



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT**  
**for**  
**TRAP CREEK CULVERT REPLACEMENT**  
**HIGHWAY 129**  
**TOWNSHIP OF CHAPPISE, ALGOMA DISTRICT, ONTARIO**  
**GWP 5222-05-00**  
**SITE # 46-333/C**  
**WP 5231-05-01**

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PML Ref.: 14TF038  
Index No.: 087FIR and 088FDR  
GEOCRES No.: 410-17  
October 5, 2016



**PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT**

**for**

**TRAP CREEK CULVERT REPLACEMENT**

**HIGHWAY 129**

**TOWNSHIP OF CHAPPISE, ALGOMA DISTRICT, ONTARIO**

**GWP 5222-05-00**

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Record of Borehole Sheets: TC1 to TC4  
Results of Grain Size Distribution Analyses – Figures TC-GS-1 and TC-GS-2

***Peto MacCallum Ltd.***  
*C O N S U L T I N G   E N G I N E E R S*  
**PART A – FOUNDATION INVESTIGATION REPORT**  
Trap Creek Culvert Replacement  
Highway 129  
Township of Chappise, Algoma District, Ontario  
GWP 5222-05-00, Site # 46-333/C  
WP 5231-05-01

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## **1. INTRODUCTION**

This report presents the factual findings obtained from the geotechnical investigation carried out for the proposed replacement of culvert located at the crossing of Trap Creek and Highway 129 (Sta. 10+002.5) in the Township of Chappise, Algoma District, Ontario.

The fieldwork was carried out on December 17, 2014 and January 17, 2015. The purpose of the investigation was to explore the subsurface conditions expected to influence the preliminary design of the Trap Creek culvert replacement and to aid the designer in selecting the suitable type of replacement structure.

AECOM Canada Ltd (AECOM) has retained Peto MacCallum Ltd. (PML) on behalf of the Ministry of Transportation Ontario (MTO) to provide preliminary foundation engineering services for the replacement of seven culverts on Highway 129. The scope of this project involves providing subsurface information for the preliminary design of the proposed Trap Creek culvert replacement.

## **2. SITE DESCRIPTION**

The proposed replacement culvert is located approximately 50 m south of Highway 129 and Highway 556 junction. The existing culvert is oriented diagonally in the northwest to southeast direction at the intersection of Highway 129 and Sheppard Morse Road, which is a local gravel road. The topography of the project area is generally flat, except for the highway embankments. Trap Creek flows from east to west side of the Highway 129. Generally, the site surrounding the culvert is covered with bushes and grass. The area along the highway on both, north and south, sides is heavily wooded.

The existing twin culvert consist of double barrels, each with 2.7 m diameter corrugated steel pipes. The total span of the culvert is 5.4 m and overall length of 50 m with a fill height of 2.3 m above the crown. This twin culvert was constructed in 1981 and the road accommodates two



lanes of vehicular traffic. The inlet and outlet of the culvert were snow covered during the fieldwork and the conditions of the embankment or culvert could not be assessed.

### **3. FIELD INVESTIGATION PROCEDURES**

The staff of PML visited the site on December 11, 2014 and January 14, 2015 to mark out the borehole locations. The underground services at the borehole locations were cleared by the respective utility companies. Public and private utility authorities were informed and all the utility clearance documents were obtained before the commencement of drilling work.

The location of boreholes in the field were established by portable GPS device. Subsequently, exp Geomatics under contract to AECOM carried out the survey of the borehole locations and elevations, and provided the co-ordinates for locations in MTM NAD 83 northing and easting. PML used the survey data provided by AECOM for preparing this report. All elevations reported in this report are referred to Geodetic and expressed in meters.

The equipment used for drilling was owned and operated by Landcore Drilling of Chelmsford, Ontario. Landcore Drilling is a specialist drilling contractor was working under the full time supervision of a PML field supervisor. The investigation included advancing four (4) boreholes numbered TC1, TC2, TC3 and TC4 to maximum depths ranging from 6.7 m to 18.3 m (El. 432.4 to El. 423.8). Boreholes TC2 and TC3 were located on the paved area of the road and these boreholes were advanced using hollow stem augers aided by a truck-mounted CME-55 drill rig. Boreholes TC1 and TC4 were located at the inlet and outlet of the culvert, respectively. These two boreholes were advanced using tripod drill rig employing 75 mm diameter casings and wash boring method. Location of boreholes is shown on the attached Drawing No. TP-1.

Representative soil samples were recovered from the boreholes at 0.75 m intervals using a conventional 51 mm O.D split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Borehole TC2 was sampled to a maximum depth of 11.3 m. Below this depth, this borehole was advanced by conducting Dynamic Cone Penetration Test (DCPT) to a depth of 18.3 m where refusal to DCPT was encountered. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

The groundwater conditions at the borehole locations were observed during the drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition,



water level measurements were taken in open boreholes. Upon completion of drilling, the boreholes were backfilled with bentonite/cement grout in accordance with the MTO guidelines and MOE Regulation 903 for borehole abandonment procedures.

The recovered soil samples were returned to our laboratory for detailed visual examination, and index tests.

#### **4. LABORATORY TEST PROCEDURES**

Laboratory tests on representative SPT samples recovered during the fieldwork were carried out by the laboratory owned by PML, located in Toronto. The laboratory testing program included the following:

- Natural moisture content determinations (29)
- Grain size distribution analyses (9)

The laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow American Society for Testing Materials (ASTM) test procedures, with the exception of hydrometer test (LS-702). The results of the grain size distribution analyses tests are presented in Figures TC-GS-1 to TC-GS-3. All of the test results are summarized on the attached Record of Borehole sheets.

#### **5. SITE GEOLOGY AND SUBSURFACE CONDITIONS**

##### **5.1 Site Geology**

The project site lies in a deep valley located within Pre-Cambrian rock formations, which in this area consist mainly of granite and other intrusive rocks such as tonalite to granodiorite foliated to gneissic with minor supracrustal inclusions. During the last ice age, continental glaciers eroded much of the bedrock and laid down a shallow mantle of glacial debris that covered the area. Based on the Quaternary Geology map published by Ontario Ministry of Northern Development and Mines, the surface conditions in the vicinity of the project area consist of Glaciofluvial ice-contact deposits, which includes gravel, sand and, and minor till includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposit.



## **5.2 Subsurface Conditions**

The existing culvert is located within approximately 4.4 to 4.6 m high embankment consisting of rock and sandy fill placed over peat. In summary, the subsurface stratigraphy consists of 600 mm to 800 mm pavement structure followed by 3.8 m rock and sandy fill. The fill is underlain by layer of 1.5 m to 2.3 m peat deposit, which is followed by sandy silt to silty sand to the maximum sampling depth of 11.3 m (El. 430.6) below the grade of highway shoulders. Peat deposit ranging in thickness from 2.1 m to 2.7 m was encountered immediately below the surface in boreholes located at the inlet and outlet, and is followed by sandy silt to silty sand to the termination depth of 6.7 m (El. 432.1) below the ground surface. For classification purposes, the soils encountered at this site can be divided into four distinct zones.

- a) Pavement Structure
- b) Sand to Silty Sand, Occasional Cobbles (Fill)
- c) Peat
- d) Sandy Silt to Silty Sand, Trace Clay

### **5.2.1 Pavement Structure**

Asphalt layer, approximately 180 mm to 240 mm thick, was encountered in two of the boreholes (TC2 and TC3) located on the paved area. Pavement structure consists of gravelly sand with varying proportions of sand and gravel (base). The thickness of this granular base was observed to be about 420 mm to 560 mm and extends to a depth of 600 mm to 800 mm (El. 441.5 to El. 441.1).

### **5.2.2 Sand to Silty Sand, Occasional Cobles (Fill)**

This granular fill layer was encountered below pavement structure in borehole TC2 and TC3. The thickness of this fill was 3.8 m in both boreholes, and the fill extends to a maximum depth of 4.6 m (El. 437.3) below the existing grade. The SPT values in this fill layer varies from as low as 3 blows/300 mm to 27 blows/300 mm, indicating very loose to compact state of denseness.

