



FINAL REPORT

Foundation Investigation Report

Replacement of Culvert No. 11X-0420/C0

Wallbridge Loyalist Road, Belleville, Ontario

MTO GWP 4053-18-00; WP 4094-20-01; Agreement 4020-E-0012-5

Submitted to:

Ministry of Transportation Ontario

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Kingston, Ontario K7K 0E5

Submitted by:

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Ottawa, Ontario, K2H 5B7

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June 14, 2024

GEOCREs No.: 31C03-001

Latitude: 44.181810°

Longitude: -77.448350°



Distribution List

1 e-Copy - Ministry of Transportation Ontario

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Table of Contents

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION AND GEOLOGY	1
2.1 Site Description	1
2.2 Regional Geology	2
3.0 INVESTIGATION PROCEDURES	2
3.1 1957 and 1958 Original Investigation (Structure No. 11X-0157/B0)	3
4.0 DESCRIPTION OF SUBSURFACE CONDITIONS	4
4.1 Site Stratigraphy Overview	4
4.1.1 Surface Cover / Surficial Materials	4
4.1.2 Fill	4
4.1.3 Glacial Till	5
4.1.4 Bedrock	5
4.2 Groundwater Conditions	5
4.3 Analytical Laboratory Testing Results	6
5.0 CLOSURE	7
TABLES	
Table 1: Summary of Borehole Locations	3
Table 2: Summary of Bedrock Surface Depths and Elevations	5
Table 3: Summary of Groundwater Conditions	6
Table 4: Steel Corrosion and Sulphate Attack, Chemical Analysis	6
DRAWINGS	
Drawing 1 – Borehole Locations and Soil Strata	

APPENDICES

APPENDIX A

Borehole Records

C-04, C-04A and C-04A

APPENDIX B

Geotechnical Laboratory Test Results

Figures B1 to B5

APPENDIX C

Previous Investigations

Results from 1957 and 1958 Original Investigation GEOCREC No. 31C00-023

APPENDIX D

Analytical Laboratory Testing Results

Eurofins Report No. 3003046

APPENDIX E

Site Photographs

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 through Belleville, Ontario as part of GWP 4053-18-00, delivered under MTO Agreement No. 4020-E-0012. The project limits extend from 1.2 km west of the Wallbridge Loyalist Road interchange to 4.3 km east of the Highway 37 interchange. 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 Culvert No. 11X-0420/C0 (WP 4094-20-01).

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 Site Description

The orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and, therefore, may differ from the magnetic north shown on the foundations drawing. For the purpose of this report, Wallbridge Loyalist Road is oriented in a north-south direction; for simplicity, the culvert is described as being oriented in an east-west direction.

Culvert No. 11X-0420/C0 which is part of the Potter Creek Tributary is located under Wallbridge Loyalist Road, approximately 220 m north of the Highway 401 / Wallbridge Loyalist Road interchange in Belleville Ontario. The site location is shown in the key plan in Drawing 1.

Based on the results of the Preliminary Structural Design Report dated March 2022, the existing structure consists of twin, 900 mm diameter corrugated steel pipe (CSP) culverts. The culverts extend below the Wallbridge Loyalist Road over a total length of approximately 25 m with the Potter Creek tributary flow from east to west. There are no drawings and no record of previous rehabilitation work available for this structure.

The Wallbridge Loyalist Road grade at the site is at approximately Elevation 104.4 m (Borehole C-04A). The embankment toes are about 1.5 m below the existing pavement grade at approximately Elevation 102.9 m with side slopes inclined at about 4 horizontals to 1 vertical (4H:1V). As such there is approximately 0.6 m of cover over the existing culverts.

At this location, Wallbridge Loyalist Road has a four-lane cross-section with one southbound and one northbound through lane and lefthand turn lanes in both directions. The signal-controlled intersection services the commercial property to the east and the existing Highway 401 on and off-ramps to the west. The land to the east of the Wallbridge Loyalist Road is mostly marsh-covered with bushes and mature trees. The land to the west of the road is mostly flat grassland between an existing Highway 401 westbound on-ramp and a commercial property.

The existing Highway 401 on-ramp has rural cross-sections with gravel shoulders. The stormwater drainage in the area is to existing culverts and ditches.

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

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 in two distinct deployments that included advancing a total of three boreholes, (numbered C-04A, C-04, and C-05). Borehole C-04A was advanced on July 17, 2023. Due to site access restrictions, the inlet and outlet Boreholes C-04 and C-05 were advanced on October 17 and 18, 2023. The borehole locations are shown in Drawing 1.

Borehole C-04A was advanced with a CME55 truck-mounted drill rig supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario. Boreholes C-04, and C-05, were advanced with portable drilling equipment supplied and operated by OGS Drilling of Almonte, Ontario. Traffic control signage and cones were required to close the driving lanes and shoulders of Wallbridge Loyalist Road in accordance with the Ontario Traffic Manual, Book 7. Temporary Conditions were provided by Beacon Lite of Kingston, Ontario.

Soil samples were obtained using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Soil samples were obtained at vertical sampling intervals of about 0.76 m at Borehole C-04A and near continuous sampling at the portable Boreholes C-04 and C-05.

HQ-sized bedrock core samples were obtained using a rotary diamond drilling technique and a triple-tube core-barrel at Borehole C-04A. Bedrock rock core samples were obtained from the portable boreholes using BW casing and a 56 mm outside diameter thin wall core-barrel.

A monitoring well was installed at Borehole C-04 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 borehole log for Borehole C-04 provided in Appendix A.

The boreholes without 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 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 fieldwork was supervised on a full-time basis by 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 labeled 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

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

compressive strength (UCS) testing was carried out on selected samples of the bedrock. The laboratory tests were carried out to MTO LS and/or ASTM Standards, as applicable at WSP's Ottawa laboratory.

Two soil samples were submitted to Eurofins Environmental Testing Canada Inc. (Eurofins) for basic chemical analysis related to the potential corrosion of buried steel elements and sulphate 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, ground surface elevations, and drilled depths are summarized in Table 1.

Table 1: Summary of Borehole Locations

Borehole	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Drilled Depths (m)	Comments
	Northing (m) (Latitude)	Easting (m) (Longitude)			
C-04	4893956.3 (44.181670°)	228973.4 (-77.448390°)	102.9	7.1	Bedrock cored
C-04A	4893972.3 (44.181810°)	228976.6 (-77.448350°)	104.4	8.0	Bedrock cored
C-05	4893972.1 (44.181810°)	228992.6 (-77.448150°)	102.9	7.0	Bedrock cored

3.1 1957 and 1958 Original Investigation (Structure No. 11X-0157/B0)

Culvert 11X-0420 is located approximately 220 m north of the Highway 401 / Wallbridge Loyalist Road interchange (Structure No. 11X-0157/B0). As such the results of the original Foundation investigations for the then proposed alignments for Structure No. 11X-0157/B0 have been reviewed for the current report and a copy of the Borehole Location and Soil Strata Drawing and borehole records are provided for reference in Appendix C.

The field work associated with the investigation for the original construction of the then proposed interchange alignment for Structure No. 11X-0157/B0 was carried out in two separate parts. The initial field work consisted of two sampled boreholes with dynamic cone penetration tests and two separate dynamic cone penetration tests carried out in November 1957. Upon completion of the 1957 investigation, a revised alignment was proposed for the crossing and a supplementary investigation was carried out in March 1958. The 1958 investigation confirmed similar subsoil findings at both the investigated sites.

The results of the original investigations indicated that the site is underlain by dense glacial clay till, overlying limestone bedrock. It is noted that bedrock was not cored as part of the original investigations.

The results of the original investigations are contained in the following report:

- MTO GEOCREs No. 31C00-023: "Foundation Report on Hwy. 401, Line "C" & County Road Revision Lots 30 & 31, Con's. II & III, Twp. of Sidney, approximately 2 Miles West of Belleville. Dated August 1959.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Site Stratigraphy Overview

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 Record of Borehole and Drillhole sheets 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 B5 in Appendix B.

Photographs of the core recovered from the underlying bedrock are shown on Figures A1 to A6, provided in Appendix A. The results of the analytical testing completed on select soil samples are provided in Appendix D.

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 and non-continuous soil sampling and therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

At the borehole locations, the subsurface conditions generally consist of a topsoil or pavement structure (asphalt and pavement granular material) over a non-cohesive and cohesive fill, overlying a 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 thicknesses of 200 mm and 900 mm was encountered at the ground surface of Boreholes C-04, and C-05, respectively.

Asphaltic concrete with a thickness of 200 mm was encountered at the ground surface at Borehole C-04A.

4.1.2 Fill

Fill consisting primarily of sand and gravel was encountered below the asphalt at Borehole C-04A. The top of this layer was encountered at Elevation 104.2 m and this layer was 0.4 m thick.

A sandy silty clay fill layer was encountered below the pavement structure fill at Borehole C-04A. The top of this layer was encountered at Elevation 103.8 m and this layer is about 0.8 m thick. The SPT N-value recorded in this layer was 6 blows per 0.3 m of penetration indicating a firm consistency. The results of grain size analysis testing carried out on one sample of the cohesive fill are illustrated in Figure B1 in Appendix B. The results of Atterberg limits testing completed on a single sample of this material indicate a liquid limit of 41, a plastic limit of 19, and a plasticity index of 22. The Atterberg limits analysis results are provided in Figure B2 in Appendix B and indicate this deposit is a silty clay (CI). The moisture content of a single sample of the cohesive fill was 26%, which is above the plastic limit of this material.

4.1.3 **Glacial Till**

A glacial till deposit generally consisting of gravelly clayey sand-silty sand, containing cobbles and boulders, was encountered below the fill material at Borehole C-04A and below the topsoil at Boreholes C-04 and C-05. The top of this deposit was encountered at elevations ranging from 103.0 m to 102.0 m. The thickness of this layer ranged from 2.7 m to 3.2 m. The SPT N-values recorded in the till deposit ranged from 17 to 83 blows per 0.3 m of penetration indicating a compact to very dense consistency. Eleven instances the SPT N-values recorded were greater than 100 blows per 0.3 m, (i.e., 50 blows/0.15 m, etc.) indicating a very dense state of compactness; however, the blow counts have likely been influenced by the presence of cobbles and boulder in the till or the proximity to the bedrock surface rather than the actual compactness of the soil matrix.

The results of grain size analysis testing carried out on four samples of this material are provided in Figure B3 in Appendix B. The results of Atterberg limits testing completed on three samples of the till deposit indicate liquid limits ranging from 16 to 19, plastic limits ranging from 11 to 13, and plasticity indices ranging from 5 to 7 as shown in Figure B4. These Atterberg limits analysis results indicate that the fines portion of the till material is classified as clayey silt-silt (CL-ML). The measured moisture content of six samples of the glacial till ranged between 6% and 9%, below the plastic limit of the material.

4.1.4 **Bedrock**

The overburden soils are underlain by limestone bedrock.

Table 2 summarizes the depths and the elevations of the bedrock surface 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 Elevation (m)
C-04	102.9	3.6	99.3
C-04A	104.4	4.6	99.8
C-05	102.9	3.3	99.6

Rock Quality Designation (RQD) values measured on the recovered limestone bedrock core samples range from about 28% to 100%, but more commonly 54% to 100% indicating a fair to excellent rock quality. The results of UCS testing carried out on three bedrock core samples gave UCS values ranging from 84 MPa to 152 MPa, indicating strong to very strong bedrock. The results of UCS testing are provided in Figure B5 in Appendix B.

