



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT
HIGH-OCCUPANCY TOLL AND
HIGH-OCCUPANCY TOLL HMS SIGN SUPPORTS
HIGHWAY 427 REHABILITATION
FROM FASKEN DRIVE TO FINCH AVENUE
TORONTO, ONTARIO
G.W.P. 202-95-00**

GEOCRES NO. 30M12-407

Submitted

to

SNC-Lavalin Inc.

Date: July 14, 2017
File: 11294

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PART 1 FACTUAL INFORMATION

1.0 INTRODUCTION

This report presents relevant factual data from previous foundation investigations for the detailed design of High-Occupancy Toll (HOT) and High-Occupancy Toll HMS (HOT HMS) sign supports. The sign supports will be located at specific locations along Highway 427, from Fasken Drive to Finch Avenue in Toronto, Ontario. This project is a part of the overall project for the rehabilitation of Highway 427.

Thurber has been retained by SNC-Lavalin Inc. (SLI) to carry out this study under the Ministry of Transportation Ontario (MTO) Agreement No. 2014-E-0060-03.

The purpose of this investigation was to review available subsurface information near the proposed locations of the HOT and HOT HMS sign supports and, based on this data, to provide borehole location plans, records of boreholes, and a written description of the subsurface conditions.

For preparation of this report, reference has been made to previous reports listed as follows:

- Foundation Investigation Report, Highway 427 Widening From Fasken Drive To Steeles Avenue, High Mast Lighting Poles, Overhead Sign Supports, Toronto,

Ontario, G.W.P. 202-95-00, Geocres No. 30M12-291, File 19-92-70, dated March 12, 2010 (Reference 1).

- Engineering Materials Office, Foundation Design Section, report titled “High Mast Lighting, Hwy. 427 from Campus Rd./Fasken Dr. to Steeles Avenue”, W.P. 615-89-00, Dist. 6, Geocres No. 30M12-224, dated January 25, 1995 (Reference 2).
- Foundation Investigation Report titled “Highway 427 Overpass Widening at Fasken Drive/Campus Road”, W.P. 187-94-01/02 and 273-66, Site 37-0986, Central Region, Geocres No. 30M12-227, dated March 3, 1972 (Reference 3).
- F.T.M.S. – Overhead Signs, Highway 427 SB to Turning Roadway Over Highway 409, Engineering Materials Office, Foundation Design Section, W.P. 48-71-22, District 6, Toronto, Geocres 30M12-206. (Reference 4).
- Foundation Investigation Report for The Proposed Underpass Structure at the Crossing of Highway 427 and Rexdale Blvd. Borough of Etobicoke, County of York, District No. 6, Toronto”, W.O. 72-11024, W.P. 126-60, Site 37-982, Geocres No. 30M12-061. (Reference 5).

2.0 SITE DESCRIPTION

Eight (8) HOT sign supports and three (3) HOT HMS sign supports are to be located at the median of the northbound and southbound lanes, along the alignment of the proposed Highway 427 between Fasken Drive and Finch Avenue in Toronto, Ontario.

The land usage adjacent to this section of Highway 427 is generally a combination of commercial, industrial and residential.

The project area is located within the physiographic region known as the South Slope which is comprised predominantly of the Halton drift (till). The Halton till is an interbedded complex of clayey silt to silt till and sand. This till comprises a slightly hummocky till plain, into which the surface watercourses have eroded 10 to 15 m deep gullies. Relatively recent fluvial sediments have been deposited in the gullies. The Halton drift overlies bedrock at depths in the order of 100 m in the vicinity of the project area. The bedrock consists of grey shale with hard siltstone and limestone interlayers of the Georgian Bay Formation.

3.0 SITE INVESTIGATION AND FIELD TESTING

A site investigation was not carried out for the current project as per the direction from MTO. Instead, selected borehole information from previous investigations at the site has been used (References 1 to 5). Table 3.1 indicates the reference boreholes that were used to assess the subsurface conditions at the proposed HOT and HOT HMS sign support locations. These are generally the closest available boreholes to each sign support. Since the boreholes were drilled between 1972 and 1994, and there has been recent and ongoing reconstruction of the highway and its structures, it is possible that the current ground surface elevations may differ and the subsurface stratigraphy may include additional fill that is not shown on the reference borehole logs. The approximate locations of the proposed HOT and HOT HMS sign supports, and previously drilled boreholes in the vicinity are shown on the Borehole Location drawings in Appendix B.

Table 3.1 Proposed HOT and HOT HMS locations and Reference Boreholes

HOT / HOT HMS Number	Station	Reference Borehole	Ground Surface Elevation (m) (Year of Investigation)	Reference Borehole Station/Location
HMS01	20+209 (NB)	1,3 (273-66) ¹	165.8 (1972)	20+343 20+347
TS01	20+913	2 (615-89-00) ²	164.5 (1994)	20+975
TS02	21+637	4 (615-89-00) ²	166.7 (1994)	20+619
TS03	22+158	4 (48-71-22) ³	173.0 (1988)	22+233
HMS02	22+697 (NB)	6 (48-71-22) ³	171.1 (1988)	22+707
TS04	22+785	6 (48-71-22) ³	171.1 (1988)	22+707
TS05	23+279	7 (615-89-00) ²	166.3 (1994)	23+231
TS06	23+821	1 (126-60) ⁴	168.4 (1972)	23+857
TS07	23+975	7 (126-60) ⁴	168.0 (1972)	23+902
TS08	24+475	11 (615-89-00) ²	162.1 (1994)	24+440
HMS03	25+045 (SB)	13 (615-89-00) ²	162.5 (1994)	25+096

(1) Reference 3

(2) Reference 2

(3) Reference 4

(4) Reference 5

4.0 SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy from previous investigations are presented on the Record of Borehole sheets in Appendix A. A general description of the

stratigraphy established at relevant boreholes near the proposed HOT and HOT HMS sign supports is presented in the following paragraphs. The factual data presented in the records of boreholes governs any interpretation of the site conditions. It should be noted that the subsurface conditions may vary between and beyond the borehole locations. It is also noted that the quoted depths are referenced to the original ground surface at the time of the investigations.

