



THURBER ENGINEERING LTD.

**PRELIMINARY
FOUNDATION INVESTIGATION REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
CULVERT 7AN
COUNTY ROAD 20, STA. 9+600, HORTON TOWNSHIP
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F07-002

Report to:

Ministry of Transportation Ontario

Latitude: 45.499758°
Longitude: -76.666943°

December 2024
Thurber File No.: 24726



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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street within the County of Renfrew, Ontario. Thurber carried out the investigation under Ministry of Transportation (MTO) Assignment No. 4018-E-0009.

This report addresses the foundation investigation for the replacement of an existing CSP culvert with a structural culvert at about Sta. 9+600 on County Road 20 (Castleford Road) in Horton Township, north of the new Bruce Street Interchange with Highway 17.

This section of the report presents the factual findings obtained from the foundation investigation conducted by Thurber as part of the current study. Thurber carried out the investigation under Ministry of Transportation (MTO) Assignment No. 4018-E-0009.

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

It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work.

2 SITE DESCRIPTION

2.1 General

The culvert crosses County Road 20 approximately 400 m east of the intersection between Highway 17 and County Road 20. Within the project limits County Road 20 is also known as Castleford Road to the north of Highway 17. For project purposes, County Road 20 is herein described as oriented east-west, and the culvert is described as oriented north-south.



In the area of the culvert, the existing County Road 20 is a two-lane road and has a posted speed limit of 80 km/h. The road surface near the culvert is at approximate elevation 146.7 m. The shoulders are not paved and have a width of approximately 2.0 m. The 2016 traffic volume for this section of County Road 20 is understood to have been 2,033 AADT based on a 2016 Survey Count provided by the MTO.

The existing culvert near the site is a corrugated steel pipe (CSP) elliptical culvert with an approximately 3.6 m horizontal span, 2.4 m vertical rise, and 26.1 m length. The culvert is approximately perpendicular to the roadway alignment. The culvert has a relatively shallow gradient with the invert of the culvert at approximately elevation 142.6 m. The cover above the existing culvert is approximately 1.7 m at the roadway centerline. A creek flows through the culvert under the roadway embankment from north to south. In July 2024, the culvert inlet and outlet were partially flooded with a ponded water depth of approximately 550 mm above invert.

Embankment side slopes, in the vicinity of the culvert, are inclined at approximately 2.8H:1V to 3.2H:1V. The existing embankment side slopes at the culvert site did not show any visible signs of global instability at the time of the investigation.

The site is in a rural setting, and the terrain along the ditch line is relatively flat in the vicinity of the culvert site. The area directly adjacent to the culvert is mostly farmland with some deciduous trees and shrubs found along the creek line. Cobbles and boulders are present on the creek bed and banks north of the culvert inlet. Driveway marker 1446 is located approximately 70 m east of the culvert site. Wire fences on wooden posts are located near the culvert inlet and approximately 4 m east from the culvert outlet. Overhead utility lines parallel the westbound ditch line and cross the road near Sta. 9+576.

Photographs of the project area are included in Appendix D. These photographs show the existing condition of the roadway embankment and the culvert at the time of the field investigation.

2.2 Site Geology

It is noted that Thurber has completed a Foundation Investigation for the proposed Highway 17 Interchange at County Road 20. The results are presented in Geocres Report 31F-234.

According to Crins et al. 2009¹, the project area is described as Ecoregion 6E (Lake Simcoe-Rideau Ecoregion) within the Mixedwood Plains Ecozone. According to Wester et al. 2018², the ecoregion is subdivided into Ecodistrict 6E-16 (Pembroke Ecodistrict). The area is characterized by glaciolacustrine dominated landscape overlying a mix of Paleozoic to Precambrian bedrock.

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Ottawa Valley Clay

¹ <https://files.ontario.ca/mnrf-ecosystemspart1-accessible-july2018-en-2020-01-16.pdf>

² <https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf>



Plains. The Ottawa Valley Clay Plains are characterized primarily by clay plains deposited by the Champlain Sea (Leda Clay) interrupted by ridges of rock or sand.

Ontario Geological Survey Map P.3784³ for Precambrian Geology for the Horton Area suggests the bedrock is dolomitic and calcitic carbonate metasedimentary bedrock including grey to white calcite marble.

3 SITE INVESTIGATION AND FIELD TESTING

The foundation investigation and field-testing program was carried out between February 26 and March 18, 2024, and consisted of one on-road borehole identified as SC7-2 and two off-road boreholes identified as SC7-1 and SC7-3. The on-road borehole was advanced with a CME 55 truck mounted drill rig utilizing NW casing and coring techniques in bedrock. The off-road Borehole SC7-1 was advanced with a CME 55 track mounted drill rig utilizing NW casing and coring techniques, and Borehole SC7-3 was advanced with portable drilling equipment. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

A summary of the borehole coordinates, elevations, and termination depths is provided in Table 3-1. The locations and elevations of the boreholes were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy and were measured relative to BM HCP 102 (Elevation 129.023 m). Horizontal locations were measured by Thurber relative to existing site features. The elevations and borehole coordinates were reviewed and referenced to the survey data provided by the MTO. The borehole coordinates and elevations are shown on the Borehole Location and Soil Strata drawing included in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 9.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
SC7-1	Near Outlet	5 039 988.2 (45.499694°)	291 758.9 (-76.666871°)	143.7	7.7
SC7-2	Westbound Lane	5 040 011.2 (45.499901°)	291 751.9 (-76.666962°)	146.7	9.8
SC7-3	Near Outlet	5 040 011.9 (45.499907°)	291 737.2 (-76.667149°)	144.4	6.8

The boreholes were advanced to depths ranging from 6.8 to 9.8 m below the existing ground surface (base elev. 137.6 to 136.0 m). Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general

³ <http://www.geologyontario.mndm.gov.on.ca/mines/data/google/mrd126/doc.kml>



accordance with ASTM D 1586. The portable drill used for Borehole SC7-3 was equipped with a full weight hammer, thus no adjustments were necessary for the SPT N values.

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

A 50 mm diameter well was installed in each of Boreholes SC7-1 and SC7-3 to allow for measurements of the groundwater level after drilling. The details for the wells are illustrated on the respective Record of Borehole sheets provided in Appendix B. The monitoring wells installed as part of the current investigation will be decommissioned by Thurber, as outlined in the Hydrogeological Investigation and Design Report.

Borehole SC7-2 was backfilled in accordance with MOE requirements (O.Reg 903, as amended) and capped with cold patch asphalt to reinstate the pavement surface

4 LABORATORY TESTING

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to testing for grain size distribution analysis and, where appropriate, Atterberg Limits in accordance with MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on a sample of the soil.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487 with the description of secondary components as outlined in the MTO Guideline for Foundation Engineering Services (GFES) Manual (April 2022) and the 4th Edition of the Canadian Foundation Engineering Manual.

In general, the encountered stratigraphy consists of silty sandy clay to silty sand fill over a native deposit of clayey silt to silty sand over marble bedrock.



