



January 21, 2013

FOUNDATION INVESTIGATION REPORT

**ROADWAY PROTECTION
REHABILITATION OF ENGLEHART RIVER BRIDGE
SITE 47-032 ON HIGHWAY 11
TOWNSHIP OF EVANTUREL, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5302-05-00**

Submitted to:
Morrison Hershfield Limited
235 Yorkland Boulevard, Suite 600
Toronto, Ontario
M2J 1T1



GEOCRES NO.: 31M-100

Report Number: 11-1191-0032 - ER

- 1 e-copy Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
- 1 e-copy Ministry of Transportation, Ontario, Downsview, Ontario (Foundations Section)
- 1 e-copy Morrison Hershfield Limited, Toronto, Ontario
- 1 Copy Golder Associates Ltd., Sudbury, Ontario



REPORT





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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the temporary roadway protection associated with the rehabilitation of the Highway 11 bridge crossing the Englehart River in the Township of Evanturel, north of Englehart, Ontario.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal (RFP), dated October 2011, and Request for Clarification Letter, dated December 12, 2011. Golder's proposal P1-1191-0032, dated December 2011, for foundation engineering services associated with this project is contained in Section 6.8 of MH's Technical Proposal that forms part of the Consultant's Agreement Number 5011-E-0009 for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated March 22, 2012. The General Arrangement (GA) drawing for the bridge was provided to Golder by MH in July 2012.

The purpose of this investigation is to establish the subsurface conditions within the vicinity of the proposed roadway protection for the Englehart River Bridge by methods of borehole drilling, in situ testing and laboratory testing on selected soil samples. The boreholes were located in the field by Golder relative to stakes installed by MH. The approximate location of the Highway 11 bridge crossing the Englehart River is shown on the Key Plan on Drawing 1.

2.0 SITE DESCRIPTION

The Highway 11 bridge crossing Englehart River is located at the easterly entrance of Englehart in the New Liskeard area. The bridge was constructed around 1973, rehabilitated in 1993 and consists of a five-span structure with the abutments and piers supported on H-piles and has a concrete deck and steel girders.

In general, the topography in the vicinity of the bridge is flat with the Englehart River located about 30 m below the bridge deck. The banks of the river and the approach embankment side slopes are vegetated with grass. The area in the vicinity of the site is landscaped with trees. The surface of the roadway at the bridge is at about Elevation 210 m on the west side of the bridge and sloping up to about Elevation 211 m on the east side of the bridge. The river water level measured by others as noted was Elevation 179.4 m in February 1973.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation associated with the proposed temporary roadway protection for the rehabilitation of the Englehart River Bridge was carried out between June 5 and 8, 2012. A total of four (4) boreholes were advanced as part of the investigation, one each at the east and west approach embankments (Boreholes ER-2 and ER-4, respectively) and one each at the east and west abutments (Boreholes ER-3 and ER-1, respectively), at approximately the locations shown on Drawing 1.

The field investigation was carried out using a track-mounted D-50 drilling rig supplied and operated by Walker Drilling of Utopia, Ontario.



The boreholes were advanced through the overburden using 108 mm inside diameter (I.D.) hollow-stem augers. In general, soil samples were obtained at intervals at depths of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler operated by automatic hammers on the drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were carried out in cohesive soils for determination of undrained shear strengths (ASTM D2573) using an MTO Standard 'N' size vane. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903-Wells (as amended).

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A.

The fieldwork was observed by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

Survey stakes offset from the Highway 11 centerline were installed by MH prior to the commencement of drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the applicable stakes installed by MH and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. The ground surface elevation at the borehole locations was surveyed by a member of our technical staff in reference to the ground surface elevations at applicable stakes installed by MH. The borehole locations shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
ER-1	5298433.9	389844.1	209.9	10.1
ER-2	5298493.2	390122.8	211.0	20.4
ER-3	5298495.2	390114.5	211.0	10.1
ER-4	5298436.2	389834.9	209.9	20.4



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature¹ indicates that the site is located in the transition zone between the Western Abitibi Subprovince of the Superior Province (to the north) and the Huronian Supergroup (to the south). The bedrock geology follows the river valley and consists of mafic metavolcanic rock (Geology of Ontario, OGS Special Volume 4¹).

Terrain mapping by the Ontario Geological Survey², describes the soils in the vicinity of the site as silty colluvial slopewash and debris creep sheet with minor talus.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets in Appendix A. The results of the laboratory tests are also presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy, as encountered in the boreholes, is shown in profile on Drawing 1.

In general, the subsurface stratigraphy encountered at the site consists of pavement structure (asphalt and granular fill) underlain by deposits of sand to sandy silt and clayey silt.

4.2.1 Asphalt

All of the boreholes were drilled through the pavement and penetrated through approximately 150 mm to 240 mm of asphalt.

4.2.2 Fill

A deposit of brown, gravelly sand to sand and gravel fill containing trace silt, between 1.5 m and 2.2 m thick was encountered underlying the asphalt in all of the boreholes. The top of the fill was encountered between Elevation 210.8 m and 209.7 m. A 0.1 m thick seam of peat was encountered in Borehole ER-1 at Elevation 207.6 m.

SPT 'N'-values measured within the fill range from 14 blows to 51 blows per 0.3 m of penetration, indicating a compact to dense relative density.

A grain size distribution of a sample of the sand and gravel fill is shown on Figure B-1 in Appendix B.

¹ Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 1. Ministry of Northern Development and Mines, Ontario.

² Northern Ontario Engineering Geology Terrain Study, Ontario Geological Society, Map 5020 and 5021.



The natural water content measured on samples of the fill ranges between about 1 per cent and 2 per cent.

4.2.3 Silty Sand to Sandy Silt

A deposit of brown to grey, silty sand to sandy silt containing trace to some clay, between 2.9 m and 5.5 m thick was encountered underlying the fill in all of the boreholes. The top of the silty sand to sandy silt deposit was encountered at depths between 1.7 m and 2.4 m below ground surface, corresponding to between Elevation 209.3 m and 207.5 m. A 0.3 m thick seam of brown silty clay was encountered within the sand to sandy silt deposit in Borehole ER-1 at Elevation 206.9 m.

SPT 'N'-values measured within the silty sand to sandy silt deposit range from 1 blow to 25 blows per 0.3 m of penetration, indicating a very loose to compact relative density. In Borehole ER-2, a SPT 'N'-value of 44 blows per 0.3 m of penetration was measured, indicating a dense relative density at the top of the deposit.

