DRAFT GEOTECHNICAL REPORT
YAKAMA NATION NASON CREEK FLOODPLAIN
SR 207 REROUTE
CHELAN COUNTY, WASHINGTON

HWA Project No. 2022-144-21

August 22, 2023

Prepared for:

Yakama Nation

&

Perteet

HWA GEOSCIENCES INC.

August 22, 2023
HWA Project No. 2022-144-21

Perteet
2707 Colby Avenue, Suite 900
Everett, WA 98201

Attention: Jennifer Saugen P.E.

Subject: **DRAFT GEOTECHNICAL REPORT**
Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

Dear Ms. Saugen:

As requested, HWA GeoSciences Inc. (HWA) has completed a geotechnical engineering study for the proposed State Route (SR) 207 Reroute adjacent to the Nason Creek Floodplain in Chelan County, Washington. This report presents the results of our field explorations, laboratory testing, and geotechnical engineering analysis and recommendations.

We appreciate the opportunity to provide geotechnical services on this project. If you have any questions regarding this report or require additional information or services, please contact the undersigned at your convenience.

Sincerely,

HWA GEOSCIENCES INC.

Donald Huling, P.E.
Geotechnical Engineer, Principal

Mary Alice Benson, L.G.
Geologist

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SR 207 REROUTE
CHELAN COUNTY, WASHINGTON

1.0 INTRODUCTION

1.1 GENERAL

This report summarizes the results of a geotechnical engineering study performed by HWA GeoSciences Inc. (HWA) for the Yakama Nation Nason Creek Floodplain SR 207 Reroute project (Project) in Chelan County, Washington. The approximate location of the project site is shown on the Site and Vicinity Map, Figure 1, and on the Site and Exploration Plan, Figure 2. Our field work included drilling four (4) machine-drilled borings and advancing twelve (12) hand borings. Laboratory testing was conducted on selected soil samples to determine relevant engineering properties for the subsurface soils. The purpose of this study was to evaluate the soil and groundwater conditions along the proposed roadway alignment to provide geotechnical engineering recommendations for the proposed improvements.

1.2 PROJECT UNDERSTANDING

We understand the project will include rerouting SR 207 in the vicinity of milepost (MP) 0.15 to MP 1.00 (Nason Creek river mile 3.2 to 4.6) around the historic Nason Creek floodplain, south from the current alignment. The purpose of this project is to improve aquatic habitat conditions and protect roadway infrastructure. The Yakama Nation Upper Columbia Habitat Restoration Project and Washington State Department of Transportation have partnered for this project.

1.3 SITE DESCRIPTION

The Project area is located in, and adjacent to, the historic Nason Creek floodplain in Chelan County, Washington. It initiates approximately 0.15 miles northeast of the intersection of US 2 and SR 207, and extends 0.85 miles along SR 207 to MP 1.00. SR 207 trends roughly northeast/southwest within the Project area and bisecting the historic floodplain in a straight line. The existing roadway is constructed with hot mix asphalt on a fill berm ranging in height from about 4 to 10 feet, and consists of two 12.5-foot-wide lanes, one each northbound and southbound, with 6-foot-wide shoulders. The roadway has minimal slope.

The main channel of Nason Creek is located west of SR 207 and flows generally north to Lake Wenatchee. The creek channel is constrained by Nason Ridge to the west, a bedrock ridge generally consisting of Chumstick Formation sedimentary rock. The historic floodplain extends beyond SR 207 to the east and contains multiple historic overflow and/or abandoned Nason

Creek channels, visible in Figure 3. There are wetlands located at the north and south ends of the Project area associated with these overflow channels.

East of SR 207 and the historic floodplain the topography slopes up gently, with a grade ranging from 8% to 12%, to Rieche Road/USFS Road 6603, and beyond to the base of Natapoc Ridge, another bedrock ridge consisting of Chumstick Formation sedimentary bedrock. USFS Road 6603 is a closed, one-lane forest service road that generally parallels SR 207 within the Project area and is primarily unpaved. Discrete areas of hot mix asphalt pavement are visible on USFS Road 6603, indicating it was likely paved when originally constructed. The roadway slopes up gently from south to north until project station 325+00, where the slope becomes steep. The slope from SR 207 to the base of Natapoc Ridge is heavily vegetated with evergreen trees, vine maple and shrubs.

Within the Project area a Chelan County PUD 115 kV aboveground pole line extends from SR 207 to Rieche Road, then parallels USFS Road 6603 to the north. Near the north end of the Project area is a Bonneville Power Administration (BPA) transmission line corridor containing three extra high voltage transmission lines. These lines trend generally east/west, crossing Nason Creek and SR 207 on two sets of lattice towers. This corridor has been cleared of vegetation, apart from grass and scattered small shrubs.

2.0 FIELD INVESTIGATION

2.1 SUBSURFACE EXPLORATION

Our geotechnical exploration program included surface reconnaissance of the alignment, drilling four (4) machine-drilled borings and completion of twelve (12) shallow geotechnical hand borings over the course of two phases of work, as described below. The approximate locations of these borings are shown on the Site and Exploration plan, Figure 2. Logs for the borings are presented in Appendix A of this report.

> **Phase 1:** Phase 1 of our field exploration program consisted of drilling twelve shallow hand borings, designated HH-1 through HH-12. Borings were drilled approximately equidistance apart within the proposed reroute alignment to depths ranging from about 0.7 to 9.2 feet below ground surface (bgs). Dynamic cone penetrometer (DCP) data was collected at eleven (11) boring locations to depths ranging from about 5.4 to 12.4 feet bgs. No DCP data was collected at HH-9 due to remote location and heavy vegetation access issues that made transportation of DCP equipment prohibitively difficult. These explorations were conducted in support of investigation of subsurface soil and groundwater conditions on the proposed Project alignment. In addition, reconnaissance of the adjacent slopes and floodplain were conducted to better understand site geology, soil, and rock types present in the vicinity of the Project alignment. Phase 1 was

completed on May 16 through 18, 2023, by HWA geologists using hand operated drilling and sampling equipment.

For the handholes conducted in Phase 1, Dynamic Cone Penetrometer (DCP) testing was performed at most boring locations to assess subsurface soil and groundwater conditions. The DCP equipment consists of a steel extension shaft assembly, with a 60-degree hardened steel cone tip attached to one end, which is driven into the soil by means of a sliding drop hammer. The base diameter of the cone is 20 mm (0.79 inches). The diameter of the shaft is 8 mm (~0.315 inches) less than the cone, to reduce rod friction at shallow penetration depths. The DCP is driven by repeatedly dropping an 8-kg (~17.6-pound) sliding hammer from a fixed height of 575 mm (~22.6 inches). The depth of cone penetration is measured after each hammer drop and the in-situ shear strength of the soil is reported in terms of the DCP index. The index is based on the average penetration depth resulting from 1 blow of the 8-kg (17.6-pound) hammer and is reported as millimeters per blow (mm/blow). The data obtained from the DCP tests was then correlated to Standard Penetration Test (SPT) N-value (blows/foot), to evaluate the strength of the subgrade soils. The DCP data, converted to SPT N-value (blows/foot), is plotted on Figures A-6 through A-17 for the hand auger borings.

Phase 2: Phase 2 of our field exploration program consisted of drilling four machine-drilled borings, designated BH-1 through BH-4. Borings were drilled within the United States Forest Service (USFS) Road 6603 road prism to depths ranging from about 36 to 41½ feet bgs. Borings were conducted on USFS Road 6603 due to accessibility issues for the drill rig on the proposed Project alignment. Samples were collected at approximate 2½-foot intervals to 20 feet, then approximate 5-foot intervals to the termination depths of the borings. These explorations were conducted in support of investigation of subsurface soil and groundwater conditions in the vicinity of the proposed Project alignment. Phase 2 was performed on June 19 and June 26, 2023 by Holocene Drilling of Puyallup, Washington, under subcontract to HWA using a track-mounted Diedrich D-50 tracked drill rig. The machine-drilled boring logs are presented in Figures A-2 through A-5.

Standard Penetration Testing (SPT) was performed in each boring for phase 2 using a 2-inch outside diameter, split-spoon sampler driven by a 140-pound automatic hammer. During the test, a sample was obtained by driving the sampler 18 inches into the soil with the hammer free-falling 30 inches. The number of blows required for each 6 inches of sampler penetration was recorded. The N-value (or resistance in terms of blows per foot) is defined as the number of blows recorded to drive the sampler the final 12 inches. If a total of 50 blows was recorded within a single 6-inch interval, the test was terminated, and the blow count was recorded as 50 blows for the number of inches of penetration achieved. This resistance, or N-value, provides an indication of the relative density of granular soils and the relative consistency of cohesive soils.

Additionally, a larger 3-inch outside diameter, Modified California sampler was utilized at specific depths during Phase 2 exploration program in order to collect ring samples to conduct direct shear tests. The sample collected with this sampler (HWA-1, S-3) has blow counts that do not reflect standardized values as they utilized the larger Modified California sampler with the standard 140-lb hammer. These values have been adjusted in our analyses to reflect standard SPT N-value blow counts for the purpose of our design.

Two relatively undisturbed samples were obtained in Shelby tubes from two of the borings (BH-2, S-5 and BH-4, S-2) in order to collect samples for direct shear and consolidation testing. Sampling with a Shelby tube consists of pushing a 3-inch O.D., thin-walled steel tube (bolted to the bottom of the sampling rods) 30 inches into undisturbed soil below the bottom of the borehole using drill rig hydraulics. The sample tube is allowed to equilibrate for a few minutes before retrieval to promote adequate recovery. Due to the method of sample collection, no SPT-N values or correlating SPT-N values are available for these samples.

A geologist from HWA logged the explorations and recorded pertinent information, including sample depths, stratigraphy, soil engineering characteristics, and groundwater occurrence. Soil samples obtained from the explorations were classified in the field and representative portions were placed in plastic bags. These soil samples were then taken to our Bothell, Washington, laboratory for further examination and testing.

The stratigraphic contacts shown on the exploration logs represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific date and location reported and, therefore, are not necessarily representative of other locations and times.

2.2 LABORATORY TESTING

Laboratory tests were conducted on selected samples retrieved from our explorations to characterize relevant engineering and index parameters of the soils encountered at the site. The tests included visual classifications, determination of natural moisture contents, Atterberg Limits, hydrometer, grain size distributions, direct shear, and consolidation tests. All tests were conducted in the HWA laboratory in general accordance with appropriate American Society for Testing and Materials (ASTM) standards. A brief description of laboratory test methodology is presented in Appendix B. The test results are presented in Appendix B and displayed on the boring logs in Appendix A, as appropriate.

3.0 GEOLOGIC AND SUBSURFACE CONDITIONS

3.1 General Geology

According to the *Geologic Map of Chelan 30-Minute by 60-Minute Quadrangle, Washington* (Tabor et al., 1987), the project area is underlain by Quaternary alluvium (Qa). This unit is defined as poorly sorted cobbles, gravel and sand. The ridges that define the width of the Nason Creek floodplain consist of the Nahahum Canyon Member of the Eocene Chumstick Formation (Tcn). This unit is defined as micaceous laminated shales and sandstones. Qa was deposited by running water and/or overbank flow from Nason Creek. Tcn rocks are composed of clay, silt and sand grains that were deposited in as still water body, such as a lake, then subsequently lithified. In general, the Tcn unit is easily erodible. A portion of the geologic map is presented in Figure 4.

3.2 Subsurface Conditions

Our explorations encountered topsoil, fill, alluvium, and buried creek bed. In general, the alluvium was more fine-grained than the geologic map unit description indicates, and is likely a mix of colluvium eroded from the Tcn rock above, and overbank deposits from Nason Creek. The borings terminated in alluvium more similar to the map unit description, and are differentiated from the atypical alluvium deposits as being buried creek bed. the Units interpreted from the boring logs are described below.

- **Topsoil:** Topsoil was encountered in HH-1 through HH-6, HH-9, HH-10, and HH-12 from ground surface to depths ranging from about ¼ to 1½ feet bgs. In general, the topsoil consisted of loose to medium dense, clayey or silty sand with varying percentages of gravel and abundant organics and roots.

- **Fill:** Fill was encountered at the ground surface or below the topsoil in HH-11, and BH-1 through BH-4 extending to depths ranging from 2 to 5 feet bgs. In general, the fill consisted of medium dense or medium stiff, clayey sand or sandy clay. Fill soils were similar to native soils, and we expect they are reworked soils placed during construction of USFS Road 6603 (BH-1 through BH-4) or the BPA transmission line corridor (HH-11).

- **Alluvium:** Alluvium was encountered underlying the fill or topsoil in HH-1 through HH-11, and BH-1 through BH-4, extending to depths of up to35 bgs and to the termination depths of most of the borings. In general, the alluvium consisted of loose to medium dense, or medium stiff, silty sand, clayey sand, or sandy clay. Alluvium soils are emplaced by running water. The high fine-grained soil content implies that this unit is likely representative of overbank flood deposits of Nason Creek. The soils consist of sediment similar to what we observed in Chumstick Formation sedimentary rock upslope on Natapoc Ridge, and colluvium from this source is likely also present in this unit. Observed bedding implies that the main depositional environment is alluvial.

- **Buried Creek bed:** Buried creek bed was encountered underlying the topsoil or alluvium in BH-1 through BH-3 and HH-12, extending to the termination depths of the borings, when encountered. In general, the buried creek bed consisted of dense to very dense sand and gravel. Much of the sand observed in BH-1 through BH-3 was angular, and appeared to be disaggregated weathered gravel that had been broken apart during drilling and/or sampling. The sand and gravel in this unit would have also been emplaced by running water and is considered alluvium; however, HWA feels the emplacement conditions are different enough to warrant a separate unit. This soil would have been placed in an active-flowing channel, implying that the main Nason Creek channel has migrated from east to west over time, and the abandoned channel has since been buried in the overbank flood deposit alluvium described above. The gravel and sand minerology observed in this unit is primarily associated with metamorphic crystalline bedrock, present upstream and in surrounding areas, and is not similar to the observed Chumstick Formation sedimentary rocks upslope.

3.3 GROUNDWATER CONDITIONS

Groundwater was encountered in BH-1 through BH-3 at depths ranging from about 30 to 40 feet below ground surface, in the buried creek bed soil. The depth to groundwater increased from south to north with the increasing slope, and was generally encountered at about the same elevation as the main Nason Creek channel. Groundwater was also encountered in HH-12 at 0.6 feet bgs in the buried creek bed soils. HH-12 was advanced in the mapped wetlands at the north extent of the Project area, at approximately the same elevation as the main Nason Creek channel. Groundwater conditions can vary over time and distance, and what we encountered during our explorations might not be representative across the Project area. Contractors should be prepared to encounter varying groundwater conditions during construction and excavation.

3.4 SITE RECONNAISSANCE

Site conditions were observed on May 16 through 18, June 20, and June 26 by an HWA geologist or geotechnical engineer. Ground surface and slope observations were made within the Project area from SR 207 to the base of Natapoc Ridge to document geomorphology, vegetation patterns and conditions, soil exposures, and surface water. Site observations are broken up by zones based on similar conditions. Four zones were identified and designated Zone 1 through Zone 4. Zone extents are shown on the Site and Exploration Plan, Figure 2.

3.4.1 Zone 1 (STA. 305+00 to 315+00)

Zone 1 extends from project stationing STA. 305+00 to 315+00, and contains explorations HH-1 through HH-3. The proposed new SR 207 alignment begins at STA. 305+00, and crossed a small wetland area that is part of the historic Nason Creek floodplain. The wetland area is at the base of a steep slope that is about 10 feet tall. No signs of slope instability were noted during our site reconnaissance, but the wetland was heavily vegetated with trees and shrubs that limited visibility. Zone 1 slopes up gently to the east with an average aspect ratio of 30Horizontal:1Vertical (30H:1V), but localized areas with steeper or more shallow aspect ratios are possible. We noted no signs of slope instability in Zone 1.

Zone 1 contains a cleared Chelan County PUD utility corridor containing the 115kV line mentioned above. The corridor extends from the edge of the wetland and parallels SR 207 to STA. 310, then defines the north Zone 1 boundary to USFS Road 6603. Outside this corridor, the remaining area within Zone 1 is heavily forested with evergreens and vine maple.

3.4.2 Zone 2 (STA. 315+00 to 325+50)

Zone 2 extends from STA. 315+00 to 325+50 and contains HH-4 though HH-7 and BH-1 through BH-4. This zone contains a large portion of the historic floodplain located east of SR 207, and a portion of the USFS Road 6603 alignment.

The historic floodplain is located at approximately the same elevation as the main Nason Creek Channel, and historic and/or abandoned channels can be seen in Figure 3. There is a steepened slope separating the historic floodplain from the higher-elevation area where the proposed realignment would be located. This steepened slope is the creek bank from when the channels contained flowing water, and was difficult to observe due to heavy tree, vine maple, and brush undergrowth, but we did not note any visible signs of slope instability at the time of our site visits. A portion of the historic floodplain is not vegetated and can be seen in Figure 2, which we identified as a sand and gravel creek bed. This creek bed was dry during our reconnaissance, but the ditch on the east edge of SR 207 contained a significant amount of water and was difficult to cross. According to the Washington State Department of Ecology records for the Nason Creek stream gage station 45J070, located downstream near the Nason Creek mouth, the Nason Creek stage was approximately 4.64 feet during our May site visit, and water levels in the creek during May were the highest recorded for the 2022 water year to date. In comparison, the stage during our June visits was approximately 1.5 feet. No flood stage has been established for Nason Creek, but based on the lack of vegetation we anticipate that during times of high flow the dry creek bed could contain water.

As described above, USFS Road 6603 was primarily an unpaved dirt road, with discrete areas where asphalt pavement was still in place. The road is in relatively decent condition considering the fact that is closed, and likely gets minimal maintenance. There were no signs of settlement, and minimal rutting. Multiple large potholes have formed, the largest of which was approximately 10 feet by 10 feet, and 1-foot deep. Water that collected in these potholes was slow to drain, and we observed that potholes would remain nearly full up to a day after rain, implying that the infiltration rate in the subgrade soil is low in the Project area.

The slope east of USFS Road 6603 slopes gently up to Natapoc Ridge, with an average aspect ratio of 7.5H:1V, and is heavily vegetated with evergreen trees, vine maple, and brush undergrowth. Observations of the ground surface were difficult to make under these conditions, but in general surface conditions were uneven and the ground surface undulated. It is possible the uneven surface is due in part to prehistoric mass wasting deposits and colluvium sourced from the Chumstick Formation sedimentary rock off Natapoc Ridge, but we noted no signs of current slope instability or failure.

3.4.3 Zone 3 (STA. 325+50 to 335+00)

Zone 3 extends from STA. 325+50 to 335+00 and contains HH-8 though HH-10. This zone contains little historic floodplain, and primarily consists of a gentle, heavily vegetated slope with an average aspect ratio of 10.5H:1V. No concerns were noted in this zone.

3.4.4 Zone 4 (STA. 335+00 to 340+50)

Zone 4 extends from STA. 335+00 to 340+50 and contains HH-11 and HH-12. This zone contains the BPA transmission line corridor and a portion of a mapped wetland. Adjacent to the north is a large section of historic floodplain, located at approximately the same elevation as the main Nason Creek channel. Surface water was observed near HH-12 during our investigation. Our Google Earth imagery search indicates that there is often surface water in the channels of the historic flood plain to the north, with water transferring from the main Nason Creek Channel through a culvert, located under SR 207 at approximately STA. 345+00, into the historic floodplain channels east of SR 207.

The BPA transmission line corridor extends from SR 207 to the top of Natapoc Ridge. It is an approximately 200-foot-wide linear cleared path vegetated with grass and small shrubs. The average aspect ration is 10H:1V. On the north edge of the transmission line corridor there is a narrow band of trees, then a steep drop down to the historic floodplain and wetland, which can be seen in Figure 3. Where the proposed new alignment is planned to rejoin the current SR 207 ROW there is an approximately 14-foot-tall, exposed soil slope with an average aspect ratio of 4H:1V. This soil appeared to be similar to the alluvium encountered in our explorations and was easily excavated. Approximately 600 feet east of SR 207 there is a large arcuate feature with an average aspect ration of 0.6H:1V that spans across most of the cleared corridor. We interpret these steep slopes to the north to be creek banks related to previously active Nason Creek channels observed in the historic floodplain in Figure 3. We did not observe signs of slope instability during our site reconnaissance; however, our observations imply that these soils are easily erodible, and could present issues during and after construction if left unmitigated.

4.0 CONCLUSIONS & RECOMMENDATIONS

4.1 GENERAL

Our subsurface exploration and site reconnaissance indicate that construction of the proposed realignment of SR 207 is feasible. However, the presence of soft to medium stiff alluvial soils, along the proposed alignment, will need to be considered during design and construction of the proposed improvements.

The fine-grained alluvial soils are expected to be compressible under the application of load. We expect that consolidation settlements will occur in areas where fill is placed to construct the new roadway. The settlements are expected to be differential in nature and range from zero to 21 inches of primary consolidation. We recommend that the design team consider a wide range of settlement mitigation measures ranging from doing nothing and accepting the anticipated settlement, preloading the areas to be filled, or the use of light weight fill.

Assuming the proposed cut and fill slopes are constructed at a maximum slope of 4H :1V (Horizontal l: Vertical), our stability analysis indicates that the proposed roadway embankment will be stable under static and pseudo-static loading conditions.

Due to the depth of the groundwater table and the consistency of the subsurface soils, we expect the potential for liquefaction of the subsurface soils to be low.

The near surface soils along the alignment consist of fine-grained alluvium that possess low infiltration capacity. Preliminary grain size screening suggests that the alluvial soils will likely possess a long-term design infiltration rate of 0.2 in/hr. Given the sloping nature of the site and the low expected infiltration rate, we expect that the use of onsite infiltration could result in increased erosion. If possible, we recommend that other means of stormwater management be considered.

4.2 SEISMIC DESIGN CONSIDERATIONS

4.2.1 Seismic Design Parameters

Earthquake loading for the project was developed in accordance with the General Procedure provided in Section 3.10 of the *AASHTO Guide Specifications for LRFD Seismic Bridge Design*, 9th Edition, 2020. For seismic analysis, the Site Class is required to be established and is determined based on the average soil properties in the upper 100 feet below the ground surface. Based on our subsurface explorations and understanding of site geology, it is our opinion that the site is underlain by soils that are consistent with Site Class D. The mapped seismic design coefficients for the design level event, which has a probability of exceedance of 7 percent in 75 years (equal to an approximate return period of approximately 1033 years), were obtained using the USGS Unified Hazard Tool to incorporate the probabilistic seismic hazard parameters from the 2014 updates to the National Hazard Maps (Peterson, et al., 2014). The recommended seismic coefficients for the design event are provided in Table 1. Site Coefficients were obtained from Tables 3.10.3.2-1 through 3.10.3.2-3 (AASHTO, 2020).

Table 1. AASHTO Guide Specifications calculated by USGS Seismic Hazard Map

Site Class	Peak Horizontal Bedrock Acceleration PBA, (g)	Spectral Bedrock Acceleration at 0.2 sec S_s, (g)	Spectral Bedrock Acceleration at 1.0 sec S_1, (g)	Site Coefficients			Peak Horizontal Acceleration PGA (A_s), (g)
				F_{pga}	F_a	F_v	
D	0.1782	0.3996	0.1179	1.44	1.3	2.33	0.257

Based on the above parameters the Peak Ground Acceleration, PGA (As) for Site Class D at the site is 0.257 g. Based on the parameters calculated and shown in Table 1 the AASHTO Seismic Performance Zone for the site is 2.

4.2.2 Liquefaction

Liquefaction is a temporary loss of soil shear strength due to earthquake shaking. Loose, saturated cohesionless soils are susceptible to earthquake-induced liquefaction; however, recent experience and research has shown that certain silts and low-plasticity clays are also susceptible. Primary factors controlling the development of liquefaction include the intensity and duration of strong ground motions, the characteristics of subsurface soils, in-situ stress conditions and the depth to groundwater.

Our explorations suggest that the water table across the site is suppressed within the very dense buried stream bed deposits underlying the project alignment. Due to the very dense nature of these soils, we expect the potential for liquefaction to occur along the project alignment to be low.

4.3 Slope Stability Analysis

HWA performed global slope stability analysis along geologic profiles A-A’ and B-B’, assuming the proposed roadway geometry. Geologic profile A-A’ is considered to be the critical profile with respect to analyzing the stability of the proposed fill embankment. Geologic profile B-B’ is considered to be the critical profile with respect to analyzing the stability of the proposed cut geometry. The location and orientation of these profiles can be seen on Figure 2, the Site and Exploration Plan. Global slope stability was analyzed under static loading and pseudo-static earthquake loading. Soil strength parameters and ground water conditions for this analysis were assumed based on field exploration observations and laboratory test results.