4.2 **Groundwater Conditions**

A monitoring well was installed at Borehole C-04 to measure the groundwater level at the site. The groundwater levels measured in the monitoring well, and the open-hole water levels, 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.

Table 3: Summary of Groundwater Conditions

Borehole	Screened Interval	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Elevation (m)	Date
Monitoring Well Water Levels					
C-04	TILL	102.9	0.0	102.9	October 31, 2023
					February 27, 2024
Open Hole Water Levels					
C-05	N/A	102.9	0.2	102.7	October 18, 2023

4.3 Analytical Laboratory Testing Results

Two soil samples were 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 D 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-04	1.8-2.1	0.002	<0.01	0.13	8.54	7,692
C-05	1.2-1.6	0.004	<0.01	0.17	8.59	5,882


5.0 CLOSURE

This report was prepared by Ben Waechter, EIT, and reviewed by Kenton Power, P.Eng., a senior geotechnical engineer with WSP. David Staseff, P.Eng., a Senior Principal Geotechnical Engineer and MTO Principal Foundations Contact for WSP conducted an independent technical and quality review of this report.



WSP Canada Inc.



Ben Waechter, EIT
Geotechnical Engineer-in-training



Kenton Power, P.Eng.
Senior Geotechnical Engineer



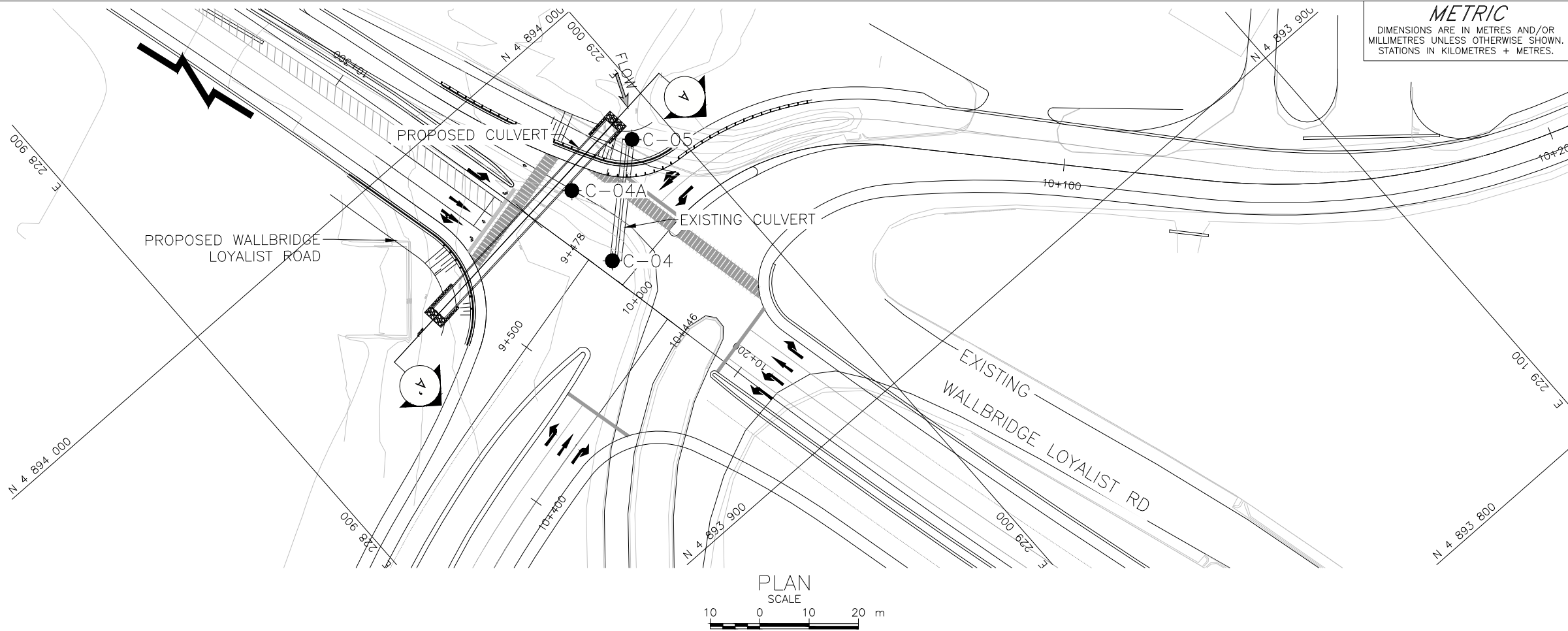
David Staseff, P.Eng.
MTO Principal Foundations Contact

BW/KCP/DS/yj

[https://wsponlinecan.sharepoint.com/sites/ca-ca00060993147/shared documents/06. deliverables/culvert s2/final/gwp 4053-18-00 rev1 final fir culvert 11x-0420 2024-03-21 \(ca0006099.3147\).docx](https://wsponlinecan.sharepoint.com/sites/ca-ca00060993147/shared%20documents/06.%20deliverables/culvert%20s2/final/gwp%204053-18-00%20rev1%20final%20fir%20culvert%2011x-0420%202024-03-21%20(ca0006099.3147).docx)

DRAWINGS

Drawing 1 – Borehole Locations and Soil Strata

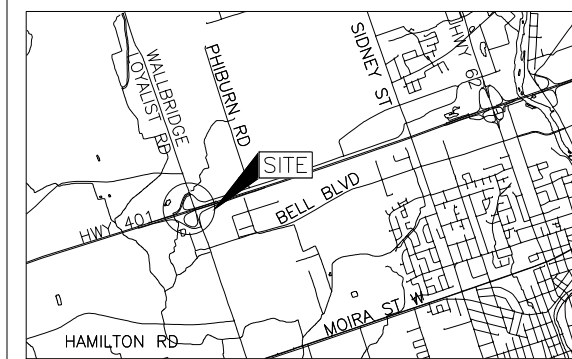


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4053-18-00

POTTER CREEK TRIBUTARY
WALLBRIDGE-LOYALIST ROAD CULVERT
BOREHOLE LOCATIONS AND SOIL
STRATA

SHEET



- 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
 - WL upon completion of drilling

Structural Site Location:
Latitude: 44.181810 Longitude: -77.448350

BOREHOLE CO-ORDINATES NAD83 (CSRS) MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
C-04	102.9	4893956.2	228973.4
C-04A	104.4	4893972.3	228976.6
C-05	102.9	4893972.1	228992.6

NOTES

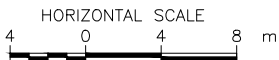
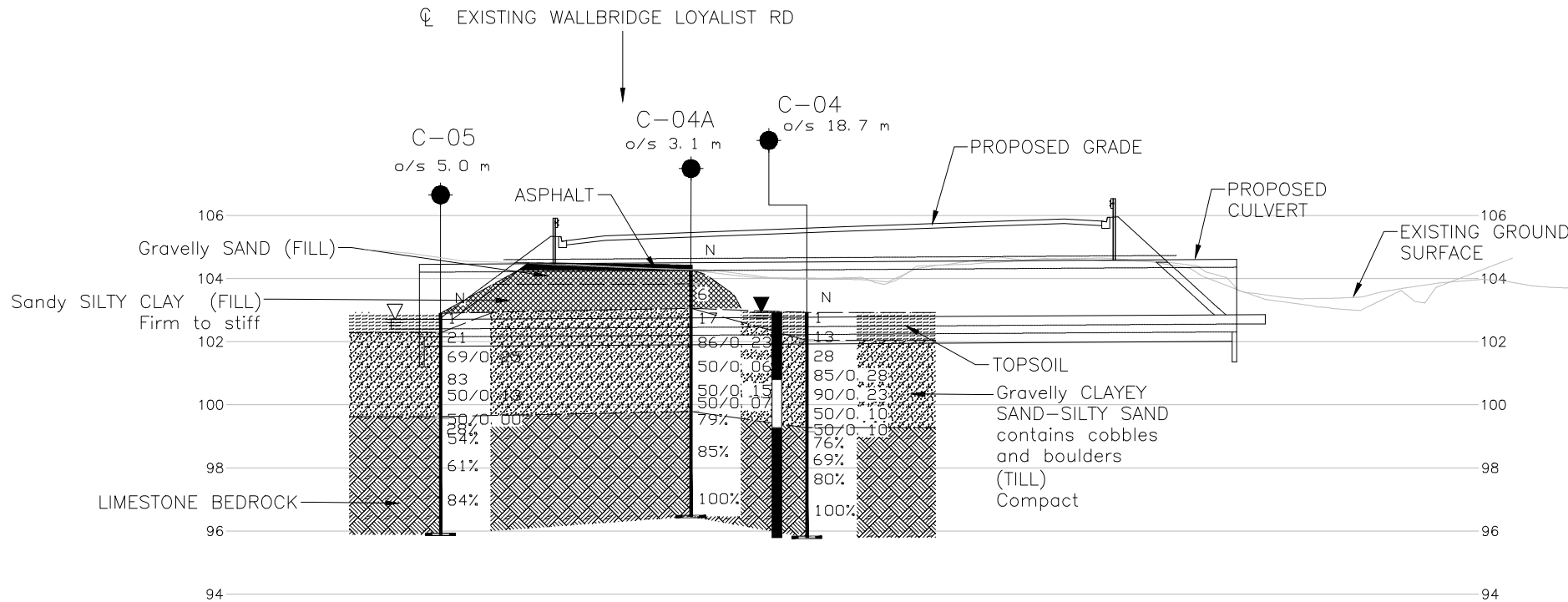
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Procurement-Ready Design Documents.

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

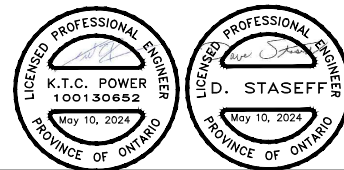
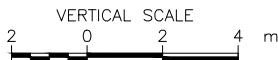
REFERENCE

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 file no.S16M-01435-01-352-001GA.dwg, received January 25, 2024.



PROFILE A-A'



NO.	DATE	BY	REVISION
Geocres No. 31C03-001			
HWY. 401	PROJECT NO. CA0006099.3147		
SUBM'D. BW	CHKD. BW	DATE: 05/09/2024	DIST. EASTERN
DRAWN: ZS/SA	CHKD. KCP	APPD. DS	DWG. 1

APPENDIX A

Borehole Records

C-04, C-04A and C-04A

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>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , 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 cm² 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, G _s)
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

Compactness¹

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 grain size. 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.

