FINAL REPORT

Foundation Investigation Report

Replacement of Pottery Creek Culvert (Site No. 11X-0422/C0)
Highway 401 from 1 km West of Wallbridge-Loyalist Road to 4.3 km East of Highway 37, Belleville, Ontario
GWP 4053-18-00, WP 4096-20-01, Agreement 4020-E-0012

Submitted to:

Ministry of Transportation Ontario
1355 John Counter Boulevard
Kingston, Ontario K7K 0E5

Submitted by:

WSP Canada Inc.
1931 Robertson Road, Ottawa, Ontario K2M 2J1

GEOCRES No.: 31C-317
Latitude: 44.179013°;
Longitude: -77.450220°

20148061B (4000)-P3

August 23, 2024

Distribution List

1 e-copy: MTO Eastern Region

1 e-copy: MTO Foundations Section

1 e-copy: WSP Canada Inc.

Table of Contents

APPENDICES

1.0 INTRODUCTION

WSP Canada Inc. (WSP, formerly Golder Associates Ltd., amalgamated with WSP in 2023) has been retained by the Ministry of Transportation, Ontario (MTO) to support future procurement-ready design phases of the widening of Highway 401 from 1 km west of Wallbridge-Loyalist Road to 4.3 km east of Highway 37 in Belleville, Ontario as part of GWP 4097-20-01, delivered under MTO Agreement No. 4020-E-0012. The overall project includes the replacement of six bridges, several structural and non-structural culverts, and operational improvements and reconfiguration of existing interchanges.

This report presents the results of the detailed foundation investigation carried out for the replacement of the Potter Creek Tributary Culvert 11X-0422/C0 (WP 4096-20-01) under Highway 401 to the west of the Highway 401 / Wallbridge-Loyalist Road interchange.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 Site Description

Culvert 11X-0422/C0 is to be located approximately 250 m west of Highway 401 / Wallbridge-Loyalist Road passing under both the eastbound and westbound lanes of Highway 401 in Belleville, Ontario. The site location is shown on Drawing 1.

At this location, Highway 401 has a four-lane cross-section with two eastbound and two westbound through lanes with paved shoulders separated by a concrete median wall. Steel beam guiderails are also present along both sides of the highway in the vicinity of the proposed culvert. The existing interchange includes a westbound onramp (existing N/S-E Ramp) and an eastbound offramp (existing W-N/S) at Wallbridge-Loyalist Road. Wallbridge-Loyalist Road is an undivided road with a single travel lane in each direction. Steel beam guiderails are present along both side of Wallbridge-Loyalist Road in the vicinity of the underpass structure.

Site photographs showing the general conditions of the site are presented in Appendix D.

2.2 Regional Geology

As delineated in *The Physiography of Southern Ontario*[1], the proposed culvert site lies within a physiographic region known as the Napanee Plain which is characterized as a flat-to-undulating plain of limestone of the Gull River and Bobcaygeon Formations overlain by glacially worked thin overburden deposits.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on September 14, October 3, and October 16, 2022, and included advancing three boreholes, numbered C-06 to C-08. The borehole locations are shown on Drawing 1.

Borehole C-06 was advanced using portable rotary drilling equipment employing a full-weight (63.5 kg) hammer dropped from the Standard Penetration Test (SPT) height. Boreholes C-07 and C-08 were advanced using a CME55 truck-mounted drill rig and a CME55 rubber track-mounted drill rig respectively. The drilling equipment was supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. (CCC) of Ottawa, Ontario.

[1] 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

Soil samples were obtained using a 50 mm outer diameter split-spoon sampler in general accordance with the SPT procedure (ASTM D1586[2]). At Boreholes C-07 and C-08, soil samples were obtained at vertical sampling intervals of about 0.76 m. Soil samples from the portable drilling equipment were obtained in continuous vertical increments of about 0.6 m. NQ-sized bedrock core samples were recovered with a triple-tube core-barrel drilling technique at Borehole C-08 and using a BW size thin-wall core barrel at Borehole C-06.

A methane pocket was encountered during bedrock coring at Borehole C-06 at an approximate depth of 5.0 m (Elev. 94.5 m). Methane concentrations above the lower explosive level were measured at the site using an RKI Model GX-2012, 4-Gas Monitor. After discussion with MTO Foundations Section, as a safety precaution no further bedrock coring was carried out at this site. Based on the methane encountered in this borehole and in other boreholes near this site, it should be expected that methane could be encountered during excavation/construction activities at elevations near or within the bedrock, throughout the project limits.

A monitoring well was installed at Borehole C-08, to observe the groundwater level at the site. The monitoring well consists of a 52 mm outside diameter PVC tube with a 1.5 m long slotted screen. Installation details are shown on the record for Borehole C-08 provided in Appendix A.

The boreholes without a monitoring well were backfilled with bentonite within the bedrock, and bentonite mixed with soil cuttings within the overburden. The boreholes were backfilled in general accordance with the intent of Ontario Regulation (O.Reg.) 903, as amended. The site conditions were restored following the completion of the fieldwork. The monitoring well has been left in place to allow for the monitoring of groundwater levels as part of the future design-build assignment up to the time of construction. As part of the construction, the monitoring well will need to be decommissioned by qualified personnel in accordance with Ontario Regulation 903 (amended).

The field work was supervised on a full-time basis by members of WSP's technical staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil and bedrock samples were identified in the field, placed in labelled containers, and transported to WSP's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses, and Atterberg limits testing were carried out on selected soil samples and uniaxial compressive strength (UCS) testing was carried out on a selected sample of the bedrock. The laboratory tests were carried out to MTO LS and/or ASTM Standards, as applicable at WSP's Ottawa laboratory.

One soil sample was sent to Eurofins Environmental Testing Canada Inc. (Eurofins) for basic chemical analysis related to the potential corrosion of buried steel elements and sulfate attack on buried concrete elements (corrosion and sulphate attack).

The borehole locations and elevations were surveyed by WSP using a Trimble R10 GPS unit referenced to the NAD83 CSRS CBNv6-2010.0 MTM Zone 9 geodetic datum. The borehole locations, including northing and easting coordinates as well as geographic coordinates, ground surface elevations, and drilled depths are summarized in Table 1.

[2] ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Table 1: Summary of Borehole Locations

Borehole	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Drilled Depth (m)	Comments
	Northing (m) (Latitude)	Easting (m) (Longitude)			
C-06	4893640.0 (44.178810°)	228836.2 (-77.450060°)	99.5	5.3	Bedrock Cored
C-07	4893661.9 (44.179013°)	228823.7 (-77.450220°)	102.4	5.8	Auger Refusal
C-08	4893694.6 (44.179300°)	228810.4 (-77.450390°)	100.9	7.3	Bedrock Cored

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ testing from the investigation are shown on the borehole and drillhole records presented in Appendix A. Photographs of the core recovered from the underlying bedrock at the boreholes are shown on Figures A1 to A4, also provided in Appendix A. The results of the in-situ field tests as presented in the borehole records and in Section 4, are uncorrected and are based on the use of an automatic hammer for the SPT. The results of the geotechnical laboratory testing carried out during the investigation are presented on the borehole records as well as on Figures B1 to B6 in Appendix B. The results of the analytical testing completed on select soil samples are provided in Appendix C.

The borehole locations and the interpreted stratigraphic profile projected along the proposed culvert alignment are provided in Drawing 1.

The stratigraphic boundaries shown on the borehole and drillhole records and on the interpreted stratigraphic section in Drawing 1 are inferred from observations of the drilling progress together with continuous soil sampling and may represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

At the boreholes the subsurface conditions consist of topsoil or asphalt surface cover, over a sand fill over a native stiff to very stiff clay, and over a compact to very dense glacial till, all underlain by limestone bedrock. A more detailed description of the overburdened soil deposits, and bedrock geology conditions encountered during the field investigation is provided in the following sections.

4.1.1 Surface Cover/ Surficial Materials

Topsoil with thickness of approximately 200 mm and 100 mm was encountered at the surface of Boreholes C-06 and C-08 respectively.

Asphalt concrete with a thickness of approximately 200 mm was encountered at the surface of Borehole C-07, which was drilled through the median of Highway 401.

4.1.2 Fill

Fill consisting of silty sand with varying amounts of gravel and clay was encountered below the asphalt at Borehole C-07 and below the topsoil at Borehole C-08. The top of this layer was encountered at elevations of 102.5 m and 100.8 m with a thickness of 1.5 m and 1.4 m at Boreholes C-07 and C-08 respectively.

The SPT N-values recorded in the fill range from 4 to 30 blows per 0.3 m of penetration indicating a loose to dense state of compactness. The measured moisture content of a single sample of the fill material was 6%. The results of grain size analysis testing carried out on a single sample of this material are illustrated in Figure B1 in Appendix B.

4.1.3 Clay (CH) to Silty Clay (CI)

A clay to silty clay deposit was encountered beneath the topsoil layer at Borehole C-06 and below the fill layers at Boreholes C-07 and C-08. The top of this layer was encountered at elevations ranging from 99.3 m to 101.0 m. The thickness of this layer ranges from about 1.2 m to 2.9 m. The SPT N-values recorded in this layer range from 9 to 19 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency; one SPT N-value of 2 blows per 0.3 m was encountered immediately below the topsoil in Borehole C-06.

