



THURBER ENGINEERING LTD.

Foundation Investigation and Design Report Gull River Culvert Replacement

Highway 811, District of Thunder Bay, Ontario

Agreement 6021-E-0005, Work Orders 1 & 23

G.W.P. 6104-17-00, Site No. 48W-0198/C0

Latitude: 49.404264°, Longitude: -89.590338°

GEOCRES No. 52H05-001

Client Name: HATCH

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**FOUNDATION INVESTIGATION AND DESIGN REPORT
GULL RIVER CULVERT REPLACEMENTS
HIGHWAY 811, DISTRICT OF THUNDER BAY, ONTARIO
AGREEMENT 6021-E-0005, WORK ORDERS 1 & 23
G.W.P. 6104-17-00, SITE NO. 48W-0198/C0
LATITUDE: 49.404264°, LONGITUDE: -89.590338°**

GEOGRES No. 52H05-001

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for design of the proposed Gull River Culvert replacement. The Gull River Culvert is located on Highway 811, approximately 17 km west of Highway 527, in the Unsurveyed Territory, District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to Hatch Corporation (Hatch), under the Ministry of Transportation Ontario (MTO) Retainer Agreement Number 6021-E-0005, Work Order 1, with additional foundation engineering services under Work Order 23.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

The site is located on Highway 811, in the Unsurveyed Territory, District of Thunder Bay, Ontario. The existing culvert, which consists of three pipes, allows Gull River to flow in a general south to north direction under Highway 811. Highway 811 generally runs in a northwest-southeast direction at the culvert site. For the purposes of this report, Highway 811 is described as running in a west-east direction.

Photographs in Appendix D show the general nature of the site and the existing culvert.

The available base plan drawing provided by Hatch indicates that the existing structure consists of three horizontal elliptical structural plate corrugated steel pipes (SPCSP); each measuring 3.1 m wide, 2.1 m high and 16.8 m long. The culvert pipes span an overall distance of approximately 11 m. The culvert invert at each existing pipe is at approximate Elevation 447.2 m. Highway 811 is a gravel road with an existing grade level of approximate Elevation 451 m at the culvert location. The highway embankment is approximately 3 to 4 m high, with 1.7 m of fill above the culvert pipes. As seen in Photo 5 in Appendix D, the inlet of the existing culvert pipes was partially obstructed by fallen timber. The local river water level was reportedly measured at Elevation 447.6 m on July 5, 2018. The site topography within the culvert area gently slopes downward from the east and west toward the culvert site. The site is surrounded by mature trees, with marshy areas near the riverbanks.

Based on published geological mapping, the quaternary geology in the area of the culvert site consists of mainly undifferentiated igneous and metamorphic bedrock, exposed at surface or covered by a discontinuous, thin layer of drift; with nearby glaciofluvial outwash and ice-contact deposits and recent fluvial deposits including gravel and sand, minor till, and recent sand, silt, gravel and clay. The bedrock in the area is described as folded tonalite suite consisting of foliated to massive tonalite to granodiorite.

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field-testing program for this project was carried out in two phases, from August 15 to 18, 2022 and from September 22 to October 2, 2022. The field program consisted of drilling and sampling eight (8) boreholes (22-01 to 22-08) to depths ranging from 5.6 to 14.6 m below the ground surface (Elevation 442.5 to 436.2 to m).

Boreholes 22-05 to 22-08 were drilled through the gravel Highway 811 embankment. Boreholes 22-01 to 22-04 were drilled off-road near the inlet and outlet of the existing culvert. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix A. The Record of Borehole sheets are included in Appendix B.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from field measurements and the topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 15 was used for the boreholes.

The boreholes through the road surface (22-05 to 22-08) were advanced using a rubber track-mounted CME55 drill rig, using hollow stem auger and/or wash boring techniques. The off-road boreholes (22-01 to 22-04) were advanced using a portable Hilti drill and tripod equipment using

wash boring techniques. In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT). Bedrock coring used an NQ size core barrel was used to advance all boreholes into bedrock.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

The rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Monitoring wells were installed in Boreholes 22-05 and 20-06. Both wells consisted of 50 mm Schedule 40 PVC pipe with a 1.5 m long slotted screen, enclosed in a column of filter sand to permit groundwater level monitoring. Monitoring well installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. A sample of the groundwater was obtained from the well at Borehole 22-05 and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of water quality parameters. Single well response tests ("slug") tests were carried out in the wells installed in both Boreholes 22-05 and 22-06. Upon collection of the final water level readings on August 18, 2022, the wells were decommissioned in accordance with MOECP O.Reg. 903.

Details of the drilling program, including drilling depths, monitoring well installation and completion details are summarized in Table 3.1 below.

Table 3.1 Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Monitoring Well Tip Depth / Elevation (m)	Completion Details
22-01	9.4 / 438.8	None installed	Borehole caved to 7.2 m and backfilled with bentonite holeplug to ground surface.
22-02	7.7 / 441.9	None installed	Borehole caved to 5.2 m and backfilled with bentonite holeplug to ground surface.
22-03	5.6 / 442.5	None installed	Borehole caved to 2.0 m and backfilled with bentonite holeplug to ground surface.
22-04	10.0 / 439.1	None installed	Borehole caved to 7.4 m and backfilled with bentonite holeplug to ground surface.



Borehole Number	Borehole Depth / Base Elevation (m)	Monitoring Well Tip Depth / Elevation (m)	Completion Details
22-05	14.6 / 436.2	9.8 / 441.0	Bentonite holeplug to 9.9 m. Filter sand from 9.9 m to 7.9 m, bentonite holeplug from 7.9 to 7.3 m, cave in material to 2.1 m, bentonite to 0.3 m, then sand to ground surface.
22-06	13.9 / 437.1	5.9 / 445.1	Cave in material to 6.1 m. Filter sand from 6.1 to 4.3, bentonite to 3.7 m, cave in material to 2.0 m, then bentonite to ground surface.
22-07	9.8 / 441.0	None installed	Borehole caved to 0.9 m and was backfilled with bentonite holeplug and sand to ground surface.
22-08	10.1 / 441.1	None installed	Borehole caved to 3.1 m and was backfilled with bentonite holeplug and sand to ground surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. Selected samples were subjected to grain size distribution analyses (sieve and hydrometer), where appropriate. Point load tests and Unconfined Compressive Strength (UCS) tests were also conducted on selected samples of the bedrock cores. The results of this testing program are summarized on the Record of Borehole sheets in Appendix B and are shown on the figures included in Appendix C.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, two soil samples and a sample of the river water were collected during the investigation and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. In order to assess the quality of the groundwater for disposal purposes, a water sample was collected from the well installed in Borehole 22-05. The results of the analytical testing are summarized in this report and presented in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix B. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata drawings in Appendix A. A general description of the

stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface stratigraphy on the road consists of sand fill with some silt to silty and trace to some gravel. The fill was underlain by native soils consisting of silty sand to sand, zones of sandy silt mixed with peat and organics, silt till, and sand and gravel. The overburden soils were underlain by tonalite bedrock. More detailed descriptions of the individual strata are presented below.

5.1 Embankment Fill

Sand embankment fill was encountered at the ground surface in Boreholes 22-05 to 22-08 located on Highway 811. The fill generally consisted of sand with trace silt to silty, and trace to some gravel. Occasional cobbles were also encountered in the fill.

The fill extended to depths ranging from 2.7 m to 5.2 m below ground surface (Elevation 448.2 to 445.8 m).

SPT 'N' values in the sand fill generally ranged from 4 to 32 blows per 0.3 m penetration, indicating a loose to dense relative density; typically compact. In Borehole 22-08, one SPT 'N' value of greater than 100 blows per 0.3 m penetration was recorded where cobbles were encountered.

The measured moisture contents generally ranged from 3 to 13%.

The results of grain size analyses conducted on selected samples of the sand fill are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C1 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	1 to 14
Sand	59 to 88
Silt & Clay	10 to 28

5.2 Topsoil

A surficial layer of topsoil ranging in thickness from 100 to 250 mm was encountered at the ground surface in Boreholes 22-01 to 22-04.

5.3 Silt Mixed with Peat and Organics

Underlying the topsoil, a layer of silt mixed with peat and organics was encountered near the ground surface in Boreholes 22-01 to 22-04. A buried layer of sandy silt mixed with peat and organics was also encountered below the embankment fill in Borehole 22-08. The silt with peat and organics generally contained silt, trace sand to sandy, trace clay, trace gravel, occasional cobbles and boulders, and wood fragments. Coring methods were used to penetrate cobbles and boulders in Boreholes 22-01 to 22-03.

The thickness of the silt mixed with peat and organics ranged from 0.5 m to 4.2 m, with the base encountered at depths ranging from 0.6 to 4.5 m (Elevation 448.5 to 445.9 m).

SPT 'N' Values in the layer ranged from 3 to 21 blows per 0.3 m penetration, indicating a very loose to compact density; typically loose. SPT 'N' values of greater than 50 per 0.3 m penetration were also recorded where cobbles or boulders were encountered.

Measured moisture contents ranged from 23 to 163%.

The results of grain size analyses conducted on samples of the silt mixed with peat and organics are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C2 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	14 to 40
Silt	59 to 82
Clay	1 to 4

5.4 Silty Sand to Sand

A deposit ranging in composition from silty sand to sand was encountered below either the silt mixed with peat or the embankment fill in Boreholes 22-01, 22-03, 22-04, 22-05, 22-06 and 22-07. The deposit also generally contained trace gravel, trace clay, and occasional cobbles. Occasional wood fragments were encountered in the silty sand in Borehole 22-07. Coring methods were used to penetrate cobbles in Boreholes 22-04 and 22-05.

The thickness of the silty sand to sand deposit ranged from 0.7 m to 5.3 m, with the base encountered at depths ranging from 2.4 to 8.7 m (Elevation 446.7 to 442.1 m).

SPT 'N' Values in the silty sand to sand ranged from 11 blows to greater than 100 blows per

0.3 m penetration, indicating a compact to very dense relative density.

Measured moisture contents generally ranged from 7 to 21%.

The results of grain size analyses conducted on samples of the silty sand to sand deposit are provided on the Record of Borehole sheets in Appendix B, and plotted on Figure C3 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 9
Sand	65 to 90
Silt	8 to 32
Clay	1 to 3
Silt and Clay	12 to 15

5.5 Silt Till

A silt till deposit was encountered below the silty sand to sand layer in Boreholes 22-01, 22-05 and 22-06 and beneath the silt mixed with peat and organics in Borehole 22-08. The silt till deposit contained trace to some sand, trace gravel, trace clay and occasional cobbles.

The thickness of the silt till ranged from 0.6 m to 1.7 m, with the base of the deposit encountered at depths ranging from 4.3 to 10.4 m. (Elevation 445.9 to 440.4 m).

SPT 'N' Values in the silt till deposit ranged from 15 to greater than 100 blows per 0.3 m penetration, indicating a compact to very dense relative density.

Recorded moisture contents in the silt till ranged from 11 to 31%.

The results of grain size analyses conducted on samples of the silt till deposit are provided on the Record of Borehole sheets in Appendix B and plotted in Figure C4 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 3
Sand	1 to 13
Silt	79 to 94
Clay	5 to 8

5.6 Sand and Gravel with Cobbles

The silty sand to sand and silt till deposits were underlain by a deposit of sand and gravel with some cobbles and occasional boulders. The sand and gravel deposit was encountered in all of the boreholes except for 22-02 and 22-03. Coring methods were frequently required to penetrate the sand and gravel layer.

The thickness of the sand and gravel deposit ranged from 0.2 m to 2.2 m, with the base encountered at depths ranging from 5.6 to 10.6 m. (Elevation 445.2 to 440.2 m).

SPT 'N' Values in the sand and gravel deposit ranged from 32 to greater than 100 blows per 0.3 m penetration, indicating a dense to very dense relative density.

Recorded moisture contents in the sand and gravel ranged from 1 to 9%

5.7 Bedrock

The overburden soils described above are underlain by bedrock. The bedrock is described as folded tonalite, is red and grey in colour and is moderately weathered to fresh. Bedrock was proven by coring 1.9 to 4.9 m in all borehole locations (3 m or greater in all boreholes except for 22-04).

Table 5.1 summarizes the depths and elevations to the top of the bedrock at the borehole locations. Photographs of the rock cores are included in Appendix C.

Table 5.1 Depths and Elevations of Top of Bedrock

Borehole	Top of Bedrock	
	Depth Below Existing Grade Level (m)	Elevation (m)
22-01	5.8	442.4
22-02	4.4	445.2
22-03	2.4	445.7
22-04	8.1	441.0
22-05	10.6	440.2
22-06	9.0	442.0
22-07	5.6	445.2
22-08	7.0	444.2

Total Core Recovery (TCR) in the bedrock ranged between 77% to 100% throughout all runs, and Solid Core Recovery (SCR) ranged between 26 to 100%. The Rock Quality Designation (RQD) determined from the recovered cores ranged between 0 and 94%, which indicates very poor to excellent rock quality. The rock quality is typically poor to fair (RQD from 26 to 75%), with the

exceptions of Borehole 22-04, which is very poor (RQD from 0 to 15%) and Borehole 22-07, which is excellent (RQD from 86 to 94%). The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, typically ranged from 0 to 7, with some broken zones with FI of greater than 10.

Average unconfined compressive strengths (UCS) of the rock ranged between 130 and 223 MPa, These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. Unconfined Compression Strength (UCS) tests were also conducted on 6 bedrock core sample specimens. The UCS test results ranged from 71 to 209 MPa. Based on the average point load and UCS test results, the bedrock is typically strong to very strong. The UCS and point load test results are presented in Appendix C.

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling, and in the monitoring wells installed in Boreholes 22-05 and 22-06. Water levels were not recorded when residual drilling water (for coring purposes) was observed in the open boreholes. The measured groundwater levels are summarized in Table 5.2 below. The monitoring wells were decommissioned on August 18, 2022 following final water level readings and slug testing.

Table 5.2 Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
22-05	August 17, 2022	3.4	447.4	In monitoring well
22-06	August 18, 2022	3.4	447.4	
22-08	August 16, 2022	3.3	447.7	In monitoring well
22-05	August 17, 2022	3.5	447.5	
22-06	August 18, 2022	1.8	449.4	Open Borehole

The groundwater level is likely to reflect the local river water level. The local river water level was measured at Elevation 447.6 m on July 5, 2018.

It should also be noted that groundwater levels are short term observations and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation and spring snow melts.

6. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the sand fill from Boreholes 22-05 and 22-06 and a sample of surface water collected from the river were submitted for analytical testing of corrosivity parameters and sulphate. The laboratory certificates of analysis are presented in Appendix C. The results of the analytical tests are summarized below in Table 6.1.

Table 6.1: Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results		
			22-05 SS3 (7'-9') (2.1 – 2.7 m)	22-06 SS6 (12.5'-14.5') (3.8 – 4.4 m)	Gull River SW
			(Sand Fill)	(Sand Fill)	(Surface Water)
Redox Potential	mV	mV	268	289	251
Sulphide	%	µg/L	<0.04	<0.04	-
pH	-	-	9.10	8.95	7.66
Chloride	µg/g	mg/L	< 10	< 10	0.57
Sulphate	µg/g	mg/L	< 10	< 10	<0.04
Conductivity	µS/cm	µS/cm	72	93	85
Resistivity*	ohm-cm	ohm-cm	13900	10800	11764*

* Calculated based on conductivity result

7. WATER QUALITY

For preliminary screening of the general groundwater quality in the project area, a sample of the groundwater from the monitoring well at Borehole 22-05 was collected on August 18, 2022. The water sample was analyzed for selected inorganic parameters included in the Ontario Provincial Water Quality Objectives (PWQO), as well as Total Suspended Solids. A filtered sub-sample was also tested for dissolved metal parameters for comparison purposes. The analytical test results are presented in Appendix C.

The analytical results of the water testing were compared to limits for the PWQO for surface water discharge. The concentrations of all parameters tested that did not meet the criteria established in the PWQO are listed below in Table 7.1. The Total Suspended Solids concentration was 81 mg/L.

Table 7.1: Water Parameters Exceeding PWQO Criteria

Sample ID	Parameter	Criteria	Parameter Limit (µg/L)	Result
22-05	Aluminum (0.2 µm)	PWQO	75	860
	Total Cobalt	PWQO	0.9	7.90
	Total Copper	PWQO	5	63.5
	Total Iron	PWQO	300	6790
	Total Phosphorus	PWQO	10	98
	Total Silver	PWQO	0.1	2.34
	Total Vanadium	PWQO	6	6.54
	Total Zinc	PWQO	20	54
22-05 Dissolved Metals (Filtered sub-sample)	Dissolved Cobalt	PWQO	0.9	6.90
	Dissolved Copper	PWQO	5	50.1
	Dissolved Iron	PWQO	300	3190
	Dissolved Phosphorus	PWQO	10	51
	Dissolved Silver	PWQO	0.1	0.22
	Dissolved Zinc	PWQO	20	39

8. SINGLE WELL RESPONSE TEST RESULTS

8.1 Test Procedure

Single well response tests (SWRT) (“slug” tests) were carried out in the 50 mm diameter wells installed in Boreholes 22-05 and 22-06. The well installed in Borehole 22-05 was screened across silty sand to silt, some sand till. The well installed in Borehole 22-06 was screened across sand, some silt to silty, trace to some gravel. The tests were completed using the following method:

- The static water level was measured and recorded, and a datalogger was inserted into the well below the water level. The datalogger was set to record water levels every 0.125 to 0.5 seconds, based on the anticipated rate of recovery of the wells.
- A slug of groundwater was removed from the well with a dedicated bailer to induce a change in hydraulic head (rising head test).

- Manual and electronic measurements were recorded until the water level in the well recovered sufficiently.
- Manual measurements were compared to electronic measurements for quality control of the data.

8.2 Hydraulic Conductivity

The slug tests were completed and analyzed using the Hvorslev method. The plots of the slug test results are included in Appendix C. The hydraulic conductivity values calculated from the in-situ slug tests are summarized in Table 8.1:

Table 8.1: Hydraulic Conductivity

Monitoring Well	Hydraulic Conductivity (m/s)	Screened Formation
22-05	2.3×10^{-5}	Sand and silt to silty sand
22-06	2.7×10^{-4}	Sand, some silt

9. MISCELLANEOUS

Thurber obtained utility clearances for the borehole locations prior to drilling. Borehole locations were selected and established in the field by Thurber Engineering Ltd.

RPM Drilling of Thunder Bay, Ontario supplied a rubber track-mounted CME55 drill rig and Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario supplied a portable Hilti drill with tripod, to conduct the drilling, sampling and in-situ testing operations for the boreholes. Traffic control services conforming to Ontario Book 7 were provided by Thurber.

Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory. Analytical testing was carried out by SGS Canada Inc.

The field investigation was supervised on a full-time basis by Mr. Ian Ross, E.I.T. and Mr. Greg Stanhope, E.I.T. of Thurber. Overall supervision of the field program was provided by Ms. Rachel Bourassa, E.I.T. and Mr. Mark Farrant, P. Eng. of Thurber.

Interpretation of the field data and preparation of this report was carried out by Ms. Madisan Chiarotto, P.Eng. and Mr. Mark Farrant, P.Eng., and reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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Principal, Designated MTO Contact

Date: August 1, 2024
File: 34812

**FOUNDATION INVESTIGATION AND DESIGN REPORT
GULL RIVER CULVERT REPLACEMENTS
HIGHWAY 811, DISTRICT OF THUNDER BAY, ONTARIO
AGREEMENT 6021-E-0005, WORK ORDERS 1 & 23
G.W.P. 6104-17-00, SITE NO. 48W-0198/C0
LATITUDE: 49.404264°, LONGITUDE: -89.590338°**

GEOGRES No. 52H05-001

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

10. GENERAL

This report provides an interpretation of the factual data from Part 1 of the report and presents foundation recommendations for the proposed replacement of the existing Gull River culvert crossing Highway 811. The discussion and recommendations presented in this report are based on the information provided by Hatch and MTO and on the factual data obtained during the course of the investigation.

Thurber carried out the foundation engineering services under the MTO Retainer Agreement Number 6021-E-0005, Work Order 1, with additional foundation engineering services under Work Order 23.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The site is located on Highway 811, in the Unsurveyed Territory, District of Thunder Bay, Ontario.

The available base plan drawing provided by Hatch indicates that the existing structure consists of three horizontal elliptical structural plate corrugated steel pipes (SPCSP); each measuring 3.1 m wide, 2.1 m high and 16.8 m long. The culvert pipes span an overall distance of approximately 11 m. The culvert invert at each existing pipe is at approximate Elevation 447.2 m.

Highway 811 is a gravel road with an existing grade level of approximate Elevation 451 m at the culvert location. The highway embankment is approximately 3 to 4 m high, with 1.7 m of fill above the culvert pipes. As seen in Photo 5 in Appendix D, the inlet of the existing culvert pipes was partially obstructed by fallen timber. The local river water level was reportedly measured at Elevation 447.6 m on July 5, 2018.

11. CULVERT REPLACEMENT

11.1 Summary of Subsurface Conditions

In general, the subsurface conditions encountered in the boreholes at this site consisted of typically compact sand embankment fill with some silt to silty and trace to some gravel, which was underlain by native deposits of compact to very dense silty sand to sand, silt till, and sand and gravel, with some zones of sandy silt mixed with peat and organics. The overburden soils were underlain by tonalite bedrock at depths from 2.4 to 10.6 m.

The groundwater level in the open boreholes and monitoring wells ranged from approximate Elevation 447.4 to 449.4 m. The local river water level was measured at Elevation 447.6 m on July 5, 2018.

11.2 Culvert Replacement Alternatives

The following types of structures were considered for replacement of the existing 3 culvert pipes:

- Option 1 – Concrete box (closed) culvert, twin cell, composed of pre-cast segments on a shifted alignment and constructed in the wet,
- Option 2 – Single-span panelized modular bridge, approximately 30.5 m long span, founded on H-piles socketed into bedrock Cast in place open footing culvert,
- Option 3 – Single-span modular girder bridge, approximately 30 m long span, founded on H-piles socketed into bedrock, and
- Option 4 – Single-span pre-cast concrete deck on steel girder bridge, approximately 30 m long span, founded on H-piles socketed into bedrock.

A preliminary draft General Arrangement (GA) drawing for the box culvert replacement alternative and draft schematic drawings for the bridge alternatives were provided by Hatch and are included in Appendix H for reference. For the bridge options, H-Piles founded in pre-drilled bedrock sockets are recommended over driven piles which may not achieve sufficient penetration due to the presence of the shallow / sloping bedrock surface. Therefore, the limited pile length will not provide sufficient lateral resistance and stability of the piles. Spread footings on engineered fill

pads were also considered for the bridge abutments, however the load demand for these options would exceed the available bearing capacity of the foundation soils at shallow depths. Conventional spread footings founded below the frost penetration depth would require deeper excavations below the groundwater level. A summary comparison table of the culvert replacement foundation alternatives based on their respective advantages and disadvantages and relative costs is provided in Appendix E.

From a foundations and constructability perspective, the concrete box culvert option on a shifted alignment and constructed in the wet is preferred over the bridge options on piled foundations, based on the following summary of advantages and disadvantages:

- If constructed in the wet, the pre-cast concrete box culvert would involve less dewatering for excavations in cohesionless soils below the groundwater level;
- The pre-cast concrete box culvert installed on a shifted alignment allows for one of the existing CSP pipes to be utilized for temporary river flow diversion during construction;
- The bridge options founded on piles socketed into bedrock will require dewatering for excavations to install cast-in-place concrete pile caps below the frost penetration depth and the groundwater level unless additional frost protection could be provided;
- Construction of the pre-cast concrete box culvert option is more conventional and cost effective than the bridge options founded on socketed piles.

Although all of the above options are considered feasible from a foundations perspective, the pre-cast concrete box culvert, constructed in the wet on a shifted alignment is considered to be the preferred option. For construction staging purposes, a temporary modular bridge would be utilized for installation of the box culvert option.

Foundation recommendations for the pre-cast concrete box culvert option and the socketed pile bridge foundation options are provided in Sections 12 and 13 below.

12. PRE-CAST CONCRETE BOX CULVERT

12.1 Foundation Design for Culvert

The invert level of the existing culvert pipes is approximate Elevation 447.2 m.

Based on the draft GA drawing provided by Hatch, the twin pre-cast concrete box culvert option (Option 1) is approximately 27.2 m long, with twin cells having 4.8 m wide by 3.0 m high opening

sizes. The proposed underside of the box would be founded at an approximate Elevation of 446 m.

The replacement culvert is proposed to be installed along a shifted alignment, with the centreline located approximately 5.7 m west of the existing culvert centreline. No grade raise is currently planned for this option, however a minor grade raise of approximately 100 to 200 mm (and associated minor embankment widening) may be considered in the detailed design stage if necessary to accommodate steel beam guide rails. In order to maintain a single lane of traffic during construction of the culvert, construction staging utilizing a temporary modular bridge (TMB) is proposed. During construction, the existing east culvert pipe is proposed to be used for temporary river flow diversion. A temporary protection system is proposed to support the diversion pipe during excavation and installation of the box culvert. Due to the large anticipated groundwater volumes for dewatering to below the base of the excavation at this site, construction in the wet is proposed for the box culvert option.

