



Foundation Investigation Report
MTO Patrol Yard – New Sand/Salt Storage Structure
Beardmore Patrol Yard, Greenstone Township
Highway 11, Beardmore, ON
Latitude: 49.613007°, Longitude: -87.954140°

Assignment #7 6023-E-0030

Geocres No.42E12-001

Prepared for:
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Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ontario Ministry of Transportation Northwest Region (MTO) to provide foundation investigation services under the Northwest Region (NWR) Geotechnical Retainer Assignment. The site is located on Highway 11 in Beardmore. The site coordinates are as follows:

- Latitude: 49.613007°, Longitude: -87.954140°

A Google Earth image illustrating the site location can be seen in Figure 1.1.

The investigation consisted of advancing four boreholes to depths of 10 m within the proposed structure footprint. It is understood that the proposed structure will be used to house sand/salt. The details on the size and shape of the structure were not known at the time of this report. Planned borehole locations were provided by the MTO in the Terms of Reference, however, final borehole locations were adjusted to suit field conditions. This report describes the subsurface conditions encountered during the investigation.

The MTO Foundations Section has assigned Geocres No. 42E12-001 to this report.



Figure 1.1: A Google Earth Image Illustrating the Site Location.

2 Site Description

The foundation investigation was conducted to investigate the subsurface conditions at the location of the proposed structure. The site is a relatively flat lot. The location for the proposed structure is south of the existing MTO garage in place of the existing sand dome.

2.1 Surficial Geology

As defined by the Ontario Ministry of Natural Resources' Northern Ontario Engineering Geology Terrain Study (NOEGTS), Map No. 42ENW, the site is in an area which primarily consists of a sand/sandy outwash plain. The area has low local relief and is generally mixed wet and dry.

Outwash plains are described in the NOEGTS as deposits with silty fine sand to sand containing fine gravel.

The presence of the above soils were confirmed from the field investigation.

3 Investigation Procedures

A geotechnical site investigation was undertaken on December 3 to December 4, 2024. The field investigation consisted of advancing a total of four boreholes. Borehole locations are illustrated on the Borehole Location and Soil Strata Drawing (Appendix C). The boreholes were advanced to depths of 10.3 m.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site. The boreholes were advanced using a drill rig mounted on an all-terrain carrier equipped with hollow stem augers, a casing advancement system and apparatus used to carry out Standard Penetration Testing as per ASTM D1586.

During the drilling operations for the boreholes, soil samples were obtained from the auger flights and using the techniques of the Standard Penetration Test (SPT). SPTs are typically taken at a frequency of every 0.75 m for the first 3 m of the borehole, and every 1.5 m afterwards, to the termination depth of the borehole. Sample frequency may vary due to circumstances experienced in the field.

Test hole locations were surveyed by TBTE with a level and rod and referenced to a temporary benchmark at the south-east corner of the existing MTO garage. The garage was not within the

2018 MTO base plan, as such, the borehole elevations have been interpolated from the H-905-11-1 surface as provided by the client. A hand-held Garmin GPS device was used in the field to record coordinates of the borehole locations, based on North American Data 1983 NAD83 (CSRS) v6 (2010 epoch).

A summary of the borehole location data is provided below and on the Borehole Location and Soil Strata Drawing (Appendix C).

Table 3.1: Summary of Borehole Information.

Test Hole Number	Co-ordinates	Surface Elevation (m)	Depth of Exploration (m)
1	Lat 49.613279 Lon –87.9542528 5497721 N, 235844 E	308.2	10.3
2	Lat 49.6128335 Lon –87.9537319 5497671 N, 235881E	308.5	10.3
3	Lat 49.6127501 Lon –87.9540348 5497662 N, 235859 E	308.4	10.3
4	Lat 49.6128093 Lon –87.9544928 5497669 N, 235826 E	308.1	10.3

All boreholes have been backfilled and/or decommissioned with auger cuttings and bentonite in accordance with the Ontario Ministry of the Environment's Regulation 903, as amended by Regulation 128/03 (water well regulation under the Ontario Water Resource Act).

4 Laboratory Testing

Soil samples obtained during the field investigation were subjected to routine laboratory testing. The routine testing typically included moisture content, Atterberg Limit tests, and grain size analysis. Typically, 100% of the recovered soil samples are tested for natural moisture content determination, and 25% of the recovered soil samples are chosen for grain size analysis and/or Atterberg limits testing, as applicable. The following test methods/standards are followed for the above testing: LS 602, LS 701, ASTM C136, ASTM D4318, ASTM D2216. The results of this testing are shown on the borehole logs (Appendix A) and on the laboratory data reports (Appendix B).

