Technical Memorandum

TO: Mr. Rodney Lakey, PE, Senior Engineer, Lewis County Public Works

FROM: Barsha Pradhan, EIT, and Benjamin Ford, PE

DATE: February 19, 2021

RE: **Summary of Geotechnical Engineering Services**
Lincoln Creek Road MP 13.7 Culvert Replacement
Lewis County, Washington
Project No. 1647009.010.013

Introduction

This memorandum summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Lincoln Creek Road MP 13.7 Culvert Replacement project in Lewis County, Washington (site; Figure 1). Services were provided in accordance with the scope outlined in Task Order No. 3 between LAI and Lewis County Public Works (County; project owner).

Project Understanding

LAI's project understanding is based on information provided by the County and on data collected during the geotechnical field exploration and laboratory testing programs. The County proposes to replace two culverts at Lincoln Creek Road milepost 13.7. The existing culverts consist of two corrugated metal squash pipes, measuring 6 feet (ft) wide by 4 ft high, that carry Wildcat Creek beneath Lincoln Creek Road. The roadway shoulder at the culvert inlet was damaged during recent flooding events.

The County plans to replace the culverts with a 16-ft-wide-by-8-ft-high, concrete split box culvert or a 20-ft-wide open-bottom culvert. Both replacement options would include wing walls. No modification will be made to the stream alignment. The County retained LAI's geotechnical engineering services to support design and construction of the culvert replacement.

Surface Conditions

The site consists of a two-lane asphalt road (Lincoln Creek Road) built on an embankment at the existing culvert crossing. The maximum fill height of the embankment is approximately 6 ft. The roadway surface near the inlet of the existing culverts was eroded during recent flooding events. The creek bank is forested with coniferous and deciduous trees with an understory of vegetation common to the area.

Geologic Conditions

Geologic information for the site and the surrounding area was obtained from the *Geologic Map of the Chehalis River and Westport Quadrangles, Washington* (Logan 1987). Surficial deposits in the vicinity of the site are mapped as alluvium (Qa), a unit that typically consists of unconsolidated or semi-consolidated alluvial clay, silt, sand, gravel, and cobble deposits. Nearshore sedimentary deposits [EN(sk)] also are mapped in the vicinity of the site and consist of Skookumchuck formation siltstone, sandstone, and conglomerate deposits.

The subsurface conditions observed in LAI's December 2020 exploration were generally consistent with the mapped geology for the site; however, undocumented embankment fill was encountered in the exploration.

Subsurface Conditions

Subsurface conditions at the site were explored on December 21, 2020 by advancing one hollow-stem auger boring (B-1) 36.5 ft below ground surface (bgs). The boring was advanced at the approximate location shown on Figure 2.

LAI personnel monitored the field exploration, collected representative soil samples, and maintained a detailed record of the subsurface soil and groundwater conditions observed. Subsurface conditions were described using the soil classification system shown on Figure 3, in general accordance with ASTM International (ASTM) standard test method D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).* A summary exploration log is presented on Figure 4.

Samples were transported to LAI's soils laboratory for further examination and testing. Natural moisture content tests were performed on select soil samples in accordance with ASTM standard test method D2216-19, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.* The natural moisture content is shown as "W = xx" (i.e., percent of dry weight) in the "Test Data" column on Figure 4.

Grain size analyses were performed in accordance with ASTM standard test method D422-63(2007)e2, *Standard Test Method for Particle-Size Analysis of Soils.* Samples selected for grain size analyses are designated with a "GS" in the "Test Data" column on Figure 4. The results of the grain size analyses are presented on Figure 5.

Atterberg limits determinations were performed in accordance with ASTM standard test method D4318-00, *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.* Samples selected for Atterberg limits determinations are designed with an "AL" in the "Test Data" column on Figure 4. The results of the Atterberg limits determinations are presented on Figure 6.

