WSP GOLDER

REPORT

Preliminary Foundation Investigation Report

Replacement of Highway 401/County Road 26 Underpass
(Structure Site No. 21X-0297/B0)
Municipality of Brighton, Northumberland County
MTO GWP 4054-17-00; MTO Agreement No. 4016-E-0034-011

Submitted to:

WSP Canada Inc.
610 Chartwell Road, Suite 300
Oakville, ON L6J 4A5

Submitted by:

WSP Golder
1931 Robertson Road Ottawa, ON Canada

1773612_CR26

July 12, 2023

GEOCRES No.: 31C-321
Latitude: 44.07941°
Longitude: -77.74208°

Distribution List

1 e-Copy - MTO East Region

1 e-Copy - MTO Foundations Section

1 e-Copy - WSP Canada Inc.

1 e-Copy - WSP Golder

Table of Contents

1.0 INTRODUCTION

WSP Golder (formerly Golder Associates Ltd., now a member of WSP Canada Inc.) has been retained by WSP Canada Inc. (WSP) on behalf of the Ministry of Transportation, Ontario (MTO) to support future procurement to support future procurement-ready design phases of the rehabilitation and widening of Highway 401 from 0.8 km east of Percy Street to 0.4 km west of Christiani Road in Northumberland County, Ontario. The overall project includes the replacement of three bridge structures and four structural culverts.

This report presents the results of the preliminary foundation investigation carried out for the replacement of the Highway 401/County Road 26 (CR26) Underpass (MTO Structure Site No. 21X-0297/B0).

The preliminary foundation engineering services for this project have been delivered under MTO Agreement No. 4016-E-0034-011 as part of MTO GWP 4054-17-00.

2.0 SITE DESCRIPTION

The Highway 401/CR26 site is located approximately 2.2 km east of County Road 30 in the Municipality of Brighton in Northumberland County, Ontario. The site location is shown on the key plan 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 underpass structure. There are no interchange ramps at this location.

CR26 is an undivided road with a rural cross-section and a single travel lane in each direction that carries traffic over Highway 401 at a skew of approximately 30 degrees. Parapet walls with railing are present along the bridge and steel beam guiderails are present along both side of CR26 beyond the bridge.

The land surrounding the structure site is agricultural, with a rolling, hummocky topography. Highway 401 has been constructed partially in cut with the pavement grade at the structure site at approximately Elevation 196 m; this is lower than the natural ground surface immediately south of the highway, which is up to approximately Elevation 200 m. The CR26 grade is at approximately Elevation 201.5 m immediately adjacent to the existing bridge abutments; the existing approach embankments are approximately 5 m to 5.5 m high relative to the Highway 401 grade, although the south approach embankment consists of approximately 1 m to 2 m of fill relative to the surround natural ground surface.

The existing bridge was constructed in 1965 under MTO Contract 65-03. It is a four-span structure with perched abutments and piers founded on spread footings The Structural Design Report for Site 21X-0297/B0 indicates that the structure itself is in fair to good condition. Based on visual observation at the time of the investigation, there are no signs of embankment instability or approach embankment settlement.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between July 11 and July 14, 2022 and included advancing three boreholes (CR26-01 to CR26-03) through the travelled lanes of CR26. The borehole locations are shown on Drawing 1.

The boreholes were advanced with a CME55 truck-mounted drill rig, supplied, and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, 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 and 1.5 m.

After sampling to a depth of approximately 18.9 m, Borehole CR26-02 was advanced to refusal without sampling, using Dynamic Cone Penetration Testing (DCPT). Borehole CR26-03, located approximately 1.5 m north of Borehole CR26-02, was augered without sampling to a depth of 19.8 m and was further advanced by SPT sampling to a termination depth of 33.7 m.

A monitoring well was installed at Borehole CR26-01 to observe the stabilised groundwater level at the site. The monitoring well consists of 52 mm outside diameter PVC tube with a 1.5 m long slotted screen. Well installation details are shown on the record for Borehole CR26-02 provided in Appendix A. The boreholes without a monitoring well were backfilled with bentonite mixed with soil cuttings within the overburden, in general accordance with the intent of Ontario Regulation (O.Reg.) 903, as amended. The site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of WSP Golder'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 samples were identified in the field, placed in labelled containers, and transported to WSP Golder'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. The laboratory tests were carried out to MTO and/or ASTM Standards, as applicable at WSP Golder's Ottawa laboratory.

One soil sample was sent to Eurofins Environmental Testing Canada Inc. (Eurofins) for basic chemical analysis related to 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 Golder 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 No.	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
CR26-01	4882907.0 (44.079410)	205320.6 (-77.742080)	201.3	29.5[1]
CR26-02	4882820.7 (44.078630)	205303.7 (-77.74227)	201.3	26.8[2]
CR26-03	4882822.0 (44.078640)	205303.7 (-77.742270)	201.3	33.7[1]

Notes: [1] Borehole terminated within glacial till
[2] Borehole terminated at DCPT refusal

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario* Site 21-297 lies in the physiographic regions known as the South Slope. The South Slope region lies between the Oak Ridges Moraine, to the north and the Iroquois Plain to the south. It covers approximately 940 square miles, extending from Niagara Escarpment to the Trent River. The eastern portion of the slope in Northumberland County is thickly covered by large drumlins pointing to the southwest. In Northumberland County fine sand and silt is found on the surface of the till up to a depth of six or eight feet. The South slope lies across the limestones of the Verulam and Lindsay Formations, the grey shales of the Georgian Bay Formation, and the reddish shales of the Queenston Formation.

4.2 Subsurface Conditions

The subsurface soil, and groundwater conditions encountered in the boreholes and the results of in-situ testing from the investigation are shown on the borehole records presented in Appendix A. The results of the geotechnical laboratory testing are presented on the borehole records as well as on Figures B1 to B5 in Appendix B. The borehole locations and the interpreted stratigraphic profile projected along the proposed structure alignment are provided in Drawing 1.

The results of the basic chemical testing/analysis completed on a select soil sample are provided in Appendix C.

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.

In general, the subsurface conditions encountered at this site consist of existing pavement structure (asphalt and pavement granular material) and non-cohesive fill associated with the existing CR26 embankment, underlain by a sand to silt to silt and sand, which is further underlain by a glacial till deposits comprising silty sand to silty gravel containing cobbles and boulders, up to the termination depth of the boreholes. A more detailed description of the overburden soil deposits, conditions encountered during the field investigation is provided in the following sections.

4.2.1 Existing Pavement Structure

An approximately 100 mm thick layer of asphalt pavement was encountered at the ground surface in the boreholes. Approximately 0.1 to 0.2 m of granular material consisting of gravelly sand to sand and gravel was encountered beneath the asphalt in both boreholes that were sampled over this zone.

