



# GEMTEC

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Submitted to:

McIntosh Perry  
1-1329 Garders Road  
Kingston, Ontario  
K7P 0L8

**Foundation Investigation Report  
Replacement of Culvert No. 8  
Station 14+900, Highway 11  
District of Muskoka, Ontario  
G.W.P.: 5461-09-00**

January 18, 2024  
GEMTEC Project: 102944.001  
Geocres No.: 31D14-001  
Latitude: 44.81946  
Longitude: -79.32379

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## DISTRIBUTION

1 ELECTRONIC COPY TO MCINTOSH PERRY CONSULTING ENGINEERS LTD.  
1 ELECTRONIC COPY TO THE MINISTRY OF TRANSPORTATION ONTARIO

## **PART A - FOUNDATION INVESTIGATION**

**Foundation Investigation Report  
Replacement of Culvert No. 8  
Station 14+900, Highway 11  
District of Muskoka, Ontario  
G.W.P.: 5461-09-00**

## 1.0 INTRODUCTION

GEMTEC has been retained by McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry), on behalf of the Ministry of Transportation, Ontario (MTO), to carry out a foundation investigation associated with the resurfacing of Highway 11 between Severn River Bridge and Kahshe Lake Road in the Township of Morrison, District of Muskoka, Ontario (Assignment number 5019-E-0002).

This report presents the results of the foundation investigation carried out for the proposed replacement of Culvert No. 8 located beneath both the north bound lane (N.B.L.) and the south bound lane (S.B.L.) of Highway 11 in the Township of Morrison, District of Muskoka, Ontario, (G.W.P. 5461-19-00).

The scope of work for the foundation engineering services associated with the replacement was outlined in GEMTEC's Proposal dated August 17, 2023. The investigation requirements were provided by McIntosh Perry.

The work has been carried out in accordance with GEMTEC's Quality Control Plan for foundation engineering services for this project.

## 2.0 SITE DESCRIPTION AND GEOLOGY

### 2.1 Site Description

The site is located on Highway 11 approximately 0.25 kilometre(s) north of the Rainbow Circle interchange. At the site, Highway 11 runs approximately north-south and the tributary creek, east-west.

The land adjacent to the site is generally undulating to rolling and consists mainly of forested area. A residential home is located adjacent to the culvert location, along the west side of Highway 11. Occasional trees and shrubs are present along the existing highway right-of-way and the tributary creek. Bedrock outcrops are visible on both the east and west sides of the right-of-way.

The existing Highway 11 in the vicinity of the site is a divided highway with two travelled lanes in both the N.B.L. and S.B.L., gravel shoulders and a posted speed limit of 90 km/hr.

#### 2.1.1 Existing Culvert

Preliminary information provided by McIntosh Perry for this assignment indicates the existing culvert is a non-rigid frame box culvert with an unknown date of construction. The existing culvert is installed in a non-linear arrangement (one bend located near the west shoulder of the highway) with a total alignment length of approximately 44 m, a clear span of 0.9 m, and a rise of 0.6 m. The invert elevation of the existing culvert is at about 227.7 m at the east end (inlet) and 227.5 m

at the west end (outlet) and the creek flows from the east to the west. The top of pavement elevation of Highway 11 at the N.B.L. and S.B.L. centrelines, in the vicinity of the existing culvert, is about 231.0 and 231.5 m, respectively. The top of the existing culvert at the N.B.L. and S.B.L. centreline is about 228.5 m and 228.2 m, respectively, corresponding to a cover of up to about 3.3 m.

The embankment sides are sloped at approximately 2.5H:1V and did not show any visible signs of distress at the time of the investigation, where visible given the thick vegetation.

Photographs showing the existing site conditions at the time of the field investigation are included in Appendix E for reference.

### **2.1.2 Proposed Culvert**

At the time of reporting, limited information was available regarding the proposed culvert. It is understood that the proposed culvert will not be installed within the alignment of the existing culvert, but rather will be installed at an approximate sixty (60) degree skew to the Highway 11 alignment, and directly link the current inlet and outlet locations of the existing culvert. Therefore, it is assumed that the proposed culvert will be installed at a similar elevation as the existing culvert.

Based on the site plan details provided to GEMTEC, it is estimated that the length of the proposed culvert will be about 40 m. The staging drawings provided to GEMTEC indicate a 1,600 mm diameter CSP is being considered for the replacement.

It is also understood that both trenchless and open-cut installation techniques are being considered.

## **2.2 Regional Geology**

As delineated in The Physiography of Southern Ontario<sup>1</sup>, this section of Highway 11 lies along the borders of the minor physiographic regions known as the Number 11 Strip and the Georgian Bay Fringe, which lie within the major physiographic region of the Laurentian Highlands.

The Number 11 Strip region is characterized by a relatively flat sand plain positioned between two bedrock dominated upland areas. The sand is potentially glaciofluvial, glaciolacustrine, and /or subaqueous fan deposits in origin, deposited during the Lake Algonquin phase.

The Georgian Bay Fringe region is characterized by thinly till-covered rock knobs and ridges, with common occurrences of outcrops of bare rock. Low lying areas between the outcrops are covered by a thin layer of glacial till composed of loose, reddish, stony sandy till derived primarily from Precambrian bedrock material. The lowland areas were subsequently inundated by glacial Lake

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<sup>1</sup> Chapman, L. J. and Putnam, D. F., 1984. The Physiography of Southern Ontario, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources.

Algonquin resulting in the deposition of thin glaciolacustrine sediments over the till. The combined thickness of the till and glaciolacustrine sediments rarely exceeds 2 to 3 m. Other low-lying areas may be filled with organic-rich sediments.

### **3.0 INVESTIGATION PROCEDURES**

The subsurface investigation for the culvert replacement was carried out between October 2 and 4, 2023, during which time, 3 boreholes (numbered 23-01 to 23-03) were advanced at the locations indicated below and as shown on Drawing 1:

- Boreholes 23-01 and 23-03, along the alignment of the proposed culvert, on the south bound shoulder and the north bound shoulder, respectively.
- Borehole 23-02 on the interior S.B.L., adjacent the centreline barrier.

Boreholes 23-01 and 23-03 were advanced from road level at the shoulders, due to the limited access with appropriate drilling equipment to the toe of embankment areas (i.e., at the planned inlet and outlet).

The boreholes were advanced through the roadway to depths ranging from about 9.8 to 10.9 m (i.e., Elevations 221.6 to 220.3 m) below ground surface, using 108 mm inside diameter (200 mm outside diameter) continuous-flight hollow-stem augers on a truck-mounted drill rig, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario.

At Boreholes 23-01 and 23-02, upon encountering auger refusal, approximately 5.0 and 3.2 m of bedrock was cored, respectively, to final depths of 9.8 m and 10.9 m, using rotary diamond drilling techniques while retrieving HQ sized bedrock core. Borehole 23-03 was terminated within the overburden at a depth of about 10.5 m below existing ground surface.

Samples of overburden in the boreholes were generally obtained at vertical intervals of about 0.76 m using a 35 mm inside diameter (50 mm outer diameter) split-spoon sampler in general accordance with ASTM D1586 - Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.