The moisture content of this fill material varies from 8% to 17.7% with an average value of 12.0%. The results of the grain size distribution analyses performed on two representative samples from this fill layer are shown on Figure TC-GS-1. The test results reveal that the sand fill consists of 0% gravel, 90% to 91% sand, 9% to 10% silt.



### 5.2.3 Peat

This peat deposit was encountered immediately below the granular fill in Boreholes TC2 and TC3 and in Boreholes TC1 and TC4, it was intercepted immediately below the ground surface. Peat deposit in Borehole TC3 was observed to be laminated with thin seams of sand. The thickness of this peat deposit range from 1.5 m to 2.7 m, and extends to a maximum depth of 6.9 m (El. 435.0) below the existing grade of the road. The SPT values in this deposit range from 1 blow/300 mm to 6 blows/300 mm. As expected, moisture content of this deposit varies widely from 30% to as high as 188%.

### 5.2.4 Silty Sand to Sandy Silt, Trace Clay

The peat deposit is immediately underlain by sandy silt to silty sand layer with varying proportions of silt and sand. This layer extends to the maximum sampling depth of 11.3 m (El. 430.6). The SPT values in this deposit range from none to 12 blows/300 mm, indicating very loose to compact state of compaction. Presence of organics near the top of this layer were also observed. Borehole TC2 was extended below the sampling depth of 11.3 m (El. 430.8) by conducting Dynamic Cone Penetration test (DCPT) and the results are reported on the borehole log. Refusal to DCPT was encountered at a depth of 18.3 m (El. 423.8) below the existing grade of the highway. Based on the DCPT results, probably the loose to dense silty sand deposit encountered above El. 430.6 continues to the refusal depth of 18.3 m (El. 423.8)

The moisture content of samples tested from this layer varied from 18.1% to 23.2%. The results of the sieve analysis test performed on seven (7) representative samples from this deposit are provided on Figure TC-GS-2. The test results indicate that this deposit consists of 0% gravel, 37% to 69% sand, 30% to 61% silt and 1% to 2% clay.

### 5.2.5 Groundwater

The groundwater was observed during and upon completion of drilling. The groundwater levels were measured at a depth of 2.1 m to 3.0 m (El. 439.8 to El. 439.1) below the existing grade of the road. However, it was observed at a depth of 600 mm (El. 438.2) below the ground surface of the inlet and outlet.

The groundwater level may fluctuate due to the influence of precipitation and seasonal changes.





## 6. CLOSURE

Mr. F. Portela carried out the field investigations under the supervision of Ms. M. Kamranzadeh, M.Sc., EIT, Project Supervisor and Mr. C. M. P. Nascimento, P. Eng., Project Manager. LandCore Drilling Ltd. supplied the drilling equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Mr. Mansoor Khorsand, B.Sc., EIT. Project Supervisor and reviewed by Mark Vasavithasan, MSc. Eng., P.Eng. Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A blue ink signature of Mansoor Khorsand, written in a cursive style, is positioned above the name and title of the Project Supervisor.

Mansoor Khorsand, B.Sc., EIT.  
Project Supervisor, Geotechnical Services



Mark Vasavithasan, M.Sc. Eng., P.Eng.  
Senior Engineer, Geotechnical Services



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



## **APPENDIX A**

### Site Photographs



**Photograph P1:** Looking south-east at the location of Borehole TC1. (January 17, 2015)



**Photograph P2:** Looking north-east at the location of Borehole TC2. The local gravel paved road running toward east. (January 17, 2015)



**Photograph P3:** Looking north-east from Highway 129 northbound lane shoulder. Borehole TC3 advanced using a truck-mounted drill rig. The gravel paved road located on west side. (December 17, 2014)



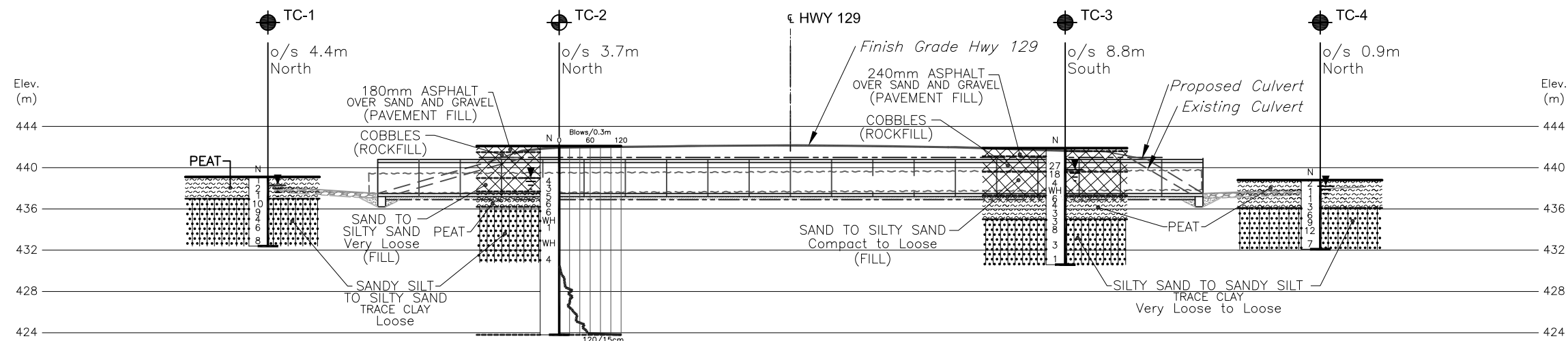
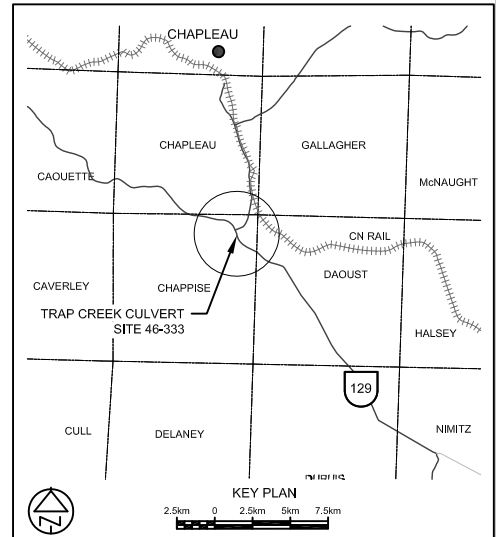


**Photograph P4:** Looking west from toe of Highway 129 embankment. Borehole TC4 was drilled at northeast of the culvert inlet. The inlet of the existing twin culvert is visible. (January 17, 2015)



## **APPENDIX B**

Borehole Locations Plan and Soil Strata at Trap Creek Culvert  
Explanation of Terms Used in Report  
Record of Borehole Sheets: TC1 to TC4  
Results of Grain Size Distribution Analyses – Figures TC-GS-1 and TC-GS-2



SCALE  
HORIZONTAL



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

BH No	ELEVATION	NORTHINGS	EASTINGS
TC-1	439.1	5 290 160.3	350 669.1
TC-2	442.1	5 290 155.5	350 682.4
TC-3	441.9	5 290 136.2	350 702.1
TC-4	438.9	5 290 141.9	350 716.8

- 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. XXX-XXX

HWY No 129				DISTSALT ST. MARIE	
SUBM'D	NA	CHECKED M.Kh	DATE OCT. 04, 2016		SITE 46-333/C
DRAWN	NA	CHECKED MV	APPROVED CN		DWG TC-1



REF AECOM Drawing: 6033379-P50.dwg dated June 2015



## 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/0.3m)	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:

R Q D (%)	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
$u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$n$	1, %	POROSITY	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$w$	1, %	WATER CONTENT	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	$D$	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$v$	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	$i$	1	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	$j$	kN/m <sup>3</sup>	SEEPAGE FORCE
$e$	1, %	VOID RATIO						

## RECORD OF BOREHOLE No TC-1

1 of 1

## METRIC

G.W.P.	5222-05-00	LOCATION	Trap Creek Coords: 5 290 160.3 N; 350 669.1 E	ORIGINATED BY	F.P.
DIST	Algoma	HWY	129	BOREHOLE TYPE	Tripod + Casing
DATUM	Geodetic	DATE	January 17, 2015	COMPILED BY	M.Kh.
				CHECKED BY	M.V.

