Technical Memorandum

TO: Erik Martin, PE, Sargent Engineers

FROM: Calvin McCaughan, PE

DATE: January 7, 2020

RE: **Summary of Geotechnical Engineering Services**
Chehalis Tribe Fish Hatchery Bridge Replacement
Oakville, Washington
Project No. 1758002.010.011

Introduction

This technical memorandum summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Chehalis Tribe Fish Hatchery Bridge Replacement project. The project is located along Howanut Road in Oakville, Washington (site; Figure 1). Geotechnical services were provided in accordance with the scope outlined in the professional services agreement between LAI and Sargent Engineers, Inc. (Sargent, project civil engineer), authorized October 2, 2019.

Project Understanding

LAI's project understanding is based on information provided by representatives of Sargent and the Chehalis Indian Tribe (Chehalis Tribe, project owner) and on its review of available geologic and geotechnical documents regarding the site and the surrounding area.

The Chehalis Tribe proposes to replace a bridge along Howanut Road with a triple box culvert (three side-by-side culverts). Preliminary design drawings indicate that each culvert will have a 10-foot (ft)-wide by 8-ft-tall opening. The Chehalis Tribe used a similar culvert configuration in a recent project, and chose to use it here as well. Seismic design is not being considered.

Details regarding the triple box culvert and project earthwork are provided in Attachment 1. LAI understands that the finished roadway surface elevation, shown in Attachment 1, will approximate existing roadway grades.

Site Conditions

The site consists of a two-lane asphalt road, built on an embankment at the existing bridge crossing. The site is bordered by farmland to the south and by brush and blackberries to the north. The bridge crosses a seasonal flood channel that drains into Black River approximately 100 ft north of the site. The channel is partially lined with concrete, and riprap is present near its confluence with the river. Area residents have indicated that, historically, the channel has been used for cattle access.

During LAI's October 24, 2019 site visit, the channel was observed to be approximately 3 to 3.5 ft above the surface water elevation of Black River. The surface of Howanut Road is approximately 8.5 ft above the channel. These elevations are based on visual observations and measurements by LAI personnel. The channel was dry during LAI's site visit.

LAI's review of river hydrographs (Ecology 2019) indicates that, during its October 2019 site visit, the river stage was approximately 85.5 ft. (Here, river stage refers to the water level above the gauge at U.S. Highway 12, approximately 1 mile upstream of the site.) Review of historical hydrographs suggests that the river is typically 2 to 3 ft higher during the wet season (between November and April), and 1 ft lower in mid-summer.

Geologic Conditions

Geologic information for the site was obtained from the *Geologic Map of the Chehalis River and Westport Quadrangles, Washington* (Logan 1987). Vashon-age glacial outwash deposits are mapped at the site and in the surrounding area. The map identifies near-surface site soils as alluvium, a mixture of silt, sand, and gravel typically deposited in streambeds and fans. Vashon glacial outwash gravel consists of recessional and proglacial, stratified gravels, cobbles, and boulders deposited in meltwater streams and deltas. The glacial outwash gravel could contain ice-contact deposits and silt layers.

The subsurface conditions observed in LAI's explorations were generally consistent with the mapped geology.

Subsurface Conditions

Subsurface conditions were explored on October 24, 2019 by advancing and sampling two hollow-stem auger borings (B-1 and B-2) at the approximate locations shown on Figure 2. Borings B-1 and B-2 were advanced 31.0 and 31.5 ft below ground surface (bgs), respectively.

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).* Summary logs of the explorations are presented on Figures 4 and 5.

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

- **Fill:** Fill was observed in borings B-1 and B-2, and consisted of sandy gravel with silt in a medium dense, moist condition. The fill extended 5 to 6 ft bgs.
- **Alluvium:** Alluvium deposits were observed beneath the fill, and generally consisted of silt with sand in a soft, moist condition. The silt graded to loose, wet sand and gravel. The alluvium extended 18 to 20 ft bgs.

LAI interprets the upper portion (silt) of this unit to be moderately compressible. The moderately compressible soil extended to 15 ft bgs in boring B-1, and to 11 ft bgs in boring B-2.

- **Outwash:** Outwash deposits were observed beneath the alluvium, and consisted of sandy gravel with silt in a medium dense to very dense, wet condition. Both borings terminated in this unit.

During the October 2019 field investigation, groundwater was observed at 13 ft bgs, or approximately 1 ft below the river elevation at time of drilling. Site groundwater levels are likely to approximate the surface water elevation of Black River, and will vary depending on local subsurface conditions, weather conditions, and other factors. Furthermore, groundwater levels are expected to fluctuate seasonally, with maximum groundwater levels occurring between November and April.

Conclusions and Recommendations

Based on the conditions observed in LAI's subsurface explorations, shallow foundations should provide suitable support for the triple box culvert. The following key points should be considered during project planning and construction:

- Construction should be completed during the dry season (May to October). If construction is completed during the wet season, the proposed subgrade elevation could be submerged, and cofferdams and internal pumping may be required to complete dewatering.
- Excavating to the proposed subgrade elevation (approximately 13 ft bgs) is likely to expose areas of soft silt. Overexcavating these areas would expose the saturated, highly permeable soils underlying the silt. Rather than overexcavating, LAI recommends placing a geotextile at the base of the excavation. Vibratory compaction should not be used on the overlying bearing pad gravel.

Culvert Design

When preparing design recommendations, LAI assumed that backfill within the excavation zone (Attachment 1) would consist of Gravel Borrow conforming to the requirements in Section 9-03.14(1) of the Washington State Department of Transportation's *2018 Standard Specifications for Road, Bridge, and Municipal Construction* (*2018 WSDOT Standard Specifications*). LAI also assumed that the Gravel Borrow would be compacted to at least 95 percent of its maximum dry density (MDD). The soil parameters provided in Table 1 can be used to design the replacement culvert.

