Exhibit 12.D.2

PRELIMINARY GEOTECHNICAL REPORT
24th Street SE Extension
Lake Stevens, Washington

HWA Project No. 2015-098-21

Prepared for
City of Lake Stevens

January 15, 2016

HWA GEOSCIENCES INC.

- Geotechnical Engineering
- Hydrogeology
- Geoenvironmental Services
- Inspection & Testing

HWA GEOSCIENCES INC.
Geotechnical & Pavement Engineering • Hydrogeology • Geoenvironmental • Inspection & Testing

January 15, 2016
HWA Project No. 2015-098-21

City of Lake Stevens
1820 Main Street
Lake Stevens, Washington 98258

Attention: Adam Emerson

Subject: **PRELIMINARY GEOTECHNICAL INVESTIGATION**
24th Street SE Extension
Lake Stevens, Washington

Dear Adam:

We are pleased to submit this geotechnical engineering report for the proposed improvements along the 24th Street SE right-of-way in Lake Stevens, Washington. The project alignment is shown on the Vicinity Map, Figure 1. This draft report includes the results of our field explorations and our engineering analyses for design and construction of the proposed roadway features.

INTRODUCTION

This report presents the results of our subsurface explorations and preliminary geotechnical studies for the proposed 24th Street SE feasibility study in Lake Stevens, Washington. The location of the project site is shown on the Vicinity Map, Figure 1, and on the Site and Exploration Plans, Figure 2. Our work included excavating 15 test pits and conducting 15 dynamic cone penetrometer (DCP) tests at the test pit locations. Appropriate laboratory tests were conducted on selected soil samples to determine relevant engineering properties of the subsurface soils. Geotechnical engineering analyses were conducted to provide recommendations for proposed roadways, retaining structures, roadway embankments, signal pole foundations, luminaires, and seismic considerations. Constructability issues are also discussed herein as related to various aspects of the project.

PROJECT UNDERSTANDING

It is our understanding that the City of Lake Stevens is considering establishing a roadway along the unimproved east-west alignment of 24th Street SE. The proposed alignment is to extend from SR-9 to the crossing of the alignment of 91st Avenue SE. The total distance is approximately 1,400 feet. The alignment is currently wooded and crosses several documented wetlands. The purpose of our work is to assess the soil conditions along the

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alignment and develop the geotechnical considerations required for design of the roadway. It is also our understanding that the City prefers construction solutions that limit impacts to wetland.

FIELD INVESTIGATION

The field exploration program to date has included a review of available geologic and geotechnical data for the project vicinity, surface reconnaissance of the alignment, the excavation of fifteen test pits with Dynamic Cone Penetrometer (DCP) tests, and probing of soils across the wetland portions. The locations of these explorations were selected in the field based on geomorphic variations and are indicated on the site and exploration plans, Figure 2. The test pits, designated TP-1 through TP-15 were excavated with a small rubber-tracked backhoe by the City of Lake Stevens. These test pits were dug to depths ranging from 7 to 9 feet below ground surface. Each exploration was monitored and logged by an engineering geologist from HWA. In addition to excavating test pits along the alignment, HWA probed the subgrade soils along the alignment with a ½ inch diameter T handled probe (T-probe) to determine the depth of soft and loose soils. The results of T-probe penetrations between TP-7 and TP-13 are presented in Figure 3.

Representative soil samples were obtained from the explorations at selected intervals and taken to our laboratory for further examination and testing. Our geologist recorded pertinent information including soil sample depths, stratigraphy, soil engineering characteristics, and ground water occurrence as the explorations were excavated. Soils were classified in general accordance with the classification system described in Figure A-1, which also provides a key to the exploration log symbols. The summary logs are presented on Figures A-2 through A-16. The stratigraphic contacts shown on the individual logs represent the approximate boundaries between soil types. The actual transitions between soil units depicted in the logs may be more gradual.

LABORATORY TESTING

Laboratory tests were conducted at HWA's laboratory in Bothell, Washington, on selected samples to determine relevant index and engineering properties of the soils encountered at the site. The tests included visual classifications, natural moisture content determinations and grain size distribution analyses. The tests were conducted in general accordance with appropriate American Society of Testing and Materials (ASTM) standards. Laboratory test results are presented in Appendix B of this report.

SITE CONDITIONS

GENERAL GEOLOGIC CONDITIONS

General geologic information for the site was obtained from the Geologic Map of the Snohomish Quadrangle, Snohomish County, Washington (Minard, 1985). The map indicates that the geology along the project corridor includes glacial till near the ground surface from the most recent continental glaciation, the Fraser Glaciation. Minard indicates patches of recessional outwash, consisting of predominantly sands and gravels, were observed near the ground surface to the east of 83rd Ave SE. Advance outwash, consisting of mostly clean pebbly sands and gravels, has also been observed at the ground surface between 79th Ave SE and 83rd Ave SE.

SOIL CONDITIONS

Our interpretations of subsurface conditions are based on our exploration data, published geologic information, and our experience in the project vicinity. The exploration data indicate that the soils in the upland areas along western end of the alignment consist of loose to medium dense gravelly, sandy silt (Weathered Drift) over dense to very dense Glacial Till. Low lying wetland areas contain soft peat and/or clay to depths of 2 to 6 feet over water-bearing gravelly sand (Recessional Outwash). Upland areas at the center to east end of the alignment are underlain with silty sand (Weathered Drift) over gravelly sand and sandy gravel (Recessional Outwash). Each of these soil units is described below with the youngest in origin described first.

- **Fill:** Loose fill soils were encountered over buried native organic materials (charcoal or peat) in test pits TP-10 and TP-12. These soils extended from the ground surface to depths ranging from 1.25 to 4.5 feet below ground surface, and consisted of loose, slightly gravelly to gravelly, silty sand with scattered rootlets. Refuse was present in test pit TP-12 located on the western edge of the upland area, at a depth of 3 to 4.5 feet. The fill materials were likely placed during activities associated with the adjacent residence.
- **Duff and Topsoil:** Loose forest litter (duff) and dark brown, sandy silt or silty sand with fine organics and abundant rootlets were encountered in the upper approximately 1 foot in each of the test pits in upland areas.
- **Peat:** Very soft to soft peat was encountered at the ground surface (or below fill) in test pits within low-lying areas. This material consists of partly decomposed organics deposited since glacial retreat in anaerobic wetland environments. It has a very high moisture content and is highly compressible.
- **Clay:** Clay was encountered in TP-13 and TP-14. The clay layer in TP-13 was medium stiff to stiff and extended from a depth of 4 feet below ground surface to 6 feet below ground surface. The material was gray and contained partly decomposed straw. The clay layer in TP-14 was stiff to very stiff and extended from a depth of 1 feet below ground surface to 3.5 feet below ground surface. Scattered gravel was encountered in this layer.

- **Weathered Drift:** Loose to medium dense, silty sand to sandy silt with variable gravel content was encountered below the topsoil in upland areas. This material consists of soils mechanically, chemically, and biologically weathered from the underlying glacial materials.
- **Recessional Outwash:** Medium dense to dense, gravelly sand and sandy gravel were encountered below the fill, peat, or weathered drift along the project alignment. These soils were interpreted as recessional outwash sands that was deposited by glacial meltwater streams as the ice sheet retreated during the last glaciation. The Recessional Outwash extended past the termination depth of most of the test pits in which it was encountered.
- **Glacial Till:** Very dense, silty, gravelly sand was encountered in the western seven test pits (TP-1 through TP-7). This material was deposited as a deforming bed of material along the sole of the glacial ice as lodgment till. It consists of an unsorted mixture of clay, silt, sand and gravel, and is very dense, having been consolidated by the weight of about 4,000 feet of ice. It is also known to contain scattered cobbles and boulders. This unit is locally referred to as "hardpan", because of its induration and an appearance similar to concrete. The Glacial Till extended past the termination depth of the test pits in which it was encountered.

GROUND WATER CONDITIONS

The explorations along the project alignment ranged in depth from 7 to 9 feet. Ground water was not encountered in the western upland test pits that extended into Glacial Till soils (TP-1 through TP-7) at the time that they were conducted. The remainder of the test pits encountered ground water seepage at depths ranging from 4.5 to 8.3 feet, within Recessional Outwash. Based on the soil conditions observed in the test pits, the observed water is believed to represent perched water that collects over the very dense and relatively impermeable glacial till soils. We expect that the level of the perched water will vary seasonally with rainfall. Our explorations were conducted near the end of a relatively dry summer. Therefore, we expect that the groundwater conditions observed at the time of our field explorations are lower than they would be during other times of the year.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

In general, the soils along the project alignment are adequate to support the proposed improvements with some mitigation in wetland areas. Along the alignment the recessional outwash and glacial till soils should be considered the bearing layer for roadway construction. The loose overlying soils in the upland areas should be removed and replaced with structural fill to provide a good base for the proposed roadway. The soft peat and clay in wetland areas will need to be over-excavated and replaced with structural fill to construct the roadway. While the

wetland soils are shallow enough to feasibly over-excavate, ground water conditions may necessitate dewatering to facilitate construction of the roadway within or near existing wetlands.

The soils along the project alignment are highly moisture sensitive, and would best be worked in the dry season. Re-use of the recessional outwash soils as structural fill may be appropriate if construction is to take place during the dry summer months. However, if roadway construction is to extend into the wet weather months, we would recommend that the native soils not be reused as structural fill.

Roadway construction will require over-excavation and replacement of the soft soils within the delineated wetlands. Structural roadway fill placed within the wetlands will act as a dam and limit the ability of water to flow from one side of the proposed roadway to the other. This damming affect can be mitigated by incorporating culverts within the structural roadway fill to promote hydraulic conductivity across the wetlands being bisected by the roadway.

Stormwater infiltration does not appear feasible for the project alignment. Dense, relatively impermeable Glacial Till along the western portion and high ground water in the central to eastern sections make infiltration infeasible.

SEISMIC CONSIDERATIONS

Earthquake loading for the proposed 24th Street SE improvements was developed in accordance with Section 3.4 of the *AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2011* (AASHTO, 2011). 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 available geotechnical information for the project corridor, the underlying soils represent AASHTO Site Class D. Table 1 presents the seismic coefficients, associated with AASHTO Site Class D that were used for the geotechnical evaluations discussed in this report. These parameters are based upon a design event with a 7 percent probability of exceedance in 75 years (equal to a return period of 1,033 years). Ground motions for the site are based on probabilistic earthquake hazard mapping efforts including those conducted by the United States Geological Survey (Frankel, et al., 2002) and (Leyendecker, et al., 2007). Accordingly, a Seismic Design Category D, as given by AASHTO (AASHTO, 2011), should be used.

Table 1.

Seismic Coefficients for Geotechnical Evaluations Using AASHTO

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, (g)
				F_{pga}	F_a	F_v	
D	0.356	0.803	0.272	1.144	1.179	1.856	0.408

Soil Liquefaction

The potential for soil liquefaction must be considered during the design of any soil-supported structure. Soil liquefaction is a phenomenon where loose, saturated, granular deposits temporarily lose strength and behave as a liquid in response to moderate to strong earthquake shaking. 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 ground water. Test-pit data shows the granular layers encountered below the water table are of a dense nature, indicating that liquefaction will likely not be a design consideration for this project.

ROADWAY CONSTRUCTION

In general, the soils along the project alignment are conducive to construction of the proposed roadway. We expect that roadway construction will require over excavation of the soft wetland soils observed within the limits of the delineated wetlands. We also expect that the loose near surface soils encountered in the upland areas will need to be over-excavated and replaced with structural fill to facilitate construction of the roadway and associated improvements. Roadway construction considerations are provided in the following sections.

Over Excavation and Replacement

Based on test-pit explorations, we anticipate the upland areas will generally require 2 to 3 feet of over-excavation to reach suitable subgrade material. We anticipate the low wetland areas will generally require 2 to 5 feet of over-excavation to completely remove the peat and reach suitable subgrade material. All over excavated areas should be replaced to grade with compacted structural fill. All over excavated limits should extend a distance laterally from the edge of the proposed embankment or structures equal to the depth of over excavation to ensure that proposed loads are distributed into competent material.