[illegible]

**RECORD OF BOREHOLE No TC-2**

1 of 2

**METRIC**

G.W.P. 5222-05-00 LOCATION Trap Creek Coords: 5 290 155.5 N; 350 682.4 E ORIGINATED BY F.P.  
DIST Algoma HWY 129 BOREHOLE TYPE C.F.H.S.A. and Dynamic Cone Penetration Test COMPILED BY M.Kh.  
DATUM Geodetic DATE January 17, 2015 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)
442.1	Ground Surface						20	40	60	80	100						
0.0	180mm asphalt over sand and gravel (PAVEMENT FILL)		1	AS	-												
441.5	cobbles		2	AS	-												
0.6	(ROCKFILL)																
439.0	Sand to silty sand		3	SS	4	▽* ▼*											
3.1	Very Loose Wet		4	SS	3												
437.7	Peat, amorphous		5	SS	5												
4.4	Dark brown		6	SS	6												
436.2	Silty sand to sandy silt trace clay		7	SS	6												
5.9	Very loose Grey Wet to loose		8	SS	WH**												
			9	SS	1												
			10	SS	WH												
			11	SS	4												
430.8	End of borehole																
11.3	Switch to dynamic cone penetration at 11.3m																
	Probable silty sand																
	Loose to dense																

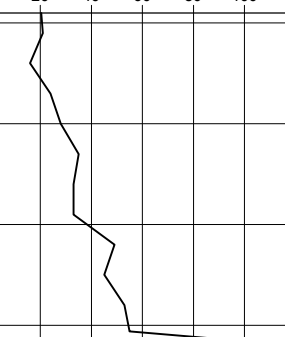
Cont'd

**RECORD OF BOREHOLE No TC-2**

2 of 2

**METRIC**

**G.W.P.** 5222-05-00      **LOCATION** Trap Creek      **Coords:** 5 290 155.5 N; 350 682.4 E      **ORIGINATED BY** F.P.  
**DIST** Algoma      **HWY** 129      **BOREHOLE TYPE** C.F.H.S.A. and Dynamic Cone Penetration Test      **COMPILED BY** M.Kh.  
**DATUM** Geodetic      **DATE** January 17, 2015      **CHECKED BY** M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
427.1								20 40 60 80 100		W <sub>P</sub>	W	W <sub>L</sub>	kN/m <sup>3</sup>	GR SA SI CL
15.0	Probable silty sand  Loose to dense  (Cont'd.)						427							
423.8	End of dynamic cone penetration test						424	120/15cm						
18.3	<div>* 2014 12 17</div> <div>▽ Water level observed during drilling</div> <div>▼ Water level measured on completion</div> <div>WH** denotes penetration due to weight of hammer and rods</div> <div>C.F.H.S.A. denotes Continuous Flight Hollow Stem Augers</div>													

**RECORD OF BOREHOLE No TC-3**

1 of 1

**METRIC**

G.W.P. 5222-05-00 LOCATION Trap Creek Coords: 5 290 136.2 N; 350 702.1 E ORIGINATED BY F.P.  
DIST Algoma HWY 129 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.Kh.  
DATUM Geodetic DATE December 17, 2014 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE										○		
								● QUICK TRIAXIAL      × LAB VANE												
441.9	Ground Surface						20	40	60	80	100	20	40	60						
0.0	240mm Asphalt over sand and gravel		1	AS																
	(PAVEMENT FILL)																			
441.1	cobbles		2	AS																
0.8																				
			3	SS	27							○								
	Sand to silty sand occasional cobbles		4	SS	18							○								
	Compact to loose Moist to wet (FILL)																			
			5	SS	4							○				0 90 (10)				
			6	SS	WH**							○								
437.3																				
4.6	Peat, amorphous sand and silt seams		7	SS	6								○							
	Dark brown																			
			8	SS	4															
			9	SS	3								○							
435.0																				
6.9	Sandy silt to silty sand trace clay		10	SS	3								○							
	Very loose Grey Wet to loose																			
			11	SS	8								○			0 69 30 1				
			12	SS	3								○							
			13	SS	1															
430.6																				
11.3	End of borehole																			

**RECORD OF BOREHOLE No TC-4**

1 of 1

**METRIC**

G.W.P. 5222-05-00 LOCATION Trap Creek Coords: 5 290 141.9 N; 350 716.8 E ORIGINATED BY F.P.  
DIST Algoma HWY 129 BOREHOLE TYPE Tripod + Casing COMPILED BY M.Kh.  
DATUM Geodetic DATE January 17, 2015 CHECKED BY M.V.

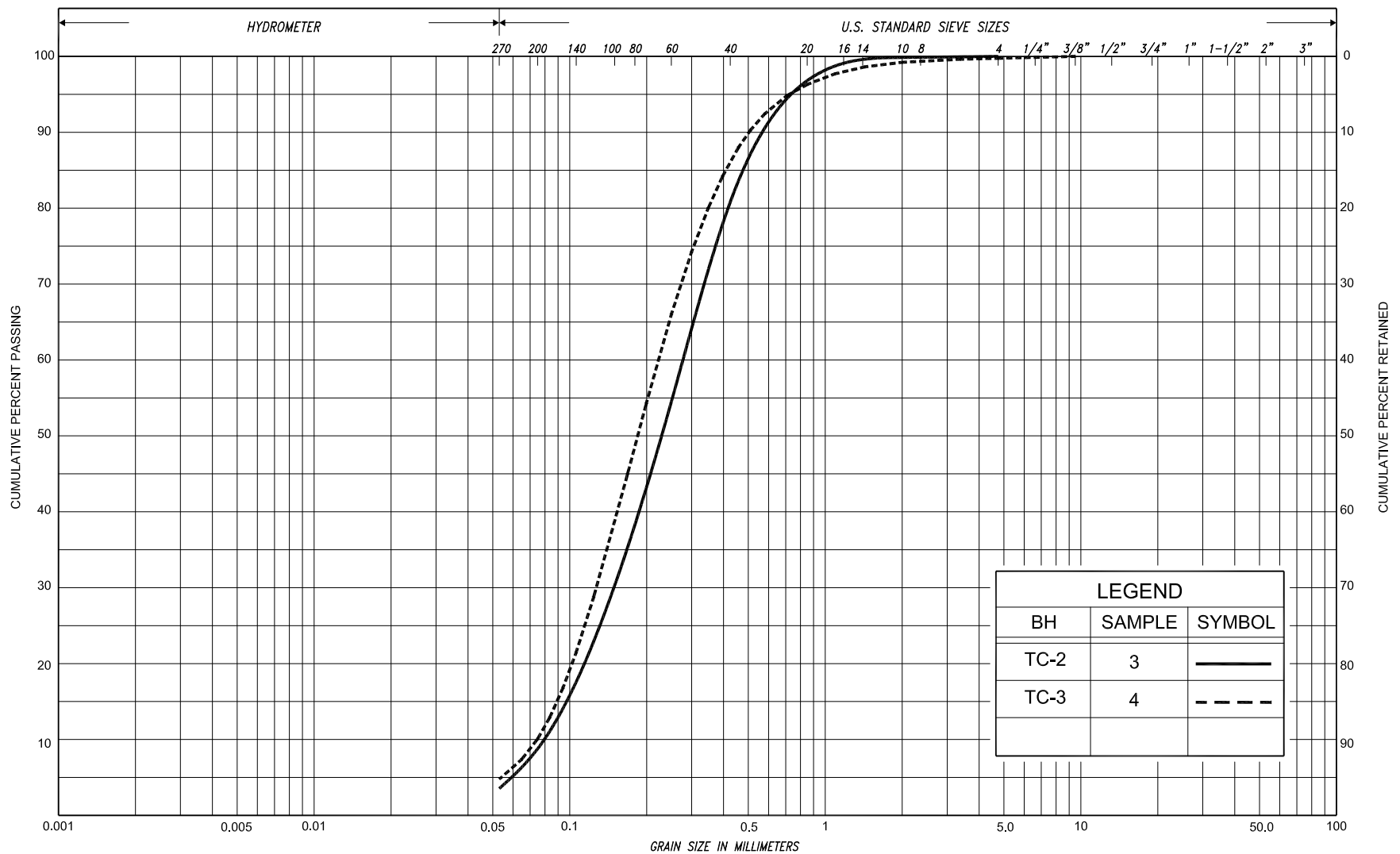
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE										○ QUICK TRIAXIAL      × LAB VANE		
								20	40	60	80	100						20	40	60
438.8	Ground Surface																			
0.0	Peat, fine fibrous  Dark brown  amorphous		1	SS	2		438													
			2	SS	1															
			3	SS	1															
			4	SS	3															
436.1	Silty sand to sandy silt trace clay  Loose to Grey Wet compact		5	SS	6			436										0 62 36 2		
6			SS	9																
7			SS	12																
8			SS	7																
432.1			End of borehole						433										0 46 52 2	
6.7																				

