



**FOUNDATION INVESTIGATION AND DESIGN REPORT
for
UTILITY PROTECTION/RELOCATION THROUGH HYDRO CORRIDOR
HIGHWAY 427 EXTENSION THROUGH HYDRO CORRIDOR
RETAINER ASSIGNMENT – TASK NO. 2013-E-0039-004
MTO FOUNDATION WO # 2014-11021
CITY OF VAUGHAN, ONTARIO**

PREPARED FOR MINISTRY OF TRANSPORTATION OF ONTARIO

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PML Ref.: 14TF024
Index No.: 010FIR and 011FDR
GEOCRES No.: **30M13-205**
November 28, 2014



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Figure HC-GS-1 – Grain Size Distribution Charts

Figure HC-PC-1 – Plasticity Charts

Explanation of Terms Used in Report

Record of Borehole Sheets

Drawing HT-1 – Borehole Locations

Drawing HT-2 – Schematic Alternative Sketches

FOUNDATION INVESTIGATION REPORT
For
Highway 427 Extension through Hydro Corridor
Retainer Assignment – Task No. 2013-E-0039-004
City of Vaughan, Ontario

1. INTRODUCTION

This report summarizes the results of a foundation investigation carried out for the detail design of for the proposed retaining structures to protect the identified hydro tower foundations in proximity of the proposed Highway 427N alignment as required in the terms of reference for this assignment.

Peto MacCallum Ltd. (PML) prepared this report for the Ministry of Transportation of Ontario (MTO) as Retainer Assignment – Task No. 2013-E-0039-004.

The retaining structures / deep cuts (including reinforced slopes) are proposed to protect the existing hydro towers within the project limits during the north extension of Highway 427. In addition, the results of the foundation investigation were considered in the presentation of related conceptual options for consideration to achieve the hydro crossing over the proposed Highway 427N extension other than retaining walls.

The purpose of this investigation report is to summarize the subsurface stratigraphy encountered along the Highway 427 extension area and through the hydro corridor.

2. SITE DESCRIPTION AND GEOLOGY

The site is located in the City of Vaughan, approximately 150 m north of Langstaff Road and about 800 m west of Highway 27. The site is generally flat farmland except toward the southwest where a construction site is located and toward the northeast where a small area is covered by woods and bushes. Currently, three high voltage hydro lines (500, 500 and 230 kV) pass through the site in a south to north direction.



Physiographically, the site is located in the region known as the Peel Plain. The underlying geological material of the plain is a till containing large amounts of shale and limestone. In much of the Peel Plain this has been modified by a veneer of clay which, occasionally when deep enough, is seen to be varved.

3. INVESTIGATION PROCEDURES

The field work for this study was carried out on August 11 to 13, 2014. The investigation included five boreholes all drilled to 9.8 m depth and located as shown on Drawing 1 attached.

The borehole locations were established in the field by the MTO and were strategically located to provide a minimum safe distance between the drilling equipment and the hydro lines. The borehole locations and elevations were surveyed by the MTO and PML. All elevations in this report are expressed in metres.

The boreholes were advanced using continuous flight solid stem augers, powered by a track-mounted CME-75 drill rig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of PML's engineering staff.

Representative soil samples were recovered from the boreholes at regular 0.75 or 1.5 m depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. Pocket penetrometer tests were performed on stiffer clay samples.

The groundwater conditions at the borehole location were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, when appropriate by measurement of the water level in the open borehole.

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.



Soils were identified in the field accordance with the MTO Soil Classification procedures. The recovered soil samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determination in addition, the laboratory testing program included the following:

- Grain size distribution analyses (13)
- Atterberg Limits Testing (13)

The results of the laboratory grain size distribution analyses and Atterberg Limits Testing are presented in Figures HC-GS-1 and HC-PC-1, respectively. All of the test results are summarized on the Record of Borehole sheets.

4. SUMMARIZED SUBSURFACE CONDITIONS

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

The borehole locations are shown on Drawing HT-1. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the stratigraphic boundaries are assumed and may vary. Refer to Drawing HT-2 for conceptual alternative cross-sections related to retaining walls.

The subsurface stratigraphy revealed in the boreholes comprised a 400 to 2200 mm thick surficial fill layer underlain by a firm to hard clayey silt till that extended to the uniform borehole termination depth of 9.8 m. Groundwater was at 7.3 m depth (elevation 180.4) in one borehole upon completion of drilling.



4.1 Fill

A 0.4 to 2.2 m thick fill layer was present surficially in all the boreholes and extended to elevation 185.5 m to 187.8 m. The composition of this surficial fill was variable, due to farming included approximately 400 to 1400 mm topsoil inclusion, rootless and organics. The inorganic soil component included mixed silty sand, clayey silt and silty clay. The fill was loose/firm to very stiff (STP - 'N' values of 5 to 12) and moist (moisture content of 14 to 31%).

4.2 Clayey Silt Till

A clayey silt till deposit was encountered below the fill materials at a depth of 0.4 to 2.2 m (elevation 185.5 to 187.8 m) and extended to the termination depth of 9.8 m (elevation 177.9 to 179.2 m) in all the boreholes. Cobbles or boulders were contained within the deposit in boreholes 11 to 13. The deposit was very stiff to hard, with SPT-'N' values of 10 to 58 and shear strength values of 135 to 225 kPa recorded in penetrometer tests. The clayey silt till contained 21 to 37% clay, 32 to 63% silt, 14 to 25% sand and 2 to 13% gravel sized particles.

The results of grain size distribution analyses and Atterberg Limits testing conducted on 13 samples of the deposit are shown in figures HC-GS-1 and HC-PC-1, respectively. The clayey silt till had a liquid limit of 23 to 35%, plastic limit of 15 to 19%, plasticity index being 7 to 16%. The moisture content of the clayey silt till ranged from 9 to 16%.

4.3 Groundwater

In the process of augering, water was detected at 7.0 m depth (elevation 180.7) in borehole 13. Upon completion of drilling, groundwater was measured in borehole 13 to be at a depth of 7.3 m (elevation 180.4 m). No water was observed in any other boreholes during or upon completion of drilling.



5. CLOSURE

Mr. S. Aziz carried out the field investigation for this study under the supervision of Mr. A. DeSira, MEng, P.Eng., and Mr. C. M. P. Nascimento, P. Eng., Project Manager. At Cost Drilling Inc. 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 report was prepared by Mr. M. Khorsand, EIT, and reviewed by Mr. D. Dundas, P.Eng. Mr. C. M. P. Nascimento, P. Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A handwritten signature in blue ink, appearing to read "Mansoor Khorsand", is located below the "Yours very truly" text.