5 Subsurface Conditions

Details of the subsurface conditions are provided on the borehole logs (Appendix A), and on the Borehole Location and Soil Strata Drawing (Appendix C).

The subsurface soils at this site generally consist of fill at surface underlain by silts and sands to the termination of the boreholes.

5.1 Fill

Gravelly sand to sand with some gravel and trace to some silt was present at the surface of all borehole locations (Elev. 308.1 to 308.5 m) and extended to depths ranging from 0.4 to 2.1 m (Elev. 306.4 to 307.7 m). The condition of this material is a loose to compact with SPT N-values ranging from 5 to 18 blows per 0.3 m. The results of two grain size analyses indicates that this material can consist of 29 to 30 % gravel, 52 to 64 % sand, 6 to 19 % silt/clay sized particles.

5.2 Silt

Silt with some sand was encountered underlying the fill at Boreholes 1 and 4 (Elev. 307.5 to 307.7 m) and extended to depths of 4.0 to 4.1 m (Elev. 304.1 m). The condition of this material is in a loose to compact with SPT N-values ranging from 4 to 23 blows per 0.3 m. The results of two grain size analyses indicates that this material can consist of 0 % gravel, 10 to 14 % sand, 86 to 90 % silt/clay sized particles.

5.3 Silt and Sand

Silt and sand was identified underlying the fill at Boreholes 2 and 3 (Elev. 306.4 to 306.8 m) and underlying the silt at Boreholes 1 and 4 (Elev. 304.1 m) and extended to the termination of the boreholes at depths of 10.3 m (Elev. 297.8 to 298.2 m). The condition of this material is a loose to compact with SPT N-values ranging from 4 to 26 blows per 0.3 m. The results of six grain size analyses indicates that this material can consist of 0 % gravel, 35 to 47 % sand, 53 to 65 % silt/clay sized particles.

5.4 Groundwater

Casing advancement with water was utilized at the boreholes during drilling operations.

Elevated water levels may have been recorded due to this drilling method and water levels may not have stabilized. Water level readings were taken upon completion of the boreholes, as shown below. Observed groundwater levels have been provided in the table below.

Groundwater levels may vary from season to season and from the effects of heavy precipitation events.

Table 5.1: Observed Groundwater Levels.

Location	Surface Elevation (m)	Groundwater Level on Completion of Drilling		Groundwater Level After Completion		
		Depth (m)	Elev. (m)	Depth (m)	Elev. (m)	Time After Comp
Borehole 1	308.2	6.4	301.8	Dry	-	2 Hours
Borehole 2	308.5	Dry	-	Dry	-	1 Hour
Borehole 3	308.4	Dry	-	-	-	-
Borehole 4	308.1	6.5	301.6	-	-	-

6 Miscellaneous

Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering Limited. The field operations were supervised by Ian Baumann and Allan Finke. Laboratory testing was managed by Rhyan Ariganello P.Eng.. This report was prepared and reviewed by Dean Vale, P.Eng., and Steven Seller, P.Eng. (TBTE's designated principal contact identified for MTO Foundation Engineering).

7 Limitations

Conclusions and recommendations presented in this report are based on the information determined at a limited number of borehole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of the dewatering procedures which may be considered during construction cannot readily be determined from site investigation or boreholes. These conditions include local and seasonal fluctuations of the groundwater level, changes in soil conditions between borehole locations, thin and/or discontinuous layers of highly permeable soils, etc.

In no way does the information contained within this report reflect any environmental aspect of the site or soil.

8 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate to contact us at your convenience.

Yours truly,

For TBT ENGINEERING



Dean Vale, P.Eng.
Geotechnical Engineer



Steve Steller, P.Eng.
Senior Engineer
Principal Contact for MTO Foundations

APPENDIX A

Borehole Logs

EXPLANATION OF TERMS

N Value: The Standard Penetration Test (SPT) N value is the number of blows required to cause a standard 51mm O.D. split barrel sampler to penetrate 0.3m into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kg, falling freely a distance of 0.76m. For penetrations of less than 0.3m N values are indicated as the number of blows for the penetration achieved. Average N value is denoted thus \bar{N} .