\* 2015 01 17

▽ Water level observed during drilling

▽ Water level measured on completion

NOTE: Borehole caved in at 1.5m



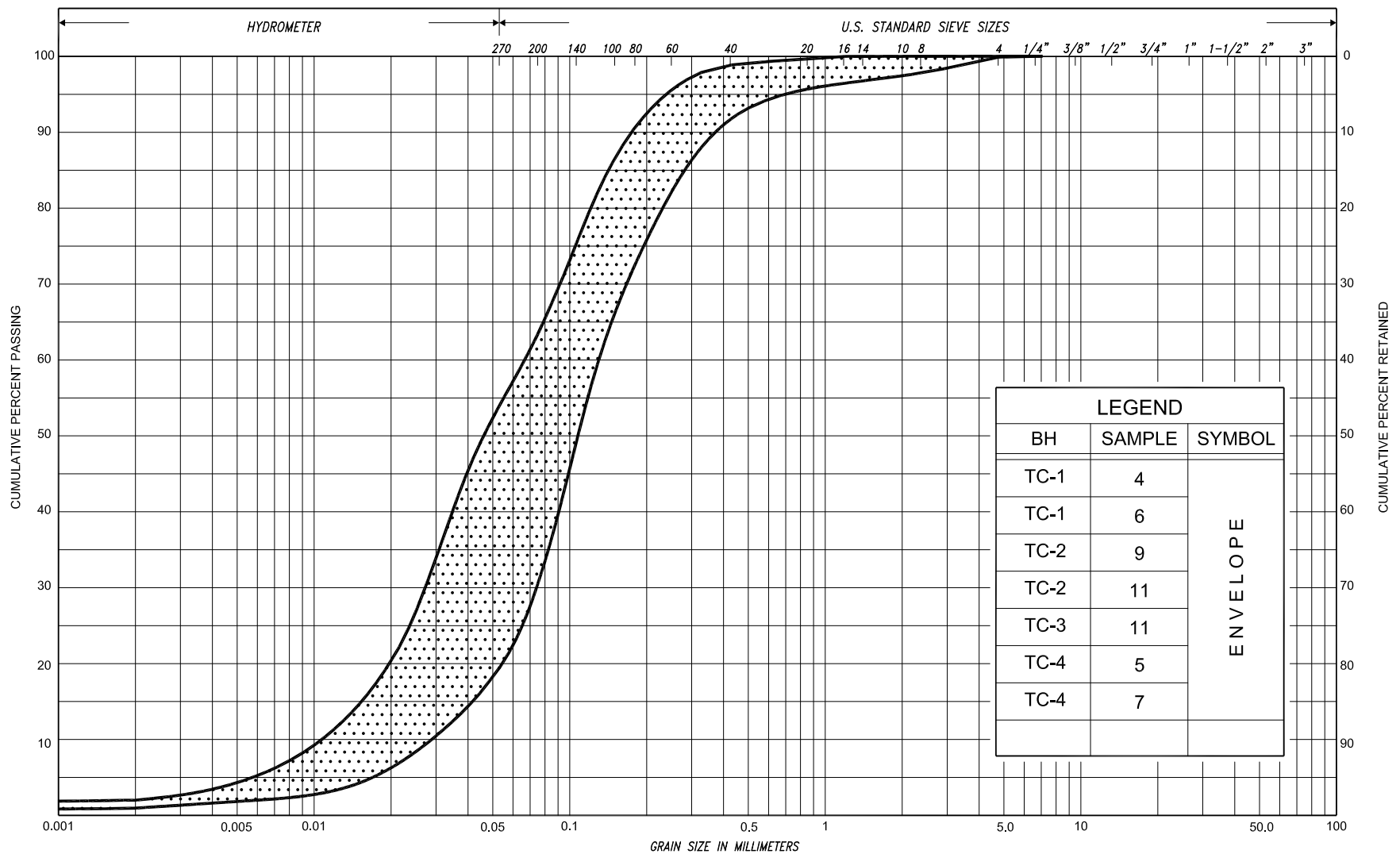
LEGEND		
BH	SAMPLE	SYMBOL
TC-2	3	—
TC-3	4	- - -

SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED		
					SAND												
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT																
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL						U.S. BUREAU	
					SAND												



# GRAIN SIZE DISTRIBUTION SAND TO SILTY SAND (FILL)

FIG No. TC-GS-1  
HWY: 129  
G.W.P. No. 5222-05-00



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED		
CLAY	FINE		MEDIUM		COARSE		SAND					GRAVEL			COBBLES	M.I.T.	
	SILT					FINE		MEDIUM		COARSE		GRAVEL					
CLAY		SILT			V. FINE		FINE		MED.		COARSE		GRAVEL			U.S. BUREAU	
							SAND										



## GRAIN SIZE DISTRIBUTION

SANDY SILT TO SILTY SAND, trace clay

FIG No. TC-GS-2

HWY: 129

G.W.P. No. 5222-05-00





**PART B – PRELIMINARY FOUNDATION DESIGN REPORT**  
**for**  
**TRAP CREEK CULVERT REPLACEMENT**  
**HIGHWAY 129**  
**TOWNSHIP OF CHAPPISE, ALGOMA DISTRICT, ONTARIO**  
**GWP 5222-05-00**  
**SITE # 46-333/C**  
**WP 5231-05-01**

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**PART B - FOUNDATION DESIGN REPORT**  
for  
Trap Creek Culvert Replacement  
Highway 129  
Township of Chappise, Algoma District, Ontario  
GWP 5222-05-00, WP 5231-05-01, Site # 46-333/C

---

**7. INTRODUCTION**

This foundation investigation and design report with the interpretation and recommendations are intended for the use of AECOM Canada Ltd on behalf of the ministry of transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The design-build contractor must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided only to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual information provided in Part A of the report, as it may affect equipment selection, proposed construction methods and scheduling.

**8. PROJECT DESCRIPTION**

**8.1 General**

This report provides preliminary foundation design recommendations based on interpretation of the geotechnical data presented in the factual report (Part A) to assist the design team in the selection of a suitable type of foundation for the culvert replacement at the crossing of Highway 129 and Trap Creek in the Township of Chappise, District of Algoma. Based on the General Arrangement drawings (GA) provided by AECOM, it is proposed to replace the existing twin barrels corrugated steel pipes culvert (CSPC) with a 3.0 m wide and 3.0 m high precast concrete box culvert.

