TETRA TECH

Holt Creek Bridge Replacement – Mile 59.7
Geotechnical Design Report

PRESENTED TO
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TABLE OF CONTENTS

LIST OF TABLES IN TEXT

APPENDIX SECTIONS

DRAWINGS

Drawing 04529-001 A Holt Creek Bridge Mile 59.7 Site Plan
Drawing 04529-003 B Holt Creek Bridge Mile 59.7 General Arrangement

FIGURES

APPENDICES

LIMITATIONS OF REPORT

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1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) has been retained by the British Columbia Ministry of Transportation and Infrastructure (BCMoTI) to provide geotechnical engineering services for the Holt Creek Trestle Replacement Project (the Project). This technical memorandum presents our observations of the existing geotechnical conditions at the site as they relate to the proposed trestle replacement.

The scope of work undertaken by Tetra Tech was in accordance with that outlined in Consulting Services Contract 861CS1191 issued by BCMoTI. This memorandum should be read in conjunction with Tetra Tech's Limitations of Use of this Document provided in Appendix A.

2.0 PROJECT DESCRIPTION

The Holt Creek Trestle is located on the now abandoned CN railway line between Duncan and Lake Cowichan, approximately 8 km to the west of Duncan. The trestle was constructed in 1922 and was part of the rail line until 1991. The Holt Creek Trestle forms part of the Cowichan Valley Trail (CVT, itself part of the Trans Canada Trail) and crosses Holt Creek, which runs into the Cowichan River about 500 m to the north of the trestle. BCMoTI maintains the trestle and most recently upgraded the structure in 2002 by adding pedestrian railings and engaging in structural rehabilitation work. The trestle is accessed from a parking lot 600 m to the east, off Robertson Road.

The Holt Creek Trestle has a span of approximately 80 m and a height of up to 35 m. The structure of the existing bridge consists of timber frame construction with foundations formed by a series of plinths or steps cut into the sides of the valley. Some of the timbers forming the bridge have been heavily creosoted at some point in the past to protect them from weathering. In keeping with convention, the left abutment of the bridge is on the west side and the right abutment of the bridge is on the east side, with Holt Creek running to the north.

3.0 DESIGN CRITERIA

Tetra Tech's geotechnical subsurface explorations and design have been carried out in accordance with the criteria outlined by SNC-Lavalin Inc. (SNCL) in the following:

- "*Holt Creek Trestle Structural Options Study (Doc. No. 662626-1000-42ER-0001)*", dated February 22, 2019.
- "*Ministry of Transportation & Infrastructure Bridge Project No. 04529 – 0001 Holt Creek Bridge Replacement – Mile 59.7*" (30% Design Submission), dated April 17, 2023.
- "*Ministry of Transportation & Infrastructure Bridge Project No. 04529 – 0001 Holt Creek Bridge Replacement – Mile 59.7*" (90% Design Submission), dated July 28, 2023.

The following design codes and standards have been used to develop the basis of design:

- National Building Code of Canada (NBCC) 2020.
- CAN/CSA S6-19 – Canadian Highway Bridge Design Code (CHBDC S6-19).
- BCMoTI Supplement to CHBDC S6-19.

For seismic design, the bridge structure has been classified as an "Other Bridge" as per the BCMoTI Supplement to CHBDC S6-19.

3.1 Design Basis

The following criteria for specific project components have been defined for developing the design. Geotechnical resistance factors have been defined based on a "typical understanding" of the subsurface conditions.

3.1.1 Bridge Pier Loading Conditions

The bridge pier loading conditions for the 90% Design Submission package were provided by SNCL via email on August 26, 2023, and are presented in Table 1.

Table 1: Summary of Bridge Pier Loading Conditions

Bridge Component	Serviceability Limit State (kN)	Ultimate Limit State (kN)
Superstructure Dead Load	1063	1241
Substructure Dead Load	1350	1620
Soil Dead Load on top of footing	210	252
Live Load	366	691
Loading on each Abutment	**2989**	**3804**

3.1.2 Static Performance

In accordance with the BCMoTI Supplement to CHBDC S6-19, a minimum Factor of Safety (FoS) of 1.54 is required for global stability of slopes beneath the bridge in static conditions, with a consequence factor of 1.0 based on a typical consequence level. The structure itself must also meet serviceability criteria defined in CHBDC S6-19 and the BCMoTI Supplement.

3.1.3 Seismic Performance

Based on the BCMoTI Supplement to CHBDC S6-19, a structure classified as an “Other Bridge” must meet Life Safety standards in the event of earthquake motions with a 2,475-year return period and Service Limited requirements in the event of earthquake motions with a 475-year return period. The seismic performance category for the bridge is classified as 3.

Ground motion parameters for the design earthquake events are based on the NBCC 2020. For seismic loading, permanent slope deformations must be estimated for FoS values less than 1.3 in pseudo-static analyses of global slope stability.

4.0 GEOLOGICAL SETTING

4.1 Surficial Geology

Surficial mapping data was obtained from Sheet 1 of Soils of South Vancouver Island (1986), compiled by the Surveys and Resource Mapping Branch of the BC Ministry of Environment. The surficial geology near the trestle is somewhat complex, with several distinct units in a 200 m radius of the trestle.

The dominant geomorphological processes that have shaped the area are glacial and fluvial, and this is reflected in the types of sediments found in the area.

The mapped units are summarized in Table 2.

Table 2: Description of Surficial Geology Map Units

Mapped Unit	Soil Components	Parent Material	Most Common Texture*	Description	Slope Classes
$\frac{CA4}{d}$	100% CA4	Fluvial	vgls	Gravelly floodplain deposits	Gently rolling – multiple slopes
$\frac{S1w^6F1w^4}{fg}$	60% S1	Moraine	gsl	Moderately to strongly cemented pans	Dominantly strongly rolling with significant inclusions of hilly – multiple slopes
	40% F1	Marine	sicl	Stonefree fine textured soils	
$\frac{F1^5Q4^4AR1^1}{ce}$	50% F1	Marine	sicl	Stonefree fine textured soils	Dominantly undulating with significant inclusions of moderately rolling – multiple slopes
	40% Q4	Fluvial	vgls	Includes marine/fluvioglacial deposits	
	10% AR1	Organic	m	Mesic type organic material	
$\frac{Q4}{e}$	100% Q4	Fluvial	vgls	Includes marine/fluvioglacial deposits	Moderately rolling – multiple slopes
$\frac{S1}{ef}$	100% S1	Moraine	gsl	Moderately to strongly cemented pans	Dominantly moderately rolling with significant inclusions of strongly rolling – multiple slopes
$\frac{S1}{EF}$	100% S1	Moraine	gsl	Moderately to strongly cemented pans	Dominantly moderately rolling with significant inclusions of strongly rolling – single slopes

*vgls - Very gravelly loamy sand, gsl - Gravelly sandy loam, sicl - Silty clay loam, m - mesic (organic)

4.2 Bedrock Geology

The project is located in southeast Vancouver Island, near the town of Duncan. The geology of Vancouver Island is heavily influenced by tectonic processes, and the area remains seismically active. The oldest volcanic rocks in the area formed during the Middle to Late Devonian as part of the Wrangellia Terrane. This terrane collided with the North American plate during the Cretaceous Period; and throughout the Paleocene and Eocene two smaller terranes (the Pacific Rim and Crescent) collided with the island, leading to further uplift and erosional processes.

The orogenic processes that formed Vancouver Island have resulted in significant regional faulting. Near the project site, there is a series of four sub-parallel regional thrust faults that strike generally northwest-southeast, and dip to the northeast. The faults are spaced approximately 3.5 km to 4 km apart, with the nearest one to the project area located about 800 m south of the trestle. Normal and strike-slip faults are also common near the project site, with extensive normal faulting to the south, and regional strike-slip faults to the west and northeast.

Bedrock in the immediate project vicinity consists of Upper Cretaceous fine-clastic sedimentary rocks belonging to the Nanaimo Group (uKN). This unit extends for about 3.8 km southwest, up Holt Creek from the trestle site. From its headwaters, Holt Creek passes through three volcanic units before meeting the Cowichan River within the Nanaimo Group (uKN) some 500 m to the north of the trestle.

The bedrock lithological units are summarized in Table 3.

Table 3: Summary of Holt Creek Trestle Bedrock Lithological Units

Lithological Unit	Age	Description
Nanaimo Group	Upper Cretaceous	Undivided sedimentary rocks
Island Plutonic Suite	Early to Middle Jurassic	Granodioritic intrusive rocks
Bonanza Group	Upper Triassic to Lower Jurassic	Undivided volcanic rocks
Vancouver Group - Karmutsen Formation	Upper Triassic	Basaltic volcanic rocks
Mount Hall Gabbro	Upper Triassic	Gabbroic to dioritic intrusive rocks
Buttle Lake Group – Fourth Lake Formation	Mississippian to Pennsylvanian	Siliceous argillite, siliciclastic rocks
Nitinat Formation	Middle to Upper Devonian	Calc-alkaline volcanic rocks
Sickler Group – Duck Lake Formation	Middle to Upper Devonian	Basaltic volcanic rocks

5.0 2018 GEOTECHNICAL WORK

Tetra Tech previously undertook a site visit on March 28, 2018. The work comprised an overview of the existing structure and a non-intrusive geotechnical assessment of the abutments and surrounding area. Details of the completed work are presented in Tetra Tech's "*Holt Creek Trestle – Rock Slope Stability*" technical memorandum, dated November 14, 2018, and summarized below.

5.1 Site Visit Observations

5.1.1 Rock Mass & Groundwater

Based on the site observations, the mudstone rock is considered to be fair rock with an RMR_{76} around 43. The siltstone is noted to be slightly more competent with an RMR_{76} around 52 as it has a slightly higher strength and improved RQD over the mudstone.

On both abutments, seepages or springs were noted fairly high up the slope. These seepage points frequently occur at the transition from overburden and till-like soil to bedrock. It was noted that the topography surrounding the valley was fairly flat and that the hydraulic gradient potentially trends down into the valley through recharge infiltration from a relatively large surrounding catchment area.

5.1.2 Potential Failure Mechanisms

There were several potential failure mechanisms identified during the review which could affect the bridge. An overview of these mechanisms is provided below for consideration in the analysis and recommendations for slope / abutment foundation improvement or rehabilitation.

Rainfall Erosion: In which soils and overburden deposits erode due to rainfall run off channelizing and eroding soil from underneath foundations, which might lead to a loss of support on the foundation. This failure mechanism might also be contributing to rock fall failure (which either impacts or undermines foundations, refer to sections below).

Rock Fall Undermining Foundation: In which rock mass failure or kinematic failures remove blocks of rock underneath the foundations and thereby reduce the integrity of the footings. The rock fall is likely caused partly by weak, fractured rock, and kinematic instability exasperated by ice jacking from freeze-thaw conditions at the site.

Rock Fall Impacting Foundation: In which rock fall occurs and impacts structural support elements further down the slope. The causes of the rock fall are as outlined above. The build up of talus behind footings might also lead to footing displacement due to the shear force applied by the quantity of talus.

Concrete Block Failure: It is conceivable that if concrete plinths on the right abutment failed, they could destroy a number of the lower footings on the right abutment and compromise the bridge.

Global Rock Mass Failure: In which the slope fails either due to loading or seismic effects. Both abutments are potentially prone to this failure mechanism.

Other Failure Mechanisms: The issue of seismic stability with respect to slope failure has also been considered within this report.

6.0 2020 SUBSURFACE EXPLORATION

Subsurface geotechnical data was obtained from a site exploration carried out in January 2020 for site characterization. The work comprised drilling two geotechnical boreholes using HQ triple-tube (HQ3) diamond coring. To supplement the data collected from the HQ3 geotechnical boreholes, two additional holes were drilled into the rock from the canyon walls under the trestle. Observations on weathering of the rock mass in these holes were collected using a bore-scope camera.

Tetra Tech carried out a geotechnical drilling exploration from January 6 to 10, 2020 to collect information on the geomechanical properties of the bedrock. The exploration included the following:

- Drilling a total of 60.36 m in two boreholes (GTH20-01 and GTH20-02) to collect geotechnical data from the drill core.
- Collection of rock core samples for laboratory testing.
- Drilling a total of 12 m in two sub-horizontal boreholes (BH20-01 and BH20-02) into the canyon walls under the trestle for camera scoping to characterize weathering profiles.
- Sacrificial rock anchor testing in BH20-01 to estimate grout to ground strength of the bedrock.

6.1 Summary of Boreholes Completed

The core drilling was completed by Drillwell Enterprises Ltd. (Drillwell) of Duncan, BC. The boreholes were vertically drilled using an HQ3 diamond coring system. Casing was advanced through overburden in the upper portion of the boreholes. The boreholes were located on either side of the trestle, adjacent to the CVT. The CVT remained open to the public during the exploration program. Contractors implemented exclusion zones around the drill rig and other equipment for protection of the public.

Tetra Tech personnel were on site full-time during drilling of the geotechnical boreholes to log the core and collect geotechnical information. A summary of the boreholes drilled during the field exploration is provided in Table 4. The borehole easting and northing were surveyed using a handheld GPS device with an accuracy of about +/- 5 m, and the borehole collar elevations were estimated from a 2023 ground survey by others.

Table 4: Summary of 2020 Rock Core Boreholes

Borehole ID	Borehole Coordinates			Total Depth (mbgl)	Drilling Dates	
	Easting	Northing	Collar Elevation (masl)		Start	End
GTH20-01	441183	5400749	87.0	30.4	January 7, 2020	January 8, 2020
GTH20-02	441083	5400754	85.0	30.0	January 9, 2020	January 10, 2020

Notes:
masl – metres above sea level,
mbgl – metres below ground level

The bencher drilling was completed by rope-accessed contractor, Jagerock Stabilization Ltd., of Chilliwack, BC. The bencher drill is a pneumatic top hammer drill used for drilling rock in high angle terrain. The boreholes were drilled into both sides of the canyon walls under the trestle. Distance of the holes below the trestle is presented in Table 5. A 63.5 mm diameter bit was used to drill the holes at an approximate angle of 20° below horizontal. The locations and orientations of the bencher holes are presented in Figure 1.

Tetra Tech made observations on the weathering profile of the rock mass through inspection with a drain camera. Table 5 summarizes the bencher boreholes drilled during the field exploration program.

Table 5: Summary of 2020 Bencher Boreholes

Borehole ID	Borehole Location			Total Depth (mbgl)	Drilling Date
	Side of Canyon	Distance Below Trestle	Elevation (masl)		
BH20-01	East	16 m	72	6.0	January 9, 2020
BH20-02	West	15 m	71	6.0	January 9, 2020

Notes:
masl – metres above sea level,
mbgl – metres below ground level

6.2 Drilling Details and Observations

GTH20-01

Borehole GTH20-01 was undertaken from January 7 to 8, 2020 and was located 5 m to the east along the CVT from the edge of the approach guard rail flair on the east side of the trestle. Core recovery was reasonable during drilling of the borehole with some minor core loss occurring in zones of highly fractured and sheared rock. The hole was plugged with bentonite chips after drilling was completed.

GTH20-02

Borehole GTH20-02 was undertaken from January 9 to 10, 2020 and was located 14 m to the west along the CVT from the edge of the approach guardrail flair on the west side of the trestle. Access to this hole location was via the Holt Creek Trestle. A water level reading was taken in the morning of January 10, before commencing drilling at a depth of 14 m. No water was encountered down the hole at this depth. GTH20-02 was plugged with bentonite chips after drilling was completed.

Significant core losses and mechanical damage were encountered between depths of 11.82 m to 16.40 m. Core losses appeared to occur in zones of weak, sheared rock and possible clay infillings. The core loss and mechanical damage was likely due to a combination of possible clay layers / infill plugging the drill bit and poor ground conditions. Attempts to improve core recovery were made through drilling shorter runs which was somewhat successful. Below 16.40 m, rock core recovery improved substantially.

BH20-01

Borehole BH20-01 was drilled into the canyon wall on the east side of the trestle, 16 vertical metres below the existing bridge deck. The hole was drilled at an approximate angle of 20° below horizontal. Borehole scoping was undertaken on January 9, after drilling of BH20-01 was completed. No water was encountered during drilling of BH20-01 or during scoping.

In general, minimal weathering was observed within this borehole. Drillers noted that the first 0.3 m to 0.5 m into the rock face resembled a zone of weaker, weathered rock, however, drilling was quickly progressed into more competent rock below these depths. Observations made with the borehole scope confirmed these notes as zones of iron staining or weak rock were not observed.

BH20-02

Borehole BH20-02 was drilled into the canyon wall on the west side of the trestle and was completed on January 9, 2020. Scoping of the borehole was undertaken on January 10, 2020. The borehole was observed to be full of clear water during scoping, approximately 15 vertical metres below the existing bridge deck. The hole was drilled at an approximate angle of 20° below horizontal. BH20-02 was plugged with Microsil® anchor grout after scoping was completed.

Large volumes of grey colored water were observed flowing out of the hole during drilling after reaching an approximate depth of 3.5 m into the rock face. A zone of iron-stained rock was observed to extend approximately 2 m into the rock face. Past this depth to the end of the hole, no staining was noted on the surface of the borehole. Throughout the borehole, veins of a white colored mineral (presumably calcite) were observed to intersect the hole. White mineral infillings in GTH20-01 and GTH20-02 were identified as calcite by their reaction to hydrochloric acid.

6.3 Rock Laboratory Testing

Rock core samples for laboratory testing were collected on site during drilling after core box photographs had been taken. The sample intervals and IDs were transcribed onto core blocks and placed in the core boxes to mark where the material had been removed.

Four samples for Unconfined Compressive Strength (UCS) testing were sent to the Wood Environment & Infrastructure Solutions (Wood) rock testing laboratory in Burlington, ON. All laboratory testing was completed in accordance with the applicable ASTM standards.

A summary of the laboratory testing program is provided in Table 6.

Table 6: Summary of 2020 Laboratory Rock Testing Results

Sample ID	Borehole	Depth (mbgl)	Rock Type	Specific Density (kg/m^3)	Unconfined Compressive Strength (MPa)
GTH20-01_1	GTH20-01	10.82 – 10.95	Mudstone	2679	32.7
GTH20-01_2	GTH20-01	19.08 – 19.21	Mudstone	2686	19.6
GTH20-02_5	GTH20-02	13.09 – 13.22	Mudstone	2642	41.6
GTH20-02_7	GTH20-02	24.84 – 24.97	Mudstone	2661	52.0

7.0 2023 SUBSURFACE EXPLORATION

7.1 Geotechnical Drilling

Subsurface geotechnical data was obtained from a site exploration carried out from May 29, 2023, to June 2, 2023. The geotechnical drilling company retained was Drillwell based out of Duncan, BC. Geotechnical boreholes were drilled vertically with solid stem auger, hollow stem auger, advance casing, and rock coring using a track mounted rig (Geoprobe 7822) that was light enough to cross the existing trestle bridge. Drilling fluid return was collected in 55-gallon barrels and disposed of by a hydrovac at the end of the drilling program.

A total of five (5) geotechnical boreholes were completed:

- Three (3) boreholes (BH23-01, BH23-03, BH23-05) were drilled on the south side of the trestle.
- Two (2) boreholes (BH23-02, BH23-04) were drilled on the north side of the trestle.

Two geotechnical boreholes (BH23-01 and BH23-02) were drilled to 10 m into bedrock, and three geotechnical boreholes (BH23-03, BH23-04, and BH23-05) were drilled to 3 m into bedrock.

The borehole locations are summarized in Table 7, and detailed borehole logs are presented in Appendix B.

Table 7: Summary of 2023 Geotechnical Drilling

Borehole ID	Easting	Northing	Elevation (m)*	Depth (mbgl)	Groundwater Depth (mbgl)
BH23-01	441178	5400743	86.5	16.7	4.3
BH23-02	441092	5400763	84.1	14.9	3.5
BH23-03	441185	5400727	84.8	9.1	4.3
BH23-04	441082	5400762	85.3	8.5	2.5
BH23-05	441221	5400733	85.0	9.0	3.4

The borehole easting and northing locations were surveyed using a handheld GPS device with an accuracy of about +/- 5 m, and the borehole collar elevations were interpreted from a 2023 ground survey by others.

Sampling in granular soil was carried out using a Standard Penetration Test (SPT) or Large Penetration Test (LPT) split-spoon sampler in general accordance with ASTM D1586-18 at 1.5 m depth intervals. SPT/LPT blow counts were recorded by the Tetra Tech field engineer for every 150 mm of penetration, and the split-spoon samples were visually classified and logged in the field. The rig was equipped with an automatic trip hammer for SPTs/LPTs.

After the samples were reviewed and logged, representative disturbed samples were selected for classification and index testing in our geotechnical laboratory.

7.2 Geotechnical Laboratory Testing

Selected soil samples collected from the drilling program were tested at Tetra Tech's laboratory in Nanaimo, BC. Moisture content and gradation tests were performed on selected soil samples.

The geotechnical laboratory test results are presented in Appendix C.

8.0 INFERRED SUBSURFACE CONDITIONS

8.1 Soil

The soil conditioned encountered during our subsurface explorations generally consisted of poorly-graded to well-graded sand and gravel. The trail embankment fill was described as loose to compact, damp sand and gravel, extending up to about 3.0 mbgl.

The underlying natural ground was described as dense to very dense, poorly-graded to well-graded, wet sand and gravel, extending up to about 5.5 mbgl.

8.2 Bedrock

The bedrock encountered during the drilling program was described as mudstone to shale, homogeneous, with veins of dolomite present and trace sulphides (pyrite), weak to medium strong, with overall good core recovery. Slickensides were observed in portions of the rock unit but were not present throughout.

The inferred bedrock profile is presented in the geological long section in Figure 2.

8.3 Groundwater

Groundwater was encountered in all boreholes near the contact between the embankment fill material and natural ground. The groundwater conditions are anticipated to vary seasonally, and perched groundwater conditions could develop as a result of high precipitation events.

8.4 Frost Penetration

Frost penetration depth was calculated using the modified Berggren Equation with climatic data obtained from the Environment Canada website https://www.canada.ca/en/services/environment/weather/data-research.html, the Climate Atlas of Canada (version 2) website https://climateatlas.ca/map/canada, and observed subsurface ground conditions.

The input parameters are presented in Table 8.

Table 8: Frost Penetration Depth Calculation Parameters

Variable		Value	Units
Selected Variables			
Mean Freezing Index (from www.climatlas.ca)	I_m	26.3	deg. days
Surface Interface Factor (from Table 13.2, CFEM 2006)	η	0.95	-
Mean Annual Air Temperature (from Environment Canada Website)	MAAT	10.1	deg
Duration of Freezing Period (from Environment Canada Website)	t	48	days
Water Content of Soil (from laboratory test results)	w	4.6	%
Dry Density of soil (from published literature)	γ_d	1,900	kg/m^3
Thermal Conductivity of Frozen Soil (from Figure 13.6 CFEM 2006)	k	1.4	W/m K
Heat Capacity and Temperature Gradient Coefficient (from Figure 13.8, CFEM 2006)	λ	0.8	-
Calculated Variables			
Design Freezing Index	I_d	39	deg. days
Latent Heat of Fusion from Water to Ice (constant)	L_s	334	kJ/kg
Specific Heat of Dry Soil (constant)	C_s	0.71	kJ/kg deg
Specific Heat of Ice (constant)	C_i	2.1	kJ/kg deg
Volumetric Latent Heat of Soil	L	29.19	kJ/m^3
Ground Surface Freezing Index	I_s	43.2	deg days
Volumetric Heat Capacity of Frozen Soil	C	35.5	°C
Thermal Ratio Parameter	β	11.2	-
Fusion Parameter	μ	0.0038	-

9.0 SEISMIC CONSIDERATIONS

The following sections outline site-specific criteria from the BCMoTI Supplement to CHBDC S6-19 which have been considered for design. Considerations for seismic hazard at the project site are based on the 2020 National Building Code Seismic Hazard Calculation for the site.

9.1 Importance Category

The bridge is classified as an “Other Bridge” in accordance with CHBDC S6-19. For the 2,475-year return period seismic event, the minimum performance levels for Other Bridges are Life Safety service and Probable Replacement. For the 475-year return period seismic event, the minimum performance levels for Other Bridges are Service Limited and Repairable damage.

Life Safety service requires that the bridge shall not collapse, and it shall be possible to evacuate the bridge safely. Probable Replacement means that the bridge spans shall remain in place, but the bridge might be unusable and might have to be extensively repaired or replaced. Permanent offsets shall be limited such that the bridge can still be evacuated safely, and lateral and vertical movements of the foundations are not restricted but shall not lead to a collapse of the bridge superstructure.

Service Limited performance requires that the bridge be usable for emergency traffic and repairable without bridge closure. At least 50% of the lanes, but not less than one, shall remain operational. If damaged, normal services shall be restored within a month. Repairable damage stipulates that some inelastic behavior may occur, but primary members shall not need to be replaced, and the structure shall be repairable in place. Permanent offsets shall not compromise the service and repair requirements of the bridge, and no residual settlement or rotation of the main structure shall occur.

9.2 Seismic Design

9.2.1 Seismicity and Site Classification

The BCMoTI supplement to CHBDC S6-19 adopts the ground motion parameters from the 2020 NBCC seismic hazard model. The ground motion parameters for the design earthquake event were obtained from the website http://www.earthquakescanada.nrcan.gc.ca/index-eng.php maintained by Natural Resources Canada for return periods of 475 years and 2,475 years.

The 2020 NBCC accounts for ground motion amplification through empirically derived factors based on the seismic site classification. Table 4.1.8.4.-B of the 2020 NBCC provides guidance for seismic site classification based on the average ground characteristics within the top 30 m from the ground surface. Based on the ground conditions encountered in the test holes and our experience on sites with similar conditions in the project area, we consider that the ground conditions below the anticipated foundation depths should be classified as Site Class B, corresponding to an average shear wave velocity of between 760 m/s and 1,500 m/s in the upper 30 m of the geotechnical profile at the site. The 2020 NBCC ground motion parameters for Site Class B ground conditions are presented in Table 9.

Table 9: Ground Motion Parameters for Site Class B for 475- and 2,475-Year Return Periods

Peak Ground Acceleration	Peak Ground Velocity	Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	Sa(5.0)	Sa(10.0)
0.575 g	0.526 m/s	1.34 g	0.886 g	0.509 g	0.326 g	0.0803 g	0.0344 g
0.291 g	0.225 m/s	0.655 g	0.408 g	0.217 g	0.115 g	0.0261 g	0.100 g

9.2.2 Liquefaction Susceptibility

Based on the results of our subsurface exploration, soil deposits at the site are not anticipated to liquefy due to the 475-year or 2,475-year return period earthquake motions. Accordingly, liquefaction-induced ground movements are not expected to occur in the event of the design earthquake motions.

10.0 SLOPE STABILITY ASSESSMENT

Using the information collected during our subsurface explorations, Tetra Tech has carried out updated stability analysis of the slopes under the proposed bridge. The stability analysis was undertaken using Rocscience Slide2 software, which is a 2-D limit equilibrium analysis program. The following sections detail the model geometry, material parameters, loading conditions, methods of analysis, and results.

10.1 Model Geometry

The geometry of the model was developed using survey data collected by Van Bower Construction Services Ltd., subcontracted to Tetra Tech in 2018. From the survey, topographic data were used to create cross-sections of the slope profile. The cross-section used in the model was taken along the centreline of the bridge.

Observations from our subsurface explorations were used to estimate boundaries between materials on the slopes. Sandy gravel overburden material was observed at the top of each slope. Weathered zones of bedrock in the model reflect conditions observed on site through borehole scoping within the valley. The weathered zone extends about 2 m below surface on the west side and 0.5 m below surface on the east side. The creek bed was assigned material properties for non-weathered mudstone as it was observed to comprise competent bedrock.

The groundwater level was interpreted from measurements within the geotechnical boreholes and observations at the project site. The interpreted groundwater levels are considered somewhat conservative because they coincide with those observed within soils, which likely reflect perched groundwater conditions.

Figure D1 shows the model geometry used in analysis.

10.2 Material Parameters

Table 10 summarizes the parameters assigned to materials in our limit equilibrium analysis. Input parameters for each material were estimated based on field and laboratory test results and observations as well as engineering judgement. Five soil/rock materials were created for this analysis to represent the weathered mudstone, non-weathered mudstone, faulted mudstone, silty clay seams, and sand and gravel overburden. Anisotropy was used to model discontinuities or bedding planes.