Table 1. Culvert Wall Design Parameters

Parameter	Value
	Level Backslope
Backfill soil unit weight (pcf)	125
Backfill soil submerged unit weight (pcf)	63
Backfill soil internal angle of friction (degrees)	34
Foundation soil internal angle of friction (degrees)	30
Active earth pressure coefficient (K_a)	0.28
At-rest earth pressure coefficient (K_0)	0.44
Passive earth pressure coefficient (K_p)	3.54
Ultimate coefficient of sliding	Cast-in-place: 0.57 Precast: 0.46

Note: Wing walls typically are designed using active earth pressure, and box culvert walls using at-rest earth pressure.
H = horizontal
pcf = pounds per cubic foot
V = vertical

Table 2 provides ultimate bearing resistances for strength, service, and extreme limit states for shallow foundation design.

Table 2. Nominal Bearing Resistance for Shallow Foundation Design

Foundation Type	Foundation Width (ft)	Ultimate Bearing Resistance (ksf)	
		Strength and Extreme Limit States	Service Limit State (2-inch Settlement)
Closed Bottom Box Culvert	12	14.9	3.2
Wing Wall Continuous Footing	8	12.3	4.0

ft = feet
ksf = kips per square foot

Table 3 provides resistance factors for shallow foundation design (AASHTO 2017).

Table 3. Resistance Factors for Shallow Foundation Design

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

Settlement Considerations

The 13-ft-deep structural excavation (including the bearing pad) will likely extend below the majority of compressible soil, and appreciable foundation settlement is not anticipated. However, 5 to 7 ft of compressible soil will remain in place beneath approach embankments. Approach embankments are likely to experience settlement if site grades are raised.

LAI estimates 1 to 2 inches of embankment settlement for every 1 ft that roadway grades are raised. Ninety percent of the total settlement should occur in the 6 months following construction. Localized pavement patching may be required within 5 years of construction.

Construction Considerations

The following geotechnical recommendations should be considered during preparation of project specifications:

- **Temporary excavations:** Temporary excavations should be completed in accordance with the guidelines set forth in Section 2-09 of the *2018 WSDOT Standard Specifications.* The contractor should be responsible for actual trench configurations and the maintenance of safe working conditions. 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 of the Washington Administrative Code). The material likely to be exposed in the structural excavations should be considered Type C soil with a maximum allowable excavation inclination of 1.5 horizontal to 1 vertical (1.5H:1V).
- **Dewatering:** During LAI's October 2019 field investigation, groundwater was observed at 13 ft bgs. At that time, the surface water elevation of nearby Black River was estimated at 12 ft bgs. A 13-ft-deep excavation is proposed for the replacement structure. As such, the excavation may be constructed below groundwater. (Note: The seasonal high groundwater table is estimated to be a few feet more than the observed groundwater elevation, and the seasonal low groundwater table is estimated to be approximately 1 ft less.)

  Soils observed beneath the silt layer (designated "ML" on Figures 4 and 5) are granular and readily transmit groundwater. In LAI's experience, a 13-ft-deep excavation that is left open for more than a few hours will flood, producing groundwater levels equal to nearby surface water levels.

  If excavation into groundwater (below river level) is required, conventional sumps and pumps are unlikely to provide a dry, stable work area. Installation of shallow cofferdams and trash pumps should be anticipated. Completing construction between May and October will reduce dewatering needs. The contractor should be responsible for design and implementation of the dewatering system.
- **Sheet pile shoring systems:** Depending on the construction schedule, installation of sheet pile shoring systems/cutoff walls may be required. The parameters provided in Table 4 can be used to design engineered shoring systems, if needed. Given the density of outwash soil deposits, it may be difficult to install sheet piles more than 20 ft bgs.

Table 4. 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	62	0	34
Alluvium	110	48	0	30
Outwash	–	62	0	38

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

- **Subgrade preparation:** The prepared subgrade should be evaluated by a qualified civil or geotechnical engineer, who is familiar with the site and can check for soft and/or disturbed areas. To help stabilize soft, inorganic materials, a non-woven geotextile should be placed along the base of the excavation, per Section 9-33.2(1), Table 3 of the *2018 WSDOT Standard Specifications.*
- **Reuse of site soil:** Site soils may contain creosote from structural remnants (Figure 5), and reuse should be coordinated with the Chehalis Tribe. If clean of hazardous materials, fill soils within the top 5 ft of the existing grade (designated “GP-GM” on Figures 5 and 6) can be reused as structural fill during dry weather. Other site soils have a high fines and moisture content, and are not suitable for reuse as structural fill.
- **Import structural fill:** Gravel Borrow, conforming to the requirements in Section 9-03.14(1) of the *2018 WSDOT Standard Specifications,* is a suitable source of import structural fill. During periods of wet weather, the fines content should not exceed 5 percent, based on the minus ¾-inch fraction. Import structural fill should be used as backfill within the limits of the structural excavation.
- **Backfilling:** Backfill around structures should be placed and compacted in accordance with Section 2-03.3(14)C, Method C of the *2018 WSDOT Standard Specifications.* Compaction and moisture control tests should be performed in accordance with Section 2-03.3(14)D of the *2018 WSDOT Standard Specifications.* Alternatively, the MDD and optimum moisture content can be determined using ASTM standard test method D1557.
- **Roadway embankments:** If widened, roadway embankments should have side slopes of 2H:1V or flatter, in accordance with Section 2-03 of the *2018 WSDOT Standard Specifications.*
- **Pavement design:** In-kind pavement sections are anticipated.

Plan Review Notes

The earthwork notes in the current project plans (Attachment 1) are generally consistent with LAI’s geotechnical recommendations. The following material specifications align with LAI’s understanding of proposed earthwork, and can be added to the plans, if needed:

- Backfill within structural excavation limits: Gravel Borrow, as described in Section 9-03.14(1) of the *2018 WSDOT Standard Specifications.*

- Gravel Base: Ballast, as described in Section 9-03.9(1) of the *2018 WSDOT Standard Specifications.*
- General fill to raise site grades or to be placed outside of the structural excavation limits: Select Borrow, as described in Section 9-03.14(2) of the *2018 WSDOT Standard Specifications.*
- Crushed Surfacing Top Course: Section 9-03.9(3) of the *2018 WSDOT Standard Specifications.*
- Class A Rock for Erosion Protection: Section 9-13.4(2) of the *2018 WSDOT Standard Specifications.*
- Geotextile beneath box culverts: Section 9-33.2(1) of the *2018 WSDOT Standard Specifications,* Table 3, for Soil Stabilization, Non-Woven. **LAI suggests adding this element to the plan sheets.**
- Geotextile for permanent erosion control: Section 9-33.2(1) of the *2018 WSDOT Standard Specifications,* Table 4, Permanent Erosion Control, Moderate Survivability, Non-Woven.

