



September 8, 2016

FOUNDATION INVESTIGATION AND DESIGN REPORT

**MUNICIPAL ROAD 3 UNDERPASS, SITE NO. 46-302
DISTRICT OF SUDBURY, TOWNSHIP OF DENISON
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 5418-15-00**

Submitted to:

Ministry of Transportation
447 McKeowan Ave.
North Bay, Ontario
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REPORT





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**FOUNDATION REPORT
MUNICIPAL ROAD 3 UNDERPASS, SITE NO. 46-302**

PART A

**FOUNDATION INVESTIGATION REPORT
MUNICIPAL ROAD 3 UNDERPASS - SITE NO. 46-302
DISTRICT OF SUDBURY, TOWNSHIP OF DENISON
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering input for temporary protection systems in support of the rehabilitation of the Municipal Road 3 (MR3) Underpass, Site 46-302. The underpass is located on Municipal Road 3 at about Sta. 10+000 in the Township of Denison, Ontario. The MR3 Underpass crosses Highway 17 approximately 14.6 km west of Highway 144 Interchange. The key plan showing the general location of this section of MR3 and the location of the investigated area are shown on Drawing 1.

The Terms of Reference and the Scope of Work for the foundation investigation and design input for temporary protection systems at the MR3 Underpass are outlined in MTO's Assignment #2 (Agreement Number 5015-E-0014) dated May 16, 2016. The scope of work for the temporary protection systems was subsequently clarified by MTO by email dated May 26, 2016, and detailed in Golder's revised Work Order Response letters dated May 31, 2016.

2.0 SITE DESCRIPTION

The orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on the drawing. For the purpose of this report, Highway 17 is oriented in a west-east direction with the MR3 Underpass crossing Hwy 17 on a slight skew generally in a north-south direction.

In general, the topography in this area is undulating with moderate to dense tree cover in the vicinity of the structure. Bedrock outcrops/rock cuts are present along both sides of the Highway 17 corridor. The existing MR3 Underpass is an approximately 84.7 m long by 9.4 m wide, two-span structure founded on strip footings (shallow foundations). Based on the General Layout drawing (Sheet 91 from Contract 79-41) provided by MTO, the bridge deck is at Elevation 250.6 m and 250.2 m at the north and south abutments, respectively. The north and south approach embankments are about 7.0 m and 6.9 m high, respectively and the embankment side slopes are inclined at about 2 Horizontal to 1 Vertical (2H:1V).

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on June 20, 2016, during which time two boreholes (Boreholes MR3-1 and MR3-2) were advanced at the bridge approaches. The boreholes were advanced using truck-mounted CME-55 drill rig, supplied and operated by Landcore Drilling Ltd of Chelmsford, Ontario.

The boreholes were advanced from the highway platform through the existing bridge approach slabs using NW casing and wash boring techniques. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The field work was supervised on a full-time basis by a members of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling



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operations; logged the boreholes; and examined and cared for the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions and Atterberg limits were carried out on selected soil samples.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by member of our technical staff, referenced to the highway centerline at the existing abutments and converted into northing/easting coordinates on the plan drawing. The ground surface elevation at the bridge abutments were obtained from the General Layout drawing provided by MTO. The MTM NAD83 (Zone 12) northing and easting coordinates and geographic coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole locations are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (Latitude)	MTM NAD83 Easting (Longitude)	Ground Surface Elevation	Borehole Depth
MR3-1	5138036.8 m (46.38151945°)	278476.5 m (80.34221272°)	250.6 m	6.7 m
MR3-2	5138012.0 m (46.38129907°)	278546.9 m (-81.34129613°)	250.2 m	6.7 m

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS) mapping by the Ministry of Natural Resources (MNR) ¹, the subsoils in the vicinity of the MR3 Underpass site generally consist of glaciolacustrine plain deposits comprised primarily of sand bordered by alluvial plain deposits comprised primarily of silt and jagged/rugged bedrock knobs.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)² the site is underlain by metasedimentary bedrock comprised of McKim pelites. The Murray fault runs roughly parallel to the Highway 17 alignment crossing to the south of the MR3 Underpass.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile on Drawing 1 are

¹ Ministry of Natural Resources. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41ISW.