Traffic control was provided throughout the duration of the field work in accordance with the Ontario Traffic Manual, Book 7, Temporary Conditions.

A monitoring well was installed in both boreholes 23-01 and 23-03 to measure the groundwater level at the site. The wells consist of a 50 mm diameter rigid PVC pipe with a 1.5 m long slotted screen section, installed within sand backfill and sealed by a section of bentonite backfill. The water levels in the monitoring wells were measured on October 5, 2023 (i.e., 2 to 3 days following installation). The monitoring wells were decommissioned on December 21, 2023, in accordance with Ontario Regulation 903, as amended.

Borehole 23-03 was backfilled with bentonite pellets mixed with native soils in the overburden. The site conditions were restored following completion of work which included the resurfacing of the pavement surface using cold-patch asphalt for boreholes advanced through the pavement.

The field work was supervised by a member of GEMTEC's technical and engineering staff, who located the boreholes and supervised the drilling, sampling, and in situ testing operations, logged the boreholes, and examined and cared for the soil samples retrieved. The soil samples were identified in the field, placed in appropriate containers, and transported to GEMTEC's laboratory in Ottawa for further examination. Index and classification tests consisting of water content determinations and grain size distribution were carried out on selected soil samples. Unconfined compression strength (UCS) testing was carried out on selected rock samples at GEMTEC's laboratory. The laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate.

One selected sample of soil from Borehole 23-02 was sent to Paracel Laboratories Ltd. for basic chemical analysis related to potential corrosion of buried steel elements and sulfate attack on buried concrete elements (corrosion and sulphate attack).

Classification of the rock mass quality of the bedrock core samples with respect to the Rock Quality Designation (RQD) and Uniaxial Compressive Strength (UCS) are described based on Table 4.26 and Table 4.21, respectively, of the Canadian Foundation Engineering Manual (CFEM, 2023<sup>2</sup>). The degree of weathering of the bedrock samples (i.e., fresh to slightly weathered) and the strength classification of the intact rock mass, based on field identification (i.e., strong to very strong), are described in accordance with Table B.3 and Table B.6, respectively, of the International Society for Rock Mechanics (ISRM<sup>3</sup>) standard classification system.

Following drilling, the borehole locations were surveyed by GEMTEC personnel using a Spectra SP60 GPS unit that has a  $\pm 2$  cm horizontal and a  $\pm 3$  cm vertical accuracy. The borehole locations, including NAD83 MTM Zone 10 northing and easting coordinates and ground surface elevations referenced to Geodetic datum (CGVD28), are shown on Drawing 1 and are summarized in Table 1.

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<sup>2</sup> Canadian Geotechnical Society, 2023. Canadian Foundation Engineering Manual, 5th Edition.

<sup>3</sup> International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.



**Table 1 – Summary of Borehole Locations**

Borehole No.	Location	NAD83 2010.0 MTM Zone 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)		
23-01	SB Shoulder	4964380.098	318723.965	231.37	9.80
23-02	SB – median lane	4964387.617	318733.118	231.23	10.90
23-03	NB Shoulder	4964389.074	318744.655	230.83	10.50

## 4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

### 4.1 General

The subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ testing from the current investigation are given on the Record of Borehole sheets presented in Appendix A. The results of the laboratory testing carried out during the current investigation are presented on the Record of Borehole sheets as well as on Figures B1 to B4 in Appendix B. The borehole locations and the interpreted stratigraphic profile projected along the proposed alignment of the planned culvert are provided on Drawing 1.

Photographs of bedrock core samples are provided in Appendix C. The results of basic chemical analysis completed on the selected soil sample are provided in Appendix D. Site photographs showing the general conditions at the site are presented in Appendix E.

The stratigraphic boundaries shown on the borehole sheets and on the interpreted stratigraphic section from Drawing 1 are inferred from observations of drilling progress and non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

### 4.2 Site Stratigraphy Summary

In general, the site stratigraphy consists of embankment fill over bedrock or native deposits of silty clay, silty sand and sandy silt, which in boreholes 23-01 and 23-02 are overlying relatively shallow bedrock. Relatively thick deposits of peat were encountered between the embankment fill and the native soils and bedrock at all the borehole locations. Boreholes 23-01 and 23-02 were terminated within the bedrock and borehole 23-03 was terminated in the silty sand/sandy silt deposits.

### 4.3 Surficial and Embankment Materials

An asphaltic concrete layer ranging in thickness from about 50 mm to 60 mm was encountered at ground surface in boreholes 23-01 and 23-02.

Below the asphaltic concrete at boreholes 23-01 and 23-02, and from ground surface at borehole 23-3, a layer of sand and gravel (base) ranging in thickness between about 130 to 150 mm was encountered.

Granular fill was observed in all three boreholes below the base layer and extends to depths ranging from about 2.8 m to 4.1 m below ground surface. The granular fill can generally be described as sand with varying amounts of gravel and silt. Organic material, including roots, was occasionally observed at lower depths within the layer, as well as cobbles and boulders.

Standard penetration tests carried out in the granular fill gave N values ranging between about 1 and 47 blows per 0.3 m of penetration, which reflect a very loose to dense compactness.

Blast rock was encountered about 1.7 m below ground surface at borehole 23-01, based on the drilling resistance, and it extends to a depth of at least 2.7 m.

The moisture content of the five samples of fill tested ranged between about 2 and 36 percent. The results of grain size analysis testing carried out the five samples of this material are provided on Figure B1 in Appendix B and are summarized in the table below.

**Table 2 – Summary of Grain Size Distribution Testing on Embankment Fill**

Test Hole	Sample Number	Sample Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
23-01	A <sup>1</sup>	0.06 to 0.2	28	67	5	
23-01	5	3.1 to 3.7	29	57	12	2
23-02	1	0.3 to 0.5	2	89	9	
23-02	4	2.4 to 2.7	1	91	6	2
23-03	2	0.8 to 1.4	18	72	10	

1. Sample 'A' represents a grab sample that was collected from within the borehole by removing the augers from the borehole (upon reaching a depth of 1.5 m) to allow for a visual assessment of the interior walls of the borehole.

### 4.4 Peat

Deposits of peat, ranging from about 0.5 to 0.8 m in thickness, were encountered in all three boreholes below the embankment fill. The peat deposits extend to depths ranging from 3.3 m to 4.8 m below ground surface. The peat is mainly amorphous at all three locations and includes traces of sand with some silt and clay content, as well as traces of wood pieces and other organic

material (e.g. roots/rootlets). At borehole 23-03, the upper portion of the deposit appears to be more fibrous.

#### 4.5 Silty Clay

A deposit of silty clay was encountered below the peat at borehole 23-03 at a depth of about 3.3 metres and extends to a depth of about 4.6 m below ground surface, therefore having a thickness of about 1.3 metres. The deposit consists of grey clay with silty sand seams.

A standard penetration test carried out in the silty clay gave an N value of 13 blows per 0.3 m of penetration, which reflect a stiff to very stiff consistency.

The measured moisture content of one sample tested was 23 percent. The results of grain size analysis testing carried out on a sample of this material are provided on Figure B2 in Appendix B and are summarized in the table below.