Dynamic Cone Penetration Test: Continuous penetration of a conical steel point (51mm O.D. 60° cone angle) driven by 475 J impact energy on 'A' size drill rods. The resistance to cone penetration is measured as the number of blows for each 0.3m advance of the conical point into the undisturbed ground.

Soils are described by their composition and consistency/condition.

Consistency: Cohesive soils are described on the basis of their undrained shear strength (c_u) as follows:

C_u (kPa)	0-12	12-25	25-50	50-100	100-200	>200
	Very Soft	Soft	Firm	Stiff	Very Stiff	Hard

Condition: Cohesionless soils are described on the basis of denseness as indicated by SPT N values as follows:

N (Blows/0.3m)	0-4	4-10	10-30	30-50	>50
	Very Loose	Loose	Compact	Dense	Very Dense

Minor Soil Components: Terminology used to represent the amount of minor components based on their percent of the sample by weight as follows:

% by weight	0-10	10-20	20-35	35-50
	Trace	Some	"ey" or "y"	And

ABBREVIATIONS AND SYMBOLS

Field Sampling, Insitu Testing, Laboratory Testing

S S	Split Spoon	T P	Thin Wall Piston
A S	Auger	O S	Osterberg
W S	Wash	R C	Rock Core
S T	Slotted Tube	P H	T W Advanced Hydraulically
B S	Block	P M	T W Advanced Manually
C S	Chunk	F S	Foil
V T	Vane Test (kPa)	P P	Pocket Penetrometer (kg/cm ²)
T W	Thin Wall Shelby Tube		

EXPLANATION OF TERMS Cont'd.

Stress and Strain

u_w	kPa	Pore Water Pressure
u		Pore Pressure Ratio
σ	kPa	Total Normal Stress
σ'	kPa	Effective Normal Stress
τ	kPa	Shear Stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal Stress
ϵ	%	Linear Strain
$\epsilon_1, \epsilon_2, \epsilon_3$	%	Principal Strains
E	MPa	Young's Modulus
G	kPa	Modulus of Shear Deformation
m	MPa	Constrained Modulus
μ		Coefficient of Friction

Mechanical Properties of Soil

m_v	kPa ⁻¹	Coefficient of Volume Change
C_c		Compression Index
C_s		Swelling Index
C_a		Rate of Secondary Consolidation
c_v	m ² /s	Coefficient of Consolidation
H	m	Drainage Path
T_v		Time Factor
U	%	Degree of Consolidation
P'_o	kPa	Effective Overburden Pressure
P'_c	kPa	Preconsolidation Pressure
τ_f	kPa	Shear Strength
c'	kPa	Effective Cohesion Intercept
ϕ'	°	Effective Angle of Internal Friction
c_u	kPa	Undrained Shear Strength
s		Sensitivity

Physical Properties of Soil

ρ_s	kg/m ³	Density of Solid Particles	e	%	Void Ratio	e_{min}	%	Void Ratio in Densest State
γ_s	kN/m ³	Unit Weight of Solid Particles	n	%	Porosity	I_D		Density Index $= \frac{e_{max}-e}{e_{max}-e_{min}}$
ρ_w	kg/m ³	Density of Water	w	%	Water Content	D	mm	Grain Diameter
γ_w	kN/m ³	Unit Weight of Water	s_r	%	Degree of Saturation	D_n	mm	n Percent Diameter
ρ	kg/m ³	Density of Soil	w_L	%	Liquid Limit	C_u		Uniformity Coefficient
γ	kN/m ³	Unit Weight of Soil	w_p	%	Plastic Limit	h	m	Hydraulic Head or Potential
ρ_d	kg/m ³	Density of Dry Soil	w_s	%	Shrinkage Limit	q	m ³ /s	Rate of Discharge
γ_d	kN/m ³	Unit Weight of Dry Soil	I_p	%	Plasticity Index = $w_L - w_p$	v	m/s	Discharge Velocity
ρ_{sat}	kg/m ³	Density of Saturated Soil	I_L		Liquidity Index = $\frac{w-w_p}{I_p}$	i		Hydraulic Gradient
γ_{sat}	kN/m ³	Unit Weight of Saturated Soil	I_c		Consistency Index = $\frac{w_L-w}{I_p}$	k	m/s	Hydraulic Conductivity
ρ'	kg/m ³	Density of Submerged Soil	e_{max}	%	Void Ratio in Loosest State	j	kN/m ³	Seepage Force
γ'	kN/m ³	Unit Weight of Submerged Soil						