The grain size distributions of five samples of the silty sand to sandy silt deposit are shown on Figure B-2 in Appendix B.

The natural water content measured on samples of the silty sand to sandy silt ranges between about 13 per cent and 28 per cent.

An Atterberg limits test was carried out on the sample of the silty clay seam and yielded a liquid limit of about 39 per cent, a plastic limit of about 16 per cent and a plasticity index of about 23 per cent. The result of the Atterberg limits testing is shown on the plasticity chart on Figure B-3 in Appendix B and indicates that the seam consists of silty clay of intermediate plasticity.

The natural water content measured on the sample of the silty clay seam is about 39 per cent.

4.2.4 Silt

A deposit of grey silt containing some clay and trace to some sand, between 1.2 m and 3.5 m thick was encountered underlying the silty sand to sandy silt in Boreholes ER-1, ER-2 and ER-4, between 5.3 m and 7.2 m below ground surface, corresponding to Elevations 204.6 m and 203.8 m, respectively. A 1.1 m thick deposit of silt was also encountered underlying the clayey silt in Borehole ER-2, at a depth of 19.3 m below ground surface at Elevation 191.7 m. Borehole ER-2 was terminated within the lower silt deposit.

SPT 'N'-values measured within the silt deposit range from 0 blows (weight of hammer) to 10 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of four samples of the silt are shown on Figure B-4 in Appendix B.

Atterberg limits testing carried out on two samples of the silt deposit yielded liquid limits ranging from about 17 per cent to 18 per cent, plastic limits ranging from about 14 per cent to 16 per cent and plasticity indices ranging from about 2 per cent to 3 per cent, as presented on Figure B-5, indicating a material of slight plasticity, while two other samples are non-plastic.

The natural water content measured on samples of the silt ranges between about 24 per cent and 27 per cent.



4.2.5 Clayey Silt

A deposit of grey, clayey silt containing trace to some sand, between 1.3 m and 13.5 m thick was encountered underlying the silty sand deposit in Borehole ER-3 and underlying the silt deposit in Boreholes ER-1, ER-2 and ER-4. The top of the clayey silt deposit was encountered at depths between 6.9 m and 8.8 m below ground surface, between Elevation 203.8 m and 201.1 m. Boreholes ER-1, ER-3 and ER-4 were terminated within the clayey silt deposit.

SPT 'N'-values measured within the clayey silt deposit range from 0 blows (weight of hammer) to 9 blows per 0.3 m of penetration and typically less than 4 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 39 kPa to 63 kPa. The SPT tests, together with the field vane tests, suggest the deposit has a firm to stiff consistency.

Atterberg limits testing carried out on five samples of the clayey silt deposit yielded liquid limits ranging from about 23 per cent to 31 per cent, plastic limits ranging from about 15 per cent to 18 per cent and plasticity indices ranging from about 5 per cent to 13 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-6 in Appendix B and indicate that the deposit consists of clayey silt of low plasticity.

The grain size distributions of three samples of the clayey silt are shown on Figure B-7 in Appendix B.

The natural water content measured on samples of the clayey silt ranges between about 25 per cent and 30 per cent.

4.2.6 Groundwater Conditions

Groundwater levels were measured in the open boreholes upon completion of drilling and are summarized below.

Borehole	Depth to Groundwater Level Below Ground Surface (m)	Groundwater Elevation (m)
ER-1	8.8	201.1
ER-2	4.6	206.4
ER-3	5.8	205.2
ER-4	3.7	206.2

Groundwater levels encountered in the boreholes during and shortly after drilling may not be representative of static levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Groundwater and river water levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.



5.0 CLOSURE

The field person supervising the drilling program was Mr. Ed Savard. This report was prepared by Mr. Evan Childerhose, P.Eng. The technical aspects were reviewed by Mr. Jorge M. A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project, who also carried out a quality control review of the report.

Report Signature Page

GOLDER ASSOCIATES LTD.

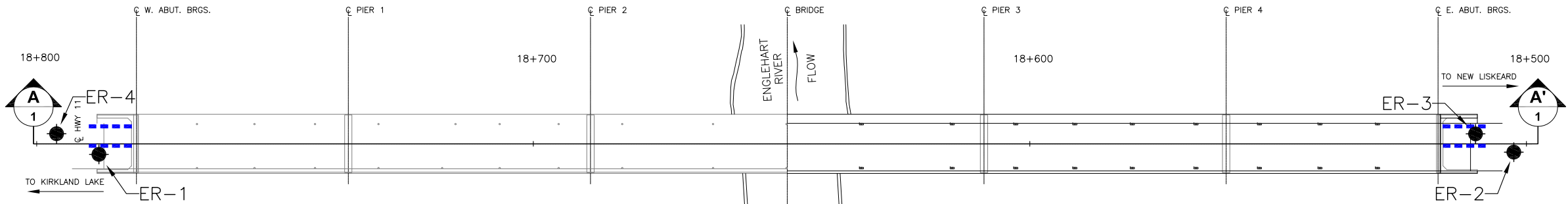
Evan Childerhose, P.Eng.
Geotechnical Engineer