**Table 3 – Summary of Grain Size Distribution Testing on Silty Clay**

Test Hole	Sample Number	Sample Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
23-03	6	3.8 to 4.4	0	28	50	23

#### 4.6 Sand and Silty Sand to Sandy Silt

Sands and silts with varying amounts of clay and traces of gravel were encountered below the peat in boreholes 23-02 and 23-03 at elevations 226.7 and 226.2 m, respectively. The thickness of the sand layer at borehole 23-02 is about 2.3 m. Borehole 23-03 was terminated in the sandy deposit at a depth of 10.5 m. The SPT N values ranged from 3 to 18 blows per 0.3 m of penetration, indicating a very loose to compact state of compaction.

The measured moisture content of the samples tested ranged from 22 to 37 percent. The results of grain size analysis testing carried out on four samples of this material are provided on Figure B3 in Appendix B and are summarized in the table below.

**Table 4 – Summary of Grain Size Distribution Testing on Sand to Silty Sand**

Test Hole	Sample Number	Sample Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
23-02	7	4.6 to 5.2	0	45	43	12
23-02	9	6.1 to 6.7	0	85	9	6
23-03	9	6.1 to 6.7	0	21	77	2

Test Hole	Sample Number	Sample Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
23-03	11	7.6 to 8.2	0	64	34	2

#### 4.7 Gravelly Sand

A deposit of gravelly sand with trace to some silt was encountered beneath the sands and silts in borehole 23-02. The deposit was fully penetrated and has a thickness of about 0.8 m.

An SPT 'N' value obtained within the deposit was 27 blows per 0.3 m of penetration, indicating a compact state of compaction.

#### 4.8 Bedrock

Precambrian bedrock was encountered below the peat deposit in Borehole 23-01 and below the gravelly sand at borehole 23-02, at depths of about 4.8 m and 7.7 m below existing ground surface, respectively (i.e., elevations 226.6 and 223.5, respectively) and was cored for lengths of about 5.0 and 3.2 m, respectively, using HQ sized drilling equipment. The retrieved bedrock core was described as fresh, black, grey, and pink Gneiss, as presented on the Record of Borehole sheets in Appendix A.

The following table summarizes the bedrock surface depths and elevations as encountered at the borehole locations during the current investigation.

**Table 5 – Summary of Bedrock Depths and Elevations**

Borehole Number	Borehole Location	Existing Ground Surface Elevation(m)	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)
23-01	Culvert Outlet	231.4	4.8	226.6
23-02	Culvert Middle	231.2	7.7	223.5

The Rock Quality Designation (RQD) values generally ranged from about 82 to 100 percent, indicating a rock mass of good to excellent quality.

Laboratory Uniaxial Compression Strength (UCS) tests were carried out on selected bedrock core samples and the measured UCS values ranged from 52 to 98 MPa, indicating the bedrock is strong. The results of the UCS testing are provided on Figure B4 in Appendix B. Photographs of core samples of the bedrock are provided in Appendix C.

#### 4.9 Groundwater Conditions

A monitoring well was installed within the overburden in each of Boreholes 23-01 and 23-03 to measure the stabilized groundwater level at the site. The groundwater levels measured in the monitoring wells are presented in the table below.

**Table 6 – Summary of Groundwater Level Depths and Elevations**

Borehole Number	Existing Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Elevation (m)	Date of Reading
23-01	231.4	2.9	228.5	October 5, 2023
23-01	231.4	2.5	228.9	December 21, 2023
23-03	230.8	2.1	228.7	October 5, 2023
23-03	230.8	1.5	229.3	December 21, 2023

It should be noted that the groundwater levels at this site are expected to fluctuate seasonally in response to changes in precipitation and snow melt and are expected to be higher during the spring and periods of precipitation.

#### 4.10 Steel Corrosion and Sulphate Attack, Chemical Analysis

One soil sample was submitted to Paracel Laboratories Ltd. for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D and are summarized in the table below.

**Table 7 – Summary of Chemical Analysis Testing**

BH No.	Sample No.	Sample Depth (m)	Sample Type	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	Resistivity (ohm-cm)	pH
23-02	5	3.1 – 3.7	Soil	0.045	0.006	0.995	1000	6.72

## 5.0 CLOSURE

The field work for this assignment was supervised by Mr. Adrian North. This report was prepared by Matthew Rainville, C.E.T. and Serge Bourque, M.Sc.E., P.Eng., and reviewed by Mr. William Cavers, P.Eng., a Principal Geotechnical Engineer with GEMTEC and the Key MTO Foundations Personnel for this project.

### GEMTEC Consulting Engineers and Scientists Limited



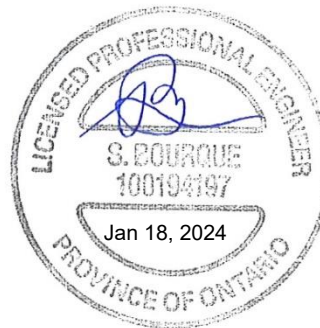
Matthew Rainville, C.E.T.  
Senior Technologist



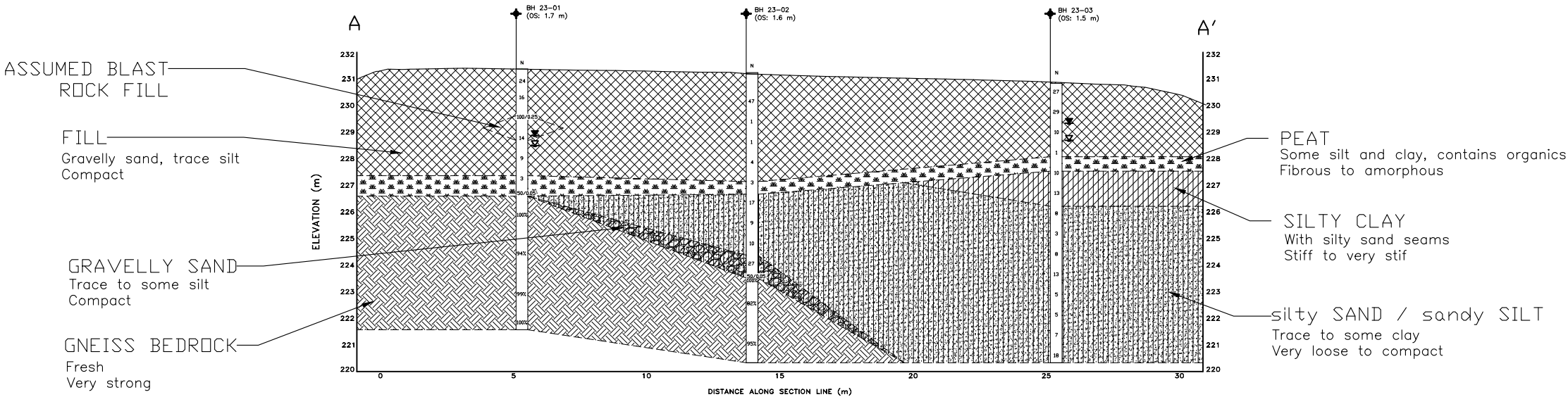
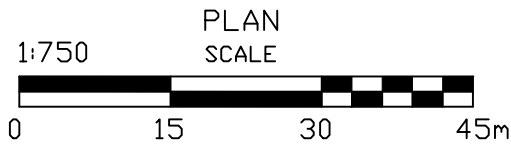
Serge Bourque, M.Sc.E., P.Eng.  
Principal Geotechnical Engineer