The results of grain size analysis testing carried out on four samples of this material are illustrated in Figure B2 in Appendix B. The results of Atterberg limits testing completed on four samples of this deposit indicate liquid limits ranging from 37 to 70, plastic limits ranging from 18 to 29 and plasticity indices ranging from 19 to 42, as shown on Figure B3 in Appendix B. These Atterberg limits testing results indicate a clay of high plasticity (CH) to a silty clay of medium plasticity (CI). The water contents of eleven tested samples of the clay range from 23% to 31%, near or slightly above the plastic limit of the material.

4.1.4 Glacial Till

A glacial till deposit generally consisting of a soil matrix of gravelly sand and silt, containing cobbles and boulders, was encountered below the clay deposit in all boreholes. In Boreholes C-06 and C-08, a layer of cobbles and boulders was encountered at the base of this till immediately above the bedrock surface. The top of this layer was encountered at elevations ranging from 97.9 m to 98.1 m. The total thickness of this layer where fully penetrated ranges from about 1.1 m to 1.8 m. Borehole C-07 was terminated in this layer at auger refusal.

The SPT N-values recorded in this layer range from 10 to greater than 100 blows but more typically 28 to 43 blows per 0.3 m of penetration, indicating a compact to dense state of compactness. The higher blow counts (e.g., 71/230 mm) recorded in the till may have been influenced by the presence of cobbles or boulders within the till or the bedrock surface, rather than the consistency of the soil matrix.

The results of grain size analysis testing carried out on two samples of this material are provided in Figure B4 in Appendix B. The results of Atterberg limits testing completed on two samples of the fines portion of this material indicate liquid limits of 15 and 16, a plastic limit of 11, and plasticity indices of 4 and 5, as shown on Figure B5 in Appendix B. These Atterberg limits testing results indicate that the fines portion of the till is silt of low plasticity (ML) to a clayey silt-silt (CL-ML). The measured water content of two samples of the till was 6% and 7%, below the plastic limit for the material.

4.1.5 Limestone Bedrock

The overburden soils are underlain by limestone bedrock. NQ-sized bedrock core samples were recovered with an NQ triple-tube core-barrel at the drilling technique at Borehole C-08 and using a BW size thin-wall core barrel at the portable Borehole C-06.

A methane pocket was encountered during bedrock coring at Borehole C-06 at an approximate depth of 5.0 m (Elevation 94.5 m). Methane concentrations above the lower explosive level (LEL) were measured at the top of the borehole casing using an RKI Model GX-2012, 4-Gas Monitor. It should be expected that methane could be encountered within the bedrock if any protection system installation, excavation, or other construction activities extend to this level.

Table 2 summarizes the depths and the elevations of the bedrock surface/refusal as encountered at the borehole locations.

Table 2: Summary of Bedrock Surface Depths and Elevations

Borehole	Existing Ground Surface Elevation (m)	Depth to Bedrock Surface (m)	Bedrock Surface/ Refusal Elevation (m)
C-06	99.5	3.2	96.3[1]
C-07	102.7	5.8	96.9[2]
C-08	100.9	4.2	96.7[1]

Note(s): 1. Bedrock surface elevation confirmed by bedrock coring.
2. Due to the presence of methane in the bedrock, after discussion with MTO Foundations Section, as a safety precaution bedrock coring was not carried out at Borehole C-07 and the borehole was terminated at auger refusal.

Rock Quality Designation (RQD) values measured on the recovered limestone bedrock core samples at Boreholes C-06 and C-08 ranged from about 48% to 97% indicating a poor to excellent rock quality. The results of uniaxial compressive strength (UCS) testing carried out on two bedrock core samples gave a UCS value of 85 MPa and 102 MPa, indicating a strong to very strong bedrock. The results of UCS testing are provided on Figure B6 in Appendix B.

4.2 Groundwater Condition

A monitoring well was installed at Borehole C-08 to measure the groundwater level at the site. The groundwater levels measured in the monitoring well are presented in Table 3.

It is expected that the groundwater levels will be subject to fluctuations both seasonally and as a result of precipitation events. In addition to the groundwater level as measured within the glacial till deposit, perched groundwater should be expected at the base of non-cohesive fills where encountered, atop the underlying lower-permeability native soils.

Table 3: Summary of Groundwater Conditions

Borehole	Screened Interval	Ground Surface Elevation (m)	Groundwater Depth (m)	Ground Water Elevation (m)	Date
C-08	Glacial Till	100.9	0.6	100.3	September 20, 2022
			1.7	99.2	December 14, 2022
			0.4	100.5	February 27, 2024

4.3 Analytical Laboratory Testing Results

One soil sample was submitted to Eurofins for chemical testing/analysis related to the 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 C and are summarized in Table 4.

Table 4: Steel Corrosion and Sulphate Attack, Chemical Analysis

Borehole	Sample Depth (m)	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
C-08	2.3-2.9	0.009	0.02	0.3	8.5	3,330

5.0 CLOSURE

This report was prepared by Ben Waechter, EIT, and reviewed by Kenton Power, P.Eng., a Senior Geotechnical Engineer with WSP. Lisa Coyne, P.Eng., a Geotechnical Engineering Fellow and MTO Principal Foundations Contact for WSP conducted an independent technical and quality review of this report.

WSP Canada Inc.

Kenton Power, P.Eng.
Senior Geotechnical Engineer

Lisa Coyne, P.Eng.
MTO Principal Foundations Contact

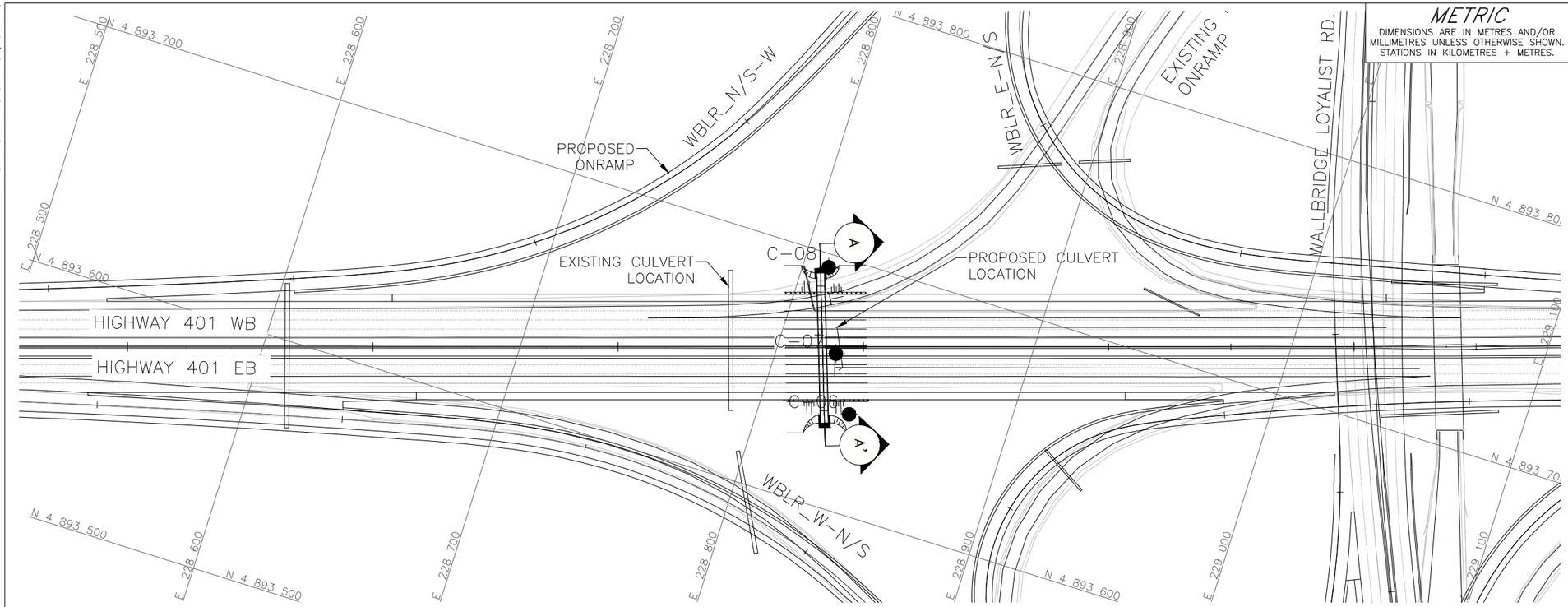
BW/KCP/LCC/yj

https://wsponline.sharepoint.com/sites/gld-152692/project files/6 deliverables/02-culvert p3/2-final/gwp 4053-18-00 rev0 fir culvert 11x-0422 (21480618b-p3) 2024-08-09.docx