Field log descriptions were checked against the laboratory samples; where appropriate, the descriptions were updated in accordance with ASTM standard test method D2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).*

Soil Conditions

The soils observed underlying existing surface conditions (i.e., asphalt pavement) were categorized into three general units:

- **Fill:** The fill observed in boring B-1 consisted of silty, gravelly sand in a medium dense, moist condition. The fill extended approximately 2 ft bgs.
- **Alluvium:** Alluvium was observed beneath the fill and consisted of elastic silt with sand and gravel content or of very gravelly, silty, sand. The alluvium was in a soft or medium dense to dense, moist to wet condition and extended 12 ft bgs.
- **Marine Sedimentary Rock:** Weathered marine sedimentary rock was observed beneath the alluvium and consisted of very stiff to hard elastic silt in a moist condition. Boring B-1 was terminated in this unit.

Groundwater Conditions

During LAI's December 2020 field investigation, zones of perched groundwater were observed between 5 and 12 ft bgs in boring B-1; no true groundwater table was observed.

Groundwater conditions will vary depending on local subsurface conditions, weather conditions, and other factors. Furthermore, site groundwater levels are expected to fluctuate seasonally, with maximum groundwater levels occurring during late winter and early spring. LAI anticipates that groundwater levels at the site will approximate the surface water elevation of Wildcat Creek.

Conclusions and Recommendations

Based on the subsurface conditions observed in the December 2020 exploration, site soils are anticipated to provide adequate support for three- or four-sided culverts built on shallow foundations, provided LAI's geotechnical recommendations are incorporated into the project design. The following key points should be considered when developing project plans and specifications:

- Shallow foundations should be installed 8 ft bgs or deeper or on a structural fill pad that extends to such depths.
- Moisture-sensitive soils ("MH" or "SM" on Figure 4) may be present at the foundation elevation of the culvert or wing wall structures. A bearing pad, measuring at least 6 inches thick, should be placed beneath foundations to limit the disturbance of poorly graded, moisture-sensitive soils.
- Site soil is highly moisture sensitive and not recommended for reuse as structural fill.
- If encountered in construction excavations, groundwater can be managed with sumps, pumps, cutoff walls, and/or diversion systems. Groundwater and surface water will need to be controlled during construction to provide a dry, stable work area.

Culvert Structures

Shallow foundations should be supported by a bearing pad, as described in the "Construction Considerations" section. When developing design recommendations for the culvert replacement, LAI assumed that backfill within the structural excavation zone would consist of Select Borrow conforming to the requirements in Section 9-03.14(2) of the Washington State Department of Transportation's 2021 *Standard Specifications for Road, Bridge, and Municipal Construction* (*2021 WSDOT Standard Specifications*). LAI also assumed that the Select Borrow would be compacted to at least 95 percent of its maximum dry density. Table 1 includes soil parameters that can be used to design culvert walls.

Table 1. Culvert Design Parameters

Parameter	Value
Backfill soil unit weight (pcf)	130
Backfill soil submerged unit weight (pcf)	68
Backfill soil internal angle of friction (degrees)	34
At-rest earth pressure coefficient (K_0)	0.44

pcf = pounds per cubic foot

Table 2 includes ultimate bearing resistances for strength, service, and extreme event limit states for shallow foundations.

Table 2. Shallow Foundation Design Nominal Bearing Resistance

Culvert Type	Foundation Width (ft)	Ultimate Bearing Resistance (ksf)[(a)]	
		Strength and Extreme Limit States	Service Limit State (1-inch settlement)
Open/Bottom Spread Footing	2	8.3	N/A[(b)]
	4	11.8	11.6
	6	15.2	8.4
Closed Bottom	14	27.1	4.9
	16	29.7	4.5
	18	32.2	4.2

Note: One-half of the service limit settlement could occur as differential settlement.
(a) Ultimate bearing resistance for intermediate foundation widths can be interpolated.
(b) Service limit state exceeds strength and extreme limit states. Use strength and extreme limit states value (8.3 ksf) for service limit state.
ft = feet
ksf = kips per square foot
N/A = not applicable

The resistance factors (AASHTO 2017) in Table 3 should be used in combination with the foundation soil and ultimate sliding resistance values in Table 4.

