FOUNDATION INVESTIGATION AND DESIGN REPORT
for
REPLACEMENT OF POTTAWATOMI RIVER TRIBUTARY CULVERT
SITE NO. 8-482C
HIGHWAY 6, SPRINGMOUNT
G.W.P. 43-00-00
DISTRICT OF LONDON, ONTARIO

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:
3 cc: McCormick Rankin (MRC) for distribution to MTO, Project Manager – West Region (London) + 1 digital copy (pdf)
3 cc: Foundation Investigation Report only to MRC for distribution to MTO, Project Manager – West Region (London) + 1 digital copy (pdf)
1 cc: MRC for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf) and Drawing (AutoCAD)
1 cc: Foundation Investigation Report only to MRC for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf) and Drawing (AutoCAD)
2 cc: MRC + 1 digital copy (pdf)
1 cc: PML Toronto
1 cc: PML Kitchener

PML Ref.: 11KF065A-C2
Index No. 107FIR and 108FDR
GEOCRES No. 41A - 224
November 21, 2012

FOUNDATION INVESTIGATION REPORT
for
REPLACEMENT OF POTTAWATOMI RIVER TRIBUTARY CULVERT
SITE NO. 8-482C
HIGHWAY 6, SPRINGMOUNT
G.W.P. 43-00-00
DISTRICT OF LONDON, ONTARIO

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:
3 cc: McCormick Rankin (MRC) for distribution to MTO, Project Manager – West Region (London) + 1 digital copy (pdf)
3 cc: Foundation Investigation Report only to MRC for distribution to MTO, Project Manager – West Region (London) + 1 digital copy (pdf)
1 cc: MRC for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf) and Drawing (AutoCAD)
1 cc: Foundation Investigation Report only to MRC for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf) and Drawing (AutoCAD)
2 cc: MRC + 1 digital copy (pdf)
1 cc: PML Toronto
1 cc: PML Kitchener

PML Ref.: 11KF065A-C2
Index No. 107FIR
GEOCRES No. 41A - 224
November 21, 2012

TABLE OF CONTENTS

FOUNDATION INVESTIGATION REPORT
for
Replacement of Pottawatomi River Tributary Culvert
Site No. 8-482C
Highway 6, Springmount
GWP 43-00-00
District of London, Ontario

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the installation of a Pottawatomi River Tributary replacement culvert, as a part of rehabilitation of Highway 6, from Springmount to Hepworth. This foundation investigation was carried out by Peto MacCallum Ltd. (PML) for McCormick Rankin (MRC), a member of MMM Group Ltd., on behalf of the Ministry of Transportation of Ontario (MTO).

The location of the replacement culvert was selected approximately 20 m south of the existing culvert after the drilling of the boreholes had been completed. In view of the encountered subsurface conditions at this site and the current conditions at Site No: 8-483C located approximately 320 m to the south, the stratigraphy at the investigated locations in this report may vary, but are expected to be representative of the selected culvert location.

The purpose of this report was to summarize the subsurface stratigraphy encountered during the foundation investigation for the new culvert.

2. SITE DESCRIPTION AND GEOLOGY

The existing culvert is located on the Highway 6 northbound and southbound lanes, about 750 m north of the intersection of Highway 6 and 21, in the Town of Springmount. The new culvert will be located about 20 m south of the existing culvert on Highway 6.

Land use in the vicinity of the site includes the existing Highway 6 transportation corridor and commercial sites. The terrain includes level areas vegetated with grass, brush and scattered trees. The topography of the site is generally flat. Site photographs of the existing culvert location are included in Appendix A.

Physiographically the site is located in the region referred to as the Bruce Peninsula. The surficial and bedrock geology consists of a thin till soil cover less than 5 m thick over dolomite bedrock.

3. INVESTIGATION PROCEDURES

The subsurface investigation was carried out on January 11 and 12, 2012. Two boreholes (CT2-1 and CT2-2) were drilled to 5.0 and 3.6 m depths, respectively at the locations shown on Drawing PRT-2, appended.

The boreholes were advanced using continuous flight hollow stem augers with a truck-mounted CME 45 drill rig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a PML field supervisor.

Soil samples were recovered from the boreholes at regular 0.75 and 1.5 m depth intervals using the standard penetration test method. Standard penetration tests were conducted to assess the strength characteristics of the substrata. Soils were identified in accordance with the MTO soil classification manual procedures. The groundwater conditions in the boreholes were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, where encountered, by measuring the groundwater level in the open boreholes.

The boreholes were backfilled with a bentonite/cement mixture, where required, in accordance with the MTO guideline and MOE Reg. 903 for borehole abandonment procedures.

The co-ordinates and ground surface elevations at the boreholes were provided by MMM Group Ltd. All elevations are reported in metres.

The recovered soil samples were returned to our laboratory in Toronto for detailed visual examination, laboratory testing and classification. The laboratory testing program included the following tests:

- Natural moisture content determinations (7)
- Grain size distribution analyses (4)
- Atterberg limits tests (4)

The grain size distribution charts are presented in Figures CT2-GS-1 to CT2-GS-3. The plasticity charts are presented in Figures CT2-PC-1 to CT2-PC-3. All of the test results are shown on the Record of Borehole sheets.

4. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test results as well as groundwater observations. The results of grain size distributions, Atterberg limits tests and moisture content determinations are also shown on the Record of Borehole sheets.

The borehole locations and stratigraphic profile prepared from the borehole data are presented on the foundation Drawing PRT-2.

Boreholes CT2-1 and CT2-2 were drilled in the vicinity of the existing culvert to 5.0 and 3.6 m, elevation 231.5 and 232.9, respectively. As indicated in the section 1 of this report the planned culvert is located 20 m to the south of the existing culvert. Subsurface conditions at the new culvert could vary from those encountered in the boreholes advanced at the existing culvert, however they are considered to be representative based on the geology of the general area.

The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill underlain by silt, silty clay/clayey silt and silty sand till. Bedrock was inferred by auger refusal at depths of 5.0 and 3.6 m, elevation 231.5 and 232.9, in boreholes CT2-1 and CT2-2 respectively. Groundwater was observed in both boreholes on completion of drilling.

4.1.1 Fill

From the ground surface, a 2.1 and 1.8 m thick fill unit extending to elevation 234.4 and 234.7 was encountered in boreholes CT2-1 and CT2-2 respectively. The fill includes a surficial 0.3 m thick compact sand and gravel, that is part of the Highway 6 shoulder pavement, underlain by loose sandy silt/sand and gravel, followed by soft to firm silty clay. The silty clay fill contacted in borehole CT2-1 contained rootlets, topsoil, organic inclusions and plastic debris. SPT N values in the fill ranged from 3 to 16.

The results of grain size distribution analysis for the cohesive silty clay fill containing organics contacted in borehole CT2-1 are included in Figure CT2-GS-1. A plasticity chart of this fill sample is presented in Figure CT2-PC-1. The Atterberg liquid and plastic limits were 61 and 31 respectively, with a plasticity index of 30. The moisture content of the sample was 35%, (elevated due to the presence of organic inclusions).

The results of grain size distribution analysis for the silty clay fill contacted in borehole CT2-2 are included in Figure CT2-GS-2. A plasticity chart of the silty clay fill sample is presented in Figure CT2-PC-2. The Atterberg liquid and plastic limits were 46 and 22 respectively, with a plasticity index of 24. The moisture content of the sample was 25%.

4.1.2 Silt

Below the fill in borehole CT2-1, a localized 0.8 m thick, compact silt stratum was contacted, extending to 2.9 m, elevation 233.6. SPT N value in the silt was 16. The moisture contact of the silt sample was 20%.

4.1.3 Silty Clay/Clayey Silt

Below the localized silt stratum in borehole CT2-1 and below the fill in borehole CT2-2, a 1.1 and 1.2 m thick, stiff to very stiff silty clay stratum was contacted to 4.0 m, elevation 232.5, and 3.0 m, elevation 233.5, respectively. SPT N values in this stratum were 10 and 16. A 0.6 m thick very stiff clayey silt stratum was encountered below the silty clay in borehole CT2-2 to the 3.6 m termination depth of the borehole, elevation 232.9.