DRAWING

Drawing 1 – Borehole Locations and Soil Strata

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
20 0 20 40 m

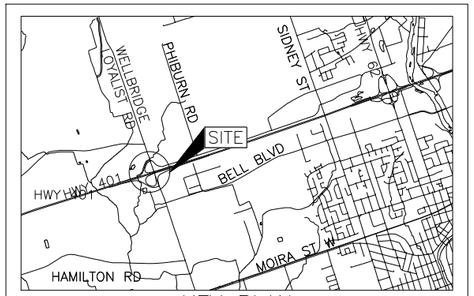
METRIC

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

CONT No.
WP No. 4096-20-01

HIGHWAY 401 WIDENING
REPLACEMENT OF CULVERT 11X-0422/CO
BOREHOLE LOCATIONS AND SOIL STRATA

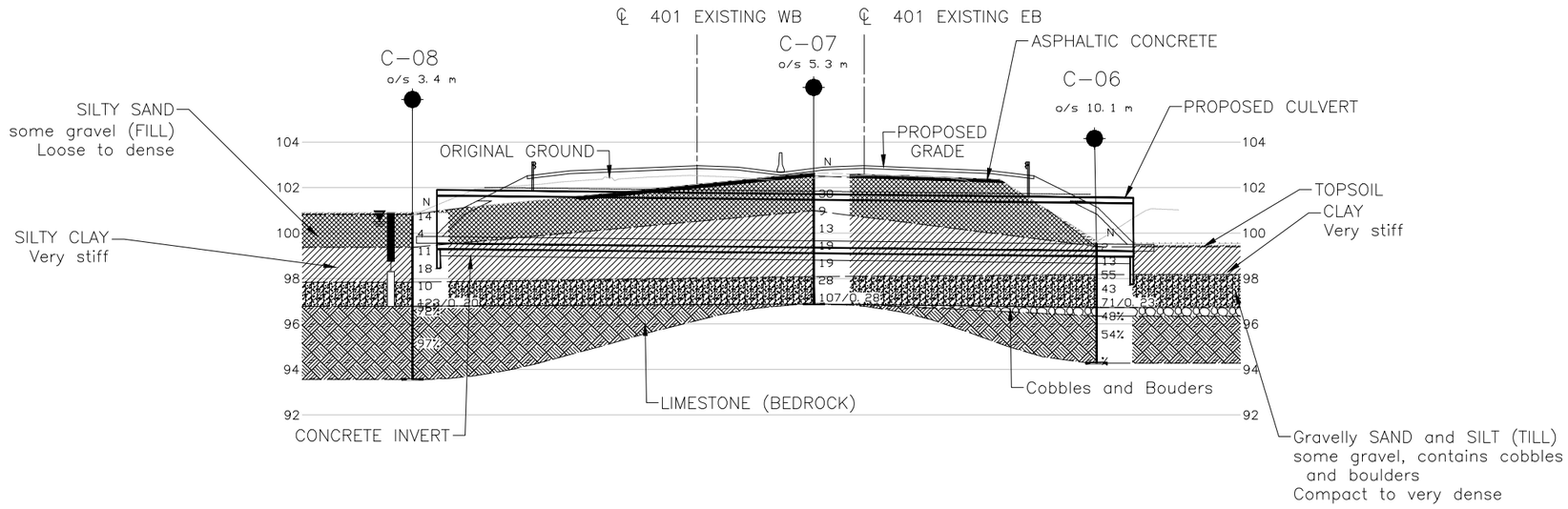
SHEET



KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on February 27, 2024



SECTION
SCALE
5 0 5 10 m

L.C. COYNE
LICENSED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO
Aug. 23, 2024

K.T.C. POWER
100130652
LICENSED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO
Aug. 23, 2024

BOREHOLE CO-ORDINATES NAD83 (CSRS) MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
C-06	99.5	4893640.0	228836.2
C-07	102.4	4893661.9	228823.7
C-08	100.9	4893694.6	228810.4

Structural Site Location: Latitude: 44.179013 Longitude: -77.45022

NOTES

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 Procurement-Ready Design Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by MTO, drawing file nos 3216057_EP.dwg and 3216057_Hwy 401 _8 Lanes Design_ACAD.dwg, received Oct. 13 2022.
General arrangement provided in digital format by WSP, drawing file no. S16M-01435-01-354-001GA.dwg, received April 11, 2024.

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31C-317

HWY. 401	PROJECT NO. 20148061B		DIST. EASTERN
SUBM'D. BW	CHKD. KCP	DATE: 8/23/2024	SITE: 11X-0422/C0
DRAWN: ZS/SA	CHKD. KCP	APPD. LCC	DWG. 1

PLOT DATE: August 23, 2024
FILENAME: S:\Clients\MTO\Hwy_401_Belleville\WB_PROJ\20148061B\VID_PROD\0001_Culvert_PT\20148061B-0001-BD-0001.dwg

APPENDIX A

Borehole Records and Bedrock Core Photographs

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS
MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (*i.e.,* SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (*i.e.,* some sand)
≤ 10	trace (*i.e.,* trace fines)

1. Only applicable to components not described by Primary Group Name.
2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve friction (f_s) are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	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
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

COARSE-GRAINED SOILS

Compactness[1]

Term	SPT 'N' (blows/0.3m)[2]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

1. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
2. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	< 12	0 to 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	> 200	> 30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ. where $\gamma = \rho \cdot g$ (i.e., mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_L or LL	liquid limit
w_P or PL	plastic limit
I_P or PI	plasticity index = $(w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
$C_{\alpha(e)}$	secondary compression index
C_α	rate of secondary compression
$C_{\alpha(\varepsilon)}$	modified secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
c′	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q or q'	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING CLASSIFICATION

Fresh (W1): no visible sign of rock material weathering.

Slightly Weathered (W2): discoloration indicates weathering of rock mass material on discontinuity surfaces. **Less than 5%** of rock mass is altered or weathered.

Moderately Weathered (W3): less than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Highly Weathered (W4): more than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Completely Weathered (W5): 100% of the rock mass is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact.

Residual Soil (W6): all rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

AXJ Axial Joint
BD Bedding
BC Broken Core
CC Continuous Core
CL Closed
CO Contact
CU Curved
CT Coated
FLT Fault
FOL Foliation
FR Fracture
GO Gouge
IN Infilled
IR Irregular
JN Joint
KV Karstic Void
K Slickensided
LC Lost Core
MB Mechanical Break
PL Planar
PO Polished
RO Rough
SA Slightly Altered
SH Shear
SM Smooth
SR Slightly Rough
SY Stylolite
UN Undulating
VN Vein
VR Very Rough

ISRM Intact Rock Material Strength Classification

Grade	Description	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak rock	0.25 – 1.0
R1	Very weak rock	1.0 – 5.0
R2	Weak rock	5.0 – 25
R3	Medium strong rock	25 – 50
R4	Strong rock	50 -100
R5	Very strong rock	100 -250
R6	Extremely strong rock	>250

PROJECT 20148061B

RECORD OF BOREHOLE No C-06

SHEET 1 OF 2

METRIC

G.W.P. 4096-20-01 LOCATION N 4893640.0; E 228836.2 MTM NAD 83 ZONE 9 (LAT. 44.178810; LONG. -77.450060) ORIGINATED BY BW

DIST Eastern HWY 401 BOREHOLE TYPE Portable Rotary Drilling Equipment with Full Weight Hammer COMPILED BY RS

DATUM Geodetic DATE October 3, 2022 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.5	GROUND SURFACE										
0.0	TOPSOIL										
0.2	CLAY (CH), highly fissured (WEATHERED CRUST) Stiff Brown w>PL		1	SS	2		99				
			2	SS	13						1 13 35 51
98.1											
1.4	Gravelly SAND and SILT (SM-ML), some gravel, contains cobbles and boulders (TILL) Very dense Brown		3	SS	55		98				
			4	SS	43						15 38 34 13
96.7			5	SS	71/0.23		97				
96.3	Cobbles and boulders										
3.2	LIMESTONE (BEDROCK) Bedrock cored from 3.2 m to 5.3 m For rock coring details see Record of Drillhole C-06		1	RC	REC 92%		96				RQD = 48%
			2	RC	REC 100%		95				RQD = 54%
94.2			3	RC	REC 100%						
5.3	END OF BOREHOLE										

NOTE (S):

1. A methane pocket was encountered during bedrock coring at an approximately depth of 5.0 m (Elev. 94.5 m). Methane concentrations above the lower explosive level were measured.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\HWY_401_BELLEVILLE\02_DATA\GINT\HWY_401_BELLEVILLE.GPJ GAL-GTA.GDT 8/23/24

PROJECT: 20148061B

RECORD OF DRILLHOLE: C-06

SHEET 2 OF 2

LOCATION: N 4893639.96 ;E 228836.22

DRILLING DATE: October 3, 2022

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATH-ERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole C-06.		96.34															
4	Rotary Drill / NQ Coring	Fresh to slightly weathered, medium to thinly bedded, light to dark grey banded black, fine to medium grained, non to slightly porous, strong, poor to fair quality LIMESTONE, with shale partings		3.20	1														BC/LC UCS = 85 MPa
					2														BC/LC BC/LC
5				94.28	3														
		- Methane pocket encountered with concentrations above the lower explosive limit		5.26															
		END OF DRILLHOLE																	
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			