5.1 Embankment Fill

5.1.1 Asphalt

Asphalt was encountered at the ground surface in the on-road borehole. The asphalt was measured to have a thickness of 50 mm.

5.1.2 Silty Sandy Clay Fill

A fill layer consisting of silty sandy clay fill was encountered at ground surface in Borehole SC7-1. Organics were noted in the upper 25 mm of the layer. The thickness of the layer was 0.9 m (base elevation at 142.8 m). The layer consistency is described as soft based on tactile evaluations of strength.

The moisture content of the two samples tested were 32% and 49%.

5.1.3 Silty Sand Fill

A fill layer consisting of silty sand with varying amounts of gravel was encountered below the silty sandy clay fill in Borehole SC7-1, below the asphalt in Borehole SC7-2, and at ground surface in Borehole SC7-3. Organics were noted in the layer in Borehole SC7-3. The thickness of the layer ranges from 0.2 to 4.6 m (base elevations ranging from 144.2 to 142.1 m). The SPT N-values ranged from 3 to 53, indicating a very loose to very dense condition.

The moisture content of the samples tested ranged from 3% to 31%. The results of grain size analyses conducted on two samples of this fill material are summarized below and are illustrated on Figure C1 in Appendix C.

Summary of Grain Size Distribution Testing – Silty Sand Fill

Soil Particle	Percentage (%)
Gravel	22 – 43
Sand	45 – 62
Silt & Clay	12 – 16

5.2 Clayey Silt (CL to CL-ML)

A native deposit of clayey silt was encountered below the silty sand fill in Boreholes SC7-1 and SC7-2. Varying amounts of sand were noted within the layer. The thickness of the layer ranged from 0.7 to 2.3 m (base elev. 141.4 to 139.9 m). The SPT N-values ranged from 2 to 8 blows, indicating a stiff consistency.

The moisture content of the samples tested ranged from 19 to 32%. The results of two grain size analysis tests conducted on samples of this material are summarized in the table below and are illustrated on Figure C2 in Appendix C.

Summary of Grain Size Distribution Testing – Clayey Silt

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	8 – 39
Silt	38 – 56
Clay	22 – 36

The results of Atterberg Limits testing carried out on two samples of this material are summarized below and are illustrated on Figure C3 in Appendix C. The laboratory results indicate that the clayey silt is of low plasticity (CL to CL-ML).

Summary of Atterberg Limit Testing – Clayey Silt

Parameter	Value
Liquid Limit	17 – 28
Plastic Limit	11 – 17
Plasticity Index	6 – 11

5.3 Silty Sand

A deposit of silty sand with varying amounts of gravel was encountered beneath the clayey silt in the Boreholes SC7-1 and SC7-2 and below the silty sand fill in Borehole SC7-3. Some clay was noted in the layer in Borehole SC7-3. The layer in Boreholes SC7-1, SC7-2, and the bottom 100 mm of Borehole SC7-3 were noted to be glacial till. The thickness of the layer ranged from 0.9 to 3.6 m (base elev. 140.6 to 139.0 m). The SPT N-values ranged from 2 to 82 blows, indicating a very loose to very dense relative density. Refusal blow counts were encountered at the base of the layer but are attributed to the bedrock surface. Although not observed within the boreholes, glacial till inherently contains cobbles and boulders.

The moisture content of the sample tested ranged from 7% to 18%. The results of gradation analyses completed on four samples of the layer are illustrated in Figure C4 of Appendix C. The results of the tests are summarized below and on the Record of Borehole sheets in Appendix B.

Summary of Grain Size Distribution Testing – Silty Sand

Soil Particle	Percentage (%)	
Gravel	3 – 23	
Sand	52 – 65	
Silt	22 – 27	18 – 28
Clay	6 – 10	

The results of Atterberg Limit testing conducted on the fines portion of a sample of the deposit from Borehole SC7-3 indicate a non-plastic material.

5.4 Bedrock

Bedrock was proven by coring in all boreholes. The depth to bedrock ranged from 3.8 to 6.7 m (elevation 140.6 to 139.0 m). The bedrock surface appears to slope down from the culvert inlet to the outlet.

The bedrock encountered consisted of fine to medium grained, grey, strong to very strong marble. Photographs of the bedrock cores are provided in Appendix C. The rock core quality measurements are summarized in the Table 5-1.

Table 5-1: Bedrock Details

Parameter	Range
Total Core Recovery (TCR), %	100
Solid Core Recovery (SCR), %	47 – 100
Rock Quality Designation (RQD), %	30 – 100
Fracture Index (fractures per 0.3 m) ⁽¹⁾	0 – >10
Unconfined Compressive Strength (MPa)	75 – 148

Notes: (1) Indicated as “FI” on Borehole Logs

The RQD values in both boreholes ranged from 30% to 100%, indicating a bedrock of poor to excellent quality (CFEM, 2023). The results of unconfined compressive strength tests (UCS) ranged from 75 MPa to 148 MPa, indicating that the tested samples of the bedrock are strong to very strong (CFEM, 2023). The UCS test results are included in Appendix C.

5.5 Groundwater

Monitoring wells with diameters of 50 mm were installed in Boreholes SC7-1 and SC7-3. Groundwater levels recorded in the wells are presented in Table 5-2.

Table 5-2: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
SC7-1	139.1	0.4	143.3	March 07, 2024
		0.5	143.2	March 22, 2024
		0.3	143.4	April 10, 2024
		0.6	143.1	April 24, 2024
		0.9	142.8	June 04, 2024
		0.5	143.2	June 25, 2024
		0.9	142.8	August 30, 2024
SC7-3	141.8	0.5	143.9	March 08, 2024
		1.0	143.4	March 22, 2024
		0.6	143.8	April 10, 2024
		0.8	143.6	April 24, 2024
		1.3	143.1	June 04, 2024
		0.8	143.6	June 25, 2024
		1.1	143.3	July 10, 2024
		1.2	143.2	August 30, 2024

Approximately 0.6 m of ponded water was present near the culvert inlet and outlet in July 2024.

These observations are considered short term as they were recorded at discrete times, and it should be noted that the groundwater level at the time of construction may be different. Seasonal fluctuations of the groundwater level are to be expected. Furthermore, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.6 Analytical Testing

One sample of the native silty clay was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity, and conductivity. The analysis results are summarized in Table 5-3. Copies of the test results are provided in Appendix C.

Table 5-3: Results of Chemical Analysis

Borehole	Sample	Depth (m)	Chloride (µg/g)	Sulphate (µg/g)	Sulphide (%)	pH (-)	Resistivity (Ohm-cm)
SC7-1	SS3A	1.5 – 1.8	194	215	0.69	7.11	1,470

6 MISCELLANEOUS

The borehole locations reflect existing site features and access constraints. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the



field program. Limitless Drilling Ltd. Renfrew, Ontario, supplied and operated the portable equipment, and George Downing Estate Drilling Ltd. of Hawkesbury, Ontario, supplied and operated the drill rigs used to drill, test, sample, and decommission the boreholes. Traffic control was performed in accordance with Ontario Book 7 and was provided by C&C Services of Renfrew, Ontario. The field investigation was supervised on a full-time basis by Mr. I. Khan, EIT, Mr. D. Amorim Pereira, Geotechnical Technician, and Mr. R. Howarth, Geotechnical Technician. Overall supervision of the field investigation program was provided by Mr. J. Gray, P.Eng.

