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DIST. 4 REGION

W.P. No. 319-89-00

CONT. No. 93-85

W. O. No.

STR. SITE No.

HWY. No. Q.E.W.

LOCATION Gray Rd. to Fifty Rd.
(Culverts)

No of PAGES -

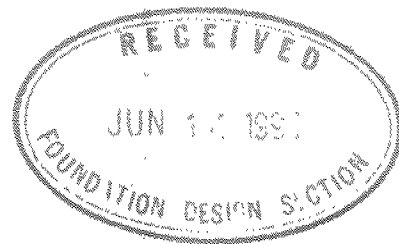
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-85



**Ministry of
Transportation**

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3-42	Foundation Investigation Report for QEW Culverts Between Gray's Rd. and Fifty Rd. W.P. 319-89-00, Site - Hwy QEW, District 4 Burlington

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

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 (R Q D), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

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 ³ /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 ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT
For
Q.E.W. Culverts
(Between Gray's Road and Fifty Road)
W.P. 319-89-00
District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted in conjunction with nine (9) proposed reinforced concrete box culverts that will carry the Q.E.W. and in some cases the North and South Service Roads. The proposed new culverts will replace existing culverts within the site limits defined by Gray's Road and Winona Road at or adjacent to the existing culverts. The culvert replacement project is associated with the Q.E.W. widening to a 6 lane divided highway.

SITE DESCRIPTION

The site is located within the area bounded by the North Service Road and the South Service Road along the Q.E.W. corridor between Gray's Road and Fifty Road in the Town of Stoney Creek, Regional Municipality of Hamilton-Wentworth. The existing Q.E.W. is a four lane median divided highway and grassland separates the Q.E.W. and the North and South Service Roads. Nine (9) separate sites (Sites A to I inclusive) were investigated within the overall site limits.

Numerous open footing and box culverts exist within the site limits facilitating the transmission of creek waters to Lake Ontario in a northerly direction beneath the service roads and the Q.E.W. The existing culverts vary in dimension and appear to have been constructed as early as the 1930's. Minimal depths of cover (up to approximately 2 to 3 metres) generally exist above the culvert roofs. The culverts appear to be of sound quality and no significant visible signs of concrete deterioration were observed.

A number of Q.E.W. underpass structures exist within the site limits. Underpass structures proceeding from west to east include Millen Road, Fruitland Road, Glover Road and Winona Road. The structures are four span structures with approach fills in the order of magnitude of 7-8 metres. The terrain across the

site is generally flat accentuated by creek slopes at the culvert inlets and outlets. Depths of water in the creeks were shallow at the time of the investigation and generally were less than one (1) metre. As mentioned earlier, grassland covers the area between the asphaltic Q.E.W. roadway and the service roads.

Land use in the area is divided into residential north of the existing North Service Road and industrial south of the existing South Service Road. In addition, an MTO district garage is located at the South Service Road just west of Winona Road. Truck Inspection Stations are also located within the site limits.

Physiographically, the site is located in the region known as the "Iroquois Plain". The Iroquois Plain is the product of the advance and retreat of the Wisconsin ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). The lowland bordering Lake Ontario, when the last glacier was receding was inundated by the glacial lake called Lake Iroquois at the site. Conditions in the old lake plain vary greatly within the Iroquois Plain. At the site location, overburden consists of a heterogeneous mixture of clayey silt, sand, and gravel, which is a till deposit of glacial origin. At some locations, the surficial cohesive deposit is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel. The overburden at the site is underlain by shale bedrock of the Queenston Formation in thickness ranging from approximately 25 metres at the western limits of the site to approximately 10 metres at the eastern limits of the site.

INVESTIGATION PROCEDURE

Soil and rock data and inherent properties were obtained by in situ and laboratory testing. The procedures employed in the foundation investigation are discussed below.

Field Investigation

The fieldwork for the investigation was carried out between 91 10 28 and 91 11 12 and consisted of twenty-five (25) sampled boreholes advanced to depths

ranging from 12.2 m to 15.7 m below the existing ground surface. Diesel powered track mounted drilling rigs equivalent to Central Mining Equipment (CME) 55 units, were used to advance the boreholes employing conventional hollow stem augering and solid stem augering techniques. It was determined that the subsoil conditions enabled the application of solid stem augering techniques exclusively at the site which resulted in improved productivity.

Subsoil samples were retrieved at 0.7 m intervals for the surficial 6.5 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved employing a standard split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). All subsoil samples were identified in the field and then placed in sealed plastic jars to ensure the preservation of the natural moisture contents. Samples were subsequently transported to the laboratory for applicable testing.

Bedrock was cored at one (1) location (site I) where shallower thicknesses of overburden were encountered. The bedrock was cored in NX size using conventional rock coring procedures. At a few locations (sites A, B, and C), in situ vane tests were conducted to determine the in situ undrained shear strength of some weaker soil present at these locations. Standard MTO 'N' vanes were used to conduct the test in accordance with ASTM D2573.

Groundwater levels were determined by monitoring the levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevations of the individual boreholes was provided by Central Region Surveys and Plans.

Laboratory Analyses

To identify the behaviour, gradation and pertinent properties of the soil present at the site, various laboratory testing were conducted. These tests included:

- 1) Atterberg Limits
- 2) Grain Size Distributions
- 3) Natural Moisture Contents
- 4) Bulk Unit Weights

The tests were carried out in accordance with standard procedures.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions", and are illustrated on the corresponding boreholes and figures included in the Appendix of this report.

Subsurface Conditions

The ground surface elevation varies both within each individual site and also from site to site. The variation within each individual site is a reflection of the creek channels present at the existing culvert locations and is generally in the order of 2.5 m to 5.0 m from the top of fill material above the culvert roof to the channel floor. The ground surface elevation increases in an easterly direction from approximately 76.1 m (Site A) to 83 m (Site I).

The entire site area has been inundated by a surficial deposit of glacial till consisting of a cohesive heterogeneous mixture of clayey silt, sand and gravel with random boulders and cobbles. The deposit was explored to depths up to 15.7 m and has generally been weathered and oxidized for up to approximately 5 metres from the ground surface. Hence, the soil is generally brown within this surficial depth and grey (unoxidized) below. At some sites, the lower thickness of the deposit has taken a red colour indicative of iron oxide compounds in the soil. Some black organic enriched soil was also found within the surficial one (1) to two (2) metres at various sites.

At sites, E, F, and G the surficial native cohesive material is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel. This deposit, also of glacial till origin, was found at depths of 10.7 m to 13.7 m below the ground surface. The thickness of this deposit explored ranged upto 2.0 m.

At Site I, the surficial native cohesive heterogeneous mixture of clayey silt, sand and gravel is underlain by shale bedrock at depths ranging from 9.8 m to 11.0 m (Elevation 72.3 m to 70.5 m).

The native heterogeneous mixture of clayey silt, sand and gravel is overlain by fill material at some locations across the site. At sites D, H and I for instance, thicknesses of an irregular mixture of clayey silt, sand and gravel fill material for a thickness up to approximately 2.1 metres was also encountered.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and a subsoil stratigraphical section are provided on Dwg. No. 3198900-A, B and C.

A detailed description of the subsurface conditions encountered is given below.

Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)

A cohesive irregular mixture of clayey silt, sand and gravel identified as fill material was encountered at some sites extending from the surface to a depth of approximately 2.1 m. It appears that this material was used as backfill material to the existing culvert at the various sites.

A grain size distribution as determined by hydrometer and mechanical sieve analyses on a representative sample of fill material (see Record of Borehole H1 in the Appendix) reveals that approximately 89% of the material is finer than 75 micrometres.

An Atterberg Limit Test was carried out on the fine grained portion of the fill material (less than 75 micrometres) to define the behaviour and plasticity of the material. The results reveal that the material has a Liquid Limit (w L) of 34% and a Plasticity Index (I P) of 16.5%. Consequently, the material is classified as a clayey silt of low plasticity. The natural moisture content of the material is 21%.

The 'N' values as determined by the Standard Penetration Test (SPT) revealed a range of 7 blows/0.3 m to 10 blows/0.3 m for the samples retrieved in this material. This reveals a consistency ranging from firm to stiff.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Underlying the fill material and occurring surficially elsewhere at the site, a native deposit consisting of a cohesive heterogeneous mixture of clayey silt, sand and gravel exists. Boulders and cobbles as inferred in the augering process during the borehole advancement also comprise the deposit. Random zones of a heterogeneous mixture of silt, sand and gravel are also found in this deposit. Red shale fragments are also present within the lower depths of the investigated deposit. The deposit was explored to a maximum thickness of 15.7 metres and is of minimum thickness at Site I (9.8 m thickness).

The upper 2.7 to 4.9 metres or so has been oxidized and in areas where organic material is not present within the surficial thickness, soil colour is brown. Organic dominated soils were found at some locations, usually within the surficial 2 metres and this material is black in colour. Below the oxidized and/or organic surficial material, the soil is unoxidized and grey throughout most of the deposit thickness. At some locations, the lower 2 to 3 metres is red in colour and random red zones are interbedded within the grey material.

The main component of this unsorted, unstratified deposit is the clayey silt material. This material matrix essentially binds the coarser sands and gravels within the deposit. A grain size distribution envelope for the deposit as determined by mechanical sieve and hydrometer analyses is given in Figure 1 in the Appendix. The envelope includes particle sizes up to 75 mm (coarse gravel)

and hence excludes the boulder and cobble sizes. The envelope does reveal that the fine grained portions (less than 75 micrometres) contribute to more than approximately 70% of the material of this deposit.

Atterberg Limit Tests were carried out to define the behaviour and plasticity of the fine grained portion of the soil and the results are plotted in Figure 2. A summary of the indices is provided in Table 1 below. Bulk Unit Weights are also included in the table.

Table 1 - Heterogeneous Mixture of Clayey Silt
Sand and Gravel (Glacial Till)

	Range	No. of Tests
Natural Moisture Content (w%)	13-21	29
Liquid Limit (w L %)	22-35	29
Plastic Limit (w P %)	14-18	29
Plasticity Index (I P %)	10-18	29
Unit Weight (kN/m ³)	19-22.3	29

The test results reveal that the fine grained portion of the deposit is of low plasticity and hence is defined as clayey silt. Natural moisture contents are generally less than or equivalent to the plastic limit of the soil indicating that the soil is in a plastic to semi-solid state.

The results of Atterberg Limit Test conducted on an organic enriched material retrieved at a depth of 1.5 m at BH B2 revealed a liquid limit (w L %) of 66%, a plasticity index (I P %) of 31% and a natural moisture content (w%) of 45%. This material would plot as an organic clay of high plasticity on the plasticity chart.

Standard Penetration Test (SPT) carried out in this deposit revealed 'N' values ranging from 5 blows/0.3 m to 54 blows/0.3 m revealing a probable firm to hard range of soil consistency. The lower values are generally indicative of localized weaker material and/or organic enriched material. In general, 'N' values are in the 12 blows/0.3 m to 25 blows/0.3 m and hence the soil is considered as stiff to very stiff.

At depths where the 'N' values were considered "low" (usually less than 10 blows/0.3 m), in situ vane tests were conducted. In general, the vanes could not be torqued and undrained shear strength values exceeded 100 kPa. The minimum undrained shear strength value obtained was 80 kPa but this lower value can be considered as an isolated weak zone within the deposit. It should be cautioned, however, that the presence of the coarse grained sand and gravel in the deposit may have influenced the accuracy of the test. It is concluded however, that the consistency ranges from stiff to hard.

Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)

At Sites E, F, and G the cohesive heterogeneous mixture of clayey silt, sand and gravel is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel at a depth ranging from 10.7 m to 13.7 m (Elevation 69.4 m to 71.8 m). Layers of silt with some sand are also present in this deposit in thicknesses up to approximately 0.5 m. The deposit is red in colour and as inferred by auger grinding, boulders and cobbles are also present within this deposit. Red shale fragments are also contained within the deposit.

Grain Size Distribution curves illustrating the gradation of the deposit and determined by mechanical sieve and hydrometer analysis are shown in Figure 3 in the Appendix. Boulder and cobble sizes are not illustrated on the Figure.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 77 blows/0.3 m to 100 blows/0.2 m indicating that the deposit is in a very dense state of denseness.

Bedrock

Shale bedrock with interbedded siltstone of the Queenston Shale Formation underlies the overburden at Site I at a depth of 9.8 m to 11 m (Elevation 72.3 m to 70.5 m). Bedrock core was retrieved in NX size for a thickness of 2.84 m at BH I2.

The shale bedrock is generally greyish red and has randomly interbedded greenish grey siltstone layers. The rock is horizontally bedded and is an extremely friable material. The rock contains moderately close to extremely closed spaced

fractures that are generally flat, planar to undulating and smooth. The rock generally is unweathered to slightly weathered.

Core recoveries and Rock Quality Designations (RQD) were determined in situ to evaluate the competence and integrity of the rock. Core recoveries were 100% and RQD's ranged from 52% to 74%. Based on these measurements, the rock can be considered to be of fair quality.

Based on index property identification, the rock is classified as weak to very weak in strength.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes throughout the duration of the field investigation. Groundwater levels, in general, are depressed at depths ranging from 10 m to 12 m below the natural ground surface (Elevation 66 m to 68 m).

Groundwater levels were however at some locations measured at shallow depths ranging from 2 to 4 metres below the natural ground surface (76.5 m to 77 m). These water levels illustrate the effect of the subartesian condition present in the heterogeneous mixture of silt, sand and gravel deposit below the cohesive heterogeneous mixture of clayey silt, sand and gravel.

Groundwater levels were not established at the borehole locations advanced on the shoulders of the Q.E.W. and the Service Roads because these boreholes were backfilled immediately for safety reasons.

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and F. Reijerse, Student Engineer, utilizing equipment owned and operated by Malone's Soil Samples.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



A handwritten signature in cursive script, appearing to read "P. Payer".

P. Payer, P. Eng.
Senior Foundation Engineer

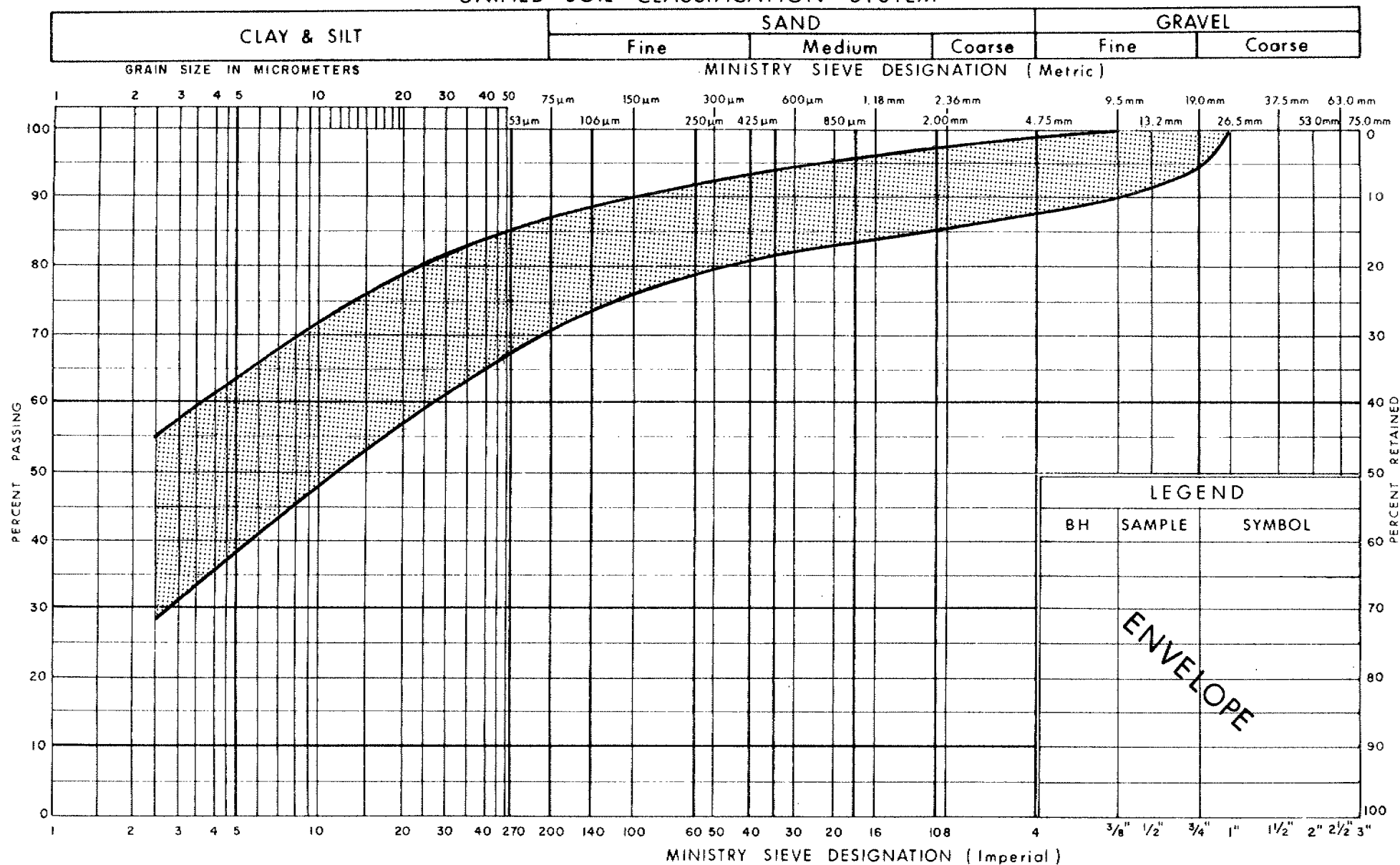


A handwritten signature in cursive script, appearing to read "M. Devata".