The discussions and recommendations presented in this report are based on the GA received by PML and the factual data obtained during the preliminary geotechnical investigation carried out by PML. The designers must review the geotechnical data presented to determine the adequacy of the information for the detail design of the proposed structure. Additional geotechnical investigation must be carried out if the geotechnical data presented is inadequate.



## **8.2 Existing Culvert**

The proposed culvert to be replaced is located at the crossing of Trap Creek and Highway 129 (Sta. 10+002.5). The existing culvert consists of double barrels with total span of 5.4 m and 50 m long corrugated steel round pipe structure with a fill height of 2.3 m above the crown. Based on the GA drawing provided by AECOM, the invert of the existing culvert at the centerline of Highway 129 (Sta. 10+000) is located at approximate elevation of El. 437.50 and the embankment above the creek bed is approximately 4.7 m high. There is no riprap on either side of the creek, i.e., inlet or outlet, to protect against scour or erosion. A review of the Google Earth Map indicates that the toe of the embankment on both sides of the culvert is eroded and undermined. The inlet side of the culvert has been eroded severely.

This culvert was constructed in 1981 and the road accommodates two lanes of vehicular traffic. The RFP reveals that the condition of the existing culvert is poor with minor deterioration of several elements of the culvert. Further, significant deterioration of the culvert barrel, barrier posts and the structural steel coating require replacement of the existing culvert.

## **8.3 Proposed Culvert**

The RFP specifies that the viability of the following three options required to be evaluated for replacing the existing culvert along the same vertical and horizontal alignments:

- Replacement with a precast concrete box culvert,
- Replacement with a cast-in-place concrete box culvert, and
- Replacement with a three-sided open footing concrete culvert.

Further, it requires that the new culvert shall be designed to be as short as possible with concrete headwalls and wing walls to contain the roadway embankment.

However, the GA provided by AECOM indicate that the proposed replacement structure will be a 40.0 m long precast concrete box culvert with an opening size of 3.0 m in span, 3.0 m in rise and a wall thicknesses of 300 mm. The proposed replacement culvert is 10.0 m shorter than the existing and does not include headwalls or wing walls on the GA provided to PML. The floor of the proposed box culvert will have no gradient and the invert at the inlet and outlet will be maintained at the same elevation (El.437.5). The founding level of the subgrade at the inlet and outlet is proposed to be at El. 436.90. It is proposed to construct the replacement culvert along the same



vertical and horizontal alignment and grade of the road at the culvert location will be maintained at the existing elevation of El. 442.21, which will result in fill height including the pavement structure of 1.4 m above the box culvert, compared to 2.3 m high fill above the existing culvert.

There is no local detour available to divert the traffic and the construction of the replacement culvert will be carried out in two stages by allowing the traffic to use one side of the highway. A properly designed temporary roadway protection along the centerline of the road will be required.

#### **8.4 Structure Foundation**

In summary, the subsurface stratigraphy at the proposed culvert generally consists of 4.4 m to 4.6 m sandy fill with occasional cobbles, followed by 1.5 m to 2.0 m peat below the highway embankment and extends to El. 435.0. The peat deposit is underlain by sandy silt to silty sand, which extends to the borehole termination depth of 11.3 m. Peat deposit ranging in thickness from 2.1 m to 2.7 m was observed immediately below the surface in Boreholes TC1 and TC4 located near the outlet and inlet of the culvert, respectively. The peat is followed by sandy silt to silty sand deposit, which extends to the borehole termination depth of 6.7 m (El. 432.1). The groundwater level was observed between El. 439.8 and El. 438.2 during the fieldwork. However, the GA drawing indicate an approximate creek water level of El. 438.6 in September 2014, which is about 1.2 m lower than the highest groundwater level observed during the investigation.

Considering the subsoil conditions, the recommendations for the replacement culvert are provided below in the order of preference. A comparison of the technical advantages and disadvantages for the replacement culvert are presented in Appendix D. The discussions with AECOM suggests that option of using pipe culvert (CSP) need not be considered. Therefore, this report does not include any discussion on the option of using CSP culvert.

##### **8.4.1 Option 1: Precast Concrete Box Culvert**

Based on the GA drawing, it is assumed that the precast box culvert will be placed at about elevation El. 436.9±. The subsoil below the proposed founding level consists of peat to a depth of 1.9 m (El. 435.0) and is not capable of supporting the proposed box culvert. The peat deposit encountered down to El. 435.0 shall be removed and replaced with Granular B Type II up to the proposed founding level of El. 436.9. The sub-excavation of peat shall extend to a distance of at least 1.0 m from the external face of the culvert invert and sloped at 1H:1V to the bottom of



excavation, i.e., El. 435.0. The proposed excavation will result in a total width of at least 5.6 m at the invert level and it will be at least 9.4 m at the bottom of excavation.

If the construction is carried out under water, the replacement fill shall consist of Granular B Type II containing particle sizes no finer than 75  $\mu\text{m}$ . However, Granular B Type II may be used if the construction is carried out in the dry, and the replacement fill shall be placed in layers not exceeding 200 mm in thickness before compaction and compacted in accordance with OPSS 501.

The option of a precast box culvert will require at least 75 mm of levelling course meeting the requirement of OPSS 422.07.08 and bedding material as specified in OPSS 422.05.13. The bedding for the replacement culvert should be placed in accordance with Section 422.07.07 of OPSS 422.

As required by Clauses 1.9.5.6 and 1.9.11.6.5 of Canadian Highway Bridge Design (CHBDC, 2014), cut-off walls at both ends of the culvert shall be provided. Cut-off walls shall be in accordance with OPSD 812.010 or made of precast concrete with similar dimensions to prevent washout of granular bedding with provision to protect the loose sandy subgrade material below invert. For the design of the 3.6 m wide precast box culvert, a geotechnical resistance of 120 kPa at U.L.S and 80 kPa at S.L.S shall be utilized. The design should meet the requirements of Clauses 1.9.5.6 and 1.9.11.6.5 of CHBDC, 2014.

There will be no grade raise of the road to impose additional load on the culvert to cause settlement. Considering the very loose to loose sandy material below the invert, the settlement induced by the bearing resistance at SLS recommended will be about 40 mm to 50 mm and most of the settlement will occur upon completion of construction. Continuing settlements to cause any differential settlements is expected to be within the tolerable limit for the proposed box culvert.

#### 8.4.2 Option 2: Cast-in-Place Reinforced Concrete Box Culvert

The loose sandy material encountered below the proposed founding level extends to more than 16.0 m (El. 426.0). Subsoil condition at this site is not favorable or capable of providing adequate geotechnical resistance for supporting cast-in place reinforced concrete culvert at the proposed invert level. Considering the depth of loose sandy material below the invert, it is not cost effective or practical to excavate and replace with lean concrete to support the culvert. In addition, construction under 3.0 m of ground water will impose greater difficulties for construction in dry conditions. In view of the subsoil conditions, deep foundation such as piles will be required if



option of using cast-in-place reinforced concrete box culvert is considered. For these reasons, this option is not preferred.

#### 8.4.3 Option 3: Three-Sided Open Precast Concrete Culvert on Strip Footing

The loose sandy material encountered below the proposed founding level of the replacement culvert is susceptible for scour. Section C1.9.11.1 of the Canadian Highway Bridge Design Code commentary (CHBDC, 2014) suggests avoiding placing open footing on material that is susceptible to scour. Same as in Option 2, use of deep foundation will be required for supporting strip footing.

If Options 2 and 3 are considered, additional investigation will be required to establish the bedrock elevation.

#### 8.4.4 Recommended Option for Culvert Replacement

From a geotechnical perspective and based on the subsurface conditions, precast concrete box culvert placed at about EI 436.9 is the preferred option for the replacement of the existing culvert.