Use of This Technical Memorandum

This technical memorandum has been prepared for the exclusive use of Sargent Engineers, Inc. and the Chehalis Indian Tribe for specific application to the Chehalis Tribe Fish Hatchery Bridge Replacement project in Oakville, Washington. Use of the information contained in this technical memorandum by others or for another project is at the user's sole risk. The findings, recommendations, and opinions presented herein are based on the field investigation completed for the project.

Closing

We trust that this memorandum provides you with sufficient information to proceed with the project. If you have questions or comments, or if we may be of further service, please contact the undersigned at (360) 791-3178.

LANDAU ASSOCIATES, INC.

CALVIN ALAN MCCAUGHAN
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44709
REGISTERED
PROFESSIONAL ENGINEER

1-7-2020

Calvin McCaughan, PE
Principal

CAM/mcs
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Attachments: Figure 1. Vicinity Map
Figure 2. Site and Exploration Location Plan
Figure 3. Soil Classification System and Key
Figures 4 and 5. Logs of Borings B-1 and B-2
Attachment 1. Box Culvert Sections/Details

References

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

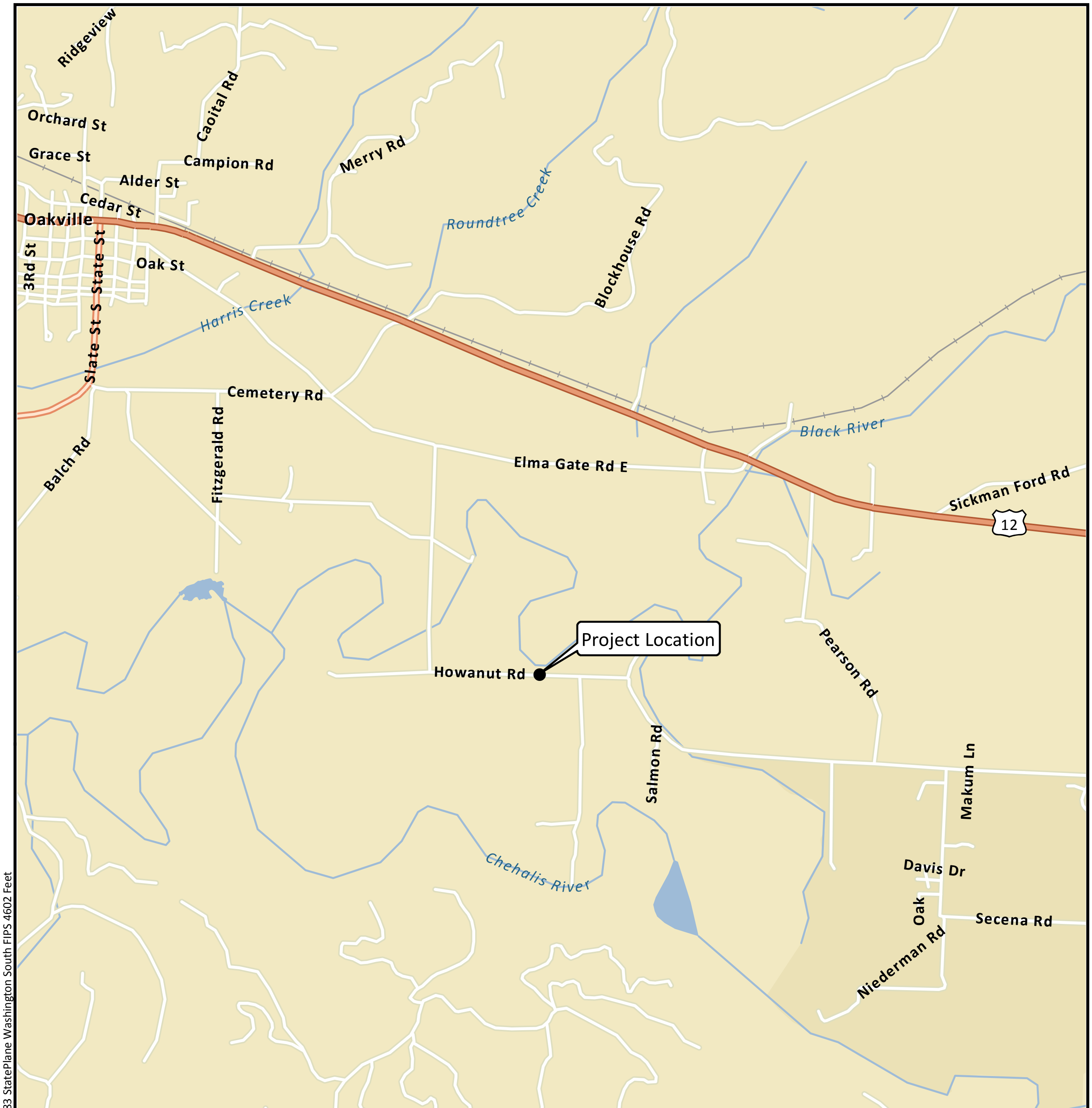
ASTM. 2017. Annual Book of ASTM Standards. In: Soil and Rock(I). West Conshohocken, PA. ASTM International.

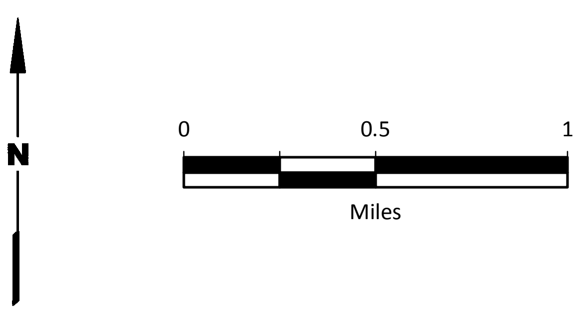
Ecology. 2019. Stream Flow Monitoring Station: Black River at Highway 12. Washington State Department of Ecology. Accessed November 4, 2019. Available online at: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=23E060#block3.