4.2.2 Fill

Underlying the existing pavement structure, a non-cohesive fill consisting of sand with varying amounts of gravel was encountered at all boreholes The top of this layer was encountered at Elevations 201.0 m and 201.1 m. The layer extends to Elevations 196.1 m and 199.8 m with thicknesses of 4.9 m and 1.3 m at Boreholes CR26-01 and CR26-02 respectively. The SPT ‘N’-values measured within this fill range from 22 to 88 blows per 0.3 m of penetration but are more typically greater than 30 blows to 56 blows indicating a generally dense to very dense state of compactness. Within the fill layers, the presence of gravel, cobbles and/or boulders were noted; in addition, the higher blow count (e.g., 88 blows per 0.3 m of penetration) is considered to represent the presence of cobbles and/or boulders and may not represent the state of compactness of the fill matrix.

The measured moisture contents of two samples of the fill were 5% and 8%. The results of grain size distribution testing carried out on two samples of the fill are shown on Figure B1 in Appendix B.

4.2.3 Upper Interbedded Sand to Silt

An interbedded non-cohesive deposit was encountered below the fill in Boreholes CR26-01 and CR26-02. The soils in this upper non-cohesive deposit vary in composition from sand containing trace to some silt, to silty sand, to silt and sand, to silt with varying proportions of gravel and/or clay. The top of this layer was encountered at Elevations 196.1 m and 199.8 m. This layer extends to Elevations 192.2 m and 192.6 m and is 3.9 m and 7.2 m in thickness at Boreholes CR26-01 and CR26-02 respectively.

The SPT ‘N’-values measured within the interbedded layers ranges from 12 blows to 48 blows per 0.3 m of penetration but more typically 16 blows to 26 blows indicating a generally compact state of compactness.

The measured moisture content of the tested samples of interbedded sand to silt layers ranges between approximately 2% to 20%. The results of grain size distribution testing carried out on five samples of the silt to sand and silt are provided in Figure B2 in Appendix B, while the result of grain size distribution testing on one sample of sand from this upper interbedded deposit is included on Figure B3 in Appendix B.

4.2.4 Sand

Sand with trace silt and gravel was encountered below the interbedded sand to silt layers in Boreholes CR26-01 and CR26-02. The top of this layer was encountered at Elevations 192.2 m and 192.6 m. The layer extends to Elevations 176.0 m and 171.4 m and is 16.2 m and 21.2 m in thickness at Boreholes CR26-01 and CR26-02 respectively. The SPT ‘N’-values measured within the sand ranges from 13 blows to 110 blows per 0.3 m of penetration but more typically 32 blows to 75 blows indicating a generally dense to very dense state of compactness.

The measured moisture content of tested samples ranges between approximately 2% and 15%. The results of grain size distribution carried out on four samples of this sand deposit are shown on Figure B3 in Appendix B (which also contains the grain size distribution test for one sample of sand from the upper interbedded layers).

4.2.5 Gravelly Silty Sand to Silty Gravel Till

A gravel and sand till with varying amounts of silt was encountered below the sand layer at all boreholes advanced at the site. The glacial till is described as consisting of a gravelly silty sand to silty gravel containing cobbles and boulders. The top of this layer was encountered at Elevations 176.0 m and 171.4 m. Boreholes CR26-01 and CR26-03 were terminated in this layer at Elevations 171.8 m and 167.6 m and Borehole CR26-02 was terminated at DCPT refusal at Elevation 174.5 m in inferred till.

The recorded SPT N-values were all greater than 100 blows per 0.3 m of penetration, suggesting a very dense compactness. The frequent spoon sampler refusals observed in Boreholes CR26-01 and CR26-03 suggests the possibility of cobbles and boulder that may have influenced the noted higher blow counts noted rather than the consistency of the soil matrix.

The water content measured on three samples ranged from 8% to 15%. The results of grain size distribution carried out on two samples of till are shown on Figure B4 in Appendix B. The results of Atterberg limits testing completed on a single sample of the till indicate a liquid limit of 17, plastic limit of 15 and plasticity index of 2. The Atterberg Limits analysis results are provided on Figure B5 in Appendix B and indicate that the fines portion of the till is a silt of low plasticity (ML).

4.3 Groundwater Conditions

A standpipe piezometer was installed at Borehole CR26-01 to measure the stabilized groundwater level at the site. The groundwater level recorded in the piezometer is shown on the borehole record in Appendix A and is summarized in Table 2.

Table 2: Summary of Groundwater Conditions

Borehole No.	Screened Interval	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Elevation (m)	Date
CR26-01	Sand / Till	201.3	20.7	180.6	July 21, 2022

The groundwater level observations at this site will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation and snow melt.

4.4 Analytical Laboratory Testing Results

One soil sample was submitted to Eurofins for chemical testing/analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix C and are summarized in Table 3

Table 3: Steel Corrosion and Sulphate Attack, Chemical Analysis

Borehole No.	Sample Depth (m)	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
CR26-01	1.5-2.1	0.058	0.01	1.27	8.88	787

5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Kinjal Gajjar, a geotechnical consultant at WSP Golder and reviewed by Kenton Power, P.Eng., a senior geotechnical engineer with WSP Golder. Lisa Coyne, P.Eng., a Fellow and MTO Designated Foundations Contact for WSP Golder, conducted an independent technical and quality review of this report.

Signature Page

WSP Golder

Kinjal Gajjar
Geotechnical Consultant

Kenton Power, P.Eng.
Senior Geotechnical Engineer

Lisa Coyne, P.Eng.
Fellow, MTO Foundations Designated Contact

KG/KCP/LCC/ljv

c:\users\ljonesvilleneuve\golder associates\1773612, mto 4016e0034 0035 retainer eastern - wo#11 - colborne to brighten\3. reporting\1-cr26\3-final\fir\1773612 rev0 final pfir 2023'07'12 - cr26 (gwp 4054-17-00).docx