The results of grain size distribution analyses for the silty clay samples are included in Figure CT2-GS-3. A plasticity chart of the two silty clay samples is presented in Figure CT2-PC-3. The Atterberg liquid limits were 35 and 36, the plastic limit of both test samples was 20 and the plasticity indices were 15 and 16 respectively. The moisture content of the samples was 20 and 21%.

4.1.4 Silty Sand Till

A cohesionless deposit of silty sand till was encountered below the silty clay at 4.0 m, elevation 232.5 in borehole CT2-1. The unit was 1.0 m thick extending to the termination of the borehole at 5.0 m, elevation 231.5. A single SPT N value in the silty sand till was 61 blows over 180 mm indicating a very dense condition.

The moisture content determination for the recovered sample was 13%.

4.1.5 Bedrock

Bedrock was inferred by auger refusal in boreholes CT2-1 and CT2-2 at 5.0 and 3.6 m, elevation 231.5 and 232.9, respectively. Based on the regional geology, it is inferred that the bedrock comprises of dolomite.

4.1.6 Groundwater

Groundwater was contacted at 0.9 m depth, elevation 235.6, in borehole CT2-1 at the time of drilling. Groundwater was not contacted in borehole CT2-2 at the time of drilling. Groundwater was observed in boreholes CT2-1 and CT2-2 at respective depths of 2.0 and 3.4 m, elevation 234.5 and 233.1 on completion of drilling. The groundwater level is subject to seasonal fluctuations and rainfall patterns.

5. MISCELLANEOUS

Mr. Alan Lo carried out the field investigation for this study under the supervision of Mrs. N .S. Balakumaran, P. Eng. Aardvaark Drilling Ltd. supplied the drill rig for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

6. CLOSURE

This Foundation Investigation Report was prepared by Mr. H. Gharegrat, P.Eng., and reviewed by Mr. G. Degil, PhD, P.Eng., Senior Foundation Engineer. Mr. C. M. P. Nascimento, P. Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

LICENSED PROFESSIONAL ENGINEER
H. Gharegrat
100078972
Nov 21, 2012
PROVINCE OF ONTARIO

Harry Gharegrat, MS, P.Eng.
Project Engineer

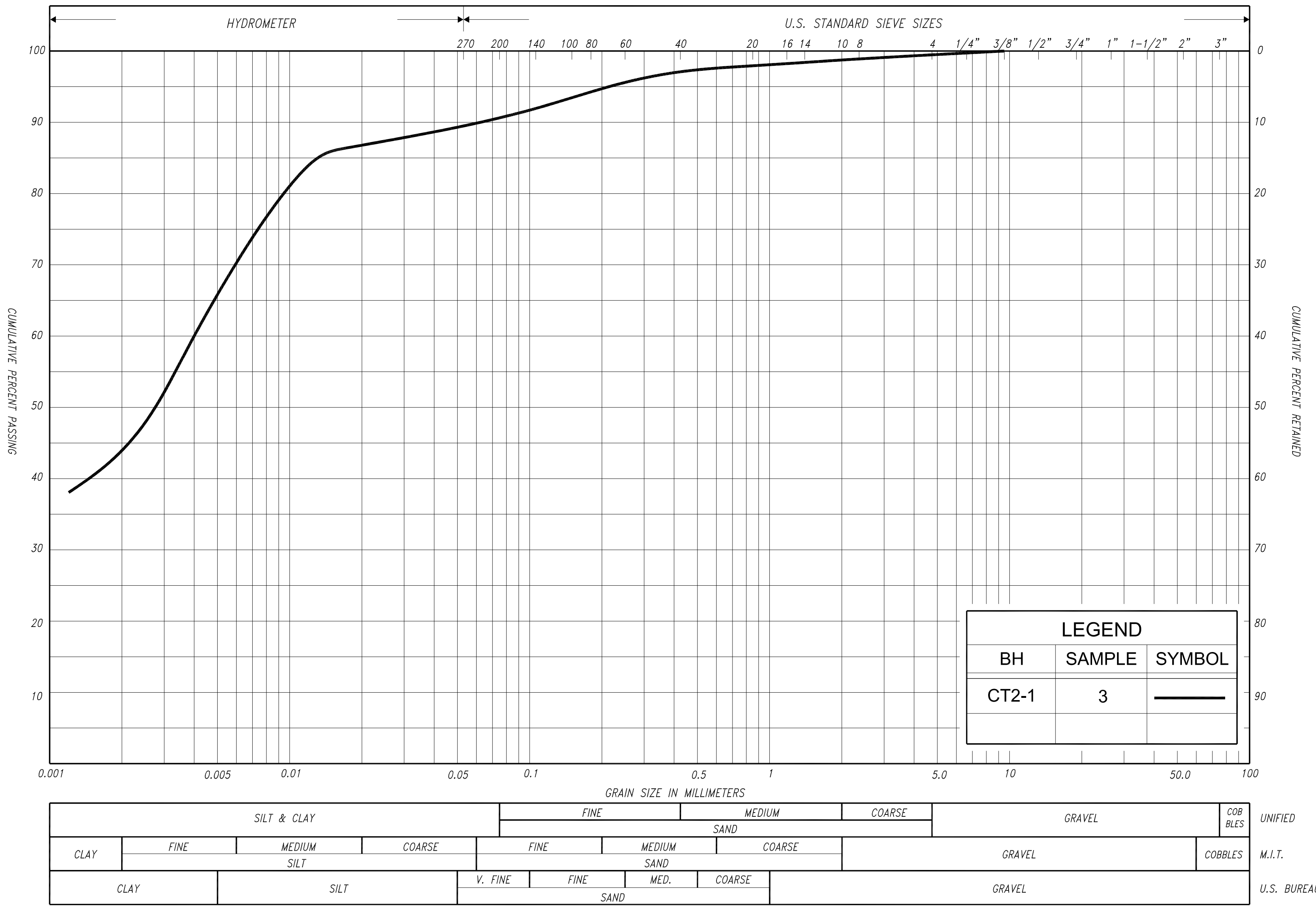
LICENSED PROFESSIONAL ENGINEER
G. DEGIL
100056241
Nov. 21/12
PROVINCE OF ONTARIO