Jorge M. A. Costa, P.Eng.
Designated MTO Contact, Principal

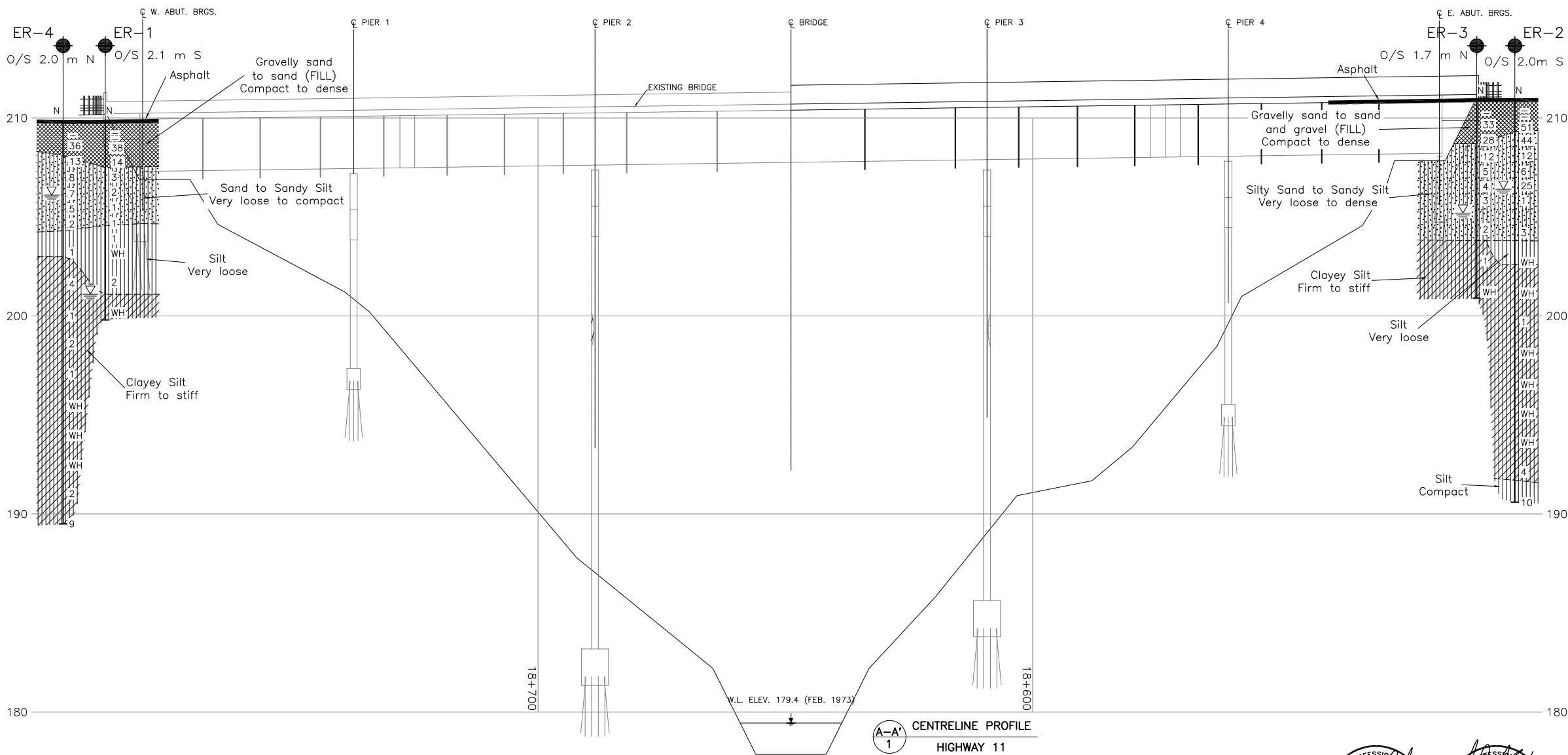
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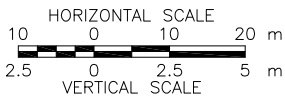
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PLAN



CENTRELINE PROFILE
HIGHWAY 11



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

CONT No.
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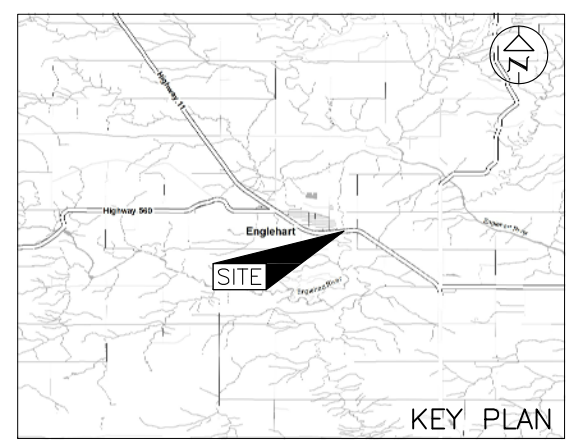
ENGLEHART (BLANCHE) RIVER
HIGHWAY 11 BRIDGE 47-032
BOREHOLE LOCATIONS AND SOIL
STRATA



SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN

LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▽ WL upon completion of drilling
- Temporary Protection System

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
ER-1	209.9	5298433.9	389844.1
ER-2	211.0	5298493.2	390122.8
ER-3	211.0	5298495.2	390114.5
ER-4	209.9	5298436.2	389834.9

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 Morrison Hershfield, drawing file nos. 47032-01.dwg, received July 23, 2012.



NO.	DATE	BY	REVISION
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APPENDIX A

Record of Boreholes



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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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) 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

	kPa	C_u, S_u	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

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



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

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

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

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



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT		11-1191-0032		RECORD OF BOREHOLE No ER-1		1 OF 1 METRIC							
W.P.		5302-05-00		LOCATION		N 5298433.9; E 389844.1							
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers							
DATUM		GEODETIC		DATE		June 5, 2012							
				ORIGINATED BY		EHS							
				COMPILED BY		AC							
				CHECKED BY		EC							
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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
209.9	GROUND SURFACE												
0.0	ASPHALT (240 mm)												
0.2	Gravelly sand to sand, trace silt (FILL) Compact to dense Brown Moist		1	AS	-								
			2	AS	-								
			3	SS	38								
			4	SS	14								
207.5	Peat seam encountered at 2.3 m depth.												
2.4	SAND to Sandy SILT, trace to some clay Very loose Brown to grey Wet		5	SS	3								
			6a	SS	2								
	SILTY CLAY seam encountered at 3.0 m depth.		6b	SS	2								
			7	SS	1								
			8	SS	1								
204.6													
5.3	SILT, some clay, trace to some sand Very loose Grey Wet		9	SS	1								
			10	SS	WH								
			11	SS	2								
201.1													
8.8	CLAYEY SILT Firm Grey Wet		12	SS	WH								
199.8													
10.1	END OF BOREHOLE												
	Note: 1. Water level at a depth of 8.8 m below ground surface (Elev. 201.1 m) upon completion of drilling.												