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. _____ LOCATION Patrol Yard N:5497721.481; E:235844.311 MTM Zone:14 ORIGINATED BY AF
DIST NWR HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TG
DATUM GEODETIC DATE 2024.12.03 - 2024.12.03 LATITUDE 49.613279 LONGITUDE -87.9542528 CHECKED BY DV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				w _p w w _L				
308.2 0.0	FILL - SAND - Gravelly, trace silt ----- - some silt		1	AS											30 64 (6)	
307.5 0.7	SILT - some sand, brown, loose to compact		2	AS											Water level @ 6.4 m on completion. Dry 2 hours after completion.	
			3	SS	8										0 10 (90)	
			4	SS	19											
			5	SS	20											
			6	SS	19											
304.1 4.1	SILT & SAND - brown, compact		7	SS	14											
			8	SS	15										Cave @ 6.4 m.	
			9	SS	12											
			10	SS	25										0 46 (54)	
297.9 10.3	End of Borehole @ 10.3 m.		11	SS	20											



ONTARIO MTO MOD 24-179-7 MTO BEARDMORE.GPJ ONTARIO MTO.GDT 2-10-25

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. _____ LOCATION Patrol Yard N:5497671.466; E:235881.322 MTM Zone:14 ORIGINATED BY AF
DIST NWR HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TG
DATUM GEODETIC DATE 2024.12.03 - 2024.12.03 LATITUDE 49.6128335 LONGITUDE -87.9537319 CHECKED BY DV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
308.5 0.0	FILL - SAND - some gravel, trace to some silt, loose		1	AS			308							○				Dry on completion and 1 hour after.			
			2	SS	7		307								○						
	----- - some silt		3	SS	5										○						
306.4 2.1	SAND & SILT - brown, loose to compact		4	SS	8		306								○					0 35 (65)	
			5	SS	22		305									○					
			6	SS	18		304									○					
								303													
			7	SS	7		302									○					0 44 (56)
			8	SS	22	301									○				Cave @ 6.7 m.		
							300														
			9	SS	16	299									○				0 47 (53)		
		10	SS	7										○							
298.2 10.3	End of Borehole @ 10.3 m.																				


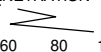
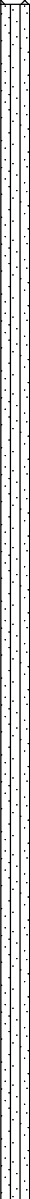
ONTARIO MTO MOD 24-179-7 MTO BEARDMORE.GPJ ONTARIO MTO.GDT 2-10-25

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. _____ LOCATION Patrol Yard N:5497662.464; E:235859.316 MTM Zone:14 ORIGINATED BY AF
DIST NWR HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TG
DATUM GEODETIC DATE 2024.12.04 - 2024.12.04 LATITUDE 49.6127501 LONGITUDE -87.9540348 CHECKED BY DV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
308.4 0.0	FILL - SAND - Gravelly, some silt, compact							20	40	60	80	100	W _p	W	W _L		Dry on completion.				
			1	AS				308													29 52 (19)
			2	SS	18																
306.8 1.6	SILT & SAND - brown, loose to compact							307													
			3	SS	5																
			4	SS	19				306												
			5	SS	16																
									305												
									304												
							303														
					302																
					301																
					300																
					299																
298.1 10.3	End of Borehole @ 10.3 m.																				

ONTARIO MTO MOD 24-179-7 MTO BEARDMORE.GPJ ONTARIO MTO.GDT 2-10-25

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. _____ LOCATION Patrol Yard N:5497669.466; E:235826.306 MTM Zone:14 ORIGINATED BY AF
DIST NWR HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TG
DATUM GEODETIC DATE 2024.12.04 - 2024.12.12 LATITUDE 49.6128093 LONGITUDE -87.9544928 CHECKED BY DV