William Cavers, P.Eng.  
Principal Geotechnical Engineer



MR/SB/WC



METRIC

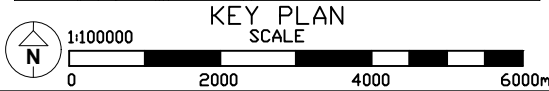
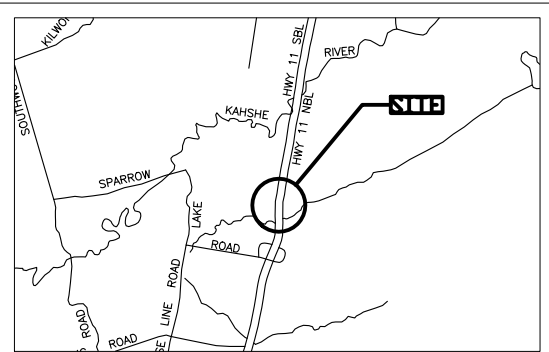
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN.

GWP No: 5461-09-00

Replacement of Culvert No. 8  
Station 14+900  
Borehole Locations and Soil Strata



SHEET  
01



#### LEGEND

- BOREHOLE - CURRENT INVESTIGATION
- OS OFFSET FROM SECTION LINE
- N STANDARD PENETRATION TEST VALUE
- #X BLOW COUNT
- X% ROCK QUALITY DESIGNATION (RQD)
- GROUNDWATER LEVEL (OCTOBER 5, 2023)
- GROUNDWATER LEVEL (DECEMBER 21, 2023)

BOREHOLE CO-ORDINATES: NAD83 (CSRS) / MTM ZONE 10			
BH ID	ELEVATION	NORTHING	EASTING
BH 23-01	231.4	4964380.098	318723.965
BH 23-02	231.2	4964387.617	318733.118
BH 23-03	230.8	4964389.074	318744.655

#### NOTES

- The Boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only, the proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

#### REFERENCES

Base plans provided in digital format by McIntosh Perry, drawing labeled: WP 5461-09-00 -Hwy 11 Severn-Kahshe WIP-2020-03-2.dwg

REVISIONS				
	DATE	BY	DESCRIPTION	
GEOCREC No: 31D14-001				
HWY: 11		PROJECT No: 102944.001		
SUBM'D: M.R.	CHKD: M.R.	DATE: 01/12/2024	SITE: -	
DRAWN: S.J.	CHKD: B.W.	APPD: W.C.	DWG: 01	





## **APPENDIX A**

Record of Borehole Sheets  
List of Abbreviations and Terminology



# RECORD OF BOREHOLE No 23-01

1 OF 1

**METRIC**

G.W.P. 5461-09-00 LOCATION N 4964380.1; E 318724.0 NAD 83 MTM ZONE 10 ORIGINATED BY AN  
DIST Eastern HWY 11 BOREHOLE TYPE Power Auger, 200 mm Diameter (Hollow Stem)/Rotary Drill, HQ Core COMPILED BY MR  
DATUM CGVD28 DATE 2023.10.03 - 2023.10.03 CHECKED BY BC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20   40   60   80   100		w <sub>p</sub>	w	w <sub>L</sub>		GR   SA   SI   CL
231.4								20   40   60   80   100						
0.2	ASPHALTIC CONCRETE													
	Gravelly sand, trace silt (BASE)		1	SS	24		231			○				28   67   (5)
	Brown Moist													
	Sand, trace gravel, trace silt (FILL)		2	SS	16		230							
	Compact Light brown Moist													
229.7	Blast rock, some sand and gravel (FILL)		3	SS	>100 for 250 mm		229							
	Moist													
228.6			4	SS	14		228							
2.7	Gravelly sand, some silt, trace clay, to sand, some silt, contains organics, possible cobbles/boulders (FILL)		5	SS	9		227							29   57   12   2
	Loose Reddish brown to dark brown Wet									○				
227.4	PEAT, some silt and clay, trace to some sand, contains wood pieces/roots		6	SS	3		226							RC #8 TCR=100% SCR=68% RQD=100% UCS=98MPa
4.0	Amorphous Dark brown Wet		7	SS	>50 for 60 mm		225							RC #9 TCR=100% SCR=91% RQD=94% UCS=85MPa
226.6	GNEISS BEDROCK		8	RC			224							RC #10 TCR=100% SCR=86% RQD=99% UCS=52MPa
	Fresh Very strong Black, grey, pink		9	RC			223							RC #11 TCR=100% SCR=96% RQD=100%
			10	RC			222							
			11	RC										
221.6	End of Borehole													
9.8														

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTD BOREHOLE LOG 102944.001\_GINT\_MTD\_GEO TECH.GPJ GEMTEC MTD.GDT 1/10/24

## RECORD OF BOREHOLE No 23-02

1 OF 1

**METRIC**

G.W.P.	5461-09-00	LOCATION	N 4964387.6; E 318733.1 NAD 83 MTM ZONE 10	ORIGINATED BY	AN
DIST	Eastern	HWY	11	BOREHOLE TYPE	Power Auger, 200 mm Diameter (Hollow Stem)/Rotary Drill, HQ Core
DATUM	CGVD28	DATE	2023.10.04 - 2023.10.04	CHECKED BY	BC

[illegible]

MTO BOREHOLE LOG 102944.001 GINT MTO GEOTECH.GPJ GEMTEC MTO.GDT 1/10/24

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

# RECORD OF BOREHOLE No 23-03

1 OF 1

**METRIC**

G.W.P. 5461-09-00 LOCATION N 4964389.1; E 318744.7 NAD 83 MTM ZONE 10 ORIGINATED BY AN  
DIST Eastern HWY 11 BOREHOLE TYPE Power Auger, 200 mm Diameter (Hollow Stem) COMPILED BY MR  
DATUM CGVD28 DATE 2023.10.02 - 2023.10.02 CHECKED BY BC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)											
								○ UNCONFINED   + FIELD VANE	● QUICK TRIAXIAL   × LAB VANE	w <sub>p</sub>	w	w <sub>L</sub>									
230.8							20	40	60	80	100				GR	SA	SI	CL			
230.0	Sand and gravel, trace silt (BASE)		1	SS	27																
0.2	Grey Moist		2	SS	29								○					18	72	(10)	
229.3	Sand, trace to some gravel, trace silt, with cobbles/boulder (FILL)																				
	Compact Brown Moist		3	SS	10																
228.1	Silty sand, trace to some gravel (FILL)																				
1.5	Loose to very loose Brown Moist to wet		4	SS	1																
227.5	PEAT to PEAT, some silt and clay, trace to some sand, contains organics																				
2.8	Fibrous to amorphous Dark brown/black to grey brown/dark brown Wet		5	SS	10																
226.2	SILTY CLAY, with silty sand seams Stiff to very stiff Grey Wet												○					0	28	50	23
3.3	Layered Silty SAND/Sandy SILT, trace to some clay Very loose to compact Grey Wet		6	SS	13																
225.0																					
			7	SS	8																
224.0																					
			8	SS	3																
223.0																					
			9	SS	8									○				0	21	77	2
222.0																					
			10	SS	13																
221.0																					
			11	SS	5									○				0	64	34	2
220.3																					
10.5	End of Borehole		12	SS	5																
			13	SS	7																
			14	SS	18																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTD BOREHOLE LOG 102944.001\_GINT\_MTD\_GEO TECH.GPJ GEMTEC MTD.GDT 1/10/24

