THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
LYON CREEK CULVERT REPLACEMENT
HIGHWAY 602, DISTRICT OF RAINY RIVER, ONTARIO
AGREEMENT 6019-E-0009, WORK ORDER 35
G.W.P. 6030-22-00, SITE NO. 45X-0151/C0

LATITUDE: 48.6252°, LONGITUDE: -93.8239°

GEOCRES No.: 52C-65

Report

to

HATCH

Date: October 17, 2023
File: 33309

103, 2010 Winston Park Drive, Oakville, ON L6H 5R7 T: 905 829 8666 F: 905 829 1166
thurber.ca

THURBER

TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1. INTRODUCTION 1
2. SITE DESCRIPTION 1
3. INVESTIGATION PROCEDURES 2
4. LABORATORY TESTING 5
5. DESCRIPTION OF SUBSURFACE CONDITIONS 5
5.1 Asphalt 5
5.2 Granular Fill 5
5.3 Silty Clay Fill 6
5.4 Topsoil 7
5.5 Silty Clay 7
5.6 Groundwater Conditions 9
6. CORROSIVITY AND SULPHATE TEST RESULTS 9
7. WATER QUALITY 10
8. SINGLE WELL RESPONSE TEST RESULTS 11
8.1 Test Procedure 11
8.2 Hydraulic Conductivity 12
9. MISCELLANEOUS 12

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

10. GENERAL 14
11. CULVERT DESIGN 15
11.1 Culvert Alternatives 15
11.2 Summary of Subsurface Conditions 16
11.3 Foundation Design for Culverts 16
11.3.1 CSP or Structural Plate CSP (SPSCP) Culvert 16
11.3.2 Concrete Box Culvert 17
11.3.3 Pre-cast Concrete Panels Supported on Sheet Pile Abutments 18
11.3.4 Frost Cover 22
11.3.5 Subgrade Preparation 22
11.3.6 Settlement Due to Grade Raise and Embankment Widening 23
11.3.7 Recommended Approach for Culvert Replacement 24
12. EXCAVATION AND GROUNDWATER CONTROL 25
13. STREAM DIVERSION PIPE 25

THURBER

14. DEWATERING ASSESSMENT 26
15. WATER QUALITY....28
16. CULVERT BACKFILL AND LATERAL EARTH PRESSURES....28
17. SEISMIC CONSIDERATIONS 29
18. COFFERDAMS....30
19. TEMPORARY PROTECTION SYSTEM 30
20. SLOPE STABILITY 31
  20.1 Permanent Slopes.... 31
  20.2 Temporary Excavation Slopes.... 32
21. EMBANKMENT RESTORATION 33
22. SCOUR AND EROSION PROTECTION....33
23. CORROSION AND SULPHATE ATTACK POTENTIAL 33
24. CONSTRUCTION CONCERNS....34
25. CLOSURE 34

STATEMENT OF LIMITATIONS AND CONDITIONS

APPENDICES

Appendix A Record of Borehole Sheets
Appendix B Laboratory and Well Test Results
Appendix C Site Photographs
Appendix D Borehole Locations and Soil Strata Drawings
Appendix E Foundation Comparison
Appendix F List of Referenced OPSS and OPSD Documents and Suggested Wording for NSSP
Appendix G Settlement Profile and Slope Stability Figures
Appendix H Draft General Arrangement Drawings

THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
LYON CREEK CULVERT REPLACEMENT
HIGHWAY 602, DISTRICT OF RAINY RIVER, ONTARIO
AGREEMENT 6019-E-0009, WORK ORDER 35
G.W.P. 6030-22-00, SITE NO. 45X-0151/C0

GEOCRES No.: 52C-65

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 the design of the proposed Lyon Creek Culvert Replacement. Lyon Creek Culvert is located on Highway 602, near Emo, in the District of Rainy River, Ontario. The site is approximately 1 km south of the Highway 11 and Highway 602 Junction.

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, under the Ministry of Transportation Ontario (MTO) Retainer Agreement Number 6019-E-0009 Assignment #35, with additional work carried out under Agreement Number 6021-E-0005 Assignment #16. The original GWP number during preliminary design was 6120-17-00, which was updated during the detailed design phase to 6030-22-00.

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 602, between Jessie Street and Howse Road, near Emo, Ontario. The existing culvert allows the Lyon Creek to flow in a south-west direction under Highway 602 towards the Rainy River outlet. Highway 602 runs in a northwest to southeast direction at the site. For the purposes of this report and consistency with the General Arrangement drawings, Highway 602 is considered to run in an east-west direction, with the culvert inlet side (northeast end) considered to be north for construction.

The available General Arrangement (GA) drawings provided by Hatch indicate that the existing structure is a cast-in-place concrete, open footing culvert. The drawings indicate that the existing culvert opening has a span of 6.1 m, height of 2.4 m, and the length is 16.34 m. There are concrete wingwalls at each corner of the culvert. The estimated culvert invert is at approximate Elev. 325.7 m at the inlet (North) and 325.6 m at the outlet (South). The existing road grade at the culvert location is Elev. 331.6 m, which varies from approximately 331.3 m to the west and 332.5 m to the east of the culvert, where the roadway surface is located within a cut area and is lower than the surrounding topography to the north and south. The general topography in the area slopes down towards the Lyon Creek valley, which curves to the west beyond the culvert inlet. The existing highway embankment side slopes above and near the culvert are inclined at approximately 2H:1V. Previous structural assessments of the culvert have noted the presence of erosion of the embankment slopes above the culvert. The local creek water level was reportedly measured at Elev. 327.1 m in July 2018. Flooding of Lyon Creek was observed throughout Spring and early Summer 2022 (see Photo 6 in Appendix C).

The lands surrounding the site are forested areas immediately along the creek, with agricultural zones in the surrounding area. A railway corridor running roughly parallel to Highway 602 exists approximately 75 m south of the site. Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on published geological information, the culvert lies within an area of glaciolacustrine deposits of silt and clay with minor sand ranging to silty clay to silt till. Based on the OGS Map MRD126-REV1 titled "Bedrock Geology of Ontario", dated 2011, the bedrock at site is identified as metasedimentary rock with iron formations to the east of the site.

3. INVESTIGATION PROCEDURES

The site investigation and field-testing program for this project was carried out in three phases, from April 30 to May 2, 2022, from August 22 to 26, 2022, and from July 26 to 28, 2023. The investigation consisted of drilling and sampling seven (7) boreholes (22-06 to 22-10 and 23-01 to 23-02). Boreholes 22-06 and 22-07 were drilled off road near the culvert inlet and outlet respectively to depths of 5.6 and 12.6 m (Elev. 321.5 and 315.2 m) respectively. Boreholes 22-08 to 22-10 were drilled through the paved portion of Highway 602 each to a depth of 16.3 m (Elev. 316.0 to 314.9 m). Flooding at the inlet and outlet of the site delayed the completion of Boreholes 22-06 and 22-07, which were drilled after the flood waters receded in August 2022. In order to obtain deeper subsurface information for the preferred foundation design, Thurber returned in July 2023 to advance Boreholes 23-01 and 23-02, which were drilled through the paved portion of Highway 602 each to a depth of 25.5 m (Elev. 306.5 to 305.9 m).

The Record of Borehole sheets are included in Appendix A. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from field measurements relative to existing site features and the topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 16 was used for the boreholes.

Boreholes 22-08 to 22-10 and 23-01 to 23-02 were advanced using rubber-tired CME 750 and D90 drill rigs, using solid stem augers and NW casing / Tricone with wash boring techniques. Borehole 22-06 was advanced using a tripod with continuous split spoon and wash boring techniques. A Dynamic Cone Penetration Test (DCPT) was conducted adjacent to Borehole 22-06. A half-weight hammer was used for driving the casing, split spoon samples and the DCPT at Borehole 22-06. The 'N' values presented on the record of borehole sheet for Borehole 22-06 have been adjusted to account for the half-weight hammer. Borehole 22-07 was advanced using a Simco track-mounted, limited access drill rig, using solid stem augers. Soil samples were obtained in all boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Field vane shear testing, typically using an MTO "N" sized shear vane was carried out in the cohesive soils. Thin-walled tube samples (Shelby Tubes) were also collected at selected depths in the cohesive soil for consolidation testing. In Boreholes 23-01 and 23-02, only limited sampling and vane shear testing was conducted in the upper 15 m depth, since sufficient subsurface information was available for the upper 15 m in Boreholes 22-06 to 22-10.

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 samples for transport to Thurber's laboratory for further examination and testing.

A monitoring well was installed in Borehole 22-07. The well consisted of 50 mm Schedule 40 PVC pipe with a 3.05 m long slotted screen, enclosed in a column of filter sand to permit groundwater level monitoring. Well installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets.

One sample of surface water was taken from Lyon creek, north of the culvert inlet, and one sample of groundwater was taken from the monitoring well installed in Borehole 22-07. Water samples were submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of water quality parameters. Upon collection of the water sampling on August 28, 2022, the well was decommissioned in general accordance with MECP 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
22-06	5.6 / 321.5	N/A	Borehole caved from 5.6 to 1.4 m. Borehole backfilled to surface with bentonite.
22-07	12.6 / 315.2	12.0 / 315.8	Piezometer installed at 12 m with 3.05 m slotted screen length. Filter sand installed from 9.7 to 12.6, bentonite holeplug backfilled from 9.7 m to surface. Monitoring well removed August 28, 2022, borehole backfilled with bentonite to surface.
22-08	16.3 / 315.1	N/A	Borehole backfilled with bentonite holeplug from 16.3 m to 1.2 m, Concrete from 1.2 m to 0.2 m, and asphalt 0.2 m to surface.
22-09	16.3 / 314.9	N/A	Borehole backfilled with bentonite holeplug from 16.3 m to 1.2 m, Concrete from 1.2 m to 0.2 m, and asphalt 0.2 m to surface.
22-10	16.3 / 316.0	N/A	Borehole backfilled with bentonite holeplug from 16.3 m to 1.2 m, Concrete from 1.2 m to 0.2 m, and asphalt 0.2 m to surface.
23-01	25.5 / 306.5	N/A	Borehole backfilled with bentonite holeplug from 25.5 m to 0.1 m, and asphalt 0.1 m to surface.
23-02	25.5 / 305.9	N/A	Borehole backfilled with bentonite holeplug from 25.5 m to 0.1 m, and asphalt 0.1 m to surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. Approximately 25% of the collected samples were subjected to grain size distribution analyses (sieve and hydrometer). One-dimensional consolidation tests were also conducted on two samples of the native silty clay. The results of this testing program are summarized on the Record of Borehole sheets in Appendix A and are shown on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, two (2) soil samples and one sample of surface water from Lyon Creek were collected during the investigation and submitted to SGS, a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. To assess the quality of the groundwater for disposal purposes, a groundwater sample from the well installed in Borehole 22-07 and a surface water sample from the creek were collected. The results of the analytical testing are summarized in this report and presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. 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 D. 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 below the asphalt typically consists of granular fill overlying silty clay fill, which is underlain by native silty clay with some sand and trace gravel. More detailed descriptions of individual strata are presented below.

5.1 Asphalt

Boreholes 22-08, 22-09, 22-10, 23-01 and 23-02 were drilled through the paved portion of Highway 602. The asphalt thickness ranged from 25 to 75 mm at the borehole locations.

5.2 Granular Fill

Granular embankment fill was encountered immediately below the pavement in Boreholes 22-08, 22-09, and 22-10. The fill was brown, and consisted of sand with some gravel, some silt and trace clay. The granular fill was encountered from the bottom of asphalt at 0.8 m depth and extended to depths ranging from 0.7 m to 2.2 m (Elev. 330.5 to 330.0 m) across the road boreholes. The thickness of the granular fill ranged from 0.6 to 2.1 m. Granular fill was also encountered in Boreholes 23-01 and 23-02, which were advanced through the granular fill to the underlaying silty clay fill without sampling.

SPT ‘N’ values in the granular fill ranged from 17 to 51 blows per 0.3 m of penetration, indicating a compact to very dense relative density, typically compact. The measured moisture content for the granular fill was generally 3 to 6% within the first 0.7 m depth. At depths greater than 0.7 m, the moisture content ranged from 10 to 33%.

The results of grain size analyses conducted on three selected samples of the sand fill are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B1 of Appendix B. The results are summarized in Table 5.1 below.

Table 5.1: Granular Fill Grain Size Analysis

Soil Particle	Percentage (%)
Gravel	15 to 21
Sand	59 to 65
Silt and Clay	18 to 22

5.3 Silty Clay Fill

Silty clay fill was encountered below the granular fill in Boreholes 22-08, 22-09 and 22-10 at depths of 0.7 to 2.2 m (Elev. 330.5 to 330.0 m). Silty clay fill was also encountered in Boreholes 23-01 and 23-02. The silty clay fill extended to depths from 5.2 to 5.6 m (Elev. 326.8 to 325.6 m) in the boreholes. The silty clay fill contained some sand to sandy, trace gravel, trace rootlets and occasional wood fragments. The fill was brown to grey in colour. The thickness of the silty clay fill ranged from 3.4 to 4.9 m.

SPT ‘N’ values in the silty clay fill ranged from 3 to 26 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. Measured moisture contents ranged from 21 to 37%.

The results of grain size analyses conducted on four selected samples of the silty clay fill are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B2 of Appendix B. The results are summarized in Table 5.2 below.

Table 5.2: Silty Clay Fill Grain Size Analysis

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	12 to 28
Silt	36 to 40
Clay	31 to 50

The results of Atterberg Limits Tests conducted on selected samples of the silty clay fill are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B6 of Appendix B. The results are summarized below in Table 5.3 below. The results indicate that the samples tested consist of intermediate to high plasticity silty clay, with group symbols of CI to CH.

Table 5.3: Silty Clay Fill Atterberg Limits Test Results

Parameter	Result
Liquid Limit	48 to 60
Plastic Limit	19 to 21
Plasticity Index	28 to 39

5.4 **Topsoil**

A 25 mm thick layer of topsoil was observed at the ground surface in Boreholes 22-06 and 22-07. The topsoil thickness may vary in other areas of the site.

5.5 **Silty Clay**

Native silty clay was encountered below the fill at depths from 5.2 to 5.6 m in Boreholes 22-08, 22-09, 22-10, 23-01 and 23-02 (Elev. 326.8 to 325.6 m) and below the 25 mm thick topsoil layer in Boreholes 22-06 and 22-07. All boreholes were terminated within the silty clay at depths ranging from 5.6 to 25.5 m (Elev. 321.5 to 305.9 m).

The silty clay was generally grey and contained some sand and trace gravel. Occasional organics and wood fragments were observed in the upper part of the silty clay in Boreholes 22-06 and 22-07, extending to depths of 1.2 to 2.1 m (Elev. 325.9 to 325.7 m). SPT 'N' values in the silty clay ranged from 4 to 61 (typically 4 to 9) blows per 0.3 m penetration, and field vane shear tests measured undrained shear strengths ranging from 57 to 220 kPa (typically 57 to 114 kPa). The SPT 'N' values and undrained shear strength values indicate that the clay has a firm to very stiff consistency (typically stiff to very stiff).

Borehole 22-07 contained a 0.5 m thick sand layer within the silty clay, extending from 2.1 m to 2.6 m depth (Elev. 325.7 to 325.2 m). One grain size analysis indicated the layer was composed of 12% gravel, 62% sand, 14% silt, and 12% clay sized particles. The results of the grain size analysis on the sand layer on the Record of Borehole sheets in Appendix A and plotted in Figure B5 of Appendix B. A moisture content of 25% was measured for the sand.

Recorded moisture contents in the silty clay ranged from 25 to 45%. The results of grain size analyses conducted on selected samples of the silty clay deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B3 and B4 of Appendix B. The results are summarized in Table 5.4.

Table 5.4: Silty Clay Grain Size Analysis

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	13 to 35
Silt	30 to 36
Clay	33 to 56

The results of Atterberg Limits tests conducted on the silty clay are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B7 and B8 of Appendix B. The results are summarized below in Table 5.5 below. The results indicate that the samples tested consist of intermediate to high plasticity silty clay, with group symbols of CI to CH.

Table 5.5: Silty Clay Atterberg Limits Test Results

Parameter	Result
Liquid Limit	40 to 68
Plastic Limit	19 to 31
Plasticity Index	18 to 40

One-dimensional consolidation tests were performed on two samples of the silty clay (thin-walled tube samples), which were collected from Boreholes 22-07 and 22-08. The results of the testing are presented in Appendix B and are summarized in the following table.

Borehole	Sample Depth (m)	e_o	C_c	C_r	p_c' (kPa)	p_o' (kPa)	OCR	c_v (m^2/year)	c_{vr} (m^2/year)
22-07	3.8 to 4.4	0.852	0.302	0.032	285	77	3.7	0.6 – 1.0	1.1 – 4.1
22-08	7.6 to 8.2	0.841	0.284	0.049	245	153	1.6	0.3 – 0.5	0.6 – 5.3

5.6 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 well installed in Borehole 22-07. The measured groundwater levels taken are summarized in Table 5.6 below. The monitoring well was decommissioned on August 28, 2022 following water sampling and slug testing.

Table 5.6: Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
22-06	August 26, 2022	---	---	Open borehole dry after caving to 1.4 m.
22-07	August 24, 2022 August 25, 2022 (8:00 AM) August 25, 2022 (12:46 PM)	7.3 5.0 4.8	320.5 322.8 323.0	In monitoring well.
22-08	May 2, 2022	5.2	326.2	Open borehole.
22-09	May 1, 2022	5.6	325.6	Open borehole.
22-10	April 30, 2022	5.6	326.7	Open borehole.

Due to the short duration of the field investigation, it is anticipated that sufficient time was not available for infiltration of groundwater into the open boreholes and monitoring well, given the presence of relatively low permeability silty clay subsurface soils. Therefore, the water level measurements recorded may not represent the stabilized groundwater level.

The groundwater level is likely to reflect the local creek water level. The surface water level of Lyon Creek was reportedly measured at Elev. 327.1 m in July 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 silty clay fill and native silty clay from Boreholes 22-07 and 22-08 and a sample of surface water taken from Lyon Creek were submitted for analytical testing of corrosivity parameters and sulphate. The laboratory certificates of analysis for the current investigation are presented in Appendix B. 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		
			22-07 SS3B (8'6"-9'6")	22-08 SS3 (5'-7')	Lyon Creek SW
			Silty Clay	Silty Clay Fill	Surface Water
Redox Potential	mV	mV	230	263	207
Sulphide	%	N/A	0.17	< 0.04	---
pH	-	-	8.25	8.85	7.77
Chloride	µg/g	mg/L	48	230	3.1
Sulphate	µg/g	mg/L	430	42	3.5
Conductivity	uS/cm	µS/cm	561	317	100
Resistivity	ohm-cm	ohm-cm	1780	3150	10,000*

** Calculated by Thurber based on conductivity result*

7. WATER QUALITY

For assessment of the general groundwater quality in the project area, a sample of the groundwater from the monitoring well at Borehole 22-07, and a surface water sample from the creek were collected on August 28, 2022. The water samples were analyzed for selected inorganic parameters included in the Ontario Provincial Water Quality Objectives (PWQO), as well as Total Suspended Solids. Filtered sub-samples were also tested for dissolved metal parameters for comparison purposes. The analytical test results are presented in Appendix B.

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. All parameters shown in Table 7.1 are from the unfiltered sample, representing total concentrations. No dissolved parameter concentrations (filtered sub-samples) exceeded the PWQO criteria. The Total Suspended Solids concentration for surface water was 12 mg/L and was 1,850 mg/L for the unfiltered water taken from the monitoring well at 22-07 (no assigned PWQO criteria).

Table 7.1 – Water Parameters Exceeding PWQO Criteria

Sample ID	Parameter	Criteria	Parameter Limit (mg/L)	Result (mg/L)
22-07 (Groundwater)	Total Arsenic	Interim PWQO PWQO	0.005 0.100	0.0084
	Total Cobalt	Interim PWQO	0.0009	0.0141
	Total Cadmium	Interim PWQO PWQO	0.0005[1] 0.0001	0.000593
	Total Copper	Interim PWQO PWQO	0.005[2]	0.0234
	Total Iron	PWQO	0.3	17.2
	Total Nickel	PWQO	0.025	0.0308
	Total Phosphorus	Interim PWQO	0.01[3]	0.599
	Total Silver	PWQO	0.0001	0.00015
	Total Uranium	Interim PWQO	0.005	0.00864
	Total Vanadium	Interim PWQO	0.006	0.0448
	Total Zinc	Interim PWQO PWQO	0.02 0.03	0.075
Lyon Creek (Surface Water)	Total Iron	PWQO	0.3	0.465
	Total Phosphorous	Interim PWQO	0.01[3]	0.108

[1] Cadmium interim PWQO follows a scale based on measured hardness as $CaCO_3$. The interim PWQO of 0.0001 mg/L is set for water with less than 100 mg/L hardness as $CaCO_3$, the interim PWQO OF 0.0005 mg/L is set for water with greater than 100 mg/L hardness as $CaCO_3$. All water samples taken have measured hardness as $CaCO_3$ greater than 100 mg/L. See Appendix B for testing results.

[2] Total Phosphorous Interim PWQO follows site specific guidelines. The interim PWQO of 0.01 mg/L is set as a high level of protection against aesthetic deterioration, the interim PWQO of 0.02 mg/L to avoid nuisance concentrations of algae in lakes, and the interim PWQO of 0.03 mg/L to avoid excessive plant growth in rivers and streams

[3] Copper interim PWQO follows a scale based on measured hardness as $CaCO_3$. The interim PWQO of 0.0001 mg/L is set for water with less than 20 mg/L hardness as $CaCO_3$, the interim PWQO OF 0.0005 mg/L is set for water with greater than 20 mg/L hardness as $CaCO_3$. All water samples taken have measured hardness as $CaCO_3$ greater than 20 mg/L. See Appendix B for testing results.

8. SINGLE WELL RESPONSE TEST RESULTS

8.1 Test Procedure

A Single Well Response Test (SWRT), or “slug” test, was carried out in the 50-mm diameter well installed in Borehole 22-07. The well was screened across silty clay. The test was completed using the following method:

- In advance of conducting the slug test, the monitoring well was developed and purged to remove excess sediment that may have entered the well during installation, to increase the representativeness of the natural groundwater in the well and to improve the transmissivity of the sand pack and well screen.

- A datalogger was inserted into the well following development to monitor the recovery of the water level in the well. The datalogger was set to record water levels every 15 seconds, based on the anticipated rate of recovery of the well.

- 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 test analyzed using the Hvorslev method. The plot of the slug test result is included in Appendix B. The hydraulic conductivity value calculated from the in-situ slug test is summarized in Table 8.1 below.

Table 8.1: Single Well Response Test Results

Monitoring Well	Hydraulic Conductivity (m/s)	Screened Formation
22-07	9.0×10^{-9}	Silty Clay

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 rubber-tired CME 750 and D-90 drill rigs, a Simco Limited Access drill rig, and tripod portable drilling equipment. RPM Drilling conducted the drilling, sampling and in-situ testing operations for the boreholes. Traffic control services were provided by ML Judson Trucking Ltd. of Emo, Ontario.

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

The field investigation was supervised on a full-time basis by Mr. Gregory Stanhope and Mr. Matthew MacAskill of Thurber. The overall supervision of the field program was conducted by Ms. Rachel Bourassa, E.I.T., Ms. Alysha Kobylinski, P.Eng., and Mr. Mark Farrant, P.Eng. of Thurber.

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

THURBER ENGINEERING LTD.

Rachel Bourassa, E.I.T.
Geotechnical Engineering Intern

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

Dr. P.K. Chatterji, Ph.D., P.Eng.
Designated MTO Principal Contact

THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
LYON CREEK CULVERT REPLACEMENT
HIGHWAY 602, DISTRICT OF RAINY RIVER, ONTARIO
AGREEMENT 6019-E-0009, WORK ORDER 35
G.W.P. 6030-22-00, SITE NO. 45X-0151/C0

GEOCRES No.: 52C-65

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 geotechnical recommendations for the proposed replacement of the existing Lyon Creek culvert crossing Highway 602. The discussion and recommendations presented in this report are based on the information provided by Hatch and on the factual data obtained during the course of the investigation.

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 General Arrangement drawings provided by Hatch indicate that the existing structure is a cast-in-place concrete, open footing culvert with a span of 6.1 m, height of 2.4 m, and a length of 16.34 m. There are concrete wingwalls at each corner of the culvert. The estimated culvert invert is at approximate Elev. 325.7 m at the inlet (North) and 325.6 m at the outlet (South). The existing road grade at the culvert location is Elev. 331.6 m, which varies from approximately 331.3 m to the west and 332.5 m to the east of the culvert, where the roadway surface is located within a cut area and is lower than the surrounding topography to the north and south. The local creek water level was reportedly measured at Elev. 327.1 m in July 2018. Flooding of Lyon Creek was observed throughout Spring and early Summer 2022.

The general topography in the area slopes down towards the Lyon Creek valley, which curves to the west beyond the culvert inlet. The existing highway embankment side slopes above and near the culvert are inclined at approximately 2H:1V. Previous structural assessments of the culvert have noted the presence of erosion of the embankment slopes above the culvert.

This report refers to the following applicable codes:

- Canadian Highway Bridge Design Code (CHBDC), 2019
- National Building Code of Canada (NBCC), 2015

11. CULVERT DESIGN

11.1 Culvert Alternatives

This section presents discussions on various options for rehabilitation or replacement of the existing culvert. Foundation recommendations for the preferred culvert types are provided.

Several culvert options being considered for this site are listed below:

- Replacement with corrugated steel pipe (CSP), structural plate corrugated steel pipe (SPCSP) or twin pipes
- Replacement with concrete box (closed) culvert composed of pre-cast segments
- Replacement with a sheet pile culvert composed of sheet pile walls or sheet pile combination walls with a pre-cast concrete panel cap

A comparison of the culvert types and foundation alternatives based on their respective advantages and disadvantages is included in Appendix E.

An additional option for rehabilitation of the existing box culvert with new concrete box culvert extensions was also considered. Through initial analysis and discussions with Hatch, several concerns were identified with this option including insufficient flow capacity for the existing culvert, bearing capacity, and the potential for differential settlement between the existing culvert and the extensions that would be too large to accommodate in the design. Based on these considerations, this option was ultimately determined to not be a feasible alternative and was not developed further.

Preliminary draft General Arrangement (GA) drawings were provided by Hatch for each of the culvert options listed above, which are attached in Appendix H. Each of these options includes lengthening of the culvert, increasing the vertical profile with an embankment grade raise of up to approximately 1.2 m above the culvert, and widening of the embankment with additional fill at each end. Recommendations for the design and installation of these culvert options are presented below.

11.2 Summary of Subsurface Conditions

In general, the subsurface stratigraphy below the asphalt typically consists of granular fill overlying silty clay fill, which is underlain by native silty clay with some sand and trace gravel.

The unstabilized groundwater level in the open boreholes and monitoring well ranged from approximate Elevation 323.0 to 326.7 m. The local creek water level was reportedly measured at Elev. 327.1 m in July 2018.

11.3 Foundation Design for Culverts

The invert level of the existing culvert (bottom of culvert) is at approximate Elevation 325.7 m at the inlet (north) and 325.6 m at the outlet (south).

Foundation design aspects for the replacement culvert include subgrade conditions and preparation, geotechnical capacities, settlement of foundation soils, lateral earth pressures, groundwater control, cofferdams, temporary stream diversion pipes, temporary roadway protection system design and restoration of the roadway embankment.

11.3.1 CSP or Structural Plate CSP (SPSCP) Culvert

Replacement of the culvert with a single or multiple CSPs or SPCSPs along the same alignment has been considered for this site. The subgrade soils will be subjected to additional loading due to the embankment grade raise and widening associated with the longer replacement culvert. The GA drawing provided by Hatch shows a design including twin 3.05 m diameter, 38.3 m long SPCSPs, with an invert level (bottom of pipe) at approximate Elev. 325 m (see Appendix H).

If this alternative is selected, the pipes should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.010. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The underside of the bedding layer should be placed at or below Elev. 324.7 m on the stiff to very stiff native silty clay. Any buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition. The subgrade preparation, placement and compaction of bedding should be carried out in the dry. Adequate preparation of the subgrade will be essential for good performance of the culvert. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction. A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the bedding material. The geotextile should meet the specifications for the OPSS Class II (OPSS 1860) and have a fabric opening size (FOS) not greater than 212 µm.

The major disadvantage of this option is that it will require a large temporary excavation of approximately 60 m long and up to 8 m deep to install the culvert (see draft GA drawing in Appendix H).

11.3.2 Concrete Box Culvert

Replacement of the culvert with a new concrete box culvert on the same alignment has also been considered for this site. The subgrade soils will be subjected to additional loading due to the embankment grade raise and widening associated with the longer replacement culvert. The GA drawing provided by Hatch shows a design with a 38.2 m long precast concrete box culvert with an opening size of 6.0 m wide by 3.0 m high, with an invert level at approximate Elev. 325.1 m and the base of the box culvert at approximate Elev. 324.7 m (see Appendix H).

In order to provide a uniform foundation subgrade and provide sufficient geotechnical resistance, a minimum 1 m thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the box culvert. The bedding material should be placed on the prepared subgrade as soon as practicable following its inspection and approval. The underside of the bedding layer should be placed on the stiff to very stiff native silty clay at or below Elev. 323.7 m. Any buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition. The subgrade preparation and placement and compaction of the bedding material should be carried out in the dry. 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 subgrade soils and the bedding material. The geotextile should meet the specifications for the OPSS Class II, and have a fabric opening size (FOS) not greater than 212 µm. The subgrade surface prepared to support the box units should have a 75 mm minimum thick top levelling course consisting of uncompacted Granular A as per OPSS 422. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

The following geotechnical resistances are recommended for the design of an approximately 6 to 7 m wide box culvert founded on a 1 m thick granular pad with the underside at or below Elevation 323.7 m on the native stiff to very stiff silty clay:

Geotechnical Resistance	Approx. 6 to 7 m Wide Culvert
Factored Geotechnical Resistance at ULS	235 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	185 kPa

A consequence factor of 1.0 was utilized in this design 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 should be calculated assuming ultimate coefficients of friction of 0.45 between the concrete and the underlying Granular A or B Type II bedding material, and 0.35 between the bedding material and the native sandy, silty clay.

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.

The major disadvantage of this option is that it will require a large temporary excavation of approximately 60 m long and up to 9 m deep to install the culvert (see draft GA drawing in Appendix H).

11.3.3 Pre-cast Concrete Panels Supported on Sheet Pile Abutments

A culvert consisting of two parallel sheet pile walls capped with pre-cast concrete panels is considered feasible at this site. The sheet piles will provide containment and resistance to lateral

THURBER

earth pressures from the embankment fill. This option will reduce the extent of temporary excavation that will be required to install the culvert. Both standard sheet piles walls and sheet pile combination walls are considered. Sheet pile combination walls consist of a combination of conventional sheet piles and H-piles to form the walls, which allow for higher lateral and axial capacities to be achieved over conventional sheet piles alone. Combination walls are expected to provide additional rigidity for lateral loading. Draft GA drawings for both sheet pile wall types are included in Appendix H.

The draft GA drawings for both sheet pile wall options show the base of the excavation (underside of the streambed material) at approximate Elevation 325.3 m and the cut-off for the top of the sheet piles (the underside of the concrete panels) at Elevation 329.1 m.

For standard sheet pile walls, the draft GA drawing shows the sheet pile tip Elevations at 305.8 m for AZ 50-700N sections. The length of the sheet pile culvert (along the creek) is approximately 23.8 m. Sheet piles wing walls of approximately 9.8 m long are also shown at each quadrant to retain the embankment fill near the culvert.

For sheet pile combination walls, the draft GA drawing shows the sheet pile tip Elevations at 309.3 m. The length of the sheet pile culvert is approximately 25.1 m along the creek, and the wing walls are approximately 10.6 m long.