Table 3. Shallow Foundation Resistance Factors

Limit State	Bearing	Sliding
Strength	0.45	Precast concrete: 0.90 Cast-in-place concrete: 0.80
Extreme	0.90	0.90
Service	1.0	1.0

Retaining Wall Design Parameters

Retaining walls may be used to contain embankment soils at the inlet and outlet of the replacement culvert. Retaining walls should be evaluated for global stability during final design. For planning purposes, the heels of culvert wing walls should be assumed to equal 80 percent of the wall height. The soil parameters in Table 4 can be used to design retaining walls; passive resistance should not be included, given the potential for scour at the face of retaining walls.

Table 4. Retaining Wall Design Parameters

Parameter	Value		
	Level Backslope	**3H:1V Backslope**	**2H:1V Backslope**
Backfill soil unit weight (pcf)	130		
Backfill soil submerged unit weight (pcf)	68		
Backfill soil internal angle of friction (degrees)	34		
Foundation soil internal angle of friction (degrees)	36		
Active earth pressure coefficient (K_a)	0.28	0.35	0.42
At-rest earth pressure coefficient (K_0)	0.44	0.55	0.66
Seismic earth pressure coefficient – Unrestrained (K_{ae})	0.41	0.58	0.66
Seismic earth pressure coefficient – Restrained (K_{ae})	0.75	N/A	N/A
Ultimate coefficient of sliding	Cast-in-place: 0.57 Precast: 0.46		

Note: LAI assumes retaining walls will be unrestrained and free to rotate.
H = horizontal
N/A = not applicable
pcf = pounds per cubic foot
V = vertical

Retaining walls may be supported on shallow foundations designed in accordance with the parameters in Tables 2 through 4.

Seismic Design

Buried structures (culverts) with span lengths of 20 ft or more typically are designed for seismic loading. Culverts with span lengths of less than 20 ft typically do not require seismic design. The seismic conditions in Table 5 were determined in accordance with the American Association of State Highway and Transportation Officials' (AASHTO) *LRFD* (Load and Resistance Factor Design) *Bridge Design Specifications* (2017). AASHTO recommends using a "7 percent probability of exceedance in 75 years" (nominal 1,000-year earthquake) design event to develop a design spectrum for structures (2017).

Table 5. Seismic Design Parameters

Site Class	M	PGA (g)	A_s (g)	S_s (g)	S_1 (g)	F_a	F_v	F_{PGA}
D	9.34	0.335	0.39	0.759	0.329	1.196	1.742	1.165

A_s = site-adjusted peak ground acceleration
F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively
F_{PGA} = peak ground acceleration coefficient
g = acceleration due to gravity
M = design earthquake moment magnitude
PGA = peak ground acceleration
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

The site is underlain with very stiff to hard marine sedimentary rock deposits. In LAI's opinion, there is a low risk that seismically induced soil liquefaction or lateral spreading will occur at the site. Given the distance between the site and the nearest known active crustal faults, the risk of ground rupture due to surface faulting is low.

Construction Considerations

The following key points should be reviewed when developing project plans and specifications:

- **Foundation bearing pads:** Moisture-sensitive soils are anticipated at the base of shallow foundations. To provide a firm working surface, LAI recommends overexcavating at least 6 inches of moisture-sensitive soil and replacing with Crushed Surfacing Base Course (bearing pad) that conforms to the requirements in Section 9-03.9(3) of the *2021 WSDOT Standard Specifications.* The bearing pad should extend within the limits of excavation. The bearing pad should be compacted to a firm, unyielding condition. Compaction should be field-verified by the engineer.
    - Before the bearing pad is installed, a separation geotextile, conforming to the requirements in Table 3, Section 9-33.2(1) of the *2021 WSDOT Standard Specifications,* should be placed on the prepared subgrade, within the limits of the excavation.
- **Reuse of site soil:** Site soil has a high fines and moisture content and should not be reused as structural fill.

