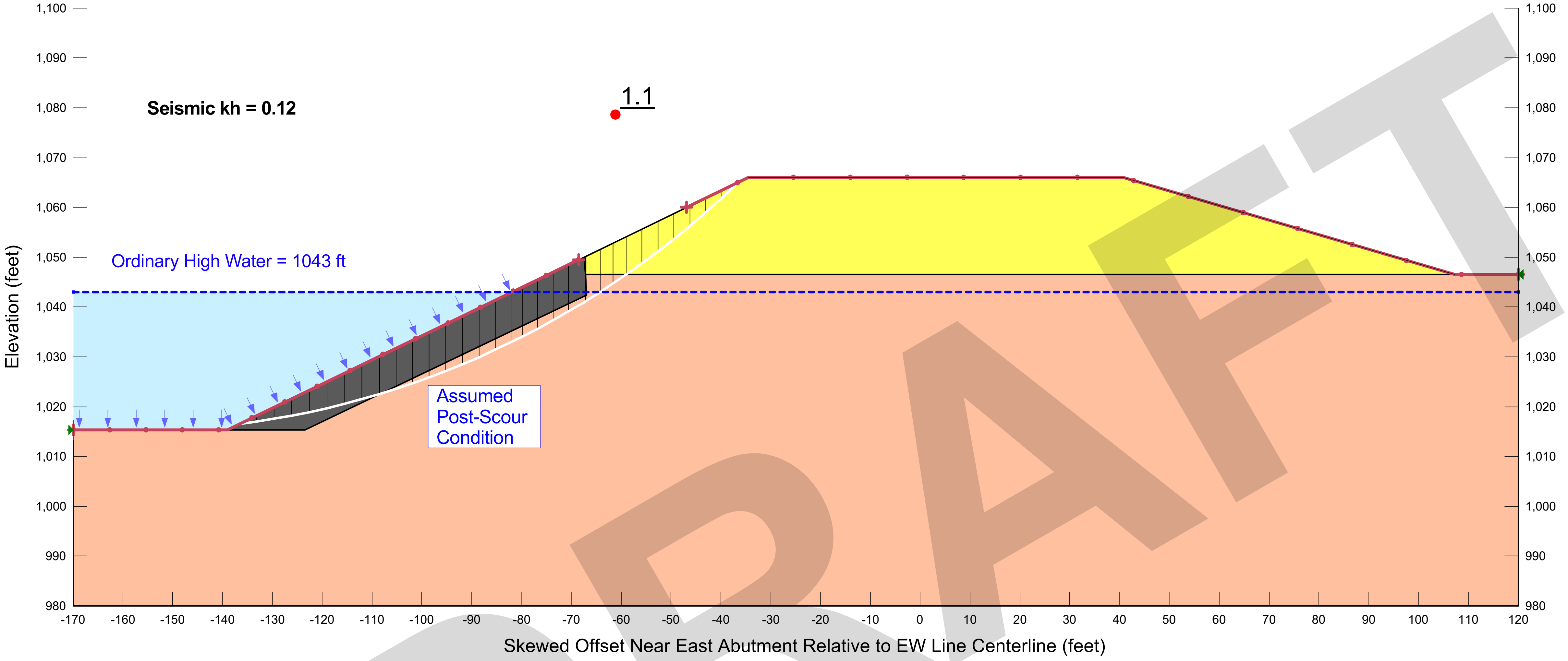
Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
YRB EAST APPROACH EMBANKMENT
STATIC CASE

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-3



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	Embankment Fill	125	0	32
🟧	Quaternary Alluvium	140	0	40
⬛	Riprap	115	0	45