11.3.3.1 Axial Resistance of Sheet Piles

Driven steel sheet piles will develop resistance to vertical loads through frictional resistance along the sides of the sheet piles within the firm to very stiff silty clay fill and the stiff to very stiff native silty clay. For sheet pile combination walls, the larger surface area of the H-piles will provide additional frictional resistance.

Based on discussions with Hatch, we understand that the axial design loads will be 840 kN/m for ULS and 640 kN/m for SLS. For standard sheet pile walls, AZ 50-700N sections are proposed, and for sheet pile combination walls, HZ 880M C - 12 / AZ 25-800 sections are proposed. Based on this information, the following table provides the recommended geotechnical axial resistances for driven sheet pile walls and sheet pile combination walls, for the application sections and pile lengths below the base of excavation:

Sheet Pile Wall Type and Section	Sheet Pile Tip Elevation (m)	Approx. Total Sheet Pile Length (m)	Approx. Embedded Sheet Pile Length (m)	Factored ULS Capacity (per m of wall) (kN/m)	SLS Capacity (per m of wall) (kN/m)
Standard Sheet Pile Wall Section AZ 50-700	305.8	23.3	19.5	840	640
Combination Wall Section HZ 880M C -12 / AZ 25-800	309.3	19.8	16	840	640

The SLS values are based on a vertical pile settlement of 25 mm at the base of the embankment fill. Elastic compression of the sheet pile will be in addition to this settlement.

A consequence factor of 1.0 was utilized in this design 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.

11.3.3.2 Pile Installation

Pile installation should be in accordance with OPSS.PROV 903.

Sheet piles should be driven to the specified elevation noted above for the selected sheet pile length. The appropriate pile driving note is “Sheet piles to be driven to Elevation XXX m” (to be completed by designer).

Tip protection should not be used for sheet piles at this site as the load bearing sheet piles will derive vertical resistance mostly from shaft friction.

Design of the sheet pile foundations must consider environmental conditions such as road salts or fluctuating water levels that may cause long term corrosion and reduce the service life of the structure.

The sheet piles will be driven partially through the silty clay embankment fill prior to excavation and removal of the existing culvert. It should be recognized that fill materials including embankment fills are heterogeneous in nature and may contain obstructions such as wood, boulders or rock fill. Occasional wood fragments were encountered in the fill in Boreholes 22-08 and 22-09. If such obstructions are encountered at the proposed locations of the sheet pile walls, they will have to be removed to facilitate sheet pile installation. Suggested text for an NSSP is included in Appendix F.

THURBER

11.3.3.3 Lateral Resistance of Sheet Piles

The depth of penetration of the sheet piles will be governed not only by the axial load demand, but also by the lateral load demand imposed by the soils retained behind and above the sheet piles as well as the surface live loads. The sheet pile design must satisfy the lateral stability requirement and allowable deflection limit.

The GA drawings show the top of the sheet piles at Elevation 329.1 m. The sheet piles will retain approximately 4 m high excavations sloped at 2H:1V behind the sheet piles. The 2H:1V slopes will be excavated mainly within the existing embankment fill. The maximum depth of excavation in front of the sheet piles will reach approximately 4 m, with the base of excavation at approximate Elevation 325.3 m. The lateral load induced by the 2H:1V slope on the sheet piles may be modelled as a surcharge. Geotechnical parameters for design of the sheet piles are provided below:

The lateral earth pressure from the silty clay can be computed as follows:

- $p_a = K_a * \gamma' * z + q$ (kPa)

Where: $K_a = 0.4$, $\gamma' = 19$ kN/m^3 above groundwater and 9 kN/m^3 below groundwater, z is depth from the top of sheet pile, q is surcharge from the 2H:1V cut slope and any live loads behind the crest of slope.

The coefficient of horizontal subgrade reaction (k_s) and the ultimate lateral resistance (p_{ult}) below the base of the excavation may be computed as follows:

- $k_s = 33 * S_u$ (kN/m^2 per metre wall)
- $p_{ult} = 2 * S_u + \gamma' * D$ (kPa)

Where, $S_u = 50$ kPa at the base of excavation (elevation 325.3 m) and increasing at 2 kPa/m with depth, $\gamma' = 9$ kN/m^3 below the base of excavation, D is depth (m) below the base of excavation.

The spring constant (K_s) and ultimate lateral resistance (P_{ult}) can be obtained by the following equations:

- $K_s = k_s * L$ (kN/m per metre wall)
- $P_{ult} = p_{ult} * L$ (kN per metre wall)

Where, L is length (m) of the sheet pile segment along the depth of embedment.

The design groundwater table and hydrostatic pressure should be Elevation 327 m behind the sheet pile and the base of excavation in front of the sheet pile.

To maintain the computed passive resistance, protection must be provided in front of the sheet piles to prevent material loss due to creek erosion.

11.3.4 Frost Cover

The depth of frost penetration at this site is approximately 2.3 m based on OPSD 3090.100. The base of any concrete footings if employed should be provided with a minimum of 2.3 m of earth cover as protection against frost action. The frost cover requirement does not apply to the pipe and box culvert options.

Frost treatment / tapers should be in accordance with OPSD 803.031 for a pipe culvert replacement or 803.010 for a box culvert replacement. As the pipe, concrete box, and sheet pile culvert options all require open cut excavation and replacement of the silty clay fill with new granular material below the frost penetration depth, frost treatment will be required for each option. Frost tapers will be required to transition between the new backfill and where the base of the pavement granular fill, including any grade raise granular fill, will be above the frost penetration depth.

11.3.5 Subgrade Preparation

Performance of the replacement culvert will depend on the preparation of the subgrade.

Any buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition.

In the event that sub-excavation is required, the width of sub-excavation should be defined by a line extending from 0.3 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The sub-excavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements and be compacted as per OPSS.PROV 501. The subgrade preparation and placement and compaction of the bedding material must be carried out in the dry.

Construction equipment should not be allowed to travel on the prepared subgrade, which must be protected from disturbance during construction. Suggested wording for an Operational Constraint on Subgrade Preparation is included in Appendix F.

11.3.6 Settlement Due to Grade Raise and Embankment Widening

The replacement culvert options are proposed to be constructed approximately on the same alignment and with a similar or larger opening size as the existing culvert. However, as the replacement culvert will be longer than the existing culvert, and a grade raise of up to approximately 1.2 m is proposed, the placement of additional fill will be required for the grade raise and to widen the embankment slopes. For the pipe and concrete box culvert options, the anticipated widened embankment will add approximately 5 m of new fill at the inlet and outlet of the culvert, where there is no existing fill beyond the existing culvert wing walls. For the sheet pile culvert option, the additional fill above the existing embankment fill height ranges from approximately 1.2 to 2.4 m along the concrete panel culvert cap. Approximately 2 to 2.5 m of new fill will be added above the existing embankment slopes behind the proposed sheet pile wing walls just east and west of the new sheet pile culvert. For each culvert option, the fill height decreases to the east and west of the culvert, to transition to the existing embankment footprint.

The placement of additional fill will induce settlement of the native silty clay. This is shown on the settlement profile (Figure SP1) included in Appendix G, which depicts the anticipated settlement along the pipe and box culvert options. The profile shows approximately 25 mm of settlement at the centreline of the highway embankment under the highest part of the grade raise, and approximately 70 to 80 mm of settlement beyond the ends of the existing embankment where no fill currently exists above the native soils (i.e. beyond the existing culvert wing walls).

For the sheet pile culvert option, the load applied by the additional fill above the concrete culvert cap will be accommodated by the sheet pile walls. Accordingly, within the culvert footprint, the anticipated foundation settlement due to the grade raise and widening is approximately 25 mm. Just beyond the culvert footprint, the foundation settlement under the grade raise and widening is anticipated to be approximately 25 mm at the centreline of the highway embankment, and up to approximately 65 mm on the embankment slopes under the 2 to 2.5 m of new fill, resulting in approximately 40 mm of differential settlement.

For each culvert option, the extent of settlement under the new fill will be greatest near the culvert location where the grade raise and widening fill is highest. The magnitude of settlement will decrease along the highway alignment beyond the culvert, as the height of the grade raise and embankment widening decreases (i.e. less fill placed on the existing embankment and embankment toe locations).

50% of the estimated settlement is anticipated to occur over 2 to 3 months after completion of the fill placement, and the remainder is estimated to occur within 2 to 3 years after construction.

The selected replacement culvert option must be designed to tolerate the estimated settlement induced by the placement of the grade raise and widening fill. This is particularly important for the sheet pile culvert option to minimize the potential of the sheet pile structure being dragged down and laterally displaced by the new fill.

Options for mitigation of the settlement include:

1. The widened portion of the embankment could be preloaded for 2 to 3 months to reduce the extent of differential settlement induced by the new fill for the selected culvert option. The 2 to 3 month preloading period would add additional time to the overall construction schedule.

2. For the sheet pile culvert option, the sheet piles could be driven to deeper depth. However, since a deeper competent stratum was not encountered in the boreholes, driving to deeper depths is not practical at this site.

3. Design the sheet pile culvert structure to accommodate the estimated foundation settlement and differential settlement.

Deferring paving of the highway until the following spring, after the culvert replacement is completed, should also be considered. This would provide additional time for settlement to occur and allow for the final highway grading to compensate for any bumps that may have formed behind the sheet piles.

11.3.7 Recommended Approach for Culvert Replacement

From a foundation engineering perspective, replacement with twin SPCSP pipes or a concrete box culvert are feasible options, however require large temporary excavations to install the culverts, and require the design to accommodate more differential settlement due to the grade raise and embankment widening than the sheet pile culvert option. The sheet pile culvert option reduces the amount of settlement due to the grade raise and widening and reduces the extent of the temporary excavation required. Therefore, the sheet pile culvert option (either standard sheet pile walls or combination walls) is recommended from a foundation engineering perspective.

12. 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 granular and silty clay fills 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), the fill soils would be classified as Type 4 soils. The native silty clay is classified as Type 3 soil, however the stability analyses for temporary excavations (see Section 20) indicate that 1H:1V temporary excavations are not recommended.

Excavation and backfilling for culvert construction should be carried out in accordance with OPSS.PROV 902. Excavations for culvert replacement will be carried out through the existing fill and into the native silty clay.

Installation of the culvert should be carried out in the dry. It is anticipated that excavation for the pipe or box culvert replacement will be carried out below the creek water level, and diversion of the surface water flow will be required. For the sheet pile culvert option, it is anticipated that creek flow will be contained within the existing culvert until the sheet pile walls are installed. Surface runoff and groundwater seepage from the embankment fill should also be anticipated and will accumulate in the excavations if not controlled. Depending on the selected culvert option. a combination of cofferdam enclosures and stream diversion along with pumping from properly filtered sumps within an enclosure will be required to maintain dry excavations during the course of staged construction.

The design of any dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 and OPSS.PROV 517. A preconstruction survey is not required at this site, thus Designer Fill-In ** in SP FOUN0003 should be “N/A”.

The groundwater level will fluctuate and the minimum groundwater elevation at the time of the proposed work should be taken as the creek water level or the design storm return period defined by the contract documents for the temporary dewatering system.

13. STREAM DIVERSION PIPE

A temporary stream diversion pipe may be required to divert creek water flow during construction of the replacement culvert or extensions. As shown on the draft GA drawings, it is anticipated that the invert level of the diversion pipe, where required, will be at or below Elevation 325.7 m, which corresponds to native silty clay.

The temporary diversion pipe should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.010. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry. The prepared subgrade should be protected from disturbance during construction.

The stream diversion pipe could be installed within the temporary open cut excavations, or within a shored excavation using a trench box.

14. 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.

Three culvert replacement options were considering for the preliminary dewatering assessment at this site (twin SPCSP pipes, box culvert, and sheet pile culvert). The pipe and culvert options also included a temporary diversion pipe adjacent to the culvert to redirect the creek flow around the work area during construction. Based on the draft GA drawings, the dimensions and conditions that were assumed for the preliminary dewatering assessment are provided in Table 14.1 below. For full dewatering to the base of the temporary excavations, the geologic unit that will need to be dewatered is silty clay.

Table 14.1: Assumed Excavation Dimensions and Ground Conditions

Structure	Assumed Excavation Footprint (m)	Lowest Assumed Elevation of Excavation (m)	Assumed Groundwater Elevation (m)	Geologic Unit(s) to Dewater
One Half of Twin SPCSP Replacement	30 x 25	324	329.0	Silty Clay

Structure	Assumed Excavation Footprint (m)	Lowest Assumed Elevation of Excavation (m)	Assumed Groundwater Elevation (m)	Geologic Unit(s) to Dewater
Culvert including diversion pipe				
One Half Precast Box Replacement Culvert including diversion pipe	30 x 25	324	329.0	Silty Clay
One Half Sheet Pile Culvert (no diversion pipe)	15 x 10	325	329.0	Silty Clay

For the purpose of estimating water taking flow rates, it was assumed that surface water flow would be directed around the excavation such that surface water will not enter the excavation at a significant rate.

The water taking will be temporary in nature for the purpose of construction dewatering for installation of the culvert. The hydraulic conductivity of the silty clay was assumed based on the results of the in-situ slug test described in Section 8, which was within the range of estimates based on grain-size using the Puckett correlation. 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 lowered to about 1 m below the proposed excavation base in order to facilitate a dry, stable work area.

It is noted that a stabilized water level was not recorded during the investigation. Therefore, a maximum ground water level elevation of 329.0 m was selected as a conservative (relatively high) water level.

It is assumed that one half of each culvert option would be constructed at a time to allow for a live lane of traffic to remain open.

The preliminary peak water taking rates for the three options were estimated to range from approximately 15,000 to 40,000 L/day, including a safety factor and a 50-mm rainfall allowance. The majority of the peak water taking rate is due to the rainfall allowance. The anticipated rate of groundwater flow through the silty clay is very small. The preliminary radius of influence was estimated to be less than 10 m from the edge of the excavation.

Considering the estimated peak water taking rate is less than 50,000 L/day, neither a PTTW nor an EASR registration will be required.

Some perched water may exist in the shallow sand seam encountered at Borehole 22-07 or within the fill that may need to be temporary managed. It is anticipated that the sand seam or fill will not be a source of continuous groundwater flow into the excavation; however, dewatering flow rates may be temporarily higher than the budgeted dewatering rate initially. If higher flow rates are initially encountered, the contractor must not dewater more than 50,000 L/day in order to remain below the minimum water taking rate for EASR registration.

15. WATER QUALITY

For assessment of the general groundwater quality at the site, a sample of the groundwater from the monitoring well at Borehole 22-07, and a surface water sample from the creek were collected on. As noted in Section 7, the water samples were tested and the results were compared to the Ontario Provincial Water Quality Objectives (PWQO). Filtered sub-samples of the groundwater and surface water were also tested for dissolved metal parameters for comparison purposes. The water sample test results are summarized in Table 7.1, and the full analytical test results are presented in Appendix B.

The test results indicate that eleven metals parameters tested from the groundwater sample and two of the metals parameters tested from the surface water sample exceeded the PWQO criteria for total (unfiltered) concentrations. However, testing of filtered samples to remove the high Total Suspended Solids, indicated considerably reduced metals concentrations, with no dissolved metals concentrations exceeding the PWQO criteria. If dewatering is used at this site, it is likely that treatment of the discharge water through the use of filtering, settling tanks or other methods may be required to reduce the amount of suspended solids and the metals concentrations prior to discharge into local surface water bodies such as creeks.

16. CULVERT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 802.010 or 803.010, as appropriate. Backfilling for the culvert should be in accordance with OPSS.PROV 401 for a CSP and OPSS.PROV 902 for a box culvert. All fills should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. 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 of the culvert 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 should be restricted in accordance with OPSS.PROV 501.

Lateral earth pressures acting on the culvert walls may be assumed to be a triangular distribution. For a fully drained backfill, 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 walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 16.1 below.

Table 16.1 – Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35°$; $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I (modified) or Type III $\phi = 32°$; $\gamma = 21.2$ kN/m^3	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive	3.7	-	3.2	-

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

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. Active earth pressures should be used for any unrestrained wall.

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 culvert.

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.

17. 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 stiff silty clay native soil, the site is classified as Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.038 g as per the National Building Code of Canada (NBCC).

In accordance with Section 6.14.7 of the CHBDC 2019, the culvert walls should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 17.1 may be used:

Table 17.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)		
	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ **kN/m³**	**Existing Granular Fill or OPSS Granular B Type I (modified) or Type III** $\phi = 32°, \gamma = 21.2$ **kN/m³**	**Silty Clay (Fill or Native)**
Active (K_{AE})[1]	0.29	0.33	0.41
Passive (K_{PE})[2]	3.6	3.2	2.5
At Rest (K_{OE})[3]	0.49	0.53	0.63

Note 1: Mononobe and Okabe, 1929, World Engineering Congress 9: 179-187

Note 2: Passive case assumes a horizontal surface in front of the wall.

Note 3: Wood, J. H. 1973, earthquake induced soil pressures on structures, PhD Thesis, California Institute of Technology, Pasadena, CA.

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

18. COFFERDAMS

Construction of cofferdams will be required for stream diversion and constructing the culvert replacement in the dry. Options for cofferdams include interlocking sheet piles or sandbags. Sheet pile cofferdams are anticipated to be feasible at this site as they can be driven into the native silty clay. The recommendations provided in Section 19 below for Temporary Protection Systems are also applicable to sheet pile cofferdams.

19. TEMPORARY PROTECTION SYSTEM

A temporary roadway protection system, if utilized, should be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2. Options for roadway protection are a soldier pile and lagging system or interlocking sheet piles. Sheet piles are anticipated to be feasible at this site as they can be driven into the native silty clay. The soil parameters in Table 19.1 may apply for the design of the temporary roadway protection system with horizontal backfill.

Table 19.1 – Soil Parameters for Temporary Protection System Design

Soil Parameter	Existing Granular Fill	Silty Clay (Fill or Native)
γ (total unit weight)	20 kN/m^3	19 kN/m^3
γ_w (submerged unit weight)	10 kN/m^3	9 kN/m^3
K_a	0.31	0.40
K_p	3.3	2.5

Full hydrostatic pressure should be considered assuming a water level at least equal to the design creek water level.

The temporary protection system may be removed or partially removed upon completion of the work. Care must be taken when removing the TPS as to not incur damage to the subgrade of the newly installed culvert.

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 configuration of this culvert site presents challenges for design of an appropriate roadway protection system for staging the culvert replacement options, due to the length and height of the shoring system required. The Contractor and shoring designer must be alerted to these concerns in order to design an appropriate protection system. Additional measures such as the use of tiebacks and deadmen may be required to provide additional lateral support of the free-standing portion of the protection system.

20. SLOPE STABILITY

20.1 Permanent Slopes

Slope stability analyses were conducted to assess the widened Highway 602 embankment side slopes under the proposed grade raise. The stability assessments assume the embankment fill

THURBER

will consist of Granular B Type II, constructed at a 2H:1V slope. If property or existing utility constraints require steeper slopes to be constructed, the stability assessments also considered utilizing rock fill to allow a steeper 1.5H:1V slope to be constructed. The results of the slope stability analyses are included in Appendix G.

Figures G1 and G2 show that a Granular B Type II embankment with 2H:1V side slopes would be stable for the short-term (undrained) and long-term (drained) conditions, with a Factor of Safety against slope failure of 1.5. Figures G3 and G4 show that 1.5H:1V slopes for a rock fill embankment would also be stable, with a Factor of Safety of 1.5 for both the short-term and long-term conditions.

20.2 Temporary Excavation Slopes

Based on the draft GA drawings attached in Appendix H, the temporary excavations required to install the new culvert are up to approximately 60 m long and 9 m deep. The excavations will be largely carried out in silty clay, with a groundwater Elevation at approximately 327 m. Due to the height of the temporary excavations that will need to be accommodated, slope stability analysis was carried out.

Figure G5 shows that temporary excavation slopes of 3H:1V below the groundwater table and 1H:1V above the groundwater table have a Factor of Safety against slope failure of 1.0, and therefore are not acceptable. In order to achieve a minimum 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 2.5H:1V. Figures G6 and G7 show Factors of Safety of 1.3 and 1.5 for temporary 2.5H:1V and 3H:1V slopes above the groundwater level respectively. Due to the height of the temporary excavations, it is recommended that 3H:1V slopes or other temporary excavation support measures be utilized, such as excavating within sheet pile enclosures. If sheet pile enclosures are utilized, the Contractor must design the sheet piles to be deep enough to retain the existing soil behind the sheet piles. The sheet pile culvert option may be beneficial as it acts a sheet pile enclosure and allows for shallower temporary excavations and less soil to be supported during construction compared to the pipe or box culvert options. In this regard, temporary excavation slopes of 2H:1V above the groundwater level and supported by sheet pile foundation walls designed as per Section 11.3.3.3 above (as shown on the GA drawing in Appendix H) are considered to be acceptable.

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

THURBER

21. EMBANKMENT RESTORATION

Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS.PROV 206. The embankment reconstruction material should consist of imported Granular B Type II or Rock Fill material. The restored embankment beyond the culvert should be reinstated at the existing slope inclination, but no steeper than 2H:1V if constructed with granular fill or 1.5H:1V if constructed with rock fill. Soils generated from the culvert excavation should not be used for reinstatement of the embankment.

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

22. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. 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 OPSD 810.010, OPSS 511 and OPSS.PROV 1004.

Typically, rock protection should be provided over all surfaces with which creek 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 (for box culvert option only) 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 1005.

23. 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 surface water is considered to be mild, due to the low chloride and sulphate concentrations in the samples tested.
- The potential for corrosion on metal and concrete from the surrounding silty clay fill and native silty clay is considered to be moderate to severe, due to the low resistivity of 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.

24. CONSTRUCTION CONCERNS

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

- Temporary excavations up to approximately 9 m deep will be required to install the replacement culvert and will require temporary excavation slopes of 3H:1V.
- A suitable roadway protection system must be designed that is capable of supporting the live highway lane for construction staging.
- Full dewatering to below the base of the culvert excavation will be required to maintain dry excavations for construction.
- The water level in the creek may fluctuate and be at a higher elevation at the time of construction than indicated in the report.

25. CLOSURE

Preparation of the design report was carried out by Mr. Mark Farrant, P.Eng. Engineering analysis was carried out by Mr. Mark Farrant, P.Eng., Mr. Michael Eastman, P.Eng., Mr. Mohamed Hosney, P.Eng., and Mr. Keli Shi, 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, M.Eng., P.Eng.
Associate, Senior Geotechnical Engineer

Dr. P.K. Chatterji, Ph.D., P.Eng.
Designated MTO Principal Contact

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

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.

THURBER

Appendix A

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

C_{pen} 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			

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 22-06

METRIC

GWP# 6120-17-00	LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 746.3 E 244 108.8	ORIGINATED BY GS
DIST Rainy River HWY 602	BOREHOLE TYPE Tripod/Continuous Split Spoon/Wash Boring	COMPILED BY MC
DATUM Geodetic	DATE 2022.08.25 - 2022.08.26 LATITUDE 48.625292 LONGITUDE -93.823363	CHECKED BY RB

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
327.1	GROUND SURFACE
0.0	**TOPSOIL:** (25mm)
	Silty **CLAY**, trace sand, trace organics Firm to Stiff Black to Brown Wet
325.9 / 1.2	Silty **CLAY**, some sand, trace gravel Very Stiff Grey Wet (CI-CH)
321.5 / 5.6	END OF BOREHOLE AT 5.6m. BOREHOLE CAVED TO 1.4m AND DRY AT 1.4m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.

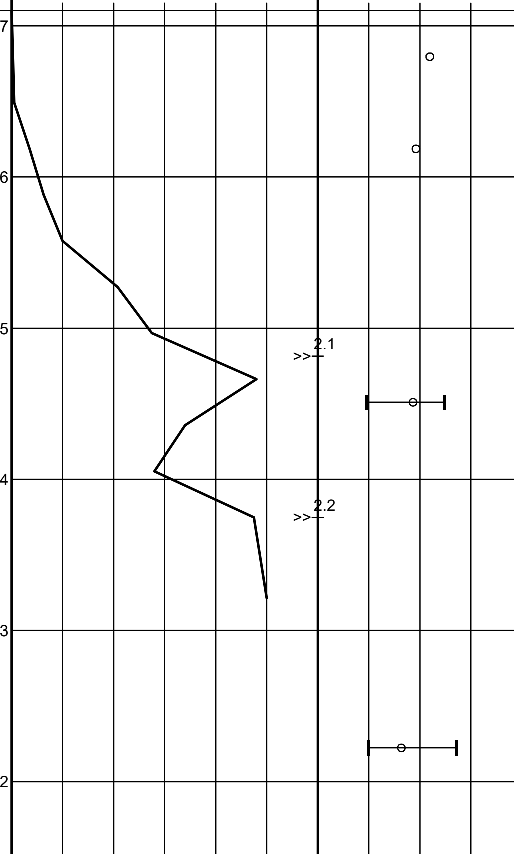
SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	4				
2	SS	9				
3	SS	17				
4	SS	37	0	19	36	45
5	SS	61	1	17	35	47

GROUND WATER CONDITIONS | ELEVATION SCALE: 327, 326, 325, 324, 323, 322

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100



PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L — WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

+ 3, × 3 : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 22-07

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 733.4 E 244 079.6 | ORIGINATED BY GS

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY MC

DATUM Geodetic | DATE 2022.08.22 - 2022.08.23 | LATITUDE 48.625173 | LONGITUDE -93.823757 | CHECKED BY RB

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.8	GROUND SURFACE					
0.0	**TOPSOIL:** (25mm)					
	Silty **CLAY**, sandy, occasional organics, occasional wood fragments, Firm to Stiff, Brown to Grey, Moist (CL-CI)	1	SS	5		
		2	SS	8	327	0 35 32 33
325.7 / 2.1	**SAND**, some gravel, some silt, some clay, Loose, Grey, Wet				326	
325.2 / 2.6	Silty **CLAY**, some sand, trace gravel, Stiff to Very Stiff, Grey, Moist (CI)	3	SS	8	325	12 62 14 12
		1	TW		324	1 16 35 48
					323	
		4	SS	7	322	
		5	SS	9	321 / 320	
		2	TW		319 / 318	

Field vane readings (sensitivity): 5.5 (approx. elev. 325.8), 3.3 (approx. elev. 324.3), 4.8 (approx. elev. 322.8); additional field vane readings at approx. elev. 321.3, 319.8, 318.2.

Groundwater level symbol at approx. elev. 323.0.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 22-07

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 733.4 E 244 079.6 | ORIGINATED BY GS

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY MC

DATUM Geodetic | DATE 2022.08.22 - 2022.08.23 | LATITUDE 48.625173 | LONGITUDE -93.823757 | CHECKED BY RB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	Silty **CLAY**, some sand, trace gravel Very Stiff Grey Moist (CI)	6	SS	8		1	20	34	45
					317				
		7	SS	14	316				
315.2 12.6	END OF BOREHOLE AT 12.6m. Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.								

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2022.08.24	7.3	320.5
2022.08.25	5.0	322.8
2022.08.25	4.8	323.0

Water level at 4.8m taken on August 25, 2022, was unstabilized.

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 22-08

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 739.6 E 244 088.0 | ORIGINATED BY MM

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers/Wash Boring | COMPILED BY AA

DATUM Geodetic | DATE 2022.02.05 - 2022.02.05 | LATITUDE 48.625230 | LONGITUDE -93.823644 | CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	GR	SA	SI	CL
331.4	GROUND SURFACE										
0.0 / 0.1	**ASPHALT:** (75mm)										
	SAND, some gravel, some silt, trace clay; Compact; Brown; Dry to Moist; (FILL)	1	SS	23	331						
		2	SS	17				15	63	22 (SI+CL)	
330.0 / 1.4	Silty **CLAY**, some sand, trace gravel; Very Stiff to Stiff; Brown to Grey; Moist to Wet; (FILL-CH)	3	SS	26	330						
		4	SS	12	329			1	12	37	50
328.4 / 3.0	Silty **CLAY**, some sand to sandy, trace gravel, occasional wood fragments; Firm; Grey; Wet; (FILL)	5	SS	7	328						
		6	SS	4	327						
325.8 / 5.6	Silty **CLAY**, some sand, trace gravel; Stiff; Grey; Wet; (CH)	7	SS	4	325			0	17	36	47
					324	Field vane, sensitivity 2.0					
		1	ST					1	16	34	49
					323	Field vane, sensitivity 1.6					
		8	SS	5	322						

Ground water level symbol shown at approx. elev. 326.2.

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 22-08

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 739.6 E 244 088.0 | ORIGINATED BY MM

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers/Wash Boring | COMPILED BY AA

DATUM Geodetic | DATE 2022.02.05 - 2022.02.05 | LATITUDE 48.625230 | LONGITUDE -93.823644 | CHECKED BY RB

ELEV DEPTH	SOIL PROFILE DESCRIPTION (Continued From Previous Page)	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa (Field Vane +)	WATER CONTENT (%)
	Silty **CLAY**, some sand, trace gravel Stiff Grey Wet (CH)					1.4	
					321		
		9	SS	6			○
					320		
						1.5	
		10	SS	5	319		○
						1.6	
					318		
		2	ST				
					317		
						1.5	
					316		
		11	SS	6			○
315.1						1.6	
16.3	END OF BOREHOLE AT 16.3m. BOREHOLE OPEN TO 16.3m AND WATER LEVEL AT 5.2m IN OPEN HOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.2m, CONCRETE TO 0.2m, AND ASPHALT TO SURFACE.						

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; STRAT PLOT; GROUND WATER CONDITIONS; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22-09

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 747.3 E 244 081.4 | ORIGINATED BY MM

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers/Wash Boring | COMPILED BY AA

DATUM Geodetic | DATE 2022.01.05 - 2022.01.05 LATITUDE 48.625299 LONGITUDE -93.823735 | CHECKED BY RB

Soil Profile

ELEV / DEPTH	DESCRIPTION
331.2	GROUND SURFACE
0.0 / 0.1	**ASPHALT:** (75mm)
	SAND, some gravel, some silt, trace clay, Very Dense, Brown, Dry to Moist (FILL)
330.5 / 0.7	Silty **CLAY**, some sand, trace gravel, Stiff, Grey, Moist (FILL)
328.2 / 3.0	Silty **CLAY**, sandy, trace gravel, occasional wood fragments, Firm to Stiff, Grey, Wet (FILL-CI)
325.6 / 5.6	Silty **CLAY**, some sand, trace gravel, Stiff, Grey, Wet (CH)

Samples

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	51	17 65 18 (SI+CL)
2	SS	11	
3	SS	14	
4	SS	9	
5	SS	4	1 28 40 31
6	SS	3	
7	SS	5	
8	SS	5	
9	SS	6	

Ground water conditions: water level symbol at approx. elevation 325.7.

Field vane shear strength: + 2.5 (at approx. elev. 324.0); + 1.3 (at approx. elev. 322.5).

Elevation scale: 331, 330, 329, 328, 327, 326, 325, 324, 323, 322

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 22-09

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 747.3 E 244 081.4 | ORIGINATED BY MM

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers/Wash Boring | COMPILED BY AA

DATUM Geodetic | DATE 2022.01.05 - 2022.01.05 | LATITUDE 48.625299 | LONGITUDE -93.823735 | CHECKED BY RB

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **CLAY**, some sand, trace gravel Stiff Grey Wet (CH)								
		1	ST						
		10	SS	6	~38				
		11	SS	7	~38 (w_P ~20, w_L ~60)	0	15	34	51
		12	SS	6	~39				
314.9 16.3	END OF BOREHOLE AT 16.3m. BOREHOLE OPEN TO 16.3m AND WATER LEVEL AT 5.6m IN OPEN HOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.2m, CONCRETE TO 0.2m, AND ASPHALT TO SURFACE.								