Limit equilibrium analyses were performed using the computer program SLIDE 5.0. Global factors of safety with respect to potential deep-seated failure surfaces were determined under the two load cases. The factor of safety computed is the ratio of the summation of the driving forces to the summation of the resisting forces. Where the factor of safety is less than 1.0, instability is predicted. For global slope stability design, minimum acceptable factors of safety under static loading conditions are commonly taken as 1.3 for slopes not supporting structures or walls. The minimum acceptable factors of safety for the pseudo-static loading is 1.1.

4.3.1 Static Loading Condition

The proposed roadway embankment geometries at the locations of Geologic Profiles A-A' and B-B' were found to be stable under the static loading condition with factor of safety significantly greater than 1.5. Therefore, static slope instability is not expected under the cut and fill geometries proposed along the alignment.

4.3.2 Pseudo-Static Stability

Seismic stability along the proposed alignment was evaluated using a pseudo-static horizontal acceleration of 0.129g, which is ½ of the peak ground acceleration (PGA) associated with the 1,033-year design earthquake for the project location. From our analyses, we conclude that, under the design earthquake, a factor of safety for global stability greater than 1.1 exists at the locations of both Geologic Profiles A-A' and B-B'. Therefore, slope instability is not expected to occur along the proposed cut and fill geometries as a result of the design earthquake.

4.4 Consolidation Settlement Analysis

The project alignment is underlain by fine-grained alluvial deposits. This soil is considered compressible and may undergo consolidation settlement as a result of the proposed roadway construction. Consolidation settlement results from the application of static loading on compressible soil deposits that have not previously experienced similar loading conditions. Consolidation settlement occurs as both primary consolidation (short term consolidation) and secondary consolidation (long term consolidation). Both mechanisms are described below.

Primary consolidation initiates immediately upon the application of load and is a result of pore water being expelled from the void space within the soil unit. As load is applied, the pore water pressure increases within the soil unit and slowly decreases as the pore water is expelled from the soil. As this process continues the void space is reduced and the volume of the soil deposit decreases. This decrease in the volume results in a reduction in the thickness of the soil unit which manifests as settlement at the ground surface. The magnitude of primary consolidation is dependent on the geometry of the compressible soil unit, with respect to the applied load, and the compressibility properties of the soils.

Secondary compression is a settlement phenomenon that occurs in soil deposits after completion of the primary consolidation stage and can continue for many years. The magnitude of the secondary compression settlement is difficult to predict but is typically a small fraction (5 to 10%) of the settlement that occurs as primary consolidation for most mineral soils.

Based on a review of preliminary plans, provided by Perteet, we expect that grade increases and embankment fill placement is proposed between proposed roadway Station 318+00 and 326+50. Placement of this embankment fill is expected to load the underlying soils and induce consolidation settlements. HWA has conducted preliminary settlement evaluations along this portion of the proposed roadway. Our evaluations were completed using the computer software Settle3D. Embankment geometry was assumed based on the preliminary layout provided by Perteet and consolidation parameters for the alluvial soils were identified from laboratory testing conducted on relatively undisturbed samples collected during our Phase 2 exploration program. Our settlement analysis indicated that construction of the proposed roadway embankment, between Station 318+00 and 326+50, could result in between 3 and 21 inches of primary consolidation within the alluvial soils. We expect that long term secondary consolidation could result in an additional 1-2 inches of settlement over the design life of the roadway. Preliminary estimates of anticipated primary settlements along the proposed fill area are provided in Figure 6.

As can be seen in Figure 6, substantial and differential primary consolidation settlements are expected to result from construction of the proposed roadway. These settlements are expected to be largest between Stations 322+00 and 326+50. Anticipated settlement should be considered as the design of the proposed realignment progresses. Possibly implementing settlement mitigation measures should be considered to achieve the desired long-term performance of the roadway.

4.5 POTENTIAL SETTLEMENT MITIGATION OPTIONS

There are several settlement mitigation measures that are commonly used to reduce or eliminate potential settlements along new roadways. These mitigation options include do nothing, over-excavation and replacement, preloading, and placement of lightweight fill. A description of each of these possible options is provided below.

- **Do Nothing:** Yakama Nation could choose to reconstruct the roadway without addressing the subsurface conditions. With this option, the proposed roadway, between Station 318+00 and 326+50, would be expected to undergo significant differential settlements. We expect these differential settlements would result in localized sags in the roadway vertical alignment and variable pavement distress. Doing nothing is a viable option if the anticipated embankment and pavement distress is determined to be acceptable.

- **Over-Excavation and Replacement:** Over excavation of compressible soils and replacement with compacted structural fill is a mitigation measure often implemented to eliminate the potential of future settlements along new roadways. This may be a viable option in areas of localized wetland crossings, where the depth of required excavation is minimal. However, subsurface investigations indicate that the base of the compressible alluvium, in the vicinity of the largest fill embankments, is approximately 30 feet below ground surface. Therefore, over-excavation and replacement would require very deep excavations that would require significant shoring. Due to the anticipated cost of over-excavation and replacement, we do not believe that it is a viable settlement and slope stability mitigation option for the project.

- **Preloading:** Preloading is often a viable way to reduce future settlements. Preloading involves placing a specified amount of soil or weight over a given area and allowing the weight to consolidate the underlying compressible or weak soils prior to construction of the proposed improvements. Preloading has been used successfully on similar projects in the past. However, the viability of preloading requires time. We would expect the underlying soils to take between 8 months and 1 year to consolidate sufficiently to sufficiently reduce future settlements. Preloading would be a viable option to reduce anticipated settlements if the project construction schedule has sufficient time available to allow for the preload to be in place.

- **Lightweight Backfill:** Lightweight material could be used to reduce the load on the underlying compressible soils, reducing anticipated future settlements. This would be achieved by excavating existing soils and replacing them with lightweight materials. The depth of excavation would depend on the type of lightweight materials. The use of lightweight materials would need to extend across the entire roadway.

  Several lightweight fill materials are available and have been used on past projects with success. These materials include Geofoam, bottom ash, volcanic rock, glass cutlet and lightweight cellular concrete. Geofoam consists of proprietary lightweight Styrofoam blocks that are readily available to contractors and have been used successfully on numerous road projects. Some drawbacks in transportation related applications are that Geofoam blocks require encapsulation with a gasoline resistant geomembrane and they have densities significantly lighter than water and thus hydrostatic uplift pressures would need to be considered if groundwater levels are able to rise above the base of the geofoam blocks. Bottom Ash is a byproduct of coal fired power plants and weighs between 45 and 75 pounds per cubic foot. Bottom ash has been used on several road projects but is becoming hard to obtain. Volcanic rock has been used as lightweight fill in the past. Volcanic rock generally weighs approximately 45 to 60 pounds per cubic foot. However, there are no readily available sources of volcanic rock in Washington State. Therefore, the cost associated with importing the material would be prohibitive for this project. Lastly, lightweight cellular concrete could be used for this project.

Lightweight cellular concrete is a proprietary product that can be manufactured onsite to a wide range of unit weights (36 to 120 pcf) and compressive strengths to match project requirements. Cellular concrete is widely available in Washington State and has been used successfully on road projects. Cellular concrete can be excavated for future utility crossings if needed.

Lightweight fill could be designed to reduce anticipated future settlements; however, the use of lightweight fill will not be able to fully eliminate anticipated future settlements.

Given the soil geometry and location of the project site, most of the above-described mitigation options present significant challenges that make them less favorable for this project. If settlement mitigation methods are to be implemented, we recommend the use of preloading or light weigh fill be considered. Additional settlement mitigation analysis and recommendations can be provided as the design progresses.

4.6 Storm Water Management

We understand that the design team would like to consider the use of onsite infiltration as a means of stormwater management for the project. Our subsurface explorations indicate the presence of fine-grained alluvial soils underlying the entirety of the project. These soils are not expected to possess much infiltration potential. The lack of infiltration potential of the onsite alluvial soils is supported by the observations of significant ponding along the forest service road during our site reconnaissance, days after the last rainfall.

Grain size methodology of estimating infiltration rates based on material properties, outlined in the Department of Ecology Stormwater Management Manual for Western Washington (DOE, 2019), was used to determine an approximate preliminary infiltration rate for the alluvial soils. Table 2 summarizes the data used in the Massmann infiltration screening analysis.

Table 2.
Infiltration Screening Based on Grain Size Analysis

Boring		HH-1	HH-4	HH-8
Depth	ft	1.5	4.2	2.4
USCS Classification		CL	ML	CL
D10	mm	0.001	0.0035	0.001
D60	mm	0.06	0.074	0.062
D90	mm	0.3	0.28	0.31
f_{fines}	%	64.7	60.9	64.8
K_{des}	in/hr	**0.2**	**0.25**	**0.2**

Our analysis of samples collected within the alluvial deposits indicate that the fine-grained soils, underlying the site, possess a preliminary design infiltration rate of approximately 0.2 inches per hour, suggesting very limited infiltration potential. Given the sloping site, and the relatively low expected infiltration rate, we recommend other means of stormwater management be considered for this project. HWA does not recommend any further infiltration testing at this site.

4.7 ROADWAY CONSTRUCTION

The new roadway alignment will be constructed through forested areas with varying topography. Our explorations indicate that the proposed roadway alignment is underlaid by fine grained alluvial soils with soft to medium stiff relative consistencies. The soils and topography along the alignment will require special geotechnical considerations. HWA recommends the following be considered during planning of the proposed improvements.

4.7.1 Subgrade Preparation

Construction of the reroute will require clearing and grubbing of the proposed roadway alignment. Clearing and grubbing should be performed in accordance with the procedures outlined in the 2-01 of *WSDOT Construction Manual* (WSDOT, 2023). Any required tree removal should also be accomplished during subgrade preparation. Care should be taken to thoroughly remove all root systems from the proposed construction area. Materials disturbed during removal of stumps should be undercut and replaced with structural fill.

Prior to completing any settlement mitigation measures, we recommend that all unsuitable materials be removed from the site prior to placement of structural fill. We recommend that qualified engineering personnel monitor the stripping operations to observe that all unsuitable materials have been removed. Care should be exercised to separate the move and stock unsuitable materials to avoid incorporation of the organic matter in structural fill sections. The subgrade excavation should be benched to avoid placing structural fill on sloped surfaces.

The existing subgrade soils are loose and or soft and are not expected to provide adequate support for the proposed roadway embankment. To stabilize the subgrade soils along the alignment we recommend that these soils be over excavated by a minimum of 2 feet below the proposed bottom of the embankment foundation elevation. The over excavated volume should be replaced with 4-8-inch quarry spalls as specified per Section 9-13.1(5) of the *WSDOT Standard Specifications* (WSDOT, 2023). A woven geotextile separator fabric, meeting the requirements of Table 3 of Section 9-33.2 of the *WSDOT Standard Specifications* (WSDOT, 2023) for soil stabilization, should be placed over the quarry spalls across the base of the excavation prior to the placement of the embankment structural fill. The placement of the quarry spalls and geotextile separator fabric will allow for placement of the embankment fill with limited loss to the subgrade soils. Failure to plan and implement these subgrade stabilization measures could result in cost overruns during construction, due to poor subgrade conditions.

4.7.2 Culvert Installation

As part of the subgrade preparation, we expect culverts will be required where the roadway crosses natural drainage features. The culvert should be founded at a grade that is capable of collecting all possible water from upslope of the roadway. If the drainage is not considered to be fish passable, the culvert pipes should be designed with a flexible piping material, such as fused HDPE, to avoid culvert separation as a result of embankment settlements. If the natural drainage features are anticipated to be fish passable, the culvert structures should consist of 4-sided box structures capable of tolerating the expected settlements. The culvert geometry and backfill should be designed to promote water flow into the culverts and avoid seepage into the quarry spalls placed to stabilize the base of the embankment excavation. This may require surface treatment at the inlet side of the culvert or possible grouting of some of the quarry spalls in the vicinity of the culvert inlet.

4.7.3 Structural Fill

The onsite soils are fine grained and are moisture sensitive. We do not recommend reusing the onsite soils as structural fill for this project. Structural fill should consist of clean, free-draining, granular soils free from organic matter or other deleterious materials. Such materials should be less than 4 inches in maximum particle dimension, with less than 7 percent fines (portion passing the U.S. Standard No. 200 sieve), as specified for “Gravel Borrow” in Section 9-03.14(1) of the *WSDOT Standard Specifications* (WSDOT, 2023). The fine-grained portion of structural fill soils should be non-plastic. Fill material having a fines content greater than 7 percent may be acceptable for structural fill in certain applications if the earthwork is performed during relatively dry weather and the contractor’s methods achieve proper compaction of the soil. Material with a fines content greater than 7 percent should be approved by the project engineer prior to use.

4.7.4 Compaction

Structural fill soils should be moisture conditioned and compacted to a dense and unyielding condition and to the requirements specified in Section 2-03.3(14)C, Method C, of the *WSDOT Standard Specifications* (WSDOT, 2023); except the standard of compaction achieved should not be less than 95% of the maximum dry density (MDD) determined for the fill materials by test method ASTM D 1557 (Modified Proctor). Structural fill should be placed and compacted in loose, horizontal lifts of not more than 8 inches in thickness. Subgrade compaction in roadbed areas should conform to the requirements of Section 2-06.3(1) of the *WSDOT Standard Specifications* (WSDOT, 2023).

At the time of placement, the moisture content of structural fill should be at or near optimum. Achievement of proper density of a compacted fill depends on the size and type of compaction equipment, the number of passes, thickness of the layer being compacted, and soil moisture-density properties. In areas where limited space restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough layers and at the proper moisture content to achieve the required relative compaction. Generally, loosely compacted soils result from poor construction technique and/or improper soil moisture content. Soils with high fines contents are particularly susceptible to becoming too wet and coarse-grained materials easily become too dry for proper compaction.

4.7.5 Temporary Excavations

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. In accordance with Part N of Washington Administrative Code (WAC) 296-155, latest revisions, all temporary cuts in excess of 4 feet in height must be either sloped or shored prior to entry by personnel. Based on the guidelines, the onsite existing fill and alluvial soils classify as Type C soils. These materials should be sloped no steeper than 1.5H:1V. These recommended maximum slopes are applicable to temporary excavations above the water table only; flatter side slopes would be required for excavations where groundwater seepage is encountered.

The contractor should monitor the stability of temporary cut slopes and adjust the construction schedule and slope inclination accordingly. The contractor should be responsible for control of ground and surface water and should employ sloping, slope protection, ditching, sumps, dewatering, and other measures, as necessary, to prevent sloughing of soils.

4.7.6 Wet Weather Earth Work

The near surface soils along the project alignment are fine-grained and considered highly moisture sensitive. We recommend that subgrade preparation, along the alignment, be completed in the dry summer months. Attempting to complete subgrade preparations outside of the dry season is expected to result in costly subgrade improvements beyond the recommendations provided in this report. General recommendations relative to earthwork performed during wet weather or in wet conditions are presented below. These recommendations should be incorporated into the contract specifications.

- Earthwork should be performed in small areas to minimize exposure to wet weather. Excavation of unsuitable and/or softened soil should be followed promptly by placement and compaction of clean structural fill. The size and type of construction equipment used may need to be limited to prevent soil disturbance. Under some circumstances, it may be necessary to excavate soils with a backhoe to minimize subgrade disturbance caused by equipment traffic.

- Any backfill material including but not limited to Gravel Borrow as specified in Section 9-03.14(1) of the *WSDOT Standard Specifications* (WSDOT, 2023) and/or Crushed Surfacing Base Course (CSBC) as specified in Section 9-03.9(3) of the *WSDOT Standard Specifications* (WSDOT, 2023) used as excavation backfill in wet weather should consist of clean granular soil with less than 5 percent passing the U.S. No. 200 sieve, based on wet sieving the fraction passing the ¾-inch sieve. The fines should be non-plastic. It should be noted this is an additional restriction on the structural fill materials specified.

- The ground surface within the construction area should be graded to promote surface water run-off and to prevent ponding.

- Within the construction area, the ground surface should be sealed on completion of each shift by a smooth drum vibratory roller, or equivalent, and under no circumstances should soil be left uncompacted and exposed to moisture infiltration.

- Excavation and placement of backfill materials should be monitored by a geotechnical engineer experienced in wet weather earthwork to determine that the work is being accomplished in accordance with the project specifications and the recommendations contained herein.

- Bales of straw combined with other best management practices such as geotextile silt fences should be strategically located to control erosion and the movement of soil.

5.0 CONDITIONS AND LIMITATIONS

We have prepared this report for use by the Yakama Nation and Perteet for use in the design of this project. This report should be provided in its entirety to prospective contractors for bidding and estimating purposes; however, the conclusions and interpretations presented herein should not be construed as a warranty of the subsurface conditions. Experience has shown that soil and groundwater conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations that may not be detected by a geotechnical study. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, HWA should be notified for review of the recommendations of this report, and revision of such if necessary. If there is a substantial lapse of time between submission of this report and the start of construction, or if conditions change due to construction operations at or adjacent to the project site, it is recommended that this report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

We recommend that HWA be retained to review the plans and specifications to verify that our recommendations have been interpreted and implemented as intended. Sufficient geotechnical monitoring, testing, and consultation should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should conditions revealed during construction differ from those anticipated, and to verify that the geotechnical aspects of construction comply with the contract plans and specifications.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology at the time the report was prepared. No warranty, express or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous or toxic substances in the soil, surface water, or groundwater at this site.

HWA does not practice or consult in the field of safety engineering. We do not direct the contractor’s operations and cannot be responsible for the safety of personnel other than our own on the site. As such, the safety of others is the responsibility of the contractor. The contractor should notify the owner if he considers any of the recommended actions presented herein unsafe.

We appreciate this opportunity to be of service.

Sincerely,

Mary Alice Benson, L.G.
Geologist

Donald J. Huling, P.E.
Principal Geotechnical Engineer

6.0 REFERENCES

American Association of State Highway and Transportation Officials, 2020. *AASHTO Guide Specifications for LRFD Seismic Bridge Design*, 9th Edition, American Association of State Highway and Transportation Officials. Washington, DC.

Department of Ecology, *Stormwater Management Manual for Western Washington*, 2019

Massmann, Joel W, *A Design Manual for Sizing Infiltration Ponds,* Washington State Transportation Commission, October 2003.

Petersen, Mark D.; Moschetti, Morgan P.; Powers, Peter M.; Mueller, Charles S., Haller, Kathleen M.; Frankel, Arthur D., Zeng, Yuehua; Rezaeian, Sanaz; Harmsen, Stephen C.; Boyd, Oliver S.; Field, Ned; Chen, Rui, Rukstales, Kenneth S.; Luco, Nico; Wheeler, Russell L.; Williams, Robert A. and Olsen, Anna H., *Documentation for the 2014 Update of the United States National Seismic Hazard Maps,* Open-File Report 2014-1091.

Tabor, R.W., Frizzell, V.A., Whetten, J.T., Waitt, R.B., Swanson, D.A., Byerly, G.R., Booth, D.B., Hetherington, M.J., and Zartman, R.E., 1987. *Geologic Map of the Chelan 30-Minute by 60-Minute Quadrangle, Washington,* United State Department of the Interior, United States Geological Survey Miscellaneous Investigations Series Map 1-1661, Scale 1:100,000.

WSDOT, 2020, *Bridge Design Manual LRFD, 2020* Washington State Department of Transportation. M 23-50

WSDOT, 2023. *Standard Specifications for Road, Bridge, and Municipal Construction,* Washington State Department of Transportation.

SITE MAP

0 500' 1000' 1500' 2000'

SCALE: 1" = 1000'

N

VICINITY MAP

0 2000' 4000' 6000' 8000'

SCALE: 1" = 4000'

N

HWA GEOSCIENCES INC.
DBE/MWBE

SITE AND VICINITY MAP

YAKAMA NATION NASON CREEK FLOODPLAIN
SR 207 REROUTE
CHELAN COUNTY, WASHINGTON

FIGURE NO.: 1

DRAWN BY: CF

CHECK BY: MAB

PROJECT # 2022-144-21

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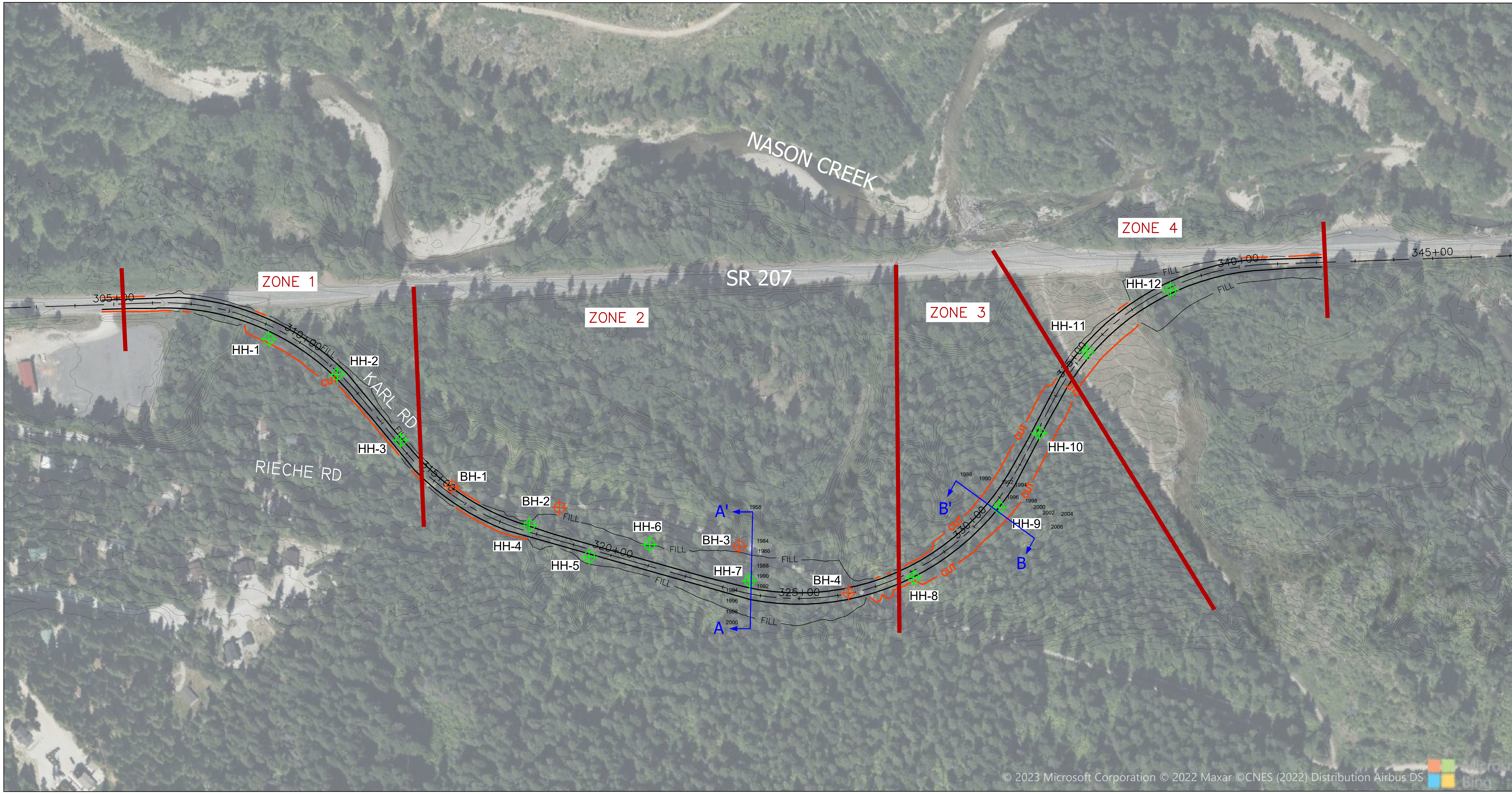

NASON CREEK FLOODPLAIN
Scale: 1" = 250'-0"

EXPLORATION LEGEND

HH-12 HAND BORING DESIGNATION AND APPROXIMATE LOCATION

BH-4 MACHINE DRILLED BORING DESIGNATION AND APPROXIMATE LOCATION

LIMITS OF RECONNAISSANCE ZONES

A — A' GEOLOGIC CROSS SECTION

BASE MAP PROVIDED BY: BING

0 125 250 375 500
SCALE: 1" = 250'

HWA GEOSCIENCES INC. DBE/MWBE

YAKAMA NATION NASON CREEK FLOODPLAIN
SR 207 REROUTE
CHELAN COUNTY, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
CF	2
CHECK BY:	PROJECT NO.:
MAB/DJH	2022-144-21