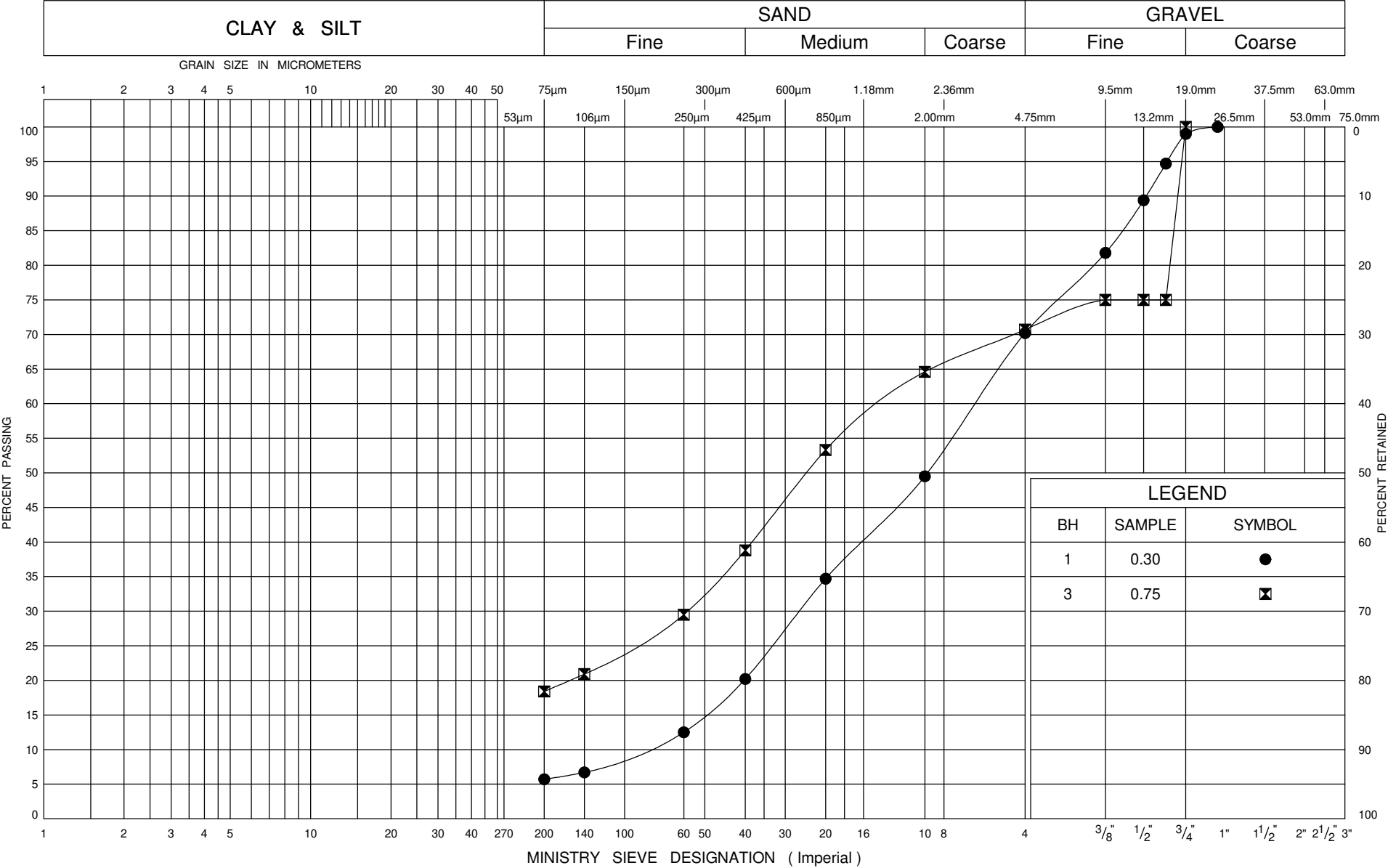
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
308.1	FILL - SAND - Gravelly, some silt, brown						308							GR SA SI CL						
0.0																				
307.7									307											
0.4	SILT - some sand, brown, loose to compact	1	AS																	Water level @ 6.5 m on completion.
		2	SS	4																
		3	SS	23																
		4	SS	16																
	5	SS	19																	
304.1	SILT & SAND - brown, loose						304													
4.0																				
				</																