Logan, R.L. 1987. *Geologic Map of the Chehalis River and Westport Quadrangles, Washington.* Washington State Department of Natural Resources.

Washington State Department of Labor and Industries. 2016. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. May 20.

WSDOT. 2017. *M41-10: Standard Specifications for Road, Bridge, and Municipal Construction 2018.* Washington State Department of Transportation. December 1.





Data Source: Esri 2012

G:\Projects\1758\002\F01VicMap.mxd 10/28/2019 NAD 1983 StatePlane Washington South FIPS 4602 Feet

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Chehalis Tribe Fish Hatchery Bridge Replacement Oakville, Washington	**Vicinity Map**	Figure 1

Legend

B-1 Boring Location and Designation

Note

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

Source: Google Imagery 2018

0 50 100

Scale in Feet

Landau Associates

Chehalis Tribe Fish Hatchery
Bridge Replacement
Oakville, Washington

Site and Exploration Location 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 $\leq 50\%$ - "very gravelly," "very sandy," "very silty," etc.
	$> 15\%$ and $\leq 30\%$ - "gravelly," "sandy," "silty," etc.
Additional Constituents:	$> 5\%$ and $\leq 15\%$ - "with gravel," "with sand," "with silt," etc.
	$\leq 5\%$ - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

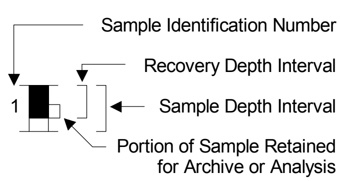
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

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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Chehalis Tribe Fish Hatchery
Bridge Replacement
Oakville, Washington

Soil Classification System and Key

Figure 3

B-1

LAI Project No: 1758002.010.

SAMPLE DATA / SOIL PROFILE

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: CAL Date: 10/24/19

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

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
~3		S-1	h2	66	W = 5
~6		S-2	h2	18	W = 4
		S-2B			
~8		S-3	b2	6	W = 44
~11		S-4	b2	3	W = 47
~16		S-5	b2	8	W = 16
~21		S-6	b2	33	W = 15
~26		S-7	b2	81	
~31		S-8	b2	50/ 5"	

USCS Symbol	Description
AC	3 inches of asphalt **(ASPHALT)**
GP-GM	Gray, sandy, fine to coarse GRAVEL with silt (medium dense, damp) **(FILL)** -Grades to brown and moist -Exaggerated blow count from contact with a rock
ML	Brown SILT with sand (medium stiff, moist) **(ALLUVIUM)** -Grades to without sand -Grades to soft and moist to wet -Grades to wet
GP	Light brown, sandy GRAVEL with silt and wood debris (loose, wet) -Water-bearing soil to boring termination
SP	Light brown, gravelly, fine to coarse SAND (dense, wet) **(OUTWASH)** -Grades to with gravel and very dense

Groundwater: ATD (approx. 13 ft)

50/ 5"

Boring Completed 10/24/19
Total Depth of Boring = 31.0 ft.

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.

1758002.010. 11/4/19 Y:\1758\002.010\T\1758002.010.GPJ SOIL BORING LOG WITH GRAPH

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Chehalis Tribe Fish Hatchery
Bridge Replacement
Oakville, Washington

Log of Boring B-1

Figure 4

B-2

LAI Project No: 1758002.010.

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: CAL Date: 10/24/19

SAMPLE DATA

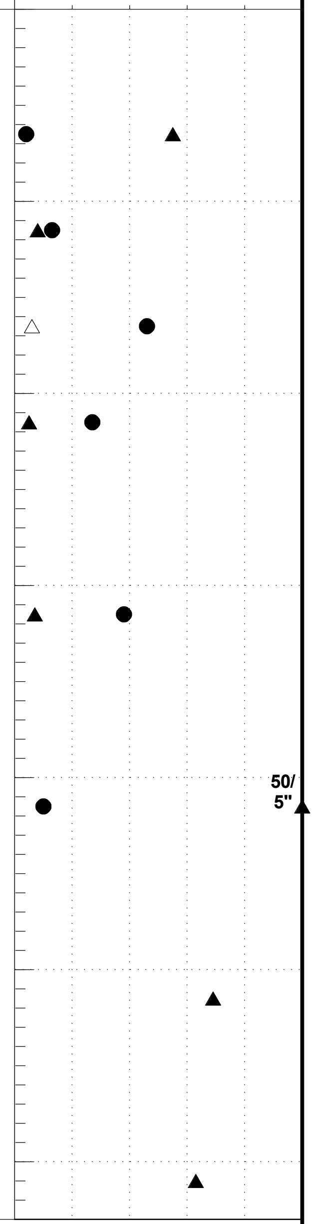
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
3		S-1	b2	55	W = 4
6		S-2	b2	8	W = 13
8		S-3	h2	6	W = 46
11		S-4	b2	5	W = 27
16		S-5	b2	7	W = 38
21		S-6	b2	50/ 5"	W = 10
26		S-7	b2	69	
31		S-8	b2	63	

SOIL PROFILE

Graphic Symbol / USCS Symbol	Description
AC	3 inches of asphalt **(ASPHALT)**
GP-GM	Gray, sandy, fine to coarse GRAVEL with silt (very dense, damp) **(FILL)** -Grades to brown
ML	-Exaggerated blow count from contact with a rock -Soil cuttings in upper 10 feet of boring smelled like diesel (assumed to be creosote from old timber bridge) Brown SILT with sand (medium stiff, damp) **(ALLUVIUM)** -Grades to soft -Grades to sandy and damp to moist
SP-SM	Brown, fine to medium SAND with silt (loose, moist) -Grades to dark gray-brown, with wood debris, and wet -Water-bearing soil to boring termination
SP	Light brown, gravelly, fine to coarse SAND (very dense, wet) **(OUTWASH)** -Grades to with gravel -Grades to gravelly

Groundwater: ATD (approx. 13 ft)

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



Boring Completed 10/24/19
Total Depth of Boring = 31.5 ft.

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.