Foundation design aspects for the replacement culvert include subgrade conditions and preparation, construction in the wet, geotechnical capacities, settlement of foundation soils, lateral earth pressures, temporary modular bridge design, roadway protection system design, groundwater control, and restoration of the roadway embankment.

As surficial organics and silt mixed with peat was encountered in several boreholes, including Boreholes 22-02 and 22-04 near the proposed replacement culvert alignment, with buried organics found in other parts of the site (Borehole 22-08), construction of the replacement culvert should include removal of any surficial or buried peat or organic soils encountered within the new footprint if practical prior to placing the new culvert.

12.2 Subgrade, Bedding Preparation and Construction in Wet Conditions

Replacement of the culvert with a concrete box culvert on a shifted alignment is considered a viable alternative for this site. It is anticipated that the subgrade soils within the culvert footprint will not be subjected to significant additional loading due to the culvert replacement.

As fully dewatering the cohesionless soils below the groundwater level is not expected to be practical at this site, involving a large volume of water to be dewatered, it is anticipated that constructing in wet conditions will be required for the culvert installation, including subgrade preparation, culvert bedding and backfilling. This approach will still require diversion of the river flow and surface water so that the excavations can be done within stagnant water. Pumping to remove groundwater seepage up to the daily flow allowance (see Section 17) should also be used

to lower the groundwater level in the excavation as much as possible for bedding placement. If the water level cannot be lowered below the culvert bedding level, then select rock fill or clear stone should be used for bedding. The minimum thickness of rock fill or clear stone bedding should be 300 mm (recommended 450 mm).

The recommended gradation of select rock fill placed below the water level is as follows:

Sieve Size	Percent Passing (%)
150 mm	100
106 mm	50 – 100
75 mm	15 – 80
26.5 mm	0 – 15
0.075 mm	0 - 2

Alternatively, a coarse 53 mm clear stone, as per OPSS.PROV 1004 could be used for backfilling in the wet below the culvert. To help provide a level surface for placement of the box culvert, OPSS.PROV 1004 19 mm Type II clear stone may be used for the top 150 mm of bedding placed below the water level.

Once the rock fill or clear stone backfill is above the water level, granular bedding for the culvert may be placed in the dry. The granular bedding placed above the water may consist of OPSS.PROV 1010 Granular A, Granular B Type II or OPSS.PROV 1004 19 mm Type II clear stone. The granular bedding should be placed in the dry so that it can be compacted as per OPSS.PROV 501.

The base of the bedding should be placed on the native compact to very dense silty sand to sand at an approximate Elevation of 445.5 m. Any peat, organic soil, excessively soft or very loose soil, large cobbles and boulders, or other deleterious material encountered within the footprint of the replacement culvert during subgrade preparation should be sub-excavated and replaced by select rock fill or clear stone up to the underside of the bedding material to provide a uniformly competent subgrade condition.

Adequate preparation of the subgrade will be essential for performance of the culvert. A separation layer consisting of a non-woven geotextile should be placed between the native foundation soils and the overlying rock fill or clear stone. The geotextile should meet the specifications for the OPSS.PROV 1860 Class II, and have a fabric opening size (FOS) not greater than 212 µm. The bedding should be completely wrapped with the geotextile to minimize migration of the fines into the rock fill or clear stone.

Rock fill used below the water level may be placed by end dumping. Granular fill must not be used to backfill excavations below the water level. The rock fill placement below the water level should follow OPSS.PROV 209 (Embankments over Swamps and Compressible Soils).

Rock fill placed above the water level should be placed in a controlled manner (not end dumped) including blading, dozing and chinking of the rock to minimize voids and bridging. Rock fill above the water level must be compacted as per OPSS.PROV 206. Where granular fill or bedding material is to be placed over rock fill, the rock fill subgrade must be blinded with spall material and rock fill chinking shall be in accordance with OPSS.PROV 206. All granular fill must be compacted as per OPSS.PROV 501.

12.3 Geotechnical Resistances

The following geotechnical resistances are recommended for the design of the approximately 10 m wide pre-cast twin cell concrete box culvert width founded at approximate Elevation 445.5 m on the compacted bedding underlain by compact to very dense silty sand to sand:

Table 12.1 Recommended Geotechnical Resistances for Concrete Box Culvert

Geotechnical Resistance	10 m Wide Twin-Cell Culvert
Factored Geotechnical Resistance at ULS	175 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	135 kPa

A consequence factor of 1.0 was utilized in estimating the geotechnical resistance, adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The above geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with CHBDC 2019, Clause 6.10.5.3.

Resistance to sliding between the concrete and the underlying rock fill or clear stone bedding material should be calculated assuming an ultimate coefficient of friction of 0.55. A resistance factor of 0.8 should be applied to this ultimate value.

The culvert should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

12.4 Settlement

The replacement culvert will be constructed on a shifted alignment with a larger opening size than the existing culvert pipes. No grade raise is currently planned, however a minor grade raise of approximately 100 to 200 mm and associated minor embankment widening may be considered in the detailed design stage. The existing east pipe will be abandoned following its use as temporary river diversion pipe, and therefore some fill or grout is anticipated to be added to replace the void left from the pipe location. Based on the native soils below the existing and proposed replacement culvert location consisting of compact to very dense silty sand to sand, silt till, and sand and gravel, post-construction settlement due to the culvert replacement and existing pipe abandonment is expected to be minimal. Provided that any peat or organic soils are removed from below the footprint of the replacement box culvert, the foundation settlement is expected to be less than 25 mm, which would be completed by the end of construction.

13. BRIDGE ABUTMENTS ON PILES SOCKETED INTO BEDROCK

13.1 Geotechnical Resistance for Socketed H-Piles

For the bridge replacement options (Options 2 to 4), the abutments could be founded on H-Piles founded in pre-drilled bedrock sockets. Driven piles may not achieve sufficient penetration due to the shallow / sloping bedrock surface. The depth to bedrock ranges from 4.4 to 10.6 m near the west abutment and from 2.4 to 9.0 m near the east abutment. Piles driven to the bedrock surface or higher if refusal on boulders occurs are anticipated to be too short to satisfy lateral pile stability. Therefore, the H-Piles should be socketed a minimum of 1.5 m into the bedrock surface to satisfy lateral pile stability. The depth of sockets may be larger to satisfy the required lateral pile stability and lateral resistance. This socket depth should be checked by the bridge designer. The factored Geotechnical Resistances and the estimated tip elevations recommended for HP 310x110 piles installed in pre-drilled bedrock sockets are presented below in Table 13.1:

Table 13.1 Recommended Axial Geotechnical Resistances for Steel HP 310x110 Piles

Foundation Element	Approximate Bedrock Depth / Elevation Below Existing Ground (m)	Factored ULS Geotechnical Resistance Per Pile (kN)	SLS Resistance (kN)
West Abutment (22-02, 22-04, 22-05)	4.4 to 10.6 / 445.2 to 440.2	2,600	Does not govern
East Abutment (22-01, 22-03, 22-06)	2.4 to 9.0 / 445.7 to 442.0	2,600	Does not govern

The actual pile tip elevations may vary during installation due to the potential sloping bedrock.

The axial resistances based on the bedrock strength are expected to exceed the factored structural capacity of the pile. Accordingly, the structural capacity of the HP 310x110 (2,000 kN per pile) will govern the design.

The SLS condition will not govern the design of piles founded on bedrock.

The structural resistance of the pile must be checked by the structural designer.

Since there is only minor grade raise and embankment widening proposed, downdrag on the piles is not considered to be an issue at this site.

13.2 Pile Installation

Pile installations must be in accordance with OPSS.PROV 903.

The steel H-piles must be installed in bedrock sockets that are clean and free of drilling cuttings or other debris. The method of installation of the piles in order to achieve a clean socket is the responsibility of the Contractor. The Contractor's drilling method must be capable of dislodging, removing or penetrating obstructions such as cobbles and boulders in the fill and native soils, and particularly in the sand and gravel overlying the bedrock. Care must be exercised while drilling into the bedrock. The drilling methodology used must be capable of advancing the pile sockets without disturbing or fracturing the bedrock at the base or sides of the sockets. The strength and hardness of the strong to very strong bedrock must also be taken into account when selecting the drilling equipment.

The cohesionless soil above the bedrock is susceptible to disturbance under conditions of unbalanced hydrostatic head, and measures must be taken to maintain base and sidewall stability during installation and prevent collapse/washing of cohesionless soils into the rock sockets.

Accordingly, a temporary liner or other methods may be required for stabilization of the drilled holes prior to installation of the piles. Selection of the drilling methods and equipment to this effect is the responsibility of the Contractor.

The annular space between the rock socket walls and pile shafts should be filled with 35 MPa concrete or grout to the top of the bedrock surface. The verticality and alignment of the piles must be maintained during concreting. During and subsequent to installation, the pre-drilled pile holes may become partially filled with water and it may not be practical to dewater the holes prior to concreting. Therefore, tremie concreting may be required for filling the rock sockets around the H-piles.

13.3 Pile Lateral Resistance

The ultimate passive resistance that can be mobilized by the embedded portion of a pile socketed in the bedrock may be assumed to be a constant with depth and is given by:

$$P_p = 6 C D L$$

Where

C	=	4,000 kPa (undrained shear strength of rock mass)
D	=	Socket diameter (m)
L	=	Depth of socket in rock (m)

The depth of the pile socket should be calculated by the design engineer but should be socketed into bedrock a minimum of 1.5 m. Deeper sockets may be required to meet the lateral resistance requirement.

14. FROST COVER

The depth of frost penetration at this site is approximately 2.5 m based on OPSD 3090.100. The frost protection requirement does not apply to the concrete box culvert option. The base of any concrete pile caps for the bridge options should be provided with a minimum of 2.5 m of earth cover as protection against frost action. If the pile caps are founded above the frost penetration depth, then additional frost protection measures such as EPS foam insulation or other methods will be required below the concrete spread footings at this site.

Spread footings founded on granular engineered fill pads for the temporary modular bridge, provided the fill pads consist of non-frost susceptible, free draining engineered fill and are above the river water level, should be provided with a minimum embedment of 0.5 m. These footings do not need to be placed below the depth of frost.

Frost treatment / tapers should be in accordance with 803.010 for a box culvert replacement. As the depth of the existing sand fill near the limits of the culvert excavation ranges from 2.7 to 3.0 m in Boreholes 22-07 and 22-08 respectively, the need for new frost tapers is not anticipated for open-cut construction.

15. BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the concrete culvert or behind the bridge abutments should be placed in accordance with OPSS.PROV 902. All backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II or Type III conforming to the requirements of OPSS PROV 1010. For culvert construction in wet conditions, as described in Section 12.2, the culvert backfill above the bedding level should consist of 53 mm diameter clear stone if placed below the water level, and OPSS PROV 1010 Granular A or B Type II or Type III if placed above the water level. Reference should be made to the backfill arrangements stipulated in OPSD 803.010 for culvert backfill and OPSD 3101.150 for bridge abutment backfill and CHBDC, as appropriate. All fills should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. Compaction of the granular materials will not be feasible below the water level. Where culvert backfill is placed below water, compaction should not commence until the backfill has been placed to approximately 500 mm above the water level. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof of the culvert. Compaction equipment to be used adjacent to the culvert or bridge abutments should be restricted in accordance with OPSS.PROV 501.

Lateral earth pressures acting on the structure may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2019, but are generally given by the expression:

$$p_h = K (\gamma h + q)$$

where,	p_h	=	horizontal pressure on the wall at depth h (kPa)
	K	=	earth pressure coefficient (see table below)
	γ	=	bulk unit weight of retained soil (see table below)
	h	=	depth below top of fill where pressure is computed (m)
	q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert or abutment walls are dependent on the material used as backfill. Typical values are shown in Table 15.1 below.

Table 15.1 Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Type III $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$		OPSS Clear Stone $\phi = 39^\circ$; $\gamma = 19 \text{ kN/m}^3$
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill
Active, K_A (Unrestrained Wall)	0.27	0.40*	0.31	0.48*	0.23
At-rest, K_0 (Restrained Wall)	0.43	0.62	0.47	0.70	0.37
Passive, K_P	3.7	-	3.2	-	4.4

* For abutment walls, if required

Note: Submerged unit weight should be used below the groundwater level/high river level.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decrease to 0 kPa at a depth of 1.7 m for Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.

16. EXCAVATION AND GROUNDWATER CONTROL

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the sand embankment fill and the native silty sand to sand and sandy silt mixed with organics at this site are classified as a Type 3 soil above the water table. Below the water table (i.e., if the groundwater flow is not controlled), these soils would be classified as Type 4 soils. The native silt till and sand and gravel below the water table are also classified as Type 4 soils. Although the soils above the water table are classified as Type 3, the stability analyses for the temporary excavations (see Section 22) indicate that 1H:1V temporary excavation slopes are not recommended.

Excavations for the box culvert or bridge abutment construction must be carried out in accordance with OPSS.PROV 902 and SP109S61. Excavations will be carried out through the existing fill,

native silt mixed with peat and organics, and native silty sand to sand that contains occasional cobbles. It should be noted that obstructions such as cobbles and boulders may be encountered within the fill and the native sand and gravel. Suggested wording for an NSSP on obstructions is included in Appendix F.

Selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment, and interpretation of the site conditions.

It is anticipated that excavation for culvert replacement will be carried out below the river water level, and diversion of the river flow will be required. Furthermore, groundwater and surface runoff will tend to seep into and accumulate in the excavations. Due to the presence of the water-bearing cohesionless soil layers, full dewatering to the base of the temporary excavations is not likely to be practical at this site. Furthermore, due to the presence of cobbles and boulders in the subsurface soils and the shallow / sloping bedrock surface, it is anticipated that watertight sheet pile cofferdam enclosures could not be driven sufficiently deep to form an effective groundwater flow cut-off for dewatering purposes. Therefore, it will likely be necessary to construct the culvert in the wet, as described in Section 12.2. Further discussion on dewatering is provided in Section 17. Please note that this option of constructing in the wet will still require some dewatering within the allowable pumping limits to lower the groundwater level as much as possible to facilitate culvert construction.

Construction of cast-in-place concrete pile caps for the bridge options or engineered fill pads and bridge footings for the temporary modular bridge (TMB) should be carried out in the dry. It is anticipated that excavations for TMB fill pads will be maintained above the approximate river water level of 448 m, and therefore the need for dewatering is not anticipated. However, any excavations that are below the water level, such as for pile cap installations below the frost penetration depth, may be very difficult to achieve as they will require dewatering to lower the water level to at least 1 m below the base of the excavation to permit construction in the dry and facilitate compaction of the backfill materials. Measures should be in place to keep the excavations free from runoff of surface water and seepage of perched groundwater at all times.

Dewatering if used must be carried out in accordance with OPSS.PROV 517 and SP517F01. The design of any dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility. A preconstruction survey is not required at this site. The dewatering design engineer and design-checking engineer must have a minimum of 5 years of experience in designing systems of a similar nature.

Dewatering if used for bridge abutment construction must remain operational and effective until the foundations are constructed.

Suggesting wording for an NSSP on Dewatering is included in Appendix F.

17. DEWATERING ASSESSMENT

Groundwater taking for construction dewatering is governed by the Ontario Water Resources Act (OWRA), Environmental Protection Act (EPA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

If the water taking rate will be greater than 50,000 L/day and less than 400,000 L/day then registration on the Environmental Activity and Sector Registry (EASR) will be required. If the water taking rate will be greater than 400,000 L/day, then a Category 3 Permit to Take Water (PTTW) will be required. On July 1, 2021, changes to EASR registrations came into effect, and storm water values no longer contribute to EASR maximum water taking rates. They are still, however, applicable to maximum water taking rates for PTTWs. A preliminary assessment of the need for water taking permitting is provided herein; however, additional analysis will be required to confirm this.

Should the concrete culvert be constructed in the wet and spread footings and engineered fill pads for the temporary modular bridge footings be founded above the river level, then the need for dewatering is not anticipated. However, for comparison purposes, two alternate options were considered for a preliminary dewatering assessment at this site. Option 1 assumes replacement of the existing culvert pipes with a twin-cell concrete box culvert. Option 3/4 assumes replacement with a permanent bridge with cast-in-place concrete piles caps, with the base founded below the frost penetration depth. In both cases, it is assumed that at least one of the existing culvert pipes will remain active to control river flow during construction and to redirect the river flow around the work area such that surface water will not enter the excavation at a significant rate. The dimensions and conditions that were assumed for the preliminary dewatering assessment are provided in Table 17.1 below. For full dewatering to the base of the temporary excavations, the geologic units that will need to be dewatered are sand fill, native silty sand to sand, native silty sand mixed with organics, peat to sand and silt mixed with peat, silt till, and sand and gravel foundation soils.

Table 17.1 Assumed Excavation Dimensions and Ground Conditions

Structure	Assumed Excavation Footprint (m)	Lowest Assumed Elevation of Excavation (m)	Assumed Groundwater Elevation (m)	Geologic Units to Dewater
Option 1 – Concrete box culvert replacement	30 x 25	445.5	448	Sand fill, silty sand to sand, sandy silt with organics, silt till, sand and gravel
Option 3/4 – Permanent bridge pile caps at frost penetration depth	14 x 6	447.5	448	Sand fill, silty sand to sand, sandy silt with organics, silt till, sand and gravel

The water taking will be temporary in nature for the purpose of construction dewatering for installation of the infrastructure. Dewatering rates were estimated using the Dupuit analytical solution. The radius of influence was calculated using the Sichardt equation. It is assumed the water level will be required to be lowered to about 1 m below the proposed excavations, in order to facilitate a dry, stable work area.

The preliminary peak water taking rates were estimated to be greater than 2,500,000 litres per day for Option 1, and greater than 1,500,000 litres per day for Option 3/4; both which include a safety factor and rainfall allowance. The preliminary radius of influence was estimated to be approximately 200 m and 100 m from the edge of the excavations, for Options 1 and 3/4 respectively.

Controlling this volume of groundwater flow would require significant dewatering effort, and a Category 3 Permit to Take Water, since the estimated peak water taking rates for both alternative options are greater than 400,000 L/day. A Hydrogeological Study would be required to provide the necessary data and analysis for application to the Ministry of the Environment, Conservation and Parks (MECP). The Hydrogeological Study will need to include an impact assessment as well as mitigation measures, a monitoring plan, and a contingency plan. The requirement for potential additional field work will need to be assessed. The duration required to receive the permit from MECP once it has been received in good order is typically 3 to 5 months, assuming no further field work or significant revisions are required.

Based on the above factors, it is recommended that consideration be given to replacing the existing culvert with the concrete box culvert option, which could be constructed in the wet. To allow for some lowering of the water level by pumping during construction, EASR registration or a PTTW may be considered for construction. In this case, the Contractor should be alerted to the need to restrict pumping to a maximum of 400,000 L/day for EASR registration, or the maximum

permitted limit if a PTTW is acquired. An NSSP in this regard is included in Appendix F. A water-taking report will be required for EASR registration if pumping between 50,000 and 400,000 L/day of groundwater is intended. A Hydrogeological Study and report will be required to support a PTTW application if pumping greater than 400,000 L/day of groundwater is intended.

18. WATER QUALITY

For preliminary screening of the general groundwater quality in the project area, a sample of the groundwater from the monitoring well at Borehole 22-05 was collected. As noted in Section 7, the water sample was tested, and the results were compared to the Ontario Provincial Water Quality Objectives (PWQO). A filtered sub-sample was also tested for dissolved metal parameters for comparison purposes. The water sample test results are summarized in Table 7.1.

The test results indicate that eight of the metals parameters tested exceeded the PWQO criteria for total concentrations. Testing of a filtered sample to remove Total Suspended Solids (TSS) indicated reduced metals concentrations for the dissolved solution, however six parameters exceeded the PWQO criteria.

If dewatering is used at this site, the groundwater should not be discharged to surface water without pre-treatment or additional testing due to the observed presence of parameters that exceed the PWQO criteria. Given that the site is in a primarily undeveloped area where contamination from industrial or commercial processes is not expected, discharge to the land surface may be considered. Typically, this would require that the discharge water does not contain significant TSS (less than 25 mg/L), and that the discharge point is located at least 30 m away from the river, where it will infiltrate and ultimately return to the watercourse.

If dewatering is used at this site, additional testing and assessment would be required to confirm the water quality and determine the appropriate groundwater discharge options and treatment methods. Additional water samples may also need to be collected and tested during construction to monitor the quality of discharge water to meet PTTW requirements.

19. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. Based on the presence of generally compact to dense fill and native soils, and relatively shallow bedrock, the site is classified as Seismic Site Class C in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2,475-year return period seismic event (2% probability

of being exceeded in 50 years) at this site is 0.051 g as per the National Building Code of Canada (NBCC 2020).

The coefficients of horizontal earth pressures for seismic loading on walls assuming a level backfill, a Site Class C, and a reference PGA of 0.051 are presented in Table 19.1 below. The vertical acceleration coefficient k_v has been ignored ($k_v = 0$).

Table 19.1 Seismic Earth Pressure Parameters

Loading Condition	Horizontal Acceleration Coefficient, k_h	Seismic Earth Pressure Coefficients (K_{AE})	
		OPSS Granular A or Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I (modified) or Type III $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$
Active (Unrestrained Wall)	0.026	0.28	0.32
Active (Restrained Wall)	0.051	0.30	0.34

In view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

20. TEMPORARY PROTECTION SYSTEM

Temporary roadway protection systems may be utilized for staged construction to support the existing culvert pipes and the temporary modular bridge footings. Roadway protection should be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2. Options for roadway protection are a drilled-in soldier pile and lagging system, or interlocking sheet piles. Due to the presence of dense to very dense native soils containing cobbles and boulders at this site, sheet piles may have limited penetration. A lateral restraining system may be required to provide additional shoring support for sheet piles. A soldier pile and lagging system may require the piles to be socketed into bedrock, depending on the required depth of penetration. The soil parameters in Table 20.1 may apply for the design of the temporary roadway protection system with horizontal backfill.

Table 20.1 Soil Parameters for Temporary Protection System Design

Soil Parameter	Existing Sand Fill	Native Silt Mixed with Organics	Native Silty Sand to Sand and Silt Till	Native Sand and Gravel
Φ (angle of internal friction)	30°	25°	33°	34°
γ (total unit weight)	20 kN/m ³	19 kN/m ³	21 kN/m ³	22 kN/m ³
γ_w (submerged unit weight)	10 kN/m ³	9 kN/m ³	11 kN/m ³	12 kN/m ³
K_a	0.33	0.41	0.30	0.28
K_p	3.0	2.5	3.4	3.5

The design of the temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors have to be considered when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system. The designer of the roadway protection system should consider the presence of an uneven or sloping bedrock surface at this site, and check whether the depth of sheet piles or soldier piles, if utilized, is sufficient to provide base fixity.

21. TEMPORARY MODULAR BRIDGE

21.1 Founding Level

A temporary modular bridge (TMB) is proposed for traffic staging purposes during construction of the replacement box culvert option. Based on discussions with Hatch, it is understood that the TMB would be located at the north shoulder of the westbound lane (outlet end of the culvert) and is only required during the first stage of the culvert construction for the replacement inlet. To accommodate the approximately 6 m wide TMB width, some temporary embankment widening is anticipated on the north side behind the TMB abutments. The design of the temporary bridge is the responsibility of the contractor. The contractor must retain a Professional Engineer, experienced in bridge design, to design the temporary bridge.

The modular bridge may be supported on pre-cast concrete bearing pads founded on 1 m thick engineered granular fill pads. The base of the 1 m thick engineered fill pads may be placed on the existing compact to loose sand embankment fill at an Elevation of 449 m or lower, but preferably above the river level of approximate Elevation 448 m, in order to minimize the need for dewatering during fill pad construction. Although the TMB footings are likely to be founded within the existing embankment fill, it should be noted that some silt with peat and organics was encountered at the toes of the existing embankment near both proposed TMB abutments at or below approximate Elevation 448 m. Care must be taken during footing construction to inspect the subgrade soils and sub-excavate and replace any organic material encountered prior to placing the engineered fill pads.

21.2 Engineered Fill Pad Construction

The 1 m thick engineered fill pads should consist of OPSS Granular A or Granular B Type II, placed in 150 mm thick lifts and compacted to 100% of the SPMDD at $\pm 2\%$ of Optimum Moisture Content (OMC).

The footing width should be approximately 2.5 to 3.0 m (minimum 2.5 m) and the forward slope of the foundation pads should be embedded at least 0.5 m below the face of the forward excavation slope. The front edge of the footing should be set back a minimum of 2 m behind the crest of the temporary excavation slope at the top of the footing level. The dimensions of the base of the fill pad excavations should be determined by assuming a granular fill pad that is 1.0 m wider than the spread footing at the level of the footing base and projecting outward and downward at 1H:1V for the side slopes of the pad.

The forward slopes of the temporary excavation in front of the TMB footings should be inclined at no steeper than 2H:1V above the water level and 3H:1V below the water level. Stability of the forward slopes is described in Section 22 below. The temporary excavation slopes for the modular bridge must be protected from erosion by covering the slopes with tarp.