Mansoor Khorsand, EIT
Project Supervisor, Geotechnical Services

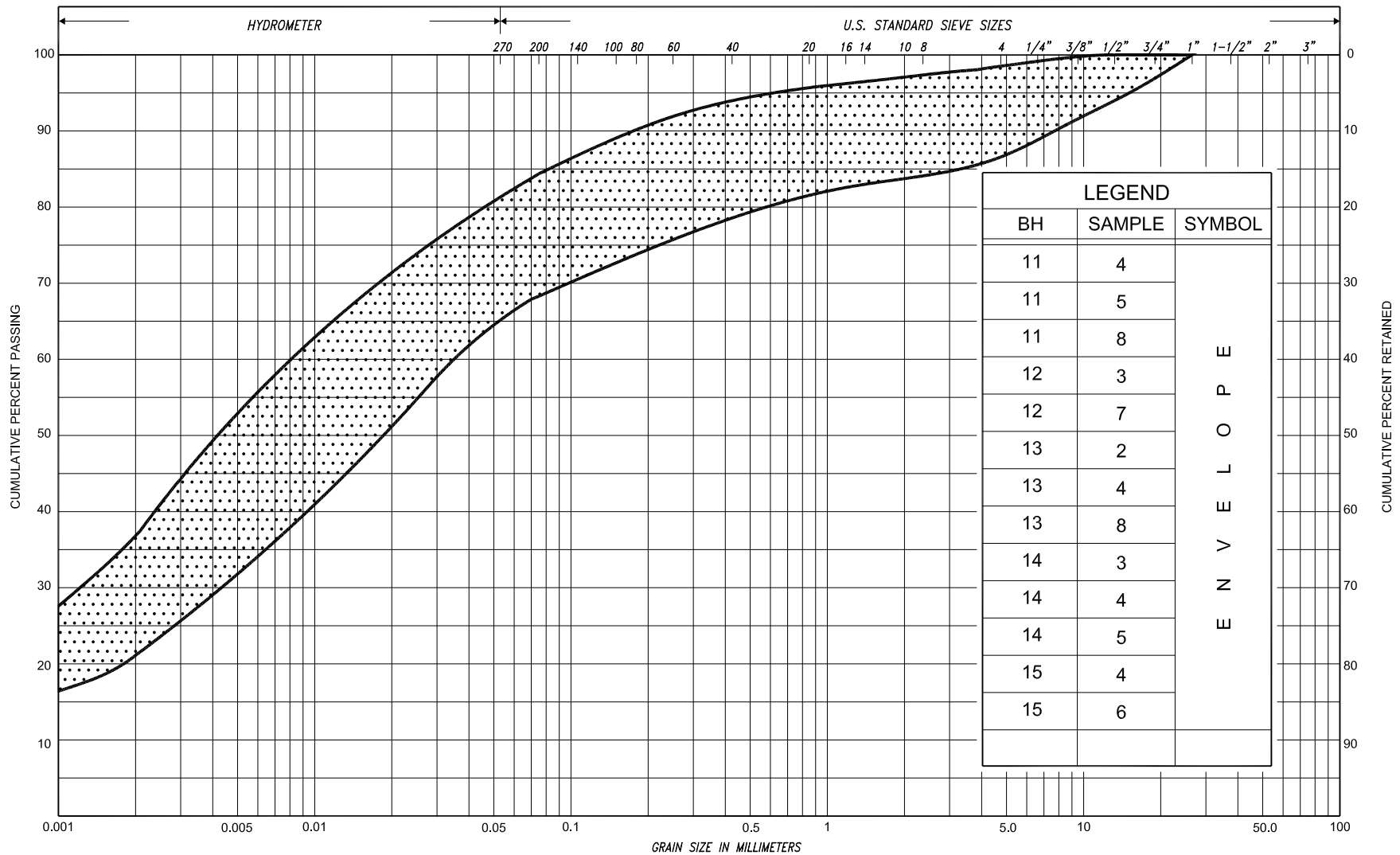


David Dundas, P.Eng
Senior Engineer, Geotechnical Services



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

MK/DD/CN:dd-mi

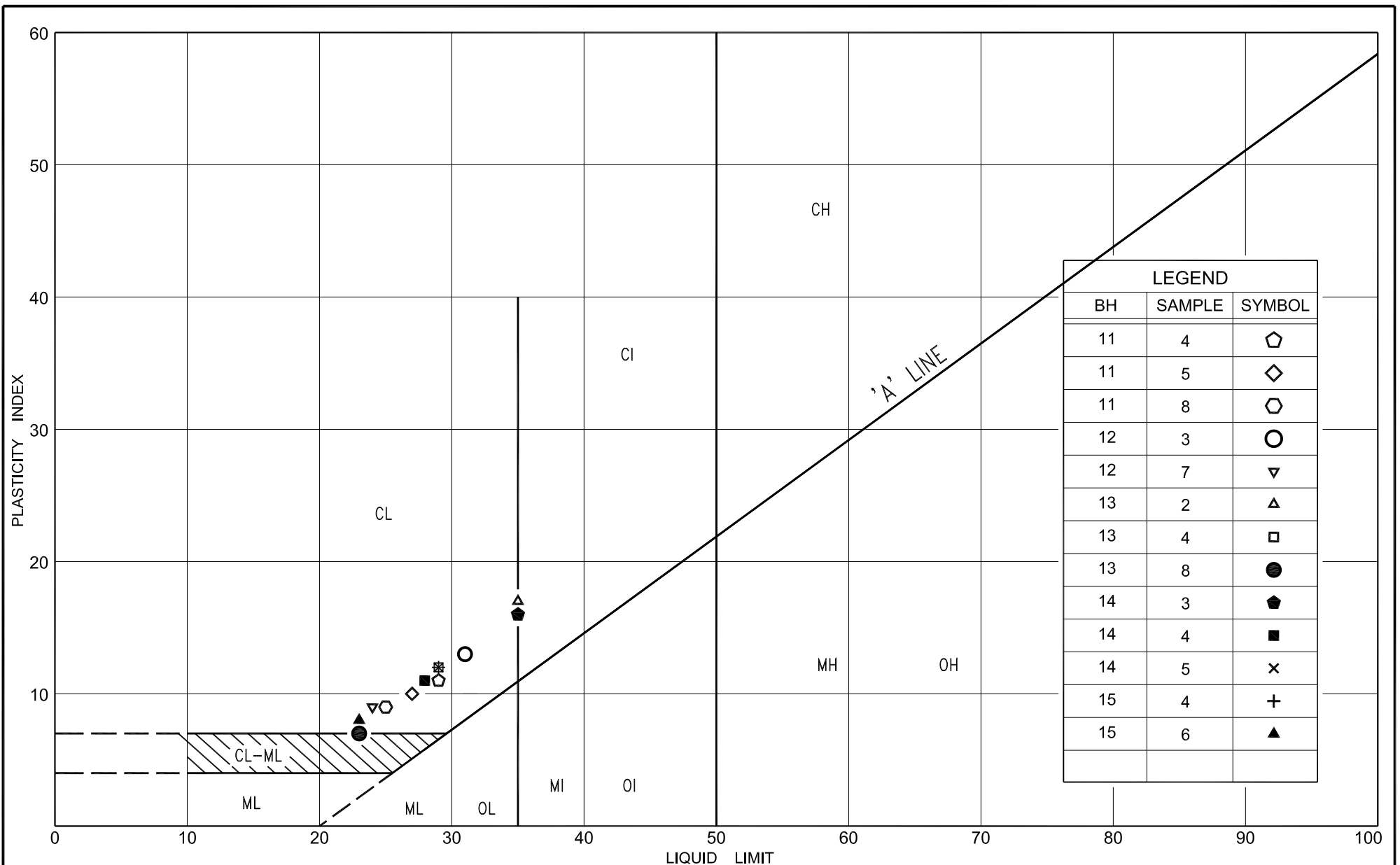


SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED					
				SAND														
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL		COBBLES	M.I.T.		
	SILT						SAND											
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL						U.S. BUREAU		
									SAND									

GRAIN SIZE DISTRIBUTION CLAYEY SILT, some to with sand, trace to some gravel (TILL)

FIG No. HC-GS-1
 HWY: 427
 G.W.P. No. 2230-09-00





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/0.3m)	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
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_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No. 11