Option 2 and 3 are technically feasible but not cost effective or practical. Considering the construction difficulties and cost of deep foundation, these two options are not recommended.

#### 8.4.5 Lateral Earth Pressure

Earth pressure for the concrete structure should be computed as per the Clause 6.12.2 (b) of Canadian Highway Bridge Design Code (CHBDC, 2014). Sufficient movement of the structure wall may not be permitted for all three options and “at rest” conditions may be assumed for the calculation of earth pressure. The earth pressure calculation should include maximum water level expected in the creek. The lateral earth and water pressure,  $p$  (kPa), may be computed using the equivalent fluid pressures presented in Section 6.12 of the CHBDC 2014 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
- $\gamma$  = unit weight of backfill material above design water level (kN/m<sup>3</sup>)
- $\gamma'$  = unit weight of submerged backfill ( $\gamma - \gamma_w$ ) material below design water level (kN/m<sup>3</sup>)
- $\gamma_w$  = unit weight of water (9.8 kN/m<sup>3</sup>)
- h<sub>1</sub> = depth below final grade (m), above design water level
- h<sub>2</sub> = depth below design water level (m)
- q = Surcharge load (kPa)
- C<sub>p</sub> = compaction pressure (refer to Clause 6.12.3 of CHBDC, 2014)
- C<sub>s</sub> = earth pressure induced by seismic events, kPa  
(refer to clause 4.6.5 of CHBDC, 2014)

Where,

- Ø = angle of internal friction of retained soil (35° for Granular A or B Type II)
- δ = angle of friction between soil and wall (24° for Granular A or B Type II)

The seismic site coefficient for the conditions at this site is provided in Section 10 of this report. Granular 'A' or 'B' should be utilized as backfill material and should be carried out in accordance with the requirements specified in the OPSS 902. The following parameters are recommended for the granular backfill:

**Table 8.4.5: Recommended Geotechnical Parameters**

GEOTECHNICAL PARAMETER	GRANULAR 'A'	GRANULAR B TYPE II
Angle of Internal Friction, degrees	35°	30°
Unit Weight, kN/m <sup>3</sup>	22.5± 0.3	21.5 ± 0.3
Coefficient of Active Earth Pressure (K <sub>a</sub> )	0.27	0.33
Coefficient of Earth Pressure at Rest (K <sub>o</sub> )	0.43	0.5
Coefficient of Passive Earth Pressure (K <sub>p</sub> )	3.69	3

Backfill shall be placed simultaneously behind both sides of the culvert, maintaining the height of backfill approximately the same. At no time should the difference in backfill elevation from one side to the other be greater than 500 mm.

## 8.5 Approach Embankment

The height of the existing approach fill is approximately 4.7 m above the creek bed. PML understands that there will be no increase in the profile grade of the road and it will be maintained at El. 442.21. No major instability problems are anticipated for the embankment constructed with





2H:1V side slope. Considering the high water level, the fill should consist of well compacted granular material, preferably Granular B Type II. Any spongy or soft area observed within the base of the embankment should be removed before placing the fill. Rip-rap should be provided on both the upstream and downstream sides of the creek to protect the toe of the embankments and to prevent erosion of creek bed in the proximity of the culvert. Rip-rap shall be in accordance with OPSD 810.010 and provided to a minimum height of 1.0 m above the high flood level expected in the creek.

## **9. FOUNDATION FROST DEPTH**

In accordance with OPSD 3090.101, a minimum of 2.3 m earth cover is required to protect against the frost penetration in the area where the site is located.

Frost tapers within the granular backfill should be constructed in accordance with OPSD 3101.150. The frost penetration depth,  $f$ , is measured from the top of the grade to the bottom of the footing.

## **10. SEISMIC CONSIDERATIONS**

The reference Peak Ground Acceleration (PGA) for the project site is 0.036 based on the Town of Chapleau, Ontario (National Building Code of Canada, 2015). The soil at this site for seismic design purposes is classified as Type E in accordance with Clause 4.4.3.2, CHBDC 2014.

### **10.1 Cover and Backfill**

Backfill materials shall meet the requirements of Group I, or Group II specified in OPSS 422.05.14, Table 1 and placed according to the procedures described in Section 422.07.11. It shall be placed in layers not exceeding 200 mm in thickness before compaction and compacted in accordance with OPSS 501. Backfill on each side of the box culvert shall be completed simultaneously and at no time, the levels on each side of the culvert exceeds more than 400 mm. Restrictions on compaction near the culvert shall be as specified in OPSS 902.07.06.02.

Cover material shall meet the requirements of OPSS 422.05.14 and placed in accordance with OPSS 422.07.12.



## **11. CONSTRUCTION CONSIDERATIONS**

### **11.1 Excavation**

Staged construction with a roadway protection system will be required to remove the existing culvert and to install the new culvert while maintaining traffic on Highway 129. Surface water should be diverted away from open excavations and all excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO Regulations for Construction Projects. The protection system for excavations should be in accordance with OPSS 539, Construction Specification for Temporary Protection Systems, and OPSS 902, Construction Specifications for Excavating and Backfilling – Structures. Excavated material shall not be stockpiled on top of the excavation.

Based on the record of boreholes, the excavations for the construction of replacement culvert will be advanced through existing granular fill material underlain by peat and native sandy deposit. For OHSA classification purposes, the fill materials and loose sandy deposit should be classified as Type 3 soils. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation.

### **11.2 Staged Construction**

The construction of culvert replacement is expected to be carried out in two stages. The subsoil conditions encountered at this site, with the exception of fill with occasional cobbles, is favourable for driving sheet piles to design and construct a shoring system to maintain traffic on Highway 129. The cobbles and boulders within the fill will have to be removed to prevent obstructions for driving the sheet piles. A shoring system consisting of sheet pile wall with strutted excavation may be feasible. Alternatively, shoring system consisting of soldier piles and timber laggings supported by rock anchors may be considered. This type of shoring system will be very costly for the type of proposed structure and additional investigation will be required to establish the bedrock elevation and quality of the rock.

Temporary roadway protection shall be designed to meet a Performance Level of 2 and constructed in accordance with OPSS 539 (Temporary Protection Systems). Additional foundation investigation may be required to determine the type and method of installation of temporary roadway protection system.



## **12. GROUNDWATER CONTROL**

The groundwater level was encountered between El. 439.8 and El. 438.2 and the excavation to the founding level will have to be carried out under 2.9 m high water level. The groundwater level should be lowered to a minimum of 0.5 m below the proposed founding levels to allow for construction in the dry and to place bedding materials.

The creek may have to be temporarily diverted and a cofferdam may be required due to the relatively pervious nature of the subsoil. A cofferdam consisting of sheet pile walls may be utilised for excavation and dewatering. Alternatively, a cofferdam consisting of sand bags and clay puddle may be constructed by damming the upstream and downstream of the culvert. Dewatering may be carried out from the sumps located along the periphery of the cofferdam. If any environmental restrictions are imposed on placing clay puddle in the creek, the culvert replacement may have to be constructed under the prevailing water level. If the construction is carried out under water, the backfill material shall consist of Granular B Type II containing particle sizes not finer than 75 µm.

The contractor shall be responsible for the selection, performance and detailed design of the dewatering system including the cofferdam. The dewatering system should be designed to conform to the requirement of OPSS 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation) and OPSS 518 (Construction Specification for Control of Water from Dewatering Operations) in addition to the NSSP provided in Appendix E.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

## **13. SCOPE OF ADDITIONAL INVESTIGATION AND DESIGN SERVICES**

The recommendations in this report are preliminary. Detailed foundation engineering services will be required during the Detail Design phase of the project.

The extent of further investigations at this site should include a minimum of 2 boreholes on the Highway 129 for recommendations on roadway protection. The boreholes should extend to sufficient depth to provide information for shoring and dewatering. It is recommended that the boreholes extend at least 3.0 m into bedrock if it is encountered.



