Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION INVESTIGATION AND DESIGN REPORT
for
MCGILLVRAY CREEK TRIBUTARY CULVERT WEST EXTENSION
HIGHWAY 11 SOUTHBOUND LANES STATION 21+938
SITE NO. 44-366/C2
TOWNSHIP OF SOUTH HIMSWORTH
NORTH BAY AREA, ONTARIO
G.W.P. 323-00-00

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PML Ref.: 10TF013A-C2
Index No.: 360FIR and 361FDR
GEOCRES No.: 31L-172
April 29, 2013

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for
McGillvray Creek Tributary Culvert West Extension
Highway 11 Southbound Lanes Station 21+938
Site No. 44-366/C2
Township of South Himsworth
North Bay Area, Ontario
GWP 323-00-00

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the proposed west extension of the existing McGillvray Creek Tributary culvert located on the Highway 11 Southbound Lanes (SBL). This culvert extension is part of the proposed new south entrance to Powassan project that extends from 5.7 km south of the Highway 534 northerly 5.0 km. The study was carried out by Peto MacCallum Ltd. (PML) for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

The existing culvert is at approximate Station 21+938, Highway 11 SBL chainage, in the Township of South Himsworth. A culvert west extension has been planned (refer to General Arrangement Drawing 'Highway 11 SBL Culvert West Extension at Sta. 21+938.272 ' prepared by AECOM dated December 2010).

A previous Foundation Investigation Report dated February 1993 for the existing culvert was obtained from the MTO library (GEOCRES No. 31L-59). A copy of the previous Report with the borehole logs and Foundation Drawing is enclosed in Appendix A for reference. The results were utilized in this report.

The purpose of this report was to summarize the subsurface stratigraphy encountered in the foundation investigation at the proposed west extension of the culvert.

2. SITE DESCRIPTION AND GEOLOGY

The contemplated extension culvert is located on the existing Highway 11 SBL about 75 m south of the existing Highway 11 SBL / Purdon Line intersection. The site is about 34 km south of the City of North Bay in the Geographic Township of South Himsworth.

Land use in the vicinity of the site includes the existing Highway 11 transportation corridor and farming activities east and west of the highway and scattered residential houses east of the Highway 11 NBL. The local topography of the culvert site is generally flat and sloping to the west.

The existing Highway 11 SBL embankment is about 8 to 9 m high at the culvert location. The McGillvray Creek Tributary flows in an east to west direction through a 3.0 × 3.0 × 56 m concrete box culvert under the Highway 11 SBL. The ground cover includes grasses and bushes near the creek area and scattered stands of trees.

The project site is located within the physiographic region known as the Number 11 Strip. The soil cover at the project site is from sandy glaciolacustrine plain deposits which overlies a Precambrian age monzonitic (granitic) rock formation.

3. INVESTIGATION PROCEDURES

The subsurface investigation comprised of one borehole (CS-1) that was carried out on December 19, 2011. The borehole was drilled to 4.6 m at the location shown on Drawing S-1, appended. A dynamic cone penetration test was conducted about 1.5 m west of borehole CS-1 to 4.3 m and the data was compiled in Record of Borehole CS-1.

The culvert control points were staked in the field by exp Geomatics according to the GA Drawing dated December 2010 prepared by AECOM. The position of the borehole relative to the culvert control point was selected by PML allowing for drill rig accessibility over the steep ground surface.

The ground surface elevation at the borehole location was established by PML using the ground surface elevation at a control point. All elevations in this report are expressed in metres.

The boreholes were advanced using continuous flight hollow stem augers through the soil cover with a track-mounted D-120 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 intervals of depth 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 borehole 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 hole.

The borehole was backfilled with a bentonite/cement mixture where required in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment.

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 (6)
- Atterberg Limits (1)
- Grain size distribution analyses (2)

The laboratory grain size distribution charts are presented in Figures CS-GS-1 and CS-GS-2 and Atterberg Limits results are presented in Figure CS-PC-1. All of the test results are summarized on the Record of Borehole sheets.

4. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended current and previous Record of Borehole Sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test results and groundwater observations. The results of laboratory grain size distributions, Atterberg Limits and moisture content determinations are also shown on the Record of Borehole Sheets.

The current and previous borehole locations, stratigraphic profile and cross-sections prepared from the borehole data are shown on Drawing S-1. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.

One borehole (CS-1) and a dynamic cone test were carried at the proposed west extension of culvert to 4.6 and 4.3 m, respectively. The subsurface stratigraphy revealed in the borehole generally comprised of fill underlain by cohesionless deposits of sandy silt over sand. Probable bedrock was inferred by auger refusal in borehole CS-1 at 4.6 m (elevation 255.6).

The current investigation results were consistent with the previous investigation. The inferred probable bedrock was at elevation 255.7 in previous investigation borehole 4 which was within the close proximity of the proposed west extension of the culvert and was cored in borehole 2 from elevation 253.8 to 251.5.

Groundwater was observed and measured in current and previous investigation at about elevation 258.0 to 258.1 at the west extension of the culvert.

4.1 Fill

A 0.3 m thick fill unit was encountered at the surface in borehole CS-1. The fill was cohesive clayey silt extending to 0.3 m (elevation 259.9). A composite N value of 3 was obtained indicating soft consistency. The moisture content determination on one sample was about 30%.

4.2 Sandy Silt

A cohesionless sandy silt was encountered below the fill layer at 0.3 m (elevation 259.9) in boreholes CS-1. The deposit was 1.9 m thick extending to sand at 2.2 m (elevation 258.0). N values ranged from 3 to 8 indicating very loose to loose relative density.

The results of grain size distribution analysis for a sandy silt sample are included in Figures CS-GS-1. The plasticity chart is presented in Figure CS-PC-1. The liquid and plastic limits of the silt sample were 19 and 17, respectively with the corresponding plasticity index value of 2. The moisture content determinations were 17 and 25%.

4.3 Sand

A cohesionless sand deposit was encountered below the sandy silt at 2.2 m (elevation 258.0). The unit was 2.4 m thick extending to the underlying probable bedrock at 4.6 m (elevation 255.6). N values ranged from 2 to 18. The stratum was found to have a very loose to compact relative density.

The results of grain size distribution analysis for a sand sample are included in Figure CS-GS-2. The moisture content determinations ranged from 19 to 25%.

4.4 Bedrock

Probable bedrock was inferred by auger refusal at 4.6 m (elevation 255.6) and by dynamic cone test refusal at 4.3 m (elevation 255.9). The previous borehole 2 indicated that granitic bedrock formation exists at the site based on a 2.3 m long core sample. In this previous borehole the bedrock was found at elevation 253.8. Probable bedrock was found at elevation 255.7 in the previous borehole 4, drilled south of the creek. It should be noted that variations in the bedrock level may occur between boreholes and should be considered+ in the design and construction.

4.5 Groundwater

During augering, groundwater was observed at 2.1 m (elevation 258.1). The groundwater was measured in previous investigation boreholes 1, 2 and 4 at about elevation 258.0 in February 1993. At the time of the investigation, December 19, 2011, the water level in the McGillvray Creek Tributary was at about elevation 258.0 and was also at about elevation 258.0 in January 2011. The groundwater level is subject to seasonal fluctuations and rainfall patterns.

5. CLOSURE

Mr. A. Djirdeh, B.Sc. carried out the field investigation for this study under the supervision of Mrs. N .S. Balakumaran, P. Eng. Walker 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.

This Foundation Investigation Report was prepared by Mrs. N. S. Balakumaran, P. Eng., and reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C. M. P. Nascimento, P. Eng., Project Manager conducted an independent review of the report.

Yours very truly

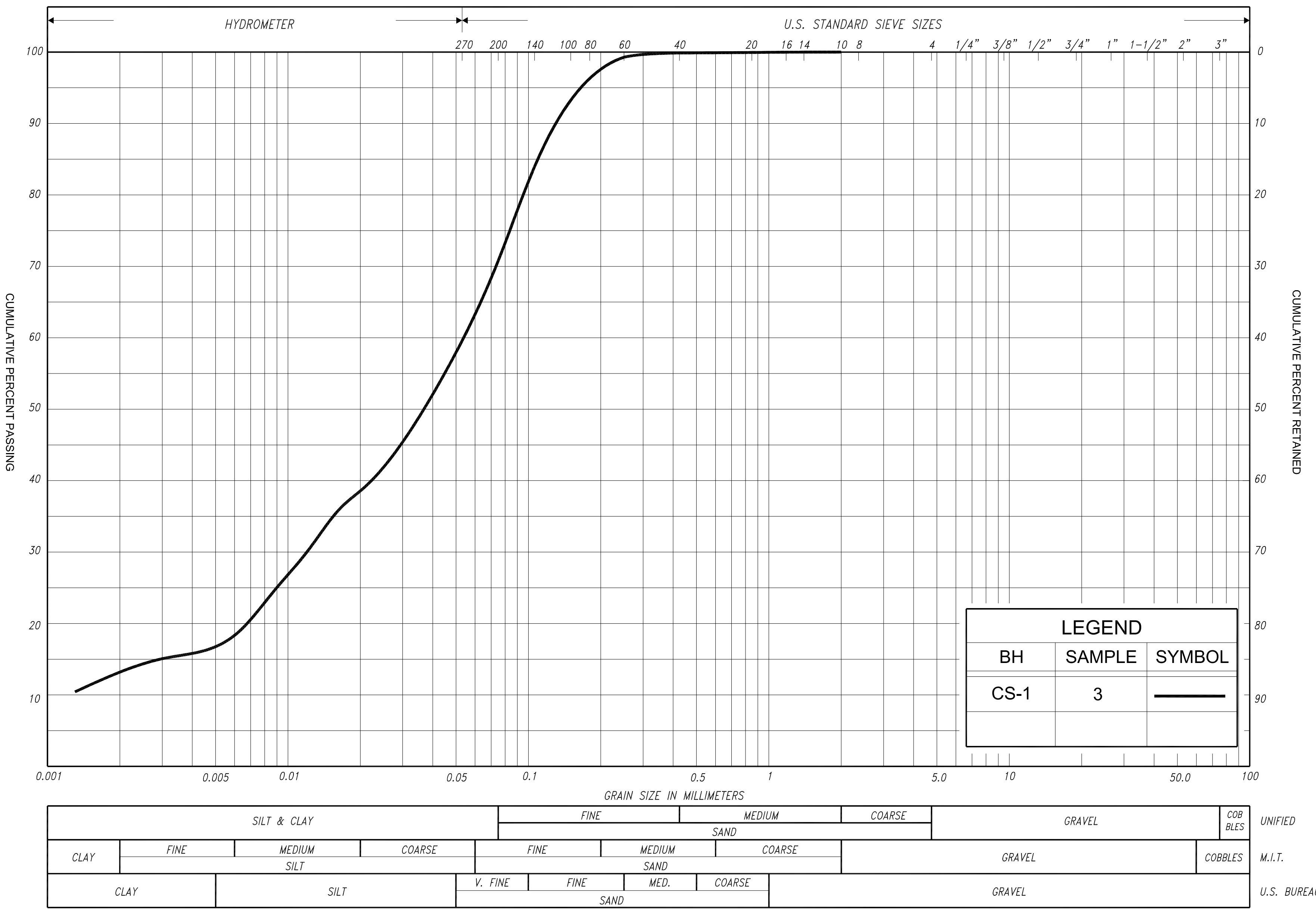
Peto MacCallum Ltd.