1 of 1

METRIC

G.W.P. 2230-09-00 **LOCATION** Coords: 4 850 295.1 N; 293 636.9 E **ORIGINATED BY** S.A.
DIST Central **HWY** 427 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** A.D.
DATUM Geodetic **DATE** August 12, 2014 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										○		
								● QUICK TRIAXIAL × LAB VANE												
188.4	Ground Surface						20	40	60	80	100									
0.0	Silty sand, with gravel		1	SS	9															
	Loose Grey/Moist dark brown																			
	Clayey silt, trace sand organics, rootlets and topsoil inclusions		2	SS	10						188									
187.0	Stiff to Dark Moist very stiff brown/brown (FILL)																			
1.4	Clayey silt some sand, trace gravel		3	SS	12															
	Very stiff Mottled Moist brown/grey (TILL)		4	SS	20															
	sand seams																			
	Hard		5	SS	32						225									
	cobbles and boulders		6	SS	48															
	sand seams																			
			7	SS	58															
	Very stiff Grey		8	SS	25															
			9	SS	29															
			10	SS	27															
178.6	End of borehole																			
9.8																				
	* Borehole dry																			
	■ Pocket penetrometer																			

* Borehole dry

■ Pocket penetrometer

RECORD OF BOREHOLE No. 12

1 of 1

METRIC

G.W.P.	2230-09-00	LOCATION	Coords: 4 850 412.5 N; 293 614.9 E	ORIGINATED BY	S.A.
DIST	Central	HWY	427	BOREHOLE TYPE	Continuous Flight Solid Stem Augers
DATUM	Geodetic	DATE	August 12, 2014	CHECKED BY	C.N.

[illegible]

RECORD OF BOREHOLE No. 13

1 of 1

METRIC

G.W.P. 2230-09-00 LOCATION Coords: 4 850 281.0 N; 293 700.5 E ORIGINATED BY S.A.

DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY A.D.

DATUM Geodetic DATE August 13, 2014 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)		
							20 40 60 80 100										20 40 60		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
187.7	Ground Surface					187													
0.0	Clayey silt, trace sand organics, rootlets		1	SS	9								○						
187.3	Stiff Dark Moist brown/black (FILL)																		
0.4	Clayey silt some sand, some gravel rootlets to 1.3m		2	SS	26							225	○			13 19 33 35			
	Very stiff Brown/ Moist to hard grey		3	SS	20							225	○						
	(TILL)																		
	trace gravel cobbles and boulders		4	SS	29							225	○			6 19 42 33			
	Grey		5	SS	17							175	○						
			6	SS	16								○						
			7	SS	19							225	○						
	cobbles and boulders		8	SS	24							225	○			5 19 50 26			
	trace sand		9	SS	20							225	○						
			10	SS	40								○						
177.9	End of borehole																		
9.8																			

RECORD OF BOREHOLE No. 14

1 of 1

METRIC

G.W.P.	2230-09-00	LOCATION	Coords: 4 850 455.8 N; 293 648.5 E	ORIGINATED BY	S.A.
DIST	Central	HWY	427	BOREHOLE TYPE	Continuous Flight Solid Stem Augers
DATUM	Geodetic	DATE	August 11, 2014	CHECKED BY	C.N.

[illegible]

RECORD OF BOREHOLE No. 15

1 of 1

METRIC

G.W.P. 2230-09-00		LOCATION	Coords: 4 850 396.8 N; 293 708.1 E	ORIGINATED BY	S.A.
DIST	Central	HWY	427	BOREHOLE TYPE	Continuous Flight Solid Stem Augers
DATUM		Geodetic	DATE	August 11, 2014	CHECKED BY
					C.N.

[illegible]

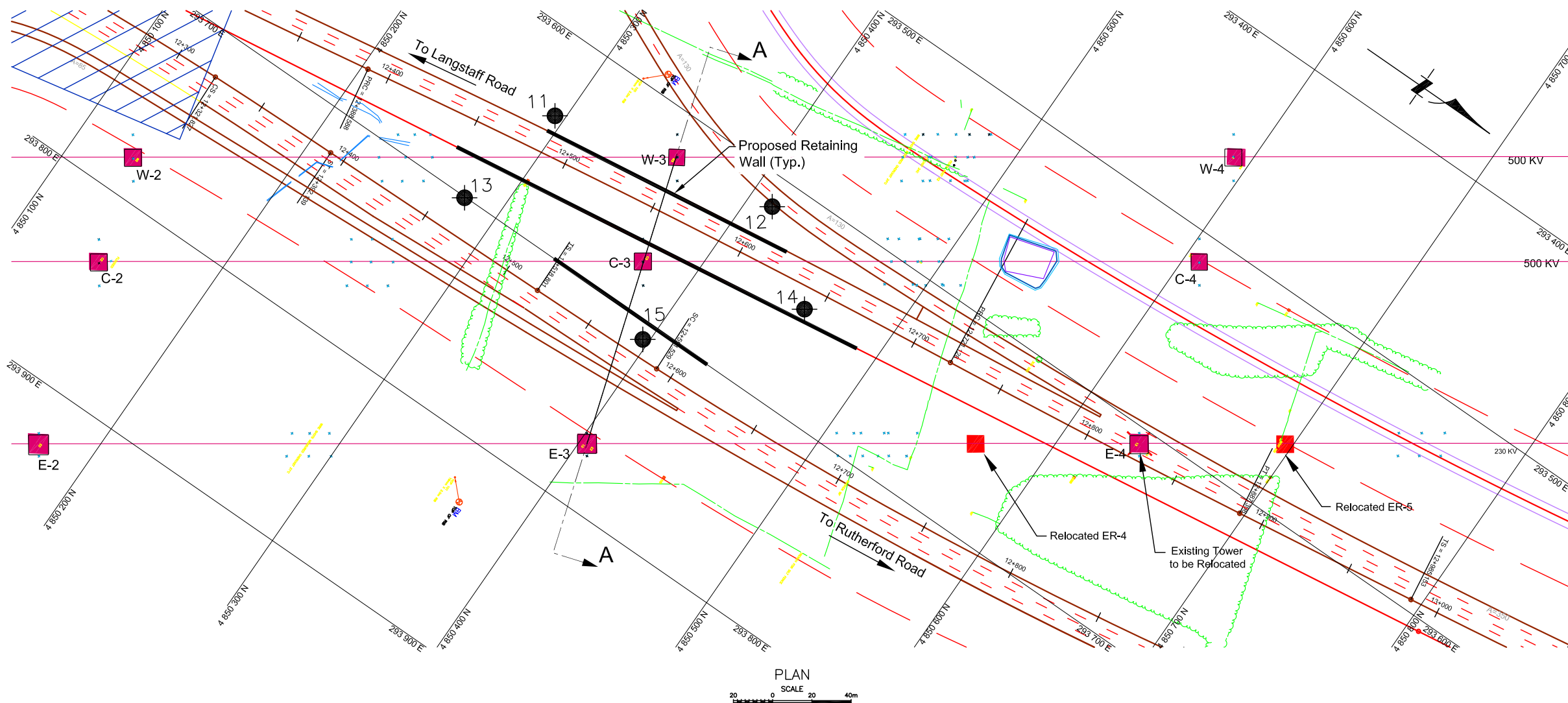
WP No.:2013-E-0039-004



PROTECTION OF HYDRO TOWERS
HIGHWAY 427 EXTENSION
BOREHOLE LOCATIONS

SHEET

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



LEGEND

- Borehole
- Borehole and cone
- Cone penetration test
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- W L at time of investigation August 2014
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
11	188.4	4 850 295.1	293 636.9
12	188.5	4 850 412.5	293 614.9
13	187.7	4 850 281.0	293 700.5
14	189.0	4 850 455.8	293 648.5
15	187.7	4 850 396.8	293 708.1