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

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
ν	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

(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
$C_{a(e)}$	secondary compression index
C_a	rate of secondary compression
$C_{a(e)}$	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 $= \sigma'_p / \sigma'_{vo}$

(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 $= \tan \delta$
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

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
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	KV Karstic Void
BD Bedding	K Slickensided
BC Broken Core	LC Lost Core
CC Continuous Core	MB Mechanical Break
CL Closed	PL Planar
CO Contact	PO Polished
CU Curved	RO Rough
CT Coated	SA Slightly Altered
FLT Fault	SH Shear
FOL Foliation	SM Smooth
FR Fracture	SR Slightly Rough
GO Gouge	SY Stylolite
IN Infilled	UN Undulating
IR Irregular	VN Vein
JN Joint	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 CA0006099.3147

RECORD OF BOREHOLE No C-04

SHEET 1 OF 2

METRIC

G.W.P. 4053-18-00

LOCATION N 4893956.3; E 228973.4 MTM NAD 83 ZONE 9 (LAT. 44.181670; LONG. -77.448390)

ORIGINATED BY RI

DIST Eastern HWY 401

BOREHOLE TYPE Portable Drill/Wash Boring, BW Coring

COMPILED BY IS

DATUM Geodetic

DATE October 17, 2023

CHECKED BY BW/KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L				
								20 40 60 80 100											
								20 40 60 80 100					25 50 75						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)						
102.9	GROUND SURFACE																		
0.0	TOPSOIL Dark brown to black Moist to wet		1	SS	1														
102.0			2	SS	13												21 38 29 12		
0.9	Gravelly CLAYEY SAND-SILTY SAND (SC-SM), contains cobbles and boulders (GLACIAL TILL) Compact to very dense Grey brown Moist to wet - Cobbles and boulders from 1.8 m to 3.6 m		3	SS	28												18 39 31 12		
			4	SS	85/0.28														
			5	SS	90/0.23														
			6	SS	50/0.10														
99.3			7	SS	50/0.10														
3.8	Slightly Weathered Bedrock LIMESTONE (BEDROCK) Bedrock cored from 3.7 m to 7.1 m For bedrock coring details see Record of Drillhole C-04		1	RC	REC 100%												RQD = 76%		
			2	RC	REC 100%												RQD = 69%		
			3	RC	REC 98%												RQD = 80%		
			4	RC	REC 100%												RQD = 100%		
95.8	END OF BOREHOLE																		
7.1	NOTE: 1. Water level in screen measured at ground surface (Elev. 102.9 m) on October 31, 2023 and and February 27, 2024.																		

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+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: CA0006099.3147

RECORD OF DRILLHOLE: C-04

SHEET 2 OF 2

LOCATION: N 4893956.25 ;E 228973.38

DRILLING DATE: October 17, 2023

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP W/L CORE AXIS	DISCONTINUITY DATA					WEATH- ERING INDEX		Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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DEPTH SCALE

1 : 50



LOGGED: RI

CHECKED: BW/KCP

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PROJECT		RECORD OF BOREHOLE No C-04A				SHEET 1 OF 2			METRIC							
G.W.P. 4053-18-00		LOCATION N 4893972.3; E 228976.6 MTM NAD 83 ZONE 9 (LAT. 44.181810; LONG. -77.448350)				ORIGINATED BY AK										
DIST Eastern HWY 401		BOREHOLE TYPE CME 55, Power Auger 200 mm Dia. (Hollow Stem), NQ Coring				COMPILED BY NV										
DATUM Geodetic		DATE July 17, 2023				CHECKED BY BW/KCP										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED								
104.4	GROUND SURFACE						20	40	60	80	100	Wp	NATURAL MOISTURE CONTENT	LIQUID LIMIT	WL	
0.0	ASPHALTIC CONCRETE		1	AS	-											
0.2	Gravelly SAND (SP), (PAVEMENT STRUCTURE), (FILL)															
103.8	Dark brown Moist		2	SS	6											2 32 29 37
0.6	Sandy SILTY CLAY (CI), trace gravel (FILL)															
103.0	Dark brown Firm to stiff w>PL		3	SS	17											
1.4	Gravelly CLAYEY SAND-SILTY SAND (SC-SM), contains cobbles and boulders (TILL) Compact Brown to grey Moist to wet - Cobbles and boulders from 2.4 m to 4.6 m		4	SS	86/0.23											20 40 27 13
			5	SS	50/0.06											
			6	SS	50/0.15											
			7	SS	50/0.07											
99.8	LIMESTONE (BEDROCK)															
4.6	Bedrock cored from 4.6 m to 8.0 m For rock coring details see Record of Drillhole C-04A		1	RC	REC 100%											RQD = 79%
			2	RC	REC 100%											RQD = 85%
			3	RC	REC 100%											RQD = 100%
96.4	END OF BOREHOLE															
8.0																

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PROJECT: CA0006099.3147

RECORD OF DRILLHOLE: C-04A

SHEET 2 OF 2

LOCATION: N 4893972.35 ;E 228976.57

DRILLING DATE: July 17, 2023

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: CCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA				WEATH- ERING INDEX	Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
							TOTAL CORE %	SOLID CORE %			DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja		Jzon	W1	W2	W3	W4	W5	W6			2	4	6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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DEPTH SCALE

1 : 50



LOGGED: AK

CHECKED: BW/KCP



PROJECT		RECORD OF BOREHOLE		No C-05		SHEET 1 OF 2		METRIC															
G.W.P. 4053-18-00		LOCATION		N 4893972.1; E 228992.6 MTM NAD 83 ZONE 9 (LAT. 44.181810; LONG. -77.448150)		ORIGINATED BY		RD															
DIST Eastern HWY 401		BOREHOLE TYPE		Portable Drill/Wash Boring, BW Coring		COMPILED BY		IS															
DATUM Geodetic		DATE		October 18, 2023		CHECKED BY		BW/KCP															
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60						80	100	20	40	60	80	100	25
102.9	GROUND SURFACE																						
0.0	TOPSOIL Dark brown Moist to wet		1	SS	1																		
102.3																							
0.6	Gravelly CLAYEY SAND-SILTY SAND (SC-SM), contains cobbles and boulders (GLACIAL TILL) Compact Grey brown Moist to wet		2	SS	21																		
			3	SS	69/0.25																		
			4	SS	83																		
			5	SS	50/0.13																		
			6	SS	50/0.06																		
99.6																							
3.3	Weathered Bedrock LIMESTONE (BEDROCK) Bedrock cored from 3.3 m to 7.0 m For bedrock coring details see Record of Drillhole C-05		1	RC	REC 98%																		
			2	RC	REC 95%																		
			3	RC	REC 99%																		
			4	RC	REC 97%																		
95.9																							
7.0	END OF BOREHOLE NOTE: 1. Water level in open hole at 0.2 m (Elev. 102.7 m) upon completion of drilling on October 18 2023.																						

PROJECT: CA0006099.3147

RECORD OF DRILLHOLE: C-05

SHEET 2 OF 2

LOCATION: N 4893972.12 ;E 228992.56

DRILLING DATE: October 18, 2023

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER
						FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP W/L CORE AXIS	DISCONTINUITY DATA				WEATH- ERING INDEX	Diametral Point Load Index (MPa)				
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon						
																		00 00			

DEPTH SCALE

1 : 50



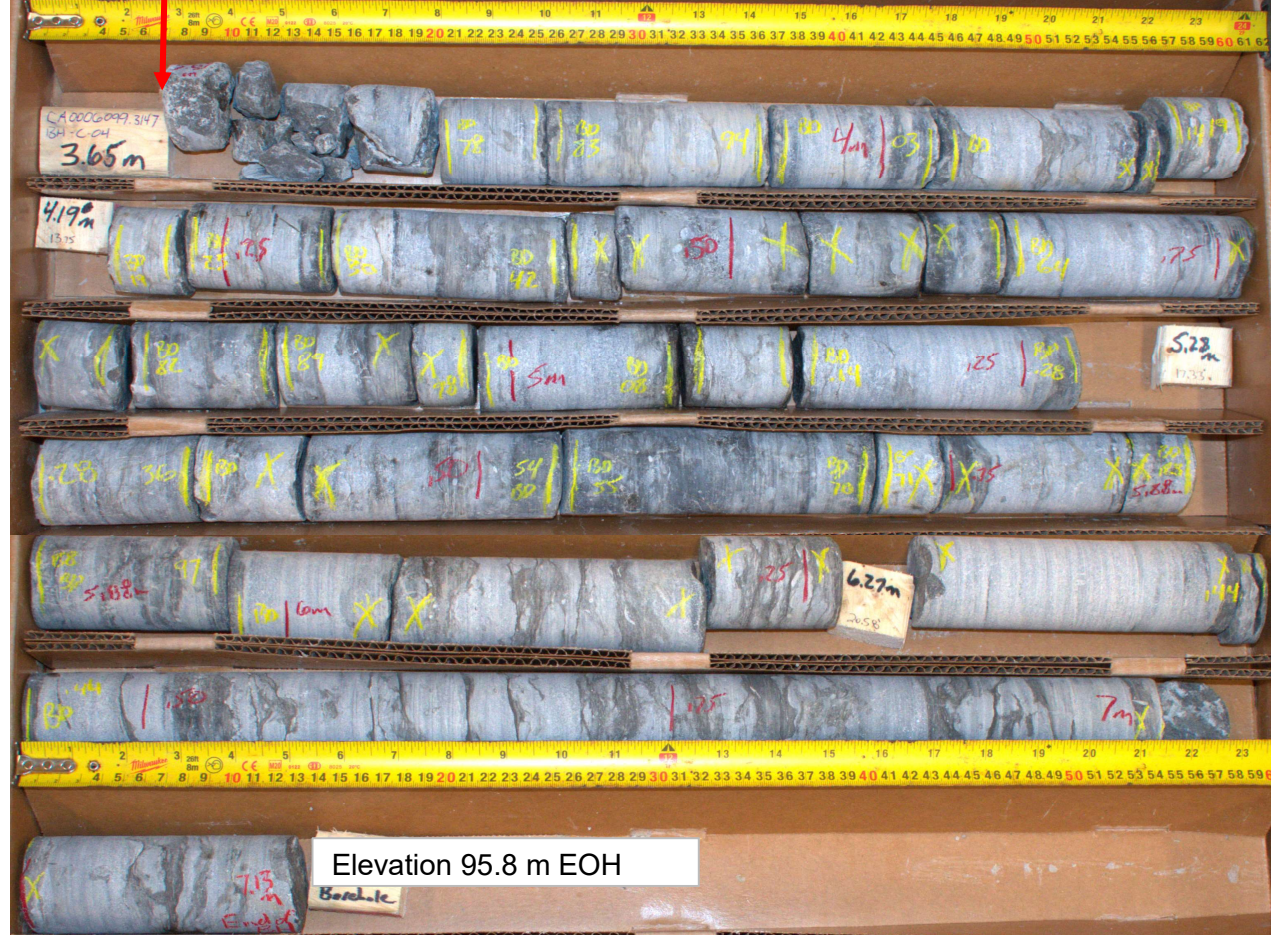
LOGGED: JS

CHECKED: BW/KCP

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Elevation 99.3 m Top of Bedrock