21.3 Geotechnical Resistances

The following geotechnical resistances in Table 21.1 are recommended for design of approximately 2.5 to 3.0 m wide concrete spread footings placed on minimum 1 m thick engineered fill pads prepared as outlined above with the underside of the pads at or below Elevation 449 m:

Table 21.1 Geotechnical Resistances for Footings on Engineered Fill Pads

Geotechnical Resistance	2.5 to 3.0 m Wide TMB Spread Footing
Factored Geotechnical Resistance at ULS	125 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	85 kPa

The lateral resistance of the concrete footings founded on Granular A or B Type II engineered fill may be computed using an unfactored friction coefficient of 0.55. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance. A resistance factor of 0.8 should be applied to this ultimate value.

The above Geotechnical Resistances assume the footings are embedded a minimum of 0.5 m below the ground surface surrounding the footings.

It is recommended that the contractor retain a geotechnical consultant who is RAQs qualified at the medium complexity level (RAQs Category – Geotechnical Structures and Embankment – Medium Complexity) to design the footings and stable slopes in front of and beside the footings for the temporary modular bridge. All final reports and drawings must be sealed and signed by a Professional Engineer, who shall also be a RAQs Designated Contact. An NSSP for this effect is attached in Appendix F.

22. STABILITY OF TEMPORARY EXCAVATION SLOPES

Slope stability analyses were conducted to assess the temporary excavation forward slopes and the required footing setback distance in front of the proposed temporary modular bridge (TMB) abutments. The analyses assume minimum 2.5 m wide footings on 1 m thick engineered fill pads; founded at approximate Elevation 449 m. The forward slopes in front of the abutments are inclined at 2H:1V above the groundwater level and 3H:1V below the groundwater level (assumed groundwater level at Elevation 448 m with only limited dewatering). The results of the stability analyses are included in Appendix G. For a typical degree of understanding, a Factor of Safety of approximately 1.3 is considered to be acceptable for global stability of temporary embankment slopes.

Figures 1 and 2 assume the footings are set back a distance of 2 m beyond the crest of the forward slopes. For an applied footing SLS load of 85 kPa, the Factors of Safety against slope instability are 1.45 and 1.32 at the west and east TMB abutments respectively. Accordingly, it is

recommended that the footings be set back 2 m from the crest of the forward slopes and that the footings be sized to limit the footing pressure to 85 kPa.

The stability of the forward slopes will rely on proper steps being taken to mitigate erosion as described in Section 24.

Assessment of temporary excavation slopes for installing the culvert in wet conditions where the TMB is not in place was also carried out. The results of the stability analyses are included in Appendix G. Figures 3 and 4 show that temporary excavation slopes of 3H:1V below the groundwater level and 1H:1V above the groundwater level have a Factor of Safety against slope failure of approximately 0.7, and therefore are not acceptable. In order to achieve a Factor of Safety of 1.3 for stability of the temporary excavation slopes, above the groundwater level the slopes should be inclined at no steeper than 2H:1V, as shown on Figures 5 and 6 for the west and east excavation slopes respectively.

Suggested wording for an Operational Constraint on Temporary Excavation Slopes is included in Appendix F.

23. APPROACH EMBANKMENTS

The existing Highway 811 embankment is approximately 3 to 4 m in height with side slopes inclined at approximately 2H:1V or flatter. Depending on the final replacement option (culvert or bridge), a minor grade raise of approximately 500 mm or less may be necessary at the approach embankments. With a potential grade raise of less than 500 mm, settlement of the foundation sand and silts is estimated to be less than 25 mm, which is expected to be completed by the end of construction.

A slope stability analysis was conducted for the 2H:1V embankment side slope adjacent to the temporary modular bridge footing during staged construction. Figure 7 in Appendix G assumes the temporary footing is set back 0.5 m from the crest of the temporarily widened side slope. For an applied footing SLS load of 85 kPa, the Factor of Safety against slope instability is 1.3 and therefore is acceptable for the temporary slope.

For the permanent reinstated embankment side slopes constructed of new backfill after the culvert has been replaced, Figure 8 shows a Factor of Safety of 1.78 for 2H:1V slopes with a traffic loading of 17 kPa. A Factor of Safety of approximately 1.5 is considered to be acceptable for global stability of permanent embankment slopes for a typical degree of understanding.

The restored embankment beyond the replacement structure should be reinstated at the existing slope inclination, but no steeper than 2H:1V. Soils generated from removal of the culvert should not be used for reinstatement of the embankment.

The stability of the embankment slopes will rely on proper steps being taken to mitigate erosion as described in Section 24.

Embankment restoration after completion of the replacement culvert construction should be carried out in accordance with OPSS.PROV 206. The embankment material may consist of imported Granular A, Granular B Type II, or Granular B Type III material.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert footprint or bridge abutment foundations, and within the embankment footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel should be conducted.

24. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet, or to prevent loss of soils in front of the abutment walls for the bridge options. Appropriate erosion protection must also be provided for temporary slopes in front of temporary modular bridge footings if used.

Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field in accordance with OPSS 810.010, OPSS.PROV 511 and OPSS.PROV 1004.

Typically, rock protection should be provided over all surfaces with which river water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS.PROV 804.

A concrete cut-off wall and a clay seal (only at the inlet) should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

Selection of streambed material should be in accordance with OPSS.PROV 1005.

25. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate content analytical tests conducted on the soil and surface water samples indicate the following conditions at the locations tested:

- The potential for corrosion on metal or concrete foundations from the surrounding sand fill or surface water is considered to be mild due to the low concentrations of sulphate and chloride in the samples tested. The effect of road deicing salt should be considering while selecting the class of concrete.
- The potential for sulphate attack on concrete from the surrounding soil or surface water is considered to be negligible due to the low sulphate concentration in the samples tested.
- Appropriate protection measures are recommended for metal or concrete structural elements. The effect of road deicing salt should be considered while selecting the corrosion protection measures.

26. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- As existing sandy silt mixed with peat and organics was encountered in the vicinity of the proposed box culvert and bridge abutment options, care must be taken during culvert or footing construction to inspect the subgrade soils and sub-excavate and replace any organic material encountered within the culvert or foundation footprints prior to placing the culvert bedding or constructing bridge footings.
- The water level in the river may fluctuate and be at a higher elevation at the time of construction than indicated in the report.
- Full dewatering to below the base of the culvert excavation may not be practical at this site and would also require a Category 3 Permit to Take Water. Accordingly, appropriate methods for constructing in the wet should be developed.
- The bedrock surface is expected to vary along the length of the culvert or pile foundations and along the roadway alignment. Bedrock may also be contacted at different depths beyond the borehole locations. Variations in the bedrock surface should be expected during installation of the structure and construction staging measures.
- Obstructions such as cobbles and boulders were noted to be present within the existing native soils, which may impede the installation of piles. An NSSP on Obstructions is provided in Appendix F.



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27. CLOSURE

Engineering analysis and preparation of the design report was carried out by Mr. Mark Farrant, P.Eng., Mr. Keli Shi, P.Eng., and Mr. Cory Zanatta, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



Mark Farrant, P.Eng.
Associate, Senior Geotechnical Engineer



P.K. Chatterji, P.Eng.
Principal, Designated MTO Contact

Date: August 1, 2024
File: 34812

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- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

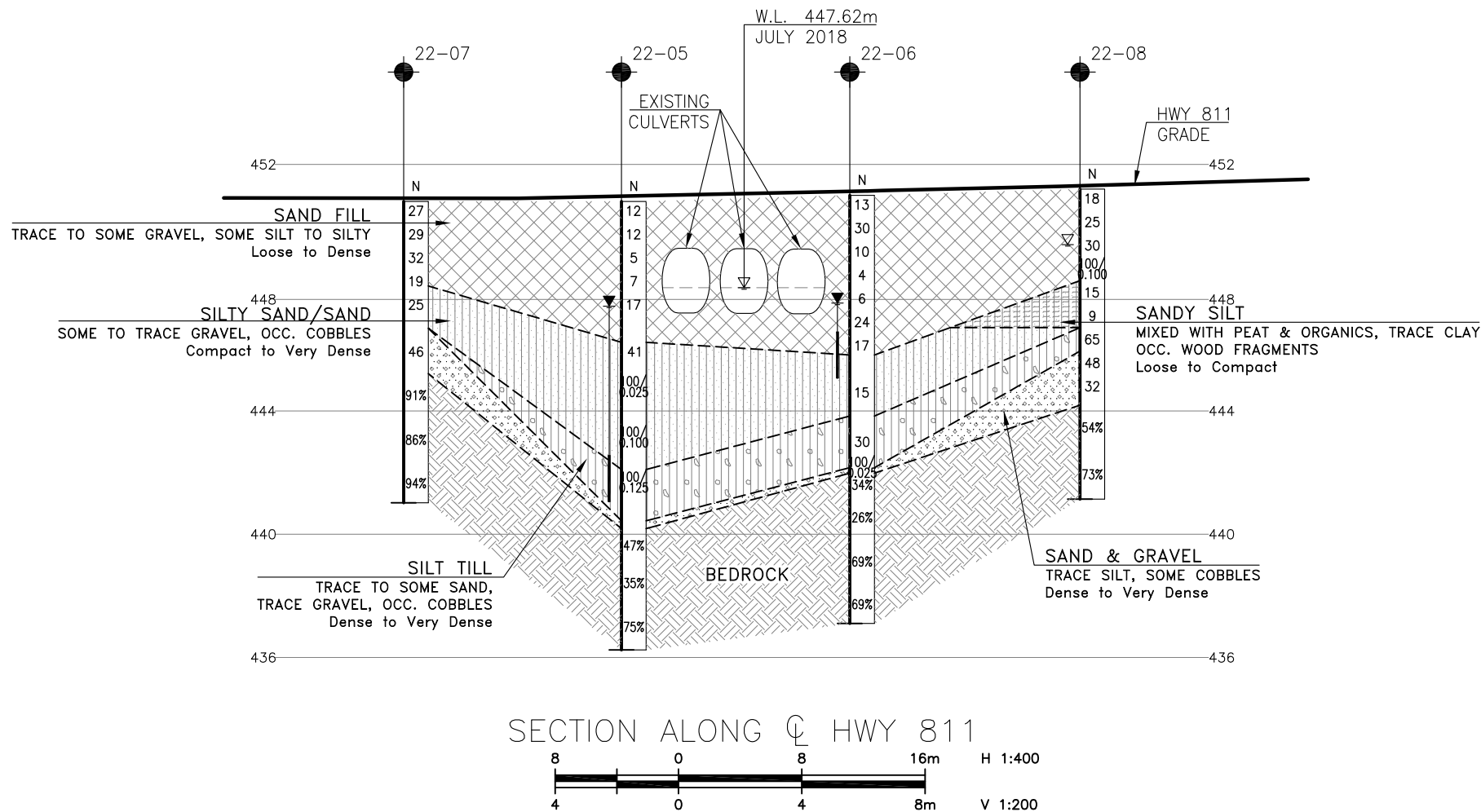
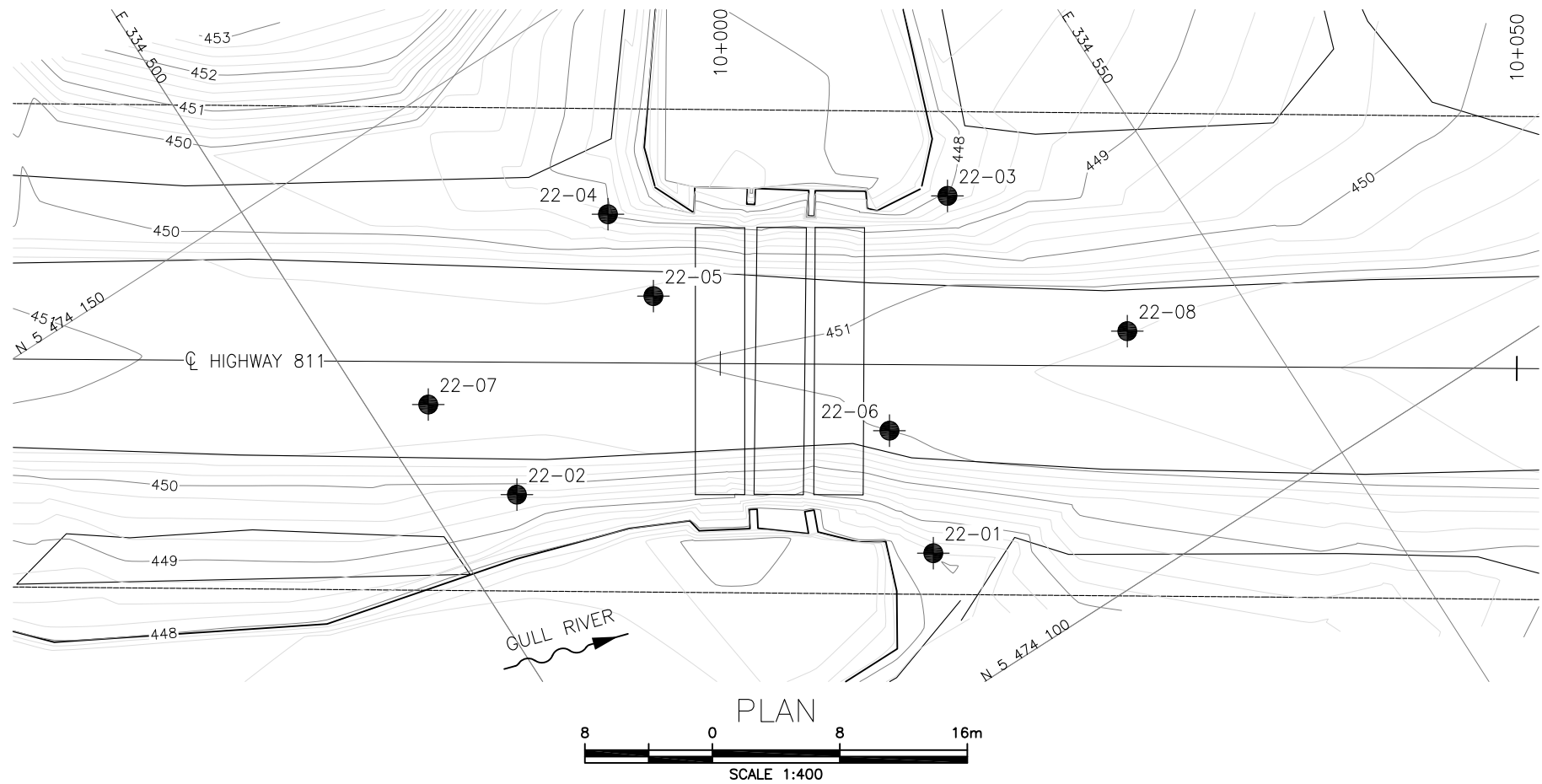
The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



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APPENDIX A

Borehole Locations and Soil Strata Drawings

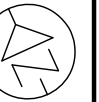


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



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GWP No 6104-17-00

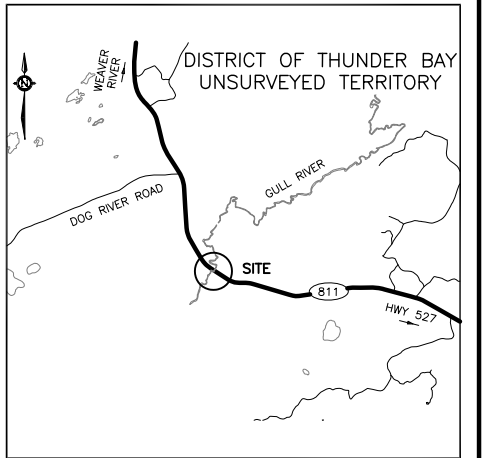
HIGHWAY 811
GULL RIVER
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



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KEYPLAN

LEGEND

●	Borehole
⊙	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⌵	Head Artesian Water
⌵	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

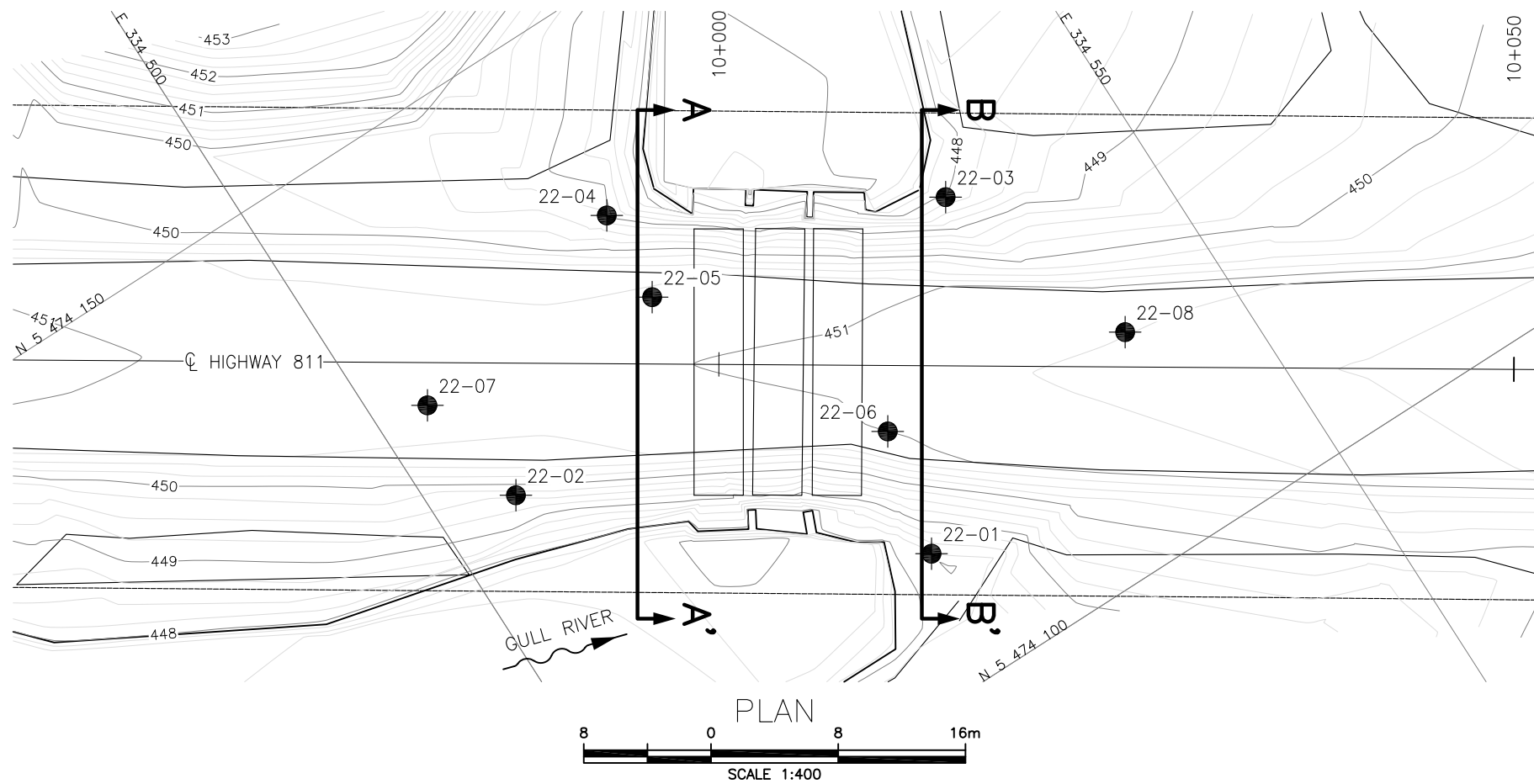
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22-02	449.6	5 474 125.7	334 505.0
22-03	448.1	5 474 126.9	334 537.9
22-04	449.1	5 474 137.5	334 519.3
22-05	450.8	5 474 131.6	334 518.9
22-06	451.0	5 474 116.5	334 526.8
22-07	450.8	5 474 133.5	334 503.3
22-08	451.2	5 474 113.7	334 542.8

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 52H05-001

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK PK	CODE
LOAD	DATE	AUG 2024	
DRAWN	AN	CHK MEF	SITE 48W-0198/CO/STRUCT
DWG	1		



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
GWP No 6104-17-00

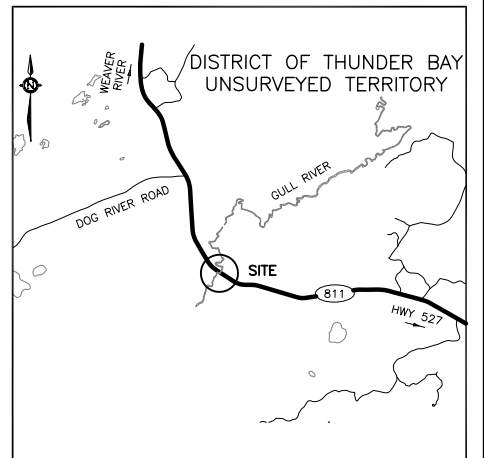
HIGHWAY 811
GULL RIVER
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

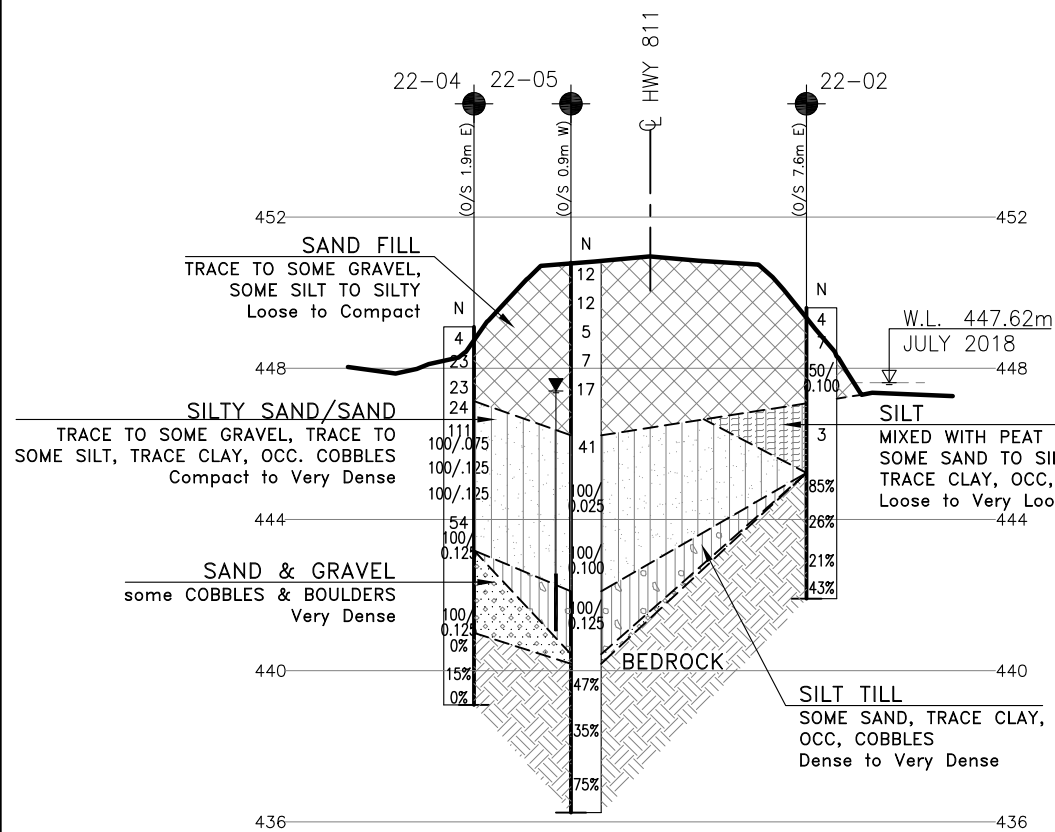
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
22-01	448.2	5 474 108.5	334 525.0
22-02	449.6	5 474 125.7	334 505.0
22-03	448.1	5 474 126.9	334 537.9
22-04	449.1	5 474 137.5	334 519.3
22-05	450.8	5 474 131.6	334 518.9
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22-07	450.8	5 474 133.5	334 503.3
22-08	451.2	5 474 113.7	334 542.8