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 19/09/12 DATA INPUT:

PROJECT 11-1191-0032			RECORD OF BOREHOLE No ER-2			1 OF 2 METRIC														
W.P. 5302-05-00			LOCATION N 5298493.2; E 390122.8			ORIGINATED BY EHS														
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AC														
DATUM GEODETIC			DATE June 5 and 6, 2012			CHECKED BY EC														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL			
								20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60								
211.0	GROUND SURFACE																			
0.0	ASPHALT (150 mm)																			
0.2	Gravelly sand to sand and gravel, trace silt (FILL) Dense Brown Moist		1	AS	-															
			2	AS	-															
			3	SS	51		210													
209.3																				
1.7	Silty SAND to Sandy SILT, trace to some clay Very loose to dense Brown to grey Moist to wet		4	SS	44		209										1 30 51 18			
			5	SS	12															
			6	SS	6		208													
			7	SS	25		207													
			8	SS	1		206													
			9	SS	3		205										0 27 60 13			
203.8							204													
7.2	SILT, some sand, some clay Very loose Grey Wet		10	SS	WH		203										0 15 68 17			
202.6																				
8.4	CLAYEY SILT Firm to stiff Grey Wet		11	SS	WH		202													
							201													
			12	SS	1		200													
							199													
			13	SS	WH		198													
							197													
			14	SS	WH															

Continued Next Page

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

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:

PROJECT 11-1191-0032			RECORD OF BOREHOLE No ER-2			2 OF 2 METRIC										
W.P. 5302-05-00			LOCATION N 5298493.2; E 390122.8			ORIGINATED BY EHS										
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AC										
DATUM GEODETIC			DATE June 5 and 6, 2012			CHECKED BY EC										
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								
	--- CONTINUED FROM PREVIOUS PAGE ---															
191.7	CLAYEY SILT Firm to stiff Grey Wet		15	SS	WH											
						195			4							
			16	SS	WH											
						194										
						193			5							
			17	SS	4											
						192										
191.3	SILT, trace to some clay, trace sand Compact Grey Wet					191										
190.6			18	SS	10											
20.4	END OF BOREHOLE Note: 1. Water level at a depth of 4.6 m below ground surface (Elev. 206.4 m) upon completion of drilling.															

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:

PROJECT <u>11-1191-0032</u>			RECORD OF BOREHOLE No ER-3			1 OF 1 METRIC								
W.P. <u>5302-05-00</u>			LOCATION <u>N 5298495.2; E 390114.5</u>			ORIGINATED BY <u>EHS</u>								
DIST <u> </u> HWY <u>11</u>			BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>			COMPILED BY <u>AC</u>								
DATUM <u>GEODETIC</u>			DATE <u>June 8, 2012</u>			CHECKED BY <u>EC</u>								
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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
211.0	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	ASPHALT (240 mm)													
0.2	Gravelly sand to sand and gravel, trace silt (FILL) Compact to dense Brown Moist		1	AS	-									55 40 (5)
			2	SS	33									
			3	SS	28									
208.7														
2.3	Silty SAND, trace to some clay Very loose to compact Grey Wet		4	SS	12									
			5	SS	5									0 59 27 14
			6	SS	4									
			7	SS	3									
			8	SS	2									
203.8														
7.2	CLAYEY SILT, trace to some sand Firm Grey Wet		9	SS	1									
			10	SS	WH									0 0 73 27
200.9														
10.1	END OF BOREHOLE													
	Note: 1. Water level at a depth of 5.8 m below ground surface (Elev. 205.2 m) upon completion of drilling.													

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:



PROJECT <u>11-1191-0032</u>		RECORD OF BOREHOLE No ER-4		1 OF 2		METRIC	
W.P. <u>5302-05-00</u>		LOCATION <u>N 5298436.2; E 389834.9</u>		ORIGINATED BY <u>EHS</u>			
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>AC</u>			
DATUM <u>GEODETIC</u>		DATE <u>June 7, 2012</u>		CHECKED BY <u>EC</u>			

[illegible]

Continued Next Page

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

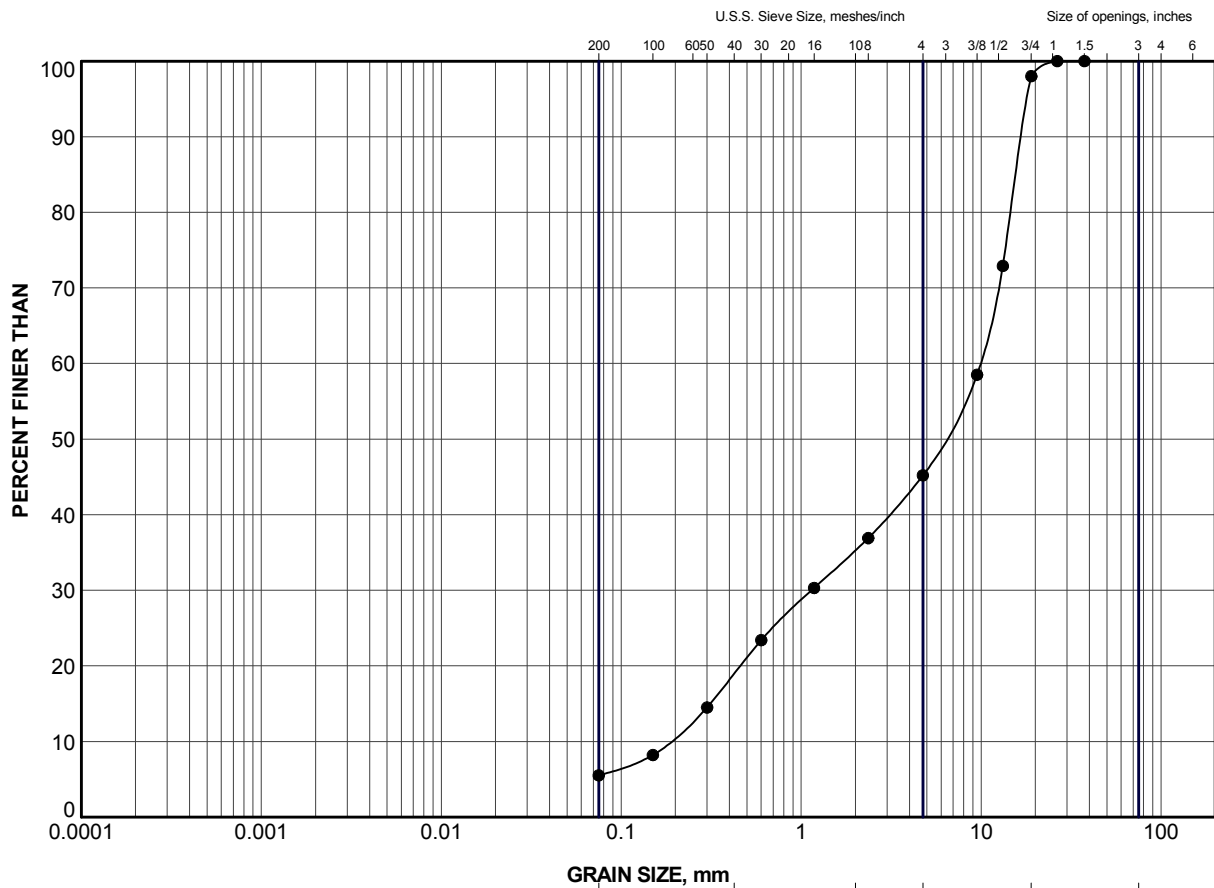
SUD-MTO 001 11-1191-0032+BH09.GPJ GAL-MISS.GDT 11/09/12 DATA INPUT:

PROJECT <u>11-1191-0032</u>				RECORD OF BOREHOLE No ER-4				2 OF 2 METRIC																		
W.P. <u>5302-05-00</u>		LOCATION <u>N 5298436.2; E 389834.9</u>				ORIGINATED BY <u>EHS</u>																				
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>AC</u>																				
DATUM <u>GEODETIC</u>		DATE <u>June 7, 2012</u>				CHECKED BY <u>EC</u>																				
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 (%)										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)													
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>														
	CLAYEY SILT, trace to some sand Firm to stiff Grey Wet		14	SS	WH		194																			
			15	SS	WH		193																			
							192																			
			16	SS	2		191																			
							190																			
189.5 20.4	END OF BOREHOLE Note: 1. Water level at a depth of 3.7 m below ground surface (Elev. 206.2 m) upon completion of drilling.		17	SS	9															0 0 87 13						



APPENDIX B


Laboratory Test Results

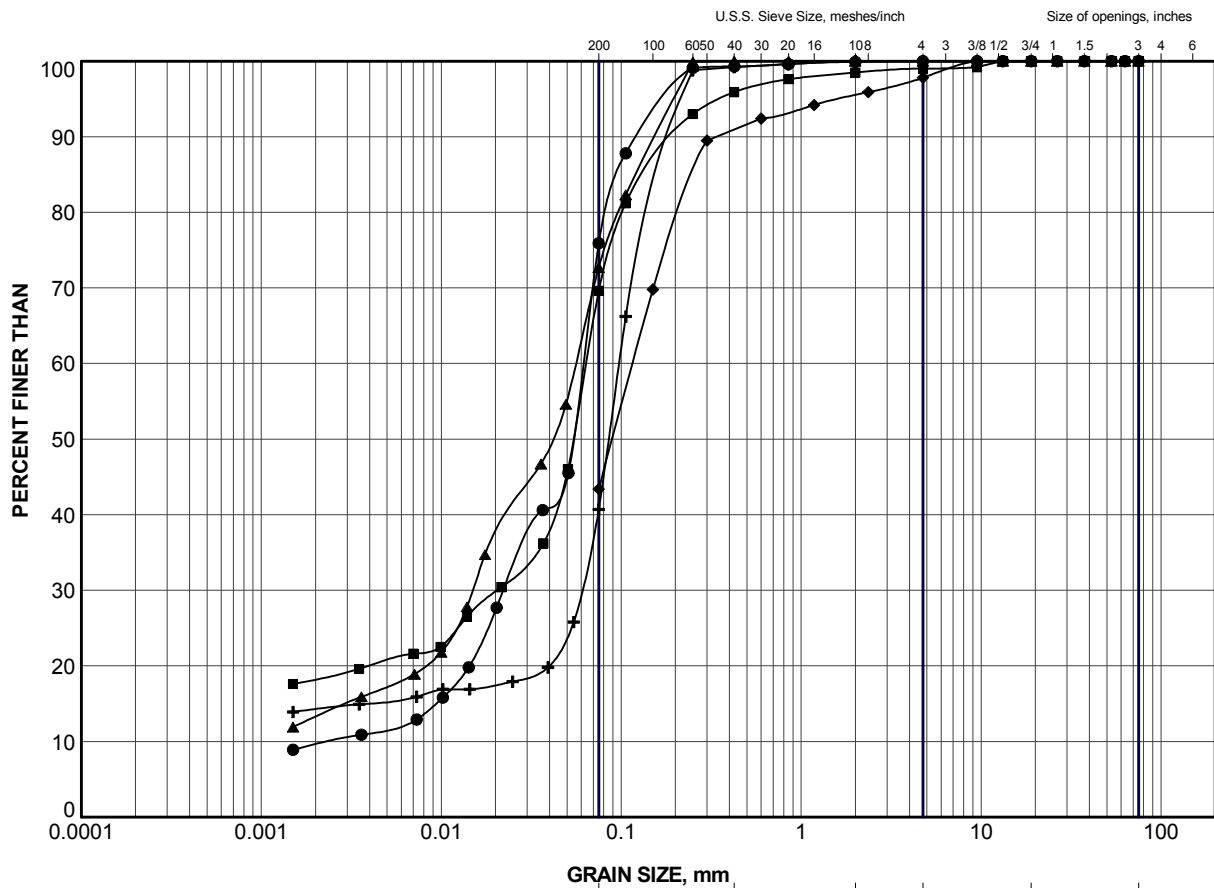


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-3	1	210.6


PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
GRAIN SIZE DISTRIBUTION Sand and gravel (FILL)					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
 Golder Associates SUDBURY, ONTARIO			FIGURE B-1		