Routine geotechnical laboratory testing were completed by Thurber's laboratory in Ottawa. UCS testing were completed by Thurber's laboratory in Oakville. Analytical testing was completed by Paracel Laboratories Ltd. in Ottawa.

Interpretation of the factual data and preparation of this report was completed by A. de Oliveira, P.Eng. The report was reviewed by Dr. F. Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:



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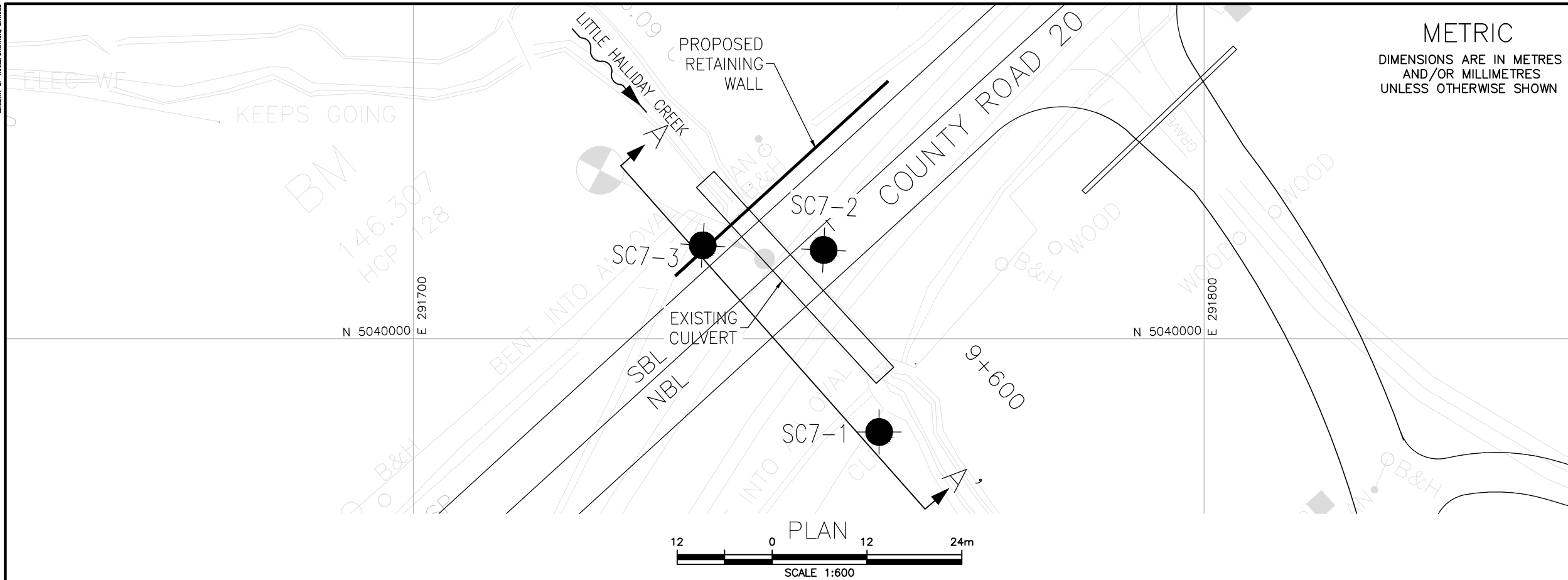


Dr. P.K. Chatterji, P.Eng.
Designated Principal Contact,
Principal, Senior Geotechnical Engineer



Appendix A.

Borehole Location Plan and Stratigraphic Drawings



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

CONT No
GWP No 4068-09-00

HIGHWAY 17 TWINNING
COUNTY ROAD 20, STATION 9+600
CULVERT 7AN
BOREHOLE LOCATION PLAN AND SOIL STRATA



SHEET
1

Ontario

THURBER



KEYPLAN

LEGEND

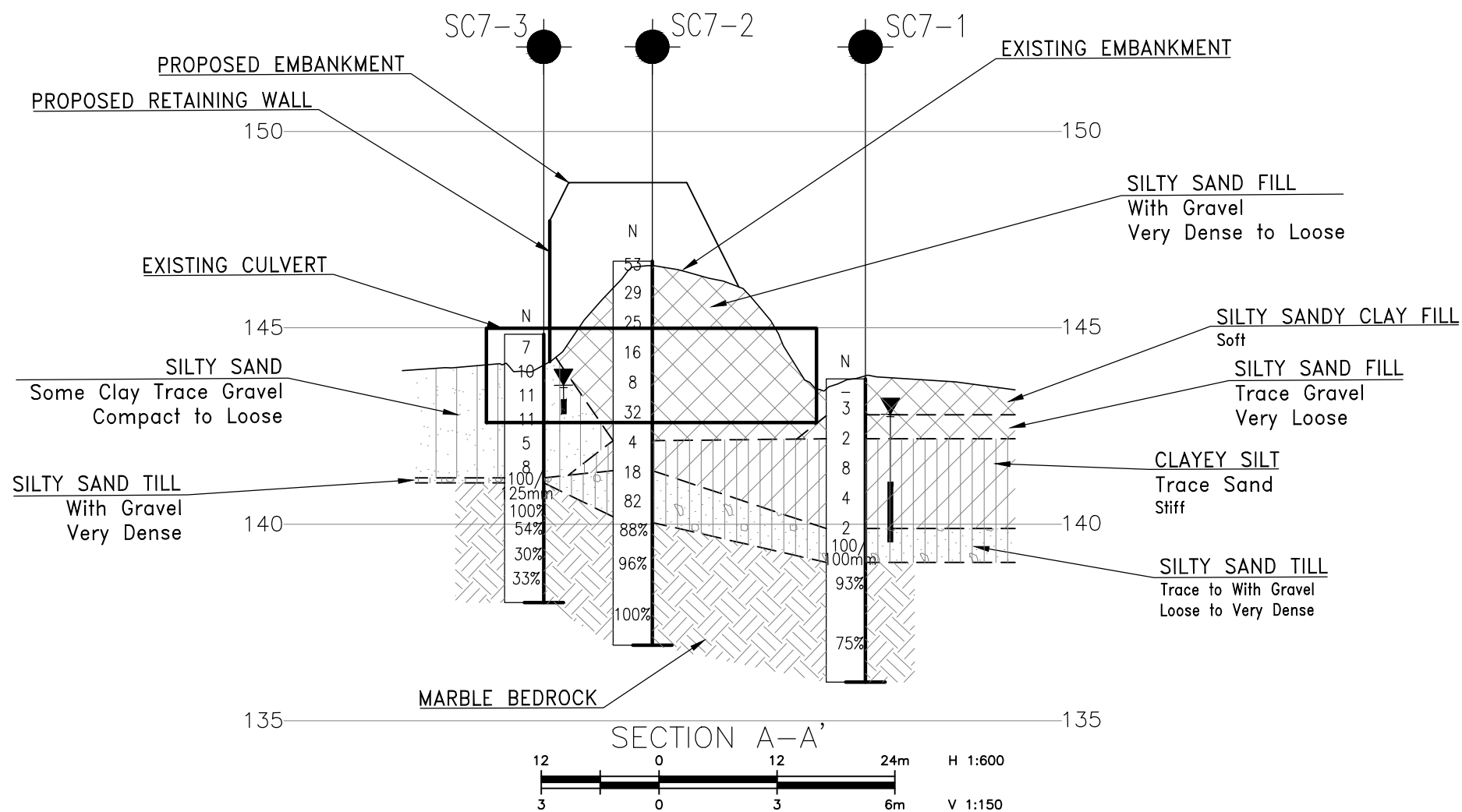
	Borehole
	Historic Borehole
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SC7-1	143.7	5 039 988.2	291 758.9
SC7-2	146.7	5 040 011.2	291 751.9
SC7-3	144.4	5 040 011.9	291 737.2