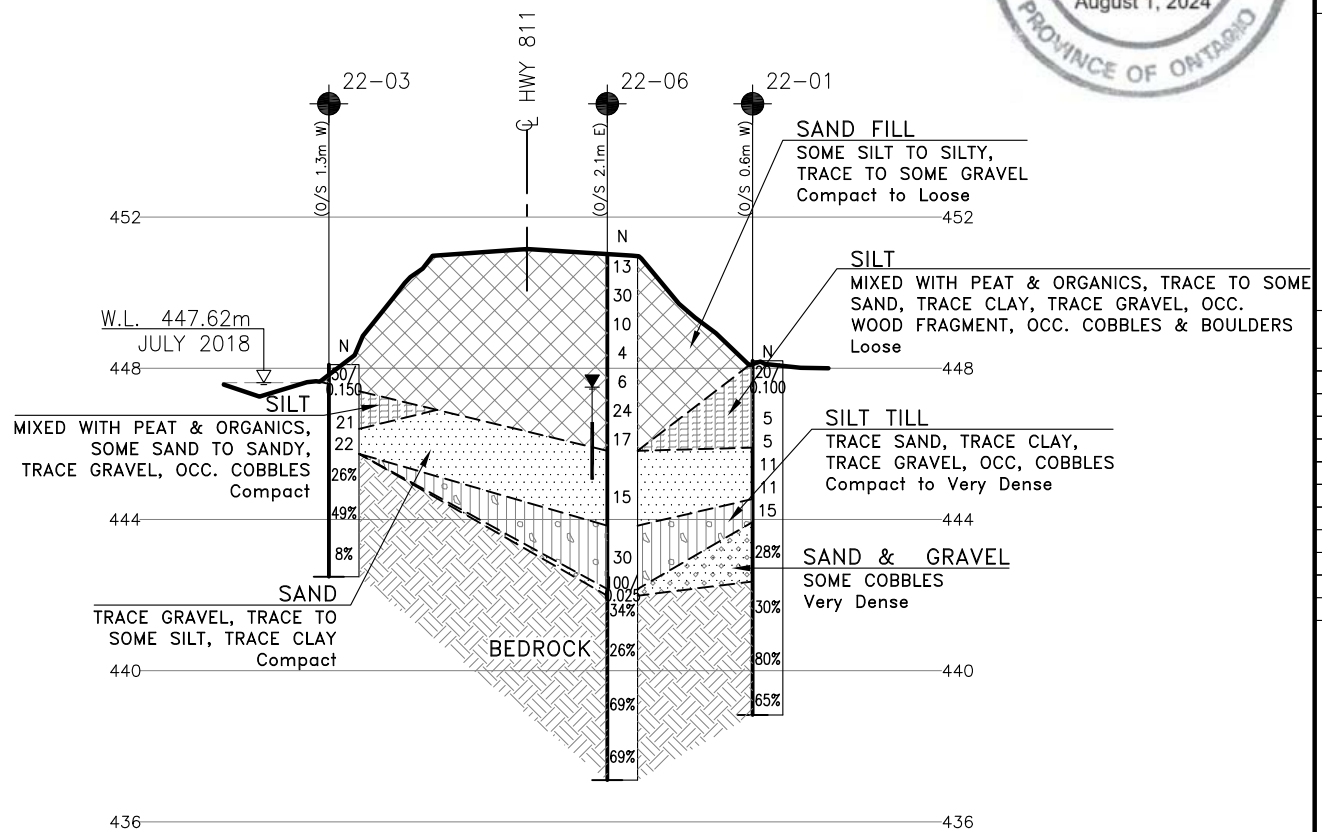
-NOTES-

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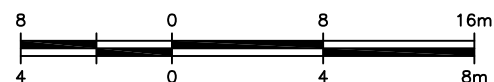
GEOCRES No. 52H05-001



SECTION A-A'



SECTION B-B'



H 1:400

V 1:200

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK PK	CODE
LOAD	DATE	AUG 2024	
DRAWN	AN	CHK MEF	SITE 48W-0198/CO/STRUCT
DWG	2		



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APPENDIX B

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$






 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No 22-01

1 OF 1

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 108.5 E 334 525.0 ORIGINATED BY IR
DIST Thunder Bay HWY 811 BOREHOLE TYPE Tripod/NQ Coring COMPILED BY AA
DATUM Geodetic DATE 2022.09.22 - 2022.09.25 LATITUDE 49.404156 LONGITUDE -89.590399 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
448.2	GROUND SURFACE						20	40	60	80	100							
0.0	TOPSOIL: (100mm)		1	SS	20/													○
0.1	SILT, mixed with peat and organics, trace to some sand, trace clay, trace gravel, occasional wood fragments, occasional cobbles and boulders Loose Brown to Black Wet				0.100													
	Cored through cobbles and boulders from 0.3m to 0.7m		2	SS	5													○
445.9			3	SS	5													○
2.3	SAND, trace gravel, trace silt, trace clay Compact Grey Wet		4	SS	11													○
444.5			5	SS	11													○
3.7	SILT, trace clay, trace sand Compact Grey Wet		6	SS	15													○
443.9	(TILL)																	
4.3	SAND and GRAVEL, some cobbles (coring required to penetrate)		1	RUN														
442.4																		
5.8	BEDROCK (FOLDED TONALITE), moderately to slightly weathered, very strong, grey/red		2	RUN														
			3	RUN														
			4	RUN														
438.8																		
9.4	END OF BOREHOLE AT 9.4m. BOREHOLE CAVED TO 7.2m. BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																	

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+³, ×³: Numbers refer to
Sensitivity 20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22-02

1 OF 1

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 125.7 E 334 505.0 ORIGINATED BY IR
DIST Thunder Bay HWY 811 BOREHOLE TYPE Tripod/NQ Coring COMPILED BY AA
DATUM Geodetic DATE 2022.10.01 - 2022.10.02 LATITUDE 49.404312 LONGITUDE -89.590673 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
449.6	GROUND SURFACE																
0.0	TOPSOIL: (200mm)																
0.2	SILT , some sand to silt and sand, mixed with peat and organics, trace clay, occasional cobbles Loose to Very Loose Dark Brown Wet <																

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22-03

1 OF 1

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 126.9 E 334 537.9 ORIGINATED BY IR
DIST Thunder Bay HWY 811 BOREHOLE TYPE Tripod/NQ Coring COMPILED BY AA
DATUM Geodetic DATE 2022.09.26 - 2022.09.27 LATITUDE 49.404321 LONGITUDE -89.590220 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
448.1	GROUND SURFACE													
0.0	TOPSOIL: (250mm)		1	SS	50/ 0.150		448							
0.2	SILT, mixed with organics and peat, some sand to sandy, trace gravel, occasional cobbles Compact Brown to Black Wet Cored through cobbles from 0.5m to 0.6m						447							
446.4			2	SS	21									
1.7	SAND, some silt, trace gravel Compact Grey Wet		3	SS	22		446							
445.7														
2.4	BEDROCK (FOLDED TONALITE), moderately to slightly weathered, very strong, grey/red Rubble zone from 2.4m to 2.7m		1	RUN			445							
			2	RUN			444							
			3	RUN			443							
442.5	Rubble zone from 5.0m to 5.2m													
5.6	END OF BOREHOLE AT 5.6m. BOREHOLE CAVED TO 2.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO THE SURFACE.													

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22-04

1 OF 2

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 137.5 E 334 519.3 ORIGINATED BY IR
DIST Thunder Bay HWY 811 BOREHOLE TYPE Tripod/NQ Coring COMPILED BY AA
DATUM Geodetic DATE 2022.09.28 - 2022.09.30 LATITUDE 49.404417 LONGITUDE -89.590475 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
449.1	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.0	TOPSOIL: (100mm)							<div><div>204060</div><div>W P W L</div><div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div></div>						
0.1	<div>SILT, some sand, trace clay, mixed with peat and organics</div> <div>Loose</div> <div>Brown</div> <div>Wet</div>		1	SS	4		449							
448.5			2	SS	23									
0.6			3	SS				448						
			4	SS	23									
447.3	<div>Silty SAND, trace gravel, trace clay</div> <div>Compact</div> <div>Brown</div> <div>Moist to Wet</div> <div>No recovery from 0.6m to 1.2m, occasional cobbles</div>													6 67 25 2
1.8	<div>SAND, trace to some gravel, trace to some silt, occasional cobbles</div> <div>Compact to Very Dense</div> <div>Grey</div> <div>Wet</div>		5	SS	24		447							
			6	SS	111									9 79 12 (SI+CL)
			7	SS	100/.075		446							
		Cored through cobbles from 3.3m to 3.7m		8	SS	100/0.125		445						
				9	SS	100/0.125								
				10	SS	54		444						
				11	SS	100/0.125								
443.2														
5.9	<div>SAND and GRAVEL, some cobbles and boulders (coring required to penetrate)</div> <div>Very Dense</div> <div>Grey</div> <div>Wet</div>						443							
441.0			12	SS	100/0.125		442							
8.1	<div>BEDROCK (FOLDED TONALITE), slightly weathered, very strong, grey/red</div>		1	RUN			441							RUN #1 TCR=100% SCR=73% ROD=0% UCS=206MPa (Avg Point Load)
			2	RUN			440							RUN #2 TCR=94% SCR=50% ROD=15% UCS=223MPa (Avg Point Load) UCS=209MPa
		Vertical fracture from 9.6m to 9.7m		3	RUN									RUN #3 TCR=88% SCR=50% ROD=0% UCS=213MPa (Avg Point Load)
439.1														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RUN #1
TCR=100%
SCR=73%
RQD=0%
UCS=206MPa
(Avg Point Load)

RUN #2
TCR=94%
SCR=50%
RQD=15%
UCS=223MPa
(Avg Point Load)

RUN #3
TCR=88%
SCR=50%
RQD=0%
UCS=213MPa
(Avg Point Load)

RECORD OF BOREHOLE No 22-04

2 OF 2

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 137.5 E 334 519.3 ORIGINATED BY IR
 DIST Thunder Bay HWY 811 BOREHOLE TYPE Tripod/NQ Coring COMPILED BY AA
 DATUM Geodetic DATE 2022.09.28 - 2022.09.30 LATITUDE 49.404417 LONGITUDE -89.590475 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
10.0	Continued From Previous Page END OF BOREHOLE AT 10.0m. BOREHOLE CAVED TO 7.4m. BOREHOLE BACKFILLED WITH BENOTNITE HOLEPLUG TO GROUND SURFACE.																

RECORD OF BOREHOLE No 22-05

1 OF 2

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 131.6 E 334 518.9 ORIGINATED BY GAS
DIST Thunder Bay HWY 811 BOREHOLE TYPE Hollow Stem Augers/Wash Boring COMPILED BY AA
DATUM Geodetic DATE 2022.08.16 - 2022.08.17 LATITUDE 49.404364 LONGITUDE -89.590481 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P W W L				
450.8	GROUND SURFACE							20 40 60 80 100						
0.0	SAND , trace to some gravel, some silt to silty Loose to Compact Brown Dry to Moist (FILL)		1	SS	12									
			2	SS	12									5 83 12 (SI+CL)
			3	SS	5									
			4	SS	7									14 64 22 (SI+CL)
			5	SS	17									
446.2														
4.6	Silty SAND , trace gravel, trace clay, occasional cobbles Dense to Very Dense Grey Wet		6	SS	41									1 65 32 2
	No recovery from SS7 due to cobbles		7	SS	100/0.025									
	Cored though cobbles from 6.1m to 6.7m													
			8	SS	100/0.100									
442.1														
8.7	SILT , some sand, trace clay, trace gravel, occasional cobbles Very Dense Grey Wet (TILL)		9	SS	100/0.125									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
20
15
10
(%) STRAIN AT FAILURE

METRIC

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 22-06

1 OF 2

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 116.5 E 334 526.8 ORIGINATED BY IR
DIST Thunder Bay HWY 811 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY AA
DATUM Geodetic DATE 2022.08.15 - 2022.08.16 LATITUDE 49.404228 LONGITUDE -89.590373 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
451.0	GROUND SURFACE							20	40	60	80	100					
0.0	SAND , some silt to silty, trace to some gravel Compact to Loose Grey and Brown Moist (FILL)		1	SS	13												13 59 28 (SI+CL)
	No recovery		2	SS	30												
			3	SS	10												
			4	SS	4												1 88 11 (SI+CL)
	No recovery Becoming wet		5	SS	6												
			6	SS	24												
			7	SS	17												
445.8																	
5.2	SAND , some silt, trace gravel Compact Grey Wet		8	SS	15												
443.8																	
7.2	SILT , trace sand, trace clay, trace gravel, occasional cobbles Dense to Very Dense Grey Wet (TILL)		9	SS	30												3 10 81 6
442.2																	
442.8	SAND and GRAVEL , some cobbles (coring required to penetrate) Very Dense Grey Wet		10	SS	100/ 0.025												
9.0	BEDROCK (FOLDED TONALITE) , slightly weathered, very strong		1	RUN													RUN #1 TCR=100% SCR=42% RQD=34%

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 22-07

2 OF 2

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 133.5 E 334 503.3 ORIGINATED BY GAS
DIST Thunder Bay HWY 811 BOREHOLE TYPE Hollow Stem Augers/Wash Boring/NQ Coring COMPILED BY MC
DATUM Geodetic DATE 2022.08.17 - 2022.08.17 LATITUDE 49.404382 LONGITUDE -89.590695 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page BOREHOLE CAVED TO 0.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND SAND TO SURFACE.													



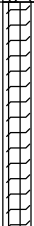



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RECORD OF BOREHOLE No 22-08

1 OF 2

METRIC

GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 113.7 E 334 542.8 ORIGINATED BY GAS
 DIST Thunder Bay HWY 811 BOREHOLE TYPE Hollow Stem Augers/Wash Boring/NQ Coring COMPILED BY MC
 DATUM Geodetic DATE 2022.08.18 - 2022.08.18 LATITUDE 49.404202 LONGITUDE -89.590153 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT					
								20	40	60			80	100	W _P	W	W _L			
451.2	GROUND SURFACE																			
0.0	SAND , some silt to silty, trace to some gravel Compact to Very Dense Brown Moist (FILL)		1	SS	18		451													
			2	SS	25		450													
			3	SS	30		449													
	Occasional cobbles		4	SS	100/ 0.100															
448.2																				
3.0	Sandy SILT , mixed with peat and organics, trace clay, occasional wood fragments Loose to Compact Black Wet		5	SS	15		448													
			6	SS	9		447													
446.7																				
4.5	SILT , some sand, trace clay Very Dense Grey Wet (TILL)		7	SS	65	446														
445.9			8	SS	48	445														
5.3	SAND and GRAVEL , some cobbles Dense Grey Wet		9	SS	32	444														
444.2			1	RUN		443														
7.0	BEDROCK (FOLDED TONALITE) , slightly weathered to fresh, very strong, grey/red Vertical fractures from 7.1m to 7.2m and 8.3m to 8.4m		2	RUN		442														

5

0

1

3

3

1

2

>10

4

3

RUN #1

TCR=100%

SCR=86%

RQD=54%

RUN #2

TCR=100%

SCR=86%

RQD=73%

UCS=217MPa

(Avg Point Load)

UCS=188MPa

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22-08

2 OF 2

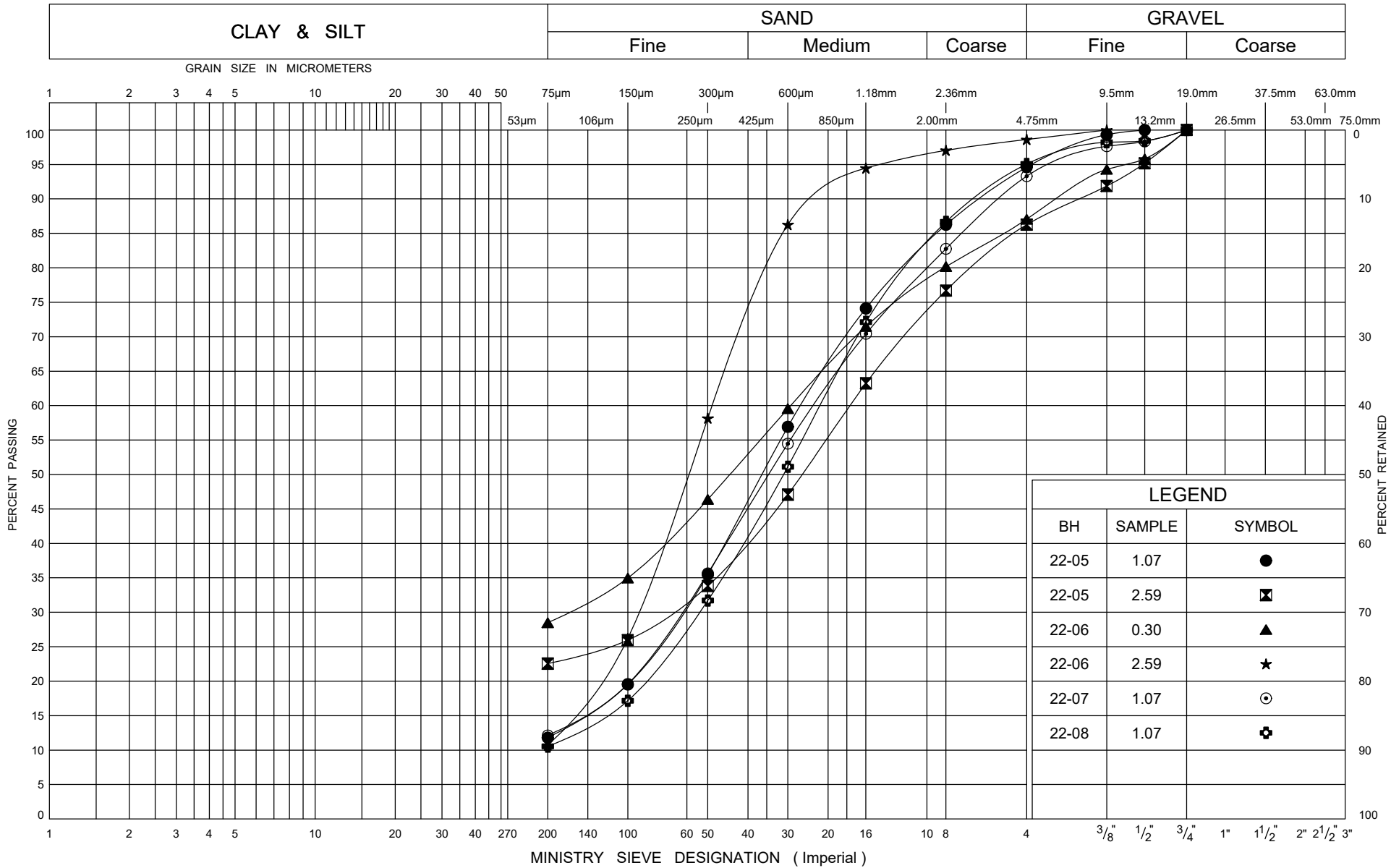
METRIC

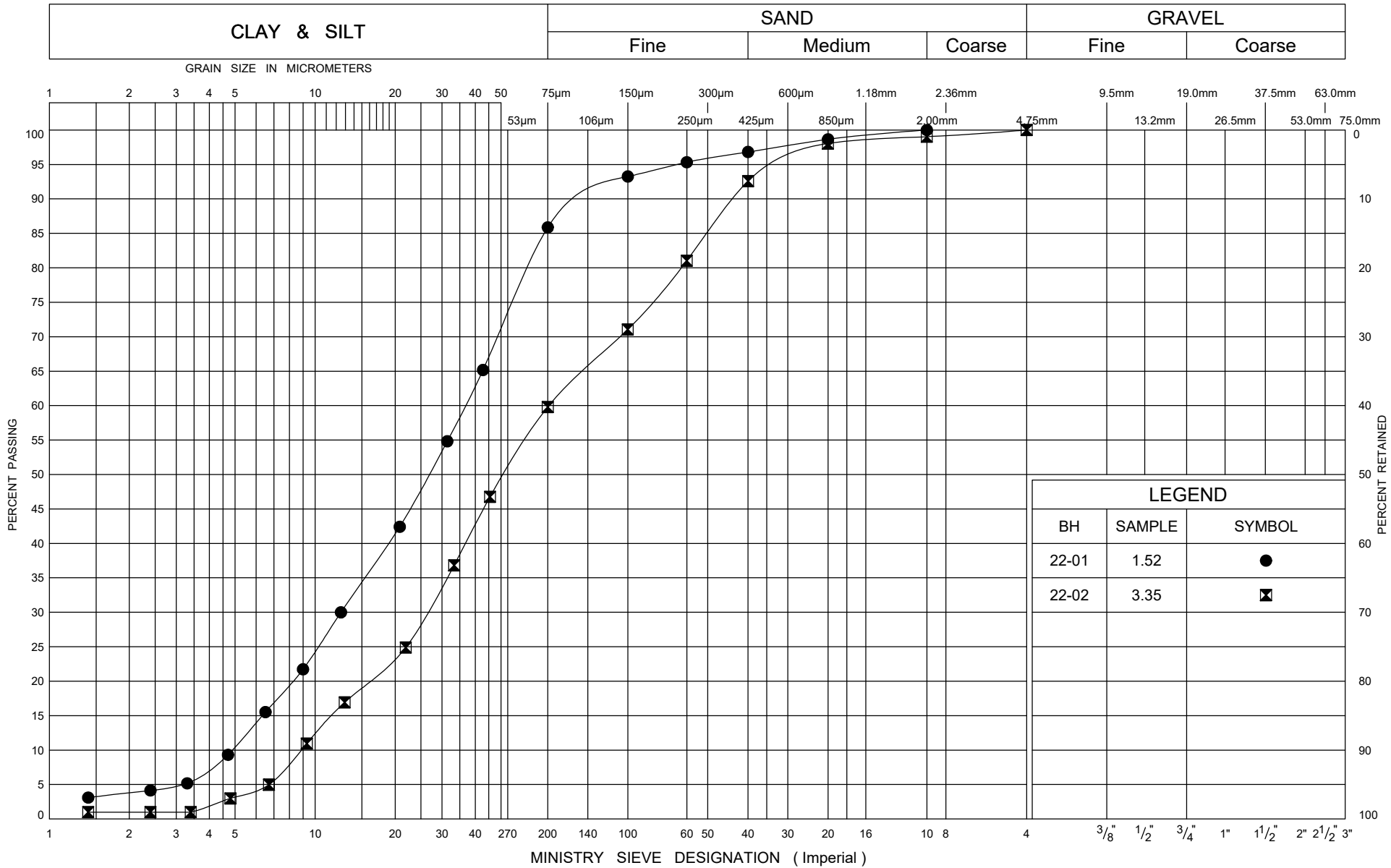
GWP# 6104-17-00 LOCATION Gull River Crossing; MTM 83-15: N 5 474 113.7 E 334 542.8 ORIGINATED BY GAS
 DIST Thunder Bay HWY 811 BOREHOLE TYPE Hollow Stem Augers/Wash Boring/NQ Coring COMPILED BY MC
 DATUM Geodetic DATE 2022.08.18 - 2022.08.18 LATITUDE 49.404202 LONGITUDE -89.590153 CHECKED BY MEF

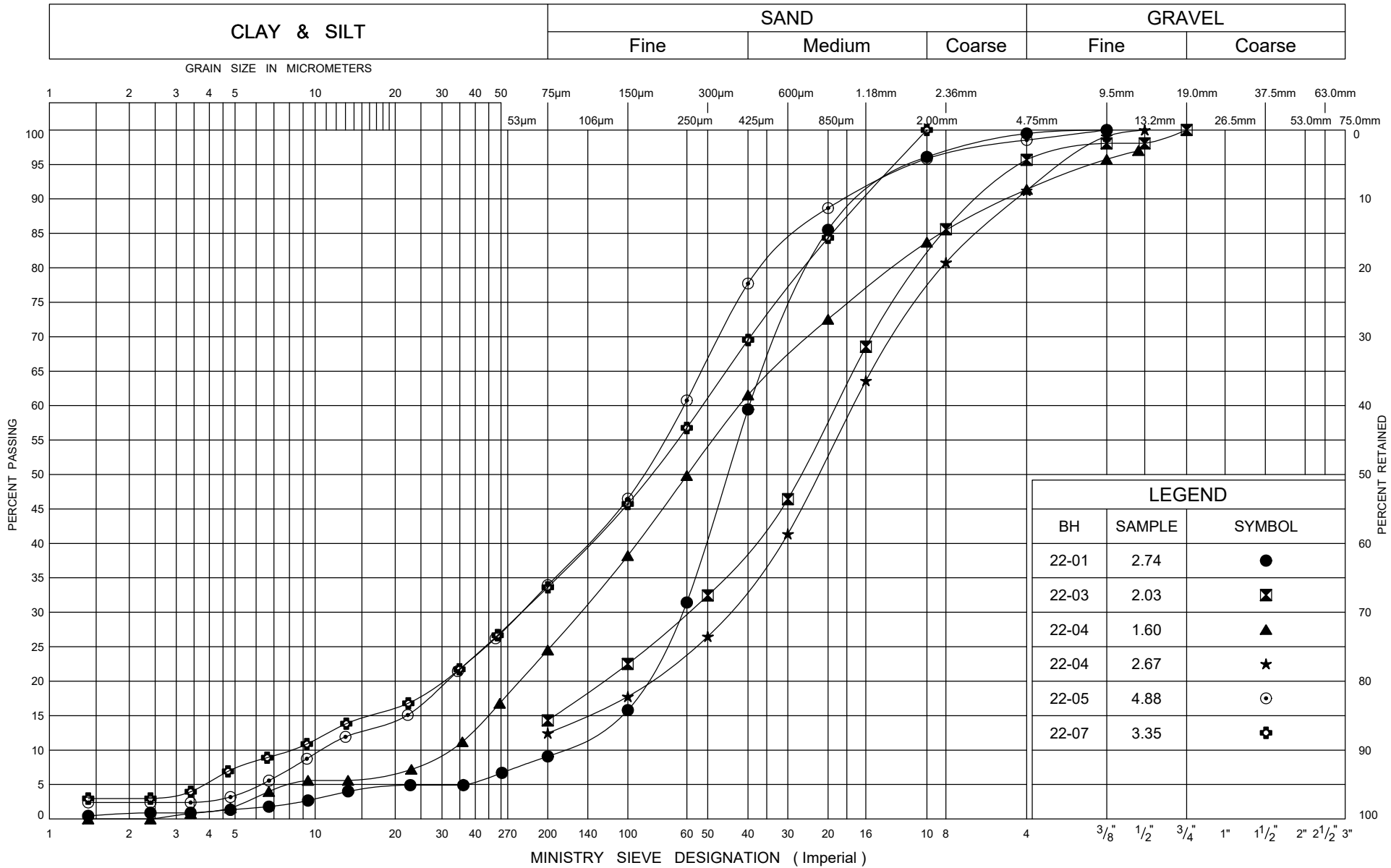
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
	Continued From Previous Page	✓													
441.1 10.1	END OF BOREHOLE AT 10.1m. BOREHOLE CAVED TO 3.1m. WATER LEVEL OBSERVED AT 1.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND SAND TO SURFACE.														