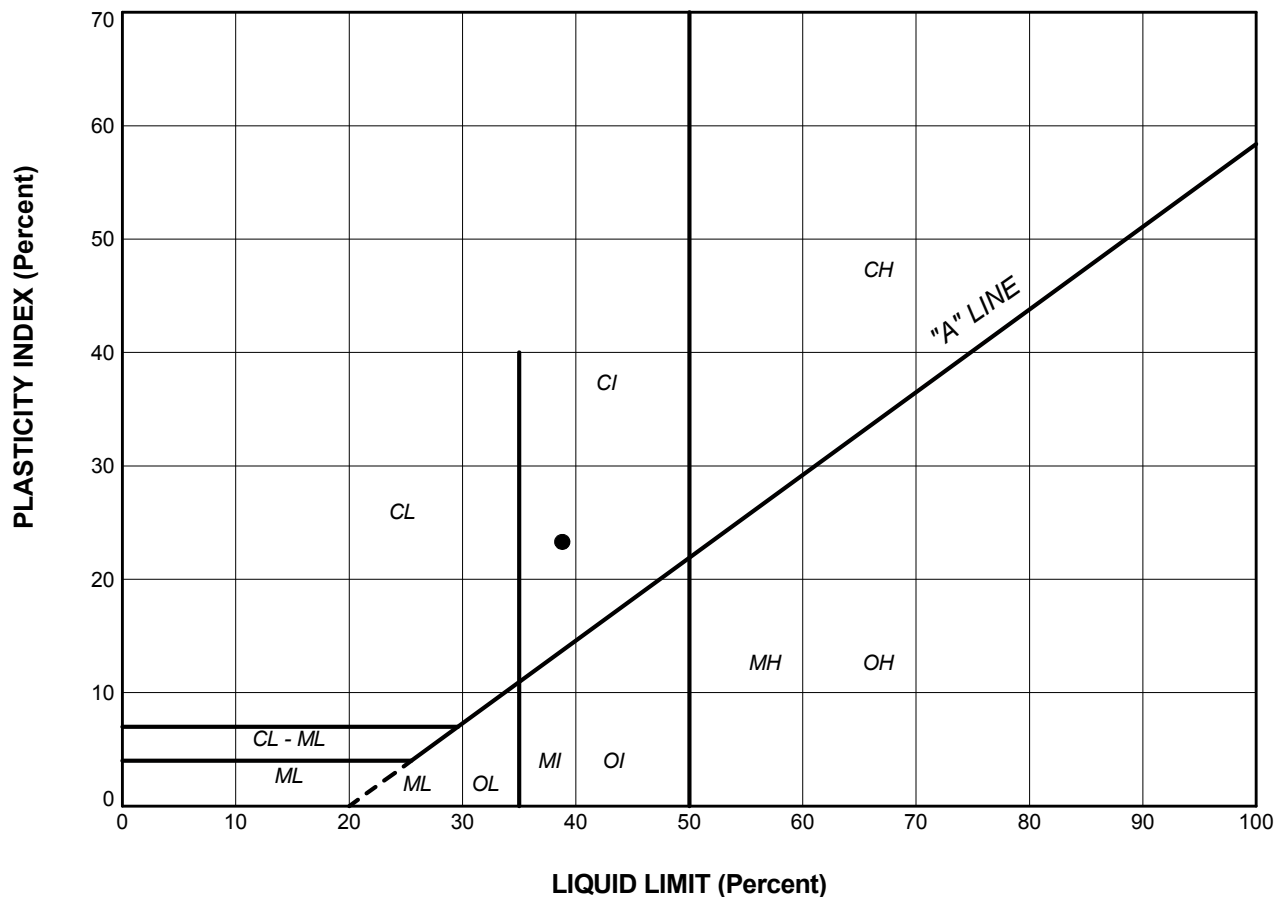


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		


LEGEND

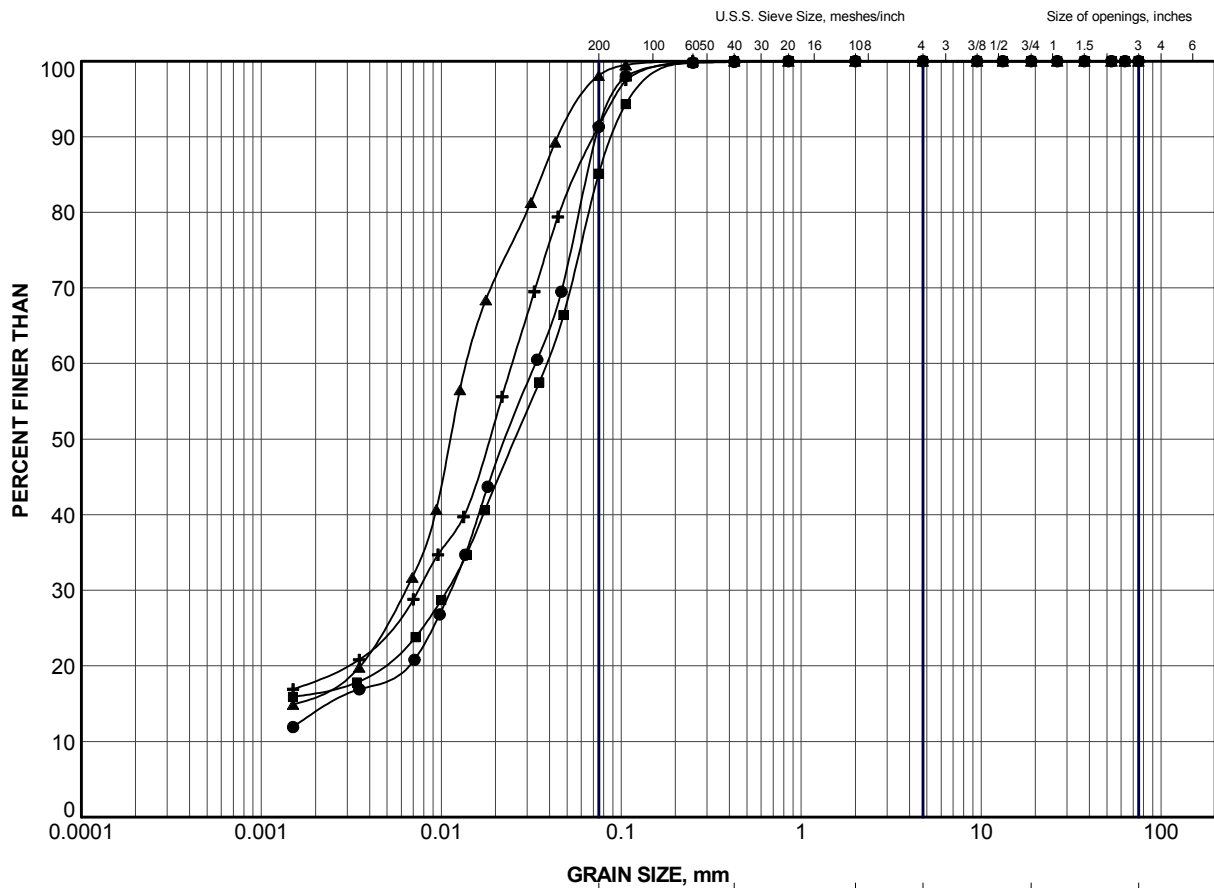
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-1	7	205.9
■	ER-2	4	209.2
▲	ER-2	9	204.6
+	ER-3	5	207.7
◆	ER-4	3	207.9