#### 14. CLOSURE

Mr. F. Portela carried out the field investigations under the supervision of Ms. M. Kamranzadeh, M.Sc., EIT, Project Supervisor and Mr. C. M. P. Nascimento, P. Eng., Project Manager. LandCore Drilling Ltd. supplied the drilling equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Mr. Mansoor Khorsand, B.Sc., EIT. Project Supervisor and reviewed by Mark Vasavithasan, MSc. Eng., P.Eng. Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

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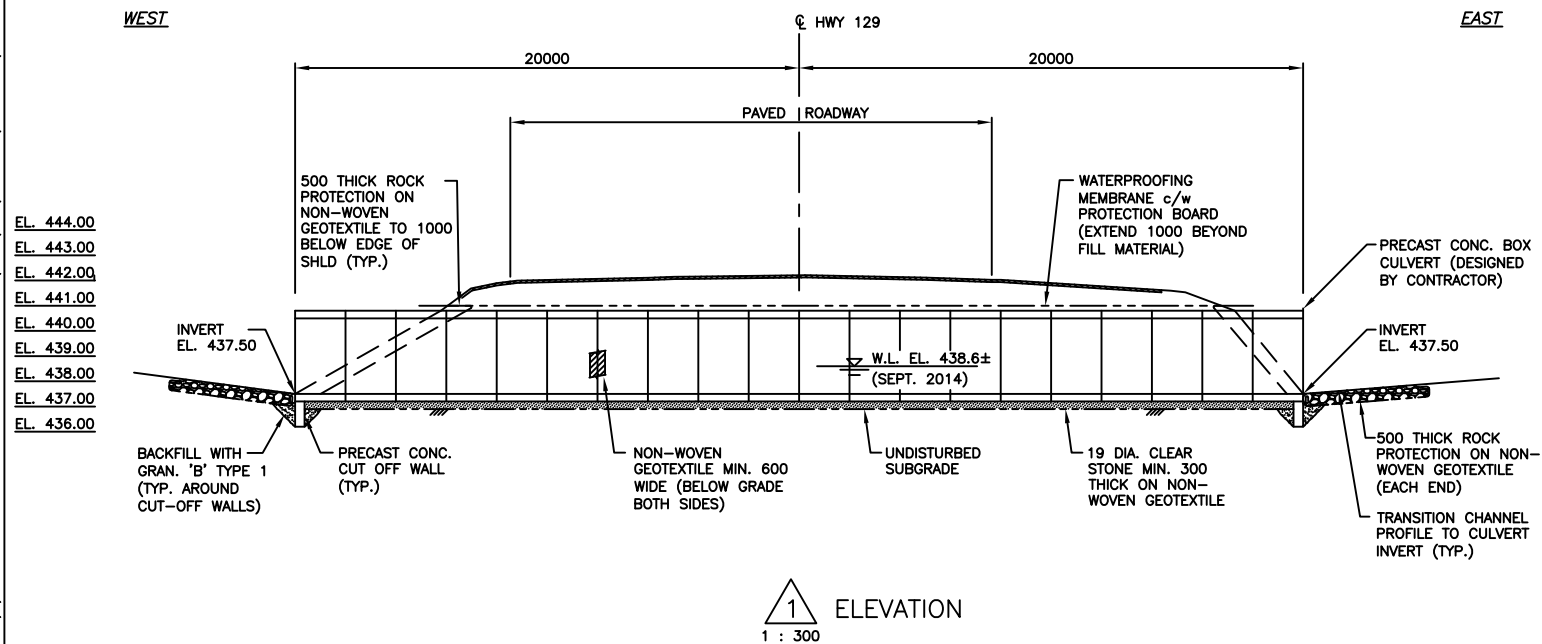
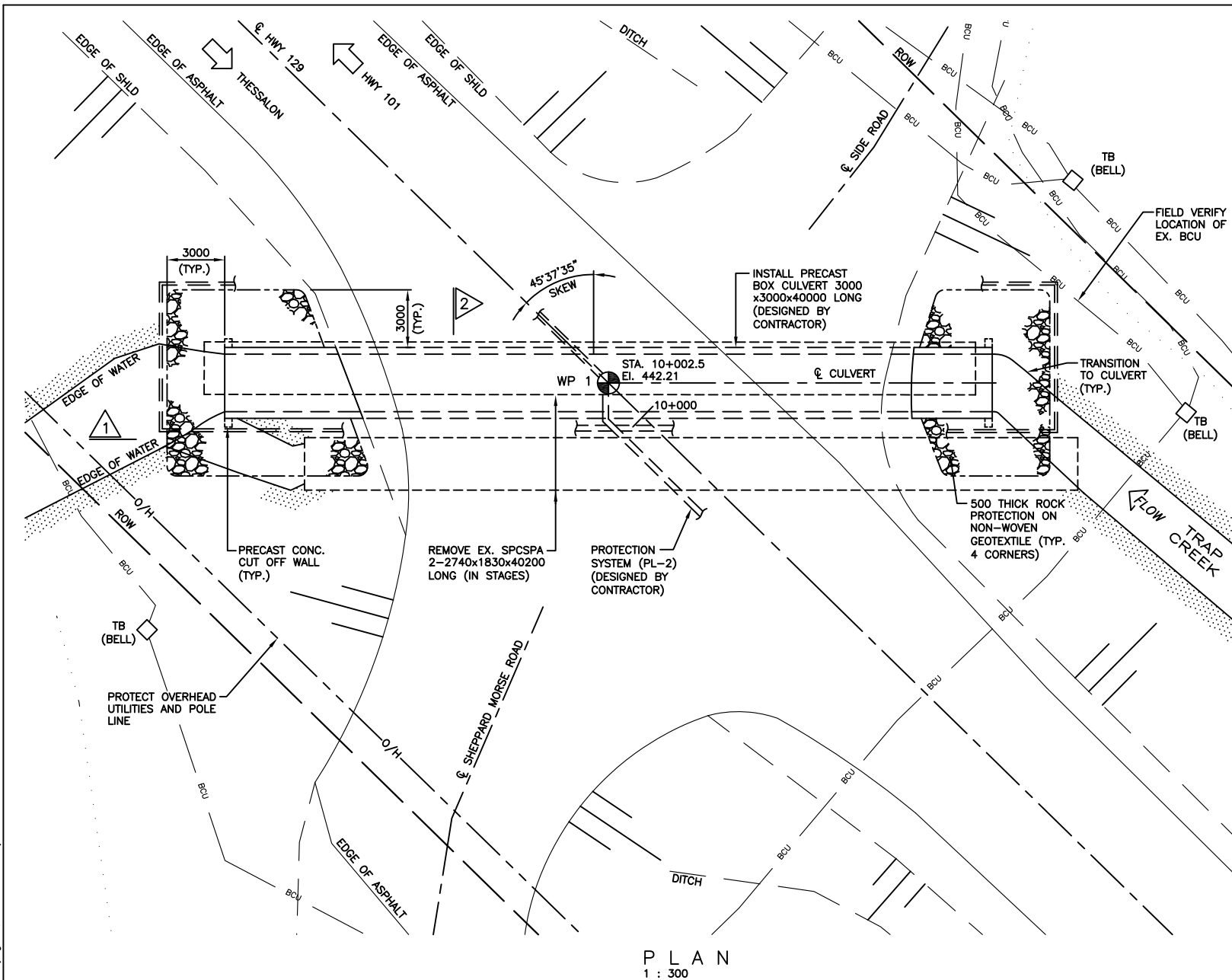
AK/MV/CN:nk



## **APPENDIX C**

### Trap Creek Culvert General Arrangement

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METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

HWY 129 CONT No WP No 5231-05-01	
TRAP CREEK CULVERT STA. 10+000, DAOUST TWP. GENERAL ARRANGEMENT	SHEET
AECOM	

GENERAL NOTES :

1. CLASS OF CONCRETE : PRECAST 40 MPa
2. CLEAR COVER TO REINFORCING STEEL : PRECAST 50 ± 10
3. REINFORCING STEEL :
  1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
  2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL SHALL BE CLASS B.
  3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.
4. GEOTEXTILE :
  1. NON-WOVEN, CLASS II, FOS 50 TO 100µm.