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

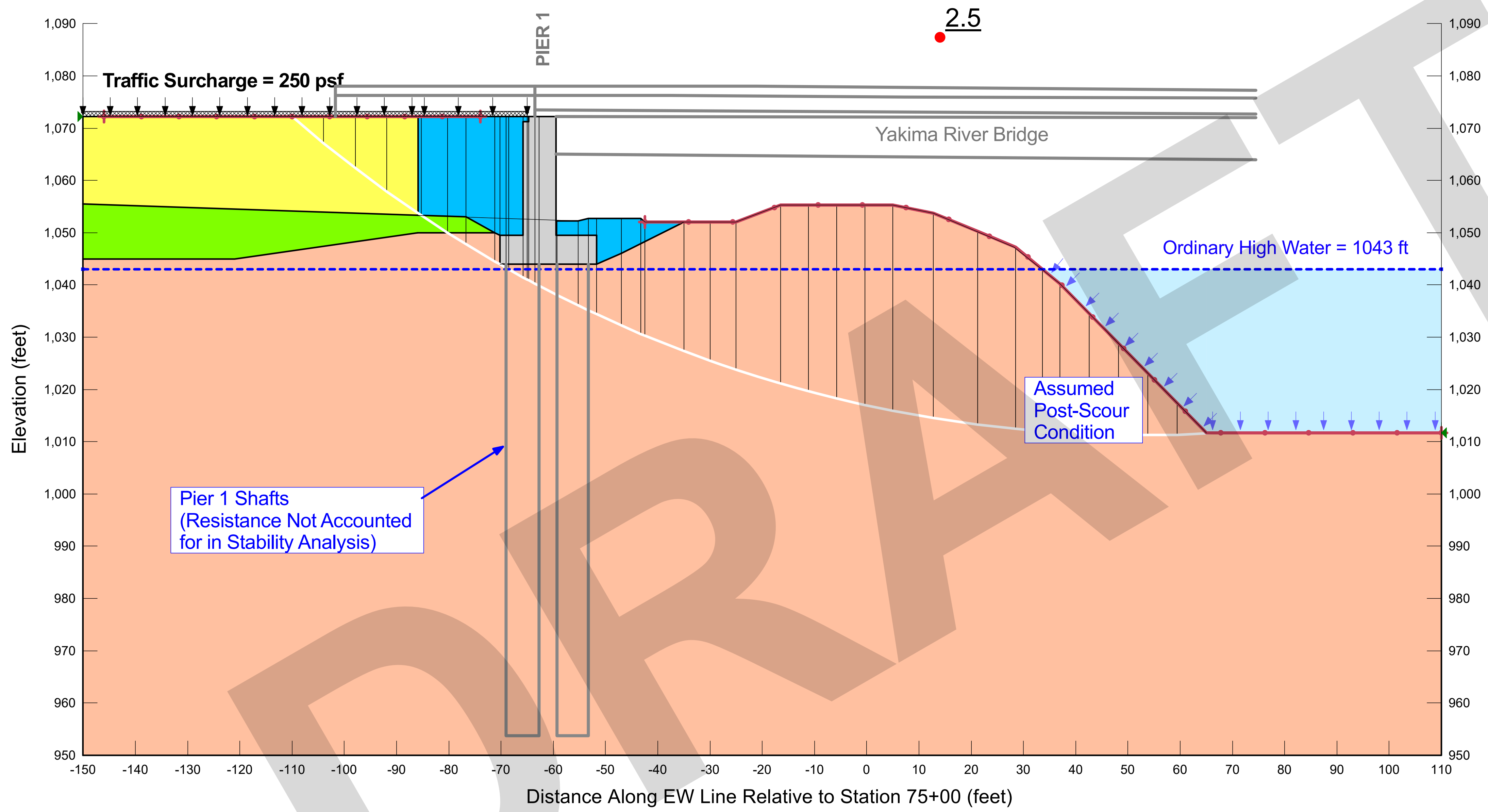
Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
YRB EAST APPROACH EMBANKMENT
SEISMIC CASE

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-4



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
⬜	Concrete Abutment	150		
🟩	County Replacement Fill	125	0	32
🟨	Embankment Fill	125	0	32
🟧	Quaternary Alluvium	140	0	40
🟦	Wall Backfill	135	0	38