Nesam S. Balakumaran, P.Eng.
Project Engineer

Carlos M.P. Nascimento, P.Eng.
Project Manager

Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

NB/CN/BRG:nb-mi-nk

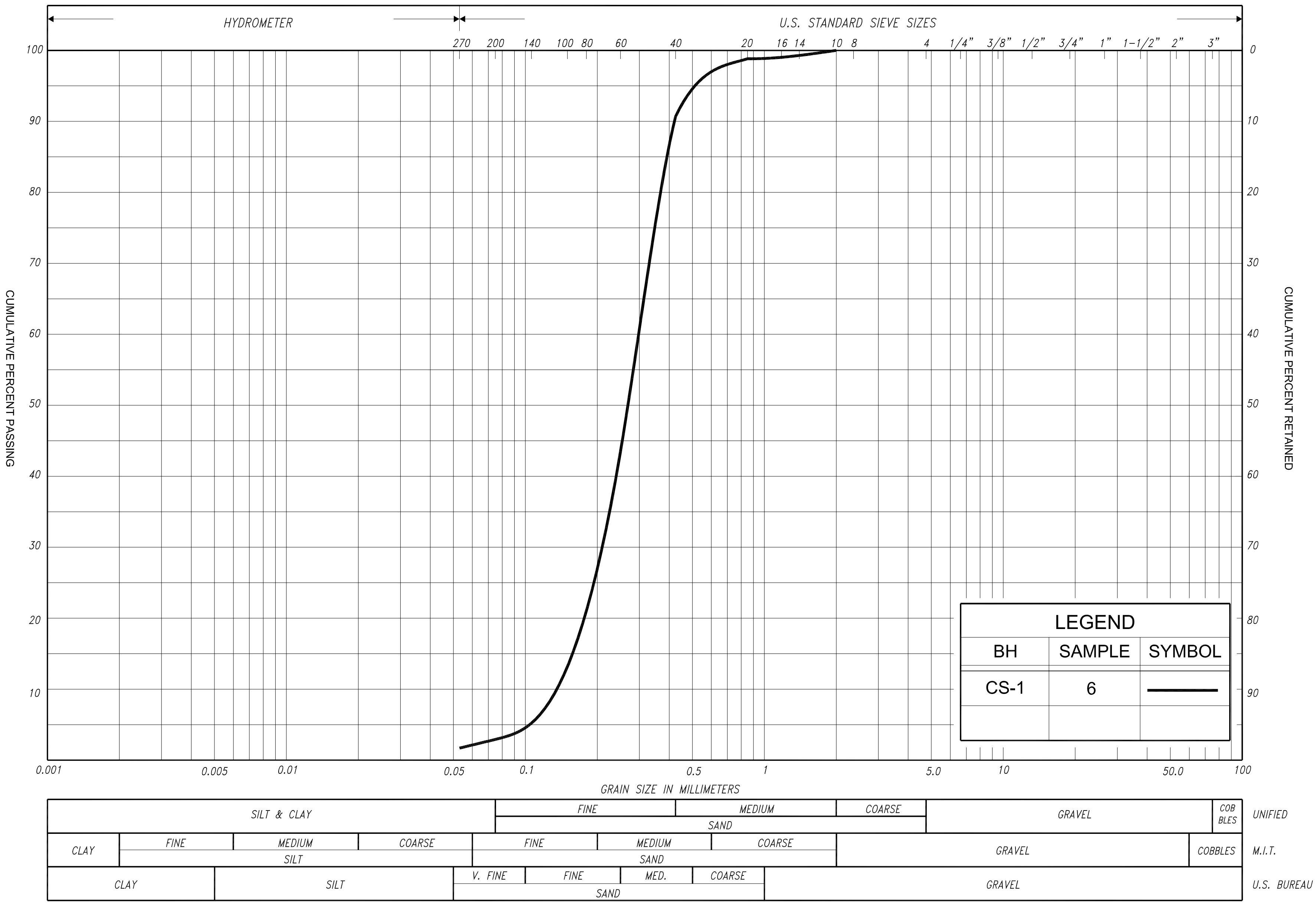


Ontario

GRAIN SIZE DISTRIBUTION

SANDY SILT, some clay

FIG No.	CS-GS-1
HWY:	11
G.W.P. No.	323-00-00

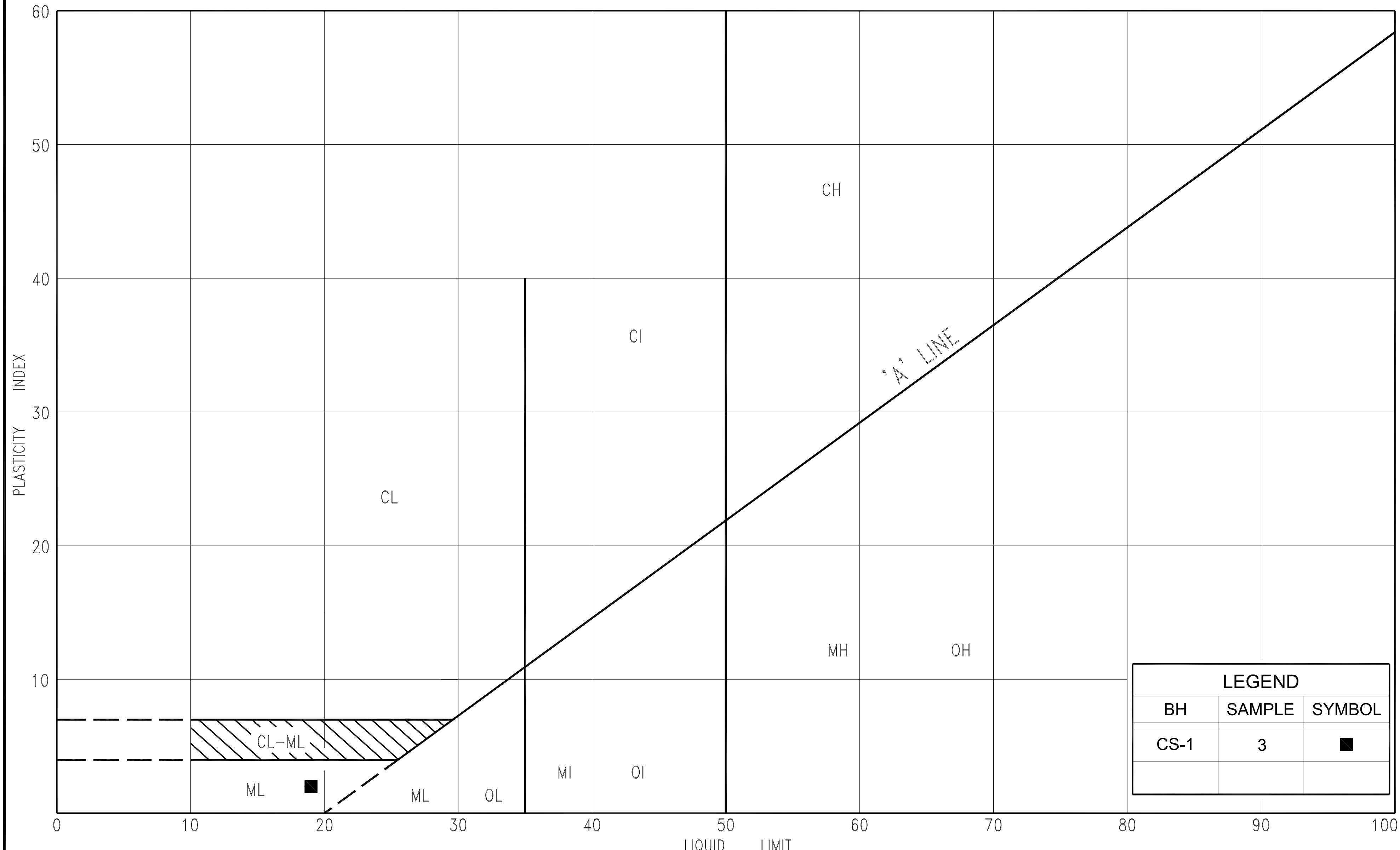


Ontario

GRAIN SIZE DISTRIBUTION

SAND, trace silt

FIG No.	CS-GS-2
HWY:	11
G.W.P. No.	323-00-00



LEGEND		
BH	SAMPLE	SYMBOL
CS-1	3	■

Ontario

PLASTICITY CHART

SANDY SILT, some clay

FIG No.	CS-PC-1
HWY:	11
G.W.P. No.	323-00-00

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

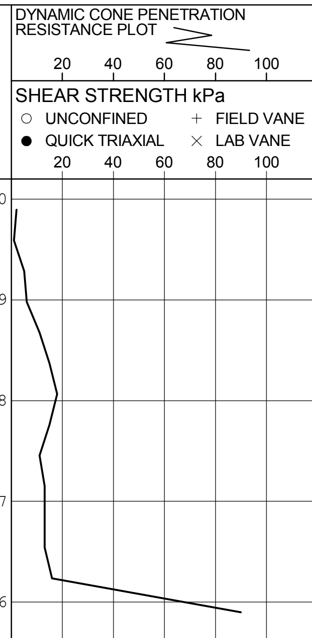
RECORD OF BOREHOLE No CS-1

METRIC

Ontario — Peto MacCallum Ltd. Consulting Engineers — Foundation Design

G.W.P.	323-00-00	LOCATION	Co-ords: 5 102 958.1 N ; 316 068.9 E	ORIGINATED BY	A.K.
DIST	North Bay HWY 11	BOREHOLE TYPE	C.F.H.S.A and Dynamic Cone Penetration Test	COMPILED BY	N.S.B.
DATUM	Geodetic	DATE	December 19, 2011	CHECKED BY	B.R.G.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
260.2	Ground Surface										
0.0	Clayey silt; Soft, Dark brown, Moist (FILL)	1	SS	3							
259.9 / 0.3	Sandy silt, some clay, rootlets to 1.2m; Very loose to loose, Grey, Wet	2	SS	6							
		3	SS	8	▽*			0	29	58	13
258.0 / 2.2	Sand, trace silt; Very loose to compact, Grey, Wet; sand seams	4	SS	2							
		5	SS	3							
		6	SS	18				0	97	(3)	
255.6 / 4.6	End of borehole; Refusal on probable bedrock										



* 2011 12 19

▽ Water level observed during drilling

C.F.H.S.A. denotes Continuous Flight Hollow Stem Augers

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

REMARKS & GRAIN SIZE DISTRIBUTION (%)

5 × Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

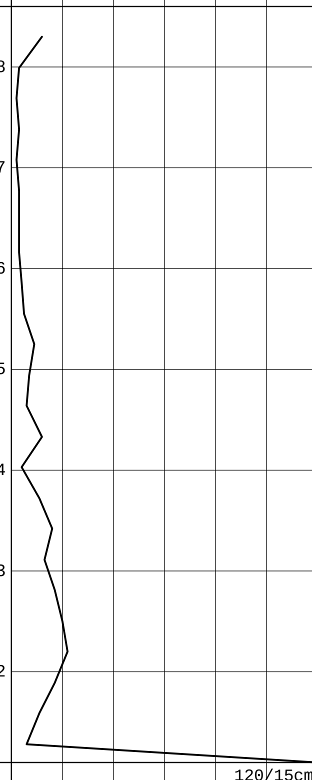
RECORD OF BOREHOLE No 1

METRIC

G.W.P. 17-93-01	**LOCATION** Coords: 5 102 779.0 N; 316 113.4 E **		**ORIGINATED BY** DK/LS
DIST North Bay	**HWY** 11	**BOREHOLE TYPE** C.F.H.S.A. and Dynamic Cone Penetration Test	**COMPILED BY** LS
DATUM Geodetic	**DATE** February 11, 1993		**CHECKED BY** BI

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) (Wp / w / WL)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
258.6	Ground surface											
0.0	Silt, some sand, trace clay; Very loose to loose, Brown, Moist	1	AS	-		258						
	Grey	2	SS	3			Wp ≈ 19, w ≈ 21		0	19	64	17
	numerous decomposed roots	3	SS	3	▼*	257	Wp ≈ 25, w ≈ 63					
	Compact	4	SS	7		256						
		5	SS	12		255	w ≈ 21		3	21	67	9
254.0 / 4.6	Silty sand, some gravel; Compact to Very dense, Brown grey, Moist	6	SS	25		254	w ≈ 15		16	53	25	6
		7	SS	70		253, 252						
251.1 / 7.5	End of borehole; Refusal on probable bedrock											

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)



* 1993 02 11

▼ Water level measured after drilling

** Refer to NAD 27 Datum

NOTE: Borehole was drilled by MTO Foundations (Geocres No. 31L-59) and redrawn for reference of this report