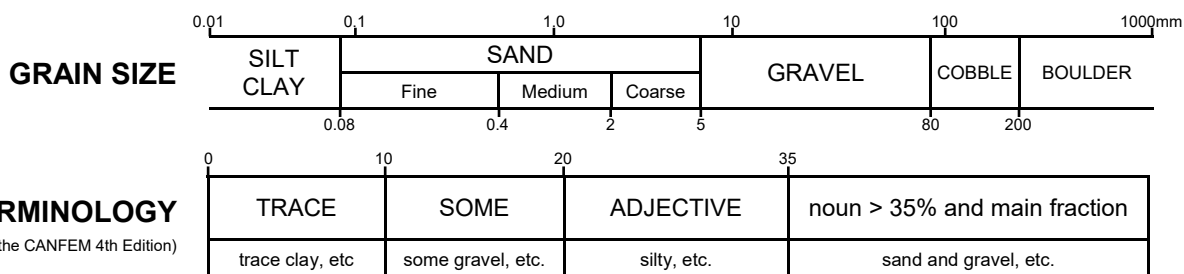
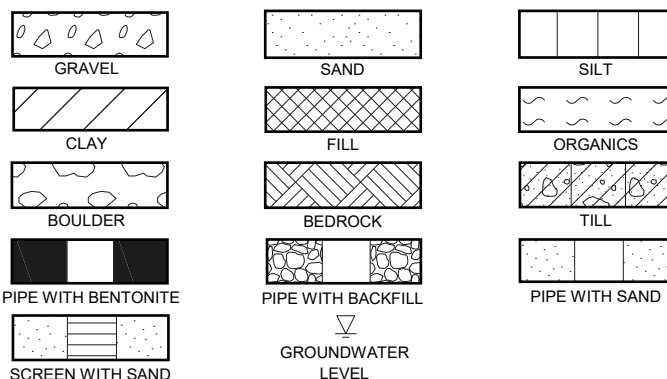
## ABBREVIATIONS AND TERMINOLOGY USED ON RECORDS OF BOREHOLES AND TEST PITS

SAMPLE TYPES	
AS	Auger sample
CA	Casing sample
CS	Chunk sample
BS	Borros piston sample
GS	Grab sample
MS	Manual sample
RC	Rock core
SS	Split spoon sampler
ST	Slotted tube
TO	Thin-walled open shelby tube
TP	Thin-walled piston shelby tube
WS	Wash sample

SOIL TESTS	
w	Water content
PL, $w_p$	Plastic limit
LL, $w_L$	Liquid limit
C	Consolidation (oedometer) test
$D_R$	Relative density
DS	Direct shear test
$G_s$	Specific gravity
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	Organic content test
UC	Unconfined compression test
$\gamma$	Unit weight

PENETRATION RESISTANCE	
<b>Standard Penetration Resistance, N</b> The number of blows by a 63.5 kg (140 lb) hammer dropped 760 millimetres (30 in.) required to drive a 50 mm split spoon sampler for a distance of 300 mm (12 in.). For split spoon samples where less than 300 mm of penetration was achieved, the number of blows is reported over the sampler penetration in mm.	
<b>Dynamic Penetration Resistance</b> The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive a 50 mm (2 in.) diameter 60° cone attached to 'A' size drill rods for a distance of 300 mm (12 in.).	
WH	Sampler advanced by static weight of hammer and drill rods
WR	Sampler advanced by static weight of drill rods
PH	Sampler advanced by hydraulic pressure from drill rig
PM	Sampler advanced by manual pressure

COHESIONLESS SOIL Compactness		COHESIVE SOIL Consistency	
SPT N-Values	Description	$C_u$ , kPa	Description
0-4	Very Loose	0-12	Very Soft
4-10	Loose	12-25	Soft
10-30	Compact	25-50	Firm
30-50	Dense	50-100	Stiff
>50	Very Dense	100-200	Very Stiff
		>200	Hard



### DESCRIPTIVE TERMINOLOGY

(Based on the CANFEM 4th Edition)

## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE	
Fresh	No visible sign of rock material weathering
Faintly weathered	Weathering limited to the surface of major discontinuities
Slightly weathered	Penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material
Moderately weathered	Weathering extends throughout the rock mass but the rock material is not friable
Completely weathered	Rock is wholly decomposed and in a friable condition but the rock and structure are preserved

CORE CONDITION
<b>Total Core Recovery (TCR)</b> The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run
<b>Solid Core Recovery (SCR)</b> The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.
<b>Rock Quality Designation (RQD)</b> The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completed broken core to 100% for core in solid segments.

BEDDING THICKNESS	
Description	Thickness
Thinly laminated	< 6 mm
Laminated	6 - 20 mm
Very thinly bedded	20 - 60 mm
Thinly bedded	60 - 200 mm
Medium bedded	200 - 600 mm
Thickly bedded	600 - 2000 mm
Very thickly bedded	2000 - 6000 mm

DISCONTINUITY SPACING	
Description	Spacing
Very close	20 - 60 mm
Close	60 - 200 mm
Moderate	200 - 600 mm
Wide	600 - 2000 mm
Very wide	2000 - 6000 mm

ROCK QUALITY	
RQD	Overall Quality
0 - 25	Very poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

ROCK COMPRESSIVE STRENGTH	
Comp. Strength, MPa	Description
1 - 5	Very weak
5 - 25	Weak
25 - 50	Moderate
50 - 100	Strong
100 - 250	Very strong