The weathered, non-weathered, and faulted mudstone utilize the Generalized Hoek-Brown (GHB) strength type which assigns homogenous properties throughout a rock mass. Values for the GHB strength parameters (m_b, s, and a) were calculated by Slide2 based on rock mass strength parameters such as the Intact Uniaxial Compressive Strength (UCS), Geological Strength Index (GSI), Intact Rock Constant (m_i) and Disturbance Factor (D).

The UCS of the mudstone was measured in the laboratory testing program. The GSI of the mudstone was assessed using the RMR_{76} values estimated from the field program, with the GSI values being 43 for mudstone and 52 for siltstone. The intact rock constant is a value based on the rock type; therefore, values for mudstone were applied. The selected values were near the average of the highest three UCS values noted in Table 6 because the lower value may reflect failure on a plane of weakness rather than a lower intact strength. Disturbance factors of 0 were used since the slope is assumed to not have been blasted during the original excavation.

The sand and gravel overburden, silty clay seams, concrete, and jointing were all represented by the Mohr-Coulomb strength envelope. A cohesion value of zero was assigned to the jointing material to represent the most conservative scenario of no cohesion.

Table 10: Material Properties used in Limit Equilibrium Analyses

Material Name	Unit Weight (kN/m^3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (MPa)	M_b	S	A
Sand and Gravel Overburden[i]	18	Mohr-Coulomb	0	34	-	-	-	-
Weathered Mudstone [ii]	26	Generalized Hoek-Brown	-	-	40	1.17374	0.0038659	0.50573
Non-Weathered Mudstone [iii]	26	Generalized Hoek-Brown	-	-	42	1.45424	0.0075298	0.50377
Silty Clay[iv]	18.6	Mohr-Coulomb	90	10	-	-	-	-
Faulted Mudstone [v]	20	Generalized Hoek-Brown	-	-	35	0.37431	0.0001104	0.54999
Joints[vi]	26	Mohr-Coulomb	0	30	-	-	-	-

i. Values based on typical material properties for sandy gravel.
ii. Based on values for UCS provided by laboratory testing of non-weathered mudstone, reduced to account for minor weathering.
iii. Representative values for unit weight and UCS based on laboratory testing results.
iv. Values based on field observations.
v. Reduced unit weight and UCS of faulted mudstone to account for sheared / crushed rock.
vi. No cohesion assigned to represent polished / slickensides joint surfaces.

10.2.1 Generalized Anisotropy

The mudstone under the trestle was observed to contain joints often with polished surfaces and slickensides. As boreholes were oriented perpendicularly, beta angles were not collected. Local folding and faulting would likely have caused too much scatter in the orientation data to undertake a meaningful kinematic analysis. A conservative orientation for this heterogeneity in the rock mass is represented in the model using the Generalized Anisotropic strength type. This allows a composite material to be modelled with different strength values assigned to any range of slice orientations.

Both weathered and non-weathered mudstone were modelled using the generalized anisotropic strength type to represent the jointed texture of the rock. Different anisotropic materials were used on the east and west sides of the creek to allow different joint orientations to be modelled. The jointing was assigned an orientation range to dip towards the face of the slope on both sides of the creek to provide the most conservative scenario. Dip angles were estimated using alpha angles collected during the subsurface exploration.

Figures D2 and D3 show the different Generalized Anisotropic Strength Functions used in the model.

10.2.2 Weak Layers

The silty clay seams / infills observed on site were represented in the model using Slide's "Weak Layers" feature. This feature allows a weak layer to be defined using only a polyline with assigned strength properties. The silty clay seams were assumed to be laterally extensive across the site, which is a conservative approach as the dip direction of the clay seams are unknown. The strength parameters for these layers were also conservatively assumed to be near the material's residual strength.

10.3 Loading

Loads from the proposed bridge foundations and seismic events were applied to the model as outlined in the sections below.

10.3.1 Bridge Foundation

Based on the loading conditions provided by SNCL as noted in Section 3.1.1 and footing areas of approximately 3.0 m by 5.7 m as per the design drawings, an estimated bearing pressure of 175 kPa was applied as a vertical pressure on the bridge abutment foundations in the slope stability model.

10.3.2 Seismic

Seismic loading was incorporated in the slope stability models by applying horizontal seismic coefficients. Initially, pseudo-static analyses were carried out using seismic coefficient equal to the full PGA values for the 475-year (0.291 g) and 2,475-year (0.575 g) return period earthquake events. Where the resulting FoS value does not meet the Code requirement, earthquake-induced ground deformation must be estimated.

10.4 Method of Analysis

Non-circular GLE/Morgenstern-Price analysis was the primary method used to assess the global FoS for slope stability. GLE/Morgenstern-Price was chosen as the primary method of analysis because it is commonly used in practice and is considered a rigorous method of analysis. Non-circular analysis was used because it reflects the anticipated method of failure for a rock mass.

10.5 Stability Analysis Results

Table 11 presents the results of the stability analysis for the valley slopes on both sides of the proposed bridge. The stability analysis outputs from Slide2 are presented on Figures D4 to D11 in Appendix D.

Table 11: Summary of Stability Analysis

Case	Seismic Coefficient	Factor of Safety	
		East	West
Static	N/A	1.55	1.77
Pseudo-Static (475-year earthquake)	0.291 g	1.05	1.44
Pseudo-Static (2,475-year earthquake)	0.575 g	0.68	0.84

The results of the stability analysis indicate that both the west and east slopes meet the minimum FoS of 1.54 prescribed by the BCMoTI Supplement to CHBDC S6-19 for the static case. The FoS from pseudo-static analysis was less than 1.3 on the east side of the valley in the event of the 475-year return period earthquake motions and on both sides of the valley in the event of the 2,475-year return period earthquake motions. Accordingly, deformation analysis for these cases is required as per the BCMoTI Supplement to CHBDC S6-19. The results show that sliding along clay seams govern stability in all cases.

10.5.1 Newmark Analysis

For cases where the pseudo-static analysis indicated an FoS less than 1.3, Newmark analysis was performed to estimate the displacement of the sliding block under seismic loading. The analysis compares the maximum ground

acceleration to the acceleration required to overcome the resisting forces of the block. The analysis method is based on that outlined in NCHRP 611 (TRB, 2008). Table 12 below presents the results of the Newmark Analysis.

As noted in Section 9.2.1, the PGA values for Site Class B conditions at the site are 0.291g for a return period of 475 years, and 0.575g for a return period of 2,475 years. Given the slope is considered medium strong rock, the sliding block is considered a rigid mass, and the wave motion is coherent throughout the slope. As a result, no height reduction factor was applied to the maximum acceleration K_{max} (i.e., α = 1). Therefore, K_{max} is constant along the slope regardless of the slope height and is equal to PGA for the applicable site condition.

The yield acceleration of the slope (K_y) was estimated using Slide2 software. K_y is the seismic acceleration required to reduce the FoS of the slope to 1.0. The displacement was then found using the mean displacement equation for Western United States rock slopes as defined in NCHRP 611:

$$\log(d) = -1.55 - 0.75 \log (K_y/K_{max}) + 3.05 \log (1 - K_y/K_{max}) - 0.76 \log(K_{max}) + 1.56 \log (PGV)$$

Where d = displacement (in).

Table 12: Input Parameters and Results of Newmark Analysis

Slope	Return Period	Pseudo-Static FoS	K_{max} = PGA	K_y	PGV (m/s)	Displacement (mm)
East	475-year	1.05	0.291g	0.335g	0.225	< 1 mm
East	2,475-year	0.68	0.575g	0.335g	0.526	< 25 mm
West	475-year	1.44	0.291g	0.467g	0.225	< 1 mm
West	2,475-year	0.84	0.575g	0.467g	0.526	< 10 mm

The structural engineer should review the estimated displacements in relation to the tolerances of the proposed bridge. If the movements exceed the tolerances of the structure, mitigation measures such as rock bolts/anchors could be considered.

11.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

11.1 Frost Protection

Based on the Modified Berggren equation using the input parameters presented in Table 2, the recommended frost penetration depth for foundation design should be 0.8 mbgl. This depth may be reduced with the use of insulation, if desired. There also may be locations where the underlying soils have low frost susceptibility, such as footings on fresh bedrock that are not susceptible to damage from frost heave. Therefore, this requirement may be relaxed depending on visual observations during construction by a Tetra Tech representative.

11.2 Foundation Design

Footings may be constructed on bedrock, competent natural soil, or compacted structural fill over bedrock. Footings on bedrock should be set back at least 3 m from the crest of the bedrock slope. Footings on soil should be set back at a 2H:1V (horizontal to vertical) projection from the crest of the bedrock slope, plus 3 m. The Serviceability Limit States (SLS) bearing pressure and factored Ultimate Limit States (ULS) bearing resistance for spread footings with minimum widths of 1,200 mm are provided in Table 12.

Provided the recommendations for site preparation presented in Section 12.2 are followed, total post-construction settlement should not exceed 25 mm, and differential settlement should be less than 20 mm over a horizontal distance of 10 m. All footings on soil should be positioned at least 800 mm below the finished grade for frost protection and confinement. Unfactored friction coefficients of 0.45 and 0.55 may be used for cast-in-place concrete on soil and rock, respectively.

Table 13: SLS and ULS Bearing Resistances

Foundation Soil	SLS Bearing Pressure (kPa)	Factored ULS Bearing Resistance [1] (kPa)
Structural Fill	175	350
Natural Sand and Gravel		
Fresh Bedrock	- [(2)]	800

[1] A geotechnical resistance factor of 0.50 was used as per CHBDC S6-19 based on a typical degree of understanding.
[2] SLS bearing pressure not provided for rock because settlement is not expected to govern the design, thus it would be equal to the factored ULS bearing pressure.

Footings should not be constructed on sloping bedrock or soil overlying sloping bedrock. Where the existing bedrock profile is sloping below footing, the overlying soil should be removed, and the bedrock should be cut into a relatively level bench (i.e., less than 150 mm variation in elevation across the footprint of the foundation). Where required, the ground surface should be raised to the design elevation and/or leveled with concrete.

11.3 Lateral Earth Pressures

Lateral earth pressures will be imposed on the proposed bridge abutments by the supported soil. Lateral earth pressures for static conditions will include at-rest or active earth pressure, compaction-induced pressure, and surcharge pressure from vehicle loading.

At-rest earth pressure may be calculated using a coefficient of earth pressure at rest (K_o) of 0.43. Surcharge pressure from vehicles may be calculated as a uniform horizontal pressure of 7.2 kPa, corresponding to the at-rest earth pressure from an additional fill height of 0.8 m. If the abutment walls are yielding (i.e., able to rotate by about 0.5% of the wall height), an active earth pressure coefficient (K_a) of 0.27 may be used in lieu of the K_o value, and the corresponding surcharge pressure may be calculated as a uniform horizontal pressure of 4.5 kPa. A minimum pressure of 12 kPa should be applied within the upper portion of the wall in both cases to account for compaction.

Assuming that the abutment walls will be non-yielding, seismic lateral earth pressure may be applied as an inverted triangular distribution, based on a seismic at-rest earth pressure coefficient (K_{oe}) of 0.58 for the 2,475-year return period earthquake motions and 0.20 for the 475-year return period earthquake motions. If the abutment walls are yielding (i.e., able to rotate by about 0.5% of the wall height), seismic lateral earth pressure may be applied as an inverted triangular distribution, based on a seismic active earth pressure coefficient (K_{ae}) of 0.20 for the 2,475-year return period earthquake motions and 0.086 for the 475-year return period earthquake motions.

11.4 Cut and Fill Slopes

Tetra Tech considers that permanent cut slopes in existing fill or natural soil at the site should be no steeper than 2H:1V (horizontal to vertical). Permanent fill slopes should also be no steeper than 2H:1V. Erosion protection should be installed as required to protect the slope faces.

12.0 CONSTRUCTION RECOMMENDATIONS

12.1 Construction Review

Tetra Tech should review the removal of the existing structures to assess the underlying ground conditions, observe sub-excavation of poor-quality soils, and review the compaction of fill materials. Geotechnical/materials engineering field services, such as observation of proof-rolling, review of bearing surfaces, and testing of soil density should be performed for quality control to assess whether requirements of this report are met. The contractor's geotechnical engineer will be responsible for review of temporary works (e.g., temporary sloping and shoring to ensure safe worker entry into excavations).

12.2 Site Preparation

Following demolition of the existing trestle structure, the proposed bridge abutments should be stripped of abandoned bridge foundations, construction debris, concrete, topsoil, organics, and natural soils down to the foundation elevation or competent subgrade. The large concrete foundation near the crest of the east abutment can remain in place. Where encountered, exposed bedrock should be hand-scaled to remove loose rock and weathered material, and bedrock below foundations should be cut into relatively level benches (i.e., less than 150 mm variation in elevation across the footprints of the foundations). Where required, the ground surface should be raised to the design elevation and/or leveled with concrete to achieve the design foundation grades.

Tetra Tech should be present to review the site preparation to assess whether the unsuitable materials have been removed and competent bedrock has been exposed and cleaned prior to installation of formwork.

12.3 Structural Fill

Structural fill should consist of Bridge End Fill in accordance with BCMoTI's 2020 Standard Specifications for Highway Construction. The structural fill should be placed in discrete lifts of maximum 150 mm thickness and compacted to at least 100% of the material's Standard Proctor Maximum Dry Density (SPMDD) prior to placing subsequent lifts. Field and laboratory testing should be completed during construction to ascertain that the gradation and compaction of structural fill are in general conformance with these recommendations.

12.4 Material Re-Use

Existing sand and gravel fills and natural soils at the site may be suitable for re-use (e.g., for site grading along approaches), provided that they are placed and compacted at a moisture content suitable for achieving the required compaction. Re-use of excavated material will be subject to Tetra Tech's review.

12.5 Excavation, Shoring, and Dewatering

All work conducted in and around excavations must be carried out in accordance with the requirements specified in the WorkSafeBC Occupational Health and Safety Regulation (OHSR).

Any unsupported excavations greater than 1.2 m in depth must be reviewed by a professional engineer prior to worker entry, in accordance with the WorkSafeBC OHSR. Alternatively, shoring may be installed to support deeper excavations. Design and review of any temporary sloping or shoring works will be the responsibility of the construction contractor's engineer.

Groundwater may be encountered within excavation to construct the proposed abutments. The contractor should be equipped with sumps and pumps to manage groundwater ingress into excavations.

13.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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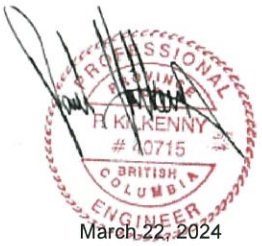

March 22, 2024

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JL/SA/PK/CL/cy/sy

PERMIT TO PRACTICE
TETRA TECH CANADA INC.

PERMIT NUMBER: 1001972

REFERENCES

BCMoTI. (2023). Ministry of Transportation & Infrastructure Bridge Project No. 04529 – 0001 Holt Creek Bridge Replacement – Mile 59.7 Issued for 30% Design Submission Package, April 17, 2023

National Highway Research Cooperative Program (2008). Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments. Report No. 611.

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Tetra Tech Canada Inc. (2018). Holt Creek Trestle – Rock Slope Stability, November 14, 2018.

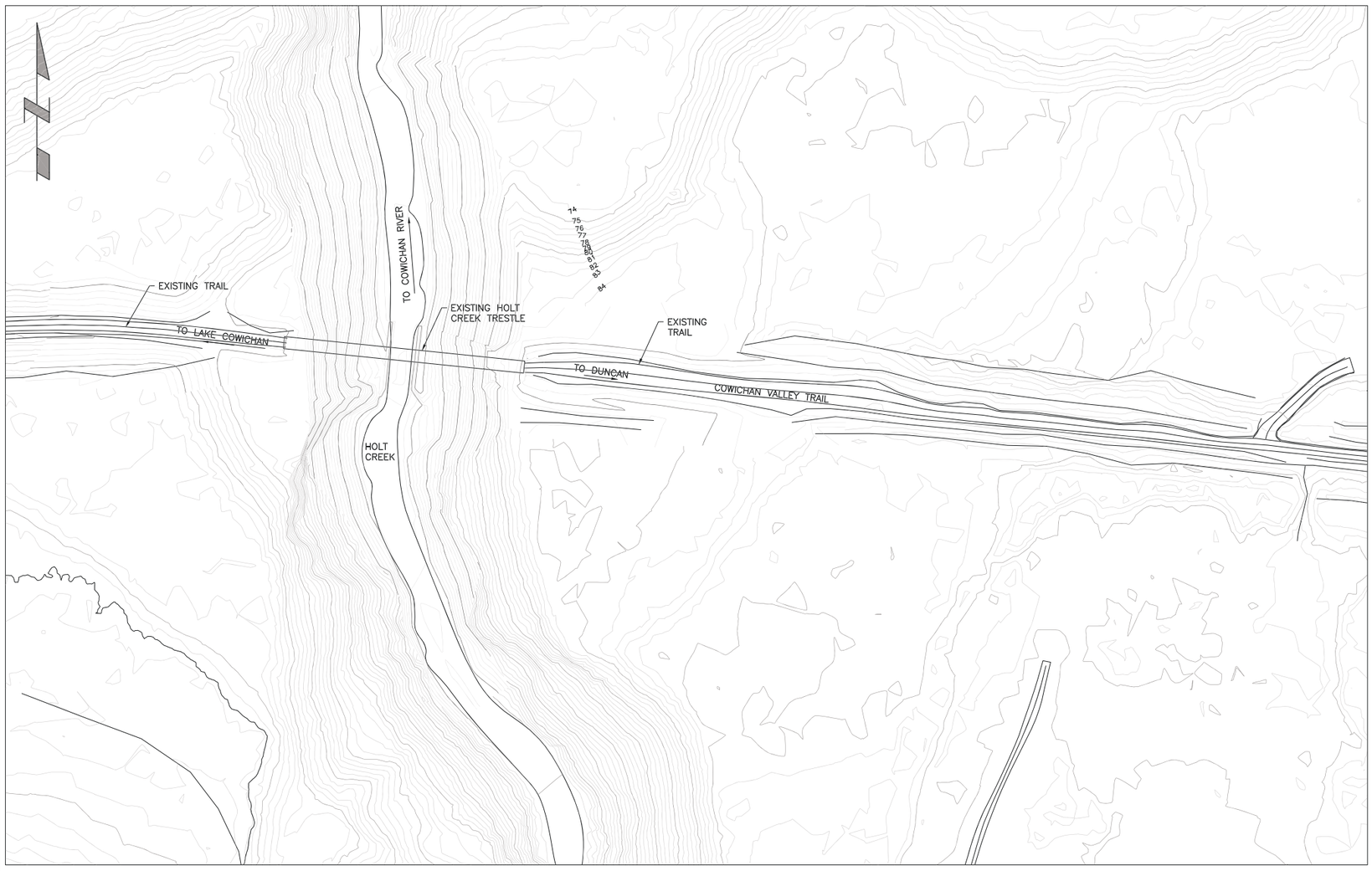
Tetra Tech Canada Inc. (2020a). Holt Creek Trestle Geotechnical Data Report, March 17, 2020.

Tetra Tech Canada Inc. (2020b). Holt Creek Trestle Geotechnical Interpretation Report, September 2, 2020.

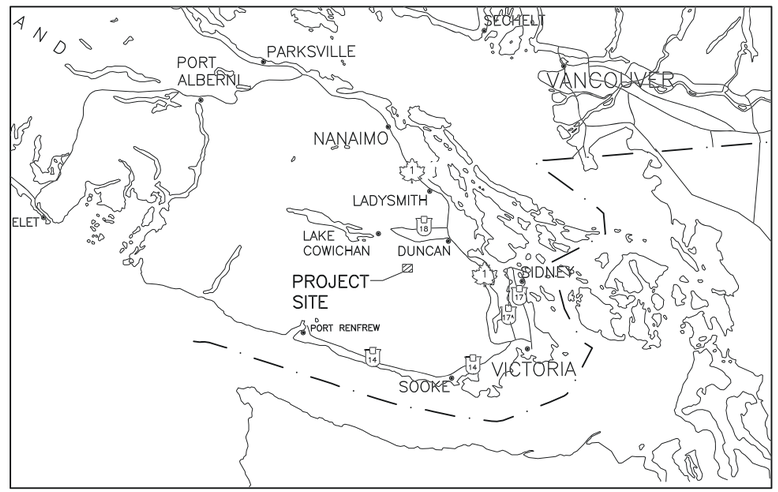
DRAWINGS

Drawing 04529-001 A Holt Creek Bridge Mile 59.7 Site Plan

Drawing 04529-003 B Holt Creek Bridge Mile 59.7 General Arrangement



SITE PLAN
SCALE 1:750



KEY MAP
NTS

NOTES:

1. SURVEY BY: BCMoTI (Jan. 2023)
2. SURVEY DATUM:
   VERTICAL: GEODETIC
   HORIZONTAL: UTM 10 NAD83 (CSRS)
3. SURVEY BENCHMARKS:
   (TO COME)
4. FOR BOREHOLE DATA SEE DRAWING.
   04529–013 & 014

LIST OF DRAWINGS

DWG No.	TITLE
04529–001	OVERALL SITE PLAN AND DRAWING LIST
04529–002	GENERAL ARRANGEMENT
04529–003	ABUTMENT – SHEET 1
04529–004	ABUTMENT – SHEET 2
04529–005	STEEL GIRDER – FRAMING PLAN AND ELEVATION
04529–006	STEEL GIRDER – DETAILS – SHEET 1
04529–007	STEEL GIRDER – DETAILS – SHEET 2
04529–008	STEEL GIRDER – DETAILS – SHEET 3
04529–009	TIMBER DECK – DETAILS – SHEET 1
04529–010	TIMBER DECK – DETAILS – SHEET 2
04529–011	BEARINGS
04529–012	STEEL RAILING DETAILS
04529–013	BOREHOLE LOGS – SHEET 1
04529–014	BOREHOLE LOGS – SHEET 2

REFERENCE DRAWINGS

DWG No.	TITLE

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

AUTHORIZED BY

DIRECTOR, ENGINEERING	REGIONAL DIRECTOR, HIGHWAYS
DATE	DATE

SNC•LAVALIN
#1100–745 Thurlow Street
Vancouver, BC,
Canada. V6E 0C5

Rev	Date	Description	Init
A	2023/04/17	ISSUED FOR 30% DESIGN SUBMISSION	LZ

REVISIONS

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure
South Coast Region

VANCOUVER ISLAND DISTRICT
COWICHAN VALLEY TRAIL

HOLT CREEK BRIDGE MILE 59.7
SITE PLAN

PREPARED UNDER THE DIRECTION OF

ENGINEER OF RECORD

DATE

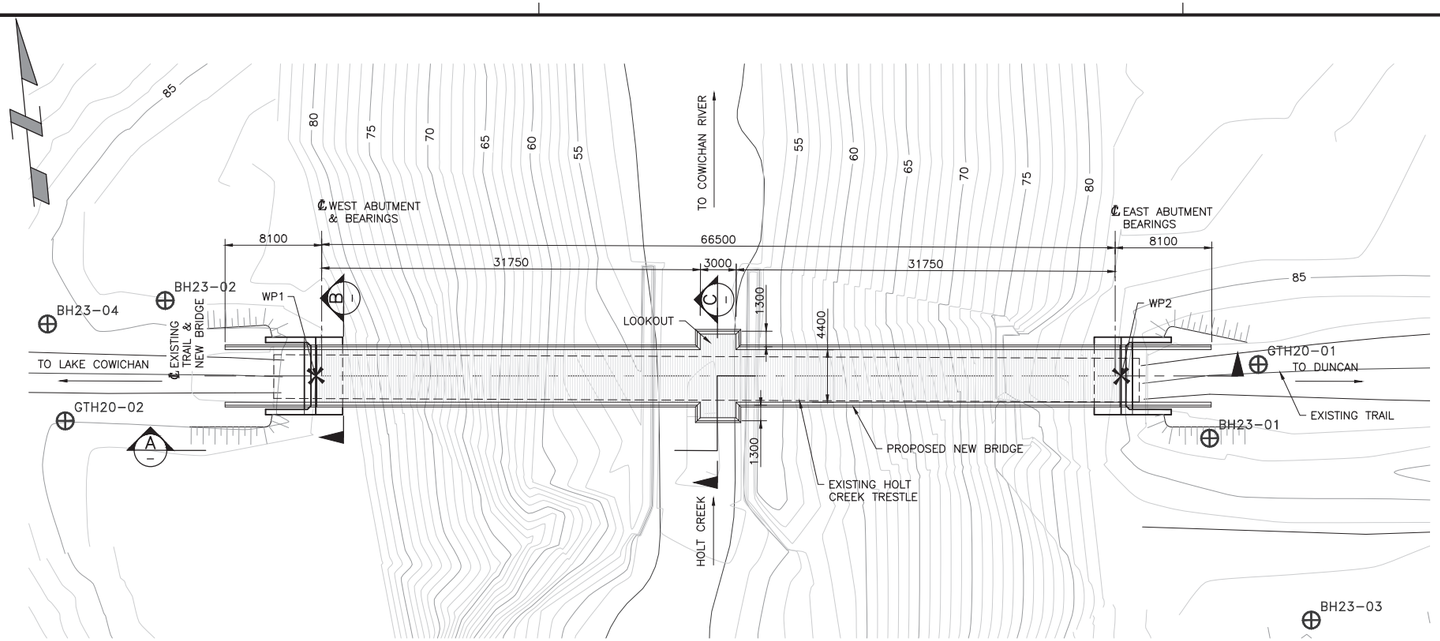
SEAL

DESIGNED KC DATE 2023/04/10
CHECKED LZ DATE 2023/04/14
DRAWN BX DATE 2023/04/10
SCALE AS NOTED
NEGATIVE No.