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

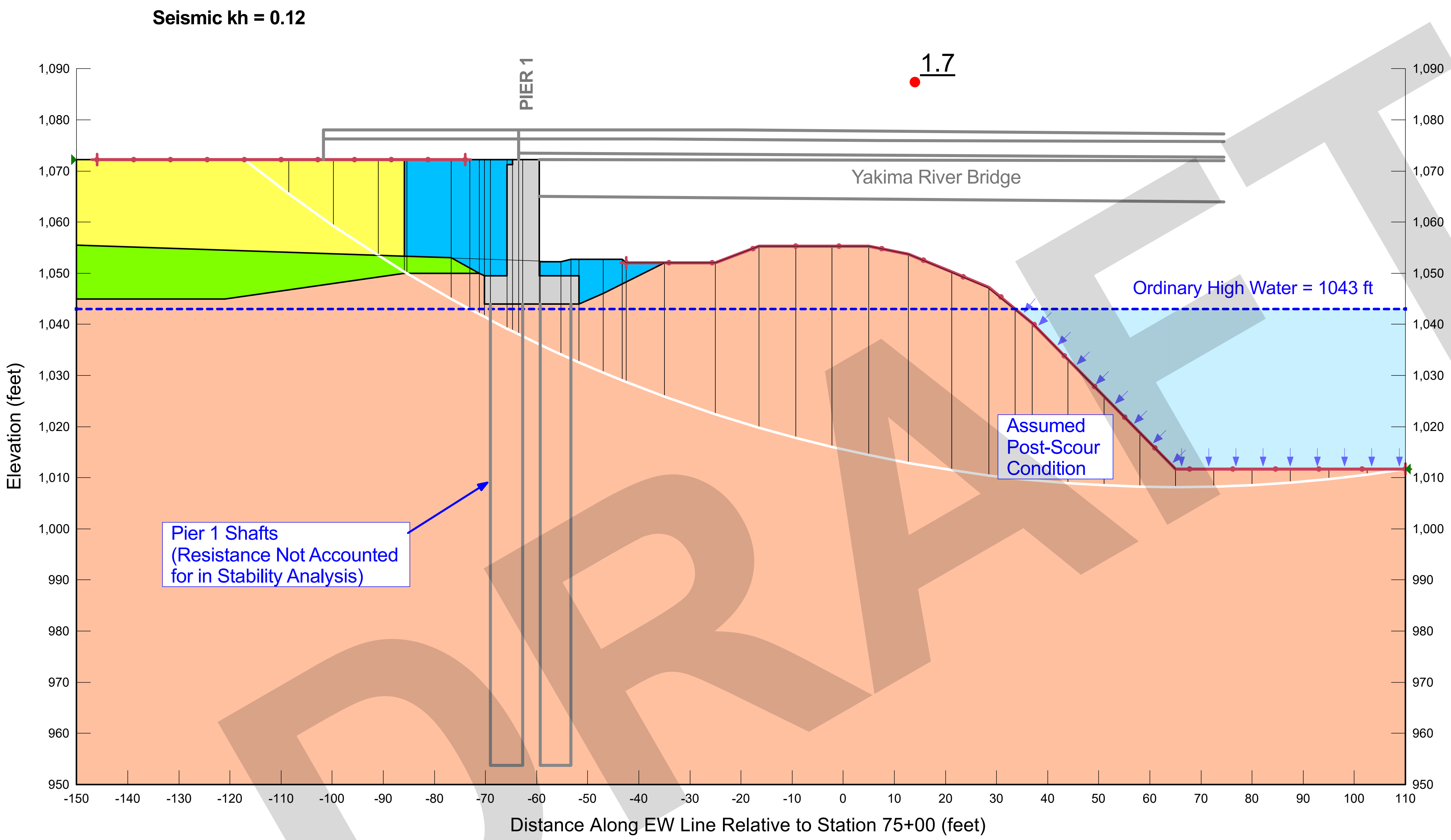
Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
YRB WEST ABUTMENT
STATIC CASE

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-5



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
⬜	Concrete Abutment	150		
🟩	County Replacement Fill	125	0	32
🟨	Embankment Fill	125	0	32
🟧	Quaternary Alluvium	140	0	40
🟦	Wall Backfill	135	0	38