Grigory Degil, PhD, P.Eng.
Senior Foundation Engineer

REGISTERED PROFESSIONAL ENGINEER
C M P Nascimento
Nov 21, 2012
PROVINCE OF ONTARIO

Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

HG/GD/CN:sq

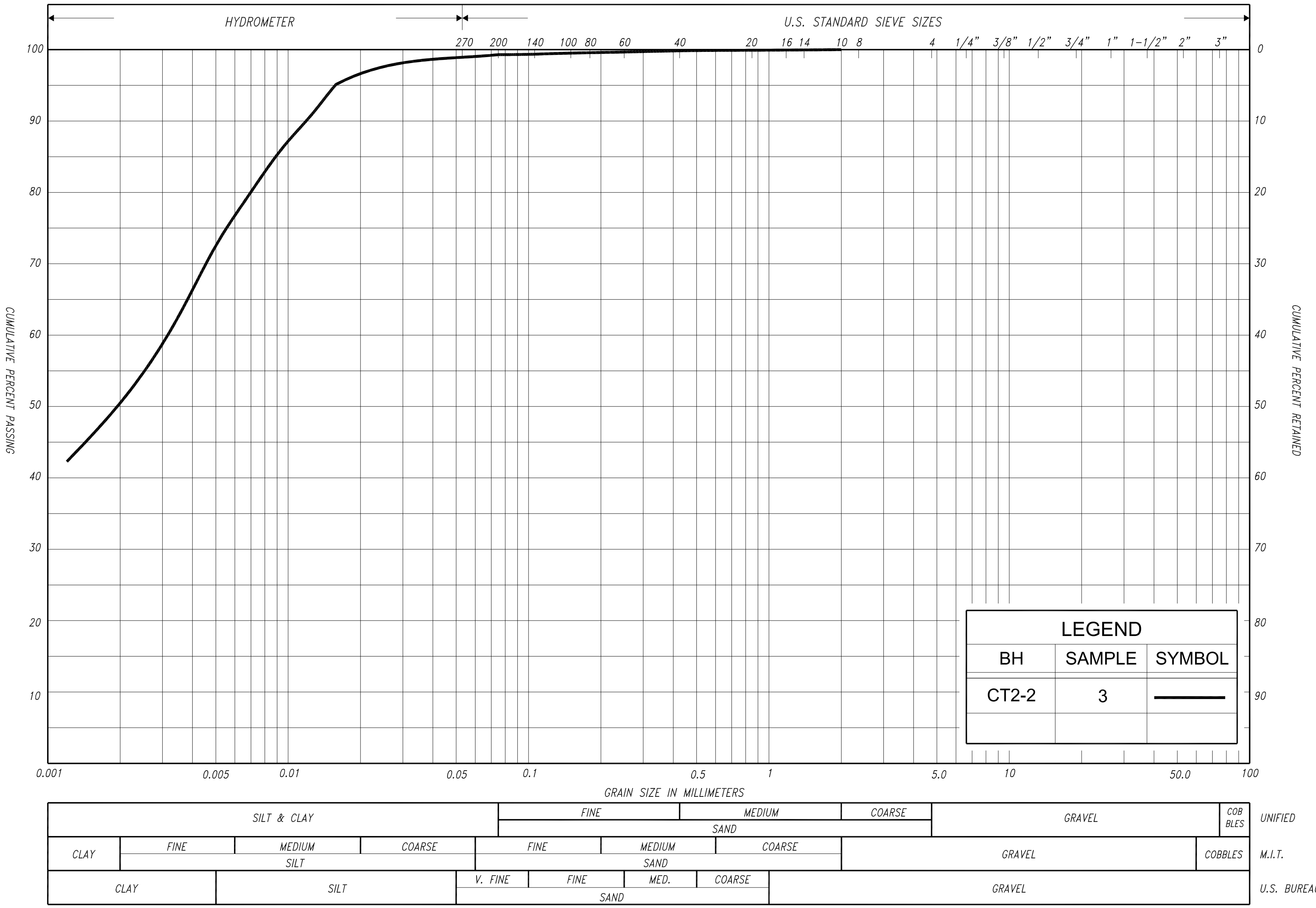


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand, trace gravel, organics (CH-OH)
(FILL)

FIG No.	CT2-GS-1
HWY:	6
G.W.P. No.	43-00-00

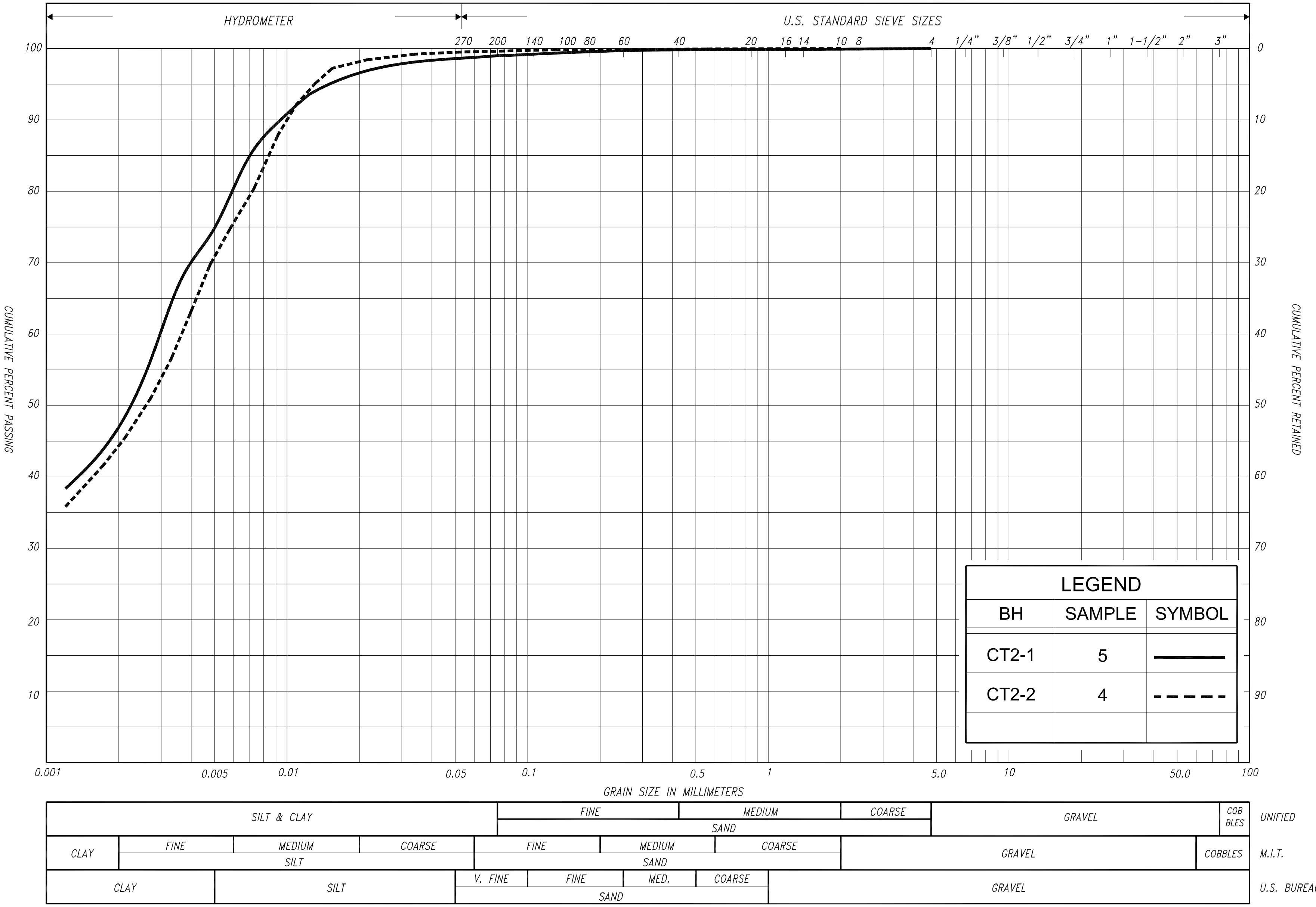


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand (CI)
(FILL)