PROJECT				
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032				
TITLE				
GRAIN SIZE DISTRIBUTION Sandy Silt to Silty Sand				
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ
DRAWN	TB	Sep 2012	SCALE	N/A
CHECK	EC	Sep 2012	REV.	
APPR	JMAC	Sep 2012		
 Golder Associates SUDBURY, ONTARIO			FIGURE B-2	



LEGEND					
SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	ER-1	6a	39	16	23

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
PLASTICITY CHART Silty Clay					
PROJECT No. 11-1191-0032			FILE No. 11-1191-0032+BH09.GPJ		
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012	FIGURE B-3		
APPR	JMAC	Sep 2012			
 Golder Associates SUDBURY, ONTARIO					



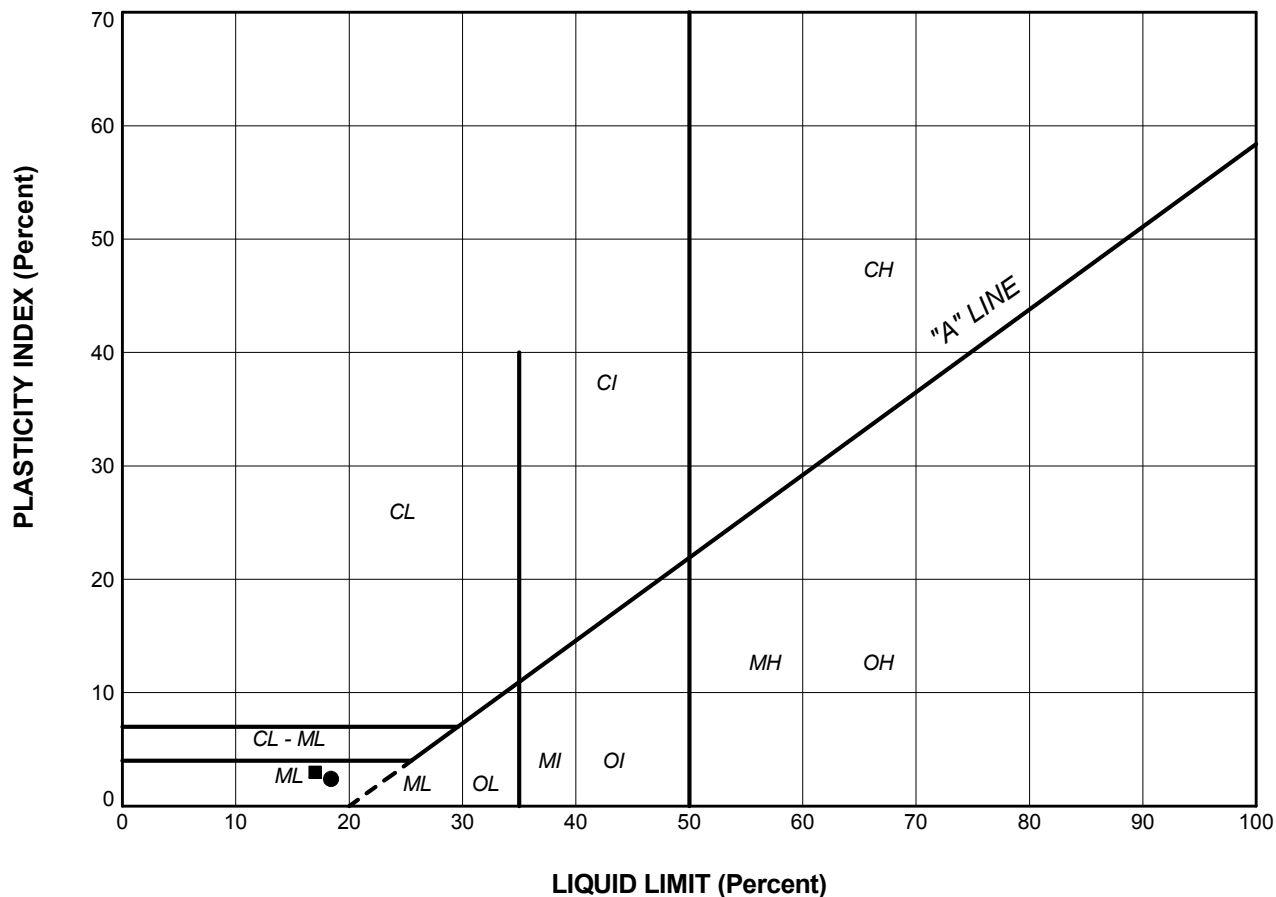
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-1	9	204.3
■	ER-2	10	203.1
▲	ER-2	17	192.4
+	ER-4	8	203.5