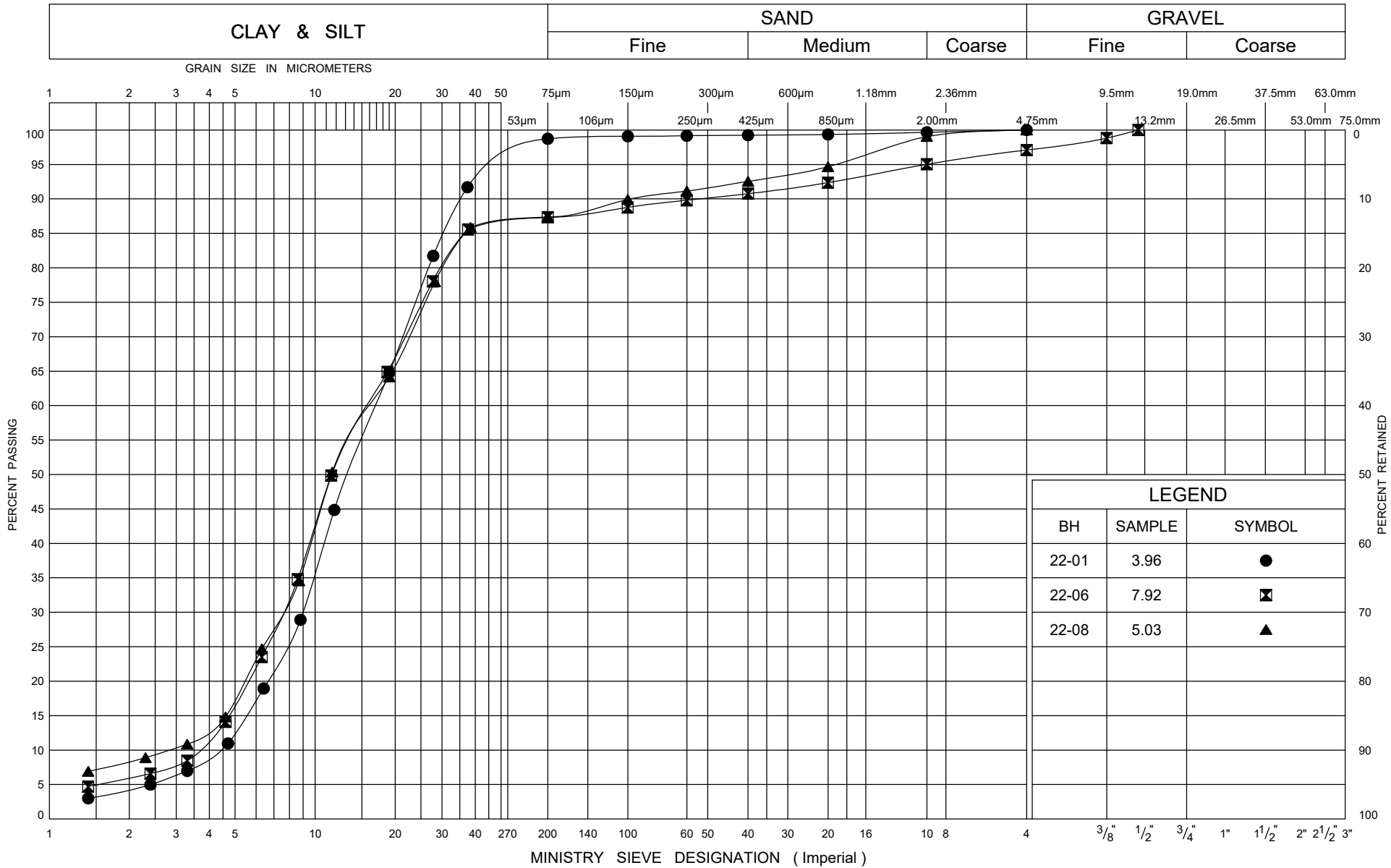
APPENDIX C

Laboratory and Well Test Results









POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	NQ BH No : 22-01

Date Drilled: 03-Oct-22

Date Tested: 29-Oct-22

Tester: GA/SS

[illegible]

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	NQ BH No : 22-02

Date Drilled: 01-Oct-22

Date Tested: 28-Oct-22

Tester: GA/SS

[illegible]

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	NQ BH No : 22-03

Date Drilled: 27-Sep-22
Date Tested: 28-Oct-22
Tester: EA

[illegible]



ASTM D5731-08

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	NQ
BH No :	22-04

Date Drilled: 30-Sep-22
Date Tested: 28-Oct-22
Tester: EA

[illegible]

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	NQ BH No : 22-05

Date Drilled: 16-Aug-22
Date Tested: 01-Dec-22
Tester: AK

[illegible]

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	BH No : 22-06

Date Drilled: 15-Aug-22
Date Tested: 01-Dec-22
Tester: AK

[illegible]

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	BH No : 22-07

Date Drilled: 17-Aug-22
Date Tested: 01-Dec-22
Tester: AK

[illegible]

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	34812
Client:	HATCH
Project Name:	Gull River Culvert
Core Size:	BH No : 22-08

Date Drilled: 18-Aug-22
Date Tested: 01-Dec-22
Tester: AK

[illegible]

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	HATCH	FILE NUMBER:	34812
PROJECT NAME:	Gull River Culvert	REPORT DATE:	7-Sep-23
BOREHOLE No.:	22-01	TEST DATE:	13-Dec-22
SAMPLE No.:	Run 4		
SAMPLE DEPTH:	29'7" - 30'5"		
DESCRIPTION:	Tonalite		

Avg. Height (cm):	10.8	Weight (g):	537.9
Avg. Diameter (cm):	4.9	Wet Density (kg/m ³):	2,641
H. to Dia. Ratio**:	2.2:1	Dry Density (kg/m ³):	2,641
Cross Sectional Area (cm ²):	18.86	Moisture Content* (%):	N/A
Sample Volume (cm ³):	203.66		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	162.8 kN
UNCONFINED COMPRESSIVE STRENGTH:	87.1 MPa

Note: * The moisture content was obtained before the test.
 ** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: AK
 REVIEWED BY: WM

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	HATCH	FILE NUMBER:	34812
PROJECT NAME:	Gull River Culvert	REPORT DATE:	7-Sep-23
BOREHOLE No.:	22-04	TEST DATE:	13-Dec-22
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	30'4" - 30'11"		
DESCRIPTION:	Tonalite		

Avg. Height (cm):	10.2	Weight (g):	503.0
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,725
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m ³):	2,725
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	184.57		

ORIGINAL SPECIMEN

34812
BH-4
RUN# 2
30'4" - 30'11"



FRACTURED SPECIMEN

34812
BH-4
RUN# 2
30'4"-30'11"



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	382.4 kN
UNCONFINED COMPRESSIVE STRENGTH:	208.7 MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: AK
REVIEWED BY: WM

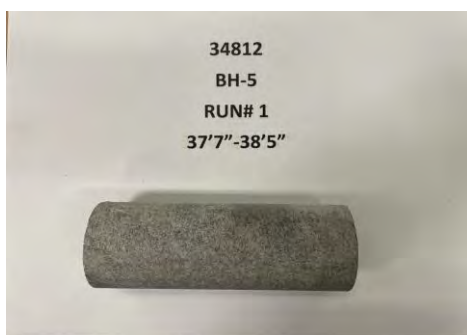
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	HATCH	FILE NUMBER:	34812
PROJECT NAME:	Gull River Culvert	REPORT DATE:	7-Sep-23
BOREHOLE No.:	22-05	TEST DATE:	13-Dec-22
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	37'7" - 38'5"		
DESCRIPTION:	Tonalite		

Avg. Height (cm):	13.2	Weight (g):	616.3
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,640
H. to Dia. Ratio**:	2.8:1	Dry Density (kg/m ³):	2,640
Cross Sectional Area (cm ²):	17.68	Moisture Content* (%):	N/A
Sample Volume (cm ³):	233.42		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	262.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	148.4 MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: AK
REVIEWED BY: WM

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	HATCH	FILE NUMBER:	34812
PROJECT NAME:	Gull River Culvert	REPORT DATE:	7-Sep-23
BOREHOLE No.:	22-06	TEST DATE:	13-Dec-22
SAMPLE No.:	Run 3		
SAMPLE DEPTH:	36.6-41.6		
DESCRIPTION:	Tonalite		

Avg. Height (cm):	13.2	Weight (g):	610.6
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,666
H. to Dia. Ratio**:	2.8:1	Dry Density (kg/m ³):	2,666
Cross Sectional Area (cm ²):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm ³):	229.01		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	125.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	71.1 MPa

Note: * The moisture content was obtained before the test.
 ** Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: AK
 REVIEWED BY: WM

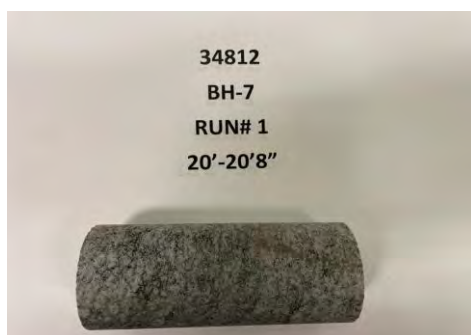
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	HATCH	FILE NUMBER:	34812
PROJECT NAME:	Gull River Culvert	REPORT DATE:	7-Sep-23
BOREHOLE No.:	22-07	TEST DATE:	13-Dec-22
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	20' - 20'8"		
DESCRIPTION:	Tonalite		

Avg. Height (cm):	11.4	Weight (g):	547.4
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,654
H. to Dia. Ratio**:	2.4:1	Dry Density (kg/m ³):	2,654
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	206.29		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	263.6 kN
UNCONFINED COMPRESSIVE STRENGTH:	148.8 MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: AK
REVIEWED BY: WM

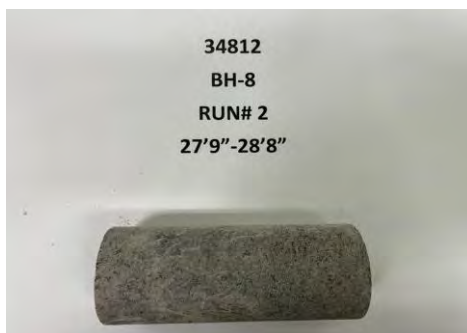
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	HATCH	FILE NUMBER:	34812
PROJECT NAME:	Gull River Culvert	REPORT DATE:	7-Sep-23
BOREHOLE No.:	22-08	TEST DATE:	13-Dec-22
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	27'9" - 28'8"		
DESCRIPTION:	Tonalite		

Avg. Height (cm):	11.9	Weight (g):	559.3
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,597
H. to Dia. Ratio**:	2.5:1	Dry Density (kg/m ³):	2,597
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	215.34		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	333.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	188.2 MPa

Note: * The moisture content was obtained before the test.
 ** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: AK
 REVIEWED BY: WM



Slug Test Analysis Report

Project: Gull River Culvert Replacements

Number: 34812

Client: Hatch

Location: Highway 811

Slug Test: 22-05

Test Well: 22-05

Test Conducted by: GS

Test Date: 2022-08-18

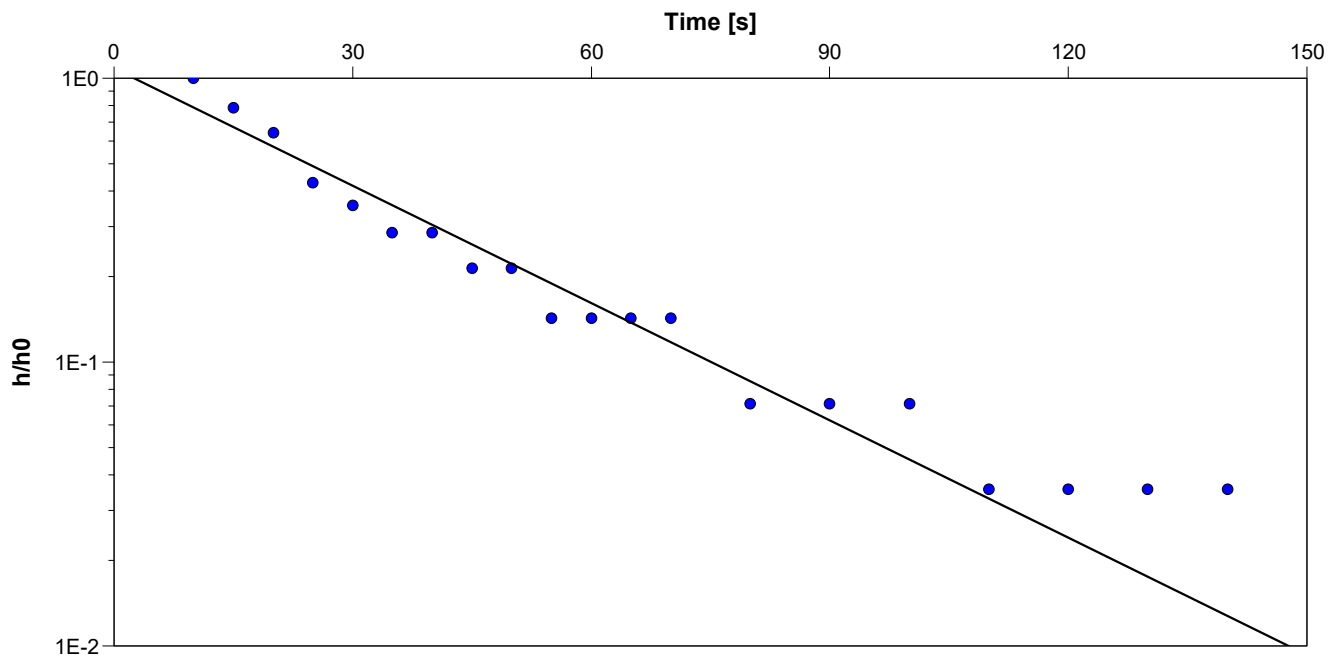
Analysis Performed by: PC

22-05 SWRT analysis

Analysis Date: 2022-11-30

Aquifer Thickness:

Checked by: AH



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]
------------------	------------------------------

22-05	2.8×10^{-5}
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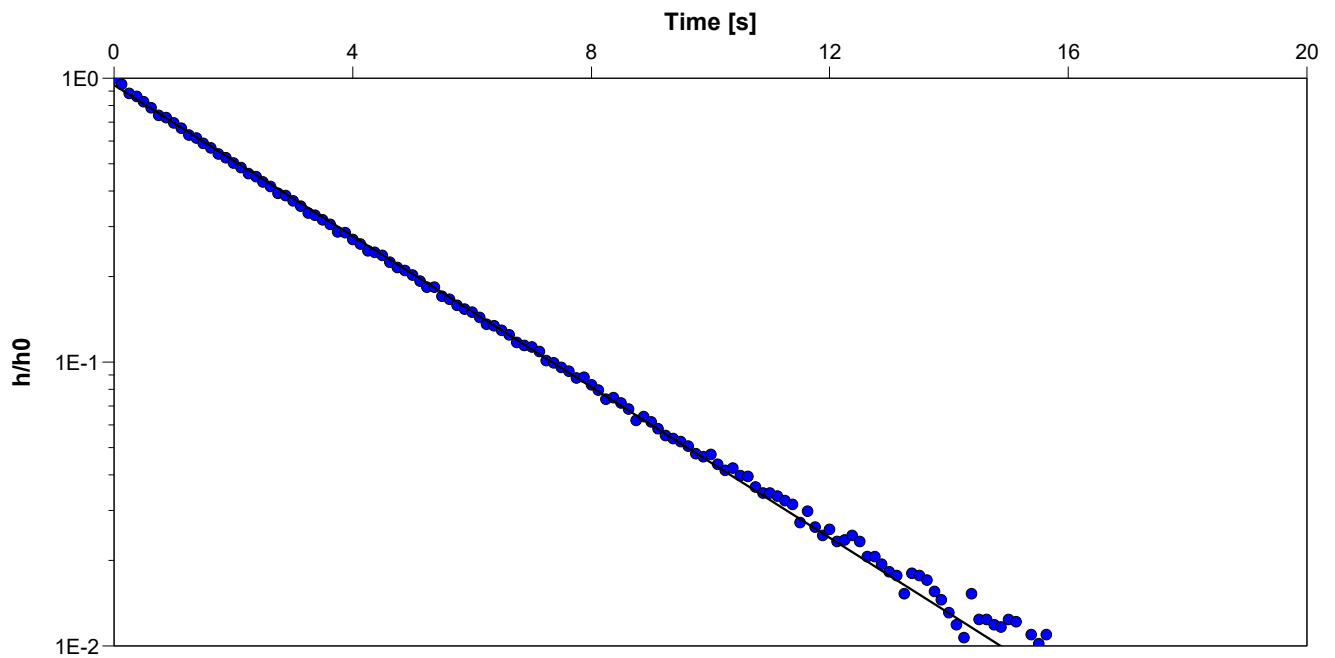
Slug Test Analysis Report

Project: Gull River Culvert Replacements

Number: 34812

Client: Hatch

Location: Highway 811	Slug Test: 22-06	Test Well: 22-06
Test Conducted by: GS		Test Date: 2022-08-17
Analysis Performed by: PC	22-06 SWRT Analysis	Analysis Date: 2022-11-30
Aquifer Thickness:		
Checked by: AH		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [m/s]	
22-06	2.7×10^{-4}	



FINAL REPORT

CA40070-OCT22 R1

34812, Gull River, ON

Prepared for

Thurber Engineering Ltd.



FINAL REPORT

CA40070-OCT22 R1

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
Address	103, 2010 Winston Park Drive	Laboratory	SGS Canada Inc.
	Oakville, ON	Address	185 Concession St., Lakefield ON, K0L 2H0
	L6H 5R7, Canada		
Contact	Rachel Bourassa	Telephone	2165
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	jill.campbell@sgs.com
Email	rbourassa@thurber.ca	SGS Reference	CA40070-OCT22
Project	34812, Gull River, ON	Received	10/12/2022
Order Number		Approved	10/28/2022
Samples	Soil (2)	Report Number	CA40070-OCT22 R1
		Date Reported	10/28/2022

COMMENTS
Temperature of Sample upon Receipt: 9 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes
Chain of Custody Number: 033414
Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.


SIGNATORIES
Jill Campbell, B.Sc.,GISAS




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FINAL REPORT

CA40070-OCT22 R1

Client: Thurber Engineering Ltd.

Project: 34812, Gull River, ON

Project Manager: Rachel Bourassa

Samplers: GS

MATRIX: SOIL

Sample Number	5	6
Sample Name	22-05 SS3 (7'-9')	22-06 SS6 (12.5'-14.5')
Sample Matrix	Soil	Soil
Sample Date	16/08/2022	15/08/2022

Parameter	Units	RL		Result	Result
Corrosivity Index					
Corrosivity Index	none	1		3	4
Soil Redox Potential	mV	no		268	289
Sulphide (Na ₂ CO ₃)	%	0.04		< 0.04	< 0.04
pH	pH Units	0.05		9.10	8.95
Resistivity (calculated)	ohms.cm	-9999		13900	10800
General Chemistry					
Conductivity	uS/cm	2		72	93
Metals and Inorganics					
Moisture Content	%	0.1		4.2	15.2
Sulphate	µg/g	10		< 10	< 10
Other (ORP)					
Chloride	µg/g	10		< 10	< 10



FINAL REPORT

CA40070-OCT22 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0244-OCT22	µg/g	10	<0.4	23	35	102	80	120	109	75	125
Sulphate	DIO0244-OCT22	µg/g	10	<0.4	10	35	96	80	120	95	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0036-OCT22	%	0.04	< 0.04	ND	20	120	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0306-OCT22	uS/cm	2	< 2	0	20	100	90	110	NA		



FINAL REPORT

CA40070-OCT22 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0306-OCT22	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.



LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm.

The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Reproduction of this analytical report in full or in part is prohibited.

This report supersedes all previous versions.

-- End of Analytical Report --

Industries & Environment - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

Laboratory Information Section - Lab use only

Received By: Steff L
Received Date: 08/12/2022 (mm/dd/yy)
Received Time: 08:00 (hr : min)

Received By (signature): [Signature]
Custody Seal Present: Yes ☒ No ☐
Cooling Agent Present: Yes ☒ No ☐
Custody Seal Intact: Yes ☒ No ☐
Temperature Upon Receipt (°C): 9.2

LAB LIMS #: 0ct 12th CA 40070

REPORT INFORMATION

Company: Thurber Engineering LTD
Contact: Rachel Bourassa
Address: 2010 Winston Park
Dr. #103, Oakville, ON L6H8R7
Phone: 416-523-1015
Fax: _____
Email: r.bourassa@thurber.ca

INVOICE INFORMATION

☒ (same as Report Information)
Company: _____
Contact: _____
Address: _____
Phone: _____
Email: _____

Quotation #: _____
Project #: 34812
Site Location/ID: Gull River, ON

TURNAROUND TIME (TAT) REQUIRED

TAT's are quoted in business days (exclude statutory holidays & weekends).
Samples received after 6pm or on weekends: TAT begins next business day

☒ Regular TAT (5-7 days)
RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days
PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

*NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

☐ O.Reg 153/04 ☒ O.Reg 406/19
Table 1 ☐ Res/Park ☐ Soil Texture: ☐ Fine ☐ Coarse
Table 2 ☐ Ind/Com ☐ MMR ☐ Other:
Table 3 ☐ Agri/Other ☐ Medium/Fine
Table ☐ Appx. ☐ MSA
Soil Volume ☐ <350m3 ☐ >350m3
RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMR
☐ CCME ☐ Other:
☐ MSA
Sewer By-Law:
☐ Sanitary
☐ Storm
☐ Municipality.

ANALYSIS REQUESTED

SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	M & I										Other (please specify)				SPLP TCLP	COMMENTS:
					Field Filtered (Y/N)	Metals & Inorganics (Cd, Cu, Fe, Hg, Pb, Ni, Se, Ag, Tl, V, Zn)	Full Metals Suite (Cd, Cu, Fe, Hg, Pb, Ni, Se, Ag, Tl, V, Zn)	ICP Metals only (As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Hg, Pb, Ni, Se, Ag, Tl, V, Zn)	PAHs only	SVOCs (Aroclor)	PCBs (Total)	F1-F4 + BTEX (no BTEX)	VOCs (all and BTEX)	BTEX only	Pesticides (Organochlorine or specify other)	Water Characterization Pkg (Specify pkg: General, Extended)	Specify tests	Specify tests		
1 22-05 SS3 (T-4')	Aug 16/2022	-	1	Soil																
2 22-06 SS6 (12.5-14.5)	Aug 15/2022	-	1	Soil																
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

Observations/Comments/Special Instructions

* Include For Consistency: PH, Soluble Sulphates, Chloride, resistivity, and electrical conductivity

Sampled By (NAME): GS

Signature: GS

Date: 08/16/2022 (mm/dd/yy)

Relinquished by (NAME): Rachel Bourassa

Signature: [Signature]

Date: 10/11/2022 (mm/dd/yy)

Revision # 1.0
Date of Issue: 02 May 2022

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection, handling and transportation of samples. (2) Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). (3) Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at <http://www.sgs.com/terms> and conditions therein. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

Pink Copy - Client

Yellow & White Copy - SGS



FINAL REPORT

CA40224-AUG22 R

34812, Gull River Cuvert

Prepared for

Thurber Engineering Ltd.



FINAL REPORT

CA40224-AUG22 R

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
Address	103, 2010 Winston Park Drive	Laboratory	SGS Canada Inc.
	Oakville, ON	Address	185 Concession St., Lakefield ON, K0L 2H0
	L6H 5R7, Canada		
Contact	Rachel Bourassa	Telephone	2165
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	jill.campbell@sgs.com
Email	rbourassa@thurber.ca	SGS Reference	CA40224-AUG22
Project	34812, Gull River Cuvert	Received	08/23/2022
Order Number		Approved	08/30/2022
Samples	Surface Water (1)	Report Number	CA40224-AUG22 R
		Date Reported	08/30/2022

COMMENTS
Temperature of Sample upon Receipt: 9 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes
Chain of Custody Number: 033177


SIGNATORIES
Jill Campbell, B.Sc.,GISAS




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FINAL REPORT

CA40224-AUG22 R

Client: Thurber Engineering Ltd.