FIG No.	CT2-GS-2
HWY:	6
G.W.P. No.	43-00-00

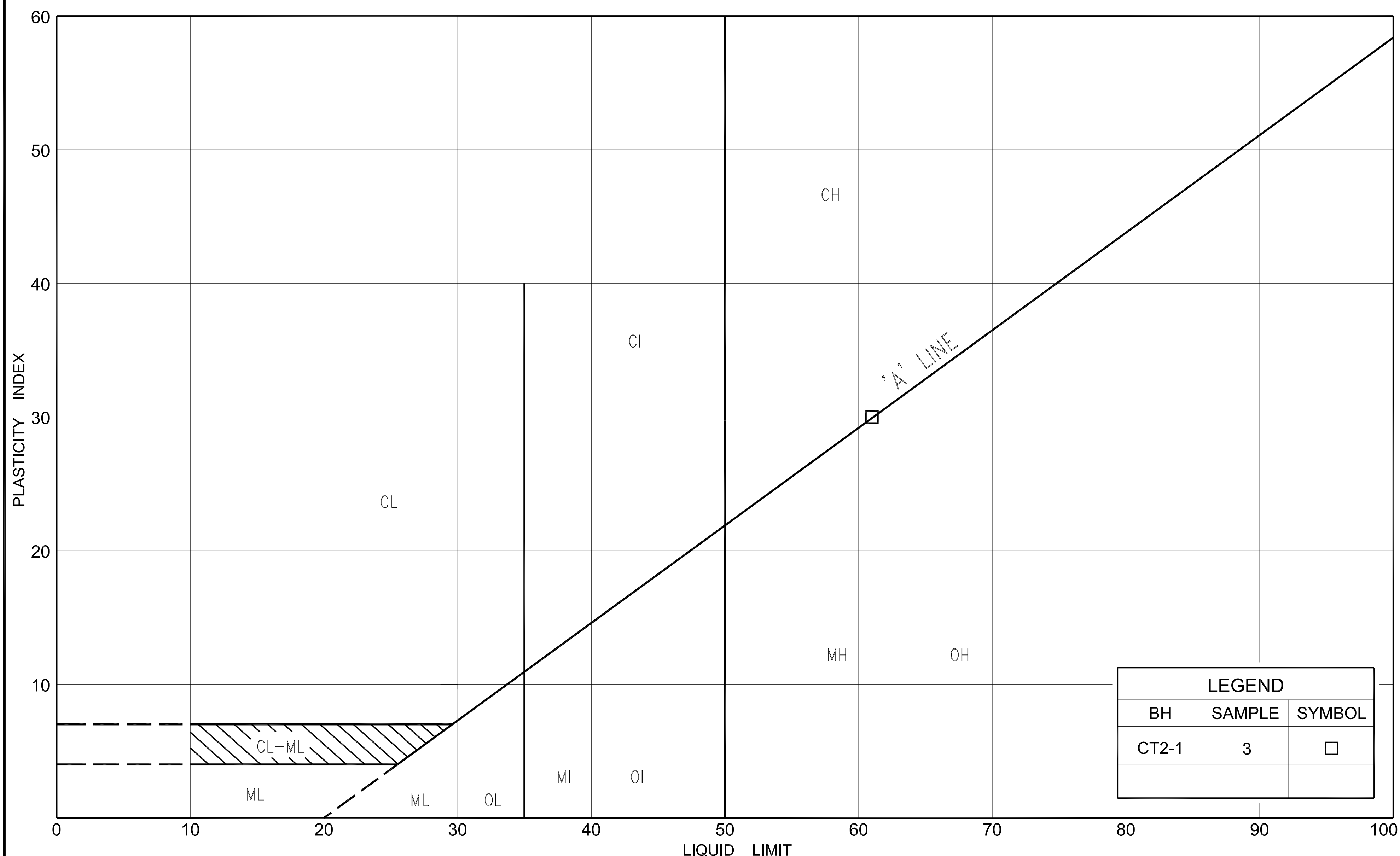


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand (CL-CI)

FIG No.	CT2-GS-3
HWY:	6
G.W.P. No.	43-00-00

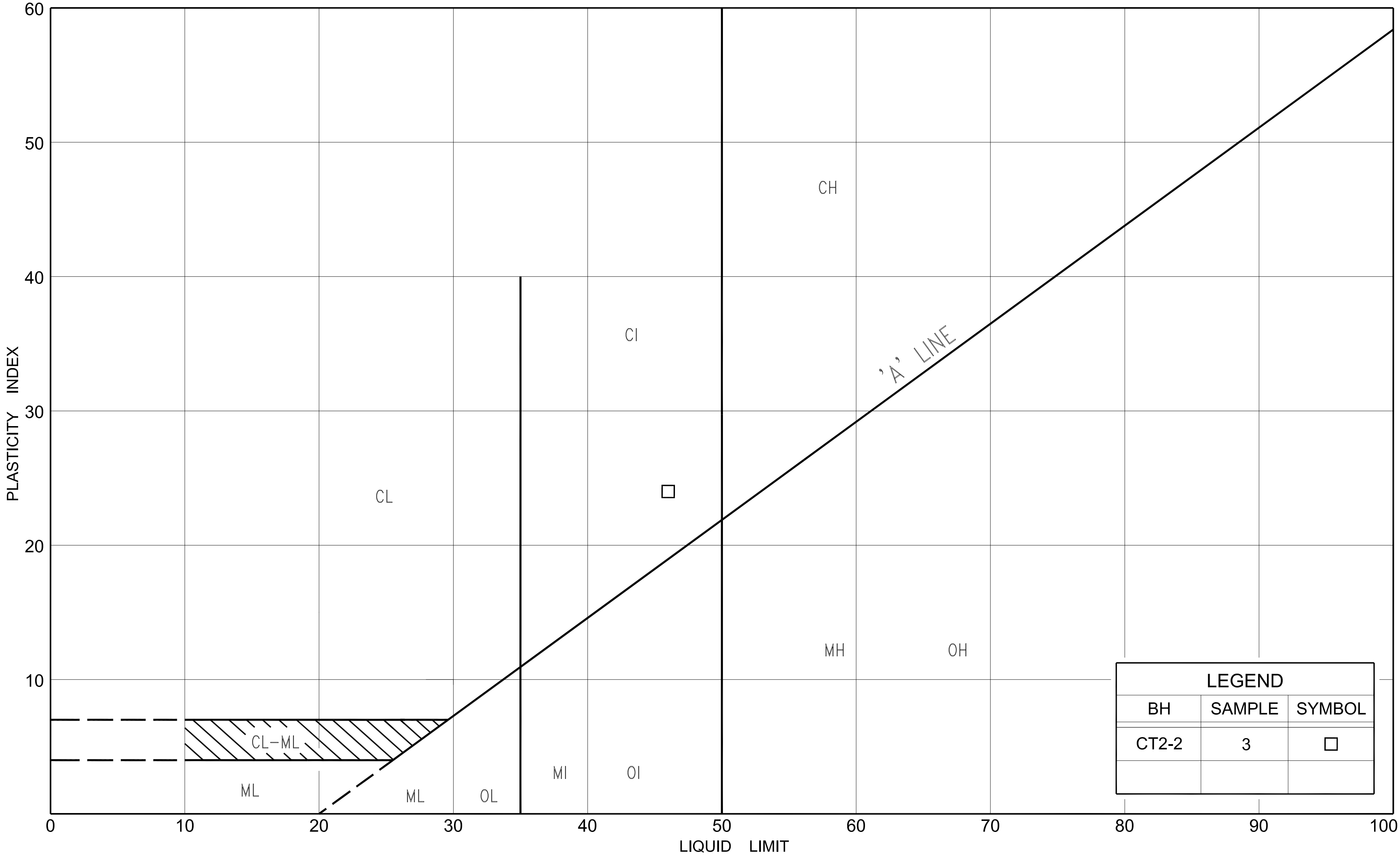


Ontario

PLASTICITY CHART

SILTY CLAY, trace sand, trace gravel, organics (CH-OH)
(FILL)