C-04 (Dry)
Core Box 1 to 2 of 2



Replacement of Culvert 11X-0420/C0
GWP: 4053-18-00 WP: 4094-20-01

Walbridge Loyalist Road / Highway 401
Belleville, Ontario

Project No. CA0006099.3147

Drawn: BW

Date: 2024-02-23

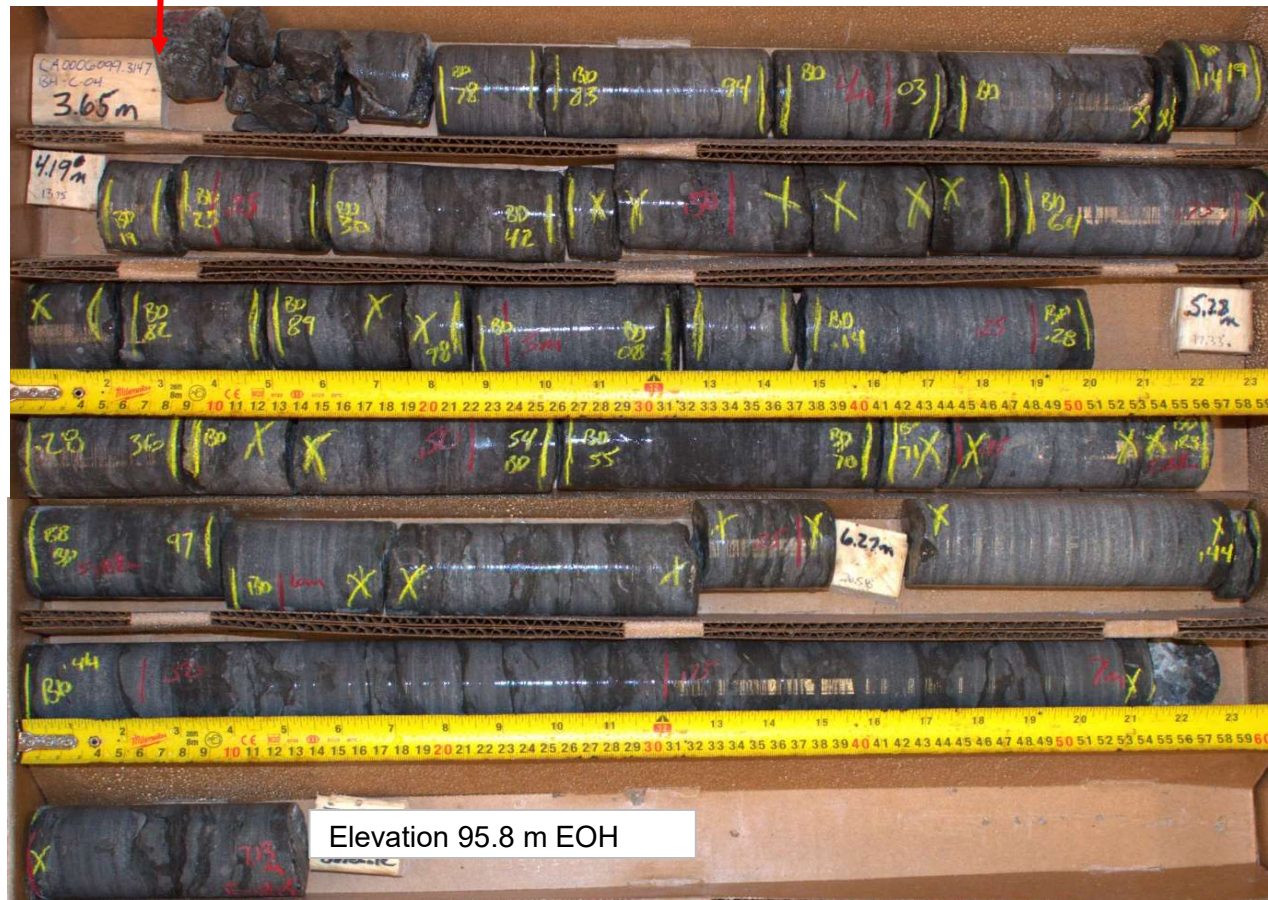
Checked: KCP

Review: DS

Figure A1

Elevation 99.3 m Top of Bedrock

C-04 (Wet)
Core Box 1 to 2 of 2



Replacement of Culvert 11X-0420/C0
GWP: 4053-18-00 WP: 4094-20-01
Walbridge Loyalist Road / Highway 401
Belleville, Ontario

Project No. CA0006099.3147

Drawn: BW

Date: 2024-02-23

Checked: KCP

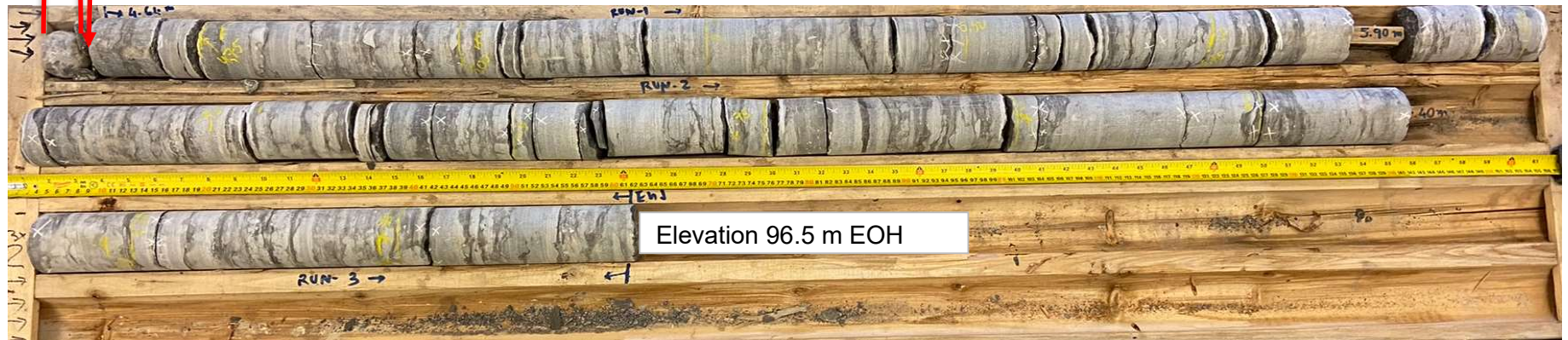
Review: DS

Figure A2

C-04A (Dry)
Core Box 1 to 2 of 2

Cobbles and Boulders

Elevation 99.8 m Top of Bedrock



Replacement of Culvert 11X-0420/C0
GWP: 4053-18-00 WP: 4094-20-01
Walbridge Loyalist Road / Highway 401
Belleville, Ontario

Project No. CA0006099.3147
Drawn: KG
Date: 2024-02-23
Checked: KCP
Review: DS

Figure A3

C-04A (Wet)
Core Box 1 to 2 of 2

Cobbles and Boulders

Elevation 99.8 m Top of Bedrock



Replacement of Culvert 11X-0420/C0
GWP: 4053-18-00 WP: 4094-20-01
Walbridge Loyalist Road / Highway 401
Belleville, Ontario

Project No. CA0006099.3147

Drawn: KG

Date: 2024-02-23

Checked: KCP

Review: DS

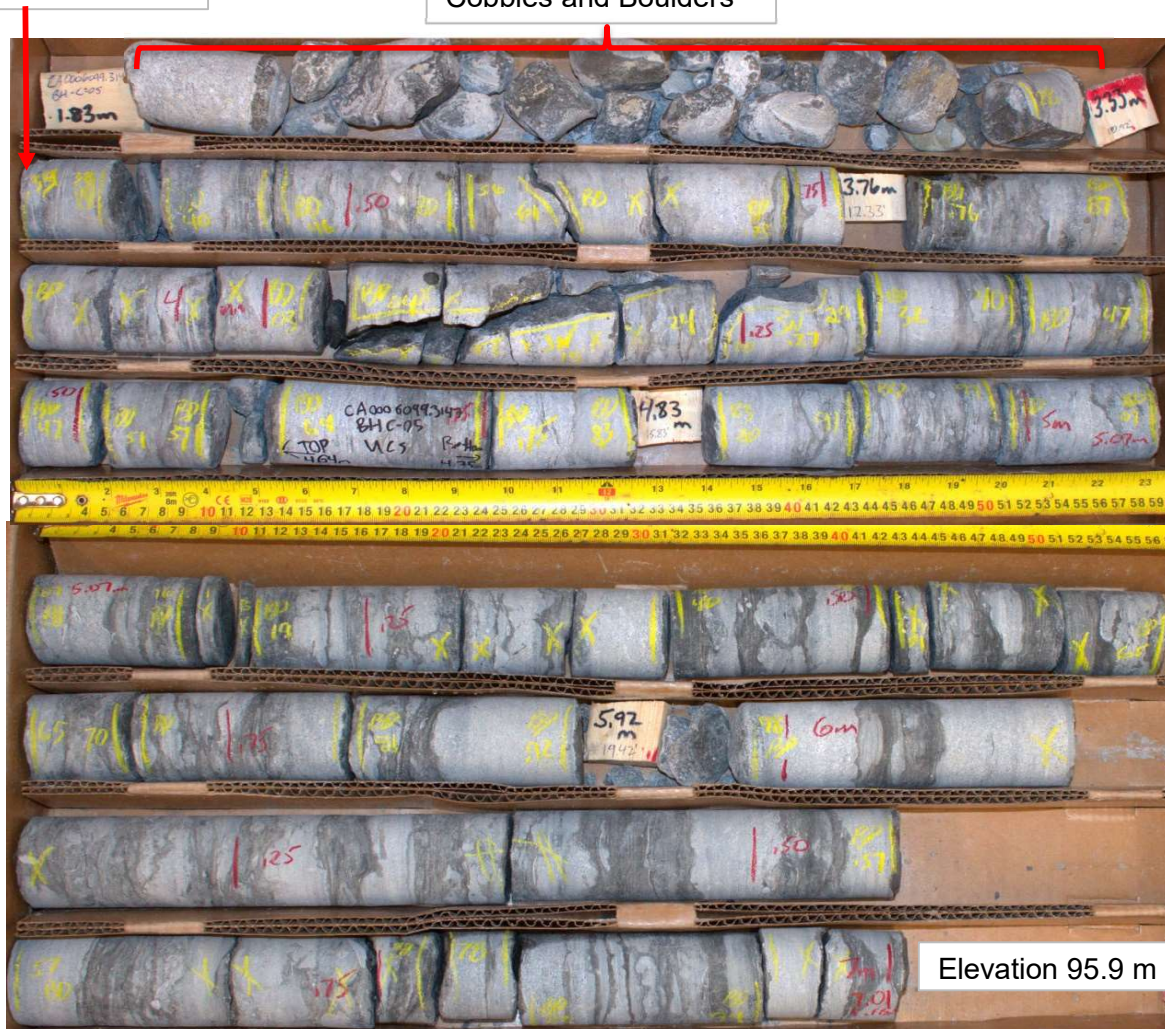
Figure A4

C-05 (Dry)

Core Box 1 to 2 of 2

Elevation 99.6 m Top of Bedrock

Cobbles and Boulders



Elevation 95.9 m EOH



Replacement of Culvert 11X-0420/C0
GWP: 4053-18-00 WP: 4094-20-01

Walbridge Loyalist Road / Highway 401
Belleville, Ontario

Project No. CA0006099.3147

Drawn: BW

Date: 2024-02-23

Checked: KCP

Review: DS

Figure A5

C-05 (Wet)