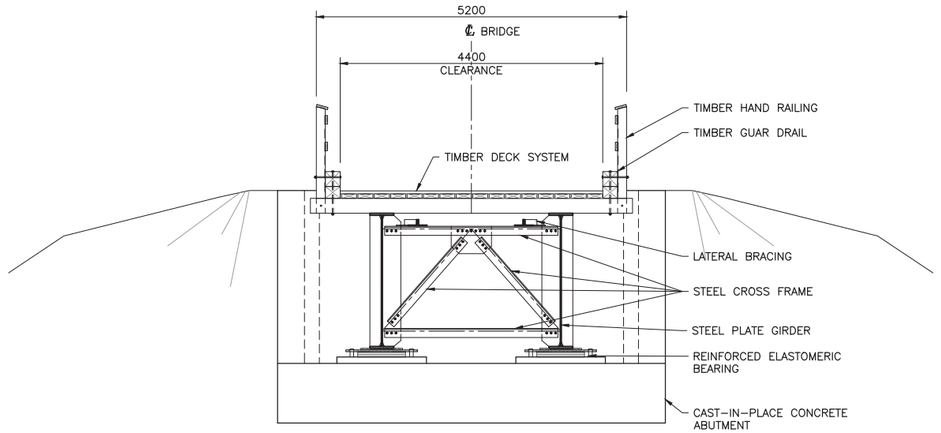
FILE No.	PROJECT No.	REG.	DRAWING No.
	04529 – 0001		04529–001 | A

H-308-r1-cs(07-08)

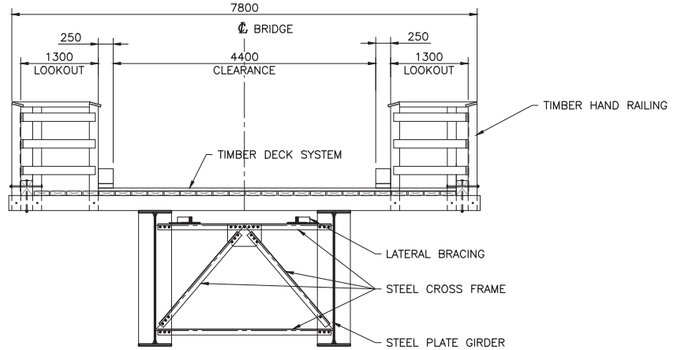
CANCEL PRINTS BEARING PREVIOUS LETTER



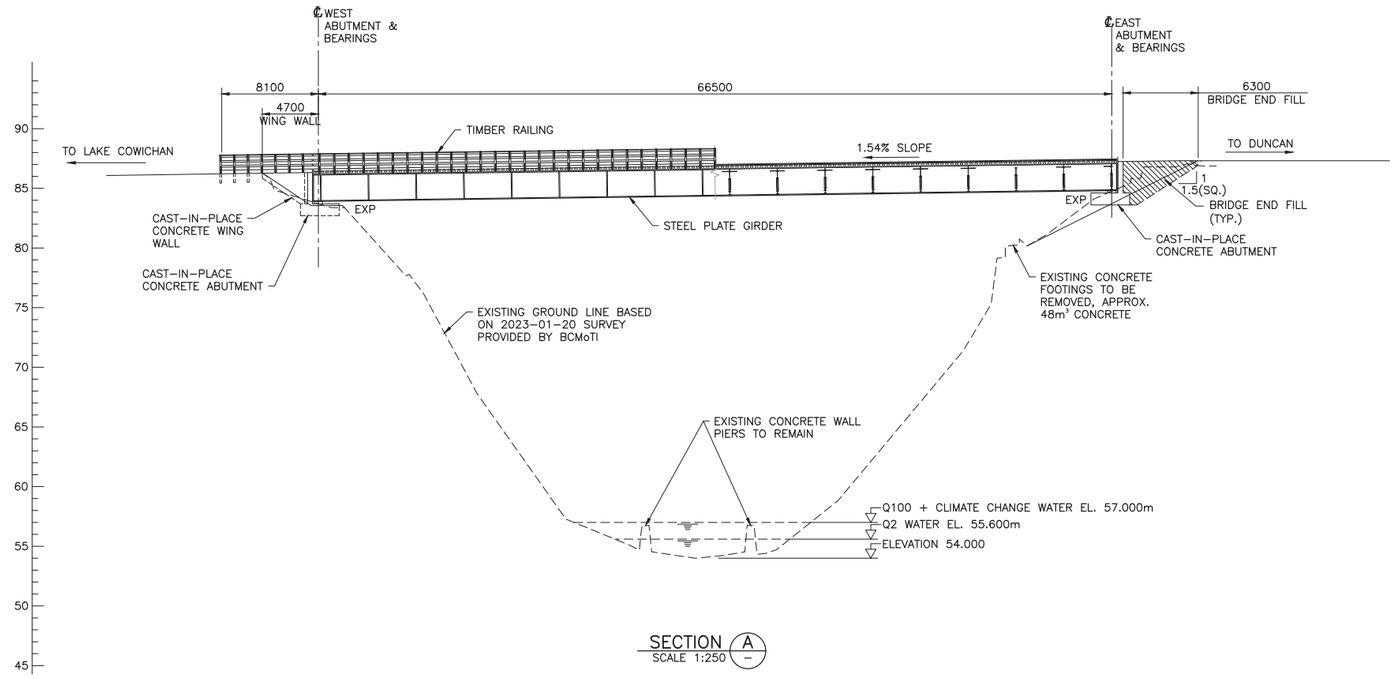
PLAN
SCALE 1:250



SECTION B
SCALE 1:50



SECTION C
SCALE 1:50

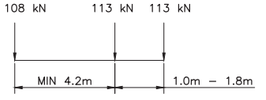


SECTION A
SCALE 1:250

WORK POINT	NORTHING	EASTING	ELEVATION
WP 1	5400755.481	441103.943	86.314
WP 2	5400748.915	441171.123	87.359

NOTES:

1. DESIGN SPECIFICATIONS:
   CAN/CSA-S6-19 AND BCMoTI SUPPLEMENT TO CAN/CSA S6-19
2. DESIGN LOADS:
   -PEDESTRIAN LOAD: 2.4 kPa
   -FIRE TRUCK LOAD: MUNICIPAL FIRE TRUCK WITH MAX. PERMITTED AXLE LOADS SHOWN BELOW



   -WIND LOAD: 1 / 50 YEAR REFERENCE = 0.650 kPa
   -DESIGN TEMPERATURE RANGE: MAX. +28°C AND MIN. -8°C
3. DESIGN SPEED: 20 km/h.
4. EARTHQUAKE:
   1/2,475 YEAR REFERENCE (2020 NBCC SEISMIC HAZARD MAP)
   Sa(0.2) = 1.660 g Sa(2.0) = 0.544 g
   Sa(0.5) = 1.480 g PGA = 0.709 g
   Sa(1.0) = 0.872 g
5. EXISTING TIMBER TRESTLE NOT SHOWN FOR CLARITY. EXISTING TRESTLE INCLUDING STEEL BEAMS SHALL BE COMPLETELY DEMOLISHED. EXISTING CONCRETE FOOTING AND PIER WALLS TO REMAIN.

PRELIMINARY
NOT FOR CONSTRUCTION
2023/07/28

SNC•LAVALIN
#1100-745 Thurlow Street
Vancouver, BC,
Canada, V6E 0C5

Rev	Date	Description	Init
C	2023/07/28	ISSUED FOR 90% DESIGN SUBMISSION	LZ
B	2023/06/06	ISSUED FOR REGULATORY APPROVAL	LZ
A	2023/04/17	ISSUED FOR 30% DESIGN SUBMISSION	LZ

REVISIONS

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure
South Coast Region

VANCOUVER ISLAND DISTRICT
COWICHAN VALLEY TRAIL

HOLT CREEK BRIDGE MILE 59.7
GENERAL ARRANGEMENT

PREPARED UNDER THE DIRECTION OF

ENGINEER OF RECORD

DATE

DESIGNED KC DATE 2023/04/10
CHECKED LZ DATE 2023/04/14
DRAWN BX DATE 2023/04/10
SCALE AS NOTED
NEGATIVE No.

FILE No.	PROJECT No.	REG.	DRAWING No.
670417-42DD-003	04529-0001		04529-003 B

CANCEL PRINTS BEARING PREVIOUS LETTER

H-308-41-a(07-08)

FIGURES

LEGEND

- 2023 BOREHOLE LOCATION
- HISTORICAL BOREHOLE LOCATION

0 30m

Scale: 1:600 @ 11"x17"

SOURCE

- BASE IMAGE PROVIDED BY GOOGLE EARTH, CIRCA 2016.

CLIENT

HOLT CREEK BRIDGE REPLACEMENT - MILE 59.7
GEOTECHNICAL DESIGN REPORT

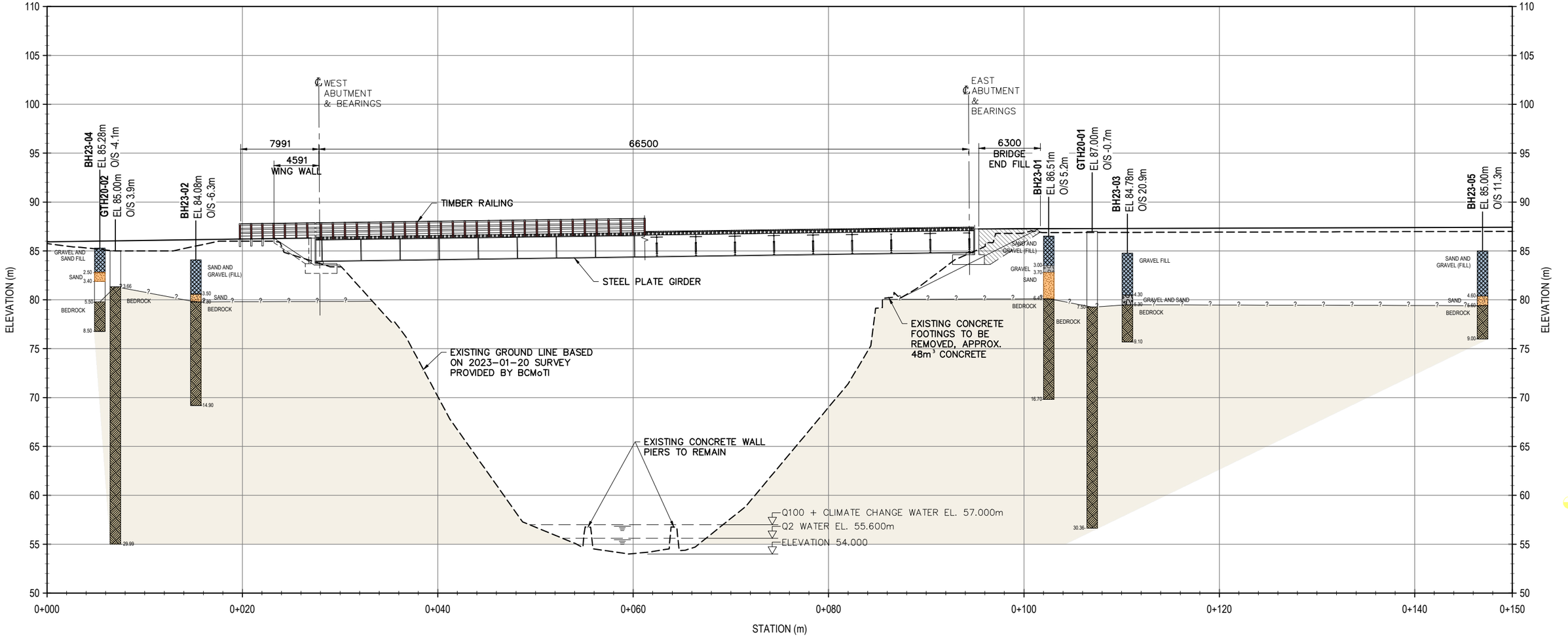
SITE INVESTIGATION LOCATIONS

TETRA TECH

PROJECT NO.	DWN	CKD	REV
ENG.ROCK03353-01	LCH	PK	0
OFFICE: Tt Van	DATE: July 2023		

Figure 1

C:\Vancouver\Drafting\Engineering\ROCK\ENG.ROCK03353-01\CAD\ROCK03353-01 Figure 1.dwg [FIGURE 1] July 20, 2023 - 11:58:56 am (BY: HUGHES, LEANNE)



Bridge CL

LEGEND

EXISTING GROUND PROFILE

0 20m

Scale: 1:400 @ 11"x17"

BOREHOLE LEGEND

SYMBOL	SOIL TYPE
	GRAVEL FILL/GRAVEL AND SAND FILL
	SAND
	GRAVEL/GRAVEL AND SAND
	BEDROCK

SOURCE

- BASE DRAWING PROVIDED BY CLIENT: 04529-003.dwg, REV C DATED 2023/07/28.

NOTE

- DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
- THE GEOLOGIC AND STRATIGRAPHIC SECTION SHOWN ON THIS DRAWINGS ARE INTERPRETED FROM BOREHOLE LOGS. STRATIGRAPHY IS KNOWN WITH CERTAINTY ONLY AT BOREHOLE LOCATIONS. ACTUAL STRATIGRAPHY AND GEOLOGIC CONDITIONS BETWEEN BOREHOLES MAY VARY FROM THAT INDICATED ON THIS DRAWING.

CLIENT

BRITISH COLUMBIA Ministry of Transportation and Infrastructure

TETRA TECH

HOLT CREEK BRIDGE REPLACEMENT - MILE 59.7
GEOTECHNICAL DESIGN REPORT

GEOLOGICAL LONG SECTION

PROJECT NO.	DWN	CKD	REV
ENG.ROCK03353-02	LCH	PK	0

OFFICE: Tt Van

DATE: September 2023

Figure 2

APPENDIX A

LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

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1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this document, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function. Where temporary or permanent drainage systems are installed within or around a structure, these systems must protect the structure from loss of ground due to mechanisms such as internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design details regarding the geotechnical aspects of such systems (e.g. bedding material, surrounding soil, soil cover, geotextile type) should be reviewed by the geotechnical engineer to confirm the performance of the system is consistent with the conditions used in the geotechnical design.

1.16 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.18 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

GEOTECHNICAL BOREHOLE LOGS

Geomechanical Drill Core Log

Hole # GTH20-01

Client:	SNC-Lavalin Inc.	Latitude:	48°45'25.10"N	Date Hole Started:	7-Jan-20
Project:	Holt Creek Trestle Replacement Subsurface Investigation	Longitude:	123°48'0.95"W	Date Hole Finished:	8-Jan-20
Project Number:	704-ENG.ROCK03146-01	Elevation (m):	85.00	Total Hole Depth (m):	30.36
Logged By:	LT	Orientation:	Vertical	Depth of Casing (m):	7.3
				Core Size:	HQ3

INTERVAL DATA														ISRM Weathering and Strength		DISCONTINUITY DATA																		Comments	Average RMR '76 Per Interval
Time	Interval From (m)	Interval To (m)	Interval Length (m)	Elev. (m)	Run No.	Lithology	Structure (Bed Thickness)	Recovery		RQD		Fracture Count		Weathering (ISRM)	Strength (ISRM)	Depth (m)	Disc. Type	JRC	Alpha	Beta	Shape	Rough	Infill (PC, CC, F)	Infill Thickness (mm)	Type (CL, PY, CO, CA, GR)	Aperture (Closed, Gapped, Open)	Weather (ISRM)	JCON (RMR'76)							
								Length (m)	%	Length (m)	%	Natural	Mechanical																						
2:10:00 PM	7.75	7.92	0.17	77.3	1	MDST	TL	0.17	100%	0.17	100%	0	2	W1	R2	-	-	-	-	-	-	-	-	-	-	C	W1	25						0 to 7.75 m is overburden (till). Significant drill spin at top and ridges along core. No features.	42
2:47:00 PM	7.92	9.12	1.20	77.1	2	MDST	TL	1.2	100%	0.75	63%	8	20	W1	R2	8.22	JN	5	35		PL	SM	-	-	-	C	W1	12							
																8.55	JN	7	39	-	PL	SM	PC	<1	CA	G	W1	12						<10% of surface coated	
																8.65	JN	5	30	-	PL	SM	-	-	-	C	W1	20							
																8.67	JN	-	41	-	-	-	-	-	-	C	-	25						Healed feature.	51
																8.71	JN	3	34	-	PL	SM	PC	<1	CA	C	W2	12						Thinly coated, approximately 10% of surface.	
																8.76	JN	5	40	-	PL	RO	-	-	-	C	W1	20							
																8.84	JN	3	41	-	PL	SM	PC	<1	CA	C	W1	12							
																8.98	JN	5	11	-	CU	SM	PC	<1	CA	C	W1	12							
	9.12	9.29	0.17	75.9	2	FLT MDST	TL	0.17	100%	0.00	0%	99	0	W2	R1	9.12	SZ	15	25	-	ST	RO	PC	170	SZ /CA	O	W3	0						Some areas of R0 mudstone . Some CA on surfaces.	19
3:30:00 PM	9.29	10.80	1.51	75.7	3	MDST	TL	1.49	99%	1.12	74%	6	15	W1	R2	9.29	SZ	9	5	-	UN	RO	F	15	CL/SZ	O	W4	0						8-20 mm of shear infill with sheared mudstone subparallel to core axis. Some clay-like infill, possibly mud. Upper contact of shear logged.	
																9.47	JN	5	15	-	UN	SM	PC	<1	CA	C	W1	20							
																9.50	JN	5	18	-	PL	SM	PC	<1	CA	C	W1	20						Calcite micro veining, <10% of surface coated	52
																9.55	VN	-	60	-	-	-	F	1	CA	C	-	25						Closed vein	
																9.66	VN	-	55	-	-	-	CC	1	CA	C	-	25						Micro veins/veinlets	
																10.14	BD	3	54	-	PL	SM	-	-	-	C	W1	12							
4:08:00 PM	10.80	12.30	1.50	74.2	4	MDST	TL	1.50	100%	1.50	100%	0	4	W1	R2	-	-	-	-	-	-	-	-	-	-	-	-	25						Stick rock. Some calcite veins at end of run.	82
4:40:00 PM	12.30	13.80	1.50	72.7	5	MDST	TL	1.48	99%	1.38	92%	3	13	W1	R2	12.70	CO	3	84	-	CU	SM	F	10	CL	O	W1	0						10 mm thick layer of light grey (S2-S3) clay. Mudstone surfaces on contact are smooth and slightly curved. No indication of weathering on MDST surfaces (no staining).	
																13.10	JN	3	35	-	PL	SM	-	-	-	C	W1	6						Minor slickensides / polished striations	62
																13.14	VN	5	65	-	PL	RO	PC	<1	CA	C	W1	25						Possibly a mechanically induced feature along a vein as there is some drill spin.	
8:45:00 AM	13.80	15.31	1.51	71.2	6	MDST	TL	1.22	81%	0.91	60%	5	18	W1	R2	14.15	SZ	3	53	-	PL	SM	F	30	CL	O	W3	0						Possible silty clay and fractured pieces of mudstone at the top of the run. Field dilatancy test undertaken on clay. Assume 0.3 m core loss at top of run from 13.8 to 14.1 m. Assume weak rock / clay washed out with drilling.0.2 m of additional core loss from 15.35 - 15.55 m in weak rock.	
																14.32	JN	5	45	-	CU	K	PC	3	CA	G	W2	6							40
																14.46	JN	5	40	-	PL	SM	PC	1	CA	G	W1	12							
																15.17	JN	1	20	-	UN	K	PC	1	CA	G	W1	6							
																15.20	SZ	15	44	-	ST	VR	F	20	CA/CL	O	W1	0						Clay and crushed rock infill approximately 20 mm thick.	
	15.31	15.55	0.24	69.7	6	FLT MDST	TL	0.03	13%	0.00	0%	1	1	W1	R0	15.31	CO	1	20	-	UN	K	F	24	SZ/CL	O	W4	0						Extremely weak, friable mudstone (R0/S6) and clay. Upper contact is smooth and slickensided. Possibly sheared MDST. Assume 0.2 m of missing core was in interval of weak mudstone and washed out with drilling.	18
9:30:00 AM	15.55	15.75	0.20	69.5	7	MDST	TL	0.20	100%	0.15	75%	1	1	W1	R2	15.60	JN	5	62	-	PL	K	PC	1	CA	G	W1	6							45
	15.75	15.90	0.15	69.3	7	FLT MDST with CLAY	TL	0.15	100%	0.00	0%	99	0	W4	S5	15.75	SZ	7	40	-	UN	SM	F	150	CL/SZ	O	W4	0						R2 mudstone fragments within S5 clay infill. No iron staining on contact. Upper contact of fault logged.	18
	15.90	16.36	0.46	69.1	7	MDST	TL	0.46	100%	0.15	33%	4	8	W1	R2	15.93	JN	9	60	-	PL	RO	PC	<1	CA	G	W1	12							
																15.97	SZ	11	57	-	IR	VR	F	15	SZ	O	W1	0						15 mm thick infill of sheared / crushed mudstone.	
																16.05	SZ	9	20	-	CU	RO	F	10	SZ/CL	O	W3	0						Sheared mudstone and clay infill.	33
																16.29	SZ	11	17	-	CU	RO	F	10	SZ/CL	O	W3	0						Possibly a continuation of feature at 16.05 m. Feature curves around core axis.	
	16.36	17.12	0.76	68.6	7	MDST with CA Microveining	VT	0.76	100%	0.60	79%	5	10	W1	R1	16.36	JN/CO	-	23	-	UN	-	F	1	SZ/CL	C	W2	25						Healed joint (closed). Approx. Appears to have clay / sheared mudstone infill.	
																16.50	JN	13	24	-	PL	VR	PC	<1	CL	G	W1	20						Thin clay infill, possibly just from drilling	
																16.72	JN	5	10	-	UN	K	PC	<1	CA	G	W1	6						Joint extends approx. 0.3 m along core, possibly the same features at 17.0 m. Intersects another joint at 16.74 m. Slickensides / striations on joint surface.	53
																16.74	JN	9	34	-	PL	RO	PC	<1	CA	G	W1	20							
																17.00	JN	5	12	-	UN	K	PC	1	CA	G	W2	6						Some clay infill	
10:40:00 AM	17.12	18.60	1.48	67.9	8	MDST with CA Microveining	VT	1.42	96%	1.32	89%	2	15	W1	R2	17.72	JN	13	35	-	ST	VR	-	-	-	G	W1	20						Calcite micro veining throughout interval. Some dissolution pits.	65
																18.30	JN	7	27	-	PL	RO	PC	<1	CA/CL	C	W1	12							
11:00:00 AM	18.60	20.17	1.57	66.4	9	MDST with CA Microveining	VT	1.53	97%	1.35	86%	3	10	W1	R1	-	-	-	-	-	-	-	-	-	-	-	-	-						0.04 m of missing core assumed to be weak mudstone washed out at top of run . End of run becomes less microfractured - transitions back to R2 mudstone.	
																18.82	CO	5	85	-	PL	SM	F	15	CL	O	W1	0						Some mechanical damage, mudstone or part of clay layer likely washed out with drilling. Approximately 15 mm thick clay layer.	54
																18.89	JN	5	40	-	PL	SM	PC	<1	CL	G	W1	12							
																20.17	VN	3	25	-	PL	PO/K	F	8	QTZ	O	W1	6						Quartz vein 8 mm thick. Wall of mudstone is slickensided / polished	
11:20:00 AM	20.17	21.70	1.53	64.8	10	MDST	TL	1.53	100%	1.50	98%	3	6	W1	R2	21.78	JN	5	5	-	PL	K	PC	<1	CA	G	W1	6						Two subparallel joints.	
																21.78	JN	5	8	-	PL	K	PC	<1	CA	G	W1	6						Slickensided / partially coated with soft white mineral that doesn't react to HCl.	63
																22.03	BD	5	56	-	PL	SM	-	-	-	G	W1	20							
12:00:00 PM	21.70	23.31	1.61	63.3	11	MDST	TL	1.50	93%	1.33	83%	2	18	W1	R2	22.14	CO	5	82	-	PL	SM	F	20	CL	O	W1	0						Clay layer is thinner than appears in photos. Approximately 10-30 mm clay seam. Upper contact is slightly rough / smooth. No slickensides and not polished.	55
																22.58	JN	9	45	-	CU	RO	PC	<1	CA	G	W1	12						Some striations / slickensides	
1:00:00 PM	23.31	24.45	1.14	61.7	12	MDST	TL	1.00	88%	0.85	75%	6	11	W1	R1	23.31	JN	13	23	-	PL	RO	PC	<1	CA	G	W1	20						0.14 m core loss at end of run, picked up at start of next run.	
																23.50	JN	3	82	-	PL	PO/K	PC	<1	CA	G	W1	6						Slickensides / striated.	
																24.12	JN	5	42	-	PL	SM	PC	<1	CA	G	W1	12						In area of mechanical damage	
																24.12	JN	5	5	-	UN	K	PC	<1	CA	G	W	6						Perpendicularly Intersects feature described above. Sub-parallel to core axis	41
																24.25	FLT	15	33	-	CU	VR	F	35	CL/SZ	O	W4	0						Upper contact of fault. Upper surface is very rough. 30 to 40 mm of clay and sheared mudstone infill.	
																24.55	FLT	5	40	-	ST	K	F	35	CL/SZ	O	W4	0						Lower contact of fault. Bottom contact is slickensided/striated - indications of movement.	

Geomechanical Drill Core Log

Hole # GTH20-01

Client:	SNC-Lavalin Inc.	Latitude:	48°45'25.10"N	Date Hole Started:	7-Jan-20
Project:	Holt Creek Trestle Replacement Subsurface Investigation	Longitude:	123°48'0.95"W	Date Hole Finished:	8-Jan-20
Project Number:	704-ENG.ROCK03146-01	Elevation (m):	85.00	Total Hole Depth (m):	30.36
Logged By:	LT	Orientation:	Vertical	Depth of Casing (m):	7.3
				Core Size:	HQ3

INTERVAL DATA														ISRM Weathering and Strength		DISCONTINUITY DATA													Comments	Average RMR '76 Per Interval
Time	Interval From (m)	Interval To (m)	Interval Length (m)	Elev. (m)	Run No.	Lithology	Structure (Bed Thickness)	Recovery		RQD		Fracture Count		Weathering (ISRM)	Strength (ISRM)	Depth (m)	Disc. Type	JRC	Alpha	Beta	Shape	Rough	Infill (PC, CC, F)	Infill Thickness (mm)	Type (CL, PY, CO, CA, GR)	Aperture (Closed, Gapped, Open)	Weather (ISRM)	JCON (RMR'76)		
								Length (m)	%	Length (m)	%	Natural	Mechanical																	
1:45:00 PM	24.45	25.60	1.15	60.6	13	MDST	TL	1.25	109%	1.15	100%	1	11	W1	R2	25.08	VN	-	13	-	-	-	-	<1	-	C	-	25	Likely a mechanical break along a vein. 0.1 m of extra core picked up from the previous end of run . Lots of drill spin, some disking.	82
2:08:00 PM	25.60	27.24	1.64	59.4	14	MDST	TL	1.57	96%	1.49	91%	5	3	W1	R2	25.70	BD	3	37	-	PL	SM	PC	<1	CA	G	W1	6		
																25.78	BD	3	47	-	PL	SM	-	-	-	C	W1	12	Extremely smooth, almost polished	64
																25.89	BD	3	50	-	PL	PO	PC	<1	CA	G	W1	6	<10% of surface coated	
																26.43	JN	5	49	-	PL	SM	PC	<1	CA	G	W1	12	<5% of surface coated	
																27.12	JN	9	52	-	PL	RO	-	-	-	C	W1	25	Likely mechanically induced.	
2:45:00 PM	27.24	28.86	1.62	57.8	15	INTER MDST/SLT	TL	1.52	94%	1.42	88%	3	8	W1	R2	28.44	JN	11	21	-	CU	RO	PC	<1	CA	G	W1	20	Bedding has become more obvious due to interbedded dark mudstone & lighter siltstone. 0.10 m missing core assumed at top of run where drillers apparently got a bit plugged.	62
																28.46	JN	5	37	-	PL	K	CC	1	CL	G	W1	6		
																28.58	JN	7	40	-	PL	RO	CC	0.05	CL	G	W1	12		
3:20:00 PM	28.86	30.36	1.50	56.1	16	MDST	TL	1.50	100%	1.18	79%	8	10	W1	R2	28.90	FLT	7	23	-	IR	K	F	50	CL/SZ	O	W4	0	Upper contact of 50 mm thick fault. Infill is crushed/sheared mudstone and clay. 15 mm clay below sheared rock. Evidence of movement on upper contact. Clay is S4/S5.	39
																28.95	FLT	11	79	-	IR	VR	F	50	CL	O	W6	0	Bottom contact of fault. Rough, less indication of movement.	
																29.10	JN	5	20	-	PL	K	PC	<1	CA	G	W1	6	Slickensides	
																29.21	JN	-	10	-	CU	-	-	-	-	G	W1	25	Healed joint with approx. 0.05 mm gap	
																29.71	JN	9	25	-	PL	RO	CC	0.05	CL	G	W1	12	Thin clay infill	
																30.00	JN	7	19	-	CU	K	PC	<1	CA	G	W1	12	Slickensides, but rough. Less than 10% of surface coated	
																30.10	JN	9	44	-	PL	SM	PC	<1	CL	G	W1	12	Intersects JN at 30.20 m	
																30.20	JN	3	30	-	PL	K	F	2	SZ/CL	G	W3	0	Clay and slickensides. Evidence of movement. Areas of weak rock at contact of joint (R0).	
																													End of hole at 30.36	

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 7.75 m to 15.97 m, Dry

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 7.75 m to 15.97 m, Wet

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 15.97 m to 24.05 m, Dry

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 15.97 m to 24.05 m, Wet

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 24.05 m to 30.36 m (EOH), Dry

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 24.05 m to 30.36 m (EOH), Wet

Geomechanical Drill Core Log

Hole # GTH20-02

Client:	SNC-Lavalin Inc.	Latitude:	48°45'25.22"N
Project:	Holt Creek Trestle Replacement Subsurface Investigation	Longitude	123°48'5.85"W
Project Number:	704-ENG.ROCK03146-01	Elevation (m):	82.00
Logged By:	LT	Hole Orientation:	Vertical

Date Hole Started:	9-Jan-20
Date Hole Finished:	10-Jan-20
Total Hole Depth (m):	29.99
Depth of Casing (m):	3.35 m
Core Size:	HQ3