FIG No.	CT2-PC-1
HWY:	6
G.W.P. No.	43-00-00

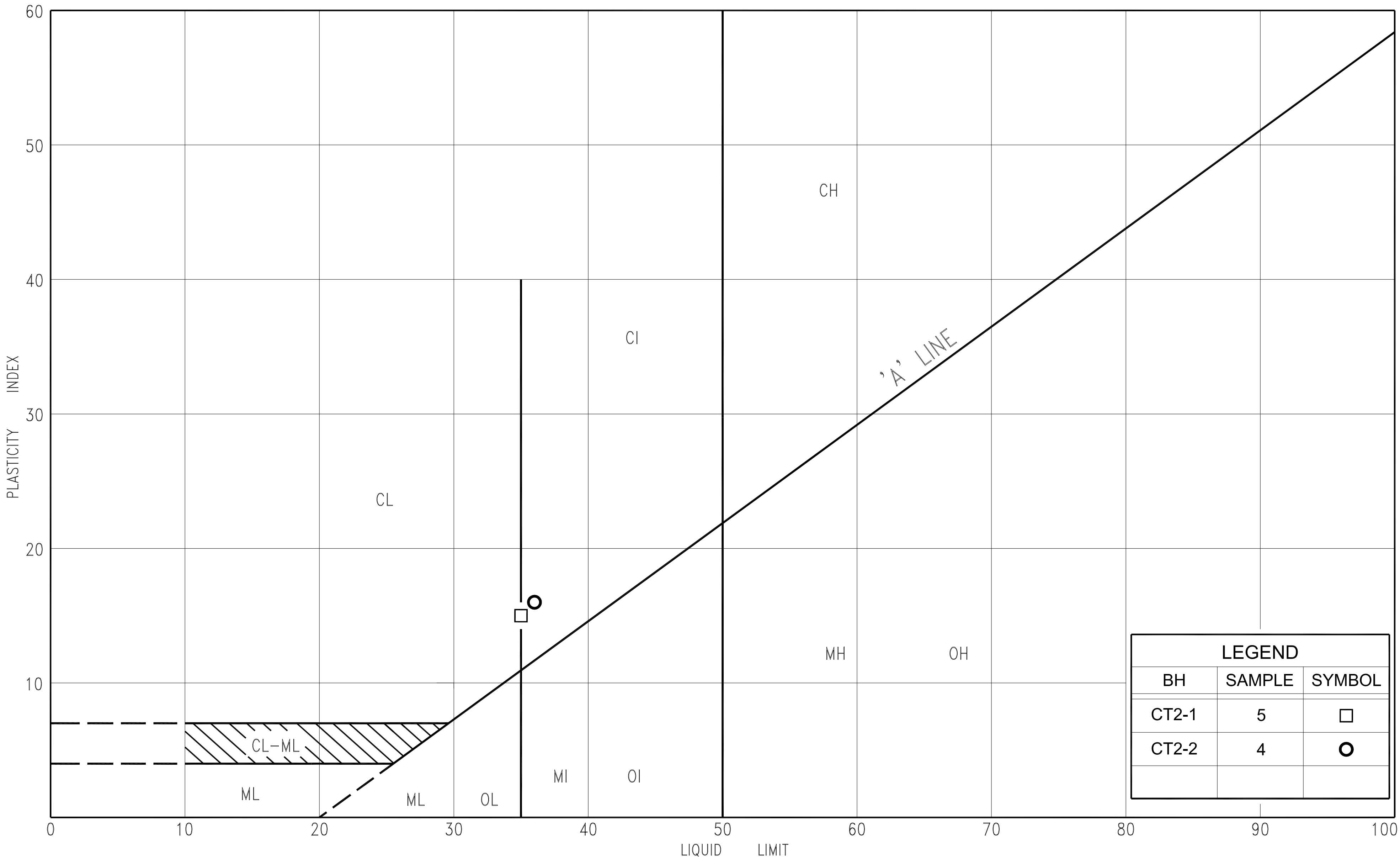


BH	SAMPLE	SYMBOL
CT2-2	3	□

PLASTICITY CHART

SILTY CLAY, trace sand (CI)
(FILL)

FIG No.	CT2-PC-2
HWY:	6
G.W.P. No.	43-00-00



LEGEND

BH	SAMPLE	SYMBOL
CT2-1	5	□
CT2-2	4	O

PLASTICITY CHART

SILTY CLAY, trace sand (CL-CI)

FIG No.	CT2-PC-3
HWY:	6
G.W.P. No.	43-00-00

EXPLANATION OF TERMS USED IN REPORT

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 63.5kg, 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 OR DENSENESS.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 – 10	10 – 20	20 – 30	30 – 40	> 40
	TRACE	*SOME*	*WITH*	*ADJECTIVE (SILTY)*	*AND (AND SILT)*

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*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3 m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	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 STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_u	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No CT2-1

METRIC

G.W.P. 43-00-00 **LOCATION** Co-ords: 4 937 284.2 N ; 424 556.0 E **ORIGINATED BY** A.L.

DIST London **HWY** 6 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** H.G.

DATUM Geodetic **DATE** January 11, 2012 **CHECKED BY** C.N.

ELEV / DEPTH	DESCRIPTION
236.5	Ground Surface
0.0	Sand and gravel Compact Brown (FILL)
236.2 / 0.3	Sandy silt, trace clay trace gravel, rootlets Loose Brown Wet Sand and gravel layer Silty clay, trace sand trace gravel, rootlets topsoil and organic inclusions, plastic debris clayey silt seams
234.4 / 2.1	Soft Dark grey moist (FILL)
	Silt, trace to some clay
233.6 / 2.9	Compact Greyish brown Moist
	Silty clay, trace sand Stiff Grey Moist
232.5 / 4.0	Silty sand, trace gravel cobbles/boulders Very dense Grey Wet (TILL)
231.5 / 5.0	End of borehole Refusal on probable bedrock

SAMPLE NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa	GR	SA	SI	CL
1	SS	16					
2	SS	8					
3	SS	3	150	1	8	47	44
4	SS	16					
5	SS	10		0	1	52	47
6	SS	61/18cm					

ELEVATION SCALE: 236, 235, 234, 233, 232

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

* 2012 01 11

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

7 , 5 × : Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No CT2-2

METRIC

G.W.P. 43-00-00 **LOCATION** Co-ords: 4 937 278.9 N ; 424 566.5 E **ORIGINATED BY** A.L.

DIST London **HWY** 6 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** H.G.

DATUM Geodetic **DATE** January 12, 2012 **CHECKED BY** C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
236.5	Ground Surface												
0.0	Sand and gravel	1	SS	14		236							
236.2 / 0.3	Compact Brown (FILL)												
	Sand and gravel trace silt, rootlets Loose Brown Moist	2	SS	7									
	Silty clay, trace sand trace gravel, rootlets	3	SS	5		235	150			0	1	49	50
234.7 / 1.8	Firm Grey moist (FILL)												
	Silty clay Very stiff Brown Moist	4	SS	16		234				0	0	56	44
233.5 / 3.0	Clayey silt Very stiff Grey Moist	5	SS	22	▼*	233							
232.9 / 3.6	End of borehole Refusal on probable bedrock												

* 2012 01 12

▼ Water level measured after drilling

■ Penetrometer test

Legend: PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; REMARKS & GRAIN SIZE DISTRIBUTION (%)

5 × Numbers refer to Sensitivity

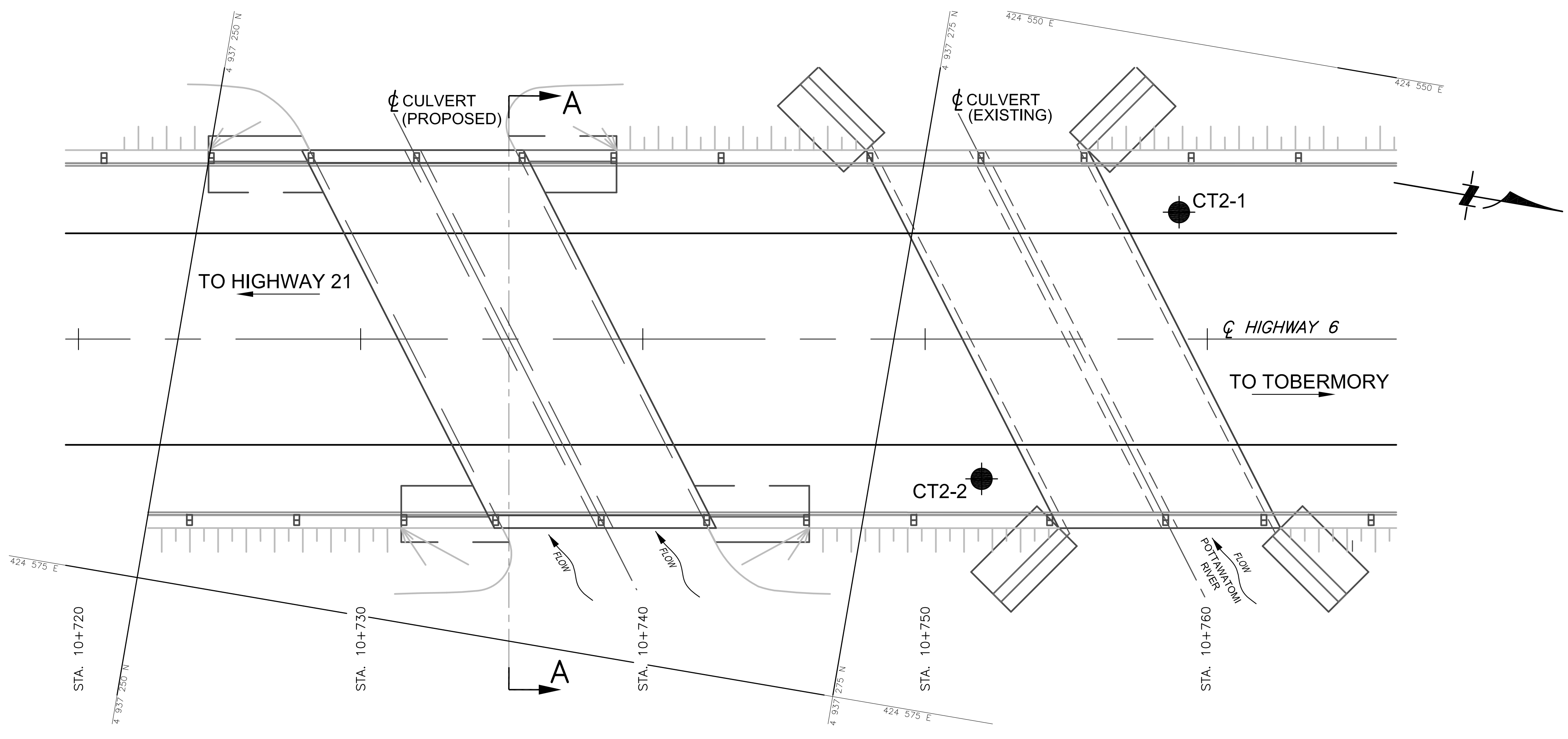
20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