Dewatering

Groundwater was encountered near the ground surface within the wetland areas and at a depth of approximately 5 feet in the central and eastern upland areas. During the wet seasons, we expect that groundwater raises above the ground surface in the wetland areas. Excavations and roadway construction in these areas will likely require dewatering. We expect that dewatering for the proposed roadway improvements can be accomplished with a series of sumps and pumps. As the observed groundwater is perched on top of the relatively impermeable glacial till soils at depth, dewatering wells will not be an appropriate means of dewatering for this project.

In the wetland areas, we expect that the contractor will likely be required to construct water tight barriers on either side of the roadway during construction to ensure that the dewatering effort does not drain the adjacent wetlands.

Retaining Walls

Construction of the proposed roadway may require construction of retaining walls on one or both sides of the alignment. The location and geometry of these walls is currently not known and will depend on the final grade of the road. We anticipate that both cut and fill walls, with heights ranging from 2 to 8 feet will be required. Cut walls will likely be required in upland areas; while fill walls and/or embankments will likely be constructed in the low areas. Based on the soil conditions we expect that cut walls will likely consist of rockery or gravity block walls. Whereas, fill walls will likely consist of mechanically stabilized earth walls or gravity block walls. Additional retaining wall recommendations can be provided once the location and geometry of the walls are determined.

Embankments side slopes may be constructed in low areas in lieu of retaining walls. Construction of sloped embankments in low lying wetland areas, however, will require more over-excavation and greater wetland impacts. Figure 4 shows the conceptual wetland-area retaining wall and embankment construction process. Retaining wall construction in wetland areas is discussed in the following section.

Wetland Area Retaining Walls

Utilizing retaining walls for wetland-area roadway construction will likely limit wetland impacts in comparison to constructing embankment side slopes. We expect that mechanically stabilized earth walls or gravity block walls will be used in wetland areas. We anticipate these walls may be 6 to 8 feet high.

Construction of wetland-area retaining walls will require over-excavation of the native peat and replacement with structural fill. Dewatering will be required prior to placing structural fill and constructing the retaining wall. We expect that the contractor will likely be required to construct water tight barriers on either side of the roadway during construction to ensure that the dewatering effort does not drain the adjacent wetlands; and that localized sumps and pumps will be used to facilitate the dewatering process.

The retaining wall elements and structural fill will be founded in the recessional outwash layer after the peat is excavated. Water conveyance systems, such as culverts, can be incorporated into the retaining wall and structural fill system to facilitate water flow between the bisected portions of wetland areas.

Subgrade Preparation

Subgrade preparation is important to limit differential settlement and increase stability of the proposed walls and embankments. All organic material should be removed from beneath the entire footprint of proposed walls and embankments. Loose or soft soil, defined as being penetrable more than 1 foot with a 1/2 inch diameter rod pushed in under a 150 lb load (T-probe pushed in by hand), should be removed and replaced with “Structural Backfill” or be suitably compacted.

Post Construction Wetland Water Conveyance

As previously noted, the proposed alignment will bisect multiple delineated wetlands. It is our understanding that the City of Lake Stevens desires to maintain hydraulic conductivity within the wetland areas to the maximum extent possible in order to limit wetland impacts. It is our understanding that surface runoff within the wetlands generally flows from north to south; flowing perpendicular to the proposed roadway.

There are several options to allow water to flow under the proposed roadway and maintain hydraulic conductivity to some extent. These options include installing a series of small diameter culvers in the structural roadway fill, installing larger box culverts or constructing a bridge. Further details associated with each of these options are provided below.

Small Diameter Culverts

A series of small diameter culverts could be installed within the structural roadway fill to allow water to flow from north to south. These culverts would be orientated north-south on relatively tight spacing. Culvert openings would be integrated into the block facing if retaining walls are utilized. Installation of small diameter culverts would allow the most flexibility with respect to the final road grade. Installation of these culverts would be fairly cost effective and would allow some hydraulic conductivity across the roadway.

Box Culverts

Larger box culverts could be installed within the wetland areas to allow water to flow from one side of the roadway to the other. Installation of the box culverts would channelize the flow of water to the locations of the structures. The box culverts would likely be founded on spread footings bearing on the very dense glacial till soils. Installation of box culverts would provide greater hydraulic conductivity and conductivity for wildlife than the use of small diameter culverts.

Bridge the Wetlands

Bridge structures could be used to carry the proposed roadway over the wetlands with very limited impact to the flow of water. The bridge structures would likely be constructed on relatively shallow driven piles or spread footing bearing on the very dense glacial till soils. Although construction of bridge structures over the wetlands would be the least impactful to the wetland flow characteristics, this option would be significantly more costly that the other two options.

LUMINAIRE AND SIGNAL POLE FOUNDATIONS

It is our understanding that the proposed roadway will require lighting and possibly signalization improvements along the corridor. We expect that the foundations associated with these improvements will likely consist of WSDOT standard plan foundations. Based on the soils

encountered in our test pits, we expect that standard plan foundations for luminaries and signal poles will be appropriate for this project. Allowable arterial bearing pressures for design of these foundations are expected to be 1500 psf but should be evaluated on a case by case basis once actual locations are determined.

Several of the test pits exhibited sidewall caving starting at 2 feet below the existing ground surface. It is likely caving will occur when excavating the luminaire foundations. Prospective contractors should be prepared to case or shore the luminaire and signal pole foundation excavations to prevent caving of the native soils.

GENERAL EARTHWORK

Structural Fill

The existing site fill and native soils are highly variable in consistency and are moisture sensitive. If construction is completed during the dry summer months, some of the excavated native material may be suitable for re-use as structural fill. If roadway construction is expected to extend into the wet weather months of October through June, we recommend that imported structural fill be used. Imported structural fill should consist of clean, free-draining, granular soils free from organic matter or other deleterious materials. Such materials should meet the gradation and quality requirements as specified for "Gravel Borrow" in Section 9-03.14(1) of the WSDOT *Standard Specifications* (WSDOT, 2016).

Compaction

Structural fill and CSBC should be moisture conditioned and compacted to the requirements specified in Section 2-03.3(14)C, Method C, of the WSDOT *Standard Specifications* (WSDOT, 2016); except the standard of compaction achieved shall not be less than 95% of the maximum dry density (MDD) determined for the fill material by test method ASTM D1557 (Modified Proctor). Subgrade compaction should conform to the requirements of Section 2-06.3(1) of the WSDOT *Standard Specifications*.

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 to achieve the required relative compaction. Generally, loosely compacted soils result from poor construction technique and/or improper 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.

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. The existing fill, wetland and recessional outwash soils are generally classified as Type C soils, per WAC 296-155. Where shoring is not used, temporary cuts in Type C soils should be sloped no steeper than 1½H:1V (horizontal:vertical). The existing glacial till soils are generally classified as Type A soils, per WAC 296-155. Where shoring is not used, temporary cuts in Type A soils should be sloped no steeper than 3/4H:1V (horizontal:vertical).

Wet Weather Earthwork

General recommendations relative to earthwork performed in 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.
- For wet weather conditions, the allowable fines content of the structural fill should be reduced to no more than 5 percent by weight of the portion of the fill material passing the ¾-inch sieve. The fines should be non-plastic.
- 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.
- Bales of straw and/or geotextile silt fences should be strategically located to control erosion and the movement of soil

FUTURE PRIVATE DEVELOPMENT

HWA is unaware of the specific future development plans along the proposed alignment. However, we anticipate the upland areas surrounding the proposed alignment are generally suitable for residential and commercial development. We do not anticipate any development within wetland areas will be completed as part of future private development. The following sections discuss conceptual development considerations for the western, central and eastern upland areas. However, these considerations should be considered preliminary and additional geotechnical evaluation of proposed private development should be completed as part of design and construction.

Future Development in Western Upland Areas

We expect that all near surface loose to medium dense material be over-excavated and replaced with suitable structural fill in preparation for development. In the western uplands (located in region spanning TP-1 to TP-7), we expect soils 2 to 4 feet below current grade will provide adequate bearing capacity to support shallow foundations.

Groundwater was not encountered in any western upland test pits, but the water level is expected to fluctuate seasonally. We recommend installation of monitoring wells to measure groundwater level fluctuation in order to determine possible construction impacts. High groundwater is not expected to prevent development of the area, but mitigation techniques may be required to combat a high groundwater level. These mitigations may include dewatering the site prior to development and/or limiting construction to the dry season to the extent possible.

We expect that the soils in these areas are adequate to support utility installation. Dewatering may be required depending on groundwater levels and utility depths.

Future Development in Central and Eastern Upland Areas

We recommend all loose to medium dense material be over-excavated and replaced with suitable structural fill in preparation for development. In the central and eastern uplands, dense material was generally encountered 4 to 5 feet below ground surface. HWA expects that the glacially consolidated soils below this layer will provide adequate bearing capacity to support shallow foundations.

Groundwater was encountered 5 feet below the ground surface in TP-9. This indicates dewatering may be required to support development of these areas depending on the time of year that construction is completed.

CONDITIONS AND LIMITATIONS

We have prepared this report for the City of Lake Stevens for use in planning and pre-design of this project. Additional explorations and analyses may be required for final design and construction. The conclusions and interpretations presented in this report should not be construed as our warranty of the subsurface conditions. Experience has shown that soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and 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.

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 in the area 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 substances in the soil, surface water, or ground water at this site.

We appreciate the opportunity to be of service. If you have any questions regarding this report, please do not hesitate to contact either of the undersigned at (425) 774-0106.

Sincerely,

HWA GEOSCIENCES INC.

CJ Jackson, P.E
Geotechnical Engineer

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

Attachments:

Figure 1	Vicinity Map
Figure 2	Site and Exploration Plans
Figure 3	Probing Depths of Wetland Soils
Figure 4	Conceptual Roadway Prisms in Wetland Areas

Appendices:

Appendix A	Test Pit Logs
Appendix B	Laboratory Data
Appendix C	Cost Estimating Tool for Conceptual Roadway Prism

REFERENCES

AASHTO, 2011, *Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition*, Washington D.C.

Frankel, et al., 2002, *Documentation for the 2002 Update of the National Seismic Hazard Maps*, USGS Open File Report, 02-420.

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Minard P.J., 1985, *Geologic Map of the Snohomish Quadrangle*, U.S. Geological Survey Miscellaneous Filed Studies Map MF-1745, scale 1:24,000.

WSDOT, 2014, *Geotechnical Design Manual*, Washington State Department of Transportation.

WSDOT, 2016, *Standard Specifications for Road, Bridge, and Municipal Construction*, Washington State Department of Transportation.

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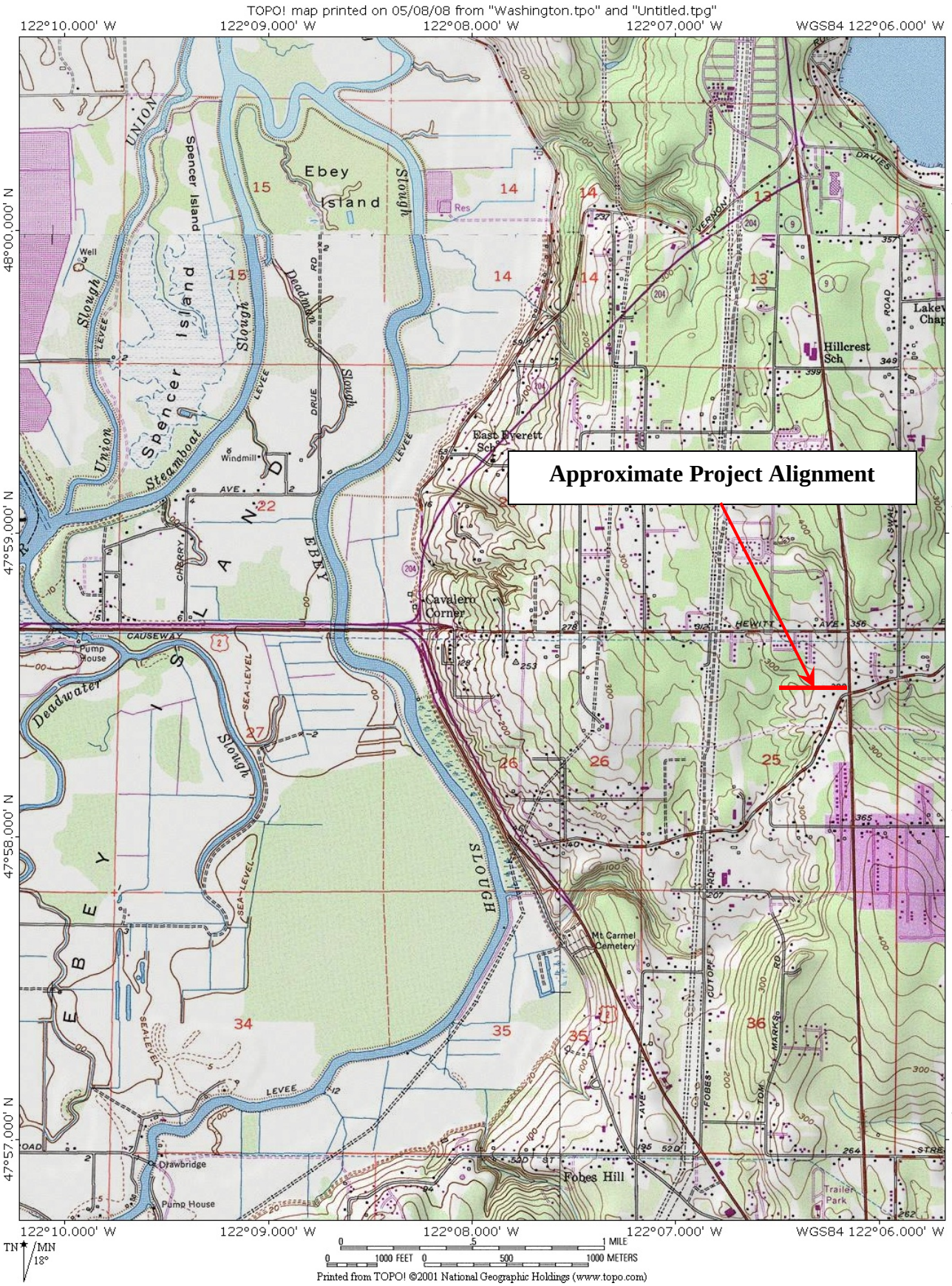