Core Box 1 to 2 of 2

Elevation 99.6 m Top of Bedrock

Cobbles and Boulders



Replacement of Culvert 11X-0420/C0
GWP: 4053-18-00 WP: 4094-20-01

Walbridge Loyalist Road / Highway 401
Belleville, Ontario

Project No. CA0006099.3147

Drawn: BW

Date: 2024-02-23

Checked: KCP

Review: DS

Figure A6

APPENDIX B

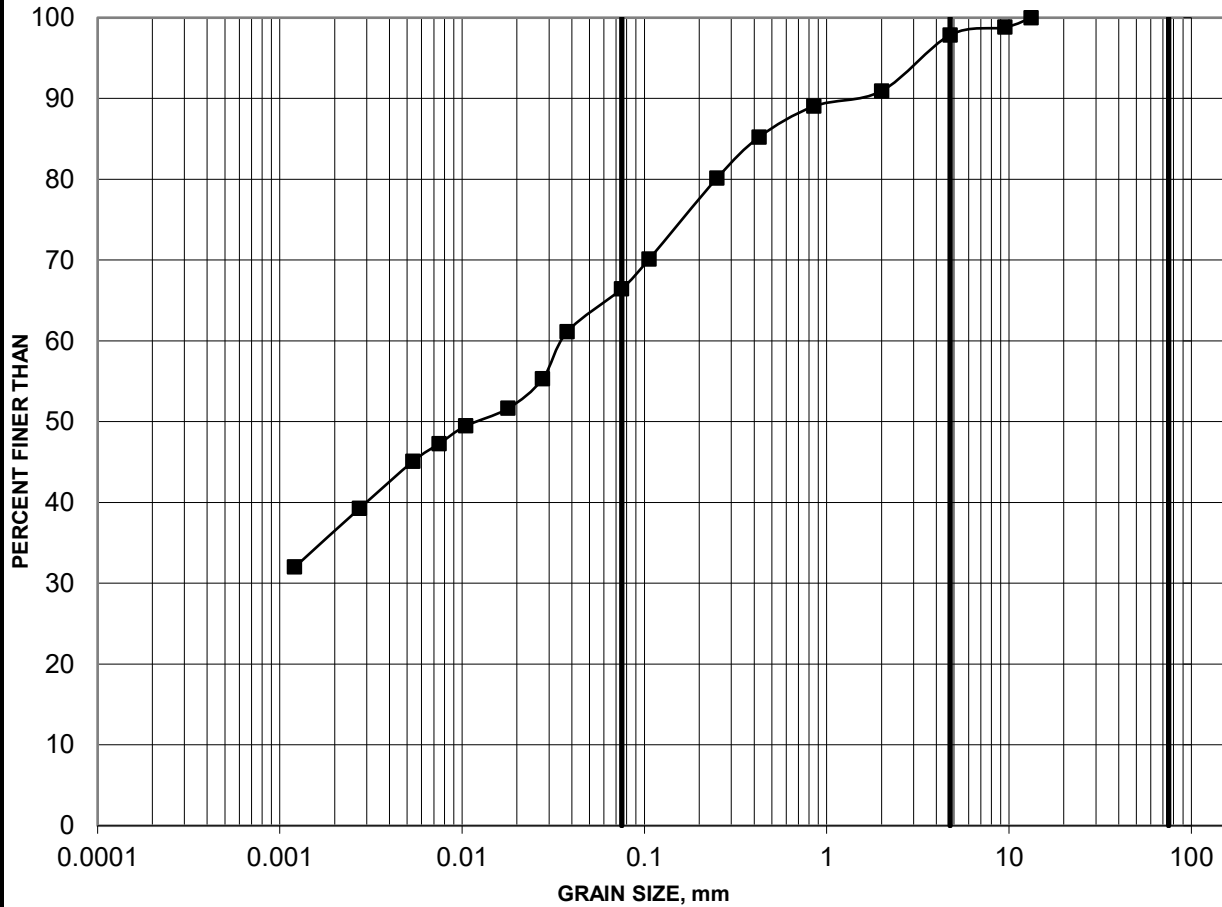
Geotechnical Laboratory Test Results

Figures B1 to B5

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sandy SILTY CLAY (CI),(FILL)



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

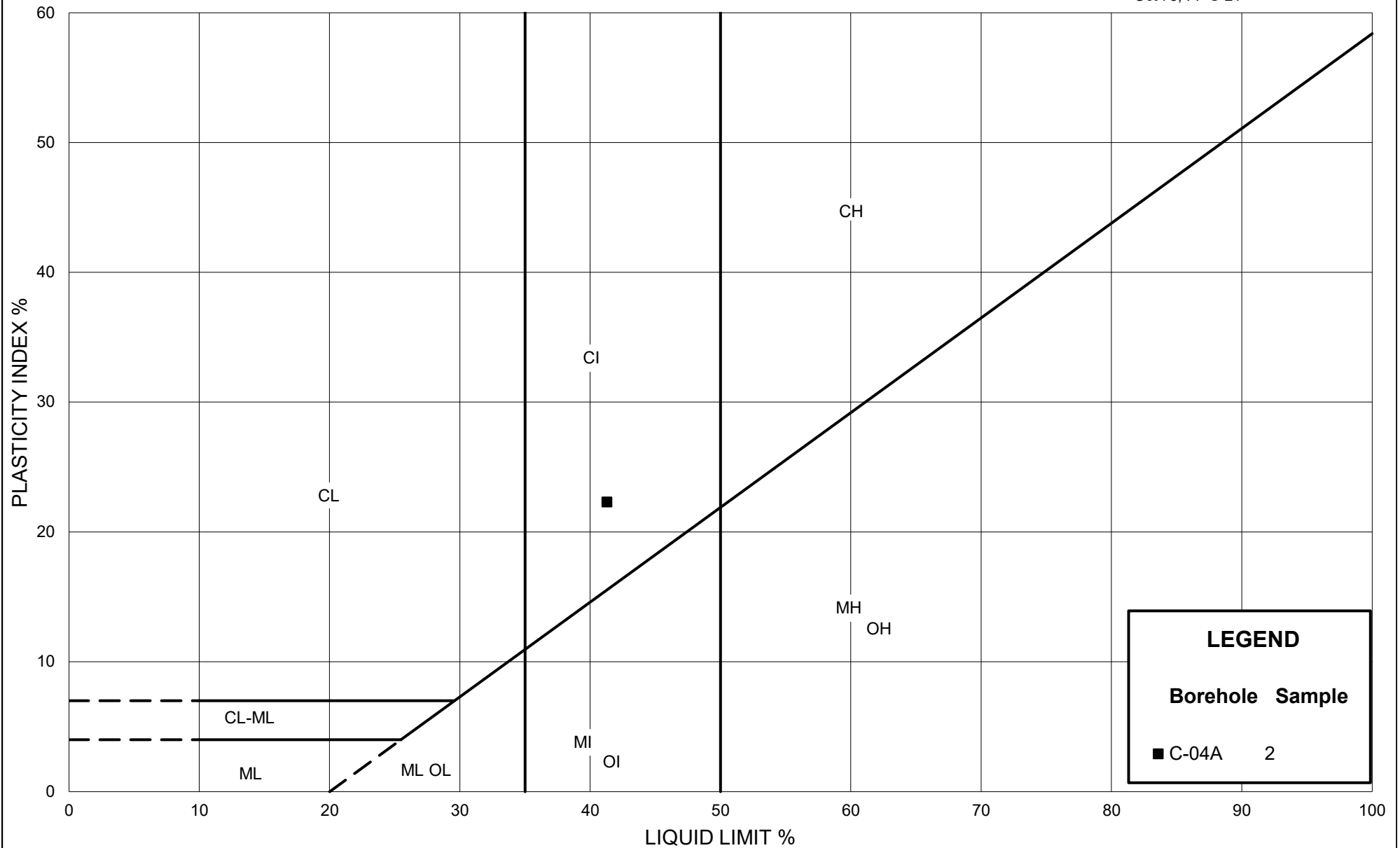
Borehole	Sample	Depth (m)	Constituents (%)			
			Gravel	Sand	Silt	Clay
■ C-04A	2	0.76-1.67	2	32	29	37

Project: CA0006099.3147/1000

wsp

Created by: CW

Checked by: MI



Ministry of Transportation

PLASTICITY CHART

SILTY CLAY (CI)(FILL)

Figure: B2

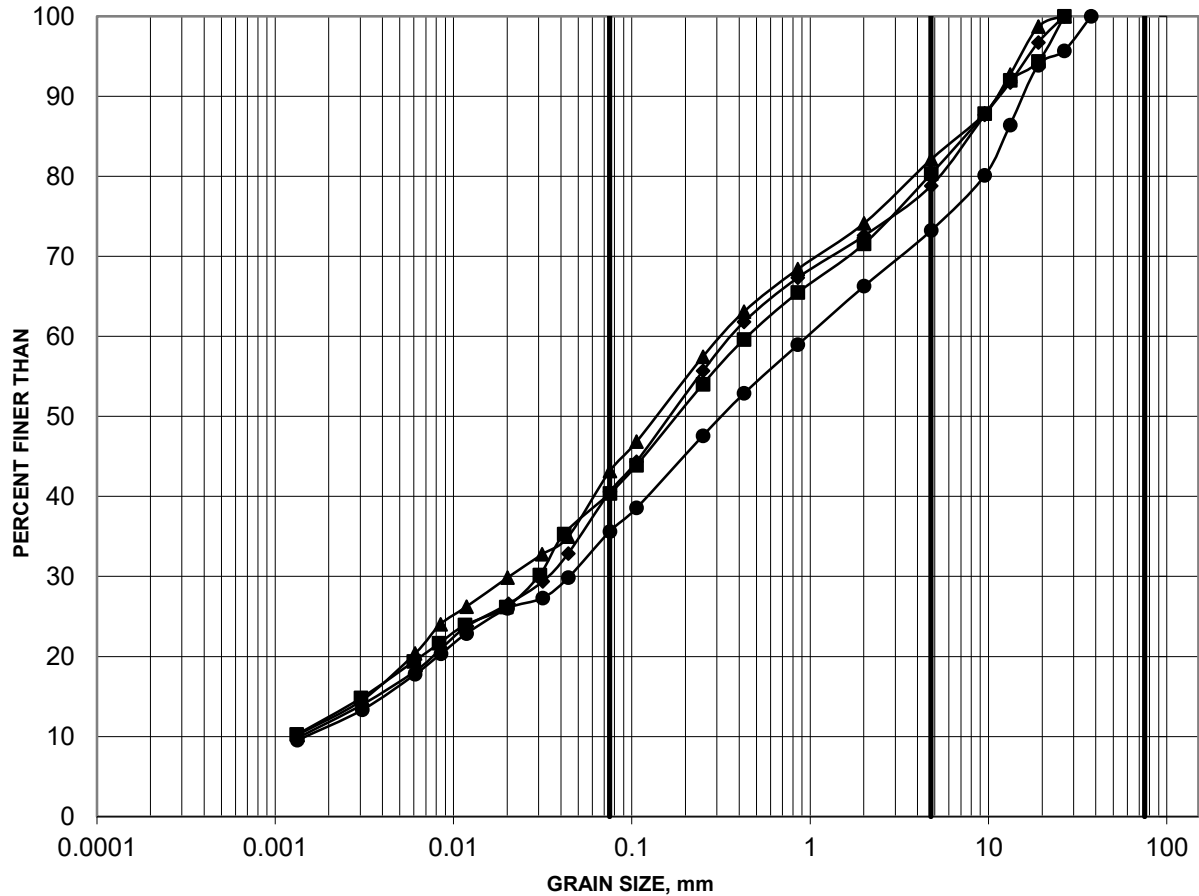
Project: CA0006099.3147/1000

Created By: CW Checked By: MI

GRAIN SIZE DISTRIBUTION

FIGURE B3

GRAVELLY CLAYEY SAND-SILTY SAND (SC-SM), (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-04A	4	2.29-2.90	20	40	27	13
◆	C-04	2	0.61-1.22	21	38	29	12
▲	C-04	3	1.22-1.83	18	39	31	12
●	C-05	4	1.93-2.39	27	37	25	11