² Ministry of Northern Development of Mines. Bedrock Geology of Ontario – Sudbury Mining Area, Ontario Geological Survey – Map 2170.



FOUNDATION REPORT MUNICIPAL ROAD 3 UNDERPASS, SITE NO. 46-302

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

Subsoil Conditions

In summary, the subsoil conditions encountered at the site consist of an asphalt and concrete roadway surface structure underlain by granular fill underlain by a clayey silt deposit at the south abutment. A more detailed description of the subsurface soils and groundwater conditions encountered in the boreholes is provided below.

Deposit / Layer Description	Boreholes		Thickness (m)		Elevation (m)		N Values (blows)	Laboratory Testing
	North Abut.	South Abut.	North Abut.	South Abut.	North Abut.	South Abut.	Relative Density / Consistency	
Asphalt	MR3-1	MR3-2	0.060	0.080	250.6	250.2	n/a	n/a
Concrete	MR3-1	MR3-2	0.310	0.270	250.5	250.1	n/a	n/a
(FILL) Gravelly Sand , trace to some silt; brown, moist to wet	MR3-1	MR3-2	0.130	0.170	250.2	249.9	n/a	n/a
(FILL) Sand and Gravel , trace to some silt; brown moist to wet	MR3-1	MR3-2	> 6.2 in MR3-1 (borehole terminated in this deposit)	5.3 m in MR3-2	250.1	249.7	N = 13 – 39 and N=19 – 30	w = 9% – 10% 3 – M (Fig. B1)
							Compact to Dense	
Clayey Silt , trace to some sand; grey, wet	n/a	MR3-2	n/a	> 0.9 (borehole terminated in this deposit)	n/a	244.4	N = 4	w = 29 % w _p = 19 w _l = 29 I _p = 10 1 – MH (Fig. B2) 1 – AL (Fig. B3)
							Soft	

Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis

w = Natural Moisture Content (%)

w_p = Plastic Limit (%)

w_l = Liquid Limit (%)

I_p = Plasticity Index (%)

AL = Atterberg Limits Test



Groundwater Conditions

Boreholes MR3-1 and MR3-2 were noted to be dry upon completion of drilling. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Adam Core, P.Eng., under the overall direction of Mr. David Muldowney, P.Eng. This Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Mr. David Muldowney, P.Eng., provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with and Designated MTO Foundations Contact for Golder, conducted an independent quality control review audit of this report.



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Report Signature Page

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PART B

FOUNDATION DESIGN REPORT
MUNICIPAL ROAD 3 UNDERPASS - SITE NO. 46-302
DISTRICT OF SUDBURY, TOWNSHIP OF DENISON
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 5418-15-00



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides engineering design recommendations for temporary protection systems in support of the rehabilitation of the existing MR3 Underpass (Site No. 46-302). The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasible alternatives and carry out the design. The foundation investigation report, discussion and recommendations are intended for the use of the MTO and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the future detail design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

The following sections of this report provide foundation recommendations for the design of temporary roadway protection to facilitate staged construction for rehabilitation of the MR3 Underpass crossing Highway 17 approximately 14.6 km west of the Highway 144 interchange in the Township of Denison. Based on discussions with MTO, we understand that excavations up to 2 m deep will be required for the proposed bridge rehabilitation.

6.2 Excavation and Dewatering

The proposed works will require removal of the asphalt and concrete approach slab and partial excavation of the existing embankment fill material. Open cut excavation side slopes in the existing embankment fill (i.e., gravelly sand fill and sand and gravel fill) should remain stable during construction if the temporary side slopes are cut back no steeper than 1H:1V above the groundwater level and 3H:1V below the groundwater level (if encountered).

Based on the subsurface conditions encountered during this investigation, groundwater is not expected to be encountered within the proposed excavation depths. Perched water, if encountered, should be drained and sources of surface water should be diverted away from the excavation area prior to beginning the excavation. Some sloughing of excavated slopes due to perched water or surface water runoff may occur and flatter side slopes may become necessary.

During construction, stockpiles should be placed at a distance away from the edge of the excavation, not less than 1.5 times the depth of excavation, and their heights should be controlled to prevent surcharging the sides of the excavation and/or overall slope.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The existing embankment fill is classified as Type 3 soils above the groundwater level and Type 4 soils below.