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31F07-002



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AO	CHK	CODE
DRAWN	RH	CHK	FG
LOAD	DATE	NOV 2024	
STRUCT	DWG	1	



Appendix B.

Record of Borehole Sheets



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT “N” Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No SC7-1

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.499694°, Long: -76.666871° Culvert 7AN; Horton Township; MTM z9: N 5 118 066.2 E 300 655.1 ORIGINATED BY RH
HWY 17 BOREHOLE TYPE CME 55 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2024.02.26 - 2024.02.26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
143.7	Ground Surface							20	40	60	80	100					
0.0	SILTY SANDY CLAY soft brown FILL - organics noted in the upper 25 mm of the layer		1	GS	-										o		
142.8															o		
0.9	SILTY SAND, trace gravel very loose grey FILL		2	SS	3										o		
142.2															o		
1.5	CLAYEY SILT (CL), trace sand stiff grey		3	SS	2										o		
															o		
			4	SS	8										o		
															o		
			5	SS	4										o		
139.9															o		
3.8	SILTY SAND, trace to with gravel very loose to very dense grey GLACIAL TILL		6	SS	2										o		
139.0			7	SS	100/										o		
4.7	MARBLE BEDROCK fresh jointed grey fine to medium grained strong		1	RUN	-	100mm											
			2	RUN	-												
136.0																	
7.7	End of Borehole																
	Monitoring Well installed: Schedule 40 PVC standpipe with 50-mm diameter and 1.5-m slotted screen. Stick-up cover installed at ground surface.																
	Water Level Readings: DATE DEPTH (m) ELEV. (m)																
	2024/03/07 0.4 143.3																
	2024/03/22 0.5 143.2																
	2024/04/10 0.3 143.4																
	2024/04/24 0.6 143.1																
	2024/06/04 0.9 142.8																
	2024/06/25 0.5 143.2																
	2024/08/30 0.9 142.8																

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

DOUBLE LINE 24726 CULVERT 7AN.GPJ 2012TEMPLATE(MTO).GDT 12-16-24

RECORD OF BOREHOLE No SC7-2

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.499901°, Long: -76.666962°
Culvert 7AN; Horton Township; MTM z9: N 5 118 072.5 E 300 646.5 ORIGINATED BY DAP
HWY 17 BOREHOLE TYPE CME 55 Truckmount / HSA / NW Casing / NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2024.03.18 - 2024.03.18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE									
146.7	Ground Surface																			
0.0	ASPHALT (50 mm)																			
0.8	SILTY SAND with gravel loose to very dense grey FILL		1	SS	53															
			2	SS	29															
			3	SS	25												22 62 16 (SI+CL)			
			4	SS	16															
			5	SS	8															
			6	SS	32												43 45 12 (SI+CL)			
142.1	Sandy CLAYEY SILT (CL-ML) stiff grey		7	SS	4												1 39 38 22			
141.4	SILTY SAND with gravel compact to very dense grey GLACIAL TILL		8	SS	18															
			9	SS	82												23 59 18 (SI+CL)			
140.0	MARBLE BEDROCK fresh jointed grey fine to medium grained very strong		1	RUN	-												RUN #1 TCR=100% SCR=66% RQD=88%			
			2	RUN	-												RUN #2 TCR=100% SCR=90% RQD=96% UCS=148MPa			
			3	RUN	-												RUN #3 TCR=100% SCR=100% RQD=100%			
136.9																				
9.8	End of Borehole																			

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

DOUBLE LINE 24726 CULVERT 7AN.GPJ 2012TEMPLATE(MTO).GDT 12-16-24

RECORD OF BOREHOLE No SC7-3

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.499907°, Long: -76.667149°
Culvert 7AN; Horton Township; MTM z9: N 5 118 064.1 E 300 651.8 ORIGINATED BY IK
HWY 17 BOREHOLE TYPE Portable / HW Casing / NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2024.03.07 - 2024.03.07 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
144.4	Ground Surface																
0.0	SILTY SAND with organics and gravel compact dark brown FILL		1	SS	7		144										20 52 28 (SI+CL)
143.5	SILTY SAND with gravel loose to compact brown		2	SS	10												
0.9	SILTY SAND, some clay trace gravel compact to loose grey		3	SS	11		143										
			4	SS	11		142										3 60 27 10 Non-plastic
			5	SS	5												
			6	SS	8		141										
140.7			7	SS	100/												
140.6	SILTY SAND with gravel very dense grey GLACIAL TILL		1	RUN	125mm												RUN #1 TCR=100% SCR=100% RQD=100%
3.8	MARBLE BEDROCK slightly weathered to fresh jointed grey fine to medium grained strong		2	RUN	-		140										RUN #2 TCR=100% SCR=63% RQD=54%
			3	RUN	-		139										RUN #3 TCR=100% SCR=53% RQD=30%
			4	RUN	-		138										RUN #4 TCR=100% SCR=47% RQD=33% UCS=75MPa
137.6	End of Borehole																
6.8	Monitoring Well installed: Schedule 40 PVC standpipe with 50-mm diameter and 1.5-m slotted screen. Stick-up cover installed at ground surface. Water Level Readings: DATE DEPTH (m) ELEV. (m) 2024/03/08 0.5 143.9 2024/03/22 1.0 143.4 2024/04/10 0.6 143.8 2024/04/24 0.8 143.6 2024/06/04 1.3 143.1 2024/06/25 0.8 143.6 2024/07/10 1.1 143.3 2024/08/30 1.2 143.2																

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



Appendix C.