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 2

METRIC

G.W.P. 17-93-01 **LOCATION** Coords: 5 102 742.0 N; 316 091.3 E ** **ORIGINATED BY** DK/LS

DIST North Bay **HWY** 11 **BOREHOLE TYPE** C.F.H.S.A. and Dynamic Cone Penetration Test **COMPILED BY** LS

DATUM Geodetic **DATE** February 10, 1993 **CHECKED BY** BI

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.1	Ground surface						259			
0.0	Silt some sand, trace clay Very loose to loose Brown Wet Occasional roots to 2.1m		1	AS	-					
			2	SS	4	▼*	258	○		0 24 62 14
			3	SS	4		257	○		
			4	SS	4			H ○		1 17 57 25
			5	SS	6		256			
255.4 3.7	Silty sand, trace gravel Compact to Very dense Brown						255			
			6	SS	68		254			
253.8 5.3	Granite bedrock									
			7	RC	REC 100%		253			RQD 100%
			8	RC	REC 100%		252			RQD 100%
251.3 7.8										

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 (20 40 60)

* 1993 02 10

▼ Water level measured after drilling

** Refer to NAD 27 Datum

NOTE: Borehole was drilled by MTO Foundations (Geocres No. 31L-59) and redrawn for reference of this report

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 3

METRIC

G.W.P. 17-93-01 **LOCATION** Coords: 5 102 791.5 N; 316 069.5 E ** **ORIGINATED BY** DK/LS

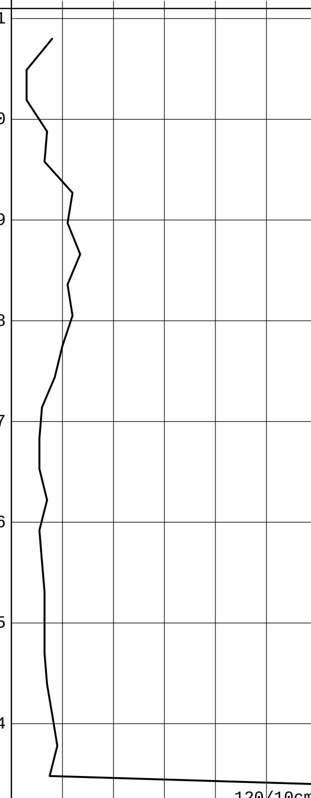
DIST North Bay **HWY** 11 **BOREHOLE TYPE** C.F.H.S.A. and Dynamic Cone Penetration Test **COMPILED BY** LS

DATUM Geodetic **DATE** February 10, 1993 **CHECKED BY** BI

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.1	Ground surface					261		
0.0	Clayey silt, Brown, Wet	1	AS	-				
260.3 / 0.8	Silt, trace clay, Compact, Brown, Wet	2	SS	24		260	H (PL–LL range)	0 9 78 13
		3	SS	16	▼*			
259.0 / 2.1	Sandy silt, Compact, Brown, Wet	4	SS	18		259	○	1 41 39 19
		5	SS	13		258	○	0 36 53 11
256.8 / 4.3	Silt, Compact, Brown, Wet	6	SS	10		257		
256.1 / 5.0	Silty sand, Dense, Brown, Wet	7	SS	30		256, 255, 254		
253.2 / 7.9	End of borehole. Refusal on probable bedrock							

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/m³

* 1993 02 10

▼ Water level measured after drilling

** Refer to NAD 27 Datum

NOTE: Borehole was drilled by MTO Foundations (Geocres No. 31L-59) and redrawn for reference of this report

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 4

METRIC

G.W.P. 17-93-01 **LOCATION** Coords: 5 102 711.7 N; 316 067.7 E ** **ORIGINATED BY** DK/LS

DIST North Bay **HWY** 11 **BOREHOLE TYPE** C.F.H.S.A. and Dynamic Cone Penetration Test **COMPILED BY** LS

DATUM Geodetic **DATE** February 10, 1993 **CHECKED BY** BI

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.0	Ground surface							
0.0	Sandy silt, some clay Loose to compact, Brown, Wet	1	AS	-				
		2	SS	7	▼*	258	○	0 36 49 15
	Grey	3	SS	5		257		
		4	SS	10		256		
256.0 / 3.0	Sandy silt, some clay and gravel Very dense, Reddish Brown, Moist TILL	5	SS	25/8cm			○	19 49 21 11
255.7 / 3.3	End of borehole Refusal on probable bedrock							

Dynamic Cone Penetration Resistance Plot: 120/8cm at elevation approx. 256.