Project: 34812, Gull River Cuvert

Project Manager: Rachel Bourassa

Samplers: Greg Stanhope

MATRIX: WATER

Sample Number 6
Sample Name Gull River SW
Sample Matrix Surface Water
Sample Date 18/08/2022

Parameter	Units	RL	Result
General Chemistry			
Conductivity	uS/cm	2	85
Redox Potential	mV	no	251
Metals and Inorganics			
Sulphate	mg/L	0.04	<0.04
Other (ORP)			
pH	No unit	0.05	7.66
Chloride	mg/L	0.04	0.57



FINAL REPORT

CA40224-AUG22 R

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0664-AUG22	mg/L	0.04	<0.04	5	20	96	90	110	101	75	125
Sulphate	DIO0664-AUG22	mg/L	0.04	<0.04	12	20	93	90	110	90	75	125

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0463-AUG22	uS/cm	2	2	0	20	99	90	110	NA		

pH
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0463-AUG22	No unit	0.05	NA	0		100			NA		



FINAL REPORT

CA40224-AUG22 R

QC SUMMARY

Redox Potential
Method: SM 2580 I

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Redox Potential	EWL0452-AUG22	mV	no	NA	0	20	100	80	120	NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.



LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

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This report supersedes all previous versions.

-- End of Analytical Report --



FINAL REPORT

CA40225-AUG22 R1

34812, Gull River Culvert

Prepared for

Thurber Engineering Ltd.



FINAL REPORT

CA40225-AUG22 R1

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7, Canada

Contact Rachel Bourassa

Telephone 905-829-8666 x 263

Facsimile

Email rbourassa@thurber.ca

Project 34812, Gull River Culvert

Order Number

Samples Solution (2)

LABORATORY DETAILS

Project Specialist Maarit Wolfe, Hon.B.Sc

Laboratory SGS Canada Inc.

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SGS Reference CA40225-AUG22

Received 08/23/2022

Approved 09/07/2022

Report Number CA40225-AUG22 R1

Date Reported 06/14/2023

COMMENTS

MAC - Maximum Acceptable Concentration
AO/OG - Aesthetic Objective / Operational Guideline
NR - Not reportable under applicable Provincial drinking water regulations as per client.

Temperature of Sample upon Receipt: 9 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

Chain of Custody Number: 033178

Turb recv'd UAL

SIGNATORIES

Maarit Wolfe, Hon.B.Sc



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CA40225-AUG22 R1

Client: Thurber Engineering Ltd.

Project: 34812, Gull River Culvert

Project Manager: Rachel Bourassa

Samplers: Greg Stanhope

MATRIX: WATER

Sample Number	7	8
Sample Name	22-05	22-05 Dissolved Metals
Sample Matrix	Solution	Solution
Sample Date	18/08/2022	18/08/2022

L1 = PWQQ_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result	Result
General Chemistry					
Alkalinity	mg/L as CaCO ₃	2		52	---
Bicarbonate	mg/L as CaCO ₃	2		52	---
Carbonate	mg/L as CaCO ₃	2		< 2	---
OH	mg/L as CaCO ₃	2		< 2	---
Colour	TCU	3		129	---
Conductivity	uS/cm	2		107	---
Turbidity	NTU	0.10		100	---
Ammonia+Ammonium (N)	as N mg/L	0.1		< 0.1	---
Phosphorus (total reactive)	mg/L	0.03		0.04	---
Total Organic Carbon	mg/L	1		19	---
Total Suspended Solids	mg/L	2		81	---
Metals and Inorganics					
Fluoride	mg/L	0.06		< 0.06	---
Bromide	mg/L	0.3		< 0.3	---
Nitrite (as N)	as N mg/L	0.03		< 0.03	---
Nitrate (as N)	as N mg/L	0.06		< 0.06	---
Sulphate	mg/L	0.2		1.2	---
Aluminum (0.2µm)	mg/L	0.001	0.075	0.86	---
Hardness	mg/L as CaCO ₃	0.05		65.6	---
Hardness (dissolved)	mg/L as CaCO ₃	0.05		---	56.47
Aluminum (total)	mg/L	0.001		3.63	---



FINAL REPORT

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MATRIX: WATER

Sample Number	7	8
Sample Name	22-05	22-05 Dissolved Metals
Sample Matrix	Solution	Solution
Sample Date	18/08/2022	18/08/2022

L1 = PWQO_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result	Result
Metals and Inorganics (continued)					
Arsenic (total)	mg/L	0.0002	0.005	0.0018	---
Arsenic (dissolved)	mg/L	0.0002		---	0.0017
Boron (total)	mg/L	0.002	0.2	0.009	---
Boron (dissolved)	mg/L	0.002		---	0.190
Barium (total)	mg/L	0.00008		0.0606	---
Barium (dissolved)	mg/L	0.00008		---	0.03646
Beryllium (total)	mg/L	0.000007	0.011	0.000150	---
Beryllium (dissolved)	mg/L	0.000007		---	0.000094
Cobalt (total)	mg/L	0.000004	0.0009	0.00790	---
Cobalt (dissolved)	mg/L	0.000004		---	0.00690
Calcium (total)	mg/L	0.01		16.8	---
Calcium (dissolved)	mg/L	0.01		---	15.7
Cadmium (total)	mg/L	0.000003	0.0001	0.000098	---
Cadmium (dissolved)	mg/L	0.000003		---	0.000079
Copper (total)	mg/L	0.0002	0.005	0.0635	---
Copper (dissolved)	mg/L	0.0002		---	0.0501
Chromium (total)	mg/L	0.00008	0.1	0.00883	---
Chromium (dissolved)	mg/L	0.00008		---	0.01131
Iron (total)	mg/L	0.007	0.3	6.79	---
Iron (dissolved)	mg/L	0.007		---	3.19
Potassium (total)	mg/L	0.009		1.14	---



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MATRIX: WATER

Sample Number	7	8
Sample Name	22-05	22-05 Dissolved Metals
Sample Matrix	Solution	Solution
Sample Date	18/08/2022	18/08/2022

L1 = PWQQ_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result	Result
Metals and Inorganics (continued)					
Potassium (dissolved)	mg/L	0.009		---	1.11
Magnesium (total)	mg/L	0.001		5.73	---
Magnesium (dissolved)	mg/L	0.001		---	4.21
Manganese (total)	mg/L	0.00001		0.106	---
Manganese (dissolved)	mg/L	0.00001		---	0.0629
Molybdenum (total)	mg/L	0.00004	0.04	0.00358	---
Molybdenum (dissolved)	mg/L	0.00004		---	0.00295
Nickel (total)	mg/L	0.0001	0.025	0.0118	---
Nickel (dissolved)	mg/L	0.0001		---	0.0082
Sodium (total)	mg/L	0.01		4.62	---
Sodium (dissolved)	mg/L	0.01		---	85.2
Phosphorus (total)	mg/L	0.003	0.01	0.098	---
Phosphorus (dissolved)	mg/L	0.003		---	0.051
Lead (total)	mg/L	0.00009	0.02	0.00700	---
Lead (dissolved)	mg/L	0.00009		---	0.00236
Silicon (total)	mg/L	0.02		10.7	---
Silicon (dissolved)	mg/L	0.02		---	5.49
Silver (total)	mg/L	0.00005	0.0001	0.00234	---
Silver (dissolved)	mg/L	0.00005		---	0.00022
Strontium (total)	mg/L	0.00008		0.0426	---
Strontium (dissolved)	mg/L	0.00008		---	0.0326



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MATRIX: WATER

Sample Number	7	8
Sample Name	22-05	22-05 Dissolved Metals
Sample Matrix	Solution	Solution
Sample Date	18/08/2022	18/08/2022

L1 = PWQQ_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result	Result
Metals and Inorganics (continued)					
Thallium (total)	mg/L	0.000005	0.0003	0.000023	---
Thallium (dissolved)	mg/L	0.000005		---	0.000013
Tin (total)	mg/L	0.00006		0.00694	---
Tin (dissolved)	mg/L	0.00006		---	0.00382
Titanium (total)	mg/L	0.00005		0.0658	---
Titanium (dissolved)	mg/L	0.00005		---	0.0236
Antimony (total)	mg/L	0.0009	0.02	< 0.0009	---
Antimony (dissolved)	mg/L	0.0009		---	< 0.0009
Selenium (total)	mg/L	0.00004	0.1	0.00017	---
Selenium (dissolved)	mg/L	0.00004		---	0.00014
Uranium (total)	mg/L	0.000002	0.005	0.000455	---
Uranium (dissolved)	mg/L	0.000002		---	0.000328
Vanadium (total)	mg/L	0.00001	0.006	0.00654	---
Vanadium (dissolved)	mg/L	0.00001		---	0.00449
Zinc (total)	mg/L	0.002	0.02	0.054	---
Zinc (dissolved)	mg/L	0.002		---	0.039



FINAL REPORT

CA40225-AUG22 R1

Client: Thurber Engineering Ltd.
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Samplers: Greg Stanhope

MATRIX: WATER

Sample Number	7	8
Sample Name	22-05	22-05 Dissolved Metals
Sample Matrix	Solution	Solution
Sample Date	18/08/2022	18/08/2022

L1 = PWQQ_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result	Result
Other (ORP)					
pH	No unit	0.05	8.6	7.84	---
Chloride	mg/L	0.2		1.5	---
Mercury (total)	mg/L	0.00001	0.0002	0.00002	---
Mercury (dissolved)	mg/L	0.00001	0.0002	---	< 0.00001



EXCEEDANCE SUMMARY

				PWQO_L / WATER
				/ - - Table 2 -
				General - July 1999
				PIBS 3303E
Parameter	Method	Units	Result	L1

22-05

Aluminum (dissolved)	SM 3030/EPA 200.8	mg/L	0.86	0.075
Cobalt	SM 3030/EPA 200.8	mg/L	0.00790	0.0009
Copper	SM 3030/EPA 200.8	mg/L	0.0635	0.005
Iron	SM 3030/EPA 200.8	mg/L	6.79	0.3
Phosphorus	SM 3030/EPA 200.8	mg/L	0.098	0.01
Silver	SM 3030/EPA 200.8	mg/L	0.00234	0.0001
Vanadium	SM 3030/EPA 200.8	mg/L	0.00654	0.006
Zinc	SM 3030/EPA 200.8	mg/L	0.054	0.02



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Alkalinity

Method: SM 2320 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Alkalinity	EWL0463-AUG22	mg/L as CaCO3	2	< 2	3	20	106	80	120	NA		

Ammonia by SFA

Method: SM 4500 | Internal ref.: ME-CA-1ENVISFA-LAK-AN-007

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Ammonia+Ammonium (N)	SKA0258-AUG22	as N mg/L	0.1	<0.1	3	10	97	90	110	102	75	125



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Bromide	DIO0557-AUG22	mg/L	0.3	<0.3	ND	20	93	90	110	80	75	125
Nitrite (as N)	DIO0557-AUG22	mg/L	0.03	<0.03	ND	20	94	90	110	99	75	125
Nitrate (as N)	DIO0557-AUG22	mg/L	0.06	<0.06	1	20	97	90	110	100	75	125
Chloride	DIO0643-AUG22	mg/L	0.2	<0.2	0	20	102	90	110	101	75	125
Sulphate	DIO0643-AUG22	mg/L	0.2	<0.2	1	20	98	90	110	94	75	125

Carbon by SFA
Method: SM 5310 | Internal ref.: ME-CA-IENVISFA-LAK-AN-009

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Total Organic Carbon	SKA0269-AUG22	mg/L	1	<1	ND	20	95	90	110	91	75	125



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Carbonate/Bicarbonate

Method: SM 2320 | Internal ref.: ME-CA-ENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Carbonate	EWL0463-AUG22	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0463-AUG22	mg/L as CaCO3	2	< 2	3	10	NA	90	110	NA		
OH	EWL0463-AUG22	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		

Colour

Method: SM 2120 | Internal ref.: ME-CA-ENVIEWL-LAK-AN-002

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Colour	EWL0468-AUG22	TCU	3	< 3	0	10	105	80	120	NA		



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0463-AUG22	uS/cm	2	2	0	20	99	90	110	NA		

Fluoride by Specific Ion Electrode
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-014

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Fluoride	EWL0464-AUG22	mg/L	0.06	<0.06	1	10	100	90	110	100	75	125

Mercury by CVAAS
Method: EPA 7471A/SM 3112B | Internal ref.: ME-CA-IENVISPE-LAK-AN-004

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Mercury (total)	EHG0048-AUG22	mg/L	0.00001	< 0.00001	0	20	116	80	120	115	70	130



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Metals in aqueous samples - ICP-MS
Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-ENVISPE-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Silver (total)	EMS0189-AUG22	mg/L	0.00005	<0.00005	ND	20	99	90	110	95	70	130
Aluminum (total)	EMS0189-AUG22	mg/L	0.001	<0.001	14	20	98	90	110	110	70	130
Aluminum (0.2µm)	EMS0189-AUG22	mg/L	0.001	<0.001	14	20	98	90	110	110	70	130
Arsenic (total)	EMS0189-AUG22	mg/L	0.0002	<0.0002	16	20	99	90	110	108	70	130
Barium (total)	EMS0189-AUG22	mg/L	0.00008	<0.00002	7	20	98	90	110	99	70	130
Beryllium (total)	EMS0189-AUG22	mg/L	0.000007	<0.000007	ND	20	99	90	110	103	70	130
Boron (total)	EMS0189-AUG22	mg/L	0.002	<0.002	4	20	96	90	110	NV	70	130
Calcium (total)	EMS0189-AUG22	mg/L	0.01	<0.01	4	20	98	90	110	97	70	130
Cadmium (total)	EMS0189-AUG22	mg/L	0.000003	<0.000003	ND	20	99	90	110	91	70	130
Cobalt (total)	EMS0189-AUG22	mg/L	0.000004	<0.000004	11	20	100	90	110	103	70	130
Chromium (total)	EMS0189-AUG22	mg/L	0.00008	<0.00008	1	20	102	90	110	103	70	130
Copper (total)	EMS0189-AUG22	mg/L	0.0002	<0.0002	5	20	97	90	110	97	70	130
Iron (total)	EMS0189-AUG22	mg/L	0.007	<0.007	10	20	92	90	110	125	70	130
Potassium (total)	EMS0189-AUG22	mg/L	0.009	<0.009	5	20	98	90	110	90	70	130
Magnesium (total)	EMS0189-AUG22	mg/L	0.001	<0.001	3	20	96	90	110	94	70	130
Manganese (total)	EMS0189-AUG22	mg/L	0.00001	<0.00001	7	20	104	90	110	94	70	130
Molybdenum (total)	EMS0189-AUG22	mg/L	0.00004	<0.00004	7	20	96	90	110	102	70	130
Sodium (total)	EMS0189-AUG22	mg/L	0.01	<0.01	3	20	96	90	110	85	70	130
Nickel (total)	EMS0189-AUG22	mg/L	0.0001	<0.0001	1	20	99	90	110	98	70	130
Lead (total)	EMS0189-AUG22	mg/L	0.00009	<0.00001	13	20	101	90	110	105	70	130



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)
Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Phosphorus (total)	EMS0189-AUG22	mg/L	0.003	<0.003	0	20	100	90	110	NV	70	130
Antimony (total)	EMS0189-AUG22	mg/L	0.0009	<0.0009	ND	20	106	90	110	110	70	130
Selenium (total)	EMS0189-AUG22	mg/L	0.00004	<0.00004	16	20	105	90	110	104	70	130
Silicon (total)	EMS0189-AUG22	mg/L	0.02	<0.02	0	20	104	90	110	NV	70	130
Tin (total)	EMS0189-AUG22	mg/L	0.00006	<0.00006	ND	20	99	90	110	NV	70	130
Strontium (total)	EMS0189-AUG22	mg/L	0.00008	<0.00002	3	20	103	90	110	100	70	130
Titanium (total)	EMS0189-AUG22	mg/L	0.00005	<0.00005	1	20	93	90	110	NV	70	130
Thallium (total)	EMS0189-AUG22	mg/L	0.000005	<0.000005	ND	20	101	90	110	105	70	130
Uranium (total)	EMS0189-AUG22	mg/L	0.000002	<0.000002	12	20	102	90	110	122	70	130
Vanadium (total)	EMS0189-AUG22	mg/L	0.00001	<0.00001	1	20	101	90	110	107	70	130
Zinc (total)	EMS0189-AUG22	mg/L	0.002	<0.002	9	20	96	90	110	114	70	130

pH
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0463-AUG22	No unit	0.05	NA	0		100			NA		



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Reactive Phosphorus by SFA
Method: SM 4500-P F | Internal ref.: ME-CA-IENVISFA-LAK-AN-004

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Phosphorus (total reactive)	SKA0265-AUG22	mg/L	0.03	<0.03	ND	10	96	90	110	86	75	125

Suspended Solids
Method: SM 2540D | Internal ref.: ME-CA-IENVIEWL-LAK-AN-004

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Total Suspended Solids	EWL0462-AUG22	mg/L	2	< 2	0	10	94	90	110	NA		

Turbidity
Method: SM 2130 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-003

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Turbidity	EWL0451-AUG22	NTU	0.10	< 0.10	0	10	99	90	110	NA		



FINAL REPORT

CA40225-AUG22 R1

QC SUMMARY

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

**LEGEND****FOOTNOTES**

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm.

The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Reproduction of this analytical report in full or in part is prohibited.

This report supersedes all previous versions.

-- End of Analytical Report --



Request for Laboratory Services and CHAIN OF CUSTODY

No: 033178

Industries & Environment - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment

- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

Page of

Laboratory Information Section - Lab use only

Received By: Scott Ren
Received Date: 08/23/2022 (mm/dd/yy)
Received Time: 08:15 (hr:min)

Received By (signature): [Signature]
Custody Seal Present: Yes ☐ No ☐
Custody Seal Intact: Yes ☐ No ☐

Cooling Agent Present: Yes ☐ No ☐ Type: Ice
Temperature Upon Receipt (°C): 9.3

LAB LIMS #: CA40225-AUG22

REPORT INFORMATION	INVOICE INFORMATION
Company: <u>Thurber Engineering Ltd.</u>	<input checked="" type="checkbox"/> (same as Report Information)
Contact: <u>Rachel Bowassa</u>	Company: _____
Address: <u>2010 Winston Park Dr. #103</u>	Contact: _____
<u>Oakville, ON L6M 5R7</u>	Address: _____
Phone: <u>905 829 8666</u>	Phone: _____
Fax: _____	Email: _____
Email: <u>rbowassa@thurber.ca</u>	

Quotation #: _____ P.O. #: _____
Project #: 34812 Site Location/ID: Gull River Culvert

TURNAROUND TIME (TAT) REQUIRED
☒ Regular TAT (5-7 days)
TAT's are quoted in business days (exclude statutory holidays & weekends).
Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days
PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: _____ *NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

☐ O.Reg 153/04 ☐ O.Reg 406/19

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☐ Sanitary
☒ PWQO ☐ MMR ☐ Storm
☐ CCME ☐ Other: _____ Municipality: _____
☐ MISA ☐ ODWS Not Reportable *See note

Soil Texture: ☐ Res/Park ☐ Ind/Com ☐ Coarse
☐ Table 1 ☐ Agri/Other ☐ Medium/Fine
☐ Table 2 ☐ Appx. _____
☐ Table 3 ☐ Soil Volume ☐ <350m3 ☐ >350m3

ANALYSIS REQUESTED										SPLP		TCLP		COMMENTS:	
M & I	SVOC	PCB	PHC	VOC	Pest	Other (please specify)	Specify tests	Specify tests							
Field Filtered (Y/N)	Metals & Inorganics (Cd, Cr, Cu, Hg, Pb, Se, Zn, Ni, Mn, Fe, Al, Si, B, As, Sb, Bi, Mo, V, Ti, U, Th, Pa, K, Rb, Cs, Sr, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y, Zr, Hf, Ta, Nb, Mo, W, Sn, Pb, Bi, Po, At, Rn, Fr, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y, Zr, Hf, Ta, Nb, Mo, W, Sn, Pb, Bi, Po, At, Rn, Fr, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr)	Full Metals Suite (Cd, Cr, Cu, Hg, Pb, Se, Zn, Ni, Mn, Fe, Al, Si, B, As, Sb, Bi, Mo, V, Ti, U, Th, Pa, K, Rb, Cs, Sr, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y, Zr, Hf, Ta, Nb, Mo, W, Sn, Pb, Bi, Po, At, Rn, Fr, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr)	ICP Metals only (Cd, Cr, Cu, Hg, Pb, Se, Zn, Ni, Mn, Fe, Al, Si, B, As, Sb, Bi, Mo, V, Ti, U, Th, Pa, K, Rb, Cs, Sr, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y, Zr, Hf, Ta, Nb, Mo, W, Sn, Pb, Bi, Po, At, Rn, Fr, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr)	PAHs only	SVOCs (all Ind PAHs, Aroclors, CPs)	PCBs Total <input type="checkbox"/> Aroclor <input type="checkbox"/>	F1-F4 + BTEX	F1-F4 only no BTEX	VOCs all Ind BTEX	BTEX only	Pesticides Organochlorine or specify other	TSS	lab filtered metals		Sewer Use: Specify pkg: Water Characterization Pkg General <input checked="" type="checkbox"/> Extended <input type="checkbox"/>
1	22-05	Aug 18/22	1:00pm	12	water	N									
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

Observations/Comments/Special Instructions

Sampled By (NAME): <u>Greg Stanhope</u>	Signature: <u>[Signature]</u>	Date: <u>Aug 18, 2022</u> (mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): <u>Greg Stanhope</u>	Signature: <u>[Signature]</u>	Date: <u>Aug 19, 2022</u> (mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.6
Date of Issue: 02 May 2022

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. (2) Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). (3) Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

APPENDIX D

Site Photographs



Photo 1: Looking west at west approach on Highway 811 (August 2022)



Photo 2: Looking east at east approach on Highway 811 (August 2022)



Photo 3: Looking south towards culvert inlet (August 2022)



Photo 4: Looking north towards culvert outlet (August 2022)



Photo 5: Looking west at culvert inlet (August 2022)



Photo 6: Looking west at culvert outlet (August 2022)

APPENDIX E

Foundation Alternative Comparison

Geotechnical Comparison of Alternative Foundation Types

Culvert Replacement Foundation Alternative	Advantages	Disadvantages	Evaluation
Pre-cast Concrete Box Culvert on Shifted Alignment	<ul style="list-style-type: none"> i. Can be constructed in the wet, requiring less dewatering of cohesionless soils. ii. Segmental option can accommodate some potential differential settlement along culvert axis. iii. Conventional construction and less expensive than bridge options. 	<ul style="list-style-type: none"> i. Requires deep and large temporary excavation for installation. ii. Subgrade soils offer lower geotechnical resistance than piles founded in bedrock. 	Preferred
Modular Bridge or Concrete Deck / Steel Girder Bridge, Founded on Socketed H-piles	<ul style="list-style-type: none"> i. Minimizes potential for disturbance of river bed. ii. High geotechnical capacities available for piles founded in bedrock. iii. Less temporary excavation required than box culvert option. 	<ul style="list-style-type: none"> i. Requires H-piles to be pre-drilled and socketed into bedrock, as driven piles may not achieve sufficient penetration due to the presence of the shallow / sloping bedrock surface. ii. Requires dewatering of excavations in cohesionless soils to install pile caps below frost penetration and groundwater levels. iii. More expensive than concrete box culvert option. 	Not Preferred
Modular Bridge or Concrete Deck / Steel Girder Bridge, Founded on Spread Footings on Engineered Fill Pads or on Native Soil	<ul style="list-style-type: none"> i. Minimizes potential for disturbance of river bed. ii. Less temporary excavation required than box culvert option. iii. More conventional construction and less expensive than H-piles founded in bedrock. 	<ul style="list-style-type: none"> i. Load demand exceeds available bearing capacity of the foundation soils at shallow depths. ii. Footings founded on native soil below frost penetration depth require deeper excavations below the groundwater level in cohesionless soils. iii. More expensive than concrete box culvert option. 	Not Recommended

APPENDIX F

List of OPSS and OPSD Documents and Suggested Wording for NSSPs

1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 209	Embankments over Swamps in Compressible Soils
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheetting
OPSS.PROV 517	Construction Specification for Dewatering and Temporary Flow Passage Systems
SP 517F01	Amendment to OPSS 517, Dewatering System – Temporary Flow Passage System
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
SP 109S61	Amendment to OPSS 902, Dewatering and Protection Systems
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1005	Material Specification for Aggregates – Streambed Material
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS.PROV 1860	Material Specification for Geotextiles
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 810.010	General Rip Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario
OPSD 3101.150	Walls, Abutment, Backfill Minimum Granular Requirement

2. Suggested Wording for NSSPs

- **Suggested Text for NSSP on Obstructions**

Excavations and installation of piles may encounter obstructions such as wood, cobbles and boulders embedded in the fill and native soils. Such obstructions may impede excavation progress and/or pile installations, if employed. Specifically, the conditions are such that sheet piles may not be able to penetrate these materials to reach the design depth of installation. A lateral restraining system may be required to provide additional shoring support if sheet piles are utilized. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.

- **Suggested Text for NSSP on Dewatering – EASR Option**

The Contractor is notified that dewatering at this site is not advised due to the highly permeable subgrade consisting of silty sand to sand. Attempting to fully dewater and lower the water table to below the final subgrade is anticipated to produce discharges of several million litres of water per day.