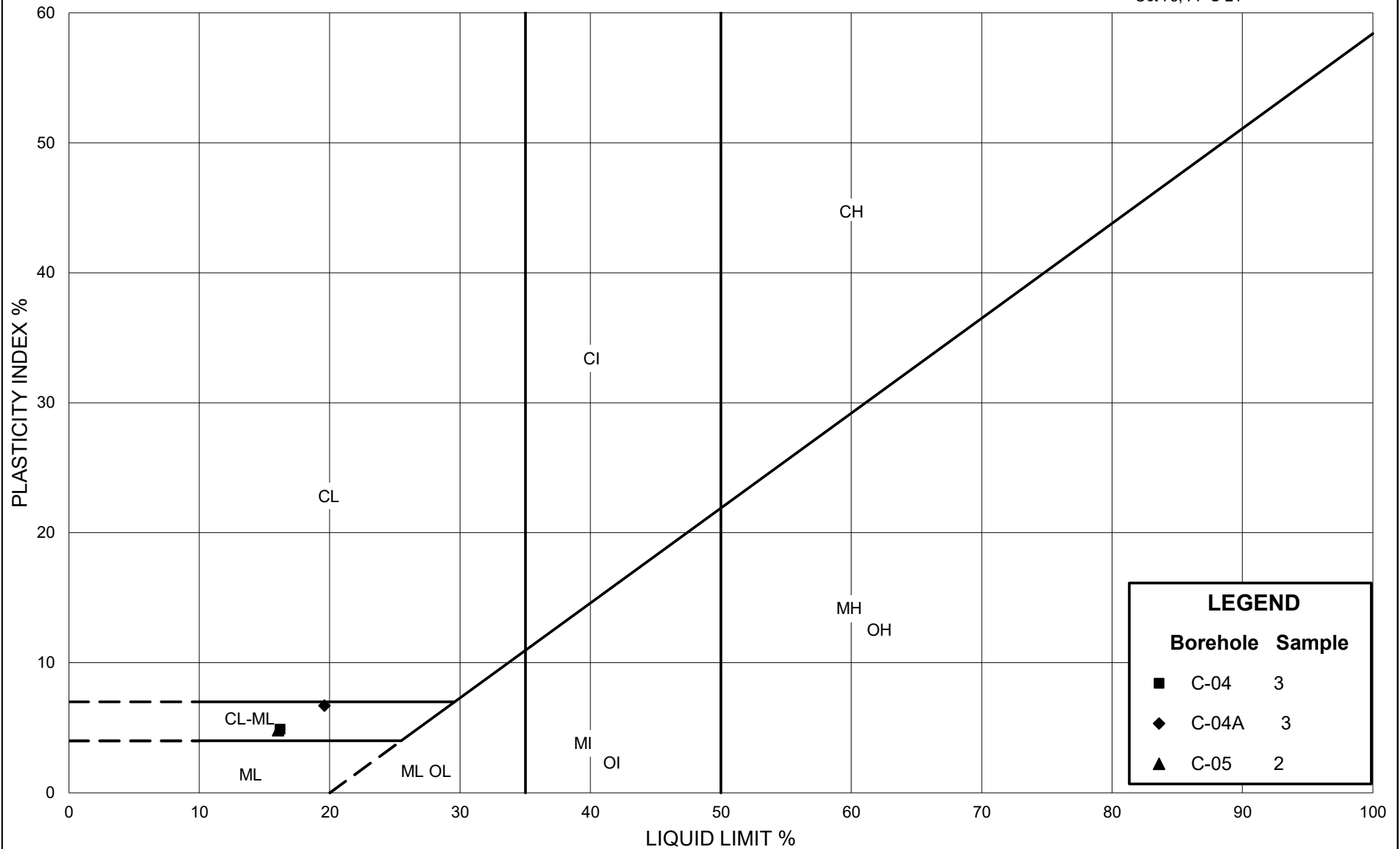
wsp

Project: CA0006099.3147/1000

<https://wsponlinecan.sharepoint.com/Sites/Global-OttawaLab/Shared Documents/Active/CA0006099.3147/phase 1000 Culvert S2/Figures/>

Created by: CW

Checked by: MI



Ontario

Ministry of Transportation

PLASTICITY CHART

CLAYEY SILT-SILT (CL-ML) TILL

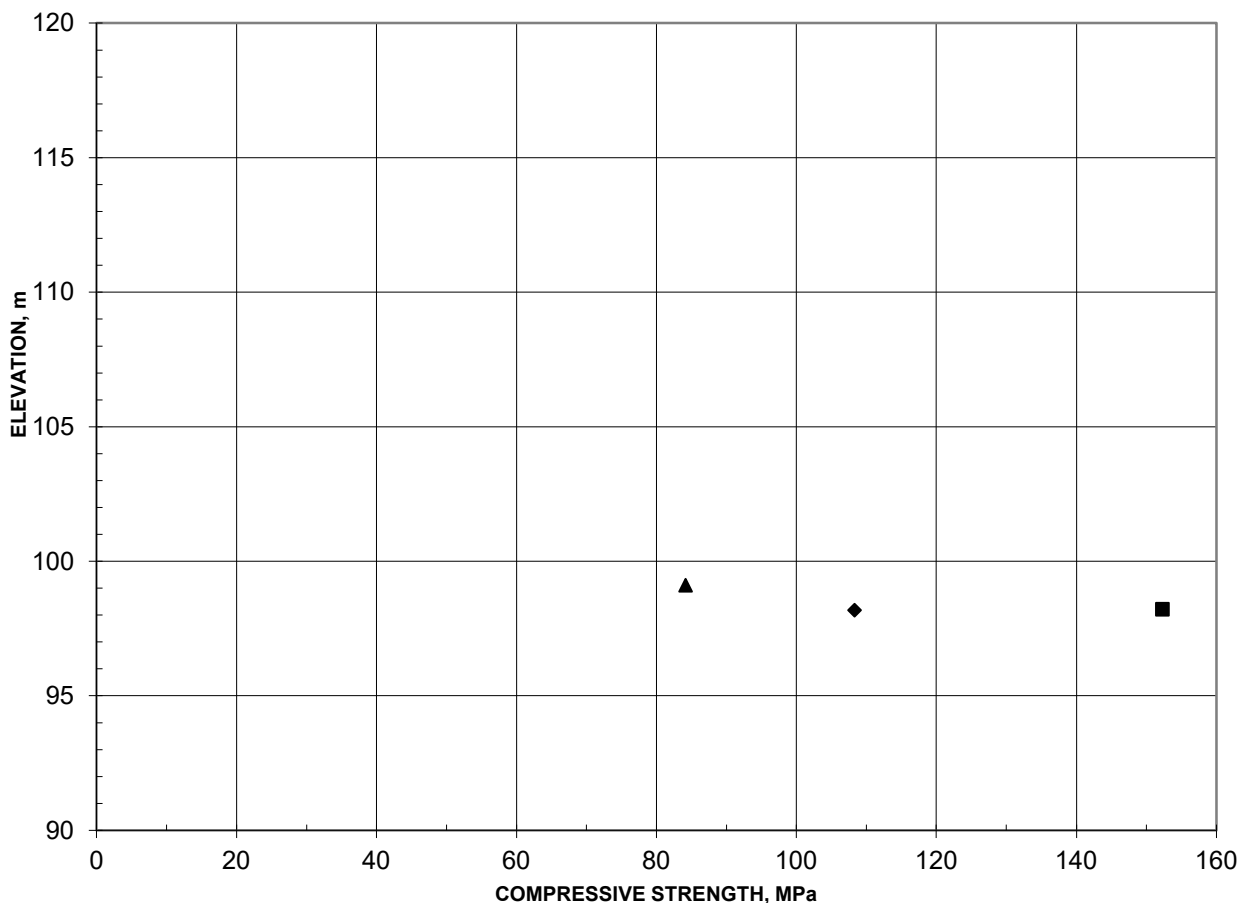
Figure: B4

Project: CA0006099.3147/1000

Created By: BW Checked By: MI

ASTM D7012 - Method C
UNIAXIAL 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
◆	C-04 RC1	4.7	2.3	2668	Limestone	152	1
■	C-05 RC1	4.7	2.0	2672	Limestone	108	1
▲	C-04A RC1	5.3	2.4	2685	Limestone	84	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 cracking 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.

wsp

Project: CA0006099.3147/1000

Created by: CW

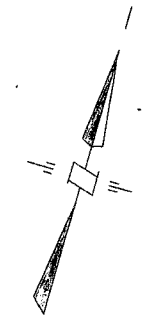
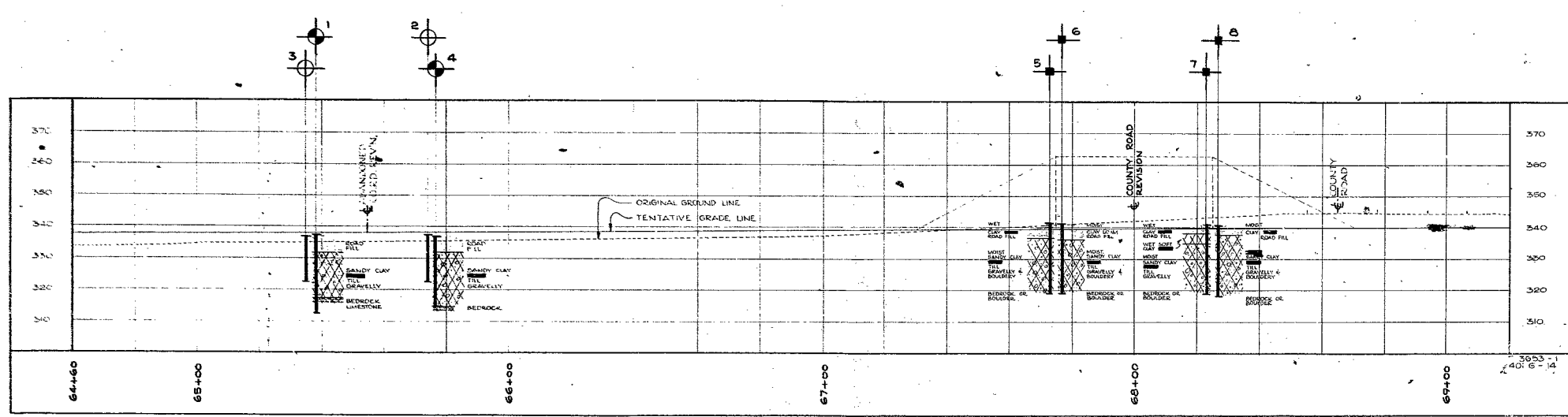
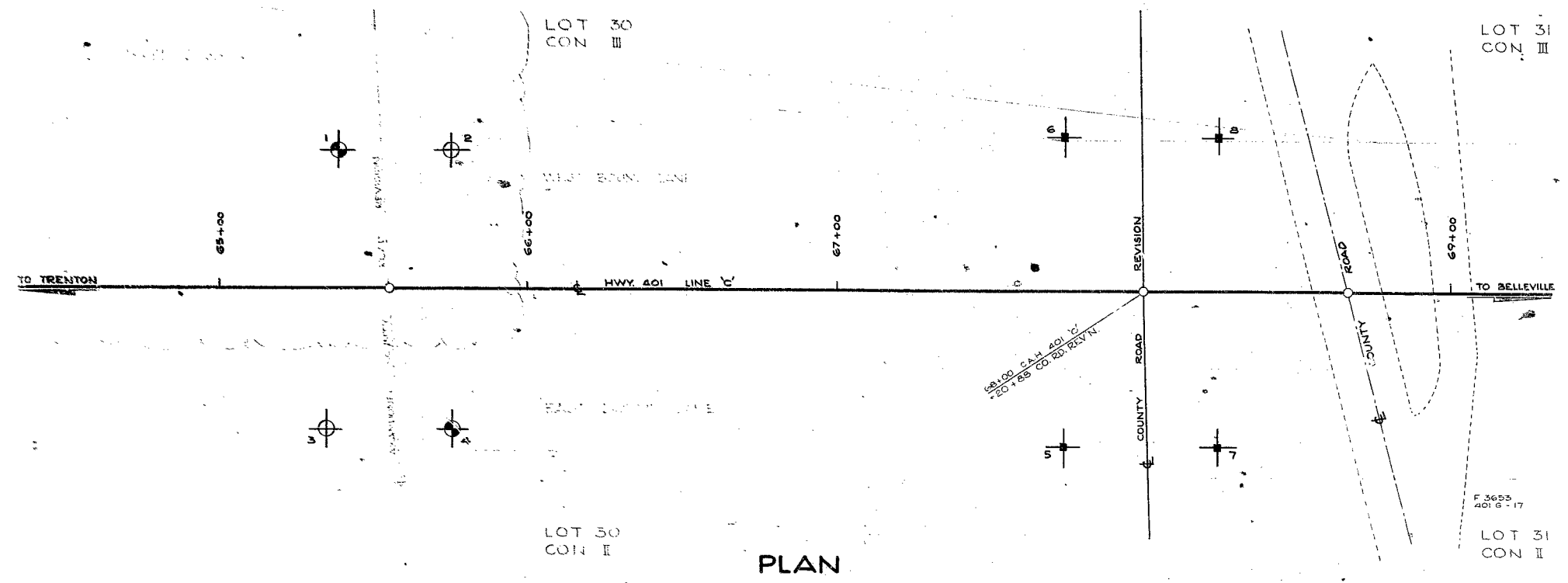
Checked by: MI