VICINITY MAP

24TH STREET SE EXTENSION
STATE ROAD 9 TO 91ST AVENUE SE
CITY OF LAKE STEVENS, WASHINGTON

FIGURE NO.
1

PROJECT NO.
2015-098

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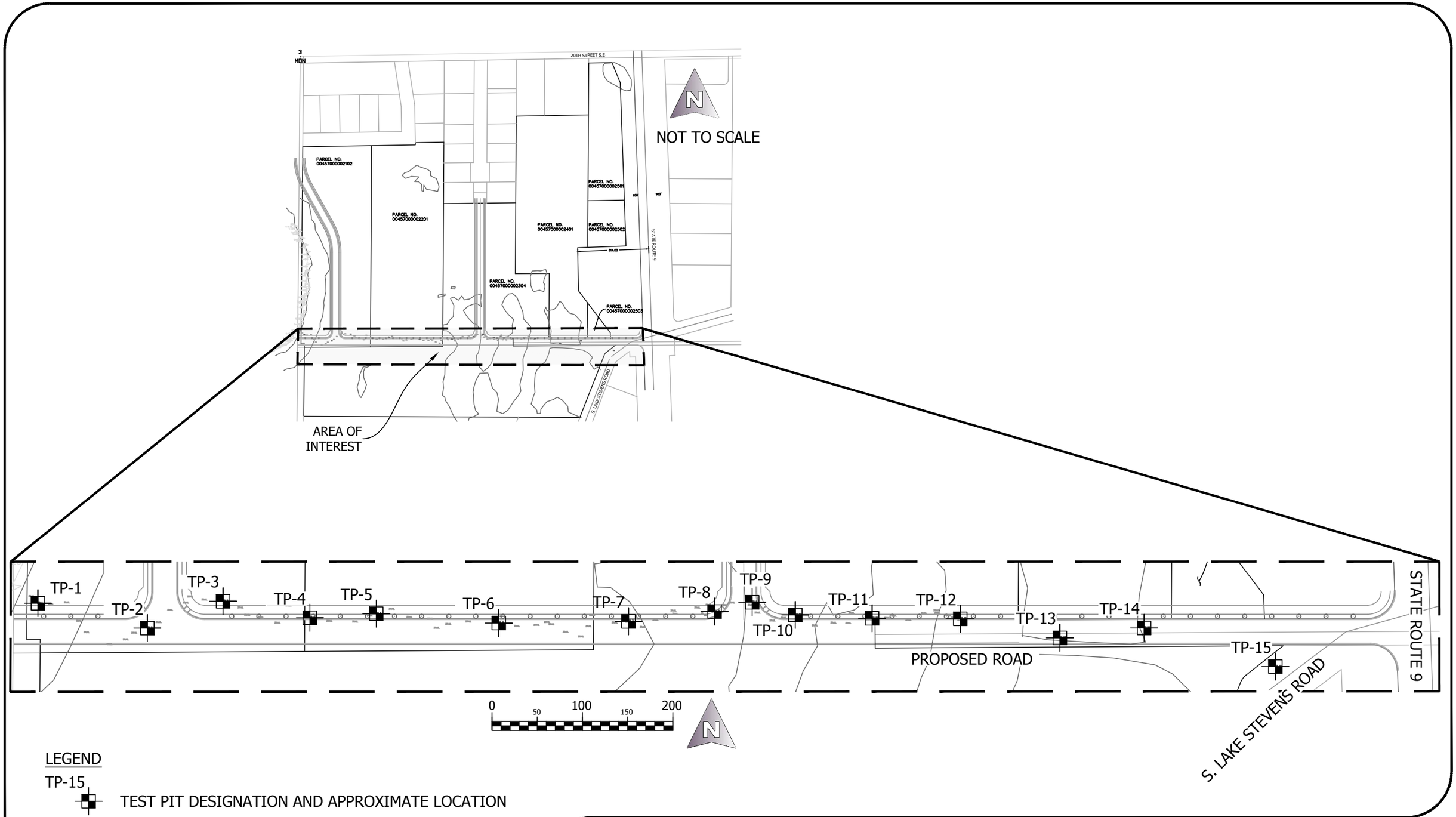

LEGEND

TP-15 TEST PIT DESIGNATION AND APPROXIMATE LOCATION

BASE MAP PROVIDED BY:

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

SITE AND EXPLORATION PLAN

DRAWN BY	FIGURE #
EFK	2
CHECK BY	PROJECT #
CJ	2015-098-21
DATE: 11.03.15	

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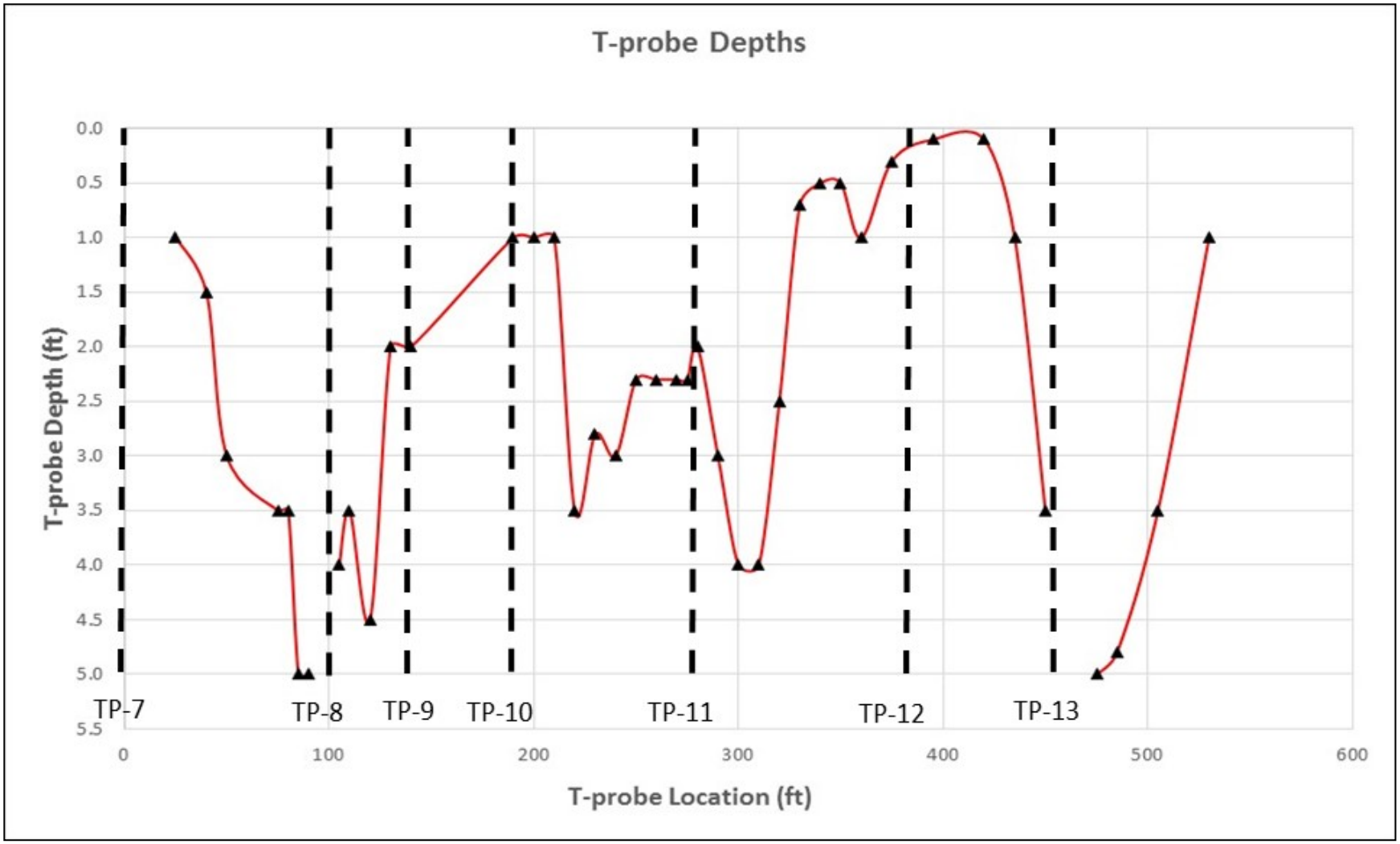


HWA GEOSCIENCES INC.

T-PROBE DEPTHS

24TH STREET SE EXTENSION
STATE ROAD 9 TO 91ST AVENUE SE
LAKE STEVENS, WASHINGTON

FIGURE NO. 3

PROJECT NO. 2015-098

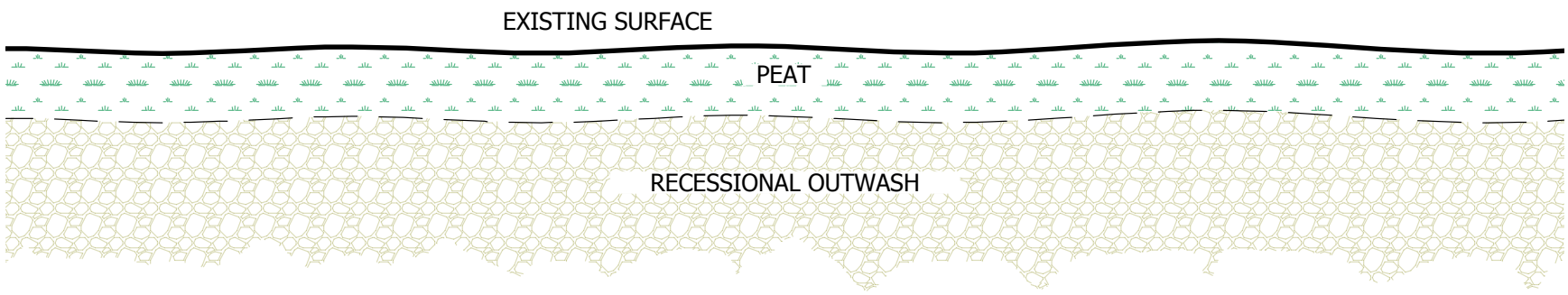
TYPICAL SOIL CROSS-SECTION DETAIL NOTES:

- PEAT = A soft, highly organic soil, consisting of partly decomposed vegetable matter.
- RECESSIONAL OUTWASH = A clean to slightly silty, fine to medium sand with varying amounts of gravel.
- Provided soil profile is general. Actual soil depths may vary significantly over relatively short distances.