In general, the subsurface conditions encountered in most boreholes consist of clayey silt embankment fill with occasional layers of organics. Underlying the embankment fill or exposed at the original ground surface is an extensive deposit of native, stiff to hard clayey silt till containing typically compact to very dense sand and silt interlayers. Deposits of native clayey silt to silt were encountered surficially in some boreholes. It is noted that glacial tills inherently contain cobbles and boulders, and could be inferred by the refusal 'N' values recorded in some boreholes. Shale bedrock was contacted below the clayey silt till and clayey silt in four boreholes at depths ranging from 21.6 m to 26.4 m (Elevations 144.2 to 142.1), and at 7.1 m (Elevation 155.4) at one location.

4.1 Embankment Fill

Boreholes 2, 4, 7 (WP 615-89-00), and Boreholes 4, 6 (WP 48-71-22) drilled within the project area, along the Highway 427 median, encountered embankment fill consisting of brown to grey clayey silt containing some sand and trace gravel. Layers of organics were encountered in two boreholes (4 and 6 from WP 48-71-22).

The thickness of the embankment fill ranged from 2.1 m to 9.1 m. The depth to the base of the embankment fill ranged from 2.1 m to 9.1 m (Elevations 160.8 to 165.0).

SPT 'N' values recorded in the cohesive embankment fill varied from 10 to 40 (typically 12 to 23) blows per 0.3 m penetration indicating a stiff to hard consistency. Lower SPT 'N' values, ranging from 4 to 9 blows per 0.3 m of penetration, indicating firm to stiff consistency, were measured in Borehole 7 (WP 615-89-00). Moisture content measured in the embankment fill ranged from 18 percent to 22 percent.

4.2 Clayey Silt Till

A clayey silt till deposit with sand and trace to some gravel was encountered surficially in Boreholes 1, 3 (WP 273-66) and 1, 7 (WP 126-60), and below the fill or other soils in Boreholes 2, 4, 7, 11 (WP 615-89-00) and 4, 6 (WP 48-71-22) at depths generally ranging from 2.1 m to 9.1 m. In Borehole 11 (WP 615-89-00), the clayey silt till was contacted below the clayey silt to silt, at 4.4 m depth (Elevation 157.7). The thickness of the clayey silt till, where fully penetrated, typically ranged from 21.6 m to 26.4 m, and was 4.2 m in Borehole 11. The depth to the base of the clayey silt till varied from 21.6 m to 26.4 (Elevations 142.1 to 144.2), and at 8.6 m (Elevation 153.5) in Borehole 11.

Boreholes 2, 4, 7 (WP 615-89-00), and 4, 6 (WP 48-71-22) were terminated within the clayey silt till at depths ranging from 9.4 m to 12.6 m (Elevations 154.1 to 161.5). SPT 'N' values ranged from 11 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration, indicating a stiff to hard consistency. Glacial tills inherently contain cobbles and boulders. Moisture content measured in the clayey silt till ranged from 8 percent to 19 percent, and occasionally up to 28 percent.

4.3 Clayey Silt to Silt

Layers of clayey silt to silt were contacted surficially in Boreholes 11 and 13 (WP 615-89-00). The combined thickness of the clayey silt to silt layer ranged from 2.9 m to 6.4 m. The depth to the base of the clayey silt to silt was 4.0 m and 7.1 m (Elevations 158.1 and 155.4) in Boreholes 11 and 13, respectively.

SPT 'N' values of the clayey silt to silt ranged from 17 to greater than 100 blows per 0.3m of penetration indicating a very stiff to hard consistency. SPT 'N' values greater than 100 blows for less than 0.3 m of penetration in Borehole 13 inferred the presence of cobbles and/or boulders.

4.4 Silty Sand to Sandy Silt Interlayers

Interlayers of silty sand to sandy silt were encountered in Boreholes 1, 7, 11 and 13 (WP 126-00 and WP 615-89-00) at various depths ranging from 1.4 m to 15.2 m. The thickness of these interlayers ranged from 0.4 m to 9.1 m. The depths to the base of the

silty sand and sandy silt layers varied from 2.5 m to 22.1 m (Elevations 145.9 to 156.6). Borehole 11 was terminated within the layer of sandy silt, at 9.6 m (elevation 152.5).

SPT 'N' values measured in the cohesionless layers generally ranged from 13 to 58 blows per 0.3 m of penetration, indicating a compact to very dense state. An SPT 'N' value of 147 blows per 0.3 m of penetration, indicating a very dense condition, was measured at approximate Elevation 146.3 in Borehole 7 (WP 126-60), drilled near Station 23+902. A moisture content measured in a sandy silt to silty sand sample was 17%.