M.S. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

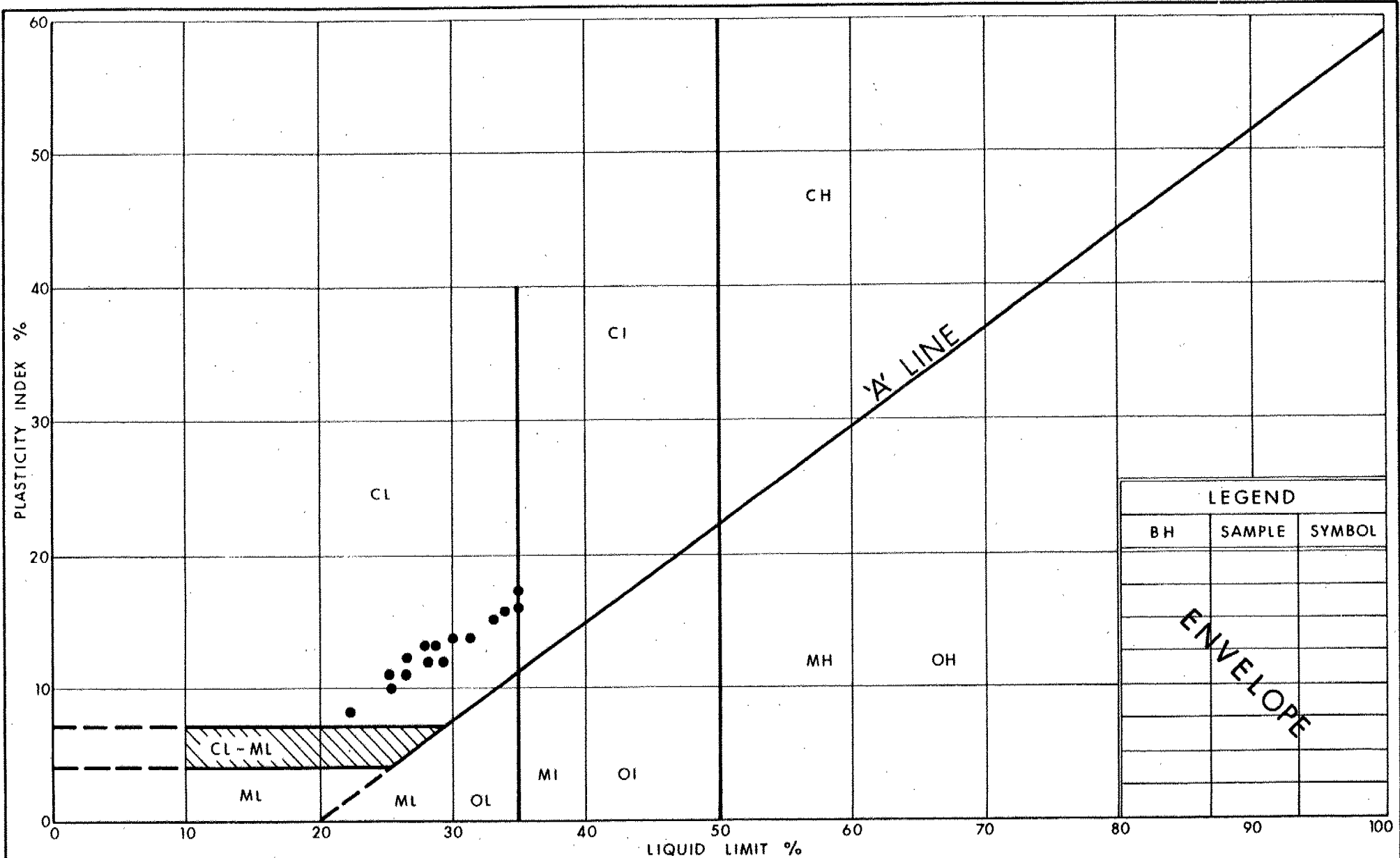


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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF CLAYEY SILT
SAND & GRAVEL (Glacial Till)

FIG No 1

W P 319 - 89 - 00



Ministry of
Transportation

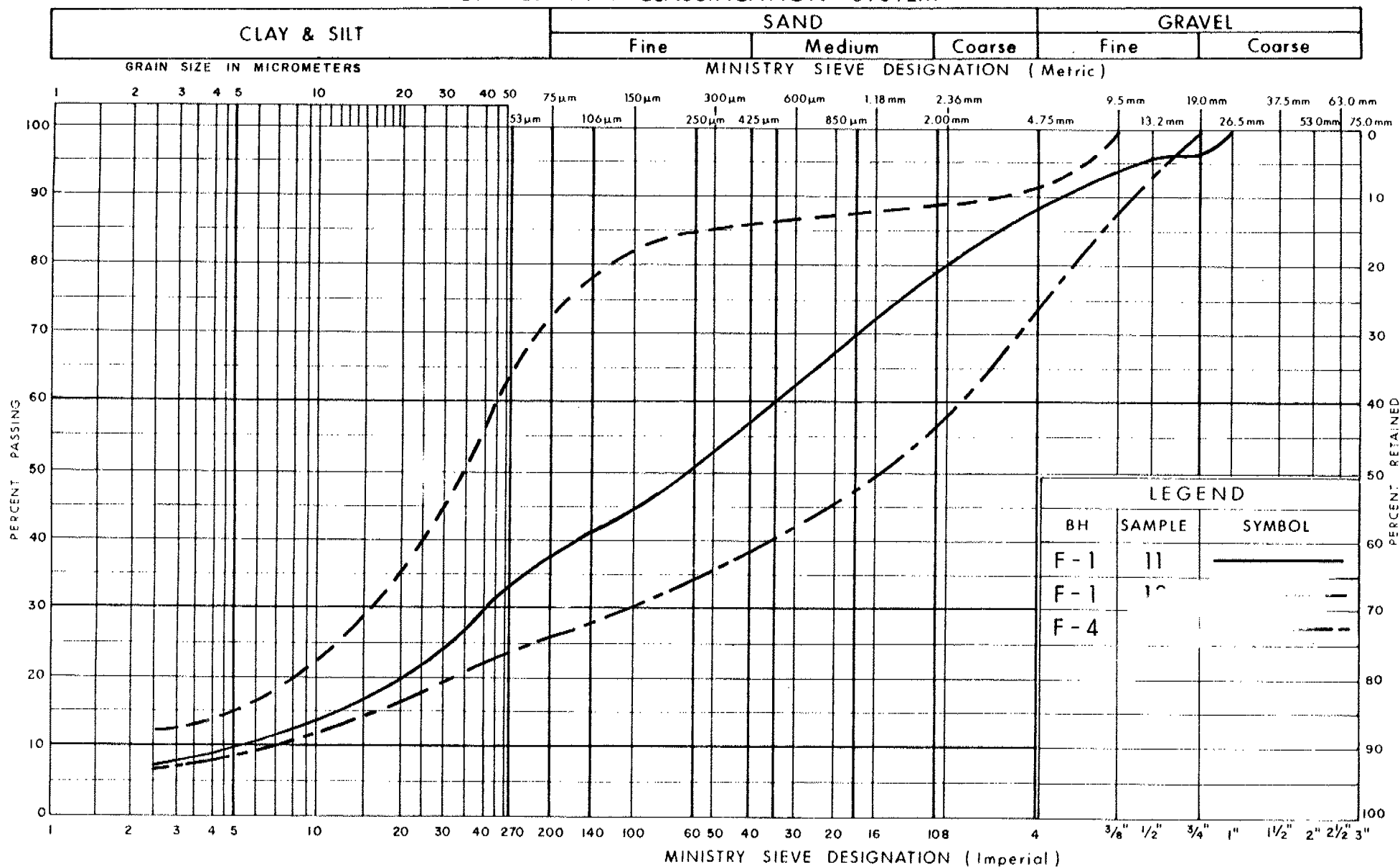
Ontario

PLASTICITY CHART
HET MIXTURE OF CLAYEY SILT,
SAND & GRAVEL (Glacial Till)

FIG No 2

W P 319-89-00

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 319-89-00

ROCK CORE DESCRIPTION **WP 319-89-00**

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CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
I2	11	9.60-10.92	100	51	9.60-12.44	SHALE , greyish red, with interbedded greenish grey SILTSTONE (18%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 9.60-9.75 m and 10.87-10.92 m); fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	12	10.92-12.44	100	74		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

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

Logged by: DAW, Soils and Aggregates Section

RECORD OF BOREHOLE No A-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 623; E 286 160 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 28 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W _p	W	W _L		
76.6	Ground Surface													
0.0	Black, some Organics Brown		1	SS	25									
			2	SS	22									
			3	SS	18									
			4	SS	32									
	Grey		5	SS	24									
			6	SS	12									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		7	SS	33									
			8	SS	20									
	Very Stiff to Hard		9	SS	14									
			10	SS	15									
			11	SS	21									
			12	SS	19									
60.9			13	SS	20									
15.7	End of Borehole # 91 10 29													

RECORD OF BOREHOLE No A-2

1 of 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 675:E 286 146 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 31 CHECKED BY PP

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			20	40	60	80	100					
76.1	Ground Surface																
0.0	Black, some organics, Firm Brown, Grey		1	SS	7												
			2	SS	23												
			3	SS	17												
			4	SS	16												
			5	SS	16												
			6	SS	16												
			7	SS	11												
			8	SS	9												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		9	SS	12												
			10	SS	8												
			11	SS	14												
63.5			12	SS	15												
12.6	End of Borehole • 91 11 01																

RECORD OF BOREHOLE No B-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 514; E 286 485 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE H5 Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 29 CHECKED BY PP

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No B-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 549; E 286 508 ORIGINATED BY FR
DIST 4 HWY G.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 30 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
77.7	Ground Surface																
0.0	trace Organics		1	SS	7		76										
	Firm		2	SS	8												
			3	SS	10		74										
			4	SS	18												
	Brown		5	SS	20		72										
	Grey		6	SS	15												
			7	SS	13		70										
	Heterogenous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	13		68										
	Stiff to Very Stiff		9	SS	19		66										
65.1			10	SS	21												
12.6	End of Borehole • 91 10 31																

RECORD OF BOREHOLE No C-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 409; E 286 829 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 29 CHECKED BY PP

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		
78.2	Ground Surface													
0.0			1	SS	7									
	Black, some Organics		2	SS	6									
	Red		3	SS	12									
	Brown		4	SS	16									
			5	SS	19									
			6	SS	21									
	Grey		7	SS	16									
			8	SS	13									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	12									
	Stiff to Very Stiff		10	SS	11									
			11	SS	15									
65.6			12	SS	27									
12.6	End of Borehole													
	* 91 10 30													

RECORD OF BOREHOLE No C-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 457; E 286 800 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 30 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
76.8	Ground Surface																
0.0	Black, trace Organics		1	SS	23		76										
	Brown		2	SS	5												
			3	SS	22		74									18.7	6 21 40 33
	Grey		4	SS	18												
			5	SS	13		72										
			6	SS	12												
			7	SS	14		70										
	Heterogenous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	15												
	Stiff to Very Stiff		9	SS	25		68										
64.2			10	SS	26		66										
12.6	End of Borehole * 91 10 31		11	SS	30												

RECORD OF BOREHOLE No D-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 049; E 287 778 ORIGINATED BY FR
DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Ceodetic DATE 91 11 01 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
79.8	Ground Surface																
79.0	Sand and Gravel (Fill Material)					*											
0.8	Firm		1	SS	5		78										
			2	SS	29												
			3	SS	22												
	Brown		4	SS	17		76										
	Grey		5	SS	12												
			6	SS	25												
			7	SS	14		74										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	13												
			9	SS	14		72										
	Stiff to Very Stiff		10	SS	14		70										
			11	SS	12												
67.2			12	SS	16		68										
12.6	End of Borehole • CWL not established																

RECORD OF BOREHOLE No D-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N4 788 077; E 287 788 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 31 to 91 11 01 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
79.1	Ground Surface													
0.0			1	SS	23		78							
			2	SS	27									
			3	SS	21									
	Brown Grey		4	SS	13		76						21.4	2 22 44 32
			5	SS	13									
			6	SS	24									
			7	SS	13		74							
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	12								21.8	7 15 45 33
	Stiff to Very Stiff.		9	SS	14		72							
			10	SS	15		70							
			11	SS	22									
66.5			12	SS	20		68							
12.6	End of Borehole													
	• 91 11 02													

RECORD OF BOREHOLE No D-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 128; E 287 805 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 04 CHECKED BY PP

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 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					
78.3	Ground Surface																
0.0			1	SS	26		78										
			2	SS	21												
			3	SS	15		76										
	Brown		4	SS	15												
	Grey		5	SS	12		74										
			6	SS	13												
	Heterogeneous Mixture of		7	SS	12		72										
	Clayey Silt, Sand and Gravel		8	SS	14												
	(Glacial Till)																
	Stiff to Very Stiff		9	SS	17		70										
			10	SS	17												
			11	SS	22		68										
65.7	Hard		12	SS	49		66										
12.6	End of Borehole																
	* 91 11 05																

RECORD OF BOREHOLE No D-4

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 171; E 287 805 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 04 CHECKED BY PP

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			20	40	60	80	100					
78.3	Ground Surface																
0.0			1	SS	20		78										
			2	SS	30												
			3	SS	18		76										
			4	SS	20												
			5	SS	12		74										
			6	SS	16												
			7	SS	12												
			8	SS	10		72										
			9	SS	13		70										
			10	SS	20												
			11	SS	20		68										
			12	SS	28		66										
65.7																	
12.6	End of Borehole																
	* 91 11 05																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No E-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 897; E 288 323 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 01 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
78.5	Ground Surface																
0.0			1	SS	23		78										
			2	SS	35												
	Brown		3	SS	27		76									21.4	6 24 44 26
	Grey		4	SS	25												
			5	SS	20												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		6	SS	19		74										
			7	SS	20												
	Stiff to Very Stiff		8	SS	17		72										
			9	SS	14		70									22.0	1 21 48 30
			10	SS	19												
			11	SS	22		68										
			12	SS	29		66										
64.8																	
13.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		13	SS	60	/13cm	64										
62.8	Red, Very Dense		14	SS	100												
15.7	End of Borehole																
	• 91 11 04 (subartesian condition)																

RECORD OF BOREHOLE No E-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 954; E 288 361 ORIGINATED BY FR
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 05 CHECKED BY PP

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			20	40	60	80	100					
77.8	Ground Surface																
0.0																	
	Firm		1	SS	6		76									23.6	10 20 37 33
			2	SS	17												
			3	SS	26												
	Brown		4	SS	23		74										
	Grey		5	SS	20												
			6	SS	15												
			7	SS	22		72										
			8	SS	18												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	18		70										
	Very Stiff to Hard		10	SS	36		68										
			11	SS	27												
65.2			12	SS	24		66										
12.6	End of Borehole = 91 11 06																

RECORD OF BOREHOLE No F-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 618; E 289 082 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 05 CHECKED BY PP

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No F-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 655; E 289 087 ORIGINATED BY PC
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Ceodetic DATE 91 11 05 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			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	W _p	W	W _L	WATER CONTENT (%)	10 20 30			
79.9	Ground Surface																
0.0			1	SS	24												
			2	SS	34												
			3	SS	33												
			4	SS	15												
			5	SS	13												
			6	SS	13												
			7	SS	14												
			8	SS	19												
			9	SS	16												
			10	SS	22												
69.2																	
10.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Red, Very Dense		11	SS	93												
67.3	Silt; trace Sand		12	SS	77												
12.6	End of Borehole = 91 11 05 subortesian condition																

RECORD OF BOREHOLE No F-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 690; E 289 096 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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	W _P	W		
79.4	Ground Surface															
0.0			1	SS	26											
			2	SS	23											
			3	SS	21											
	Brown Grey		4	SS	17											
			5	SS	16											
			6	SS	13											
			7	SS	14											
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		8	SS	16											
			9	SS	19											
			10	SS	20											
			11	SS	25											
67.2																
12.2	Het. Mixt. of Silt, Sand & Gravel															
66.8	(Glacial Till) Very Dense		12	SS	100											
12.6	End of Borehole • 91 11 11															

RECORD OF BOREHOLE No F-4

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 724; E 289 108 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	PLASTIC UNIT w _p	NATURAL MOISTURE CONTENT w	LIQUID UNIT w _L			
79.4	Ground Surface													
0.0						*								
	trace Organics		1	SS	32		78							
	Hard		2	SS	31									
	Brown		3	SS	26									
	Grey		4	SS	13		76					22.3	1 17 43 39	
			5	SS	12									
			6	SS	12									
			7	SS	12		74							
			8	SS	13							21.1	7 21 42 30	
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		9	SS	15		72							
			10	SS	20		70							
			11	SS	21		68							
67.2														
12.2	Het. Mixt. of Silt, Sand & Gravel													
66.8	(Glacial Till) Very Dense		12	SS	100								26 48 19 7	
12.6	End of Borehole													
	* GWL not established													

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No G-1

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 787 460; E 289 623 ORIGINATED BY PC
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Geodetic DATE 91 11 06 CHECKED BY PP

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			20	40	60	80	100					
80.1	Ground Surface																
0.0			1	SS	30												
			2	SS	33												
	Brown		3	SS	24		78										
	Grey		4	SS	14											21.4	11 15 43 31
			5	SS	13		76										
			6	SS	13												
	Het. Mixt. of Silt, Sand and Gravel (Glacial Till)		7	SS	23		74									22.2	48 33 15 4
			8	SS	54												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	23		72										
69.4	Stiff to Very Stiff		10	SS	28		70										
10.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		11	SS	98	/15cm	68										
67.5	Red, Very Dense		12	SS	95												
12.6	End of Borehole • 91 11 07																

RECORD OF BOREHOLE No G-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 520; E 289 623 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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			20	40	60	80	100					
80.1	Ground Surface																
0.0			1	SS	32												
			2	SS	40												
	Hard		3	SS	30		78									22.3	1 14 45 40
	Brown		4	SS	24												
	Grey		5	SS	13		76										
			6	SS	11												
			7	SS	12												
			8	SS	17		74									21.7	0 14 46 40
			9	SS	17												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		10	SS	17		72										
	Stiff to Very Stiff		11	SS	24		70										
67.5			12	SS	25		68										
12.6	End of Borehole • 91 11 11																

RECORD OF BOREHOLE No G-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 475 E 289 627 ORIGINATED BY PC
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 05 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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	W _p	W		
80.2	Ground Surface															
0.0																
	Brown		1	SS	17											
	Grey		2	SS	28											
			3	SS	27											
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		4	SS	13											
			5	SS	14											
			6	SS	12											
	Stiff to Very Stiff		7	SS	14											
			8	SS	17											
	Red, Hard		9	SS	17											
			10	SS	31											
			11	SS	36											
67.6			12	SS	88											
12.5	End of Borehole • 91 11 07															

RECORD OF BOREHOLE No H-1

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 787 966; E 291 092 ORIGINATED BY FR
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Geodetic DATE 91 11 12 CHECKED BY PP

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		
81.4	Ground Surface													
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	10	DRY *	80						19.1	0 11 47 42
79.3	Brown, Firm to Stiff		2	SS	8									
2.1			3	SS	18		78							
			4	SS	18									
			5	SS	22									
	Brown		6	SS	14		76							
	Grey		7	SS	15									
			8	SS	13									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Hard		9	SS	16		74							
			10	SS	22		72							
			11	SS	36									
68.8			12	SS	35		70							
12.6	End of Borehole * Dry Upon Completion													

RECORD OF BOREHOLE No H-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 011; E 291 111 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
DATUM Geodetic DATE 91 11 11 CHECKED BY PP

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 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
80.7	Ground Surface													
0.0						DRY *								
			1	SS	29		80							
			2	SS	27									
			3	SS	22		78						20.9	12 15 37 36
			4	SS	31									
	Brown Grey		5	SS	20		76							
			6	SS	15									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		7	SS	15		74						21.9	6 18 48 28
	(Glacial Till)		8	SS	14									
			9	SS	16		72							
	Stiff to Very Stiff		10	SS	12		70							
68.1			11	SS	24									
			12	SS	28									
12.6	End of Borehole • Dry Upon Completion													