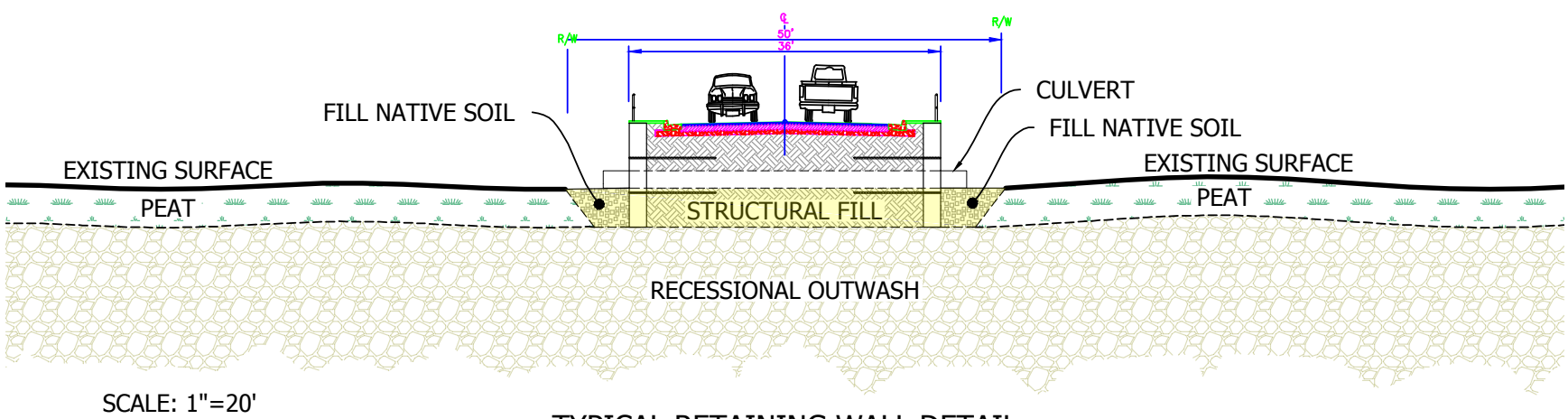
GENERAL CONSTRUCTION STEPS FOR RETAINING WALL AND EMBANKMENT:

- Excavate peat in the wet
- Seal and dewater excavation footprint.
- Construct retaining wall (or embankment) and structural fill section. Install water conveyance systems and utilities during this stage.
- Construct roadway surface and pedestrain features.
- Discontinue dewatering and remove watertight shoring to facilitate water flow through roadway prism.

APPROXIMATE AREA OF SOIL REMOVAL

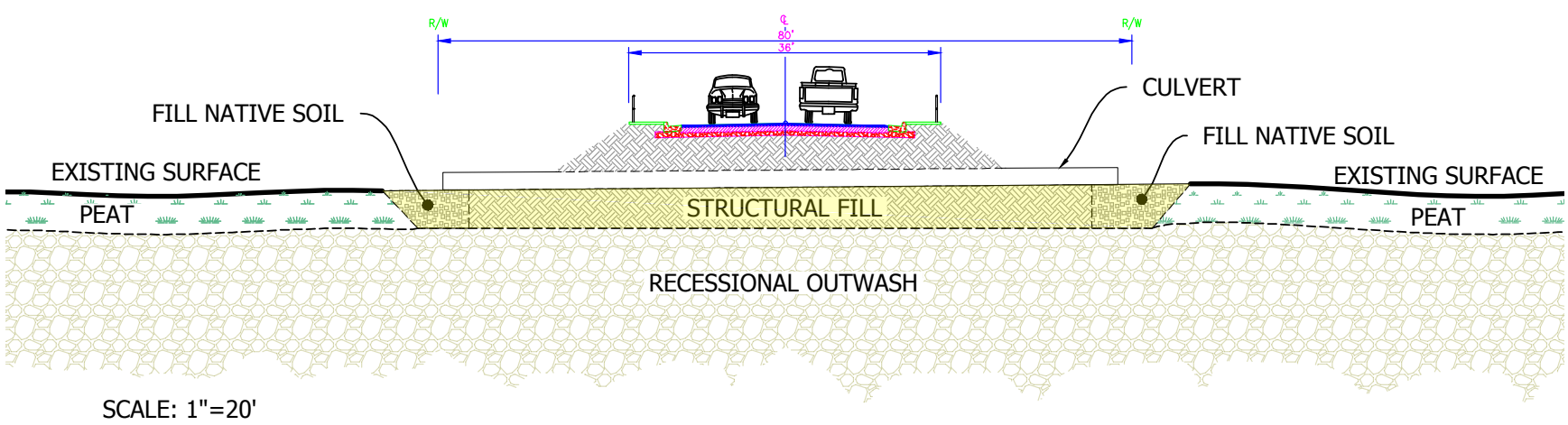


TYPICAL SOIL DETAIL



SCALE: 1"=20'

TYPICAL RETAINING WALL DETAIL



SCALE: 1"=20'

TYPICAL EMBANKMENT DETAIL

BASE MAP PROVIDED BY:

HWA GEOSCIENCES INC.	PRELIMINARY GEOTECHNICAL INVESTIGATION 24th STREET SE - EXTENSION LAKE STEVENS, WASHINGTON	TYPICAL ROAD DETAIL	DRAWN BY EFK CHECK BY CJ DATE: 01.13.15	FIGURE # 4 PROJECT # 2015-098

S:\2015 PROJECTS\2015-098-21-24TH STREET SE LAKE STEVENS\CAD 2015-098\HWA 2015-098 RM.DWG, <Layout2> Plotted: 1/13/2016 6:04 PM

Appendix A:
Test Pit Logs

The test pits were excavated on October 12 through 14, 2015, by City of Lake Stevens public works personnel and HWA personnel. Test pits were excavated using a Yanmar ViC55 trackhoe. Test pits were advanced along the proposed road alignment in wetland and upland areas to depths ranging from 7 to 9 feet below ground surface. Samples were taken based on soil conditions observed in the excavation. The test pit locations are plotted on the site and exploration plans, Figures 2. Logs of these test pits can be found in Figures A-2 through A-16, of Appendix A.

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

TEST SYMBOLS

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

SAMPLE TYPE SYMBOLS

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

GROUNDWATER SYMBOLS

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

COMPONENT DEFINITIONS

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

COMPONENT PROPORTIONS

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

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

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

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

MOISTURE CONTENT

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

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24th Street SE Extension
Lake Stevens, Washington

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 2015-098-21 FIGURE: A-1

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W end of alignment
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff & Topsoil.			
		SM	Loose, light yellow brown, gravelly, silty, SAND, dry. Abundant roots to 1.5 feet. **(WEATHERED DRIFT)**	S-1		
2		SM	Medium dense, light yellow brown, gravelly, silty, SAND, dry. Non-plastic.	S-2		
4		SM	Dense, olive gray, slightly gravelly, silty, fine to medium SAND, dry.	S-3		
		SM	Very dense, gray, silty, gravelly, fine to medium SAND, moist. Scattered cobbles. Diamicton. **(GLACIAL TILL)**	S-4		
6						
8			Test pit terminated at 7 feet. No ground water seepage. Minor caving from 0.5 to 2.5 feet.			
10						
12						
14						

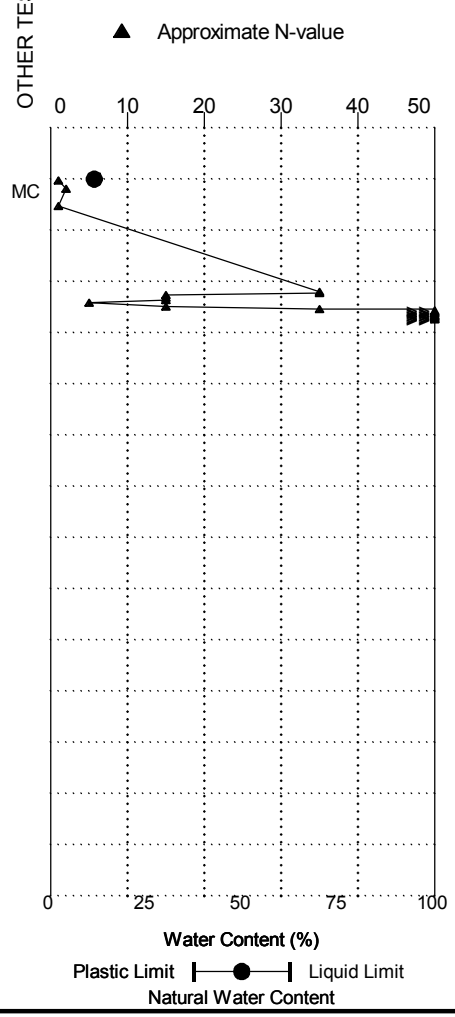

PHOTO OF TEST PIT

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.

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24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 1

PROJECT NO.: 2015-098 FIGURE: A-2

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: 2nd TP from W end, on ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil. Abundant rootlets. Scattered roots to 4.5 feet.				
		GM	Loose, dark yellow brown, slightly sandy, silty, fine to coarse GRAVEL, dry. Non-plastic. **(WEATHERED DRIFT)**		S-1		GS
2		GM	Medium dense, yellow brown, slightly sandy to sandy, very silty, fine to coarse GRAVEL, dry. Abundant cobbles.		S-2		
4		GP GM	Dense, olive gray, clean to slightly silty, fine to coarse sandy, fine to coarse GRAVEL, dry.				
		SM	**(RECESSIONAL OUTWASH)**				
6			Very dense, gray, fine to coarse gravelly, silty, fine to medium SAND, dry grading to damp. Diamicton. Boulder at 6 feet. **(GLACIAL TILL)**		S-3		
8					S-4		
10			Test pit terminated at 9 feet. No ground water seepage. Minor caving from 3 to 4.5 feet.				
12							
14							

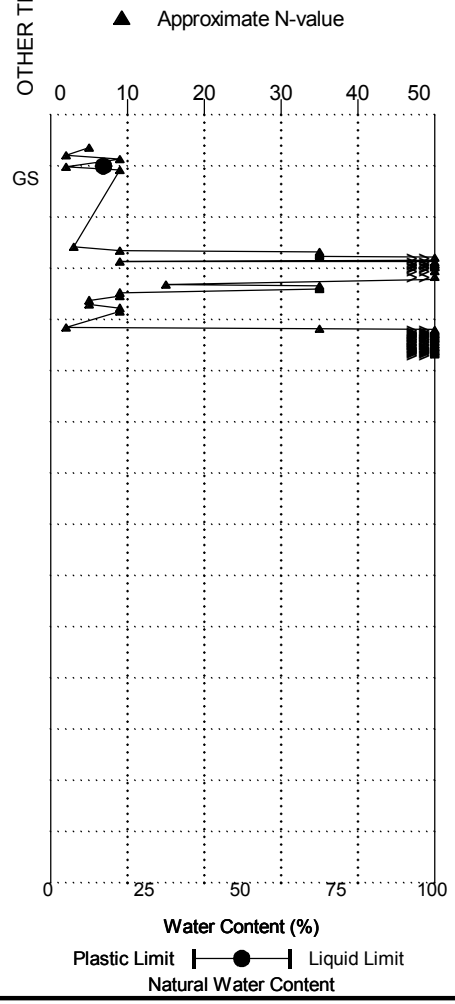

PHOTO OF TEST PIT

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24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 2

PROJECT NO.: 2015-098 FIGURE: A-3

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W side of low area E of TP-2 ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		SM	Loose grading to medium dense, reddish brown, gravelly, silty, fine to medium SAND, moist.		S-1		
2		GM	**(WEATHERED DRIFT)**				
		SM	Dense, rust-mottled light gray, silty, fine to medium sandy, GRAVEL,damp.		S-2	GS	
4			Very dense, gray, gravelly, silty, fine to medium SAND, moist. Diamicton. **(GLACIAL TILL)**		S-3		
6		SM	Very hard digging below 5.5 feet; scraping with bucket teeth.		S-4		
8			Test pit terminated at 7 feet. No ground water seepage. No caving.				
10							
12							
14							