4.5 Shale Bedrock

Shale bedrock was encountered or inferred in five boreholes drilled in proximity to the proposed HOT and HOT HMS sign supports at the following depths and elevations:

Table 4.1 Bedrock depths and elevations

HOT/HOT HMS Number and Station	Reference Borehole	Borehole Approx. Station	Bedrock depth (m)	Bedrock Elevation (m)
HMS01 20+209 (NB)	1,3 (273-66) ¹	20+343 20+347	21.6 to 22.3	144.2 to 144.0
TS06 23+821	1 (126-60) ³	23+857	26.4 (inferred)	142.1 (inferred)
TS07 23+975	7 (126-60) ³	23+902	25.5	142.5
HMS03 25+045 (SB)	13 (615-89-00) ²	25+096	7.1	155.4

(1) Reference 3

(2) Reference 2

(3) Reference 5

4.6 Groundwater Conditions

The water levels measured in the open boreholes drilled during the previous investigations are summarized below.

Table 4.2 Water Level Measurements in Open Boreholes

HOT/HOT HMS Number	Station	Reference Borehole	Date	Depth (m)	Elevation (m)	Comments
HMS01	20+209 (NB)	1,3 (273-66) ¹	February 1972	0.5 to 0.9	165.3	-
TS01	20+913	2 (615-89-00) ²	August 1994	-	-	Borehole Caved-in at 2.4 m
TS02	21+637	4 (615-89-00) ²	July 1994	7.9	158.8	-
TS03	22+158	4 (48-71-22) ³	March 1988	9.5	163.5	-
HMS02	22+697 (NB)	6 (48-71-22) ³	March 1988	6.2	164.9	-
TS04	22+785	6 (48-71-22) ³	March 1988	6.2	164.9	-
TS05	23+279	7 (615-89-00) ²	August 1994	0.7	165.6	-
TS06	23+821	1 (126-60) ⁴	March 1972	0.3	168.1	-
TS07	23+975	7 (126-60) ⁴	March 1972	0.8	167.2	-
TS08	24+475	11 (615-89-00) ²	August 1994	2.4	159.7	-
HMS03	25+045 (SB)	13 (615-89-00) ²	August 1994	2.0	160.5	-

(1) Reference 3

(2) Reference 2

(3) Reference 4

(4) Reference 5

Based on the observations in the open boreholes, the water level varies between 0.3 m and 9.8 m depth below the original ground surface (Elevations 158.8 to 168.1). It should be noted that these are very short term observations and groundwater levels are subject

to seasonal fluctuations, severe climatic events and site alterations resulting from construction activities.

5.0 MISCELLANEOUS

Interpretation of the subsurface data and preparation of this report were carried out by Ms. Rocio Palomeque Reyna.

The report was reviewed by Dr. Sydney Pang, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng.
Associate, Senior Foundation Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact



Appendix A

Record of Boreholes

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.

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 (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $\times \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ² /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX $= w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

30 M 12-227

25

WP 107-94-01/02

DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & TESTING OFFICE				RECORD OF BOREHOLE No. 1				FOUNDATION SECTION					
JCR 72-11005				LOCATION Co-ords. 15,874,679 E; 972,830 N.				ORIGINATED BY TK					
W.P. 27-66				ROBING DATE Jan. 3 & 4, 1972				COMPILED BY TJ					
DATUM Geodetic				BOREHOLE TYPE Penn Drill and Diamond Drill				CHECKED BY [Signature]					
ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLING POINT	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT		SUNKE DENSITY	REMARKS
			NUMBER	TYPE		20	40	60	80	100	PLASTIC LIMIT		
Sub. 1	Ground Level					SHEAR STRENGTH P.S.F.				WATER CONTENT %			
	0.0 Met. mix. of clayey silt sand & gravel, ool. clayey silt seam		1	SS	21								
	Very Stiff to Hard		2	SS	34								
			3	SS	47								
			4	SS	66								
	Brown Grey		5	SS	14								
			6	SS	12								
	Clayey Till		7	SS	14								
			8	SS	11								
			9	SS	11								
			10	SS	14								
			11	SS	100								
			12	SS	100								
			13	SS	189								
			14	SS	21								
473.1			15	SS	100								
71.0	Shale Bedrock												
	Weathered Sand		16	SI	100								
161.1													
83.0	End of Borehole												

20
15-17 % STRAIN AT FAILURE
10

20
15 ϕ 5 % STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

1 OF 1 METRIC

W.P. 615-89-00 LOCATION Coords.: N 4 839 195 E 296 285
 DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Auger
 DATUM Geodetic DATE 1994 05 09
 ORIGINATED BY LO
 COMPILED BY LO
 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
164.5	Ground Surface													
0.0	CLAYEY SILT Traces of Gravel Some Sand Suff to Very Suff		1	SS	23		164							
	Sand		2	SS	15									
161.6	(FILL MATERIAL)		3	SS	18		162							
2.9	Trace Organics		4	SS	17									
			5	SS	14		160							
	CLAYEY SILT Traces to Some Gravel Some Sand Suff to Hard		6	SS	28									
	(GLACIAL TILL)		7	SS	50									
			8	SS	63		158							
	Brown													
	Grey		9	SS	21		156							
155.1			10	SS	75	/15cm								
9.4	End of Borehole													
	• WATER LEVEL NOT ESTABLISHED DUE TO THE WALLS CAVING AT 8 FEET.													