RECORD OF BOREHOLE No H-4

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 787 045; E 291 107 ORIGINATED BY TS
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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			20	40	60	80	100					
80.1	Ground Surface																
0.0						DRY *											
	Hard		1	SS	30												
			2	SS	32		78										
			3	SS	26												
	Brown		4	SS	27												
	Grey		5	SS	17		76										
			6	SS	15												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		7	SS	16		74										
			8	SS	17												
			9	SS	15		72										
			10	SS	17		70										
			11	SS	29												
67.5			12	SS	25		68										
12.6	End of Borehole * Dry Upon Completion																

RECORD OF BOREHOLE No 1-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 786 590; E 292 183 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
83.0	Ground Surface																
0.0			1	SS	17		82										
			2	SS	25												
			3	SS	23		80										
	Brown Grey		4	SS	15												
			5	SS	18												
			6	SS	16		78										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		7	SS	21												
			8	SS	23												
			9	SS	23		76										
	Stiff to Very Stiff		10	SS	17		74										
72.3			11	SS	70	/15cm	72										
10.7	Bedrock - Shale Red, Unweathered to slightly																
70.8	Weathered, Weak to Very Weak					/3cm											
12.2	End of Borehole • GWL not established																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 1-2

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 786 606; E 292 193 ORIGINATED BY FR
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY FR
 DATUM Cedetic DATE 91 11 11 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
82.1	Ground Surface																
0.0			1	SS	54											22.8	4 20 43 33
	Brown		2	SS	29												
	Grey		3	SS	19												
			4	SS	13												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		5	SS	15											21.5	5 20 43 32
	Stiff to Very Stiff		6	SS	18												
			7	SS	23												
			8	SS	27												
			9	SS	22											21.8	2 18 41 39
72.3			10	SS	23												
9.8	Bedrock - Shale with interbedded siltstone		11	RC	REC 100%												RQD = 52%
	Red, Unweathered to Slightly Weathered, Weak to Very Weak		12	RC	REC 100%												RQD = 74%
69.7																	
12.4	End of Borehole • 91 11 12 GWL not established																

RECORD OF BOREHOLE No 1-4

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 786 670; E 292 215 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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	W _P	W	W _L		
81.5	Ground Surface																
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	7	*											
80.3																	
1.2	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		2	SS	13		80										
			3	SS	22												
			4	SS	25		78										
			5	SS	22												
			6	SS	18		76										
			7	SS	20												
			8	SS	18												
			9	SS	20		74										
			10	SS	18		72										
70.5			11	SS	111		70										
11.0	Bedrock - Shale Red, Unweathered to slightly Weathered, Weak to Very Weak				**												
69.3																	
12.2	End of Borehole * GWL not established ** Sampler bouncing																



Ministry
of
Transportation

File

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 93-85

WP 319-89-00 DIST 4

HWY QEW STR SITE -

Q.E.W. Culverts
(Between Gray's Road and Fifty Road)

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FOUNDATION INVESTIGATION REPORT
For
Q.E.W. Culverts
(Between Gray's Road and Fifty Road)
W.P. 319-89-00
District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted in conjunction with nine (9) proposed reinforced concrete box culverts that will carry the Q.E.W. and in some cases the North and South Service Roads. The proposed new culverts will replace existing culverts within the site limits defined by Gray's Road and Winona Road at or adjacent to the existing culverts. The culvert replacement project is associated with the Q.E.W. widening to a 6 lane divided highway.

SITE DESCRIPTION

The site is located within the area bounded by the North Service Road and the South Service Road along the Q.E.W. corridor between Gray's Road and Fifty Road in the Town of Stoney Creek, Regional Municipality of Hamilton-Wentworth. The existing Q.E.W. is a four lane median divided highway and grassland separates the Q.E.W. and the North and South Service Roads. Nine (9) separate sites (Sites A to I inclusive) were investigated within the overall site limits.

Numerous open footing and box culverts exist within the site limits facilitating the transmission of creek waters to Lake Ontario in a northerly direction beneath the service roads and the Q.E.W. The existing culverts vary in dimension and appear to have been constructed as early as the 1930's. Minimal depths of cover (up to approximately 2 to 3 metres) generally exist above the culvert roofs. The culverts appear to be of sound quality and no significant visible signs of concrete deterioration were observed.

A number of Q.E.W. underpass structures exist within the site limits. Underpass structures proceeding from west to east include Millen Road, Fruitland Road, Glover Road and Winona Road. The structures are four span structures with approach fills in the order of magnitude of 7-8 metres. The terrain across the

site is generally flat accentuated by creek slopes at the culvert inlets and outlets. Depths of water in the creeks were shallow at the time of the investigation and generally were less than one (1) metre. As mentioned earlier, grassland covers the area between the asphaltic Q.E.W. roadway and the service roads.

Land use in the area is divided into residential north of the existing North Service Road and industrial south of the existing South Service Road. In addition, an MTO district garage is located at the South Service Road just west of Winona Road. Truck Inspection Stations are also located within the site limits.

Physiographically, the site is located in the region known as the "Iroquois Plain". The Iroquois Plain is the product of the advance and retreat of the Wisconsin ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). The lowland bordering Lake Ontario, when the last glacier was receding was inundated by the glacial lake called Lake Iroquois at the site. Conditions in the old lake plain vary greatly within the Iroquois Plain. At the site location, overburden consists of a heterogeneous mixture of clayey silt, sand, and gravel, which is a till deposit of glacial origin. At some locations, the surficial cohesive deposit is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel. The overburden at the site is underlain by shale bedrock of the Queenston Formation in thickness ranging from approximately 25 metres at the western limits of the site to approximately 10 metres at the eastern limits of the site.

INVESTIGATION PROCEDURE

Soil and rock data and inherent properties were obtained by in situ and laboratory testing. The procedures employed in the foundation investigation are discussed below.

Field Investigation

The fieldwork for the investigation was carried out between 91 10 28 and 91 11 12 and consisted of twenty-five (25) sampled boreholes advanced to depths

ranging from 12.2 m to 15.7 m below the existing ground surface. Diesel powered track mounted drilling rigs equivalent to Central Mining Equipment (CME) 55 units, were used to advance the boreholes employing conventional hollow stem augering and solid stem augering techniques. It was determined that the subsoil conditions enabled the application of solid stem augering techniques exclusively at the site which resulted in improved productivity.

Subsoil samples were retrieved at 0.7 m intervals for the surficial 6.5 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved employing a standard split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). All subsoil samples were identified in the field and then placed in sealed plastic jars to ensure the preservation of the natural moisture contents. Samples were subsequently transported to the laboratory for applicable testing.

Bedrock was cored at one (1) location (site I) where shallower thicknesses of overburden were encountered. The bedrock was cored in NX size using conventional rock coring procedures. At a few locations (sites A, B, and C), in situ vane tests were conducted to determine the in situ undrained shear strength of some weaker soil present at these locations. Standard MTO 'N' vanes were used to conduct the test in accordance with ASTM D2573.

Groundwater levels were determined by monitoring the levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevations of the individual boreholes was provided by Central Region Surveys and Plans.

Laboratory Analyses

To identify the behaviour, gradation and pertinent properties of the soil present at the site, various laboratory testing were conducted. These tests included:

- 1) Atterberg Limits
- 2) Grain Size Distributions
- 3) Natural Moisture Contents
- 4) Bulk Unit Weights

The tests were carried out in accordance with standard procedures.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions", and are illustrated on the corresponding boreholes and figures included in the Appendix of this report.

Subsurface Conditions

The ground surface elevation varies both within each individual site and also from site to site. The variation within each individual site is a reflection of the creek channels present at the existing culvert locations and is generally in the order of 2.5 m to 5.0 m from the top of fill material above the culvert roof to the channel floor. The ground surface elevation increases in an easterly direction from approximately 76.1 m (Site A) to 83 m (Site I).

The entire site area has been inundated by a surficial deposit of glacial till consisting of a cohesive heterogeneous mixture of clayey silt, sand and gravel with random boulders and cobbles. The deposit was explored to depths up to 15.7 m and has generally been weathered and oxidized for up to approximately 5 metres from the ground surface. Hence, the soil is generally brown within this surficial depth and grey (unoxidized) below. At some sites, the lower thickness of the deposit has taken a red colour indicative of iron oxide compounds in the soil. Some black organic enriched soil was also found within the surficial one (1) to two (2) metres at various sites.

At sites, E, F, and G the surficial native cohesive material is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel. This deposit, also of glacial till origin, was found at depths of 10.7 m to 13.7 m below the ground surface. The thickness of this deposit explored ranged upto 2.0 m.

At Site I, the surficial native cohesive heterogeneous mixture of clayey silt, sand and gravel is underlain by shale bedrock at depths ranging from 9.8 m to 11.0 m (Elevation 72.3 m to 70.5 m).

The native heterogeneous mixture of clayey silt, sand and gravel is overlain by fill material at some locations across the site. At sites D, H and I for instance, thicknesses of an irregular mixture of clayey silt, sand and gravel fill material for a thickness up to approximately 2.1 metres was also encountered.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and a subsoil stratigraphical section are provided on Dwg. No. 3198900-A, B and C also included in the Appendix.

A detailed description of the subsurface conditions encountered is given below.

Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)

A cohesive irregular mixture of clayey silt, sand and gravel identified as fill material was encountered at some sites extending from the surface to a depth of approximately 2.1 m. It appears that this material was used as backfill material to the existing culvert at the various sites.

A grain size distribution as determined by hydrometer and mechanical sieve analyses on a representative sample of fill material (see Record of Borehole H1 in the Appendix) reveals that approximately 89% of the material is finer than 75 micrometres.

An Atterberg Limit Test was carried out on the fine grained portion of the fill material (less than 75 micrometres) to define the behaviour and plasticity of the material. The results reveal that the material has a Liquid Limit (w_L) of 34% and a Plasticity Index (I_P) of 16.5%. Consequently, the material is classified as a clayey silt of low plasticity. The natural moisture content of the material is 21%.

The 'N' values as determined by the Standard Penetration Test (SPT) revealed a range of 7 blows/0.3 m to 10 blows/0.3 m for the samples retrieved in this material. This reveals a consistency ranging from firm to stiff.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Underlying the fill material and occurring surficially elsewhere at the site, a native deposit consisting of a cohesive heterogeneous mixture of clayey silt, sand and gravel exists. Boulders and cobbles as inferred in the augering process during the borehole advancement also comprise the deposit. Random zones of a heterogeneous mixture of silt, sand and gravel are also found in this deposit. Red shale fragments are also present within the lower depths of the investigated deposit. The deposit was explored to a maximum thickness of 15.7 metres and is of minimum thickness at Site I (9.8 m thickness).

The upper 2.7 to 4.9 metres or so has been oxidized and in areas where organic material is not present within the surficial thickness, soil colour is brown. Organic dominated soils were found at some locations, usually within the surficial 2 metres and this material is black in colour. Below the oxidized and/or organic surficial material, the soil is unoxidized and grey throughout most of the deposit thickness. At some locations, the lower 2 to 3 metres is red in colour and random red zones are interbedded within the grey material.

The main component of this unsorted, unstratified deposit is the clayey silt material. This material matrix essentially binds the coarser sands and gravels within the deposit. A grain size distribution envelope for the deposit as determined by mechanical sieve and hydrometer analyses is given in Figure 1 in the Appendix. The envelope includes particle sizes up to 75 mm (coarse gravel)

and hence excludes the boulder and cobble sizes. The envelope does reveal that the fine grained portions (less than 75 micrometres) contribute to more than approximately 70% of the material of this deposit.

Atterberg Limit Tests were carried out to define the behaviour and plasticity of the fine grained portion of the soil and the results are plotted in Figure 2. A summary of the indices is provided in Table 1 below. Bulk Unit Weights are also included in the table.

Table 1 - Heterogeneous Mixture of Clayey Silt
Sand and Gravel (Glacial Till)

	Range	No. of Tests
Natural Moisture Content (w%)	13-21	29
Liquid Limit (w L %)	22-35	29
Plastic Limit (w P %)	14-18	29
Plasticity Index (I P %)	10-18	29
Unit Weight (kN/m ³)	19-22.3	29

The test results reveal that the fine grained portion of the deposit is of low plasticity and hence is defined as clayey silt. Natural moisture contents are generally less than or equivalent to the plastic limit of the soil indicating that the soil is in a plastic to semi-solid state.

The results of Atterberg Limit Test conducted on an organic enriched material retrieved at a depth of 1.5 m at BH B2 revealed a liquid limit (w L %) of 66%, a plasticity index (I P %) of 31% and a natural moisture content (w%) of 45%. This material would plot as an organic clay of high plasticity on the plasticity chart.

Standard Penetration Test (SPT) carried out in this deposit revealed 'N' values ranging from 5 blows/0.3 m to 54 blows/0.3 m revealing a probable firm to hard range of soil consistency. The lower values are generally indicative of localized weaker material and/or organic enriched material. In general, 'N' values are in the 12 blows/0.3 m to 25 blows/0.3 m and hence the soil is considered as stiff to very stiff.

At depths where the 'N' values were considered "low" (usually less than 10 blows/0.3 m), in situ vane tests were conducted. In general, the vanes could not be torqued and undrained shear strength values exceeded 100 kPa. The minimum undrained shear strength value obtained was 80 kPa but this lower value can be considered as an isolated weak zone within the deposit. It should be cautioned, however, that the presence of the coarse grained sand and gravel in the deposit may have influenced the accuracy of the test. It is concluded however, that the consistency ranges from stiff to hard.

Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)

At Sites E, F, and G the cohesive heterogeneous mixture of clayey silt, sand and gravel is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel at a depth ranging from 10.7 m to 13.7 m (Elevation 69.4 m to 64.8 m). Layers of silt with some sand are also present in this deposit in thicknesses up to approximately 0.5 m. The deposit is red in colour and as inferred by auger grinding, boulders and cobbles are also present within this deposit. Red shale fragments are also contained within the deposit.

Grain Size Distribution curves illustrating the gradation of the deposit and determined by mechanical sieve and hydrometer analysis are shown in Figure 3 in the Appendix. Boulder and cobble sizes are not illustrated on the Figure.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 77 blows/0.3 m to 100 blows/0.2 m indicating that the deposit is in a very dense state of denseness.

Bedrock

Shale bedrock with interbedded siltstone of the Queenston Shale Formation underlies the overburden at Site I at a depth of 9.8 m to 11 m (Elevation 72.3 m to 70.5 m). Bedrock core was retrieved in NX size for a thickness of 2.84 m at BH I2.

The shale bedrock is generally greyish red and has randomly interbedded greenish grey siltstone layers. The rock is horizontally bedded and is an extremely friable material. The rock contains moderately close to extremely closed spaced

fractures that are generally flat, planar to undulating and smooth. The rock generally is unweathered to slightly weathered.

Core recoveries and Rock Quality Designations (RQD) were determined in situ to evaluate the competence and integrity of the rock. Core recoveries were 100% and RQD's ranged from 52% to 74%. Based on these measurements, the rock can be considered to be of fair quality.

Based on index property identification, the rock is classified as weak to very weak in strength.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes throughout the duration of the field investigation. Groundwater levels, in general, are depressed at depths ranging from 10 m to 12 m below the natural ground surface (Elevation 66 m to 68 m).

Groundwater levels were however at some locations measured at shallow depths ranging from 2 to 4 metres below the natural ground surface (76.5 m to 77 m). These water levels illustrate the effect of the subartesian condition present in the heterogeneous mixture of silt, sand and gravel deposit below the cohesive heterogeneous mixture of clayey silt, sand and gravel.

Groundwater levels were not established at the borehole locations advanced on the shoulders of the Q.E.W. and the Service Roads because these boreholes were backfilled immediately for safety reasons.

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

As part of the planned widening of the Q.E.W. from four (4) lanes to six (6) lanes and to satisfy hydrological requirements at the site, it has been proposed to remove existing open footing concrete culverts and replace them with new reinforced concrete box culverts. A total of nine (9) individual site locations as shown on Dwg. No. 3198900-A, B and C in the Appendix were investigated and a summary of the individual project scope of work is summarized in Table 3a. The dimensions of the proposed culverts and the maximum cover over the roof slab are also included in Table 3a. Table 3b summarizes proposed culvert invert elevations and roadway profile grades.

The extent of the culvert replacement varies from the replacement between the North and South Service Roads to an entire replacement that includes replacement of the culverts beneath the service roads. Culvert lengths therefore range from 50 m to 146 m in a northerly alignment. The proposed Q.E.W. and Service Road grades vary from 78.5 m to 81.2 m within the project site limits and culvert invert elevations range from 75.1 m to 78.1 m. Culvert heights range from 1.3 m to 2.30 m and the maximum cover over the slab roof ranges from 1.3 m to 2.8 m. The maximum height of approach fill required at the culvert sides is 4.8 m. The culvert spans vary from triple culverts at 2.4 m width to a 5 m single span box culvert.

Recommendations pertaining to the following foundation and geotechnical considerations are included in the purview of this report.

- 1) Structure Foundations
- 2) Backfill to Structure
- 3) Construction Considerations

Table 3a - Project Description and Culvert Details

Site	WP	Station	<u>Culvert Description</u>			Max Cover Over Slab (m) (F)	<u>Description</u>
			<u>Span</u> (S)	<u>Height</u> (H)	<u>Length</u> (L)		
A	135-07	23+561	3.08	1.34	61	1.9	Remove existing Q.E.W.
B	135-08	23+924	3.65	1.98	50	2.8	Culvert and Connect
C	135-09	24+247	4.24	1.52	70	2.2	New Culvert to NSR and SSR Culvert
D	135-13	25+289	4.0	1.52	146	1.4	Twin Cell with 25+294
		25+294	3.06	1.52	84	1.4	Remove existing Q.E.W. Culvert and Connect New Culvert to NSR and SSR Culverts
E	135-15	25+866	4.27	2.3	85	1.3	Remove existing Q.E.W. Culvert. Connect New Culvert to NSR Culvert
F	135-19	26+653	5.0	1.8	102	2.0	Remove and Replace existing Q.E.W., EB Ramp and WB Ramp Culverts
G	135-20	27+215	2x2.4	1.6	71	2.5	Remove existing Q.E.W. Culvert and Replace with Twin Culverts
H	135-27	28+771	2x2.4	1.8	115	2.2	Remove existing Q.E.W. SSR & NSR Culverts and Replace with Twin Cell Culverts
I	135-32	29+926	3x2.4	1.8	105	3	Remove existing Q.E.W. SSR & NSR Culverts

Table 3b - Proposed Culvert Invert Elevations
and Profile Grade Elevations

Site	WP	<u>Culvert Invert Elevations (m)</u>		<u>Profile Grade Elevation (m)*</u>
		<u>South</u>	<u>North</u>	
A	135-07	75.7	75.4	78.6
B	135-08	75.5	75.1	80.2
C	135-09	75.6	75.5	79.2
D	135-13	77.2	76.9	80.2
E	135-15	77.2	76.5	80.2
F	135-19	76.7	76.0	80.4
G	135-20	78.1	77.8	81.4
H	135-27	77.6	77.1	81.4
I	135-32	78.0	76.6	81.6

* Highest Elevation

1) Structure Foundations

All culvert foundations can be founded at the proposed invert elevations within the surficial cohesive heterogeneous mixture of clayey silt, sand and gravel deposit supported by the box culvert slab on grade shallow foundation. In view of the uniform conditions across the entire site, bearing capacities at the proposed invert elevations are also uniform and are summarized in Table 4 below.