INTERVAL DATA														ISRM Weathering and Strength		DISCONTINUITY DATA													
Time	Interval From (m)	Interval To (m)	Interval Length (m)	Elev. (m)	Run No.	Lithology	Structure (Bed Thickness)	Recovery		RQD		Fracture Count		Weathering (ISRM)	Strength (ISRM)	Depth (m)	Disc. Type	JRC	Alpha	Beta	Shape	Rough	Infill (PC, CC, F)	Infill Thickness (mm)	Type (CL, PY, CO, CA, GR)	Aperture (Closed, Gapped, Open)	Weather (ISRM)	JCON (RMR'76)	Comments	Average RMR '76 Per Interval
								Length (m)	%	Length (m)	%	Natural	Mechanical																	
11:00:00 AM	3.66	5.18	1.52	78.3	1	MDST	TL	0.65	43%	0.65	43%	0	18	W1	R2	-	-	-	-	-	-	-	-	-	-	-	-	25	0.72 m of missing core. Assume weathered MDST washed out at top of run. Drillers also reported that the last approx. 0.15 m of run felt like a gap/void. Intense mechanical damage / drill spin / ribbing with decreased core diameter. Some ground up cobbles from overburden at top of run. No discernable natural features.	40
11:30:00 AM	5.18	6.61	1.43	76.8	2	MDST	TL	1.32	92%	1.32	92%	3	5	W1	R2	5.53	BD	3	77	-	PL	SM	PC	<1	CL	C	W1	20	0.09 m missing core. Assumed at top of run. Ribbing of core. BD feature is possibly a mechanical fracture along bedding.	63
																6.42	JN	3	17	-	PL	PO/K	PC	<1	CA	G	W1	6		
																6.57	JN	3	13	-	PL	K	PC	<1	CA	G	W1	6		
12:00:00 PM	6.61	7.92	1.31	75.4	3	MDST	TL	1.16	89%	0.93	71%	5	25	W1	R2	6.71	JN	3	16	-	PL	PO/K	PC	<1	CA	G	W1	6	A lot of mechanical damage in this run. 0.15 m of missing core, likely at 6.97 m where core was reduced to rubble.	43
																6.77	JN	3	20	-	PL	PO/K	PC	<1	CA	G	W1	6		
																7.40	JN	5	19	-	PL	SM	PC	<1	CA	G	W1	12	Some striations, fairly smooth, but not polished.	
																7.70	JN	7	21	-	PL	SM	PC	<1	CL	G	W1	12		
																7.90	JN	3	14	-	PL	K	PC	<1	CA	G	W1	6	Some mechanical damage, but smooth, slickensided surface.	
12:30:00 PM	7.92	8.79	0.87	74.1	4	FLT MDST	TL	0.55	63%	0.00	0%	99	999	W3	R2	8.52	SZ	11	25	-	PL	RO	F	280	SZ/CL	O	W3	0	0.28 m of rubble, including a 50 mm layer of clay and sheared mudstone. 0.32 m lost core assumed in this rubble / fault zone. Mudstone is R2, clay is S2. Lower contact of shear logged, upper contact lost in rubble / mechanical damage.	23
																8.54	SZ	13	36	-	ST	RO	F	40	SZ/CL	O	W3	0	Upper contact of shear. Appears to be intersecting features. 40 mm of sheared / broken mudstone with some possible clay infill and calcite veining infill.	
																8.58	SZ	11	37	-	ST	RO	F	40	SZ/CL	O	W3	0	Lower contact of shear.	
																8.70	FLT	11	34	-	IR	RO	F	60	SZ/CL	O	W2	0	Upper contact of fault.	
																8.76	JN	13	69	-	CU	RO	PC	<1	CA	G	W1	20	Intersects fault, potentially part of fault.	
																8.79	FLT	7	30	-	PL	K	F	60	SZ/CL	O	W2	0	Lower contact of fault. Clay coating on contact surface. Calcite veins and slickensides, polished surfaces also observed in sheared mudstone infill.	
	8.79	9.44	0.65	73.2	4	MDST	TL	0.65	100%	0.36	55%	2	999	W1	R2	9.05	VN	5	10	-	PL	K	F	15	CA	O	W1	6	5 to 15 mm thick calcite vein. Both contacts of vein are slickensided.	48
																9.19	SZ	9	30	-	PL	RO	F	24	SZ	O	W1	0	0.24 m infill of sheared mudstone with calcite veining.	
2:16:00 PM	9.44	10.97	1.53	72.6	5	FLT MDST	TL	0.60	39%	0.25	16%	2	999	W3	R2	10.57	SZ	15	88	-	IR	VR	F	80	SZ/CL	O	W3	0	Lower shear contact logged, upper contact lost in mechanical damage. Approximately 80 mm of sheared / crushed mudstone and clay-like infill. Clay has pieces of mudstone in it. Clay is S4.	25
																10.84	SZ	5	27	-	PL	SM	F	130	SZ/CL	O	W4	0	Upper contact of shear logged, lower contact lost in mechanical damage. 130 mm infill of sheared / crushed mudstone and clay. Some sub-horizontal structures to core axis in fault infill, possibly relic of bedding.	
3:10:00 PM	10.97	12.49	1.52	71.0	6	MDST	TL	0.85	56%	0.85	56%	0	999	W1	R2	-	-	-	-	-	-	-	-	-	-	-	-	-	Run not provided in split, logged out of core box. Extreme mechanical damage. Core got stuck in tube down the hole. Split came out but contained no core. Core was stuck in rods. Drill bit had to be removed and tubes hit with a hammer to remove core. All seams or infill or fractured zones destroyed. 0.67 m of missing core. Drillers believe it came from bottom of run where the drill became plugged up.	45
3:48:00 PM	12.49	13.17	0.68	69.5	7	MDST	TL	0.48	71%	0.48	71%	1	5	W1	R2	12.49	JN	11	10	-	UN	RO	-	-	-	G	W1	25	Core catcher could not grab onto rock to bring it up to surface, likely due to fractured rock mass. Run not provided in split, logged out of core box. Angular, fresh surfaces from mechanical damage observed. Drill spin on most surfaces. 0.2 m of Core loss assumed at bottom of run from 12.97 to 13.17 m, drillers noted top of run felt better.	70
8:30:00 AM	13.17	14.77	1.60	68.8	8	MDST	TL	1.60	100%	1.32	83%	4	10	W1	R2	-	-	-	-	-	-	-	-	-	-	-	-	-	Reduced diameter for first 0.7 m of run.	
																14.40	VN	-	14	-	-	-	F	3	CA	C	W1	25	Closed vein	70
																14.48	JN	11	51	-	ST	RO	-	-	-	C	W1	20		
																14.53	JN	5	5	-	UN	SM	-	-	-	C	W1	20	Sub-parallel to core axis and another joint at the same depth	
																14.53	JN	5	5	-	UN	SM	-	-	-	C	W1	20		
9:00:00 AM	14.77	16.15	1.38	67.2	9	MDST	TL	1.38	100%	1.38	100%	2	4	W1	R2	-	-	-	-	-	-	-	-	-	-	-	-	-	Run received in two splits as half of the core fell out and had to be retrieved from the bottom of the hole.	
																15.39	BD	9	62	-	PL	RO	PC	<1	CA	G	W1	12	Rough, but evidence of movement, slickensides.	58
																15.92	JN	3	5	-	PL	K	F	5	CA	O	W1	6	5 mm calcite vein infill, sub-parallel to core axis. Joint extends along core axis for approximately 0.5 m.	
10:00:00 AM	16.15	17.55	1.40	65.9	10	MDST	TL	1.40	100%	1.40	100%	2	30	W1	R2	-	-	-	-	-	-	-	-	-	-	-	-	-	Recovery greater than core length, accounts for 0.25 m of core loss in run 7. Depths presented in core photos from 12.49 to 17.55 are off by 0.25 m.	
																16.35	JN	3	15	-	PL	PO/K	PC	<1	CA	G	W1	6	Very polished, slickensides.	55
																17.31	FLT	3	27	-	PL	SM	F	40	CL/SZ	O	W5	0	Approximately 40 mm of S2/S3 clay infill with broken / sheared mudstone. Upper contact logged. Extremely planar and smooth, but no slickensides.	
11:08:00 AM	17.55	18.05	0.50	64.5	11	MDST	TL	0.50	100%	0.37	74%	4	2	W1	R2	17.67	BD	5	51	-	PL	K	PC	<1	CA	G	W1	6	Clay residue noted at top of run.	
																17.74	BD	3	52	-	CU	K	PC	<1	CA	G	W1	6		41
																17.77	BD	3	52	-	PC	K	PC	<1	CA	G	W1	6		
																17.89	JN	5	27	-	PL	K	PC	<1	CA	G	W1	6		
	18.05	18.35	0.30	64.0	11	FLT MDST	TL	0.30	100%	0.00	0%	3	1	W3	R0	18.05	CO	-	44	-	-	-	F	300	CA/SZ	C	W3	25	Very weak, friable R0 to R1 rock. Degrades when handled. Sheared MDST with calcite veining. Contact is closed.	35
																18.23	JN	11	74	-	CU	VR	-	-	-	G	W2	12		
																18.35	CO/FLT	9	32	-	PL	RO	F	300	SZ/CA	O	W3	0	Bottom contact of fault. Roughly follows a 1 mm thick calcite vein.	
	18.35	18.89	0.54	63.7	11	MDST	TL	0.54	100%	0.44	81%	2	2	W1	R2	18.65	JN	15	50	-	IR	VR	-	-	-	C	W1	25		55
																18.79	JN	5	43	-	PL	SM	PC	<1	CL/CA	G	W1	6		
11:40:00 AM	18.89	20.42	1.53	63.1	12	MDST	TL	1.50	98%	0.91	59%	8	26	W1	R2	18.91	JN	3	37	-	PL	PO/K	PC	<1	CA	G	W1	6		
																19.29	JN	7	45	-	PL	SM	-	-	-	G	W1	20		
																19.50	JN	5	25	-	PL	SM	PC	<1	CA	G	W1	12		
																19.55	VN	-	22	-	-	-	F	10	CA	G	W1	25	Closed vein	
																19.83	BD	5	65	-	PL	K	PC	<1	CA	G	W1	6		49
																19.98	BD	13	65	-	ST	VR	PC	<1	CA	G	W1	25	Possibly mechanical	
																20.08	JN	7	35	-	PL	SM	PC	<1	CA	G	W1	20		
																20.16	FLT	5	12	-	PL	K/PO	F	26	SZ/CL	O	W4	0	Very polished / slickensides. Upper contact of fault logged. 26 mm of sheared R0 mudstone and S2 clay infill.	

Geomechanical Drill Core Log

Hole # GTH20-02

Client:	SNC-Lavalin Inc.	Latitude:	48°45'25.22"N
Project:	Holt Creek Trestle Replacement Subsurface Investigation	Longitude	123°48'5.85"W
Project Number:	704-ENG.ROCK03146-01	Elevation (m):	82.00
Logged By:	LT	Hole Orientation:	Vertical

Date Hole Started:	9-Jan-20
Date Hole Finished:	10-Jan-20
Total Hole Depth (m):	29.99
Depth of Casing (m):	3.35 m
Core Size:	HQ3

INTERVAL DATA														ISRM Weathering and Strength		DISCONTINUITY DATA														
Time	Interval From (m)	Interval To (m)	Interval Length (m)	Elev. (m)	Run No.	Lithology	Structure (Bed Thickness)	Recovery		RQD		Fracture Count		Weathering (ISRM)	Strength (ISRM)	Depth (m)	Disc. Type	JRC	Alpha	Beta	Shape	Rough	Infill (PC, CC, F)	Infill Thickness (mm)	Type (CL, PY, CO, CA, GR)	Aperture (Closed, Gapped, Open)	Weather (ISRM)	JCON (RMR'76)	Comments	Average RMR '76 Per Interval
								Length (m)	%	Length (m)	%	Natural	Mechanical																	
12:00:00 PM	20.42	21.94	1.52	61.6	13	MDST	TL	1.52	100%	1.00	66%	6	14	W1	R2	20.39	JN	3	38	-	CU	SM	PC	<1	CA	C	W1	25	Mechanical break along joint. Infilled with calcite, intersects joint below.	
																20.62	JN	5	45	-	PL	SM	PC	<1	CA	G	W1	12		
																20.70	JN	9	30	-	PL	RO	PC	<1	CA	G	W1	20		
																21.60	JN	5	27	-	CU	SM	PC	<1	CL/CA	G	W1	12	Clay coating on very smooth surface. Indication of some movement along surface.	47
																21.66	SZ	15	40	-	IR	VR	F	90	SZ	O	W3	0	50-100 mm zone of sheared / crushed rock. Upper contact logged. Highly damaged.	
																21.75	SZ	15	35	-	IR	VR	F	90	SZ	O	W1	0	Lower contact of shear.	
12:30:00 PM	21.94	23.16	1.22	60.1	14	MDST	TL	1.22	100%	1.22	100%	3	3	W1	R2	22.00	JN	1	12	-	PL	PO/K	PC	<1	CA	G	W1	6	Joint extends for approximately 0.22 m along axis.	
																22.25	BD	7	65	-	PL	SM	-	-	-	G	W1	20		65
																23.00	JN	1	35	-	CU	SM	PC	<1	CA	G	W1	12	Very little coating on surface. Very smooth, but not polished.	
1:00:00 PM	23.16	24.68	1.52	58.8	15	MDST	TL	1.52	100%	1.52	100%	1	10	W1	R2	24.68	JN	5	23	-	PL	SM	PC	<1	CA	G	W1	12		69
2:10:00 PM	24.68	26.21	1.53	57.3	16	MDST	TL	1.53	100%	1.53	100%	5	3	W1	R2	24.68	JN	7	23	-	PL	SM	-	-	-	G	W1	20	Possibly a continuation of the joint at the end of the previous run , some mechanical damage.	
																25.61	BD	5	44	-	PL	PO/K	PC	<1	CA	G	W1	6		67
																25.78	BD	3	69	-	PL	PO/K	PC	<1	CA	G	W1	6		
																26.06	BD	17	76	-	IR	VR	-	-	-	G	W1	25	Possibly mechanical features.	
																26.21	JN	9	31	-	PL	RO	PC	<1	CA	G	W1	20	Some striations, but is rough.	
3:00:00 PM	26.21	27.73	1.52	55.8	17	MDST	TL	1.52	100%	1.52	100%	2	2	W1	R2	26.41	BD	7	60	-	PL	K	PC	<1	CA	G	W1	6	Slickensides, but not polished.	
																27.71	JN	3	27	-	PL	K	PC	<1	CA	G	W1	6		58
3:20:00 PM	27.73	29.41	1.68	54.3	18	MDST	TL	1.60	95%	1.59	95%	4	5	W1	R2	27.73	JN	3	24	-	PL	K/PO	PC	<1	CA	G	W1	6		
																28.13	JN	11	64	-	UN	RO	PC	<1	CA	G	W1	20		67
																28.14	JN	9	19	-	PL	RO	PC	<1	CA	G	W1	12	Striations	
																28.44	BD	7	55	-	PL	SM	PC	<1	CA	G	W1	20	Very little coating	
3:47:00 PM	29.41	29.99	0.58	52.6	19	MDST	TL	0.58	100%	0.58	100%	1	2	W1	R2	29.83	JN	11	35	-	UN	RO	PC	<1	CA	G	W1	20		72
																													End of hole at 29.99 m	

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 3.66 – 14.92 m, Dry

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 3.66 m – 14.92 m, Wet

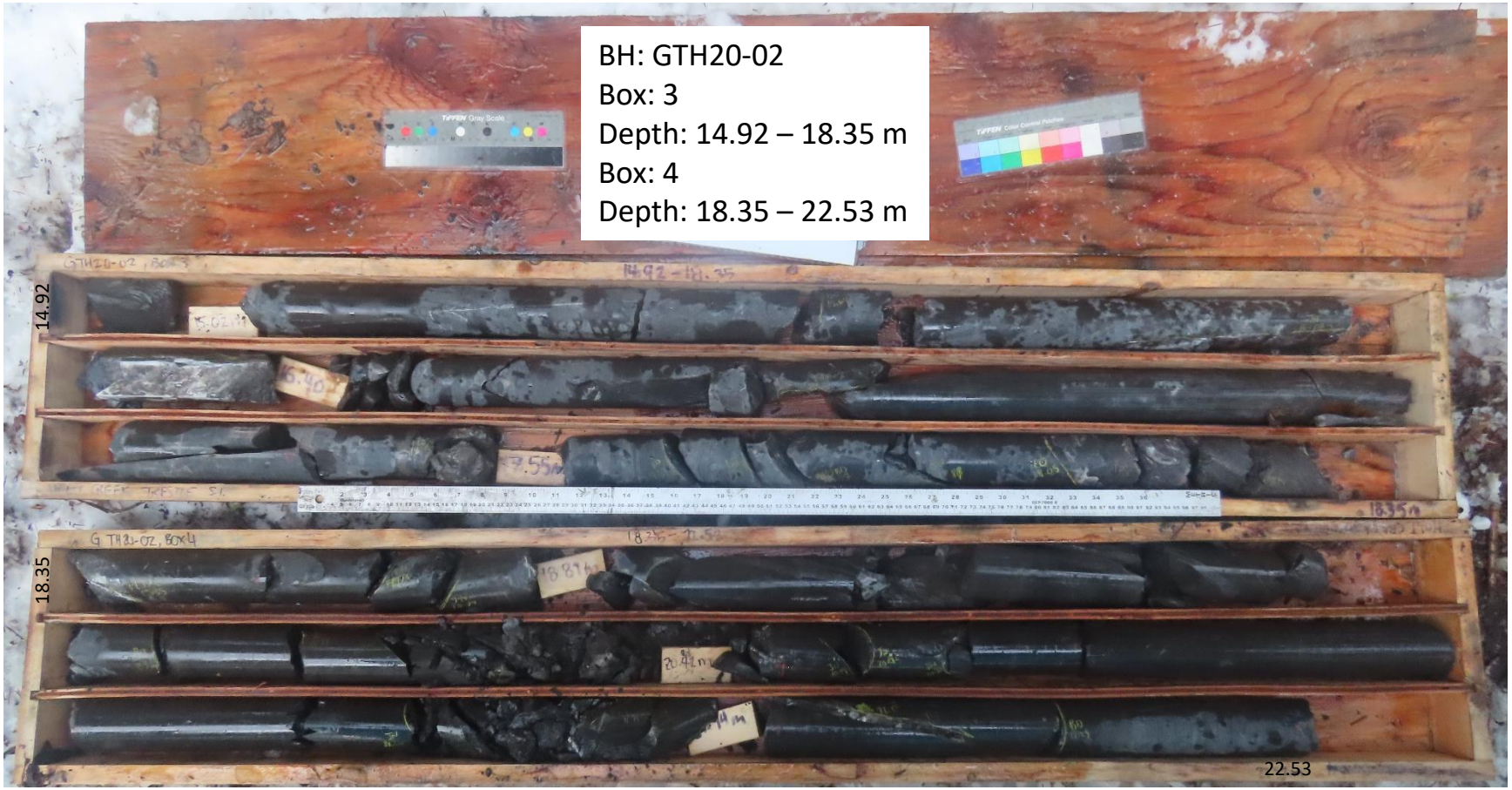


Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 14.92 m – 22.53 m, Dry

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 14.92 m – 22.53 m, Wet

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 22.53 m – 29.99 m (EOH), Dry

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 22.53 m – 29.99 m (EOH), Wet

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 7.75 m to 15.97 m, Dry

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 7.75 m to 15.97 m, Wet

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 15.97 m to 24.05 m, Dry

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 15.97 m to 24.05 m, Wet

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 24.05 m to 30.36 m (EOH), Dry

Photo Taken: January 8, 2020

Description: Borehole GTH20-01, 24.05 m to 30.36 m (EOH), Wet

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 3.66 – 14.92 m, Dry

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 3.66 m – 14.92 m, Wet

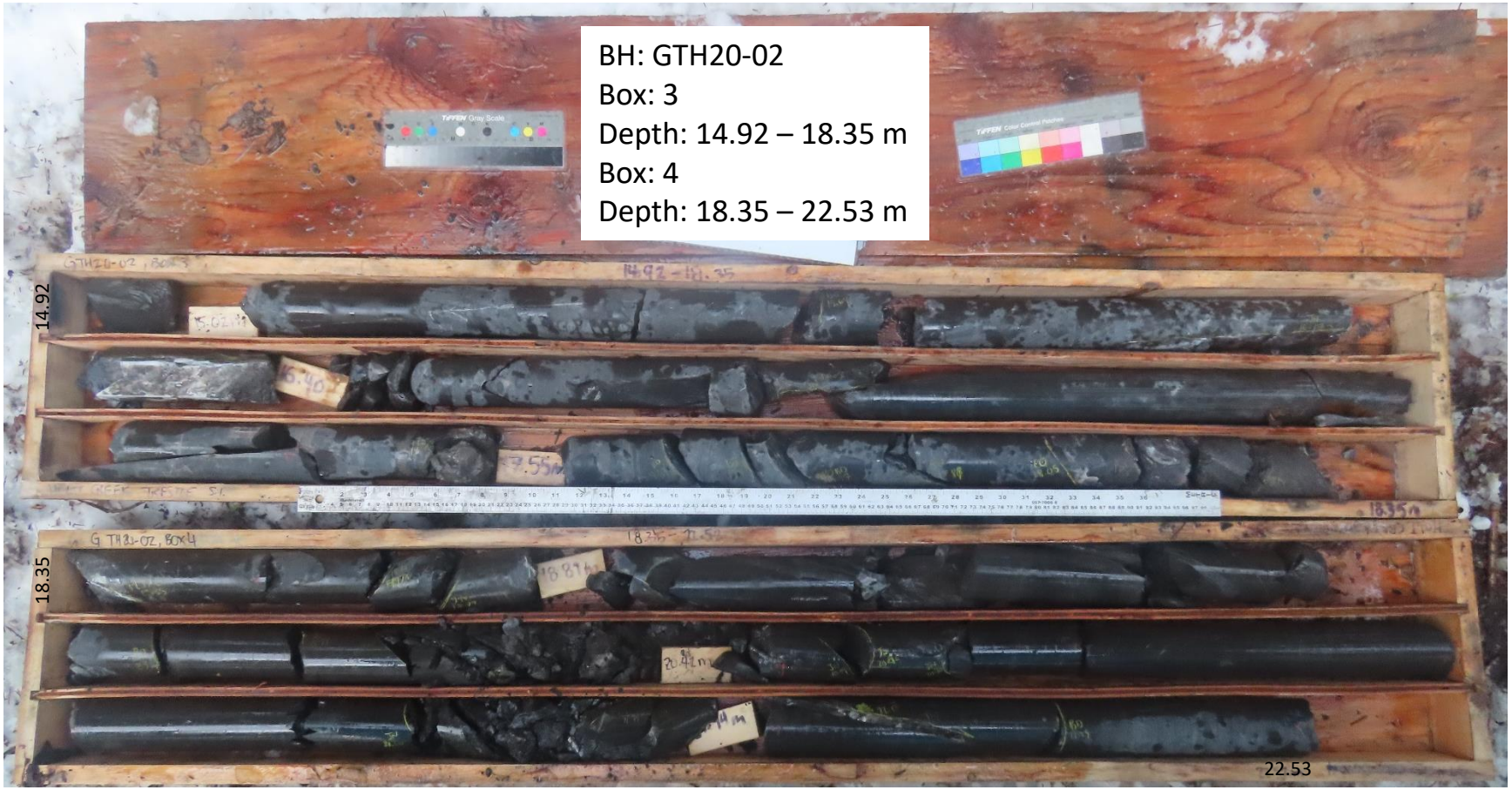


Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 14.92 m – 22.53 m, Dry

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 14.92 m – 22.53 m, Wet

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 22.53 m – 29.99 m (EOH), Dry

Photo Taken: January 10, 2020

Description: Borehole GTH20-02, 22.53 m – 29.99 m (EOH), Wet

SUMMARY LOG

Drill Hole #: **BH23-01**

Ministry of Transportation and Infrastructure

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC

Prepared by:
Logged by: JL Reviewed by:

Datum: UTM Zone 10 Alignment:
Northing/Easting: 5400743 , 441178 Station/Offset:
Elevation: 103.0 m *Coordinates taken with GPS May 31, 2023*

Date(s) Drilled: May 30, 23
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400 / SPT "N" (BLOWS/300 mm) / Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	ELEVATION (m)
0							**SAND AND GRAVEL (FILL)**, fine to coarse, subangular to subrounded, trace fines, trace organics, well graded, brown, non-cohesive, damp, loose			
		4		G1					**Sieve** (Sa#G1) G:54% S:42% F:4%	
1										104
									...switch to hollow stem auger	
	2 2 3 2	5.9		SPT1	25					
2										105
3							**GRAVEL**, fine to coarse, sandy, trace silt, trace organics, trace organic odour, poorly graded, brown, damp, compact			106
	7 15 9 10	3.8		LPT1	33				**Sieve** (Sa#LPT1) G:67% S:27% F:6%	
									...switch to advance casing method	
							3.7m			
4							...**SAND (SP)**, fine with some coarse, gravelly (fine to coarse, subangular to subrounded), trace silt, trace clay, no odour, plastic fines, moist to wet, very dense			107
	4.3m									
	50			LPT2	83					
5										

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 16.7 m
Depth to Top of Rock: 6.4 m

MOTI-SOIL-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

Ministry of Transportation and Infrastructure

SUMMARY LOG

Drill Hole #: **BH23-01**

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400743 , 441178
Elevation: 103.0 m
Alignment:
Station/Offset:
Coordinates taken with GPS May 31, 2023

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: May 30, 23
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400 / SPT "N" (BLOWS/300 mm) / Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING — Drillers Estimate {G % S % F %}	ELEVATION (m)
5							...**SAND (SP)**, fine with some coarse, gravelly (fine to coarse, subangular to subrounded), trace silt, trace clay, no odour, plastic fines, moist to wet, very dense *(continued)*			
	SPT 33 50	▲	SPT	SPT2	100				...casing set at 5.7 m for coring	
6										109
							6.4m			
							BEDROCK, highly friable, brownish grey with oxidation mottling			
7										110
8										111
9										112
10										

Legend Sample Type:
A-Auger; **B**-Becker; **C**-Core; **G**-Grab; **V**-Vane; **L#**-Lab Sample; **S**-Split Spoon; **O**-Odex (air rotary); **W**-Wash (mud return); **T**-Shelby Tube

Final Depth of Hole: 16.7 m
Depth to Top of Rock: 6.4 m

MOTI-SOIL-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

ROCK CORE LOG

Drill Hole #: **BH23-01**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400743 , 441178
Elevation: 103.00 m
Alignment:
Station/Offset:
Coordinates taken with GPS May 31, 2023

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: May 30, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

DEPTH (m)	DRILLING DETAILS (RECOVERY % / RQD % 20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
5														
6									**START OF ROCK CORE AT 6.4m**					109
7		2	Fair		R2-R3	F	3.19		MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins		1	JN; IR; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 2.0; Ja 1; Jn 6; Dips Aplha 36 JN; PL; SM; Spacing 60mm - 0.2m; Infill Br; Thickness 1 - 10cm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 47 JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 0.75; Jn 6; Dips Aplha 62 JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 0.75; Jn 6; Dips Aplha 64 JN; IR; RO; Spacing 60mm - 0.2m; Infill Br; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 70		110
8		3	Excellent		R2	F						JN; ST; RO; Spacing 60mm - 0.2m; Thickness 0.5 - 2.5mm; Jr 3.0; Jn 6; Dips Aplha 42		111
9		4	Fair		R2	F					1	JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 0.75; Jn 6; Dips Aplha 89 JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 0.75; Jn 6; Dips Aplha 47 JN; IR; RO; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 69 JN; IR; RO; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 45 JN; IR; VR; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 75		112
10		5	Excellent		R2	F	2.94				1	JN; IR; VR; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 88 JN; IR; RO; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 69		

Discontinuity Spacing: No. of fractures/m

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Final Depth of Hole: 16.7 m
Depth to Top of Rock: 6.4 m

ROCK CORE LOG

Drill Hole #: **BH23-01**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400743 , 441178
Elevation: 103.00 m
Alignment:
Station/Offset:
Coordinates taken with GPS May 31, 2023

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: May 30, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

DEPTH (m)	DRILLING DETAILS	RECOVERY % / RQD % (20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
10										MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins *(continued)*			JN; PL; RO; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.5; Ja 0.75; Jn 6; Dips Aplha 79		
													JN; PL; RO; Spacing 60mm - 0.2m; Infill Cl; Thickness 0.025 - 0.5mm; Jr 1.5; Ja 4; Jn 6; Dips Aplha 30		
			6	Excellent		R2	F	2.14				5 1	JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 0.75; Jn 6; Dips Aplha 30		
11													JN; PL; K; Spacing 60mm - 0.2m; Infill Br; Thickness 0.5 - 2.5mm; Jr 0.5; Ja 0.75; Jn 6; Dips Aplha 45		114
											BR				
12															115
			7	Excellent		R2	F	3.8							
13															116
													JN; IR; RO; Spacing 0.2m - 0.6m; Infill Br; Thickness 0.5 - 2.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 74		
													BD; IR; K; Spacing 0.2m - 0.6m; Thickness 0.025 - 0.5mm; Jr 1.5; Ja 0.75; Jn 6; Dips Aplha 74		
14			8	Excellent		R2	F	5.36				1			117
15															