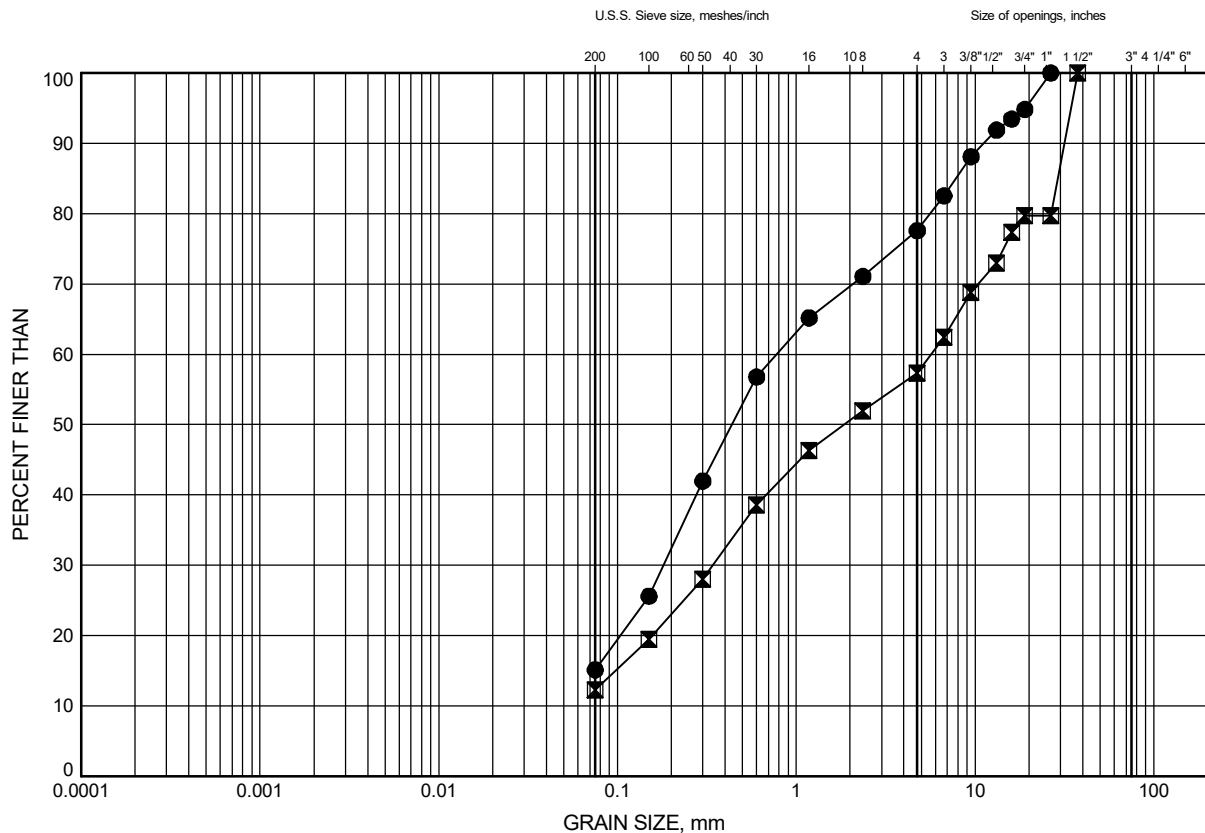
Laboratory Testing



Appendix C.1
Particle Size Analysis Figures
Atterberg Limit Test Results
Unconfined Compressive Strength Testing Results
Rock Core Photos

GRAIN SIZE DISTRIBUTION

FILL: Silty Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC7-2	1.8	144.9
⊠	SC7-2	4.1	142.6

Date August 2024

WP# 4068-09-00

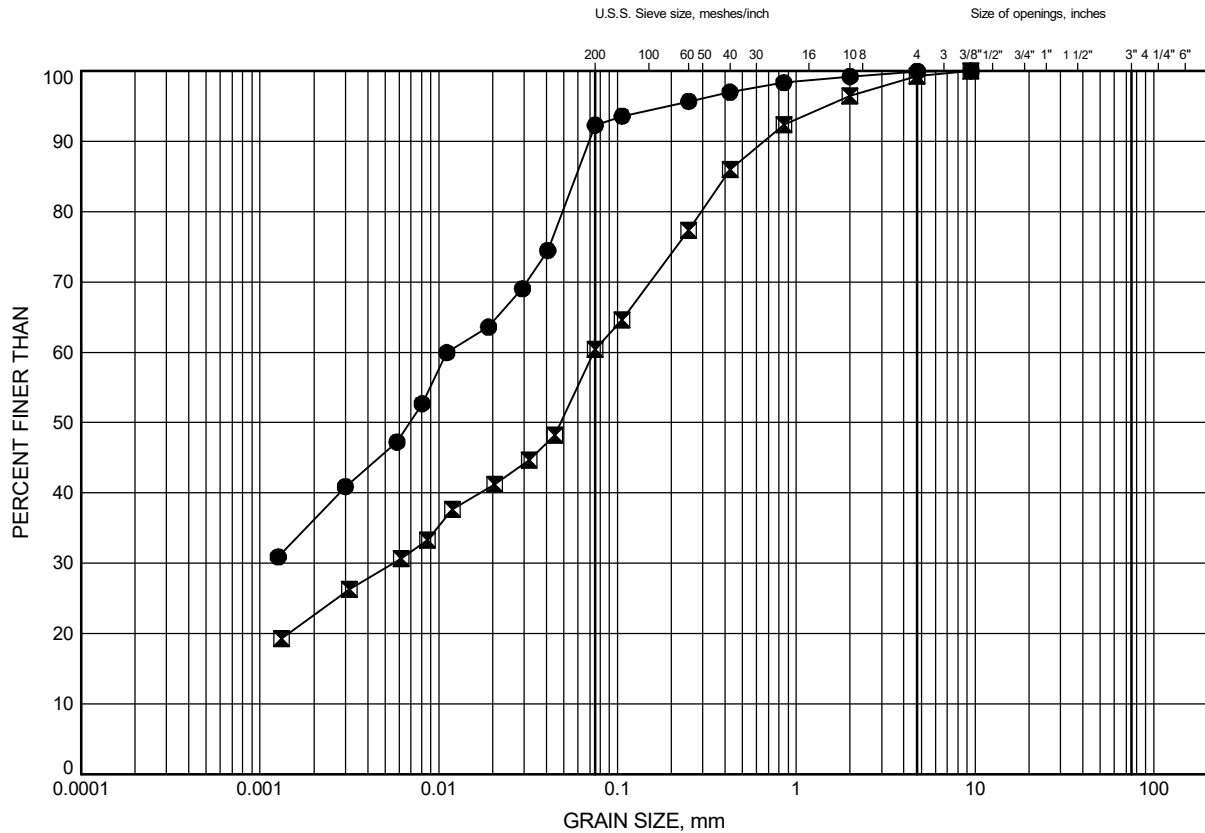


Prep'd RH

Chkd. AO

GRAIN SIZE DISTRIBUTION

Clayey Silt (CL to CL-ML)



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC7-1	2.0	141.7
⊠	SC7-2	4.9	141.8