Table 4 - Spread Footing Soil Capacity

Factored Capacity at U.L.S. (kPa)	300
Bearing Capacity at S.L.S. (kPa)	200

Settlements developed as the result of the applied pressures in Table 4 are expected to be within 25 mm magnitude and because the deformations will be recompression in nature should occur immediately during construction. It is recommended that any new culvert be articulated from any existing culvert to allow for these deformations to be realized without influencing the existing structure.

All softened and/or organic material encountered at the founding elevation shall be removed and replaced with mass concrete or granular material such as Granular 'A'. Any granular material must be placed and compacted to achieve 100% of the Proctor maximum drydensity as outlined in OPSS 501.08.02. Inspection of the founding material at sites A to C inclusive in particular shall be implemented because of organic material encountered at these locations during the field investigation. At Site B, it is recommended that the native material be subexcavated to Elevation 74.

To protect the founding soil from disturbance as a result of weathering, and construction related activities, it is recommended that a concrete working slab be placed on the founding soil.

The footings must be protected against the scouring forces of the creek water. This can be obtained by constructing aprons and rip-rap at the culvert inlet and outlet. The design of the scour protection shall be made in conjunction with applicable hydrological parameters.

Adequate frost protection cover shall be provided for footings subject to frost penetration as for instance during winter construction.

2) Backfill to Structure

Fill material in the order of 1.3 m to 2.3 m will be required at the culvert sides and an additional 1.3 to 2.8 m will be required above the culvert roof elevation. Recommendations pertaining to the selection of material type, stability and settlement of the approach fills and method of construction are given below.

Material

It is recommended that the backfill material against the culvert wall consist of a granular material such as Granular 'A' or Granular 'B' to prevent hydrostatic pressure build-up on the culvert walls. Design parameters of the soil are given in Table 5 below. Weep holes should also be designed in the walls to facilitate the drainage.

Table 5 - Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Unfactored Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³) γ	22.8	21.2
Coefficient of Earth Pressure at Rest (K_o)*		
- S.L.S. Type II	0.43	0.5
- U.L.S.	0.51	0.58

*Horizontal surface backfill only.

The backfill beyond the granular wedge as illustrated on OPSD series can consist of acceptable borrow material as defined in OPSS 212.05

Stability

There are no longitudinal fill slope instabilities anticipated for slopes constructed at 2H:1V. All slopes should be protected against surface erosion using conventional methods.

Settlement

It is anticipated that approximately 10 mm of settlement within the fill itself and as a result of the elastic recompression of the native subsoil at the site can be realized. These settlements will be realized during or immediately following construction.

Backfill Construction

In the placement of the backfill material, all softened and/or organic material should be excavated for their full depth within the plan limits prior to fill placement.

The backfill to the culvert walls shall be constructed in accordance with OPSS 902 series and applicable OPSD 803 series. The backfill shall be constructed in 300 mm lifts on alternating sides of the culvert so that the maximum differential in backfill at any time does not exceed 300 mm. Compaction of the backfill material shall be carried out in accordance with OPSS 501 series. Excessive vibratory equipment loadings should be prevented from inducing any additional lateral pressure on the culvert walls during the compaction procedure.

3) Construction Considerations

Temporary Shoring

To facilitate the removal and construction of the replacement culverts, a temporary roadway diversion and roadway protection scheme will be required in order to maintain traffic during the execution of the work. A staged construction sequence therefore appears to be a necessary construction procedure.

Two (2) shoring schemes have been summarized below. The alternative that proves to be the most economical and technically feasible from both a design and construction point of view shall be selected. The shoring scheme shall be reviewed by this office in the preliminary stages of design.

(a) Cantilever Soldier Pile - Timber Lagging Wall

One method of roadway protection is the application of the conventional cantilever soldier pile - timber lagging wall based on the principles of limiting equilibrium. To facilitate the design of the cantilever type wall and the required soldier pile embedment depth, the soil parameters in Table 6 are provided.

Table 6 - Roadway Protection Soil Parameters

<u>Soil</u>	<u>Unfactored Angle of Internal Friction (ϕ)</u>	<u>*Coefficient of Active Earth Pressure</u>		<u>*Coefficient of Passive Earth Pressure</u>	
		<u>S.L.S. Type II</u>	<u>U.L.S.</u>	<u>S.L.S. Type II</u>	<u>U.L.S.</u>
Het. Mix. of Clayey Silt, Sand and Gravel (Glacial Till)	30°	0.33	0.4	3	2.5
Het. Mix. of Silt, Sand and Gravel (Glacial Till)	35°	0.27	0.34	3.7	2.9

* These earth pressure coefficients apply to horizontal backfill surfaces only. The design of the shoring system shall include the appropriate earth pressures computed in accordance with Section 6.6.1.2 of the O.H.B.D.C. The loadings induced by the surcharge traffic and adjustment for any sloping surface shall be incorporated in the design.

Soldier piles can be installed using conventional pile driving methods or alternatively in preaugered drilled shafts. For soldier piles installed in preaugered holes, a concrete toe is recommended to anchor the soldier pile toe and a lean mix concrete (0.7 MPa) is recommended as backfill for the annular space along the shaft of the predrilled hole. In view of the cohesive and impervious nature of the material, conventional augering equipment can be used to excavate the shaft and place the soldier pile assembly in the dry. An NSSP, however, should be included in the tender documents that indicates that larger boulders and cobbles are characteristic components of glacial till deposits and hence can be found at the site. In addition, the Contractor shall be informed that the drilled hole shall be maintained throughout the installation of the soldier pile.

(b) Raker Supported Soldier Pile - Timber Lagging Wall

Should alternative (a) produce excessive, uneconomical soldier pile embedment lengths, rakers can be used to resist the induced lateral earth pressures. The raker foundations can be founded within the surficial heterogeneous mixture of clayey silt, sand and gravel at or below the site specific culvert invert elevations using the bearing capacities tabulated in Table 4.

Rakers must be installed while an earth berm remains in front of the soldier pile. Slots should be cut into this berm to install rakers before the supporting berm is removed. Soldier piles and lagging can be installed as previously described.

Dewatering

No dewatering problems are anticipated in the construction of the structure foundations in view of the impervious nature of the native subsoil. Furthermore, the groundwater table at the time of the investigation was below the proposed culvert invert elevation. Conventional sump pump techniques will suffice in discharging any surface runoff or localized seepage from the excavation.

Inflow from the existing creeks must be prevented to enable construction in the "dry". The contractor shall take any special measures to ascertain this flow impediment. One such method can include the construction of impervious earth dikes composed of suitable clay material (see OPSS 1205).

Temporary Slopes

Temporary slopes to facilitate the excavation and construction of the culvert shall not be steeper than $1\frac{1}{2}:1V$.

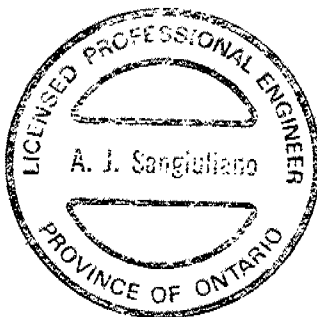
Excavation

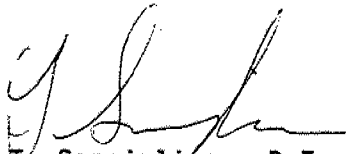
The excavation for the proposed concrete culverts adjacent to any existing culverts shall be carefully controlled to avoid undermining the existing culvert foundations.


MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and F. Reijerse, Student Engineer, utilizing equipment owned and operated by Malone's Soil Samples.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.

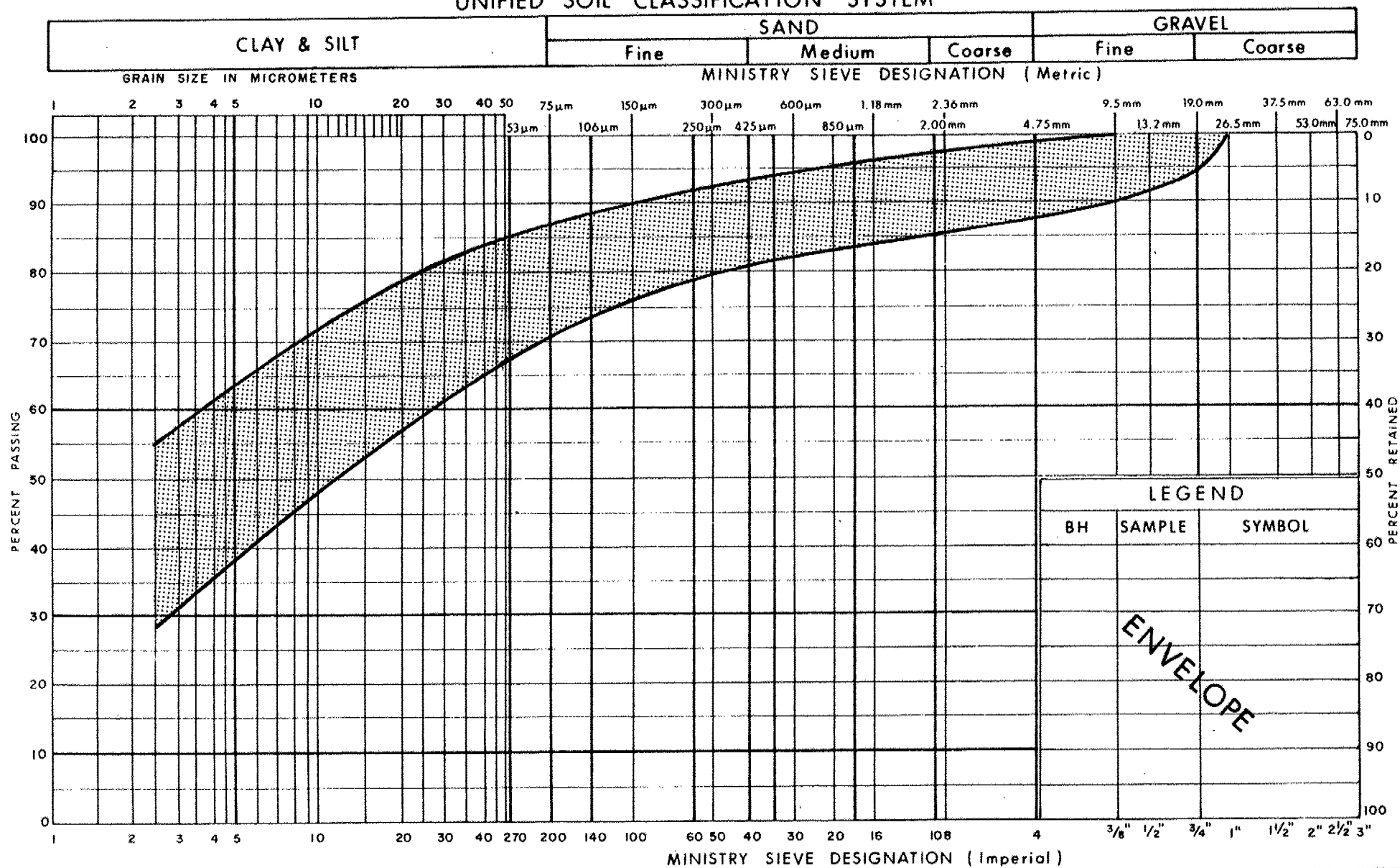



T. Sangiuliano, P.Eng.
Foundation Engineer


M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

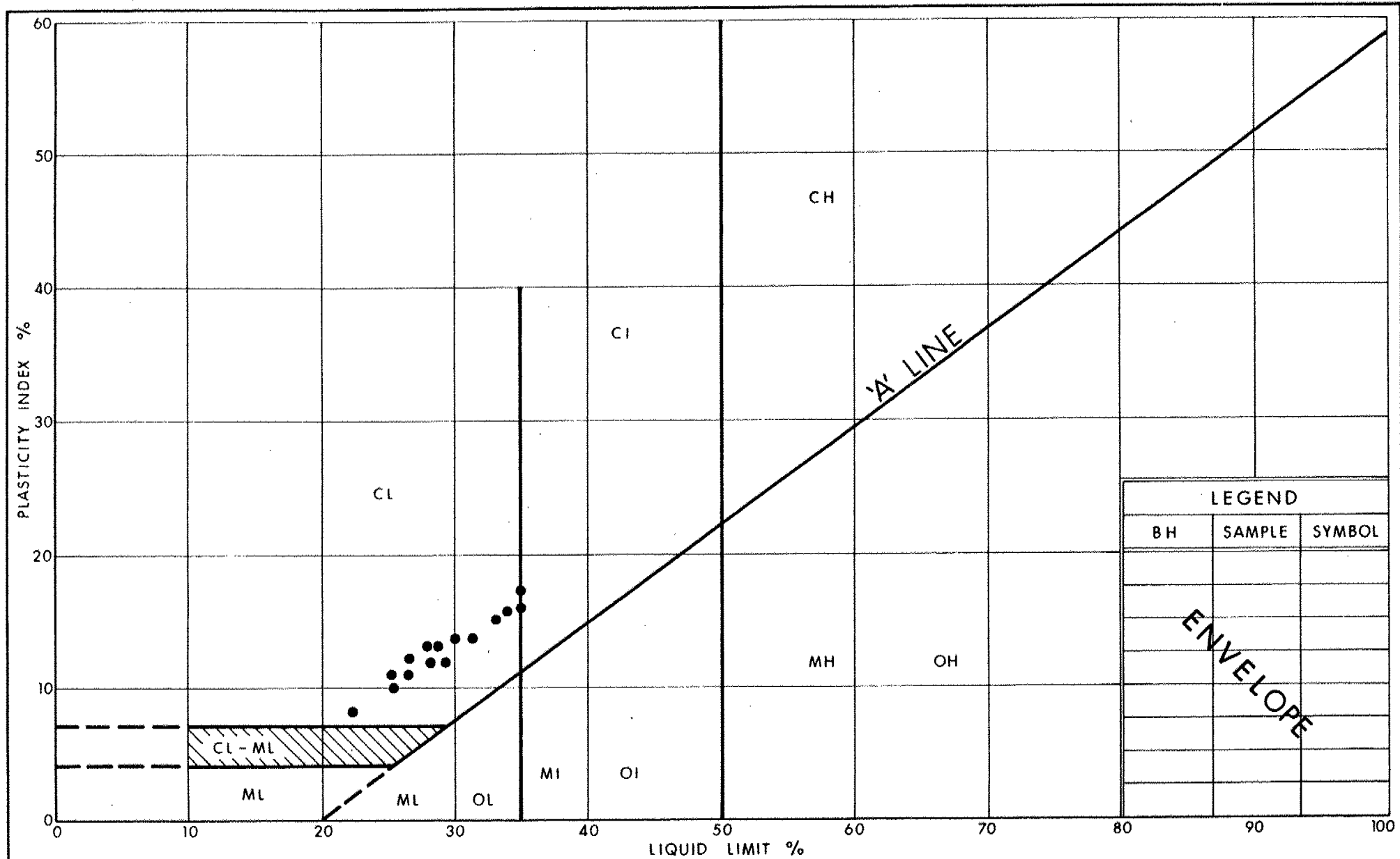


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF CLAYEY SILT
SAND & GRAVEL (Glacial Till)

FIG No 1

W P 319 - 89 - 00



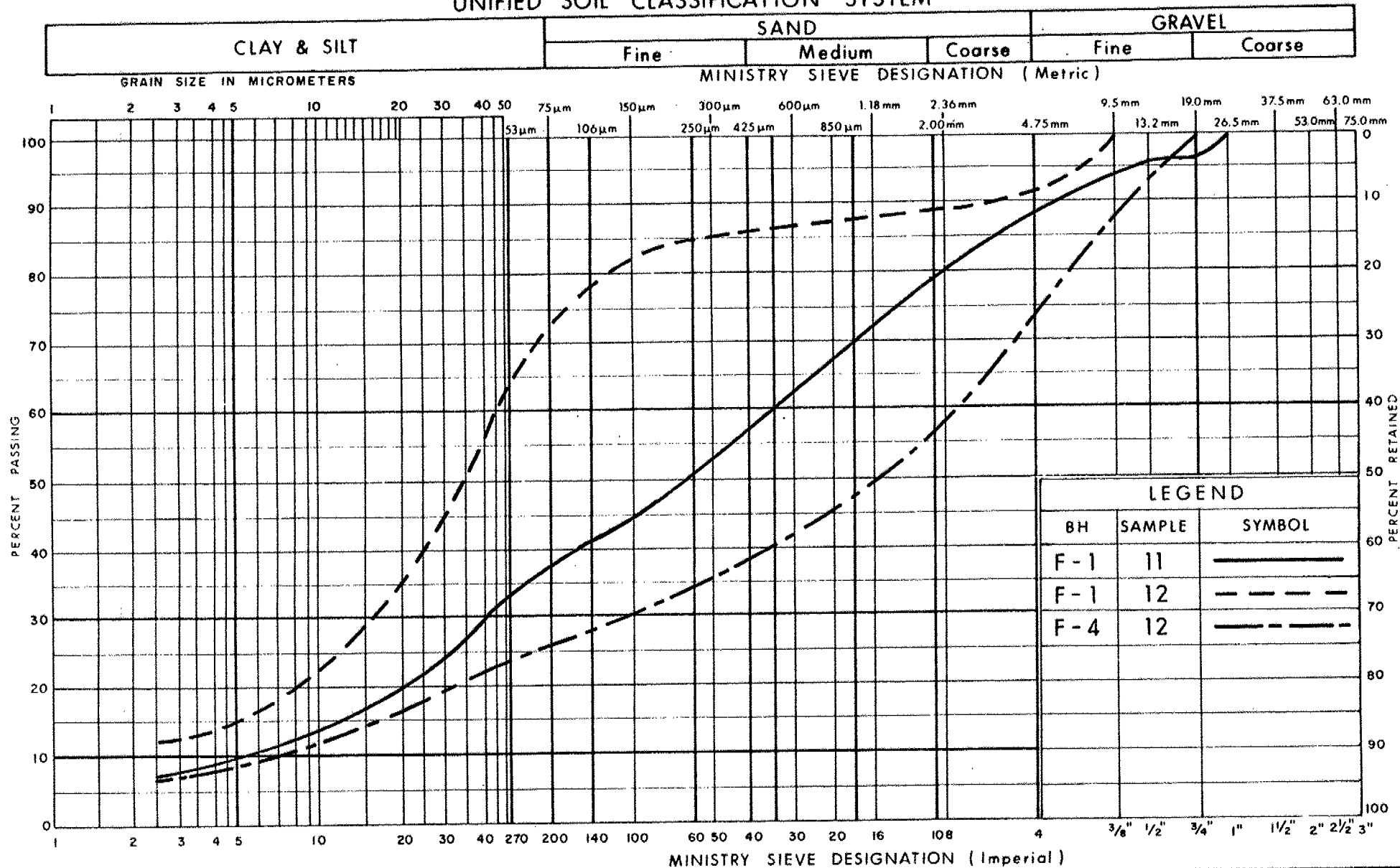
Ministry of
Transportation

PLASTICITY CHART HET MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 319 -89 -00

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

HET MIXTURE OF

SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 319-89-00

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.