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 615-89-00

LOCATION Coords.: N 4 839 786 E 295 897

ORIGINATED BY LQ

DIST 8 HWY 427

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY LQ

DATUM Geodetic

DATE 1994 08 10

CHECKED BY BB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W		
188.7	Ground Surface															
0.0																
	CLAYEY SILT Trace to some Gravel Some Sand Stiff		1	SS	13											
			2	SS	13											
			3	SS	12											
			4	SS	17											
			5	SS	14											
			6	SS	18											
			7	SS	19											
160.5	(FILL MATERIAL)															
5.9			8	SS	28											
	Trace Organics															
	CLAYEY SILT Trace to some Gravel Some Sand Very Stiff to Hard (GLACIAL TILL)		9	SS	30											
	Brown															
	Grey															
			10	SS	30											
			11	SS	45											
154.1			12	SS	19											
12.6	End of Borehole															

+3, x³; Numbers refer to Sensitivity 20 15-25 (%) STRAIN AT FAILURE 10

EXPLANATION OF TERMS USED IN REPORT

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS N_c .

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON A 1" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDAINED SHEAR STRENGTH AS FOLLOWS:

S_u (FSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: 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 DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG. CUU = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

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

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ ANGLE OF WALL FRICTION
 k_o COEFFICIENT OF EARTH PRESSURE AT REST
 k_a COEFFICIENT OF ACTIVE EARTH PRESSURE
 k_p COEFFICIENT OF PASSIVE EARTH PRESSURE
 i ANGLE OF INCLINATION OF SURCHARGE
 α SLOPE ANGLE-BACKFACE OF WALL
 β ANGLE OF SLOPE
 N, N_q, N_c BEARING CAPACITY FACTORS
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' UNIT WEIGHT OF SUBMERGED SOIL
 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} e IN LOOSEST STATE
 e_{min} e IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_p PLASTIC LIMIT
 w_s SHRINKAGE LIMIT
 I_p PLASTICITY INDEX = $w - w_p$
 I_L LIQUIDITY INDEX = $\frac{w - w_p}{w_L - w_p}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w_p}{w_L - w_s}$
 A_c ACTIVITY = $\frac{I_p}{w_L - w_p}$ Soil Fraction
 O_m ORGANIC MATTER CONTENT

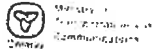
STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 τ_f PEAK SHEAR STRENGTH
 τ_R RESIDUAL SHEAR STRENGTH
 c COHESION INTERCEPT
 $\sigma_1, \sigma_2, \sigma_3$ NORMAL PRINCIPAL STRESSES
 u PORE WATER PRESSURE
 u_a EXCESS u
 r_u PORE PRESSURE RATIO
 q_u UNCONFINED COMPRESSIVE STRENGTH
 s_u UNDRAINED SHEAR STRENGTH
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν POISSON'S RATIO
 E MODULUS OF ELASTICITY
 G MODULUS OF SHEAR DEFORMATION
 k_s MODULUS OF SUBGRADE REACTION
 σ, α STABILITY COEFFICIENTS
 A, B PORE PRESSURE COEFFICIENTS

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY THE USE OF APOSTROPHE ABOVE THE SYMBOL.

HYDRAULIC TERMS

h HYDRAULIC HEAD OR POTENTIAL
 q RATE OF DISCHARGE
 v VELOCITY OF FLOW
 i HYDRAULIC GRADIENT
 j SEEPAGE FORCE PER UNIT VOLUME
 η COEFFICIENT OF VISCOSITY
 k COEFFICIENT OF HYDRAULIC CONDUCTIVITY
 k_h k IN HORIZONTAL DIRECTION
 k_v k IN VERTICAL DIRECTION
 α_v COEFFICIENT OF VOLUME CHANGE
 c_v COEFFICIENT OF CONSOLIDATION
 C_c COMPRESSION INDEX
 C_r RECOMPRESSION INDEX
 d DRAINAGE PATH DISTANCE
 T_v TIME FACTOR
 U DEGREE OF CONSOLIDATION



RECORD OF BOREHOLE No 4

METRIC

W P 48-71-22 LOCATION Sta. 406 + 50; o/s 26.0' Lt. (Imperial Chainage)
DIST 6 HWY 427/409 BOREHOLE TYPE Cone Test, Solid Stem Auger
DATUM Geodetic DATE 88 03 29

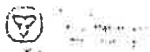
ORIGINATED BY TS
COMPILED BY TS
CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(feet)	ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES	20 40 60 80 100	W _p		
567.6	173.0	Ground Surface										
0.0	0.0	Irregular Mixture of Clayey Silt, Some Sand, Trace Gravel (Fill)		1	SS	40						
		Some Organics		2	SS	12					20.2	14 14 40.32
				3	SS	10						
				4	SS	22						
		Brown/Grey Stiff to Very Stiff		5	SS	20						
537.6	163.9	Ret. Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		6	SS	37						
30.0	9.1			7	SS	71					22.6	
		Brown Grey		8	SS	31						
526.1	160.4											
41.5	12.6	End of Borehole										

*3, *5: Numbers refer to Sensitivity
20
15
10

(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 6

METRIC

W P 6d-71-22 LOCATION Co-ords: N 4 840 755, E 245556 ORIGINATED BY TS
DIST 6 HWY 427/409 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
DATUM Geodetic DATE 88 03 30 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV (feet)	DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	20	40	60	80	100	WATER CONTENT (%)	GR SA SI CL
561.4	0.0	Ground Surface											
341.4	171.1	Irregular Mixture of Clayey Silt Sand and Gravel (Fill)		1	SS	16							
		Brown/Grey		2	SS	16							
		Stiff to Very Stiff		3	SS	18							
		Organic Inclusions		4	SS	23							
				5	SS	30							
341.4	165.0	Het. Mix. of Clayey Silt, Sand and Gravel		6	SS	20							
20.0	6.8	Brown Grey (Glacial Till)		7	SS	41							
529.9	161.5	V. Stiff to Hard		8	SS	20							
31.5	9.6	End of Borehole											