- **Structural fill:** Select Borrow, as described in Section 9-03.14(2) of the *2021 WSDOT Standard Specifications,* is a suitable source of structural fill. During periods of wet weather, the fines content should not exceed 5 percent, based on the minus ¾-inch fraction. Structural fill should be used as backfill within the limits of the structural excavation.
- **Shoring systems:** Sheet pile shoring systems/cutoff walls may be difficult to advance in the hard marine sedimentary rock deposits. The contractor should be prepared for difficult driving conditions if sheet pile systems are required for temporary shoring or dewatering.
- **Temporary excavations:** Temporary excavations should be completed in accordance with the guidelines set forth in Section 2-09 of the *2021 WSDOT Standard Specifications.* Actual excavation trench configurations and the maintenance of safe working conditions, including temporary excavation stability, are the responsibilities of the contractor. Temporary excavations in excess of 4 ft should be shored or sloped in accordance with the requirements outlined in Safety Standards for Construction Work, Part N (Washington State Department of Labor and Industries, Chapter 296-155 Washington Administrative Code). The soil likely to be exposed in the excavation sidewalls should be considered Type C. The maximum allowable excavation inclination in Type C soils is 1.5H:1V. The soil parameters in Table 6 should be used to design engineered shoring systems.

Table 6. Recommended Soil Parameters for Design of Temporary Shoring

Soil Unit	Moist Unit Weight (pcf)	Submerged Unit Weight (pcf)	Cohesion (psf)	Internal Angle of Friction (degrees)
Fill	125	63	0	32
Alluvium	120	58	0	32
Marine Sedimentary Rock	130	68	4,000	—

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

- **Dewatering/bypass:** If encountered during construction excavation, groundwater can likely be managed with sumps, pumps, cutoff walls, and/or diversion systems. Groundwater and surface water will need to be controlled during construction to provide a dry, stable work area. Completing construction during summer and early fall, when Wildcat Creek is at its lowest level, will reduce the magnitude of dewatering required for the project. In general, site soils are fine- to coarse-grained and will produce water if not properly treated.
- **Roadway embankment:** Embankments should be constructed with 2H:1V slopes or flatter, in accordance with the requirements in Section 2-03 of the *2021 WSDOT Standard Specifications.*
- **Oversized material:** Cobbles and boulders are often found in alluvial soils and may be encountered during excavation. The contractor should be prepared to manage such oversized material.

Use of This Technical Memorandum

Landau Associates has prepared this technical memorandum for the exclusive use of Lewis County Public Works for specific application to the Lincoln Creek Road MP 13.7 Culvert Replacement project in Lewis County, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Reuse of the information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that, within the limitations of scope, schedule, and budget, its services have been provided in a manner consistent with that level of skill and care ordinarily exercised by members of the profession currently practicing in the same locality, under similar conditions as this project. Landau Associates makes no other warranty, either express or implied.

Closing

We trust that this technical memorandum provides you with sufficient information to proceed with the project. If you have questions or comments, or if we can be of further service, please contact Benjamin Ford at (360) 791-3178 or at bford@landauinc.com.

LANDAU ASSOCIATES, INC.

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Attachments:
- Figure 1. Vicinity Map
- Figure 2. Site and Exploration Plan
- Figure 3. Soil Classification System and Key
- Figure 4. Log of Boring B-1
- Figure 5. Grain Size Distribution
- Figure 6. Plasticity Chart