1758002.010. 11/4/19 Y:\1758\002.010\T\1758002.010.GPJ SOIL BORING LOG WITH GRAPH

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Chehalis Tribe Fish Hatchery
Bridge Replacement
Oakville, Washington

Log of Boring B-2

Figure 5

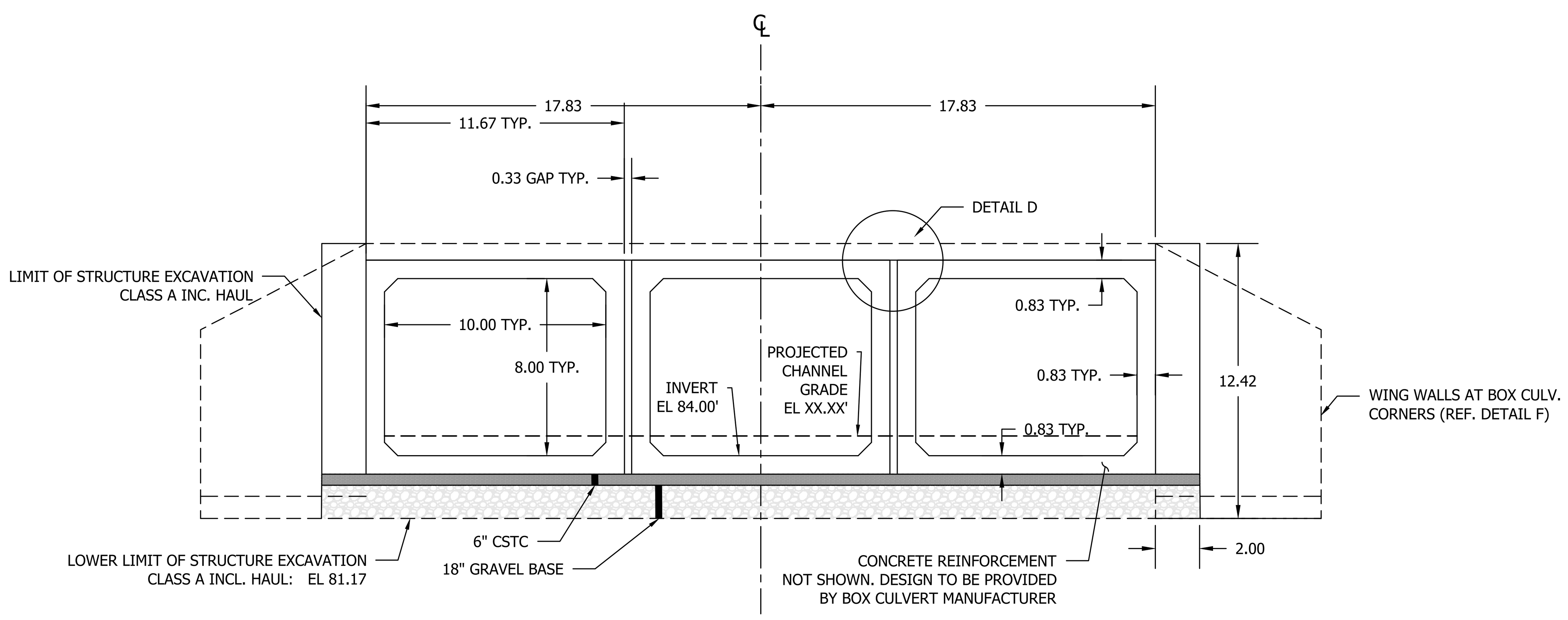
ATTACHMENT 1

Box Culvert Sections/Details

DIMENSIONS SHOWN ARE IN FEET
(Unless Noted Otherwise)