APPENDIX C

Previous Investigations

Results from 1957 and 1958 Original Investigation GEOCREs No. 31C00-023

SOME DEFECTS IN NEGATIVE DUE
TO CONDITION OF ORIGINAL DOCUMENTS



LEGEND			
AUGER HOLE			
BORE HOLE			
PENETRATION HOLE			
BORE & PENETRATION HOLE			

HOE NO	ELEVATION	STATION	DISTANCE FROM E
1	337.5'	65+36'	45' LT
2	337.5'	65+75'	45' LT
3	336.8'	65+35'	45' RT
4	337.0'	65+76'	45' RT
5	341.74'	67+75'	50' RT
6	341.43'	67+75'	50' LT
7	341.17'	68+25'	50' RT
8	340.99'	68+25'	50' LT

NOTE
THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM CORRELATIONAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS - ONTARIO		
MATERIALS & RESEARCH SECTION - DOWNSVIEW		
COUNTY ROAD REVISION PROJECT NO. 152 W. C. BELLEVILLE SHOW LOCATION & ELEVATION OF HOLES		
HWY. NO. 401 LINE 'C'	W.P. 45-57	DIV. NO. 5
CO. HASTINGS		
TWP. SIDNEY	LOTS 30 & 31	CON'S I & II
SCALE 1 IN = 20 FT	SUBMITTED BY	DATE 28 APRIL 58
DRAWN BY R.E.F.	APPROVED BY	DRAWING NO. F-57-45A

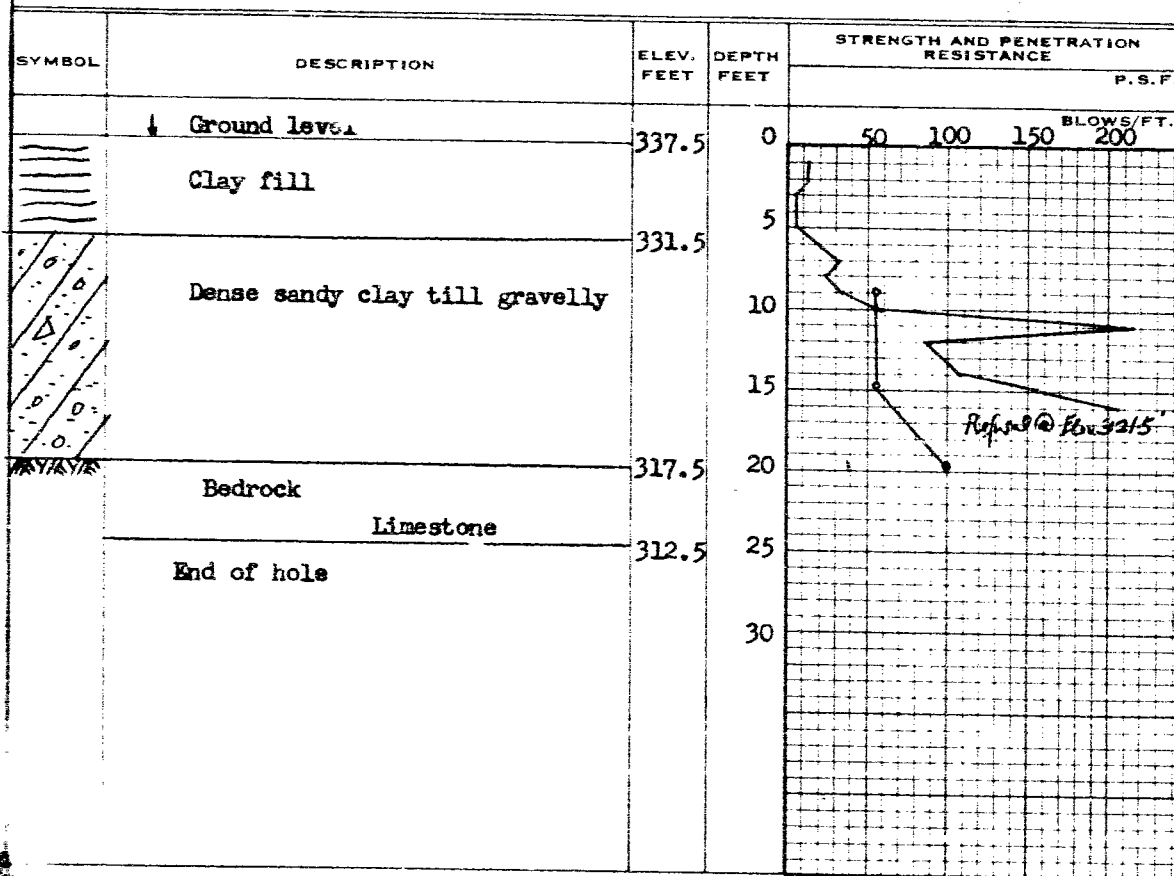
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 45 - 57 BORE HOLE NO. 1
 JOB F57 - 45 STATION 65 + 38 (45' LT)
 DATUM Elev. 337.5' COMPILED BY A.L.
 BORING DATE Nov. 6/57 CHECKED BY _____

2" DIA. SPLIT TUBE _____
 2" SHELBY TUBE _____
 2" SPLIT TUBE _____
 2" DIA. CONE _____
 2" SHELBY _____
 CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) _____ O
 VANE TEST (C) AND SENSITIVITY (S) _____ +
 NATURAL MOISTURE AND LIQUIDITY INDEX _____ LI
 LIQUID LIMIT _____ X
 PLASTIC LIMIT _____



CONSISTENCY		SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DR. WT.			
10 20 30			
		SS1	
		SS2	
		SS3	

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 45-57 BORE HOLE NO. 2

JOB F57 - 45 STATION 68/75 (45' LT)

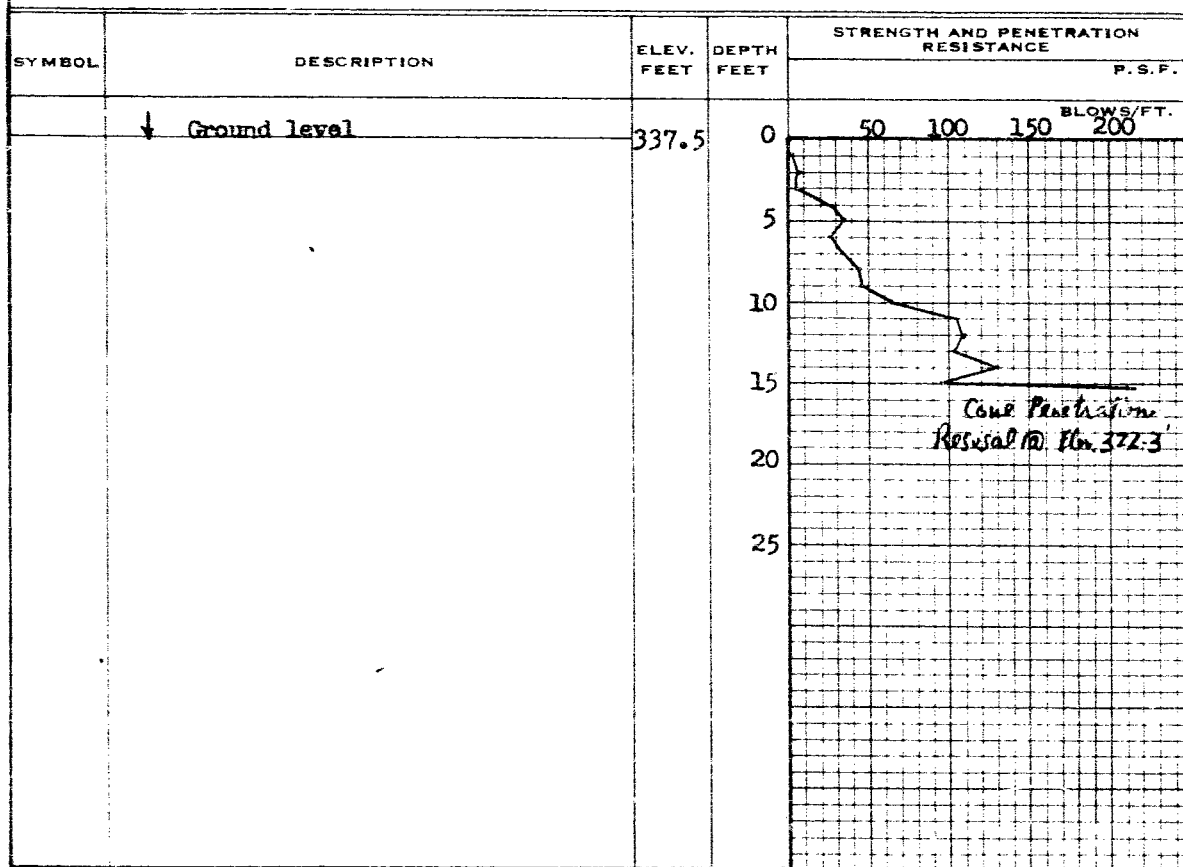
DATUM Elev. 337.5 _____ COMPILED BY A.J. _____

BORING DATE Nov. 1/57 CHECKED BY _____

2" DIA. SPLIT TUBE _____
2" SHELBY TUBE _____
2" SPLIT TUBE _____
2" DIA. CONE _____
2" SHELBY _____
CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) -----	○
VANE TEST (C) AND SENSITIVITY (S) -----	+s
NATURAL MOISTURE AND	LI
LIQUIDITY INDEX -----	X
LIQUID LIMIT -----	○
PLASTIC LIMIT -----	○

[illegible]

MATERIALS AND RESEARCH SECTION

BORING DATE Nov. 2/57 CHECKED BY

2" DIA. SPLIT TUBE _____
2" SHELBY TUBE _____
2" SPLIT TUBE _____
2" DIA. CONE _____
2" SHELBY _____
CASING _____

1/2 UNCONFINED COMPRESSION (Qu) --- O
VANE TEST (C) AND SENSITIVITY (S) --- +
NATURAL MOISTURE AND LIQUIDITY INDEX --- LI
LIQUID LIMIT --- X
PLASTIC LIMIT ---