MINISTRY OF TRANSPORTATION, ONTARIO

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

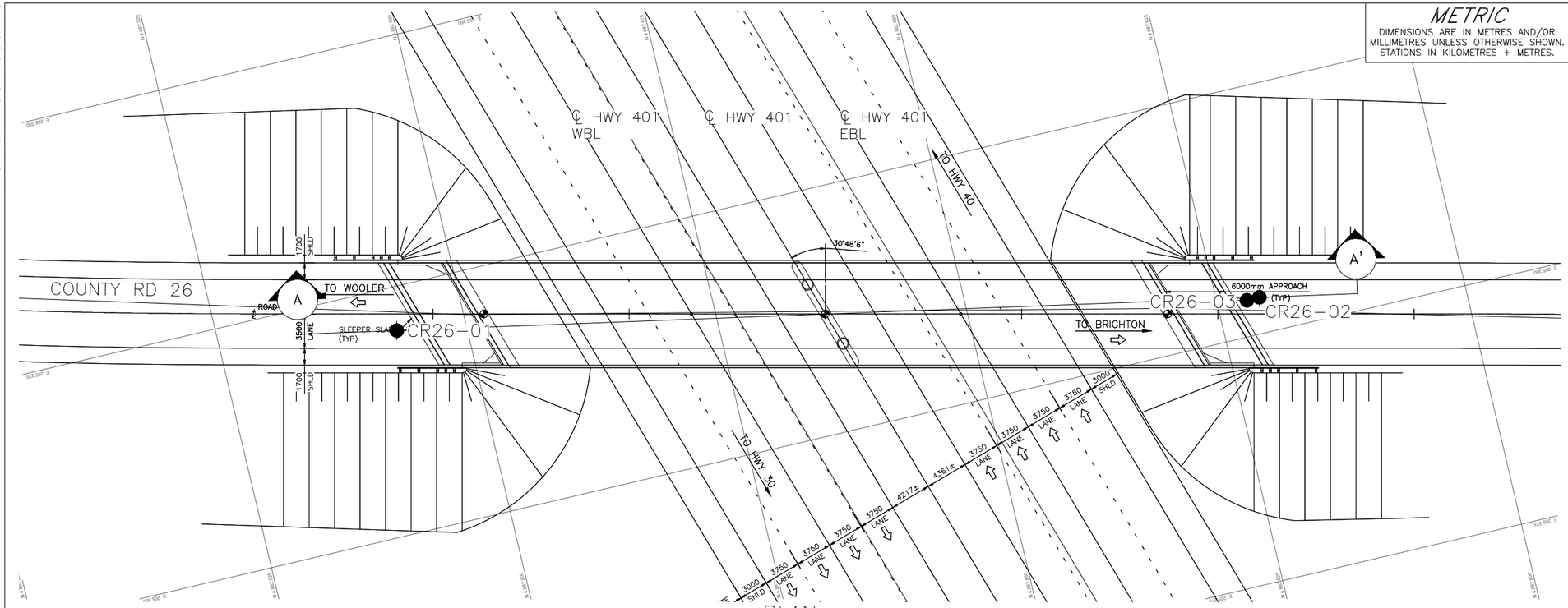
CONT No.
GWP No. 4054-17-00

REPLCEMENT OF HIGHWAY 401 UNDERPASS AT COUNTY RD 26

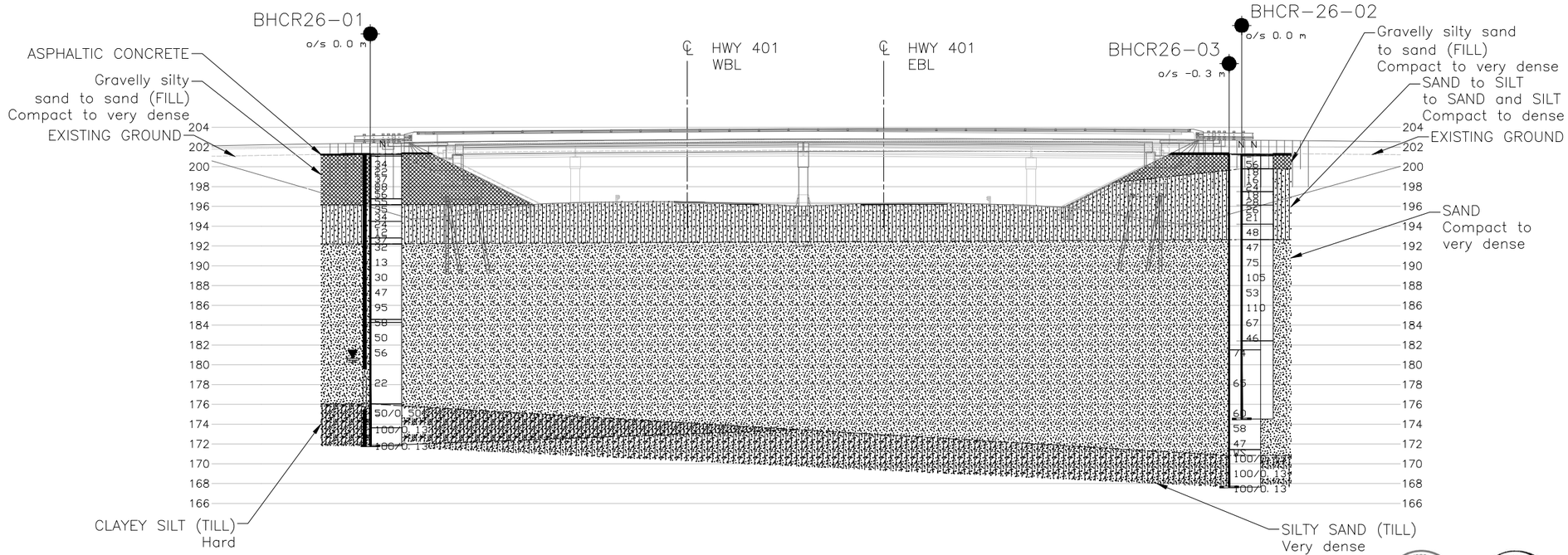
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

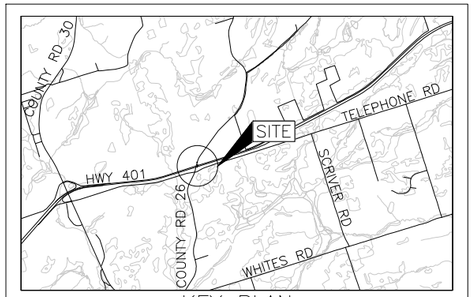
WSP GOLDER



PLAN
SCALE
5 0 5 10 m



PROFILE
SCALE
5 0 5 10 m



KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- Borehole – Current Investigation
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- Seal
- Piezometer
- WL in piezometer, measured on July 21, 2022.

BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
BHCR26-01	201.3	4882907.0	205320.6
BHCR26-02	201.3	4882820.7	205303.7
BHCR26-03	201.3	4882822.0	205303.7

Structural Site Location Latitude: 44.07941 Longitude: -77.74208

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 Contracts 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 WSP, drawing file no. S17M-0172-11-300-001GA.dwg received April 05, 2022, and General Arrangement Drawing file no. S17M-0172-11-300-001GA, received February 2023.