6.3 Temporary Roadway Protection

Based on discussions with MTO, we understand that a temporary roadway protection system will be required to facilitate staged construction at this site. The temporary support system could consist of either driven steel sheet piling or soldier piles and lagging where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds. Support to the system could be in the form of struts and wales and rakers or anchors. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadway.

The design of the temporary roadway protection system, may be designed using the following parameters:

Soil Type	Unit Weight	Internal Angle of Friction	Undrained Shear Strength (S_u , kPa)	Coefficient of Earth Pressure		
	(γ , kN/m ³)	(ϕ , degrees)	(S_u , kPa)	Active K_a	At Rest K_o	Passive, K_p
New Granular 'A'	22	35	-	0.27	0.43	3.69
New Granular 'B' Type II	21	35	-	0.27	0.43	3.69
New Granular 'B' Type I	21	32	-	0.31	0.47	3.25
Existing Gravelly Sand (Fill)	20	30	-	0.33	0.50	3.00
Existing Sand and Gravel (Fill) (Compact to Dense)	20	32	-	0.31	0.47	3.25
Clayey Silt (Soft)	17	25	25	0.41	0.58	2.46

The temporary protection system should be assessed for both the drained (ϕ) and undrained (S_u) cases, based on the more conservative earth pressure conditions. The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.

Design of the temporary support system should include an evaluation of base stability, soil squeezing stability and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM, 2006). Further, the native soil (i.e., clayey silt) at this site is sensitive to disturbance from driving operations for pile installation, which should be considered in the design and installation of the temporary protection system.

Consideration could be given to either partial or full removal of the temporary protection system upon completion of construction or each stage of construction (as required). Where possible, full removal of the temporary shoring system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work at the bridge site. However, where the temporary shoring system penetrates into cohesive soils, there is a potential risk



that full removal will result in a void within the soil column due to adhesion along the sheet pile (or H-pile) walls (CFEM 2006). Given the limited depth of the proposed excavation for the bridge rehabilitation at this site, it is anticipated that the temporary shoring will primarily be installed within the existing granular embankment fill with little to no risk of pile adhesion. If the temporary shoring systems, as designed and installed by the Contractor, extends into the cohesive clayey silt deposit, there is a potential risk of adhesion which should be re-evaluated after pile installation depending on the depth of penetration. For piles installed to a toe elevation lower than the bottom of the Borehole (BH MR3-2 bottom Elev. 243.5 m) penetrating greater than 1 m into the clayey silt deposit consideration will need to be given to only partial depth removal.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Adam Core, P.Eng., and Mr. David Muldowney, P.Eng., provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with and Designated MTO Foundations Contact for Golder, conducted an independent quality control review of this report.



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REFERENCES

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Occupational Health and Safety Act and Regulation for Construction Projects (as amended).

Ministry of Natural Resources. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41ISW.

Ministry of Northern Development of Mines. Bedrock Geology of Ontario – Sudbury Mining Area, Ontario Geological Survey – Map 2170.

ASTM International:

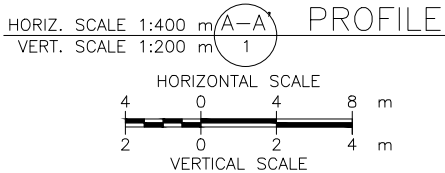
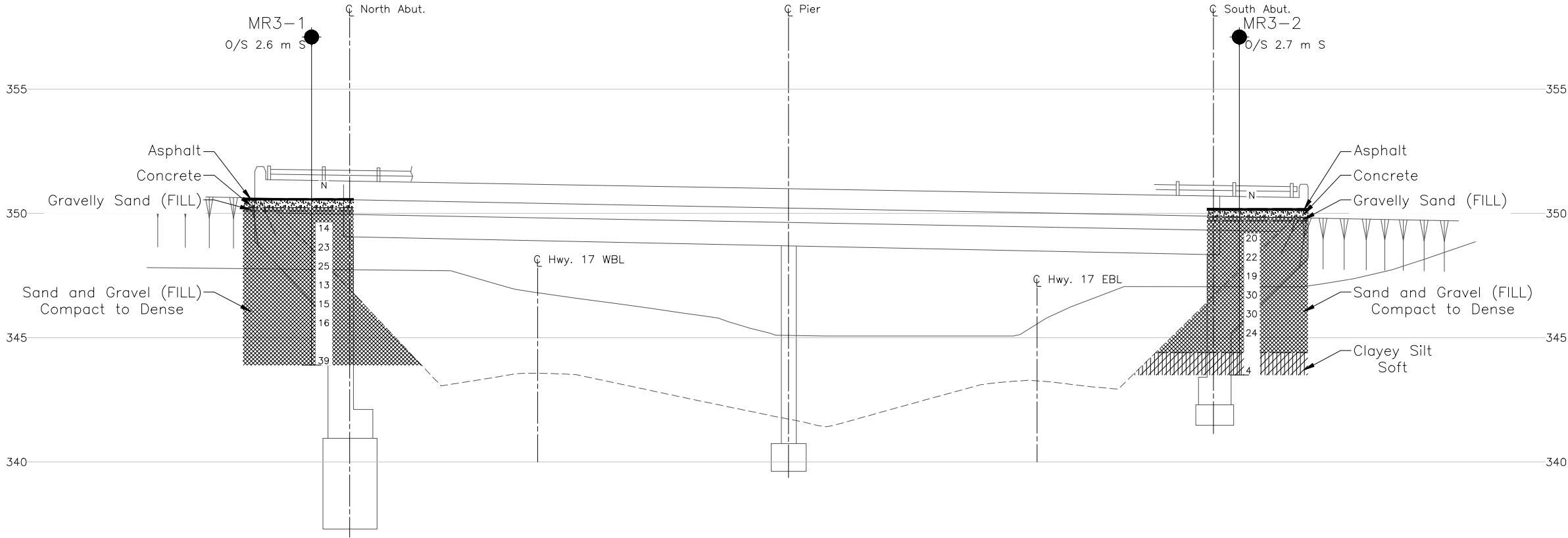
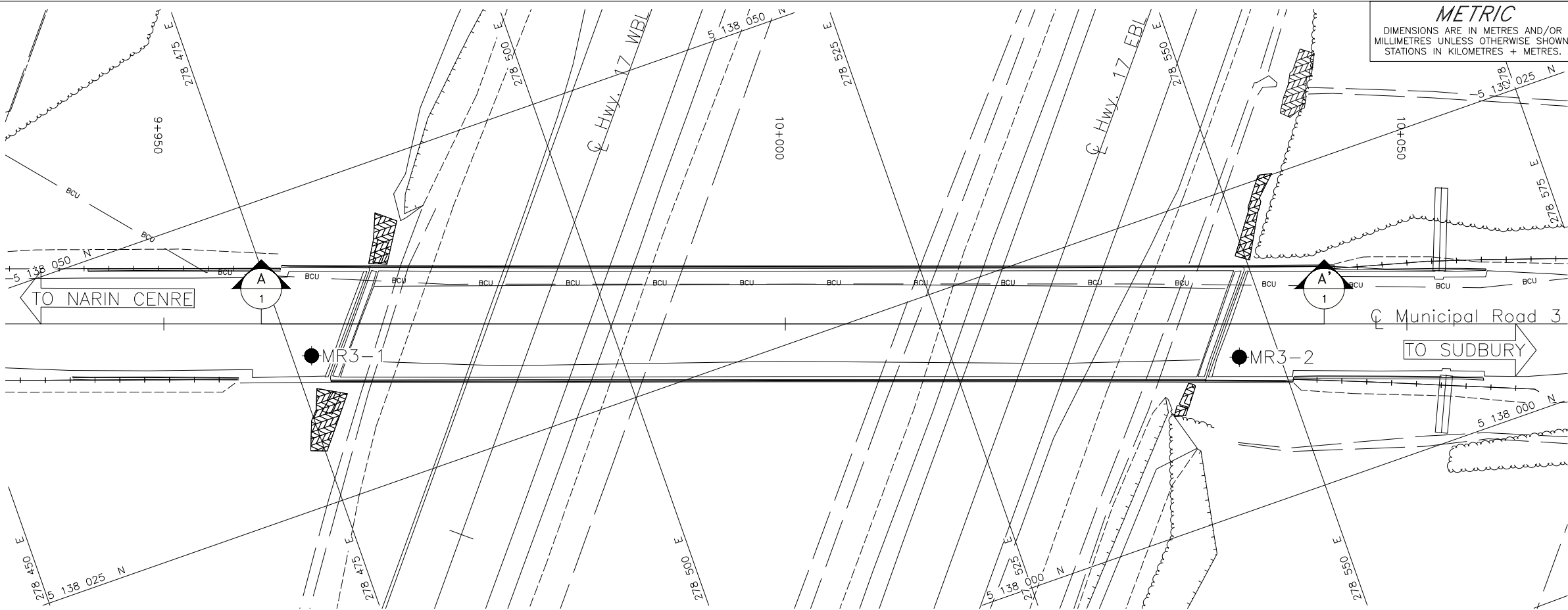
ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils
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Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 539	Construction Specification for Temporary Protection Systems
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Ontario Water Resource Act:

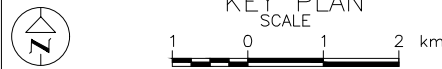
Regulation 903	Wells (as amended)
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METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5418-15-00

MUNICIPAL ROAD 3 UNDERPASS
BOREHOLE LOCATIONS AND SOIL
STRATA



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
MR3-1	250.6	5138036.8	278476.5
MR3-2	250.2	5138012.0	278546.9

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.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MTO, drawing file nos. bdims202-mto79041-0000099, received June 21, 2016 and bdims202-mto79041-0000099.tif (for bridge profile), received July 28, 2016.



NO.	DATE	BY	REVISION
Geocres No. 411-346			
HWY. MUNICIPAL ROAD 3	PROJECT NO. 1648295	DIST. SUDBURY	
SUBM'D. AC	CHKD. AC	DATE: 9/07/2016	SITE: 46-302
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. 1



PHOTOGRAPHS

**Photograph 1: Municipal Road 3 Underpass
Looking North from South Abutment (August 2016)**



**Photograph 2: Municipal Road 3 Underpass
Looking South from North Abutment (August 2016)**





PHOTOGRAPHS

**Photograph 3: Municipal Road 3 Underpass
Looking Northeast from West side of South Abutment (August 2016)**





APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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 = $(w_l - w_p)$
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 = $\tan \delta$
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

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. 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.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; 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

Piezo-Cone Penetration Test (CPT)

A 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 (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	c_u, s_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
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
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	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT 1648295				RECORD OF BOREHOLE No MR3-1				1 OF 1 METRIC									
G.W.P. 5418-15-00				LOCATION N 5138036.8; E 278476.5 MTM ZONE 12 (LAT. 46.38151945; LONG. -81.34221272)				ORIGINATED BY AC									
DIST SUDBURY HWY MR3				BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY TB									
DATUM GEODETIC				DATE June 20, 2016				CHECKED BY DAM									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
250.6	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (60 mm)																
250.2	CONCRETE (310 mm)																
0.5	Gravelly sand (FILL) Brown Moist Sand and gravel, trace to some silt (FILL) Compact to dense Brown Moist		1	SS	14		250										41 51 (8)
			2	SS	23		249										
			3	SS	25		248										
			4	SS	13		247										
			5	SS	15		246										
			6	SS	16		245										44 45 (11)
			7	SS	39		244										
243.9	END OF BOREHOLE																
6.7	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 MTM ZN 12 INC LAT/LONG 1648295_RET2.GPJ GAL-MISS.GDT 30/08/16 DATA INPUT:

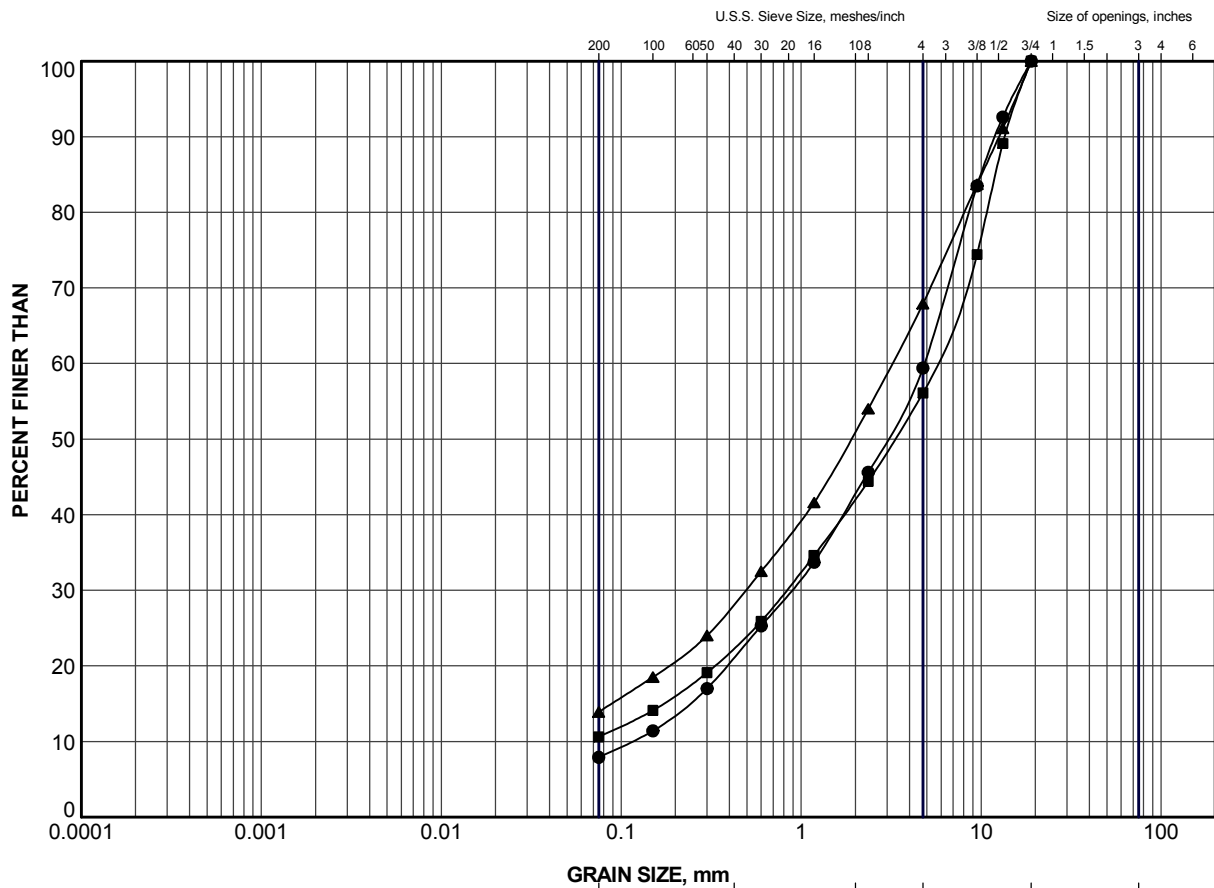
PROJECT 1648295		RECORD OF BOREHOLE No MR3-2				1 OF 1 METRIC											
G.W.P. 5418-15-00		LOCATION N 5138012.0; E 278546.9 MTM ZONE 12 (LAT. 46.38129907; LONG. -81.34129613)				ORIGINATED BY AC											
DIST SUDBURY HWY MR3		BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY TB											
DATUM GEODETIC		DATE June 20, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
250.2	GROUND SURFACE																
0.0	ASPHALT (80 mm)																
249.9	CONCRETE (270 mm)																
0.5	Gravelly sand (FILL) Brown Moist Sand and gravel, trace some silt (FILL) Compact to dense Brown Moist to wet		1	SS	20												
			2	SS	22												
			3	SS	19												
			4	SS	30												
			5	SS	30												
			6	SS	24												
244.4	CLAYEY SILT, trace to some sand Soft Grey Wet		7	SS	4												
243.5	END OF BOREHOLE																
6.7	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 MTM ZN 12 INC LAT/LONG 1648295_RET2.GPJ GAL-MISS.GDT 30/08/16 DATA INPUT:




APPENDIX B

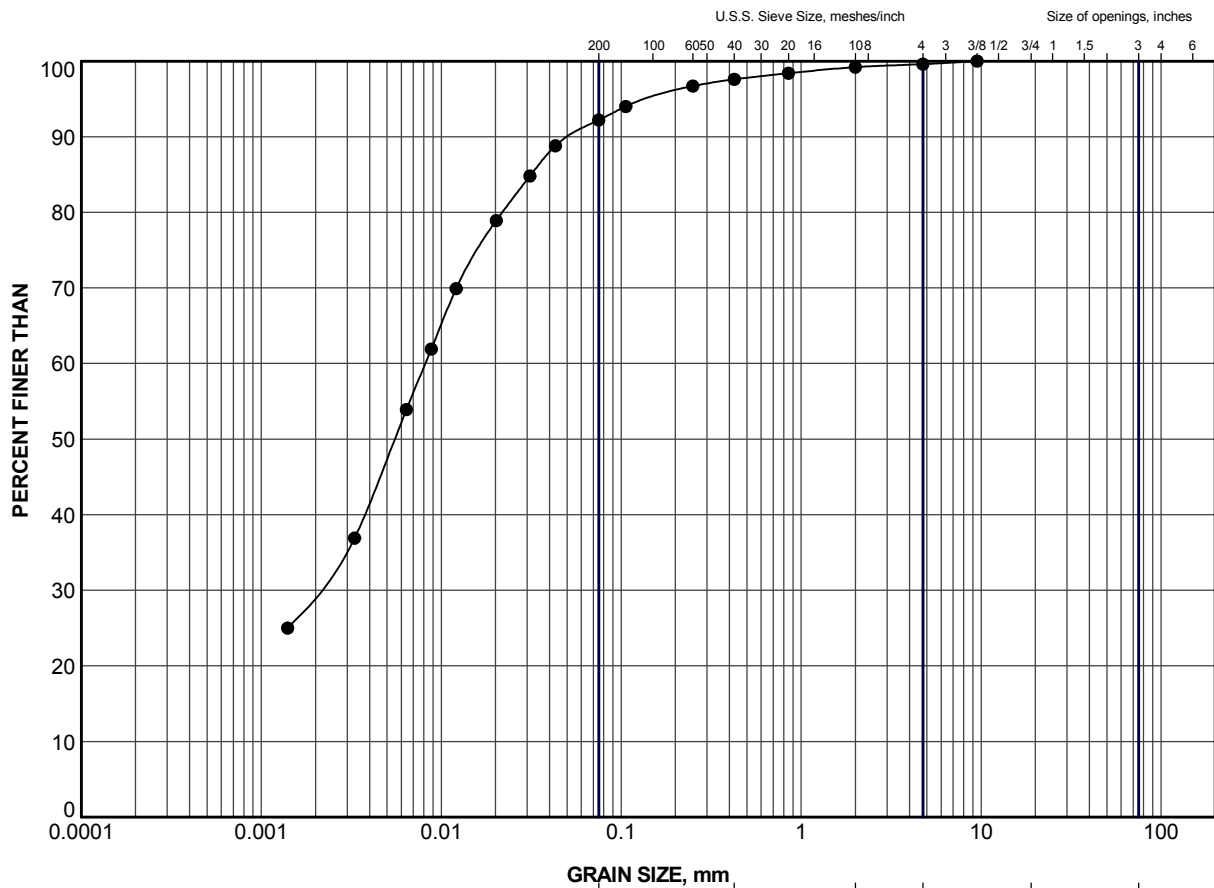
Laboratory Test Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR3-1	1	249.5
■	MR3-1	6	245.7
▲	MR3-2	4	246.8


PROJECT					
HIGHWAY 17 MUNICIPAL ROAD 3 UNDERPASS					
TITLE					
GRAIN SIZE DISTRIBUTION SAND and GRAVEL (FILL)					
PROJECT No.		1648295		FILE No. 1648295_RET2.GPJ	
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.
CHECK	DAM	Aug 2016			
APPR	JMAC	Aug 2016			
 Golder Associates SUDBURY, ONTARIO			FIGURE B1		