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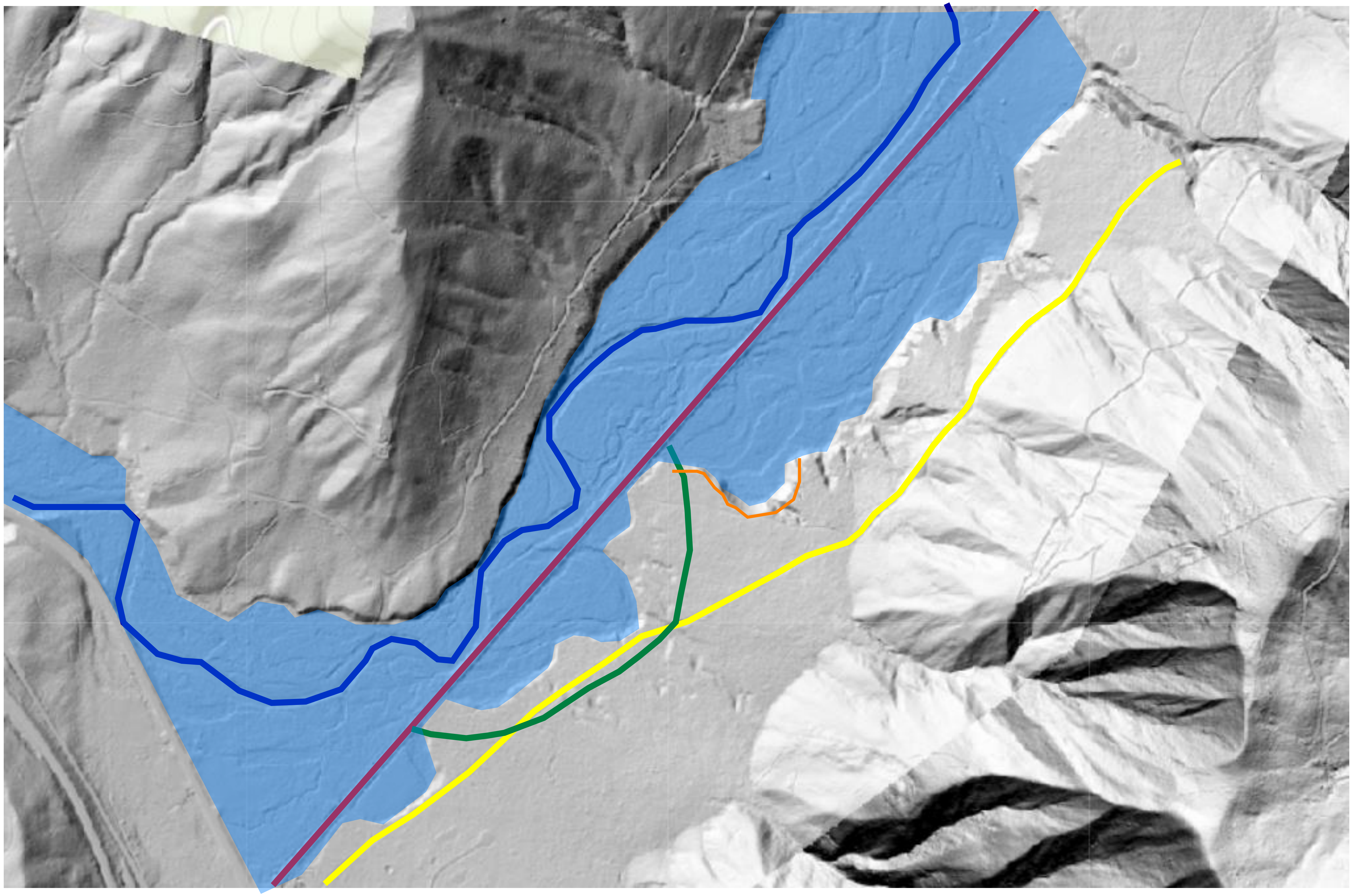
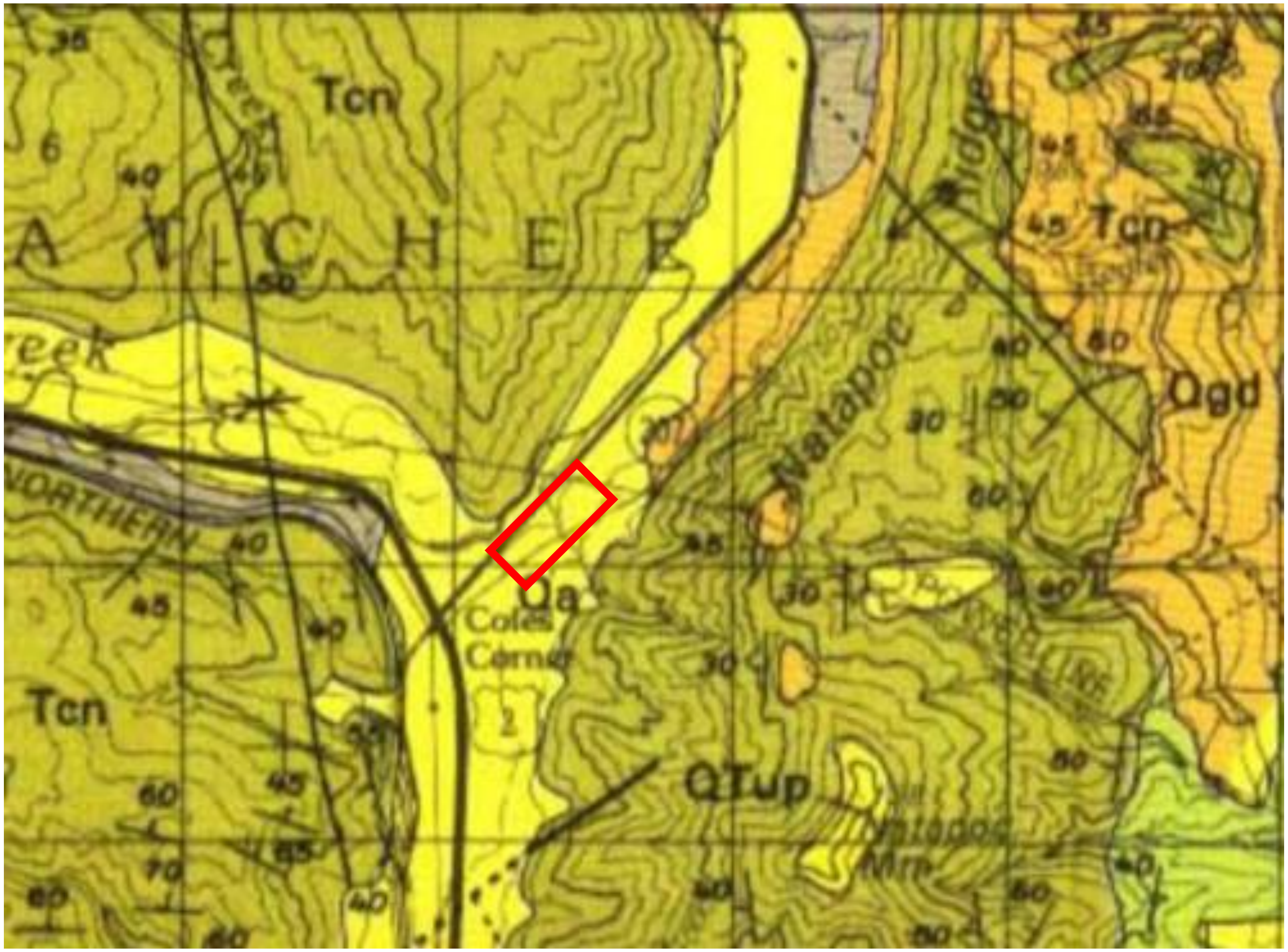


Legend

- Current SR 207 alignment
- Rieche Road/USFS Road 6603
- Approximate Proposed realignment
- Nason Creek main channel
- Nason Creek Floodplain
- Top of steep slope in Zone 4

Portions of the Chelan 2015 and Wenatchee Upper 2017 LiDAR sets, accessed from the Washington State DNR LiDAR Portal on 6/23/2023. Not to scale

HWA GeoSciences Inc. DBE/MWBE	LIDAR	FIGURE NO. 3
	YAKAMA NATION NASON CREEK FLOODPLAIN SR 207 REROUTE CHELAN COUNTY, WASHINGTON	PROJECT NO. 2022-144-21



Qa — ALLUVIUM (HOLOCENE AND PLEISTOCENE)—Moderately sorted cobble gravel along rivers grading to poorly sorted gravelly sand on small-tributary fans; as mapped, includes some material in fans similar to unit Qt

Tcn — Nahahum Canyon Member—Olive-brown carbonaceous, micaceous, finely laminated lacustrine shale interbedded with laminated sandstone turbidites and rocks similar to undivided part (Tc) of the Chumstick Formation

Approximate Project Area

N

Portion of the Geologic Map of the Chelan 30-Minute by 60-Minute Quadrangle, Washington (Tabor et al., 1987). Not to scale.

HWA GEOSCIENCES INC.
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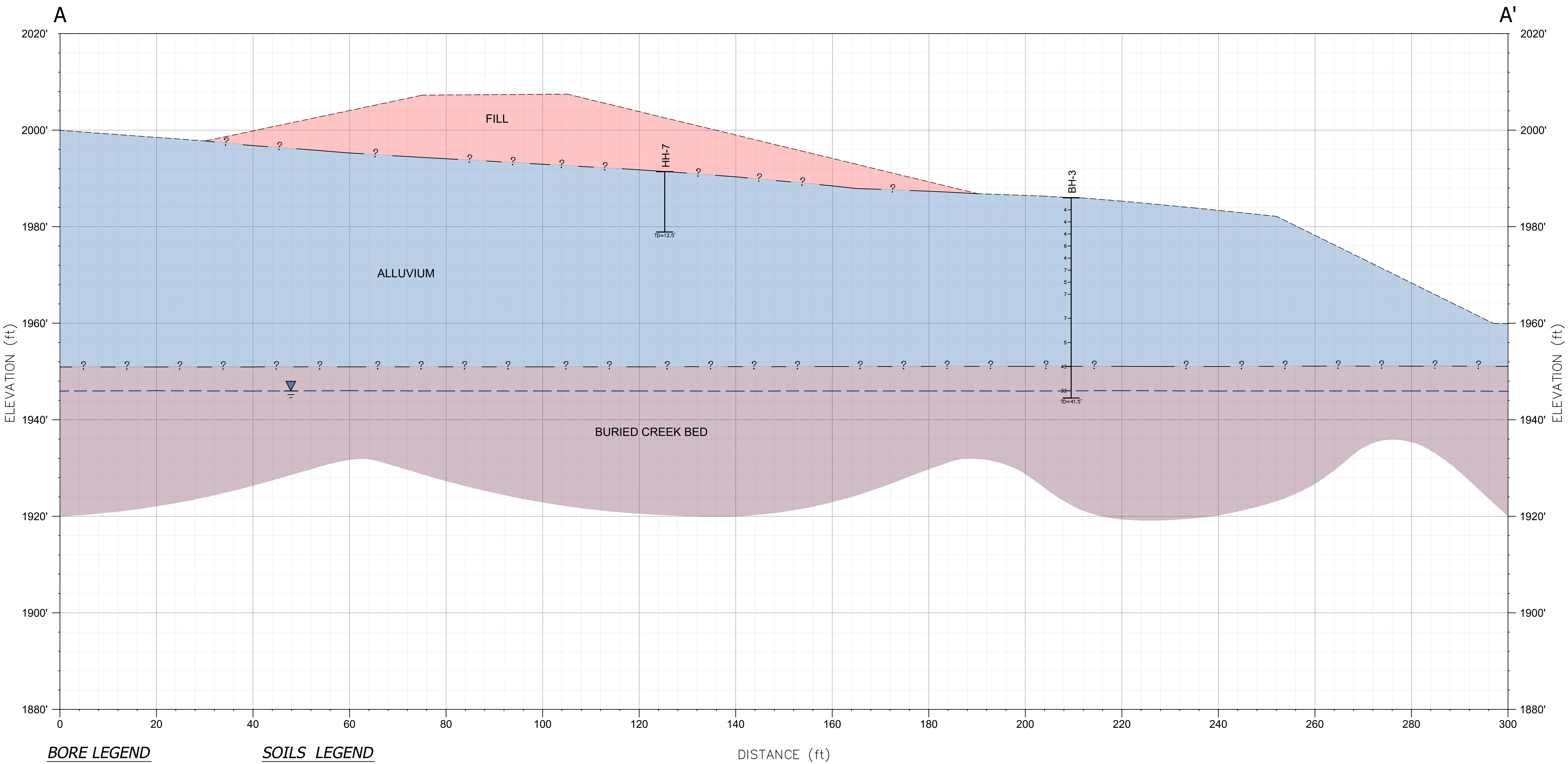
GEOLOGIC MAP

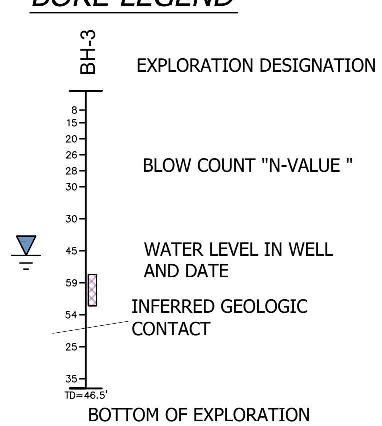
YAKAMA NATION NASON CREEK FLOODPLAIN
SR 207 REROUTE
CHELAN COUNTY, WASHINGTON

FIGURE NO. 4

PROJECT NO. 2022-144

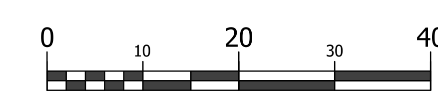


BORE LEGEND



SOILS LEGEND

- FILL
- ALLUVIUM
- BURIED CREEK BED



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YAKAMA NATION NASON CREEK FLOODPLAIN SR 207 REROUTE CHELAN COUNTY, WASHINGTON	GEOLOGIC CROSS SECTION A-A' STATION 323+75	DRAWN BY: CF CHECK BY: DJH	FIGURE NO.: 5A PROJECT NO.: 2022-144-21

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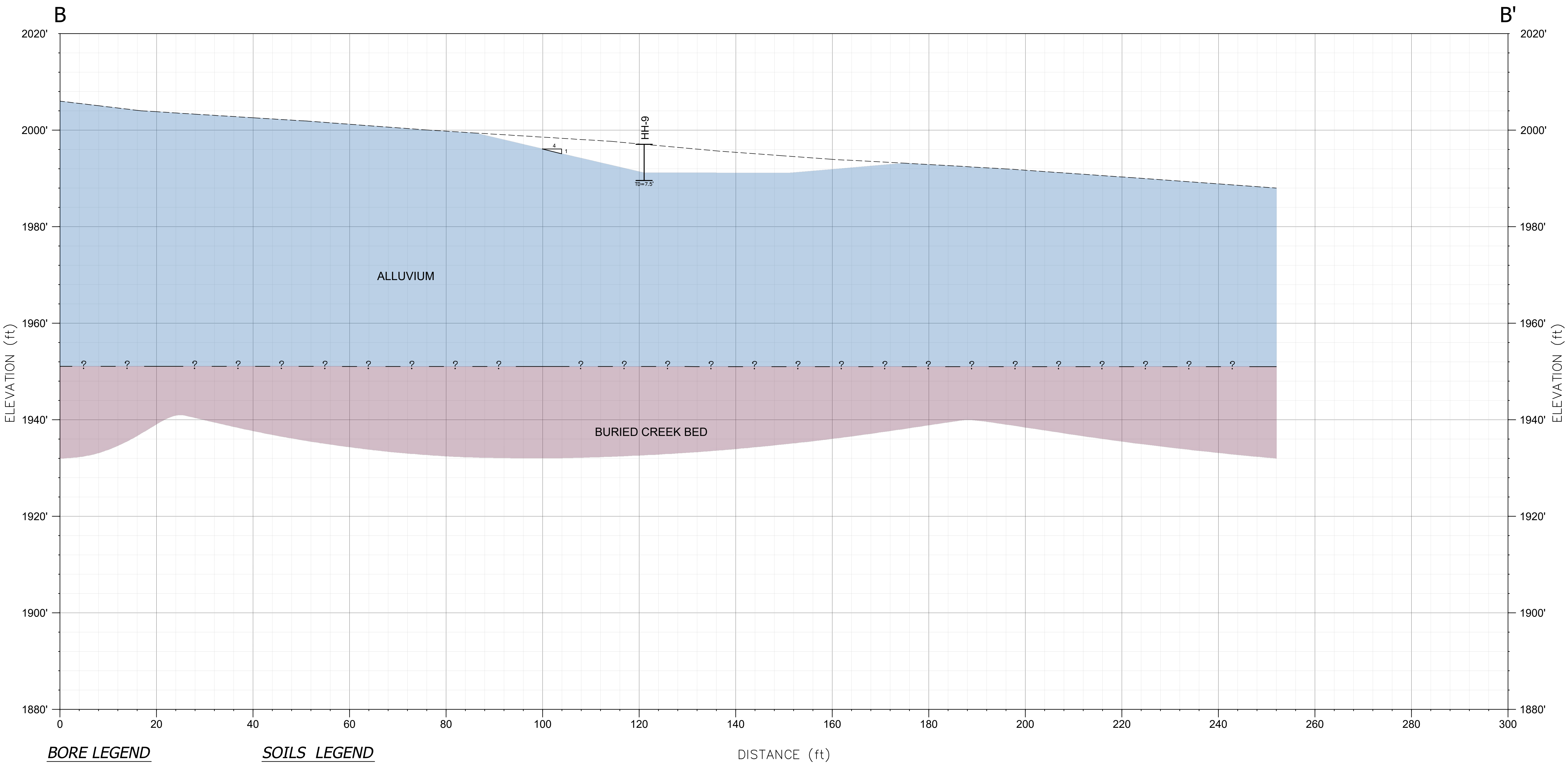

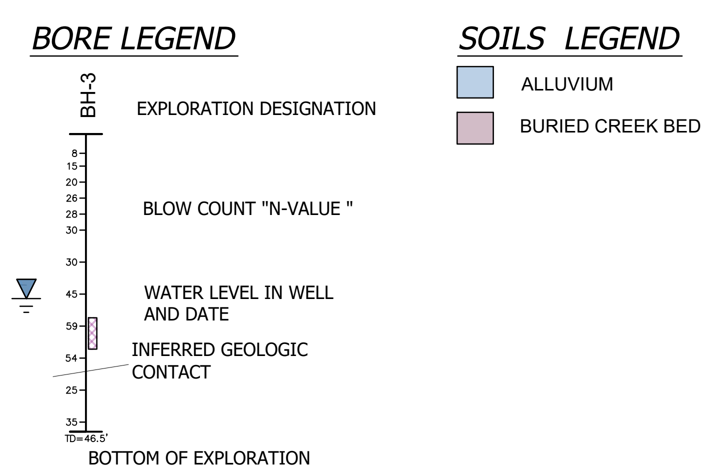

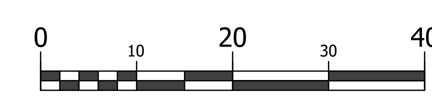

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YAKAMA NATION NASON CREEK FLOODPLAIN
SR 207 REROUTE
CHELAN COUNTY, WASHINGTON

GEOLOGIC CROSS
SECTION B-B'
STATION 330+75

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CHECK BY: DJH	PROJECT NO.: 2022-144-21

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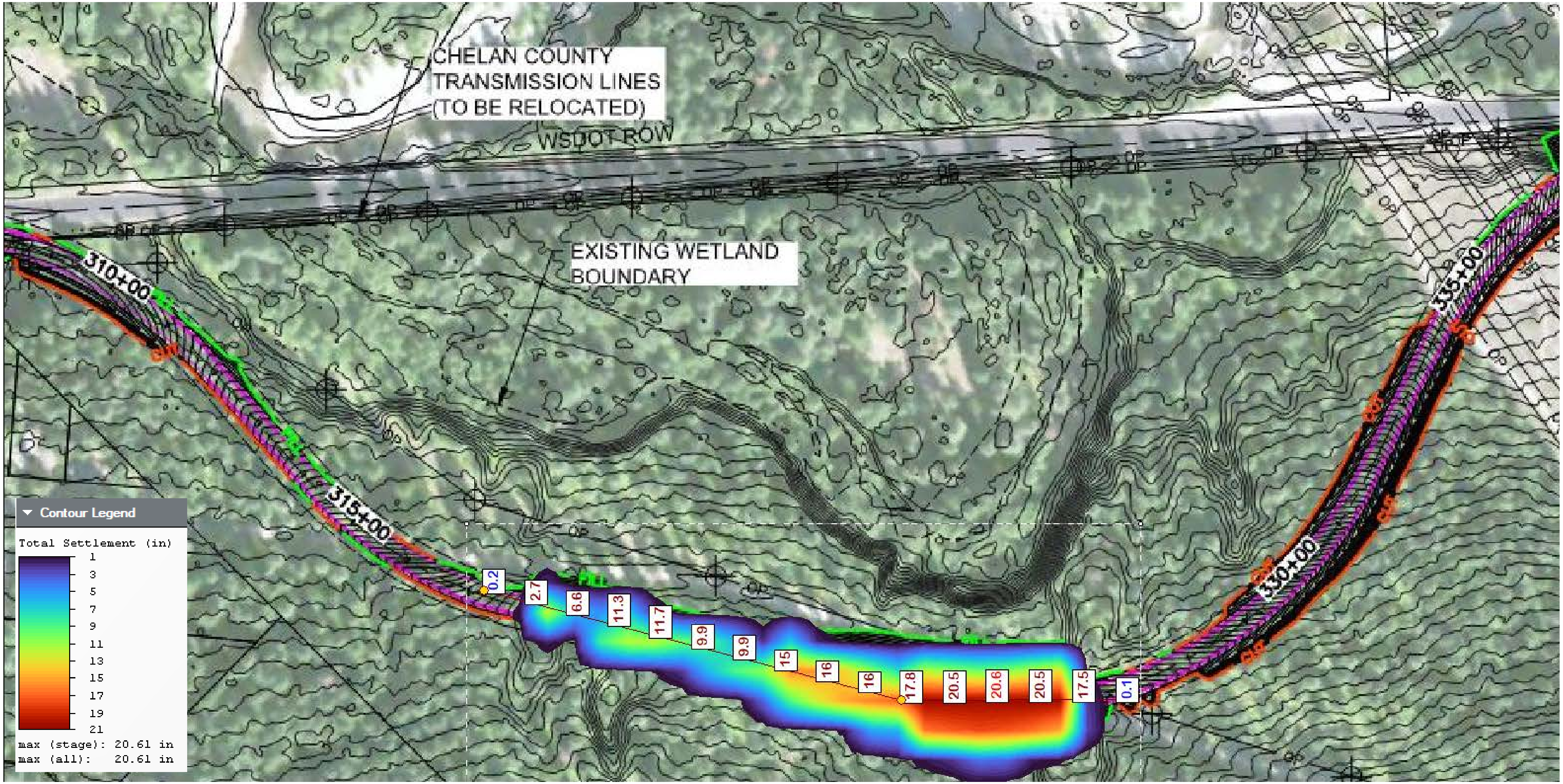

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SETTLEMENT ANALYSIS

YAKAMA NATION NASON CREEK FLOODPLAIN
SR 207 REROUTE
CHELAN COUNTY, WASHINGTON

FIGURE NO.
6

PROJECT NO.
2022-144-21

APPENDIX A

FIELD EXPLORATIONS

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

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

USCS SOIL CLASSIFICATION SYSTEM

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

TEST SYMBOLS

%F	Percent Fines
AL	Atterberg Limits: PL = Plastic Limit, LL = Liquid Limit
CBR	California Bearing Ratio
CN	Consolidation
DD	Dry Density (pcf)
DS	Direct Shear
GS	Grain Size Distribution
K	Permeability
MD	Moisture/Density Relationship (Proctor)
MR	Resilient Modulus
OC	Organic Content
pH	pH of Soils
PID	Photoionization Device Reading
PP	Pocket Penetrometer (Approx. Comp. Strength, tsf)
Res.	Resistivity
SG	Specific Gravity
CD	Consolidated Drained Triaxial
CU	Consolidated Undrained Triaxial
UU	Unconsolidated Undrained Triaxial
TV	Torvane (Approx. Shear Strength, tsf)
UC	Unconfined Compression

SAMPLE TYPE SYMBOLS

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

GROUNDWATER SYMBOLS

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

COMPONENT DEFINITIONS

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

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)
Components are arranged in order of increasing quantities.	