Discontinuity Spacing: No. of fractures/m

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Final Depth of Hole: 16.7 m
Depth to Top of Rock: 6.4 m

ROCK CORE LOG

Drill Hole #: **BH23-01**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400743 , 441178
Elevation: 103.00 m
Alignment:
Station/Offset:
Coordinates taken with GPS May 31, 2023

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: May 30, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

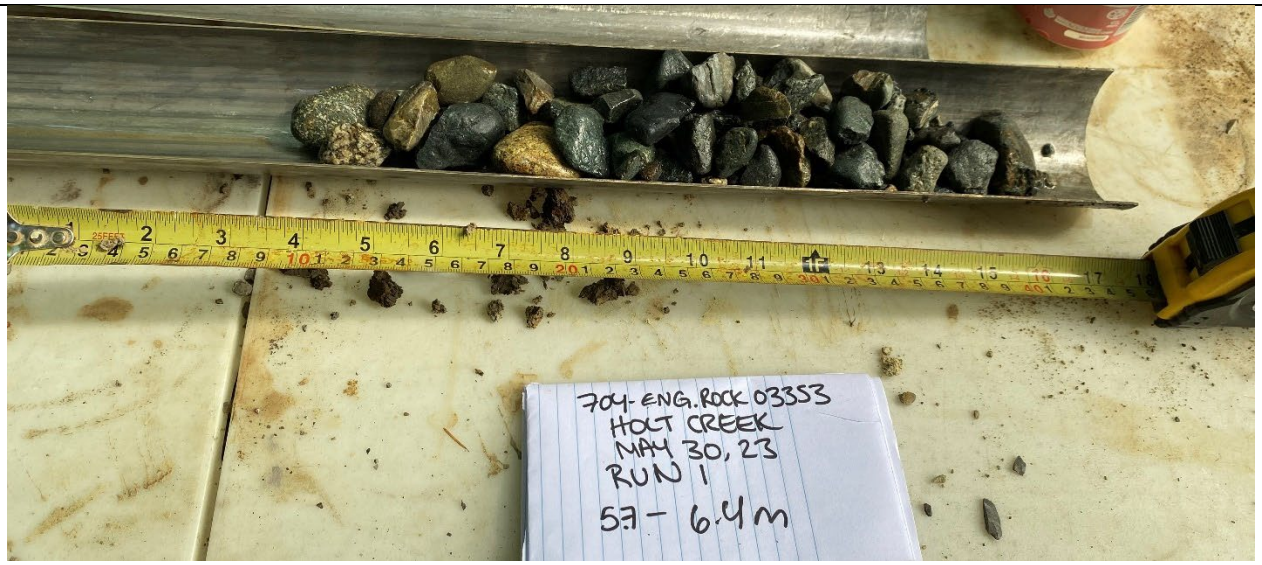
DEPTH (m)	DRILLING DETAILS	RECOVERY % / RQD % (20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
15			9	Good		R2	F	0.88		MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins *(continued)*		1	BD; IR; RO; Spacing 0.2m - 0.6m; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 79 JN; IR; RO; Spacing 0.2m - 0.6m; Thickness 0.025 - 0.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 75 JN; IR; RO; Spacing 0.2m - 0.6m; Thickness 0.5 - 2.5mm; Jr 3.0; Ja 0.75; Jn 6; Dips Aplha 85		
16															119
			10	Excellent		R2	F			16.7m					
17															120
18															121
19															122
20															

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Discontinuity Spacing: No. of fractures/m

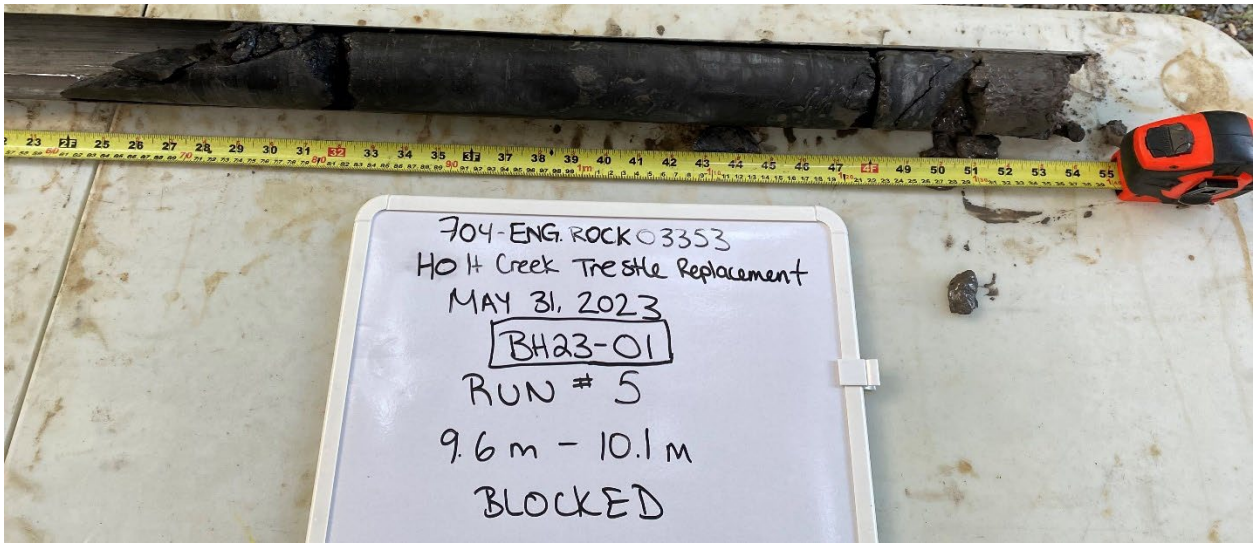
Final Depth of Hole: 16.7 m
Depth to Top of Rock: 6.4 m



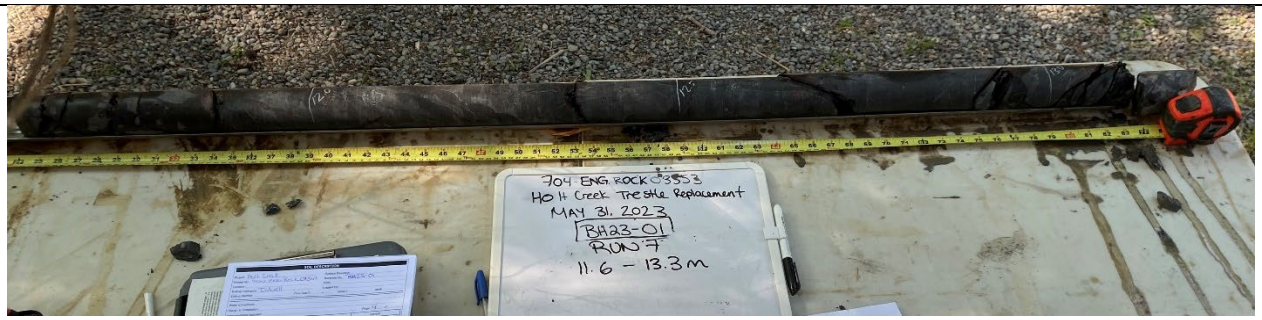
BH23-01 Rock Core 5.7 m to 6.4 m

BH23-01 Rock Core 6.4 m to 7.9 m

BH23-01 Rock Core 8.2 m to 9.6 m



BH23-01 Rock Core 9.6 m to 10.1 m



BH23-01 Rock Core 11.6 m to 13.3 m

BH23-01 Rock Core 13.3 m to 14.8 m

BH23-01 Rock Core 14.8 m to 16.3 m

SUMMARY LOG

Ministry of Transportation and Infrastructure — British Columbia

Drill Hole #: BH23-02

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC

Date(s) Drilled: May 31, 23
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/advance casing/core

Prepared by:
Logged by: JL Reviewed by:

Datum: UTM Zone 10 Alignment:
Northing/Easting: 5400763 , 441092 Station/Offset:
Elevation: 106.0 m *Coordinates taken with GPS June 2, 2023*

DEPTH (m)	DRILLING DETAILS (SPT)	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400	SPT "N" (BLOWS/300 mm) Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	ELEVATION (m)
0								**SAND and GRAVEL(FILL)**, fine with some coarse, subangular to subrounded, some fines, brown with some oxidation, trace organics, slight organic odour, non-cohesive, damp, loose			
		7.4			G1						
1											107
	2 2 3 2	6.6			G2					**Sieve** (Sa#SPT1) G:47% S:41% F:12%	
					SPT1	0					
2											108
3	7 16 18 27	5.5			LPT1	33		…below 3.0 m, compact			109
	3.5m										
		14.7			G3			**SAND (SP)**, gravelly (fine to coarse), some silt to silty, trace clay, no odour, dark brown with trace oxidation, wet, compact		**Sieve** (Sa#G3) G:10% S:68% F:22%	
4											110
	50				SPT2	100		4.3m **BEDROCK**			
	50				SPT3	100					
5										...casing set at 4.9 m for coring	

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 14.9 m
Depth to Top of Rock: 4.6 m

ROCK CORE LOG

Drill Hole #: **BH23-02**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10 Alignment:
Northing/Easting: 5400763 , 441092 Station/Offset:
Elevation: 106.00 m *Coordinates taken with GPS June 2, 2023*

Date(s) Drilled: May 31, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/advance casing/core

Prepared by:
Logged by: JL Reviewed by:

DEPTH (m)	DRILLING DETAILS	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
3	RECOVERY % / RQD % (20 40 60 80)													
	Water-3.5m													
4									**START OF ROCK CORE AT 4.6m**					110
5		1	Very Poor		R2	F			MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins			JN; IR; VR; Spacing <20mm; Infill Br; Thickness 10 - 100cm; Jr 3.0; Ja 8; Jn 6; Dips Aplha 43 JN; IR; K; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 45		111
		2	Fair		R2	F	4.61					JN; PL; SM; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 2.0; Ja 1; Jn 6; Dips Aplha 62 JN; PL; K; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 67 JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.5 - 2.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 55 JN; IR; RO; Spacing 60mm - 0.2m; Thickness >10mm; Jr 3.0; Ja 1; Jn 6; Dips Aplha 38		
6		3	Poor		R2	F						JN; IR; K; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 58 JN; IR; K; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 33 JN; IR; K; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 53 JN; PL; K; Spacing 60mm - 0.2m; Thickness >10mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 43 JN; IR; K; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 38		112
7		4	Good		R2	F						JN; PL; K; Spacing 60mm - 0.2m; Thickness 10 - 100cm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 45 JN; PL; K; Spacing 0.2m - 0.6m; Thickness >10mm; Jr 0.5; Ja 1; Jn 6; MECH; K; Spacing 0.2m - 0.6m;		113
8														

MOTI-ROCK-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

Discontinuity Spacing:
No. of fractures/m

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Final Depth of Hole: 14.9 m
Depth to Top of Rock: 4.6 m

ROCK CORE LOG

Drill Hole #: **BH23-02**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400763 , 441092
Elevation: 106.00 m
Alignment:
Station/Offset:
Coordinates taken with GPS June 2, 2023

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: May 31, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/advance casing/core

DEPTH (m)	DRILLING DETAILS (RECOVERY % / RQD % 20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
8									MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins *(continued)*			Thickness <0.1mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 29		
												MECH; PL; K; Spacing 0.2m - 0.6m; Thickness <0.1mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 28		
												MECH; PL; K; Spacing 0.2m - 0.6m; Thickness <0.1mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 30		
												MECH; PL; K; Spacing 20mm - 60mm; Thickness <0.1mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 90		
9												MECH; PL; K; Spacing 20mm - 60mm; Thickness <0.1mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 30		115
		5	Good		R2	F	1.99					MECH; PL; K; Spacing 20mm - 60mm; Thickness <0.1mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 35		
												MECH; PL; K; Spacing 0.2m - 0.6m; Thickness <0.1mm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 28		
										BR				
10														116
												BD; PL; SM; Spacing 0.2m - 0.6m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 30		
												BD; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 20		
												BD; PL; SM; Spacing 60mm - 0.2m; Thickness 0.5 - 2.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 33		
												JN; PL; PO; Spacing 60mm - 0.2m; Thickness 0.5 - 2.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 82		
11		6	Fair		R2	F	5.18					JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.1 - 0.25mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 73		117
												JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.5 - 2.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 65		
												JN; PL; SM; Spacing 60mm - 0.2m; Thickness >10mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 63		
												JN; PL; SM; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 59		
12												JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 45		118
		7	Excellent		R2	F	5.7					JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 75		
												JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 72		
13												JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 59		

Discontinuity Spacing:
No. of fractures/m

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Final Depth of Hole: 14.9 m
Depth to Top of Rock: 4.6 m

ROCK CORE LOG

Ministry of Transportation and Infrastructure — British Columbia

Drill Hole #: BH23-02

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10 — Alignment:
Northing/Easting: 5400763 , 441092 — Station/Offset:
Elevation: 106.00 m — *Coordinates taken with GPS June 2, 2023*

Date(s) Drilled: May 31, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/advance casing/core

Prepared by:
Logged by: JL Reviewed by:

DEPTH (m)	DRILLING DETAILS	RECOVERY % / RQD % (20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
13										MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins *(continued)*			JN; IR; RO; Spacing 60mm - 0.2m; Thickness 1 - 10cm; Jr 3.0; Ja 1; Jn 6; Dips Aplha 42 JN; IR; RO; Spacing 60mm - 0.2m; Thickness >10mm; Jr 3.0; Ja 1; Jn 6; Dips Aplha 45 JN; ST; RO; Spacing 60mm - 0.2m; Thickness 0.5 - 2.5mm; Jr 3.0; Ja 1; Jn 6; Dips Aplha 70 JN; PL; RO; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 1.5; Ja 1; Jn 6; Dips Aplha 68		
14			8	Poor		R2	F						JN; C; SM; Spacing 0.2m - 0.6m; Thickness 0.025 - 0.5mm; Jr 2.0; Ja 1; Jn 6; Dips Aplha 30 JN; PL; K; Spacing 0.2m - 0.6m; Thickness 1 - 10cm; Jr 0.5; Ja 1; Jn 6; Dips Aplha 40 JN; IR; RO; Spacing 60mm - 0.2m; Thickness >10mm; Jr 1.5; Ja 1; Jn 6; Dips Aplha 30 FLT; Cu; VR; Spacing 60mm - 0.2m; Thickness 1 - 10cm; Jr 3.0; Ja 1; Jn 6; Dips Aplha 20		120
			9	Excellent		R2	F	7.78		14.9m			FLT; IR; VR; Spacing 60mm - 0.2m; Thickness >10mm; Jr 3.0; Ja 1; Jn 6;		
15													JN; IR; RO; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 3.0; Ja 1; Jn 6; Dips Aplha 65 JN; PL; SM; Spacing 60mm - 0.2m; Thickness 0.025 - 0.5mm; Jr 1.0; Ja 1; Jn 6; Dips Aplha 76 JN; IR; RO; Spacing 60mm - 0.2m; Thickness 2.5mm - 10mm; Jr 3.0; Ja 1; Jn 6; Dips Aplha 83		121
16															122
17															123
18															

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

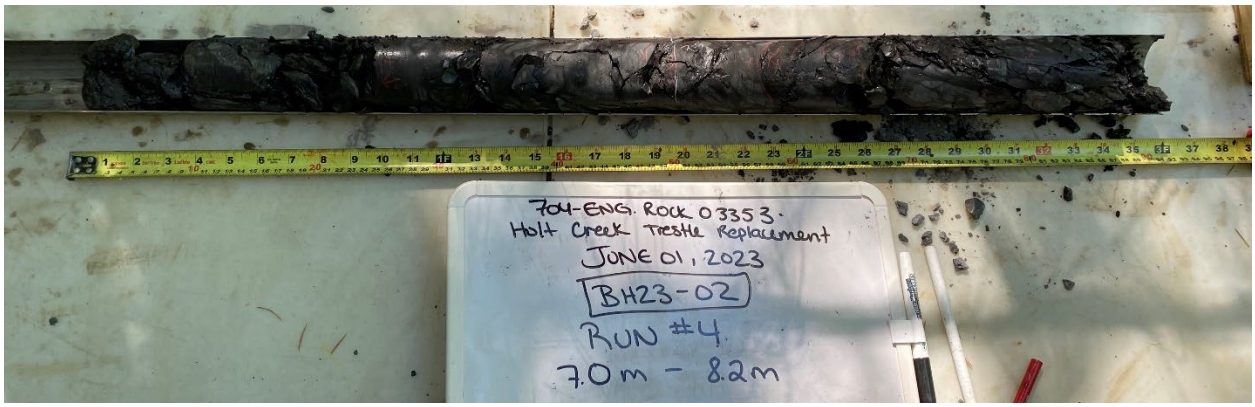
Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Discontinuity Spacing: No. of fractures/m

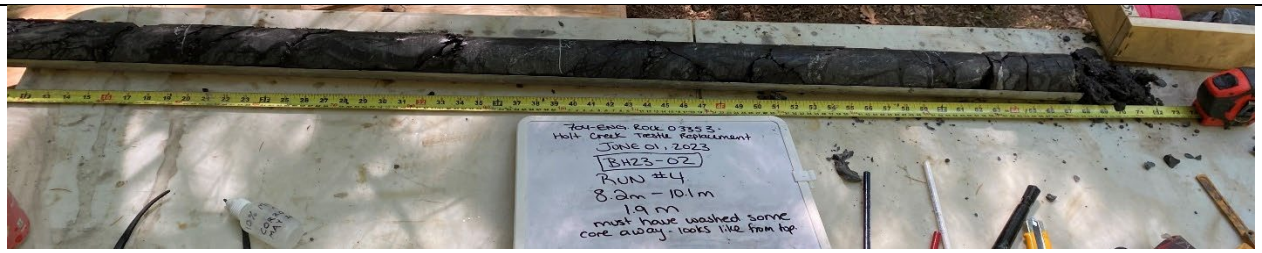
Final Depth of Hole: 14.9 m
Depth to Top of Rock: 4.6 m

BH23-02 Rock Core 5.2 m to 6.2 m

BH23-02 Rock Core 6.2 m to 7.0 m



BH23-02 Rock Core 7.0 m to 8.2 m



BH23-02 Rock Core 8.2 m to 10.1 m

BH23-02 Rock Core 10.1 m to 11.6 m

BH23-02 Rock Core 11.6 m to 13.1 m

BH23-02 Rock Core 13.2 m to 14.2 m

SUMMARY LOG

Drill Hole #: **BH23-03**

Ministry of Transportation and Infrastructure — BRITISH COLUMBIA

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC

Prepared by:
Logged by: JL Reviewed by:

Datum: UTM Zone 10 Alignment:
Northing/Easting: 5400727 , 441185 Station/Offset:
Elevation: 98.0 m *Coordinates taken with GPS May 30, 2023*

Date(s) Drilled: May 29, 03
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Advance Casing/Core

DEPTH (m)	DRILLING DETAILS	SPT	Pocket Penetrometer (kPa) / Shear Strength (kPa) 100 200 300 400 — SPT "N" (BLOWS/300 mm) — Wp% W% WL% 20 40 60 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING — Drillers Estimate {G % S % F %}	ELEVATION (m)
0								**GRAVEL (FILL)**, fine to coarse, sandy to and sand, trace fines, brown, non-cohesive, damp, very loose			
1		1 1 2 1	▲		SPT1	0					99
2		1 2 1 2	▲		SPT2	17					100
3		14 5 3 4	▲		SPT3	8					101
4		5 7 9 11	▲		SPT4	0					102
	4.3m ▼							4.3m			
5		53 50	10.3 ● ▲		LPT1	66		**GRAVEL and SAND**, fine to coarse, subangular to subrounded, some silt, brown with oxidation mottling, non-cohesive, wet, very dense		**Sieve** (Sa#LPT1) G:45% S:40% F:15% ...casing set at 4.9 m for coring	

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 9.1 m
Depth to Top of Rock: 5.3 m

MOTI-SOIL-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

Ministry of Transportation and Infrastructure

SUMMARY LOG

Drill Hole #: **BH23-03**

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400727 , 441185
Elevation: 98.0 m
Coordinates taken with GPS May 30, 2023

Prepared by:
Logged by: JL Reviewed by:

Alignment:
Station/Offset:

Date(s) Drilled: May 29, 03
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Advance Casing/Core

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400 ; SPT "N" (BLOWS/300 mm) ; Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	ELEVATION (m)
5	SPT 50			SPT5	0					
							BEDROCK 5.3m			
6										104
7										105
8										106
9							9.1m			107
10										

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 9.1 m
Depth to Top of Rock: 5.3 m

MOTI-SOIL-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

ROCK CORE LOG

Drill Hole #: **BH23-03**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10 — Alignment:
Northing/Easting: 5400727 , 441185 — Station/Offset:
Elevation: 98.00 m — *Coordinates taken with GPS May 30, 2023*

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: May 29, 03
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Advance Casing/Core

DEPTH (m)	DRILLING DETAILS	RECOVERY % / RQD % (20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
4	Water-4.3m														
5										**START OF ROCK CORE AT 5.3m**					103
6			1				SW			MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins		1	JN; IR; SM; Jr 3.0; Ja 4; Jn 20; Dips Aplha 40 JN; IR; SM; Jr 3.0; Ja 5; Jn 2; Dips Aplha 27 JN; IR; RO; Jr 3.0; Ja 5; Jn 20; Dips Aplha 33 JN; PL; RO; Jr 1.5; Ja 5; Jn 20; JN; IR; RO; Jr 1.0; Ja 5; Jn 20;		104
7			2				F	3.46			BR	12 1 2 12 1	JN; IR; RO; Dips Aplha 90 JN; IR; SM; Jr 1.5; Jn 2; Dips Aplha 60 JN; PL; RO; Jr 1.0; Jn 2; Dips Aplha 59 JN; PL; RO; Jr 1.5; Ja 0.75; Jn 2; Dips Aplha 38 JN; PL; RO;		105
8			3				F	3.41				1 12 1	JN; PL; RO; Jr 1.0; Jn 2; Dips Aplha 28 JN; PL; SM; Jr 2.0; Ja 5; Jn 20; Dips Aplha 46 JN; PL; RO; Dips Aplha 25		106
9															

Discontinuity Spacing: No. of fractures/m

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Final Depth of Hole: 9.1 m
Depth to Top of Rock: 5.3 m

ROCK CORE LOG

Drill Hole #: **BH23-03**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**

Location: Duncan, BC

Prepared by:

Logged by: JL Reviewed by:

Datum: UTM Zone 10 Alignment:

Northing/Easting: 5400727 , 441185 Station/Offset:

Elevation: 98.00 m *Coordinates taken with GPS May 30, 2023*

Date(s) Drilled: May 29, 03

Drilling Company: Drillwell

Driller:

Drill Make/Model: Geoprobe 7822

Drilling Method: Advance Casing/Core

DEPTH (m)	DRILLING DETAILS	RECOVERY % / RQD % (20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
9										9.1m			JN; PL; RO; Dips Aplha 25		
10															108
11															109
12															110
13															111
14															

Discontinuity Spacing:
No. of fractures/m

Rock Strength (MPa)

R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering

F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Final Depth of Hole: 9.1 m
Depth to Top of Rock: 5.3 m

MOTI-ROCK-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

BH23-03 Rock Core 4.9 m to 6.4 m

BH23-03 Rock Core 6.4 m to 7.9 m

BH23-03 Rock Core 7.9 m to 9.1 m

SUMMARY LOG

Drill Hole #: **BH23-04**

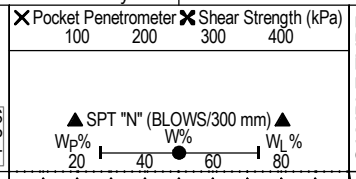
BRITISH COLUMBIA — Ministry of Transportation and Infrastructure

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400762 , 441082
Elevation: 102.0 m
Coordinates taken with GPS June 2, 2023

Alignment:
Station/Offset:

Date(s) Drilled: June 01, 23
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

Prepared by:
Logged by: JL Reviewed by:



DEPTH (m)	DRILLING DETAILS (SPT)	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING — Drillers Estimate {G % S % F %}	ELEVATION (m)
0	10, 11, 7, 7 (4.6)	SPT	SPT1	25		**GRAVEL and SAND (FILL)**, fine to coarse, subangular to subrounded, trace fines, trace organics (rootlets), slight organic odour, brown with trace oxidation, dry, compact			
1									103
								...switch to hollow stem auger	
	6, 12, 12, 5 (2.4)		SPT2	22					
2									104
	19, 40, 50 (8.4) ▼2.5m	>>	LPT1	10		…below 2.3 m, moist, very dense		**Sieve** (Sa#LPT1) G:44% S:41% F:15%	
	50		SPT3	0		2.5m — **SAND**, coarse with some fine, gravelly (coase with some fine), silty, trace clay, trace organic odour, tan with heavy oxidation, wet, very dense			
3						3.4m		...casing set at 3.4 m for coring	105
4									106
5									

Legend Sample Type:
A-Auger; **B**-Becker; **C**-Core; **G**-Grab; **V**-Vane; **L#**-Lab Sample; **S**-Split Spoon; **O**-Odex (air rotary); **W**-Wash (mud return); **T**-Shelby Tube

Final Depth of Hole: 8.5 m
Depth to Top of Rock: 5.5 m

MOTI-SOIL-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

ROCK CORE LOG

Drill Hole #: **BH23-04**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10 — Alignment:
Northing/Easting: 5400762 , 441082 — Station/Offset:
Elevation: 102.00 m — *Coordinates taken with GPS June 2, 2023*

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: June 01, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

DEPTH (m)	DRILLING DETAILS (RECOVERY % / RQD %, 20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	ELEVATION (m)
4													
5									**START OF ROCK CORE AT 5.5m**				107
6		4				F	3.58		MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins		2 1 3 1	JN; IR; RO; Jr 2.0; Ja 5; Jn 2; Dips Aplha 27 JN; IR; RO; Jr 2.0; Ja 5; Jn 2; Dips Aplha 65 JN; IR; RO; Jr 1.5; Jn 2; Dips Aplha 74 JN; IR; RO; Jr 3; Jn 2; Dips Aplha 56 JN; IR; RO; Jr 3; Ja 5; Jn 2; Dips Aplha 69 JN; IR; RO; Jr 1.5; Ja 4; Jn 1; Dips Aplha 74	108
7		5				F	5.16			BR	10 1 10 1	JN; IR; SM; Jr 1; Jn 2; Dips Aplha 78 JN; IR; VR; Jr 3; Jn 2; Dips Aplha 82 JN; IR; VR; Jr 3; Jn 2; Dips Aplha 85 JN; IR; VR; Jr 2; Jn 2; Dips Aplha 63 BD; PL; K; Jr 3; Jn 2; Dips Aplha 25 BD; IR; K; Jr 1; Ja 5; Jn 2; Dips Aplha 23 JN; PL; SM; Jr 1; Ja 5; Jn 2; Dips Aplha 55 JN; PL; SM; Jr 1; Jn 1; Dips Aplha 45 JN; IR; RO; Jr 2; Ja 1; Jn 2; Dips Aplha 60	109
8		6				F			8.5m			JN; IR; VS; Jr 3; Ja 4; Jn 1; Dips Aplha 69 JN; IR; SM; Jr 3; Ja 5; Jn 2; Dips Aplha 65 JN; IR; SM; Jr 3; Ja 5; Jn 2; Dips Aplha 30	110
9													