Date August 2024

WP# 4068-09-00

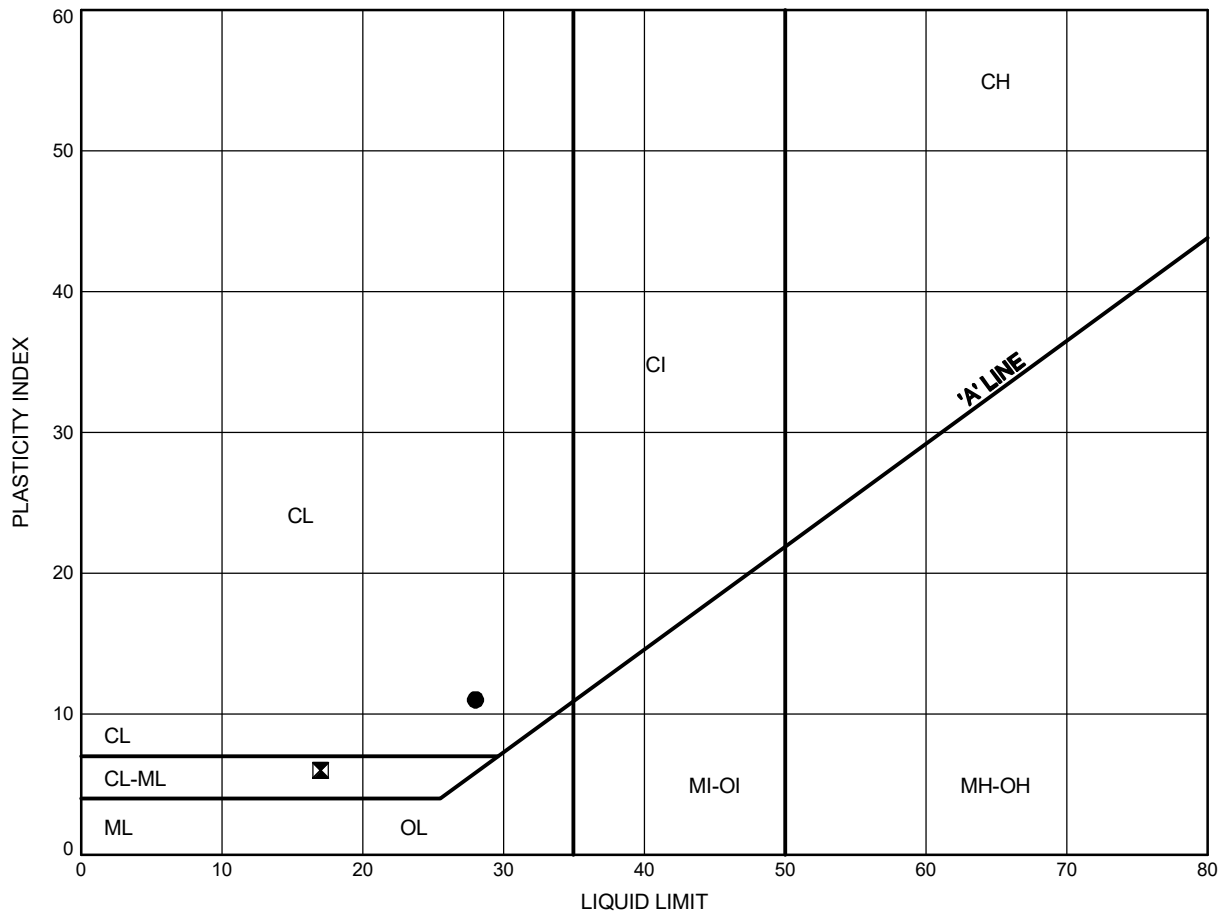


Prep'd RH

Chkd. AO

ATTERBERG LIMITS TEST RESULTS

Clayey Silt (CL to CL-ML)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC7-1	2.0	141.7
⊠	SC7-2	4.9	141.8

Date August 2024

WP# 4068-09-00

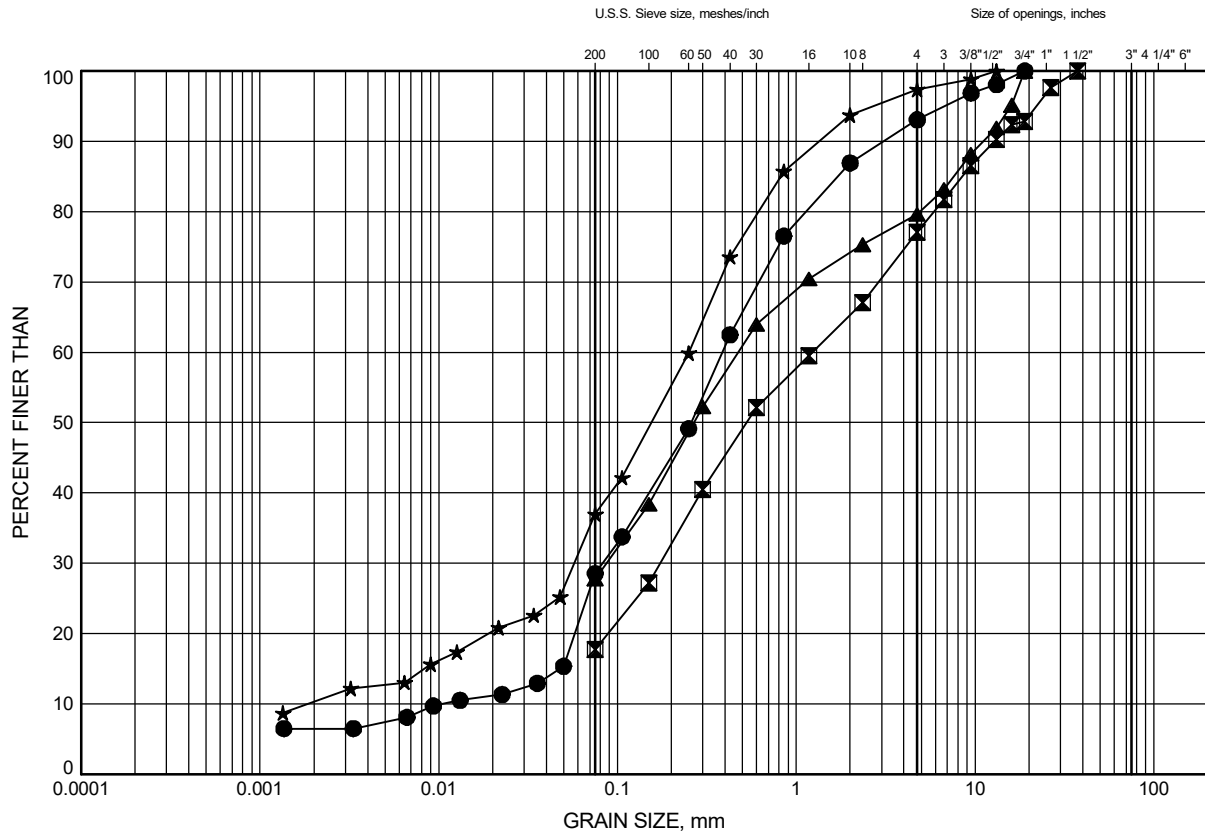


Prep'd RH

Chkd. AO

GRAIN SIZE DISTRIBUTION

Silty Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC7-1	4.1	139.6
⊠	SC7-2	6.4	140.3
▲	SC7-3	0.4	144.0
★	SC7-3	2.1	142.3