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

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

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

MOISTURE CONTENT

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

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

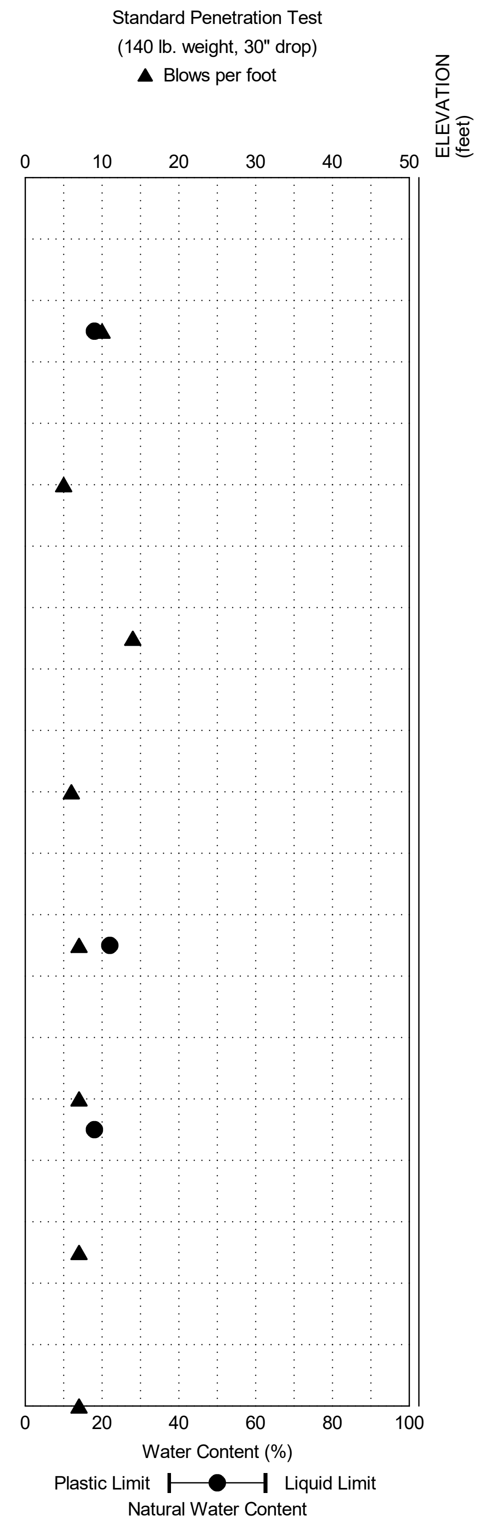
LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 2022-144-21 FIGURE: A-1

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT, Cal Mod w/Autohammer
LOCATION: See Figure 2

DATE STARTED: 5/19/2023
DATE COMPLETED: 5/19/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0	CL	Brown, sandy CLAY, moist, micaceous. **(FILL)**				
	CL	Stiff, brown, sandy CLAY. moist. Micaceous, 1-2" bedding. **(ALLUVIUM)**	S-1	4-4-6		
5		Medium stiff, brown, sandy CLAY, moist. Micaceous, trace gravel and charcoal, 1-2" bedding.	S-2	3-2-3		
		Same as previous.	S-3a S-3b S-3c	6-6-8		
10		Medium stiff, brown, sandy CLAY, moist. Few sand interbeds, scattered woody debris, charcoal. Wood looks fresh.	S-4	2-3-3		
		Same as previous, no charcoal.	S-5	2-2-5		
15			S-6a	2-4-3		
	SM	Loose, brown, silty SAND, moist. Micaceous, 1/4-2" bedding.	S-6b			
	CL	Medium stiff, brown, sandy CLAY, moist. Micaceous, scattered wood, charcoal.	S-7	2-3-4		
20						



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

BORING:
BH-1

PROJECT NO.: 2022-144-21 FIGURE: A-2

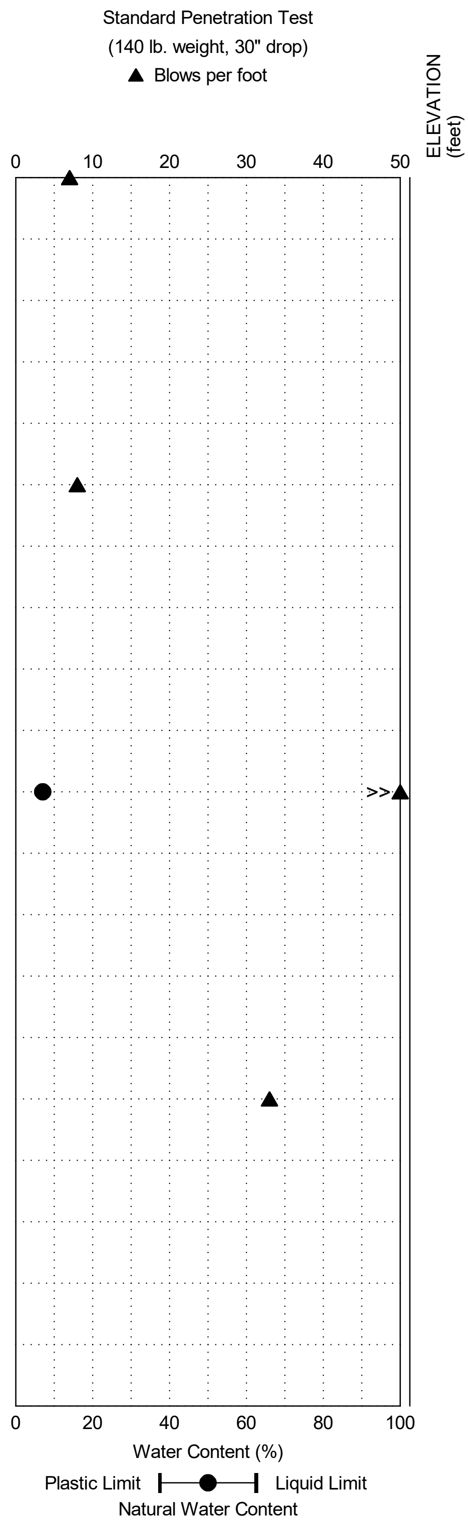
BORING-DSM 2022-144.GPJ 8/8/23

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT, Cal Mod w/Autohammer
LOCATION: See Figure 2

DATE STARTED: 5/19/2023
DATE COMPLETED: 5/19/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
20	SC	Loose, brown, clayey SAND, moist. Micaceous, few clay lenses.	S-8	2-3-4		
25		Clay fraction decreasing, grades to yellowish-brown.	S-9	3-4-4		
		Gravelly drill action.				
30	SP SM	Very dense, olive brown, slightly silty, gravelly SAND, wet. Gravel broken by drill action, sampling. **(BURIED CREEK BED)**	S-10	24-37-25	GS	∇
35	GM	Dense, dark olive brown, silty, sandy GRAVEL, wet. Gravel broken by drill action and sampling.	S-11	16-10-23		

BH-1 terminated at about 36.5 feet below ground surface (bgs).
Groundwater encountered at about 30 feet bgs during the exploration.
Boring abandoned with 3/8" bentonite chips.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

BORING:
BH-1

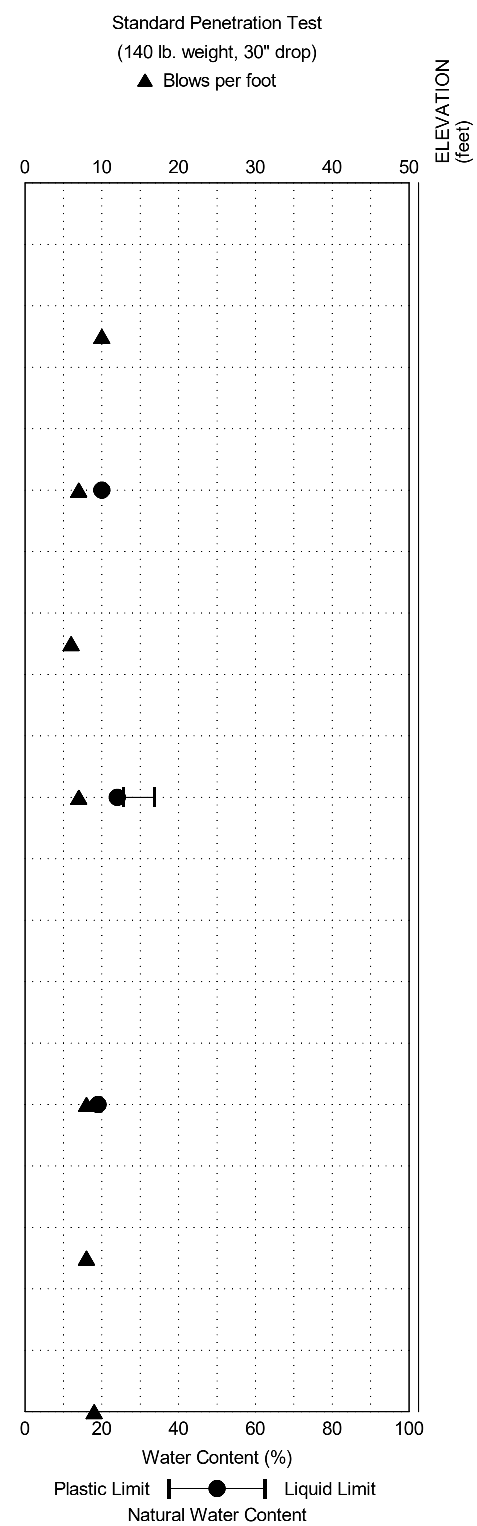
PROJECT NO.: 2022-144-21 FIGURE: A-2

BORING-DSM 2022-144.GPJ 8/8/23

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT w/Autohammer, Shelby Tube
LOCATION: See Figure 2

DATE STARTED: 5/19/2023
DATE COMPLETED: 5/19/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		CL	Brown, sandy CLAY, moist, micaceous. **(FILL)**					
		SC	Medium dense, brown, clayey SAND, moist. Micaceous, scattered charcoal. 1-2" bedding. **(ALLUVIUM)**		S-1	4-5-5		
5		CL	Loose, brown, sandy CLAY, moist. Clay fraction increasing with depth.		S-2	2-2-5		
			Same as previous, 2 inch sand lens at 7.5 feet.		S-3	2-2-4		
10		ML	Medium stiff, brown, sandy SILT, moist. Micaceous, few fine sand interbeds.		S-4	2-3-4	AL %F	
		SC	Loose, olive brown, clayey SAND, moist.		S-5		DS	
15		CL	Loose, brown, sandy CLAY, moist. Micaceous, 1-3" bedding.		S-6	2-3-5		
			Clay fraction decreasing.		S-7	2-3-5		
20								



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

BORING:
BH-2

PROJECT NO.: 2022-144-21 FIGURE: A-3

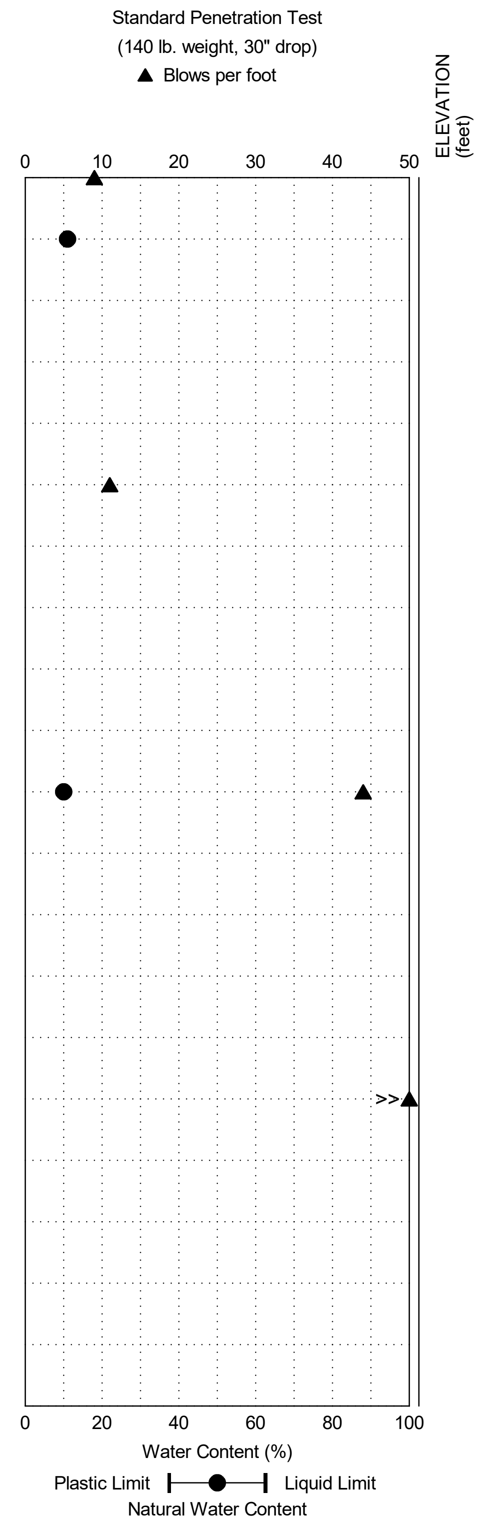
BORING-DSM 2022-144.GPJ 8/8/23

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT w/Autohammer, Shelby Tube
LOCATION: See Figure 2

DATE STARTED: 5/19/2023
DATE COMPLETED: 5/19/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
20		Same as previous.	S-8a	3-4-5		
	SM	Loose, yellowish-brown, silty SAND, moist. Scattered gravel, sample noticable less moist than previous samples.	S-8b			
25		Medium dense, yellowish-brown, gravelly, silty SAND, moist. Micaceous.	S-9	3-4-7		
30	SM	Dense, dark grayish-brown, silty SAND, moist. Micaceous, slightly gravelly. **(BURIED CREEK BED)**	S-10	5-11-33		
35	GM	Very dense, dark grayish-brown, silty, sandy GRAVEL, wet.	S-11	24-50/6"		∇

BH-2 terminated at about 36 feet below ground surface (bgs).
Groundwater encountered at about 35 feet bgs during the exploration.
Boring abandoned with 3/8" bentonite chips.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

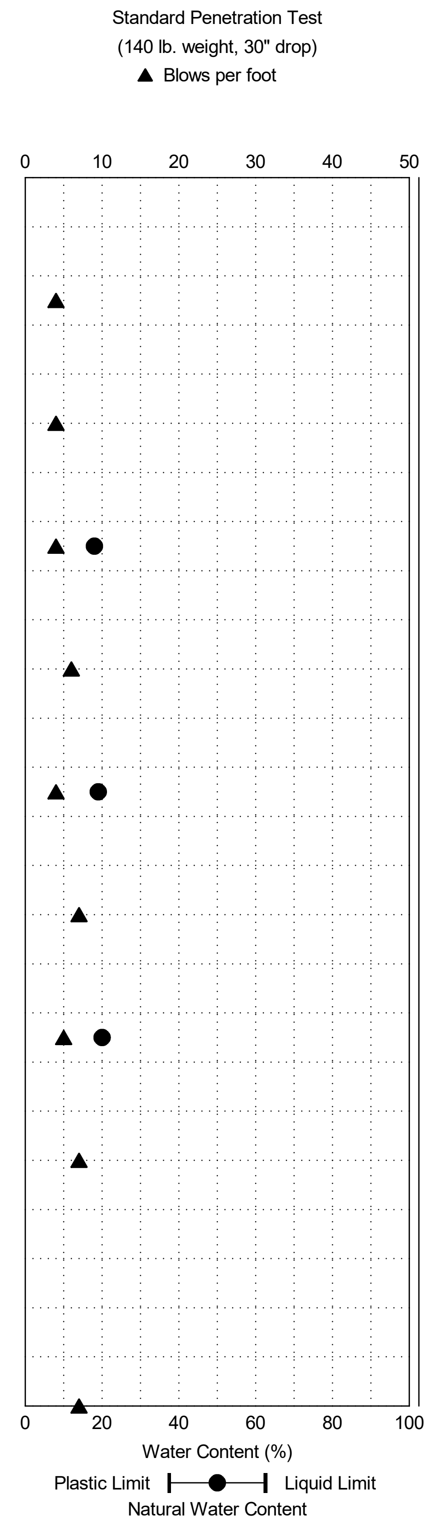
BORING:
BH-2

PROJECT NO.: 2022-144-21 FIGURE: A-3

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT w/Autohammer
LOCATION: See Figure 2

DATE STARTED: 6/26/2023
DATE COMPLETED: 6/26/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER	ELEVATION (feet)
0	CL	Medium stiff, brown, very sandy, CLAY, moist. Micaceous. **(FILL)**	S-1	1-1-3			
5	SC	Loose, yellowish-brown, very clayey SAND, moist. Micaceous, poor recovery. **(ALLUVIUM)**	S-2	2-1-3			
	CL	Loose, yellowish-brown, sandy CLAY, moist. Micaceous, 1-2" bedding.	S-3	2-2-2			
10		Same as previous. 1/2" clay lens at 10 feet.	S-4	2-3-3			
	SM	Loose, yellowish-brown, silty, fine to medium SAND, moist. Micaceous, 1-3" bedding.	S-5	2-2-2	GS		
15		Becomes very clayey.	S-6	2-3-4			
	CL	Loose, yellowish-brown, sandy CLAY, moist. Micaceous, 2-3" bedding.	S-7	2-2-3			
20		Same as previous.	S-8	1-2-5			
25							



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

BORING:
BH-3

PROJECT NO.: 2022-144-21 FIGURE: A-4

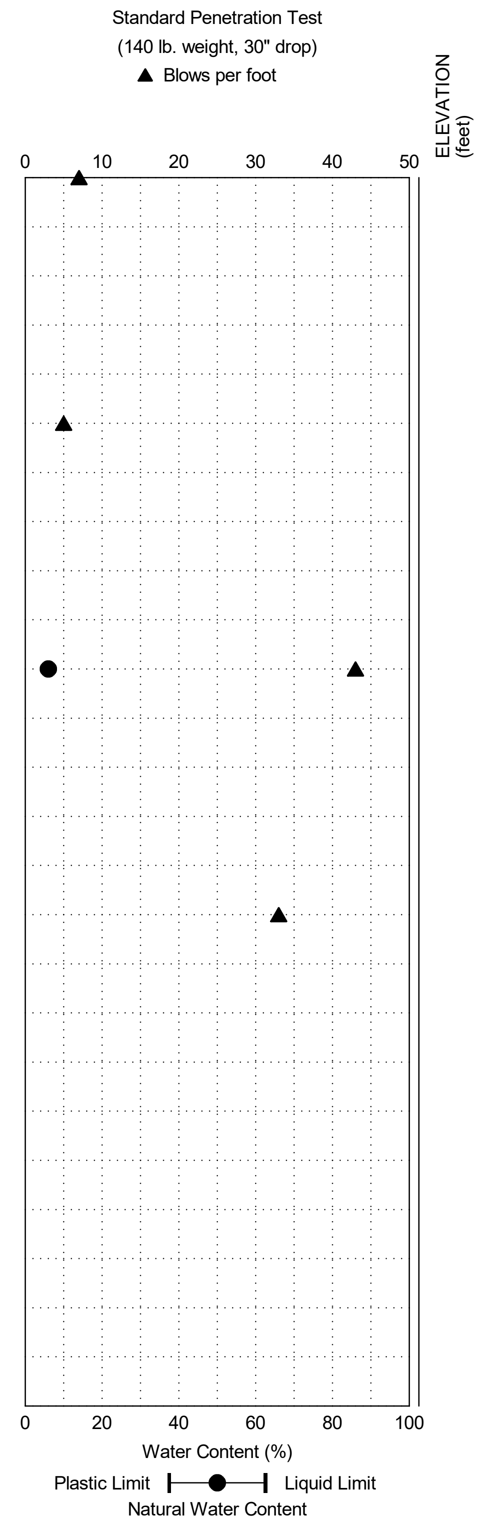
BORING-DSM 2022-144.GPJ 8/8/23

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT w/Autohammer
LOCATION: See Figure 2

DATE STARTED: 6/26/2023
DATE COMPLETED: 6/26/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
25		Loose, yellowish-brown, sandy CLAY, moist. Micaceous, 1/2-3" bedding.	S-9	2-3-4		
30		Same as previous.	S-10	2-2-3		
35	SM	Dense, dark grayish-brown, silty, very gravelly, fine to course SAND, moist. Micaceous, sand angular to subrounded, gravel broken by drill action and sampling. **(BURIED CREEK BED)**	S-11	13-19-24		
40		Dense, dark grayish-brown, silty, fine to coarse SAND, wet. Scattered gravel.	S-12	27-15-18		∇

BH-3 terminated at about 41.5 feet below ground surface (bgs).
Groundwater encountered at about 40 feet bgs during the exploration.
Boring abandoned with 3/8" bentonite chips.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

BORING:
BH-3

PAGE: 2 of 2

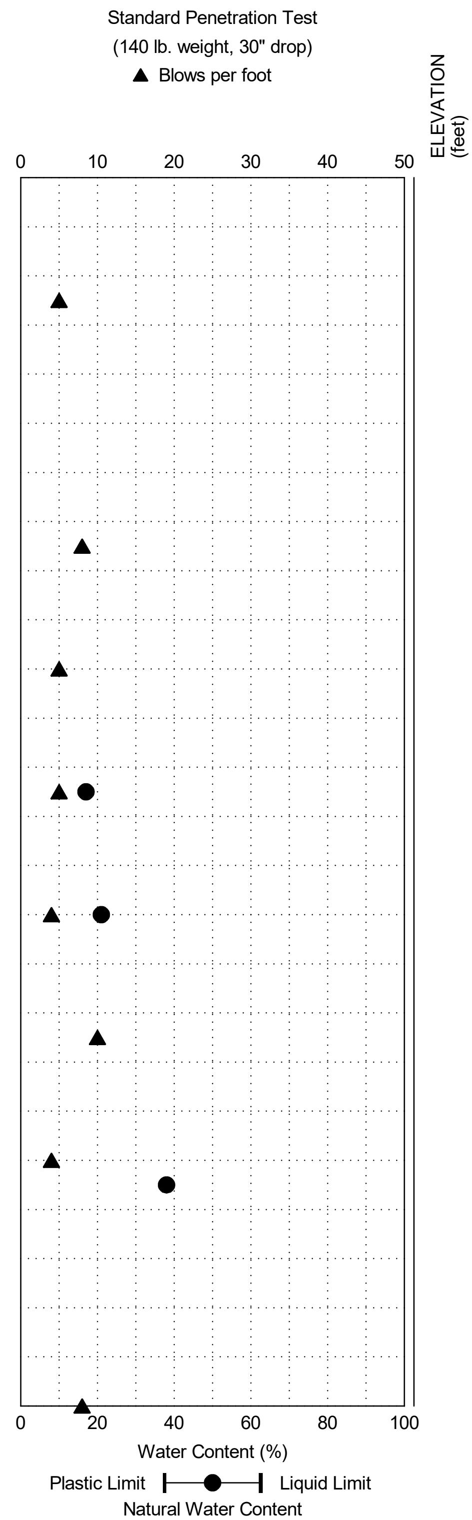
PROJECT NO.: 2022-144-21 FIGURE: A-4

BORING-DSM 2022-144.GPJ 8/8/23

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT w/Autohammer, Shelby Tube
LOCATION: See Figure 2

DATE STARTED: 6/26/2023
DATE COMPLETED: 6/26/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0	CL	Brown, sandy CLAY, moist. Micaceous. **(FILL)**				
	CL	Medium stiff, brown, sandy CLAY, moist. Micaceous, 1-3" bedding. **(ALLUVIUM)**	S-1	6-2-3		
5		Shelby tube collected, soil appears to be same as previous.	S-2		DS CN	
		Medium stiff, brown, slightly sandy CLAY, moist. Scattered organics, 1-3" bedding.	S-3a	3-4-4		
	SC	Loose, yellowish-brown, clayey SAND, moist. Micaceous, 1-3" bedding.	S-3b			
10		Same as previous, trace gravel.	S-4	2-2-3		
	SM	Loose, brown, very silty SAND, moist. Micaceous.	S-5	3-2-3		
15		Loose, brown, silty SAND, moist. Micaceous, 1-4" bedding.	S-6	1-2-2		
		Becomes medium dense, silt fraction decreases with depth.	S-7	3-5-5		
20		Becomes loose.	S-8a	1-2-2		
	ML	Medium stiff, brown, sandy SILT, moist to wet. Micaceous, scattered charcoal.	S-8b			
25						



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

BORING:
BH-4

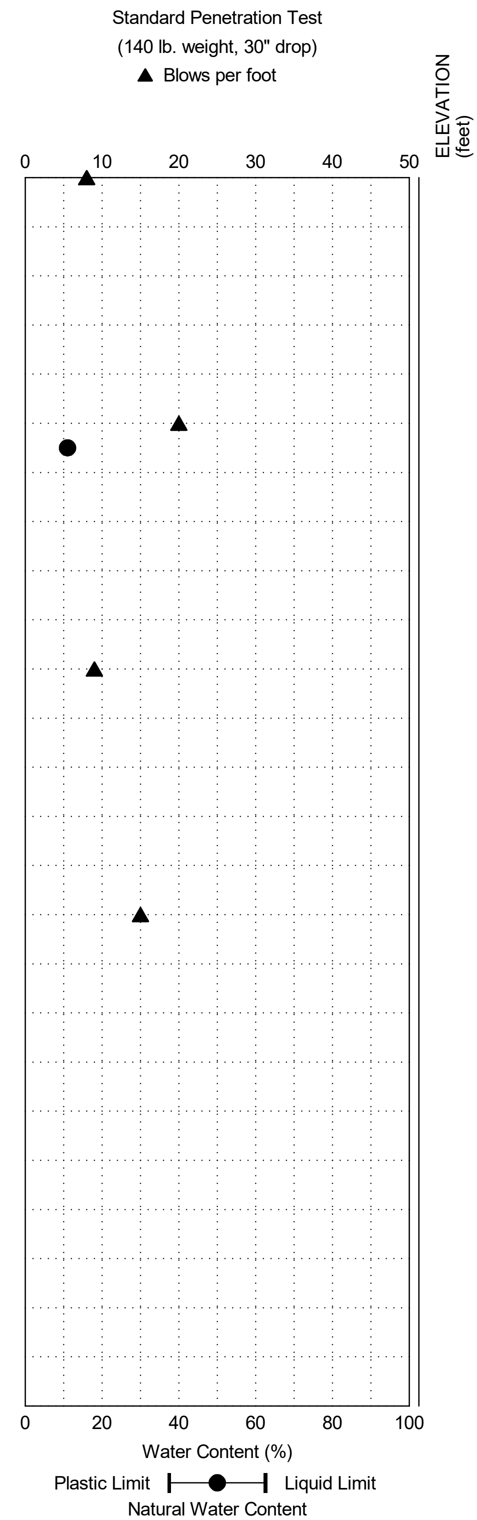
PROJECT NO.: 2022-144-21 FIGURE: A-5

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Diedrich D-50 Tracked rig, HSA w/4,25" ID
SAMPLING METHOD: SPT w/Autohammer, Shelby Tube
LOCATION: See Figure 2