DEPTH SCALE
1 : 50

LOGGED: BW
CHECKED: KCP

RECORD OF BOREHOLE No C-07

SHEET 1 OF 1 **METRIC**

PROJECT 20148061B
G.W.P. 4096-20-01
DIST Eastern HWY 401
DATUM Geodetic

LOCATION N 4893661.9; E 228823.7 MTM NAD 83 ZONE 9 (LAT. 44.179013; LONG. -77.450220)
BOREHOLE TYPE Power Auger, 200 mm Dia. (Hollow Stem)
DATE October 16, 2022

ORIGINATED BY BW
COMPILED BY RS
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
102.7	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE										
0.2	Silty sand, some gravel (SM) (FILL) Dense Brown and grey Moist		1	AS	-		102				
			2	SS	30				○		16 49 (35)
101.0							101				
1.7	CLAY (CH), highly fissured (WEATHERED CRUST) Very stiff Brown w>PL		3	SS	9						
			4	SS	13		100				0 2 39 59
			5	SS	19						0 7 35 58
			6	SS	19		99				
98.1											
4.6	Gravelly SAND and SILT (SM-ML), some gravel, contains cobbles and boulders (TILL) Compact Brown		7	SS	28		98				
			8	SS	107/0.28						
96.9							97				
5.8	END OF BOREHOLE Auger Refusal on Inferred Bedrock										

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY_401_BELLEVILLE\02_DATA\GINT\HWY_401_BELLEVILLE.GPJ GAL-GTA.GDT 8/23/24

PROJECT 20148061B

RECORD OF BOREHOLE No C-08

SHEET 1 OF 2

METRIC

G.W.P. 4096-20-01 LOCATION N 4893694.6; E 228810.4 MTM NAD 83 ZONE 9 (LAT. 44.179300; LONG. -77.450390) ORIGINATED BY BW

DIST Eastern HWY 401 BOREHOLE TYPE Power Auger, 200 mm Dia. (Hollow Stem), NQ Coring COMPILED BY NV

DATUM Geodetic DATE September 14, 2022 CHECKED BY KCP

ELEV / DEPTH	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 ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.9	GROUND SURFACE										
0.0 / 0.1	TOPSOIL, Brown, Moist		1	SS	14	▽					
	Silty sand (SM) (FILL), Compact to loose, Brown, Moist		2	SS	4		100				
99.4											
1.5	SILTY CLAY (CI) (WEATHERED CRUST), Very stiff, Brown, w>PL		3	SS	11		99				1 12 34 53
			4	SS	18		98				
97.9											
3.1	Gravelly SILTY SAND (SM) (TILL), Compact, Brown		5	SS	10		97				
96.8			6	SS	123/0.20						33 36 22 9
4.2	Cobbles and Boulders		1	RC	REC 94%						RQD = 56%
	LIMESTONE (BEDROCK) Bedrock cored from 4.2 m to 7.3 m. For rock coring details see Record of Drillhole C-08		2	RC	REC 100%		96				RQD = 72%
			3	RC	REC 100%		95				RQD = 97%
93.6							94				
7.3	END OF BOREHOLE										

NOTE:

1. Water level measured in monitoring well:

Date	Depth (m)	Elev. (m)
20-Sep-22	0.6	100.3
14-Dec-22	1.7	99.2
27-Feb-24	0.4	100.5

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY_401_BELLEVILLE\02_DATA\GINT\HWY_401_BELLEVILLE.GPJ GAL-GTA.GDT 8/23/24

PROJECT: 20148061B

RECORD OF DRILLHOLE: C-08

SHEET 2 OF 2

LOCATION: N 4893694.63 ;E 228810.36

DRILLING DATE: September 14, 2022

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATH-ERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole C-08.		96.73															
5	Rotary Drill / NQ Coring	Fresh to slightly weathered, thinly bedded to thinly laminated, light to dark grey banded black, fine to medium grained, non to slightly porous, fair to excellent quality very strong, LIMESTONE, with shale partings		4.16	1														
6					2														BC
7					3														UCS = 102 MPa
				93.56															
		END OF DRILLHOLE		7.33															
8																			
9																			
10																			
11																			
12																			
13																			
14																			

DEPTH SCALE

1 : 50

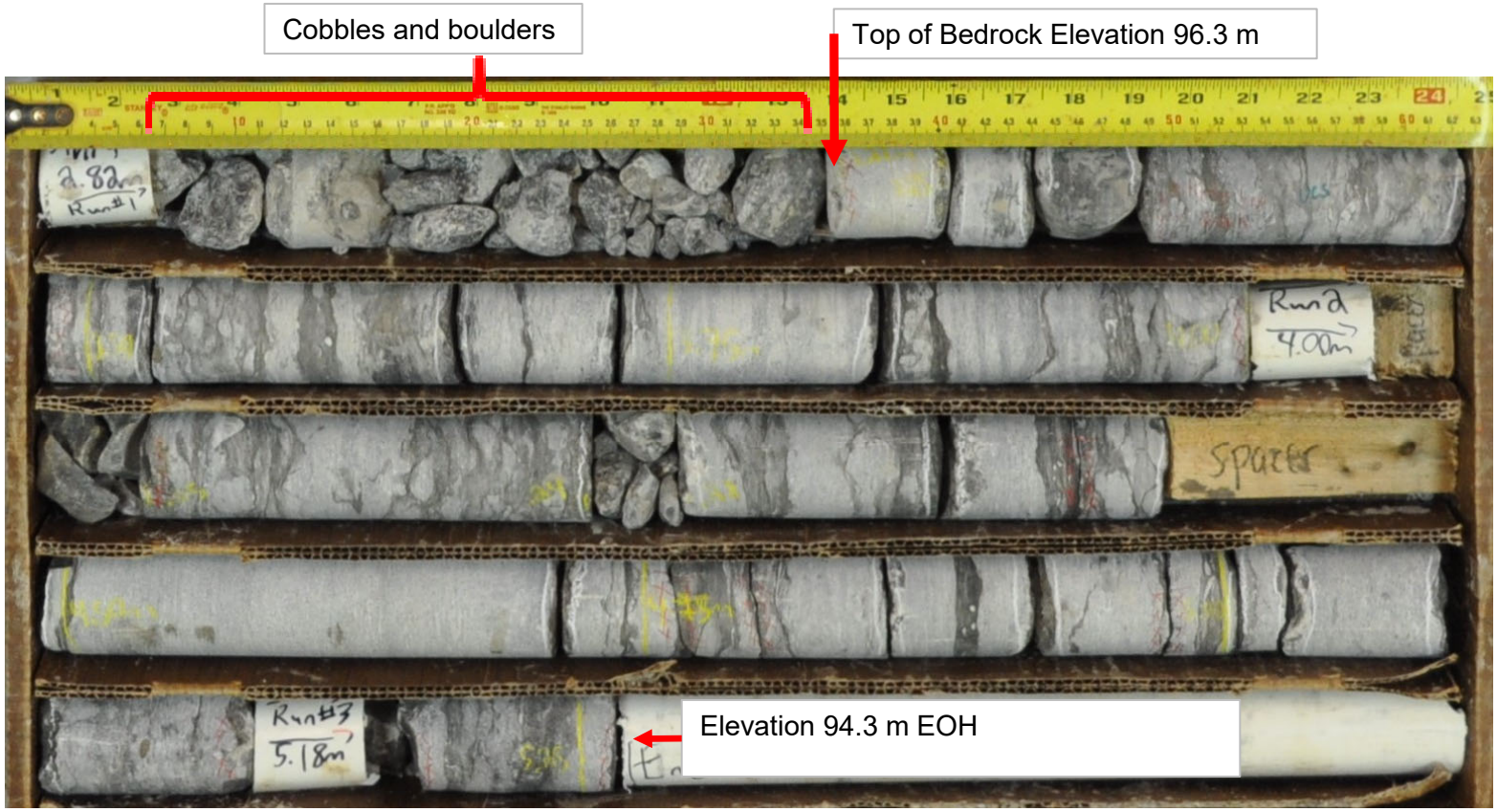
LOGGED: BW

CHECKED: KCP

GTA-RCK 046 S:\CLIENTS\MTO\HWY_401_BELLEVILLE\02_DATA\GINT\HWY_401_BELLEVILLE.GPJ GAL-MISS.GDT 8/23/24

BH C-06 (Dry)

Core Box 1 & 2 of 2



Note:

1. A methane pocket was encountered during bedrock coring at Borehole C-06 an approximately depth of 5.0 m (Elev. 94.5 m). Methane concentrations above the lower explosive level were measured at the site using an RKI Model GX-2012, 4-Gas Monitor.