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:

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

MECHANICAL PROPERTIES OF SOIL

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

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

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^3/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						

RECORD OF BOREHOLE No A-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 623; E 286 160 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 28 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	IN VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L	10 20 30		
76.6	Ground Surface												
0.0													
	Black, some Organics		1	SS	25		76						
	Brown		2	SS	22								
			3	SS	18		74					20.7	3 19 51 27
			4	SS	32								
	Grey		5	SS	24		72						
			6	SS	12								
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		7	SS	33		70					19.9	9 18 47 25
	Very Stiff to Hard		8	SS	20								
			9	SS	14		68					19.0	1 12 36 51
			10	SS	15		66						
			11	SS	21		64						
			12	SS	19								
60.9			13	SS	20		62						
15.7	End of Borehole												
	91 10 29												

RECORD OF BOREHOLE No A-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 675;E 286 146 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 31 CHECKED BY PP

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			20 40 60 80 100	20 40 60 80 100					
76.1	Ground Surface													
0.0	Black, some organics, Firm Brown, Grey Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		1	SS	7									
			2	SS	23									
			3	SS	17									
			4	SS	16									
			5	SS	16									
			6	SS	16									
			7	SS	11									
			8	SS	9									
			9	SS	12									
			10	SS	8									
			11	SS	14									
63.5			12	SS	15									
12.6	End of Borehole - 91 11 01													

RECORD OF BOREHOLE No B-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 514; E 286 485 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 29 CHECKED BY PP

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
77.0	Ground Surface																
0.0	Black, some Organics		1	SS	6		76									17.4	0 3 55 42
	Firm		2	SS	5												
	Brown, trace Organics		3	SS	9												
			4	SS	22		74										
			5	SS	20											19.8	8 20 41 31
			6	SS	16												
			7	SS	13		72										
			8	SS	13												
	Grey																
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	12		70										
	Stiff to Very Stiff		10	SS	10		68									21.0	8 19 40 33
			11	SS	13												
64.4			12	SS	13		66										
12.6	End of Borehole																
	+ 91 10 30																

RECORD OF BOREHOLE No B-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 549; E 286 508 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 30 CHECKED BY PP

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 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					
77.7	Ground Surface																
0.0	trace Organics		1	SS	7												
	Firm		2	SS	8		76			3							
			3	SS	10		74			>100							
	Brown		4	SS	18											19.8	4 18 43 35
	Grey		5	SS	20		72										
			6	SS	15												
	Heterogenous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		7	SS	13		70										
	Stiff to Very Stiff		8	SS	13		68										
			9	SS	19												
65.1			10	SS	21		66										
12.6	End of Borehole + 91 10 31																

RECORD OF BOREHOLE No C-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 409; E 286 829 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 29 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
78.2	Ground Surface																
0.0			1	SS	7												
	Black, some Organics		2	SS	6												
	Red		3	SS	12												
	Brown		4	SS	16												
			5	SS	19												
			6	SS	21												
	Grey		7	SS	16												
			8	SS	13												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	12												
	Stiff to Very Stiff		10	SS	11												
			11	SS	15												
65.6			12	SS	27												
12.6	End of Borehole																
	* 91 10 30																

RECORD OF BOREHOLE No C-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 457; E 286 800 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 30 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L			
76.8	Ground Surface							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	WATER CONTENT (%) 10 20 30					
0.0	Black, trace Organics Brown		1	SS	23		76							
			2	SS	5									
			3	SS	22		74					18.7	6 21 40 33	
			4	SS	18									
	Grey		5	SS	13		72							
			6	SS	12									
			7	SS	14		70							
	Heterogenous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	15									
	Stiff to Very Stiff		9	SS	25		68							
			10	SS	26		66							
64.2			11	SS	30									
12.6	End of Borehole * 91 10 31													

RECORD OF BOREHOLE No D-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 049; E 287 778 ORIGINATED BY FR
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 01 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			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	W _P	W	W _L		
79.8	Ground Surface																
79.0	Sand and Gravel (Fill Material)					*											
0.8	Firm		1	SS	5												
			2	SS	29												
			3	SS	22												
	Brown		4	SS	17												
	Grey		5	SS	12												
			6	SS	25												
			7	SS	14												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	13												
			9	SS	14												
	Stiff to Very Stiff		10	SS	14												
			11	SS	12												
67.2			12	SS	16												
12.6	End of Borehole * GWL not established																

RECORD OF BOREHOLE No D-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N4 788 077; E 287 788 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 10 31 to 91 11 01 CHECKED BY PP

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	20					
79.1	Ground Surface												
0.0			1	SS	23								
			2	SS	27								
			3	SS	21								
	Brown Grey		4	SS	13							21.4	2 22 44 32
			5	SS	13								
			6	SS	24								
			7	SS	13								
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	12							21.8	7 15 45 33
	Stiff to Very Stiff.		9	SS	14								
			10	SS	15								
			11	SS	22								
66.5			12	SS	20								
12.6	End of Borehole												
	* 91 11 02												

RECORD OF BOREHOLE No D-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 128; E 287 805 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 04 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	w _p	w		
78.3	Ground Surface												
0.0			1	SS	26								
			2	SS	21								
			3	SS	15								
	Brown		4	SS	15								
	Grey		5	SS	12								
			6	SS	13								
	Heterogeneous Mixture of Cloyey Silt, Sand and Gravel (Glacial Till)		7	SS	12								
	Stiff to Very Stiff		8	SS	14								
			9	SS	17								
			10	SS	17								
			11	SS	22								
65.7	Hard		12	SS	49								
12.6	End of Borehole												
	* 91 11 05												

RECORD OF BOREHOLE No D-4

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 788 171; E 287 805 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 04 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60
78.3	Ground Surface														
0.0			1	SS	20										
			2	SS	30										
			3	SS	18										
	Brown		4	SS	20								20.9	3 22 49 26	
	Grey		5	SS	12										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		6	SS	16										
			7	SS	12										
	Stiff to Very Stiff		8	SS	10								20.7	10 19 45 26	
			9	SS	13										
			10	SS	20										
			11	SS	20										
65.7			12	SS	28										
12.6	End of Borehole														
	• 91 11 05														

RECORD OF BOREHOLE No E-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 897; E 288 323 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 01 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
78.5	Ground Surface													
0.0			1	SS	23									
			2	SS	35									
	Brown		3	SS	27									
	Grey		4	SS	25									
			5	SS	20									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		6	SS	19									
			7	SS	20									
			8	SS	17									
	Stiff to Very Stiff		9	SS	14									
			10	SS	19									
			11	SS	22									
			12	SS	29									
64.8														
13.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		13	SS	60	/13cm								
62.8	Red, Very Dense		14	SS	100									
15.7	End of Borehole • 91 11 04 (subartesian condition)													

RECORD OF BOREHOLE No E-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 954; E 288 361 ORIGINATED BY FR
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 05 CHECKED BY PP

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		
77.8	Ground Surface													
0.0														
			1	SS	6		76							
			2	SS	17									
			3	SS	26									
			4	SS	23		74							
			5	SS	20									
			6	SS	15									
			7	SS	22		72							
			8	SS	18									
			9	SS	18		70							
			10	SS	36		68							
			11	SS	27									
			12	SS	24		66							
65.2														
12.6	End of Borehole • 91 11 06													

RECORD OF BOREHOLE No F-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 618; E 289 082 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 05 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
80.1	Ground Surface													
0.0			1	SS	16									
			2	SS	30									
			3	SS	26									
			4	SS	20									
	Brown		5	SS	14								21.6	3 17 44 36
	Grey		6	SS	15									
	Heterogeneous Mixture of		7	SS	32									
	Clayey Silt, Sand and Gravel		8	SS	17								21.2	8 18 42 32
	(Glacial Till)													
	Stiff to Hard		9	SS	24									
69.4			10	SS	22									
10.7	Heterogeneous Mixture of		11	SS	100	/20cm								12 50 33 5
	Silt, Sand and Gravel													
	(Glacial Till)													
	Red, Very Dense													
67.5	Silt, trace Sand		12	SS	110									8 18 61 13
12.6	End of Borehole													
	* 91 11 07													

RECORD OF BOREHOLE No F-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 655; E 289 087 ORIGINATED BY PC
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 05 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	w _p w w _L	10 20 30			
79.9	Ground Surface													
0.0	Brown, Very Stiff to Hard Grey, Stiff to Very Stiff Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	24									
			2	SS	34		78							
			3	SS	33									
			4	SS	15		76							
			5	SS	13									
			6	SS	13		74							
			7	SS	14									
			8	SS	19		72							
			9	SS	16									
			10	SS	22		70							
69.2														
10.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Red, Very Dense		11	SS	93									
67.3	Silt, trace Sand		12	SS	77									
12.6	End of Borehole • 91 11 05 subortesion condition													

RECORD OF BOREHOLE No F-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 690; E 289 096 ORIGINATED BY TS
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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			20	40	60	80	100					
79.4	Ground Surface																
0.0			1	SS	26		78										
			2	SS	23												
			3	SS	21												
	Brown Grey		4	SS	17		76										
			5	SS	16												
			6	SS	13												
			7	SS	14		74										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		8	SS	16												
			9	SS	19		72										
			10	SS	20		70										
			11	SS	25												
67.2							68										
12.2	Het. Mixt. of Silt, Sand & Gravel																
66.8	(Glacial Till) Very Dense		12	SS	100												
12.6	End of Borehole * 91 11 11																

RECORD OF BOREHOLE No F-4

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 724; E 289 108 ORIGINATED BY TS
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
79.4	Ground Surface													
0.0						*								
	trace Organics		1	SS	32									
	Hard		2	SS	31									
	Brown		3	SS	26									
	Grey		4	SS	13									
			5	SS	12									
			6	SS	12									
			7	SS	12									
			8	SS	13									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		9	SS	15									
			10	SS	20									
			11	SS	21									
67.2														
12.2	Het. Mixt. of Silt, Sand & Gravel													
66.8	(Glacial Till) Very Dense		12	SS	100									
12.6	End of Borehole													
	* GWL not established													

RECORD OF BOREHOLE No G-1

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 787 460; E 289 623 ORIGINATED BY PC
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Geodetic DATE 91 11 06 CHECKED BY PP

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			20	40	60	80	100					
80.1	Ground Surface																
0.0			1	SS	30												
			2	SS	33												
	Brown		3	SS	24		78									21.4	11 15 43 31
	Grey		4	SS	14												
			5	SS	13		76										
			6	SS	13												
	Het. Mixt. of Silt, Sand and Gravel (Glacial Till)		7	SS	23		74									22.2	48 33 15 4
			8	SS	54												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	23		72										
			10	SS	28												
69.4	Stiff to Very Stiff						70										
10.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		11	SS	98	/15cm											
67.5	Red, Very Dense		12	SS	95		68										
12.6	End of Borehole • 91 11 07																

RECORD OF BOREHOLE No G-2

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 520; E 289 623 ORIGINATED BY TS
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W _p W W _L	10 20 30				
60.1	Ground Surface													
0.0			1	SS	32									
			2	SS	40									
	Hard		3	SS	30									
	Brown		4	SS	24									
	Grey		5	SS	13									
			6	SS	11									
			7	SS	12									
			8	SS	17									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	17									
	Stiff to Very Stiff		10	SS	17									
			11	SS	24									
67.5			12	SS	25									
12.6	End of Borehole • 91 11 11													

RECORD OF BOREHOLE No G-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 475 E 289 627 ORIGINATED BY PC
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 05 CHECKED BY PP

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			20	40					
80.2	Ground Surface													
0.0			1	SS	17	DRY *								
			2	SS	28									
	Brown		3	SS	27									
	Grey		4	SS	13									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		5	SS	14									
			6	SS	12									
	Stiff to Very Stiff		7	SS	14									
			8	SS	17									
	Red, Hard		9	SS	17									
			10	SS	31									
			11	SS	36									
67.6			12	SS	88									
12.6	End of Borehole • 91 11 07													

RECORD OF BOREHOLE No H-1

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 787 966; E 291 092 ORIGINATED BY FR
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Geodetic DATE 91 11 12 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		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	W _p W W _L		
81.4	Ground Surface											
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	10							
79.3	Brown, Firm to Stiff		2	SS	8						19.1	0 11 47 42
2.1	Brown Grey Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Hard		3	SS	18							
			4	SS	18							
			5	SS	22							
			6	SS	14							
			7	SS	15							
			8	SS	13							
			9	SS	16							
			10	SS	22							
			11	SS	36							
68.8			12	SS	35							
12.6	End of Borehole • Dry Upon Completion											

RECORD OF BOREHOLE No H-3

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 787 011; E 291 111 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
DATUM Geodetic DATE 91 11 11 CHECKED BY PP

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 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
80.7	Ground Surface												
0.0													
			1	SS		29							
			2	SS		27							
			3	SS		22							
			4	SS		31							
	Brown Grey		5	SS		20							
			6	SS		15							
			7	SS		15							
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		8	SS		14							
	(Glacial Till)												
			9	SS		16							
	Stiff to Very Stiff		10	SS		12							
			11	SS		24							
68.1			12	SS		28							
12.6	End of Borehole • Dry Upon Completion												

RECORD OF BOREHOLE No H-4

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 787 045; E 291 107 ORIGINATED BY TS
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Geodetic DATE 91 11 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W _p W W _L	10 20 30			
80.1	Ground Surface													
0.0			1	SS	30	DRY *								
	Hard		2	SS	32									
			3	SS	26									
	Brown		4	SS	27									
	Grey		5	SS	17									
			6	SS	15									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		7	SS	16									
	(Glacial Till)		8	SS	17									
	Stiff to Very Stiff		9	SS	15									
			10	SS	17									
			11	SS	29									
67.5			12	SS	25									
12.6	End of Borehole • Dry Upon Completion													

RECORD OF BOREHOLE No 1-1

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 786 590; E 292 183 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L			
83.0	Ground Surface													
0.0			1	SS	17		82							
			2	SS	25									
			3	SS	23		80							
	Brown Grey		4	SS	15									
			5	SS	18		78							
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		6	SS	16									
			7	SS	21		76							
			8	SS	23									
	Stiff to Very Stiff		9	SS	23		74							
72.3			10	SS	17									
10.7	Bedrock - Shale Red, Unweathered to slightly		11	SS	70	/15cm	72							
70.8	Weathered, Weak to Very Weak		12	SS	100	/3cm								
12.2	End of Borehole • GWL not established													

RECORD OF BOREHOLE No 1-2

1 OF 1

METRIC

W.P. WP 319-89-00 LOCATION Co-ords: N 4 786 606; E 292 193 ORIGINATED BY FR
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY FR
 DATUM Geodetic DATE 91 11 11 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
82.1	Ground Surface						82						
0.0	Brown Grey Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		1	SS	54	*	82					22.8	4 20 43 33
			2	SS	29		80						
			3	SS	19								
			4	SS	13								
			5	SS	15		78					21.5	5 20 43 32
			6	SS	18								
			7	SS	23		76						
			8	SS	27								
			9	SS	22		74					21.8	2 18 41 39
			10	SS	23								
72.3	Bedrock - Shale with interbedded siltstone Red, Unweathered to Slightly Weathered, Weak to Very Weak		11	RC	REC 100%		72						RQD = 52%
9.8			12	RC	REC 100%		70						RQD = 74%
69.7	End of Borehole												
12.4	• 91 11 12 GWL not established												

RECORD OF BOREHOLE No 1-4

1 OF 1

METRIC

W.P. 319-89-00 LOCATION Co-ords: N 4 786 670; E 292 215 ORIGINATED BY TS
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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			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					
81.5	Ground Surface																
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	7	*											
80.3			2	SS	13		80										
1.2	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		3	SS	22												
			4	SS	25		78										
			5	SS	22												
			6	SS	19												
	Brown		7	SS	20		76										
	Grey		8	SS	18												
	Stiff to Very Stiff		9	SS	20		74										
70.5			10	SS	18		72										
11.0	Bedrock - Shale		11	SS	111		70										
69.3	Red, Unweathered to slightly Weathered, Weak to Very Weak				**												
12.2	End of Borehole																
	• GWL not established																
	** Sampler bouncing																

ROCK CORE DESCRIPTION

WP 319-89-00

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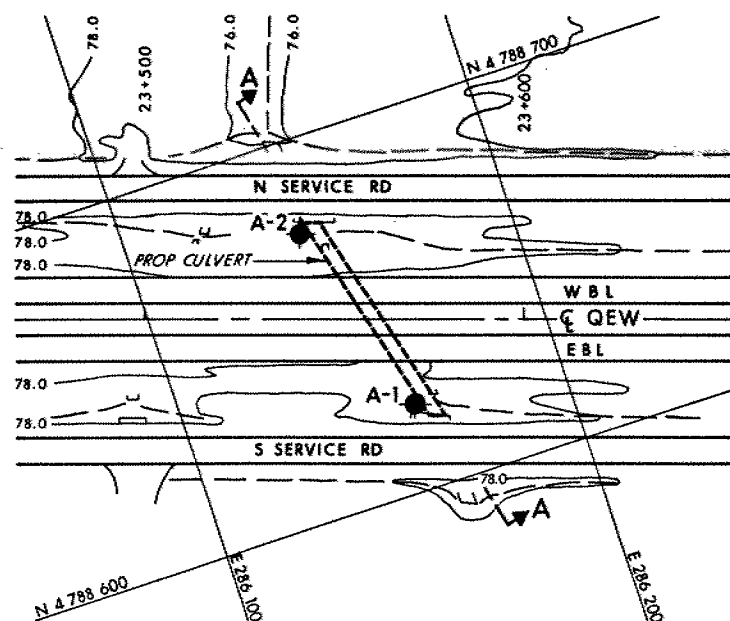
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
12	11	9.60-10.92	100	51	9.60-12.44	SHALE, greyish red, with interbedded greenish grey SILTSTONE (18%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 9.60-9.75 m and 10.87-10.92 m); fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	12	10.92-12.44	100	74		