References

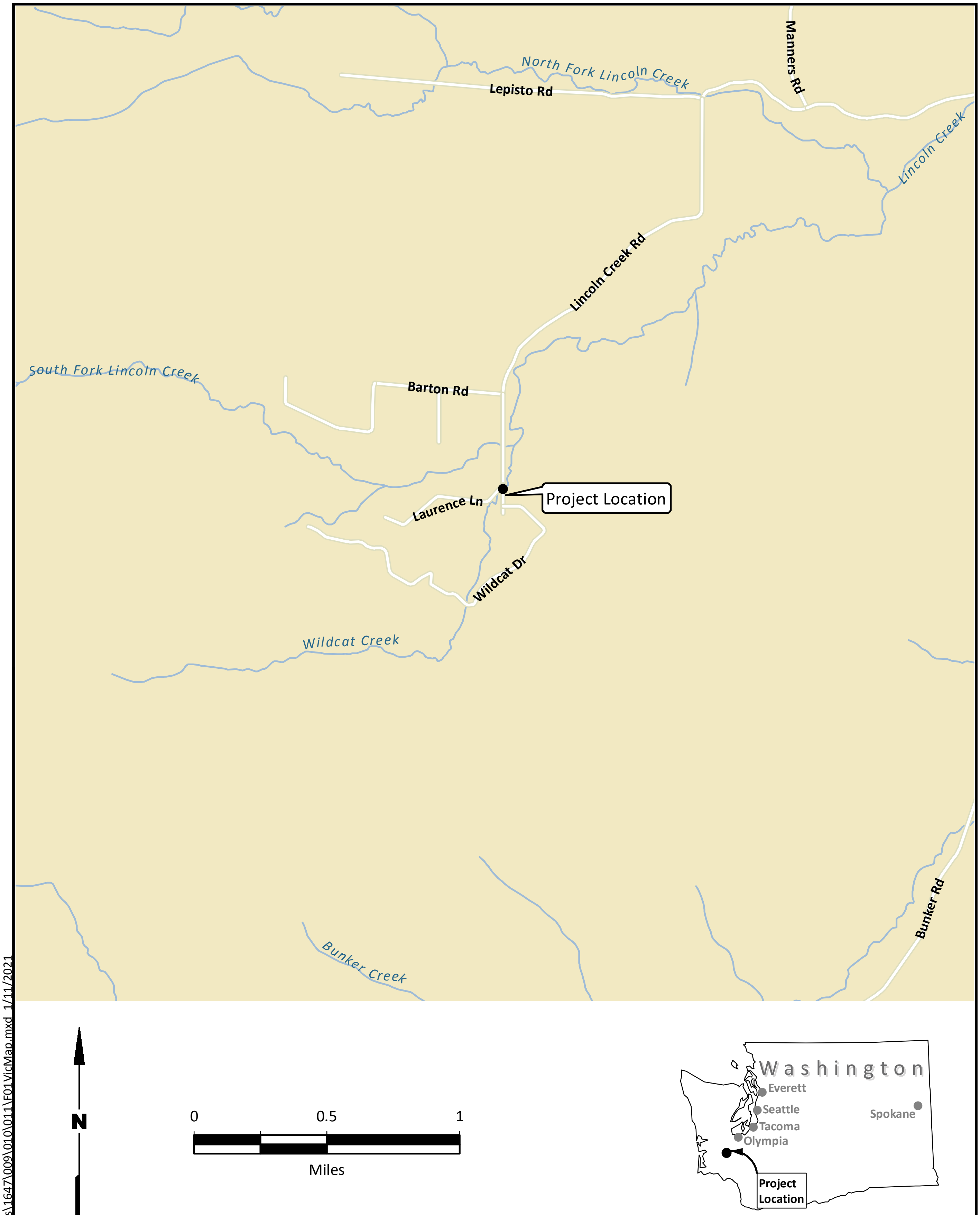
AASHTO. 2017. *LRFD Bridge Design Specifications, Customary U.S. Units.* 8th Edition. American Association of State Highway and Transportation Officials. September.

ASTM. 2003. D420-D5876: Annual Book of Standards. In: *Soil and Rock (I).* ASTM International. West Conshohocken, PA.

LNI. 2020. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries. June 2.

Logan, R.L. 1987. *Geologic Map of the Chehalis River and Westport Quadrangles, Washington.* Open File Report 87-8. Washington State Department of Natural Resources. Washington Division of Geology and Earth Resources.

WSDOT. 2020. *M41-10: Standard Specifications for Road, Bridge, and Municipal Construction.* 2021 Edition. Washington State Department of Transportation. September 9.



Data Sources: Esri; Lewis County GIS.

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Lincoln Creek Road Culvert Replacement Lewis County, Washington	**Vicinity Map**	Figure 1

Legend

B-1 ⊕ Approximate Boring Location and Designation

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Lewis County GIS; Esri World Imagery.