NOTE

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

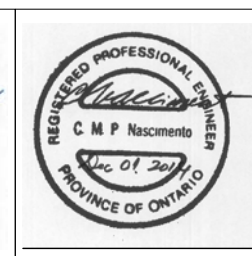
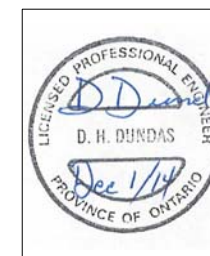
REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 30M13-205

HWY No	427	DIST	CENTRAL
SUBMD	NA	CHECKED M.KH.	DATE DEC. 01, 2014
DRAWN	NA	CHECKED DD	APPROVED CN
			DWG HT-1

NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RECORD OF BOREHOLES AND REPORT.
- REFER TO DRAWING HT-2 IN DESIGN REPORT FOR SCHEMATIC SECTIONS.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference Composite of MTO Drawings: P6450-XB01_Base_Mapping.dwg;
P6450_XB08_Hatch.dwg and P6450_XPD-427Extension_September_22, 2009
_Revised_December_06_10.dwg and Exhibit 7-1 in PDR



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FOUNDATION DESIGN REPORT
For
Highway 427 Extension through Hydro Corridor
Retainer Assignment – Task No. 2013-E-0039-004
City of Vaughan, Ontario

1. INTRODUCTION

This report provides detail design foundation engineering recommendations for the proposed retaining structures to protect the identified hydro tower foundation in proximity of the proposed Highway 427N alignment as required in the terms of reference for this assignment.

Peto MacCallum Ltd. (PML) prepared this report for the Ministry of Transportation of Ontario (MTO) as Retainer Assignment – Task No. 2013-E-0039-004.

In addition, this report presents conceptual options for consideration to achieve the hydro crossing over the proposed Highway 427N extension other than retaining walls.

2. OPTIONS

It is recommended that consideration should be given to the limitations that the selected hydro crossing solutions would have on future expansion of Highway 427N. It is also recommended that consideration should be given to the liability that would be undertaken by MTO related to the performance of the hydro tower foundations and to traffic safety if the hydro towers were to be located within Highway 427N alignment and especially within the median with foundations protected by retaining walls designed by MTO.

The options for the hydro crossing are listed below in priority order from a foundations engineering perspective. The provision of design details for options other than Option D – retaining walls, is beyond the scope of the current assignment. Options A through C has been presented as concepts for consideration of MTO.

a) Overhead Spanning

- Spanning Highway 427 with overhead wires from relocated E4 and C3 along their current alignments:



This has been a common method for hydro crossings over 400 series highways.

b) Underground Crossing

- Spanning Highway 427 with underground crossings to carry hydro wires using open cut or tunnelling techniques:

Underground hydro crossings are common but require waterproofing and consideration of electro - magnetic fields in confined spaces.

c) Re-founding Hydro Towers Below Road Level

- Re-found existing towers that would otherwise require retaining walls to permit the proposed Highway 427N extension alignment:

Especially in the median, relocating the towers to new foundations extending below the road grade would simplify any retaining wall requirements and eliminate the need for ground anchors or deadman anchors to provide horizontal resistance to tower loads.

d) Retaining Walls

- Protecting existing hydro tower foundations with retaining walls:

Retaining walls would be required where highway cuts encroach within the defined slope offset geometry. Reference is made to Section 3 of this report for recommendations per the requirements of the terms of reference for this assignment.

The following table presents the options in priority order and compares the advantages and disadvantages of each alternative approach. It is recommended that the owner of the hydro towers should review and accept the option proposed by MTO as well as the associated design details (for example, for retaining structures if that is the selected option) to confirm that the design is acceptable to hydro tower owner.

The assessment of the existing headroom below the hydro lines for the installation of the retaining structures should be made by the contractor in co-operation with the hydro tower owner.



Option	Advantages	Disadvantages
a) Overhead Spanning	<ul style="list-style-type: none"> Improved road safety due to improved sight lines and elimination of obstructions in the median Liability for performance and safety of hydro tower foundations and construction procedures would be the responsibility of the owner of towers rather than MTO Access to towers would be easier than if hydro towers were located in the median Future road expansion would be less complicated Road utilities (drainage and High Mast Lighting) could be placed within the median per typical design 	<ul style="list-style-type: none"> Hydro towers would have to be relocated
b) Underground Crossing	<ul style="list-style-type: none"> Improved road safety due to improved sight lines and elimination of obstructions in the median Liability for performance and safety of hydro tower foundations and construction procedures would be the responsibility of the owner of towers rather than MTO Access to towers would be easier than if hydro towers were located in the median Future road expansion would be less complicated Road utilities (drainage and High Mast Lighting) could be placed within the median per typical design 	<ul style="list-style-type: none"> Underground conduits would be required Special provisions could be required to deal with electro-magnetic field issues related to high voltage transmission wires
c) Re-founding Below Road Level	<ul style="list-style-type: none"> Less complex and more reliable solution to protecting hydro tower foundations than retaining walls Construction could be completed faster than with the retaining wall option 	<ul style="list-style-type: none"> Tower construction and existing tower removal would be required prior to road construction



Option	Advantages	Disadvantages
d) Retaining Walls	<ul style="list-style-type: none"> Relocation or hydro towers not be required 	<ul style="list-style-type: none"> Hazard for public safety due to impairment of sightlines and introduction of obstruction in median More complicated construction procedures required to provide lateral support to tower foundations with probable requirement for ground anchors or deadman anchors at the median location Difficulties in accessing the tower for maintenance if it is perched within retaining walls in the median Imposes limitation for future expansion of road Introduces additional complexity to median drainage systems and utility corridors such as for high mast lighting Increases to construction time due to the time required for construction of retaining walls and anchors

3. RETAINING WALL SOLUTIONS

3.1 General

This portion of the report provides detail design recommendations per the terms of reference for this assignment that specified a retaining wall solution to protect identified existing hydro tower foundations. The purposes of the hydro tower foundations are to provide lateral as well as axial support against the loads imposed by the tower and transmission lines. Information about these loads would have to be indicated by the owner of the hydro towers for the detail design of



retaining walls to proceed. At the time of writing this report, the details of these imposed loads have not been provided. Consequently, this report focusses on conceptual design and process for implementing a retaining wall design into a construction contract.

Refer to Appendix A for a preliminary design level plan showing the location of the hydro towers in close proximity to the proposed Highway 427N alignment. Based on drawings available at the time of reporting as the basis for measurements of the distances between the center of Langstaff Road and the locations of hydro towers, the approximate height of retaining walls required for Highway 427N would be in the order of 2.5m to 4m. The actual extent and geometry of proposed retaining walls should be established during the design process.

A minimum horizontal distance to any excavation below the toe of hydro tower foundations is required to prevent reduction in the capacity of the existing hydro tower foundations to resist both axial and lateral loadings. This requirement is to prevent loss of support of the existing hydro tower foundations, which consist of four 1.2m diameter 4m deep caissons for each tower. For retaining wall solutions, both the during-construction and the after-construction conditions need to be considered. In order to address these requirements, it is recommended that the distance to excavations from the top edge of hydro tower foundations should be a minimum of 6m and that cut slopes from that point should be no steeper than 2H:1V. If the project requires closer encroachment than the recommended 6m horizontal distance plus 2H:1V slope, retaining walls would be required.