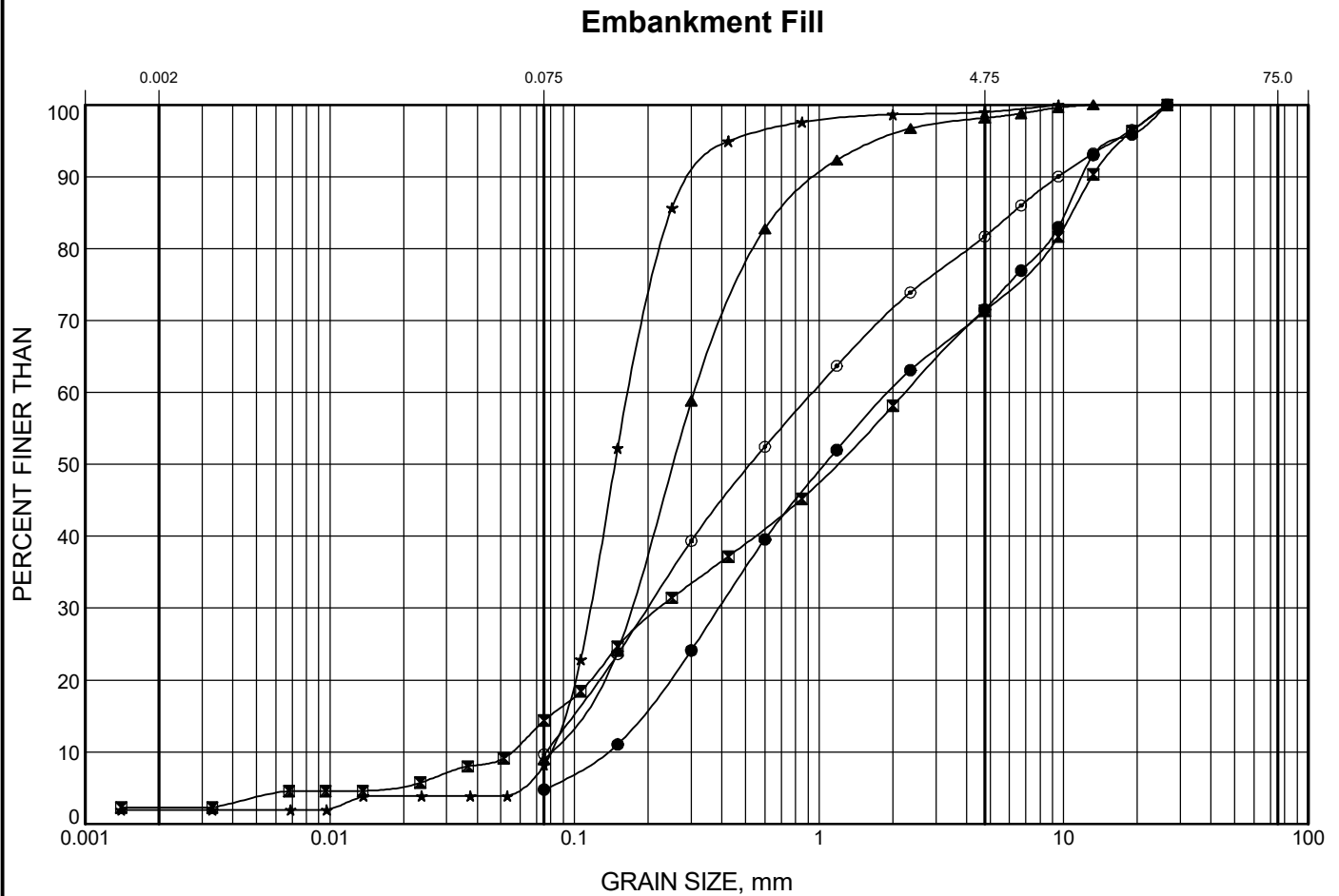
## **APPENDIX B**

### Laboratory Test Results

# GRAIN SIZE DISTRIBUTION

## Hwy 11, Replacement of Culvert #8

FIGURE B1



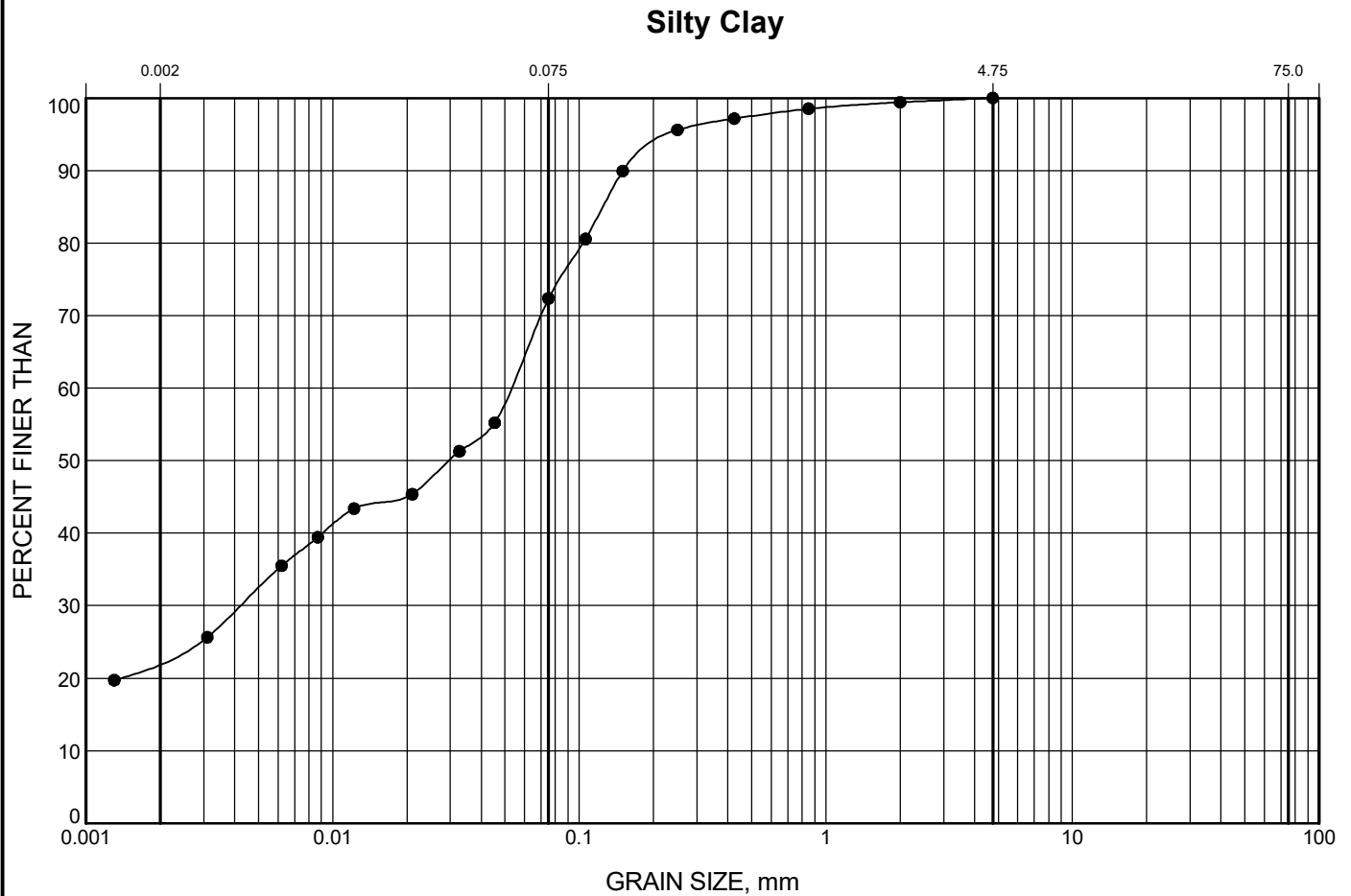
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLES
		SAND			GRAVEL		

Legend	Borehole	Sample	Depth (m)	% Gravel	% Sand	% Silt	% Clay
●	23-01	A	0.06 - 0.2	28	67		5
⊠	23-01	5	3.1 - 3.7	29	57	12	2
▲	23-02	1	0.3 - 0.5	2	89		9
★	23-02	4	2.4 - 2.7	1	91	6	2
⊙	23-03	2	0.8 - 1.4	18	72		10

# GRAIN SIZE DISTRIBUTION

Hwy 11, Replacement of Culvert #8

FIGURE B2



CLAY	SILT	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLES
		SAND			GRAVEL		