DATE STARTED: 6/26/2023
DATE COMPLETED: 6/26/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER	ELEVATION (feet)
25		SM	Loose, brown, silty SAND, moist. Micaceous, 1/2-3" bedding.		S-9	4-3-5			
30			Becomes medium dense, slightly rust mottled.		S-10a	6-9-11			
			Medium dense, brown, gravelly, silty SAND, moist. Micaceous, 1/4-2" bedding. Few very dark brown, very fine sand beds.		S-10b				
35		SC	Loose, brown, clayey SAND. moist. Micaceous, scattered charcoal.		S-11	3-4-5			
40			Medium dense, brown, clayey SAND, moist. Micaceous.		S-12	5-7-8			

BH-4 terminated at about 41.5 feet below ground surface.
No groundwater encountered during the exploration.
Boring abandoned with 3/8" bentonite chips.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

BORING:
BH-4

PROJECT NO.: 2022-144-21 FIGURE: A-5

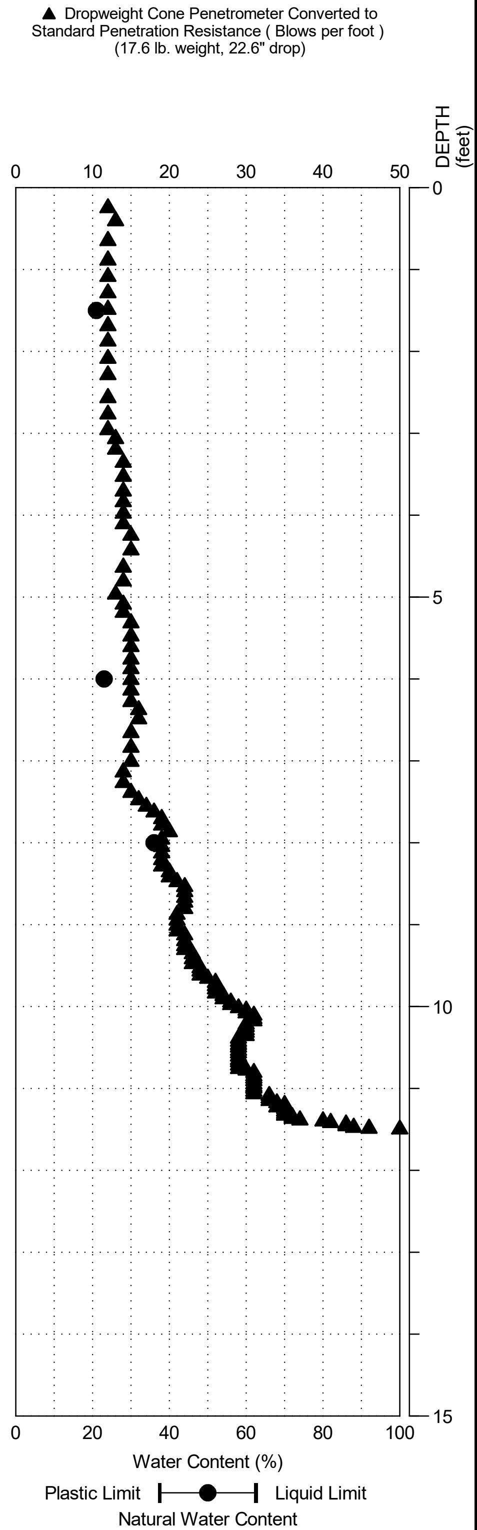
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2023
DATE COMPLETED: 5/16/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	OTHER TESTS	GROUNDWATER
0	SC	Medium dense, dark brown, gravelly, clayey SAND, moist. Abundant roots. **(TOPSOIL)**			
	CL	Stiff, brown, sandy CLAY, moist to wet. **(ALLUVIUM)**	S-1	GS	
	SM	Medium dense, slightly rust mottled olive brown, silty SAND, moist.	S-2		
	SC	Medium dense, rust-mottled brown, clayey SAND, wet.	S-3		∇
		Medium dense to very dense, or very stiff to hard soil.			

HH-1 terminated at 9 feet below ground surface (bgs).
DCP terminated at 11.47 feet bgs.
Groundwater encountered at 8 feet bgs during the exploration.
Boring abandoned with native cuttings.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 1

PAGE: 1 of 1

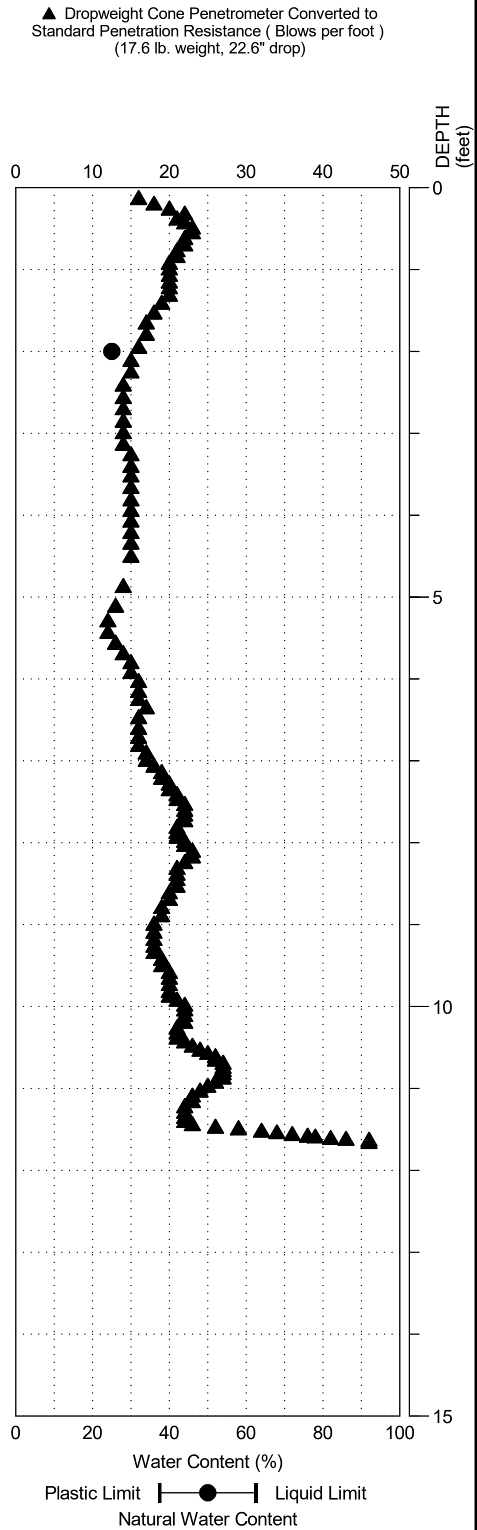
PROJECT NO.: 2022-144-21 FIGURE: A-6

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2023
DATE COMPLETED: 5/16/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SC	Medium dense, olive brown, clayey SAND, moist. Abundant roots, organics. **(TOPSOIL)**					
		CL	Very stiff, olive brown, sandy CLAY, moist. **(ALLUVIUM)**					
			Becomes stiff, sand fraction increases.		S-1			
5								
			Becomes very stiff.					
			Medium dense to dense, or very stiff to hard soil.					
10								
15								



HH-2 terminated at 7.4 feet below ground surface (bgs).
DCP terminated at 11.65 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.

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GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 2

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-7

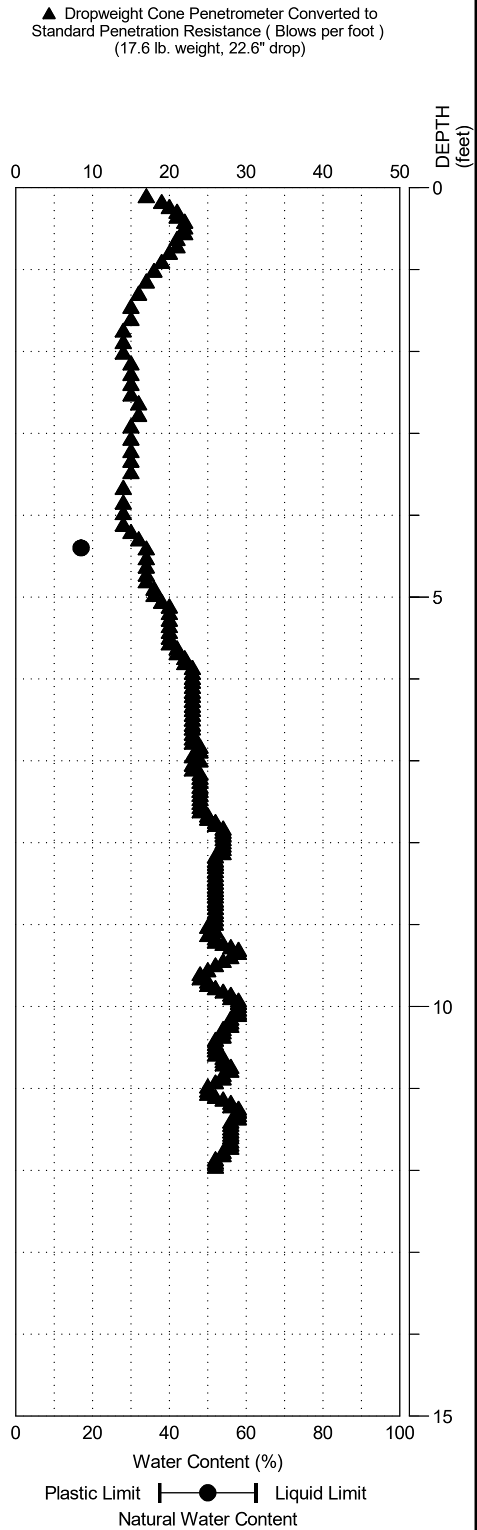
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2023
DATE COMPLETED: 5/16/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SM	Medium dense, brown, silty SAND, moist. Scattered gravel, cobbles, abundant roots. **(TOPSOIL)**					
		CL	Stiff to very stiff, olive brown, sandy CLAY, moist. **(ALLUVIUM)**					
		SM	Medium dense, olive brown, silty SAND, moist.	Grab	S-1			
5								
			Medium dense or very stiff soil.					
10								
15								

HH-3 terminated at 8.2 feet below ground surface (bgs).
DCP terminated at 11.95 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 3

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-8

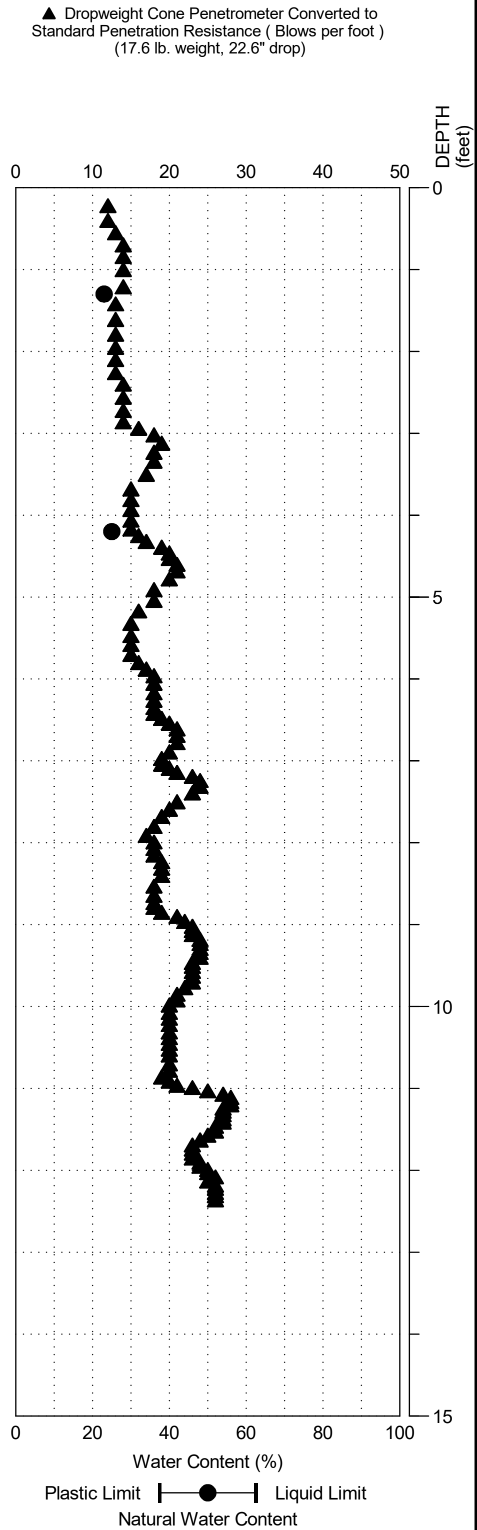
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2023
DATE COMPLETED: 5/17/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SM	Medium dense, very dark brown, silty SAND, moist. Abundant roots, organics. **(TOPSOIL)**					
		SC	Medium dense, olive brown, clayey SAND, moist. Abundant roots. **(ALLUVIUM)**					
		CL	Stiff, olive brown, sandy CLAY, moist.	Grab	S-1			
		SC	Medium dense, olive brown, very clayey SAND, moist.					
		ML	Stiff, olive brown, sandy SILT, moist.	Grab	S-2		GS	
5								
		CL	Very stiff, slightly rust-mottled olive brown, sandy CLAY, moist. Scattered charcoal.					
		SC	Medium dense, olive brown, clayey SAND, moist. Trace woody organics.					
			Medium dense or very stiff soil.					
10								
15								

HH-4 terminated at 8.8 feet below ground surface (bgs).
DCP terminated at 12.36 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 4

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-9

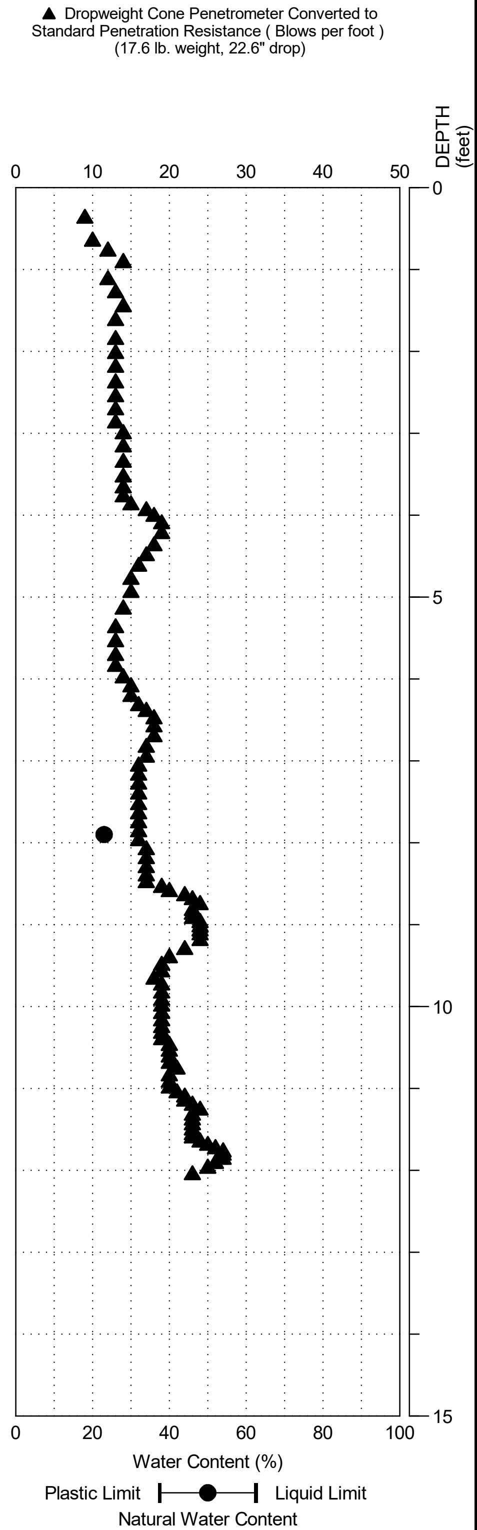
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2023
DATE COMPLETED: 5/17/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SC	Loose to medium dense, brown, clayey SAND, moist, Abundant roots and organics. Scattered gravel and charcoal. **TOPSOIL)**					
		CL	Stiff, olive brown, sandy CLAY, moist. Scattered roots. **(ALLUVIUM)**					
5			Becomes stiff to very stiff. Sand fraction increases, trace gravel.					
			Becomes very stiff.					
		ML	Very stiff, brown, sandy SILT, moist.		S-1			
10			Medium dense or very stiff soil.					

HH-5 terminated at 8.3 feet below ground surface (bgs).
DCP terminated at 12.03 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 5

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-10

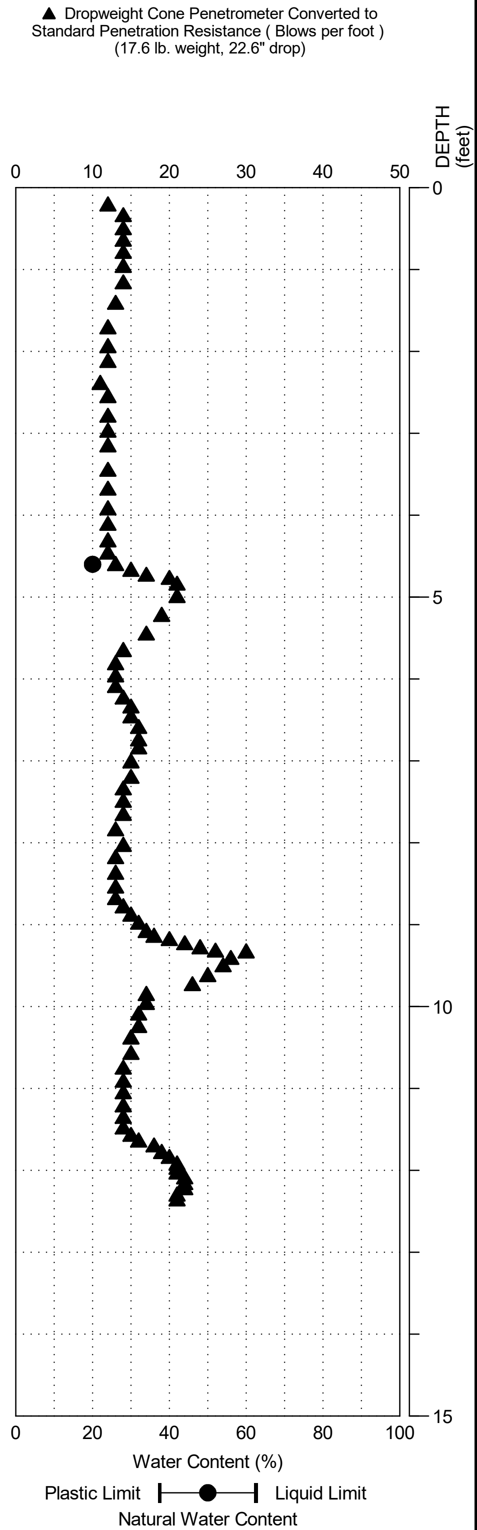
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2023
DATE COMPLETED: 5/17/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SC	Medium dense, dark brown, clayey SAND, moist. Abundant roots. **(TOPSOIL)**					
		CL	Stiff, olive brown, sandy CLAY, moist. **(ALLUVIUM)**					
5			Very stiff, olive brown, slightly gravelly, sandy CLAY, moist. Scattered roots.	Grab	S-1			
			Stiff, olive brown, sandy CLAY, moist. Scattered charcoal.					
			Contains scattered roots.					
			Sand fraction increases.					
			Medium dense, or very stiff to hard soil.					
10								
15								

HH-6 terminated at 8 feet below ground surface (bgs).
DCP terminated at 12.35 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 6

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-11

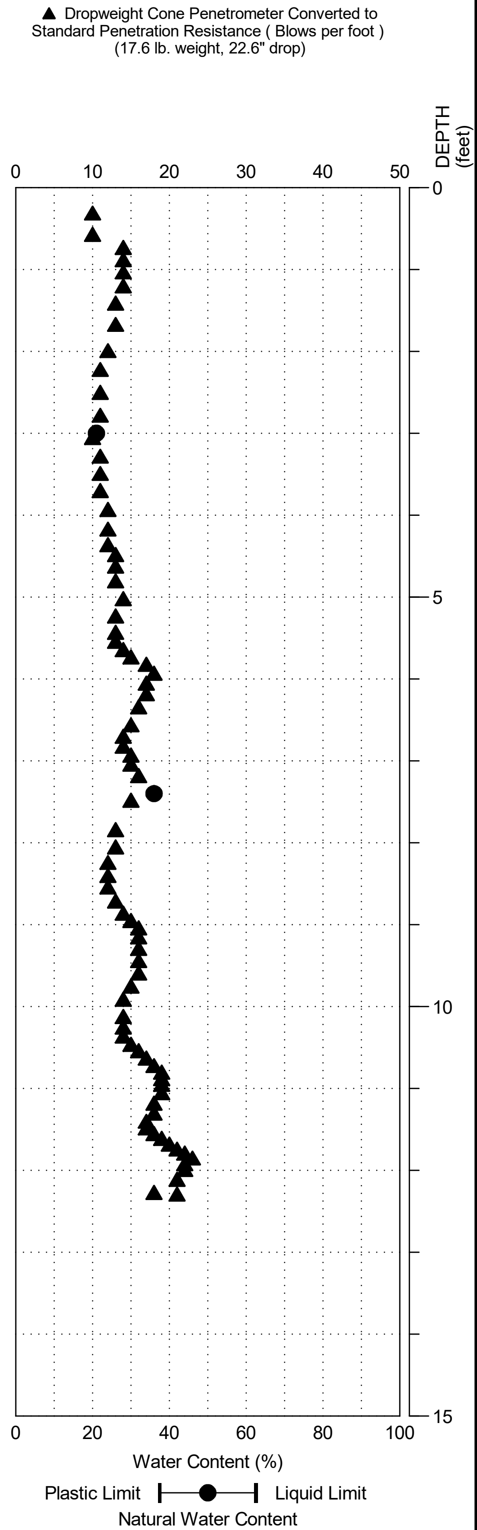
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2023
DATE COMPLETED: 5/17/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		CL	Stiff, olive brown, sandy CLAY, moist. Scattered charcoal, roots. **(ALLUVIUM)**					
		SC	Medium dense, olive brown, very clayey SAND, moist.	Grab	S-1			
		CL	Stiff, olive brown, sandy clay, moist.					
5			Very stiff, olive brown, sandy CLAY, moist. Scattered charcoal.					
			Stiff, reddish-brown, CLAY, moist. Scattered charcoal. Interbedded with olive brown, sandy CLAY, moist.	Grab	S-2			
			Primarily sandy clay.					
			Medium dense, or stiff to hard soil.					
10								
15								

HH-7 terminated at 9.2 feet below ground surface (bgs).
DCP terminated at 12.29 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 7