CONT No
GWP No 43-00-00

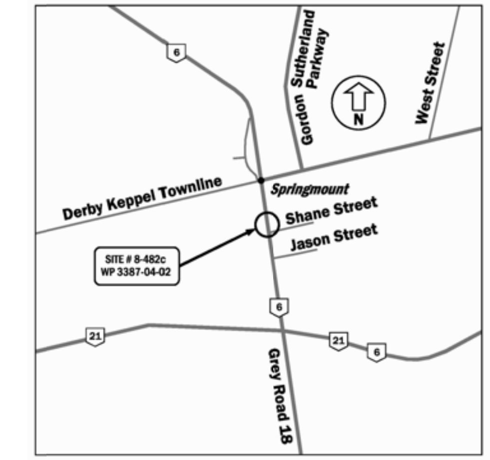
POTTAWATOMI RIVER TRIBUTARY CULVERT
HIGHWAY 6
SPRINGMOUNT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN
SCALE

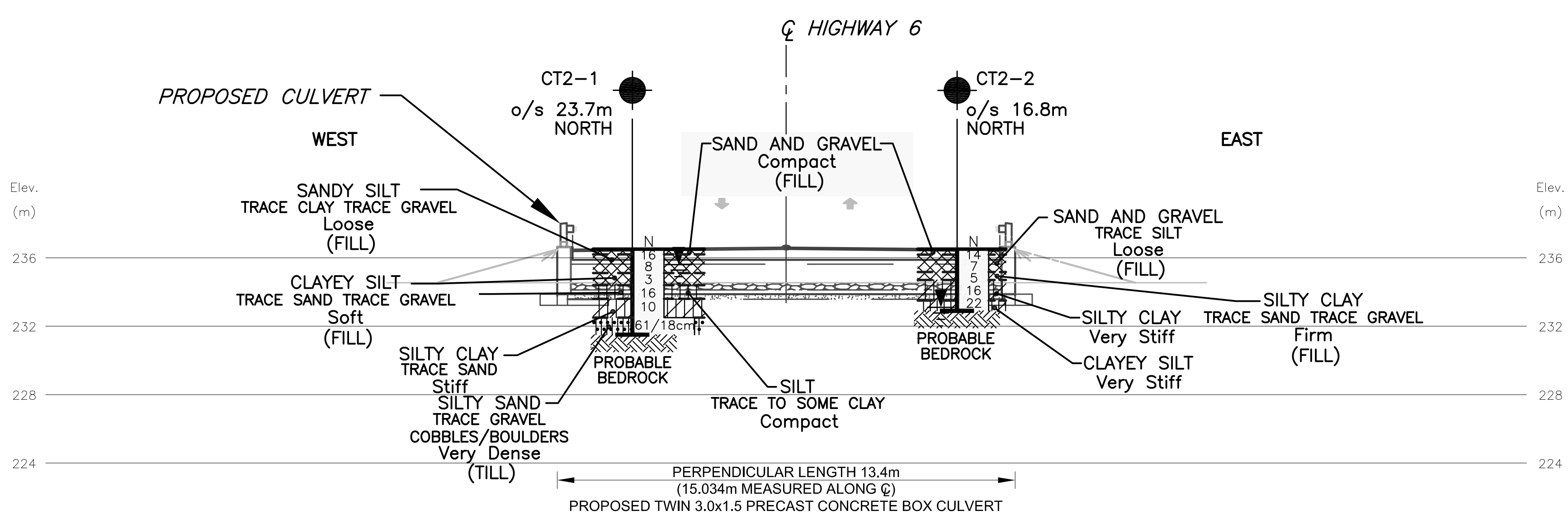


KEY PLAN
NOT TO SCALE

LEGEND

- Borehole
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation Jan. 2012
- * Water level not established
- Head ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
CT2-1	236.5	4 937 284.2	424 556.0
CT2-2	236.5	4 937 278.9	424 566.5



PROFILE A-A ALONG CULVERT ℄
SCALE
HORIZONTAL
VERTICAL

NOTES:

1. PROPOSED REPLACEMENT CULVERT LOCATION SELECTED AFTER COMPLETION OF BOREHOLE DRILLING.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
4. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

REF MRC Drawing: 3811011-340-001GA_D.dwg dated May 2012

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS | DATE | BY | DESCRIPTION

Geocres No. 41A-224

HWY No 6			DIST London
SUBM'D NA	CHECKED HG	DATE NOV. 16, 2012	SITE 8-482C
DRAWN NA	CHECKED DG	APPROVED CN	DWG PRT-2

APPENDIX A

Site Photographs

Photograph 1: Looking southeast along Highway 6 towards the culvert site. Drill rig on CT2-1. (January 11, 2012)

Photograph 2: Looking north from the east side of Highway 6 towards the existing culvert. (January 11, 2012)

Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION DESIGN REPORT
for
REPLACEMENT OF POTTAWATOMI RIVER TRIBUTARY CULVERT
SITE NO. 8-482C
HIGHWAY 6, SPRINGMOUNT
G.W.P. 43-00-00
DISTRICT OF LONDON, ONTARIO

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:
3 cc: McCormick Rankin (MRC) for distribution to MTO, Project Manager – West Region (London) + 1 digital copy (pdf)
3 cc: Foundation Investigation Report only to MRC for distribution to MTO, Project Manager – West Region (London) + 1 digital copy (pdf)
1 cc: MRC for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf) and Drawing (AutoCAD)
1 cc: Foundation Investigation Report only to MRC for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf) and Drawing (AutoCAD)
2 cc: MRC + 1 digital copy (pdf)
1 cc: PML Toronto
1 cc: PML Kitchener

PML Ref.: 11KF065A
Index No. 108FDR
GEOCRES No. 41A - 224
November 21, 2012

TABLE OF CONTENTS

FOUNDATION DESIGN REPORT
for
Replacement of Pottawatomi River Tributary Culvert
Site No. 8-482C
Highway 6, Springmount
GWP 43-00-00
District of London, Ontario

1. INTRODUCTION

As part of the rehabilitation of Highway 6, from Springmount to Hepworth, the existing Pottawatomi River Tributary twin culvert near Station 10+755 on Highway 6 will be replaced at a location approximately 20 m south of the existing culvert. This report was prepared for McCormick Rankin (MRC), a member of MMM Group Ltd., on behalf of the Ministry of Transportation of Ontario (MTO).

This report provides foundation engineering comments and recommendations for design and construction of the new Pottawatomi River Tributary twin culvert at Station 10+735 on Highway 6, and temporary roadway protection, which will be required for the staged construction.

The existing culvert is located under the Highway 6 northbound and southbound lanes, about 750 m north of the intersection of Highway 6 and Highway 21, in the Town of Springmount. According to the MRC draft GA drawing dated May 2012, the new culvert will be a twin 3.0 by 1.5 m precast concrete box culvert with a total length of 15.0 m measured along the culvert centre-line. The precast box units will be installed using full road closure. The retaining walls at the four corners will be constructed using temporary roadway protection while maintaining two lanes of traffic.

In summary, the subsurface stratigraphy revealed in the boreholes drilled along the alignment of the existing culvert generally comprised a road embankment fill underlain by native silt, silty clay/clayey silt and silty sand till. Bedrock was inferred by auger refusal at depths of 5.0 and 3.6 m, elevation 231.5 and 232.9, respectively. The bedrock surface slopes upwards from west to east with a change in elevation of about 1.4 m in 11.5 m which corresponds to approximate 8.2H: 1V slope or 7°. Groundwater was observed in boreholes CT2-1 and CT2-2 at respective depths of 2.0 and 3.4 m, elevation 234.5 and 233.1 on completion of drilling. It is inferred that the subsurface conditions at the new culvert are consistent with those at the existing culvert located 20 m to the north. However, subsurface conditions, specifically the bedrock depth, at the new culvert location may vary from those encountered in the boreholes advanced at the existing culvert.

The foundation frost penetration depth at the site is 1.4 m according to OPSD 3090.101.