Date August 2024

WP# 4068-09-00



Prep'd RH

Chkd. AO

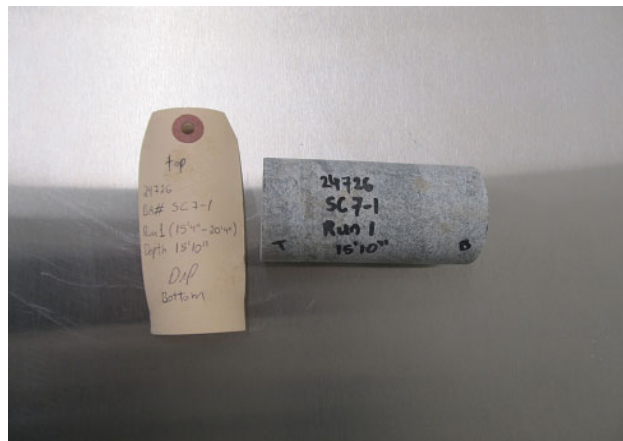
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

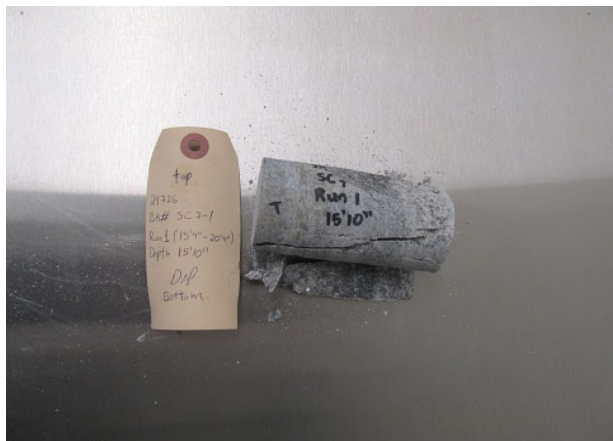
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	10-Jul-24
BOREHOLE No.:	SC7-1	TEST DATE:	9-May-24
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	4.83 m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.5	Weight (g):	448.0
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,718
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,718
Cross Sectional Area (cm ²):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm ³):	164.82		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	135.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	78.1 MPa

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

TEST DONE BY: GF
 REVIEWED BY: WM

UCS SC7-1 Run 1

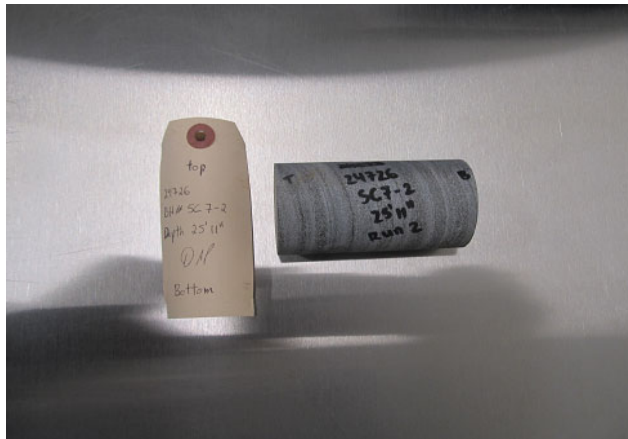
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

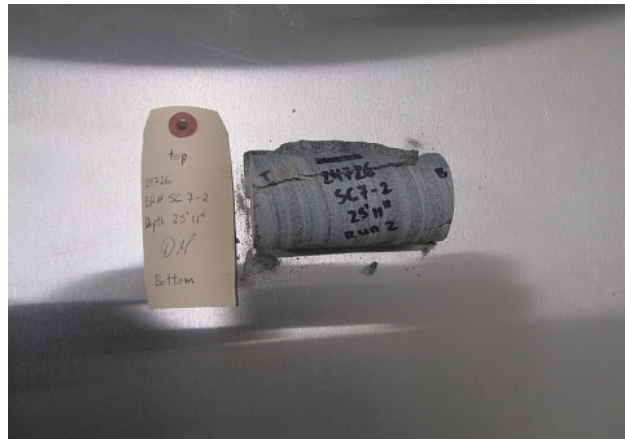
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	10-Jul-24
BOREHOLE No.:	SC7-2	TEST DATE:	9-May-24
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	7.90 m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.5	Weight (g):	453.7
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,753
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,753
Cross Sectional Area (cm ²):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm ³):	164.82		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	257.3 kN
UNCONFINED COMPRESSIVE STRENGTH:	148.3 MPa

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

TEST DONE BY: GF
 REVIEWED BY: WM

UCS SC7-2 Run 2

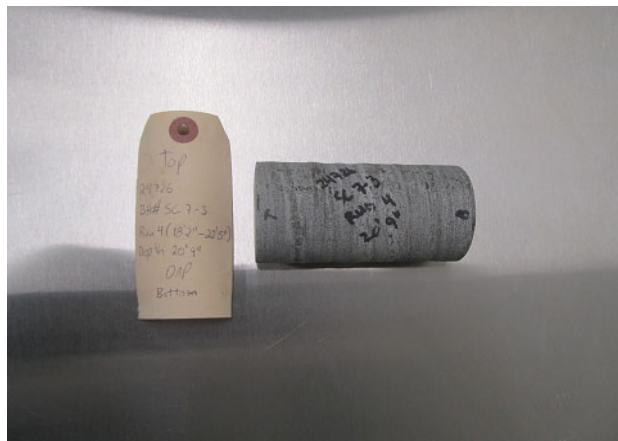
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	10-Jul-24
BOREHOLE No.:	SC7-3	TEST DATE:	9-May-24
SAMPLE No.:	Run 4		
SAMPLE DEPTH:	6.32 m		
DESCRIPTION:	Marble		

Avg. Height (cm):	10.0	Weight (g):	521.6
Avg. Diameter (cm):	5.0	Wet Density (kg/m ³):	2,656
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,656
Cross Sectional Area (cm ²):	19.63	Moisture Content* (%):	N/A
Sample Volume (cm ³):	196.35		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	147.6 kN
UNCONFINED COMPRESSIVE STRENGTH:	75.2 MPa

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

TEST DONE BY: GF
 REVIEWED BY: WM

UCS SC7-3 Run 4

Borehole SC7-1

Run 1 and 2

Depth 4.7 to 7.7 m

Elevation 139.0 to 136.0 m

Dry Sample

Run 1 Start
elev. 139.0 m

Run 1 End
elev. 137.5 m



Run 2 Start
elev. 137.5 m

Run 2 End
elev. 136.0 m



THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 7AN (County Road 20, Sta. 9+600)
Renfrew, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole SC7-1
Run 1 and 2
Depth 4.7 to 7.7 m
Elevation 139.0 to 136.0 m
Wet Sample