Cast-in-place gravity retaining walls, Retained Soils Systems (RSS) or permanent soldier pile walls are options that could be considered to protect the hydro tower foundations where the cut geometry encroaches on the recommended minimum offset. If the road geometry requires closer encroachment to hydro tower foundations, permanent soldier pile walls should be considered to eliminate the need for excavation behind walls. In addition, the retaining walls should be designed to resist surcharge forces from portions of the slope extending above the top of the wall and residual loads imposed by the hydro towers. Ground anchor or deadman anchor solutions may be required where retaining walls to supplement the resistance of cantilever soldier pile walls in close



proximity to hydro tower foundations and particularly where retaining walls are required to enclose hydro tower foundations in the median of Highway 427.

If the RSS option is selected, a high performance, high appearance RSS wall should be specified. The design, supply and construction of the RSS wall should conform to the NSSP provided in Appendix B. The RSS supplier would be responsible for all aspects of design of the RSS including the detail design of the retaining structure and its internal stability. The contract information should include drawings to show location, length, height, elevations, performance level and appearance level of RSS walls.

Where retaining walls are required, it is recommended that a cut-type RSS system (such as the Durisol RSS) should be specified for this application as it employs soldier pile technology that permits top down construction and provides a permanent shoring wall and as such can be constructed without excavation behind the wall and without significantly relaxing stresses that resist the horizontal loads imposed by the hydro tower foundations. Consideration could be given to sole specification of Durisol type system instead of using the RSS open bidding system.

The requirements for the extent of additional analysis and design cannot be determined until the detailed plans showing the geometry and proximity of the Highway 427 cut are known. In order to carry out the analysis, the axial and lateral loads imposed by the hydro tower would have to be known.

If the Durisol RSS is adopted, the RSS supplier would carry out the detail design per the normal RSS process. If an RSS system is selected, the contract bidding information should include the Records of Boreholes for the relevant boreholes with direction that this information should be used in design.

At the time of this investigation, the final alignment plan and design details, such as cut depth, for the proposed Highway 427 extension have not been finalized. It is recommended that Peto MacCallum Ltd. should review the final design and drawings when they are available to determine if the recommendations provided in this report are still pertinent.



3.2 Design Recommendations

General recommendations for retaining walls are provided below.

3.2.1 Foundation Preparation

The fill layer encountered across the site should not be used as the founding material for spread footings for gravity retaining walls because the fill layer is susceptible to compression that could result in excessive settlement of the retaining walls. Consequently, it is recommended to found the foundations of retaining walls on top of the very stiff to hard clayey silt stratum. Preparation of the subgrade for construction of the foundation should be performed and monitored in accordance with OPSS 902.

3.2.2 Bearing Resistance

Based on the Records of Boreholes 11 to 15, the anticipated native subgrade soil at the founding elevation for the proposed retaining structures will range from stiff to hard clayey silt till at the proposed founding levels. The geotechnical resistances at factored Ultimate Limit State and Serviceability Limit States at the recommended founding level for spread footings are provided below:

Factored Geotechnical axial Resistance at ULS = 450 kPa
Geotechnical axial Resistance at SLS = 300 kPa

The recommended founding elevation at each borehole is at or below the elevation indicated in the following table. The designer should use the information from the borehole in closest proximity to each proposed retaining structure.

BOREHOLE NUMBER	FOUNDATION ELEVATION AT OR BELOW
11	186.0 m
12	187.0 m
13	186.5 m
14	187.0 m
15	185.0 m



The exposed founding surface should be covered by a lean concrete slab with minimum thickness of 100mm within 4 hours of exposure to prevent loosening or softening of ground at the founding elevation during the construction.

3.2.3 Seismic Design

The seismic site coefficient for the stratigraphic conditions at this site is 1.0 [soil profile Type I, Canadian Highway Bridge Design Code (CHBDC) 2006 Edition, clause 4.4.6. The ground conditions at the site are not susceptible to disturbance by liquefaction from seismic forces.

3.2.4 Frost Depth

The foundation frost depth for structure foundations at this site is 1.2 m, according to OPSD-3090.101.

3.2.5 Sliding and Base Friction

The following parameters should be used for sliding resistance of retaining wall and RSS wall foundations.

PARAMETER	STIFF to VERY STIFF CLAYEY SILT TILL
	(STA. 12+500 – 12+550)
Friction Angle, degrees	0
Cohesion, kPa	100
Unit Weight, kN/m ³	20.0

An equivalent unfactored friction angle at the footing/ground interface of 26 degrees can be assumed for design. If additional sliding resistance is required, foundation keys or footing anchors could be adopted.



3.2.6 Earth Pressure

The retaining walls should be designed to resist lateral loads imposed by the hydro tower foundations. The details of the lateral loads from the hydro tower foundations should be determined through discussion with the owner of the hydro towers.

The retaining walls or retaining soil system should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure, p (kPa) may be computed using the equivalent fluid pressure diagrams presented in Section 6.9 of the CHBDC or employing the following equation.

$$p = K(\gamma h + q) + C_p + C_s$$

where K = coefficient of lateral earth pressure (dimensionless)
 γ = unit weight of free-draining granular material, kN/m³
 h = depth below final grade, m
 q = surcharge load, kPa, if present
 C_p = compaction pressure, kPa (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 ϕ = angle of internal friction of retained soil
 δ = angle of friction between the soil and wall

Free-draining granular material should be used as backfill behind retaining walls other than soldier pile/lagging walls. The following table indicates design values for conventional design gravity walls and for conventional design of soldier pile/lagging walls. For RSS walls, the RSS supplier should determine the values for design.

PARAMETERS	GRANULAR A OR GRANULAR B TYPE II	GRANULAR B TYPE I	NATIVE GROUND
Undrained Shear Strength c_u (kPa)	-	-	100
Internal Friction Angle, ϕ (degrees)	35	32	-
Unit weight, γ (kN/m ³)	22.8	21.0	20.0
Coefficient of Active Earth Pressure, K_a	0.27	0.31	to be determined during design
Coefficient of Earth Pressure At Rest, K_o	0.43	0.47	to be determined during design
Coefficient of Passive Earth Pressure, K_p	3.69	3.25	to be determined during design



The at-rest coefficient of earth pressure should be used for design of unyielding walls. The active earth pressure coefficient should be used for unrestrained structures. The earth pressure coefficients should be reviewed if the slope of the backfill exceeds 10° to the horizontal. Alternatively, the material above the top of the wall could be treated as a surcharge load (q in the preceding equation).

The magnitude of the passive resistance is dependent on the actual lateral movement of the structure toward the retained soil. Refer to Figure C6.16 of the CHBDC for this computation. The subsoil/backfill should be considered as medium dense sand for the project.

The horizontal force at the base of the retaining RSS or conventional retaining wall will be resisted in part by the friction force developed through the granular backfill or along the interface between the granular backfill and the founding soil, subject to site specific design details. An unfactored friction factor of 0.6 is considered to be appropriate for development through the granular backfill and an unfactored friction factor of 0.45 for the interface between the granular backfill and founding soil.

3.2.7 Global Slope Stability and Settlement

In view of the state of the ground at this site, neither global slope stability nor settlement will be a design issue.

3.2.8 Excavation

All excavation at the retaining wall and RSS wall locations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO regulations. For this purpose, the encountered fill is considered soil Type 3, and the stiff to very stiff clayey silt is considered soil Type 2.



The OHSA requires that an excavation be cut at a predetermined inclination, based on the soil type. For example, excavation entirely in Type 2 soils, side slopes should be cut vertically in the lower 1.2 m from the base of the excavation and at an inclination of 1 horizontal to 1 vertical above the height of 1.2 m and; in Type 3 soil, side slopes for excavation should be cut at an inclination of 1 horizontal to 1 vertical from the base of excavation. In the case of an excavation containing more than one soil type, the highest numbered soil type shall govern the requirements for slope geometry.