Foundations Investigation

Replacement of Structural Culvert 11X-0422/CO
GWP 4053-18-00; WP 4096-20-01

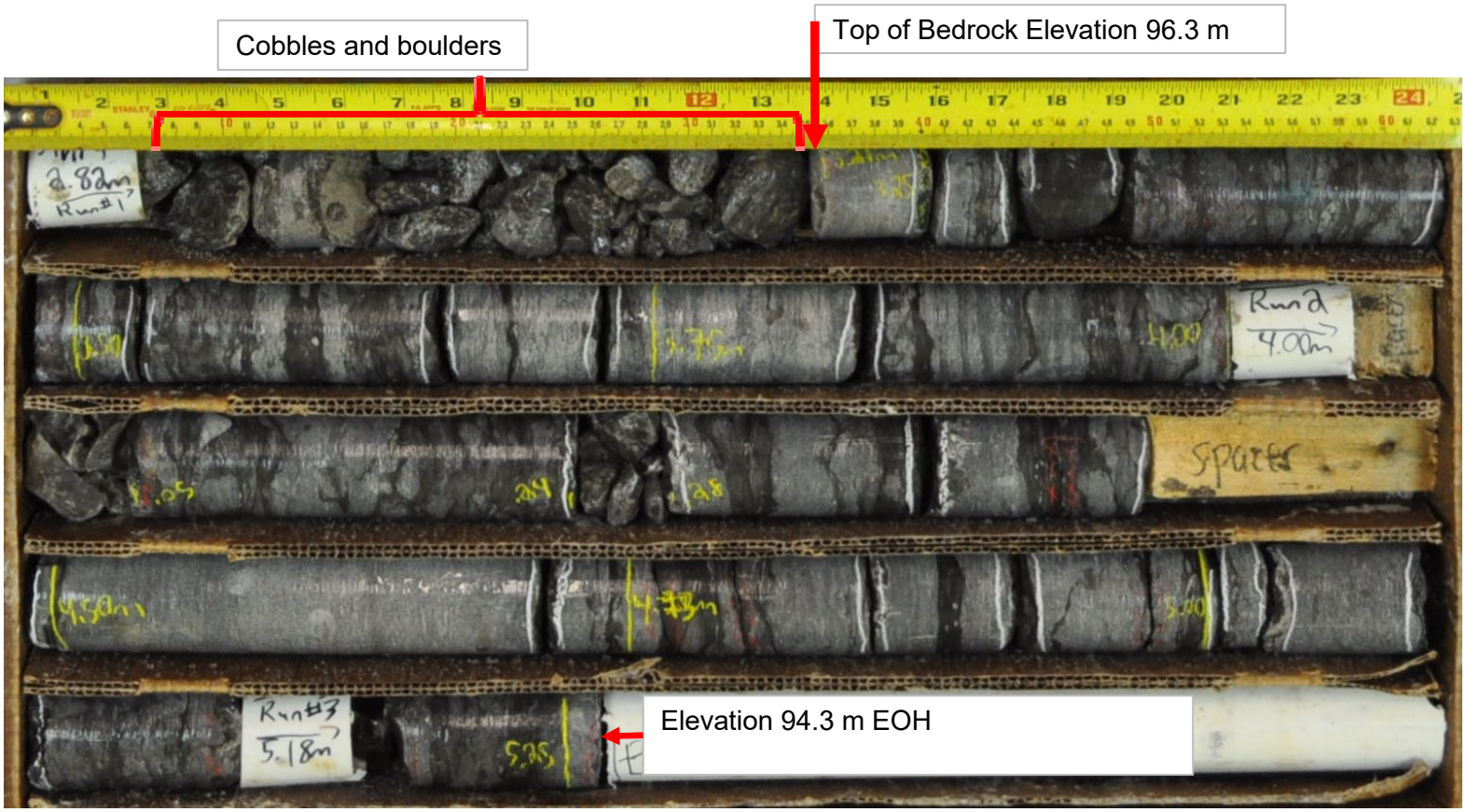
Highway 401, Belleville, Ontario

Project No.	20148061B
Drawn:	BW
Date:	2022-09-30
Checked:	KCP
Review:	LCC

Figure A1

BH C-06 (Wet)

Core Box 1 & 2 of 2



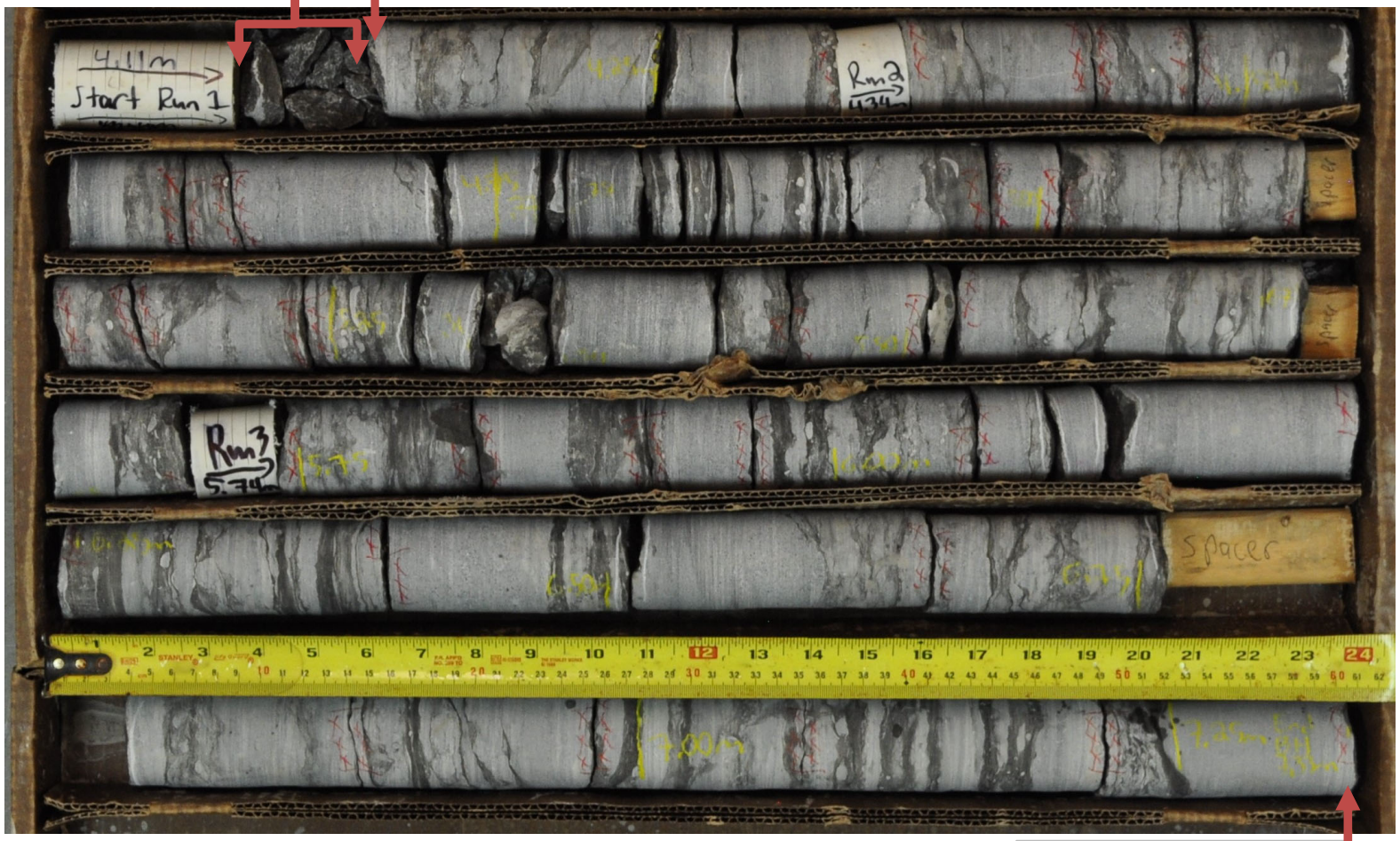
Note:

1. A methane pocket was encountered during bedrock coring at Borehole C-06 an approximately depth of 5.0 m (Elev. 94.5 m). Methane concentrations above the lower explosive level were measured at the site using an RKI Model GX-2012, 4-Gas Monitor.

wsp	**Foundations Investigation** **Replacement of Structural Culvert 11X-0422/CO** **GWP 4053-18-00; WP 4096-20-01** **Highway 401, Belleville, Ontario**	Project No. 20148061B Drawn: BW Date: 2022-09-30 Checked: KCP Review: LCC	**Figure A2**

BH C-08 (Dry)

Core Box 1 & 2 of 2



wsp	**Foundations Investigation** **Replacement of Structural Culvert 11X-0422/CO** **GWP 4053-18-00; WP 4096-20-01** **Highway 401, Belleville, Ontario**	Project No. 20148061B Drawn: BW Date: 2022-09-30 Checked: KCP Review: LCC	**Figure A3**

BH C-08 (Wet)