ONTARIO MTO MOD 24-179-7 MTO BEARDMORE.GPJ ONTARIO MTO.GDT 2-10-25

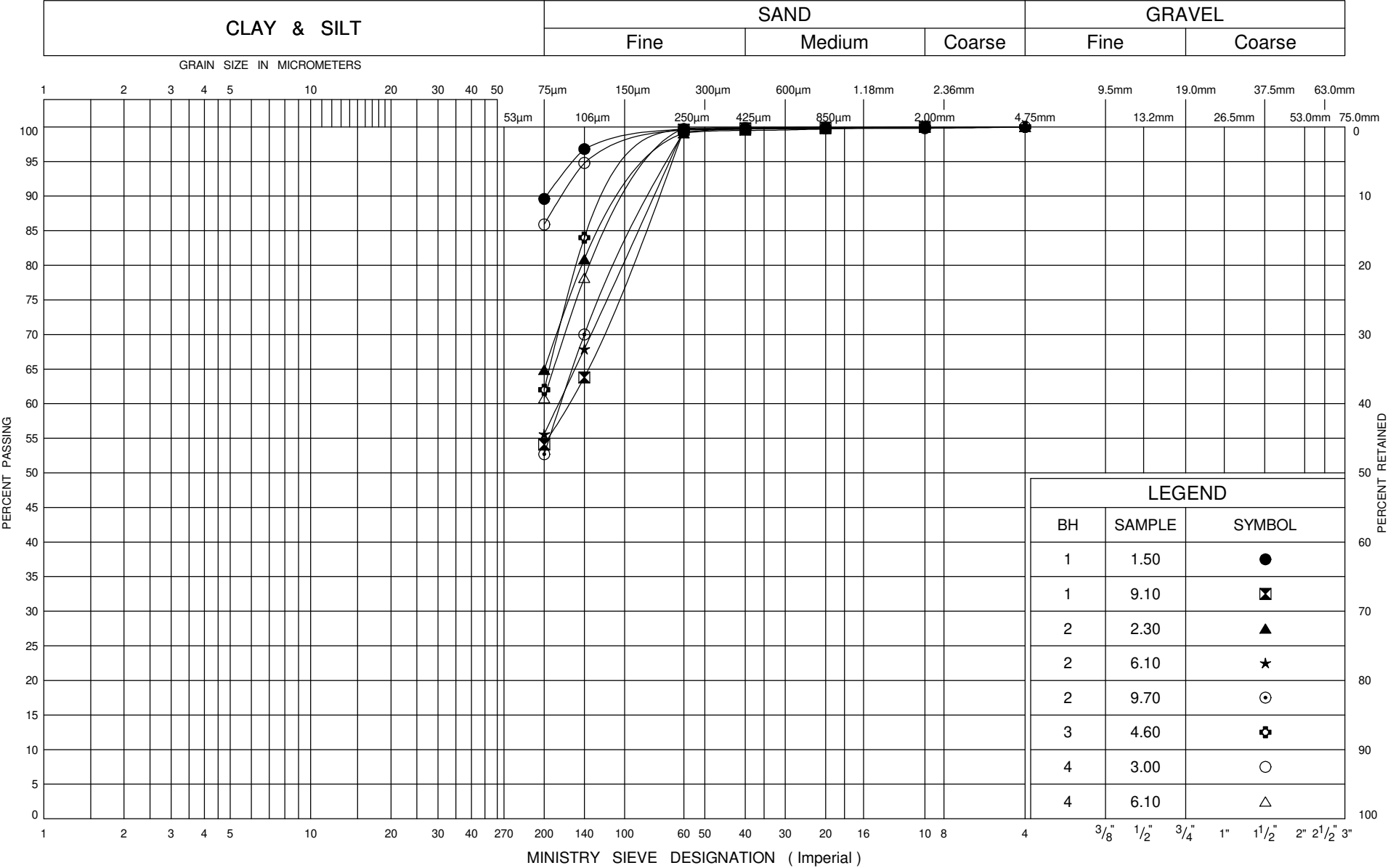
APPENDIX B

Laboratory Test Data

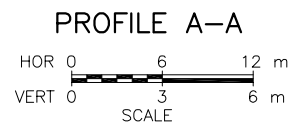
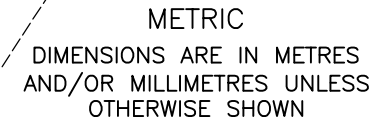
UNIFIED SOIL CLASSIFICATION SYSTEM





UNIFIED SOIL CLASSIFICATION SYSTEM



APPENDIX C
Borehole Location and Soil Strata Drawing



LEGEND			
	Borehole		
'N'	Std Pen Test (Blows/0.3m)		
	Water Level on Completion		
EOH	End of Borehole		

No	ELEVATION	CO-ORDINATES (MTM 14)	
		NORTH	EAST
BH 1	308.2	14 5 497 721	235 844
BH 2	308.5	14 5 497 671	235 881
BH 3	308.4	14 5 497 662	235 859
BH 4	308.1	14 5 497 669	235 826

[illegible]