Elevation scale: 321, 320, 319, 318, 317, 316, 315

Field vane shear strength points (sensitivity): 1.6 (near 321), 1.5 (near 319.5), 1.7 (near 318), 1.6 (near 316.5), 1.7 (near 315)

+ ³, × ³ : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 22-10

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 730.6 E 244 103.6 | ORIGINATED BY MM

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers/Wash Boring | COMPILED BY AA

DATUM Geodetic | DATE 2022.04.30 - 2022.01.05 | LATITUDE 48.625151 | LONGITUDE -93.823430 | CHECKED BY RB

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH (kPa)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
332.3	GROUND SURFACE								
0.0	**ASPHALT:** (75mm)								
0.1	**SAND**, some gravel, some silt, trace clay, Compact, Brown to Grey, Moist (FILL)	1	SS	25		332		○	
		2	SS	22		331		○	
		3	SS	25				○	21 59 20 (SI+CL)
330.1 / 2.2	Silty **CLAY**, some sand, trace gravel, Firm to Stiff, Grey, Wet (FILL-CH)	4	SS	5		330		○	
		1	ST			329			
		5	SS	7		328		wP–w–wL	0 17 36 47
					∇	327	+ (1.7)		
326.7 / 5.6	Silty **CLAY**, some sand, trace gravel, Stiff, Grey, Wet (CH)	6	SS	6		326		○	
						325	+ (1.3)		
		7	SS	7		324		○	
							+ (1.5)		
		8	SS	7		323		wP–w–wL	0 16 37 47

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

WATER CONTENT (%): PLASTIC LIMIT wP, NATURAL MOISTURE CONTENT w, LIQUID LIMIT wL; 20 40 60

UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 2020LIBRARY(MTO) - COPY.GLB MTO-33309.GPJ 11/16/22

RECORD OF BOREHOLE No 22-10

METRIC

GWP# 6120-17-00 | LOCATION Lyon Creek Culvert; MTM NAD 83-16: N 5 387 730.6 E 244 103.6 | ORIGINATED BY MM

DIST Rainy River HWY 602 | BOREHOLE TYPE Solid Stem Augers/Wash Boring | COMPILED BY AA

DATUM Geodetic | DATE 2022.04.30 - 2022.01.05 | LATITUDE 48.625151 | LONGITUDE -93.823430 | CHECKED BY RB

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (field vane, sensitivity)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Stiff Grey Wet (CH)							+ 1.4			
							322				
			9	SS	7				○		
							321	+			
			10	SS	5		320		○		
							319	+ 1.5			
			11	SS	5				○		
							318	+ 1.1			
			12	SS	6		317		○		
316.0 16.3	END OF BOREHOLE AT 16.3m. BOREHOLE OPEN TO 16.3m AND WATER LEVEL AT 5.6m IN OPEN HOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.2m, CONCRETE TO 0.2m, AND ASPHALT TO SURFACE.						316	+ 1.3			

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 23-01

METRIC

GWP# 6120-17-00 LOCATION Lyon Creek Culvert N 5 387 734.6 E 244 099.9 ORIGINATED BY MM

DIST Rainy River HWY 602 BOREHOLE TYPE Solid Stem Auger/ HW Wash Boring COMPILED BY JW

DATUM Geodetic DATE 2023.07.26 - 2023.07.27 LATITUDE 48.625186 LONGITUDE -93.823482 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
332.0	GROUND SURFACE								
0.0	**ASPHALT:**(25mm)								
	No sampling through fill above 4.6m					331			
						330			
						329			
						328			
327.4 / 4.6	Silty **CLAY**, some sand; Stiff; Grey; Moist; (FILL)	1	SS	9		327	~37		
326.8 / 5.2	Silty **CLAY**, some sand; Stiff to Very Stiff; Grey; Wet					326			
						325			
						324			
						323			
		2	SS	7			~39		
						322			

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

$+^3, \times^3$: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 23-01

METRIC

GWP# 6120-17-00	LOCATION Lyon Creek Culvert N 5 387 734.6 E 244 099.9		ORIGINATED BY MM
DIST Rainy River HWY 602	BOREHOLE TYPE Solid Stem Auger/ HW Wash Boring		COMPILED BY JW
DATUM Geodetic	DATE 2023.07.26 - 2023.07.27 LATITUDE 48.625186	LONGITUDE -93.823482	CHECKED BY MEF

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand Stiff to Very Stiff Grey Wet (CH)						321				
							320				
							319				
			3	SS	5		318		~40		
							317				
			4	SS	4				~38		
							316	Field vane ~108, sensitivity 1.8			
			5	SS	5		315		~40		
								Field vane ~102, sensitivity 1.9			
							314				
			6	SS	5				wP ~27, w ~40, wL ~63		0 16 32 52
							313	Field vane ~96, sensitivity 1.6			
							312				

Continued Next Page

Legend: Shear strength: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Plastic limit w_P, natural moisture content w, liquid limit w_L.

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 2020LIBRARY(MTO) - COPY.GLB MTO-33309.GPJ 9/1/23

RECORD OF BOREHOLE No 23-01

METRIC

GWP# 6120-17-00 LOCATION Lyon Creek Culvert N 5 387 734.6 E 244 099.9 ORIGINATED BY MM

DIST Rainy River HWY 602 BOREHOLE TYPE Solid Stem Auger/ HW Wash Boring COMPILED BY JW

DATUM Geodetic DATE 2023.07.26 - 2023.07.27 LATITUDE 48.625186 LONGITUDE -93.823482 CHECKED BY MEF

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand Stiff to Very Stiff Grey Wet (CH)	▨	7	SS	5						
							311	+ 1.7			
			8	SS	6						
							310	+ 1.6			
			9	SS	7		309				
							308	+ 1.6			
			10	SS	7						
306.5							307	+ 1.6			
25.5	END OF BOREHOLE AT 25.5m. BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m, ASPHALT PATCH TO SURFACE.										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 23-02

METRIC

GWP# 6120-17-00 LOCATION Lyon Creek Culvert N 5 387 741.5 E 244 085.7 ORIGINATED BY MM

DIST Rainy River HWY 602 BOREHOLE TYPE Solid Stem Auger/ HW Wash Boring COMPILED BY JW

DATUM Geodetic DATE 2023.07.27 - 2023.07.28 LATITUDE 48.625247 LONGITUDE -93.823675 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
331.3	GROUND SURFACE					
0.0	**ASPHALT:**(25mm)					
	No sampling through fill above 4.6m				331	
					330	
					329	
					328	
					327	
326.7 / 4.6	Silty **CLAY**, some sand, trace rootlets, Firm, Brown, Wet (FILL)	1	SS	7		~37 (plotted)
					326	
325.7 / 5.6	Silty **CLAY**, some sand, trace gravel, Stiff to Very Stiff, Grey, Wet				325	
					324	
					323	
					322	
		2	SS	7		~38 (plotted)

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); GROUND WATER CONDITIONS; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 2020LIBRARY(MTO) - COPY.GLB MTO-33309.GPJ 9/1/23

RECORD OF BOREHOLE No 23-02

METRIC

GWP# 6120-17-00 LOCATION Lyon Creek Culvert N 5 387 741.5 E 244 085.7 ORIGINATED BY MM

DIST Rainy River HWY 602 BOREHOLE TYPE Solid Stem Auger/ HW Wash Boring COMPILED BY JW

DATUM Geodetic DATE 2023.07.27 - 2023.07.28 LATITUDE 48.625247 LONGITUDE -93.823675 CHECKED BY MEF

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Stiff to Very Stiff Grey Wet						321				
							320				
							319				
							318				
							317				
							316				
			3	SS	5				○		
							315	+ 1.8			
			4	SS	5				○		
							314				
								+ 1.7			
							313				
			5	SS	8				○		
							312	+ 1.8			

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 23-02

METRIC

GWP# 6120-17-00	LOCATION Lyon Creek Culvert N 5 387 741.5 E 244 085.7		ORIGINATED BY MM
DIST Rainy River HWY 602	BOREHOLE TYPE Solid Stem Auger/ HW Wash Boring		COMPILED BY JW
DATUM Geodetic	DATE 2023.07.27 - 2023.07.28	LATITUDE 48.625247 LONGITUDE -93.823675	CHECKED BY MEF

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (Field Vane, kPa / sensitivity)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **CLAY**, some sand, trace gravel Stiff to Very Stiff Grey Wet (CH)	6	SS	7	311	+ 1.9	~40	
		7	SS	5	310	+ 2.1	~40	
		8	SS	7	309 / 308	+ 2.0	~41 (wP ~31, wL ~68)	1 13 30 56
		9	SS	8	307 / 306	+ 1.9	~40	
305.9 25.5	END OF BOREHOLE AT 25.5m. BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m, ASPHALT PATCH TO SURFACE.							

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; STRAT PLOT; GROUND WATER CONDITIONS.

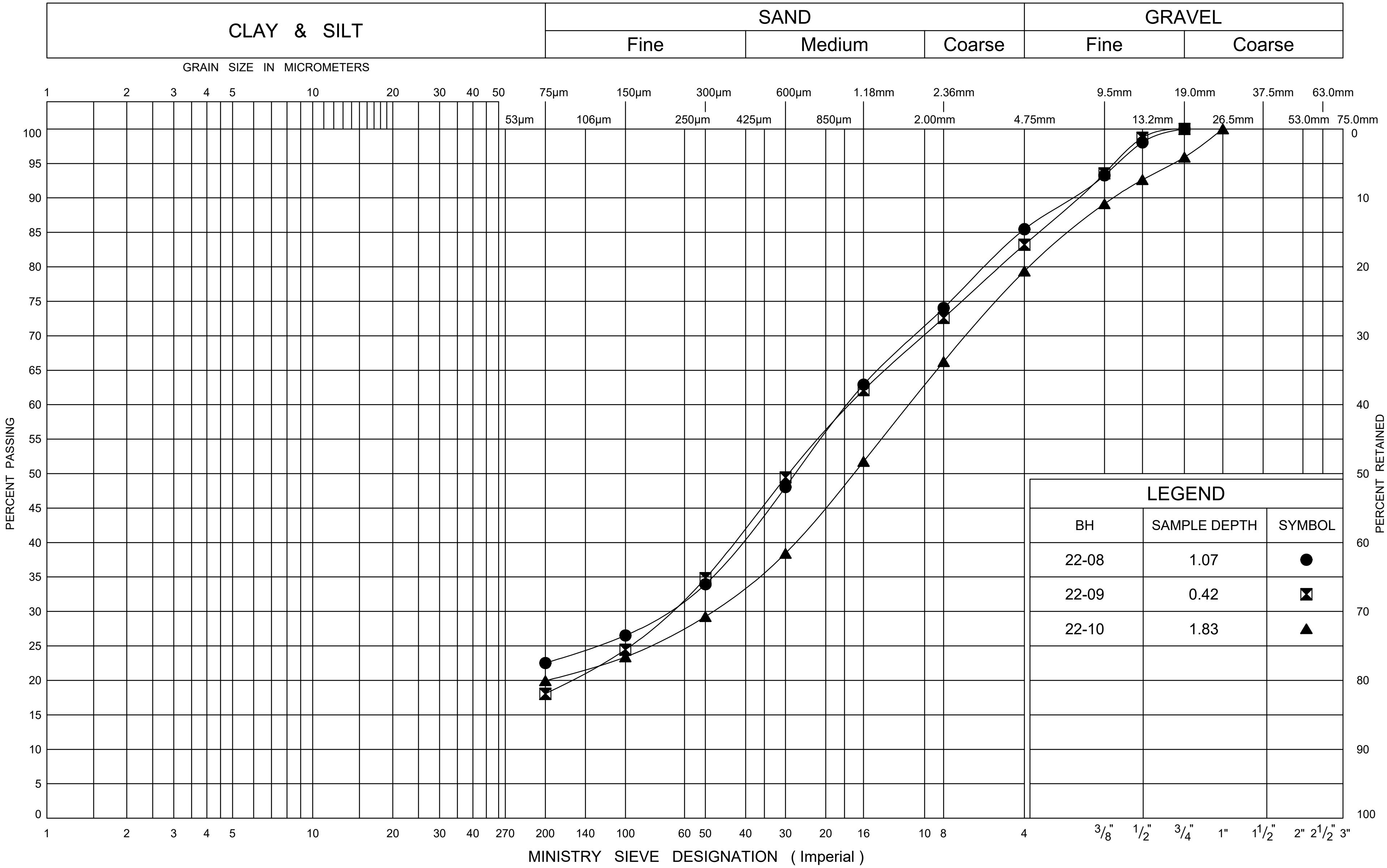
+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

THURBER

Appendix B

Laboratory and Well Test Results



ONTARIO MOT GRAIN SIZE 3 MTO-33309.GPJ ONTARIO MOT.GDT 11/16/22

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

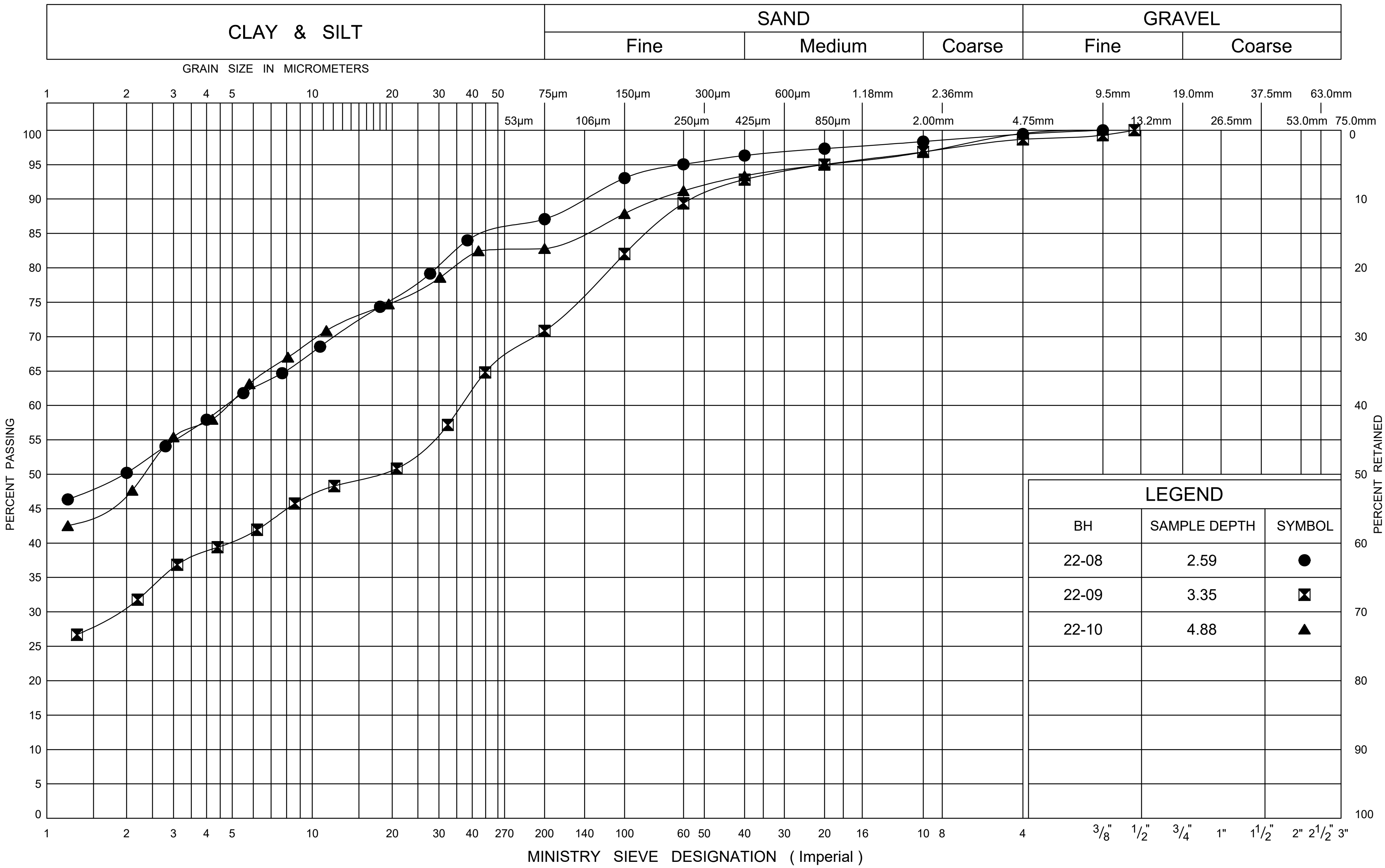
SAND FILL

FIG No B1

GWP# 6120-17-00

Lyon Creek Culvert

78 12 M



ONTARIO MOT GRAIN SIZE 3 MTO-33309.GPJ ONTARIO MOT.GDT 11/16/22

Ministry of Transportation
Ontario

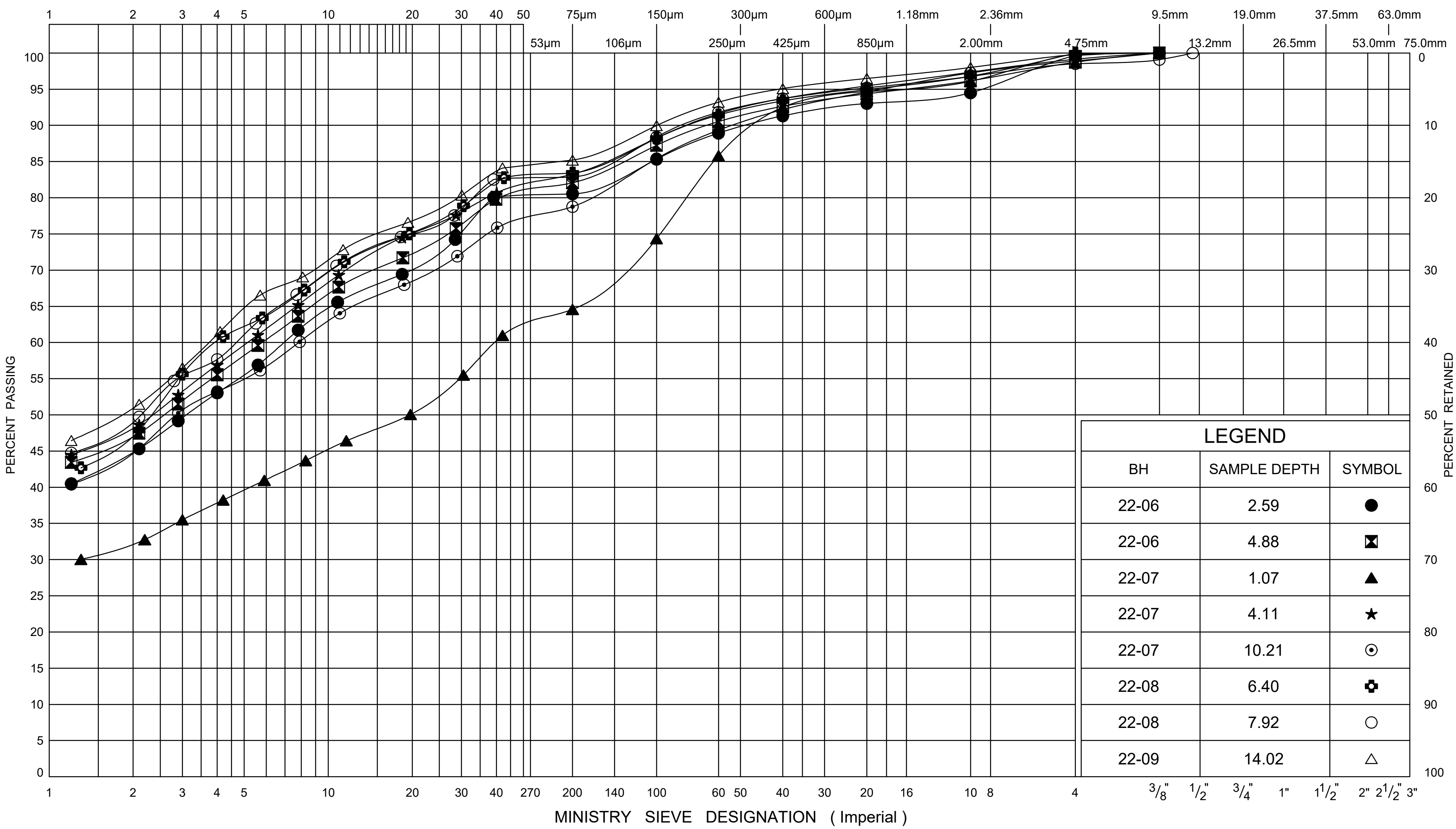
GRAIN SIZE DISTRIBUTION

Silty CLAY FILL

FIG No B2

GWP# 6120-17-00

Lyon Creek Culvert



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
22-06	2.59	●
22-06	4.88	⧗
22-07	1.07	▲
22-07	4.11	★
22-07	10.21	⊙
22-08	6.40	✥
22-08	7.92	○
22-09	14.02	△

Ministry of Transportation
Ontario

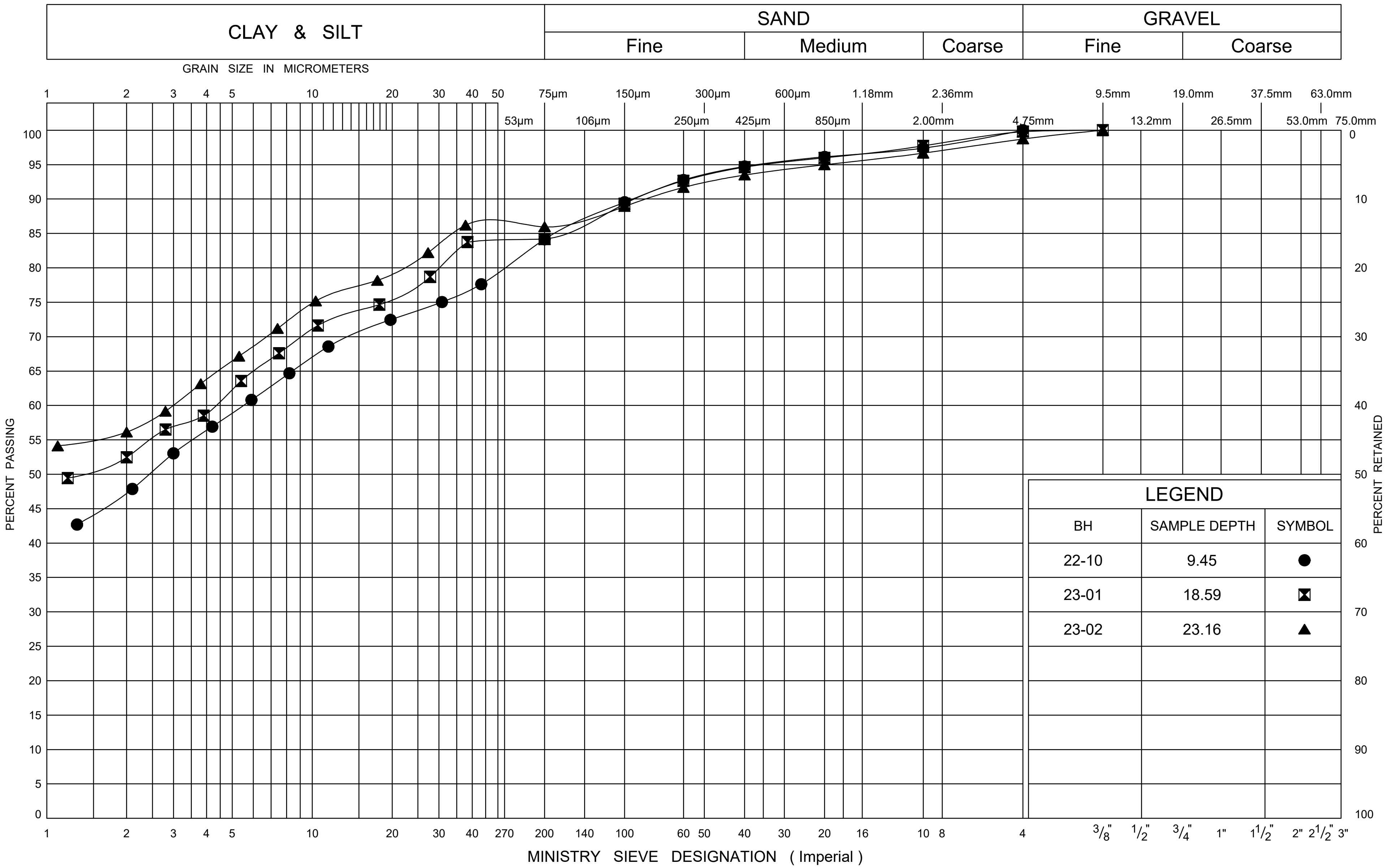
GRAIN SIZE DISTRIBUTION

Silty CLAY

FIG No B3

GWP# 6120-17-00

Lyon Creek Culvert



LEGEND

BH	SAMPLE DEPTH	SYMBOL
22-10	9.45	●
23-01	18.59	⧗
23-02	23.16	▲

Ministry of Transportation
Ontario

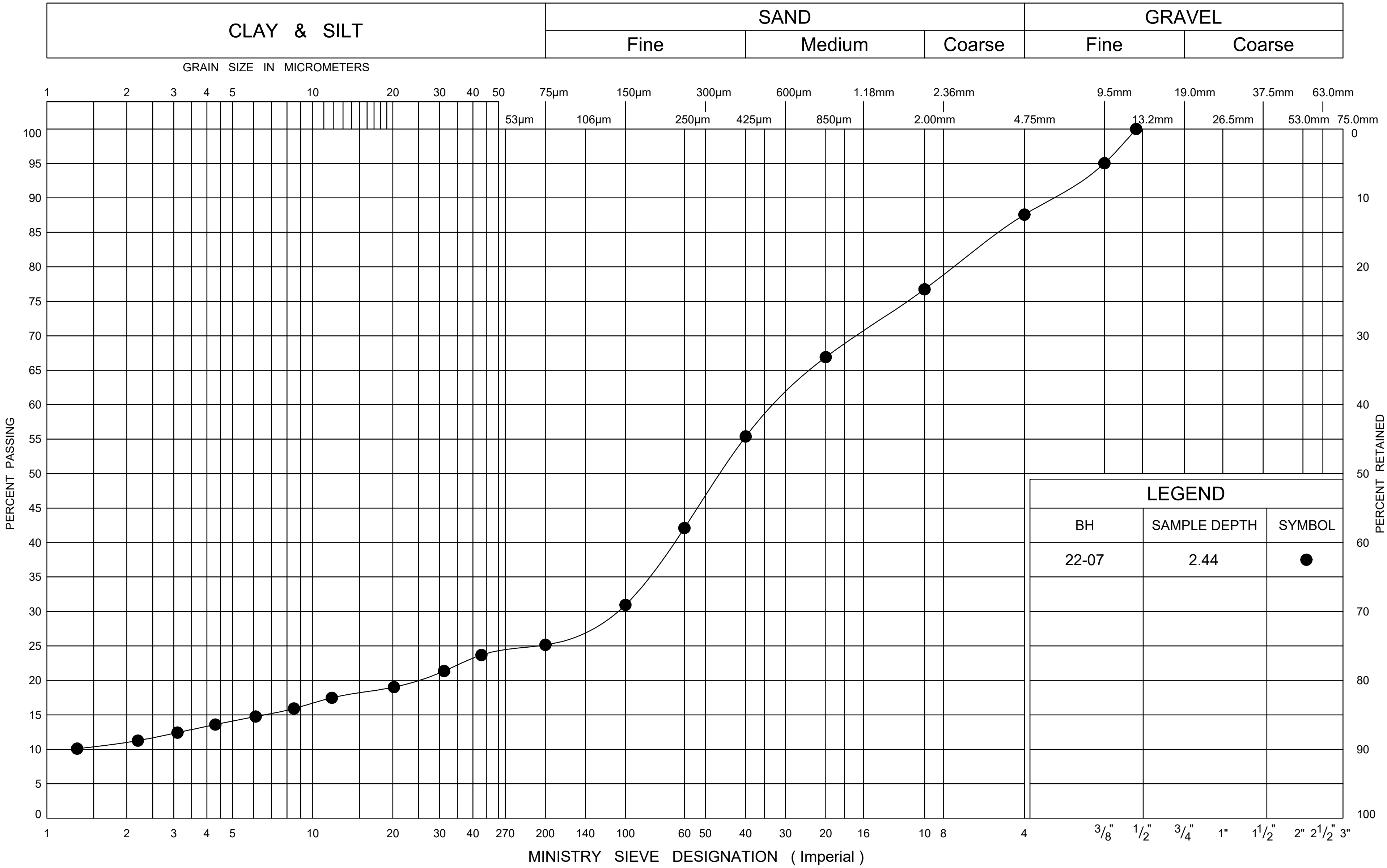
GRAIN SIZE DISTRIBUTION

Silty CLAY

FIG No B4

GWP# 6120-17-00

Lyon Creek Culvert



LEGEND

BH	SAMPLE DEPTH	SYMBOL
22-07	2.44	●

Ministry of Transportation
Ontario

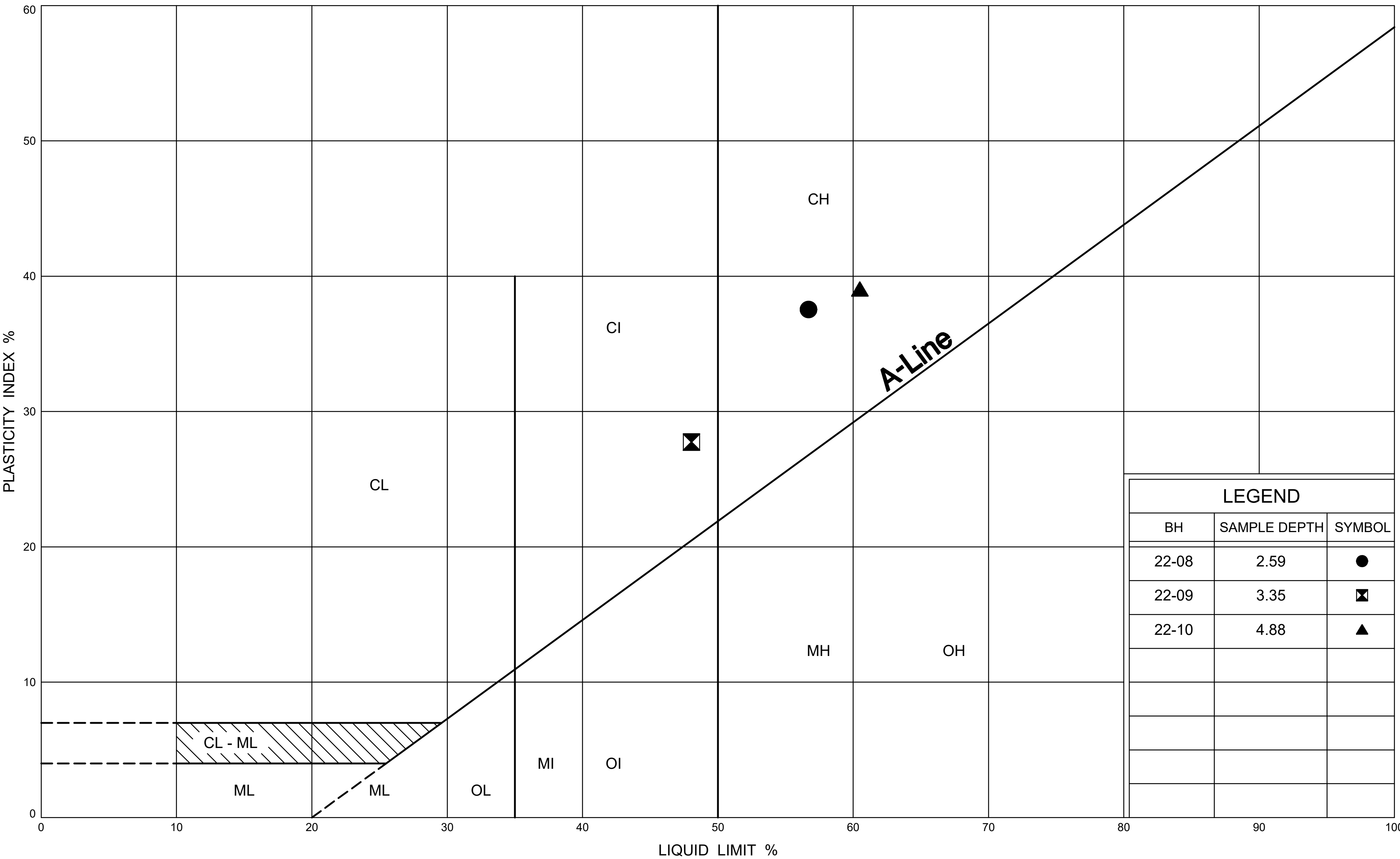
GRAIN SIZE DISTRIBUTION
SAND

FIG No B5

GWP# 6120-17-00

Lyon Creek Culvert

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE DEPTH	SYMBOL
22-08	2.59	●
22-09	3.35	⧗
22-10	4.88	▲