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-12

HAND HOLE WITH DCP TO SPT 2022-144.GPJ 8/8/23

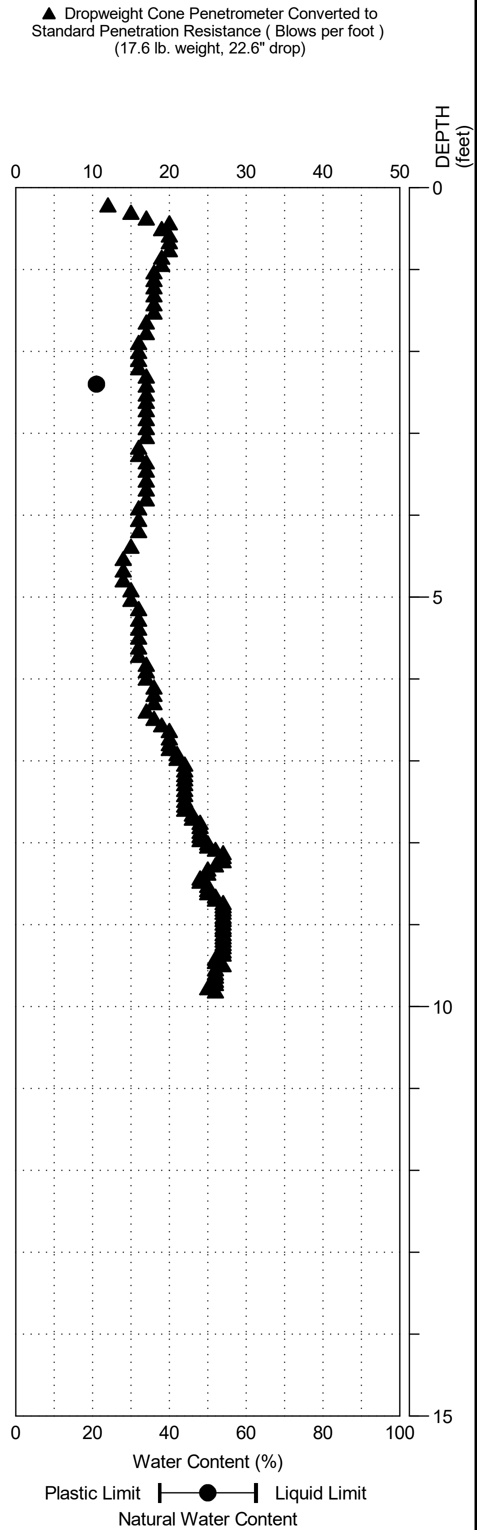
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/18/2023
DATE COMPLETED: 5/18/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		CL	Very stiff, olive brown, sandy CLAY, moist. **(ALLUVIUM)**					
			Scattered charcoal.					
			Very stiff, olive brown, sandy CLAY, moist.		S-1		GS	
5			Sand fraction increases.					
		SM	Medium dense, olive brown, silty SAND, moist.					
			Medium dense or very stiff soil.					
10								
15								

HH-8 terminated at 8 feet below ground surface (bgs).
DCP terminated at 9.81 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 8

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-13

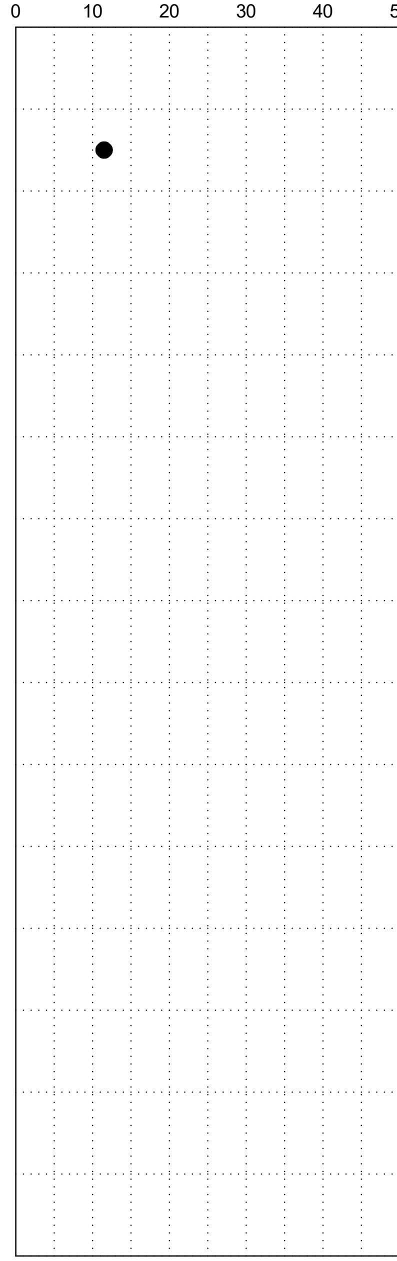
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/18/2023
DATE COMPLETED: 5/18/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SC	Loose to medium dense, brown, clayey SAND, moist. Scattered roots, organics. **(TOPSOIL)**					
		CL	Stiff to very stiff, olive brown, sandy CLAY, moist. Scattered roots. **(ALLUVIUM)**	Grab	S-1			
5		SC	Loose to medium dense, olive brown, slightly gravelly, very clayey SAND, moist.					
		CL	Stiff to very stiff, olive brown, sandy CLAY, moist. Scattered charcoal.					

HH-8 terminated at 8.4 feet below ground surface.
No DCP conducted due to remote location/access issues.
No groundwater encountered during the exploration.
boring abandoned with native cuttings.



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

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH- 9

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-14

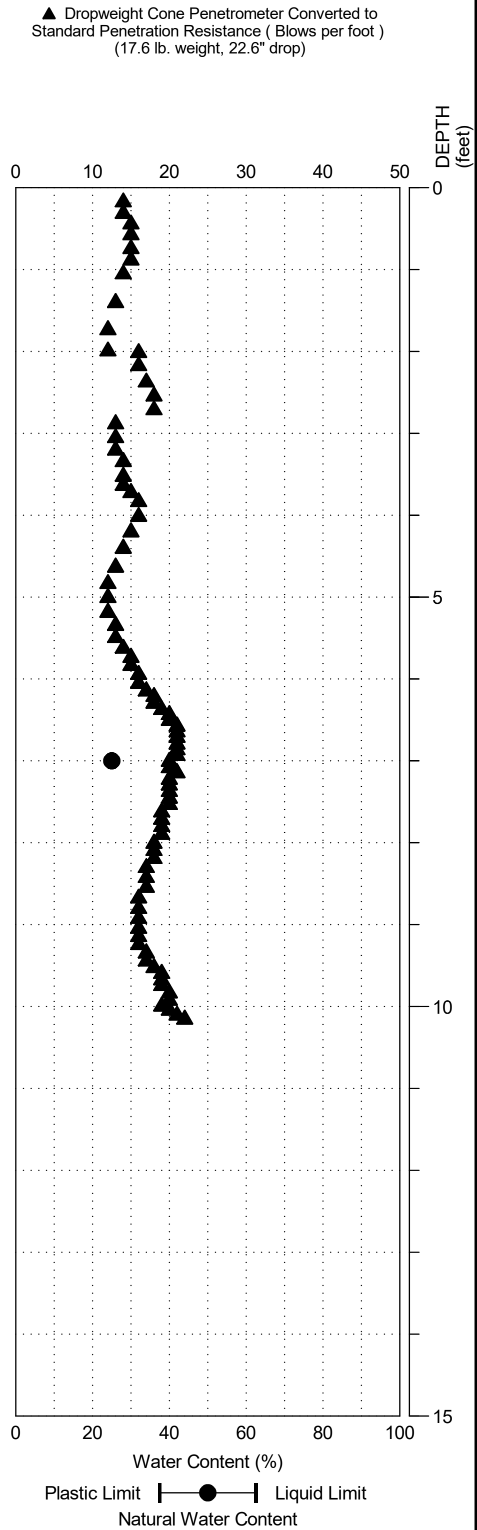
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/18/2023
DATE COMPLETED: 5/18/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SC	Medium dense, brown, clayey SAND, moist. Scattered organics. **(TOPSOIL)**					
		CL	Stiff, olive brown, sandy CLAY, moist. Scattered organics. **(ALLUVIUM)**					
			Scattered gravel.					
			Scattered charcoal.					
5			Becomes very stiff.					
			Very stiff, oilve brown, sandy CLAY, moist.		S-1			
			Medium dense or very stiff soil.					
10								

HH-10 terminated at 8.7 feet below ground surface (bgs).
DCP terminated at 10.13 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH-10

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-15

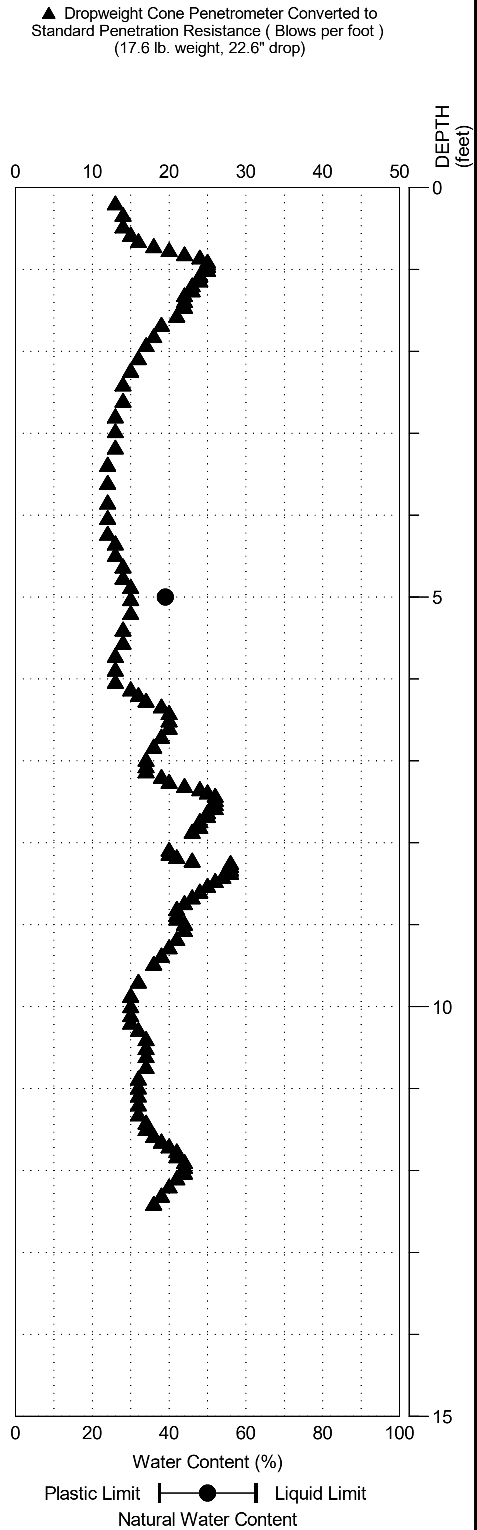
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2023
DATE COMPLETED: 5/16/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SC	Medium dense, dark olive brown, clayey SAND, moist. Scattered charcoal, roots. **(FILL)**					
		CL	Stiff, olive brown, sandy CLAY, moist. **(ALLUVIUM)**					
5				Grab	S-1			
			Becomes very stiff.					
		SC	Medium dense, olive brown, gravelly, clayey SAND, moist.					
			Medium dense or very stiff soil.					
10								

HH-11 terminated at 9 feet below ground surface (bgs).
DCP terminated at 12.4 feet bgs.
No groundwater encountered during the exploration.
Boring abandoned with native cuttings.



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

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH-11

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-16

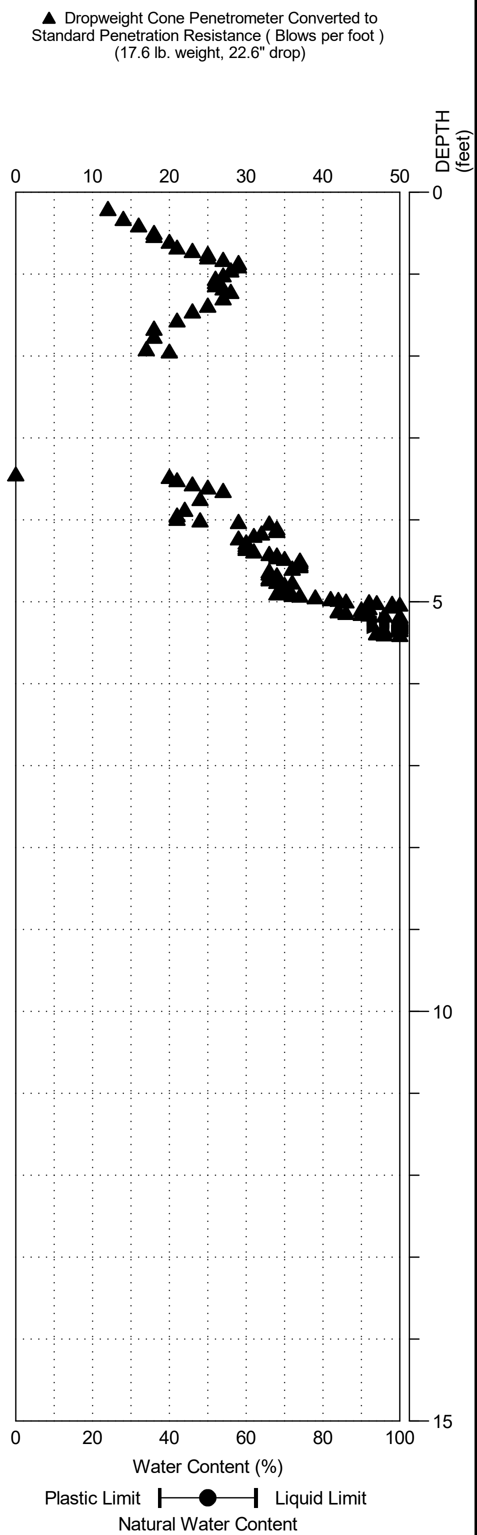
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Bucket Auger, 3" ID
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2023
DATE COMPLETED: 5/16/2023
LOGGED BY: M.A. Benson

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SM	Medium dense, very dark brown, silty, gravelly SAND, moist. Abundant roots. **(TOPSOIL/WETLAND DEPOSITS)**					▽
		GP	Medium dense, dark gray, sandy GRAVEL, wet. **(BURIED CREEK BED)**					
			Medium dense or very stiff soil.					
			DCP rods drop 1.5 feet under own weight. Very loose or very soft soil.					
			Medium dense to very dense, or very stiff to hard soil.					
5								

HH-12 terminated at 0.7 feet below ground surface (bgs) due to refusal on cobbles.
DCP terminated at 5.4 feet bgs.
Groundwater encountered at 0.6 feet bgs during the exploration.
Boring abandoned with native cuttings.



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

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

HAND HOLE:
HH-12

PAGE: 1 of 1

PROJECT NO.: 2022-144-21 FIGURE: A-17

APPENDIX B

LABORATORY TESTING

APPENDIX B

LABORATORY TESTING

Representative soil samples obtained from the explorations were placed in plastic bags to prevent loss of moisture and transported to our Bothell, Washington, laboratory for further examination and testing. Laboratory tests were conducted on selected soil samples to characterize relevant engineering and index properties of the site soils.

MOISTURE CONTENT OF SOIL: The moisture content of selected soil samples (percent by dry mass) was determined in general accordance with ASTM D 2216. The results are shown at the sampled intervals on the appropriate summary logs in Appendix A and on the Summary of Material Properties provided on Figures B-1 and B-2 in Appendix B.

PARTICLE SIZE ANALYSIS OF SOILS: Selected samples were tested to determine the particle (grain) size distribution of material in general accordance with ASTM D 422. The results are summarized on the attached Summary of Material Properties, Figures B-1 and B-2, and Particle Size Analysis of Soils reports, Figures B-3 and B-4 (Appendix B) which also provide information regarding the classification of the sample.

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ATTERBERG LIMITS): Selected samples were tested using method ASTM D 4318, multi-point method. The results are reported on the attached Liquid Limit, Plastic Limit, and Plasticity Index report, Figure B-5 (Appendix B)

DIRECT SHEAR TESTING: Selected samples were tested to determine shear strength parameters of the material in general accordance with ASTM D 3080. The results are summarized in the direct shear test reports, Figures B-6 and B-7 (Appendix B).

CONSOLIDATION TESTING: A select sample was tested to determine consolidation parameters of the material in general accordance with ASTM D 2435. The results are summarized in the direct shear test reports, Figures B-8 through B-12 (Appendix B).

EXPLORATION DESIGNATION	TOP DEPTH (feet)	BOTTOM DEPTH (feet)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS (%) LL	PL	PI	% GRAVEL	% SAND	% FINES	ASTM SOIL CLASSIFICATION	SAMPLE DESCRIPTION
BH-1,S-1	2.5	4.0	18.1									CL	Brown, sandy lean CLAY
BH-1,S-5	12.5	14.0	21.9									CL	Brown, sandy lean CLAY
BH-1,S-6b	15.5	16.5	17.7									SM	Yellowish-brown, silty SAND
BH-1,S-10	30.0	31.5	6.9						42.9	47.6	9.5	SP-SM	Dark grayish-brown, poorly graded SAND with silt and gravel
BH-2,S-2	5.0	6.5	19.6									CL	Yellowish-brown, sandy lean CLAY
BH-2,S-4	10.0	11.5	23.9			34	26	8			54.4	ML	Yellowish-brown, sandy SILT
BH-2,S-6	15.0	16.5	18.9									CL	Yellowish-brown, sandy lean CLAY
BH-2,S-8b	21.0	21.5	10.7									SM	Yellowish-brown, silty SAND
BH-2,S-10	30.0	31.5	10.2									SM	Dark grayish-brown, silty SAND
BH-3,S-3	7.5	9.0	18.4									CL	Olive, lean CLAY with sand
BH-3,S-5	12.5	14.0	19.1						0.0	52.5	47.5	SM	Olive, silty SAND
BH-3,S-7	17.5	19.0	20.0									CL	Olive, sandy lean CLAY
BH-3,S-11	35.0	36.5	6.2									SM	Dark olive-gray, silty SAND with gravel
BH-4,S-5	12.5	14.0	17.1									SM	Olive, silty SAND
BH-4,S-6	15.0	16.5	21.0									SM	Olive, silty SAND
BH-4,S-8b	20.5	21.5	38.2									ML	Olive-brown, SILT with sand and organics
BH-4,S-10b	30.5	31.5	11.1									SM	Olive, silty SAND
HH- 1,S-1	1.5	2.0	21.1							35.3	64.7	CL	Olive-brown, sandy lean CLAY
HH- 1,S-2	6.0	6.5	23.0									SM	Olive, silty SAND
HH- 1,S-3	8.0	8.5	36.0									SC	Brown, clayey SAND

Notes:
1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report test, other graphs and tables, and the exploration logs.
2. The soil classifications in this table are based on ASTM D2487 and D2488 as applicable.

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

SUMMARY OF
MATERIAL PROPERTIES

PAGE: 1 of 2

PROJECT NO.: 2022-144-21 FIGURE: B-1

EXPLORATION DESIGNATION	TOP DEPTH (feet)	BOTTOM DEPTH (feet)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS (%)			% GRAVEL	% SAND	% FINES	ASTM SOIL CLASSIFICATION	SAMPLE DESCRIPTION
						LL	PL	PI					
HH- 2,S-1	2.0	2.5	24.8									CL	Olive-brown, sandy lean CLAY
HH- 3,S-1	4.4	4.9	16.8									SM	Light olive-brown, silty SAND
HH- 4,S-1	1.3	1.8	22.9									CL	Olive, sandy lean CLAY
HH- 4,S-2	4.2	4.7	25.1							39.1	60.9	ML	Olive, sandy SILT
HH- 5,S-1	7.9	8.3	22.7									ML	Light olive-brown, sandy SILT
HH- 6,S-1	4.6	5.1	19.9									CL	Olive, sandy lean CLAY
HH- 7,S-1	3.0	3.5	20.6									SC	Olive, clayey SAND
HH- 7,S-2	7.4	7.9	35.8									CL	Brown, lean CLAY with trace organics
HH- 8,S-1	2.4	2.9	20.7							35.2	64.8	CL	Olive, sandy lean CLAY
HH- 9,S-1	1.5	2.0	23.1									CL	Olive, sandy lean CLAY with trace organics
HH-10,S-1	7.0	7.5	25.3									CL	Olive, sandy lean CLAY
HH-11,S-1	5.0	5.5	39.0									CL	Olive, sandy lean CLAY

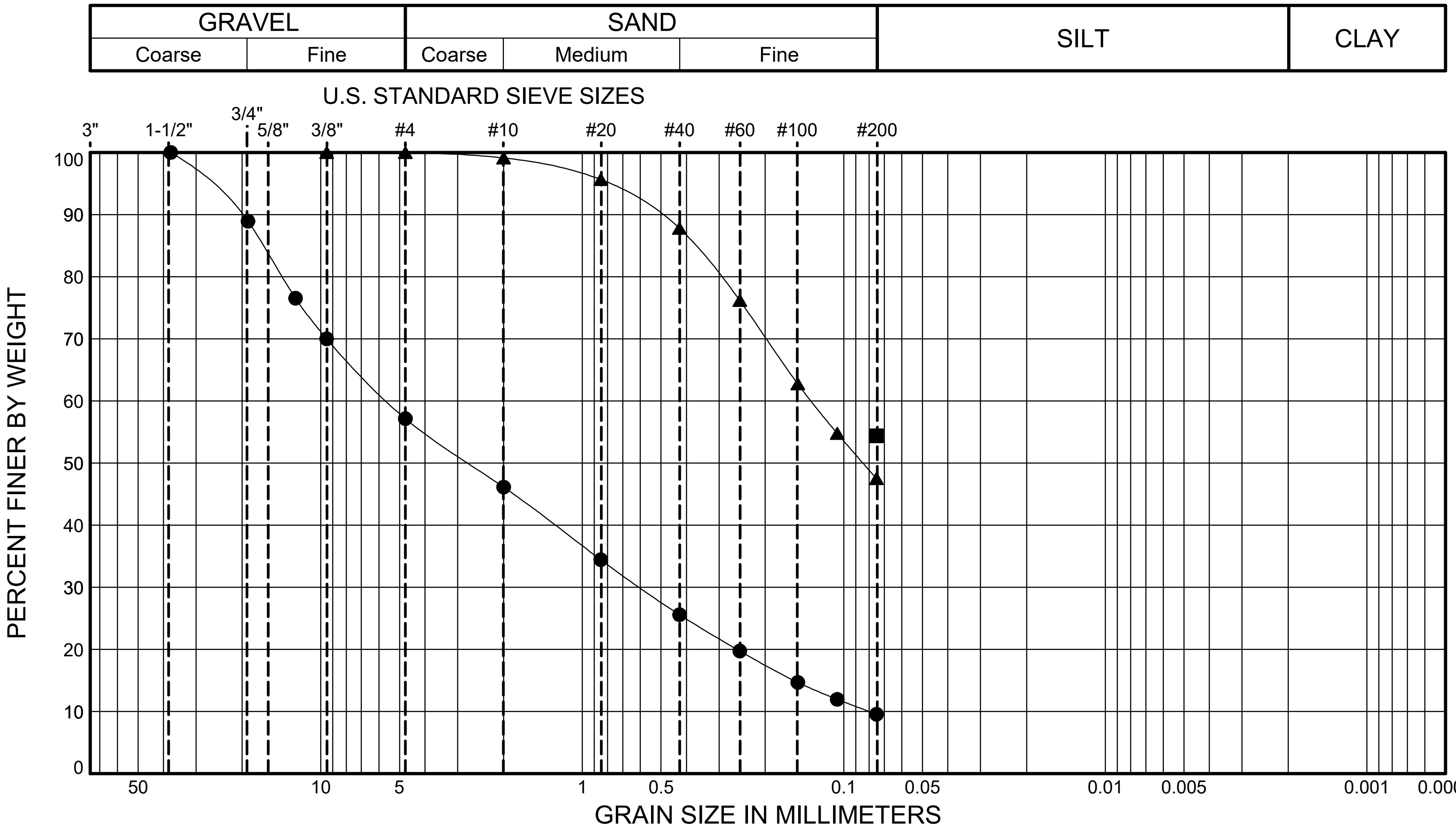
Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report test, other graphs and tables, and the exploration logs.
2. The soil classifications in this table are based on ASTM D2487 and D2488 as applicable.