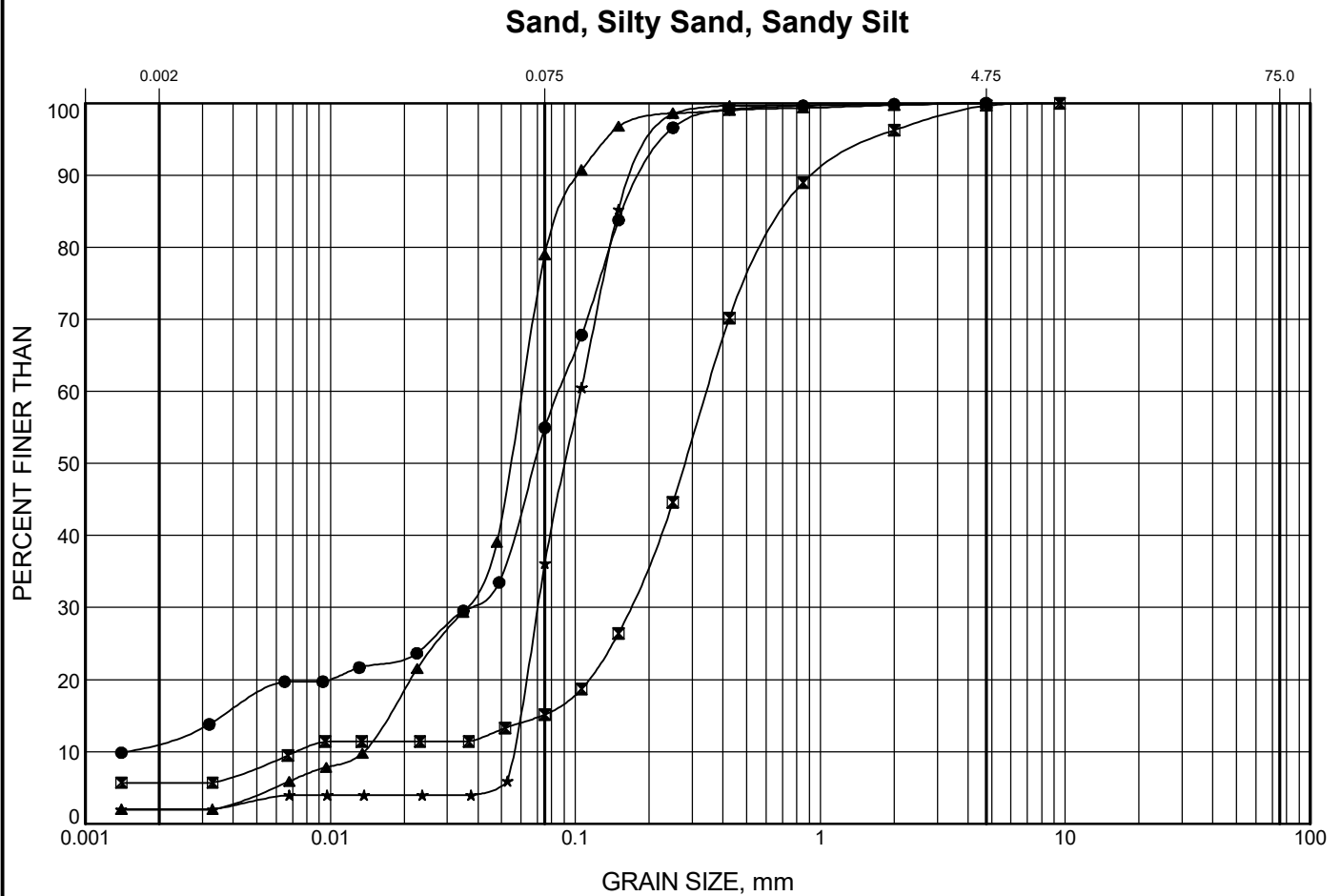
Legend	Borehole	Sample	Depth (m)	% Gravel	% Sand	% Silt	% Clay
●	23-03	6	3.8 - 4.4	0	28	50	23




# GRAIN SIZE DISTRIBUTION

## Hwy 11, Replacement of Culvert #8

FIGURE B3



Legend	Borehole	Sample	Depth (m)	% Gravel	% Sand	% Silt	% Clay
●	23-02	7	4.6 - 5.2	0	45	43	12
⊠	23-02	9	6.1 - 6.7	0	85	9	6
▲	23-03	9	6.1 - 6.7	0	21	77	2
★	23-03	11	7.6 - 8.2	0	64	34	2

	Client: McIntosh Perry	<b>FIGURE B4</b> <b>Rock Core Compressive Strength</b>
	Project: GWP 5461-09-00 - Hwy 11 - Kahshe - Culvert Investigation	
	Project #: 102944001	

Date/Time Sampled: 23/10/17 12:21:00 PM	Date/Time Tested: 23/10/17 12:22:05 PM
---	--

BH	Sample No	Depth	Description	Diameter, mm	Area, mm <sup>2</sup>	Length After Capping, mm	L/D	Load, kN	Comp. Str., MPa
23-01	08	5.02-5.18	Bedrock	63.0	3122	125	1.98	305.090	97.7
23-01	09	7.01-7.11	Bedrock	63.6	3174	126	1.98	271.150	85.4
23-01	10	8.36-8.68	Bedrock	63.2	3140	125	1.98	163.380	52.0
23-02	13	8.53-8.96	Bedrock	63.3	3143	125	1.98	195.620	62.2



## **APPENDIX C**

### Photographs of Bedrock Core Samples

**BOREHOLE: 23-01**  
**BORING DATE: OCTOBER 3, 2023**  
**DEPTH: 4.78 to 9.80 mbgs**



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**FIGURE C1**

File No.  
102944.001

ROCKCORE PHOTOGRAPH  
BOREHOLE 23-01

**BOREHOLE: 23-02**  
**BORING DATE: OCTOBER 4, 2023**  
**DEPTH: 7.72 to 10.90 mbgs**



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**FIGURE C2**

File No.

102944.001

ROCKCORE PHOTOGRAPH  
BOREHOLE 23-02



## **APPENDIX D**

### Chemical Analysis of Soil Sample Relating to Corrosion

## Certificate of Analysis

**GEMTEC Consulting Engineers and Scientists Limited**

32 Steacie Drive  
Kanata, ON K2K 2A9  
Attn: Matt Rainville

Client PO:  
Project: 102944.001  
Custody:

Report Date: 19-Oct-2023  
Order Date: 12-Oct-2023

**Order #: 2341205**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
2341205-01	BH23-02 SA5 10'-12'

Approved By:



Dale Robertson, BSc  
Laboratory Director

Certificate of Analysis

Report Date: 19-Oct-2023

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 12-Oct-2023

Client PO:

Project Description: 102944.001

**Analysis Summary Table**

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	13-Oct-23	13-Oct-23
Conductivity	MOE E3138 - probe @25 °C, water ext	13-Oct-23	13-Oct-23
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	12-Oct-23	12-Oct-23
Resistivity	EPA 120.1 - probe, water extraction	13-Oct-23	19-Oct-23
Solids, %	CWS Tier 1 - Gravimetric	13-Oct-23	13-Oct-23