The stability of slopes within the prescribed geometry adjacent to the hydro tower foundations should be maintained for all excavations below the top of the hydro tower foundation. Excavation should be limited to a zone defined previously in this report. If this zone is encroached upon, shoring will be required to protect the hydro tower foundations. The shoring system could consist of soldier piles and lagging or sheet piles or any other equivalent method. Alternatively, as previously recommended, instead of specifying an RSS system open to bidding a specific requirement could be made for the Durasol RSS system, which is founded on a soldier pile system and well suited to construction cut applications since it eliminates the need for temporary shoring.

3.2.9 Groundwater Control

The groundwater was observed during the course of the field work. Groundwater was only observed at Borehole 13 where the water level was below the proposed foundation level. However, a requirement for maintaining the prevailing groundwater elevation a minimum depth of 0.3 m below the base of excavations should be included in contract documents. Responsibility for selection of dewatering techniques is the responsibility of the contractor, but it is considered that seepage from soil fissures or surface water run-off that enters the excavation should be handled by conventional sump pumping techniques. It is noted that groundwater levels are subjected to fluctuations due to seasonal and rainfall patterns.



3.2.10 Backfill, Drainage Control and Erosion Control

The drainage behind the RSS walls should be designed by the RSS supplier.

The backfill behind the alternative cast-in-place retaining walls should consist of suitable free draining granular materials such as Granular A or B Type I or Type II and the backfill geometry should be according to OPSD 3121.150. The backfill should be placed and compacted to at least 95% of the ASTM D-698 (standard Proctor) maximum dry density.

Backfilling adjacent to retaining structures should be carried out in conformance with OPSS 501. Operation of compaction equipment adjacent to retaining structures should be restricted to limit the compaction pressure noted in clause 6.9.3 of the CHBDC.

A subdrain system (OPSS 405) and weep holes (OPSD-3190.100) should be installed to minimize the build-up of hydrostatic pressure behind the cast-in-place reinforced concrete walls. The subdrains tiles should be surrounded by a properly designed granular filter or non-woven Class II geotextile (with an FOS of 75 – 100 µm according to OPSS 1860) to prevent migration of fines into the system. The drainage pipes should be installed on a positive grade and lead to frost-free outlets.

The earth fill slopes should be protected against surface erosion by sodding and suitable vegetation. Refer to OPSS 803 or 804 for time constraints and the type of seed and mulch required.

The upper 600 mm of backfill against the wall should consist of relatively impermeable local clayey material to mitigate stormwater infiltration.



4. CLOSURE

This Foundation Investigation Report was prepared by Mr. Mansoor Khorsand, EIT, and reviewed by Mr. D. Dundas, P.Eng., Senior Foundation Engineer. Mr. C. M. P. Nascimento, P. Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A handwritten signature in blue ink, appearing to be "Mansoor Khorsand", is located below the "Yours very truly" text.

Mansoor Khorsand, EIT
Project Supervisor, Geotechnical Services



David Dundas, P.Eng
Senior Engineer, Geotechnical Services



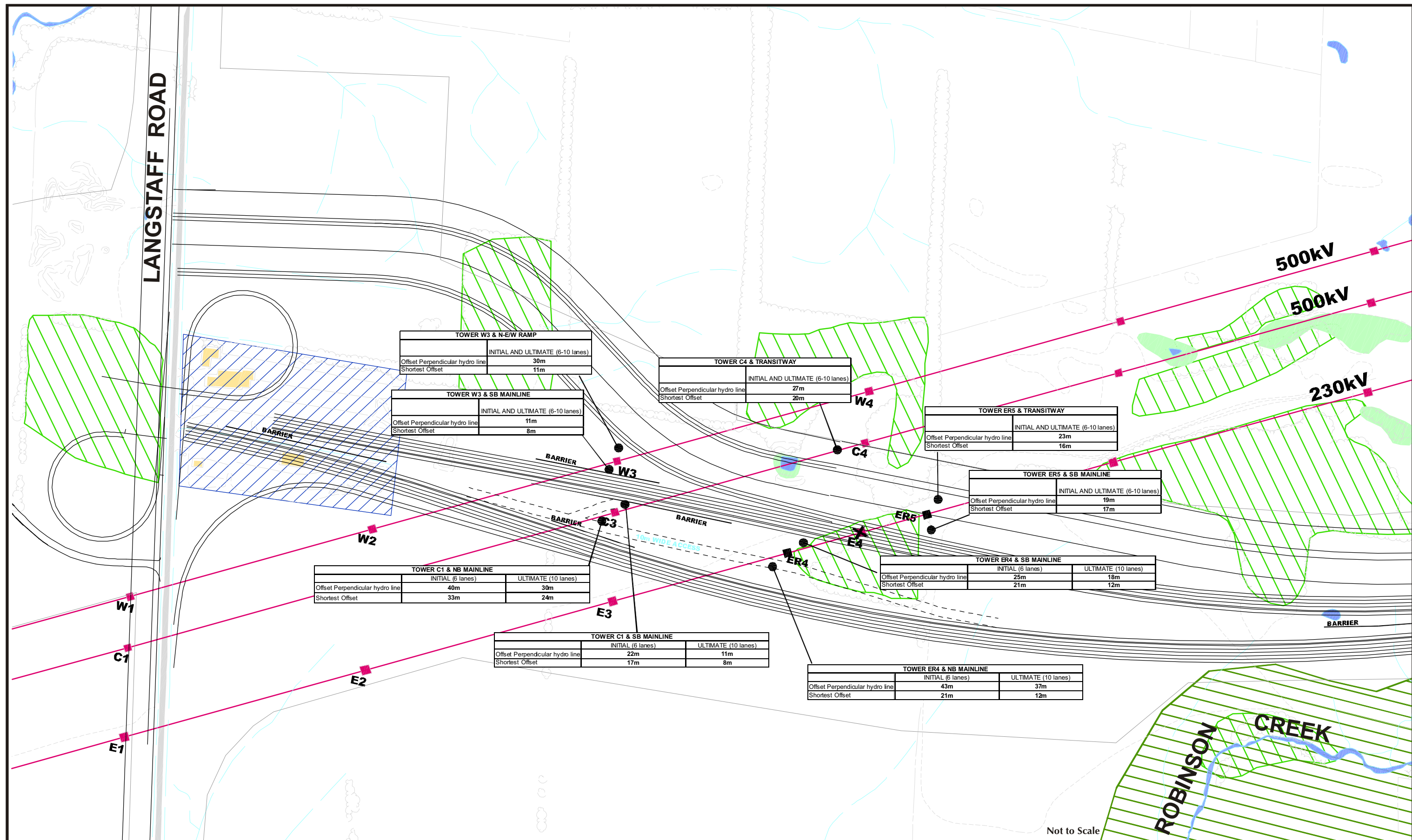
Carlos M.P. Nascimento, P.Eng.
Project Manager and
MTO Designated Principal Contact

MK/DD/CN:dd-mi



APPENDIX A

PDR - Hydro One - Tower Offsets and Conceptual Access Road





APPENDIX B

Standard Specifications and NSSP's



LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 405	Construction Specification for Pipe Subdrains
OPSS 501	Construction Specification for Compacting
OPSS 803	Construction Specification for Sodding
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling
OPSS 1860	Material Specification for Geotextiles
OPSD-3090.101	Foundation Frost Depth for Southern Ontario
OPSD 3121.150	Minimum Granular Backfill Requirements – Retaining Walls
OPSD-3190.100	Retaining Wall and Abutment Wall Drain Detail



NSSP – RSS Wall

RETAINED SOIL SYSTEM, TRUE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, FALSE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, HIGH PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, HIGH PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, MEDIUM PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, MEDIUM PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, LOW PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, LOW PERFORMANCE - Item No.