Core Box 1 & 2 of 2

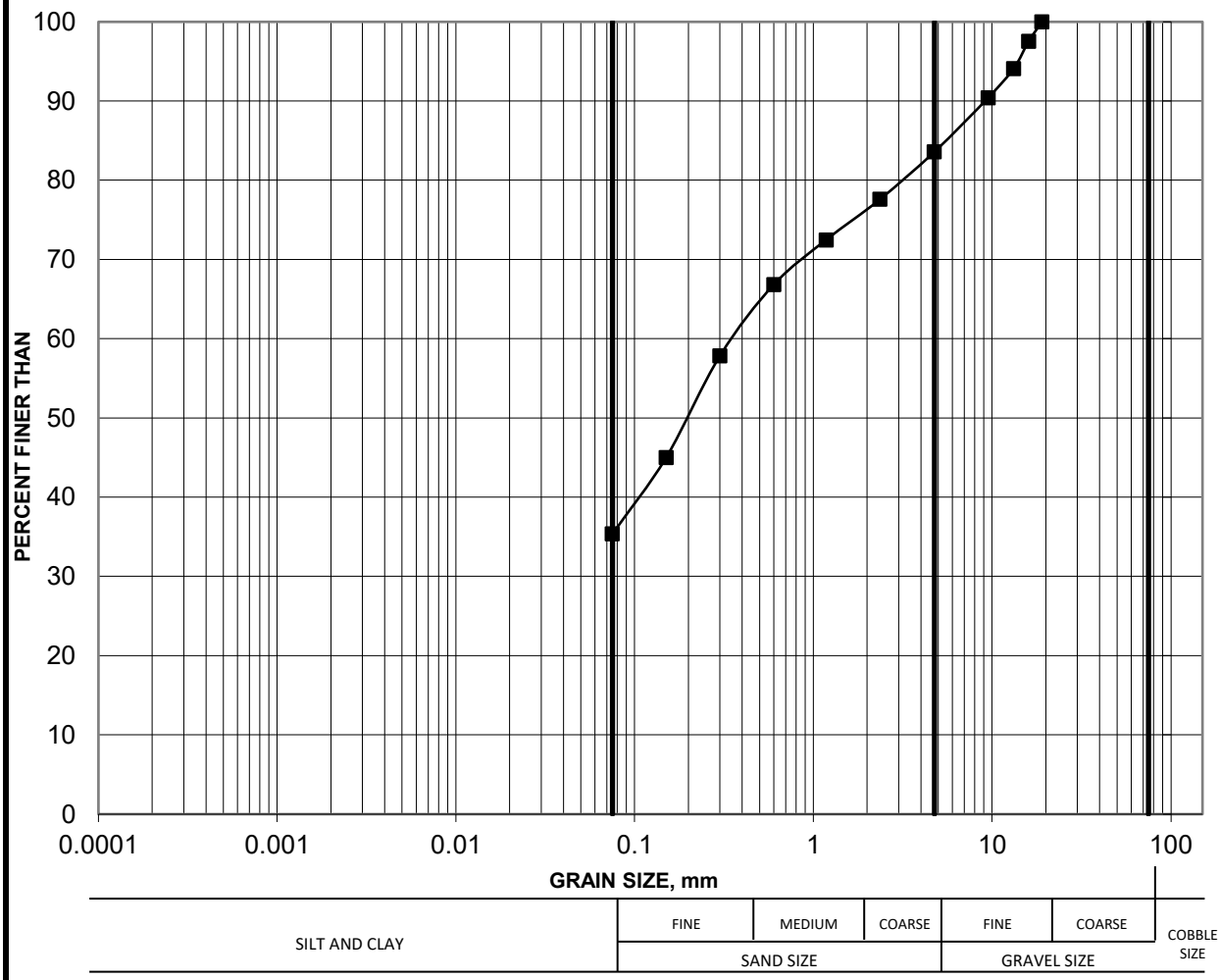
wsp	**Foundations Investigation** **Replacement of Structural Culvert 11X-0422/CO** **GWP 4053-18-00; WP 4096-20-01** **Highway 401, Belleville, Ontario**	Project No. 20148061B Drawn: BW Date: 2022-09-30 Checked: KCP Review: LCC	**Figure A4**

APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION	FIGURE B1

SILTY SAND (SM) (FILL)



	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
—■—	C-07	2	0.76-1.37	16	49	35	

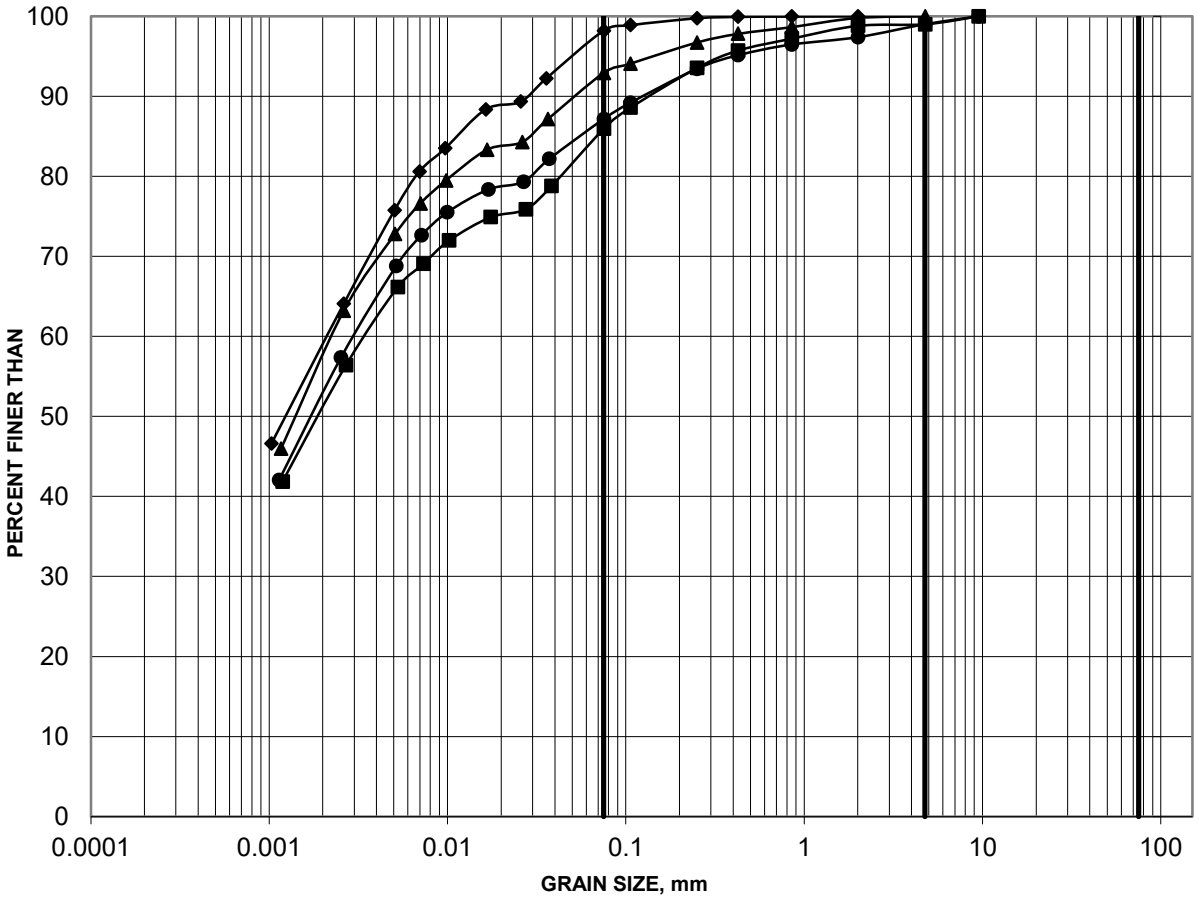
Project: 20148061B/4000

Created by: KCP

Checked by: CW

GRAIN SIZE DISTRIBUTION	FIGURE B2

SILTY CLAY (CI) TO CLAY (CH)