Certificate of Analysis

Report Date: 19-Oct-2023

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 12-Oct-2023

Client PO:

Project Description: 102944.001

Client ID:	BH23-02 SA5 10'-12'	-	-	-	-
Sample Date:	04-Oct-23 10:30	-	-	-	-
Sample ID:	2341205-01	-	-	-	-
Matrix:	Soil	-	-	-	-
MDL/Units					

#### Physical Characteristics

% Solids	0.1 % by Wt.	82.8	-	-	-	-
----------	--------------	------	---	---	---	---

#### General Inorganics

Conductivity	5 uS/cm	995	-	-	-	-
pH	0.05 pH Units	6.72	-	-	-	-
Resistivity	0.1 Ohm.m	10.0	-	-	-	-

#### Anions

Chloride	10 ug/g	448	-	-	-	-
Sulphate	10 ug/g	64	-	-	-	-

Certificate of Analysis

Report Date: 19-Oct-2023

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 12-Oct-2023

Client PO:

Project Description: 102944.001

### Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>								
Chloride	ND	10	ug/g					
Sulphate	ND	10	ug/g					
<b>General Inorganics</b>								
Conductivity	ND	5	uS/cm					
Resistivity	ND	0.1	Ohm.m					

Certificate of Analysis

Report Date: 19-Oct-2023

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 12-Oct-2023

Client PO:

Project Description: 102944.001

### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	208	10	ug/g	192			8.0	35	
Sulphate	122	10	ug/g	122			0.1	35	
General Inorganics									
Conductivity	313	5	uS/cm	278			11.9	5	QR-04
pH	7.94	0.05	pH Units	7.97			0.4	2.3	
Resistivity	31.9	0.1	Ohm.m	36.0			11.9	20	
Physical Characteristics									
% Solids	92.2	0.1	% by Wt.	92.1			0.2	25	

Certificate of Analysis

Report Date: 19-Oct-2023

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 12-Oct-2023

Client PO:

Project Description: 102944.001

### Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	284	10	ug/g	192	92.1	82-118			
Sulphate	219	10	ug/g	122	96.4	80-120			

## Certificate of Analysis

Client: GEMTEC Consulting Engineers and Scientists Limited

Report Date: 19-Oct-2023

Order Date: 12-Oct-2023

Client PO:

Project Description: 102944.001

Qualifier Notes:**QC Qualifiers:**

QR-04 Duplicate results exceeds RPD limits due to non-homogeneous matrix.

Sample Data Revisions:

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

Soil results are reported on a dry weight basis unless otherwise noted.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Any use of these results implies your agreement that our total liability in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.



## **APPENDIX E**

### Photographs of Project Site



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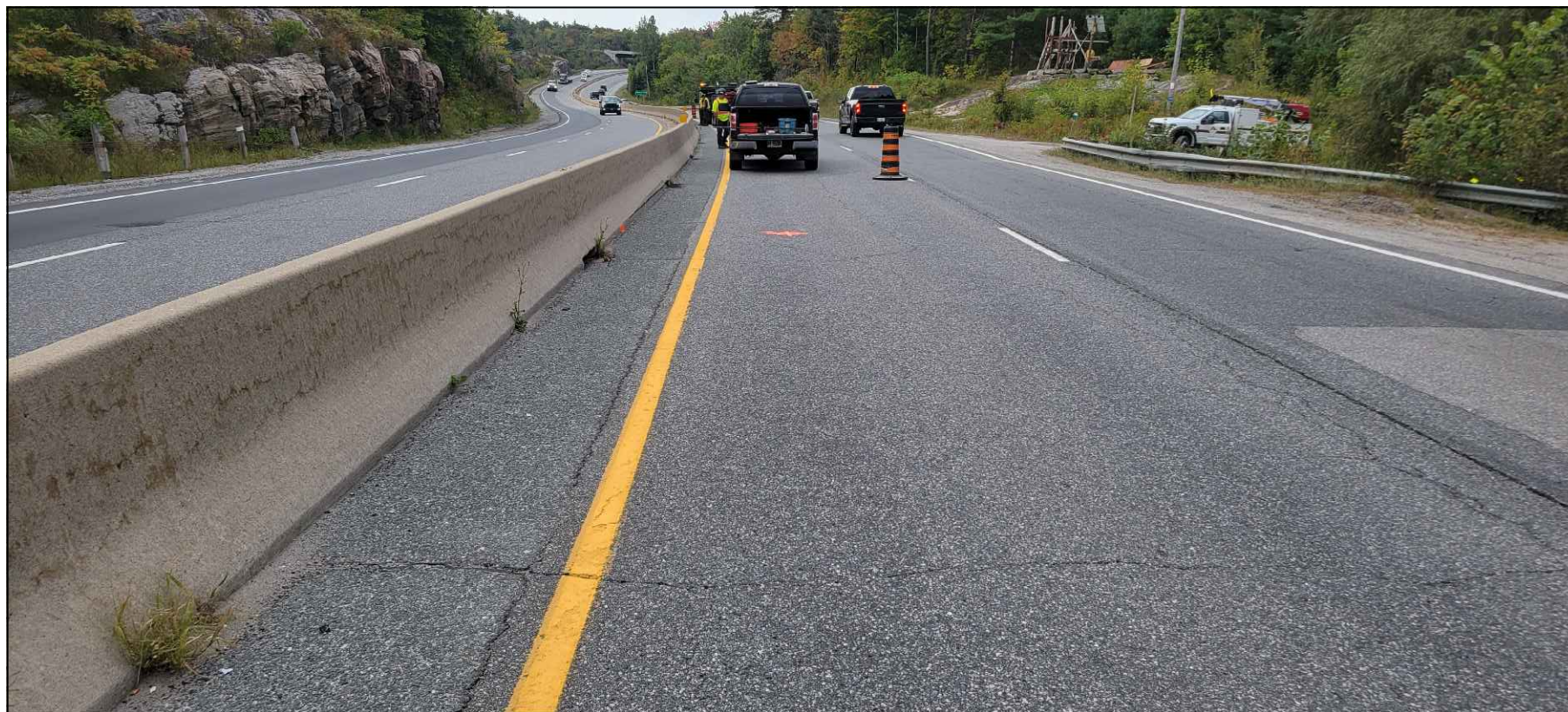
## FIGURE E1

File No.

102944.001

PHOTOGRAPH  
BOREHOLE 23-01  
LOOKING NORTH





CONSULTING ENGINEERS  
AND SCIENTISTS

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**FIGURE E2**

File No.

102944.001

PHOTOGRAPH  
BOREHOLE 23-02  
LOOKING SOUTH





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### FIGURE E3

File No.

102944.001

PHOTOGRAPH  
BOREHOLE 23-03  
LOOKING NORTH





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## FIGURE E4

File No.

102944.001

PHOTOGRAPH  
BOREHOLE 23-03  
LOOKING SOUTH





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## FIGURE E5

File No.

102944.001

PHOTOGRAPH  
LOOKING AT PROPOSED ALIGNMENT - WEST TO EAST

experience • knowledge • integrity



civil	civil
geotechnical	géotechnique
environmental	environnement
structural	structures
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

expérience • connaissance • intégrité