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31C-321

HWY. 401		PROJECT NO. 1773612	DIST. EASTERN
SUBM'D. KCP	CHKD. KG	DATE: 7/12/2023	SITE: 21-297
DRAWN: ZS	CHKD. KCP	APPD. LCC	DWG. 1

L. C. COYNE 2023/07/12 PROVINCE OF ONTARIO

K. K. C. POWER 100139552 2023-07-12 PROVINCE OF ONTARIO

PLOT DATE: July 12, 2023
FILENAME: S:\Clients\MTO\Hwy_401_Colborne_to_Brighton\09_PROJ\1773612_Parsons_CulvertReplacement\40_PROD\0005_Geotech_Road_26_Underpass\1773612-0005-BC-0001.dwg

APPENDIX A

Borehole Records

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

3. 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.
4. 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 $\gamma = \rho g$ (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_α	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
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
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	$(\sigma_1 - \sigma_3)/2$ 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

PROJECT 1773612

RECORD OF BOREHOLE No CR26-01

SHEET 1 OF 3

METRIC

G.W.P. 4054-17-00 LOCATION N 4882907.0; E 205320.6 MTM NAD ZONE 9 (LAT. 44.079410; LONG. -77.742080) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID Hollow Stem Augers COMPILED BY TR

DATUM GEODETIC DATE July 14, 2022 CHECKED BY KCP/LCC

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
201.3	GROUND SURFACE										
0.0	ASPHALT / CONCRETE (100 mm)		1A 1B	AS	-		201				
0.3	(SW) gravelly SAND (PAVEMENT STRUCTURE) (FILL) Brown Moist										
	(SM) Gravelly silty sand, contains cobbles (FILL) Compact to very dense Brown Moist		2	SS	34		200		○		25 55 (20)
			3	SS	22						
			4	SS	37		199				
			5	SS	88		198				
			6	SS	56						
196.7							197				
4.6	(SM) Gravelly silty sand, some clay (FILL) Very dense Black to light brown Moist		7A 7B	SS	55				○		22 47 (31)
196.1							196				
5.2	(SW) SAND, trace silt, trace gravel Dense Brown Moist		8	SS	35						
			9	SS	34		195		○		3 90 (7)
194.4											
6.9	(ML) SILT, some sand, some clay Compact Brown Moist		10	SS	24		194				
			11	SS	12				○		0 16 67 17
192.8							193				
8.5	(SM/ML) SAND and SILT Dense Brown Moist		12A 12B	SS	37				○		0 58 (42)
192.2											
9.1	(SP) SAND, trace to some silt and gravel Very dense to compact Light brown to brown Moist to wet		13	SS	32		192				
			14	SS	13		191				
							190				

Continued Next Page

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

PROJECT 1773612

RECORD OF BOREHOLE No CR26-01 SHEET 2 OF 3 METRIC

G.W.P. 4054-17-00 LOCATION N 4882907.0; E 205320.6 MTM NAD ZONE 9 (LAT. 44.079410; LONG. -77.742080) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID Hollow Stem Augers COMPILED BY TR

DATUM GEODETIC DATE July 14, 2022 CHECKED BY KCP/LCC

SOIL PROFILE			SAMPLES			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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	(SP) SAND, trace to some silt and gravel Very dense to compact Light brown to brown Moist to wet						189				
			15	SS	30						
							188				
			16	SS	47						
							187				
			17	SS	95		186				
							185				
			18A 18B	SS	58						
							184				
			19	SS	50		183		○		2 86 (12)
							182				
			20	SS	56		181				
						▼					
							180				
							179				
			21	SS	22		178				

Continued Next Page

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

RECORD OF BOREHOLE No CR26-01

SHEET 3 OF 3 **METRIC**

PROJECT 1773612
G.W.P. 4054-17-00
DIST Eastern HWY 401
DATUM GEODETIC

LOCATION N 4882907.0; E 205320.6 MTM NAD ZONE 9 (LAT. 44.079410; LONG. -77.742080)
BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID Hollow Stem Augers
DATE July 14, 2022

ORIGINATED BY JS
COMPILED BY TR
CHECKED BY KCP/LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	(SP) SAND, trace to some silt and gravel Very dense to compact Light brown to brown Moist to wet						177				
176.0											
25.3	(GM) SILTY GRAVEL, trace to some sand, some clay, contains cobbles and boulders (TILL) Dense		22	SS	50/0.05		176				
			23	WS	-		175		○		63 6 18 13
173.6			24	SS	100/0.1		174				
27.7	(SM) SILTY SAND, trace to some clay, some gravel, contains cobbles and boulders (TILL) Dense Brown Wet						173				
171.8			25	SS	100/0.1		172				
29.5	END OF BOREHOLE NOTES: 1. Water level measured in monitoring well at 20.7 m (Elev. 180.6 m) below ground surface on July 21, 2022.										

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY_401_COLBORNE_TO_BRIGHTON\02_DATA\GINT\HWY_401_COLBORNE_TO_BRIGHTON.GPJ GAL-GTA.GDT 7/11/23 TR

RECORD OF BOREHOLE No CR26-02

SHEET 1 OF 3 | METRIC

PROJECT 1773612 | G.W.P. 4054-17-00 | DIST Eastern | HWY 401 | DATUM GEODETIC

LOCATION N 4882820.7; E 205303.7 MTM NAD ZONE 9 (LAT. 44.078630; LONG. -77.742270) | BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID Hollow Stem Augers | DATE July 11, 2022

ORIGINATED BY JS | COMPILED BY TR | CHECKED BY KCP/LCC

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
201.3	GROUND SURFACE										
0.0	ASPHALT / CONCRETE (100 mm)		1A 1B	AS	-		201				
0.2	(SW-SW/GW) gravelly SAND to SAND and GRAVEL (PAVEMENT STRUCTURE) (FILL) Brown Moist		2	SS	56						
199.8	(SW) SAND, some gravel, trace silt (FILL) Very dense Brown Moist		3	SS	18		200				
1.5	(ML) Sandy SILT, trace gravel, some clay Compact Brown Moist		4	SS	16		199		○		2 22 (76)
197.5			5	SS	24		198				
3.8	(ML/SM) SILT and SAND, some clay Compact Brown Moist		6	SS	18		197		○		0 33 55 12
196.1			7	SS	28						
5.2	(SP) SAND, trace to some silt Compact Brown Moist		8	SS	26		196				
194.2			9	SS	21		195				
7.1	(ML/SM) SILT and SAND, some clay Dense Brown Moist		10	SS	48		194		○		0 42 (58)
192.6							193				
8.7	(SP) SAND, trace silt Dense to very dense Brown Moist		11	SS	47		192				
			12	SS	75		191				
							190				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT 1773612

RECORD OF BOREHOLE No CR26-02 SHEET 2 OF 3 METRIC

G.W.P. 4054-17-00 LOCATION N 4882820.7; E 205303.7 MTM NAD ZONE 9 (LAT. 44.078630; LONG. -77.742270) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID Hollow Stem Augers COMPILED BY TR

DATUM GEODETIC DATE July 11, 2022 CHECKED BY KCP/LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	(SP) SAND, trace silt Dense to very dense Brown Moist		13	SS	105		189				0 88 (12)
							188				
			14	SS	53		187				
							186				
			15	SS	110		185				
			16	SS	67		184				0 85 (15)
182.4			17	SS	46		183				
18.9	START OF DCPT Inferred SAND, some silt					▽	182				
							181				
							180				
							179				
							178				

Continued Next Page

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

RECORD OF BOREHOLE No CR26-02

SHEET 3 OF 3 **METRIC**

PROJECT 1773612
G.W.P. 4054-17-00
DIST Eastern HWY 401
DATUM GEODETIC

LOCATION N 4882820.7; E 205303.7 MTM NAD ZONE 9 (LAT. 44.078630; LONG. -77.742270)
BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID Hollow Stem Augers
DATE July 11, 2022

ORIGINATED BY JS
COMPILED BY TR
CHECKED BY KCP/LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	w_P w w_L	γ kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						177				
							176				
							175				
174.5											
26.8	END OF DCPT END OF BOREHOLE at DCPT Refusal NOTES: 1. Open Borehole dry at a depth of 18.9 m (Elev. 182.4 m) on completion of augering.										