The Contractor is permitted to dewater a maximum of 400,000 L/day in order to remove as much of the standing water in the temporary excavation as possible. Water levels likely to prevail during construction will necessitate subgrade preparation, placement of bedding, culvert installation, and other works under standing water.

Dewatering volumes between 50,000 L/day and 400,000 L/day require registration under the Environmental Activity and Sector Registry (EASR). The Contractor shall be responsible for the registration of the site.

The dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01. A preconstruction survey is not required. Considering the conditions on site, it is recommended that a dewatering engineer with a minimum of 5 years of experience in designing dewatering systems should be retained by the contractor for design of an effective dewatering system.

- **Suggested Text for NSSP on Dewatering – PTTW Option**

It is anticipated that the culvert will be constructed in the wet. Dewatering to lower the water table in the excavations is anticipated to produce discharges of several million litres of water per day. A Permit to Take Water will be required if pumping greater than 400,000 L/day will be done. Dewatering, if employed, is the responsibility of the Contractor.



If dewatering will be used to construct the replacement culvert in the dry, then an appropriate dewatering system must be designed and be effective to maintain the water level at a minimum depth of 1 m below the final subgrade. The dewatering system must remain operational and effective throughout construction, including structure excavation, subgrade preparation, culvert bedding placement, and backfilling to allow the work to proceed in the dry.

The dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01. A preconstruction survey is not required. Considering the conditions on site, it is recommended that a dewatering engineer with a minimum of 5 years of experience in designing dewatering systems should be retained by the contractor for design of an effective dewatering system.

- **Suggested Text for NSSP on Temporary Modular Bridge**

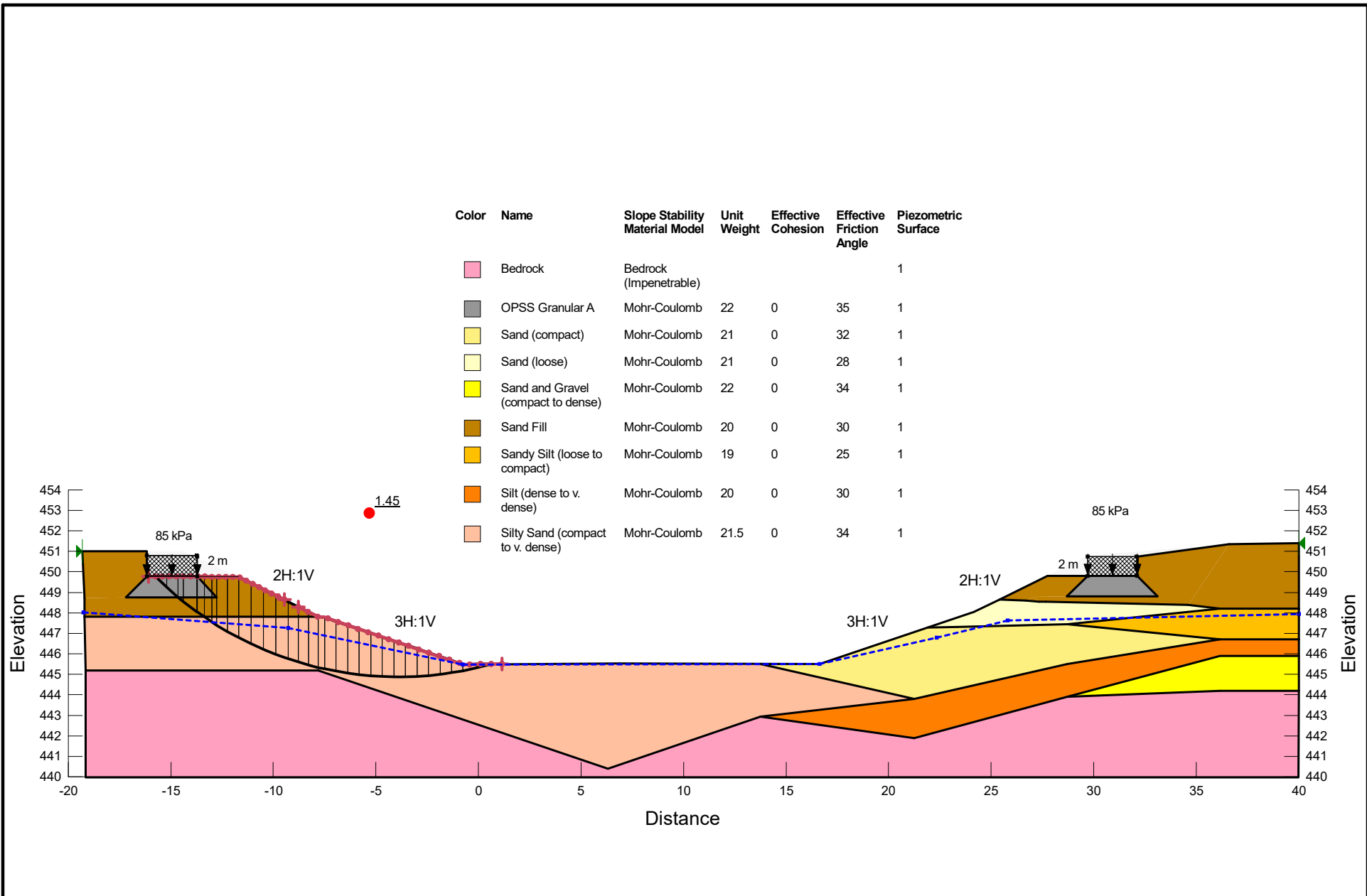
The Contractor is responsible for the detailed design of the Temporary Modular Bridge (TMB) including, but not limited to, slope stability of the temporary excavation slopes in front of and beside the TMB abutment footings, determination of the bearing capacity for the abutment footings and safe footing set back distance from the open excavation, as well as the performance of the temporary footings throughout construction. As a minimum, modular bridge footings shall be set back a minimum two (2) metres from the top of the temporary excavation. The temporary excavation slopes shall be no steeper than two (2) horizontal to one (1) vertical above the groundwater level and three (3) horizontal to one (1) vertical below the groundwater level. The contractor is responsible for retaining a RAQS approved Licensed Geotechnical Engineer with a medium-complexity rating (RAQs Category – Geotechnical Structures and Embankment – Medium Complexity) to confirm all aspects of the modular bridge slope stability and foundation design. All final reports and drawings must be sealed and signed by a Professional Engineer, who shall also be a RAQs Designated Contact.


- **Suggested Text for Operational Constraint on Temporary Excavation Slopes**

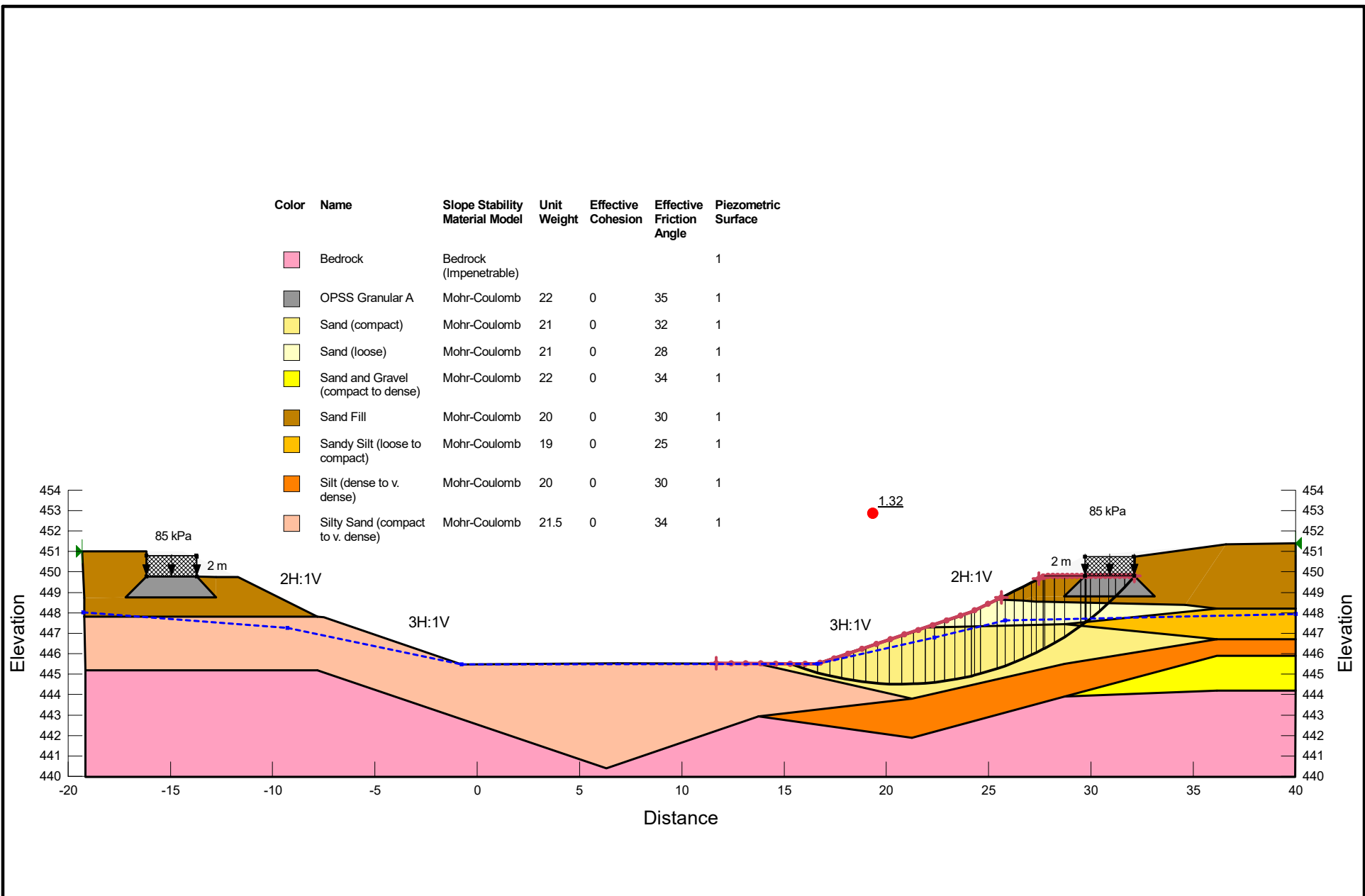
The Contractor is notified that unsupported temporary slopes at this site, for excavations or otherwise, are not stable if inclined at one (1) horizontal to one (1) vertical or steeper above the groundwater level. Temporary slopes are therefore restricted to inclinations of no steeper than two (2) horizontal to one (1) vertical above the groundwater level and three (3) horizontal to one (1) vertical below the groundwater level.


APPENDIX G

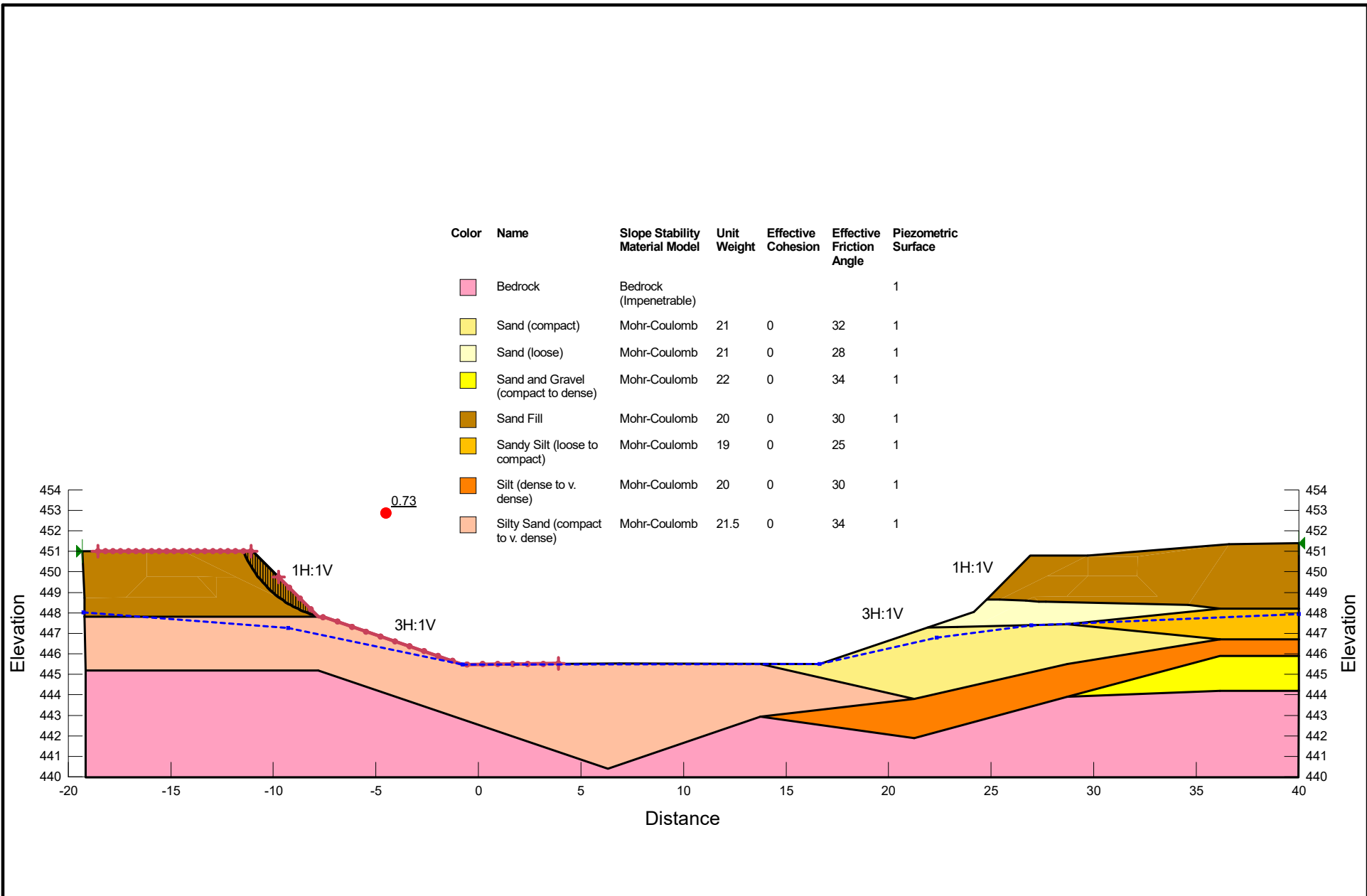
Slope Stability Analysis Figures




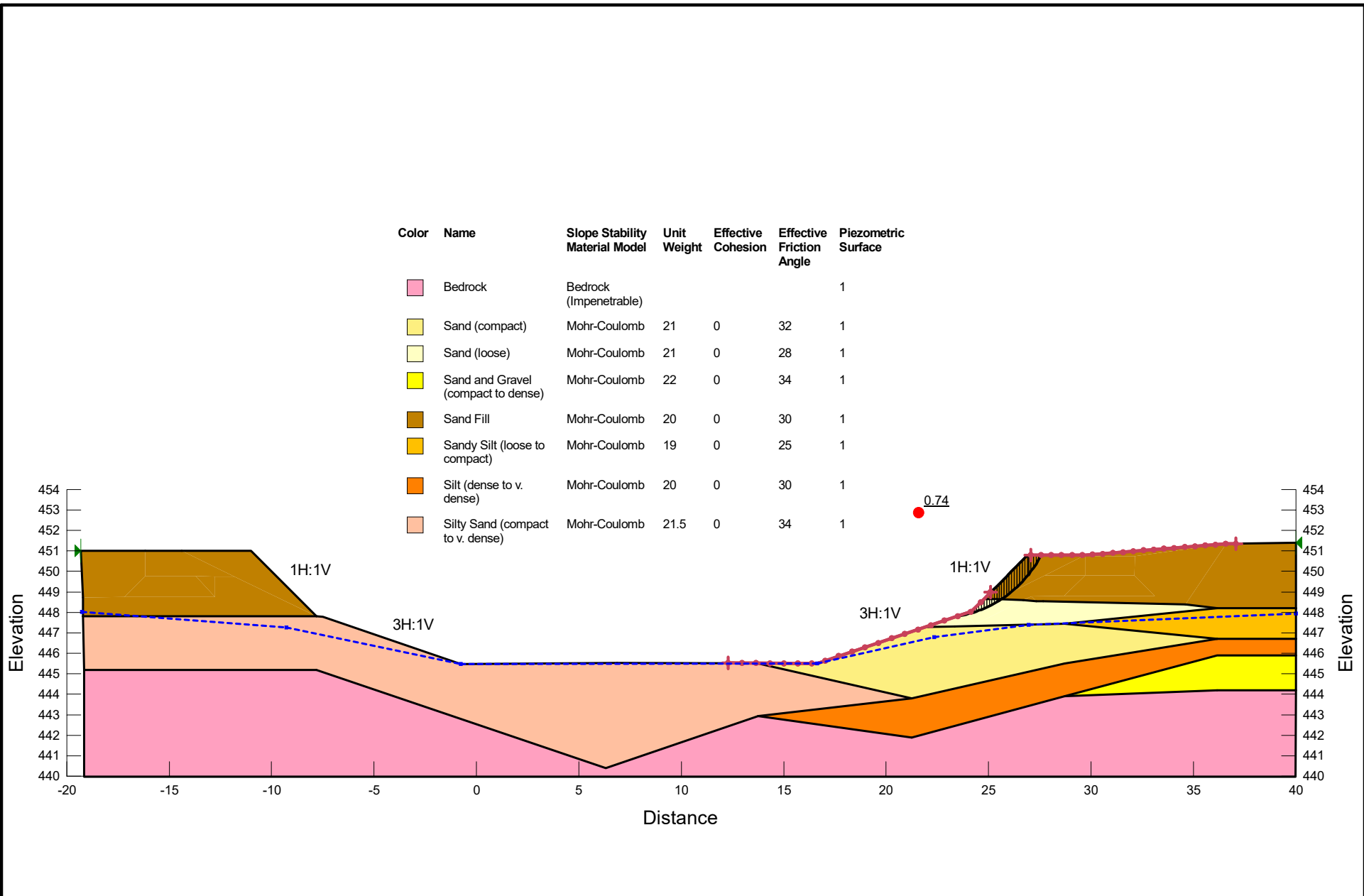
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	Gull River Culvert Replacement			
	Analysis			
	West Abutment - TMB Front Slope, 85 kPa, 2 m Setback			
THURBER	Seismic Coefficient	Last Run	Scale	Figure 1
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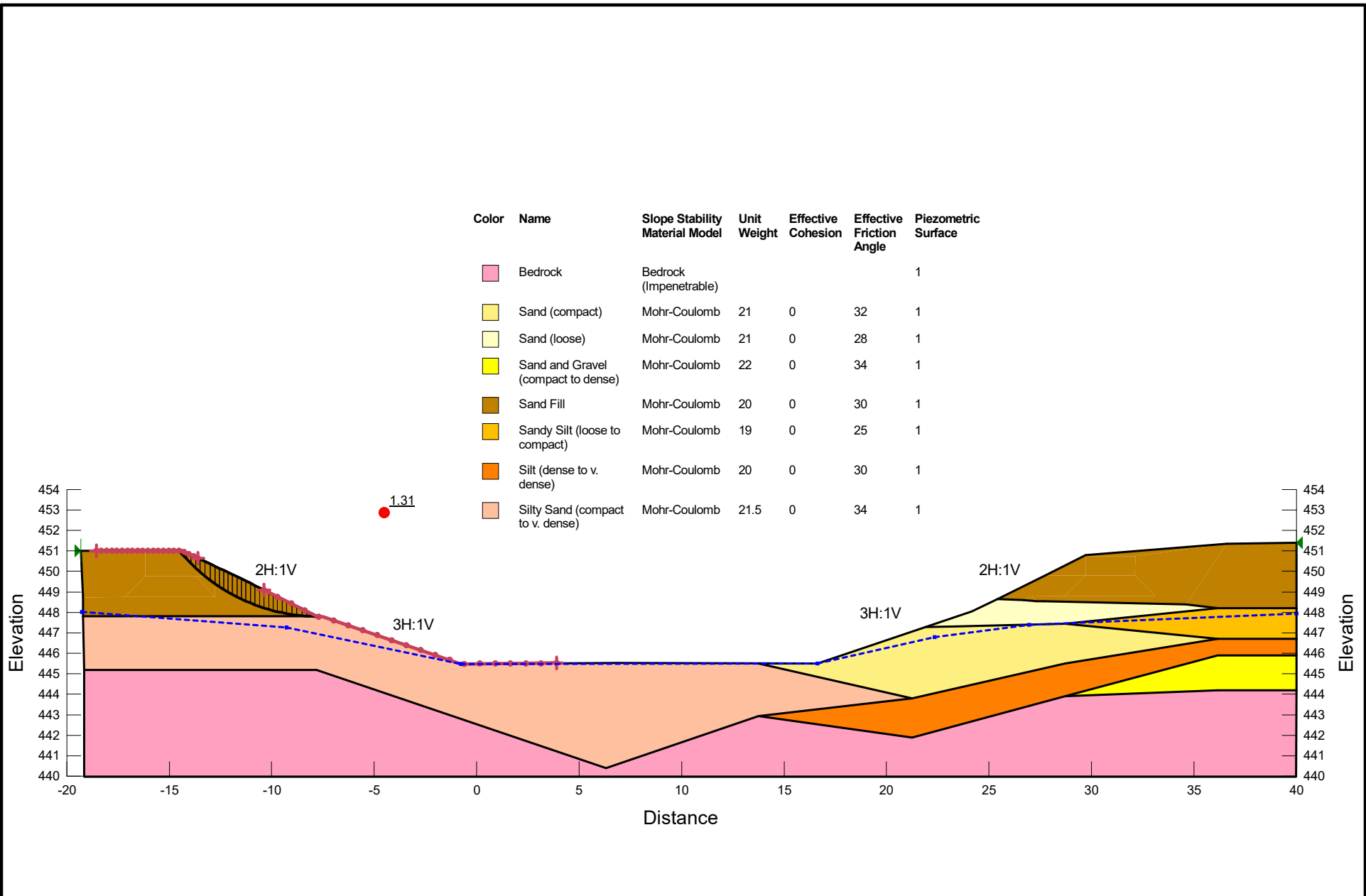
 THURBER	Project			Additional Details
	Gull River Culvert Replacement			
	Analysis			
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	Seismic Coefficient	Last Run	Scale	Figure 2
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	Project			Additional Details
	Gull River Culvert Replacement			
	Analysis			
	West Excavation - 1H:1V Slope above GWL			
Seismic Coefficient	Last Run		Scale	Figure 3
	H: 0g, V: 0g			
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	Project		Additional Details
	Gull River Culvert Replacement		
	Analysis		
East Excavation - 1H:1V Slope above GWL			
Seismic Coefficient	Last Run	Scale	Figure 4
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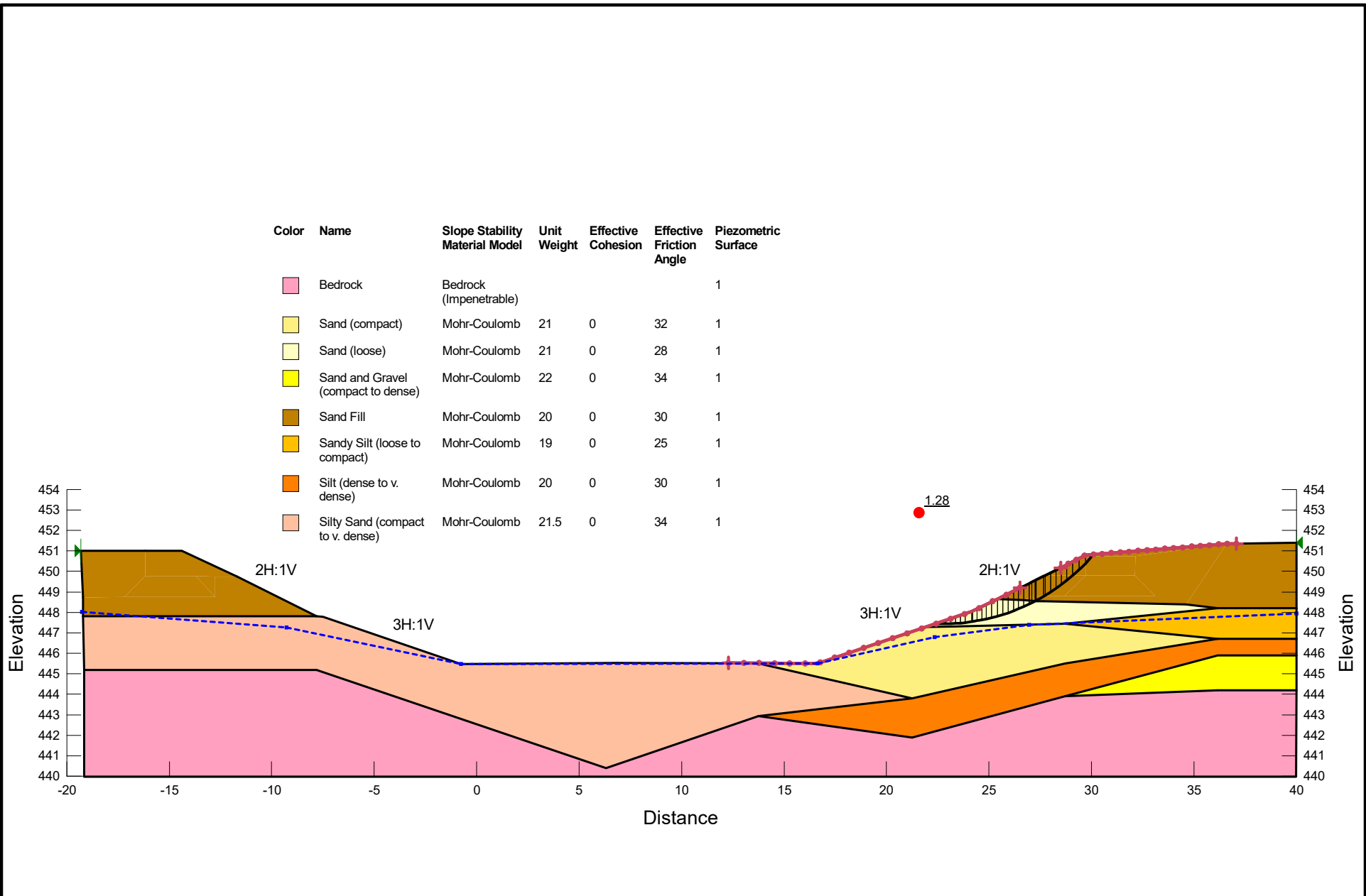