* 1993 02 10

▼ Water level measured after drilling

** Refer to NAD 27 Datum

NOTE: Borehole was drilled by MTO Foundations (Geocres No. 31L-59) and redrawn for reference of this report

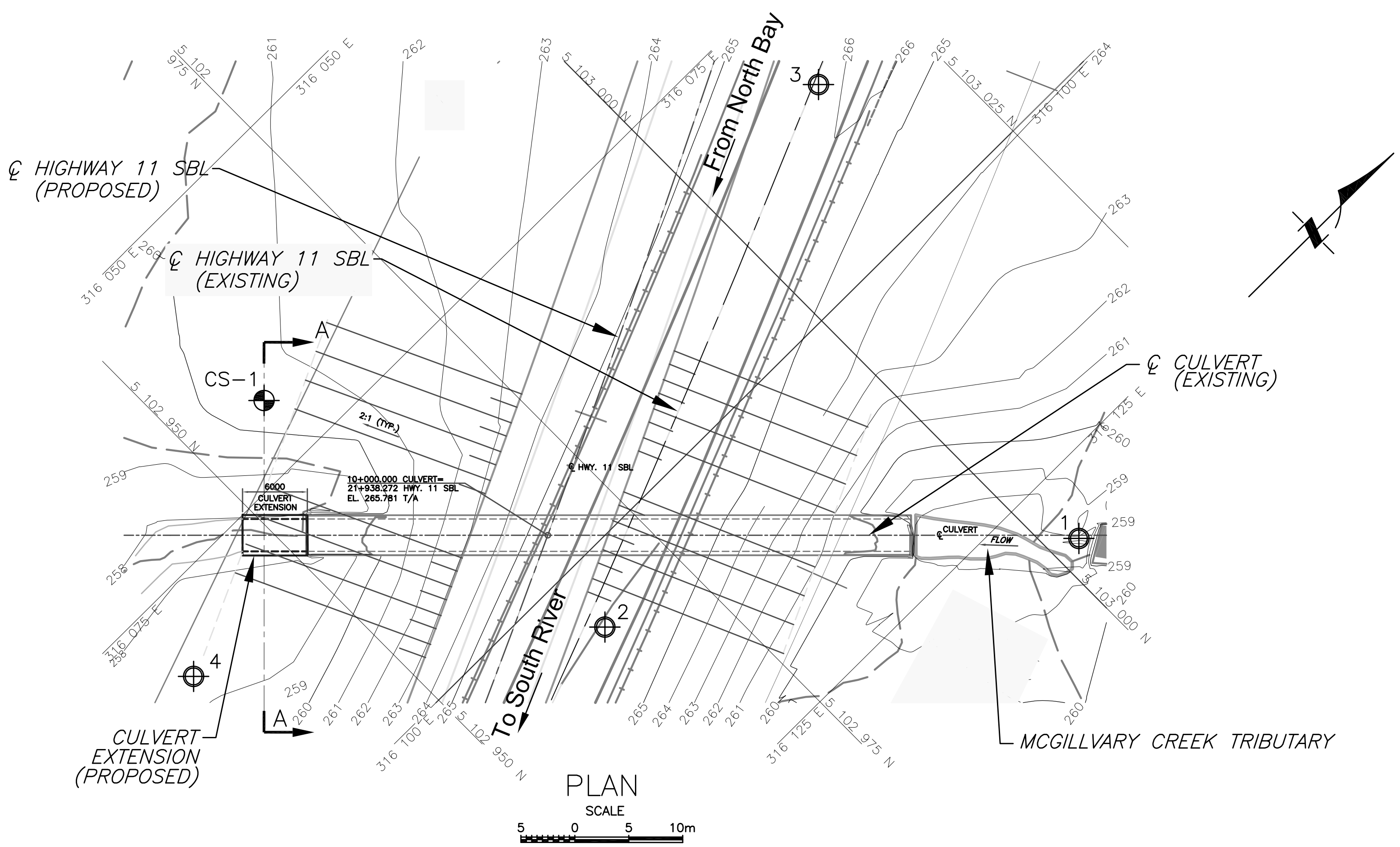
Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

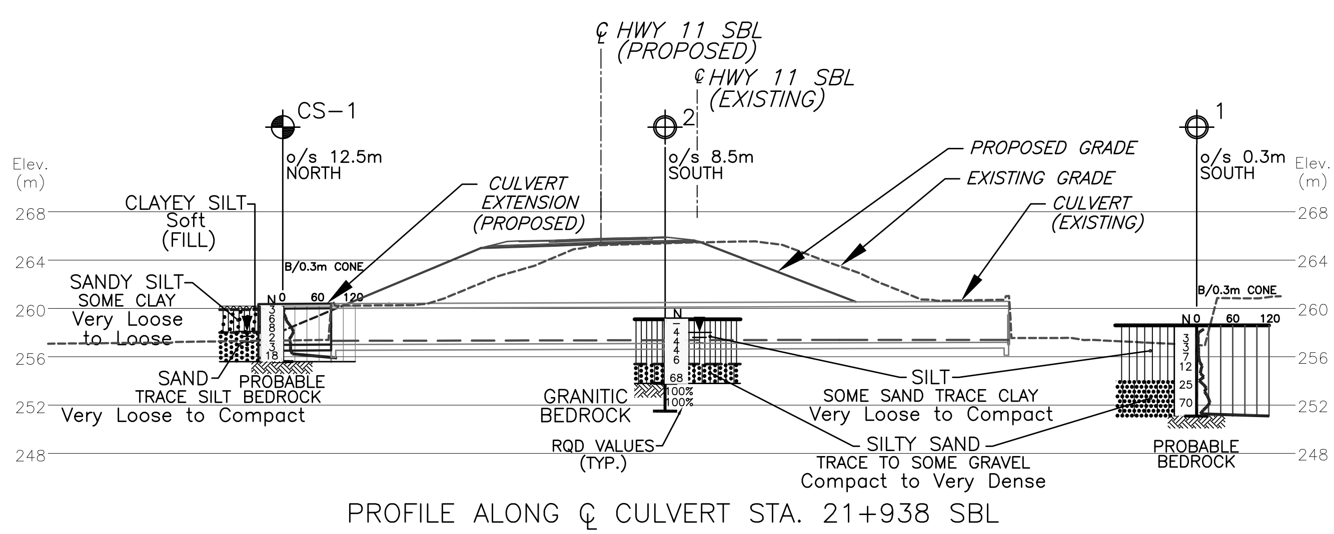
7 , 5 × : Numbers refer to Sensitivity

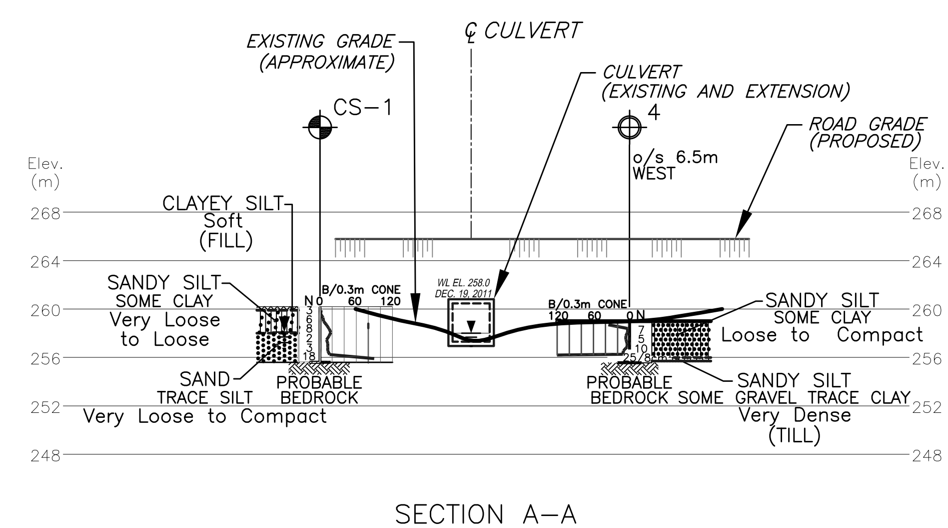
20, 15 — 5, 10 (%) STRAIN AT FAILURE

CONT No GWP No 323-00-00 WP No	
MCGILLVARY CREEK TRIBUTARY CULVERT WEST EXTENSION HIGHWAY 11 SBL STA. 21+938 BOREHOLE LOCATIONS AND SOIL STRATA	SHEET

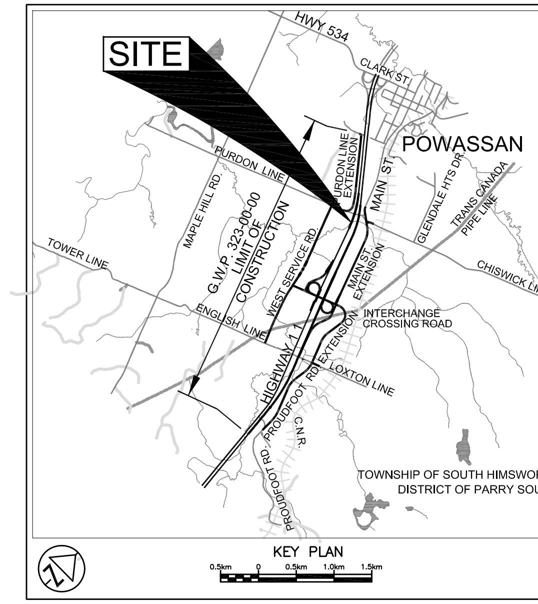
Peto MacCallum Ltd.
CONSULTING ENGINEERS







SCALE
5 0 5 10m



LEGEND

- Borehole
- Borehole and Cone
- Borehole from previous investigation (Geocres No. 31L-59)
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation Feb. 1993 (boreholes 1 to 4) & Dec. 2011 (borehole CS-1)
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
CS-1	260.2	5 102 958.1	316 068.9
1**	258.6	5 102 779.0	316 113.4
2**	259.1	5 102 792.0	316 091.3
3**	261.1	5 102 791.5	316 069.5
4**	259.0	5 102 711.7	316 067.7

** COORDINATES FOR BOREHOLES 1 TO 4 REFER TO NAD 27 DATUM

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

NOTES:

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

REF AECOM Drawings:
60157537 Mcgillvray_Creek_Trib_SBL-CULVERT-21+938_1_GA.dwg dated Dec., 2010; Hwy 11 Base-Trow.dwg; Hwy 11-Design.dwg; Hwy11_MTO_InRoads_Contours.dwg

REVISIONS DATE	BY	DESCRIPTION

Geocres No. XXX-XXX

HWY No 11			DIST North Bay
SUBM'D NA	CHECKED NSB	DATE APRIL 26, 2013	SITE 44-366/C2
DRAWN NA	CHECKED BRG	APPROVED CN	DWG CS-1

APPENDIX A

Previous Foundation Investigation Report
(GEOCRES No. 31L-59)

Culvert CS

Geocres No.
31L-59

FOUNDATION INVESTIGATION REPORT
for
Tributary to McGillvray Creek Culvert
Proposed Southbound Lanes, Highway 11
W.P. ~~51-75-01~~ 17-93-01
District 13, North Bay

INTRODUCTION

This report summarizes the information obtained from the foundation investigation carried out at the above noted site. The investigation was carried out at the request of the Northern Region Structural Section to design a culvert required for the proposed four laning of Highway 11. The field work was carried out on 93 02 10 and 93 02 11 and consisted of three (3) sampled boreholes and three (3) dynamic cone penetration tests along the length of the proposed culvert site. In addition, one (1) sampled borehole and one (1) dynamic cone penetration test were advanced approximately 50 m north of the culvert location where high fill is expected.