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

WATER CONTENT (%): 20 40 60

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

$\circ^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\HWY_401_COLBORNE_TO_BRIGHTON\02_DATA\GINT\HWY_401_COLBORNE_TO_BRIGHTON.GPJ GAL-GTA.GDT 7/11/23 TR

PROJECT 1773612

RECORD OF BOREHOLE No CR26-03 SHEET 1 OF 3 METRIC

G.W.P. 4054-17-00 LOCATION N 4882822.0; E 205303.7 MTM NAD ZONE 9 (LAT. 44.078640; LONG. -77.742270) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID HSA then Wash Boring COMPILED BY TR

DATUM GEODETIC DATE July 12 & 13, 2022 CHECKED BY KCP/LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
201.3	GROUND SURFACE										
0.0	For soil stratigraphy from 0 m to 19.8 m refer to Record of Borehole BHCR26-02						201 200 199 198 197 196 195 194 193 192 191 190				

Continued Next Page

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

PROJECT 1773612

RECORD OF BOREHOLE No CR26-03 SHEET 2 OF 3 METRIC

G.W.P. 4054-17-00 LOCATION N 4882822.0; E 205303.7 MTM NAD ZONE 9 (LAT. 44.078640; LONG. -77.742270) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID HSA then Wash Boring COMPILED BY TR

DATUM GEODETIC DATE July 12 & 13, 2022 CHECKED BY KCP/LCC

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 (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	For soil stratigraphy from 0 m to 19.8 m refer to Record of Borehole BHCR26-02						189 188 187 186 185 184 183 182 181 180 179 178				
181.5 / 19.8	(SP) SAND, trace to some silt Very dense Brown Moist to wet		1	SS	74	▽					
			2	SS	65				○		0 83 (17)

GTA-MTO 001 S:\CLIENTS\MTO\HWY_401_COLBORNE_TO_BRIGHTON\02_DATA\GINT\HWY_401_COLBORNE_TO_BRIGHTON.GPJ GAL-GTA.GDT 7/11/23 TR

Continued Next Page

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

PROJECT 1773612

RECORD OF BOREHOLE No CR26-03 SHEET 3 OF 3 METRIC

G.W.P. 4054-17-00 LOCATION N 4882822.0; E 205303.7 MTM NAD ZONE 9 (LAT. 44.078640; LONG. -77.742270) ORIGINATED BY JS

DIST Eastern HWY 401 BOREHOLE TYPE CME 55 Truck Mounted, 108 mm ID HSA then Wash Boring COMPILED BY TR

DATUM GEODETIC DATE July 12 & 13, 2022 CHECKED BY KCP/LCC

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	(SP) SAND, trace to some silt Very dense Brown Moist to wet						177				
							176				
			3	SS	60		175				
							174				
			4	SS	58						
							173				
			5	SS	47		172				
171.4											
29.9	(SM) Gravelly SILTY SAND, some clay, contains cobbles and boulders (TILL) Very dense Brown to grey-brown Moist to wet		6A		WS		171				
			6B		100/0.13						
							170				
			7	SS	100/0.13		169				
167.6			8	SS	100/0.13		168		o		20 35 28 17
33.7	END OF BOREHOLE NOTES: 1. Wet soils encountered at a depth of approximately 22.2 m (Elev. 179.1 m). 2. Switched from hollow stem auger to wash boring using HQ Casing at 22.9 m depth.										

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

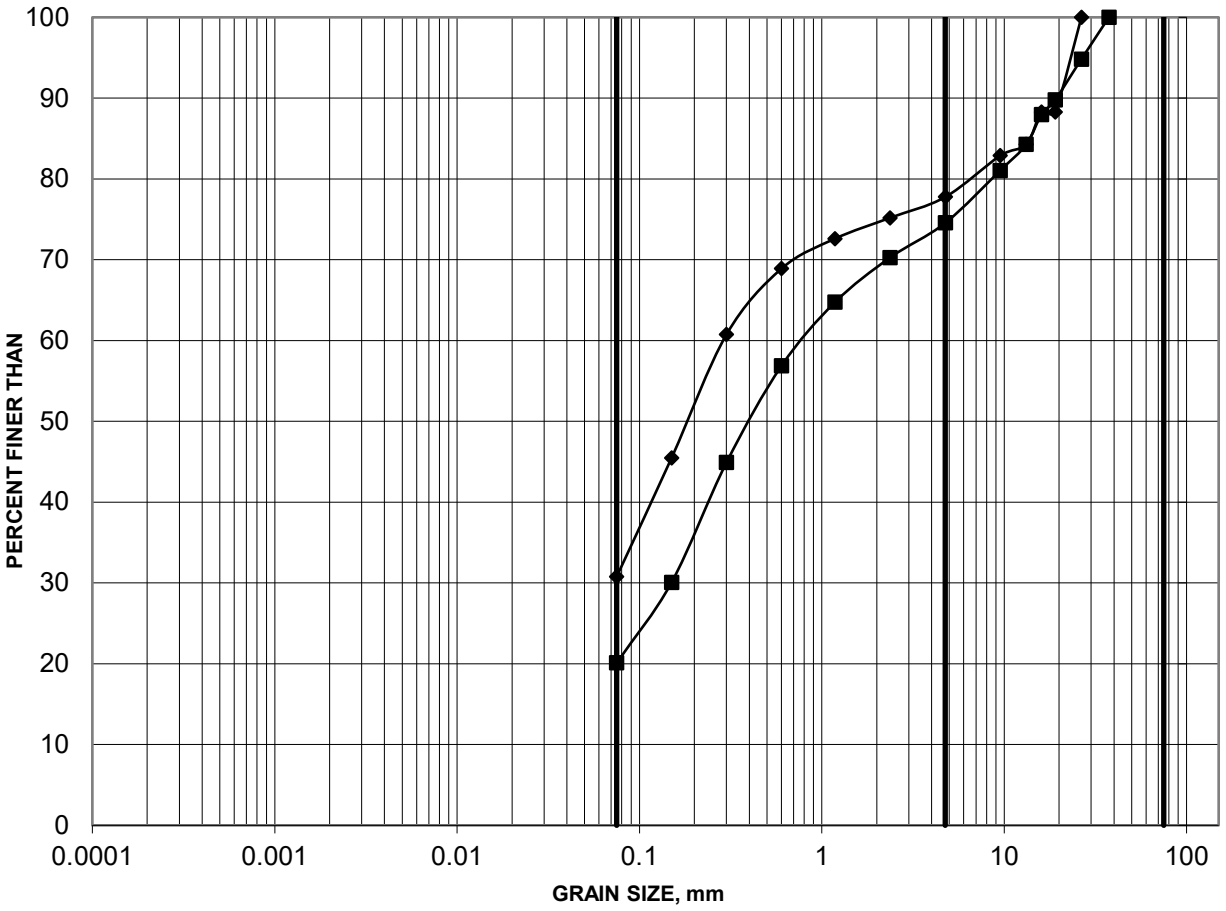
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