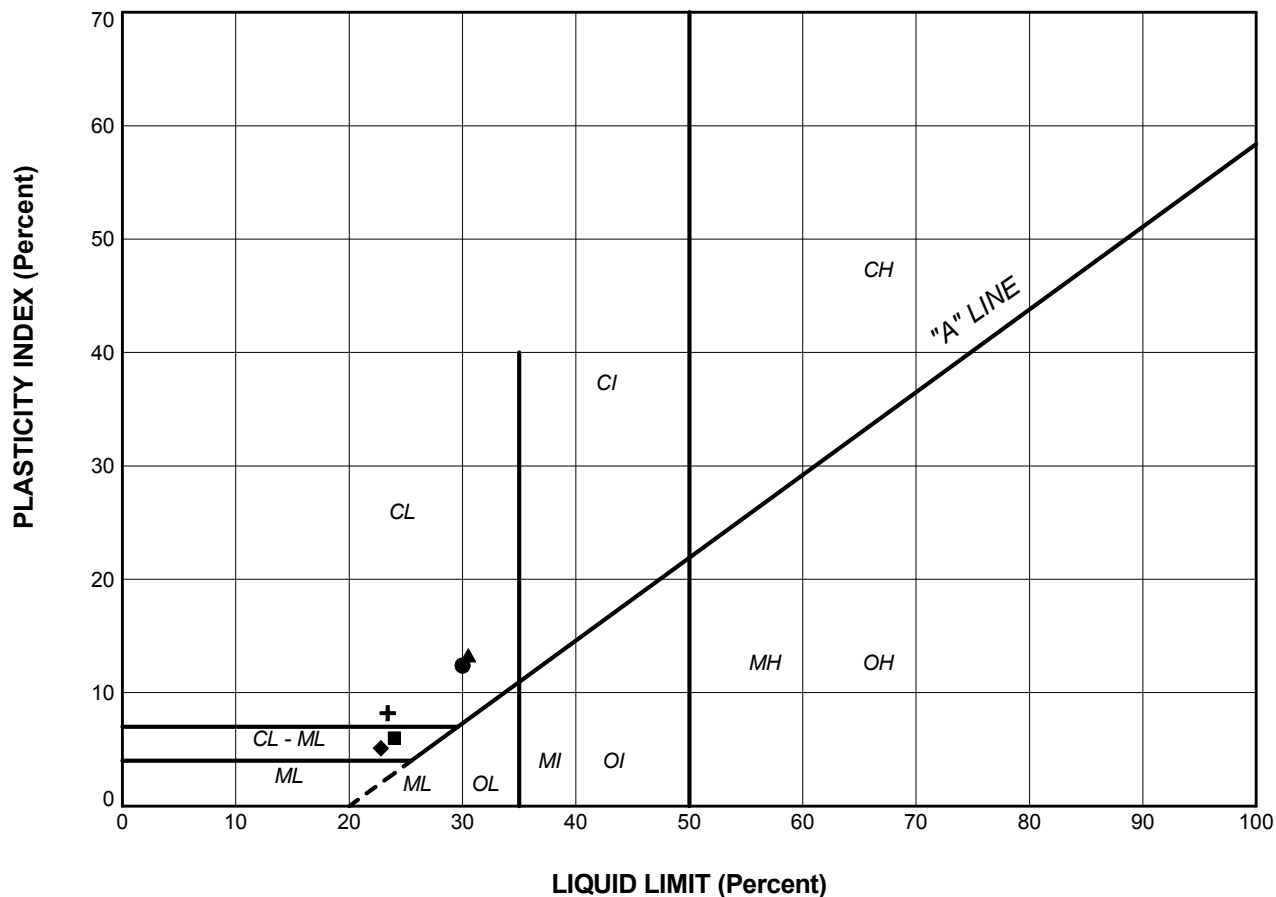
PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
GRAIN SIZE DISTRIBUTION Silt					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-4		





PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
PLASTICITY CHART Silt					
PROJECT No.		11-1191-0032		FILE No. 11-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-5		

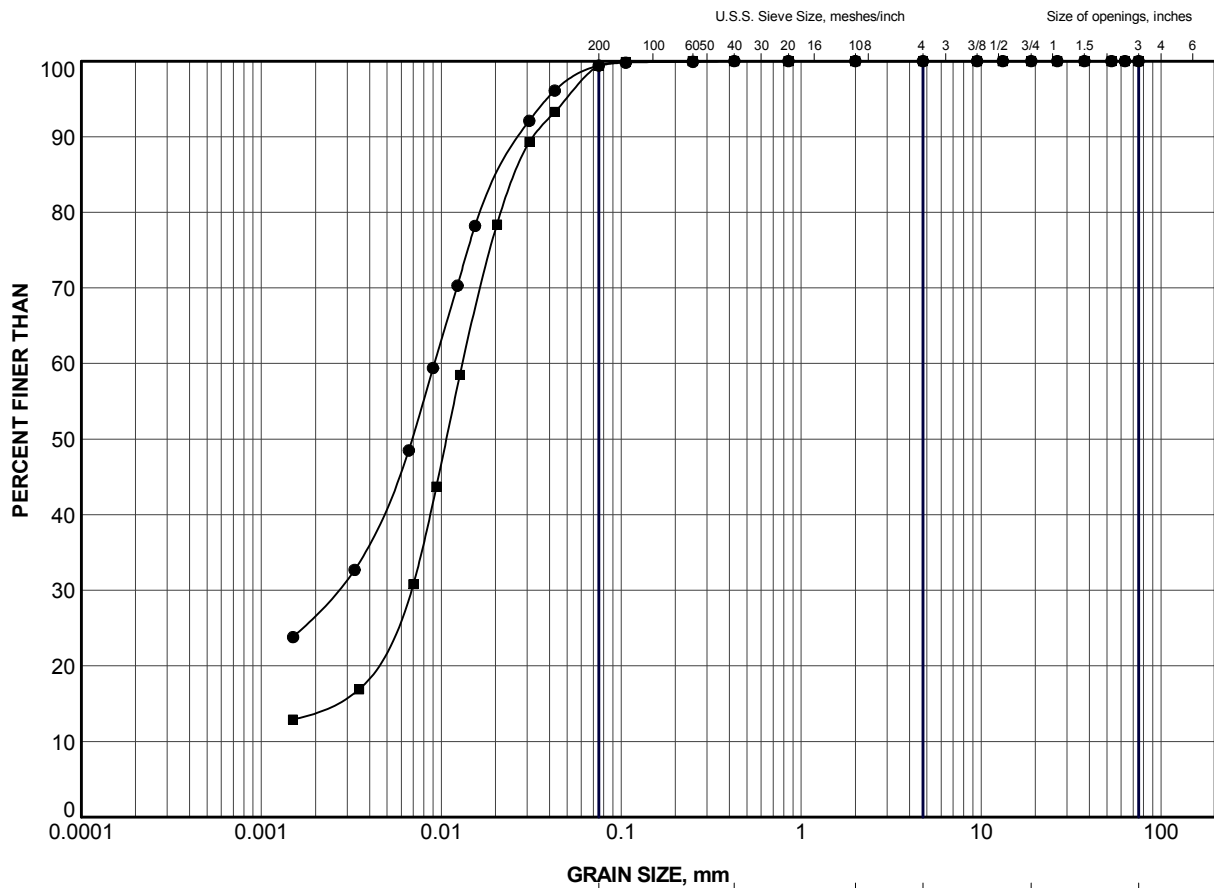




LEGEND					
SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	ER-2	15	30	18	12
■	ER-2	17	24	18	6
▲	ER-3	10	31	17	13
+	ER-4	12	23	15	8
◆	ER-4	17	23	18	5

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032					
TITLE					
PLASTICITY CHART Clayey Silt					
PROJECT No.		11-1191-0032		FILE No. 11-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-6		






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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-3	10	201.6
■	ER-4	17	189.8

PROJECT				
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-032				
TITLE				
GRAIN SIZE DISTRIBUTION Clayey Silt				
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ
DRAWN	TB	Sep 2012	SCALE	N/A
CHECK	EC	Sep 2012	REV.	
APPR	JMAC	Sep 2012		
 Golder Associates SUDBURY, ONTARIO			FIGURE B-7	

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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Asia	+ 86 21 6258 5522
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Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