3, 4, 5: Numbers refer to Sensitivity
20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 815-89-00

LOCATION Coords.: N 4 841 287 E 295 339

ORIGINATED BY LO

DIST 8 HWY 427

BOREHOLE TYPE Solid Stem Auger

COMPILED BY LO

DATUM Geodetic

DATE 1994 09 11

CHECKED BY BB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
166.3	Ground Surface												
0.0	CLAYEY SILT Trace Gravel Some Sand Firm to Stiff		1	SS	4								
164.2	(FILL MATERIAL)		2	SS	9								
2.1			3	SS	29								
	Brown		4	SS	30								
	Grey		5	SS	16								
	CLAYEY SILT TO SILT Trace Gravel; Trace to some Sand Stiff to Hard (GLACIAL TILL)		6	SS	14								
	Silty Sand Seams		7	SS	13								
			8	SS	16								
			9	SS	34								
158.7			10	SS	34								
9.6	End of Borehole												

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

Co-ords: N 4841 828, E 295 134

JOB 72-11024

LOCATION: 5,885,263 N; 968,288 E.

W.P. 126-60

BORING DATE March 8, 1972

ORIGINATED BY VK

DATUM Geodetic

BOREHOLE TYPE Auger & sample with C.H.E.

COMPILED BY VK

CHECKED BY

METRIC UNITS

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		20	40	60	80	100	w_p	w			w_L
SHEAR STRENGTH P.S.F.															
○ UNCONFINED + FIELD VANE															
● QUICK TRIAXIAL x LAB. VANE															
WATER CONTENT %															
15 30 45															
148.9	552.6	Ground Level													
0.0	0.0														
		Het. mix. of clayey silt, sand & gravel													
			1	SS	14										
			2	SS	76										
			3	SS	78										
		Brown Grey	4	SS	21										
		Glacial Till	5	SS	22										
		Stiff to Hard	6	SS	21										
			7	SS	43										
140.0	525.0		8	SS	20										
8.4	27.6	Silty sand with some gravel.	9	SS	18										
157.8	517.6	Compact	10	SS	95										
10.7	35.0		11	SS	73										
			12	SS	55										
153.2	502.6		13	SS	28										
15.2	50.0	Silty sand to sandy silt, with trace of clay and gravel.	14	SS	43										
147.2	483.1	Compact to Dense													
21.2	69.5	Het. mix. of clayey silt, sand & gravel. (Glacial Till)	15	SS	140										
		Hard													
		Fragments of Shale	16	SS	100/3"										
142.1	466.1														
26.4	86.5	End of Borehole Probable Bedrock													

20
15 \diamond 5 % STRAIN AT FAILURE
10

FOUNDATIONS OFFICE

LOCATION

Co-ORDS: N 4 841 846, E 295 053

Co-ords. 5,885,320 N; 968,022 E.

W.P. 126-60

BORING DATE March 13, 1972

ORIGINATED BY VK

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Auger & sample with C.M.E.

CHECKED BY

15 $\frac{20}{10}$ 5 % STRAIN AT FAILURE

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 615-89-00

LOCATION Coords.: N 4 842 341, E 294 896

ORIGINATED BY T.G.

DIST 8 HWY 427

BOREHOLE TYPE Solid Stem Auger

COMPILED BY L.O.

DATUM Geodetic

DATE 1994 08 15

CHECKED BY B.B.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID UNIT MOISTURE UNIT UNIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W _p W W _L	10 20 30	10 20 30		
162.1	Ground Surface															
0.0	CLAYEY SILT TO SILT Traces of Sand Very Stiff		1	SS	23											
160.7			2	SS	37											
1.4	SILTY SAND TO SAND Traces of fines Dense to Very Dense		3	SS	52											
159.8			4	SS	43											
2.5	CLAYEY SILT TO SILT Traces of Sand Hard		5	SS	61											
158.1			6	SS	30											
4.0	SAND - Poorly Graded, Traces of Fines, Very Dense		7	SS	89											
157.7			8	SS	67											
4.4	CLAYEY SILT Trace of Gravel Some Sand Hard to Very Stiff (GLACIAL TILL)		9	SS	29											
153.5			10	SS	45											
6.6	SANDY SILT Trace Gravel Trace Sand Occasional Seams of Sand Dense															
152.5																
9.8	End of Borehole															

RECORD OF BOREHOLE No 13

1 OF 1

METRIC

W.P. 515-59-00

LOCATION Coords.: N 4 842 931, E 294 659

ORIGINATED BY T.G.

DIST 6 HWY 427

BOREHOLE TYPE Solid Stem Auger

COMPILED BY L.O.