FIGURE B1

GRAVELLY SILTY SAND FILL



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

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	CR26-01	2	0.76-1.37	25	55	20	
◆	CR26-01	7A	4.57-4.88	22	47	31	

Project: 1773612_WO 11

GOLDER
MEMBER OF WSP

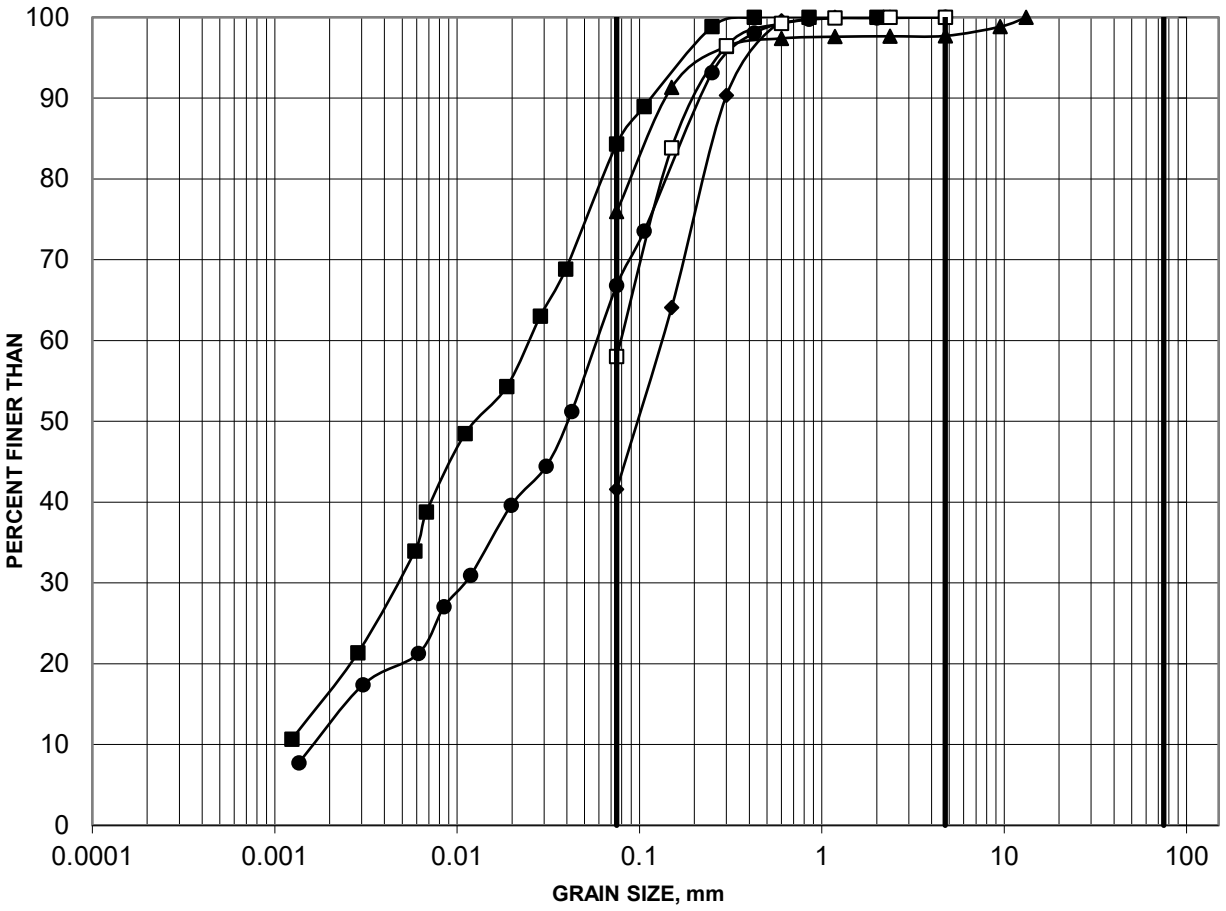
Created by: KG
Checked by:

https://golderassociates.sharepoint.com/sites/11407g/WO11 Colborne to Brighten/2. Technical Work/5. Lab Testing/1-CR26/Figures/

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILT TO SAND AND SILT



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

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	CR26-01	11	7.62-8.23	0	16		84
◆	CR26-01	12B	8.54-8.99	0	58		42
▲	CR26-02	4	2.29-2.90	2	22		76
●	CR26-02	6	3.81-4.42	0	33	55	12
□	CR26-02	10	7.62-8.23	0	42		58