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

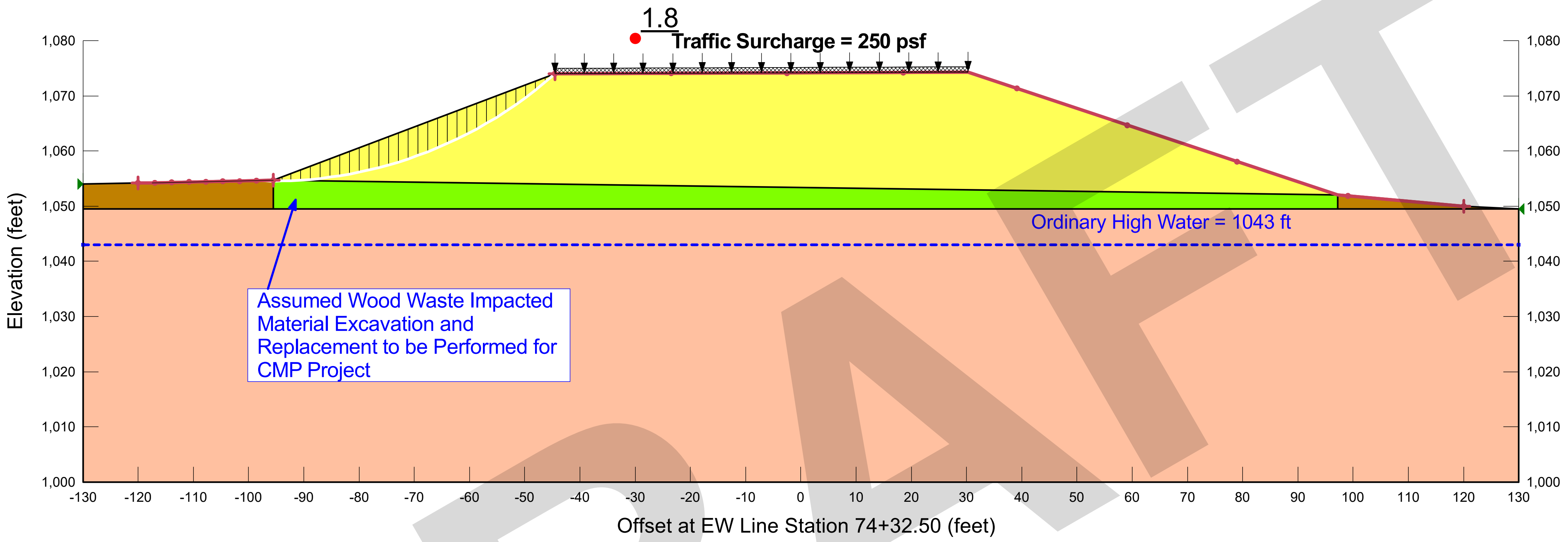
Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
YRB WEST ABUTMENT
SEISMIC CASE

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-6



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	County Replacement Fill	125	0	32
🟨	Embankment Fill	125	0	32
🟫	Loose GM with Wood Waste	120	0	24
🟧	Quaternary Alluvium	140	0	40