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION	
				RESISTANCE	P.S.F.
↓	Ground level	336.8	0	BLOWS/FT.	
			5		
			10		
			15	Cone Penetration Refusal @ Elev. 312.3	
			20		
			25		

[illegible]

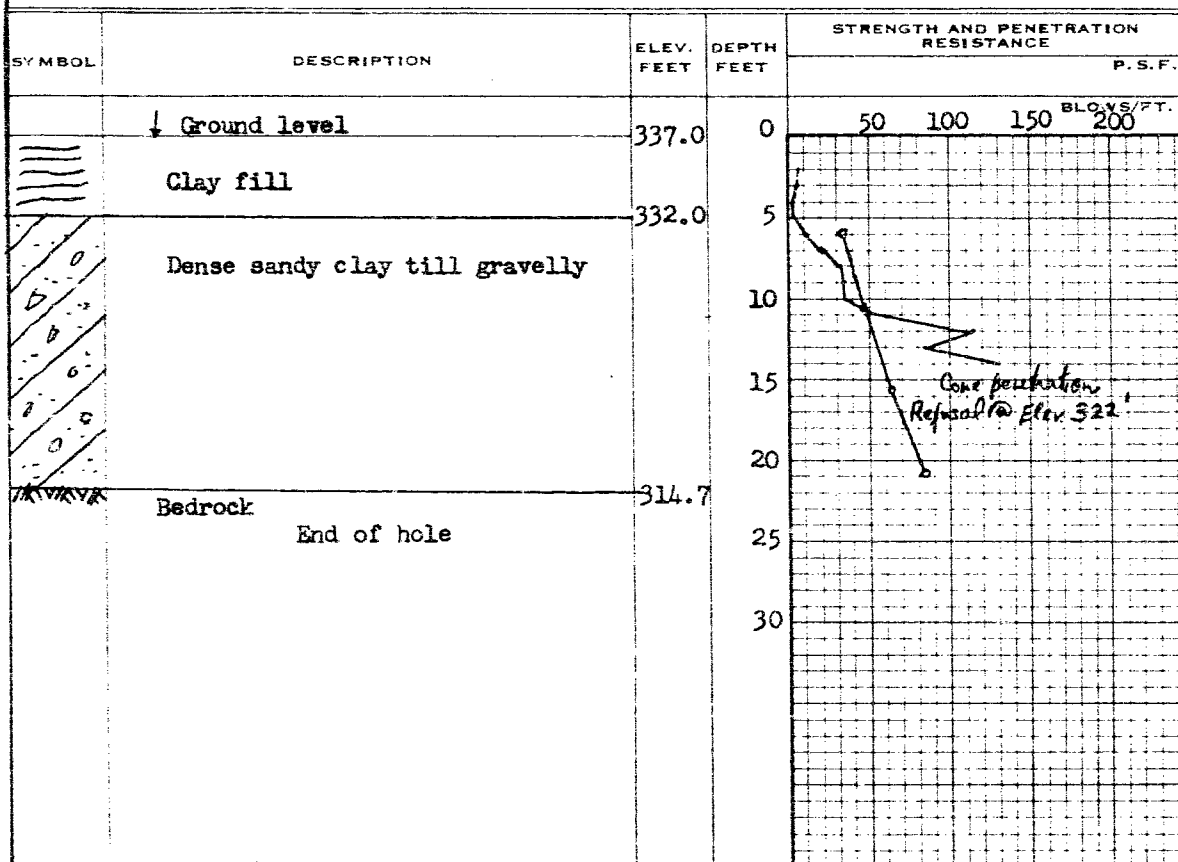
DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.P. 45-5 BORE HOLE NO. 4
 JOB F57-45 STATION 65+76 (45' RT)
 DATUM Elev. 337.0' COMPILED BY A.L.
 BORING DATE Nov. 7/57 CHECKED BY _____

2" DIA. SPLIT TUBE _____
 2" SHELBY TUBE _____
 2" SPLIT TUBE _____
 2" DIA. CONE _____
 2" SHELBY _____
 CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Q_u) _____ O
 VANE TEST (C) AND SENSITIVITY (S) _____ +
 NATURAL MOISTURE AND LIQUIDITY INDEX _____ LI
 LIQUID LIMIT _____ X
 PLASTIC LIMIT _____



CONSISTENCY			SAMPLE	NATURAL
MOIST. CONTENT- % DRY WT.				UNIT WT
10	20	30		P.C.F.
	*		TW1	135.0
	*		TW2	140.0
		*	SS3	-----
	*		SS4	-----

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 45 - 57 BORE HOLE NO. 5

JOB F57 - 45 STATION 67475 (50' BT)




DATUM Elev. 341.7 _____ COMPILED BY _____ A.L. _____

BORING DATE Mar. 26/58 CHECKED BY _____

2" DIA. SPLIT TUBE -----
2" SHELBY TUBE -----
2" SPLIT TUBE -----
2" DIA. CONE -----
2" SHELBY -----
CASING -----

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) _____	O
VANE TEST (C) AND SENSITIVITY (S) _____	S
NATURAL MOISTURE AND _____	LI
LIQUIDITY INDEX _____	X
LIQUID LIMIT _____	o
PLASTIC LIMIT _____	

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE	
				P.S.F.	
	↓ Ground level	341.7	0		
	Clay fill	336.7	5		
	Dense grey sandy clay till gravelly	319.2	10		
			15		
			20		
	Probably bedrock		25		
	end of auger borehole		30		

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 45 - 57 BORE HOLE NO. 6

JOB F57 - 45 STATION 67#75 (50' LT)


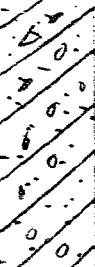
DATUM Elev. 341.4 _____ COMPILED BY A.L. _____

BORING DATE Mar. 26/58 CHECKED BY _____

2" DIA. SPLIT TUBE _____
 2" SHELBY TUBE _____
 2" SPLIT TUBE _____
 2" DIA. CONE _____
 2" SHELBY _____
 CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Qu)	---	O
VANE TEST (C) AND SENSITIVITY (S)	---	+ ²
NATURAL MOISTURE AND		LI
LIQUIDITY INDEX	-----	X
LIQUID LIMIT	-----	o
PLASTIC LIMIT	-----	o

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE	
				P.S.F.	
	↓ Ground level	341.4	0	BLOWS/FT.	
	Clay fill	336.4	5		
	Dense grey sandy clay till gravelly		10		
			15		
			20		
		319.4	25		
	Probably bedrock end of auger borehole		30		

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 45 - 57 BORE HOLE NO. 7

JOB F57-45 STATION 68.25 (50' BT)



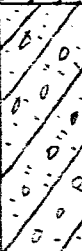

DATUM Elev. 341.2 COMPILED BY A.L.

BORING DATE Mar. 26/58 CHECKED BY _____

2" DIA. SPLIT TUBE _____
2" SHELBY TUBE _____
2" SPLIT TUBE _____
2" DIA. CONE _____
2" SHELBY _____
CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) _____	O
VANE TEST (C) AND SENSITIVITY (S) _____	+ S
NATURAL MOISTURE AND	
LIQUIDITY INDEX _____	X
LIQUID LIMIT _____	
PLASTIC LIMIT _____	

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE			
				P.S.F.			
				BLOWS/FT.			
	↓ Ground level	▽ W.L.	341.2	0			
	Clay fill		338.2				
	Soft grey sandy clay (very wet)		335.2	5			
	Dense grey sandy clay till, gravelly			10			
				15			
				20			
	Probably bedrock		319.2	25			
	end of auger borehole			30			

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

W.P. 45 - 57 ----- BORE HOLE NO. 8 -----

JOB F57 - 45 STATION 68+25 (50' IT)


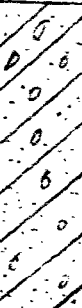
DATUM Elev. 341' _____ COMPILED BY A.L.

BORING DATE Mar. 26/58 CHECKED BY

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) --- 0
VANE TEST (C) AND SENSITIVITY (S). --- +5
NATURAL MOISTURE AND LIQUIDITY INDEX --- LI
LIQUID LIMIT --- X
PLASTIC LIMIT --- 0

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE				
				P.S.F.				
	↓ Ground level			BLOWS/FT.				
	Clay fill	341.0	0					
	Dense grey sandy clay till, gravelly	338.0	5					
			10					
			15					
			20					
		318.5	25					
	Probably bedrock							
	end of auger borehole							

[illegible]

APPENDIX D

Analytical Laboratory Testing Results

Eurofins Report No. 3003046

Client: WSP Canada Inc.
1931 Robertson Road,
Ottawa, Ontario
K2H 5B7

Attention: Mr. Kenton Power

PO#:

Invoice to: WSP Canada Inc.

Report Number: 3003046
Date Submitted: 2023-11-08
Date Reported: 2023-11-16
Project: CA000699.3147
COC #: 911776

Page 1 of 3

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:

Raheleh Zafari, Environmental 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

Client: WSP Canada Inc.
1931 Robertson Road,
Ottawa, Ontario
K2H 5B7
Attention: Mr. Kenton Power
PO#:
Invoice to: WSP Canada Inc.

Report Number: 3003046
Date Submitted: 2023-11-08
Date Reported: 2023-11-16
Project: CA000699.3147
COC #: 911776

					Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	
Group	Analyte	MRL	Units	Guideline	1710367 Soil 2023-10-17 C-04 Sa4/6-6.92'	1710368 Soil 2023-10-18 C-05 Sa3/4-5.33'
Anions	Cl	0.002	%		0.002	0.004
	SO4	0.01	%		<0.01	<0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.13	0.17
	pH	2.00			8.54	8.59
	Resistivity	1	ohm-cm		7692	5882

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

Client: WSP Canada Inc.
1931 Robertson Road,
Ottawa, Ontario
K2H 5B7
Attention: Mr. Kenton Power
PO#:
Invoice to: WSP Canada Inc.

Report Number: 3003046
Date Submitted: 2023-11-08
Date Reported: 2023-11-16
Project: CA000699.3147
COC #: 911776

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 452020 Analysis/Extraction Date 2023-11-10 Analyst IP Method Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	100	90-110
pH	6.63	99	90-110
Resistivity			
Run No 452093 Analysis/Extraction Date 2023-11-13 Analyst IP Method AG SOIL			
SO4	<0.01 %	96	70-130
Run No 452308 Analysis/Extraction Date 2023-11-16 Analyst AsA Method C CSA A23.2-4B			
Chloride	<0.002 %	99	90-110

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 E

Site Photographs



Photograph 1: Looking west towards Borehole C-05 and existing culvert inlets; October 19, 2023



Photograph 2: Looking north towards Borehole C-05 along east ditchline; October 19, 2023



Photograph 3: Looking east (upstream) from culvert inlet from Borehole C-05; October 19, 2023



Photograph 4: Looking south from Borehole C-04 along Wallbridge Loyalist Road west ditchline; October 19, 2023



Photograph 5: Looking east from Borehole C-04 across Wallbridge Loyalist Road; October 19, 2023



Photograph 6: Looking north towards Borehole C-04A along Wallbridge Loyalist Road west ditchline; October 19, 2023



Photograph 7: Looking south towards Borehole C-04A along Wallbridge Loyalist Road; October 19, 2023



Photograph 8: Looking east towards Borehole C-04 and culvert outlets; October 19, 2023