Project: 1773612_WO 11

GOLDER
MEMBER OF WSP

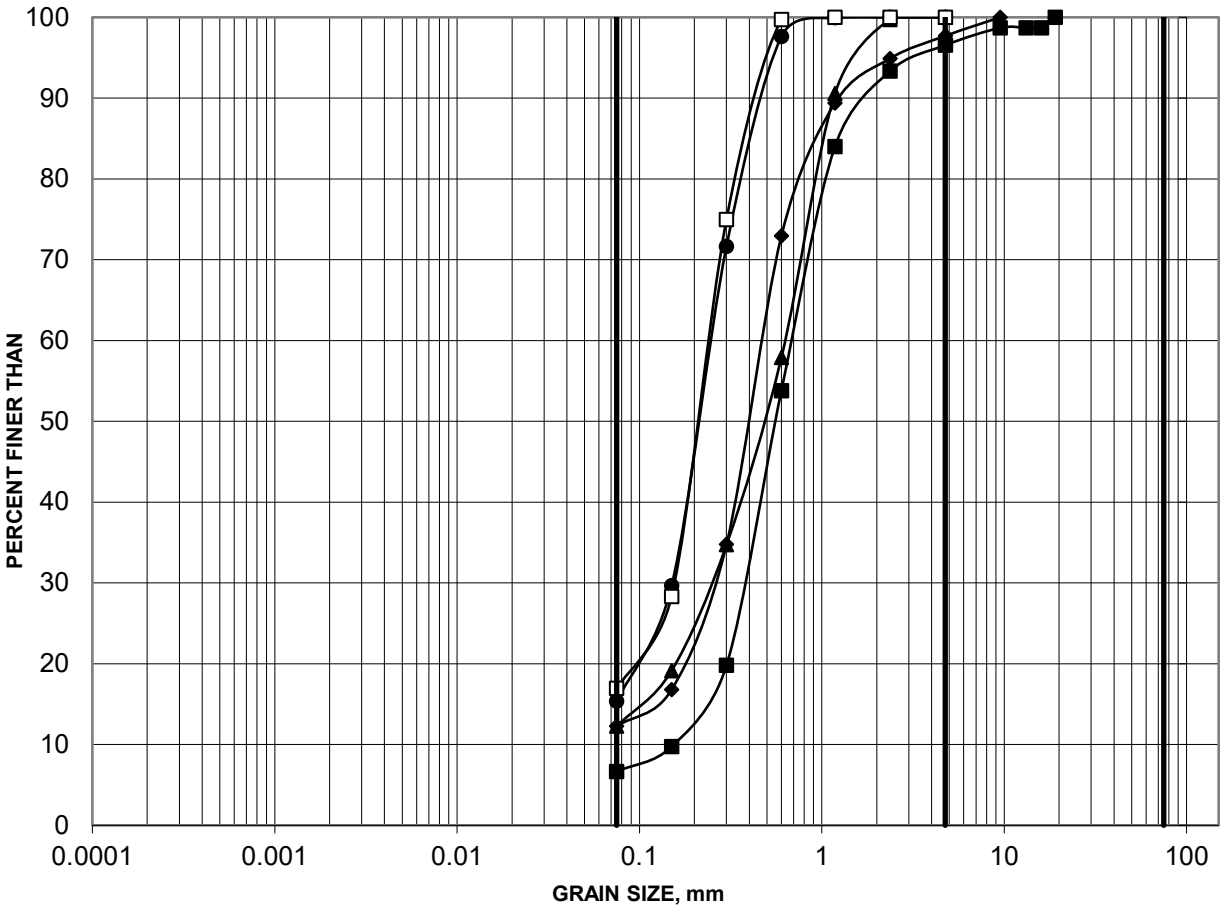
Created by: KG
Checked by:

https://golderassociates.sharepoint.com/sites/11407g/WO11 Colborne to Brighten/2. Technical Work/5. Lab Testing/1-CR26/Figures/

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND



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

	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
■	CR26-01	9	6.10-6.71	3	90	7	
◆	CR26-01	19	18.29-18.90	2	86	12	
▲	CR26-02	13	12.19-12.80	0	88	12	
●	CR26-02	16	16.76-17.37	0	85	15	
□	CR26-03	2	22.87-23.48	0	83	17	

Project: 1773612_WO 11

GOLDER
MEMBER OF WSP

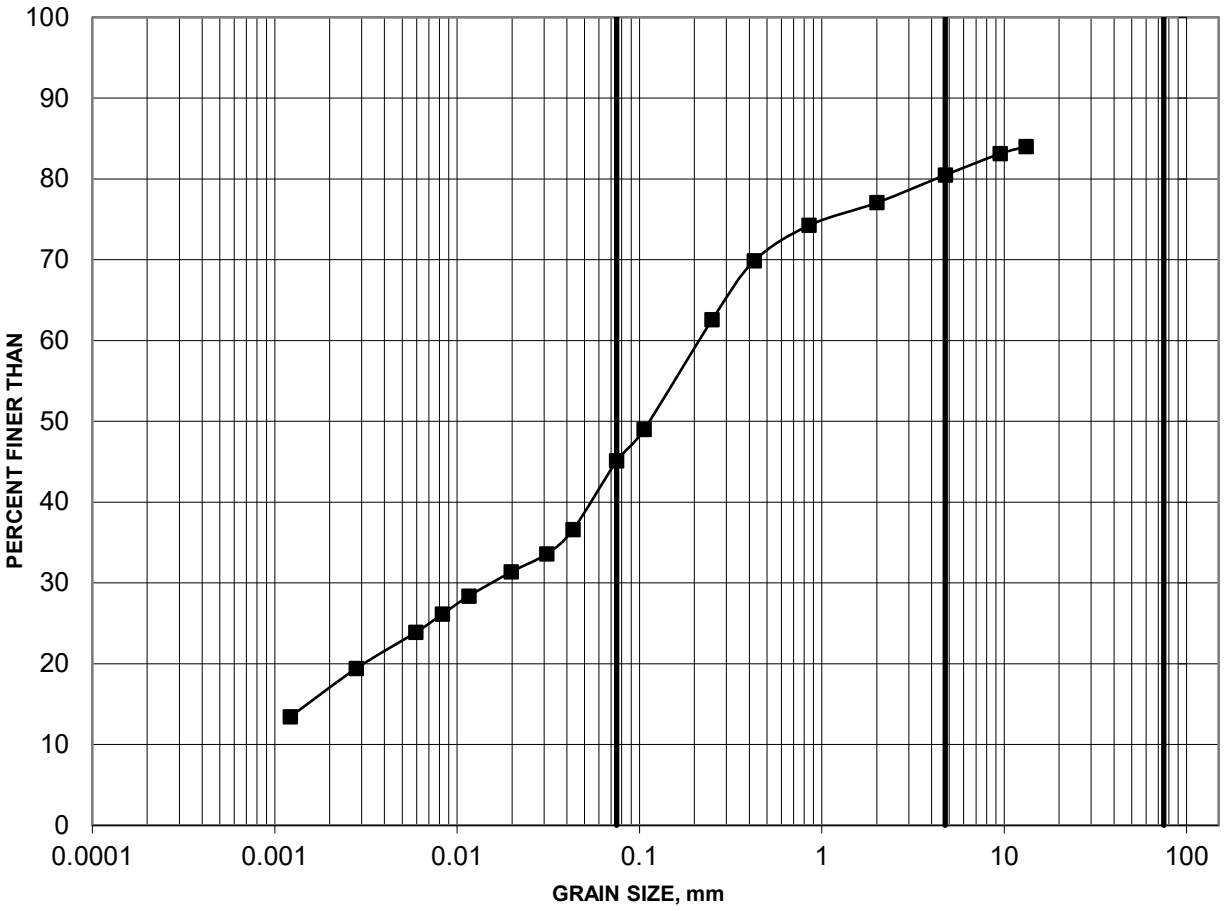
Created by: KG
Checked by:

https://golderassociates.sharepoint.com/sites/11407g/WO11 Colborne to Brighten/2. Technical Work/5. Lab Testing/1-CR26/Figures/