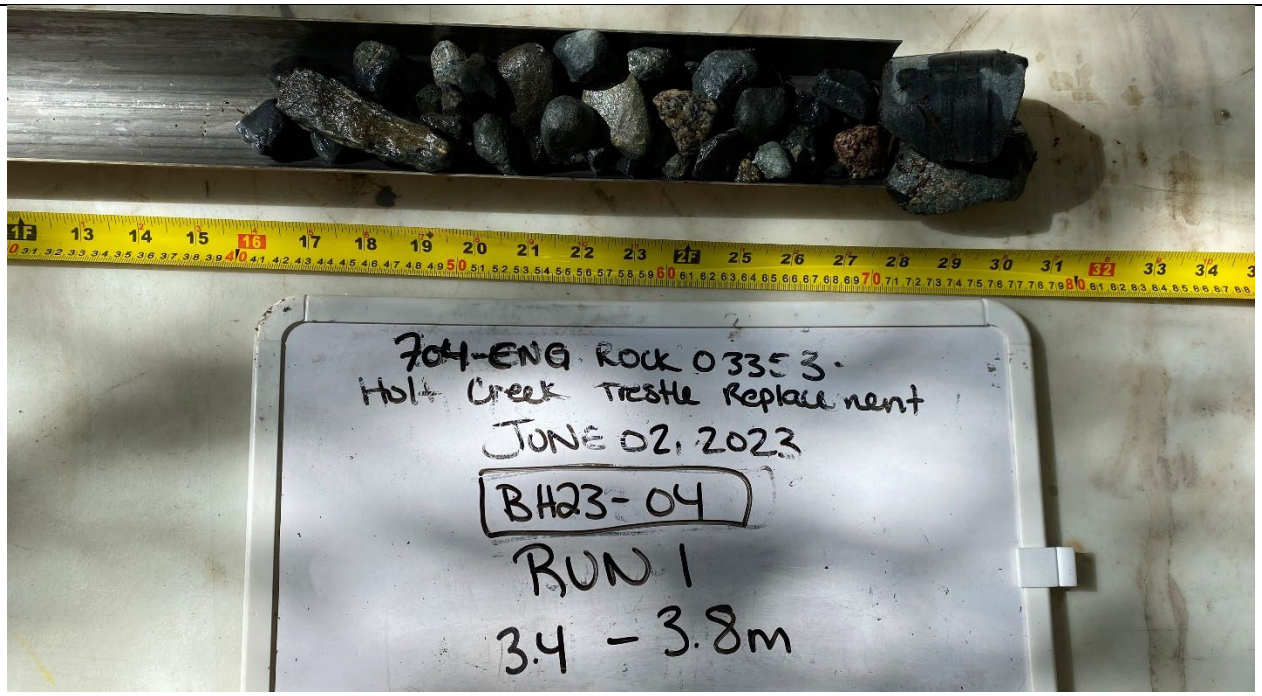
Discontinuity Spacing: No. of fractures/m

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

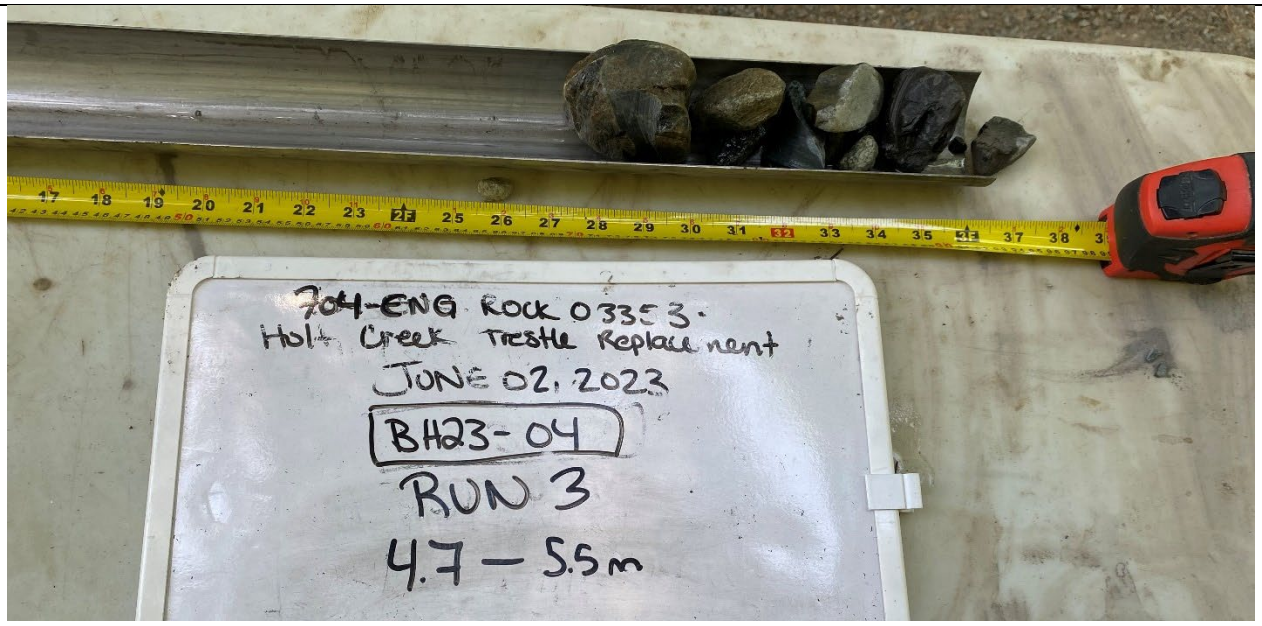
Final Depth of Hole: 8.5 m
Depth to Top of Rock: 5.5 m

MOTI-ROCK-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

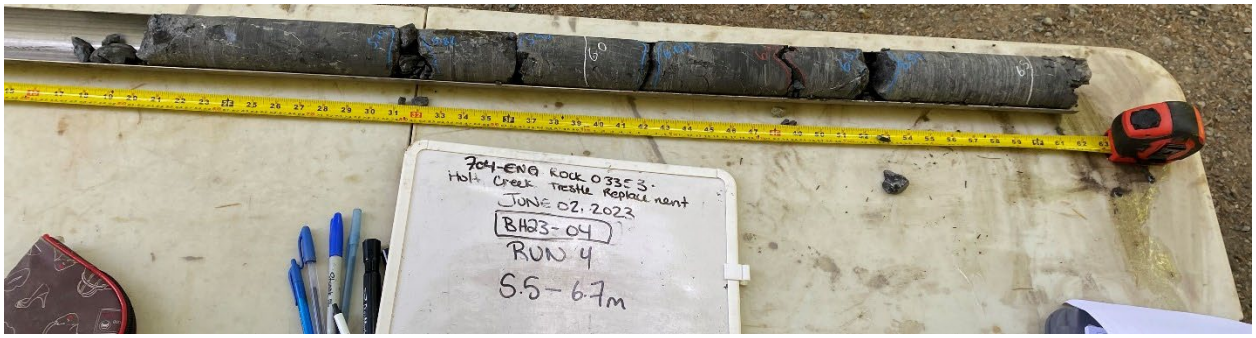


BH23-04 Rock Core 3.4 m to 3.8 m

BH23-04 Rock Core 3.8 m to 4.1 m

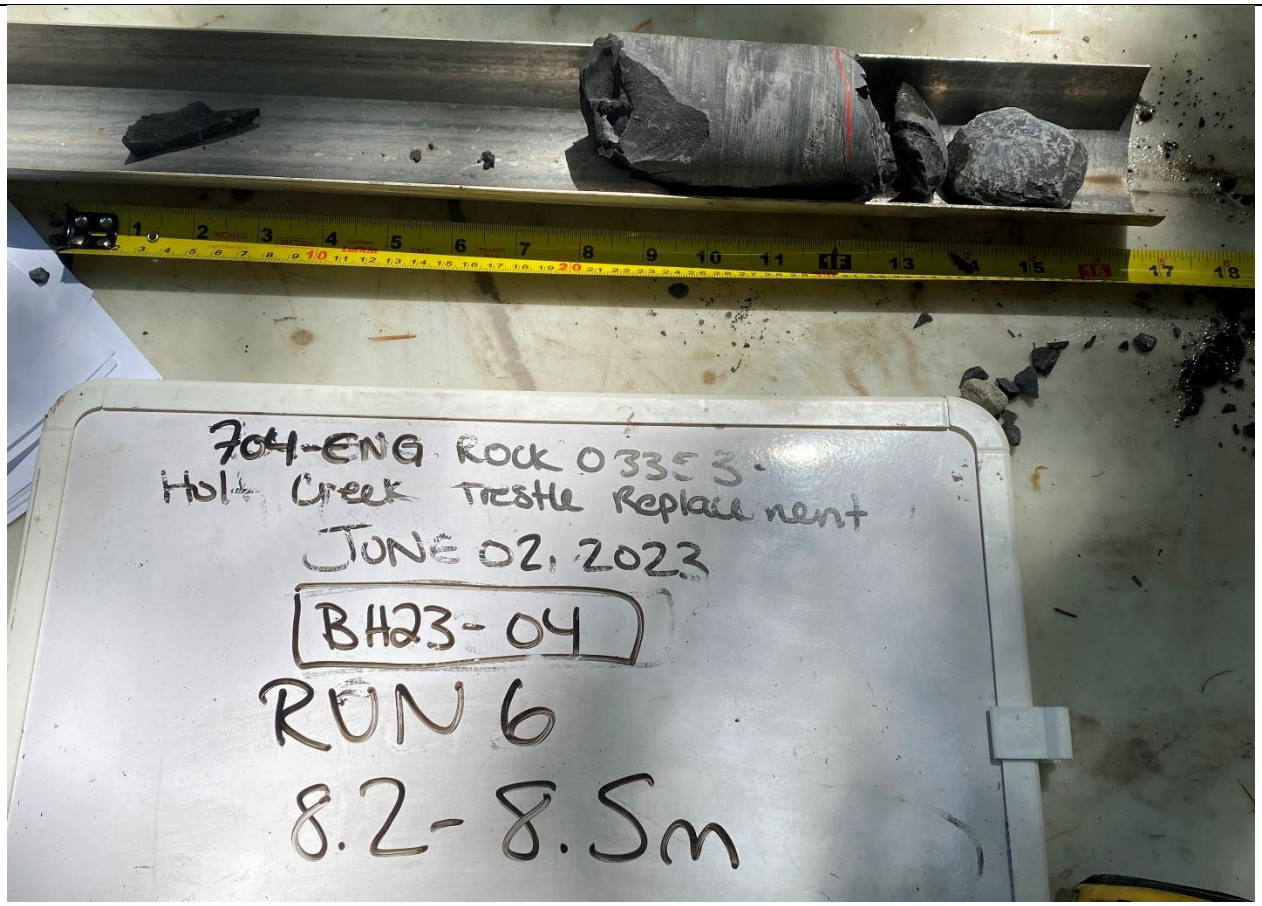


BH23-04 Rock Core 4.7 m to 5.5 m



BH23-04 Rock Core 5.5 m to 6.7 m

BH23-04 Rock Core 6.7 m to 8.2 m



BH23-04 Rock Core 8.2 m to 8.5 m

SUMMARY LOG

Drill Hole #: **BH23-05**

Ministry of Transportation and Infrastructure

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400733 , 441221
Elevation: 100.0 m
Alignment:
Station/Offset:
Coordinates taken with GPS May 29, 2023

Prepared by:
Logged by: JL Reviewed by:

Date(s) Drilled: May 29, 23
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

DEPTH (m)	DRILLING DETAILS	SPT	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400 / SPT "N" (BLOWS/300 mm) / Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	ELEVATION (m)
0								**SAND and GRAVEL (FILL)**, subrounded to rounded, fine to coarse, trace fines, damp, brown, very loose to loose			
1											101
		3 2 2 4	5.9		SPT1	25				...at 1.5 m, switched to hollow stem auger	
2											102
3		2 2 1 1	5		SPT2	33		...below 3.0 m, poorly graded, moist, trace organics		**Sieve** (Sa#SPT2) G:47% S:48% F:5%	103
	3.4m ▼										
4											104
								4.6m			
		1 1 15 21	17.1		SPT3	25		**SAND**, fine to coarse, gravelly (fine), silty, trace to some clay, compact, brown, wet, trace organics (wood debris)		...at 4.6 m, SPT bouncing for a few blows before breaking through, Gravelly sand **Sieve** (Sa#SPT3) G:21% S:49% F:30%	
5											

Legend Sample Type:
A-Auger; B-Becker; C-Core; G-Grab; V-Vane; L#-Lab Sample; S-Split Spoon; O-Odex (air rotary); W-Wash (mud return); T-Shelby Tube

Final Depth of Hole: 9.0 m
Depth to Top of Rock: 5.7 m

SUMMARY LOG

Drill Hole #: **BH23-05**

Ministry of Transportation and Infrastructure

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC

Date(s) Drilled: May 29, 23
Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

Prepared by:
Logged by: JL Reviewed by:

Datum: UTM Zone 10
Northing/Easting: 5400733 , 441221
Elevation: 100.0 m

Alignment:
Station/Offset:
Coordinates taken with GPS May 29, 2023

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400	SPT "N" (BLOWS/300 mm) Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	ELEVATION (m)
5								**SAND**, fine to coarse, gravelly (fine), silty, trace to some clay, compact, brown, wet, trace organics (wood debris) *(continued)*			
	SPT 43 50 2.1		▲		SPT4	75		5.6m **BEDROCK**		...casing set at 5.8 m for coring	
6											106
7											107
8											108
9											109
10											

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 9.0 m
Depth to Top of Rock: 5.7 m

MOTI-SOIL-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

ROCK CORE LOG

Drill Hole #: **BH23-05**

Ministry of Transportation and Infrastructure — British Columbia

Project: **Holt Creek Trestle Replacement**
Location: Duncan, BC
Datum: UTM Zone 10
Northing/Easting: 5400733 , 441221
Elevation: 100.00 m
Alignment:
Station/Offset:
Coordinates taken with GPS May 29, 2023

Date(s) Drilled: May 29, 23
Drilling Company: Drillwell
Driller:
Drill Make/Model: Geoprobe 7822
Drilling Method: Auger/Core

Prepared by:
Logged by: JL Reviewed by:

DEPTH (m)	DRILLING DETAILS (RECOVERY % / RQD %, 20 40 60 80)	CORE RUN NO	CORE QUALITY	DISCONTINUITY SPACING	INTACT ROCK STRENGTH	WEATHERING	UCS (MPa)	ROCK SYMBOL	ROCK MASS DESCRIPTION	CLASSIFICATION	# OF JOINTS	STRUCTURAL DISCONTINUITY DESCRIPTION	INSTALLATION	ELEVATION (m)
4														
5														105
									START OF ROCK CORE AT 5.7m					
6		1				F	2.06		MUDSTONE, dark grey, weak, trace slickensides, homogenous, trace dolomitic veins		1 2 4 1	BD; UN; RO; Jr 3; Jn 2; Dips Aplha 70 BD; UN; RO; Jr 3; Jn 2; Dips Aplha 80 BD; ST; SM; Jr 3; Jn 2; Dips Aplha 70 BD; UN; SM; Jr 3; Ja 5; Jn 2; Dips Aplha 80 BD; UN; SM; Jr 3; Ja 5; Jn 2; Dips Aplha 70		106
7		2				F				BR	1 6 5	BD; UN; RO; Jr 3; Ja 5; Jn 2; Dips Aplha 85 BD; PL; SM; Jr 3; Ja 5; Jn 2; Dips Aplha 75 JN; PL; SM; Jr 3; Ja 5; Jn 2; Dips Aplha 35 JN; PL; SM; Jr 1; Ja 5; Jn 2; Dips Aplha 50 JN; UN; RO; Jr 3; Jn 2; Dips Aplha 40 JN; ST; RO; Jr 3; Ja 5; Jn 2; Dips Aplha 34 JN; UN; SM; Jr 3; Ja 5; Jn 2; Dips Aplha 40 JN; UN; RO; Jr 3; Ja 5; Jn 2; Dips Aplha 25		107
8														108
		>3				F	6.22							
9									9.0m					

Discontinuity Spacing:
No. of fractures/m

Rock Strength (MPa)
R0 Extremely Weak >1
R1 Very Weak 1-5
R2 Weak 5-25
R3 Medium Strong 25-50
R4 Strong 50-100
R5 Very Strong 100-250
R6 Extremely Strong >250

Weathering
F Fresh
SW Slightly
MW Moderately
HW Highly
CW Completely
RS Residual Soil

Final Depth of Hole: 9.0 m
Depth to Top of Rock: 5.7 m

MOTI-ROCK-REV3 HOLT CREEK TRESTLE BRIDGE.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-7-12

BH23-05 Rock Core 5.7 m to 6.5 m

BH23-05 Rock Core 6.5 m to 8.1 m

BH23-05 Rock Core 6.5 m to 8.1 m

APPENDIX C

GEOTECHNICAL LABORATORY TESTING RESULTS

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Holt Creek Trestle Replacement	Sample No.:	289
Project No.:	704-ENG.ROCK03353-02	Date Tested:	June 28, 2023
Client:	MoTI	Tested By:	EE
Project Engineer:	Chris Longley	Page:	1 of 1

B.H. Number	Sample Number Depth (m)	Moisture Content (%)	Visual Description of Soil
BH23-01	SPT1 @ 1.5 - 2.1	5.9	SAND, some gravel, trace silt, damp, black.
BH23-05	SPT1 @ 1.5 - 2.1	4.6	SAND, gravelly, trace silt, damp, brown.
BH23-05	SPT4 @ 5.5 - 5.7	2.1	GRAVEL, sandy, some silt, dry, grey.
BH23-04	SPT1 @ 0.0 - 0.6	4.6	SAND and GRAVEL, some silt, damp, brown.
BH23-04	SPT2 @ 1.5 - 2.1	2.4	GRAVEL, some sand, trace silt, dry, brown.
BH23-02	G1 @ 0.6 - 0.9	7.4	SAND, gravelly, some silt, moist, brown.
BH23-02	LPT1 @ 3.0 - 3.6	5.5	SAND and GRAVEL, some silt, trace organics, damp, brown.

Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-01

Depth: G1 @ 0.6 - 0.9 m

Soil Description: GRAVEL and SAND, trace silt, trace organics, damp, brown.

Cu: 41.7

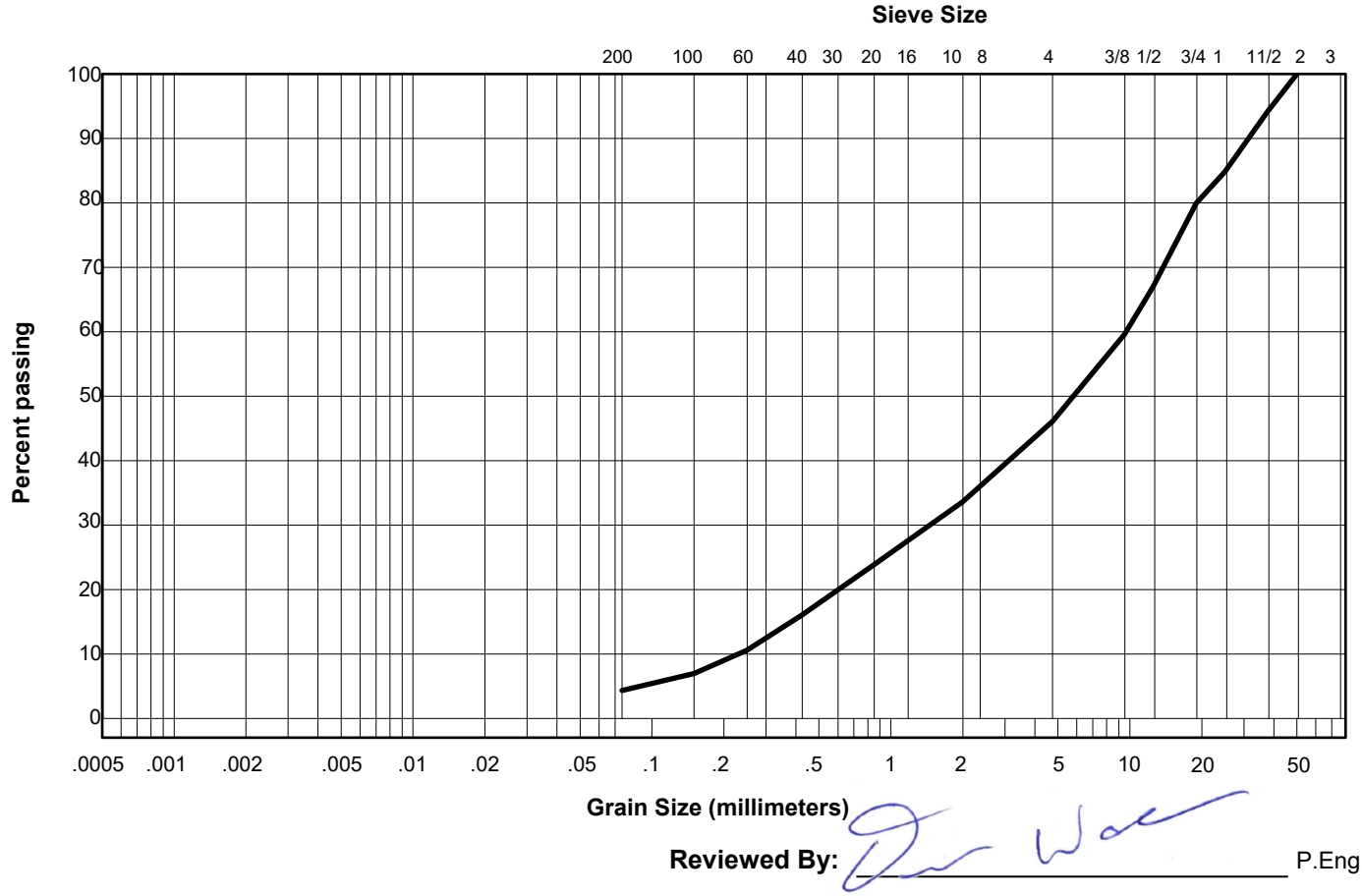
Cc: 1.0

Natural Moisture Content: 4.0%

Remarks:

Sieve Size (mm)	Percent Passing
50.000	100
37.500	94
25.000	85
19.000	80
12.500	67
9.500	60
4.750	46
2.000	34
0.850	24
0.425	16
0.250	11
0.150	7
0.075	4.4

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-01

Depth: LPT1 @ 3.1 - 3.7 m

Soil Description: GRAVEL, sandy, trace silt, damp, brown.

Cu: 82.5

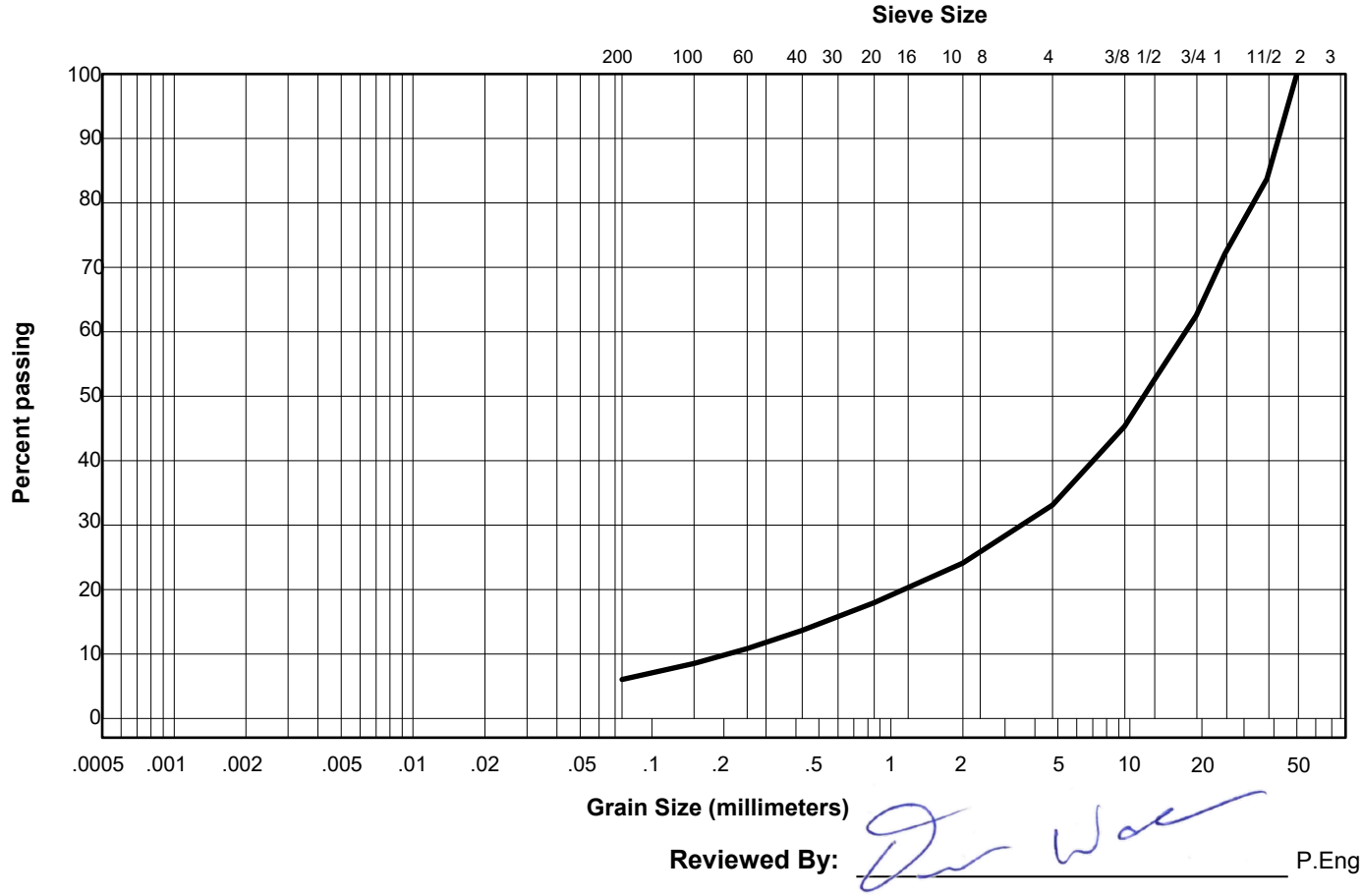
Cc: 3.5

Natural Moisture Content: 3.8%

Remarks:

Sieve Size (mm)	Percent Passing
50.000	100
37.500	84
25.000	72
19.000	62
12.500	52
9.500	45
4.750	33
2.000	24
0.850	18
0.425	14
0.250	11
0.150	9
0.075	6.0

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-05

Depth: SPT2 @ 3.0 - 3.7 m

Soil Description: SAND and GRAVEL, trace silt, damp, brown.

Cu: 29.2

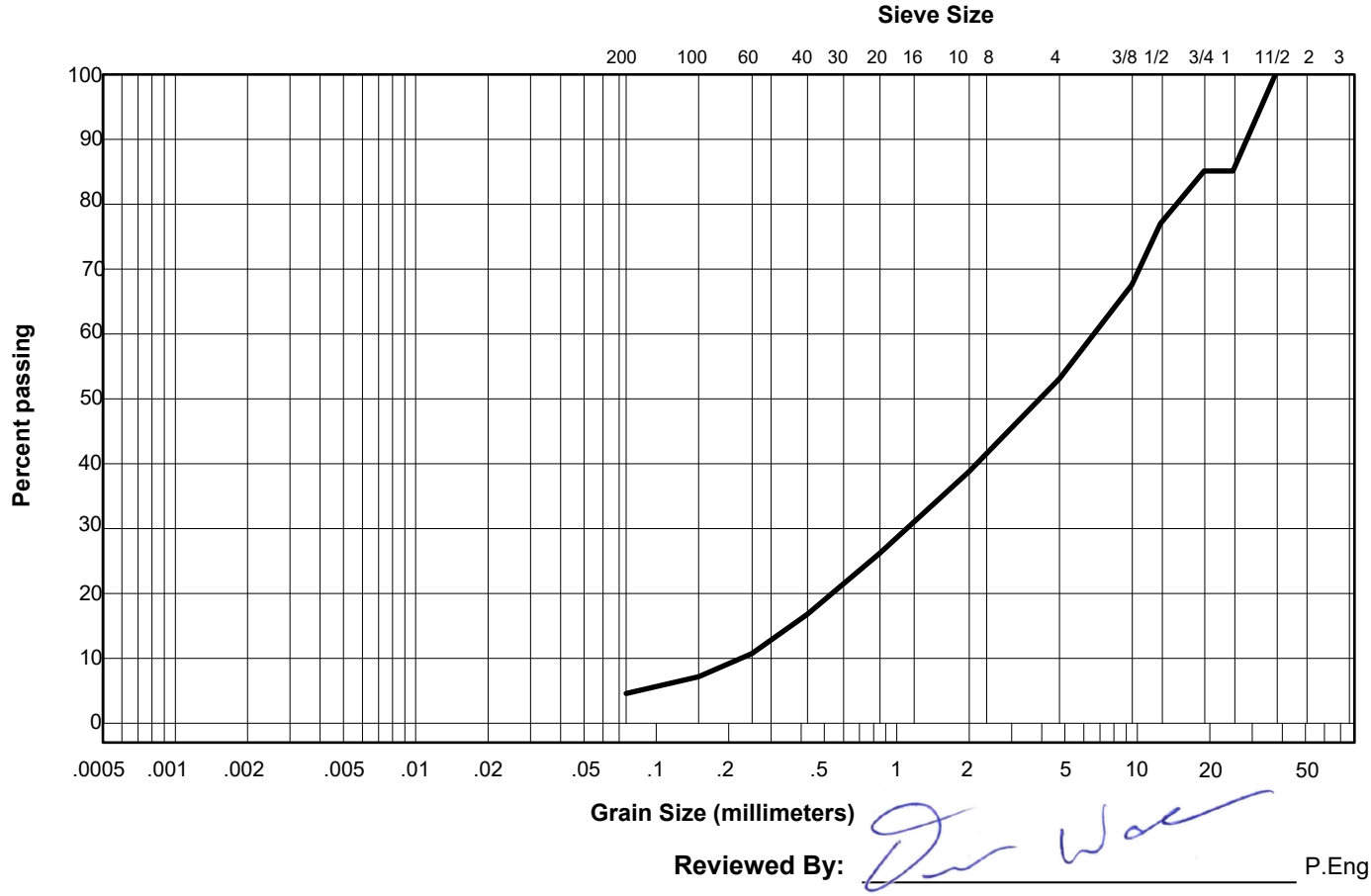
Cc: 0.8

Natural Moisture Content: 5.0%

Remarks:

Sieve Size (mm)	Percent Passing
37.500	100
25.000	85
19.000	85
12.500	77
9.500	68
4.750	53
2.000	39
0.850	26
0.425	17
0.250	11
0.150	7
0.075	4.6

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-05

Depth: SPT3 @ 4.6 - 5.2 m

Soil Description: SAND, silty, gravelly, trace organics, moist, brown.