DATUM Geodetic

DATE 1994 08 15

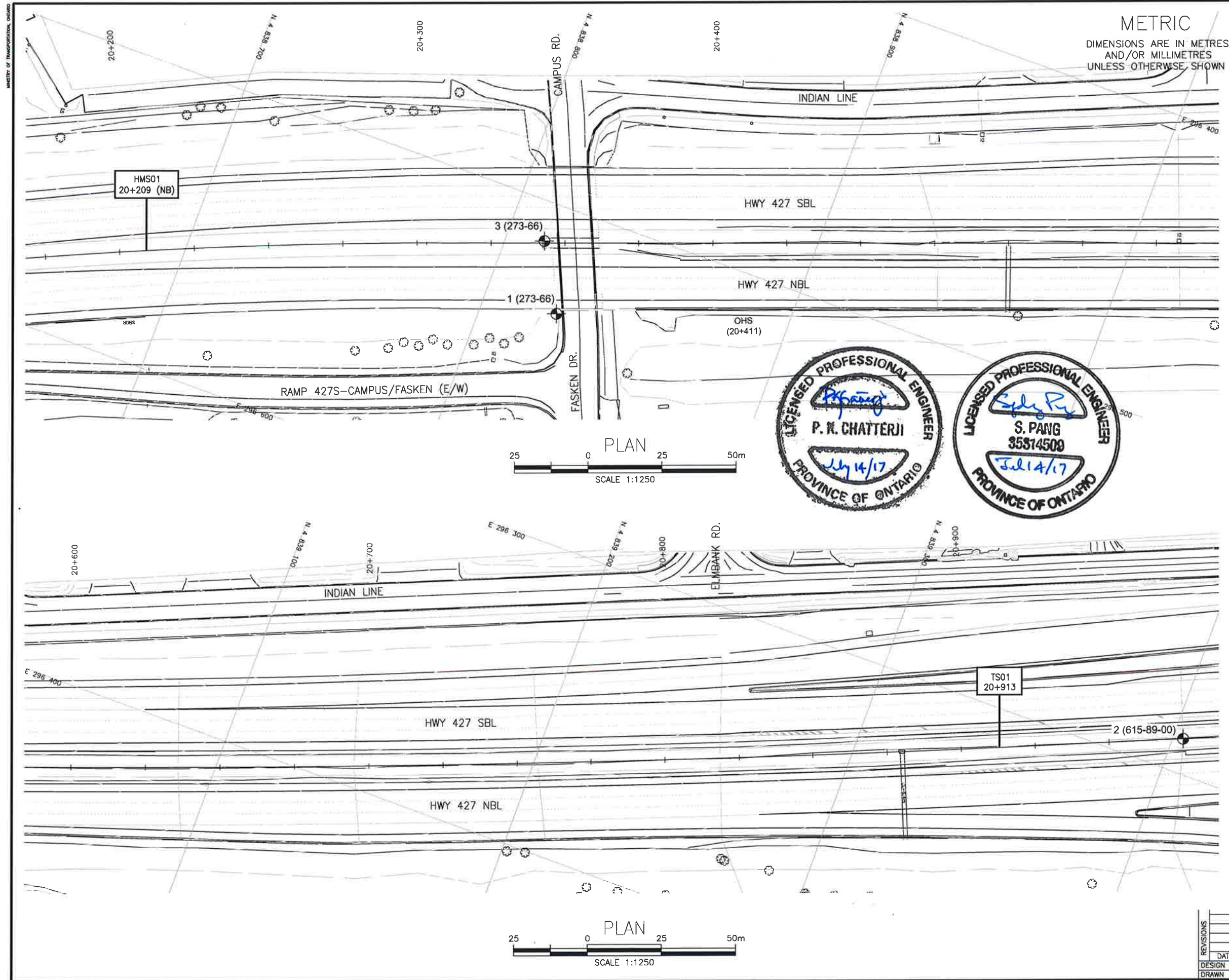
CHECKED BY B.B.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W _p	W	W _L		
162.5	Ground Surface															
0.0	CLAYEY SILT TO SILT Trace Gravel Trace to some Sand Very Stiff to Hard		1	SS	58											
			2	SS	17											
			3	SS	122											
			4	SS	125											
			5	SS	149	/23cm										
157.3			6	SS	150	/28cm										
5.2	SILTY SAND Some Gravel Some Fines Dense		7	SS	32											
155.8			8	SS	150											
5.9	CLAYEY SILT Traces of Gravel Some Sand Hard		9	SS	112	/8cm										
155.4			10	SS	100	/8cm										
7.1	BEDROCK Weathered Gray Shale Hard															
152.9																
9.6	End of Borehole															



Appendix B

Borehole Locations Drawings



CONT NO 2014-2016
GWP No 202-95-00

HIGHWAY 427 WIDENING
HOT TOLL & HOT HMS
SIGN SUPPORT
BOREHOLE LOCATIONS PLAN

SNC-LAVALIN

THURBER ENGINEERING LTD.



- Legend:
- Borehole
 - Borehole and Cone
 - N Blows /0.3m (Std Pen Test, 475J/blow)
 - CONE Blows /0.3m (60' Cone, 475J/blow)
 - PH Pressure, Hydraulic
 - Water Level
 - Head Artesian Water
 - Piezometer
 - 90% Rock Quality Designation (RQD)
 - A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
1 (273-66)	165.8	4 838 825.1	296 534.9
3 (273-66)	166.2	4 838 812.8	296 513.2
2 (615-89-00)	164.5	4 839 403.4	296 288.5