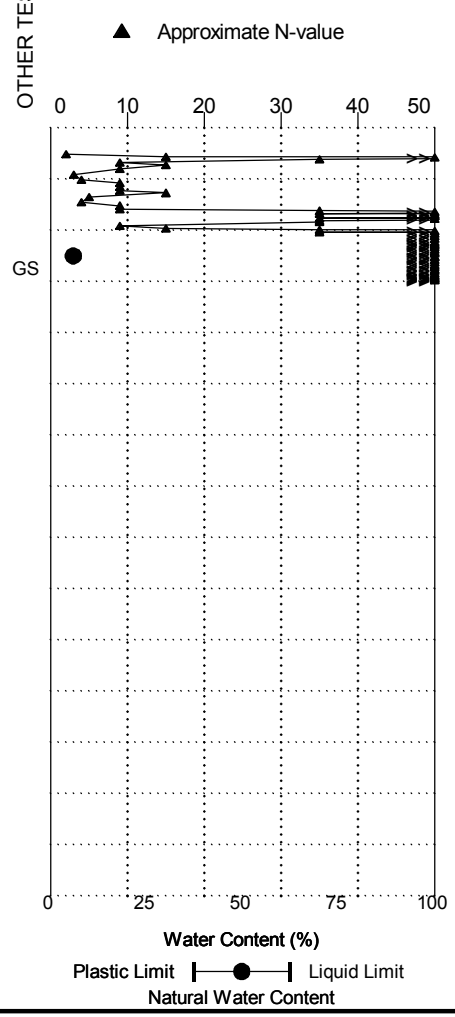

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 3

PROJECT NO.: 2015-098 FIGURE: A-4

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: East side of low area E of TP-2 ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		GM	Loose grading to medium dense, slightly sandy, silty, GRAVEL, damp. Abundant roots to approx. 1.5 feet. **(WEATHERED DRIFT)**		S-1		GS
2		GP GM	Dense grading to very dense, dark olive gray, slightly silty, fine to coarse sandy, fine to coarse GRAVEL, damp. **(RECESSIONAL OUTWASH)**		S-2		
4		SM	Very dense, gray, gravelly, very silty, fine to medium SAND, damp grading to moist. Scattered cobbles. Diamicton. **(GLACIAL TILL)**		S-3		
6					S-4		
8			Test pit terminated at 7 feet. No ground water seepage. No caving.				
10							
12							
14							

▲ Approximate N-value

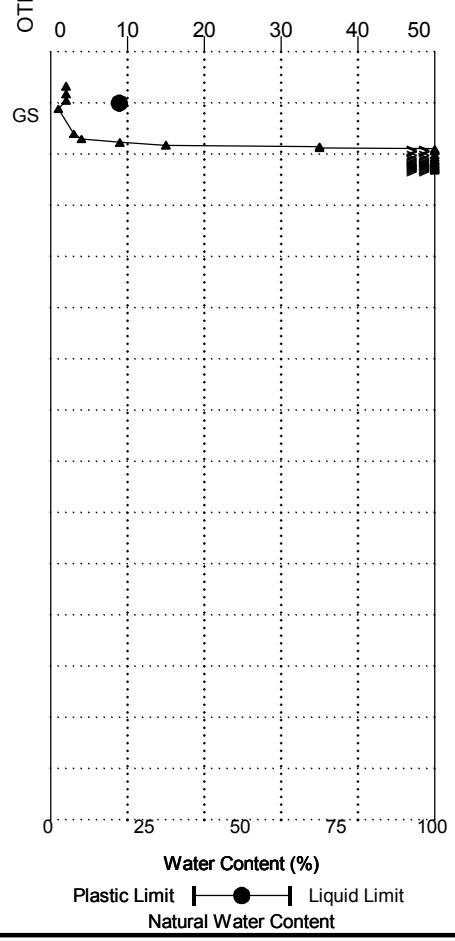

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 4

PROJECT NO.: 2015-098 FIGURE: A-5

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: On a ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil. Depth varies from 0.5 to 1.5 feet.				
		SM	Loose grading to medium dense, brown grading to yellow brown, gravelly, silty, fine to mediumSAND, moist.		S-1		MC
2		GM	Abundant roots to 1.5 feet. **(WEATHERED DRIFT)**		S-2		GS
4			Dense, rust-mottled light gray, silty, fine to medium sandy, GRAVEL, damp. Scattered cobbles. Diamicton. **(GLACIAL TILL)** Grades to very dense and olive brown with some rust mottling. Not difficult to dig.				
6					S-3		
8							
10			Test pit terminated at 8.5 feet. No ground water seepage. No caving.				
12							
14							

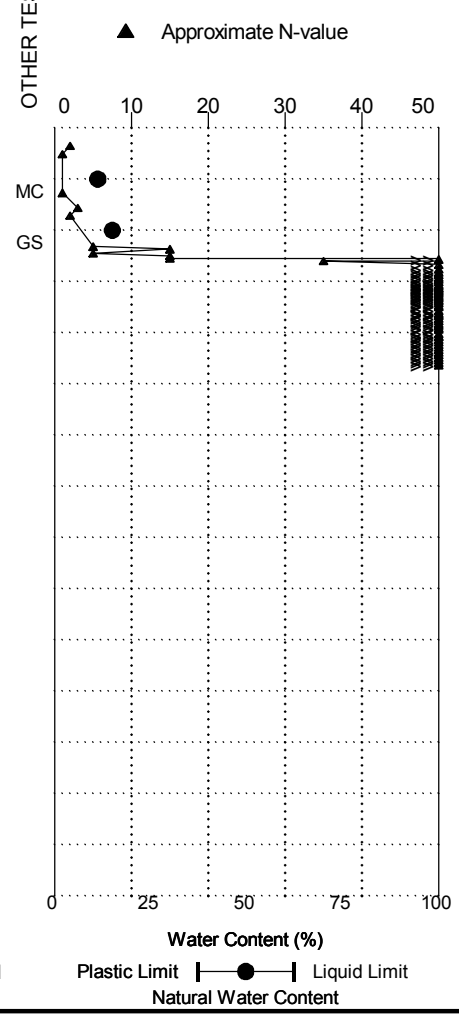

PHOTO OF TEST PIT

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24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 5

PROJECT NO.: 2015-098 FIGURE: A-6

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: On a ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		ML SM	Loose, reddish brown, slightly gravelly, sandy SILT, damp. Roots to 1.5 feet. **(WEATHERED DRIFT)**		S-1		MC
2		SM	Dense, rust-mottled light gray, gravelly, very silty, fine to medium SAND, moist. Scattered cobbles. Diamicton. **(GLACIAL TILL)**		S-2		
4			Becomes very dense and olive brown with minor rust mottling. Harder digging.		S-3		GS
6							
8					S-4		
10			Test pit terminated at 8 feet. No ground water seepage. No caving.				
12							
14							

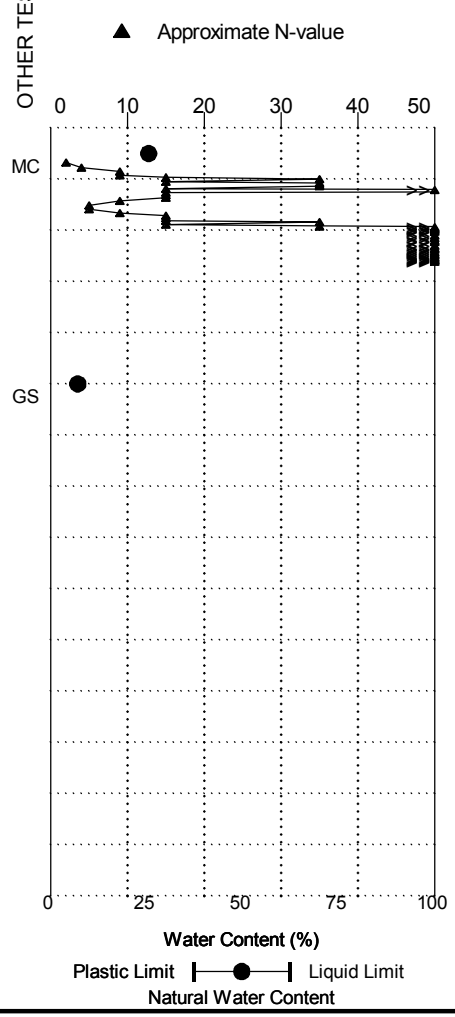

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 6

PROJECT NO.: 2015-098 FIGURE: A-7

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: Ridge, just W of western wetland
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil. Abundant roots.			
		SM	Loose, yellow brown, slightly gravelly, very silty, fine to medium SAND, dry. Scattered cobbles. Abundant roots to 2.5 feet. **(WEATHERED DRIFT)**	S-1, S-2	GS	
2		SM	Medium dense grading to dense, olive gray with olive brown, gravelly, very silty, fine to medium SAND, moist.			
4		SM	Dense grading to very dense, gray, gravelly, silty, fine to coarse SAND, moist. Diamicton. **(GLACIAL TILL)**	S-3		
6			More gravelly from 7 to 7.5 feet.	S-4		
8			Test pit terminated at 8 feet. No ground water seepage. No caving.			
10						
12						
14						

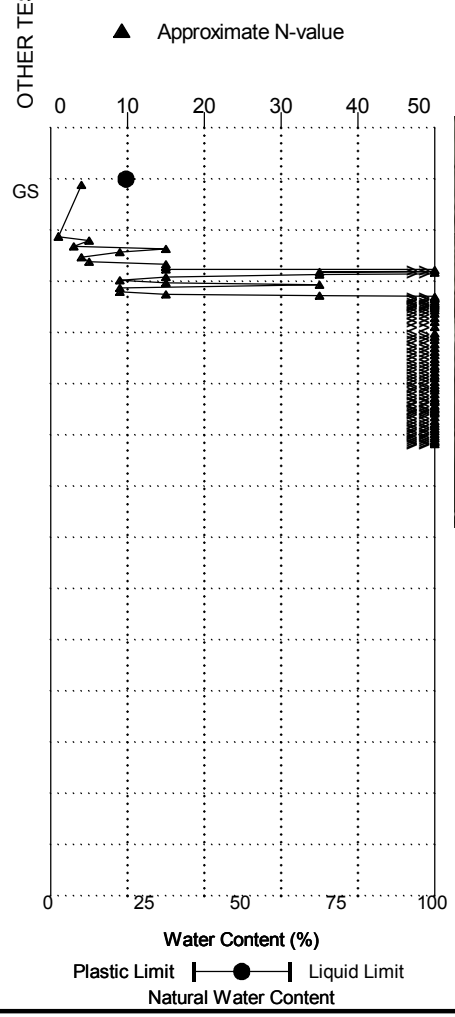

PHOTO OF TEST PIT

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24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 7

PROJECT NO.: 2015-098 FIGURE: A-8

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W side of western wetland
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0		PT	Very soft, dark brown, PEAT, wet. Scattered partly decomposed wood. **(PEAT)**		S-1		
2		PT	Becomes brown.		S-2		
4		ML	Loose grading to medium dense, gray, sandy SILT grading to silty, fine to medium SAND, wet.		S-3		
		SM	**(RECESSIONAL OUTWASH)**		S-4		
6		SM SP	Dense, rust-mottled olive brown, silty, fine to medium SAND, moist.				
8			Medium dense, rust-mottled olive brown, clean, gravelly, fine to medium SAND, wet. Lens of sandy GRAVEL at 6 to 6.5 feet.				
10			Test pit terminated at 9 feet. Minor ground water seepage at 4.5 feet; heavy below 5.5 feet. Heavy caving, from 5 to 9 feet.				
12							
14							

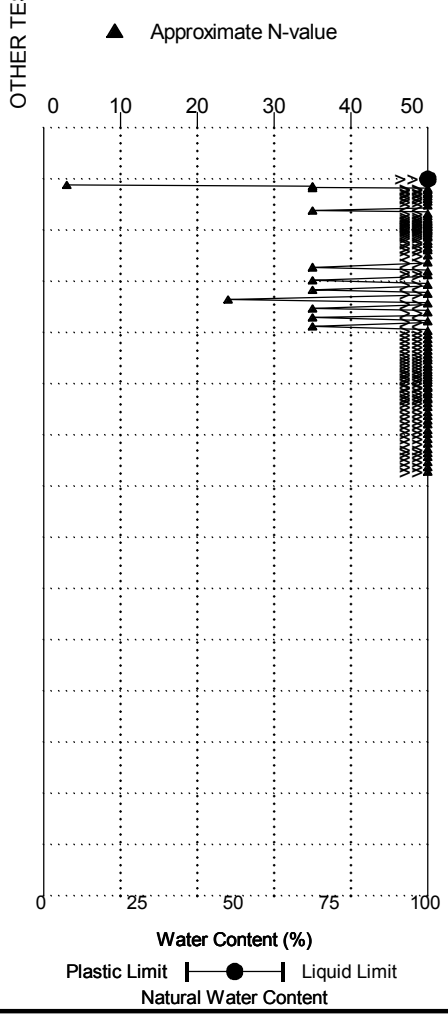

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 8

PROJECT NO.: 2015-098 FIGURE: A-9

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W edge of upland, E of western wetland
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		SM	Loose, reddish brown grading to dark yellow-brown, silty, fine to medium SAND, moist. Scattered gravel and charcoal. Abundant roots.		S-1		
2		SM	**(WEATHERED DRIFT)**				
			Medium dense, light olive brown, silty, fine to medium SAND, moist. Scattered gravel. **(RECESSIONAL OUTWASH)**		S-2		
4					S-3		
6		GW GM	Medium dense grading to dense, olive gray with rust mottling, slightly silty, sandy, fine to coarse GRAVEL, wet. Abundant cobbles.		S-4		
8							
10							
12							
14							

Test pit terminated at 8 feet.
Moderate ground water seepage at 5 feet.
Moderate caving, 5 to 8 feet.