Cu:

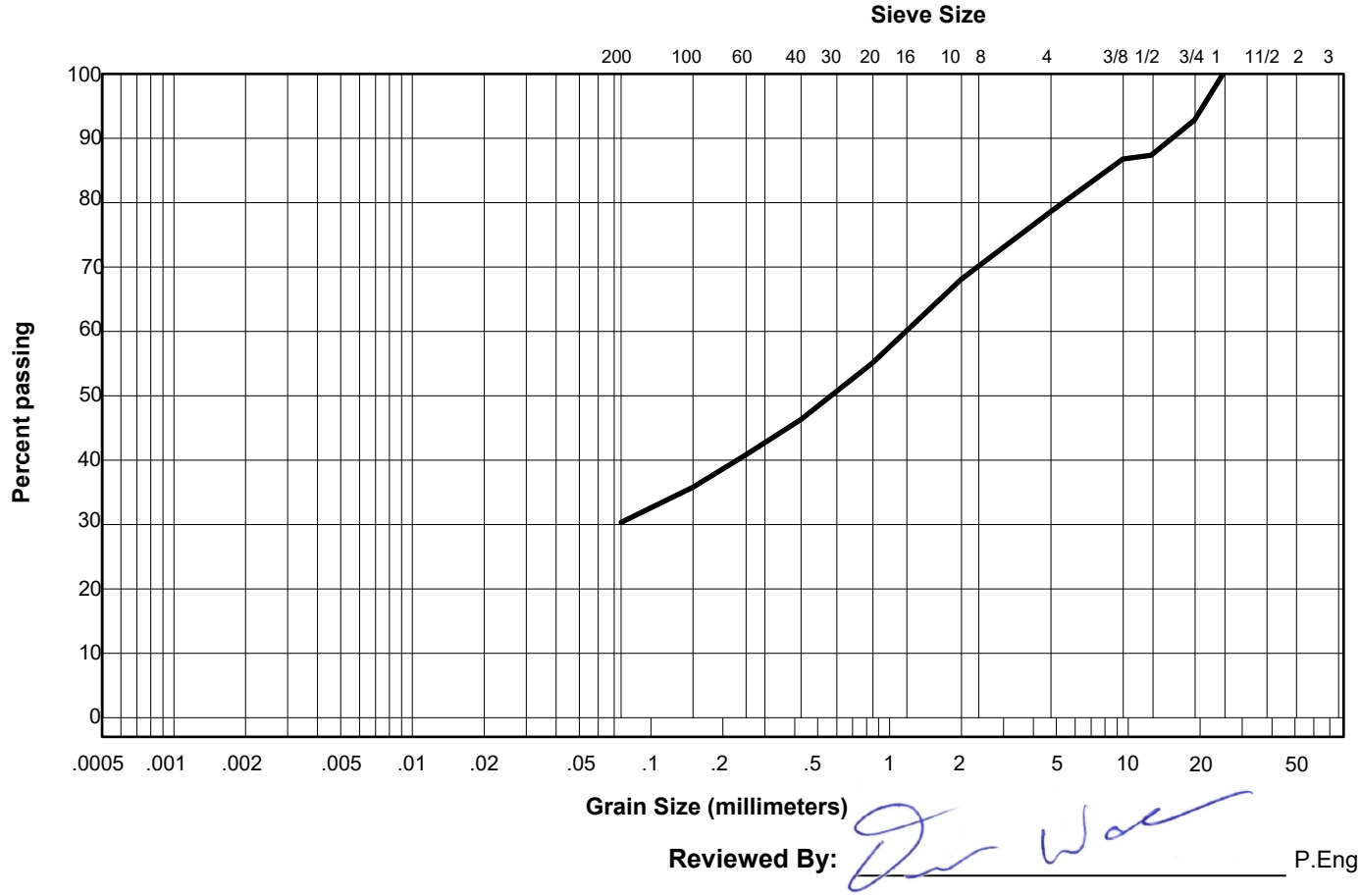
Cc:

Natural Moisture Content: 17.1%

Remarks:

Sieve Size (mm)	Percent Passing
25.000	100
19.000	93
12.500	87
9.500	87
4.750	79
2.000	68
0.850	55
0.425	46
0.250	41
0.150	36
0.075	30.3

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-02

Depth: G2 @ 1.5 - 1.7 m

Soil Description: GRAVEL and SAND, some silt, damp, brown.

Cu:

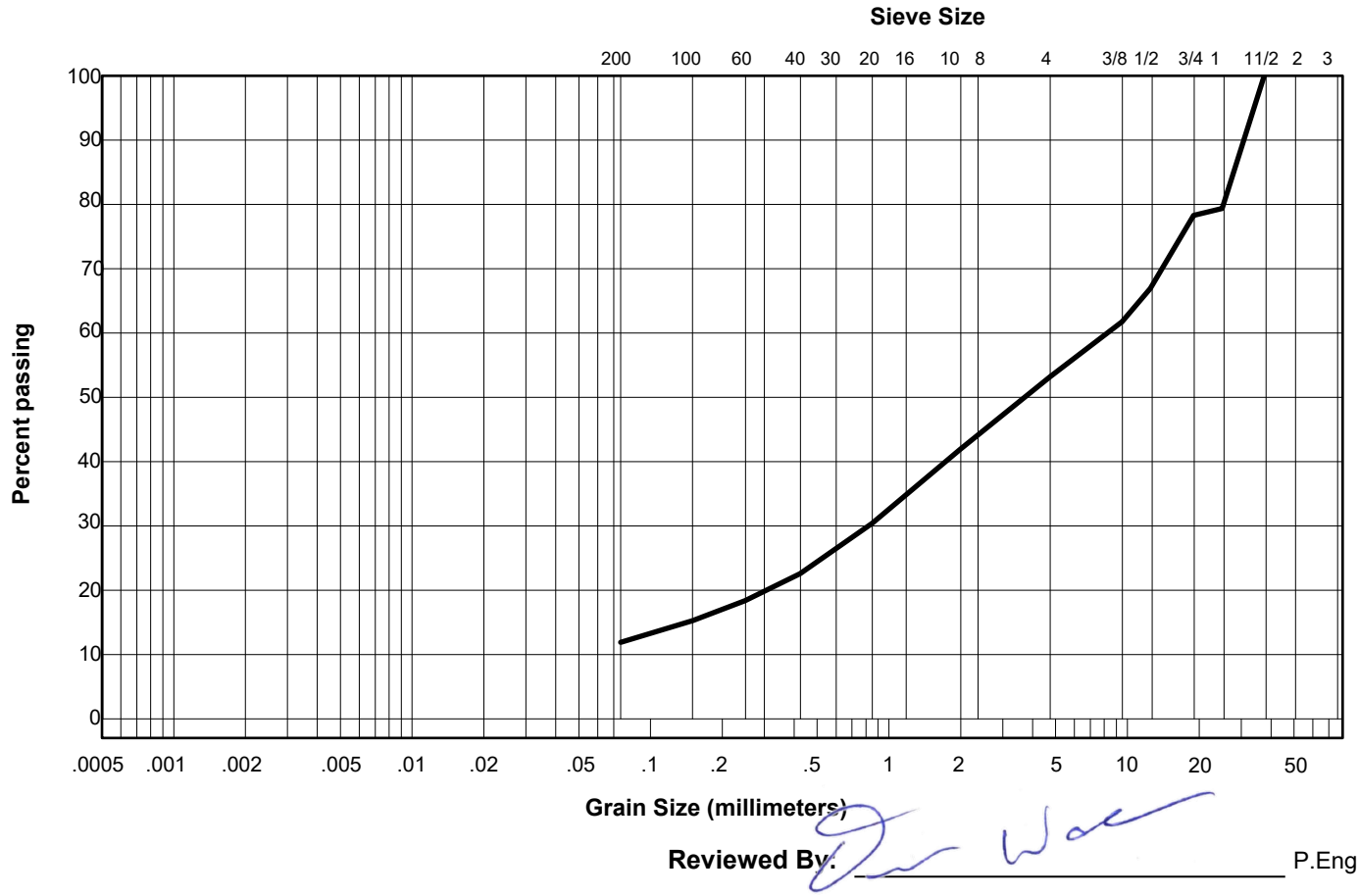
Cc:

Natural Moisture Content: 6.6%

Remarks:

Sieve Size (mm)	Percent Passing
37.500	100
25.000	79
19.000	78
12.500	67
9.500	62
4.750	53
2.000	42
0.850	30
0.425	23
0.250	18
0.150	15
0.075	11.9

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-02

Depth: G3 @ 3.6 - 4.0 m

Soil Description: SAND, silty, some gravel, moist, grey.

Cu:

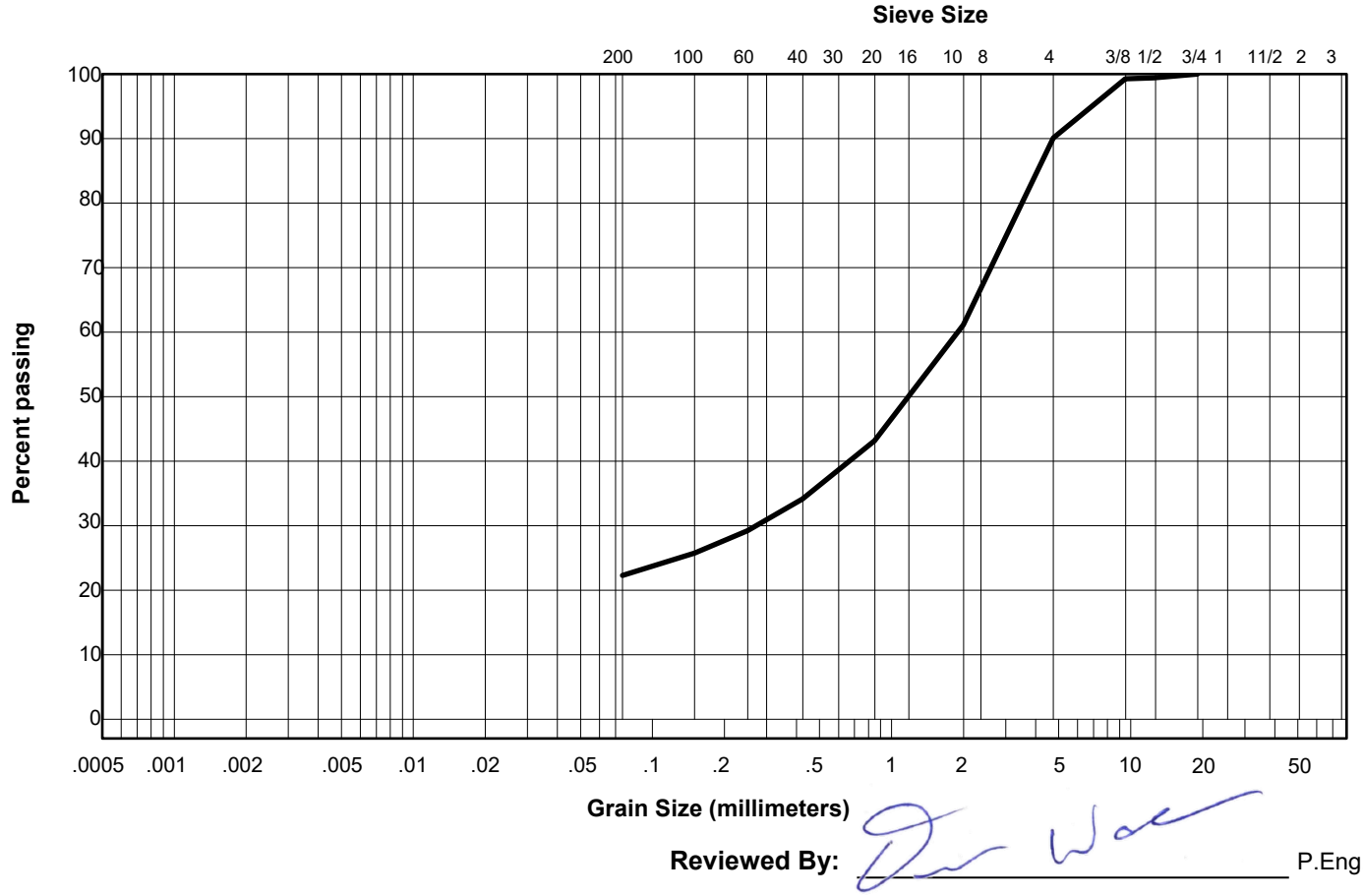
Cc:

Natural Moisture Content: 14.7%

Remarks:

Sieve Size (mm)	Percent Passing
19.000	100
12.500	99
9.500	99
4.750	90
2.000	61
0.850	43
0.425	34
0.250	29
0.150	26
0.075	22.3

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-03

Depth: LPT1 @ 4.4 - 4.7 m

Soil Description: GRAVEL and SAND, some silt, moist, brown.

Cu:

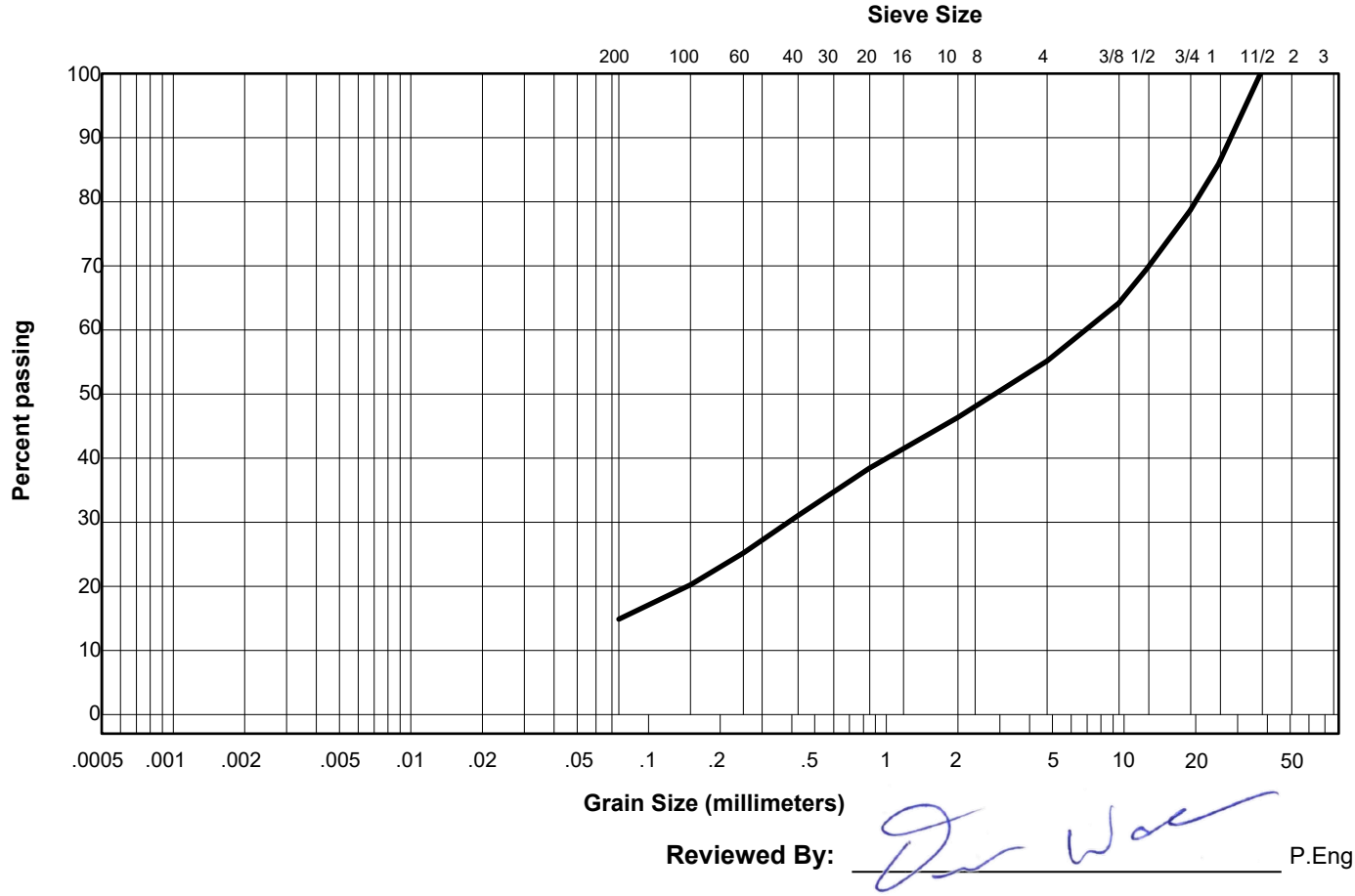
Cc:

Natural Moisture Content: 10.3%

Remarks:

Sieve Size (mm)	Percent Passing
37.500	100
25.000	86
19.000	79
12.500	70
9.500	64
4.750	55
2.000	46
0.850	38
0.425	31
0.250	25
0.150	20
0.075	14.9

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Holt Creek Trestle Replacement

Project Number: 704-ENG.ROCK03353-02

Date Tested: June 28, 2023

Borehole Number: BH23-04

Depth: LPT1 @ 2.3 - 2.64 m

Soil Description: GRAVEL and SAND, some silt, moist, brown.

Cu:

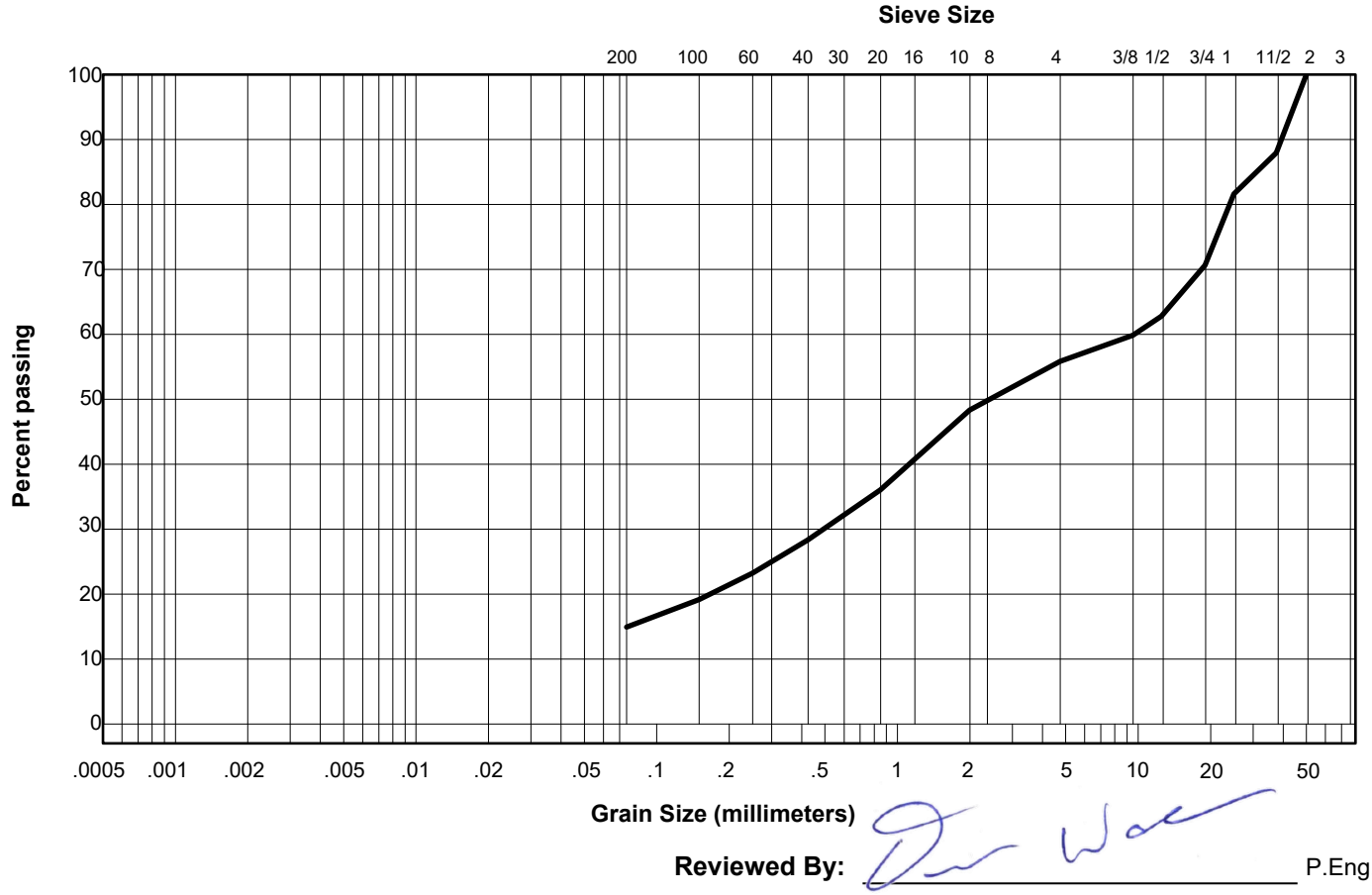
Cc:

Natural Moisture Content: 8.4%

Remarks:

Sieve Size (mm)	Percent Passing
50.000	100
37.500	88
25.000	82
19.000	71
12.500	63
9.500	60
4.750	56
2.000	48
0.850	36
0.425	28
0.250	23
0.150	19
0.075	14.9

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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TETRA TECH