SITE DESCRIPTION

The site is located on the proposed southbound lanes of Highway 11, approximately 2.0 km south of the intersection of Highway 534 and 50 m west of the existing Highway 11 embankment in the Township of South Himsworth, District of Parry Sound.

The immediate area is moderately rolling with scattered surficial boulders and mainly grassy vegetation. The property on which the site is located is presently used as livestock pasture. According to the Northern Ontario Engineering Geology Terrain Study published by the Ministry of Natural Resources, the site is located in a Sandy Glaciolacustrine Plain.

The existing Highway 11 embankment is 8 m to 10 m high at this location with the watercourse accommodated by a 3.05 m x 3.05 m x 32 m rigid frame concrete box culvert.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in-situ and laboratory testing. The procedures employed are discussed below.

Field

The field work for the investigation was carried out on 93 02 10 and 93 02 11 and consisted of four (4) sampled boreholes and four (4) dynamic cone penetration tests advanced to depths of 3.3 to 7.9 m. 2.3 m of rock core was obtained in BH 2.

The boreholes were advanced using conventional hollow stem augering techniques with a track mounted continuous flight auger machine. The sampling program consisted of disturbed samples taken directly from the auger in the surface soil and by split spoon sampler in accordance with Standard Penetration Test (ASTM D1586) for the subsurface strata. Standard Penetration ('N') values were recorded for assessment of the denseness of the materials encountered. All subsoil samples were identified in the field and returned to the laboratory for further examination and appropriate testing.

Groundwater level was monitored in open boreholes throughout the investigation. Water level in the creek was also measured during the time of the investigation. All boreholes were backfilled upon completion of the field work.

Surveying required to ascertain borehole locations and elevations was carried out by the Northern Region Surveys and Plans Section.

Laboratory

The laboratory testing on selected soil samples consisted of the following:

- Atterberg Limit Test
- Grain Size Distribution
- Natural Moisture Content Determination
- Organic Content Determination

Laboratory results are given in the following section of this report and are illustrated on Record of Borehole sheets included in the Appendix.

SUBSURFACE CONDITIONS

General

The Record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes are shown in Dwg. No. ~~517501-A.~~ 179301-A.

The subsurface stratigraphy in BH 1 to 3 typically comprises of a 3.7 to 5 m thick layer of silt overlying a 1.6 to 2.9 m sand deposit. Depth to bedrock in these boreholes ranges from 5.3 to 7.9 m. In BH 4, a 3 m thick layer of sandy silt was found overlying a minor layer (0.3 m thick) of non-cohesive glacial till. Bedrock was encountered at shallow depth (3.3 m). In order to verify bedrock, 2.3 m of rock core was taken from BH 2. A subsurface profile is shown in Dwg. No. ~~517501-B.~~ 179301-B.

Following are the specific descriptions of the materials encountered in the investigation:

Silt, Some Sand, Trace Clay, Occasional Clayey and Sandy Zones

This material was encountered at the surface in BH 1 to BH 3 to a depth of 3.7 m to 5.0 m. It is typically described as Silt, Some Sand, Trace Clay. In BH 3 occasional clayey pockets and sandy zones were recorded. The Standard Penetration Resistance 'N' values range from 3 to 24 blows/0.3 m indicating very loose to compact denseness. Occasional rootlets and organics were found in this stratum in both BH 1 and BH 2. Typical properties of this material as determined by laboratory tests carried out on representative samples are summarized as follows :

Property	Range	No. of Test
Natural Moisture Content (w%)	19.0-65.5	9
Liquid Limit (w_l)	20-31	4
Plastic Limit (w_p)	15-28	4
Grain Size Distribution (%)		7
Gravel	0-3	
Sand	9-41	
Silt & Clay	58-91	
Organic Content (%)	2.1-4.3	2

Sandy Silt, Some Clay

This non-cohesive stratum was contacted at the surface in BH 4 to a depth of 3.0 m. It is typically described as Sandy Silt, Some Clay. The Standard Penetration Resistance 'N' values ranged from 5 to 10 blows/0.3 m, indicating a loose to compact denseness. Laboratory tests carried out on a representative sample indicated a natural moisture content of 29.5% and grain size distribution of 0% gravel, 36% sand and 64% silt and clay.

Silty Sand, Trace to Some Gravel

This material was encountered in BH 1 to 3 overlying bedrock. The Standard Penetration Resistance 'N' values ranged from 20 to 68 blows/0.3 m, indicating a compact to very dense state of denseness. Laboratory tests carried out on a representative sample indicated a natural moisture content of 12% and grain size distribution of 16% gravel, 53% sand and 31% silt and clay.

Heterogeneous Mixture of Sandy Silt Trace Gravel (Glacial Till)

This material was encountered from 3.0 m to 3.3 m in BH 4. It lies directly over bedrock and the Standard Penetration Resistance 'N' value was 25 blows/8 cm with the split spoon sampler bouncing on bedrock. Laboratory tests carried out on a representative sample indicated a natural moisture content of 10% and grain size distribution of 19% gravel, 49% sand and 32% silt and clay.

Bedrock

Bedrock was encountered at shallow depth at El. 255.7 m (BH 4) on the west side and found sloping down to El 251.1 m (BH 1) at the east end.

Bedrock was cored in BH 2. The rock cores obtained were used for rock quality determination and classification. Detailed description of the rock are attached in the Appendix. Bedrock is a slightly weathered to unweathered granite. Core recoveries and Rock Quality Designations are 100%. The rock is considered strong.

Groundwater

During the time of the investigation, the water level in the creek was at El. 257.5 m. It is probable that the creek elevation rises considerably during periods of high runoff.

Ground water level was measured in the boreholes to be between El. 258.0 and EL. 259.0 m approximately.

Groundwater levels are subject to seasonal fluctuations and hence may vary from the elevations given in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of D. Kwok, Project Foundation Engineer and L. Sheppard, Pavement Design and Evaluation Officer, using the equipment owned and operated by Dominion Soil Investigation Inc. Bedrock was classified by MTO petrographyer D. Williams.

The project was carried out by D. Kwok under the general supervision of B. Iyer, Senior Foundation Engineer. The report was written by D. Kwok, reviewed by B. Iyer, and approved by M. Devata, Chief Foundation Engineer.

REGISTERED PROFESSIONAL ENGINEER
P. PAYER
PROVINCE OF ONTARIO

P. Payer, P. Eng.
Senior Foundation Engineer

APPENDIX

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.P. ~~81-73-01~~ 17-93-01 LOCATION Co-ords N 5 107 779.0 E 316 113.4

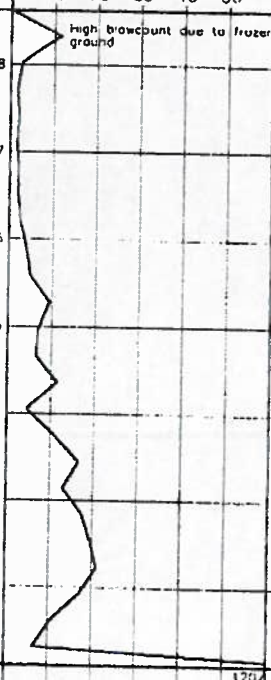
DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger & Cone Test

DATUM Geodetic DATE 93 02 11

ORIGINATED BY UK/LS
COMPILED BY LS
CHECKED BY BL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.6 / 0.0	Ground Surface								
	Silt, Some Sand, Trace Clay, Loose to Very Loose; brown / grey; Numerous Decomposed roots; Compact	1	AS	–		258			
		2	SS	3					0 19 64 17
		3	SS	3	▽*	257	wp–w 65.5		
		4	SS	7		256			
		5	SS	12		255			3 21 67 9
254.0 / 4.6	Silty Sand, Some Gravel, Brown to Grey, Compact	6	SS	25		254			10 53 25 6
						253			
		7	SS	70		252			
251.1 / 7.5	End of Borehole; Auger Refusal, Probable Bedrock								

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (10 20 30 40 50)
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L



* 93 02 11 Unstabilized water level measured upon completion

^{3}, ^{5} Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 2

METRIC

W.P. 17-93-01 LOCATION Co-ords. N 5 102 742.0 E 316 091.3 ORIGINATED BY DK/LS

DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger, Dynamic Cone & NQ Core Barrel COMPILED BY LS