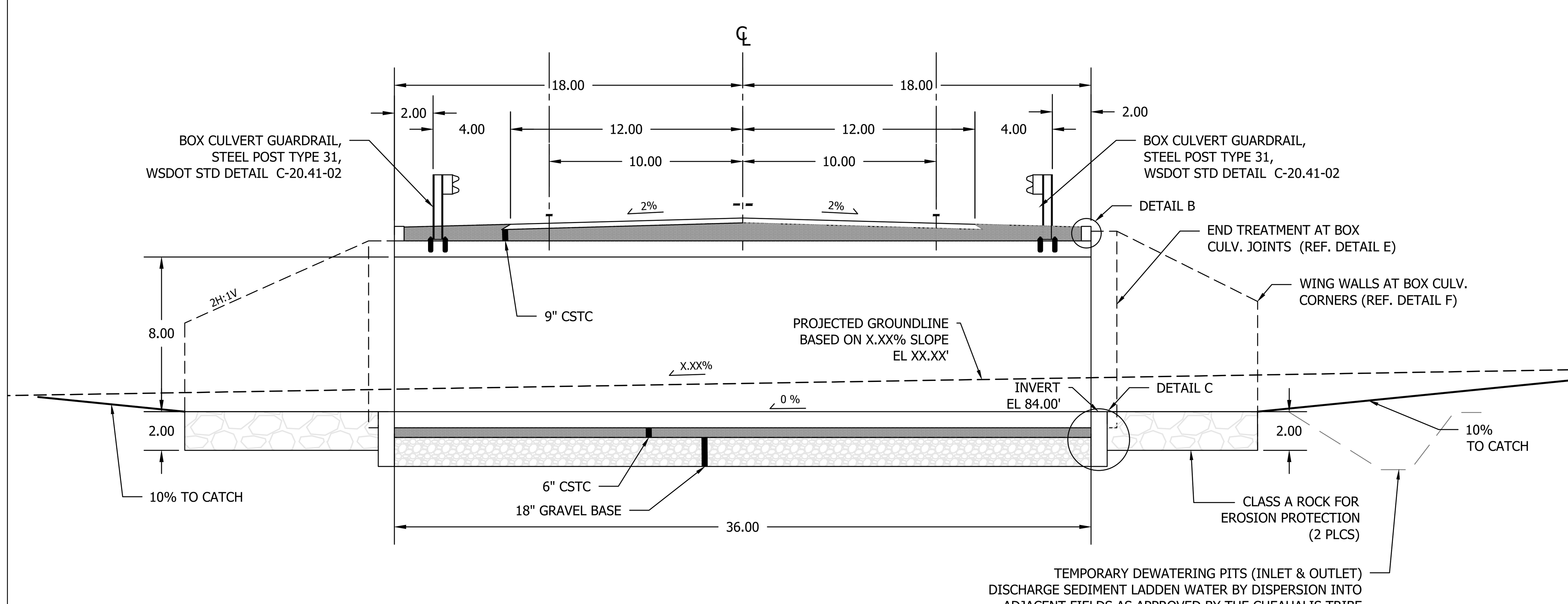
BOX CULVERT NOTES

1. ALL PRECAST REINFORCED BOX CULVERTS SHALL CONFORM TO THE LATEST EDITION OF ASTM C1433.
2. JOINTS FOR PRECAST SECTIONS SHALL BE TONGUE AND GROOVE TYPE AND SHALL BE SEALED WITH MASTIC OR SAND/CEMENT GROUT. JOINT SEALANT AND PRIMERS SHALL BE INCLUDED IN THE COST PER LINEAR FOOT OF BOX CULVERT.
3. LIFTING HOLES SHALL BE FILLED WITH CONCRETE PLUG AFTER THE BOX SECTIONS ARE IN PLACE.
4. END SECTIONS FOR THE PRECAST UNITS SHALL BE CAST IN PLACE IN ACCORDANCE WITH THE PLAN DETAILS.
5. SURFACE AND SUBSURFACE WATER SHALL BE CONTROLLED SO DRY CONDITIONS ARE AVAILABLE DURING EXCAVATION AND BEDDING PREPARATION. BACKFILLING OF THE TRENCH SHOULD BE FILLED TO THE LEVEL OF THE TOP OF THE CULVERT, FILLING AND COMPACTING EVENLY ON EACH SIDE.
6. THE CONTRACTOR MAY ELECT TO PROVIDE HEADWALLS, 6" CONCRETE CURB, WINGWALLS AS PRECAST CONCRETE. ALTERNATIVE REINFORCING AND CONNECTION DETAILS TO BE SUBMITTED BY THE CONTRACTOR AND APPROVED BY THE ENGINEER.
7. BEDDING, BACKFILL, AND EROSION CONTROL AGGREGATE MATERIAL SHALL BE PAID FOR UNDER THE CONCRETE BOX CULVERT UNIT PRICE WITH NO ADDITIONAL COMPENSATION ALLOWED.