APPENDIX D

SLOPE STABILITY ASSESSMENT

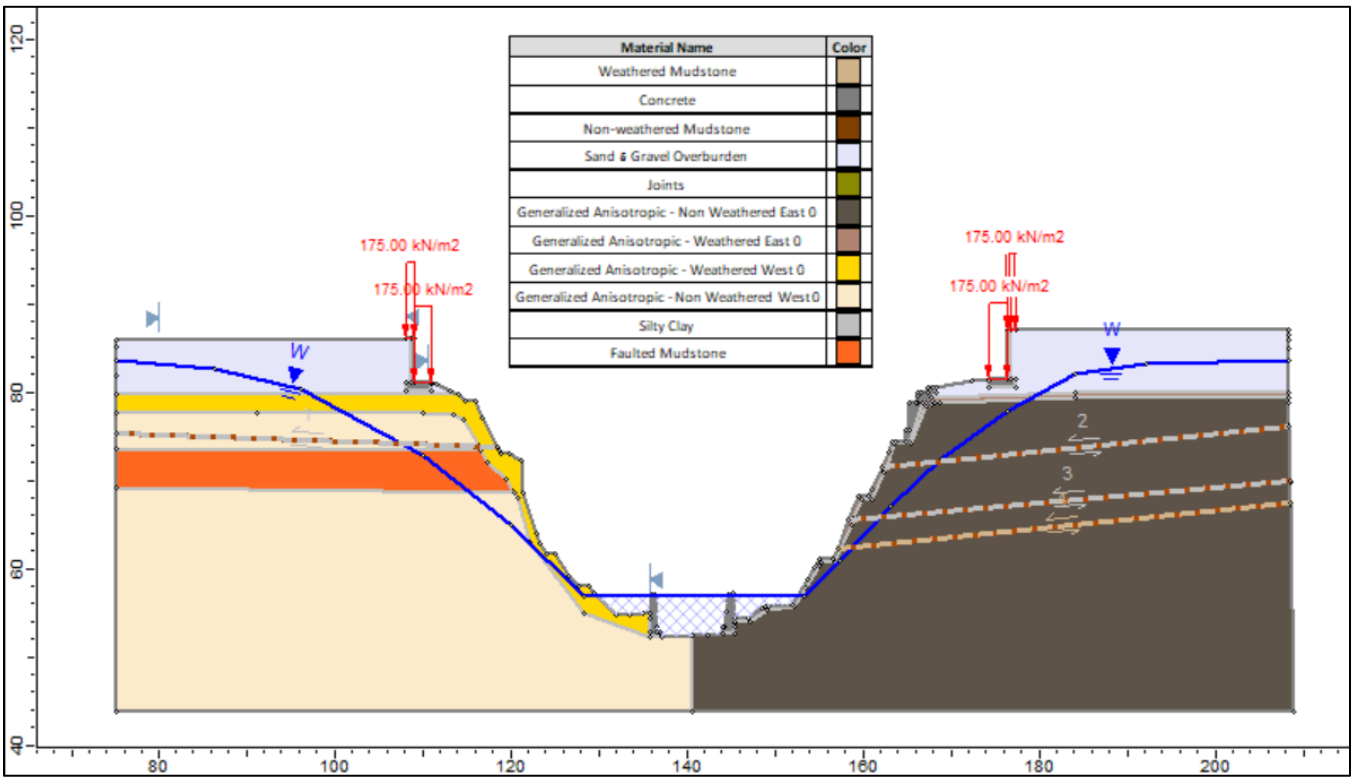


Figure D1. Model Geometry

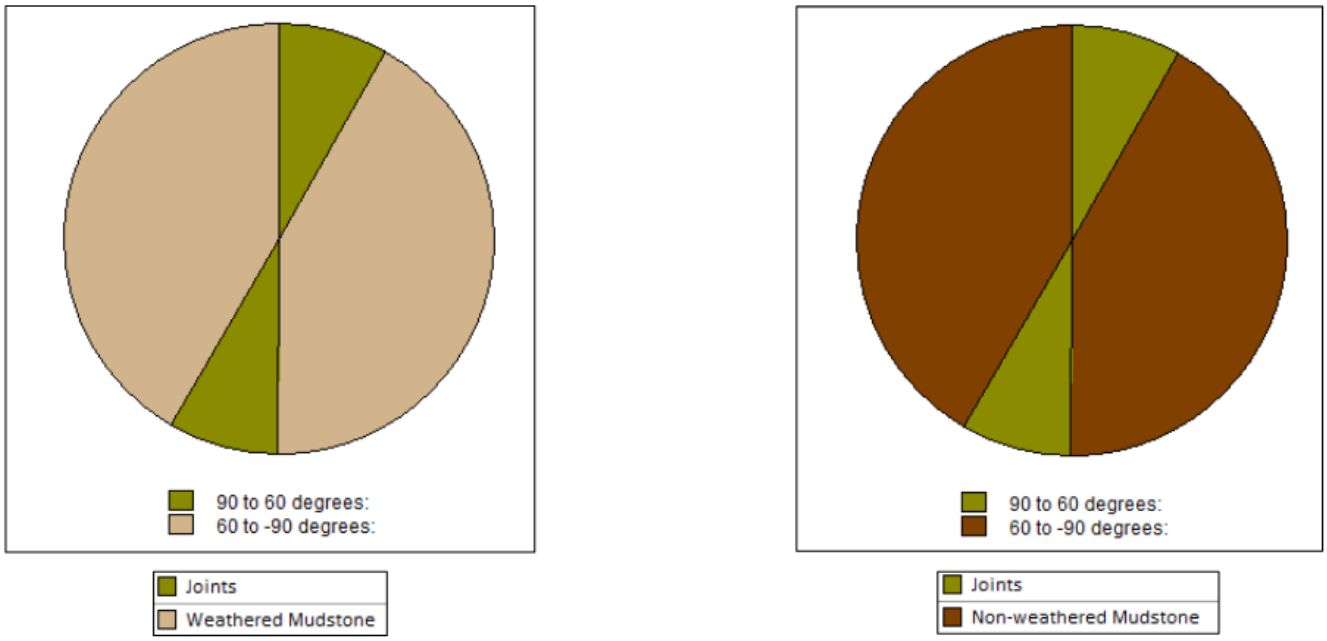


Figure D2. Generalized Anisotropic Strength Functions – East Side

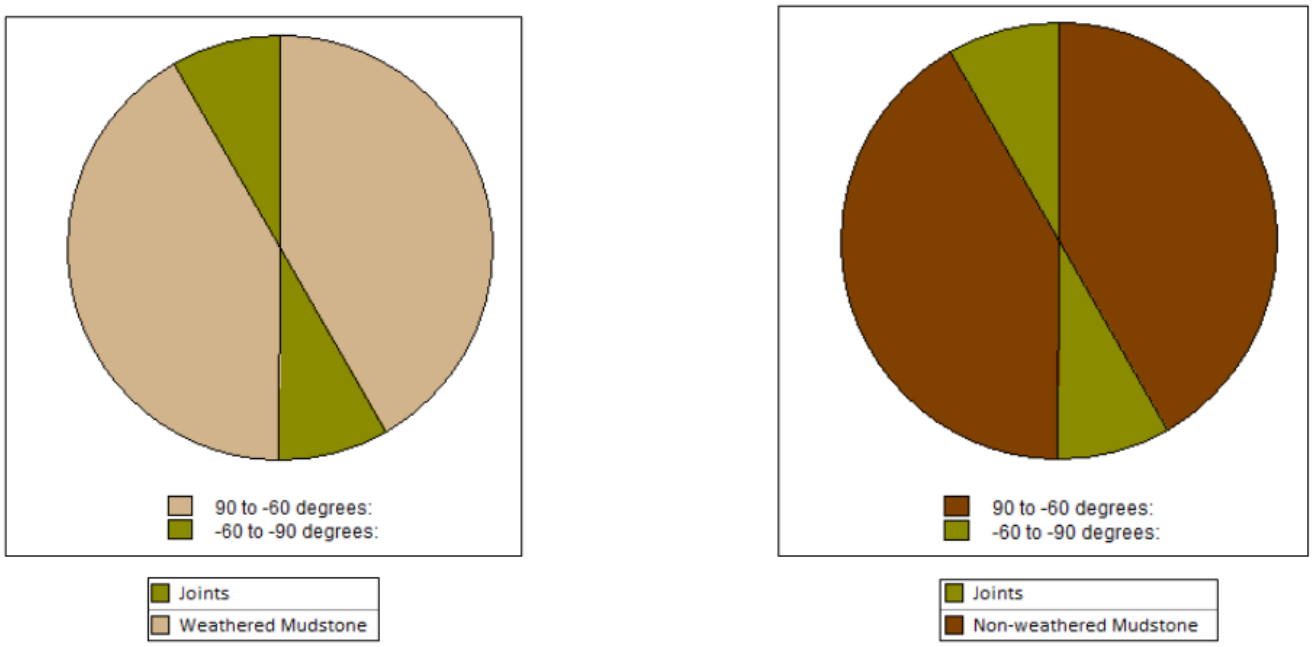


Figure D3. Generalized Anisotropic Strength Functions – West Side

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

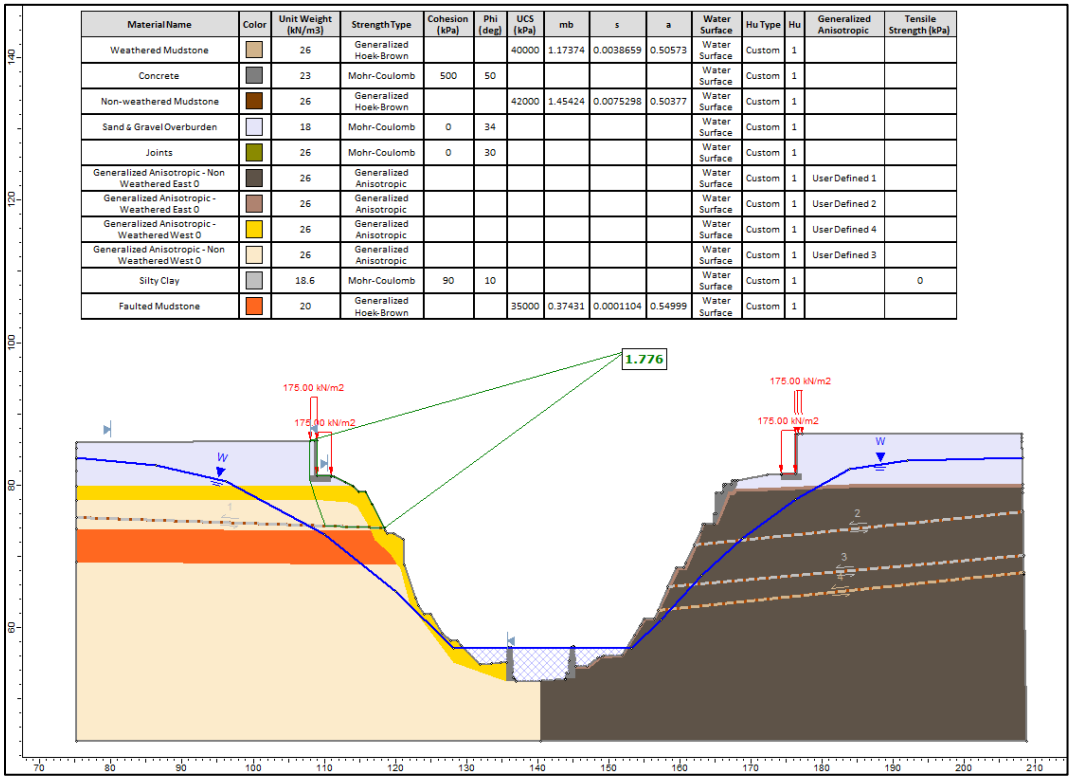


Figure D4. West Abutment - Static Analysis

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

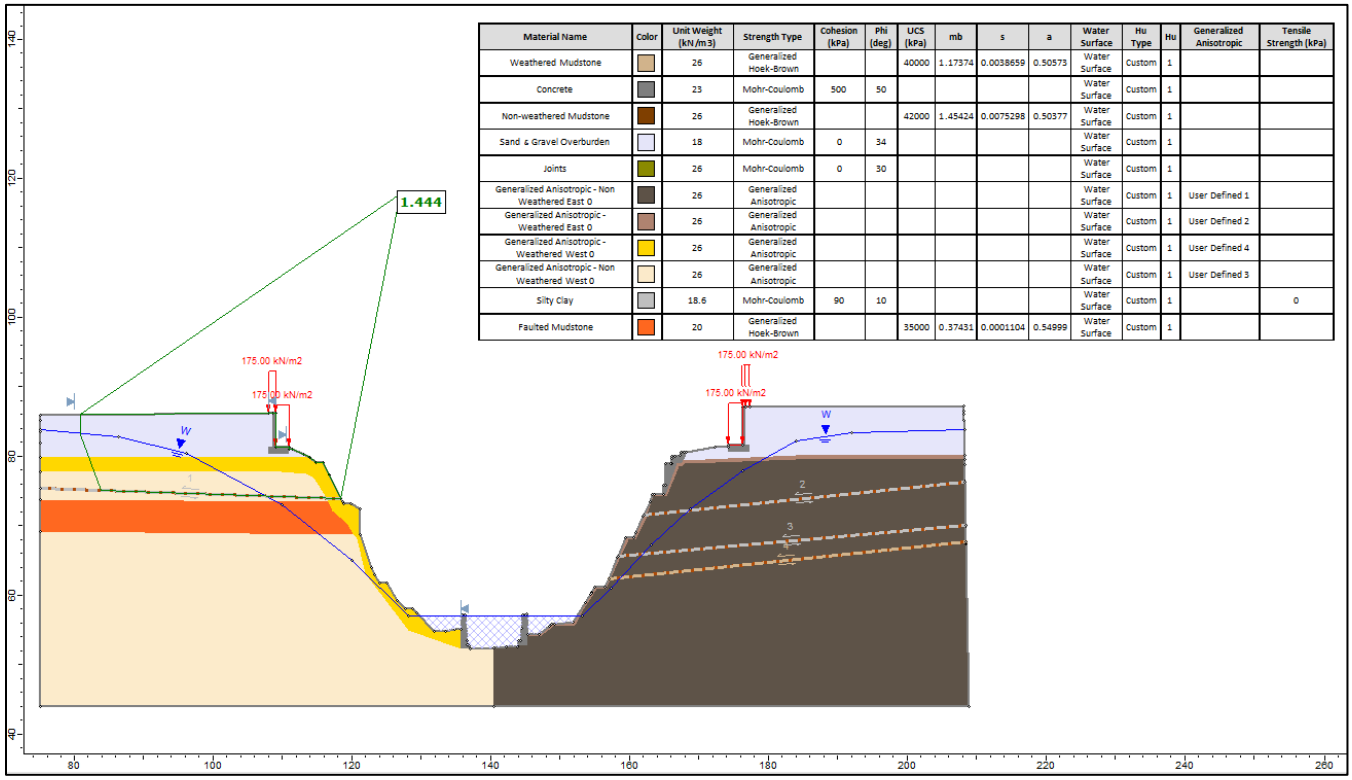
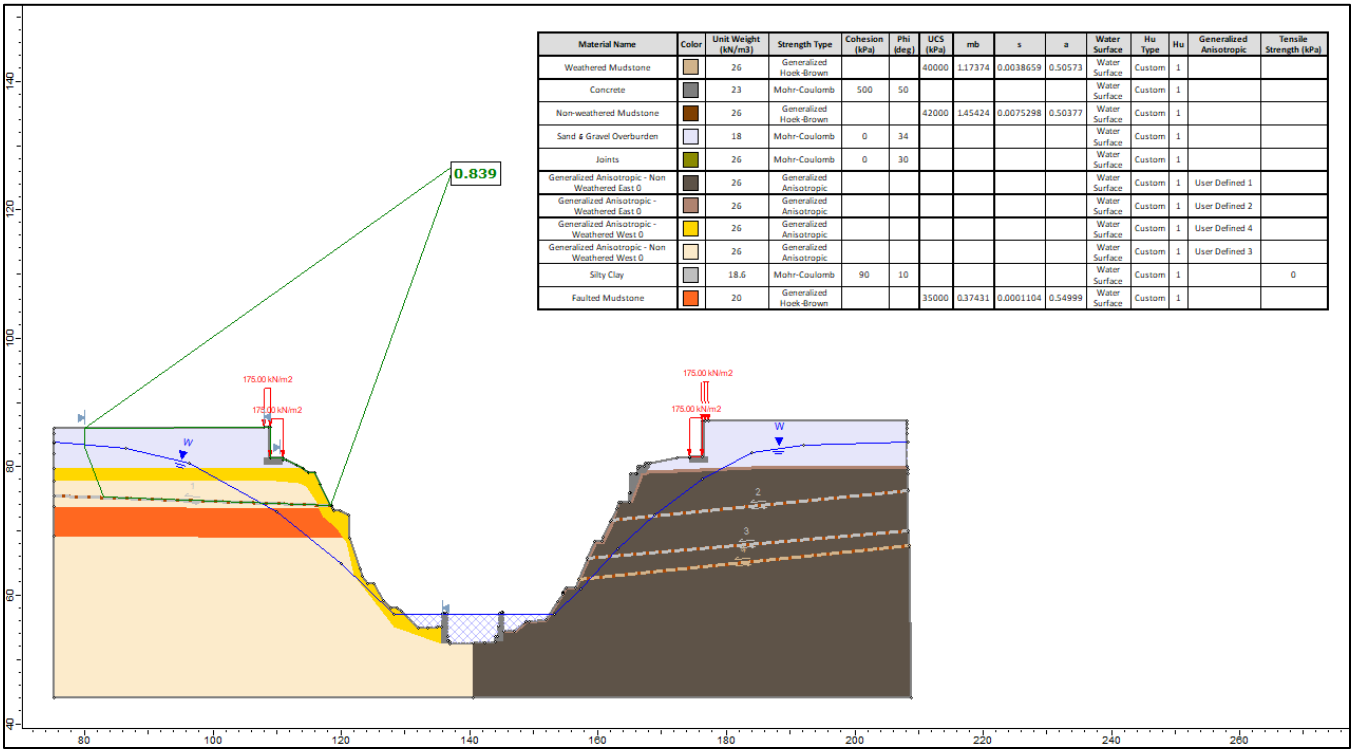
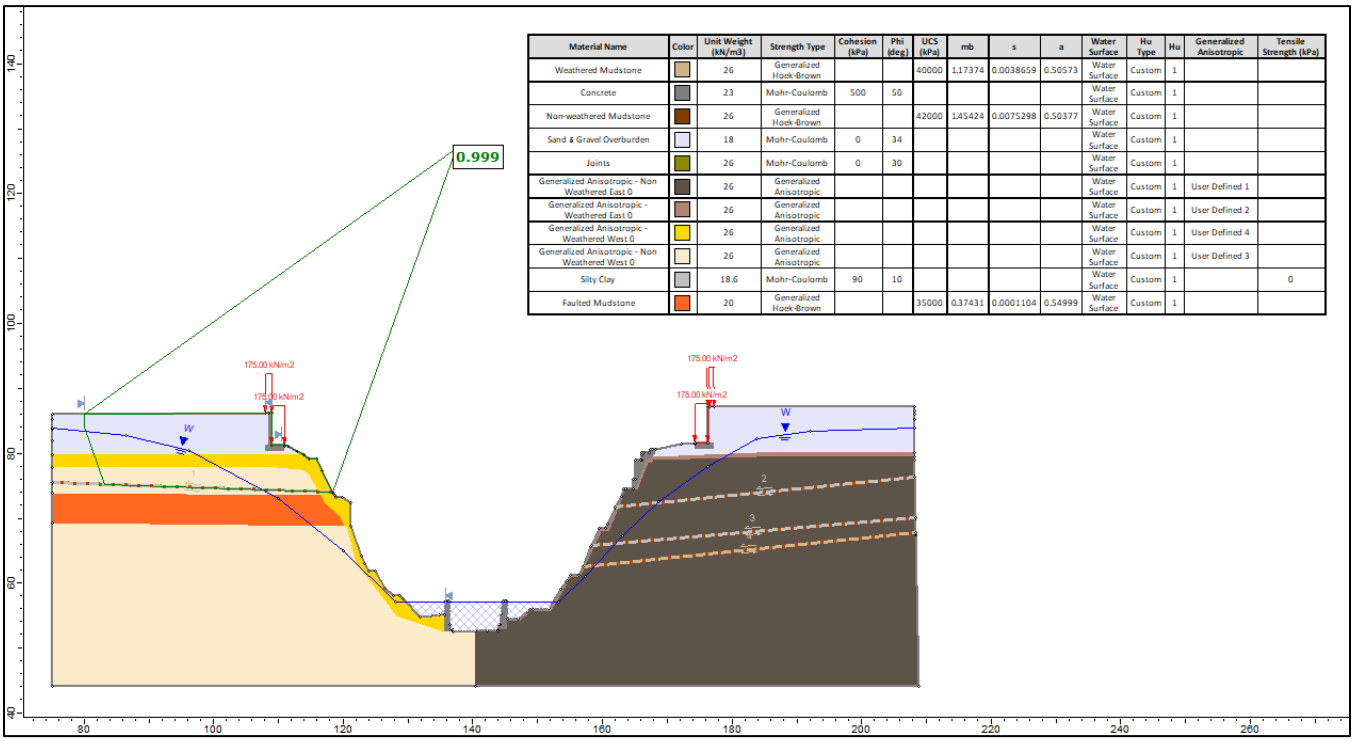


Figure D5. West Abutment – Pseudo-Static Analysis (475-Year, K_h = 0.291g)



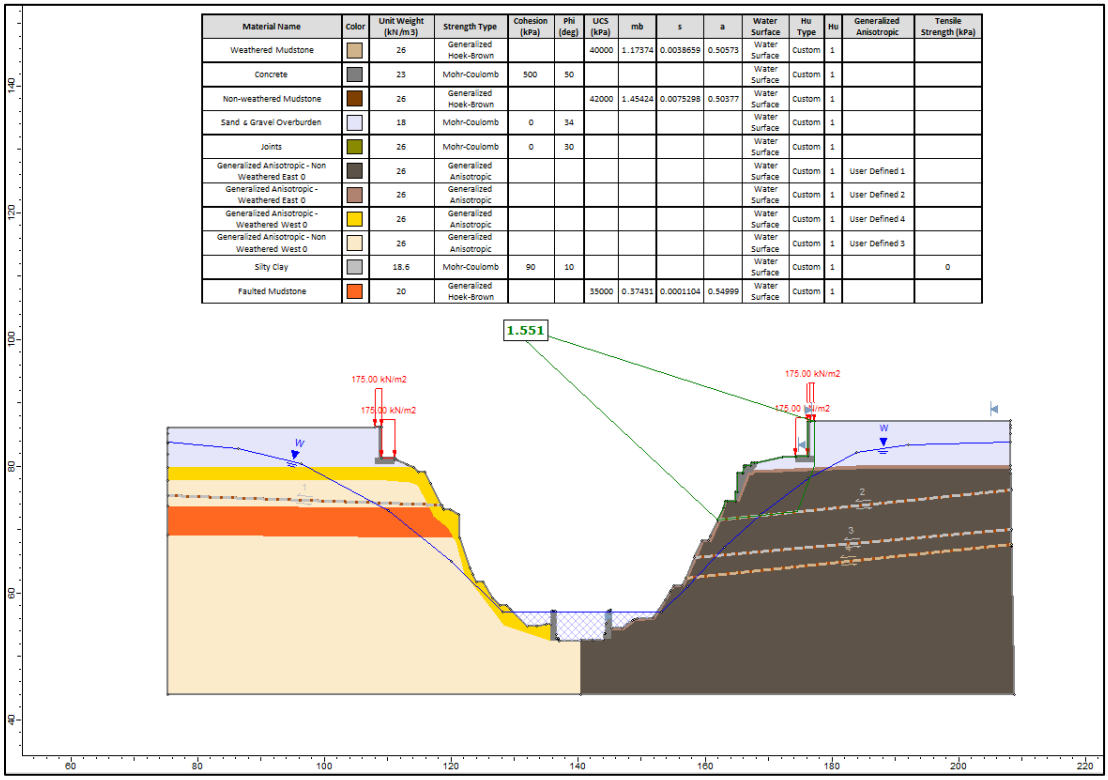
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

Figure D6. West Abutment – Pseudo-Static Analysis (2,475-Year, K_h = 0.575g)



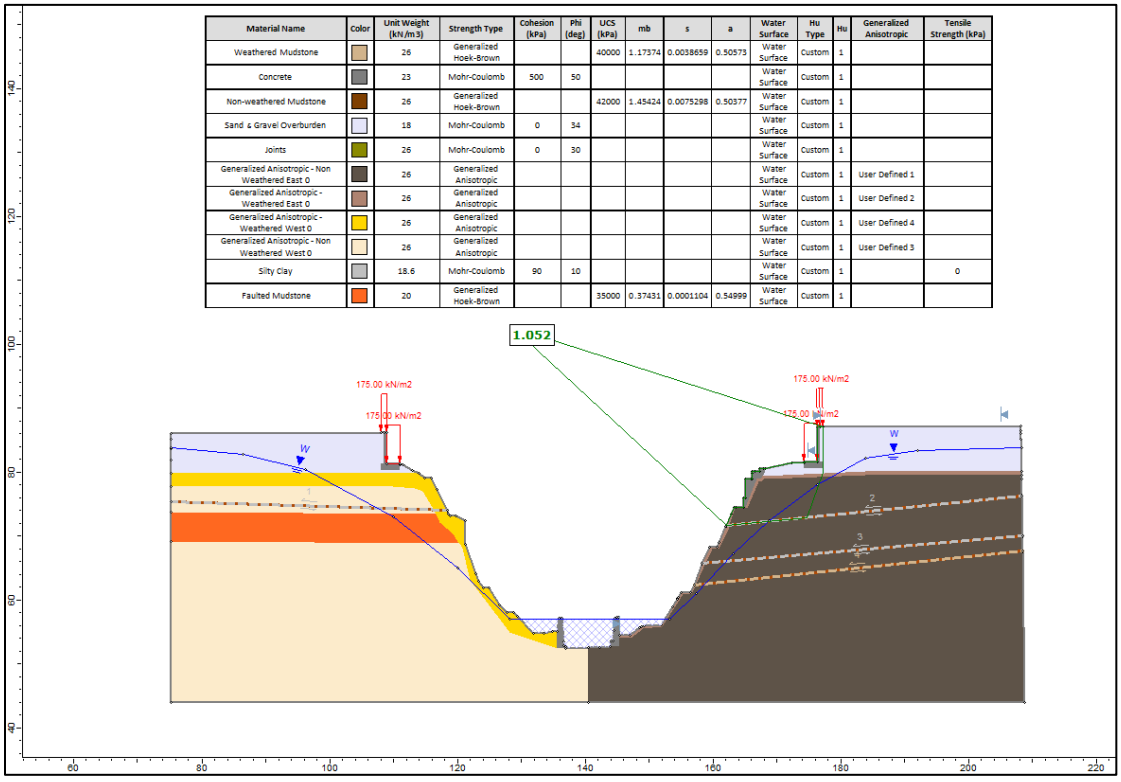
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

Figure D7. West Abutment – Pseudo-Static Analysis (Yield Acceleration, K_y = 0.467g)



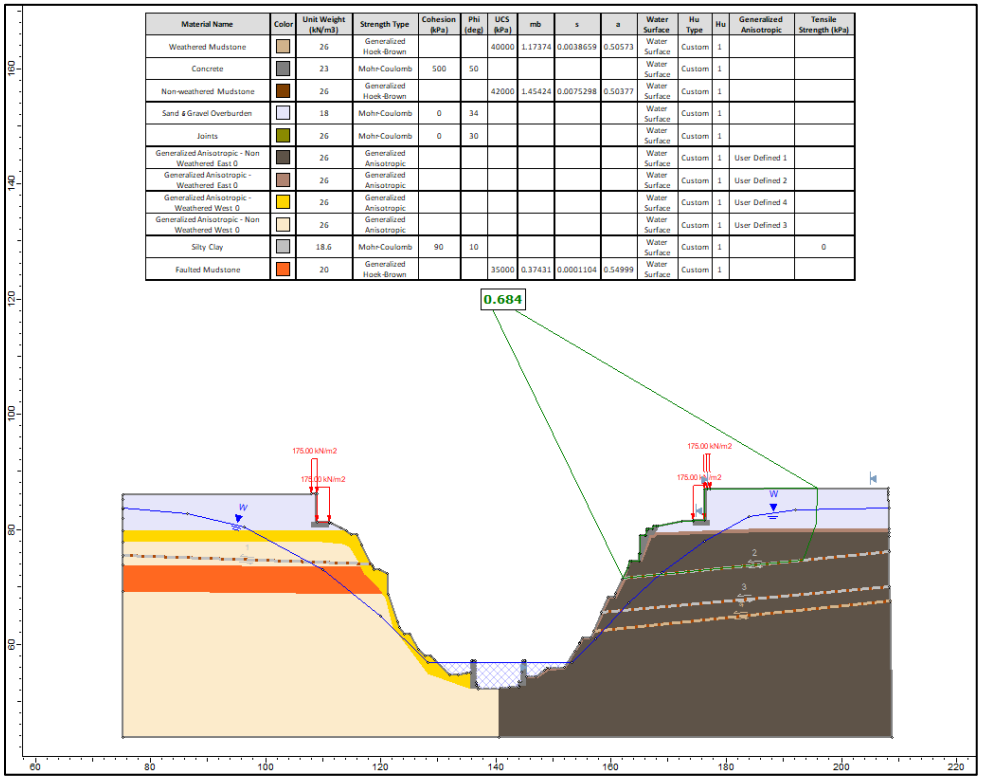
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

Figure D8. East Abutment - Static Analysis



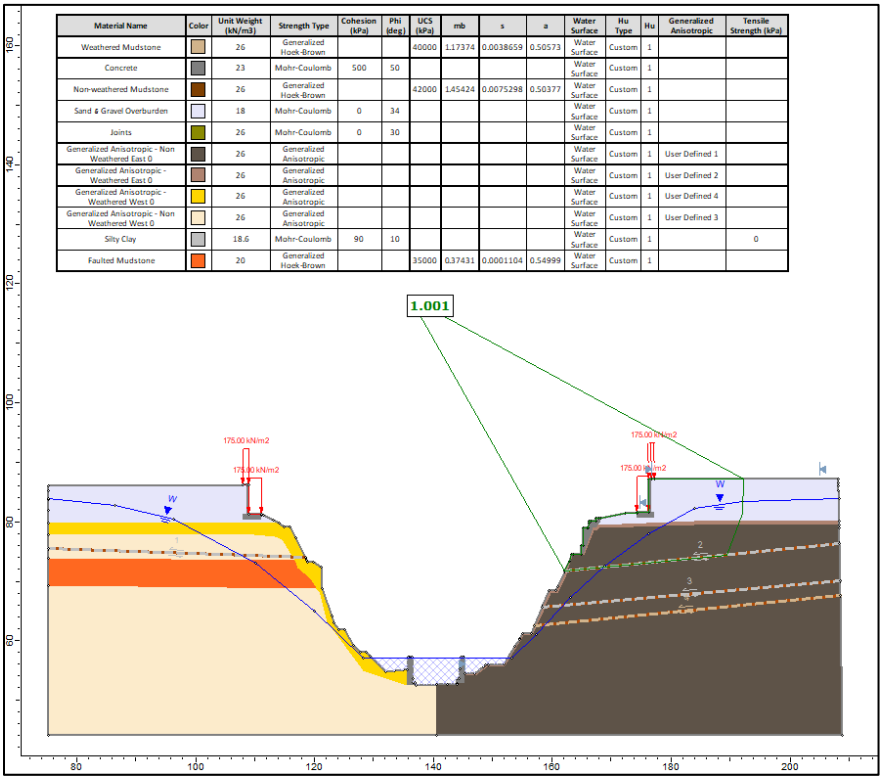
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

Figure D9. East Abutment – Pseudo-Static Analysis (475-Year, K_h = 0.291g)



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

Figure D10. East Abutment – Pseudo-Static Analysis (2,475-Year, K_h = 0.575g)



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	mb	s	a	Water Surface	Hu Type	Hu	Generalized Anisotropic	Tensile Strength (kPa)
Weathered Mudstone		26	Generalized Hoek-Brown			40000	1.17374	0.0038659	0.50573	Water Surface	Custom	1		
Concrete		23	Mohr-Coulomb	500	50					Water Surface	Custom	1		
Non-weathered Mudstone		26	Generalized Hoek-Brown			42000	1.45424	0.0075298	0.50377	Water Surface	Custom	1		
Sand & Gravel Overburden		18	Mohr-Coulomb	0	34					Water Surface	Custom	1		
Joints		26	Mohr-Coulomb	0	30					Water Surface	Custom	1		
Generalized Anisotropic - Non Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 1	
Generalized Anisotropic - Weathered East 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 2	
Generalized Anisotropic - Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 4	
Generalized Anisotropic - Non Weathered West 0		26	Generalized Anisotropic							Water Surface	Custom	1	User Defined 3	
Silty Clay		18.6	Mohr-Coulomb	90	10					Water Surface	Custom	1		0
Faulted Mudstone		20	Generalized Hoek-Brown			35000	0.37431	0.0001104	0.54999	Water Surface	Custom	1		

Figure D11. East Abutment – Pseudo-Static Analysis (Yield Acceleration, K_y = 0.335g)