*CR = CORE RECOVERY

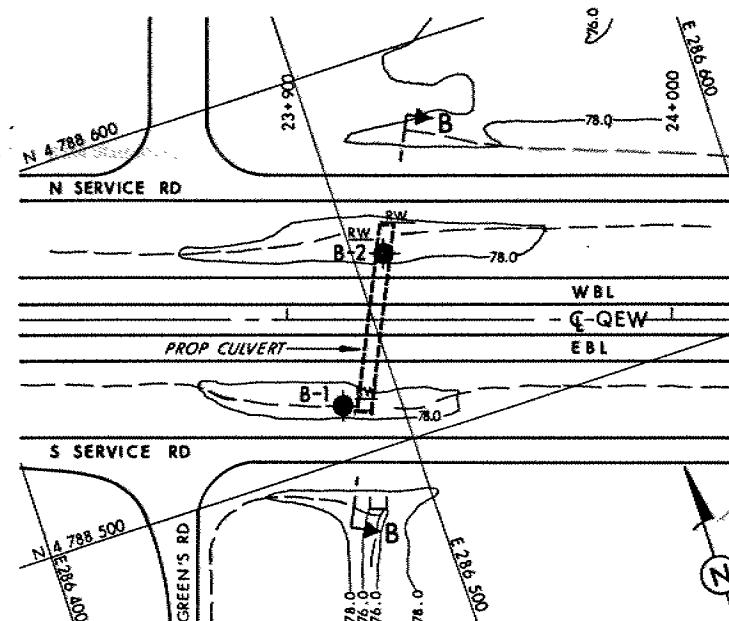
*RQD = ROCK QUALITY DESIGNATION

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

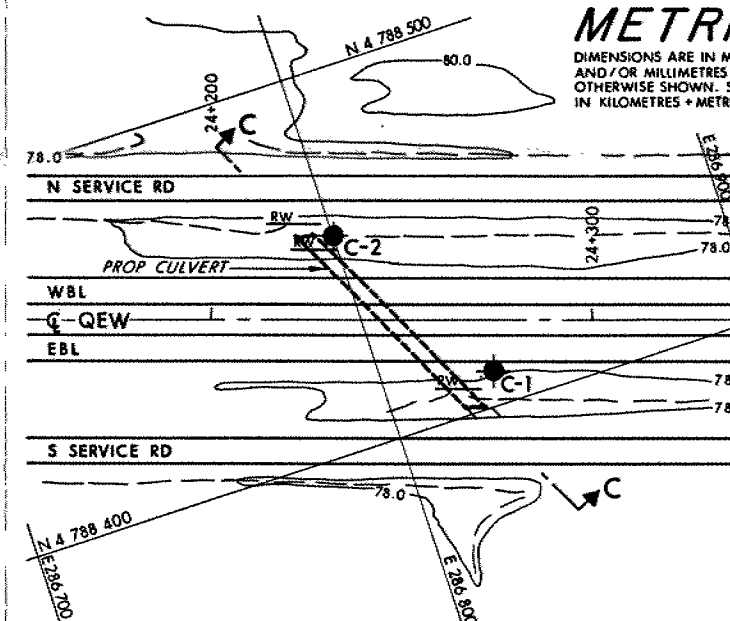
Logged by: DAW, Soils and Aggregates Section



SITE A



SITE B



SITE C

METRIC

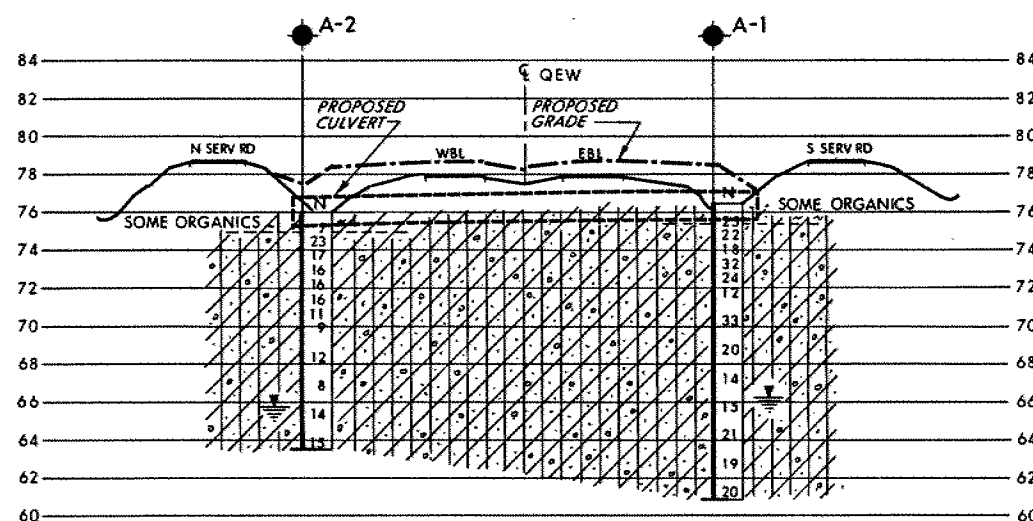
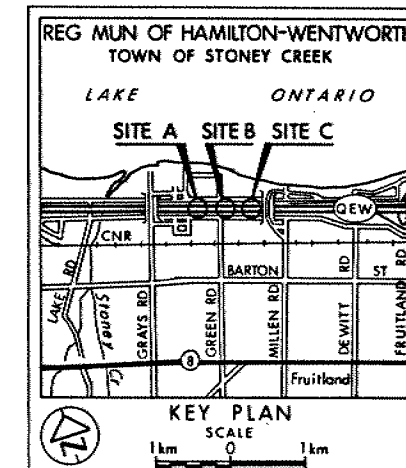
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 319-89-00

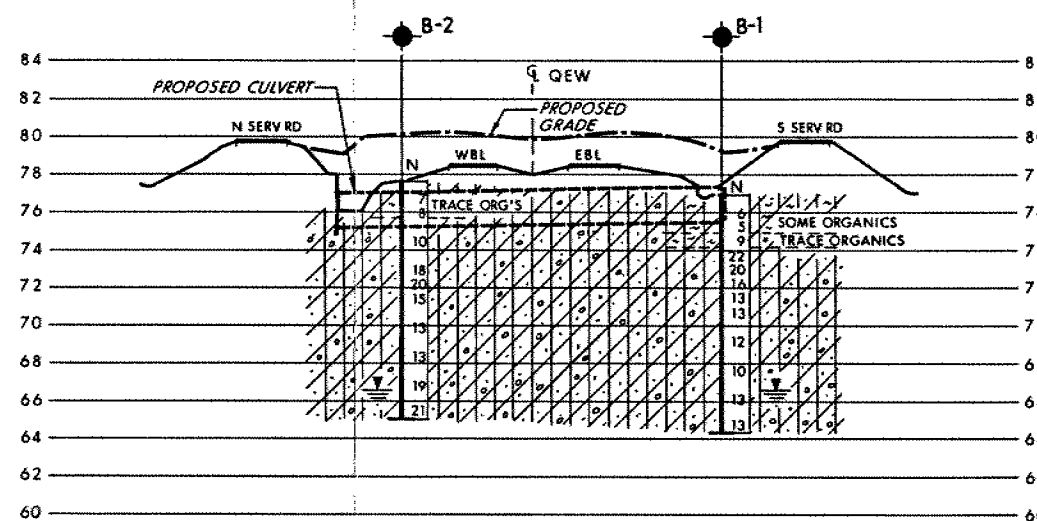
CULVERTS, SITES A, B & C
[Between Grays Rd & Millen Rd]
BORE HOLE LOCATIONS & SOIL STRATA



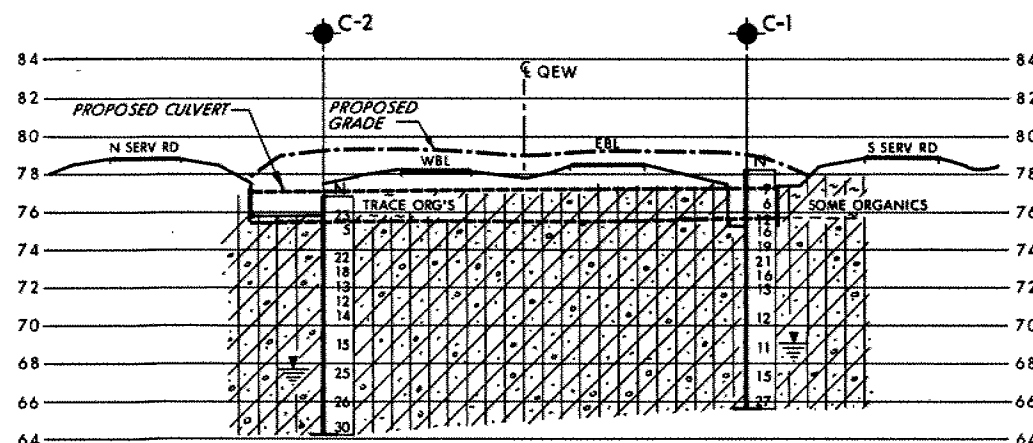
SHEET



SECTION A-A



SECTION B-B



SECTION C-C

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1991 10 and 11.

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
A-1	76.6	4 788 623	286 160
A-2	76.1	4 788 675	286 146
B-1	77.0	4 788 514	286 485
B-2	77.7	4 788 549	286 508
C-1	78.2	4 788 409	286 829
C-2	76.8	4 788 457	286 800

SOIL STRATIGRAPHY LEGEND



HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL
Firm to Hard (Glacial Till)

NOTE

For Sites D, E & F refer to Dwg 3198900-B
For Sites G, H & I refer to Dwg 3198900-C

=NOTE=

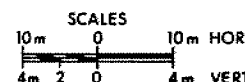
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

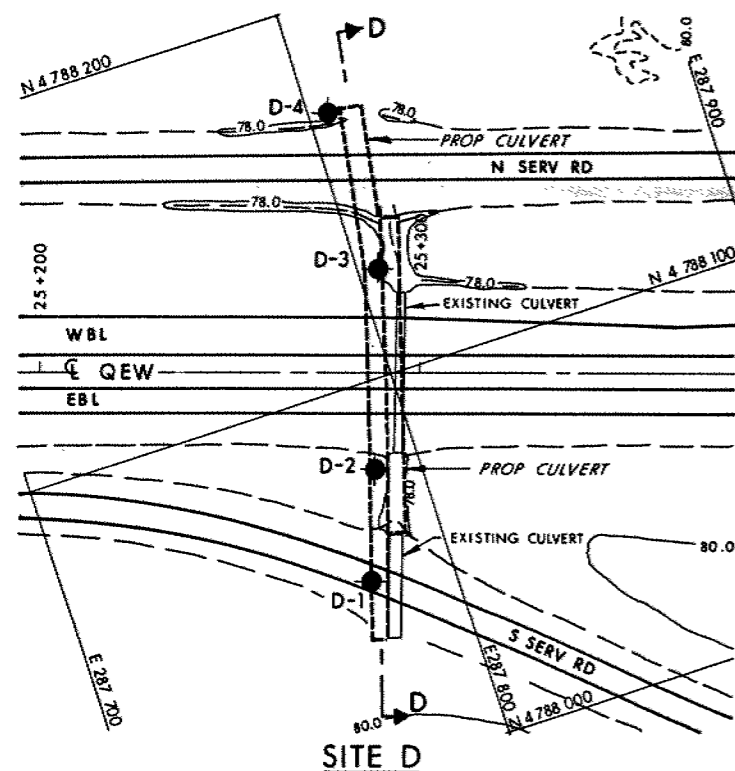
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

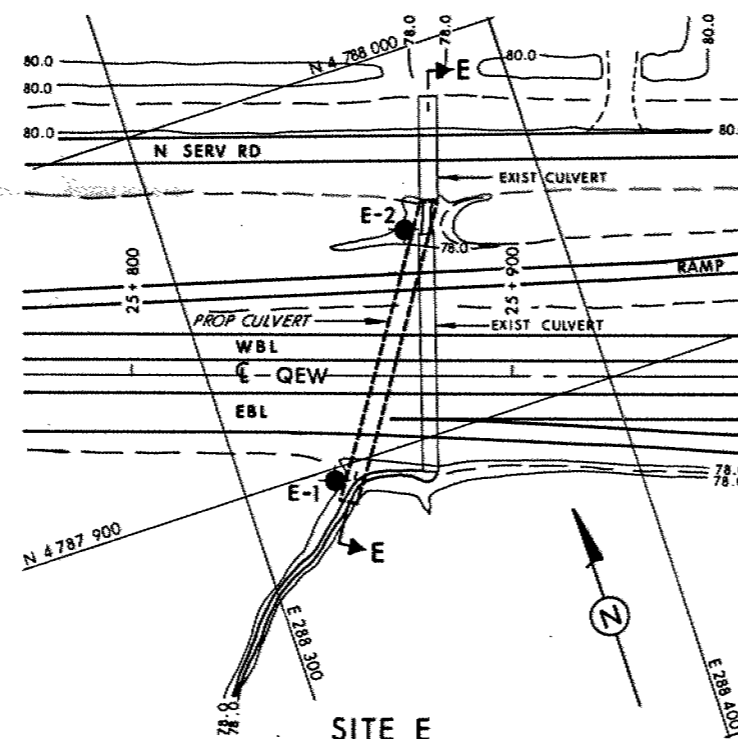
Geocres No 30M4-70

HWY No QEW	SUBM'D T.S.	CHECKED	DATE 1992 04 07	DIST 4
DRAWN R.S.	CHECKED	APPROVED		SITE
				DWG 3198900-A

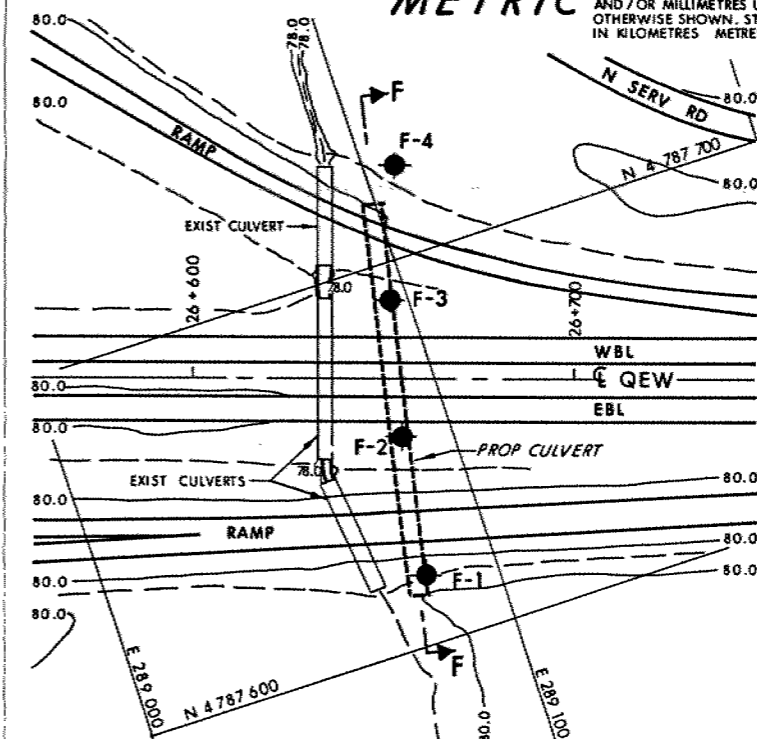




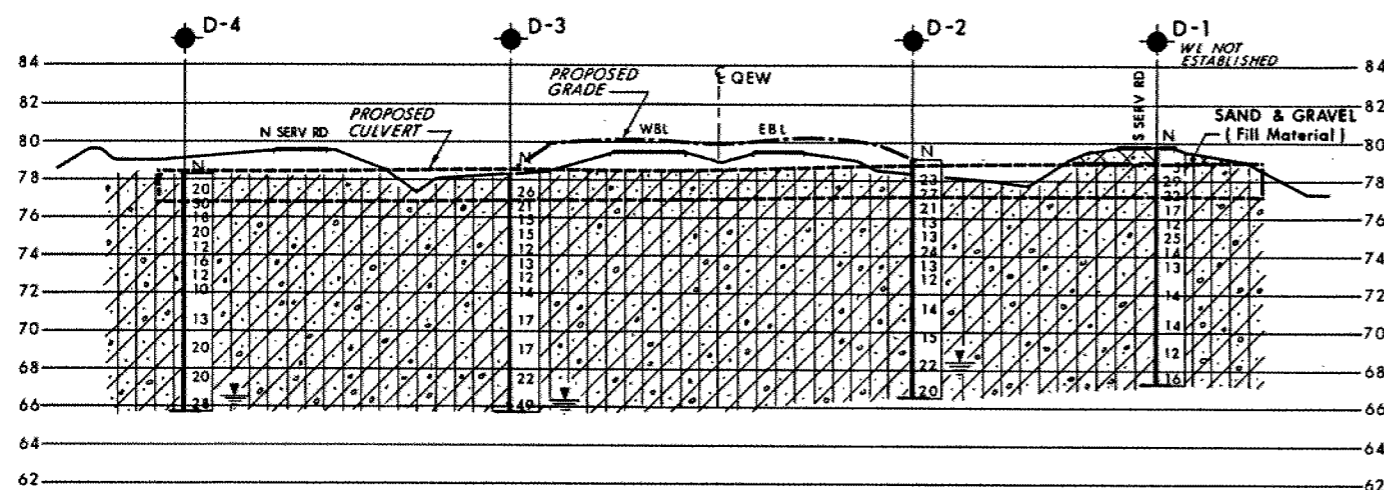
SITE D



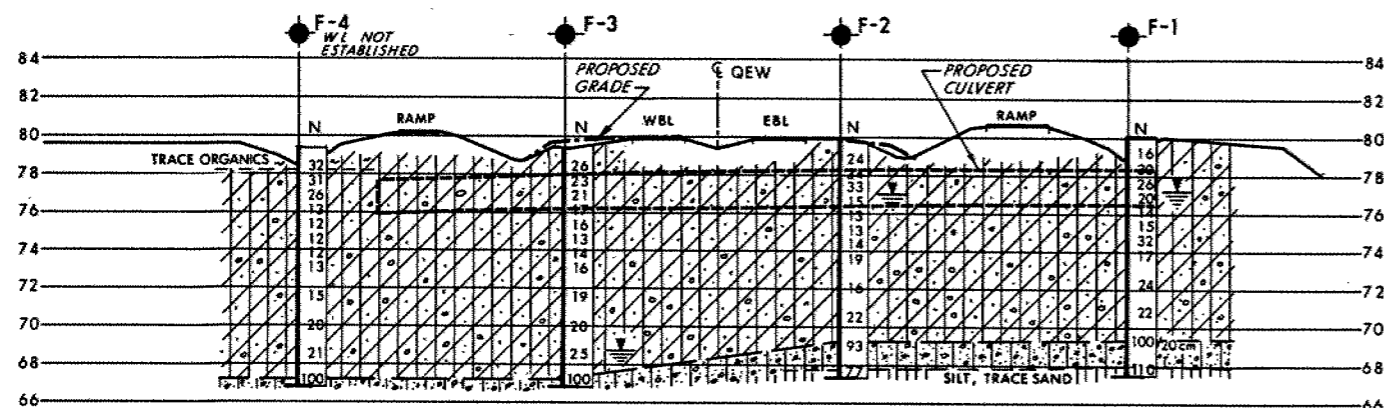
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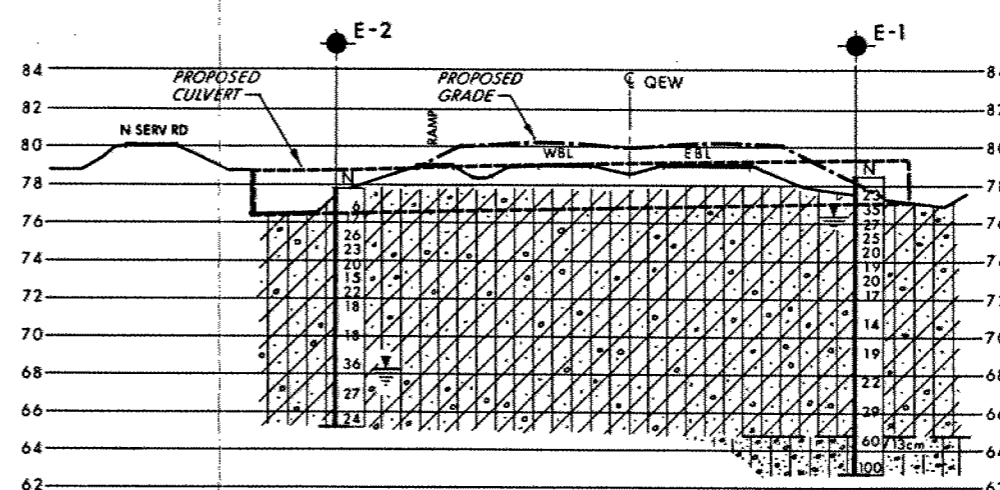
SITE F