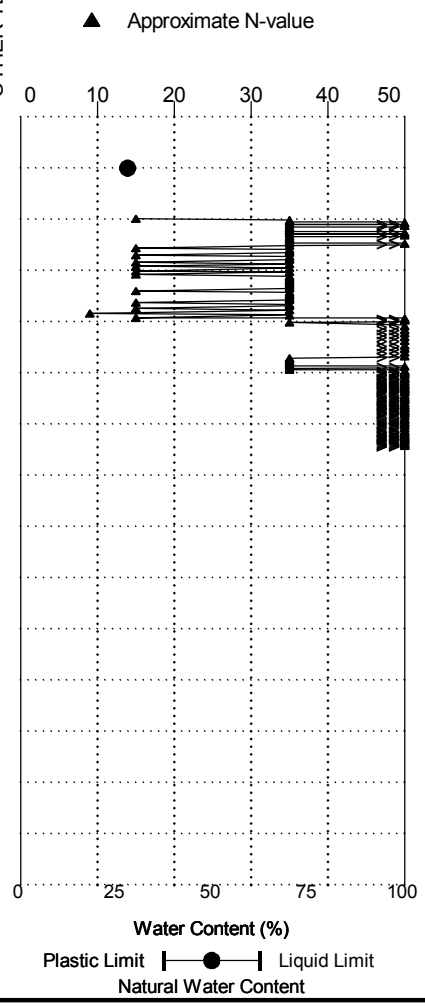

PHOTO OF TESTPIT

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.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 9

PROJECT NO.: 2015-098 FIGURE: A-10

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: Upland; 50 ft E of TP-9
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0	SM	Loose, brown, slightly gravelly, silty, fine to medium SAND, moist. Scattered roots. **(FILL)**	S-1		
	GM	Charcoal layer up to 3 inches thick, over:	S-2		
2	SM	Medium dense, light gray, silty, fine to medium sandy, fine GRAVEL, moist. **(RECESSIONAL OUTWASH, scorched by fire)**	S-3	GS	
4		Medium dense grading to dense, light olive brown, silty, fine gravelly, fine to medium SAND, moist.			
	GM	**(RECESSIONAL OUTWASH)** Medium dense to dense, dark brown, silty, sandy, fine GRAVEL, moist. Non-organic.	S-4		
6	SP	Medium dense to dense, brown, clean, fine to medium SAND, moist.	S-5		
8		Test pit terminated at 8.5 feet. Moderate ground water seepage at 8.3 feet. No caving.			
10					
12					
14					

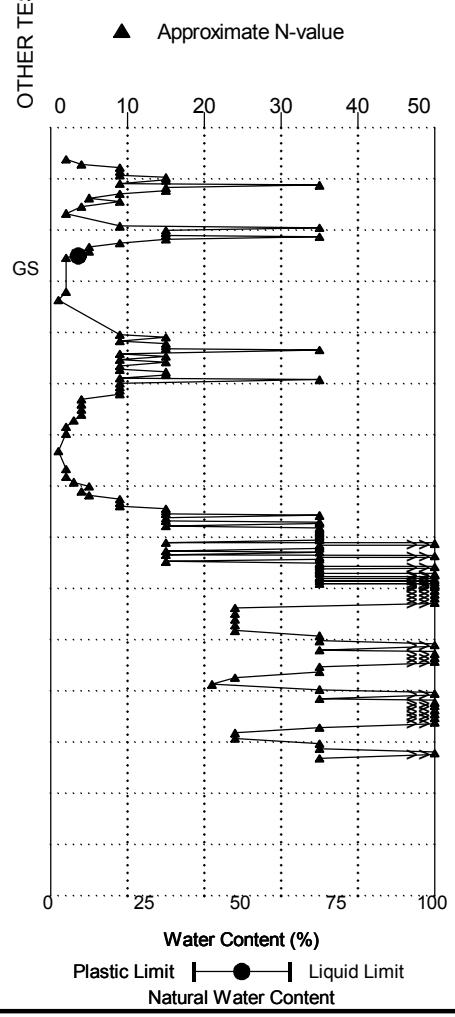

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-10

PROJECT NO.: 2015-098 FIGURE: A-11

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: Wetland W of house
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0		PT	Very soft, dark brown, PEAT, moist. Scattered partly decomposed wood. **(PEAT)**				
2		SM	Loose grading to medium dense, olive gray and olive brown, silty, fine to coarse gravelly, fine to medium SAND, moist. Scattered cobbles. **(RECESSIONAL OUTWASH)**		S-1		
4							
5		GW	Medium dense, clean, fine to coarse sandy, fine to coarse GRAVEL, wet. Water bearing.		S-2		
6		SM	Medium dense, gray, silty, gravelly, fine to medium SAND, wet.				
6.5		SP SM	Medium dense, olive brown, clean to slightly silty, fine to medium SAND, wet. Slightly gravelly below approx. 7 feet.		S-3		
8							
10							
12							
14							

Test pit terminated at 8.5 feet.
Moderate ground water seepage at 5.2 feet, east end.
Minor ground water seepage at 3.5 feet, west end.
Heavy caving from 2.5 to 7 feet.

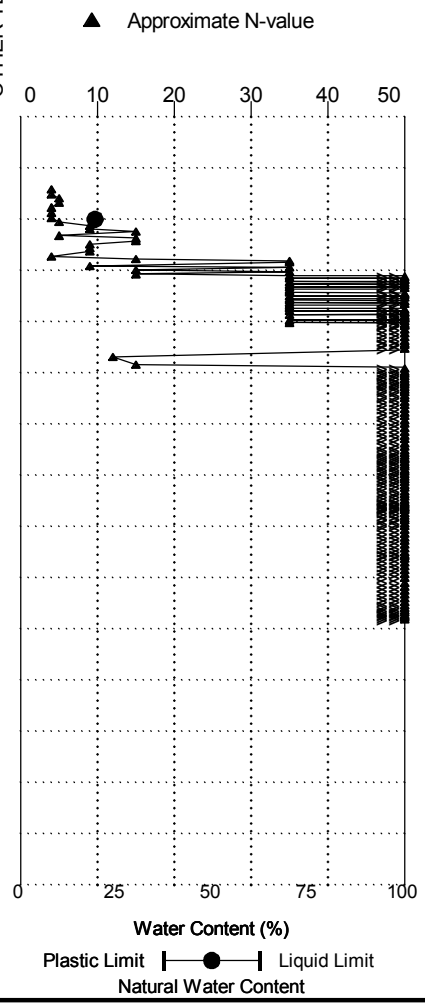


PHOTO OF TEST PIT

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.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-11

PROJECT NO.: 2015-098 FIGURE: A-12

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W edge of rise by house
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0		GM	Loose, brown, silty, fine to medium sandy, GRAVEL, damp. Scattered roots. **(FILL)**		S-1		GS
2		GM	Becomes yellow brown, dry.				
4		SM	Loose, brown, silty, gravelly, fine to medium SAND, dry, with Garbage: Steel, glass and glass bottles, sheet metal, tire. **(FILL with REFUSE)**				
		PT	Charcoal layers over Soft, dark brown, PEAT, wet. **(PEAT)**		S-2		
6		SM	Medium dense to dense, gray and olive gray, clayey, silty, fine to coarse gravelly, fine to medium SAND, wet. **(RECESSIONAL OUTWASH)**		S-3		
8					S-4		
10			Test pit terminated at 9 feet. Minor ground water seepage at 6 feet. Moderate caving from 4.5 to 6 feet.				
12							
14							

▲ Approximate N-value

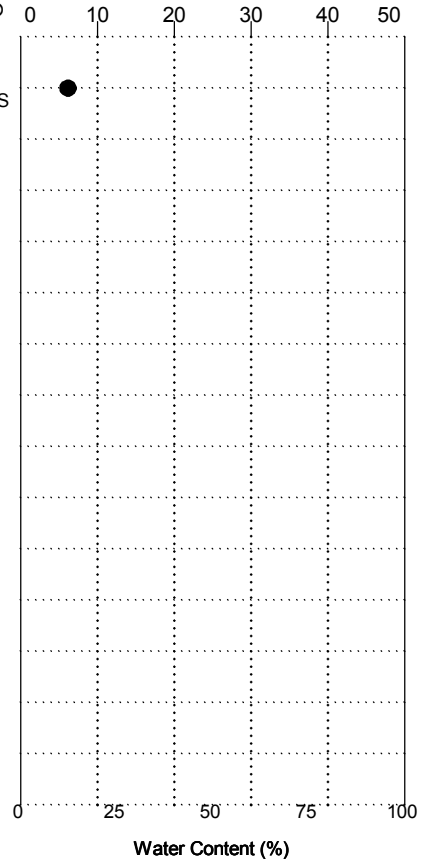


PHOTO OF TEST PIT

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.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-12

PROJECT NO.: 2015-098 FIGURE: A-13

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: N of driveway, edge of upland
DATE COMPLETED: 10/14/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		CL	Stiff, brown, silty CLAY, moist. Scattered gravel.		S-1		AL
2		CL	Very stiff, rust-mottled olive gray, silty CLAY, moist. Scattered gravel.		S-2 S-3		
4		GM	Dense, light brown, silty, sandy, fine to coarse GRAVEL, wet.				
		GM	**(RECESSIONAL OUTWASH)** Becomes olive brown, and slightly silty to clean.				
6							
8					S-4		
10							
12							
14							

Test pit terminated at 8 feet.
Heavy ground water seepage below 2 feet.
Moderate caving within gravel while digging.
Heavy caving when to 6 feet, surface to 6 feet.

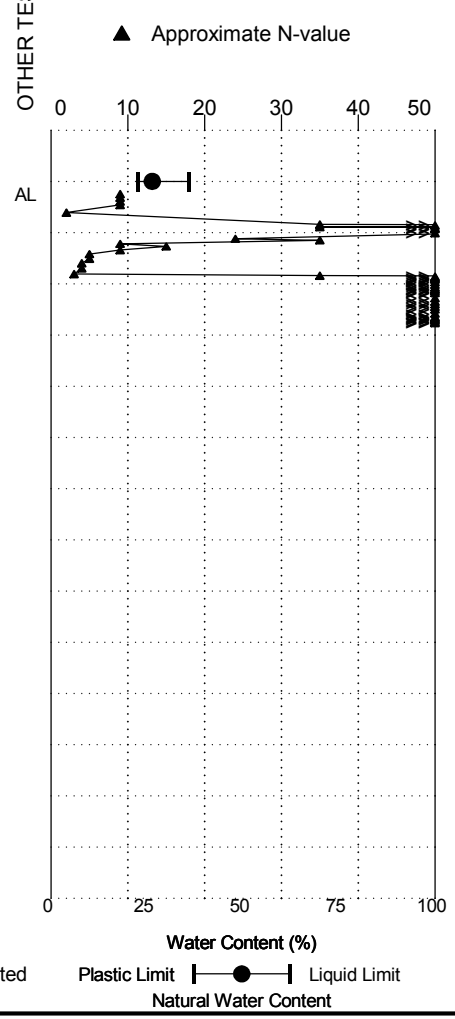


PHOTO OF EAST SIDE OF PIT

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.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-14

PAGE: 1 of 1

PROJECT NO.: 2015-098 FIGURE: A-14

DJH TP 2015-098.GPJ 1/13/16

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: N of driveway, edge of upland
DATE COMPLETED: 10/14/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		CL	Stiff, brown, clayey SILT, moist. Scattered gravel.		S-1		AL
2		ML	Very stiff, rust-mottled olive gray, clayey SILT, moist. Scattered gravel.		S-2		
		CL			S-3		
		ML					
4		GM	Dense, light brown, silty, sandy, fine to coarse GRAVEL, wet. **(RECESSIONAL OUTWASH)**				
		GM	Becomes olive brown, and slightly silty to clean.				
6							
8					S-4		
10							
12							
14							

Test pit terminated at 8 feet.
Heavy ground water seepage below 2 feet.
Moderate caving within gravel while digging.
Heavy caving when to 6 feet, surface to 6 feet.