Run 1 Start
elev. 139.0 m

Run 1 End
elev. 137.5 m



Run 2 Start
elev. 137.5 m

Run 2 End
elev. 136.0 m

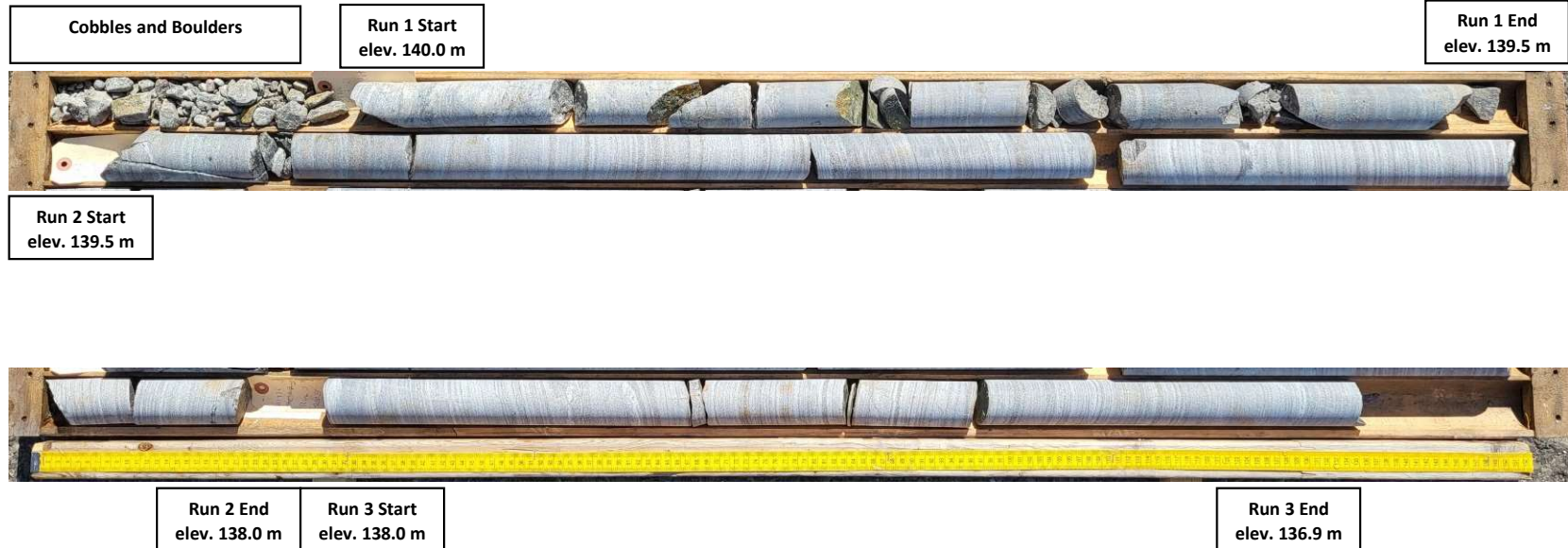
Borehole SC7-2

Run 1, 2, and 3

Depth 6.7 to 9.8 m

Elevation 140.0 to 136.9 m

Dry Sample



THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 7AN (County Road 20, Sta. 9+600)
Renfrew, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole SC7-2

Run 1, 2, and 3

Depth 6.7 to 9.8 m

Elevation 140.0 to 136.9 m

Wet Sample

Cobbles and Boulders

Run 1 Start
elev. 140.0 m

Run 1 End
elev. 139.5 m



Run 2 Start
elev. 139.5 m



Run 2 End
elev. 138.0 m

Run 3 Start
elev. 138.0 m

Run 3 End
elev. 136.9 m



THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 7AN (County Road 20, Sta. 9+600)
Renfrew, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole SC7-3
Run 1, 2, 3 and 4
Depth 3.8 to 6.8 m
Elevation 140.6 to 137.6 m
Dry Sample

Run 1 Start elev. 140.6 m	Run 1 End elev. 140.5 m	Run 2 Start elev. 140.5 m
------------------------------	----------------------------	------------------------------

Run 2 End elev. 139.6 m	Run 3 Start elev. 139.6 m
----------------------------	------------------------------



Run 3 End elev. 138.9 m	Run 4 Start elev. 138.9 m
----------------------------	------------------------------

Run 4 End elev. 137.6 m

Borehole SC7-3
Run 1, 2, 3 and 4
Depth 3.8 to 6.8 m
Elevation 140.6 to 137.6 m
Wet Sample

Run 1 Start elev. 140.6 m	Run 1 End elev. 140.5 m	Run 2 Start elev. 140.5 m
------------------------------	----------------------------	------------------------------

Run 2 End elev. 139.6 m	Run 3 Start elev. 139.6 m
----------------------------	------------------------------



Run 3 End elev. 138.9 m	Run 4 Start elev. 138.9 m
----------------------------	------------------------------

Run 4 End elev. 137.6 m



Appendix C.2

Analytical Testing Results

Certificate of Analysis

Report Date: 11-Mar-2024

Client: Thurber Engineering Ltd.

Order Date: 5-Mar-2024

Client PO: Culvert 105 and Culvert 7

Project Description: 24726 task 700.706a

Client ID:	SC105-2 SS#2 2'6"-4'6"	SC7-1 SS#3A 5'-6'	-	-	
Sample Date:	28-Feb-24 09:00	26-Feb-24 15:00	-	-	-
Sample ID:	2410180-01	2410180-02	-	-	-
Matrix:	Soil	Soil	-	-	-
MDL/Units					

Physical Characteristics

% Solids	0.1 % by Wt.	87.5	76.1	-	-	-	-
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General Inorganics

Conductivity	5 uS/cm	90	679	-	-	-	-
pH	0.05 pH Units	7.24	7.11	-	-	-	-
Resistivity	0.1 Ohm.m	111	14.7	-	-	-	-

Anions

Chloride	10 ug/g	<10	194	-	-	-	-
Sulphate	10 ug/g	<10	215	-	-	-	-

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax: 613-731-9064

12-March-2024

Date Rec. : 07 March 2024
LR Report: CA13227-MAR24
Reference: Project#: 2410180

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide (Na ₂ CO ₃) %
1: Analysis Start Date		12-Mar-24
2: Analysis Start Time		07:24
3: Analysis Completed Date		12-Mar-24
4: Analysis Completed Time		09:03
5: RL		0.01
6: SC105-2 SS#2 2'-6" 4'-8"	28-Feb-24 09:00	< 0.01
7: SC7-1 SS#3A 5'-6'	26-Feb-24 15:00	0.69

RL - SGS Reporting Limit

Method Descriptions

Parameter	Description	SGS Method Code
Sulphide (Na ₂ CO ₃)	Sulphide by ECS	ME-CA-[ENV]ARD-LAK-AN-020

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety



Appendix D.

Site Photographs



Photo 1. Looking east along north embankment and culvert inlet (April 24, 2024)



Photo 2. Looking south at culvert outlet (March 22, 2024)



**Photo 3. Looking northeast along south embankment and culvert outlet
(April 24, 2024)**



Photo 4. Looking west along north embankment (March 22, 2024)



Photo 5. Looking east along County Road 20 eastbound (March 18, 2024)