It is understood that a precast concrete box culvert is proposed at the new culvert location to achieve the culvert replacement in the planned five-day road closure window. Therefore, the recommendations for a cast-in-place culvert and a discussion of the advantages and disadvantages of the two culvert options are not included in this report. Although the GA drawing indicates that a precast box culvert is planned at the site, MRC has requested recommendations for both open footings and closed box options.

Since the new culvert site has been preloaded by the existing embankment negligible settlements are anticipated under the new culvert.

Recommendations for the proposed cast-in-place retaining wall footings are provided in the report as well as for the roadway protection.

It is noted that no responsibility or liability is assumed by the consultants or MTO for alerting the contractor to critical construction issues. The requirement to deliver acceptable construction quality remains the responsibility of the contractor.

A list of the standard specifications referenced in this report is compiled in Table 1. All elevations in this report are expressed in metres.

2. POTTAWATOMI RIVER TRIBUTARY CULVERT (NEW)

2.1 Foundations

The invert level of the new precast concrete twin box culvert, is specified to be near elevation 234.1 at the inlet with a 0.2% grade down to the outlet. The subgrade level for a concrete box culvert is interpreted to be about 0.6 m below the proposed invert levels at elevation 233.5 allowing for the thickness of concrete base of the culvert and for the 300 mm Granular A bedding thickness. If the culvert is supported on open footings a founding elevation of 233.2 is assumed. The proposed road grade at the new culvert will be about elevation 236.3.

The footing subgrade level for the cast-in-place wing walls and headwalls of the proposed culvert are estimated at elevation 233.2.

Based on the inferred subsurface conditions, it is considered that the precast box culvert can be supported on its base or on open footings and the wing wall and the headwalls on spread footings. Recommendations for both foundation conditions are provided in the following sections.

2.1.1 Precast Box Culverts

The soils revealed in the boreholes at the twin culvert subgrade elevation (elevation 233.5) is inferred to consist of native stiff silty clay over very dense silty sand within borehole CT2-1 and very stiff clayey silt within borehole CT2-2.

The recommended factored geotechnical bearing resistance at ULS and geotechnical reaction at SLS for the twin 3.0 m wide precast concrete box culvert constructed on 300 mm thick Granular A or Granular B Type II bedding placed over the stiff silty clay and very stiff clayey silt are as follows:

CULVERT SECTION	SUBGRADE SOIL TYPE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL REACTION AT SLS (kPa)
Entire Length	Very stiff clayey silt or stiff silty clay	180	120

The geotechnical reaction at SLS normally allows for 25 mm compression of the founding medium. Since the new culvert site has been preloaded by the existing embankment negligible settlements are anticipated under the proposed culvert and the uniform recommended resistance and reaction values may be used for design.

2.1.2 Spread Footings (Open Footing Culvert and Head Wall/Wing Wall)

The subgrade soils revealed in the boreholes below the possible open footing culvert, retaining/wing wall and headwall footing anticipated subgrade level (elevation 233.2) comprised stiff silty clay overlying very dense silty sand and assumed bedrock at the west end (borehole CT2-1) and very stiff clayey silt overlying assumed bedrock at the east end (borehole CT2-2).

The recommended factored geotechnical resistance at ULS and geotechnical reaction at SLS for the possible open footing culvert and for the headwalls and retaining/wing walls constructed on footings placed on very stiff clayey silt or stiff silty clay is as follows:

HEADWALLS AND WING WALLS	FOUNDING SOIL TYPE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL REACTION AT SLS (kPa)
West End	Stiff silty clay	180	120
East End	Very stiff clayey silt	270	180
<u>Culvert Section</u> Entire Length	Very stiff clayey silt or stiff silty clay	180	120

The geotechnical reaction at SLS normally allows for 25 mm compression of the founding medium. Since the new culvert site has been preloaded by the existing embankment, negligible settlements are anticipated under the proposed headwalls and wing walls.

2.2 General Comments

2.2.1 Subgrade Preparation

Preparation of the subgrade for construction of the twin culverts, headwalls and retaining/wing walls should be performed and monitored in accordance with OPSS 902. A site review should be conducted by qualified geotechnical personnel during preparation of the subgrade and compaction of the granular fill.

A 300 mm thick granular bedding is recommended below the twin box culverts. The bedding material should comprise Granular A, satisfying the specifications within OPSS 1010, compacted to 95% of the ASTM D-698 (standard Proctor) maximum dry density in conformance to OPSS 501 (Method A).

The geometry of the subgrade preparation, cover backfill and frost taper treatment for the precast concrete box culverts should be carried out in accordance with MTOD 803.21, OPSS 422 and MTO SP 422S01.

Granular B Type II fill should be preferred for construction under wet conditions.

2.2.2 Modulus of Subgrade Reaction

The estimated recommended value of the modulus of subgrade reaction for the box culvert constructed on undisturbed subgrade native soils is as follows:

SOIL TYPE	MODULUS OF SUBGRADE REACTION, MN/m^3
Very stiff clayey silt or stiff silty clay	30

For culverts placed on very dense silty sand or bedrock, the minimum slab thickness will govern.

2.2.3 Sliding Resistance

The following parameters should be used to compute sliding resistance of precast box culvert and cast-in-place headwall and wing wall foundations. The friction angles have been reduced by a factor of 0.67 for precast box culvert foundations to account for the smooth concrete base.

SOIL TYPE	FOUNDATION FRICTION ANGLE, DEGREES		COHESION, kPa	UNIT WEIGHT, kN/m^3
	CAST-IN-PLACE	PRECAST		
Granular A or Granular B Type II	35	23	0	22.8
Stiff Silty Clay	15	10	75	20.0
Very Stiff Clayey Silt	15	10	150	20.0
Very Dense Silty Sand Till	40	27	0	21.5

The structural designer should use a factor of 0.8 for the friction angle and cohesion values when performing the sliding resistance check.

2.2.4 Seismic Site Coefficient

The seismic site coefficient for the conditions at the subject site is 1.0 – Type I soil profile as per clause 4.4.6 of the CHBDC.

3. CULVERT AND RETAINING WALL BACKFILL

Backfill adjacent to the twin culverts should be placed in accordance with OPSS 422 and MTO SP 422S01 while backfill adjacent to headwalls and wing walls should be placed in accordance with OPSD 3121.150. Requirement for frost taper is provided in the Pavement Design Report.

Backfill should be brought up simultaneously on each side of the culvert and operation of heavy equipment within 0.5 times the height of the culvert (each side) should be restricted to minimise the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction. Refer to OPSS 501 for additional comments.

The new culvert must be designed to support the stress imposed by the overlying fill as well as to resist the unbalanced lateral earth pressure and compaction pressure exerted by the backfill adjacent to the culvert walls.

The lateral earth and water pressure, p (kPa), should be computed using the equivalent fluid pressures presented in Section 6.9 of the Canadian Highway Bridge Design Code (CHBDC) or employing the following equation assuming a triangular pressure distribution.

$$p = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p + C_s$$

where p = lateral earth pressure (kPa)
K = lateral earth pressure coefficient
γ = unit weight of backfill material above design water level (kN/m^3)
γ' = unit weight of submerged backfill material below design water level (kN/m^3)
= $\gamma - \gamma_w$
γ_w = unit weight of water
= 9.8 kN/m^3
h_1 = depth below final grade (m), above design water level
h_2 = depth below design water level (m)
q = any surcharge load (kPa)
C_p = compaction pressure (refer to clause 6.9.3 of CHBDC)
C_s = earth pressure induced by seismic events, kPa (refer to clause 4.6.4 of CHBDC)
where Ø = angle of internal friction of retained soil (35º for Granular A or B Type II)
δ = angle of friction between soil and wall (23.5º for Granular A or B Type II)

The seismic site coefficient for the conditions at this site was provided in Section 2.2.4.

The following parameters are recommended for estimating the earth pressure for granular backfill:

PARAMETER	GRANULAR A OR GRANULAR B TYPE II
Angle of Internal Friction, degrees	35
Unit Weight, kN/m^3	22.8
Coefficient of Active Earth Pressure (K_a)	0.27
Coefficient of Earth Pressure At Rest (K_o)	0.43
Coefficient of Passive Earth Pressure (K_p)	3.69

The design should consider both the maximum water level in the stream and the stabilised groundwater level condition. The maximum stream water level will be dictated by flood flow conditions and should be defined by the project hydrological engineer.