GRAIN SIZE DISTRIBUTION

FIGURE B4

GRAVELLY SILTY SAND TILL



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

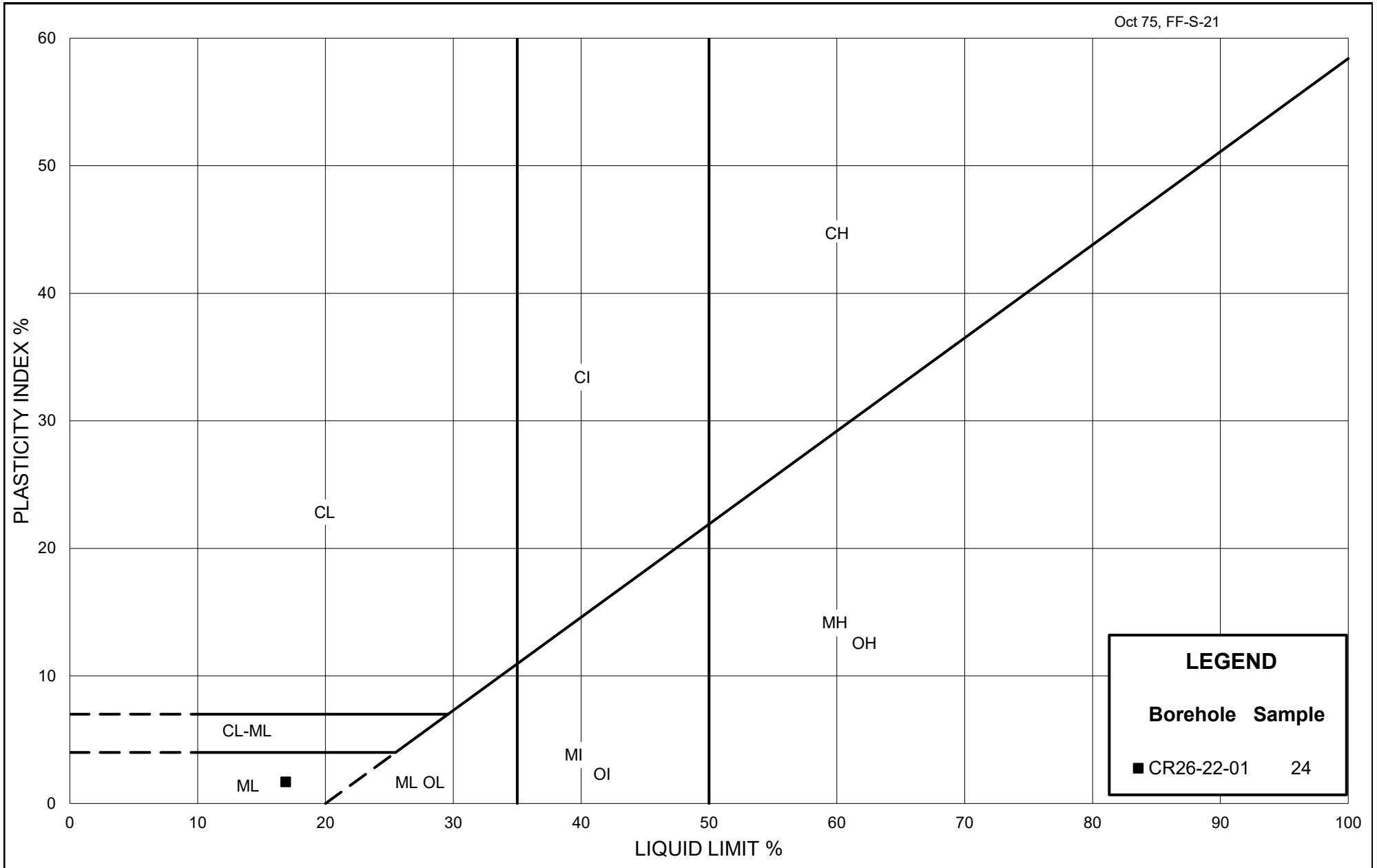
	Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
—■—	CR26-03	8	33.53-33.66	20	35	28	17

Project: 1773612_WO 11

GOLDER
MEMBER OF WSP

Created by: KG
Checked by:

https://golderassociates.sharepoint.com/sites/11407g/WO11 Colborne to Brighten/2. Technical Work/5. Lab Testing/1-CR26/Figures/



Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT TILL

Figure:	B5
Project:	1773612_WO11
Created By: MI	Checked By:

APPENDIX C

Analytical Laboratory Test 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: 1985544
Date Submitted: 2022-09-07
Date Reported: 2022-09-15
Project: 1773612-W011
COC #: 899907

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: 1985544
Date Submitted: 2022-09-07
Date Reported: 2022-09-15
Project: 1773612-W011
COC #: 899907

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1649736 Soil 2022-07-14 CR26-22-01 Sa3/5-7'	1649737 Soil 2022-07-20 H-22-02 Sa2/2.5-4.5'	1649738 Soil 2022-07-19 L-22-01 Sa2/2.5-4.5'	1649739 Soil 2022-07-26 471-22-03 Sa3/5-7'
Anions	Cl	0.002	%		0.058	0.005	0.007	0.016
	SO4	0.01	%		0.01	0.01	<0.01	0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		1.27	0.25	0.23	0.44
	pH	2.00			8.88	8.89	9.32	9.24
	Resistivity	1	ohm-cm		787	4000	4348	2273

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.		
					1649740 Soil 2022-07-06 472-22-04 Sa2/2.5-4.5'	1649741 Soil 2022-07-27 473-22-03 Sa2/2.5-4.5'	1649742 Soil 2022-07-04 474-22-04 Sa3/5-7'
Anions	Cl	0.002	%		0.014	0.011	0.013
	SO4	0.01	%		0.06	<0.01	0.13
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.55	0.36	0.89
	pH	2.00			8.15	9.01	8.15
	Resistivity	1	ohm-cm		1818	2778	1124

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: 1985544
Date Submitted: 2022-09-07
Date Reported: 2022-09-15
Project: 1773612-W011
COC #: 899907

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 429467 **Analysis/Extraction Date** 2022-09-13 **Analyst** IP **Method** Cond-Soil			
Electrical Conductivity		90	90-110
pH	7.24	101	90-110
Resistivity			
Run No 429500 **Analysis/Extraction Date** 2022-09-14 **Analyst** IP **Method** AG SOIL			
SO4	<0.01 %	104	70-130
Run No 429575 **Analysis/Extraction Date** 2022-09-14 **Analyst** CK **Method** C CSA A23.2-4B			
Chloride	<0.002 %		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

golder.com