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Lincoln Creek Road
Culvert Replacement
Lewis County, Washington

Site and Exploration Plan

Figure
2

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL(1)	TYPICAL DESCRIPTIONS (2)(3)
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)	▨	**GW**	Well-graded gravel; gravel/sand mixture(s); little or no fines
			▨	**GP**	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	▨	**GM**	Silty gravel; gravel/sand/silt mixture(s)
			▨	**GC**	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)	▨	**SW**	Well-graded sand; gravelly sand; little or no fines
			▨	**SP**	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)	▨	**SM**	Silty sand; sand/silt mixture(s)
			▨	**SC**	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)		▨	**ML**	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
			▨	**CL**	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
			▨	**OL**	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)		▨	**MH**	Inorganic silt; micaceous or diatomaceous fine sand
			▨	**CH**	Inorganic clay of high plasticity; fat clay
			▨	**OH**	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL		▨	**PT**	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT	■ ▨	**AC** or **PC**	Asphalt concrete pavement or Portland cement pavement
ROCK	▨	**RK**	Rock (See Rock Classification)
WOOD	▨	**WD**	Wood, lumber, wood chips
DEBRIS	▨	**DB**	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent: > 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents: > 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents: > 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

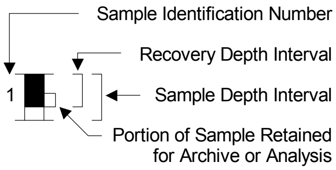
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽	Approximate water level at time of drilling (ATD)
▼	Approximate water level at time after drilling/excavation/well

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Lincoln Creek Road
Culvert Replacement
Lewis County, Washington

Soil Classification System and Key

Figure
3

B-1

LAI Project No: 1647009.010

SAMPLE DATA

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
S-1	b2	3	W = 63 AL
S-2	b2	3	
S-3	b2	25	W = 25 GS
S-4	b2	31	
S-5	b2	24	W = 35 AL
S-6	b2	31	W = 31 AL
S-7	b2	50	
S-8	b2	48	
S-9	b2	53	

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35

Elevation (ft)

SOIL PROFILE

Drilling Method: Hollow-Stem Auger

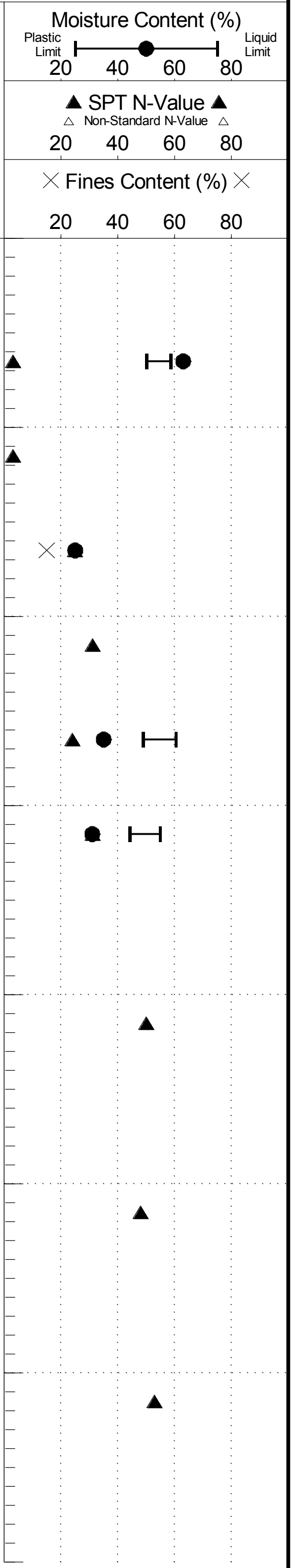
Ground Elevation (ft): Not Measured

Drilled By: Holocene Drilling Inc.

Logged By: BP Date: 12/21/20

USCS Symbol	Description
AC	2 inches of asphalt over 2 inches of base course **(ASPHALT)**
SM	Gray, gravelly, silty, fine to coarse SAND (medium dense, moist) **(FILL)**
MH	Dark gray, elastic SILT with trace organics (soft, moist) **(ALLUVIUM)** -Grades to gray-brown, moist to wet, and sandy
SM	-Fractured rock observed in sampler shoe Gray, silty, very gravelly, fine to coarse SAND (medium dense, wet) -Fractured rock observed in sampler shoe -Grades to dense
MH	Gray, elastic SILT (very stiff, moist) **(MARINE SEDIMENTARY ROCK)** -Grades to hard

Groundwater: Perched



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Lincoln Creek Road
Culvert Replacement
Lewis County, Washington

Log of Boring B-1

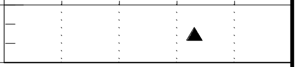
Figure
4
(1 of 2)

B-1

LAI Project No: 1647009.010

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: BP Date: 12/21/20

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		Groundwater	Moisture Content (%) Plastic Limit – Liquid Limit 20 40 60 80 ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
35		S-10	b2	66		▥	MH	Gray, elastic SILT (hard, moist)		▲



Boring Completed 12/21/20
Total Depth of Boring = 36.5 ft.