SECTION B-B (SHEET 11): BOX CULVERT_INLET SECTION

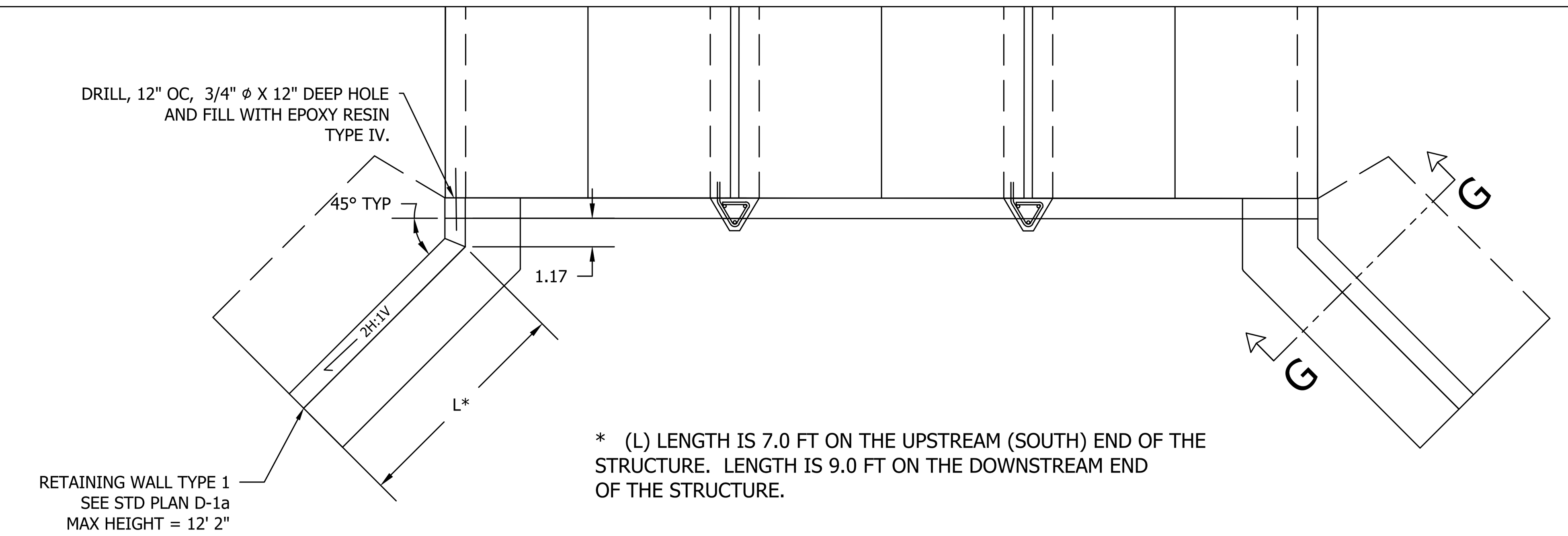
1"=5' on 24x36" Paper



SECTION A-A (SHEET 11): STREAM PROFILE OF CENTER BOX CULVERT

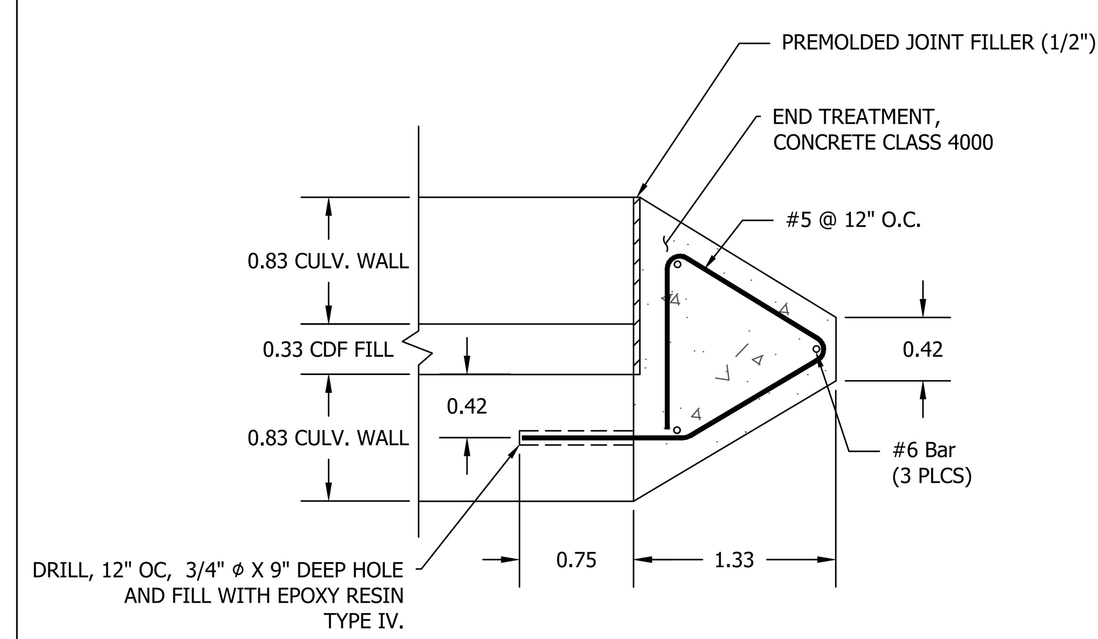
1"=5' on 24x36" Paper

GEOMETRY, STRIPING, AND PAVEMENT SECTIONS ARE SYMMETRIC ABOUT THE CENTERLINE FOR SECTIONS 2 THRU 5

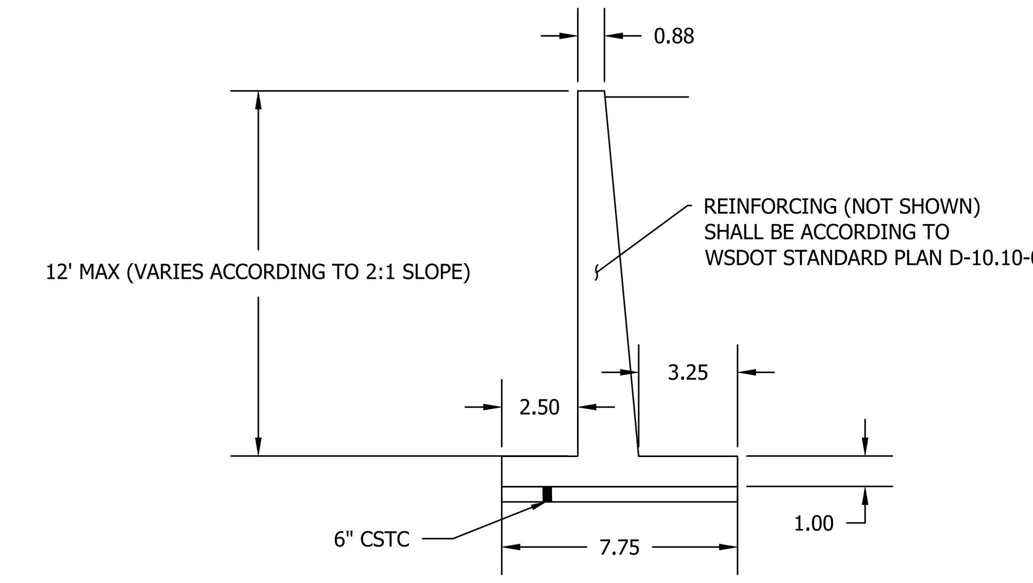


* (L) LENGTH IS 7.0 FT ON THE UPSTREAM (SOUTH) END OF THE STRUCTURE. LENGTH IS 9.0 FT ON THE DOWNSTREAM END OF THE STRUCTURE.