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

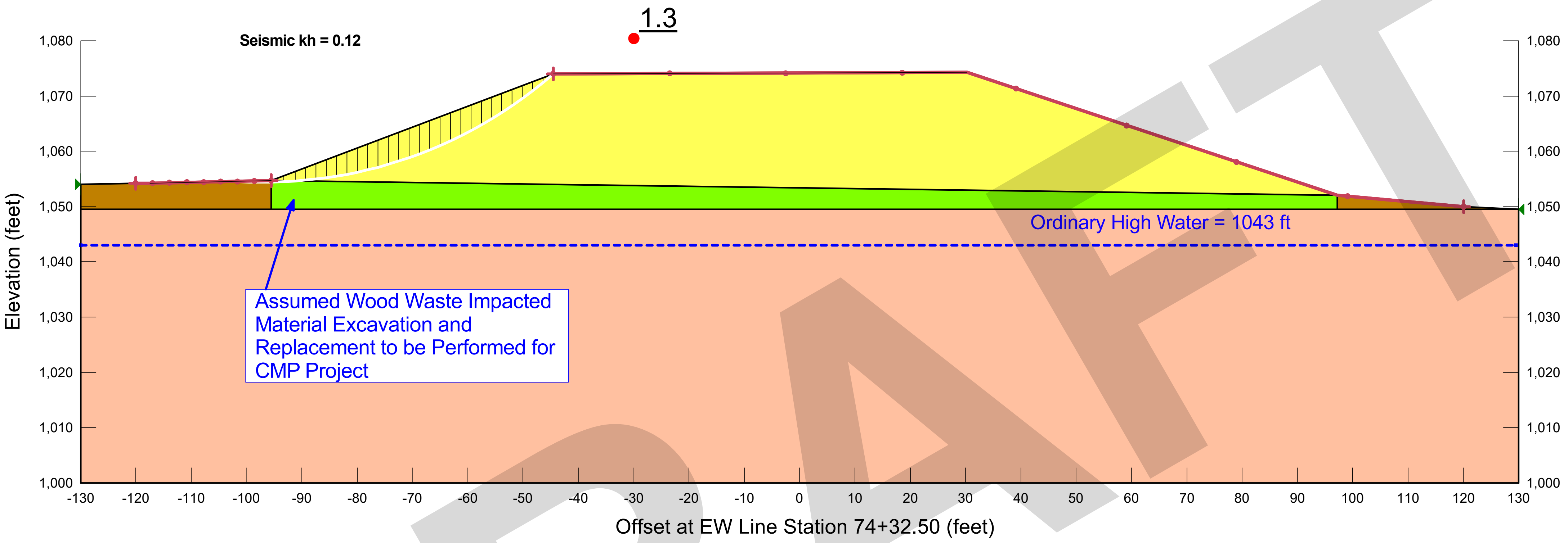
Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
YRB WEST APPROACH EMBANKMENT
STATIC CASE

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-7



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	County Replacement Fill	125	0	32
🟨	Embankment Fill	125	0	32
🟫	Loose GM with Wood Waste	120	0	24
🟧	Quaternary Alluvium	140	0	40