The coefficient of earth pressure at rest should be employed to design rigid and unyielding walls.

4. HEADWALLS AND RETAINING/WING WALLS

For headwalls and retaining/wing walls design, the previous recommendations and geotechnical parameters for foundations and backfill should be utilized. The wall founding levels should match those of the respective culverts where the walls are designed integral with the culvert structures. For walls designed separately from the culvert structure, the founding levels should be established with 1.4 m of earth cover for adequate frost protection.

The design of the walls should be checked for sliding resistance using the geotechnical parameters provided previously in Section 2.2.3 for cast-in-place concrete foundations.

A weeping tile system and/or weep holes should be installed to minimise the build-up of hydrostatic pressure behind the walls. The weeping tiles should be surrounded by a properly designed granular filter or non-woven Class II geotextile (with an FOS of 75-150 µm according to OPSS 1860) placed to prevent migration of fines into the system.

5. CONSTRUCTION CONSIDERATIONS

5.1 Staged Construction

MRC is proposing a five day road closure to install the precast box culverts and remove the existing culverts. Following this, the cast-in-place concrete retaining walls would be constructed using roadway protection at all four corners while maintaining two lanes of traffic.

It is recommended that a suitable roadway protection scheme following OPSS 539 be implemented to support the walls of the excavations and adjacent traffic lanes during staged construction.

5.2 Roadway Protection

Roadway protection will be required at all four corners for constructing the retaining walls.

The removal of the existing culvert will not require a roadway protection system since the highway will be closed to traffic. It should be noted that 1.4 m of earth cover on the remaining concrete should be provided for adequate frost protection after partial removal of the existing culvert.

A roadway protection system designed for performance level 2 according to OPSS 539 is recommended to prevent excessive lateral and/or vertical movement of the existing embankment during construction. The contractor is responsible for the selection, performance and detailed design of the roadway protection scheme. The contractor should monitor the movement of the roadway protection system. To meet the performance Level 2, the maximum lateral displacement is limited to 25 mm with a maximum allowable angular distortion of 1:200.

In case excessive movement is experienced in the roadway protection system, a monitoring system should be implemented to check the horizontal and vertical displacements of the roadway surface during construction of the retaining walls. A maximum of 12 mm of settlement should be allowed on the travelled highway section.

Alternative roadway protection schemes such as sheet piling or anchored soldier piles and lagging were considered. Typically, sheet piling can be used to reduce loss of native soils below the water table. Soldier piles and lagging are generally considered suitable for applications above groundwater table in cohesionless soils.

The following table presents an overview assessment of the advantages and disadvantages, including relative costs and risk/consequences of the roadway protection system alternatives from the foundation perspectives at the subject site.

ALTERNATIVES	ADVANTAGES	DISADVANTAGES
Sheet piles	• Sheet piles will be interlocked therefore loss of native soils will be negligible • Suitable for high water table • Suitable to drive for varying bedrock profile, if required • Low risk of soil loss	• Higher cost than for soldier piles • May require soil anchors/rakers for lateral support • Larger construction equipment is required than for soldier piles and lagging
Soldier piles and lagging	• Lower cost than for sheet piles • Smaller construction equipment is required than for sheet piles	• Excessive settlement may occur due to loss of cohesionless soils with high water table • Unsuitable with high water table • High risk of soil loss

Based on the above table, the relatively low excavation depth of about 3.0 m and the presence of mostly cohesive soils and fill materials an anchored or braced soldier pile and lagging system is considered feasible and is recommended at the site. The presence of debris in the fill and cobbles and boulders in the native soils must be considered during installation of soldier piles.

5.3 Excavation

Excavation to the anticipated founding level of the new culvert is expected to extend through the granular and cohesive embankment fill and native silt, silty clay and clayey silt. Subject to adequate groundwater control, excavation of the soils should be feasible using conventional equipment. All excavations should be conducted in accordance with OPSS 902.

According to OHSA criteria, the soft clayey silt fill should be considered Type 4 soil and the firm silty clay fill soils, the compact sand and gravel fill, compact silt, stiff to very stiff silty clay and very stiff clayey silt are considered as Type 3 soils if proper dewatering measures are implemented. Since open cut procedures are governed by soils with the highest soil type number, temporary cut slopes over the full depth of excavation inclined at 3 horizontal to 1 vertical should be provided assuming adequate drainage measures are in place.

5.4 Groundwater Control

Groundwater was observed at 2.0 and 3.4 m depth, elevation 234.5 and 233.1 in the boreholes on completion of drilling. These levels are at or immediately above the culvert and retaining wall founding elevations.

It is anticipated that conventional procedures such as dam and pump will be sufficient to dewater the foundation excavation for the retaining walls construction and to backfill the excavation for the removal of the existing culvert. These measures will likely be inadequate during the relatively wetter remainder of the year and additional groundwater control from sumps may be required. The contractor should be made responsible for the design and operation of the dewatering system.

6. EROSION CONTROL

The protective measures noted in the OPSD 800 series to deal with erosion (inlet/outlet treatment, headwalls, cut-off walls etc.) are considered to be appropriate. The backfill should comprise OPSS Granular A or Granular B Type II. The cut-off walls should extend laterally to protect the granular backfill material and to a depth at least equal to the fluctuation of the water level at the culvert location to prevent flow below the culvert that could erode the granular base/bedding material. The requirements of CHBDC clauses 1.9.5.6 and 1.9.11.6.5 should be applied.

Inlet and outlet protection in accordance with OPSS 511 and 1004 and OPSD 810.010 is recommended to prevent erosion adjacent to the culvert as well as scour that could undermine the culvert foundation. The actual design requirements concerning the length and width of aprons at the inlet/outlet of the culvert as well as the rock size, apron thickness, height of erosion protection on the embankment slope and type of material (clay seals at the inlet, drainage and/or filter blankets at the outlet) will be dictated by stream hydraulics, stream configuration, the water level in the stream and should be established by a hydraulic engineer. A non-woven Class II geotextile with an FOS of 75-150 μm according to OPSS 1860 should be placed below the rip-rap to minimize the potential for erosion of fine particles from below the treatment.

Any newly constructed embankment slopes and retained soils behind the headwalls and wing walls should be covered with topsoil or suitable excess earth material and seeded in accordance with OPSS 802 and 804, as soon after grading as possible to prevent erosion. Where slopes are inclined at 2.5H: 1V or steeper, the permanent slopes should be protected with erosion control blankets. Also, sod (as per OPSS 803) shall be placed where slopes are steeper than 3H:1V. Additional appropriate erosion control measures for the project should be assessed using the following erodibility K factor.

SOIL TYPE	K FACTOR
Sand and gravel fill	0.18
Silty Clay (fill or native)	0.38
Clayey Silt fill with organics	0.2
Silt	0.6
Silty Sand Till	0.5

7. CLOSURE

This Foundation Design Report was prepared by Mr. H. Gharegrat, P. Eng., and reviewed by Mr. G. Degil, PhD, P.Eng., Senior Foundation Engineer. Mr. C. M. P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

LICENSED PROFESSIONAL ENGINEER
H. Gharegrat
100078972
Nov 21, 2012
PROVINCE OF ONTARIO

Harry Gharegrat, MS, P.Eng.
Project Engineer

LICENSED PROFESSIONAL ENGINEER
G. DEGIL
100056241
Nov. 21/12
PROVINCE OF ONTARIO

Grigory Degil, PhD, P.Eng.
Foundation Engineer

REGISTERED PROFESSIONAL ENGINEER
C M P Nascimento
Nov 21, 2012
PROVINCE OF ONTARIO

Carlos M.P. Nascimento, P.Eng.
Project Manager and
MTO Designated Principal Contact

HG/GD/CN:sq

TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS 803	Construction Specification for Sodding
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS 1004	Material Specification for Aggregates - Miscellaneous
OPSS 1010	Material Specification for Aggregates, Base, Subbase, Select Subgrade and Backfill Material
OPSS 1860	Material Specification for Geotextiles
SP 422S01	Construction Specification for Precast Concrete Box Culvert
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Depth for Southern Ontario
OPSD 3121.150	Minimum Granular Backfill Requirements - Walls Retaining
MTOD 803.21	Bedding and Backfill for Precast Concrete Box Culverts