WINGWALL PLAN VIEW

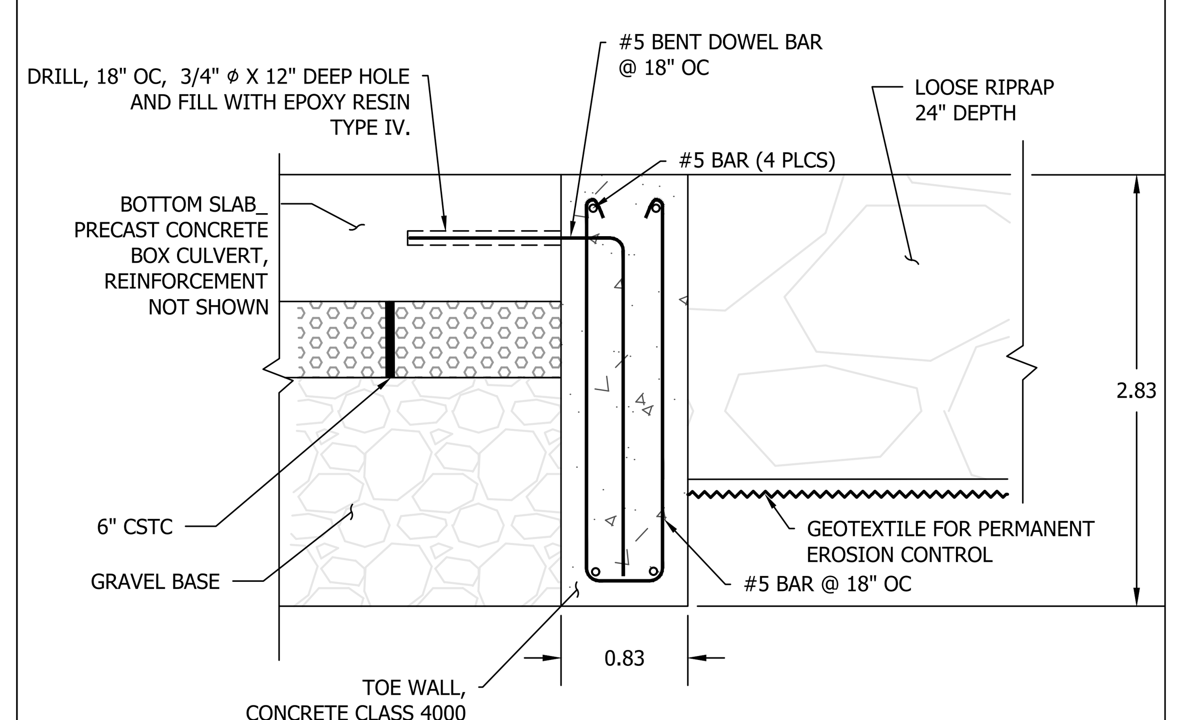


DETAIL E

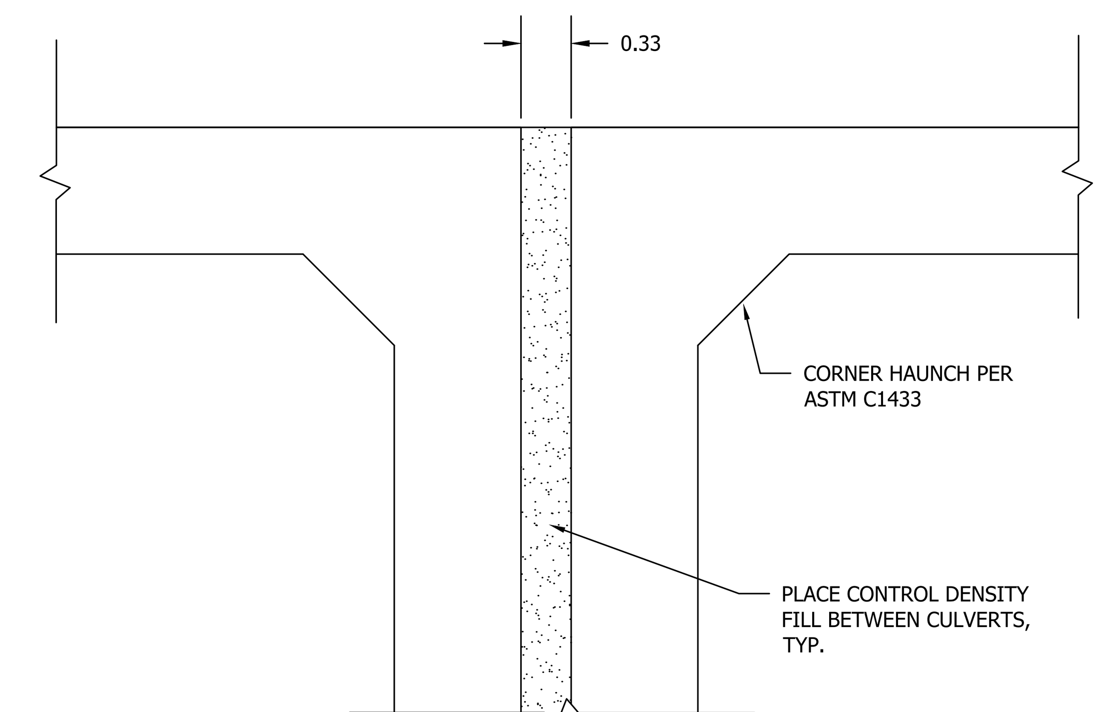


SECTION G-G

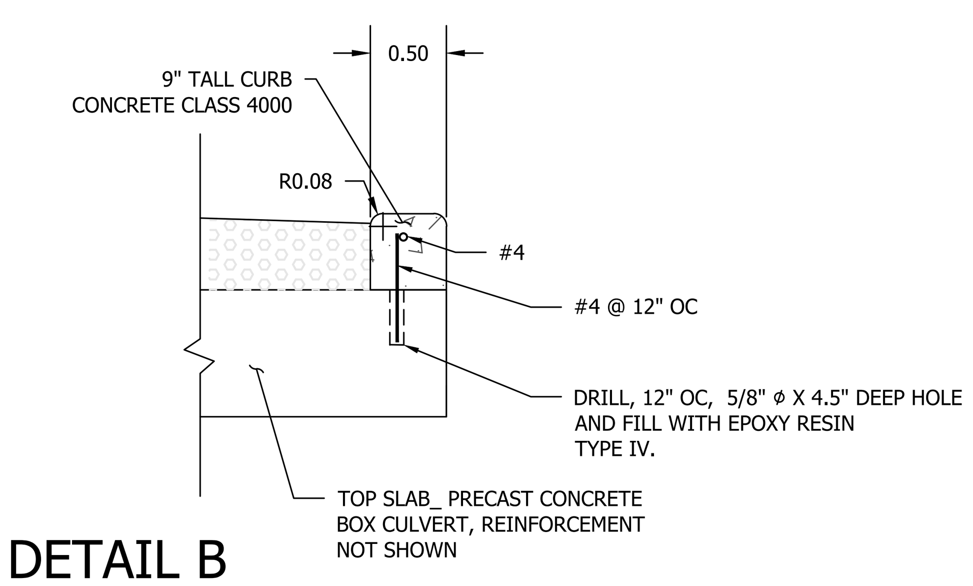
DETAIL F



DETAIL C



DETAIL D



DETAIL B

SARGENT
SARGENT ENGINEERS, INC.
320 Ronlee Lane NW • Olympia, WA 98502
Tel. 360 867-9284 • Fax 360 867-9318
SEI Pr. No. - A19157.00

THE CHEHALIS TRIBE
CONFEDERATED TRIBES OF THE CHEHALIS RESERVATION
PO BOX 536
OAKVILLE WA 98568
PHONE NO. (360) 273-5911
FAX NO. (360) 273-5914

REVISIONS			
NO.	BY	DATE	REMARKS
X	XXX	XX/XX/XX	X X

ERIK CHRISTOPHER MAGILL — STATE OF WASHINGTON — 40851 — REGISTERED PROFESSIONAL ENGINEER

PRELIMINARY

PROJECT INFORMATION	
DESIGNED	ECM
DRAWN	ECM
CHECKED	.
APPROVED	.
DATE	10/21/2019
OTHER	.

BOX CULVERT SECTIONS/DETAILS

HOWANUT - HATCHERY BRIDGE REPLACEMENT
PROJECT NUMBER A19157.00
30% CD PLANS

SHEET NUMBER
1