Ministry of Transportation
Ontario

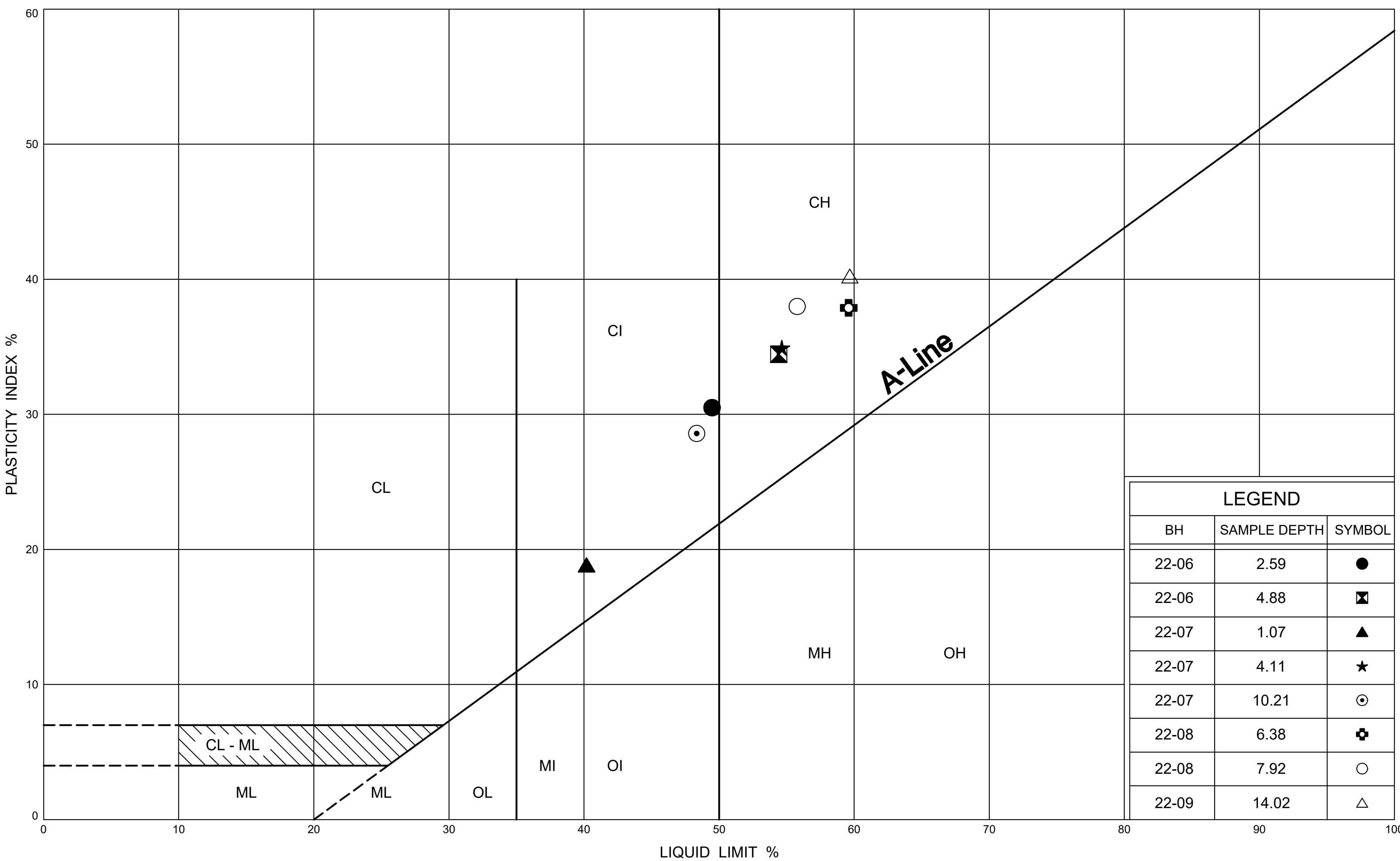
PLASTICITY CHART

Silty CLAY FILL

FIG No B6

GWP# 6120-17-00

Lyon Creek Culvert



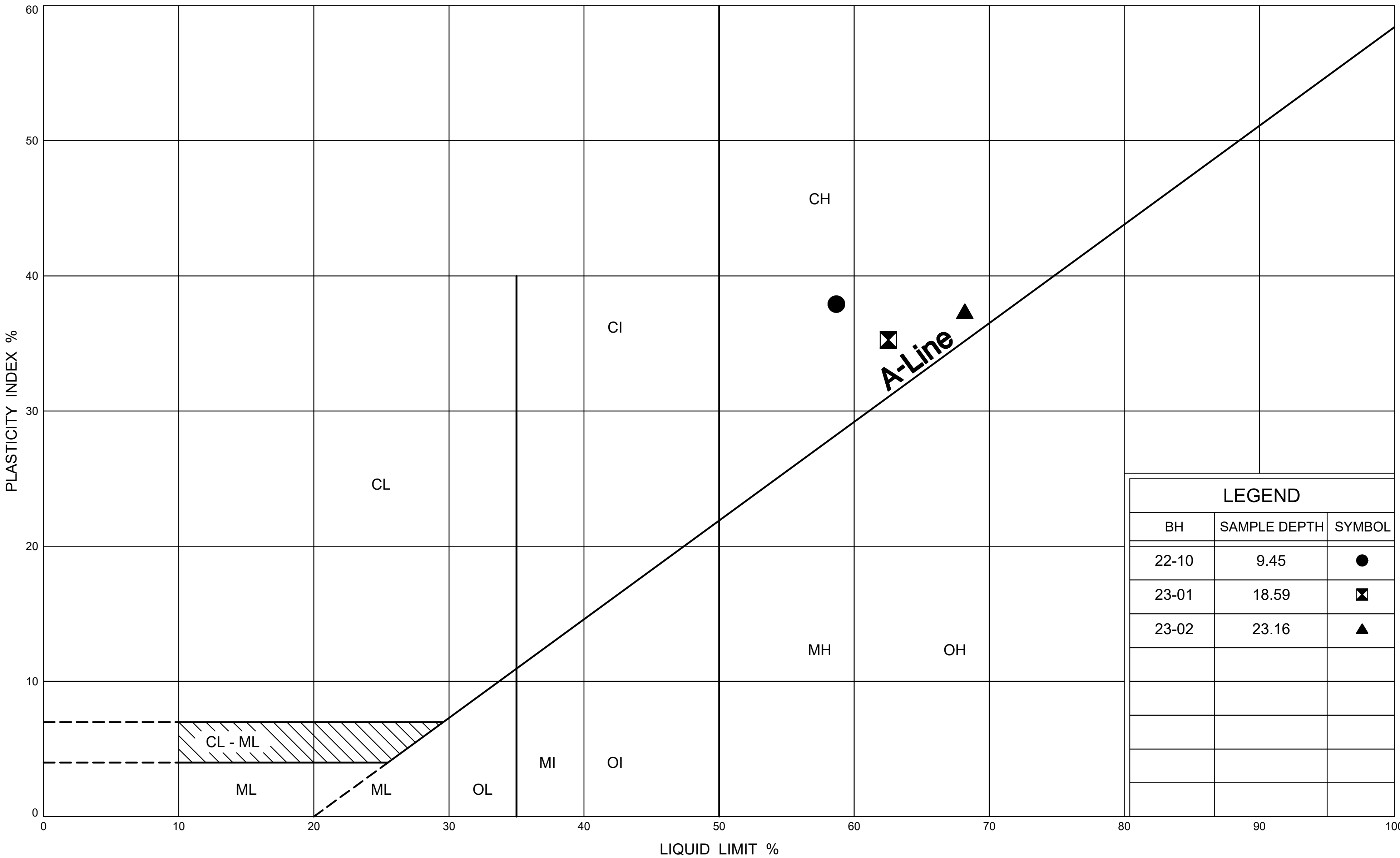
LEGEND		
BH	SAMPLE DEPTH	SYMBOL
22-06	2.59	●
22-06	4.88	⊠
22-07	1.07	▲
22-07	4.11	★
22-07	10.21	⊙
22-08	6.38	✿
22-08	7.92	○
22-09	14.02	△

Ministry of Transportation
Ontario

PLASTICITY CHART
Silty CLAY

FIG No B7	
GWP# 6120-17-00	
Lyon Creek Culvert	

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE DEPTH	SYMBOL
22-10	9.45	●
23-01	18.59	⧗
23-02	23.16	▲

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty CLAY

FIG No B8

GWP# 6120-17-00

Lyon Creek Culvert

THURBER ENGINEERING LTD.

Consolidation Test Report

CLIENT: MTO

FILE NUMBER: 33309

PROJECT: Cameron and Lyon Creek Culvert Investigations

REPORT DATE: October 12, 2022

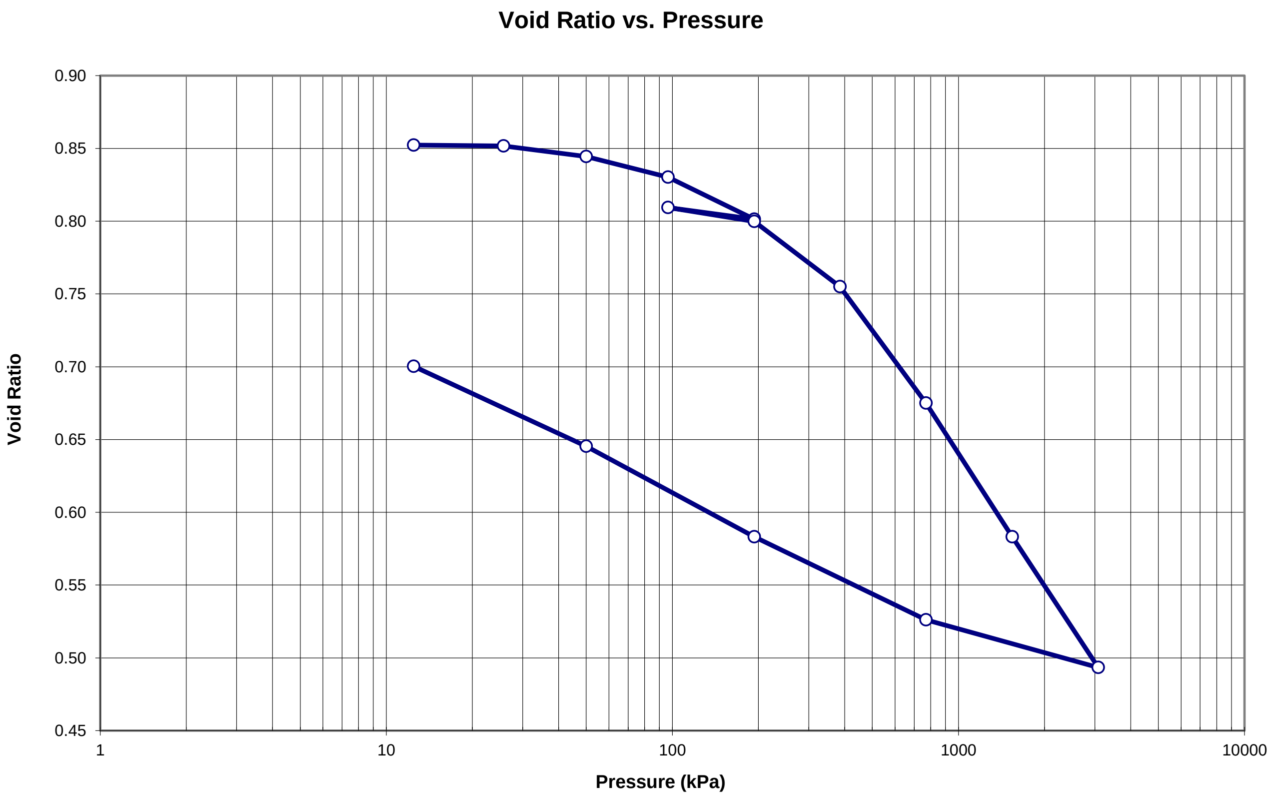
TEST DATES: September 21, 2022 - October 04, 2022

SAMPLE: BH 22-07 ST1 12.5'-14.5'
Silty clay, some sand, some gravel, brown, moist.

PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-11, method B.

	Start of Test	End of Test
Sample Height (mm)	25.40	23.32
Wet Dens. (kg/m^3)	1920.7	2002.9
Dry Dens. (kg/m^3)	1460.6	1590.9
Moisture Cont. (%)	31.5	25.9
Void Ratio	0.852	0.700
Saturation (%)	100.0	100.0

Note: A Specific Gravity (Gs) of 2.705 was obtained for the void ratio and saturation calculations.



TEST DONE BY: BT
REVIEWED BY: WM

THURBER ENGINEERING LTD.

Consolidation Test Report

Cameron and Lyon Creek Culvert Investigations
33309 BH 22-07 ST1 12.5'-14.5'

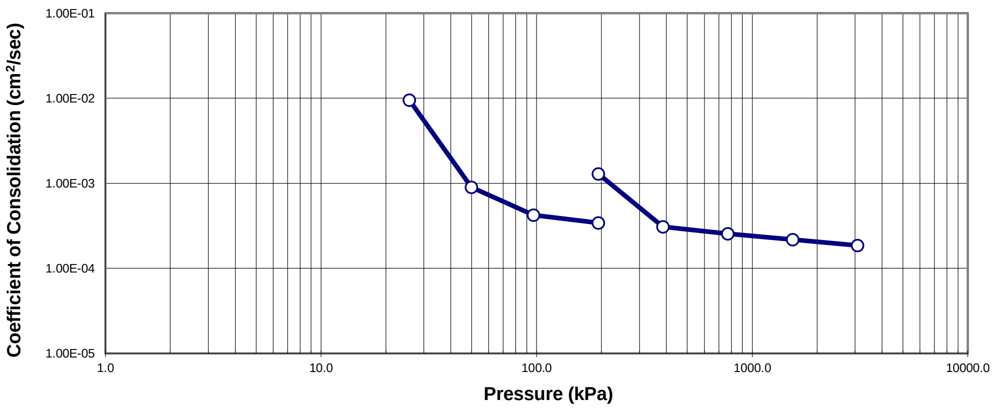
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer. The average moisture content of the trimmings was 31.4%.

LOADING: A seating load of 12.45 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied after 100% primary consolidation was reached at each load increment.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	D_{90} (mm)	t_{90} (min)	c_v (cm^2/s)	Void Ratio	m_v (m^2/kN)	k (cm/s)
0.0	25.400					0.852		
12.5	25.404	25.402				0.852		
25.7	25.395	25.400	-0.046	2.40	9.49E-03	0.852	2.67E-05	2.49E-08
49.9	25.296	25.346	-0.091	25.20	9.01E-04	0.844	1.61E-04	1.42E-08
96.6	25.101	25.199	-0.174	52.85	4.24E-04	0.830	1.65E-04	6.87E-09
193.2	24.706	24.904	-0.340	64.00	3.42E-04	0.801	1.63E-04	5.47E-09
96.6	24.816	24.761				0.809		
193.2	24.685	24.751	-0.108	16.81	1.29E-03	0.800	5.46E-05	6.90E-09
385.7	24.069	24.377	-0.474	68.06	3.08E-04	0.755	1.30E-04	3.92E-09
770.6	22.972	23.521	-0.855	76.56	2.55E-04	0.675	1.18E-04	2.96E-09
1540.7	21.712	22.342	-0.987	80.82	2.18E-04	0.583	7.12E-05	1.52E-09
3081.4	20.481	21.097	-0.990	84.64	1.86E-04	0.493	3.68E-05	6.71E-10
770.6	20.932	20.707				0.526		
193.2	21.712	21.322				0.583		
49.9	22.567	22.140				0.645		
12.5	23.319	22.943				0.700		

Coefficient of Consoildation vs. Pressure



Note: C_v and k calculated using t_{90} values (square root of time method)

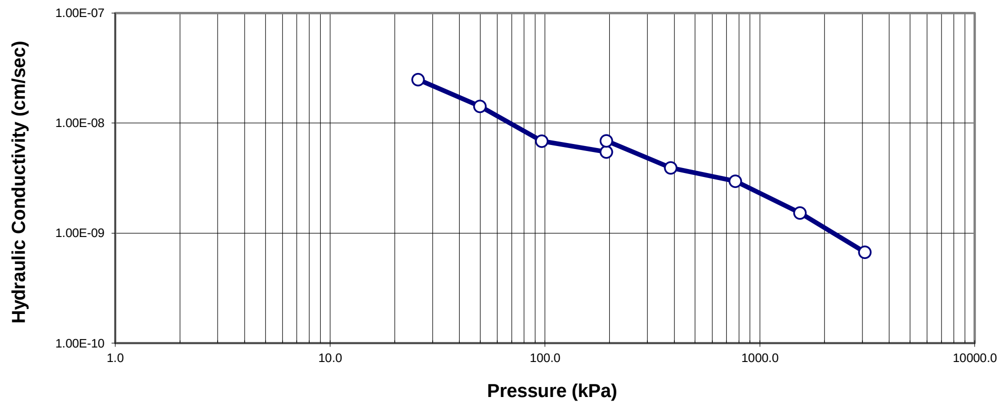
TEST DONE BY: BT
REVIEWED BY: WM

Consolidation Test Report

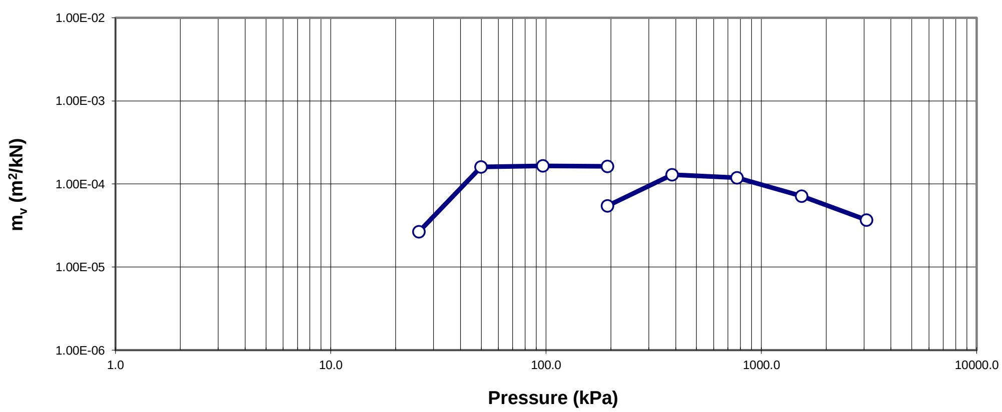
Cameron and Lyon Creek Culvert Investigations
33309

BH 22-07 ST1 12.5'-14.5'

Hydraulic Conductivity vs. Pressure



m_v vs. Pressure



TEST DONE BY: BT
REVIEWED BY: WM

THURBER ENGINEERING LTD.

Consolidation Test Report

CLIENT: MTO | FILE NUMBER: 33309

PROJECT: Cameron and Lyon Creek Culvert Investigations | REPORT DATE: October 12, 2022

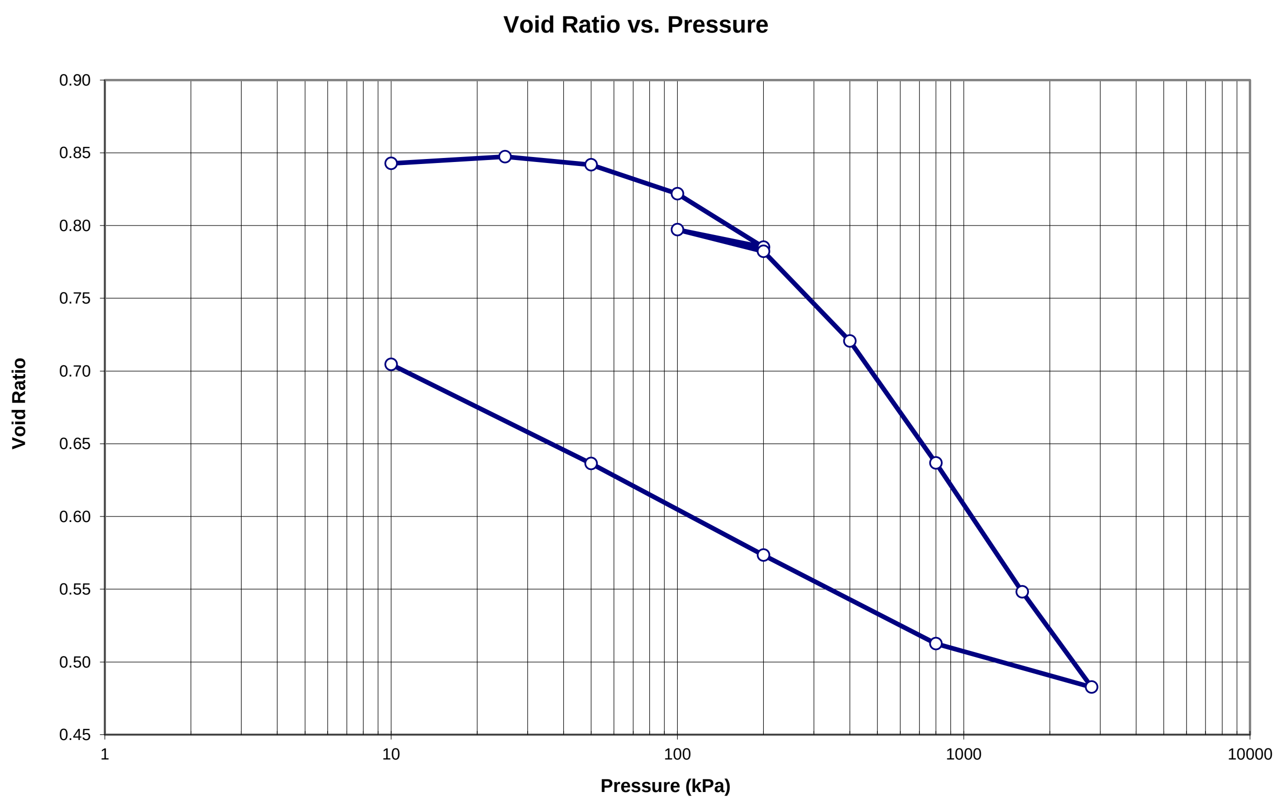
TEST DATES: September 22, 2022 - October 06, 2022

SAMPLE: BH 22-08 ST1 25'-27'
Silty clay, some sand, some gravel, brown, moist

PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-11, method B.

	Start of Test	End of Test
Sample Height (mm)	25.40	23.52
Wet Dens. (kg/m^3)	1923.1	1996.7
Dry Dens. (kg/m^3)	1466.1	1583.5
Moisture Cont. (%)	31.2	26.1
Void Ratio	0.841	0.705
Saturation (%)	100.0	100.0

Note: A Specific Gravity (Gs) of 2.699 was obtained for the void ratio and saturation calculations.



TEST DONE BY: BT
REVIEWED BY: WM

THURBER ENGINEERING LTD.

Consolidation Test Report

Cameron and Lyon Creek Culvert Investigations
33309 BH 22-08 ST1 25'-27'

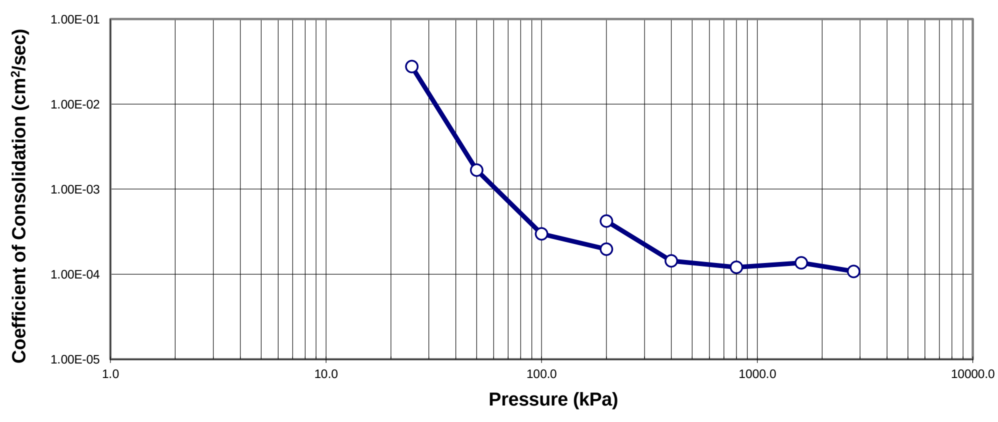
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer. The average moisture content of the trimmings was 30.6%.

LOADING: A seating load of 10 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied after 100% primary consolidation was reached at each load increment.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	D_{90} (mm)	t_{90} (min)	c_v (cm^2/s)	Void Ratio	m_v (m^2/kN)	k (cm/s)
0.0	25.400					0.841		
10.0	25.423	25.412				0.843		
25.0	25.488	25.455	-0.081	0.83	2.76E-02	0.847		
50.0	25.410	25.449	-0.097	13.69	1.67E-03	0.842	1.22E-04	1.99E-08
100.0	25.136	25.273	-0.255	75.69	2.98E-04	0.822	2.16E-04	6.32E-09
200.0	24.630	24.883	-0.478	111.30	1.97E-04	0.785	2.01E-04	3.88E-09
100.0	24.794	24.712				0.797		
200.0	24.589	24.691	-0.168	51.12	4.21E-04	0.782	8.27E-05	3.42E-09
400.0	23.738	24.163	-0.731	144.00	1.43E-04	0.721	1.73E-04	2.43E-09
800.0	22.583	23.160	-1.026	156.50	1.21E-04	0.637	1.22E-04	1.44E-09
1600.0	21.359	21.971	-1.058	125.44	1.36E-04	0.548	6.78E-05	9.04E-10
2800.0	20.455	20.907	-0.883	142.80	1.08E-04	0.483	3.52E-05	3.74E-10
800.0	20.867	20.661				0.512		
200.0	21.707	21.287				0.573		
50.0	22.577	22.142				0.636		
10.0	23.517	23.047				0.705		

Coefficient of Consoildation vs. Pressure



Note: C_v and k calculated using t_{90} values (square root of time method)

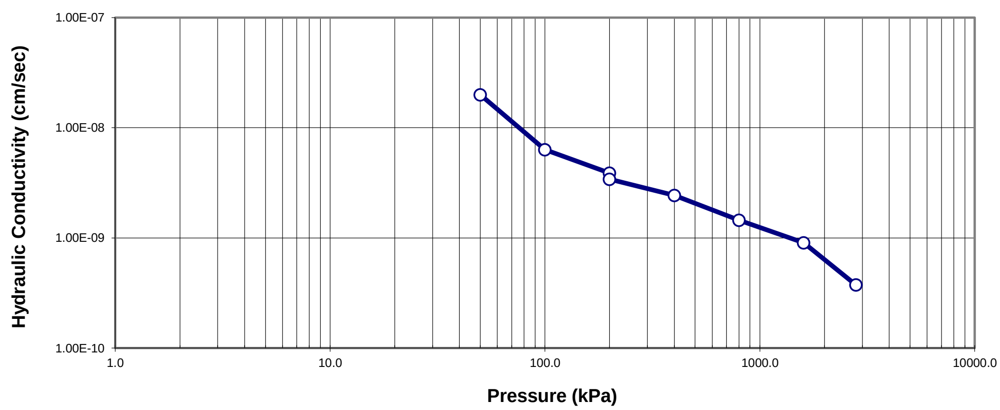
TEST DONE BY: BT
REVIEWED BY: WM

THURBER ENGINEERING LTD.

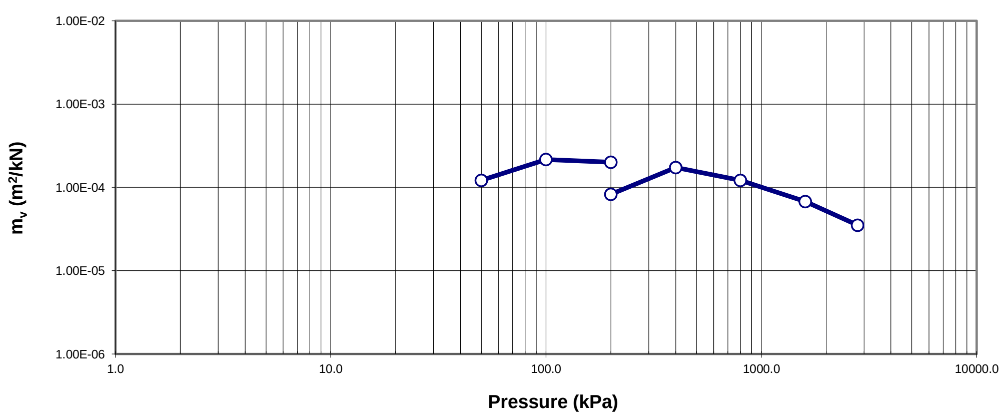
Consolidation Test Report

Cameron and Lyon Creek Culvert Investigations
33309 BH 22-08 ST1 25'-27'

Hydraulic Conductivity vs. Pressure



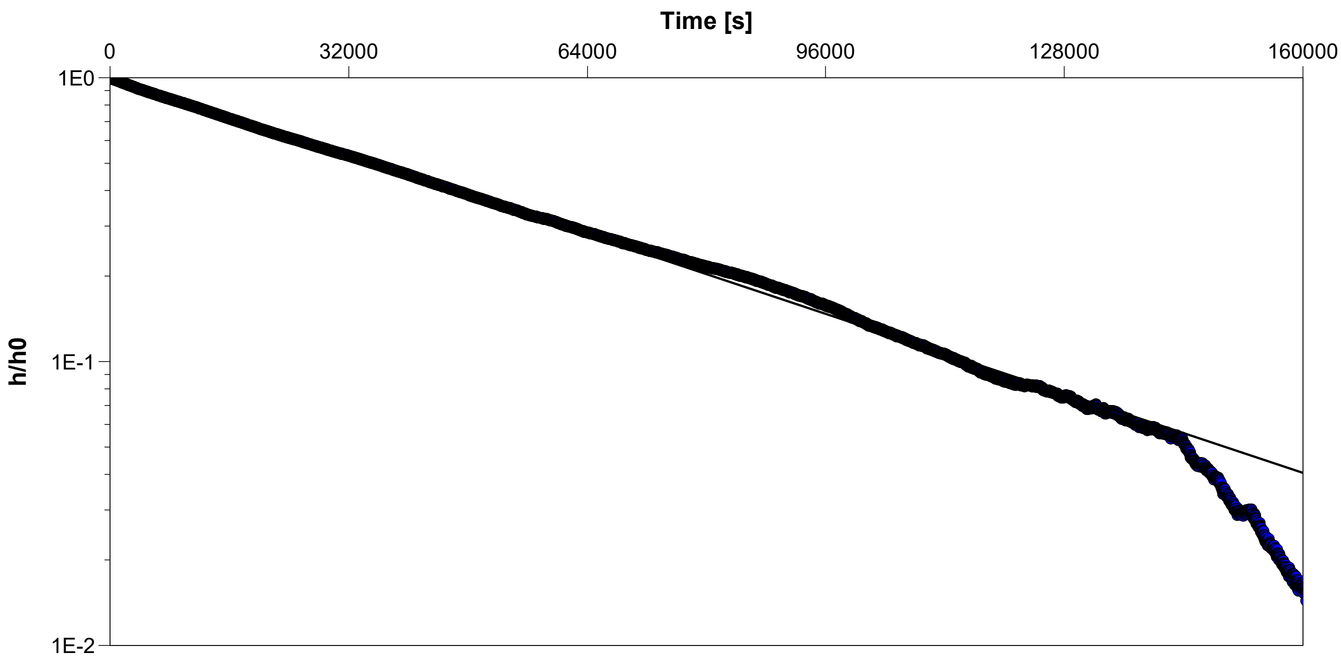
m_v vs. Pressure



TEST DONE BY: BT
REVIEWED BY: WM

THURBER ENGINEERING LTD.