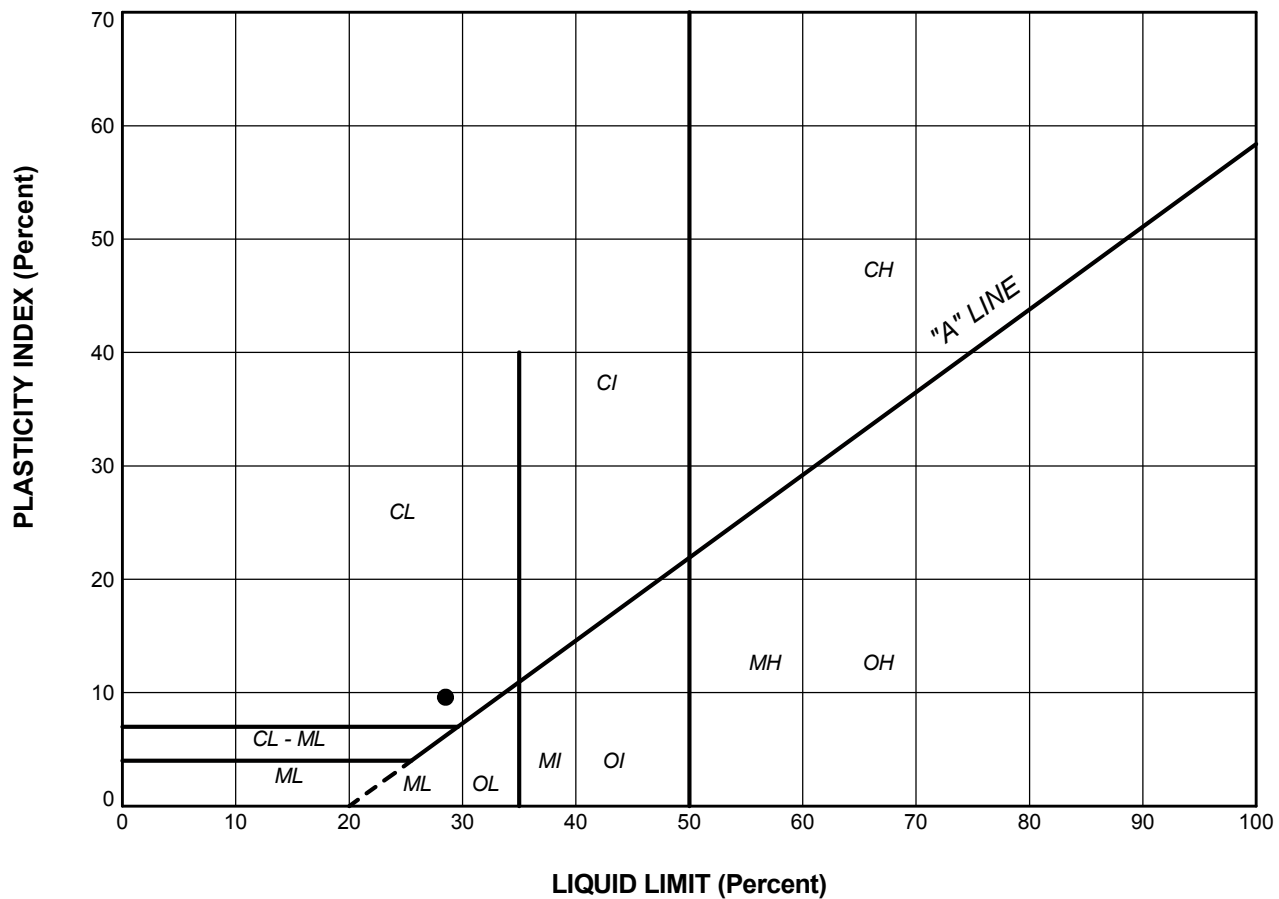


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR3-2	7	243.8

PROJECT						HIGHWAY 17 MUNICIPAL ROAD 3 UNDERPASS					
TITLE						GRAIN SIZE DISTRIBUTION CLAYEY SILT					
PROJECT No.			1648295			FILE No.			1648295_RET2.GPJ		
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.						
CHECK	DAM	Aug 2016									
APPR	JMAC	Aug 2016									
 Golder Associates SUDBURY, ONTARIO			FIGURE B2								



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	MR3-2	7	28.5	18.9	9.6

PROJECT					
HIGHWAY 17 MUNICIPAL ROAD 3 UNDERPASS					
TITLE					
PLASTICITY CHART CLAYEY SILT					
PROJECT No. 1648295			FILE No. 1648295_RET2.GPJ		
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.
CHECK	DAM	Aug 2016	FIGURE B3		
APPR	JMAC	Aug 2016			



As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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