40
45
50
55
60
65
70

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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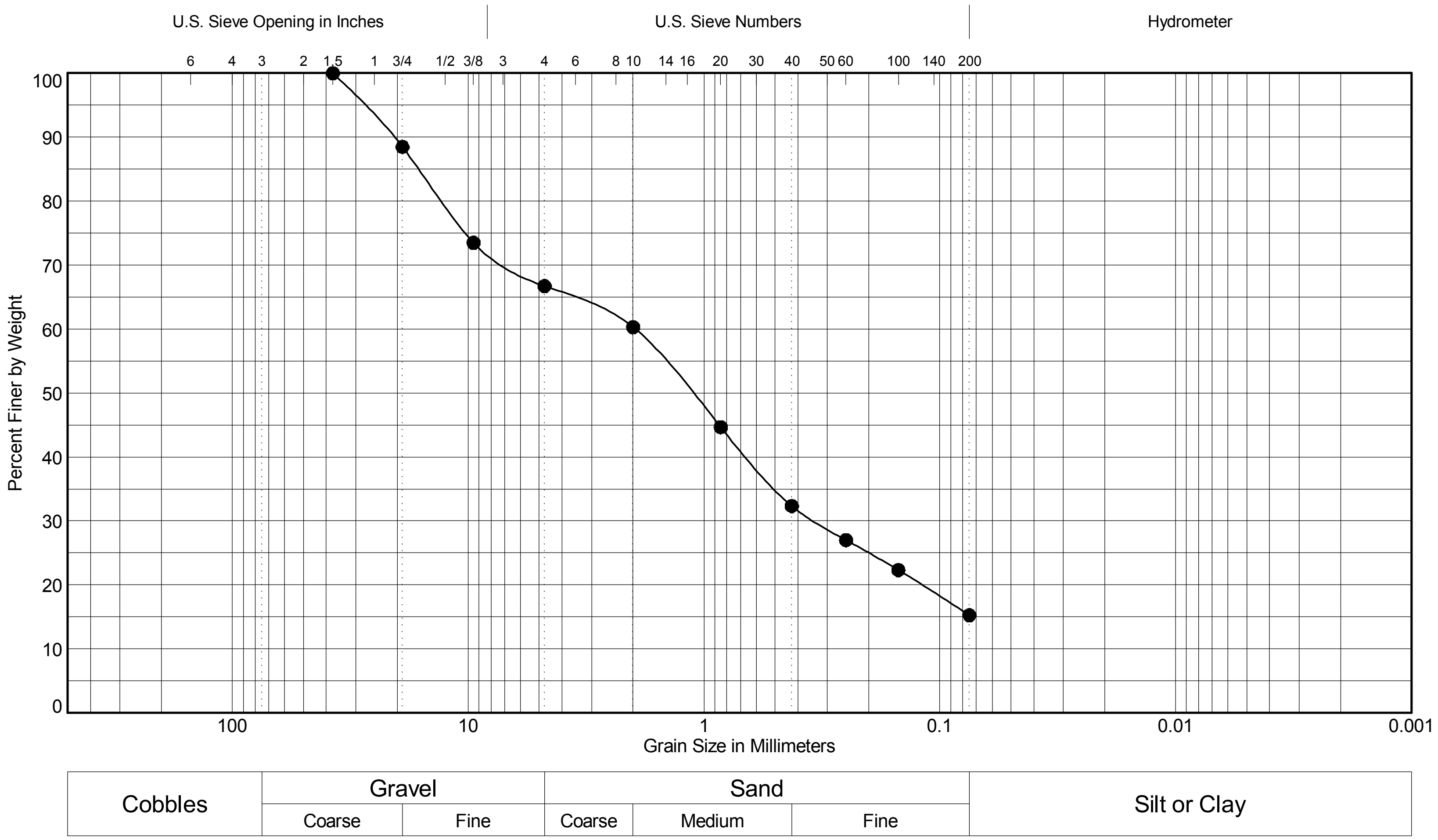
Lincoln Creek Road
Culvert Replacement
Lewis County, Washington