Slug Test Analysis Report		
Project: Lyon Creek Culvert Replacement		
Number: 33309		
Client: MTO		
Location: District of Rainey River	Slug Test: 22-07	Test Well: 22-07
Test Conducted by: GS		Test Date: 2022-08-25
Analysis Performed by: JR	22-07 SWRT Analysis	Analysis Date: 2022-10-27
Aquifer Thickness:		
		Checked by: PC



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
22-07	9.0×10^{-9}	

FINAL REPORT

CA40191-OCT22 R1

33309, C.ameron and Lyon Creek Culvert

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
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	CA40191-OCT22
Project	33309, C.ameron and Lyon Creek Culvert	Received	10/26/2022
Order Number		Approved	11/04/2022
Samples	Soil (1)	Report Number	CA40191-OCT22 R1
		Date Reported	11/08/2022

COMMENTS

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

Chain of Custody Number: No.1

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

TABLE OF CONTENTS

First Page....... 1-2

Index....... 3

Results....... 4

QC Summary....... 5-6

Legend....... 7

Annexes....... 8

FINAL REPORT

CA40191-OCT22 R1

Client: Thurber Engineering Ltd.
Project: 33309, C.ameron and Lyon Creek Culvert
Project Manager: Rachel Bourassa
Samplers: Rachel Bourassa

MATRIX: SOIL

Sample Number	5
Sample Name	22-07 SS3B (8'6"-9'6")
Sample Matrix	Soil
Sample Date	23/10/2022

Parameter	Units	RL	Result
Corrosivity Index			
Corrosivity Index	none	1	12
Soil Redox Potential	mV	no	230
Sulphide (Na2CO3)	%	0.04	0.17
pH	pH Units	0.05	8.25
Resistivity (calculated)	ohms.cm	-9999	1780
General Chemistry			
Conductivity	uS/cm	2	561
Metals and Inorganics			
Moisture Content	%	0.1	23.7
Sulphate	µg/g	0.4	430
Other (ORP)			
Chloride	µg/g	0.4	48

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Chloride	DIO0587-OCT22	µg/g	0.4	<0.4	1	35	98	80	120	92	75	125
Sulphate	DIO0587-OCT22	µg/g	0.4	<0.4	3	35	99	80	120	107	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Sulphide (Na2CO3)	ECS0088-OCT22	%	0.04	< 0.04	ND	20	117	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Conductivity	EWL0670-OCT22	uS/cm	2	< 2	0	20	99	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0670-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.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety

Request for Laboratory Services and CHAIN OF CUSTODY

- 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

No: 1

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: ED
Received Date (mm/dd/yy): 10-26-22
Received Time: 1140
Received By (signature): [signature]
Custody Seal Present: ✓
Custody Seal Intact: ✓
Cooling Agent Present: ✓
Temperature Upon Receipt (°C) 9X3
LAB LIMS #: Oct 26th CA40191

REPORT INFORMATION

Company: Thurber Engineering Ltd.
Contact: Rachel Bourassa
Address: 103-2010 Winston Park Drive, Oakville, Ontario
Phone: 416-523-1015
Email: rbourassa@thurber.ca
Email:

INVOICE INFORMATION

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

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 33309
Site Location/ID: Cameron and Lyon Creek Culvert

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

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:
Rush Confirmation ID:

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

REGULATIONS

Regulation 153/04: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ R/P/I ☐ I/C/C ☐ A/O

Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☐ PWQO ☐ CCME ☐ MISA ☐ MMER ☑ Other:

Sewer By-Law: ☐ Sanitary ☐ Storm Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

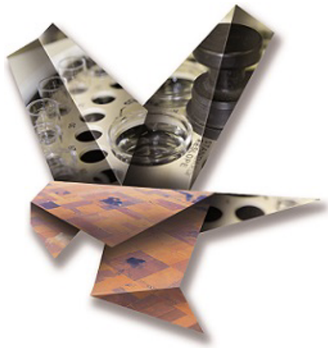
Analysis columns: Field Filtered (Y/N); Metals & Inorganics; PAH☐ ABN☐ SVOC(all)☐; PCB Total ☐ Aroclor ☐; PHC F1-F4☑ VOC☐ BTEX☑ BTEX/F1☐ F2-F4☐; VOC ☐ BTEX ☐ THM ☐; Pesticides OC☐ OP☐; TCLP M&I☐ VOC☐ PCB☐ B(a)P☐ ABN☐ Ignit.☐; Water Pkg Gen.☐ Ext.☐; Sewer Use:; Corrosivity/Resistivity

#	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PAH/ABN/SVOC	PCB	PHC/BTEX	VOC/BTEX/THM	Pesticides	TCLP	Water Pkg	Sewer Use	Corrosivity/Resistivity					COMMENTS
1	22-07 SS3B (8'6" - 9'6")	8/23/22	–	1	Soil		☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	
2	22-02 SS1 (0'-2')	8/27/22	–	1	Soil		☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	
3							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
4							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
5							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
6							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
7							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
8							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
9							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
10							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
11							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
12							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Observations/Comments/Special Instructions: *Corrosivity should include Sulphate

Sampled By (NAME): Rachel Bourassa /GS	Signature: [signature]	Date: 8/27/22 (mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): Rachel Bourassa	Signature: [signature]	Date: 10/26/22 (mm/dd/yy)	Yellow & White Copy - SGS

Revision # 1.1
Date of Issue: 04 April, 2018



FINAL REPORT

CA40152-JUN22 R1

33309, C.ameron and Lyon Creek Culvert

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
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	CA40152-JUN22
Project	33309, C.ameron and Lyon Creek Culvert	Received	06/09/2022
Order Number		Approved	06/26/2022
Samples	Soil (1)	Report Number	CA40152-JUN22 R1
		Date Reported	11/08/2022

COMMENTS

Temperature of Sample upon Receipt: 8 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

Chain of Custody Number:1

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

TABLE OF CONTENTS

First Page 1-2

Index 3

Results 4

QC Summary 5-6

Legend 7

Annexes 8

FINAL REPORT

Client: Thurber Engineering Ltd.

Project: 33309, C.ameron and Lyon Creek Culvert

Project Manager: Rachel Bourassa

Samplers: Rachel Bourassa

MATRIX: SOIL

Sample Number	6
Sample Name	22-08 SS3 (5'-7')
Sample Matrix	Soil
Sample Date	02/05/2022

Parameter	Units	RL		Result
Corrosivity Index				
Corrosivity Index	none	1		4
Soil Redox Potential	mV	no		263
Sulphide (Na2CO3)	%	0.04		< 0.04
pH	pH Units	0.05		8.85
Resistivity (calculated)	ohms.cm	-9999		3150
General Chemistry				
Conductivity	uS/cm	2		317
Metals and Inorganics				
Moisture Content	%	0.1		18.7
Sulphate	µg/g	0.4		42
Other (ORP)				
Chloride	µg/g	0.4		230

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Chloride	DIO0242-JUN22	µg/g	0.4	<0.4	3	35	97	80	120	99	75	125
Sulphate	DIO0242-JUN22	µg/g	0.4	<0.4	5	35	96	80	120	96	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Sulphide (Na2CO3)	ECS0029-JUN22	%	0.04	< 0.04								

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Conductivity	EWL0245-JUN22	uS/cm	2	2	0	20	101	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0245-JUN22	pH Units	0.05	NA	0		99			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.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety

Request for Laboratory Services and CHAIN OF CUSTODY

- 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

No: 1

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Nicole Bryant
Received Date (mm/dd/yy): June 9/22
Received Time: 10:00
Received By (signature): [signature]
Custody Seal Present: ☑
Custody Seal Intact: ☑
Cooling Agent Present: ☑ Ice
Temperature Upon Receipt (°C): 8°C x3
LAB LIMS #: CA40523-JUN22

REPORT INFORMATION

Company: Thurber Engineering Ltd.
Contact: Rachel Bourassa
Address: 103-2010 Winston Park Drive, Oakville, Ontario
Phone: 416-523-1015
Email: rbourassa@thurber.ca
Email:

INVOICE INFORMATION

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

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 33309
Site Location/ID: Cameron and Lyon Creek Culvert

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

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:
Rush Confirmation ID:

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

REGULATIONS

Regulation 153/04: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ R/P/I ☐ I/C/C ☐ A/O
Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☐ PWQO ☐ CCME ☐ MISA ☐ MMER ☑ Other:

Sewer By-Law: ☐ Sanitary ☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

Field Filtered (Y/N); Metals & Inorganics; PAH ☐ ABN ☐ SVOC(all) ☐; PCB Total ☐ Aroclor ☐; PHC F1-F4 ☑ VOC ☐ BTEX ☑ BTEX/F1 ☐ F2-F4 ☐; VOC ☐ BTEX ☐ THM ☐; Pesticides OC ☐ OP ☐; TCLP M&I ☐ VOC ☐ PCB ☐ B(a)P ☐ ABN ☐ Ignit. ☐; Water Pkg Gen. ☐ Ext. ☐; Sewer Use:; Corrosivity/Resistivity

#	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PAH/ABN/SVOC	PCB	PHC/BTEX	VOC/BTEX/THM	Pesticides	TCLP	Water Pkg	Sewer Use	Corrosivity/Resistivity					COMMENTS
1	22-03 SS4(7'6" - 9'6")	5/3/22	9:00 A.M.	1	SOIL		☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	
2	22-08 SS3(5' - 7')	05/02/22	11:00 A.M.	1	SOIL		☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	
3							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
4							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
5							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
6							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
7							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
8							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
9							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
10							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
11							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
12							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Observations/Comments/Special Instructions: *Jars from a different Lab were used

Sampled By (NAME):	Rachel Bourassa	Signature: Rachel Bourassa	Date: 05/03/22	(mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME):	Rachel Bourassa	Signature: Rachel Bourassa	Date: 06/07/22	(mm/dd/yy)	Yellow & White Copy - SGS

FINAL REPORT

CA40013-SEP22 R

33309, Emo, ON.

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Brad Moore Hon. B.Sc
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Rachel Bourassa	Telephone	705-652-2143
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	brad.moore@sgs.com
Email	rbourassa@thurber.ca	SGS Reference	CA40013-SEP22
Project	33309, Emo, ON.	Received	09/01/2022
Order Number		Approved	09/06/2022
Samples	Surface Water (1)	Report Number	CA40013-SEP22 R
		Date Reported	09/06/2022

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of custody: 010116

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

First Page 1

Index 2

Results 3

Exceedance Summary 4

QC Summary 5-6

Legend 7

Annexes 8

FINAL REPORT

CA40013-SEP22 R

Client: Thurber Engineering Ltd.

Project: 33309, Emo, ON.

Project Manager: Rachel Bourassa

Samplers: Grey Stanhope

MATRIX: WATER

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

			Sample Number	6
			Sample Name	Lyon Creek SW
			Sample Matrix	Surface Water
			Sample Date	28/08/2022
Parameter	**Units**	**RL**	**L1**	**Result**
General Chemistry				
Conductivity	uS/cm	2		100
Redox Potential	mV	no		207
Metals and Inorganics				
Sulphate	mg/L	0.04		3.5
Other (ORP)				
pH	No unit	0.05	8.6	7.77
Chloride	mg/L	0.04		3.1

EXCEEDANCE SUMMARY

No exceedances are present above the regulatory limit(s) indicated

FINAL REPORT

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 l Internal ref.: ME-CA-[ENV]IC-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	DIO0073-SEP22	mg/L	0.04	<0.04	4	20	97	90	110	96	75	125
Sulphate	DIO0073-SEP22	mg/L	0.04	<0.04	7	20	98	90	110	97	75	125

Conductivity

Method: SM 2510 l Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	uS/cm	2	< 2	0	20	99	90	110	NA		

pH

Method: SM 4500 l Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	No unit	0.05	NA	1		100			NA		

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	EWL0057-SEP22	mV	no	NA	0	20	103	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.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety

Request for Laboratory Services and CHAIN OF CUSTODY

No: 010116

- 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 1 of 1

Laboratory Information Section - Lab use only

Received By: [signature]
Received By (signature): [signature]
Received Date (mm/dd/yyyy): 09 / 01 / 2022 (mm\dd\yy)
Custody Seal Present: ☒
Cooling Agent Present: ☒ Ice
Received Time: 11 : 30
Custody Seal Intact: ☒
Temperature Upon Receipt (°C): 9 / 8 / 3
LAB LIMS #: 40012-13

REPORT INFORMATION

Company: Thurber Engineering LTD
Contact: Rachel Bourassa
Address: 2010 Winston Park Dr #103 Oakville ON L6M 5R7
Phone: 416 523 1015
Email: rbourassa@thurber.ca
Email:

INVOICE INFORMATION

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

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 33309
Site Location/ID: Emo, ON

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

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:
Rush Confirmation ID:

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

REGULATIONS

Regulation 153/04: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ R/P/I ☐ I/C/C ☐ A/O
Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☑ PWQO ☐ MMER ☐ CCME ☐ Other: ☐ MISA

Sewer By-Law: ☐ Sanitary ☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PAH☐ ABN☐ SVOC(all)☐	PCB Total ☐ Aroclor ☐	PHC F1-F4☐ VOC☐ BTEX☐ BTEX/F1☐ F2-F4☐	VOC☐ BTEX☐ THM☐	Pesticides OC☐ OP☐	TCLP M&I ☐ VOC ☐ PCB☐ B(a)P ☐ ABN ☐ Ignit.☐	Water Pkg Gen.☐ Ext.☐	Sewer Use:	TSS	Lab Filtered Metals	Water Characterization Package (general)	Corrosivity *		COMMENTS:
1	Lyon Creek SW	Aug 28/22		15	Water											✓	✓	✓	✓		
2	22-07	Aug 28/22		14	Water											✓	✓	✓			
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

Observations/Comments/Special Instructions: *Corrosivity Includes pH, Soluable Sulphate, chloride, Resistivity, Electrical Conductivity.

Sampled By (NAME): Greg Stanhope
Signature: GS
Date: Aug / 28 / 2022 (mm/dd/yy)
Pink Copy - Client

Relinquished by (NAME): Rachel Bourassa
Signature: Rachel Bourassa
Date: Aug / 31 / 2022 (mm/dd/yy)
Yellow & White Copy - SGS

Revision #: 1.1
Date of Issue: 04 April, 2018

FINAL REPORT

CA40012-SEP22 R1

33309, Emo, ON.

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
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	CA40012-SEP22
Project	33309, Emo, ON.	Received	09/01/2022
Order Number		Approved	11/11/2022
Samples	Ground Water (1)	Report Number	CA40012-SEP22 R1
		Date Reported	11/11/2022

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: 010116

SIGNATORIES

Jill Campbell, B.Sc.,GISAS

TABLE OF CONTENTS

First Page 1-2

Index 3

Results 4-8

Exceedance Summary 9

QC Summary 10-17

Legend 18

Annexes 19

FINAL REPORT

CA40012-SEP22 R1

Client: Thurber Engineering Ltd.

Project: 33309, Emo, ON.

Project Manager: Rachel Bourassa

Samplers: Grey Stanhope

MATRIX: WATER

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

			Sample Number	8
			Sample Name	22-07
			Sample Matrix	Ground Water
			Sample Date	28/08/2022
Parameter	**Units**	**RL**	**L1**	**Result**
General Chemistry				
Total Suspended Solids	mg/L	2		1850
Alkalinity	mg/L as CaCO3	2		456
Bicarbonate	mg/L as CaCO3	2		456
Carbonate	mg/L as CaCO3	2		< 2
OH	mg/L as CaCO3	2		< 2
Colour	TCU	3		43
Conductivity	uS/cm	2		1560
Turbidity	NTU	0.10		850
Ammonia+Ammonium (N)	as N mg/L	0.1		0.4
Phosphorus (total reactive)	mg/L	0.03		< 0.03
Total Organic Carbon	mg/L	1		7
Ion Ratio	-	-9999		1.23
Total Dissolved Solids (calculated)	mg/L	-9999		955
Conductivity (calculated)	uS/cm	-9999		1990
Langeliers Index 4° C	@ 4° C	-9999		0.83
Saturation pH 4°C	pHs @ 4°C	-9999		7.07

FINAL REPORT

CA40012-SEP22 R1

Client: Thurber Engineering Ltd.
Project: 33309, Emo, ON.
Project Manager: Rachel Bourassa
Samplers: Grey Stanhope

MATRIX: WATER

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

Sample Number	8
Sample Name	22-07
Sample Matrix	Ground Water
Sample Date	28/08/2022

Parameter	Units	RL	L1	Result
Metals and Inorganics				
Fluoride	mg/L	0.06		0.19
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		27
Hardness (dissolved)	mg/L as CaCO3	0.05		573
Aluminum (dissolved)	mg/L	0.001	0.075	0.010
Aluminum (0.2µm)	mg/L	0.001	0.075	0.007
Arsenic (dissolved)	mg/L	0.0002		0.0043
Boron (dissolved)	mg/L	0.002		0.146
Barium (dissolved)	mg/L	0.00008		0.150
Beryllium (dissolved)	mg/L	0.000007		< 0.000007
Cobalt (dissolved)	mg/L	0.000004		0.00165
Calcium (dissolved)	mg/L	0.01		146
Cadmium (dissolved)	mg/L	0.000003		0.000085
Copper (dissolved)	mg/L	0.0002		0.0020
Chromium (dissolved)	mg/L	0.00008		< 0.00008
Iron (dissolved)	mg/L	0.007		0.010
Potassium (dissolved)	mg/L	0.009		5.19
Magnesium (dissolved)	mg/L	0.001		50.5
Manganese (dissolved)	mg/L	0.00001		0.430
Molybdenum (dissolved)	mg/L	0.00004		0.0156

FINAL REPORT

Client: Thurber Engineering Ltd.
Project: 33309, Emo, ON.
Project Manager: Rachel Bourassa
Samplers: Grey Stanhope

MATRIX: WATER

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

			Sample Number	8
			Sample Name	22-07
			Sample Matrix	Ground Water
			Sample Date	28/08/2022
Parameter	**Units**	**RL**	**L1**	**Result**
Metals and Inorganics (continued)				
Nickel (dissolved)	mg/L	0.0001		0.0044
Sodium (dissolved)	mg/L	0.01		105
Phosphorus (dissolved)	mg/L	0.003		< 0.003
Lead (dissolved)	mg/L	0.00009		< 0.00009
Silicon (dissolved)	mg/L	0.02		6.86
Silver (dissolved)	mg/L	0.00005		< 0.00005
Strontium (dissolved)	mg/L	0.00008		0.601
Thallium (dissolved)	mg/L	0.000005		0.000011
Tin (dissolved)	mg/L	0.00006		0.00142
Titanium (dissolved)	mg/L	0.00005		0.00021
Antimony (dissolved)	mg/L	0.0009		0.0011
Selenium (dissolved)	mg/L	0.00004		0.00012
Uranium (dissolved)	mg/L	0.000002		0.00726
Vanadium (dissolved)	mg/L	0.00001		0.00189
Zinc (dissolved)	mg/L	0.002		0.004
Hardness	mg/L as CaCO3	0.05		763
Aluminum (total)	mg/L	0.001		11.4
Arsenic (total)	mg/L	0.0002	0.005	0.0084
Boron (total)	mg/L	0.002	0.2	0.151
Barium (total)	mg/L	0.00008		0.268
Beryllium (total)	mg/L	0.000007	1.1	0.000582
Cobalt (total)	mg/L	0.000004	0.0009	0.0141

Client: Thurber Engineering Ltd.

Project: 33309, Emo, ON.

Project Manager: Rachel Bourassa

Samplers: Grey Stanhope

MATRIX: WATER

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

			Sample Number	8
			Sample Name	22-07
			Sample Matrix	Ground Water
			Sample Date	28/08/2022
Parameter	**Units**	**RL**	**L1**	**Result**
Metals and Inorganics (continued)				
Calcium (total)	mg/L	0.01		189
Cadmium (total)	mg/L	0.000003	0.0005	0.000593
Copper (total)	mg/L	0.0002	0.005	0.0234
Chromium (total)	mg/L	0.00008	0.1	0.0282
Iron (total)	mg/L	0.007	0.3	17.2
Potassium (total)	mg/L	0.009		8.23
Magnesium (total)	mg/L	0.001		70.8
Manganese (total)	mg/L	0.00001		0.934
Molybdenum (total)	mg/L	0.00004	0.04	0.0111
Nickel (total)	mg/L	0.0001	0.025	0.0308
Sodium (total)	mg/L	0.01		95.9
Phosphorus (total)	mg/L	0.003	0.01	0.599
Lead (total)	mg/L	0.00009	0.025	0.0127
Silicon (total)	mg/L	0.02		27.5
Silver (total)	mg/L	0.00005	0.0001	0.00015
Strontium (total)	mg/L	0.00008		0.602
Thallium (total)	mg/L	0.000005	0.0003	0.000259
Tin (total)	mg/L	0.00006		0.00168
Titanium (total)	mg/L	0.00005		0.232
Antimony (total)	mg/L	0.0009	0.02	< 0.0009
Selenium (total)	mg/L	0.00004	0.1	0.00024
Uranium (total)	mg/L	0.000002	0.005	0.00864

FINAL REPORT

Client: Thurber Engineering Ltd.
Project: 33309, Emo, ON.
Project Manager: Rachel Bourassa
Samplers: Grey Stanhope

MATRIX: WATER

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

Sample Number	8
Sample Name	22-07
Sample Matrix	Ground Water
Sample Date	28/08/2022

Parameter	Units	RL	L1	Result
Metals and Inorganics (continued)				
Vanadium (total)	mg/L	0.00001	0.006	0.0448
Zinc (total)	mg/L	0.002	0.02	0.075
Cation sum	meq/L	-9999		21.94
Anion Sum	meq/L	-9999		17.86
Anion-Cation Balance	% difference	-9999		10.25
Other (ORP)				
pH	No unit	0.05	8.6	7.90
Chloride	mg/L	0.2		290
Mercury (total)	mg/L	0.00001	0.0002	0.00007
Mercury (dissolved)	mg/L	0.00001	0.0002	0.00005

EXCEEDANCE SUMMARY

Parameter	Method	Units	Result	PWQO_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E L1
22-07				
Arsenic	SM 3030/EPA 200.8	mg/L	0.0084	0.005
Cadmium	SM 3030/EPA 200.8	mg/L	0.000593	0.0005
Cobalt	SM 3030/EPA 200.8	mg/L	0.0141	0.0009
Copper	SM 3030/EPA 200.8	mg/L	0.0234	0.005
Iron	SM 3030/EPA 200.8	mg/L	17.2	0.3
Nickel	SM 3030/EPA 200.8	mg/L	0.0308	0.025
Phosphorus	SM 3030/EPA 200.8	mg/L	0.599	0.01
Silver	SM 3030/EPA 200.8	mg/L	0.00015	0.0001
Uranium	SM 3030/EPA 200.8	mg/L	0.00864	0.005
Vanadium	SM 3030/EPA 200.8	mg/L	0.0448	0.006
Zinc	SM 3030/EPA 200.8	mg/L	0.075	0.02

QC SUMMARY

Alkalinity

Method: SM 2320 | Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	mg/L as CaCO3	2	< 2	0	20	100	80	120	NA		

Ammonia by SFA

Method: SM 4500 | Internal ref.: ME-CA-[ENV]SFA-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)	SKA0040-SEP22	as N mg/L	0.1	<0.1	1	10	97	90	110	98	75	125

FINAL REPORT

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-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	DIO0070-SEP22	mg/L	0.3	<0.3	ND	20	99	90	110	102	75	125
Nitrite (as N)	DIO0070-SEP22	mg/L	0.03	<0.03	ND	20	99	90	110	102	75	125
Nitrate (as N)	DIO0070-SEP22	mg/L	0.06	<0.06	ND	20	100	90	110	103	75	125
Chloride	DIO0134-SEP22	mg/L	0.2	<0.2	15	20	101	90	110	100	75	125
Sulphate	DIO0134-SEP22	mg/L	0.2	<0.2	3	20	99	90	110	94	75	125
Chloride	DIO0195-SEP22	mg/L	0.2	<0.2	1	20	98	90	110	99	75	125
Sulphate	DIO0195-SEP22	mg/L	0.2	<0.2	NV	20	97	90	110	NV	75	125

Carbon by SFA

Method: SM 5310 | Internal ref.: ME-CA-[ENV]SFA-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	SKA5019-SEP22	mg/L	1	<1	0	20	100	90	110	96	75	125

QC SUMMARY

Carbonate/Bicarbonate

Method: SM 2320 | Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0055-SEP22	mg/L as CaCO3	2	< 2	0	10	NA	90	110	NA		
OH	EWL0055-SEP22	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		

Colour

Method: SM 2120 | Internal ref.: ME-CA-[ENV]EWL-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	EWL0075-SEP22	TCU	3	< 3	ND	10	100	80	120	NA		

QC SUMMARY

Conductivity

Method: SM 2510 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	uS/cm	2	< 2	0	20	99	90	110	NA		

Fluoride by Specific Ion Electrode

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0070-SEP22	mg/L	0.06	<0.06	ND	10	103	90	110	97	75	125
Fluoride	EWL0083-SEP22	mg/L	0.06	<0.06	0	10	102	90	110	99	75	125

Mercury by CVAAS

Method: EPA 7471A/SM 3112B I Internal ref.: ME-CA-[ENV]SPE-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)	EHG0005-SEP22	mg/L	0.00001	< 0.00001	18	20	105	80	120	101	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-[ENV]SPE-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)	EMS0061-SEP22	mg/L	0.00005	<0.00005	ND	20	107	90	110	99	70	130
Aluminum (total)	EMS0061-SEP22	mg/L	0.001	<0.001	3	20	100	90	110	99	70	130
Aluminum (0.2µm)	EMS0061-SEP22	mg/L	0.001	<0.001	3	20	100	90	110	99	70	130
Arsenic (total)	EMS0061-SEP22	mg/L	0.0002	<0.0002	2	20	102	90	110	91	70	130
Barium (total)	EMS0061-SEP22	mg/L	0.00008	<0.00002	10	20	106	90	110	108	70	130
Beryllium (total)	EMS0061-SEP22	mg/L	0.000007	<0.000007	ND	20	96	90	110	88	70	130
Boron (total)	EMS0061-SEP22	mg/L	0.002	<0.002	12	20	101	90	110	99	70	130
Calcium (total)	EMS0061-SEP22	mg/L	0.01	<0.01	3	20	101	90	110	102	70	130
Cadmium (total)	EMS0061-SEP22	mg/L	0.000003	<0.000003	ND	20	104	90	110	104	70	130
Cobalt (total)	EMS0061-SEP22	mg/L	0.000004	<0.000004	10	20	105	90	110	107	70	130
Chromium (total)	EMS0061-SEP22	mg/L	0.00008	<0.00008	1	20	99	90	110	92	70	130
Copper (total)	EMS0061-SEP22	mg/L	0.0002	<0.0002	ND	20	103	90	110	119	70	130
Iron (total)	EMS0061-SEP22	mg/L	0.007	<0.007	ND	20	97	90	110	125	70	130
Potassium (total)	EMS0061-SEP22	mg/L	0.009	<0.009	1	20	96	90	110	114	70	130
Magnesium (total)	EMS0061-SEP22	mg/L	0.001	<0.001	0	20	95	90	110	109	70	130
Manganese (total)	EMS0061-SEP22	mg/L	0.00001	<0.00001	9	20	101	90	110	91	70	130
Molybdenum (total)	EMS0061-SEP22	mg/L	0.00004	<0.00004	3	20	102	90	110	108	70	130
Sodium (total)	EMS0061-SEP22	mg/L	0.01	<0.01	3	20	98	90	110	110	70	130
Nickel (total)	EMS0061-SEP22	mg/L	0.0001	<0.0001	4	20	99	90	110	104	70	130
Lead (total)	EMS0061-SEP22	mg/L	0.00009	<0.00001	0	20	106	90	110	111	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 I Internal ref.: ME-CA-[ENV]SPE-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)	EMS0061-SEP22	mg/L	0.003	<0.003	13	20	96	90	110	NV	70	130
Antimony (total)	EMS0061-SEP22	mg/L	0.0009	<0.0009	ND	20	98	90	110	128	70	130
Selenium (total)	EMS0061-SEP22	mg/L	0.00004	<0.00004	ND	20	102	90	110	89	70	130
Silicon (total)	EMS0061-SEP22	mg/L	0.02	<0.02	13	20	93	90	110	NV	70	130
Tin (total)	EMS0061-SEP22	mg/L	0.00006	<0.00006	ND	20	108	90	110	NV	70	130
Strontium (total)	EMS0061-SEP22	mg/L	0.00008	<0.00002	0	20	104	90	110	105	70	130
Titanium (total)	EMS0061-SEP22	mg/L	0.00005	<0.00005	6	20	101	90	110	NV	70	130
Thallium (total)	EMS0061-SEP22	mg/L	0.000005	<0.000005	ND	20	96	90	110	99	70	130
Uranium (total)	EMS0061-SEP22	mg/L	0.000002	<0.000002	1	20	108	90	110	118	70	130
Vanadium (total)	EMS0061-SEP22	mg/L	0.00001	<0.00001	3	20	99	90	110	102	70	130
Zinc (total)	EMS0061-SEP22	mg/L	0.002	<0.002	2	20	101	90	110	110	70	130

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	No unit	0.05	NA	1		100			NA		

QC SUMMARY

Reactive Phosphorus by SFA

Method: SM 4500-P F | Internal ref.: ME-CA-[ENV]SFA-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)	SKA0035-SEP22	mg/L	0.03	<0.03	ND	10	104	90	110	93	75	125

Suspended Solids

Method: SM 2540D | Internal ref.: ME-CA-[ENV]EWL-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	EWL0066-SEP22	mg/L	2	< 2	1	10	99	90	110	NA		

Turbidity

Method: SM 2130 | Internal ref.: ME-CA-[ENV]EWL-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	EWL0064-SEP22	NTU	0.10	< 0.10	4	10	100	90	110	NA		

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.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety

Request for Laboratory Services and CHAIN OF CUSTODY

No: 010116

- 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 1 of 1

Laboratory Information Section - Lab use only

Received By: [signature]
Received Date (mm/dd/yyyy): 09/01/2022 (mm\dd\yy)
Received Time: 11 : 30
Received By (signature): [signature]
Custody Seal Present: ☐
Custody Seal Intact: ☐
Cooling Agent Present: ☒ ice
Temperature Upon Receipt (°C): 9, 9, 9 / 9 x 3
LAB LIMS #: 40012-13

REPORT INFORMATION

Company: Thurber Engineering LTD
Contact: Rachel Bourassa
Address: 2010 Winston Park Dr
#103 Oakville ON L6M 5R7
Phone: 416 523 1015
Email: rbourassa@thurber.ca
Email:

INVOICE INFORMATION

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

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 33309
Site Location/ID: Emo, ON

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)
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:
Rush Confirmation ID:

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

REGULATIONS

Regulation 153/04: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ___ ☐ R/P/I ☐ I/C/C ☐ A/O
Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☑ PWQO ☐ MMER ☐ CCME ☐ Other: ☐ MISA

Sewer By-Law: ☐ Sanitary ☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PAH☐ ABN☐ SVOC(all)☐	PCB Total ☐ Aroclor ☐	PHC F1-F4 ☐ VOC☐ BTEX☐ BTEX/F1☐ F2-F4☐	VOC☐ BTEX☐ THM☐	Pesticides OC☐ OP☐	TCLP M&I ☐ VOC ☐ PCB☐ B(a)P ☐ ABN ☐ Ignit.☐	Water Pkg Gen.☐ Ext.☐	Sewer Use:	TSS	Lab Filtered Metals	Water Characterization Package (general)	Corrosivity *		COMMENTS:
1	Lyon Creek SW	Aug 28/22		15	Water											✓	✓	✓	✓		
2	22-07	Aug 28/22		14	Water											✓	✓	✓			
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

Observations/Comments/Special Instructions: *Corrosivity Includes pH, Soluble Sulphate, Chloride, Resistivity, Electrical Conductivity.