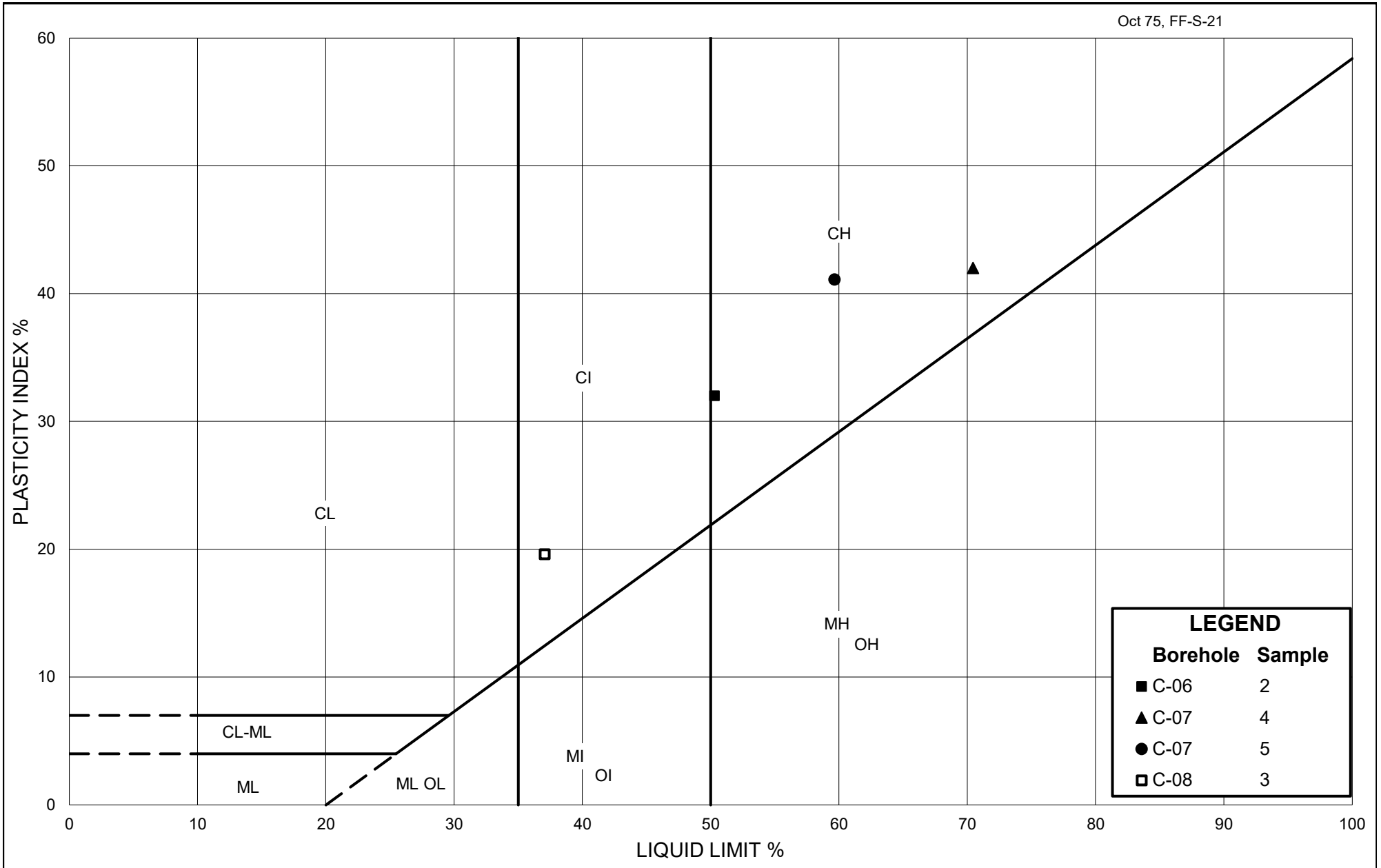
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	C-06	2	0.61-1.22	1	13	35	51
◆	C-07	4	2.29-2.90	0	2	39	59
▲	C-07	5	3.05-3.66	0	7	35	58
●	C-08	3	1.52-2.13	1	12	34	53

Project: 20148061B-4000

Created by:	BW
Checked by:	CW

https://golderassociates.sharepoint.com/sites/35409g/Shared Documents/Active/2020/20148061B/figures/Culvert P3/



Ministry of Transportation

Ontario

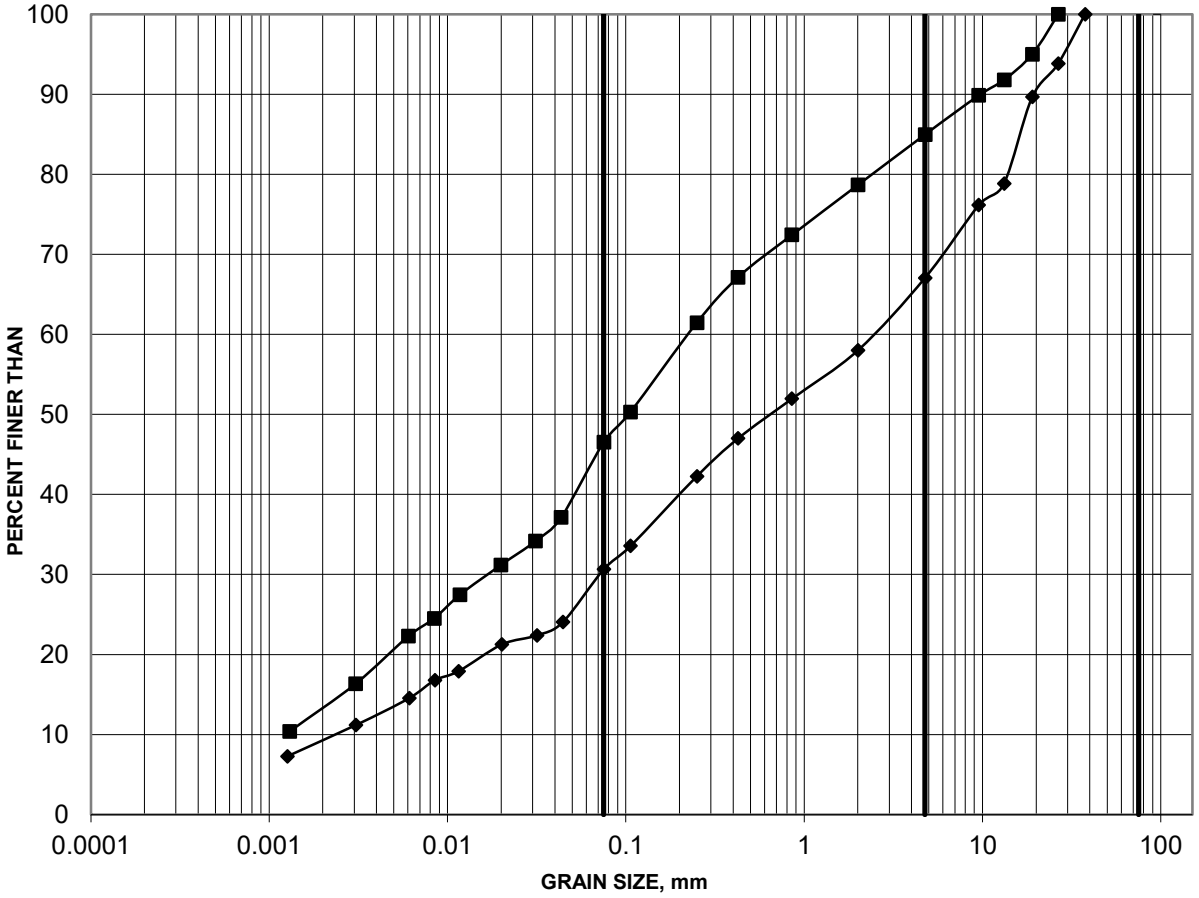
PLASTICITY CHART

CLAY (CH) TO SILTY CLAY (CI)

Figure:	B3
Project:	20148061B-4000
Created By: KCP	Checked By: CW

GRAIN SIZE DISTRIBUTION	FIGURE B4

GRAVELLY SILTY SAND TO GRAVELLY SAND AND SILT (SM-ML) (TILL)



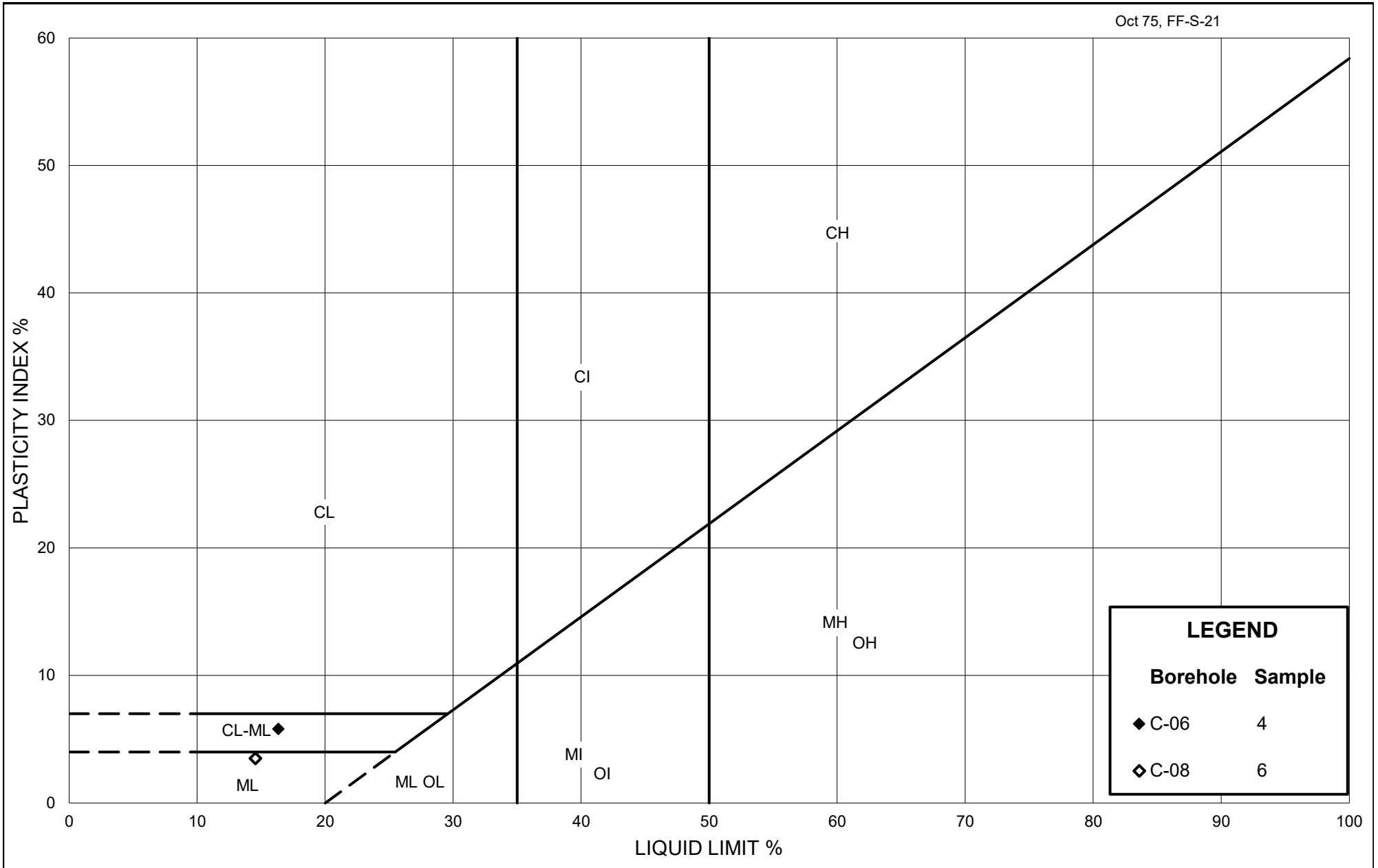
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	C-06	4	1.83-2.44	15	38	34	13
◆	C-08	6	3.81-4.17	33	36	22	9