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

SUMMARY OF MATERIAL PROPERTIES

PROJECT NO.: 2022-144-21 FIGURE: B-2



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	BH-1	S-10	30.0 - 31.5	(SP-SM) Dark grayish-brown, poorly graded SAND with silt and gravel	7				42.9	47.6	9.5
■	BH-2	S-4	10.0 - 11.5	(ML) Yellowish-brown, sandy SILT	24	34	26	8			54.4
▲	BH-3	S-5	12.5 - 14.0	(SM) Olive, silty SAND	19				0.0	52.5	47.5

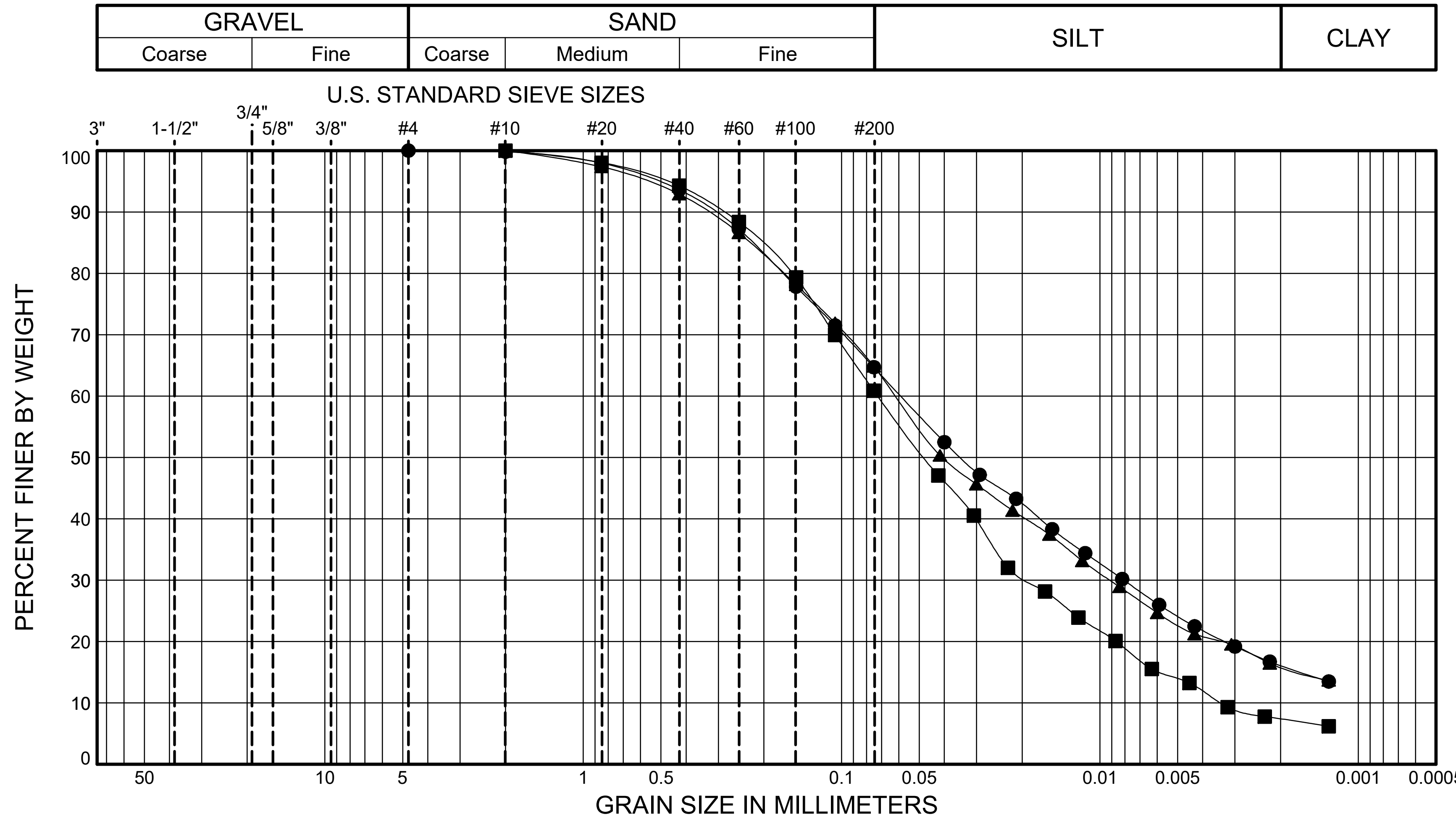
HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

PARTICLE-SIZE ANALYSIS OF SOILS METHOD ASTM D422

PROJECT NO.: 2022-144-21 FIGURE: B-3

HWAGRSZ 2022-144.GPJ 7/11/23



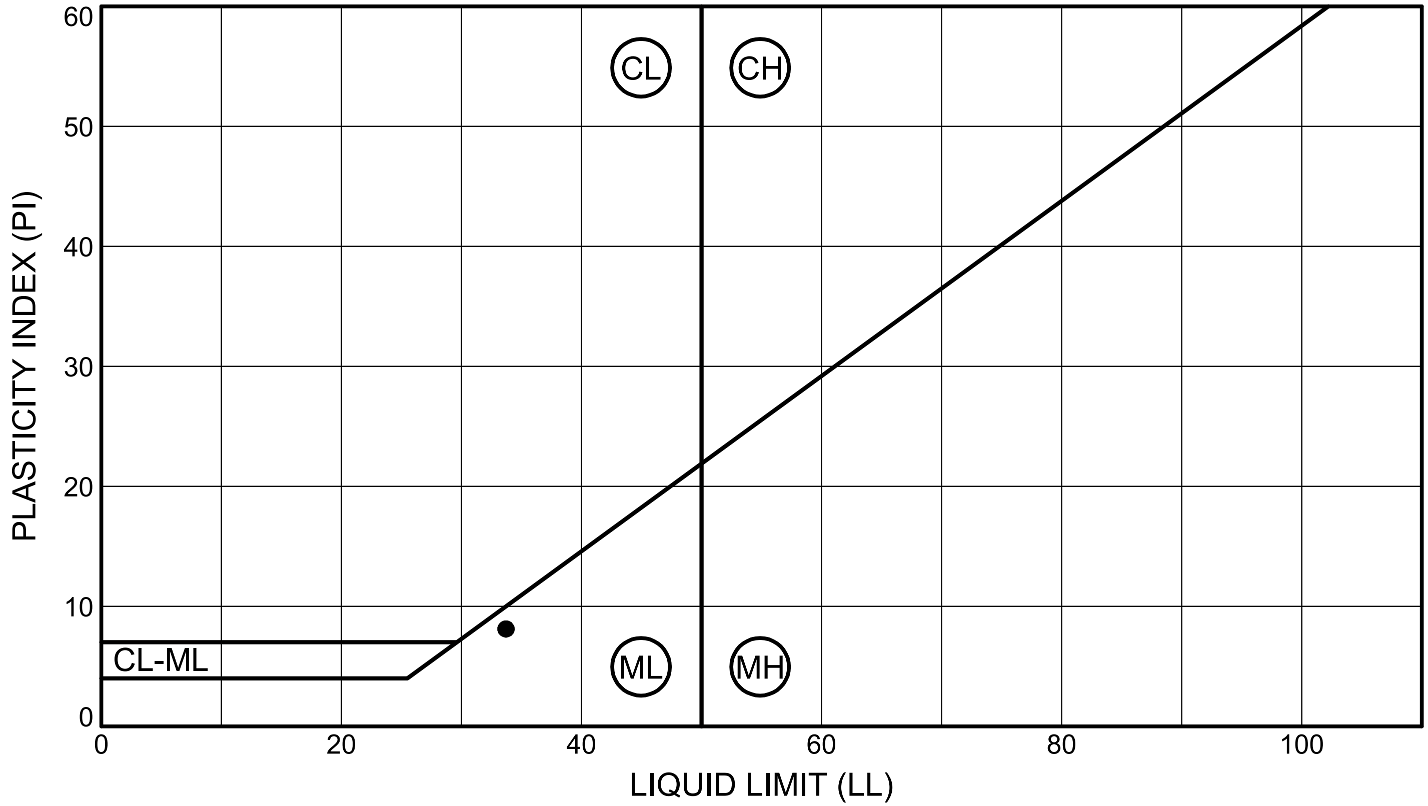
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	HH- 1	S-1	1.5 - 2.0	(CL) Olive-brown, sandy lean CLAY	21					35.3	64.7
■	HH- 4	S-2	4.2 - 4.7	(ML) Olive, sandy SILT	25					39.1	60.9
▲	HH- 8	S-1	2.4 - 2.9	(CL) Olive, sandy lean CLAY	21					35.2	64.8

HWA GEOSCIENCES INC.

Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

PARTICLE-SIZE ANALYSIS OF SOILS METHOD ASTM D422

PROJECT NO.: 2022-144-21 FIGURE: B-4



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	BH-2	S-4	10.0 - 11.5	(ML) Yellowish-brown, sandy SILT	24	34	26	8	54.4

HWA GEOSCIENCES INC.

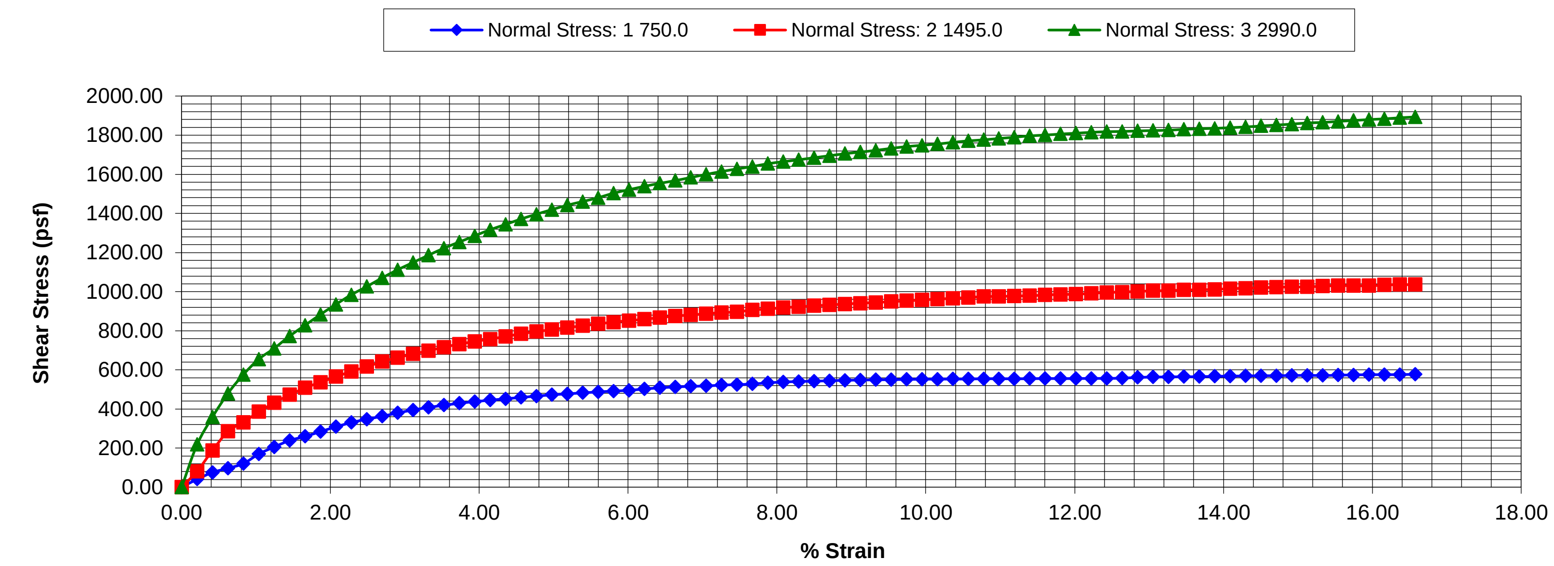
Yakama Nation Nason Creek Floodplain
SR 207 Reroute
Chelan County, Washington

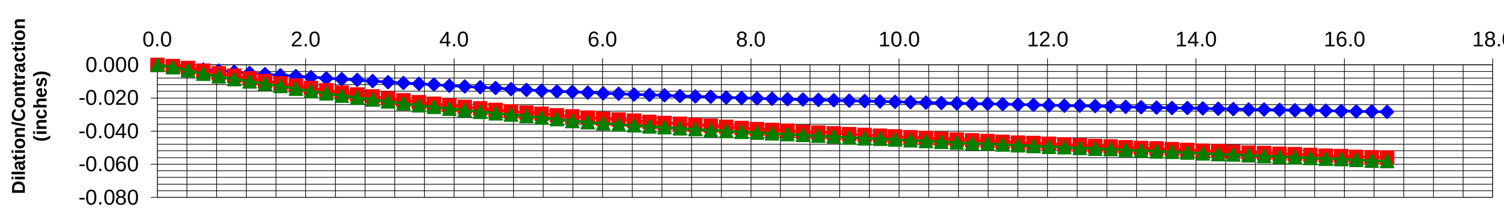
LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS
METHOD ASTM D4318

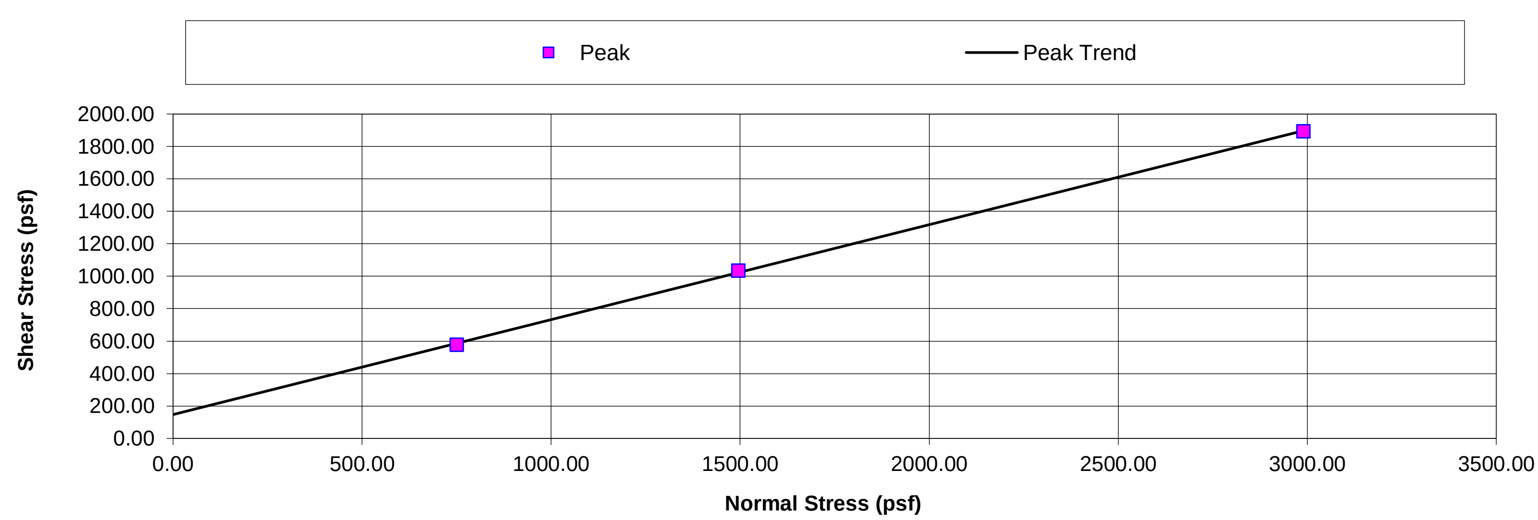
PROJECT NO.: 2022-144-21 FIGURE: B-5

HWA GeoSciences Inc. Materials Testing Laboratory						
Direct Shear Test of Soils Under Consolidated Drained Conditions (ASTM D 3080)						
Project Name:	Nason Creek Floodplain			**Project Number:**	2022-144	
Sample Point:	BH-2	**Sample No.:** S-5		**Sample Depth:**	12.5	
Soil Description:	Olive-brown, clayey SAND					
Soil Color:	Olive-brown			Average Strain Rate:	0.5	% per min.
Soil Group Symbol:	SC			Soil Specific Gravity:	2.65	(assumed)

Normal Stress (psf)	750.00	1495.00	2990.00	**Average**	Indicated Strength Parameters		
Peak Stress (psf)	577.35	1035.57	1892.98				
Initial Moisture Content (%):	23.3	23.3	23.3	23.3		Cohesion	phi Angle
Wet Unit Weight (pcf):	111.2	111.1	110.5	110.9		psf	(degrees)
Dry Unit Weight (pcf):	90.2	90.1	89.6	90.0	Peak	147.2	30.3
Calculated Void Ratio	0.833	0.835	0.845	0.838			
Calculated Porosity	0.454	0.455	0.458	0.456			
Calculated Saturation (%)	74.1	73.9	73.0	73.7			
Final Moisture Content (%)	28.5	27.9	24.5	27.0			







Checked By: SEG

Figure B-6

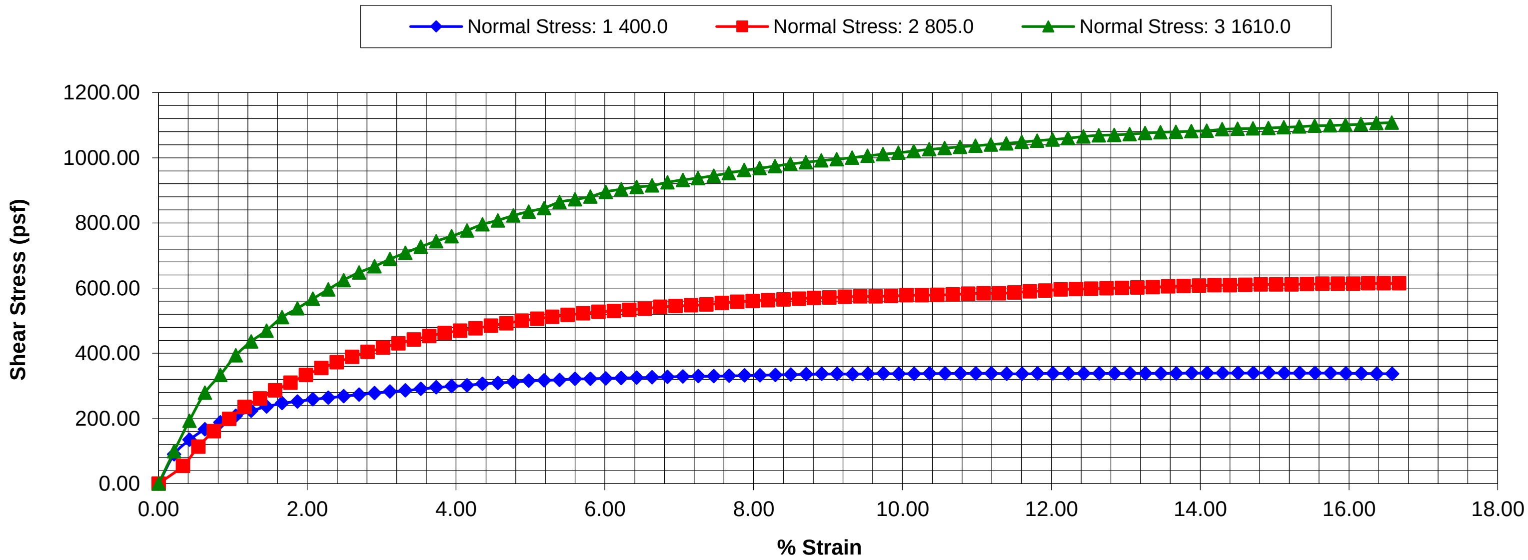
HWA GEOSCIENCES INC. Materials Testing Laboratory
Direct Shear Test of Soils Under Consolidated Drained Conditions (ASTM D 3080)

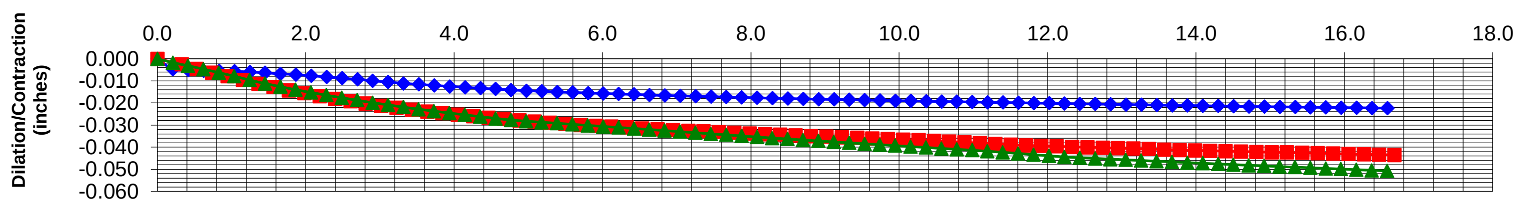
Project Name:	Nason Creek Floodplain		**Project Number:**	2022-144
Sample Point:	BH-4	**Sample No.:** S-2	**Sample Depth:**	5.0
Soil Description:	Olive-brown, lean CLAY with sand			
Soil Color:	Olive-brown		Average Strain Rate:	0.5 % per min.
Soil Group Symbol:	CL		Soil Specific Gravity:	2.65 (assumed)

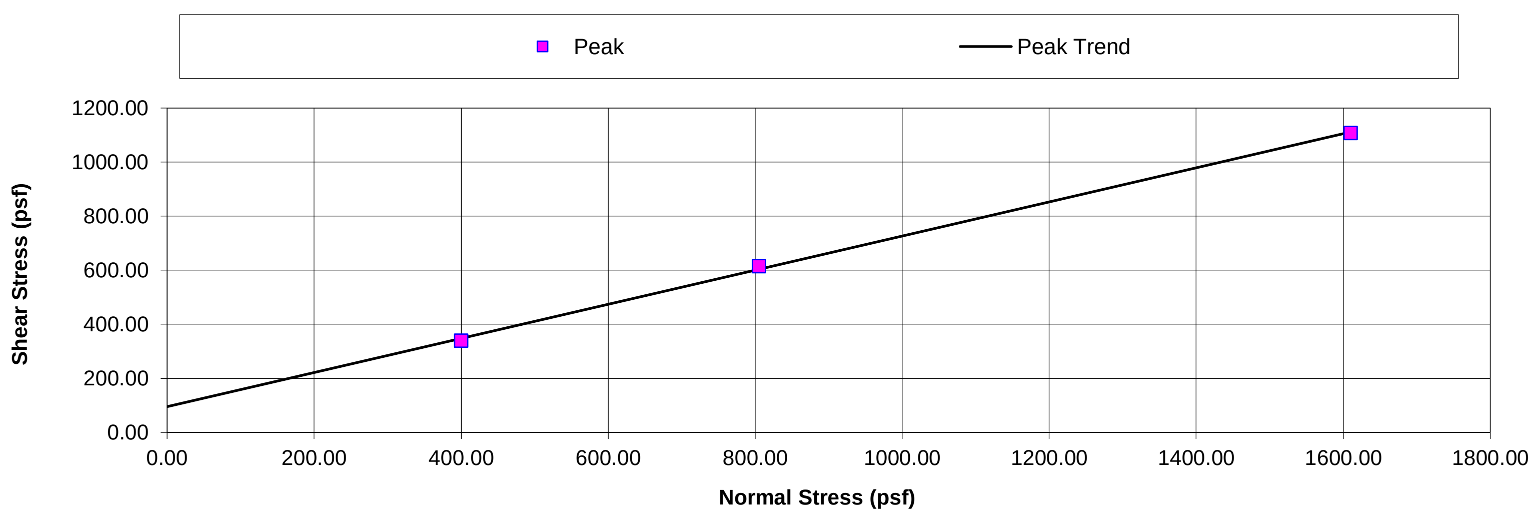
Normal Stress (psf)	400.00	805.00	1610.00	**Average**
Peak Stress (psf)	340.20	614.78	1107.60	
Initial Moisture Content (%):	26.4	26.4	26.4	26.4
Wet Unit Weight (pcf):	108.1	107.0	106.8	107.3
Dry Unit Weight (pcf):	85.5	84.6	84.5	84.9
Calculated Void Ratio	0.934	0.954	0.957	0.948
Calculated Porosity	0.483	0.488	0.489	0.487
Calculated Saturation (%)	75.0	73.4	73.2	73.9
Final Moisture Content (%)	29.8	29.2	27.1	28.7

Indicated Strength Parameters

	Cohesion psf	phi Angle (degrees)
Peak	95.3	32.3



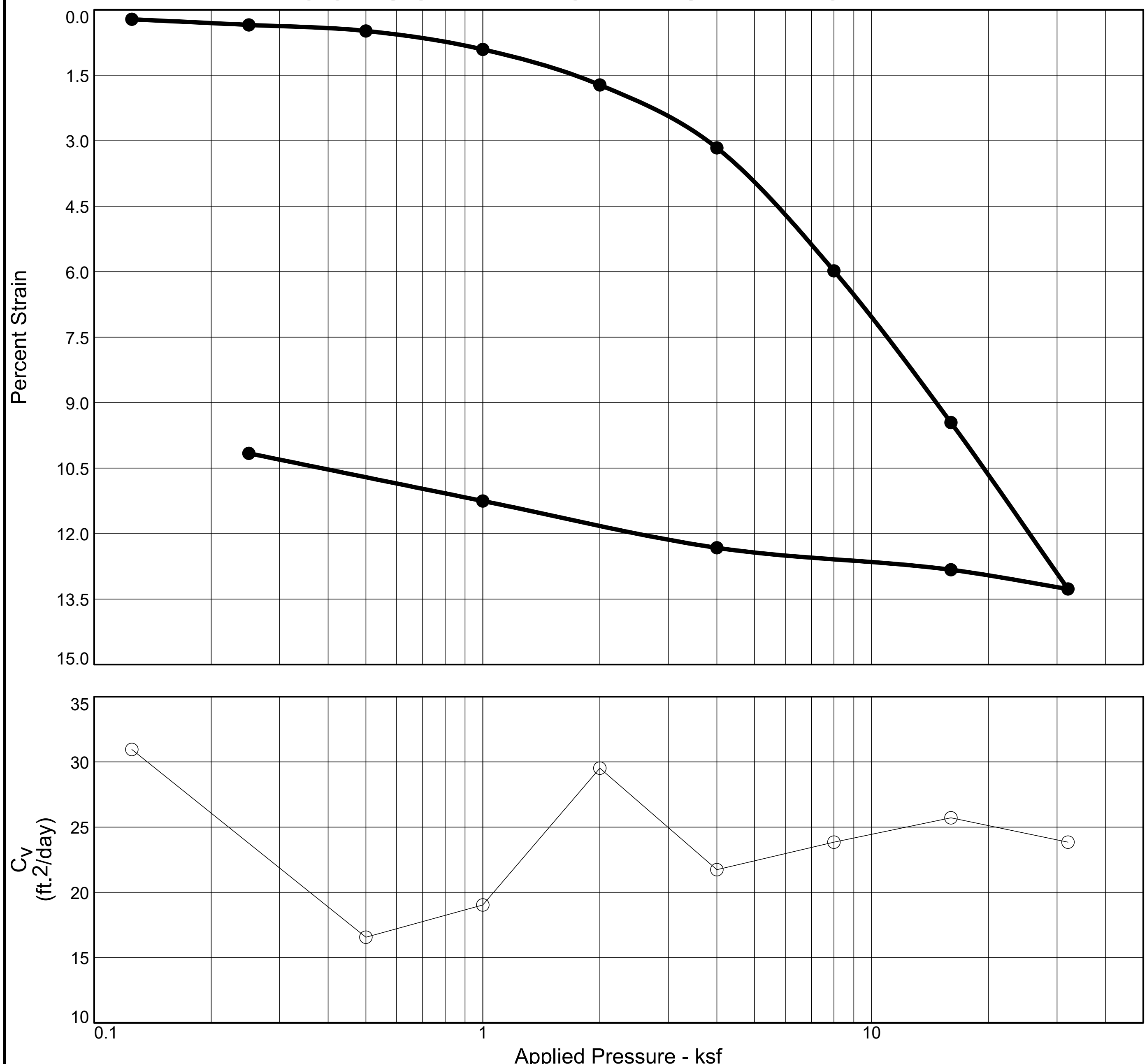




Checked By: SEG

Figure B-7

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
84.9 %	26.3 %	88.6			2.65	CL		0.822