DATUM Geodetic DATE 93 02 10 CHECKED BY BI

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.1	Ground Surface							
0.0	Silt, Some Sand, Trace Clay, Brown to Grey, Very Loose, Occ. Rootlets		1	AS	-			
			2	SS	4	▽*	258	0 24 62 14
			3	SS	4		257	
			4	SS	4		256	1 17 57 25
255.4			5	SS	6			
3.7	Silty Sand, Trace Gravel, Brown, Compact to Dense						255	
253.8			6	SS	68		254	
5.3	Granitic Bedrock		7	RC	REC	100%	253	RQD 100%
251.5			8	RC	REC	100%	252	RQD 100%
7.6	End of Borehole							
	* Water Level measured on 93 02 11							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: o UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; x LAB VANE — 10 20 30 40 50

Dynamic cone refusal: 120/10cm

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

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

15◇5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 3

 METRIC

W.P. 17-93-01 LOCATION Co-ords N 5 102 781.5 E 316 069.5 ORIGINATED BY DK/LS

DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger & Dynamic Cone Penetration Test COMPILED BY LS

DATUM Geodetic DATE 93 02 10 CHECKED BY BI

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.1	Ground Surface						
0.0	Clayey	1	AS	-			
	Silt, Trace Clay, Brown, Compact	2	SS	24		260	0 9 78 13
		3	SS	16	▼*		
						259	
	Sandy	4	SS	18			1 41 39 19
		5	SS	13		258	0 36 53 11
						257	
256.1		6	SS	10			
5.0	Silty Sand, Trace Gravel, Brown, Dense					256	
						255	
		7	SS	30			
						254	
253.2							
7.9	End of Borehole. Auger Refusal, Probable Bedrock						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × LAB VANE: 10 20 30 40 50

High blowcount due to frozen ground

120/10cm

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

* Water level measured three hours after the completion of drilling

+3, ×5: Numbers refer to Sensitivity

20 15○5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4

METRIC

W.P. ~~[illegible]~~ 17-93-01 LOCATION Co-ords. N 5 102 711.7 E 316 067.7 ORIGINATED BY DK/LS

DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger & Dynamic Cone Penetration Test COMPILED BY LS

DATUM Geodetic DATE 93 02 09 CHECKED BY BI

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER (SAMPLES)	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 10 20 30 40 50)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.0	Ground Surface										
0.0			1	AS	-			High blowcount due to frozen ground			
	brown / grey		2	SS	7	▼*	258				0 36 49 15
	Sandy Silt, Some Clay		3	SS	5						
	Loose to Compact						257				
			4	SS	10						
256.0											
255.7	See Note 1 for description		5	SS	25	/8cm	256	120/8cm			
3.3	End of Borehole — Auger Refusal, Probable Bedrock										19 49 21 11

Note 1: Heterogeneous mixture of Sandy Silt, some Clay and Gravel (Glacial Till) reddish brown very dense

* Water Level measured on 93 02 10

+3, ×5 : Numbers refer to Sensitivity

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

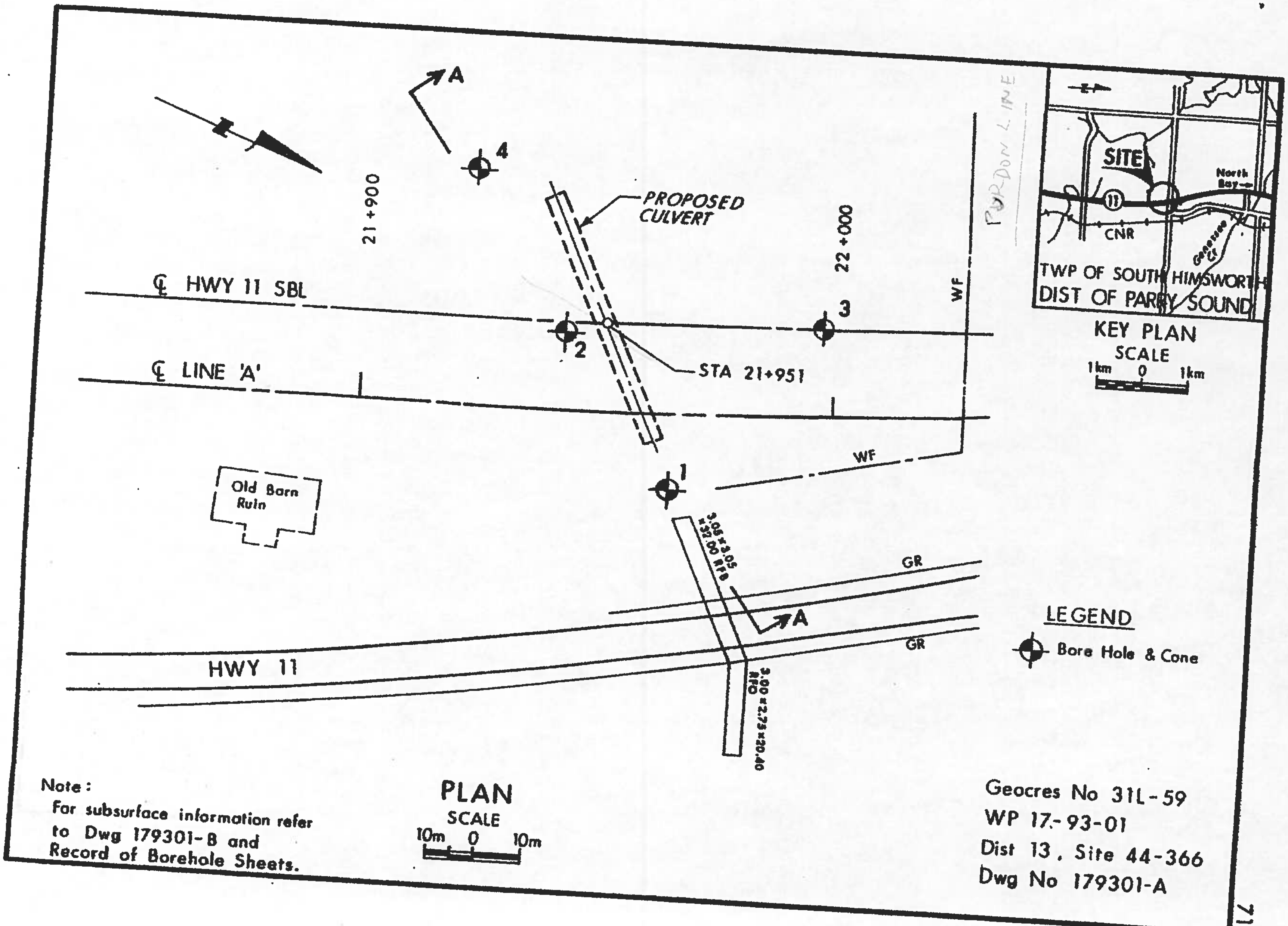
ROCK CORE DESCRIPTION
WP ~~51-75-01~~ 17-93-01

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	7	5.33-6.86	100	100	5.33-7.57	**GRANITE** (biotite-bearing, garnetiferous, and gneissic), moderate reddish orange to moderate orange pink to dark grey; fine to coarse grained; strong; unweathered to slightly weathered; fractures wide to close spaced, near vertical to flat, planar to undulating, smooth to rough.
	8	6.86-7.57	100	100		

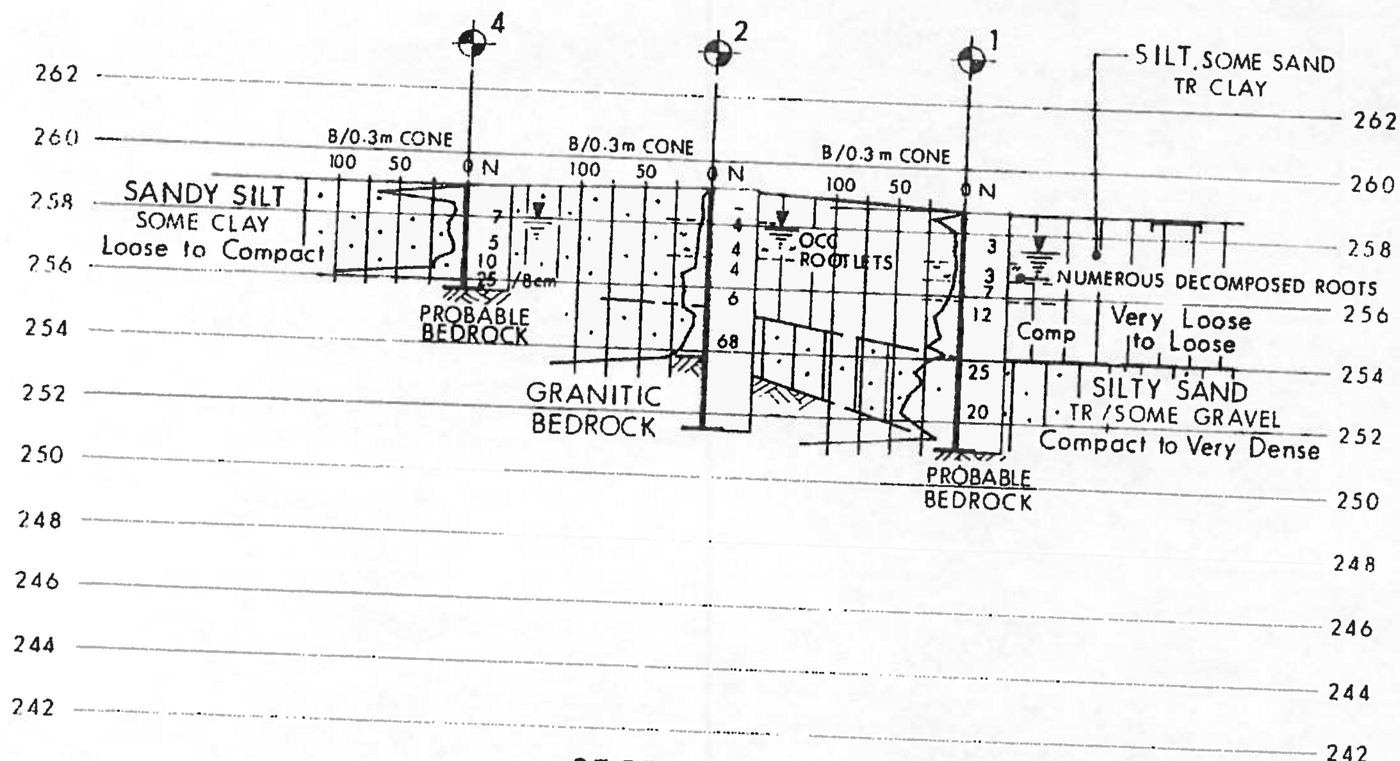
*CR = CORE RECOVERY
*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section