CONSTRUCTION NOTES :

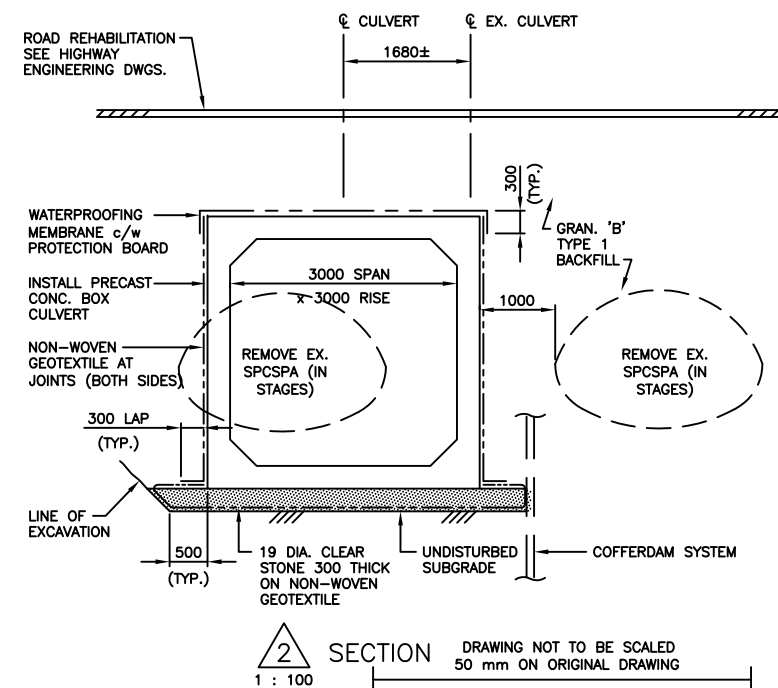
1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS OF THE EXISTING WORK AND ALL DETAILS ON SITE AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE PROCEEDING WITH THE WORK.
2. THE CONTRACTOR SHALL CARRY OUT SITE SURVEYS TO DETERMINE THE EXISTING ELEVATIONS OF ASPHALT PRIOR TO REMOVALS.
3. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH CULVERT WALLS, KEEPING THE HEIGHT OF BACKFILL APPROXIMATELY THE SAME, AT NO TIME SHALL THE DIFFERENCE IN BACKFILL HEIGHTS BE GREATER THEN 200mm.
4. ALL SITE ACCESS TO COMPLETE THE WORK IS THE RESPONSIBILITY OF THE CONTRACTOR.

APPLICABLE STANDARD DRAWINGS :

OPSD 3941.200 FIGURES IN CONCRETE, SITE NUMBER, AND DATE, LAYOUT

LIST OF ABBREVIATIONS :

BCU	BELL CONDUIT UNDERGROUND	SBGR	STEEL BEAM GUIDE RAIL
CL	CENTRELINE	SHLD	SHOULDER
CONC.	CONCRETE	SPCSP	STRUCTURAL PLATE CORRUGATED STEEL PIPE
c/w	COMPLETE WITH		
DIA.	DIAMETER		
DWG.	DRAWING	STA	STATION
EL.	ELEVATION (METRES)	TYP.	TYPICAL
EX.	EXISTING	T/P	TOP OF PAVEMENT
MIN.	MINIMUM	W.L.	WATER LEVEL
ROW	RIGHT OF WAY		



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	J.P.	CHK G.M.	CODE CHBDC 2006 LOAD CL.-625-ONT
DRAWN	T.G.	CHK J.P.	SITE 46-333/C
			STRUCT
			SCHEME
			DWG P1



## **APPENDIX D**

### Comparison of Alternate Culvert Options



## COMPARISON OF ALTERNATE CULVERT OPTIONS

Option 1: Precast Concrete Box Culvert	Option 2: Cast In-Place Concrete Box Culvert	Option 3: Three-Sided Open Culvert
<b>Advantages:</b> 1. High degree of quality and uniformity, design flexibility, superior strength and durability 2. Reduced weather dependency during installation 3. Reduced impact on traffic interruption 4. Ease of construction and installation in wet conditions are possible	<b>Advantages:</b> 1. Reduces uneven settlement 2. Reduces water leakage and deterioration of culvert 3. Ability to withstand differential settlements 4. Longer life span of the structure 5. Degradation of subgrade can be avoided 6. Replacing of overburden with concrete can be done under water using tremie	<b>Advantages:</b> 1. Generally allows for natural streambed to remain intact 2. Less accumulation of sediments in the upstream of channel 3. Permits the removal of overburden within the width of footing 6. Ease of installation for precast open culvert 7. Natural stream bed may be maintained
<b>Disadvantages:</b> 1. Natural stream bed will not remain intact 2. Cause sediment accumulation in the upstream of the channel 3. Higher cost for removal of overburden below groundwater level 4. Possibility for degradation of subgrade	<b>Disadvantages:</b> 1. Natural stream bed will not remain intact 2. Cause sediments accumulation in the upstream of the channel 3. Very high cost for removal of overburden and to replace with lean concrete. Weather dependent during construction 5. Major dewatering scheme is required to construct the floor slab under 3.0 m high water 6. Adequate geotechnical resistance is not available near the proposed invert level 7. Significant depth of excavation and replacement with concrete	<b>Disadvantages:</b> 1. Increased impact on commuting and longer interruption of traffic 2. Weather dependent during construction 3. Adequate geotechnical resistance is not available near the proposed invert level 4. Significant depth of excavation and replacement with concrete
<b>Cost of Construction:</b> Total Cost \$ 13,000/m	<b>Cost of Construction:</b> Realistic estimate not feasible	<b>Cost of Construction:</b> Realistic estimate not feasible
<b>Recommended</b>	<b>Not practical and cost effective; Not Recommended</b>	<b>Not practical and cost effective; Not Recommended</b>





## **APPENDIX E**

### List of Standard Specifications Relevant to Report Non-Standard Special Provisions (NSSP)



## LIST OF STANDARD SPECIFICATIONS RELEVANT TO 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 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 518	Construction Specification for Control of Water from Dewatering Operations
OPSS 539	Temporary Protection Systems
OPSS 902	Excavation and Backfilling of Structures
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
OPSD 812. 010	Cut Off Wall for Structural Plate Pipe Arch and Circular CSP
OPSD 3090.101	Foundation, Frost Penetration depths for Southern Ontario
OPSD 3101.150	Walls Abutment, Backfill Minimum Granular Requirement



## **NON-STANDARD SPECIAL PROVISIONS (NSSP)**

### **NSSP – Surface Water Control and Dewatering (Addition to OPSS 518)**

The Contractor shall take measures for necessary surface water diversions and drainage and to lower the prevailing groundwater level a minimum of 0.5 m below the base of the excavations for work in-the-dry in overburden and to the bedrock surface for work in-the-dry in bedrock, if applicable.

In view of the relatively pervious subsoil conditions encountered at this site, the dewatering design and the implementation should prevent unsafe conditions, such as sloughing and boiling under unbalanced groundwater conditions. Although the Contractor shall be responsible for designing and implementing measures for surface water control and dewatering, the Contractor is also advised that damming of the drain and diversion of the flow by pumping through temporary conduits for construction staging will likely be required at this site.

### **NSSP – Installation of Shoring of Roadway Protection (Addition to OPSS 539)**

The Contractor is advised that cobbles and/or boulders may be encountered during the installation of shoring elements and during excavation of the embankment. The Contractor shall select and use the appropriate methods for shoring installation and excavations to account for such possible obstructions.