Sampled By (NAME): Greg Stanhope	Signature: GS	Date: aug / 28 / 2022	(mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): Rachel Bourassa	Signature: Rachel Bourassa	Date: aug / 31 / 2022	(mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.1
Date of Issue: 04 April, 2018

FINAL REPORT

CA40012-SEP22 R1

33309, Emo, ON.

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
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	CA40012-SEP22
Project	33309, Emo, ON.	Received	09/01/2022
Order Number		Approved	11/11/2022
Samples	Surface Water (1)	Report Number	CA40012-SEP22 R1
		Date Reported	11/11/2022

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: 010116

SIGNATORIES

Jill Campbell, B.Sc.,GISAS

Jill Campbell

TABLE OF CONTENTS

First Page 1-2

Index 3

Results 4-8

Exceedance Summary 9

QC Summary 10-17

Legend 18

Annexes 19

FINAL REPORT

Client: Thurber Engineering Ltd.
Project: 33309, Emo, ON.
Project Manager: Rachel Bourassa
Samplers: Grey Stanhope

MATRIX: WATER

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

Sample Number 7
Sample Name Lyon Creek SW
Sample Matrix Surface Water
Sample Date 28/08/2022

Parameter	Units	RL	L1	Result
General Chemistry				
Total Suspended Solids	mg/L	2		12
Alkalinity	mg/L as CaCO3	2		37
Bicarbonate	mg/L as CaCO3	2		37
Carbonate	mg/L as CaCO3	2		< 2
OH	mg/L as CaCO3	2		< 2
Colour	TCU	3		49
Conductivity	uS/cm	2		99
Turbidity	NTU	0.10		8.5
Ammonia+Ammonium (N)	as N mg/L	0.1		< 0.1
Phosphorus (total reactive)	mg/L	0.03		< 0.03
Total Organic Carbon	mg/L	1		11
Ion Ratio	-	-9999		1.16
Total Dissolved Solids (calculated)	mg/L	-9999		49
Conductivity (calculated)	uS/cm	-9999		99
Langeliers Index 4° C	@ 4° C	-9999		-1.59
Saturation pH 4°C	pHs @ 4°C	-9999		9.27

FINAL REPORT

CA40012-SEP22 R1

Client: Thurber Engineering Ltd.
Project: 33309, Emo, ON.
Project Manager: Rachel Bourassa
Samplers: Grey Stanhope

MATRIX: WATER

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

Sample Number	7
Sample Name	Lyon Creek SW
Sample Matrix	Surface Water
Sample Date	28/08/2022

Parameter	Units	RL	L1	Result
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		3.8
Hardness (dissolved)	mg/L as CaCO3	0.05		41.8
Aluminum (dissolved)	mg/L	0.001	0.075	0.015
Aluminum (0.2µm)	mg/L	0.001	0.075	0.009
Arsenic (dissolved)	mg/L	0.0002		0.0008
Boron (dissolved)	mg/L	0.002		0.015
Barium (dissolved)	mg/L	0.00008		0.0110
Beryllium (dissolved)	mg/L	0.000007		< 0.000007
Cobalt (dissolved)	mg/L	0.000004		0.000041
Calcium (dissolved)	mg/L	0.01		11.1
Cadmium (dissolved)	mg/L	0.000003		< 0.000003
Copper (dissolved)	mg/L	0.0002		0.0012
Chromium (dissolved)	mg/L	0.00008		< 0.00008
Iron (dissolved)	mg/L	0.007		0.093
Potassium (dissolved)	mg/L	0.009		0.977
Magnesium (dissolved)	mg/L	0.001		3.42
Manganese (dissolved)	mg/L	0.00001		0.00071
Molybdenum (dissolved)	mg/L	0.00004		0.00024

Client: Thurber Engineering Ltd.

Project: 33309, Emo, ON.

Project Manager: Rachel Bourassa

Samplers: Grey Stanhope

MATRIX: WATER

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

Sample Number	7
Sample Name	Lyon Creek SW
Sample Matrix	Surface Water
Sample Date	28/08/2022

Parameter	Units	RL	L1	Result
Metals and Inorganics (continued)				
Nickel (dissolved)	mg/L	0.0001		0.0009
Sodium (dissolved)	mg/L	0.01		3.65
Phosphorus (dissolved)	mg/L	0.003		0.033
Lead (dissolved)	mg/L	0.00009		< 0.00009
Silicon (dissolved)	mg/L	0.02		1.15
Silver (dissolved)	mg/L	0.00005		< 0.00005
Strontium (dissolved)	mg/L	0.00008		0.0290
Thallium (dissolved)	mg/L	0.000005		< 0.000005
Tin (dissolved)	mg/L	0.00006		< 0.00006
Titanium (dissolved)	mg/L	0.00005		0.00088
Antimony (dissolved)	mg/L	0.0009		< 0.0009
Selenium (dissolved)	mg/L	0.00004		< 0.00004
Uranium (dissolved)	mg/L	0.000002		0.000117
Vanadium (dissolved)	mg/L	0.00001		0.00066
Zinc (dissolved)	mg/L	0.002		< 0.002
Hardness	mg/L as CaCO3	0.05		41.6
Aluminum (total)	mg/L	0.001		0.226
Arsenic (total)	mg/L	0.0002	0.005	0.0011
Boron (total)	mg/L	0.002	0.2	0.010
Barium (total)	mg/L	0.00008		0.0138
Beryllium (total)	mg/L	0.000007	0.011	0.000018
Cobalt (total)	mg/L	0.000004	0.0009	0.000357

SGS

FINAL REPORT

CA40012-SEP22 R1

Client: Thurber Engineering Ltd.

Project: 33309, Emo, ON.

Project Manager: Rachel Bourassa

Samplers: Grey Stanhope

MATRIX: WATER

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

			Sample Number	7
			Sample Name	Lyon Creek SW
			Sample Matrix	Surface Water
			Sample Date	28/08/2022
Parameter	**Units**	**RL**	**L1**	**Result**
Metals and Inorganics (continued)				
Calcium (total)	mg/L	0.01		10.9
Cadmium (total)	mg/L	0.000003	0.0001	0.000015
Copper (total)	mg/L	0.0002	0.005	0.0016
Chromium (total)	mg/L	0.00008	0.1	0.00048
Iron (total)	mg/L	0.007	0.3	0.465
Potassium (total)	mg/L	0.009		1.06
Magnesium (total)	mg/L	0.001		3.49
Manganese (total)	mg/L	0.00001		0.101
Molybdenum (total)	mg/L	0.00004	0.04	0.00033
Nickel (total)	mg/L	0.0001	0.025	0.0013
Sodium (total)	mg/L	0.01		3.43
Phosphorus (total)	mg/L	0.003	0.01	0.108
Lead (total)	mg/L	0.00009	0.01	0.00025
Silicon (total)	mg/L	0.02		1.54
Silver (total)	mg/L	0.00005	0.0001	< 0.00005
Strontium (total)	mg/L	0.00008		0.0297
Thallium (total)	mg/L	0.000005	0.0003	0.000006
Tin (total)	mg/L	0.00006		< 0.00006
Titanium (total)	mg/L	0.00005		0.00682
Antimony (total)	mg/L	0.0009	0.02	< 0.0009
Selenium (total)	mg/L	0.00004	0.1	< 0.00004
Uranium (total)	mg/L	0.000002	0.005	0.000169

FINAL REPORT

CA40012-SEP22 R1

Client: Thurber Engineering Ltd.

Project: 33309, Emo, ON.

Project Manager: Rachel Bourassa

Samplers: Grey Stanhope

MATRIX: WATER

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

Sample Number	7
Sample Name	Lyon Creek SW
Sample Matrix	Surface Water
Sample Date	28/08/2022

Parameter	Units	RL	L1	Result
Metals and Inorganics (continued)				
Vanadium (total)	mg/L	0.00001	0.006	0.00143
Zinc (total)	mg/L	0.002	0.02	0.003
Cation sum	meq/L	-9999		1.07
Anion Sum	meq/L	-9999		0.92
Anion-Cation Balance	% difference	-9999		7.24
Other (ORP)				
pH	No unit	0.05	8.6	7.68
Chloride	mg/L	0.2		3.6
Mercury (total)	mg/L	0.00001	0.0002	< 0.00001
Mercury (dissolved)	mg/L	0.00001	0.0002	< 0.00001

EXCEEDANCE SUMMARY

Parameter	Method	Units	Result	PWQO_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E L1
Lyon Creek SW				
Iron	SM 3030/EPA 200.8	mg/L	0.465	0.3
Phosphorus	SM 3030/EPA 200.8	mg/L	0.108	0.01

QC SUMMARY

Alkalinity

Method: SM 2320 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	mg/L as CaCO3	2	< 2	0	20	100	80	120	NA		

Ammonia by SFA

Method: SM 4500 I Internal ref.: ME-CA-[ENV]SFA-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)	SKA0040-SEP22	as N mg/L	0.1	<0.1	1	10	97	90	110	98	75	125

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 l Internal ref.: ME-CA-[ENV]IC-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	DIO0070-SEP22	mg/L	0.3	<0.3	ND	20	99	90	110	102	75	125
Nitrite (as N)	DIO0070-SEP22	mg/L	0.03	<0.03	ND	20	99	90	110	102	75	125
Nitrate (as N)	DIO0070-SEP22	mg/L	0.06	<0.06	ND	20	100	90	110	103	75	125
Chloride	DIO0134-SEP22	mg/L	0.2	<0.2	15	20	101	90	110	100	75	125
Sulphate	DIO0134-SEP22	mg/L	0.2	<0.2	3	20	99	90	110	94	75	125
Chloride	DIO0195-SEP22	mg/L	0.2	<0.2	1	20	98	90	110	99	75	125
Sulphate	DIO0195-SEP22	mg/L	0.2	<0.2	NV	20	97	90	110	NV	75	125

Carbon by SFA

Method: SM 5310 l Internal ref.: ME-CA-[ENV]SFA-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	SKA5019-SEP22	mg/L	1	<1	0	20	100	90	110	96	75	125

QC SUMMARY

Carbonate/Bicarbonate

Method: SM 2320 | Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0055-SEP22	mg/L as CaCO3	2	< 2	0	10	NA	90	110	NA		
OH	EWL0055-SEP22	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		

Colour

Method: SM 2120 | Internal ref.: ME-CA-[ENV]EWL-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	EWL0075-SEP22	TCU	3	< 3	ND	10	100	80	120	NA		

QC SUMMARY

Conductivity

Method: SM 2510 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	uS/cm	2	< 2	0	20	99	90	110	NA		

Fluoride by Specific Ion Electrode

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0070-SEP22	mg/L	0.06	<0.06	ND	10	103	90	110	97	75	125
Fluoride	EWL0083-SEP22	mg/L	0.06	<0.06	0	10	102	90	110	99	75	125

Mercury by CVAAS

Method: EPA 7471A/SM 3112B I Internal ref.: ME-CA-[ENV]SPE-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)	EHG0005-SEP22	mg/L	0.00001	< 0.00001	18	20	105	80	120	101	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-[ENV]SPE-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Silver (total)	EMS0061-SEP22	mg/L	0.00005	<0.00005	ND	20	107	90	110	99	70	130
Aluminum (total)	EMS0061-SEP22	mg/L	0.001	<0.001	3	20	100	90	110	99	70	130
Aluminum (0.2µm)	EMS0061-SEP22	mg/L	0.001	<0.001	3	20	100	90	110	99	70	130
Arsenic (total)	EMS0061-SEP22	mg/L	0.0002	<0.0002	2	20	102	90	110	91	70	130
Barium (total)	EMS0061-SEP22	mg/L	0.00008	<0.00002	10	20	106	90	110	108	70	130
Beryllium (total)	EMS0061-SEP22	mg/L	0.000007	<0.000007	ND	20	96	90	110	88	70	130
Boron (total)	EMS0061-SEP22	mg/L	0.002	<0.002	12	20	101	90	110	99	70	130
Calcium (total)	EMS0061-SEP22	mg/L	0.01	<0.01	3	20	101	90	110	102	70	130
Cadmium (total)	EMS0061-SEP22	mg/L	0.000003	<0.000003	ND	20	104	90	110	104	70	130
Cobalt (total)	EMS0061-SEP22	mg/L	0.000004	<0.000004	10	20	105	90	110	107	70	130
Chromium (total)	EMS0061-SEP22	mg/L	0.00008	<0.00008	1	20	99	90	110	92	70	130
Copper (total)	EMS0061-SEP22	mg/L	0.0002	<0.0002	ND	20	103	90	110	119	70	130
Iron (total)	EMS0061-SEP22	mg/L	0.007	<0.007	ND	20	97	90	110	125	70	130
Potassium (total)	EMS0061-SEP22	mg/L	0.009	<0.009	1	20	96	90	110	114	70	130
Magnesium (total)	EMS0061-SEP22	mg/L	0.001	<0.001	0	20	95	90	110	109	70	130
Manganese (total)	EMS0061-SEP22	mg/L	0.00001	<0.00001	9	20	101	90	110	91	70	130
Molybdenum (total)	EMS0061-SEP22	mg/L	0.00004	<0.00004	3	20	102	90	110	108	70	130
Sodium (total)	EMS0061-SEP22	mg/L	0.01	<0.01	3	20	98	90	110	110	70	130
Nickel (total)	EMS0061-SEP22	mg/L	0.0001	<0.0001	4	20	99	90	110	104	70	130
Lead (total)	EMS0061-SEP22	mg/L	0.00009	<0.00001	0	20	106	90	110	111	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 I Internal ref.: ME-CA-[ENV]SPE-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)	EMS0061-SEP22	mg/L	0.003	<0.003	13	20	96	90	110	NV	70	130
Antimony (total)	EMS0061-SEP22	mg/L	0.0009	<0.0009	ND	20	98	90	110	128	70	130
Selenium (total)	EMS0061-SEP22	mg/L	0.00004	<0.00004	ND	20	102	90	110	89	70	130
Silicon (total)	EMS0061-SEP22	mg/L	0.02	<0.02	13	20	93	90	110	NV	70	130
Tin (total)	EMS0061-SEP22	mg/L	0.00006	<0.00006	ND	20	108	90	110	NV	70	130
Strontium (total)	EMS0061-SEP22	mg/L	0.00008	<0.00002	0	20	104	90	110	105	70	130
Titanium (total)	EMS0061-SEP22	mg/L	0.00005	<0.00005	6	20	101	90	110	NV	70	130
Thallium (total)	EMS0061-SEP22	mg/L	0.000005	<0.000005	ND	20	96	90	110	99	70	130
Uranium (total)	EMS0061-SEP22	mg/L	0.000002	<0.000002	1	20	108	90	110	118	70	130
Vanadium (total)	EMS0061-SEP22	mg/L	0.00001	<0.00001	3	20	99	90	110	102	70	130
Zinc (total)	EMS0061-SEP22	mg/L	0.002	<0.002	2	20	101	90	110	110	70	130

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-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	EWL0055-SEP22	No unit	0.05	NA	1		100			NA		

QC SUMMARY

Reactive Phosphorus by SFA

Method: SM 4500-P F | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-004

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Phosphorus (total reactive)	SKA0035-SEP22	mg/L	0.03	<0.03	ND	10	104	90	110	93	75	125

Suspended Solids

Method: SM 2540D | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-004

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Total Suspended Solids	EWL0066-SEP22	mg/L	2	< 2	1	10	99	90	110	NA		

Turbidity

Method: SM 2130 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-003

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Turbidity	EWL0064-SEP22	NTU	0.10	< 0.10	4	10	100	90	110	NA		

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 report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety

Request for Laboratory Services and CHAIN OF CUSTODY

No: 010116

- 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 1 of 1

Laboratory Information Section - Lab use only

Received By: [signature]
Received By (signature): [signature]
Received Date (mm/dd/yyyy): 09/01/2022 (mm\dd\yy)
Custody Seal Present: ☐
Custody Seal Intact: ☐
Received Time: 11 : 30
Cooling Agent Present: ☐ ice
Temperature Upon Receipt (°C): 9, 9, 3
LAB LIMS #: 40012-13

REPORT INFORMATION	INVOICE INFORMATION	PROJECT INFORMATION
Company: Thurber Engineering LTD	☑ (same as Report Information)	Quotation #: P.O. #:
Contact: Rachel Bourassa	Company:	Project #: 33309 Site Location/ID: Emo, ON
Address: 2010 Winston Park Dr #103 Oakville ON L6M 5R7	Contact:	**TURNAROUND TIME (TAT) REQUIRED**
	Address:	☑ Regular TAT (5-7days) — TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day
Phone: 416 523 1015		RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days
Email: rbourassa@thurber.ca	Phone:	PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION
Email:	Email:	Specify Due Date: Rush Confirmation ID:

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

REGULATIONS

Regulation 153/04: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ___ ☐ R/P/I ☐ I/C/C ☐ A/O; Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☑ PWQO ☐ MMER ☐ CCME ☐ Other: ☐ MISA

Sewer By-Law: ☐ Sanitary ☐ Storm; Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

#	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PAH☐ ABN☐ SVOC(all)☐	PCB Total☐ Aroclor☐	PHC F1-F4☐ VOC☐ BTEX☐ BTEX/F1☐ F2-F4☐	VOC☐ BTEX☐ THM☐	Pesticides OC☐ OP☐	TCLP M&I☐ VOC☐ PCB☐ B(a)P☐ ABN☐ Ignit.☐	Water Pkg Gen.☐ Ext.☐	Sewer Use:	TSS	Lab Filtered Metals	Water Characterization Package (general)	Corrosivity *	COMMENTS:
1	Lyon Creek SW	Aug 28/22		15	Water											✓	✓	✓	✓	
2	22-07	Aug 28/22		14	Water											✓	✓	✓		
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

Observations/Comments/Special Instructions: *Corrosivity includes pH, Soluble Sulphate, Chloride, Resistivity, Electrical Conductivity.

Sampled By (NAME): Greg Stanhope	Signature: GS	Date: Aug / 28 / 2022	(mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): Rachel Bourassa	Signature: Rachel Bourassa	Date: Aug / 31 / 2022	(mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.1
Date of Issue: 04 April, 2018

THURBER

Appendix C

Site Photographs

THURBER

Photo 1: Looking North at Lyon Creek Culvert, August 28, 2022

Photo 2: Looking West along HWY 602 at Lyon Creek Culvert, August 28, 2022

Photo 3: Looking south at Lyon Creek Culvert, August 22, 2022

Photo 4: Looking East along HWY 602 from Lyon Creek Culvert, August 28, 2022

THURBER

Photo 5: Looking North from Lyon Creek Culvert, August 22, 2022

THURBER

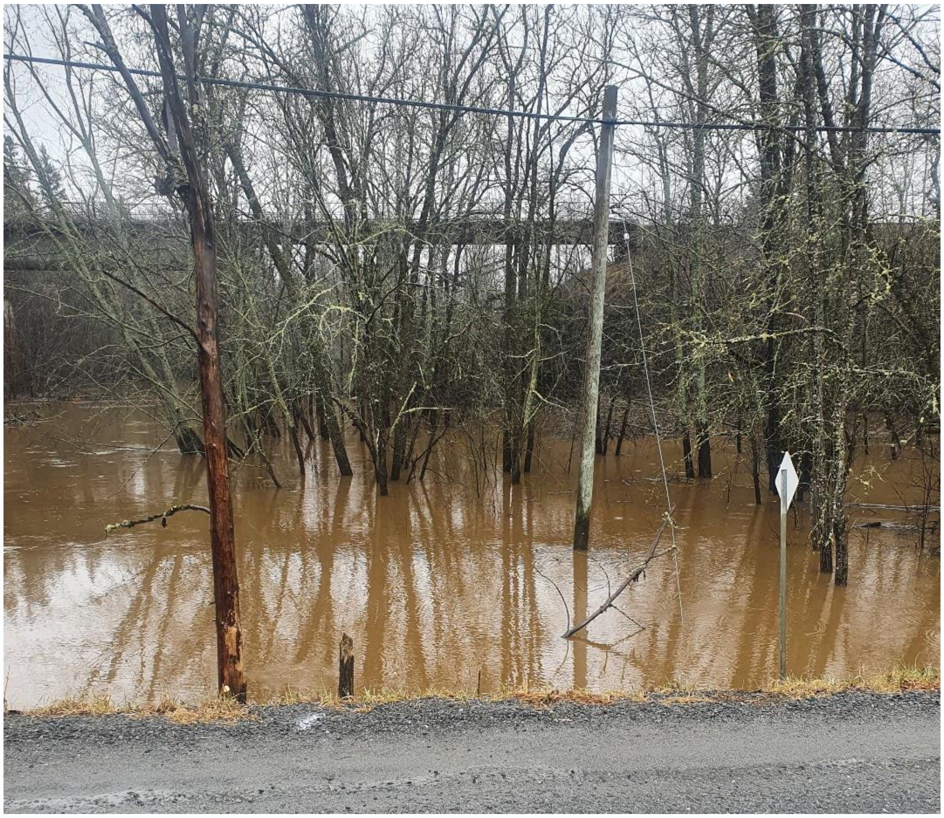


Photo 6: Looking South from HWY 602 at flooding of Lyon Creek, May 4, 2022

THURBER

Appendix D

Borehole Locations and Soil Strata Drawings

METRIC

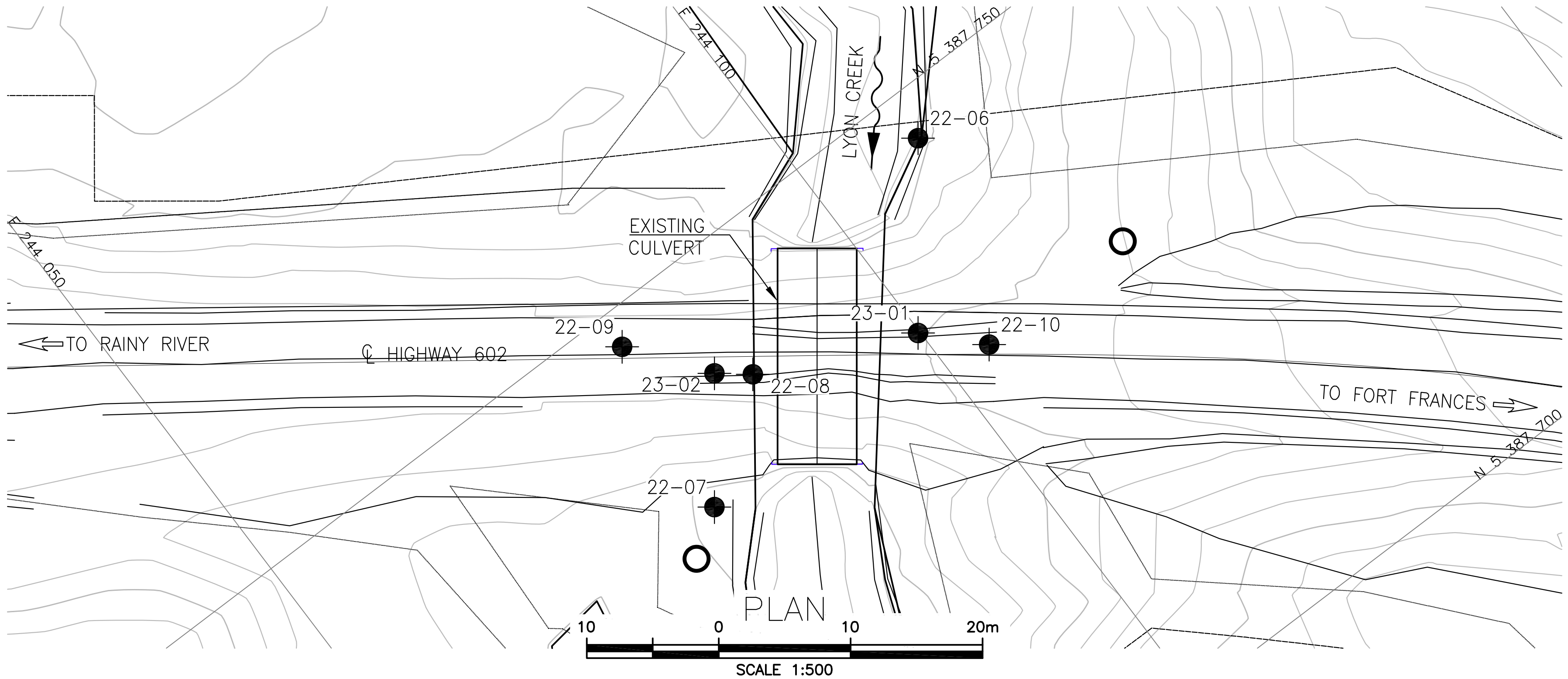
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

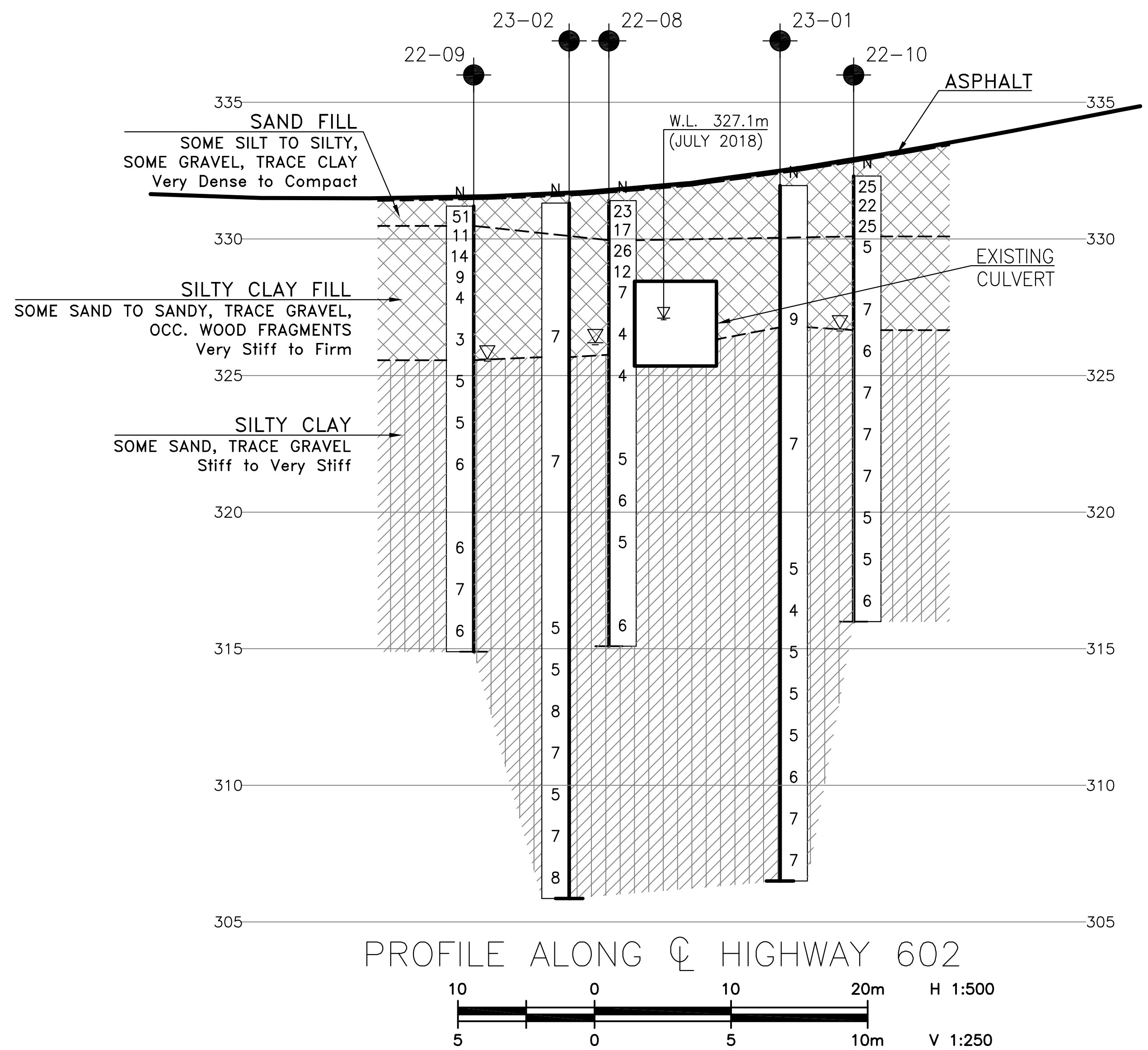
CONT No 2023-6036
GWP No 6030-22-00

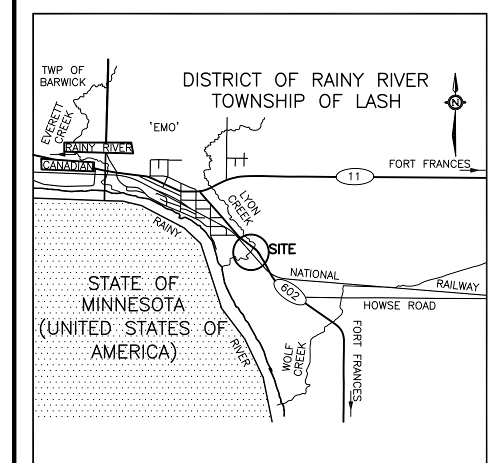
HIGHWAY 602
CULVERT CROSSING AT LYON CREEK
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 12

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
22-06	327.1	5 387 746.3	244 108.8
22-07	327.8	5 387 733.4	244 079.6
22-08	331.4	5 387 739.6	244 088.0
22-09	331.2	5 387 747.3	244 081.4
22-10	332.3	5 387 730.6	244 103.6
23-01	332.0	5 387 734.6	244 099.9
23-02	331.3	5 387 741.5	244 085.7

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 16.