A
4
21+900
PROPOSED
CULVERT
22+000
PURDON LINE
WF
℄ HWY 11 SBL
2
3
℄ LINE 'A'
STA 21+951
WF
1
Old Barn
Ruin
3.05×3.05
×32.00 RFB
GR
A
GR
HWY 11
3.00×2.75×20.40
RFO
SITE
North
Bay
11
CNR
TWP OF SOUTH HIMSWORTH
DIST OF PARRY SOUND
KEY PLAN
SCALE
1km 0 1km
LEGEND
Bore Hole & Cone
Note:
For subsurface information refer
to Dwg 179301-B and
Record of Borehole Sheets.
PLAN
SCALE
10m 0 10m
Geocres No 31L-59
WP 17-93-01
Dist 13, Site 44-366
Dwg No 179301-A



SECTION A-A

SCALE
10m 0 10m Hor
2m 0 2m Vert

Note :
- For Plan refer to Dwg 179301-A
- For Subsoil information of BH-3 refer to Record of Borehole sheets

Geocres No 31L-59
WP 17-93-01
Dist 13 , Site 44-366
Dwg No 179301-B

Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION DESIGN REPORT
for
MCGILLVRAY CREEK TRIBUTARY CULVERT WEST EXTENSION
HIGHWAY 11 SOUTHBOUND LANES STATION 21+938
SITE NO. 44-366/C2
TOWNSHIP OF SOUTH HIMSWORTH
NORTH BAY AREA, ONTARIO
G.W.P. 323-00-00

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PML Ref.: 10TF013A-C2
Index No.: 361FDR
GEOCRES No.: 31L-172
April 29, 2013

TABLE OF CONTENTS

FOUNDATION DESIGN REPORT
For
McGillvray Creek Tributary Culvert West Extension
Highway 11 Southbound Lanes Station 21+938
Site No. 44-366/C2
Township of South Himsworth
North Bay Area, Ontario
GWP 323-00-00

1. INTRODUCTION

The proposed west extension of the culvert for the Tributary to McGillvray Creek located on the Highway 11 Southbound Lanes (SBL) is planned as part of the proposed new south entrance to Powassan. The project extends from 5.7 km south of the Highway 534 northerly 5.0 km. This report was prepared for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

This foundation design report provides foundation engineering comments and recommendations for the proposed culvert extension design and construction.

According to the General Arrangement (GA) drawing dated December 2010, the Highway 11 SBL culvert extension is located at Sta. 21+938 (Highway 11 SBL chainage) in the Township of South Himsworth. The existing McGillvray Creek Tributary culvert is a 3.0 by 3.0 m concrete box with a total length of 56 m. The proposed west extension of the culvert will match the 3.0 by 3.0 m opening and will be a cast-in-place concrete box with a total length of 6 m.

The existing Highway 11 SBL will be realigned at the culvert location. The proposed new SBL centreline will be located about 7.0 m west of the existing centreline. The proposed road grade is at elevation 265.8 and raised less than 0.5 m above existing grade at the culvert location. Although the culvert invert level is at elevation 257.1, the existing grade in front of the west end of the culvert is 0.4 m higher, at elevation 257.5 according to the profile provided in the GA drawing and the side slopes are inclined at 2H:1V or flatter.

In summary, the subsurface stratigraphy revealed in the borehole generally comprised a 0.3 m thick fill over 1.9 m thick cohesionless sandy silt underlain by 2.4 m thick cohesionless sand mantling probable bedrock. The probable bedrock was inferred by auger and dynamic cone refusal at 4.6 and 4.3 m (elevation 255.6 and 255.3), respectively. The current borehole was consistent with the previous investigation results at the west extension location. The bedrock level may vary from those in the current and previous boreholes. The groundwater level observed during the field investigation was at 2.1 m depth (elevation 258.1) and consistent with previous investigation at about elevation 258.0 in the McGillvray Creek Tributary. However, variations may occur due to seasonal changes and precipitation patterns.

From a foundation perspective, the construction of a precast culvert or the proposed cast-in-place culvert for the west extension is feasible, subject to the following comments.

Due to the 7 m westerly realignment of the existing Highway SBL at the culvert location, the underlying soils under the existing west portion of the culvert may settle about 10 mm and new west portion of the culvert may settle about 20 mm. The resulting differential settlement between the adjacent new and existing culvert sections will be some 10 mm. It is assumed that the adequacy of the existing culvert to withstand the estimated differential settlement of 10 mm in relation to the culvert extension section will be checked and designed by the structural engineer.

It is understood that a cast-in-place concrete box was contemplated for the proposed west culvert extension. Recommendations for a precast culvert and a discussion of the advantages and disadvantages of the two culvert options are also included in this report.

The construction of the culvert extension will need to consider groundwater control measures for construction under wet or dry conditions, as outlined in the report. In this regard, the installation of a precast concrete culvert extension may require a lower level of dewatering effort than a cast-in-place concrete that needs to be constructed in dry conditions. The attached NSSP in Appendix FDR-A, warning the Contractor of the difficulties associated with dewatering in pervious subgrade soils and high water levels at the site should be included in the contract specifications.

The probable bedrock level may be higher than those encountered in the current and previous investigation boreholes put down at the site and bedrock excavation will be required to accommodate the full granular bedding thickness above the bedrock to avoid point loads under the culvert extension. An allowance for possible rock excavation should be included in the contract.

The “red-flag” issues outlined in the preceding paragraphs and the recommended methods of overcoming these issues noted in the following sections of the report are intended to alert and aid the designer and the contractor. It is noted that no responsibility or liability is assumed by the consultants for alerting the contractor to all critical issues. The requirement to deliver acceptable construction quality remains the responsibility of the contractor.

The foundation frost penetration depth at the site is 1.9 m according to OPSD 3090.100.

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

2. FOUNDATIONS

The invert level of the proposed west culvert extension culvert is inferred to be approximately elevation 257.1 that is the same as the existing west end of the existing culvert. The subgrade level for the concrete box culvert extension is interpreted to be about at elevation 256.3, 0.8 m below the proposed invert level allowing for the thickness of concrete base of the culvert extension and for the bedding and levelling course. The proposed road grade at the culvert location will be about elevation 265.8.

The subgrade soils revealed in the boreholes below the anticipated culvert extension subgrade level (elevation 256.3) comprised of 0.4 to 0.7 m thick compact sand mantling probable bedrock.

Groundwater was contacted in borehole CS-1 at elevation 258.1. The water level in the creek was at elevation 258.0 at the time investigation and in January 2011, that is about 1.7 m above the inferred subgrade level.

It is estimated that excavation of about 0.3 m thick fill, 1.9 m thick cohesionless sandy silt and 1.7 m cohesionless sand deposits will be required to achieve the anticipated culvert subgrade level at the west extension location based on borehole CS-1.

It is inferred that excavation of about 1.2 m thick of native soils will be required based on existing grade level at elevation 257.5 in front of west end of the culvert.

The underlying cohesionless soils that are in the zone of influence below the design subgrade level are considered capable of adequately supporting the stress imposed by the concrete box culvert.

The culvert bedding should be 300 mm thick and comprise Granular A or Granular B Type II with a maximum particle size of 37.5 mm. Under the prevailing wet conditions, Granular B Type II material is recommended.

The estimated maximum total settlement of the new culvert at the new west end (outlet) is some 5 mm and with 20 mm at the west end of the existing culvert due to the 3.5 m high additional fill loading from the SBL embankment centreline shift. It is estimated that the resulting differential post-construction settlement between the two ends of the new culverts will in the order of 15 mm.

The estimated magnitude of the differential settlements under the new culvert of 15 mm is considered to be tolerable for the cast-in-place or precast concrete culverts. Construction joints, if required, could be added at the structural design engineer's discretion to accommodate the maximum estimated 15 mm of settlement.

The west portion of the existing culvert may settle about 10 mm due to realignment of the Highway 11 SBL at the culvert location. The resulting differential settlement between the adjacent new and existing culvert sections will be some 10 mm. It is assumed that the adequacy of the existing culvert to withstand the estimated differential settlement of 10 mm will be checked and designed by the structural engineer.

The recommended geotechnical bearing resistance at Ultimate Limit States (ULS) and the geotechnical reaction at Serviceability Limit States (SLS) for the 3.0 m wide concrete box culvert extension constructed on the native cohesionless soils are as follows:

CULVERT SECTION	SUBGRADE SOIL TYPE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL REACTION AT SLS (kPa)
West Extension	Loose to Compact Cohesionless Sand	200	125

The geotechnical resistance at SLS normally allows for 25 mm compression of the founding medium. In addition, the cohesionless soil settlements under the proposed culvert discussed previously in this section should be considered. A foundation embedment depth of 1.9 m and groundwater level about 1.0 m above the level of the culvert invert were assumed for computation of the geotechnical resistance.