MATERIAL DESCRIPTION

Olive-brown, lean CLAY with sand

Project No. 2022-144 **Client:**

Project: Yakama Nation Nason Creek Floodplain

Source of Sample: BH-4 **Depth:** 5.0 **Sample Number:** S-2

HWA GEOSCIENCES INC. DBE/MWBE

Remarks:

Assumed Specific Gravity

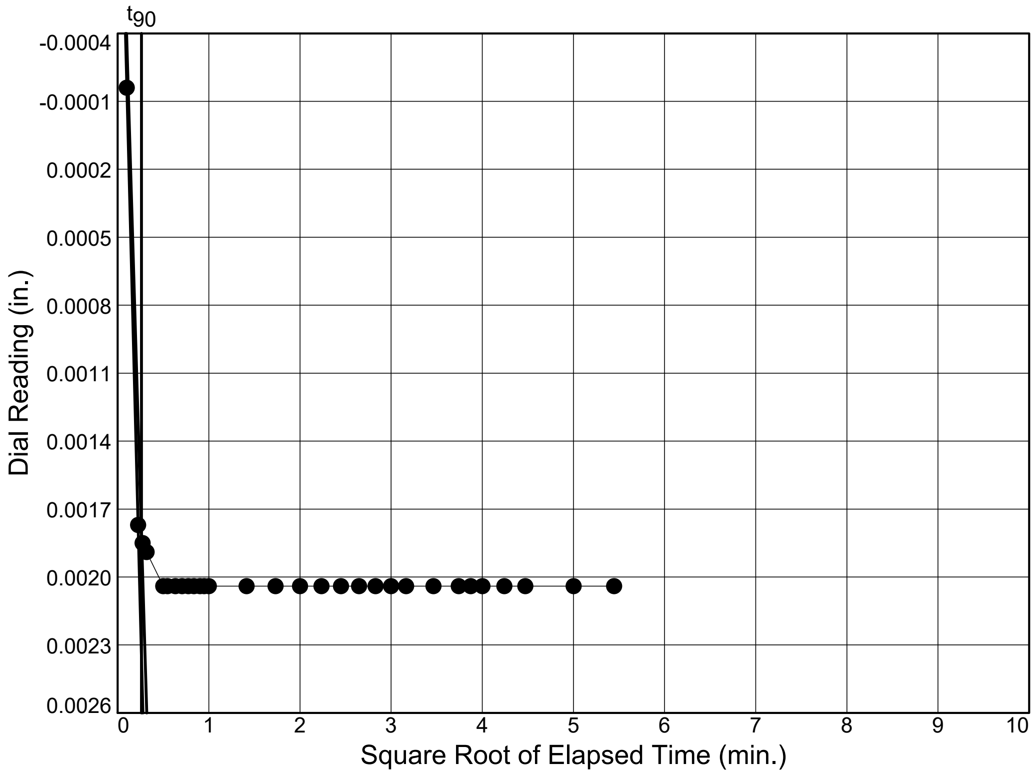
Figure B-8

Tested By: AH **Checked By:** SEG

Dial Reading vs. Time

Project No.: 2022-144
Project: Yakama Nation Nason Creek Floodplain

Source of Sample: BH-4 Depth: 5.0 Sample Number: S-2



Load No.= 1

Load= 0.13 ksf

D_0 = -0.0017

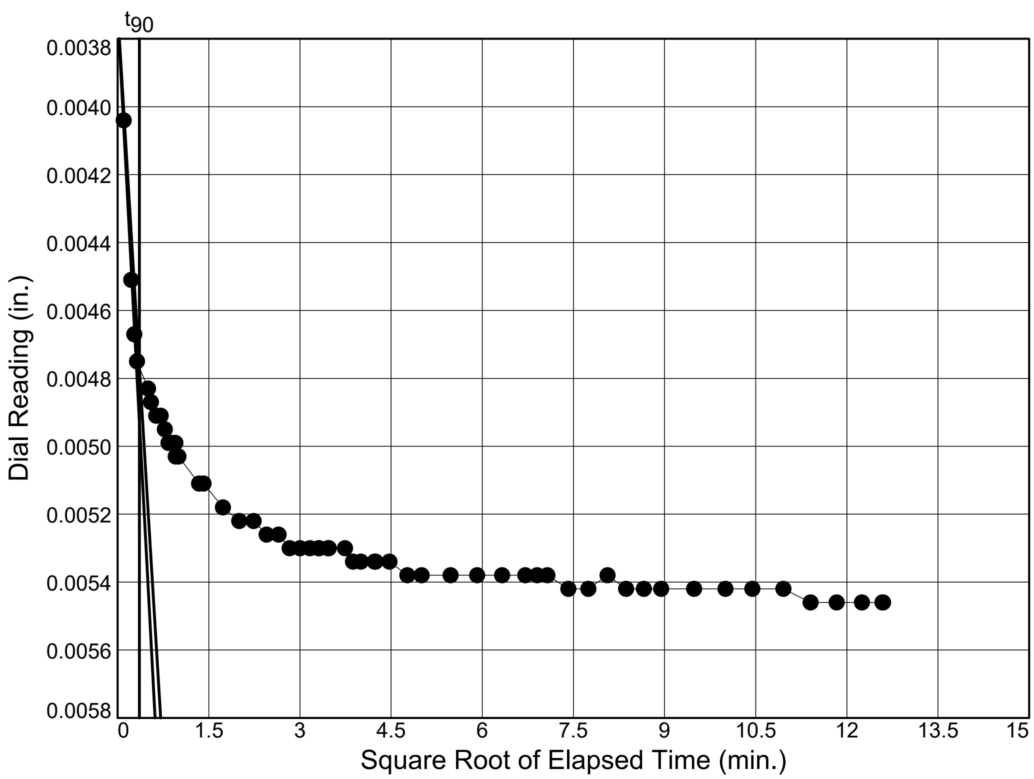
D_{90} = 0.0018

D_{100} = 0.0022

T_{90} = 0.07 min.

C_v @ T_{90}

30.950 ft.^{2}/day



Load No.= 3

Load= 0.50 ksf

D_0 = 0.0037

D_{90} = 0.0048

D_{100} = 0.0049

T_{90} = 0.13 min.

C_v @ T_{90}

16.564 ft.^{2}/day

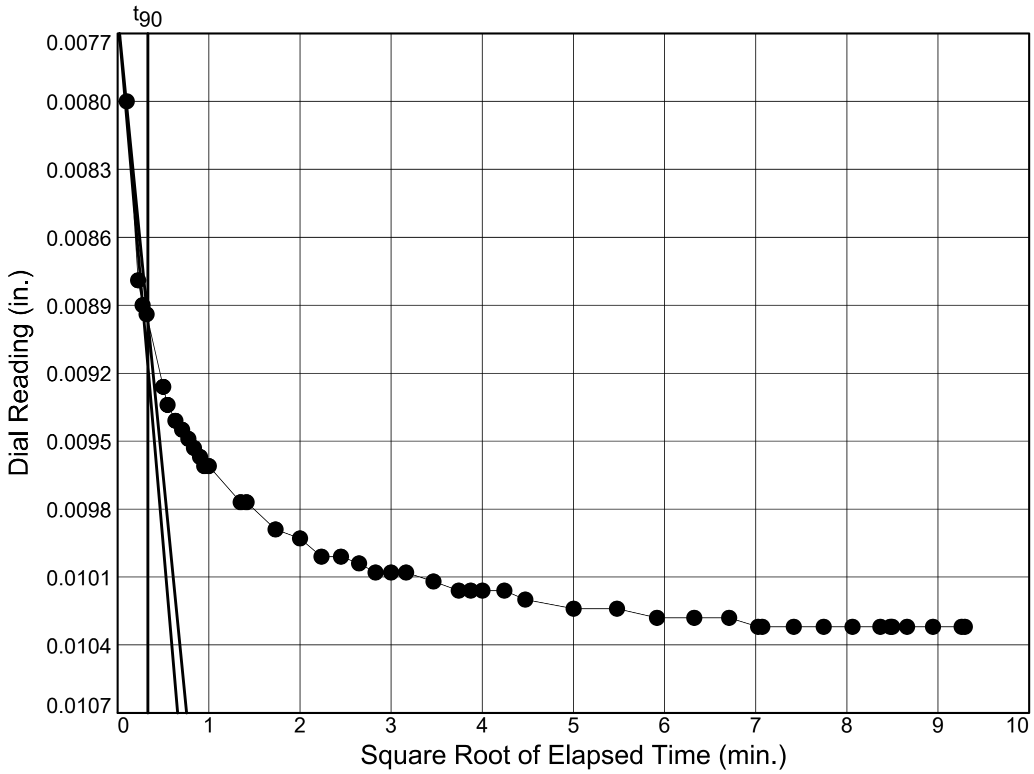
Figure B-9

HWA GeoSciences Inc.

Dial Reading vs. Time

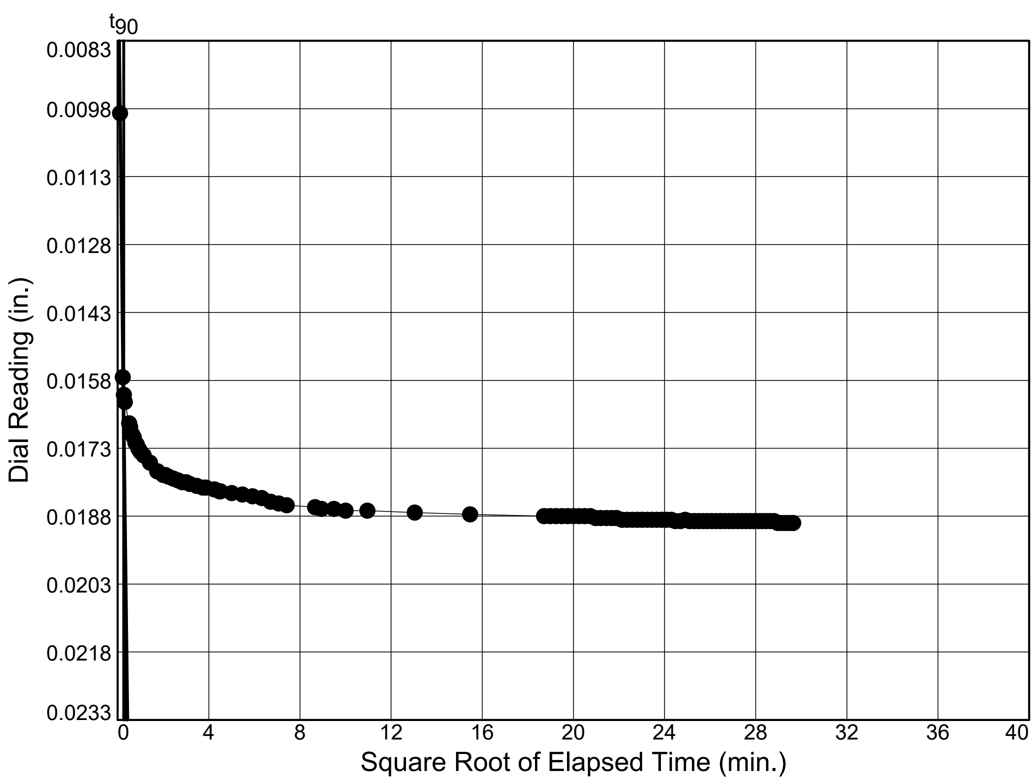
Project No.: 2022-144
Project: Yakama Nation Nason Creek Floodplain

Source of Sample: BH-4 Depth: 5.0 Sample Number: S-2



Load No.= 4
Load= 1.00 ksf
D_0 = 0.0076
D_{90} = 0.0090
D_{100} = 0.0091
T_{90} = 0.11 min.

C_v @ T_{90}
19.029 ft.^{2}/day



Load No.= 5
Load= 2.00 ksf
D_0 = 0.0052
D_{90} = 0.0161
D_{100} = 0.0173
T_{90} = 0.07 min.

C_v @ T_{90}
29.521 ft.^{2}/day

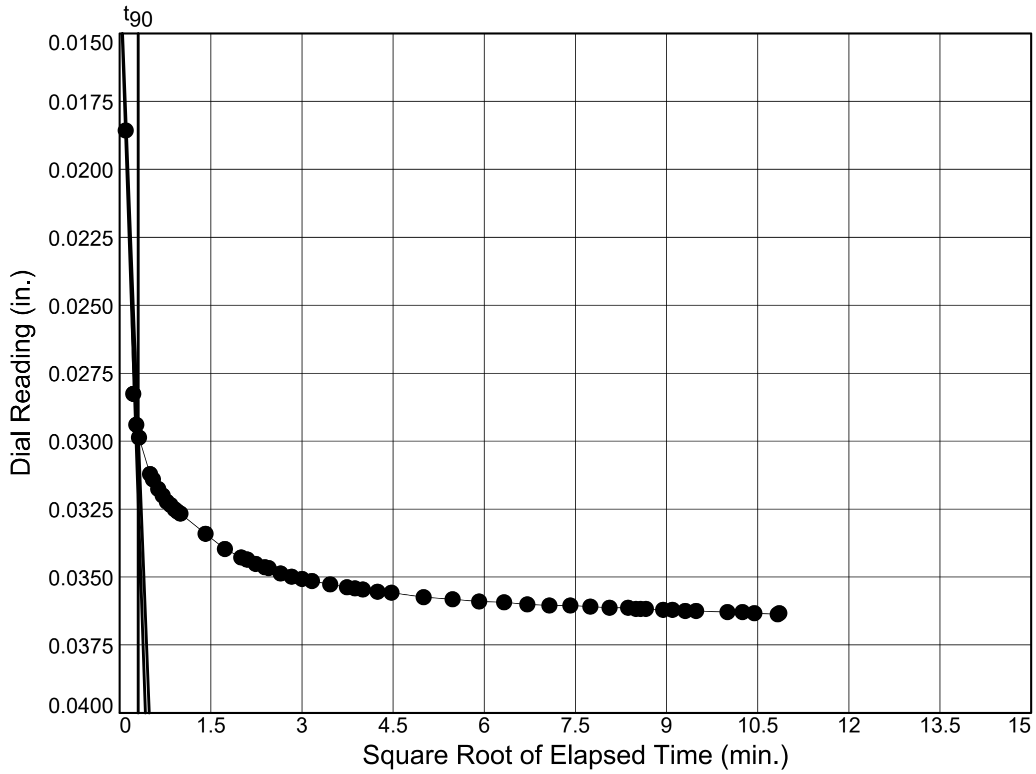
Figure B-10

HWA GeoSciences Inc.

Dial Reading vs. Time

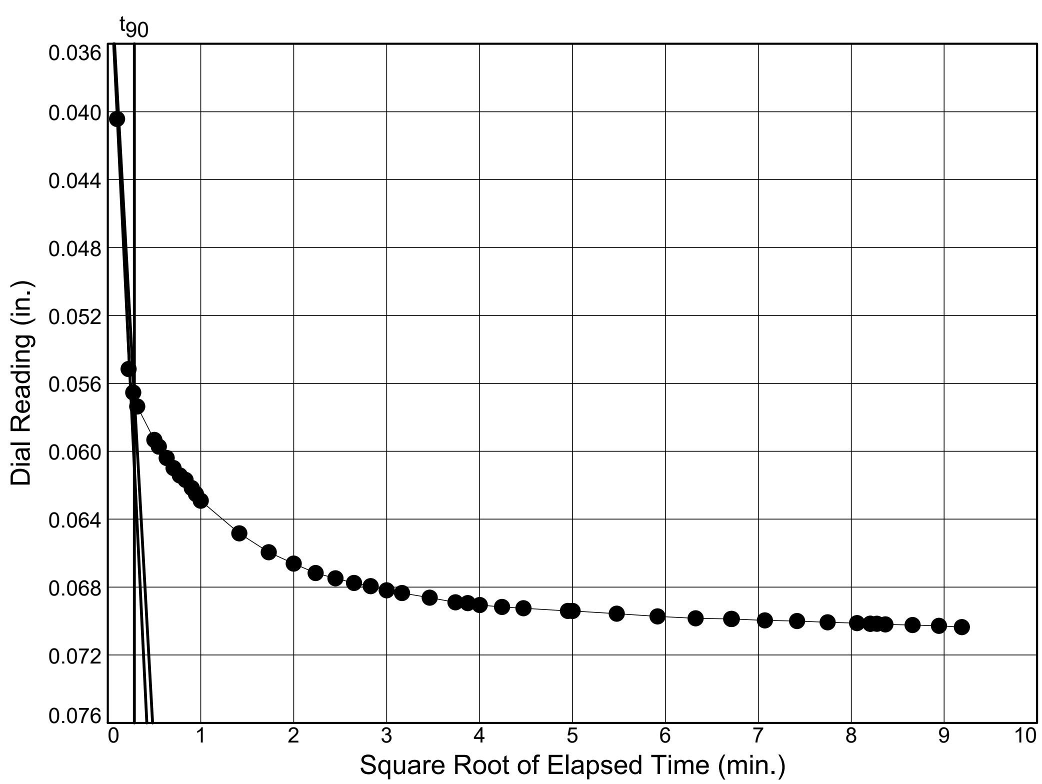
Project No.: 2022-144
Project: Yakama Nation Nason Creek Floodplain

Source of Sample: BH-4 Depth: 5.0 Sample Number: S-2



Load No.= 6
Load= 4.00 ksf
D_0 = 0.0124
D_{90} = 0.0298
D_{100} = 0.0317
T_{90} = 0.09 min.

C_v @ T_{90}
21.735 ft.^{2}/day



Load No.= 7
Load= 8.00 ksf
D_0 = 0.0289
D_{90} = 0.0568
D_{100} = 0.0598
T_{90} = 0.08 min.

C_v @ T_{90}
23.850 ft.^{2}/day

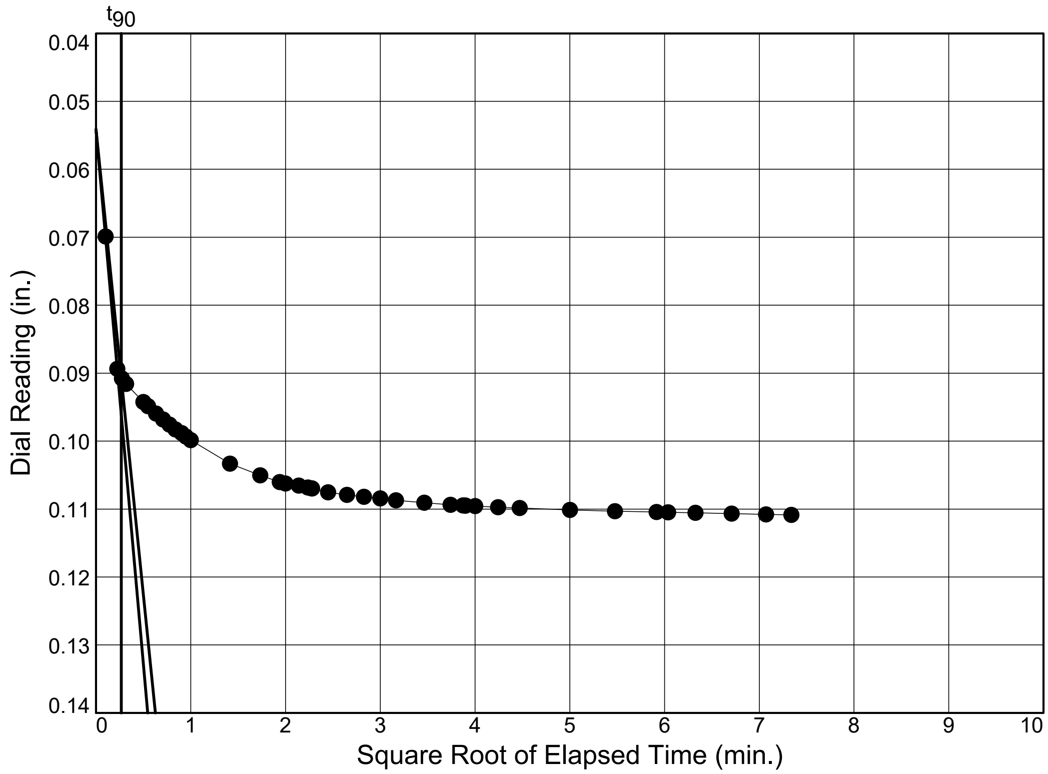
Figure B-11

HWA GeoSciences Inc.

Dial Reading vs. Time

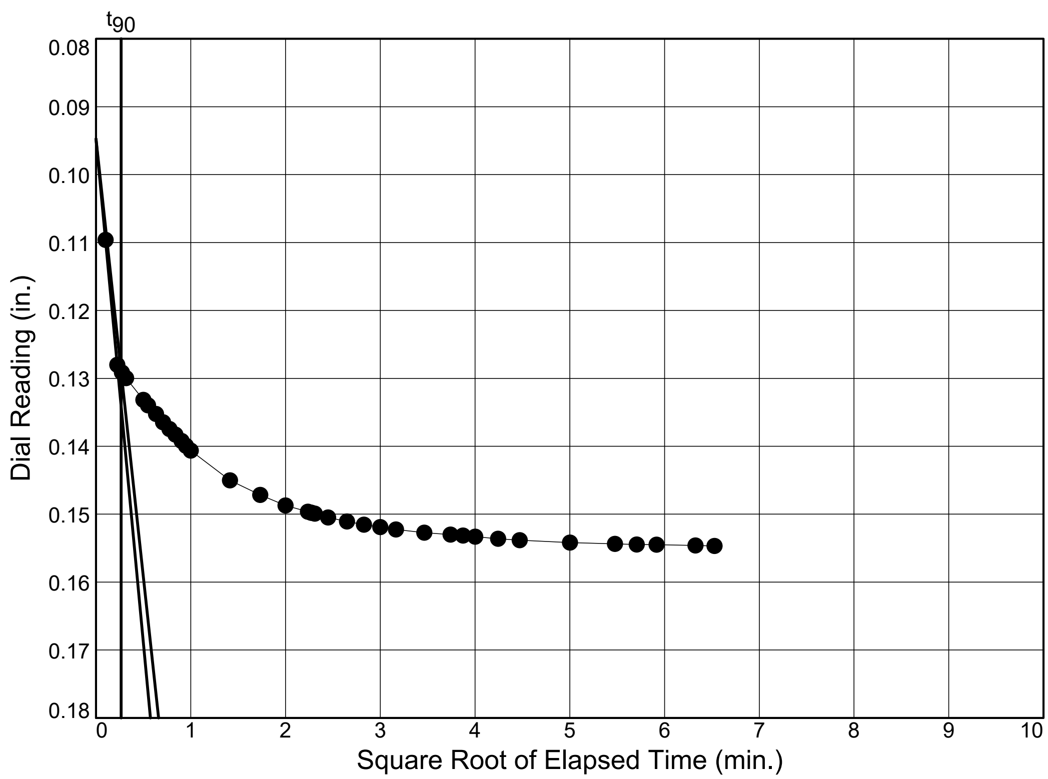
Project No.: 2022-144
Project: Yakama Nation Nason Creek Floodplain

Source of Sample: BH-4 Depth: 5.0 Sample Number: S-2



Load No.= 8
Load= 16.00 ksf
D_0 = 0.0541
D_{90} = 0.0906
D_{100} = 0.0946
T_{90} = 0.07 min.

C_v @ T_{90}
25.718 ft.^{2}/day



Load No.= 9
Load= 32.00 ksf
D_0 = 0.0947
D_{90} = 0.1289
D_{100} = 0.1327
T_{90} = 0.07 min.

C_v @ T_{90}
23.843 ft.^{2}/day

Figure B-12