GEOCRES No. 52C-65

REVISIONS	DATE	BY	DESCRIPTION

DESIGN RB	CHK MEF	CODE	LOAD	DATE OCT 2023	
DRAWN AN	CHK RB	SITE 45X-0151/C0	STRUCT	DWG 2	

FILENAME: H:\Drafting\33000\33309\TED-33309-PLPR-LC.dwg
PLOTDATE: 10/24/2023 4:07 PM

MINISTRY OF TRANSPORTATION, ONTARIO

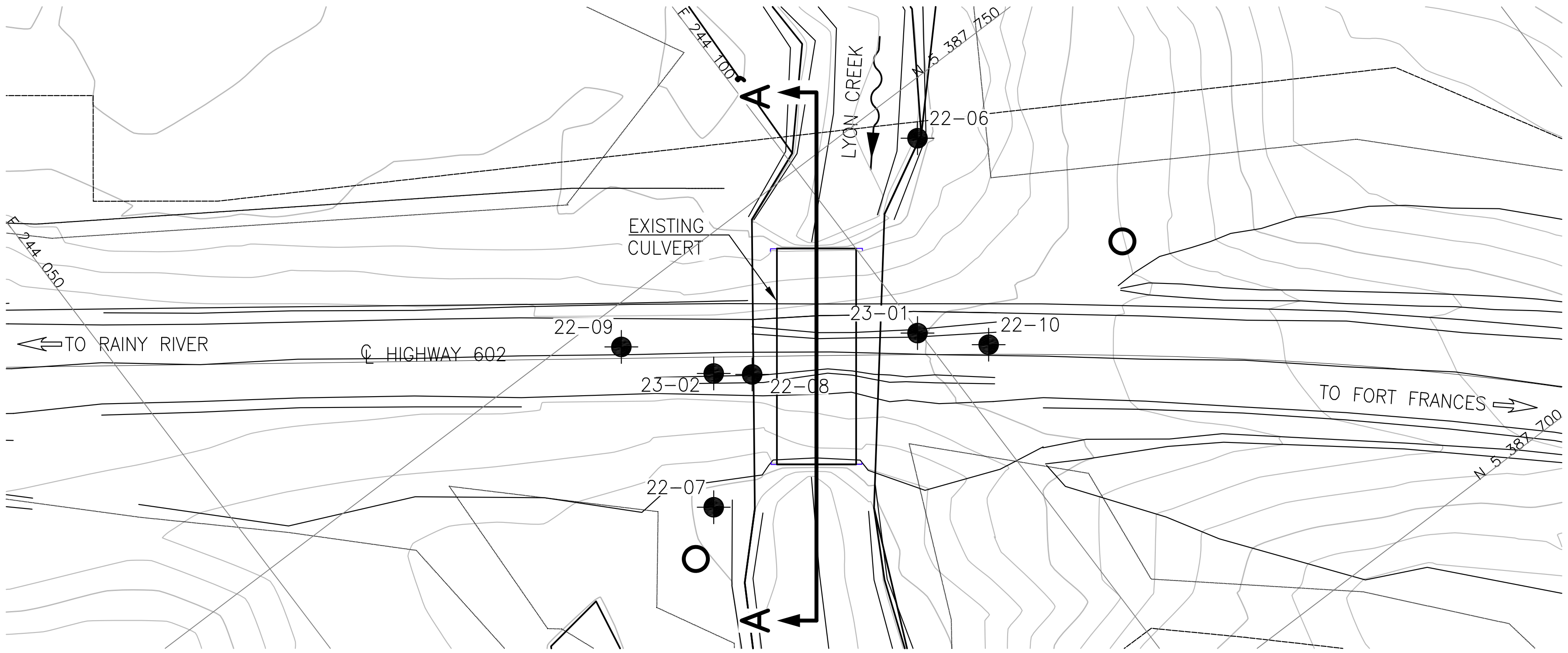
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No 2023-6036
GWP No 6030-22-00

HIGHWAY 602
CULVERT CROSSING AT LYON CREEK
BOREHOLE LOCATIONS AND SOIL STRATA

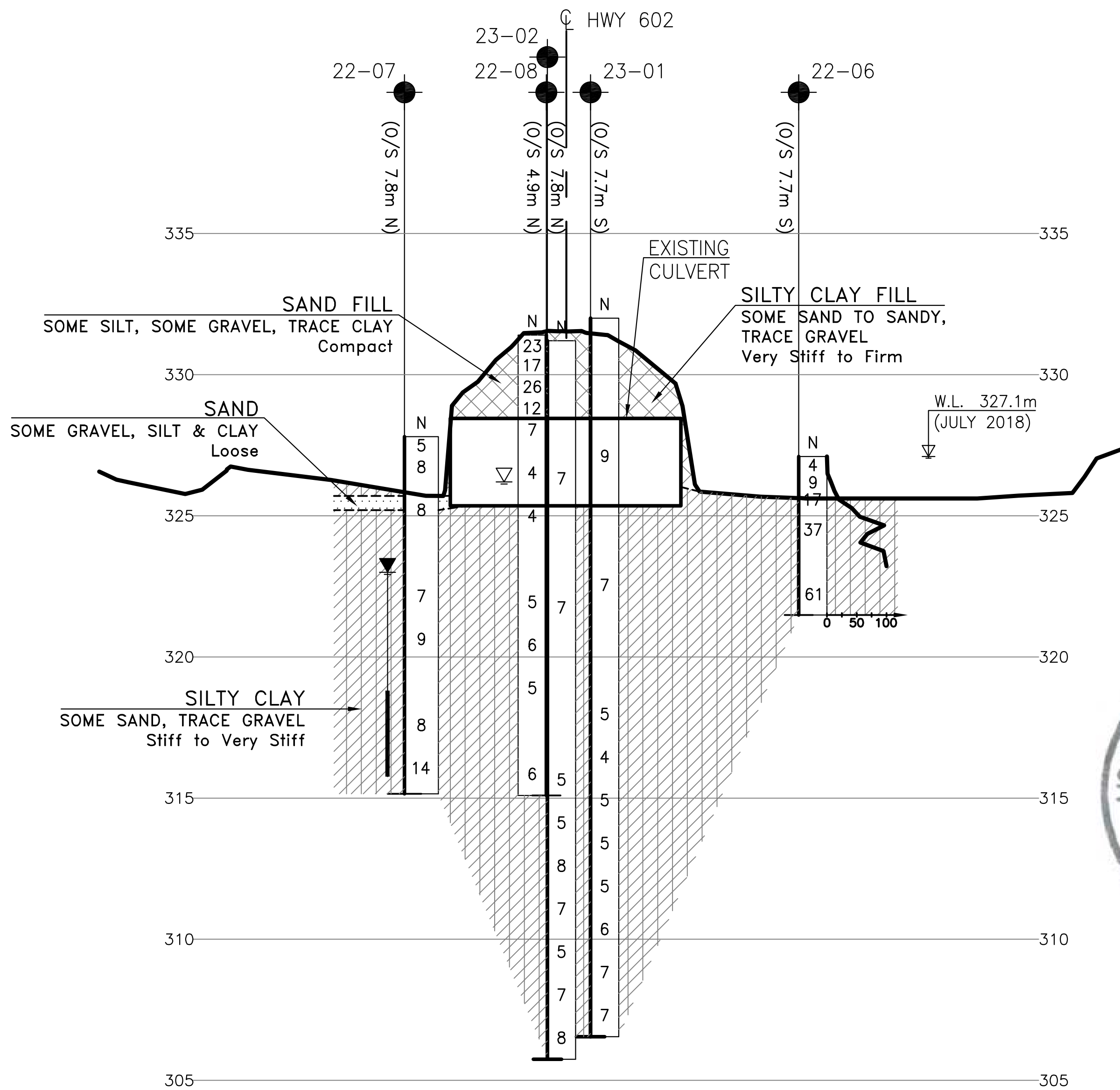
SHEET 13

THURBER ENGINEERING LTD.



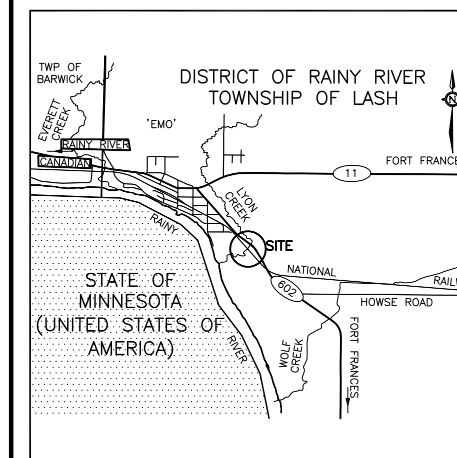
PLAN

10 0 10 20m
SCALE 1:500



PROFILE ALONG A-A'

10 0 10 20m H 1:500
5 0 5 10m V 1:250



KEYPLAN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct. 17, 2023
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
Oct. 17, 2023
PROVINCE OF ONTARIO

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
ǀ	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
22-06	327.1	5 387 746.3	244 108.8
22-07	327.8	5 387 733.4	244 079.6
22-08	331.4	5 387 739.6	244 088.0
22-09	331.2	5 387 747.3	244 081.4
22-10	332.3	5 387 730.6	244 103.6
23-01	332.0	5 387 734.6	244 099.9
23-02	331.3	5 387 741.5	244 085.7

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 16.

GEOCRES No. 52C-65

REVISIONS	DATE	BY	DESCRIPTION

DESIGN RB	CHK MEF	CODE	LOAD	DATE OCT 2023
DRAWN AN	CHK RB	SITE 45X-0151/C0	STRUCT	DWG 3

FILENAME: H:\Drafting\33000\33309\TED-33309-PLPR-LC.dwg
PLOTDATE: 10/24/2023 4:09 PM

Appendix E

Foundation Comparison

THURBER

GEOTECHNICAL COMPARISON OF ALTERNATIVE FOUNDATION TYPES

Corrugated Steel Pipe (CSP), Structural Steel CSP (SPCSP), or Twin SPCSPs	Concrete Box Culvert	Sheet Pile Wall or Sheet Pile Combination Wall Culvert with Pre-Cast Concrete Panel Cap
Advantages: i. Conventional construction. ii. Segmented pipes can accommodate some potential differential settlement along culvert axis iii. Less expensive than concrete box culvert option.	Advantages: i. Relatively rapid installation and less disturbance to subgrade soils if pre-cast segments are used. ii. Segmental option can accommodate some potential differential settlement along culvert axis.	Advantages: i. Minimizes potential for disturbance of creek bed. ii. Less temporary excavation required than pipe or box culvert options. iii. Provides shoring and foundation elements in one operation. iv. Less extent of differential settlement associated with the embankment grade raise and widening.
Disadvantages: i. Requires deep and large temporary excavation for installation ii. Steel pipes may have shorter design life than concrete culverts. iii. Multiple pipes needed to meet hydraulic requirements. iv. Large potential for differential settlement associated with embankment grade raise and widening.	Disadvantages: i. Requires deep and large temporary excavation for installation ii. More expensive than a CSP culvert or box culvert extension option. iii. Large potential for differential settlement associated with embankment grade raise and widening.	Disadvantages: i. Embankment grade raise will cause settlement of the sheet piles, which requires mitigation.
FEASIBLE	**FEASIBLE**	**RECOMMENDED**

THURBER

Appendix F

List of Referenced OPSS and OPSD Documents and Suggested Wording for NSSPs

THURBER

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

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS.PROV 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
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
OPSS.PROV 903	Construction Specification for Deep Foundations
SP FOUN0003	Dewatering Structure Excavations
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS 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 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
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

THURBER

2. Suggested Wording for NSSPs

- **Suggested Text for Operational Constraint on Subgrade Preparation**

The Contractor is advised that the soil that will be exposed at the culvert subgrade level is moisture sensitive and may become disturbed or otherwise negatively impacted when subjected to construction or personnel traffic, freeze-thaw actions, ingress or ponding water. The Contractor shall be responsible for protecting the subgrade by implementing adequate groundwater control measures and minimizing construction and personnel traffic on the founding subgrade.

The subgrade preparation and placement and compaction of the bedding material must be carried out in the dry.

Any buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition.

Immediately following excavation, the base should be inspected by the foundation engineering specialist to confirm that the exposed subgrade surface conforms to the design requirements.

- **Suggested Text for NSSP on Installation of Steel Sheet Piles**

Obstructions such as wood, boulders or rock fill may be present within the existing embankment fill. These obstructions may impede the driving of sheet piles and at some locations the sheet piles may not be able to penetrate these materials to reach the design depth of installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the piles to the design depth.

- **Suggested Text for NSSP on Temporary Excavation Slopes**

The Contractor is notified that unsupported temporary slopes at this site, for excavations or otherwise, are not stable if inclined 1H:1V or steeper above the groundwater level. Temporary unsupported slopes at this site are restricted to inclinations of no steeper than 3H:1V below the groundwater level and 2.5H:1V above the groundwater level. Temporary excavation slopes that are supported such as through the use of sheet piles that are designed and installed to be deep enough to retain the existing soil behind the piles may be inclined at 2H:1V above the groundwater level.

THURBER

Appendix G

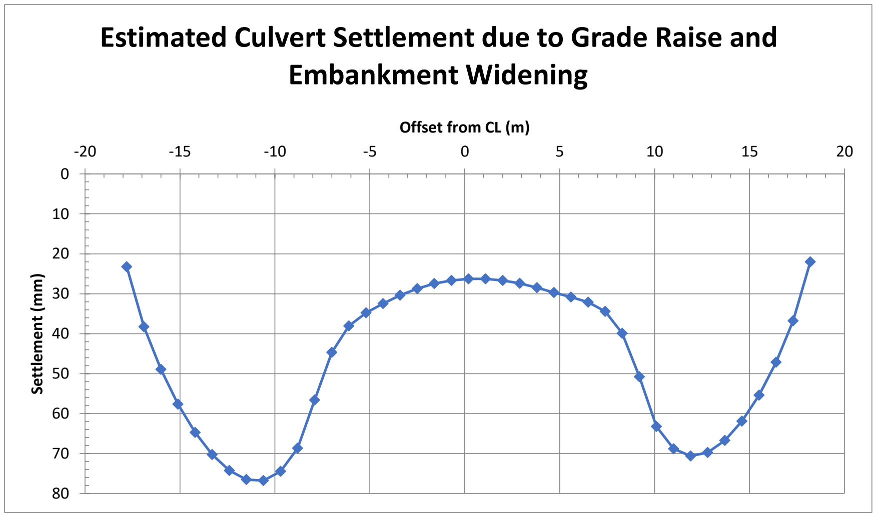
Settlement Profile and Slope Stability Analysis Figures

Figure SP1: Lyon Creek Culvert Replacement - Settlement Profile

Distance vs. Total Settlement

Project Title Lyon Creek
Filename: 11+080

Distance (n	Total Settlement (mm)	
0	23.24134018	-17.8
0.9	38.25533315	-16.9
1.8	48.96121649	-16
2.7	57.64181965	-15.1
3.6	64.7049577	-14.2
4.5	70.2578895	-13.3
5.4	74.25742005	-12.4
6.3	76.53675436	-11.5
7.2	76.78645918	-10.6
8.1	74.48667078	-9.7
9	68.69910726	-8.8
9.9	56.60406739	-7.9
10.8	44.70634728	-7
11.7	38.04987481	-6.1
12.6	34.79083864	-5.2
13.5	32.48500658	-4.3
14.4	30.39473047	-3.4
15.3	28.71380758	-2.5
16.2	27.47537969	-1.6
17.1	26.67347943	-0.7
18	26.28737834	0.2
18.9	26.29701961	1.1
19.8	26.68588942	2
20.7	27.43018727	2.9
21.6	28.47919993	3.8
22.5	29.72401782	4.7
23.4	30.82742481	5.6
24.3	32.10269094	6.5
25.2	34.42260922	7.4
26.1	39.90462237	8.3
27	50.80128508	9.2
27.9	63.23062459	10.1
28.8	68.82671635	11
29.7	70.62875195	11.9
30.6	69.74617657	12.8
31.5	66.74383444	13.7
32.4	61.92601023	14.6
33.3	55.417545	15.5
34.2	47.16305684	16.4
35.1	36.78926198	17.3
36	22.03699135	18.2



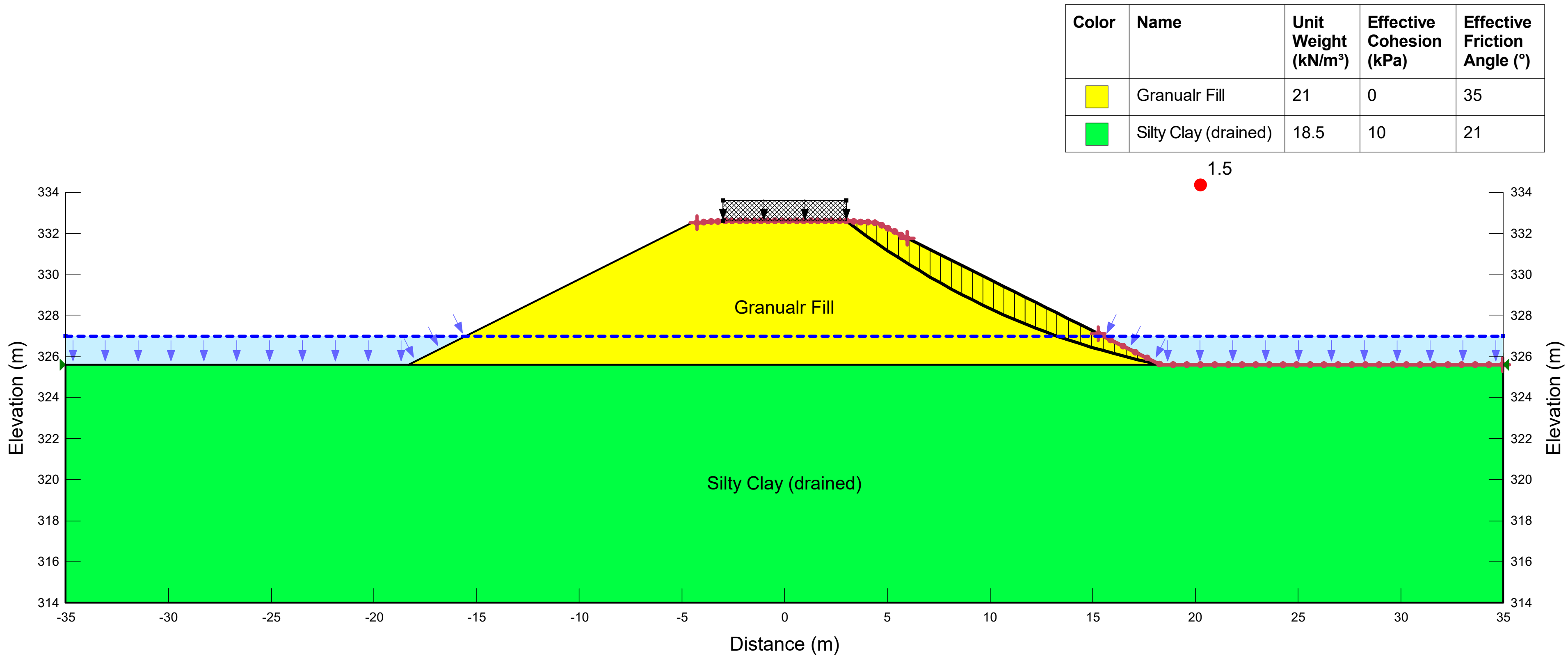


Figure G1. Lyon Creek Culvert Replacement - Granular Fill with Slope 2:1 [Drained Analysis]

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Yellow	Granualr Fill	21	0	35
Green	Silty Clay (Undrained)	18.5	65	0

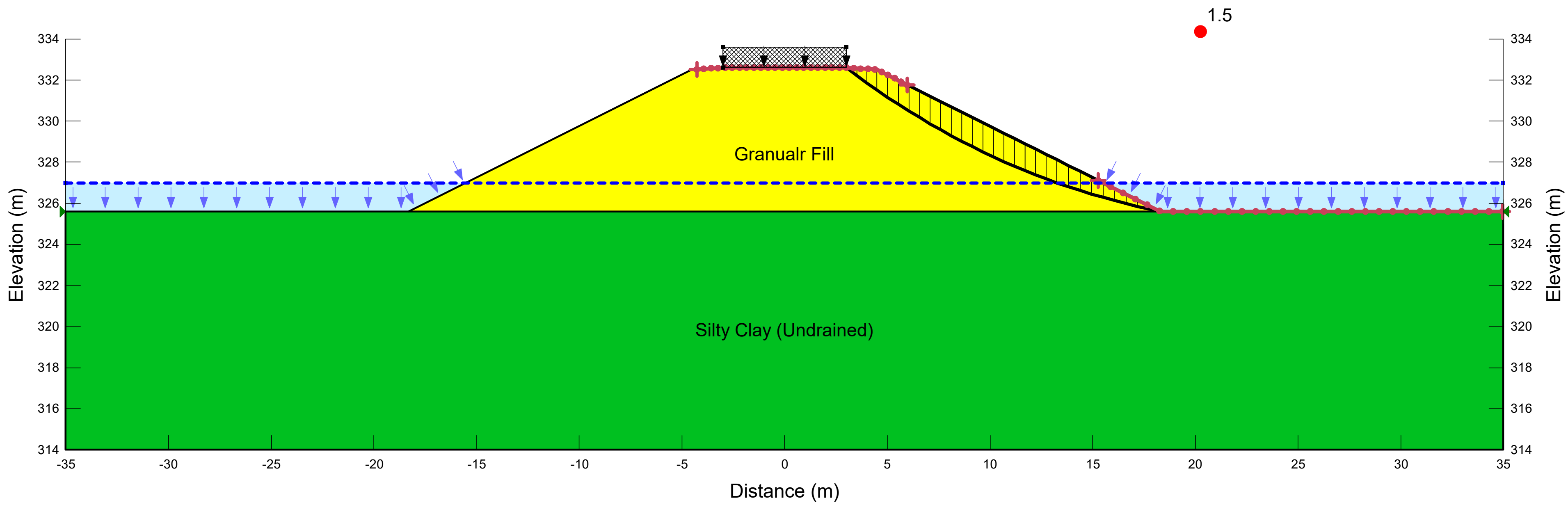


Figure G2. Lyon Creek Culvert Replacement - Granular Fill with Slope 2:1 [Undrained Analysis]

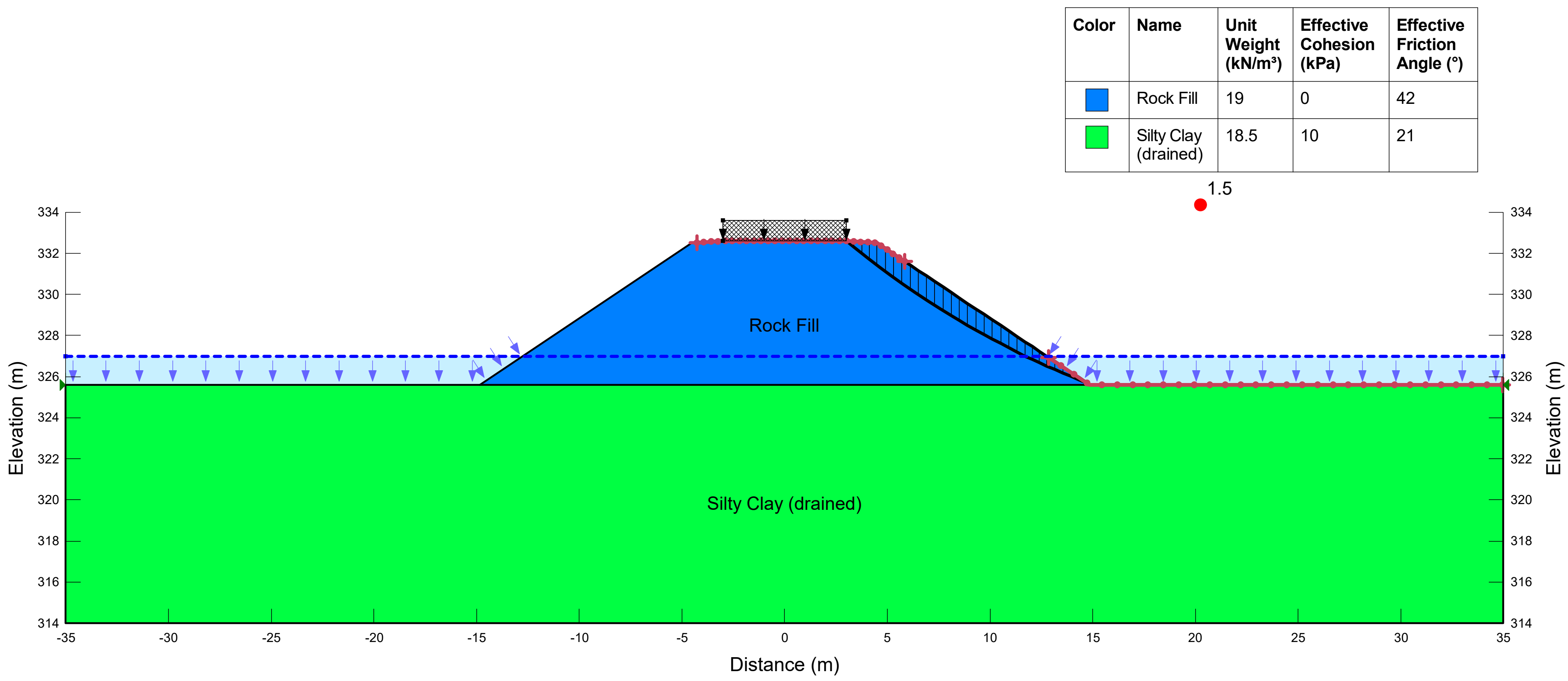


Figure G3. Lyon Creek Culvert Replacement - Rock Fill with Slope 1.5:1 [Drained Analysis]

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Rock Fill	19	0	42
	Silty Clay (Undrained)	18.5	65	0

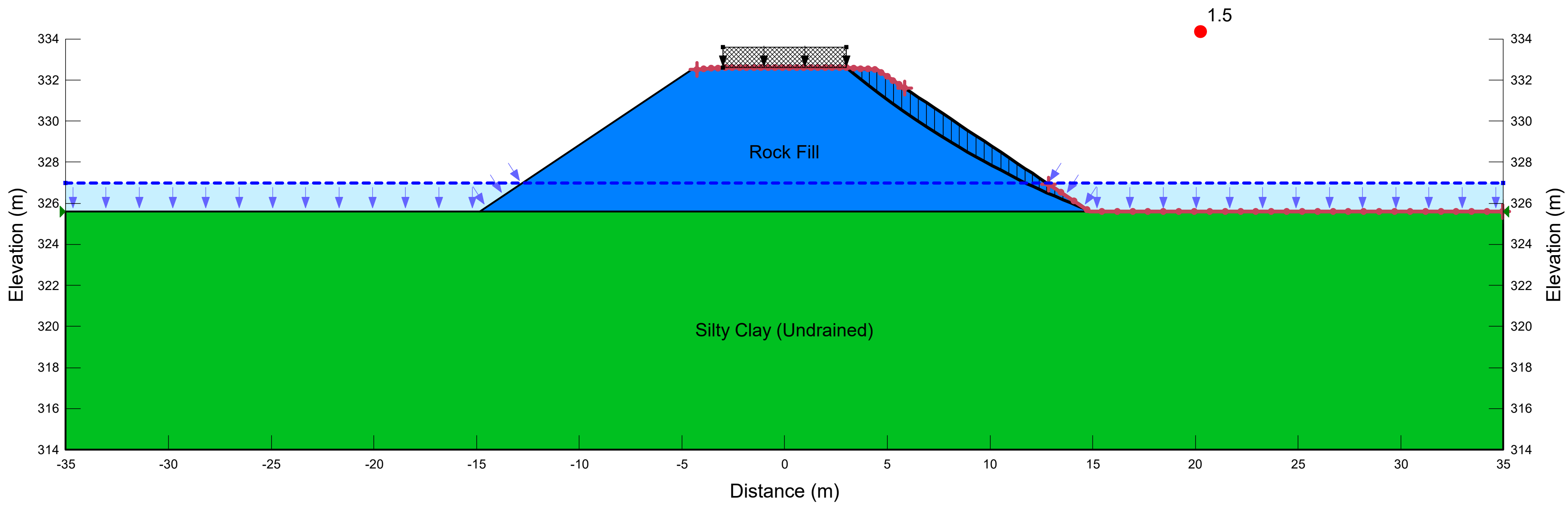


Figure G4. Lyon Creek Culvert Replacement - Rock Fill with Slope 1.5:1 [Undrained Analysis]

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Existing Sand Fill	20	0	32
	Exsting Silty Clay Fill	20	0	27
	Silty Clay (drained)	18.5	10	21

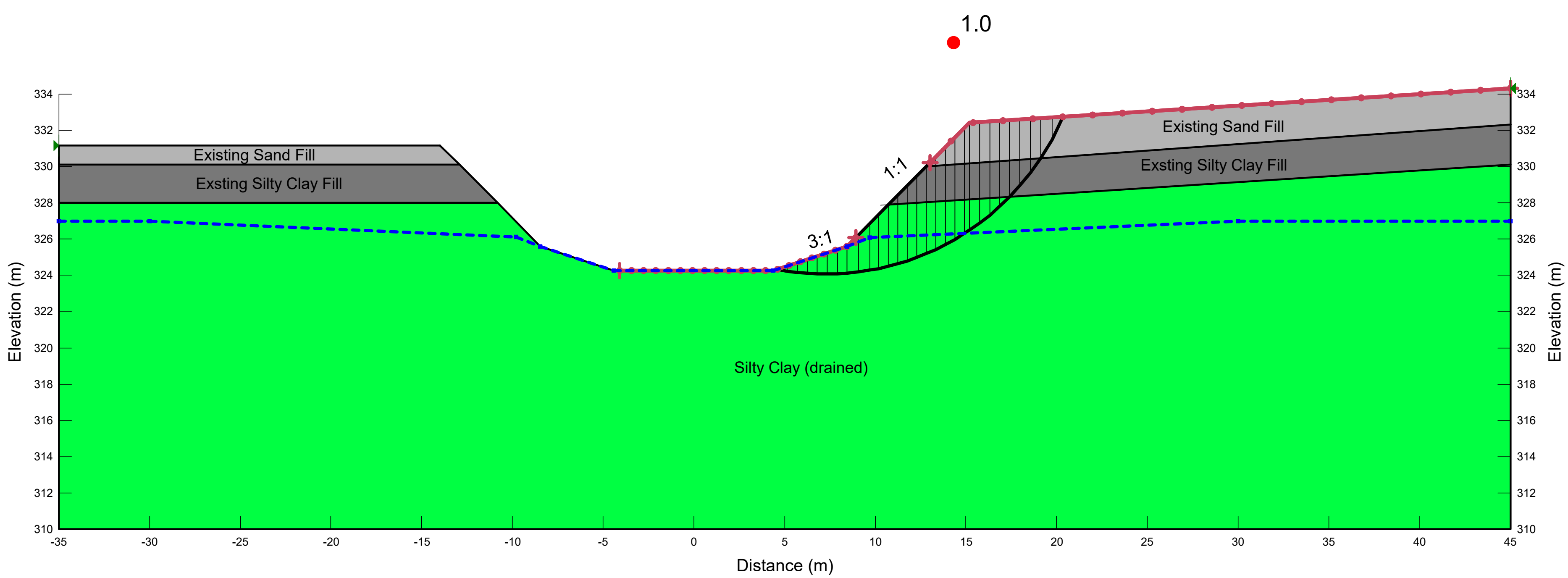


Figure G5. Lyon Creek Culvert Replacement - Temporary Excavation - Side Slopes 1:1 [Drained Analysis]

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Existing Sand Fill	20	0	32
	Exsting Silty Clay Fill	20	0	27
	Silty Clay (drained)	18.5	10	21

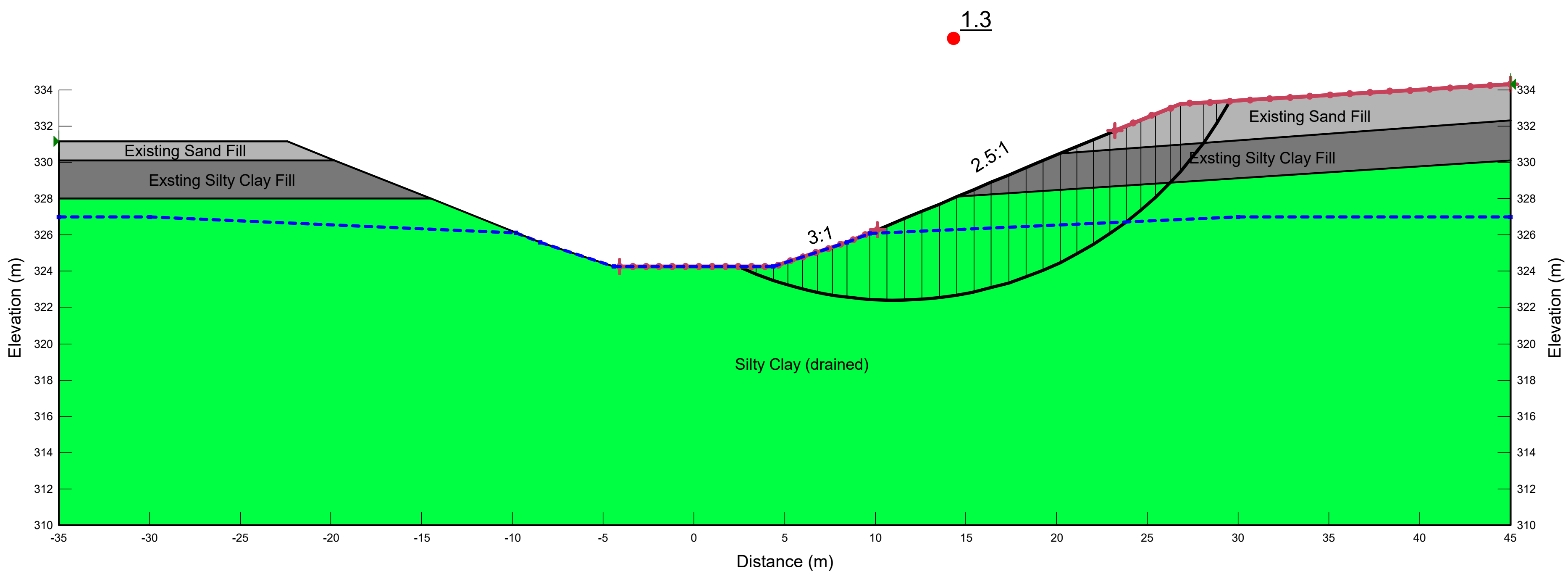


Figure G6. Lyon Creek Culvert Replacement - Temporary Excavation - Side Slopes 2.5:1 [Drained Analysis]