SECTION D-D



SECTION F-F



SECTION E-E

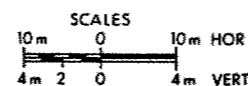
SOIL STRATIGRAPHY LEGEND

HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL Firm to Hard (Glacial Till)

HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL Very Dense (Glacial Till)

NOTE

For Sites A, B & C refer to Dwg 3198900-A
For Sites G, H & I refer to Dwg 3198900-C



METRIC

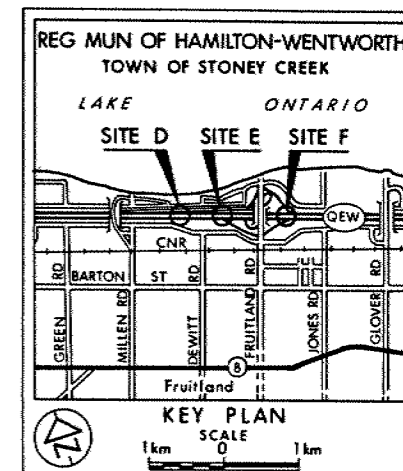
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES METRES.

CONT No
WP No 319-89-00

CULVERTS, SITES D, E & F
(Between Millen Rd & Jones Rd)
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1991 11

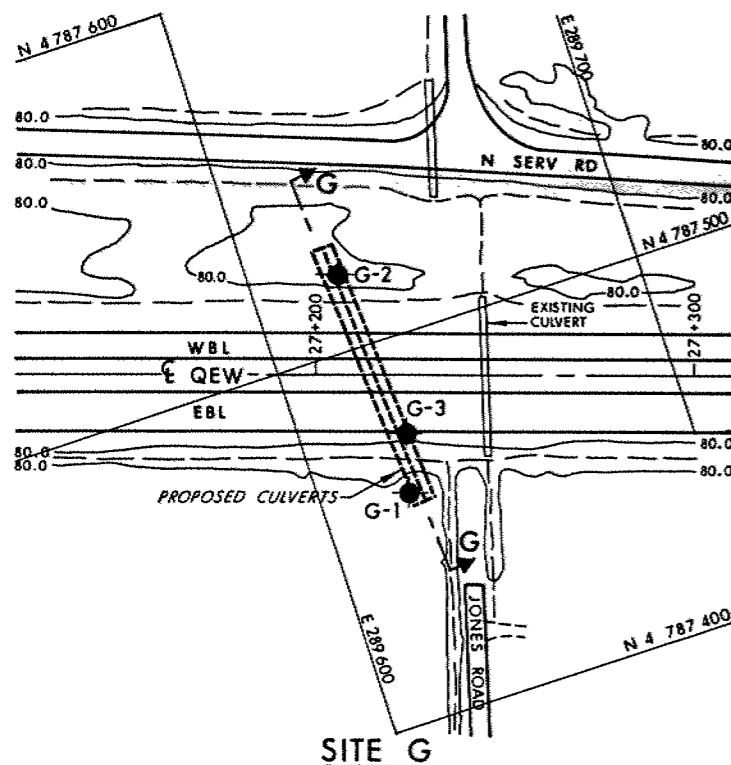
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
D-1	79.8	4788 049	287 778
D-2	79.1	4788 077	287 788
D-3	78.3	4788 128	287 805
D-4	78.3	4788 171	287 805
E-1	78.5	4787 897	288 323
E-2	77.8	4787 954	288 361
F-1	80.1	4787 618	289 082
F-2	79.9	4787 655	289 087
F-3	79.4	4787 690	289 096
F-4	79.4	4787 724	289 108

NOTE

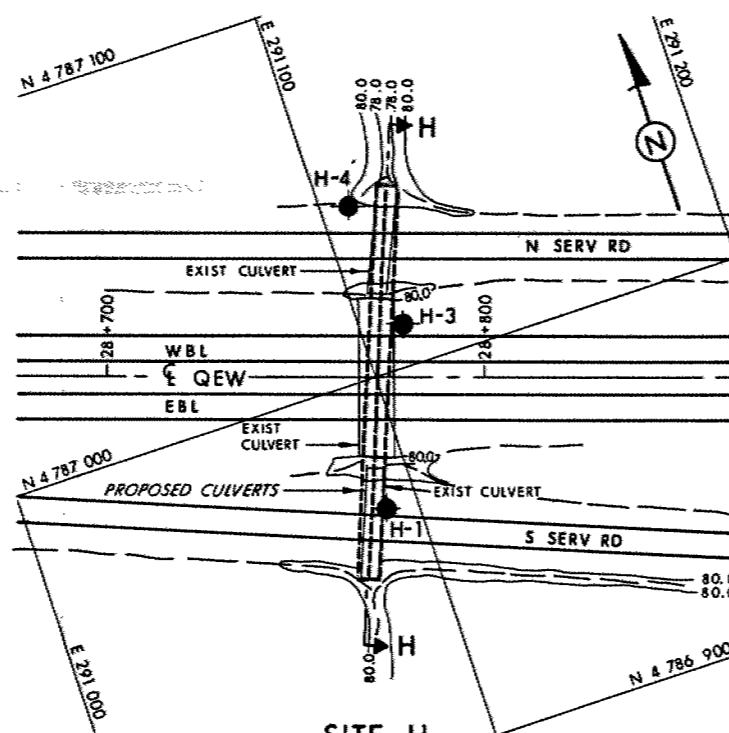
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

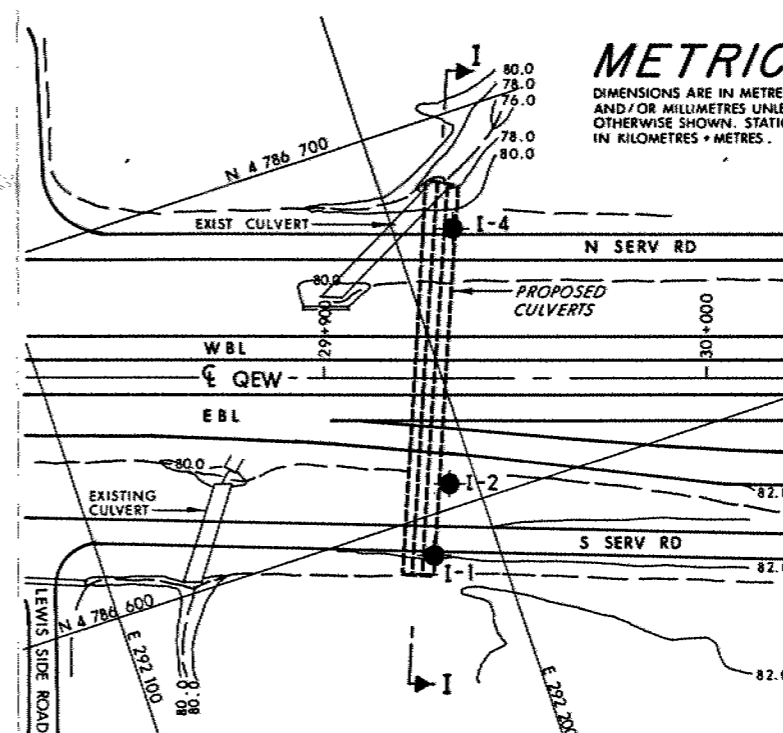
DATE	BY	DESCRIPTION
1992 04 07	RS	APPROVED
Geocres No 30 M4-70		
HWY No QEW	SUBM'D TS	CHECKED TS
DATE 1992 04 07	SITE	DIST 4
DRAWN RS	CHECKED RS	DWG 3198900-B



SITE G



SITE H



SITE I

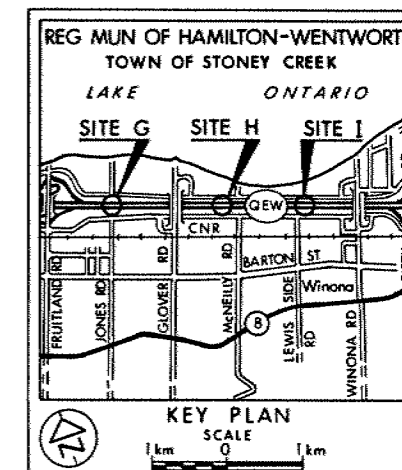
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 319-89-00

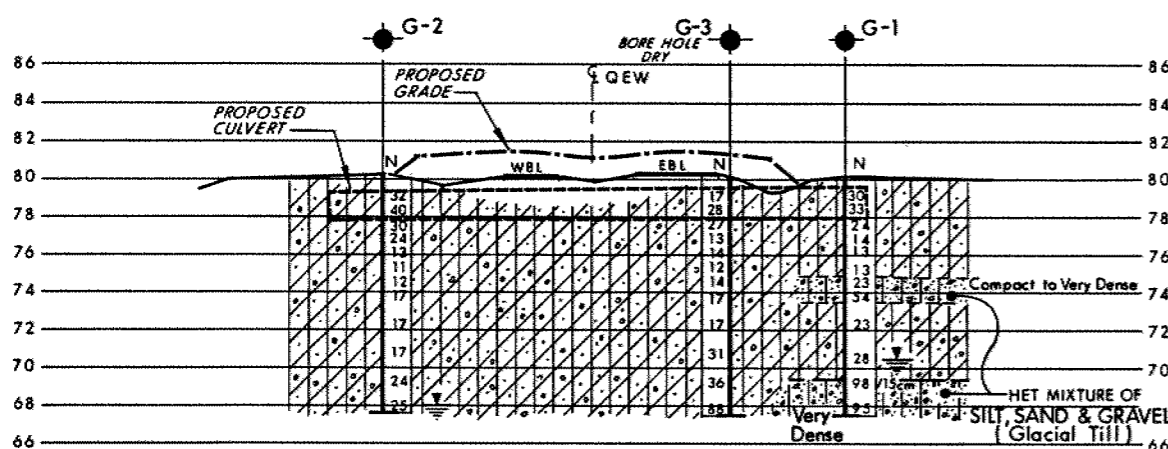
CULVERTS, SITES G, H & I
(Between Jones Rd & Winona Rd)
BORE HOLE LOCATIONS & SOIL STRATA



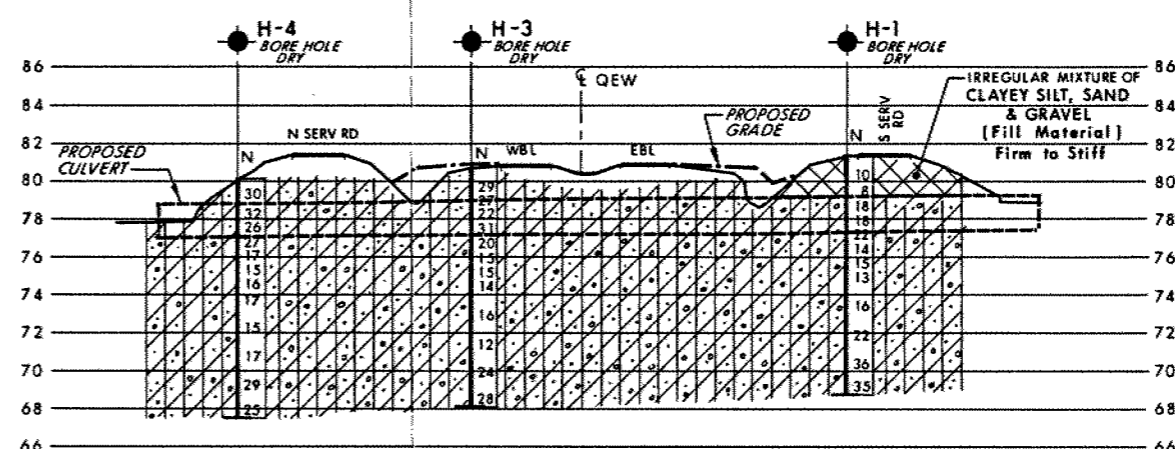
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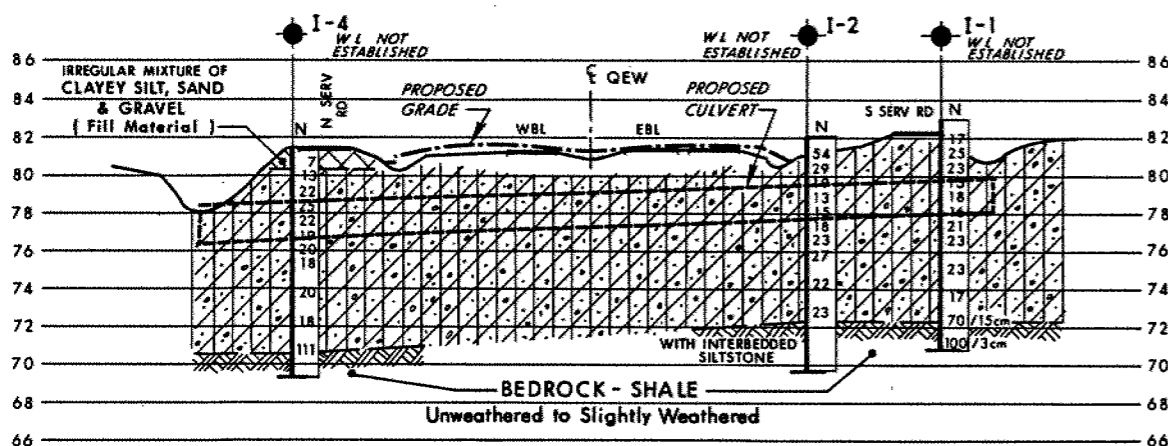
KEY PLAN
SCALE
1 km 0 1 km



SECTION G-G



SECTION H-H



SECTION I-I

SOIL STRATIGRAPHY LEGEND



HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL
Stiff to Hard (Glacial Till)

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1991 II

No	ELEVATION	CO-ORDINATES NORTH	EAST
G-1	80.1	4 787 460	289 623
G-2	80.1	4 787 520	289 623
G-3	80.2	4 787 475	289 627
H-1	81.4	4 787 966	291 092
H-3	80.7	4 787 011	291 111
H-4	80.1	4 787 045	291 107
I-1	83.0	4 786 590	292 183
I-2	82.1	4 786 606	292 193
I-4	81.5	4 786 670	292 215

NOTE

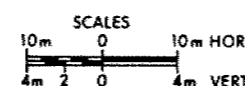
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
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Geocres No 30M4-70

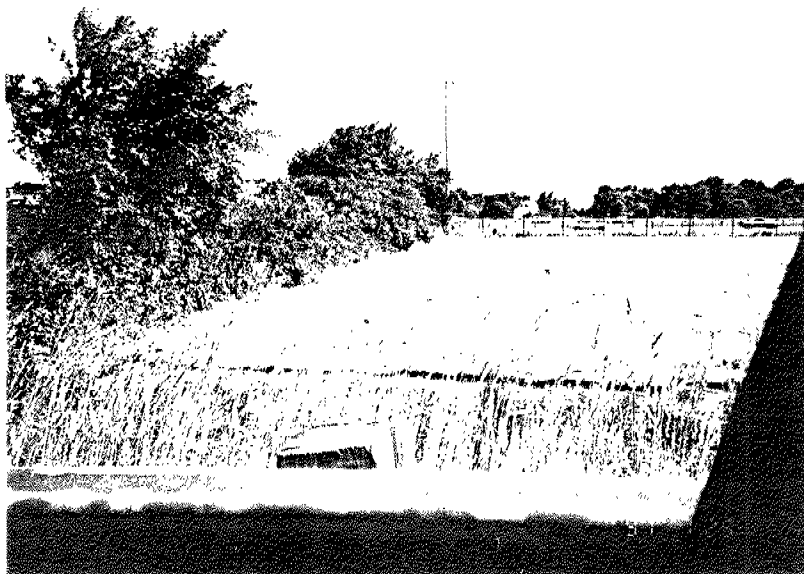
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DRAWN R5	CHECKED R5	APPROVED		SITE
				DWG 3198900-C



P. 10F3



HIGH MAST POLE PROPOSED LOCATION (LOOKING EAST)
AT WEST OF FIFTY RD I/C (ADJACENT TO S. SERVICE RD.)

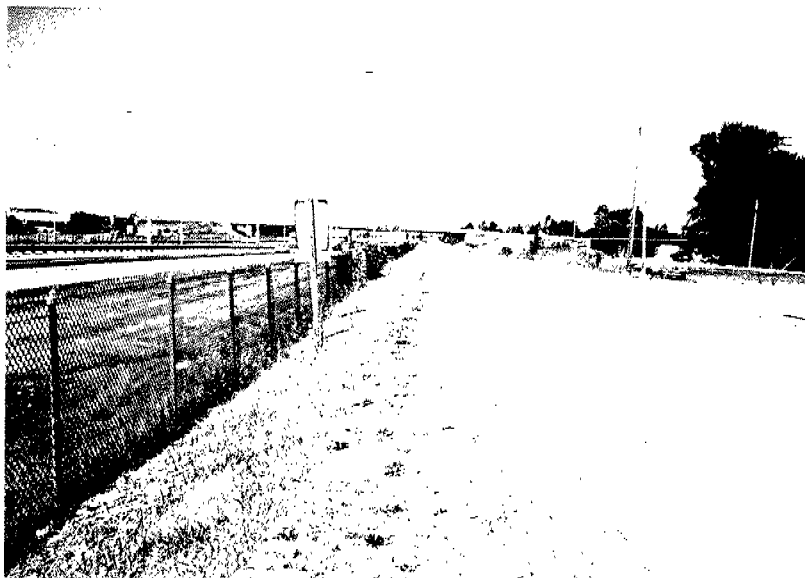


HIGH MAST POLE PROPOSED LOCATION (LOOKING NORTH)
AT WEST OF FRUITLAND RD I/C (ADJACENT TO S. SERVICE RD.)