Project Gull River Culvert Replacement		
Analysis West Excavation - 2H:1V Slope above GWL		
Seismic Coefficient H: 0g, V: 0g	Last Run 2024-06-17, 09:27:39 AM	Scale 1:262

Additional Details

Figure 5











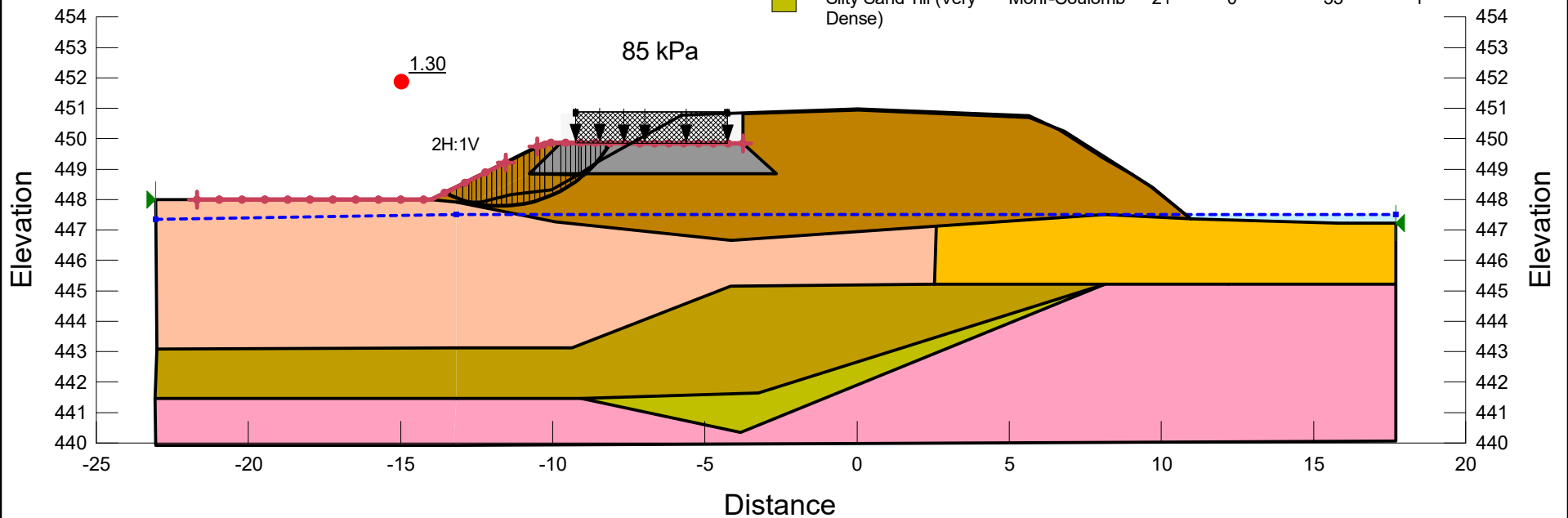
	Project Gull River Culvert Replacement		Additional Details
	Analysis East Excavation - 2H:1V Slope above GWL		
	Seismic Coefficient H: 0g, V: 0g	Last Run 2024-06-17, 09:20:33 AM	

Figure 6









Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Gravelly Sand (very dense)	Mohr-Coulomb	21	0	34	1
	OPSS Granular A	Mohr-Coulomb	22	0	35	1
	Sand Fill	Mohr-Coulomb	20	0	30	1
	Sandy Silt (loose to compact)	Mohr-Coulomb	19	0	25	1
	Silty Sand (compact to v. dense)	Mohr-Coulomb	21.5	0	34	1
	Silty Sand Till (Very Dense)	Mohr-Coulomb	21	0	33	1

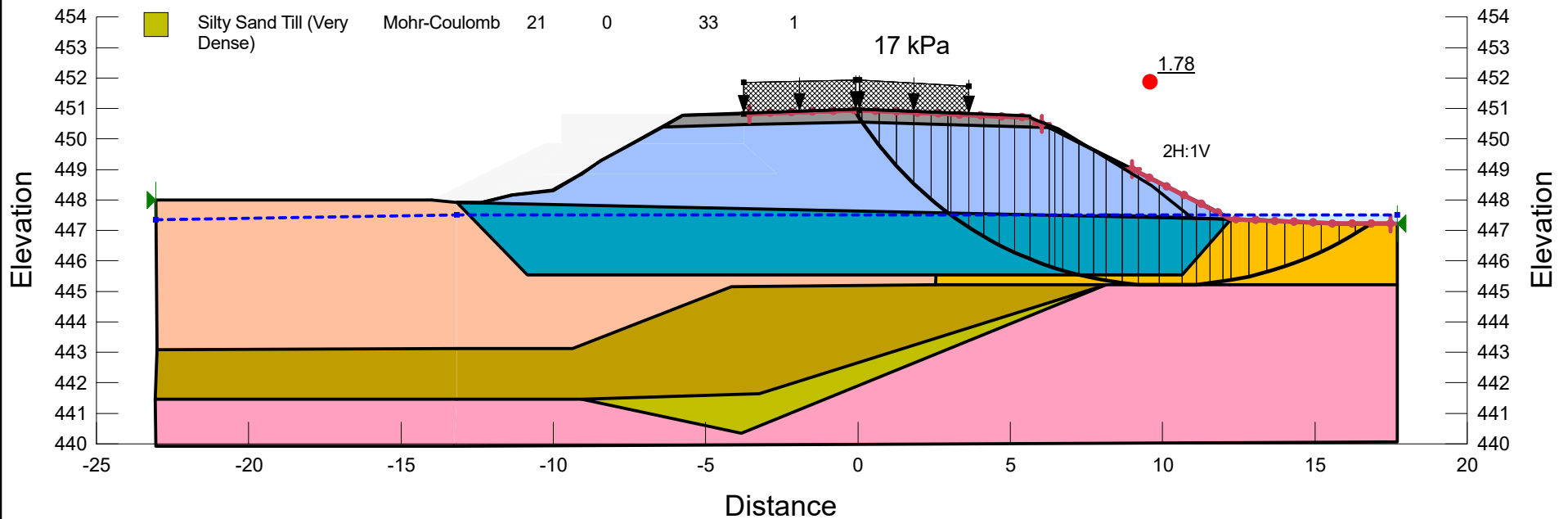


Project Gull River Culvert Replacement		
Analysis TMB Loading North Embankment Side Slope		
Seismic Coefficient H: 0g, V: 0g	Last Run 2024-06-17, 10:41:52 AM	Scale 1:203

Additional Details

Figure 7

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Clear Stone	Mohr-Coulomb	19	39	0	1
	Gravelly Sand (very dense)	Mohr-Coulomb	21	0	34	1
	OPSS Gran. B Type III	Mohr-Coulomb	21	32	0	1
	OPSS Granular A	Mohr-Coulomb	22	0	35	1
	Sandy Silt (loose to compact)	Mohr-Coulomb	19	0	25	1
	Silty Sand (compact to v. dense)	Mohr-Coulomb	21.5	0	34	1
	Silty Sand Till (Very Dense)	Mohr-Coulomb	21	0	33	1



Project		
Gull River Culvert Replacement		
Analysis		
Embankment South Slope - Post Culvert Replacement		
Seismic Coefficient	Last Run	Scale
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Additional Details
Figure 8

APPENDIX H

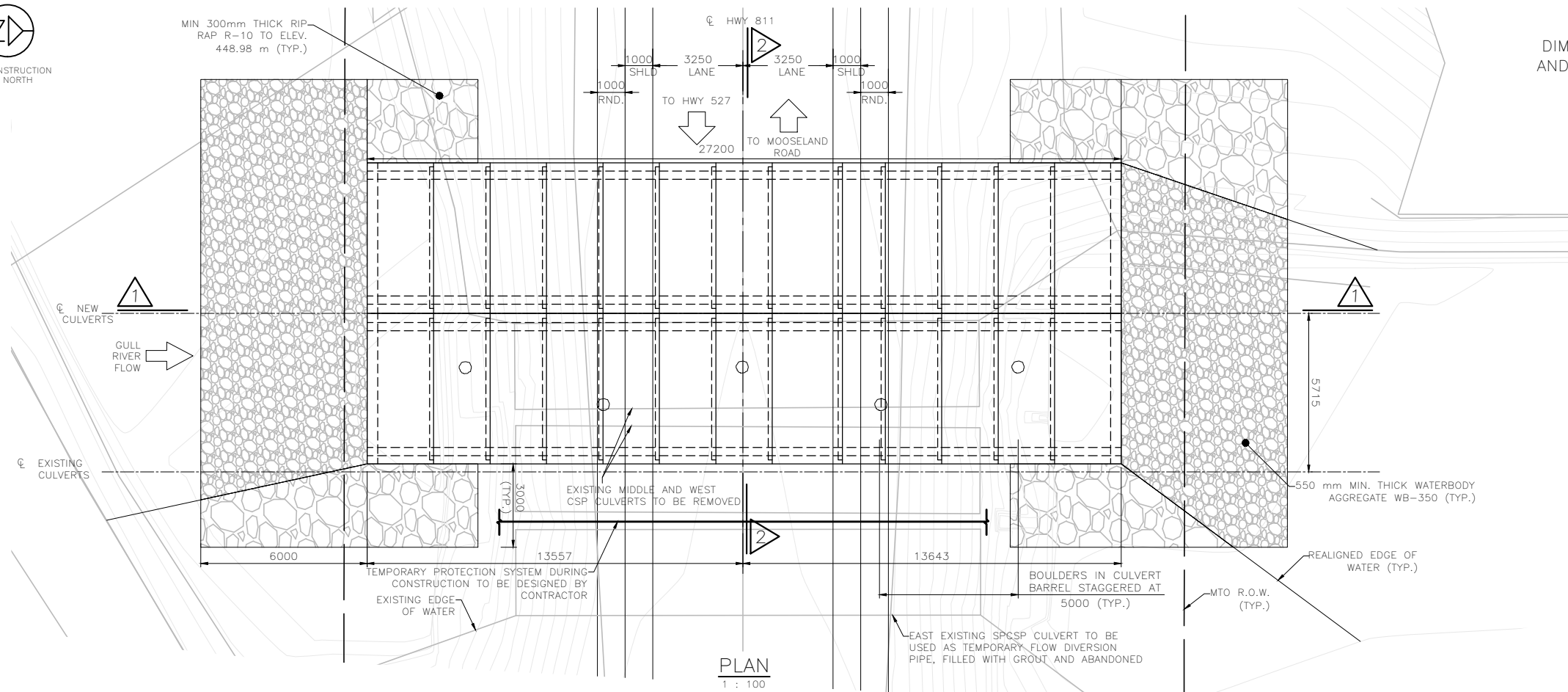
Preliminary Draft Replacement Alternative Drawings



00-0-707 00-0

MINISTRY OF TRANSPORTATION ONTARIO

Jun 21, 2024, 3:06pm Login name: SHAL20520



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN

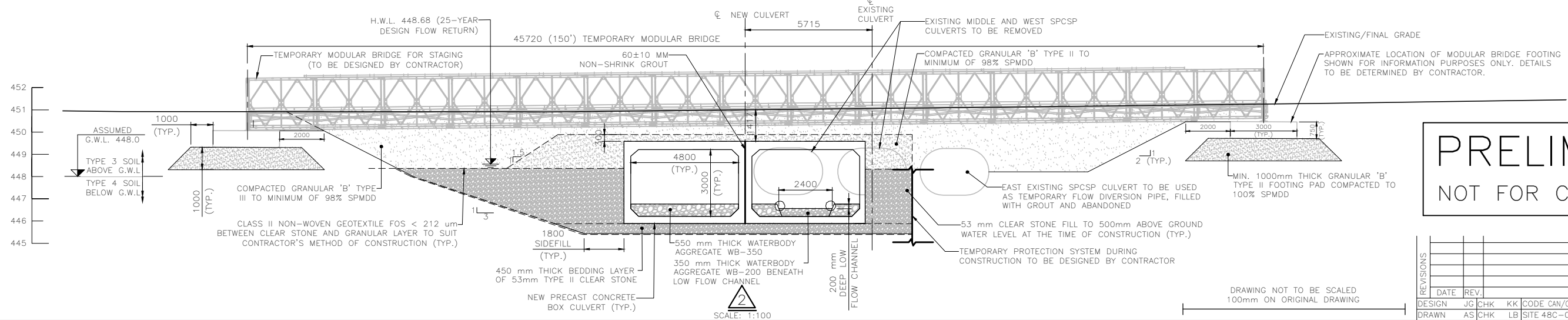
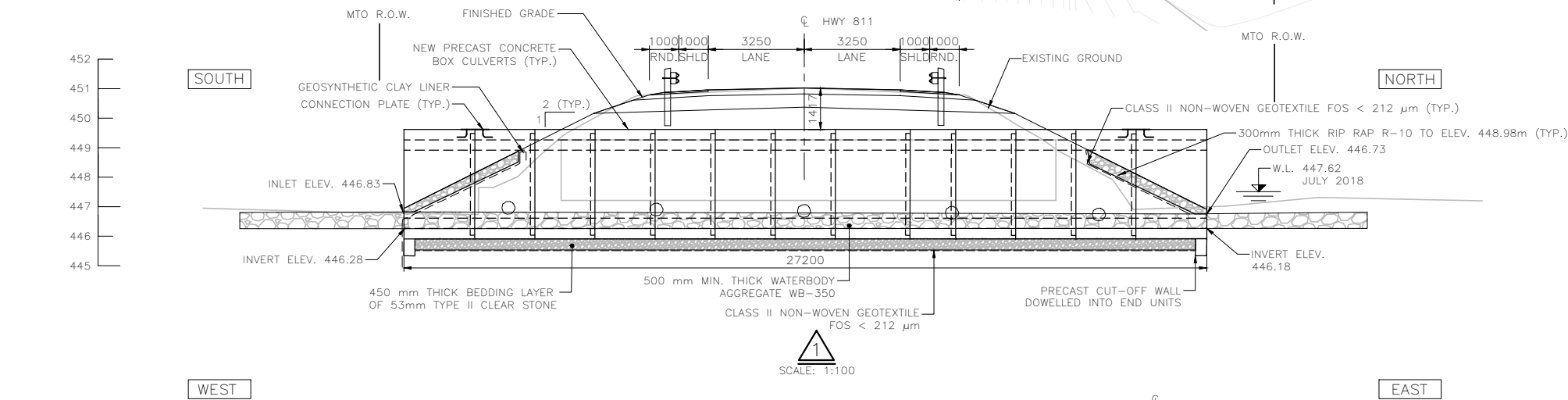
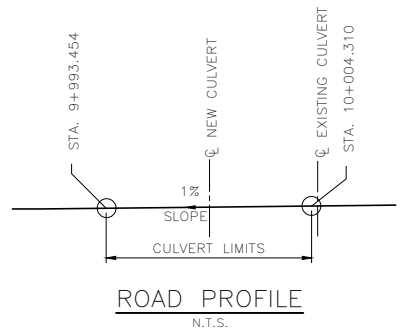
CONT No. 2023-6009
WP No. 6075-18-01



SHEET |

GULL RIVER
CULVERT REPLACEMENT
OPTION 1-TWIN PRECAST
CONCRETE BOX CULVERT

HATCH



PRELIMINARY
NOT FOR CONSTRUCTION

[illegible]

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN

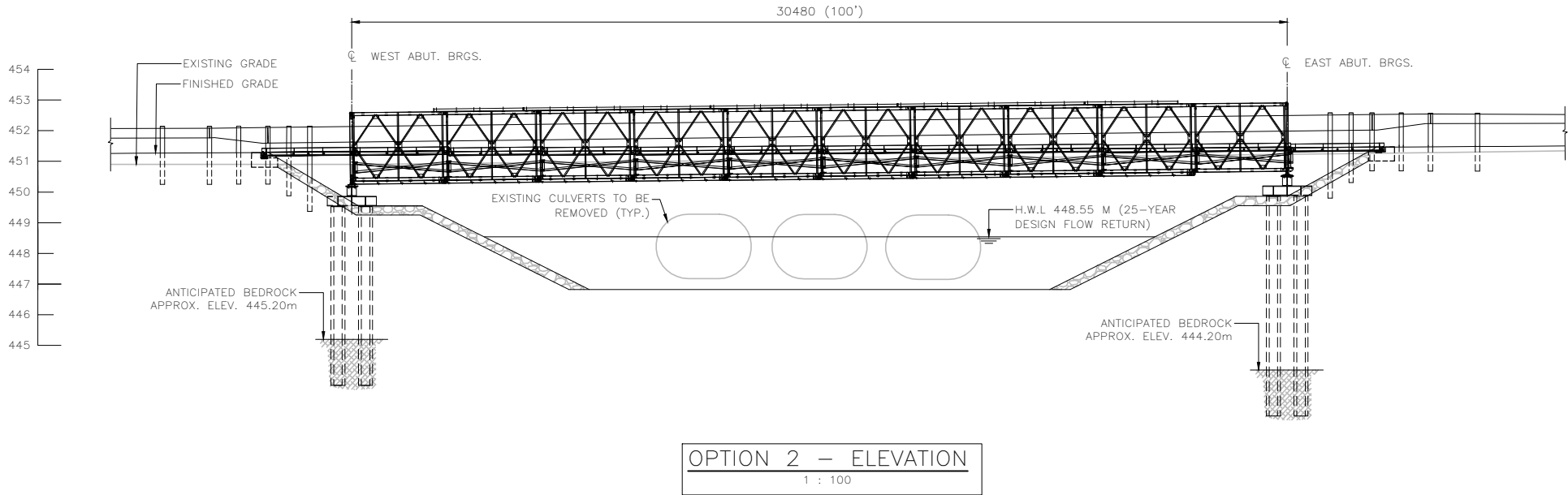
CONT No. 2023-6009
WP No. 6075-18-01



GULL RIVER
CULVERT REPLACEMENT

SHEET

HATCH



OPTION 2 – ELEVATION
1 : 100

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS						
		DATE	REV.	DESCRIPTION		
DESIGN	JG	CHK	KK	CODE CAN/CSA S6-19	LOAD CL-800-ONT	DATE JUNE 2024
DRAWN	AS	CHK	LB	SITE 48C-D111/B1		DWG

Jun 19, 2024, 4:16pm Login Name: SHL20520
Drawing Name: C:\working\hatch-dss-canada-central\4297017\G1-869894-GULL RIVER GA_recovering
PR-D-707 86-05 MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN

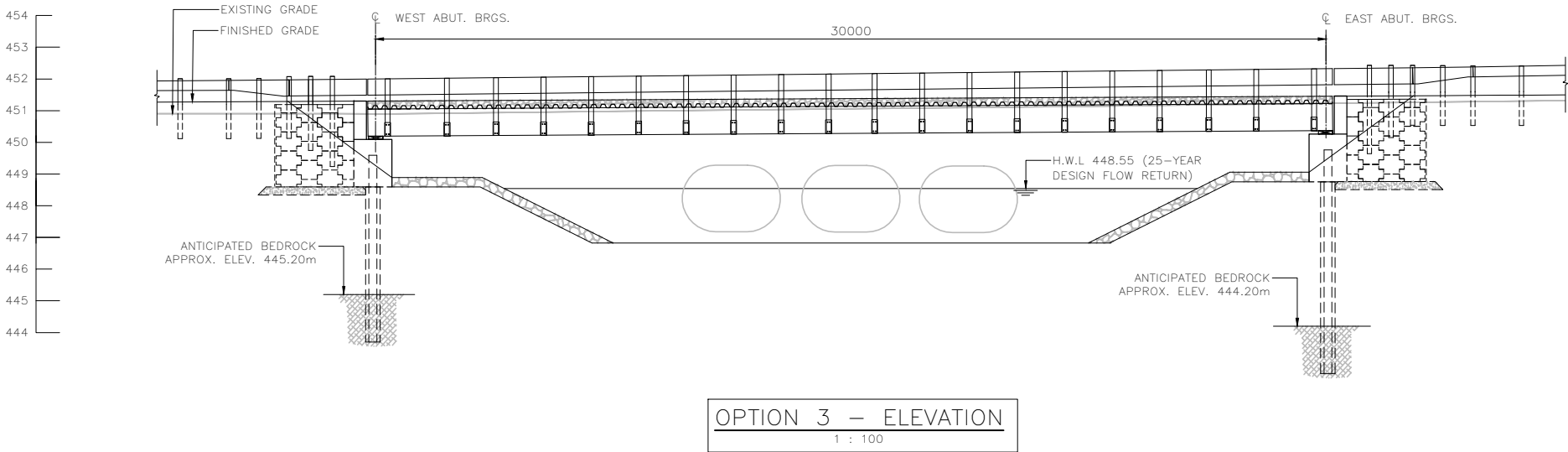
CONT No. 2023-6009
WP No. 6075-18-01



GULL RIVER
CULVERT REPLACEMENT

SHEET

HATCH



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS							
		DATE	REV.			DESCRIPTION	
DESIGN	JG	CHK	KK	CODE	CAN/CSA S6-19	LOAD CL-800-ONT	DATE JUNE 2024
DRAWN	AS	CHK	LB	SITE	48C-0111/B1		DWG

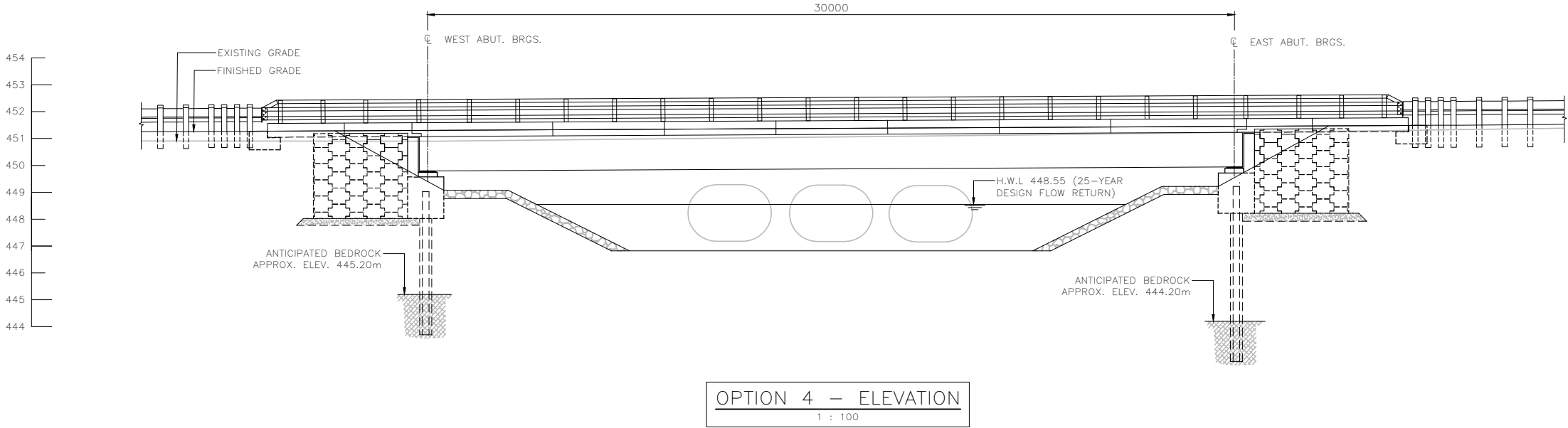
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN

CONT No. 2023-6009
WP No. 6075-18-01

GULL RIVER
CULVERT REPLACEMENT

SHEET

HATCH



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS						
		DATE	REV.	DESCRIPTION		
DESIGN	JG	CHK	KK	CODE CAN/CSA S6-19	LOAD CL-800-ONT	DATE JUNE 2024
DRAWN	AS	CHK	LB	SITE 48C-D111/B1		DWG