Log of Boring B-1



Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-1	S-3	7.5	25	Silty, very gravelly, fine to coarse SAND	SM

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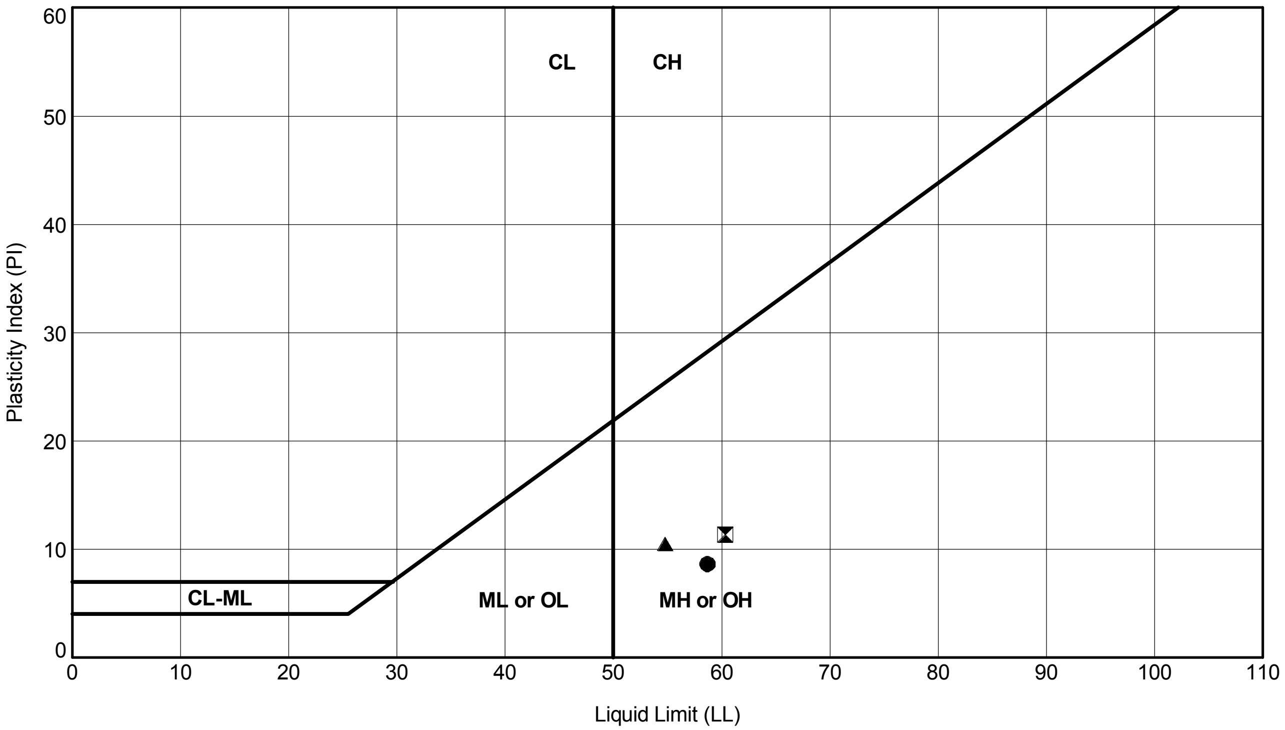
Lincoln Creek Road
Culvert Replacement
Lewis County, Washington

Grain Size Distribution

Figure
5



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-1	S-1	2.5	59	50	9	63	Elastic SILT	MH
⧗	B-1	S-5	12.5	60	49	11	35	Elastic SILT	MH
▲	B-1	S-6	15.0	55	44	11	31	Elastic SILT	MH

ASTM D 4318 Test Method

1647009.01 2/19/21 C:\USERS\MSKINNER\DESKTOP\1647009.010.GPJ ATTERBERG LIMITS FIGURE

LANDAU ASSOCIATES

Lincoln Creek Road
Culvert Replacement
Lewis County, Washington

Plasticity Chart

Figure
6