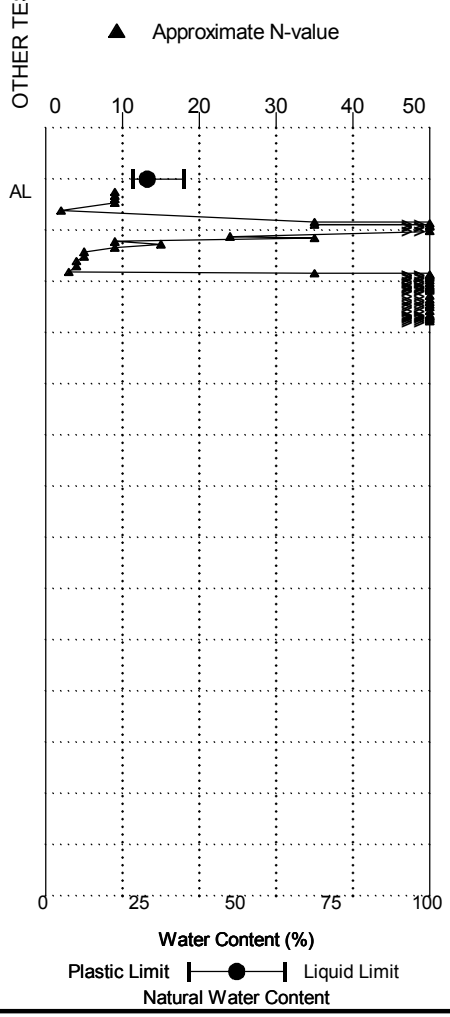


PHOTO OF TEST PIT

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.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-14

PROJECT NO.: 2015-098 FIGURE: A-15

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: E end of alignment, nearS Lk Stevens R
DATE COMPLETED: 10/14/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose, dark brown, slightly organic, gravelly, silty SAND, moist. Scattered roots.				
		SW SM	**(TOPSOIL)**		S-1		GS
2			Loose grading to medium dense, reddish brown grading to rust-mottled yellow brown, slightly silty, fine to medium SAND, moist. Scattered gravel.				
		SM	**(WEATHERED DRIFT)**		S-2		
4		GW GM	Medium dense to dense, rust-mottled yellow brown and olive gray, slightly silty, fine to coarse gravelly, fine to medium SAND, moist. Scattered cobbles.		S-3		
			(RECESSIONAL OUTWASH)				
6		SP	Medium dense to dense, slightly silty, sandy, fine to coarse GRAVEL, moist. Scattered cobbles.		S-4		
			Medium dense, olive gray, clean, fine to medium SAND, wet.				
8		GW	Dense, olive brown, clean, fine to coarse sandy, fine to coarse GRAVEL, wet.		S-5		
10			Test pit terminated at 9 feet. Minor ground water seepage at 5.5 feet; heavy below 7.5 feet. No caving.				
12							
14							

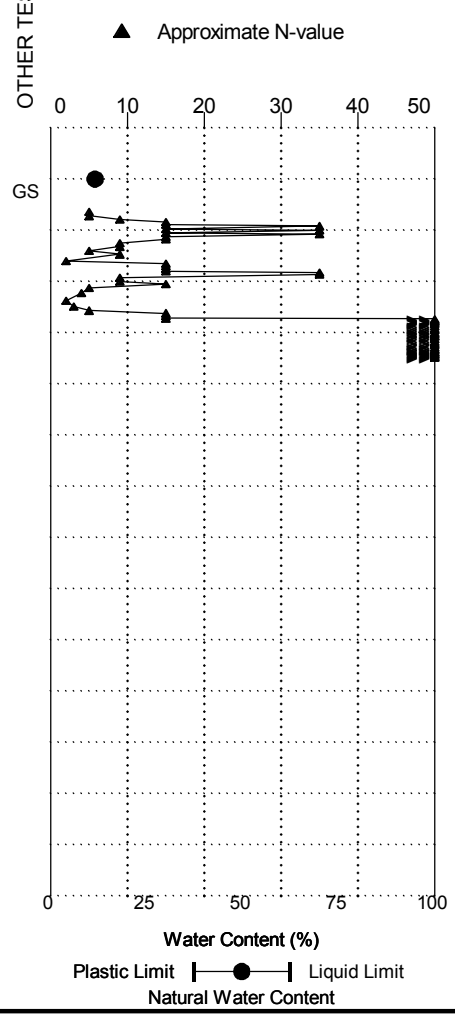


PHOTO OF TEST PIT

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.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-15

PROJECT NO.: 2015-098 FIGURE: A-16

Appendix B:
Laboratory Results

Laboratory tests were conducted on selected soil samples to characterize relevant engineering and index properties of the site soils. Laboratory testing, as described below, consisted of determining soil moisture content, plasticity characteristics (Atterberg Limits), and grain size distribution. All laboratory testing was completed in accordance with ASTM (American Society of Testing Materials) specifications.

Moisture Content

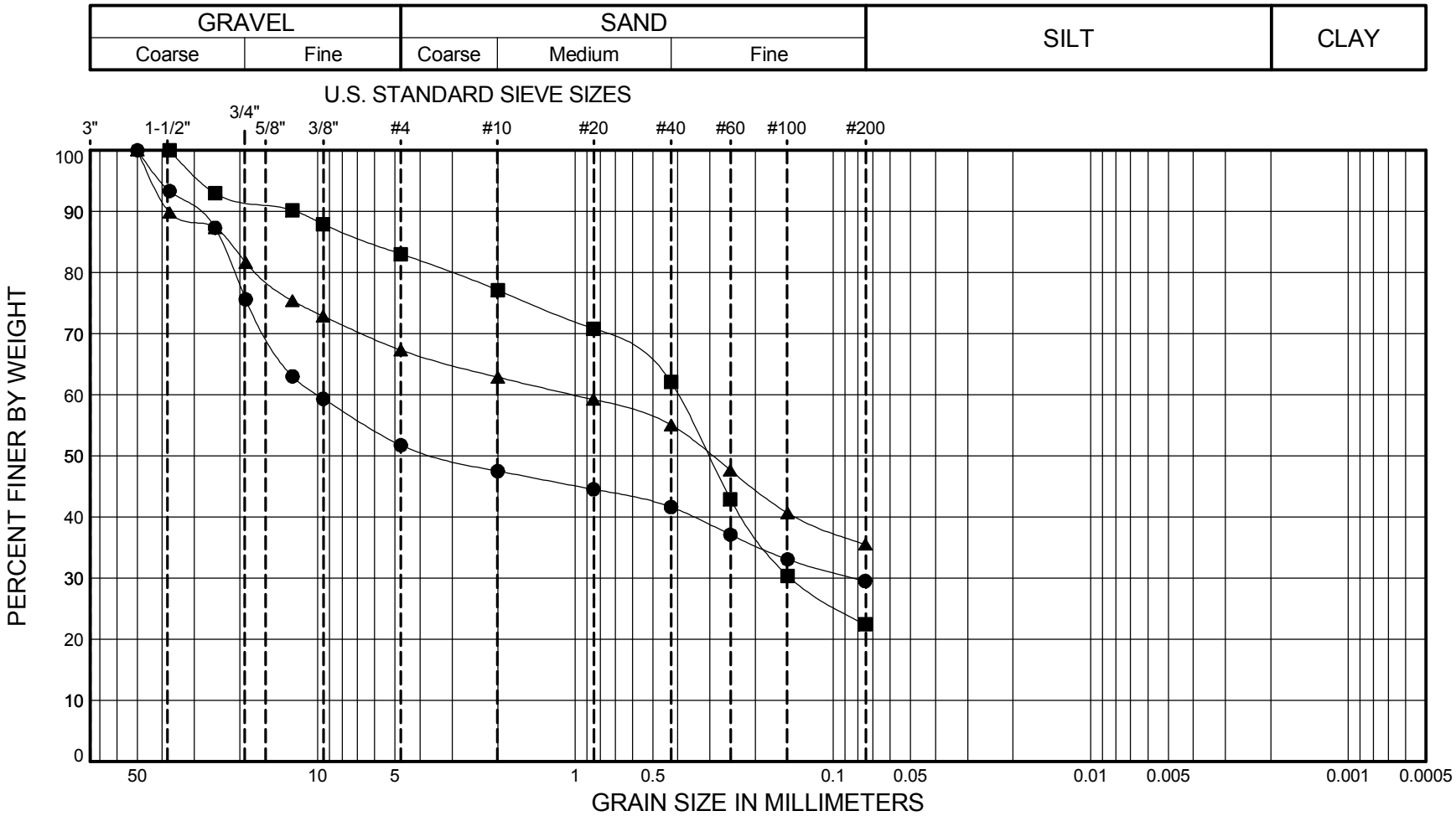
The moisture content for select samples collected from the explorations was determined in general accordance with ASTM D 2216. The results are shown at the sampled interval on the appropriate logs in Appendix A.

Plasticity Characteristics

Plasticity tests (Atterberg Limits) were performed on select samples from TP-13 and TP-14. The tests were conducted in general accordance with ASTM D 4318.

Grain Size Distribution/ Percent Fines Analysis

The grain size distribution and percentage of fines of representative samples from the explorations were determined in general accordance with ASTM D 422 and ASTM D 1140, respectively.



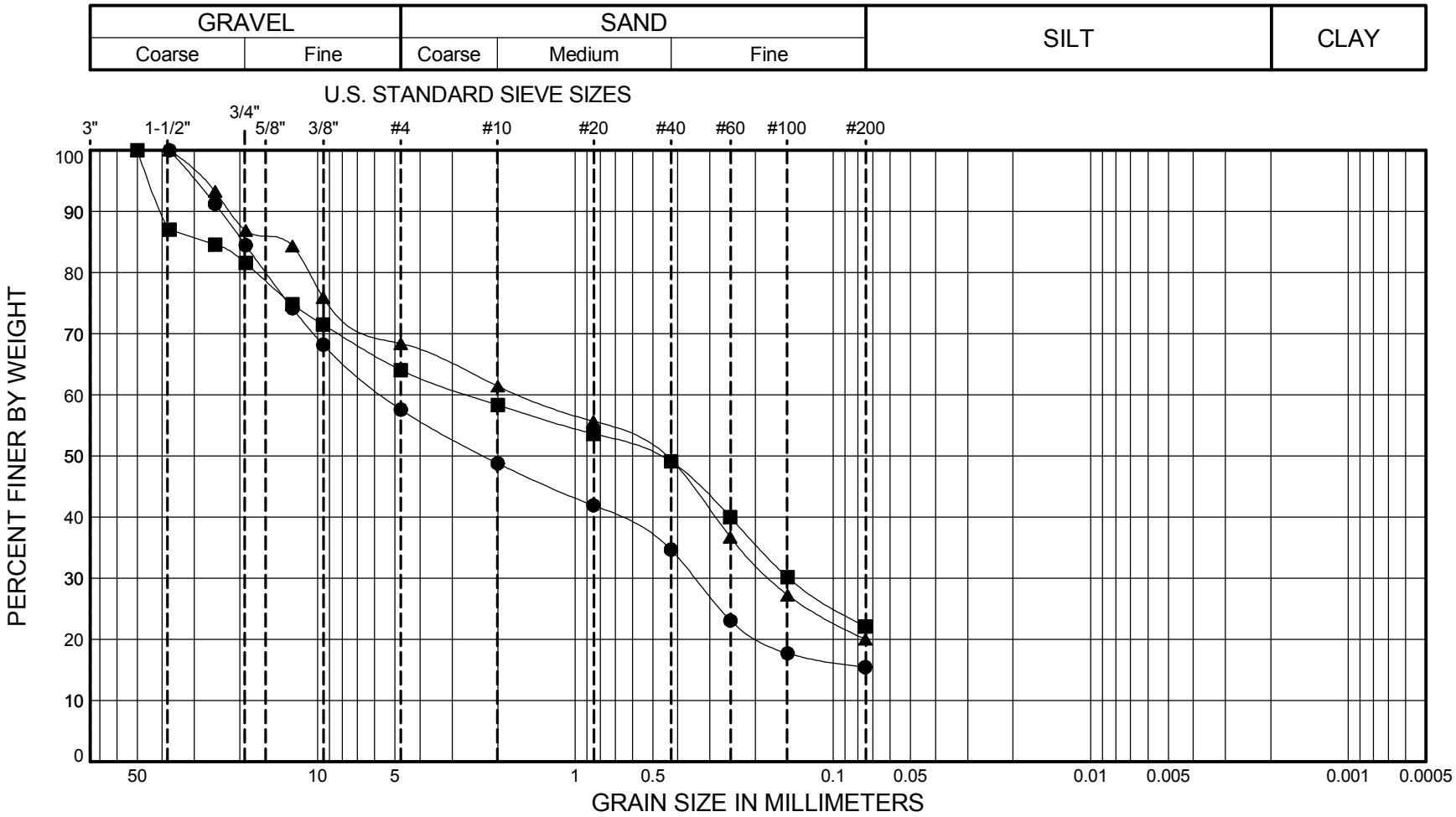
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP- 2	S-1	1.0 - 1.5	(GM) Brown, silty GRAVEL with sand	14				48.3	22.2	29.5
■	TP- 3	S-2	2.5 - 3.0	(SM) Olive brown, silty SAND with gravel	6				17.0	60.6	22.4
▲	TP- 4	S-1	1.0 - 1.5	(GM) Brown, silty GRAVEL with sand	18				32.7	31.8	35.5