Project: 20148061B-4000

Created by:	BW
Checked by:	CW

https://golderassociates.sharepoint.com/sites/35409g/Shared Documents/Active/2020/20148061B/figures/Culvert P3/



Ministry of Transportation

Ontario

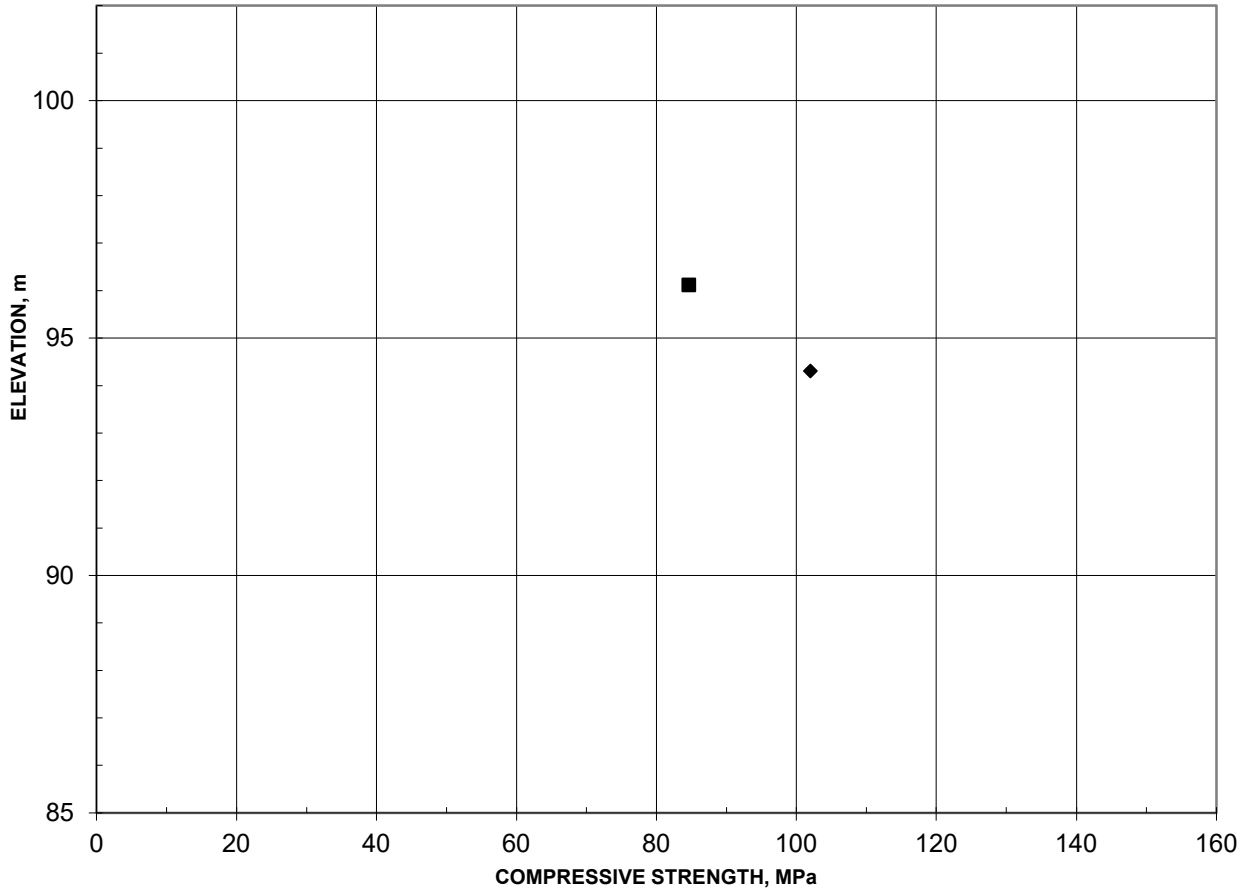
PLASTICITY CHART

GLACIAL TILL

Figure:	B5
Project:	20148061B-4000
Created By: KCP	Checked By: CW

ASTM D7012 - Method C
UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORE
SUMMARY OF LABORATORY TEST RESULTS

FIGURE B5



Borehole	Depth (m)	L/D	Bulk Density (kg/m^3)	Lithology	UCS (MPa)	Failure Type
BHC-06 RC1	3.4	2.1	2611	Limestone	85	1
BHC-08 RC1	6.6	2.5	2715	Limestone	102	1

Notes:

Failure Types

1. Well formed cones on both ends
2. Well formed cones on one end, vertical cracks through cap
3. Columnar vertical craking through both ends
4. Diagonal fracture with no cracking through ends
5. Side fractures at top or bottom
6. Side fractures at both sides of top or bottom

Remarks

- Cores tested in vertical direction.
- Cores tested in air-dry condition.
- Time to failure > 2 and < 15 minutes.

Project: 20148061B

Created by:	KCP
Checked by:	CW

APPENDIX C

Analytical Laboratory Testing Results

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
.
Attention: Mr. Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1986686
Date Submitted: 2022-09-22
Date Reported: 2022-09-29
Project: Belleville 20148061B-1-162
COC #: 900600

Dear Kenton Power:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: _____
Emma-Dawn Ferguson, Chemist

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: https://directory.cala.ca/.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

eurofins | Environment Testing

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
.
Attention: Mr. Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1986686
Date Submitted: 2022-09-22
Date Reported: 2022-09-29
Project: Belleville 20148061B-1-162
COC #: 900600

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1652793 Soil 2022-09-08 H62-01 SS6 12.5-14.5'	1652794 Soil 2022-09-08 H62-05 SS3 5-7'	1652795 Soil 2022-09-15 C-01 SS2 2.5-4.5'	1652796 Soil 2022-09-14 C-08 SS4 7.5-9.5'
Anions	Cl	0.002	%		0.135	0.083	0.093	0.009
	SO4	0.01	%		0.03	0.02	0.02	0.02
General Chemistry	Electrical Conductivity	0.05	mS/cm		2.92	2.03	0.22	0.30
	pH	2.00			8.33	8.89	8.30	8.50
	Resistivity	1	ohm-cm		341	493	4540	3330

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1652797 Soil 2022-08-31 C-09 SS3 5-7'	1652798 Soil 2022-09-07 C-10 SS3 5-6.75'	1652799 Soil 2022-09-13 H-37-02 SS3 2.5-4.5'	1652800 Soil 2022-09-13 H37-01 SS3 5-7'
Anions	Cl	0.002	%		0.005	0.002	0.002	0.014
	SO4	0.01	%		0.04	0.02	0.02	0.03
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.44	0.17	0.17	0.47
	pH	2.00			7.87	8.23	8.20	8.56
	Resistivity	1	ohm-cm		2270	5880	5880	2130

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

eurofins | Environment Testing

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
.
Attention: Mr. Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1986686
Date Submitted: 2022-09-22
Date Reported: 2022-09-29
Project: Belleville 20148061B-1-162
COC #: 900600

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 430396 **Analysis/Extraction Date** 2022-09-27 **Analyst** IP **Method** Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	101	90-110
pH	7.85	100	90-110
Resistivity			
Run No 430430 **Analysis/Extraction Date** 2022-09-28 **Analyst** AA **Method** C CSA A23.2-4B			
Chloride	<0.002 %		90-110
Run No 430473 **Analysis/Extraction Date** 2022-09-28 **Analyst** IP **Method** AG SOIL			
SO4	<0.01 %	98	70-130

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX D

Site Photographs

Photograph 1: Looking north across Highway 401 from Borehole C-06 along proposed culvert alignment (May 2022)

Photograph 2: Looking northeast at Borehole C-08 along Highway 401 N/S-W on-ramp near proposed culvert inlet (September 2022)

Photograph 3: Looking south of Highway 401 towards Borehole C-06 near proposed culvert outlet; May 2022

wsp.com