Cascade Mill Parkway Project
Yakima County, Washington

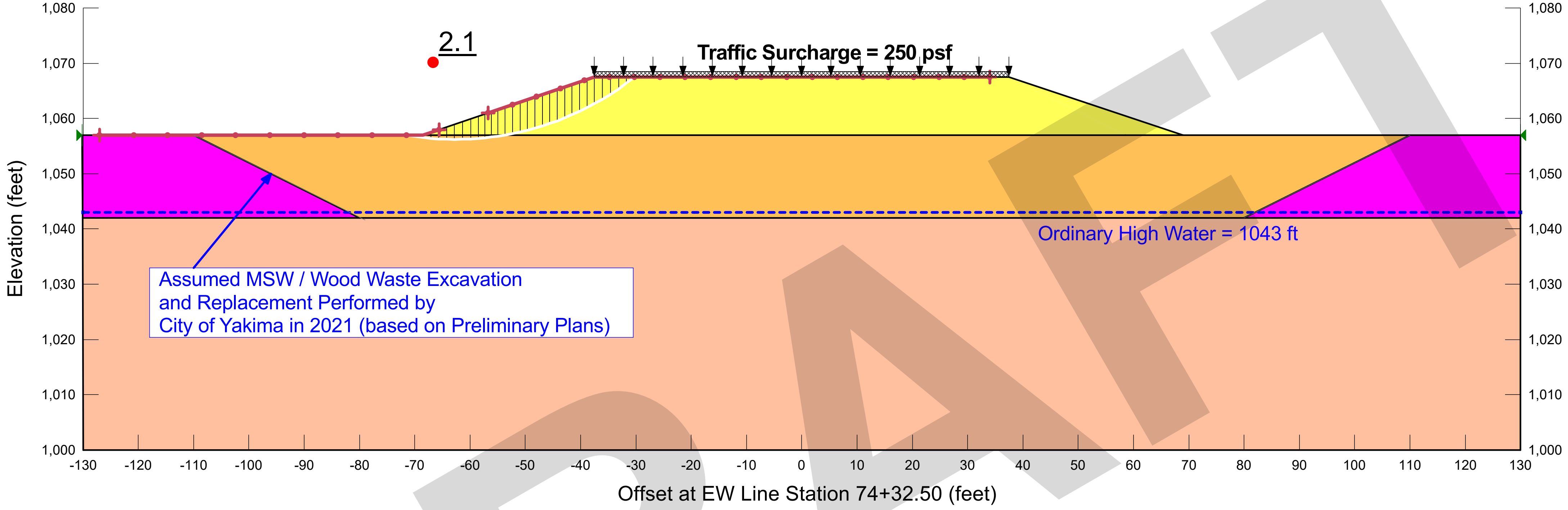
GLOBAL STABILITY ANALYSIS
YRB WEST APPROACH EMBANKMENT
SEISMIC CASE

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-8

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟧	City Replacement Fill	125	0	32
🟨	Embankment Fill	125	0	32
🟪	MSW and/or Wood Waste	50	0	18
🟧	Quaternary Alluvium	140	0	40

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

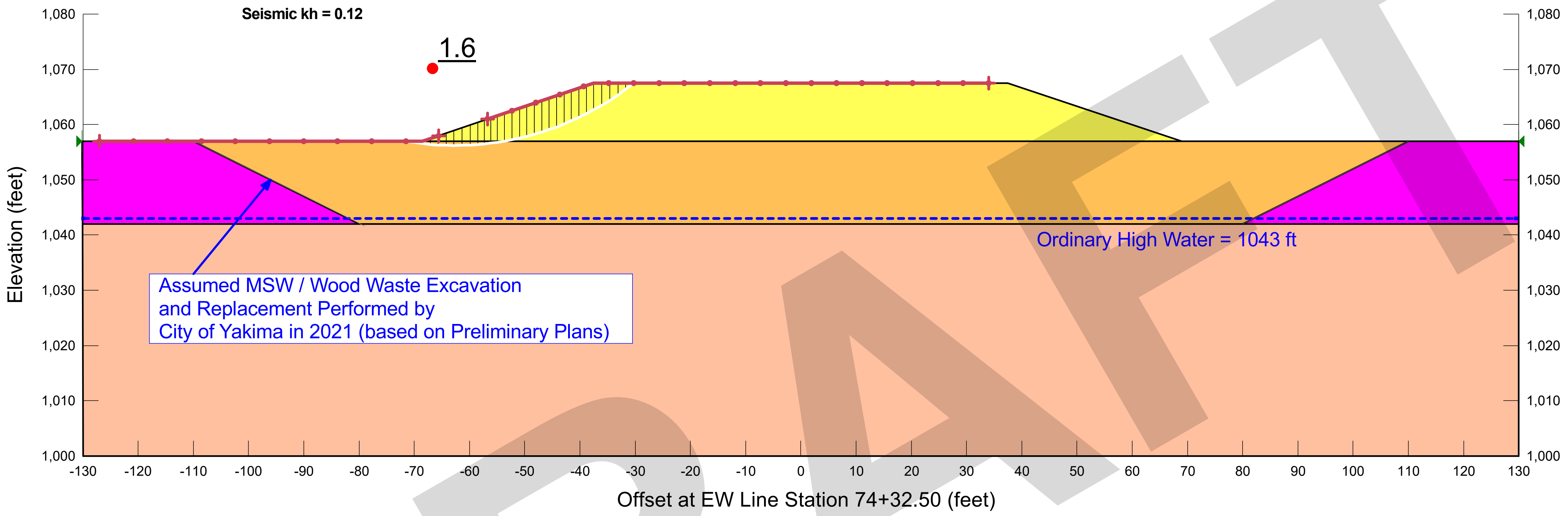
Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
FILL EMBANKMENT WEST OF I-82
STATIC CASE

September 2022 106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-9



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟧	City Replacement Fill	125	0	32
🟨	Embankment Fill	125	0	32
🟪	MSW and/or Wood Waste	50	0	18
🟫	Quaternary Alluvium	140	0	40

Cascade Mill Parkway Project
Yakima County, Washington

GLOBAL STABILITY ANALYSIS
FILL EMBANKMENT WEST OF I-82
SEISMIC CASE

September 2022
106384-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. F-10

Directory: P:\SEA\106000s\106384 Mill Parkway\-002 Geotech\GC-007_YRB Abutments Global Stability\

Important Information

About Your Geotechnical/Environmental Report

IMPORTANT INFORMATION

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