Non Standard Special Provision

January, 2008

1.0 SCOPE

This special provision covers the requirements for the design and construction of Retained Soil Systems (RSS) walls and steep slopes.

Additional requirements for RSS precast concrete facing elements shall be as specified in the Contract documents.

2.0 REFERENCES

This special provision refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, General:

OPSS 102	Weighing of Materials
OPSS 180	Management and Disposal of Excess Materials

- **Ontario Provincial Standard Specifications, Construction**

OPSS 501	Compacting
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Canadian Standards Association Standards:

CAN/CSA-S6-00	Canadian Highway Bridge Design Code (CHBDC)
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- **Ministry of Transportation Publications:**

MTO Designated Sources of Materials (DSM)
Qualification Criteria for RSS



3.0 DEFINITIONS

For the purposes of this special provision the following definitions apply:

Alignment Elements: means components specified by the manufacturer that are constructed on the foundation for RSS to facilitate placing of the facing elements to the correct lines and grades, such as concrete levelling pads and soldier piles.

Approved Product Drawings: means the documentation for an RSS that has been submitted by the manufacturer and accepted by the Ministry for listing in the DSM, according to the Qualification Criteria for RSS.

Backfill for RSS: means the material specified by the manufacturer as part of the engineered materials comprising the backfill for the RSS.

Constructed Height: means the vertical distance between the foundation for RSS and the top of the currently placed and compacted backfill for RSS, measured at the point of the design height.

Corrective Work: means work carried out by the Contractor to repair deficiencies identified by the Owner during the RSS warranty period.

Design Checking Engineer: means the Engineer retained by the Contractor who checks the original design and working drawings.

Design Engineer: means the Engineer retained by the Contractor who produces the original design and working drawings.

Design Height: means the maximum difference in elevation between the foundation for RSS and the corresponding top of backfill for RSS, over the full length or perimeter of the RSS.

External Stability: means stability against deep-seated failure of the foundation for RSS, including adequate bearing capacity at specified settlements of the foundation.

Facing Elements: means components specified by the manufacturer that delineate the front face of the RSS and to which reinforcing elements may be attached, such as precast concrete panels, split-face concrete blocks, and geo-synthetic panels.

Foundation for RSS: means the base on which the RSS is constructed, such as excavation to a specified elevation and construction of a granular 'A' pad.

Internal Stability: means stability against failure of the engineered materials comprising the RSS, including adequate resistance against excessive elongation, breakage and pullout of the reinforcing elements.

Manufacturer: means the firm who supplies the design and proprietary components, and who specifies the backfill and other materials, for the RSS selected by the Contractor.



Manufacturer's Representative: means an individual with continuous full-time employment with the manufacturer for a period of at least three (3) years, and who is knowledgeable in the design and construction of the RSS selected by the Contractor.

Obstruction: means any part of the work and any existing condition within the Contract limits that affects the design, construction and performance of the RSS, such as structures, catch basins and manholes, drainage pipes and sewers, and utilities.

Performance Tolerance – Local: means the joint gap between any two constructed facing elements, measured at any point along the joint between the facing elements and perpendicular to the line of the joint.

Performance Tolerance – Global: means the vector distance between any point on the constructed RSS and the corresponding point on the theoretical RSS surface as defined in the Contract documents.

Placing Tolerances: means tolerances specified by the manufacturer on the placing of the RSS components and backfill for RSS to ensure compliance of the constructed RSS with the performance tolerances.

Reinforcing Elements: means components specified by the manufacturer that are placed within the backfill for RSS and connected to the facing elements to mechanically stabilize the backfill for RSS, such as metal tie strips, metal grids and geo-synthetic grids,

Retained Soil System (RSS): means a proprietary system listed in the DSM used to retain horizontal loads for applications such as true and false abutment structures, retaining walls and steep slopes; or, to retain vertical loads for applications such as embankments over soft ground.

RSS Superintendent: means the Contractor's authorized representative in responsible charge of the construction of the RSS.

Structure: means any bridge, culvert, tunnel, retaining wall, overhead sign, high mast light pole, wharf, dock, or any part thereof.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

4.1 Submissions

4.1.1 Working Drawings

The Contractor shall submit working drawings for all RSS. A separate submission shall be made for each RSS in the Contract. All submissions shall bear the seal and signature of the Design Engineer and the Design Checking Engineer.

The RSS Superintendent shall have a copy of the working drawings on site at all times during the construction of the RSS.



At least two weeks prior to commencement of construction of the RSS, the Contractor shall submit to the Contract Administrator, for information purposes only, three (3) sets of the working drawings.

4.1.2 Working Drawing Requirements

Working drawings shall include at least the following:

- Statement from the manufacturer confirming the experience and expertise of the Design Engineer and Design Checking Engineer to provide design services for the manufacturer's RSS;
- All design, fabrication and construction drawings and specifications for the RSS;
- Location and value of the design height of the RSS;
- Defined lines and grades, type, and quantity in m³ of the backfill for RSS;
- Details at obstructions, and connections to other structures, where shown in the Contract drawings;
- Statement of bearing resistance required by the RSS foundation according to the CHBDC;
- Statement of satisfactory internal and external stability;
- Placing tolerances for the RSS.

4.1.3 RSS Superintendent

At least two weeks prior to commencement of construction of the RSS, the Contractor shall submit in writing to the Contract Administrator the name(s) of the RSS Superintendent for each RSS in the Contract.

During construction of an RSS, the Contractor shall not change the RSS Superintendent for that RSS without written permission from the Contract Administrator. The Contractor shall submit in writing to the Contract Administrator the proposed change for RSS Superintendent at least one week prior to the actual change in RSS Superintendent.

4.1.4 Manufacturer's Representative

At least two weeks prior to commencement of construction of the RSS, the Contractor shall submit in writing to the Contract Administrator the name(s) of the manufacturer's representative for each RSS in the Contract.

For each occasion the Contractor arranges for the manufacturer's representative to be on site, the Contractor shall submit 48 hours advance notice in writing to the Contract Administrator giving the dates and locations the manufacturer's representative will be on site.

4.1.5 Certificates of Conformance

For each RSS in the Contract, the Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the QVE upon completion of the RSS.

4.1.6 Milestone Inspection



For each RSS in the Contract, the Contractor shall submit to the Contract Administrators Milestone Inspection Report following an Interim Inspection by the QVE at each of the following milestones, and prior to commencement of subsequent operations on that RSS:

- a) Layout and marking of all lines and grades needed to construct the RSS; and construction of the alignment elements, where applicable;
- b) Delivery and storage on site of facing elements and reinforcing elements, where applicable;
- c) Installation of the facing elements; placement and compaction of the backfill for RSS; and installation of the reinforcing elements, where applicable;

For RSS where the design height is greater than 5.0 m, the Contractor shall submit a series of Written Permissions to Proceed for milestone c) corresponding to the constructed height of the RSS at 5.0 m, 10.0 m, and 15.0 m, as applicable, up to and including the design height.

The Milestone Inspection submissions in no way supersede the inspection and testing intervals required for the construction of the RSS, as specified in the working drawings.

4.1.7 RSS Warranty

The Contractor shall submit a warranty to the Owner to address all deficiencies identified by the Owner related to the performance of the RSS for a period of 36 months from the date of certification of completion of the Contract.

4.1.8 Repair Procedures for Corrective Work

At least two weeks prior to commencement of any corrective work at an RSS during the warranty period, the Contractor shall submit to the Manager of Contracts, for information purposes only, three copies of his repair procedures for that RSS.