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Existing Sand Fill	20	0	32
	Exsting Silty Clay Fill	20	0	27
	Silty Clay (drained)	18.5	10	21

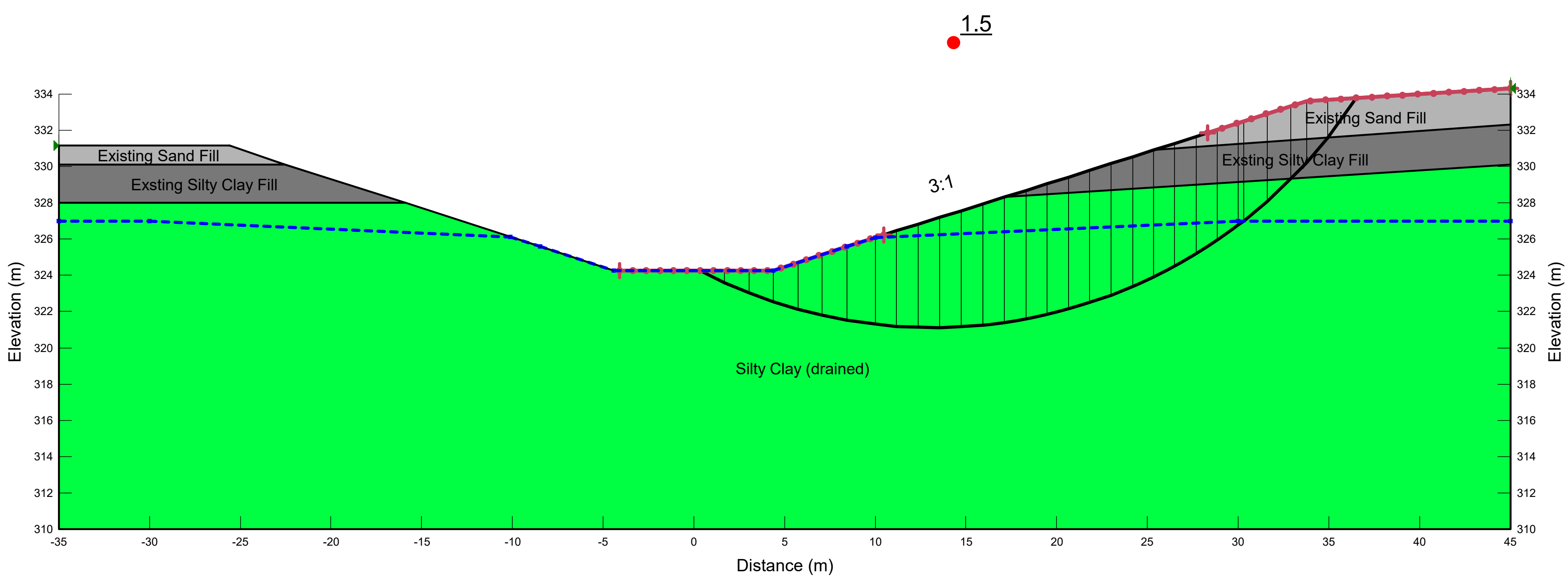


Figure G7. Lyon Creek Culvert Replacement - Temporary Excavation - Side Slopes 3:1 [Drained Analysis]

THURBER

Appendix H

Draft General Arrangement Drawings

CONT No. 2022-XXXX
WP No. 6123-17-01

LYON CREEK CULVERT

OPTION 1 – TWIN SPCSP CULVERT REPLACEMENT – GENERAL ARRANGEMENT

SHEET

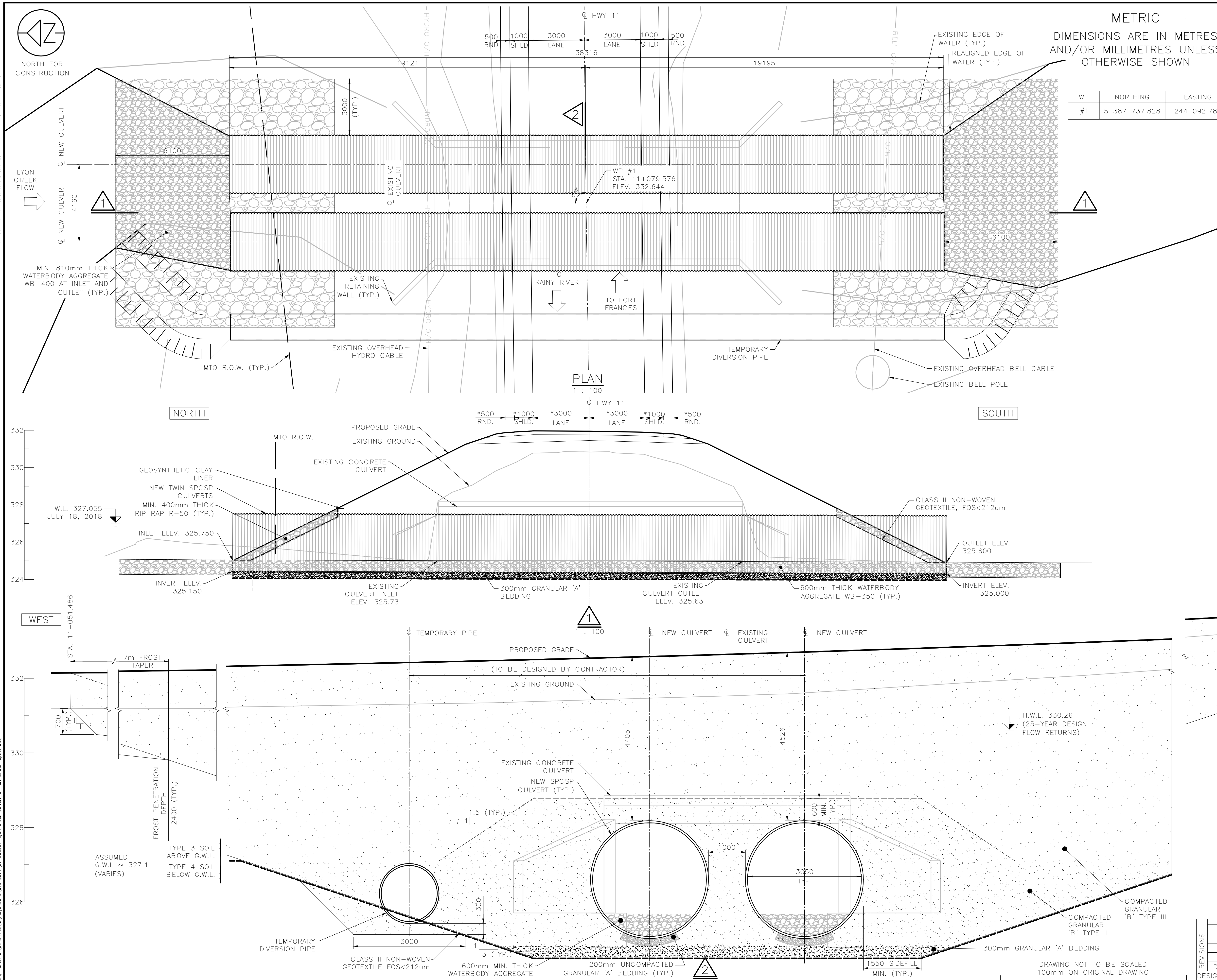
HATCH

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

WP	NORTHING	EASTING
#1	5 387 737.828	244 092.780

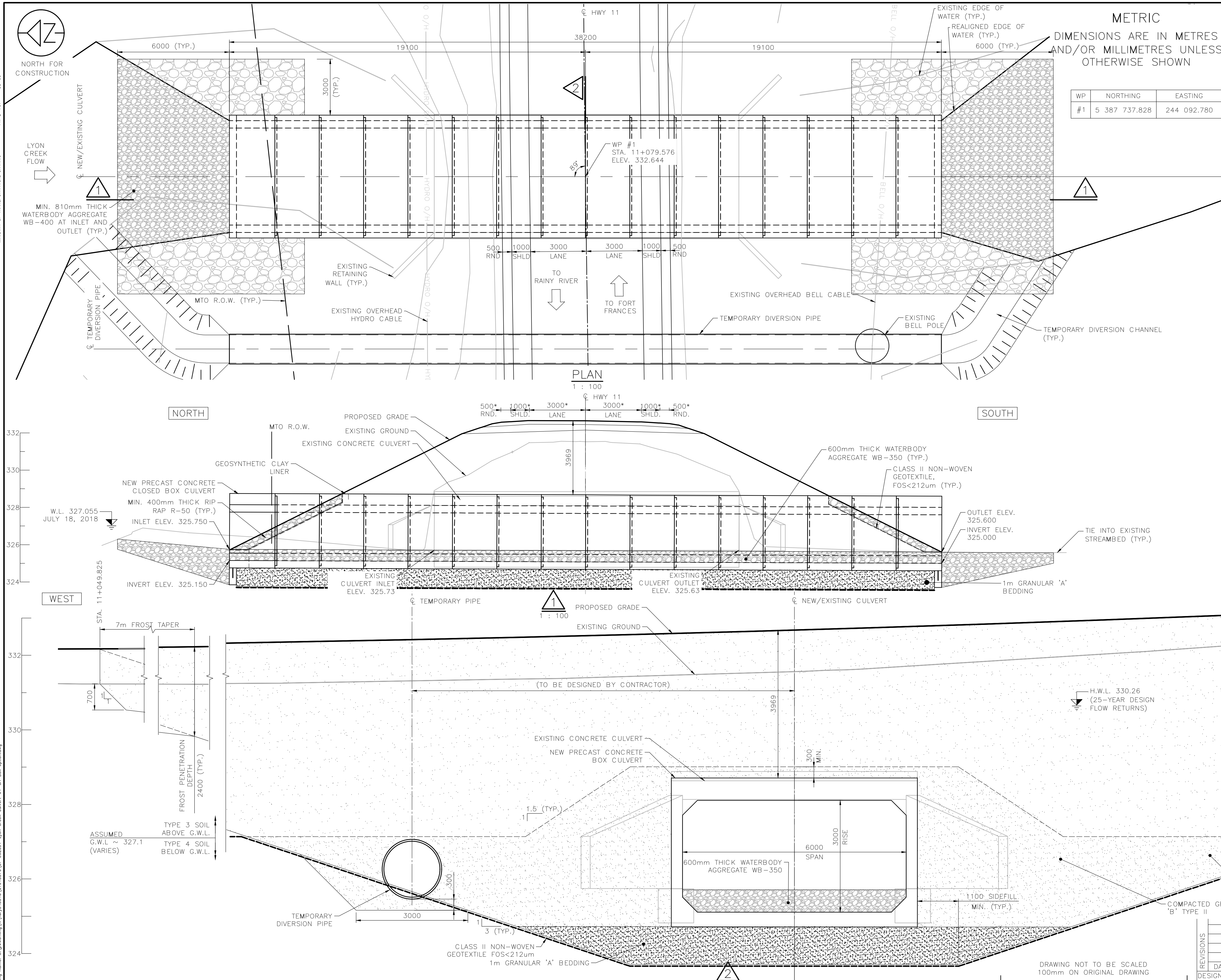
GENERAL NOTES

1. CULVERT SHALL BE TWIN STRUCTURAL PLATE CORRUGARED STEEL CULVERT WITH 3050mm DIAMETER (MIN. WALL THICKNESS =6mm, CORRUGATION PROFILE IS 152mm x 51mm). CONTRACTOR IS RESPONSIBLE TO DESIGN, SUPPLY, ASSEMBLE AND ERECT THE NEW CULVERT. CULVERT DESIGN SHALL BE IN ACCORDANCE WITH CHBDC S6-19, LIVE LOAD SHALL BE CL-625-ONT.



REVISIONS	DATE	REV.	DESCRIPTION

DESIGN	PC	CHK CP	CODE CAN/CSA S6-19	LOAD CL-625-ONT	DATE JAN. 2023
DRAWN	RN	CHK PT	SITE 45X-0151/C0		DWG 2



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

WP	NORTHING	EASTING
#1	5 387 737.828	244 092.780

CONT No. 2022-XXXX
WP No. 6123-17-01

LYON CREEK CULVERT

OPTION 2 - PRECAST CONCRETE CLOSED BOX CULVERT REPLACEMENT - GENERAL ARRANGEMENT

SHEET

HATCH

GENERAL NOTES

1. FACTORED GEOTECHNICAL AXIAL RESISTANCE AT ULS: 230kPa, GEOTECHNICAL RESISTANCE AT SLS FOR 25mm OF SETTLEMENT: 180kPa, ASSUMING CULVERT IS CONSTRUCTED ON AT LEAST 1m OF GRANULAR BEDDING.

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS		
DATE	REV.	DESCRIPTION

DESIGN PC	CHK CP	CODE CAN/CSA S6-19	LOAD CL-625-ONT	DATE JAN. 2023	
DRAWN RN	CHK PT	SITE 45X-0151/C0		DWG	1

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No. 2022-XXXX
WP No. 6123-17-01

LYON CREEK CULVERT

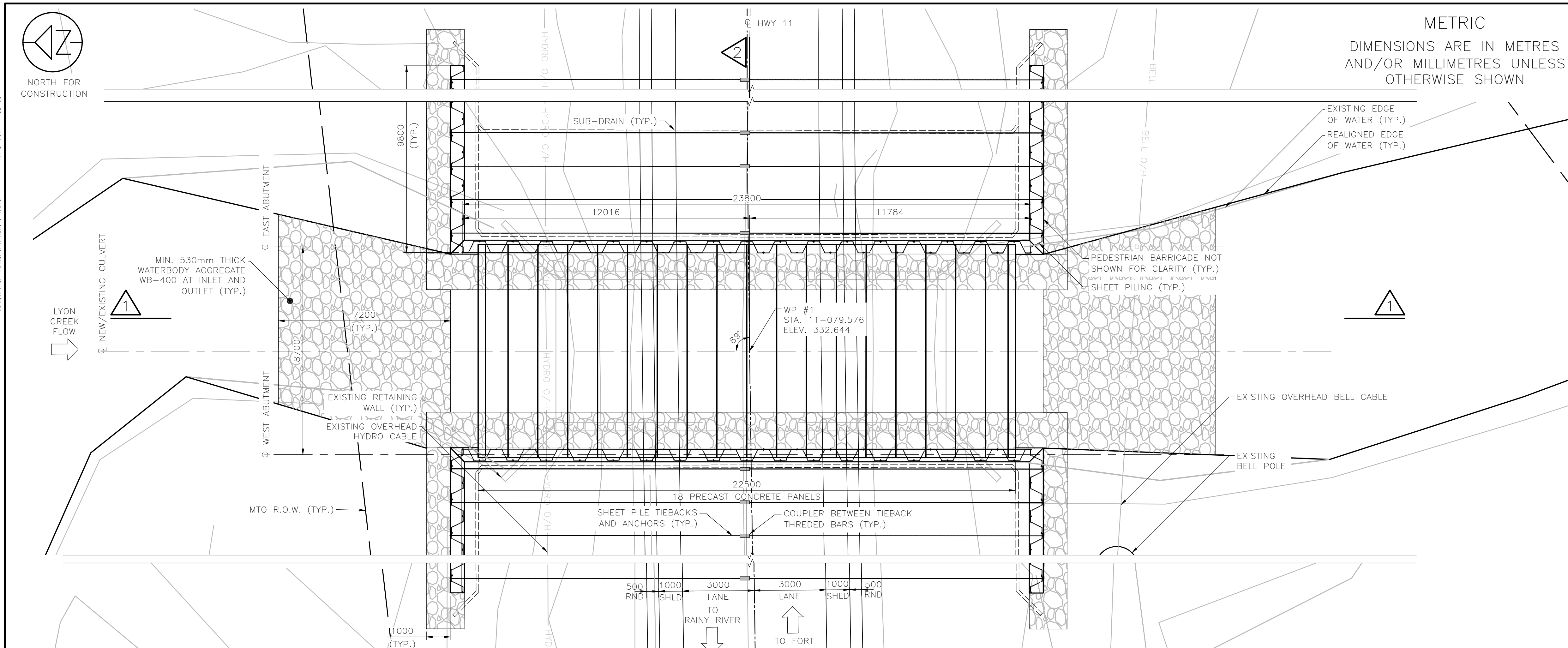
OPTION 3 - SHEET PILE CULVERT REPLACEMENT
GENERAL ARRANGEMENT

SHEET

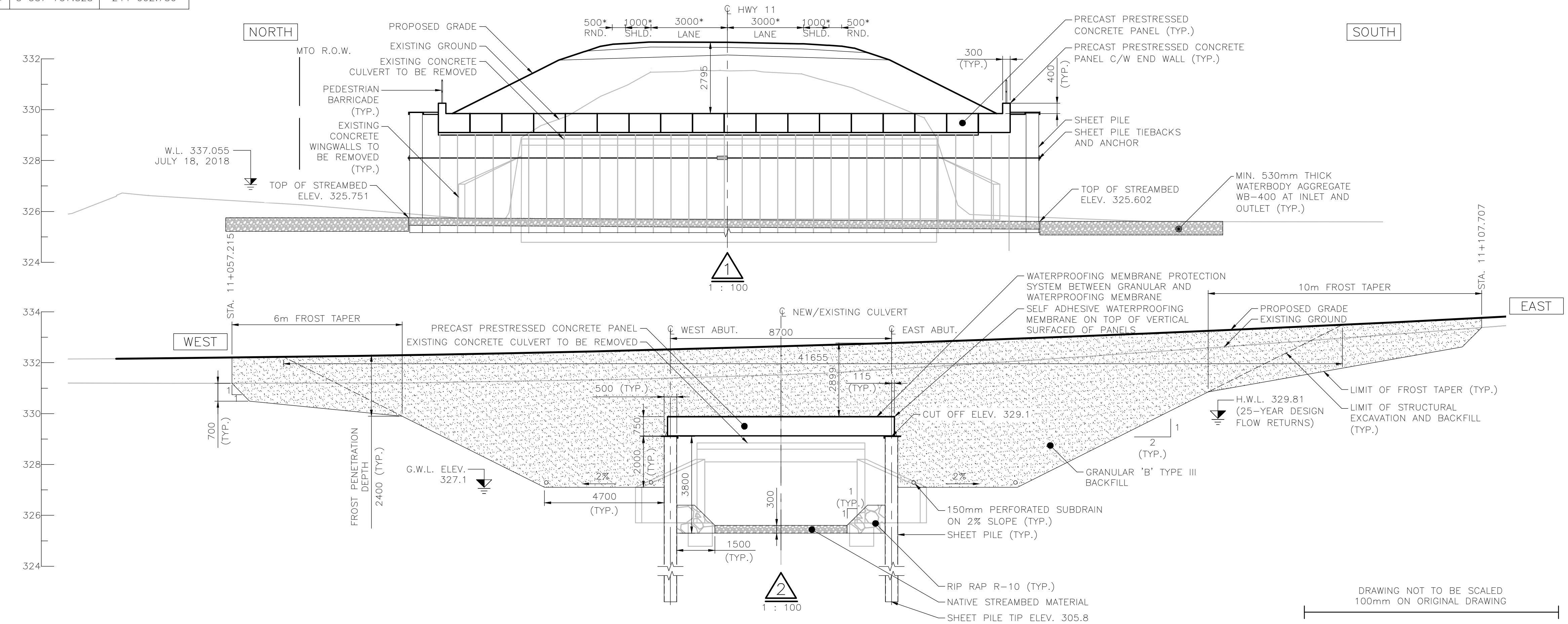
HATCH

GENERAL NOTES

1. SHEET PILES SHALL BE AZ 50-700N OR APPROVED EQUIVALENT. MINIMUM ELASTIC SECTION MODULUS = 4955cm³/m, MINIMUM MOMENT OF INERTIA = 124890cm⁴/m. MINIMUM FLANGE THICKNESS = 23mm. MINIMUM WEB THICKNESS = 16mm.

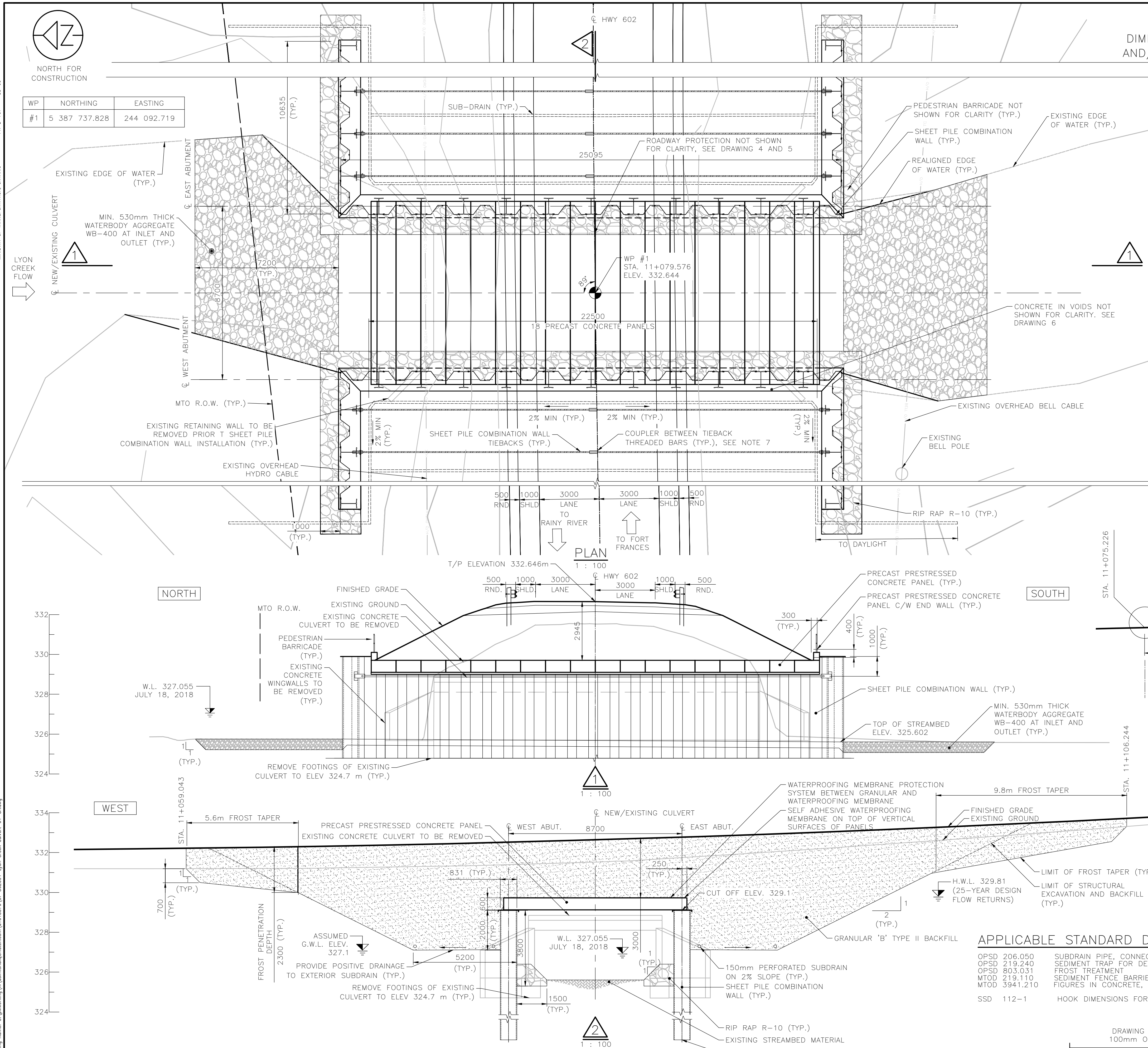


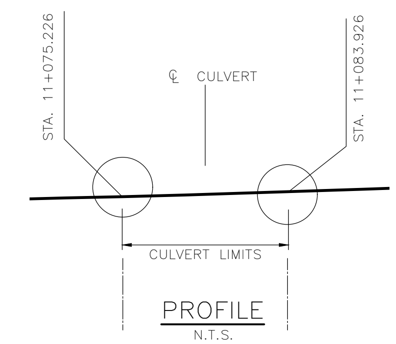
WP	NORTHING	EASTING
#1	5 387 737.828	244 092.780



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	REV.	DESCRIPTION		
DESIGN PC	CHK CP	CODE CAN/CSA S6-19	LOAD CL-625-ONT	DATE JAN. 2023	
DRAWN RN	CHK PT	SITE 45X-0151/C0		DWG	1





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

CONT No. 2023-6036
WP No. 6123-17-01

LYON CREEK CULVERT STRUCTURAL REPLACEMENT
GENERAL ARRANGEMENT

SHEET 11

HATCH

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA I
3. BOREHOLE LOCATIONS AND SOIL STRATA II
4. REMOVALS
5. CONSTRUCTION STAGING I
6. CONSTRUCTION STAGING II
7. PANEL AND SHEET PILE COMBINATION WALL LAYOUT
8. PRESTRESSED CONCRETE PANEL TYPE P1
9. PRESTRESSED CONCRETE PANEL TYPE P2
10. PEDESTRIAN BARRICADE

ABBREVIATIONS

ABUT.	ABUTMENT
BH	BOREHOLE
℄	CENTRELINE
ELEV.	ELEVATION
G.W.L.	GROUND WATER LEVEL
H.W.L.	HIGH WATER LEVEL
HWY.	HIGHWAY
INV.	INVERT
MAX	MAXIMUM
MIN	MINIMUM
MTO	MINISTRY OF TRANSPORTATION OF ONTARIO
R.O.W.	RIGHT OF WAY
RND.	ROUNDING
SHLD.	SHOULDER
STA.	STATION
SPMDD	STANDARD PROTOR MAXIMUM DRY DENSITY
T/P	TOP OF PAVEMENT
TYP.	TYPICAL
W.L.	WATER LEVEL
WP	WORKING POINT (TOP OF PAVEMENT)

GENERAL NOTES

CLASS OF CONCRETE

ALL PRECAST CONCRETE 60MPa
ALL CAST-IN-PLACE CONCRETE 35MPa

CLEAR COVER TO REINFORCEMENT

STEEL REINFORCING .... 40mm±10
STEEL PRESTRESSING STRAND .... 45mm±5

REINFORCEMENT

1. REINFORCING STEEL SHALL BE GRADE 400W. STAINLESS STEEL REINFORCEMENT SHALL BE TYPE 316LN OR DUPLEX 2205, WITH A MINIMUM YIELD STRENGTH OF 500MPa
2. UNLESS SHOWN OTHERWISE, LAP LENGTHS NOT INDICATED ON THE CONTRACT DRAWINGS SHALL BE CLASS 'B'. LAPS PER CAN/CSA-S6-19.
3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SSD 112-1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES

1. THE CONTRACTOR IS ADVISED NOT TO RELY ON THE WATER LEVEL SHOWN ON DRAWINGS. THE WATER LEVEL IS SUBJECT TO VARIATIONS.
2. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS OF THE PROPOSED WORK AND ALL DETAILS ON SITE AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE PROCEEDING WITH THE WORK.
3. THE CONTRACTOR IS RESPONSIBLE FOR STABILITY OF BOTH EXISTING AND NEW STRUCTURES THROUGHOUT REMOVALS AND CONSTRUCTION.
4. THE CONTRACTOR IS RESPONSIBLE FOR TEMPORARY FLOW CONTROL DURING CONSTRUCTION AS PER THE CONTRACT DOCUMENTS. THE CONTRACTOR IS TO DETERMINE THE SIZE OF TEMPORARY PIPES BASED ON MINIMUM 2-YEAR STORM EVENT OF 3.38 m^3/s.
5. ALL DISTURBED EARTH SLOPES SHALL BE REINSTATED TO THEIR ORIGINAL GROUND CONTOUR UPON COMPLETION OF THE WORK (EXCEPT WHERE OTHERWISE NOTED) AND BE TREATED WITH TOPSOIL IN ACCORDANCE WITH OPSS 802. EROSION CONTROL BLANKET AND SEED IN ACCORDANCE WITH OPSS 804.
6. ALL DISTURBED CREEK BANKS TO BE REINSTATED WITH MINIMUM 300mm THICK RIP RAP.
7. COUPLER POSITION MAY BE ADJUSTED TO SUIT CONTRACTOR'S STAGING LIMITS.
8. CONTRACTOR TO ADHERE TO IN-WATER TIMING DATES SPECIFIED ELSEWHERE IN THE CONTRACT DOCUMENTS.
9. THE CONTRACTOR SHALL DESIGN ADEQUATE ROADWAY PROTECTION SYSTEMS TO MEET THEIR METHOD OF OPERATION. ROADWAY PROTECTION SYSTEMS TO BE PERFORMANCE LEVEL 2 AS PER OPSS.PROV 539.

* DIMENSIONS SHOWN ARE IN ACCORDANCE WITH SHEET PILE COMBINATION WALL SECTION HZ 880M C - 12 / AZ 25-800. CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND REPORT ALL DEVIATIONS TO CONTRACT ADMINISTRATOR FOR REVIEW PRIOR TO ANY RELATED WORK COMMENCING. ANY DEVIATIONS FROM THE CONTRACT DRAWINGS, INCLUDING GEOMETRY, STRUCTURE LAYOUT OR DIMENSIONS OF COMPONENTS, ETC., THAT ARE THE RESULT OF AN APPROVED SUBSTITUTION OF THE SPECIFIED COMBINATION WALL SECTION ARE THE RESPONSIBILITY OF THE CONTRACTOR. THE CONTRACTOR SHALL PROVIDE REVISED LAYOUT DRAWINGS TO THE CONTRACT ADMINISTRATOR FOR REVIEW A MINIMUM OF 7 DAYS PRIOR TO COMMENCING ANY RELATED WORK.

LICENSED PROFESSIONAL ENGINEER R.D.SHORT 100084181 OCT. 19, 2023 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER L.K.BALLIOS 100189672 OCT. 19, 2023 PROVINCE OF ONTARIO

APPLICABLE STANDARD DRAWINGS

OPSD 206.050	SUBDRAIN PIPE, CONNECTION AND OUTLET
OPSD 219.240	SEDIMENT TRAP FOR DEWATERING
OPSD 803.031	FROST TREATMENT
MTOD 219.110	SEDIMENT FENCE BARRIER
MTOD 3941.210	FIGURES IN CONCRETE, SITE NUMBER AND DATE, LAYOUT
SSD 112-1	HOOK DIMENSIONS FOR REINFORCING STEEL BARS

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS		
2023/10/19	A1	DESIGN COMPLETE SUBMISSION
DATE	REV.	DESCRIPTION

DESIGN	JG	CHK	LB	CODE CAN/CSA S6-19	LOAD CL-625-ONT	DATE	OCT. 2023	
DRAWN	AS	CHK	JG	SITE 45X-0151/C0		DWG		1

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

Oct 20, 2023, 1:23pm Login name: SHAL20520