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2015-098 FIGURE: B-1



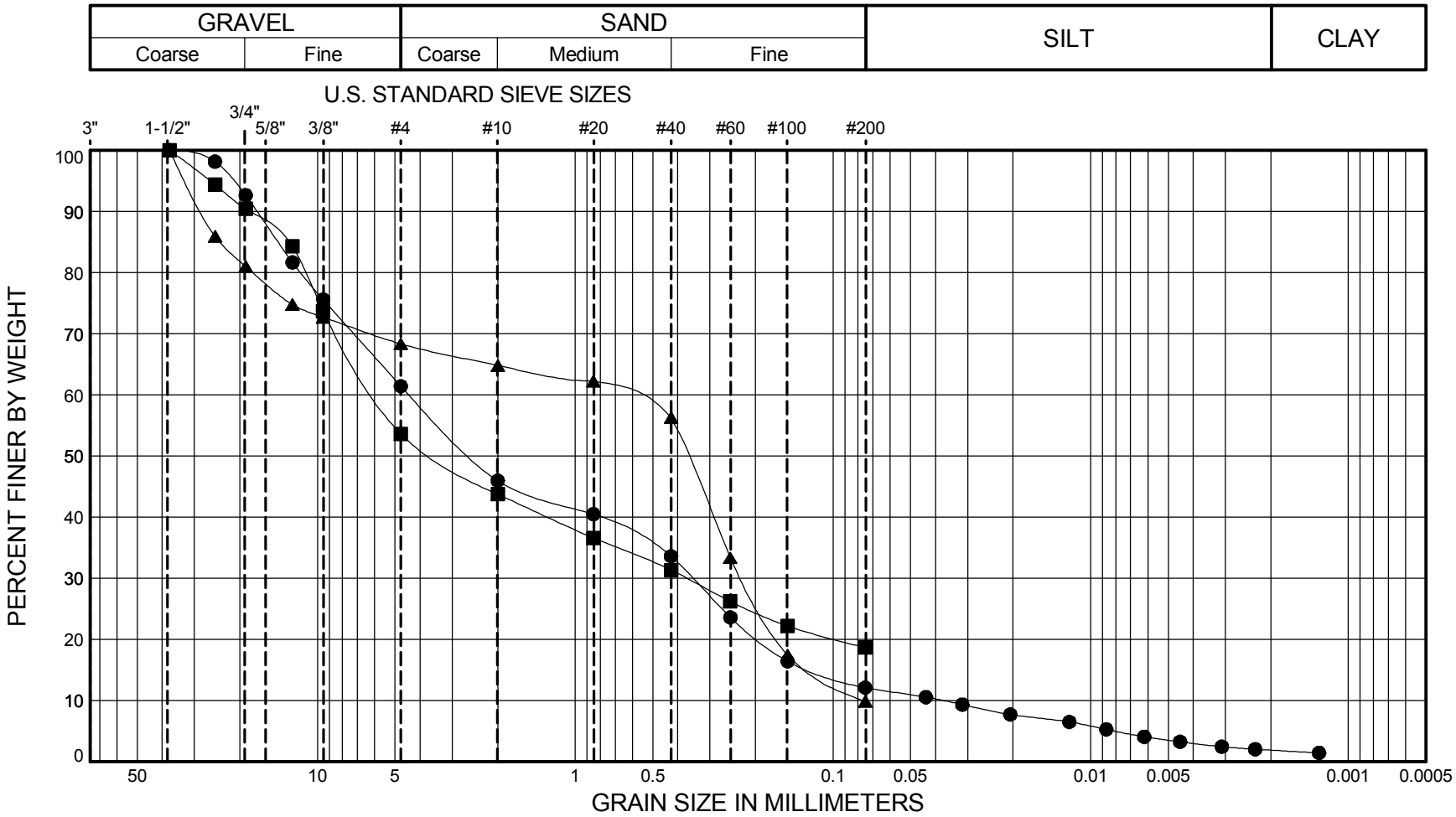
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP- 5	S-2	2.0 - 3.0	(GM) Brown, silty GRAVEL with sand	15				42.4	42.1	15.4
■	TP- 6	S-3	5.0 - 5.5	(SM) Yellowish brown, silty SAND with gravel and cobbles	7				36.0	41.9	22.1
▲	TP- 7	S-1	1.0 - 1.5	(SM) Dark yellowish brown, silty SAND with gravel and cobbles	20				31.6	48.4	20.0

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2015-098 FIGURE: B-2



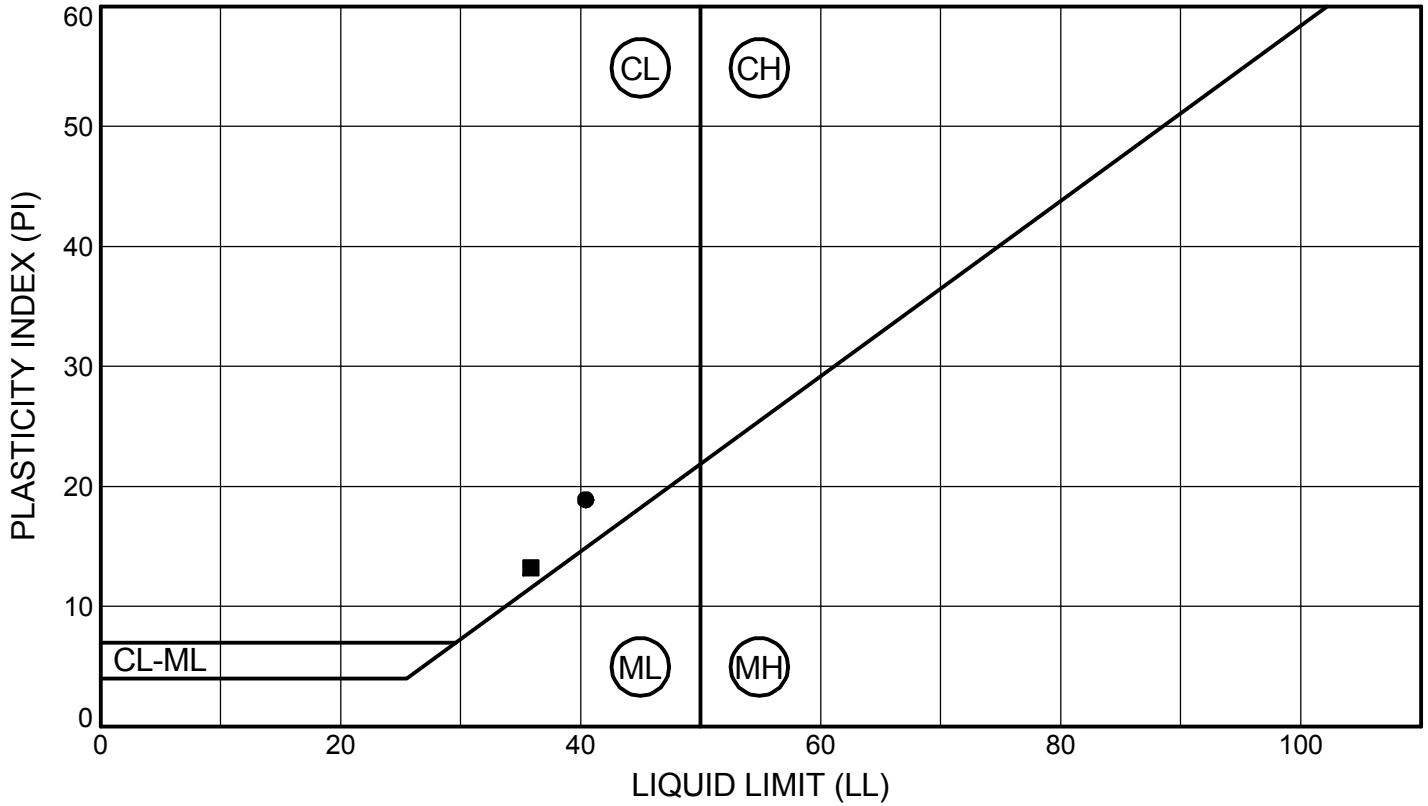
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP-10	S-3	2.5 - 3.0	(SM) Olive brown, silty SAND with gravel	7				38.6	49.3	12.1
■	TP-12	S-1	1.0 - 2.0	(GM) Dark brown, silty GRAVEL with sand	12				46.4	35.0	18.7
▲	TP-15	S-1	1.0 - 1.5	(SW-SM) Dark yellowish brown, well graded SAND with silt and gravel	11				31.7	58.4	9.9

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2015-098 FIGURE: B-3



SYMBOL	SAMPLE	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	TP-13S-2	(CL) Olive gray, lean Clay	33	40	22	18	
■	TP-14S-1	(CL) Grayish brown, lean CLAY	26	36	23	13	

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PLASTICITY CHART

PROJECT NO.: 2015-098 FIGURE: B-4

Appendix C:
Cost Estimating Tool

The City of Lake Stevens requested that HWA develop a rough order of magnitude costing tool to help estimate the costs required to construct embankment and retaining wall roadway prisms within wetland areas. Tables C-1 and C-2 present those cost estimates. Tables C-1 and C-2 are not intended to be design or bid documents. The cost information presented in Tables C-1 and C-2 is based strictly on conceptual roadway prism design. Further geotechnical investigation is required to develop the finalized roadway prism design. The estimated costs presented Tables C-1 and C-2 should not be construed as our warranty of actual construction costs; the roadway prism may vary during final design.

The basic assumptions used to develop the costing information in Table C-1 are presented below:

- Retaining wall height = 8 feet
- Width of roadway prism = 36 feet
- Length of roadway prism = 100 feet
- Over-excavation depth = 4.5 feet

Table C-1. Estimated Cost to Construct Retaining Prism in Wetland Area

Task:	**Estimated Cost ($):**
Over-excavation	35,000
Dewatering	20,000
Wall Construction	56,000
Structural Fill Placement	45,000
Culvert Installation	15,000
Roadway Construction	22,000
Grand Total ($)	193,000
Cost/Linear Foot ($)	1,930.00

The basic assumptions used to develop the costing information in Table C-1 are presented below:

- Embankment height = 8 feet
- Width of roadway prism = 36 feet
- Length of roadway prism = 100 feet
- Over-excavation depth = 4.5 feet

Table C-2. Estimated Cost to Construct Embankment Prism in Wetland Area

Task:	**Estimated Cost ($):**
Over-excavation	55,000
Dewatering	25,000
Embankment Construction	86,000
Culvert Installation	22,000
Roadway Construction	22,000
Grand Total ($)	210,000
Cost/Linear Foot ($)	2,100.00