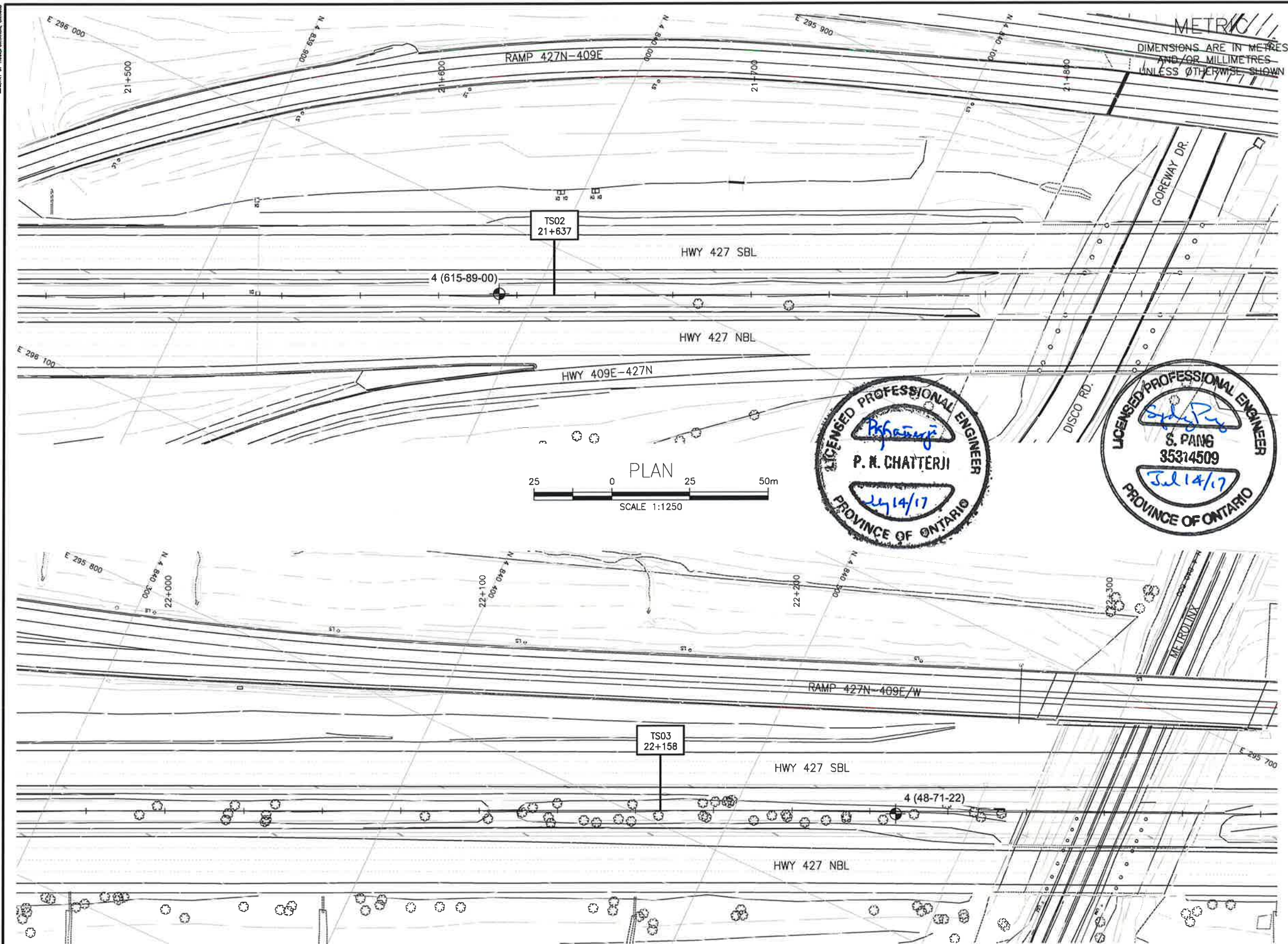
- NOTES-
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
 - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M12-407

REVISIONS

DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP CODE
DRAWN	AN	CHK RPR SITE
LOAD		DATE JUL 2017
STRUCT		DWG 1

FILENAME: H:\Drafting\1000\11294\11294-TED-11294-BHPL.dwg
PLOTDATE: 7/7/2017 1:34 PM

CONT NO 2014-2016
GWP No 202-95-00HIGHWAY 427 WIDENING
HOT TOLL & HOT HMS
SIGN SUPPORT
BOREHOLE LOCATIONS PLANSHEET
251-2

KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

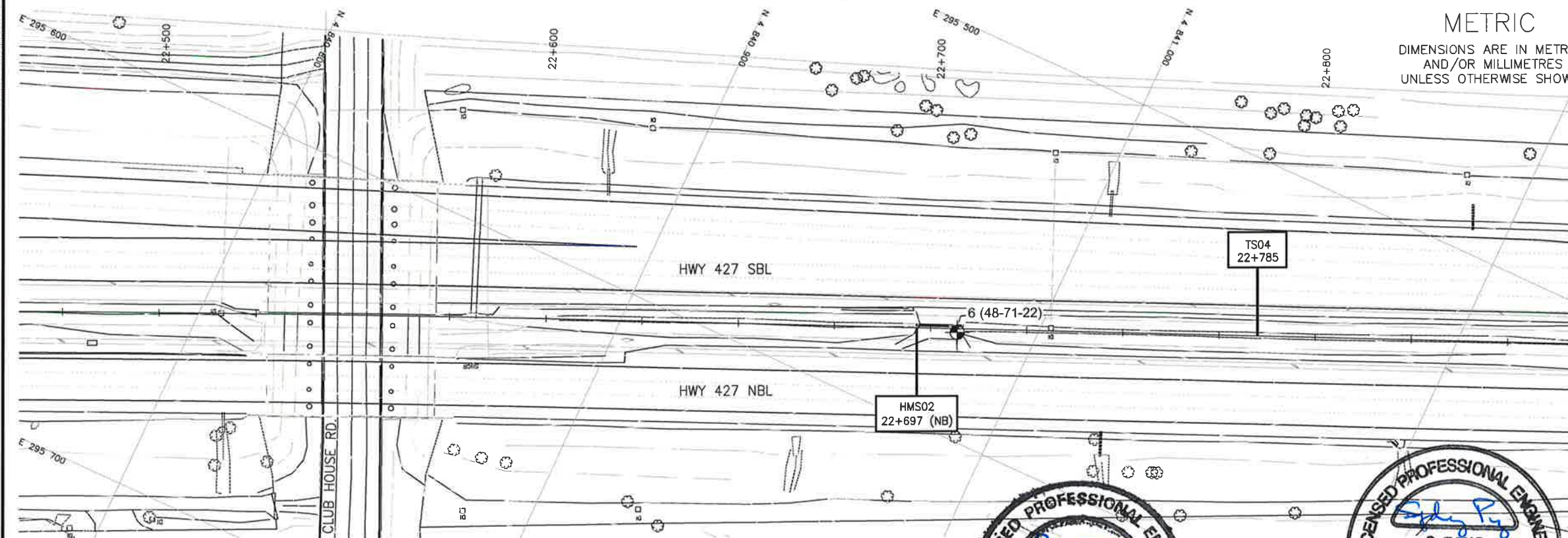
NO	ELEVATION	NORTHING	EASTING
4 (48-71-22)	173.0	4 840 547.7	295 765.4
4 (615-89-00)	166.7	4 839 989.4	296 020.9

-NOTES-

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- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCREs No. 30M12-407

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK	SKP
DRAWN	AN	CHK	RPR
CODE	LOAD	DATE	JUL 2017
SITE	STRUCT	DWG	2



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

CONT NO 2014-2016
GWP No 202-95-00

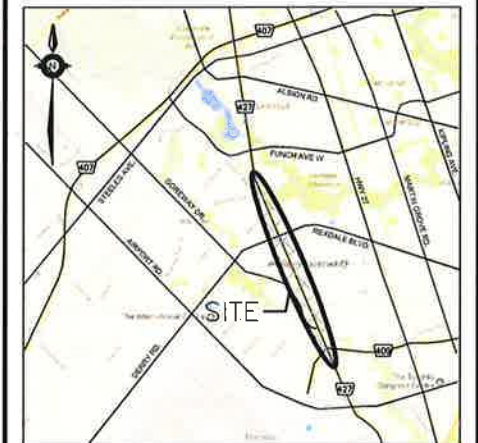


HIGHWAY 427 WIDENING
HOT TOLL & HOT HMS
SIGN SUPPORT
BOREHOLE LOCATIONS PLAN

SHEET
251-3








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
6 (48-71-22)	171.1	4 840 980.9	295 573.9
7 (615-89-00)	166.3	4 841 462.0	295 365.4

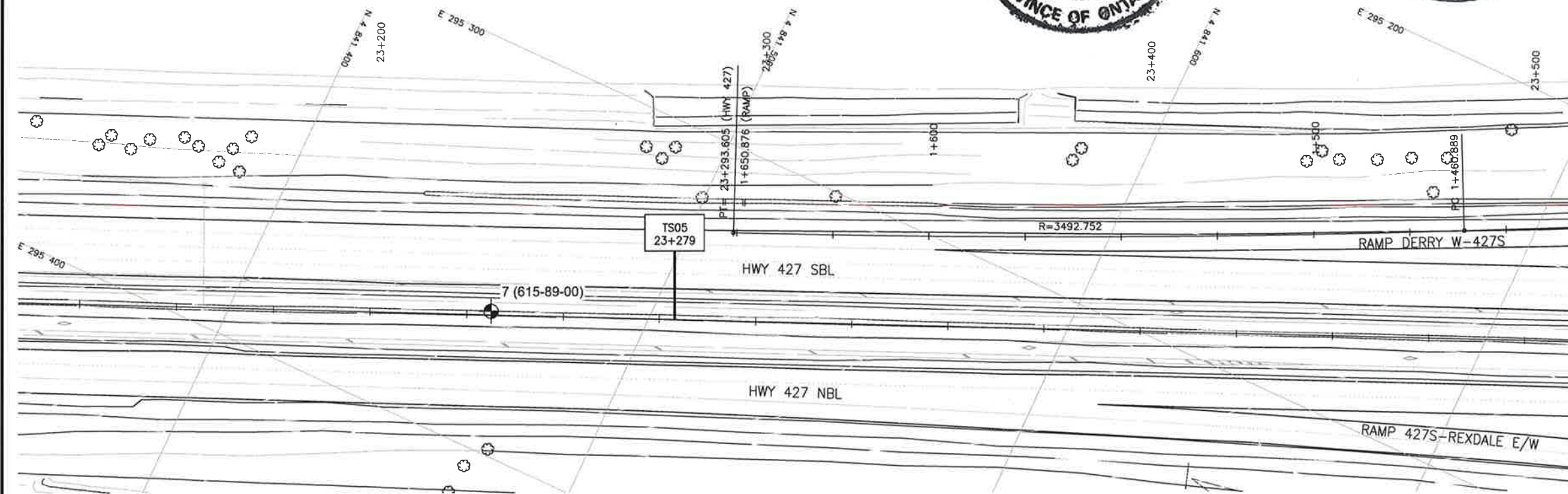
-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M12-407

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PLAN

SCALE 1:1250