The repair procedures shall include a description of the cause and fully detail the corrective work required to correct the deficiencies identified by the Owner.

The repair procedures shall bear the seal and signature of an Engineer (who may be different than the Design Engineer and Design Checking Engineer), and be signed by the manufacturer's representative.

4.2 Design

4.2.1 General

The Contractor shall be responsible for the design of the RSS and for ensuring the RSS as designed is compatible with the work.

The geometric requirements of the RSS, such as lines and grades of the facing elements and typical cross-sections, shall be as specified in the Contract drawings.



The foundation for RSS shall be as specified in the Contract documents.

4.2.2 RSS Selection

The Contractor shall select an RSS from the DSM that meets the Application, Performance and Appearance requirements for that RSS, as specified in the Contract drawings.

The Contractor shall select an RSS from the DSM designated as either ‘A’ (Accepted) or ‘DE’ (Demonstration). RSS designated as ‘DE’ status require inspection, instrumentation and monitoring of the constructed RSS, and reporting of the findings to the Ministry by the manufacturer, according to the Qualification Criteria for RSS.

Where there is more than one RSS in the Contract, the Contractor shall select the RSS from the same DSM listing, including type and colour of facing elements, according to the following groupings:

- a) All RSS covered under the same tender item number(s) for payment;
- b) All RSS with the same Performance and Appearance requirements that abut the same structure, existing and/or part of the work.

4.2.3 Performance Tolerances

Performance tolerances for the RSS shall be according to Table 1.

• TABLE 1 – PERFORMANCE TOLERANCES FOR RSS		
Performance Requirement	Performance Tolerance (mm)	
	Local	Global
Abutments	Joint Gap ¹ ± 5	≤ 20
High	Joint Gap ¹ ± 10	≤ 30
Medium	N/A	≤ 50
Low	N/A	≤ 100

Note 1: Joint Gap shall be as specified in the working drawings.



4.2.4 Obstructions

The Contractor shall be responsible for developing design details of the RSS at obstructions, for all obstructions shown in the Contract drawings.

Where an obstruction is shown in the Contract drawings but not located to sufficient accuracy for the design of the RSS, the Contractor shall locate the obstruction in the field to sufficient accuracy as required to design the RSS.

4.2.5 Foundation Report

A Foundation Investigation Report that describes the subsurface conditions at the RSS is available, as specified in the Contract documents.

The Owner warrants the data in the Foundation Investigation Report, except that interpretations of the data and opinions expressed in the Foundation Investigation Report are not warranted.

5.0 MATERIALS

5.1 General

All materials for the selected RSS shall be according to the Approved Product Drawings for that RSS.

6.0 EQUIPMENT

6.1 Restriction on Skid-Steer Vehicles

Skid-steer vehicles will not be permitted on any area where the depth of backfill for RSS over installed reinforcing elements is less than 0.5 m.

7.0 CONSTRUCTION

7.1 General

The RSS shall be constructed according to the working drawings and this Special Provision.

Construction of the RSS shall not commence until the Contractor has submitted all applicable Certificates of Conformance for the foundation for RSS.

7.2 RSS Superintendent

The Contractor shall schedule his operations such that the construction of an RSS is at all times under the responsible charge of an RSS Superintendent who has been advised on site by the manufacturer's representative as to the required procedures for the construction of that RSS, for the specified operations and time periods.



7.3 Manufacturer's Representative

The manufacturer's representative shall be on site to advise the RSS Superintendent as to the procedures and placing tolerances required for the construction of the RSS.

For each RSS in the Contract, the Contractor shall arrange for the manufacturer's representative to be on site at commencement of each of the following operations, for a time period of three (3) working days per operation or until the operation is complete, whichever is less:

- a) Layout of the RSS; and construction of the alignment elements, where applicable;
- b) Installation of the facing elements;
- c) Placement and compaction of the backfill for RSS; and installation of the reinforcing elements, where applicable.

Whenever there is a change in the RSS Superintendent during construction of an RSS, the Contractor shall arrange for the manufacturer's representative to return to the site for the same operations and time periods as at commencement.

7.4 Backfill for RSS

Backfill for RSS shall be placed within the lines and grades shown on the working drawings. All backfill for RSS shall be compacted according to OPSS 501.

Unless otherwise shown in the Contract drawings, the Contractor shall not place backfill for RSS against an adjacent concrete structure that is part of the work until the concrete in that structure has obtained a compressive strength at least 70% of the concrete strength specified in the Contract.

7.5 Management of Excess Materials

Management of excess materials shall be according to OPSS 180.

7.6 Corrective Work

At least one week prior to commencement of any corrective work at an RSS during the warranty period, the Contractor shall submit written notice of commencement to the Manager of Contracts.

The Contractor shall repair all deficiencies according to the repair procedures for corrective work. All corrective work shall be done within the RSS warranty period, unless prevented by seasonal shutdown, in which case the corrective work shall be done during the first eight weeks of the following construction season.

The Contractor shall provide access to the corrective work for inspection by the Owner when requested.



8.0 QUALITY ASSURANCE

8.1 Acceptance Criteria at End of the RSS Warranty Period

The Owner will accept the RSS at the end of the RSS warranty period if none of the deficiencies listed in Table 2 are found during the warranty inspections. Where deficiencies are found, the RSS will not be accepted until the Contractor has carried out corrective work to repair the deficiencies.

TABLE 2 – RSS DEFICIENCIES	
Number	Description of Deficiency
1.	Performance tolerance exceeds tolerances given in Table 1.
2.	Damaged facing elements and damaged alignment elements, where applicable.
3.	Dead and dying vegetative elements that are an integral part of the RSS.

8.2 Warranty Inspections

Throughout the warranty period the Owner will carry out warranty inspections of the RSS for deficiencies as per Table 2. The Owner will notify the Contractor as to the date and time of the inspection(s) and the Contractor may, at his discretion, be present during the inspection(s).

Within two weeks following a warranty inspection the Owner will notify the Contractor in writing of all deficiencies that require corrective work.

9.0 MEASUREMENT FOR PAYMENT

9.1 Actual Measurement

9.1.1 Backfill for Retained Soil System, High Performance Backfill for Retained Soil System, Medium Performance Backfill for Retained Soil System, Low Performance

Measurement will be of the mass in tonnes of the material placed within the theoretical lines and grades shown in the stamped working drawings. The method of determining the mass shall be according to OPSS 102.



10.0 BASIS OF PAYMENT

10.1 Retained Soil System, True Abutment - Item Retained Soil System, False Abutment - Item Retained Soil System, Wall/Slope, High Performance – Item Retained Soil System, Wall/Slope, Medium Performance – Item Retained Soil System, Wall/Slope, Low Performance – Item

Payment at the contract price for the above tender items shall be full compensation for all labour, equipment and material to do the work, including all costs associated with the manufacturer's representative on site.

Payment for construction of the foundation for RSS will be made under the appropriate tender items in the Contract.

No payment will be made for corrective work, including investigation of deficiencies, design of repairs, site access, traffic staging and removal of existing work, except where the corrective work is required as a result other than an act or fault of the Contractor.

10.2 Backfill for Retained Soil System, High Performance – Item Backfill for Retained Soil System, Medium Performance – Item Backfill for Retained Soil System, Low Performance – Item

Payment at the contract price for the above tender items shall be full compensation for all labour, equipment and material to do the work.

When the Contract does not contain a separate tender item for backfill for RSS, the contract price for the RSS contract items in which the backfill for RSS is incorporated shall include full compensation for all labour, equipment and material required to place and compact the backfill for RSS.

WARRANT: Always with these tender items.