2.2 General Comments

2.2.1 Subgrade Preparation

Preparation of the subgrade for construction of the culverts should be performed and monitored in accordance with OPSS 902. All the cobbles and boulders should be removed from the subgrade level. A site review should be conducted by qualified geotechnical personnel during preparation of the subgrade and compaction of the granular bedding.

As recommended, previously a 300 mm thick granular bedding should be provided below the new culvert section. The bedding material should comprise Granular B Type II, satisfying the specifications within SP 110S13, 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 cast-in-place or precast box culvert may be carried out in general accordance with MTOD 803.21, OPSS 422 and MTO SP 422S01. Reference is made to MTO SP 109S31 if the proposed cast-in-place culvert extension is substituted by a precast culvert type.

Topsoil and any other deleterious soils revealed during the preparation at or below the subgrade should be excavated prior to placement of the granular base below the box culvert and replaced with compacted Granular A or Granular B Type II material. Granular B Type II should be preferred for construction under wet conditions.

The probable bedrock level may be higher than those encountered in the current and previous investigation boreholes put down at the site and bedrock excavation will be required to accommodate the full granular bedding thickness above the bedrock to avoid point loads under the culvert. An allowance for possible rock excavation should be carried out in the contract.

Wet cohesionless silty / sandy soils are anticipated at the subgrade final excavation level elevation 256.3. Site conditions may be unfavourable due to about 1.7 m higher water level above the subgrade final excavation level and the existing pervious wet sandy/silty soils. Groundwater control will be required for construction of the proposed culvert as outlined Section 5.2 of this report.

As an alternative to facilitate underwater construction of the subgrade and bedding and minimize disturbance of the cohesionless native soils, the subgrade should be immediately covered with a layer of biaxial geogrid (25 by 35 mm maximum aperture / 1.2 to 2.0 kN/m minimum peak tensile strength). Granular B Type II should be used to backfill over the geogrid where required to bring the grade up to the bottom of the granular bedding. For water level not higher than elevation 257.0 and to obtain adequate compaction of the granular material underwater conditions, the granular bedding may be temporarily placed to a level about 300 mm above the design grade to be above the estimated groundwater level and be compacted from the surface. The fill grade should then be lowered to the design level of the bedding by carefully excavating the excess bedding material. Under the anticipated wet conditions the levelling course may not be required. It is recommended to provide the minimum 300 mm thickness of granular bedding above the geogrid.

For a cast-in-place concrete culvert alternative, upon establishing the granular bedding level, as outlined in the previous paragraph, the groundwater level should be lowered sufficiently below the level of the base of the culvert (at least 200 to 300 mm) to allow for the placement of the cast-in-place concrete in the dry.

2.2.2 Modulus of Subgrade Reaction

The estimated values of the modulus of subgrade reaction for box culvert constructed on undisturbed compacted materials are as follows.

SOIL TYPE	MODULUS OF SUBGRADE REACTION (MN/m^{3})
Granular A or Granular B Type II	45
Sandy Soils	10

2.2.3 Sliding Resistance

The following parameters should be used to compute sliding resistance of cast-in-place box culvert, headwalls and wingwalls foundations. The friction angles should be 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})
Granular A or Granular B Type II	35	0	22.8
Sandy Soils	30	0	20.0

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

2.2.4 Seismic Site Coefficient

The seismic site coefficient for the conditions at the proposed Highway 11 SBL Tributary Creek culvert site is 1.0 –Type I soil profile as per clause 4.4.6 of the CHBDC.

3. CULVERT BACKFILL

Backfill adjacent to the culverts should be placed in accordance with OPSD 3121.150, OPSS 422 and MTO SP 422S01. The requirement for frost tapes 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 minimize the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction. Refer to OPSS 902 for additional comments.

The proposed 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 design:

PARAMETER	GRANULAR A OR GRANULAR B TYPE II	EXCAVATED MATERIAL (*)
Angle of Internal Friction, degrees	35	30
Unit Weight, kN/m^3	22.8	20.0
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure At Rest (K_o)	0.43	0.50
Coefficient of Passive Earth Pressure (K_p)	3.69	3.00

(*) Assumes that excavated native soils used for backfill are inorganic cohesionless soils.

The design should consider both the maximum water level in the stream and the stabilized 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 WINGWALLS

For headwalls and wingwalls design, if required, the previous recommendations and geotechnical parameters for culvert foundations and backfill should be utilized for the design of the foundations. The wall founding levels should match those of the culvert where the walls are designed integral with the culvert structure. For walls designed separately from the culvert structure, the founding levels should be provided with 1.9 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 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 Excavation

Excavation to the anticipated founding level of the proposed Highway 11 SBL Tributary culvert west extension is expected to extend through the native deposits of cohesionless silty / sandy soils. 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.

The probable bedrock level may be higher than those encountered in the current and previous investigation boreholes put down at the site and bedrock excavation will be required to accommodate the full granular bedding thickness above the bedrock to avoid point loads under the culvert extension. An allowance for possible rock excavation should be included in the contract.

Since the existing cut-off wall will provide protection, excavation of native soils to accommodate the granular bedding layer under the proposed culvert extension is not expected to undermine the existing culvert west end. Excavation should not extend to within approximately 0.5 m of the existing west end of culvert unless protection is implemented to protect the existing culvert west end.

The native silty/sandy soils above the water table are classified as Type 3 soils necessitating temporary cut slopes to be inclined at 1H:1V. Below the water table, cut slopes should be shaped at 3H:1V or flatter. Where composite soil types exist, the excavation slopes should be cut to the requirements of the soil type with the highest number that is present in the slope according to OHSA.

5.2 Groundwater Control

The stabilized groundwater level is expected to be consistent with the water level in the McGillvray Creek Tributary, near elevation 258.0 about 1.7 m above the inferred subgrade level. It will be necessary to implement measures to temporarily lower groundwater table and to permit construction of cast-in-place or precast culvert and headwalls and wingwalls. The groundwater level should be lowered to a minimum of 0.5 m below the proposed founding levels.

For construction in the dry, it is considered that dewatering system will be required. The contractor is responsible for the selection, performance and detailed design of the dewatering system. It should be noted that dam and pumping techniques may not be sufficient due to pervious subgrade soils. Also, cofferdams will be difficult to install due to shallow soil cover above the bedrock.

An underwater construction alternative to prepare the culvert subgrade and bedding layer is provided in Section 2.2.1 and may be applicable for the precast culvert alternative. For construction of a cast-in-place culvert extension, however, groundwater control will likely be required to establish dry conditions, as outlined above. Care should be taken to use filtered sumps to avoid removing firm soil particles from the subgrade causing potential undermined foundation conditions.

From the Foundations standpoint the requirement for a permit to take water (PTTW) will depend on the water tightness of the contractor's selected type of dewatering system. The PTTW requirement will also depend on the groundwater levels at the time of construction since these are subject to seasonal fluctuations and precipitation patterns. A PTTW may be required to address other engineering facets, such as those of Hydrology engineering.

The flow of surface water should be diverted away from the excavations.

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 rip rap 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 headwalls and wingwalls if these are incorporated 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. Additional appropriate erosion control measures for the project should be assessed using the following erodibility K factor.

SOIL TYPE	K FACTOR
Sand	0.2
Silt	0.3

7. DISCUSSION OF CULVERT EXTENSION TYPES

The following table summarizes the advantages and disadvantages of two culvert extension types from the foundation perspective.

Culvert Extension	Advantages	Disadvantages
Precast Concrete Box Culvert Extension	• Shorter culvert construction schedule than cast-in-place concrete culvert extension • Lower level of dewatering effort than a cast-in-place culvert extension • Installation of precast extension can be carried out in wet conditions	• Precast concrete provides lower sliding resistance than cast-in-place concrete • Proposed length and opening may not be commercially available (off the shelf)
Cast-in-place Concrete Box Culvert Extension	• Cast-in-place concrete provides higher sliding resistance than precast concrete • Can be designed to match the existing culvert opening	• Longer culvert construction schedule than precast concrete culvert extension construction • Construction of cast-in-place culvert extension requires dry condition and there are potential difficulties associated with dewatering due to the relatively high permeability subgrade soils, the potential shallow bedrock and high water table at site

From the foundation perspective, the precast concrete box culvert extension is preferred over cast-in-place culvert extension due to difficulties associated with dewatering. However, it is noted that the selection of culvert type also depends on other considerations such as scheduling and commercially available (off the shelf) precast culvert section size. These facets are to be evaluated by AECOM.

8. CLOSURE

This Foundation Design Report was prepared by Mrs. N. S. Balakumaran, P. Eng., and reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C. M. P. Nascimento, P. Eng., Project Manager conducted an independent review of the report.

Yours very truly

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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 802	Construction Specification for Topsoil
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS 1004	Material Specification for Aggregates - Miscellaneous
OPSS 1860	Material Specification for Geotextiles
SP 109S31	Substitution of Precast Concrete Box Culverts for Cast-in-Place Concrete Box Culverts
SP 110S13	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
SP 422S01	Construction Specification for Precast Concrete Box Culvert
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Depth for Northern Ontario
OPSD 3121.150	Minimum Granular Backfill Requirements - Walls Retaining
MTOD 803.21	Bedding and Backfill for Precast Concrete Box Culverts

APPENDIX FDR-A

NSSP – Difficulties Associates with Dewatering

DIFFICULTIES ASSOCIATED WITH DEWATERING – Item No.

Non Standard Special Provision **April 2013**

The Contractor is warned of the difficulties associated with dewatering at the proposed culvert extension site due to the relatively high permeability of the subgrade soils, the potential presence of shallow bedrock and high water table at the site. Installation of sheet pile cofferdams may need to be designed for the presence of shallow bedrock. The contractor is responsible for the selection, performance and detailed design of the types of cofferdams and dewatering systems.