P. 20F3



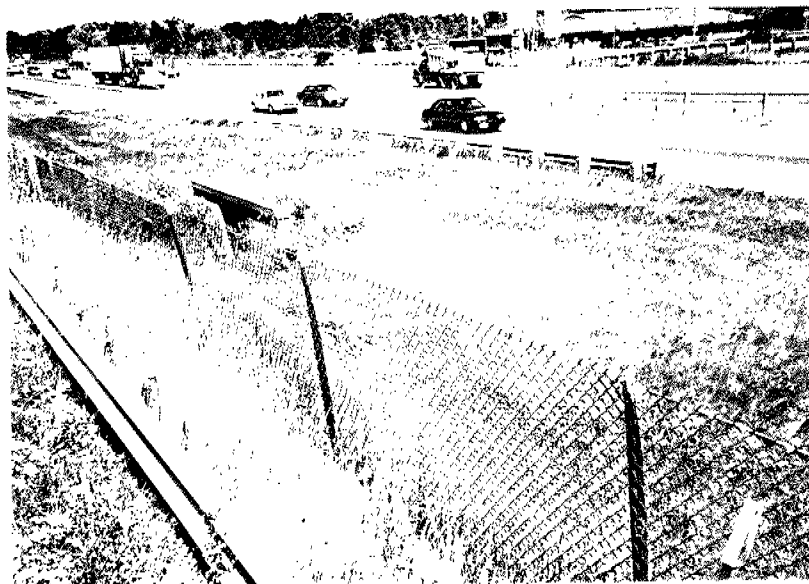
HIGH MAST POLE PROPOSED LOCATION (LOOKING WEST)
AT EAST OF FRUITLAND RD I/C (ADJACENT TO N. SERVICE RD.)



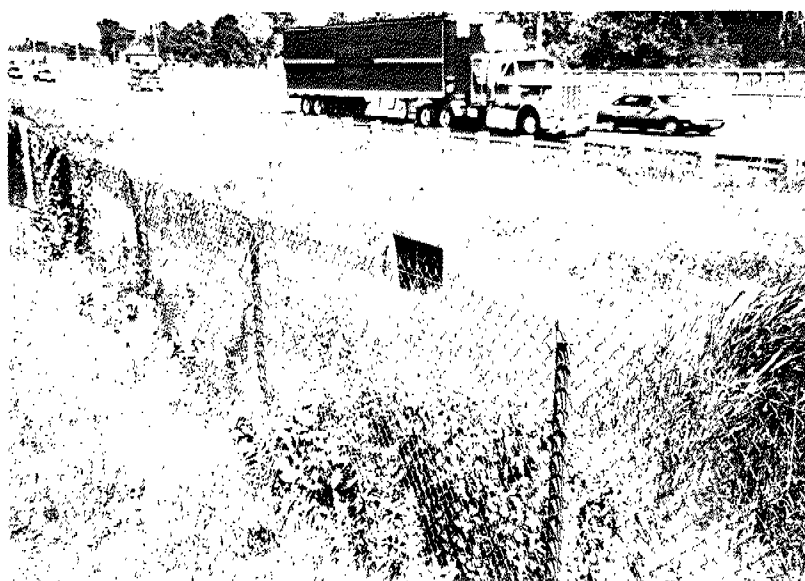
NOISE BARRIER PROPOSED LOCATION (LOOKING WEST)
(FOR STA. 23+042 TO 23+600) ADJACENT TO N. SERVICE RD.



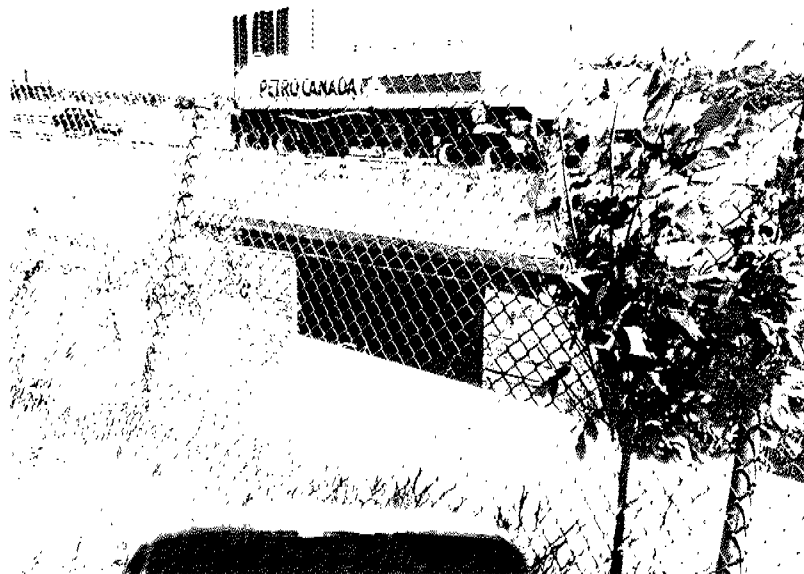
NOISE BARRIER PROPOSED LOCATION (LOOKING WEST)
(FOR STA. 28+700 TO 30+200) (ADJACENT TO N. SERVICE RD.)



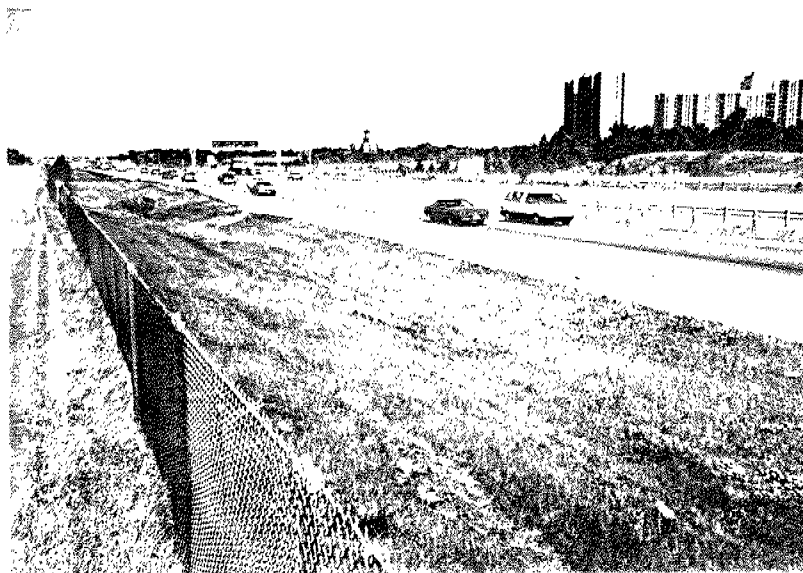
CULVERT 135-08, LOOKING WEST



CULVERT 135-07, LOOKING WEST



CULV. 135-09, LOOKING NW AT EXISTING CULVERT



CULV. 135-09, LOOK. NW AT PROPOSED CULVERT LOCATION



CULV. 135 - 13, LOOKING NORTH



CULV. 135-13, LOOKING NORTH



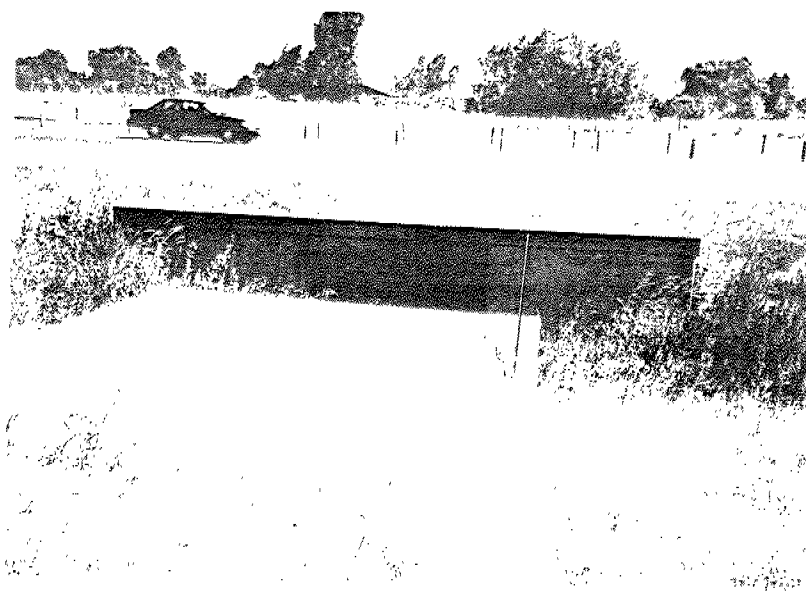
CULV. 137-15 , LOOKING SOUTH



CULV. 137-19 , LOOKING SW



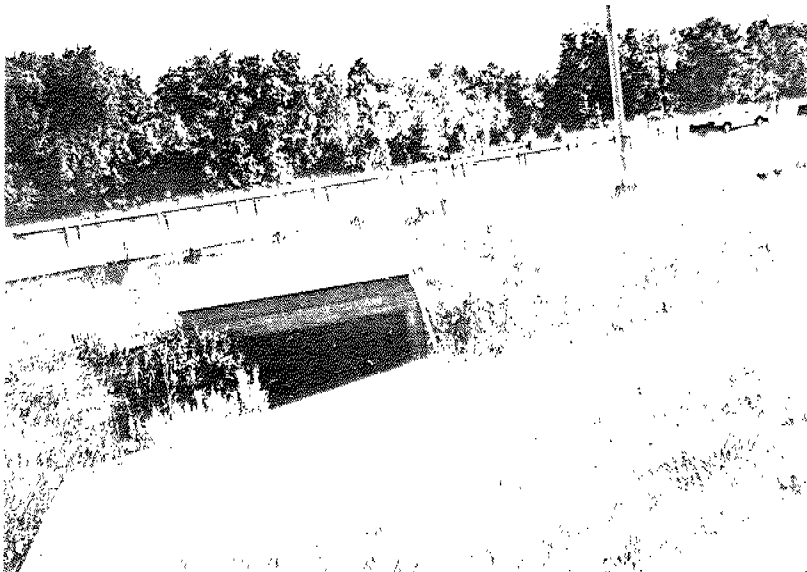
CULV. 135-20 , LOOKING SOUTH



CULV. 135-27 , LOOKING NORTH



CULV. 135- 32 , LOOKING NE



CULV. 135 - 32 , LOOKING NE

G.I.-30 SEPT. 1976

REMARKS: _____

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 95-45



Ministry of
Transportation

Ontario

INDEX

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1	Index
2	Abbreviations & Symbols
	Foundation Investigation Report for
3 - 19	Q.E.W. Culverts Fruitland Road to Fifty Road W.P. 434-92-01 Hwy. Q.E.W., Central Region, Burlington
20 - 49	Q.E.W. Culverts Fifty Road to Casablanca Blvd. W.P. 434-92-02 Hwy. Q.E.W., Central Region, Burlington

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned projects.

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'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	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 ³ /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 ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT
For
Q.E.W. Culverts
(Between Fruitland Road and Fifty Road)
W.P. 434-92-01
Central Region, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted in conjunction with three (3) proposed reinforced concrete box culverts that will carry the Q.E.W. and in some cases the North and South Service Roads. The proposed new culverts will replace existing culverts between Fruitland Road and Fifty Road at or adjacent to the existing culverts. The culvert replacement project is associated with the Q.E.W. widening.

SITE DESCRIPTION

The site is in the Town of Stoney Creek, Regional Municipality of Hamilton-Wentworth. The existing Q.E.W. is a four lane median divided highway and grassland separates the Q.E.W. and the North and South Service Roads.

The terrain across the site is generally flat accentuated by creek slopes at the culvert inlets and outlets. Depths of water in the creeks were shallow at the time of the investigation and generally were less than one (1) metre.

Land use in the area is divided into residential north of the existing North Service Road and industrial south of the existing South Service Road.

INVESTIGATION PROCEDURE

Soil and rock properties were obtained by in situ and laboratory testing. The procedures employed in the foundation investigation are discussed below.

Field Investigation

The fieldwork for the investigation was carried out between 91 11 05 and 91 11 12. Track mounted drilling rigs were used to advance the boreholes employing conventional hollow stem and solid stem augering techniques.

Subsoil samples were retrieved at 0.7 m intervals for the surficial 6.5 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved employing a standard split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). All subsoil samples were identified in the field and then placed in sealed plastic jars to ensure the preservation of the natural moisture contents. Samples were subsequently transported to the laboratory for applicable testing.

Groundwater levels were determined by monitoring the levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevations of the individual boreholes was provided by Central Region Surveys and Plans.

Laboratory Analyses

To identify the behaviour, gradation and pertinent properties of the soil present at the site, various laboratory testing were conducted. These tests included:

- 1) Atterberg Limits
- 2) Grain Size Distributions
- 3) Natural Moisture Contents
- 4) Bulk Unit Weights

The tests were carried out in accordance with standard procedures.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions", and are illustrated on the corresponding boreholes and figures included in the Appendix of this report.

SUBSURFACE CONDITIONS

The ground surface elevation varies both within each individual site and also from site to site. The variation within each individual site is a reflection of the creek channels present at the existing culvert locations and is generally in the order of 2.5 m to 5.0 m from the top of fill material above the culvert roof to the channel floor. The ground surface elevation increases in an easterly direction.

Across the entire site area, the overburden consists of glacial till consisting of a cohesive heterogeneous mixture of clayey silt, sand and gravel with random boulders and cobbles.

At some locations, the cohesive glacial till is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel. This deposit, also of glacial till origin, has thicknesses ranging up to 2.0 m.

At Site I, the surficial native cohesive heterogeneous mixture of clayey silt, sand and gravel is underlain by shale bedrock at depths ranging from 9.8 m to 11.0 m (Elevation 72.3 m to 70.5 m).

The native heterogeneous mixture of clayey silt, sand and gravel is overlain by fill material at some locations across the site. At sites H and I for instance, thicknesses of an irregular mixture of clayey silt, sand and gravel fill material for a thickness up to approximately 2.1 metres was also encountered.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and a subsoil stratigraphical section are provided on Dwg. No. 4349201-A (Sheet 371-1 of the Contract Drawings).

Details of subsurface materials encountered at borehole locations are illustrated in the Record of Borehole Sheets

Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)

A cohesive irregular mixture of clayey silt, sand and gravel identified as fill material was encountered at some sites extending from the surface to a depth of approximately 2.1 m. It appears that this material was used as backfill material to the existing culvert at the various sites.

An Atterberg Limit Test reveals that the material has a Liquid Limit (w_L) of 34% and a Plasticity Index (I_p) of 16.5%. Consequently, the material is classified as a clayey silt of low plasticity. The natural moisture content of the material is 21%.

The 'N' values as determined by the Standard Penetration Test (SPT) revealed a consistency ranging from firm to stiff.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Underlying the fill material and occurring surficially elsewhere at the site, a native deposit consisting of a cohesive heterogeneous mixture of clayey silt, sand and gravel exists. Boulders and cobbles as inferred in the augering process during the borehole advancement also comprise the deposit. Random zones of a heterogeneous mixture of silt, sand and gravel are also found in this deposit. Red shale fragments are also present within the lower depths of the investigated deposit. The deposit was explored to a maximum thickness of 12.6 metres and is of minimum thickness at Site I (9.8 m thickness).

The main component of this unsorted, unstratified deposit is the clayey silt material. This material matrix essentially binds the coarser sands and gravels within the deposit. A grain size distribution envelope for the deposit as determined by mechanical sieve and hydrometer analyses is given in Figure 1 in the Appendix. The envelope includes particle sizes up to 75 mm (coarse gravel) and hence excludes the boulder and cobble sizes. The envelope does reveal that the fine grained portions (less than 75 micrometres) contribute to more than approximately 70% of the material of this deposit.

Atterberg Limit Tests were carried out to at these and nearby sites define the behaviour and plasticity of the fine grained portion of the soil and the results are plotted in Figure 2. A summary of the indices is provided in Table 1 below. Bulk Unit Weights are also included in the table.

Table 1 - Heterogeneous Mixture of Clayey Silt
Sand and Gravel (Glacial Till)

	Range
Natural Moisture Content (w%)	13-21
Liquid Limit (w L %)	22-35
Plastic Limit (w P %)	14-18
Plasticity Index (I P %)	10-18
Unit Weight (kN/m ³)	19-22.3

The test results reveal that the fine grained portion of the deposit is of low plasticity and hence is defined as clayey silt. Natural moisture contents are generally less than or equivalent to the plastic limit of the soil indicating that the soil is in a plastic to semi-solid state.

Standard Penetration Test (SPT) carried out in this deposit revealed 'N' values ranging from 11 blows/0.3 m to 54 blows/0.3 m revealing a probable stiff to hard range of soil consistency. In general, 'N' values are in the 12 blows/0.3 m to 25 blows/0.3 m and hence the soil is considered as stiff to very stiff.

Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)

At Site G the cohesive heterogeneous mixture of clayey silt, sand and gravel is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel at a depth ranging from 10.7 m to 12.6 m (Elevation 69.4 m to 67.5 m). Layers of silt with some sand are also present in this deposit in thicknesses up to approximately 0.5 m. The deposit is red in colour and as inferred by auger grinding, boulders and cobbles are also present within this deposit. Red shale fragments are also contained within the deposit.

Bedrock

Based on tests in the general area, shale bedrock with interbedded siltstone of the Queenston Shale Formation underlies the overburden at Site I at a depth of 9.8 m to 11 m (Elevation 72.3 m to 70.5 m). Bedrock core was retrieved in NX size for a thickness of 2.84 m at BH I2.

The shale bedrock is generally greyish red and has randomly interbedded greenish grey siltstone layers. The rock is horizontally bedded and is an extremely friable material. The rock contains moderately close to extremely closed spaced fractures that are generally flat, planar to undulating and smooth. The rock generally is unweathered to slightly weathered.

Core recoveries and Rock Quality Designations (RQD) were determined in situ to evaluate the competence and integrity of the rock. Core recoveries were 100% and RQD's ranged from 52% to 74%. Based on these measurements, the rock can be considered to be of fair quality.

Based on index property identification, the rock is classified as weak to very weak in strength.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes throughout the duration of the field investigation.

Groundwater conditions at the borehole locations are illustrated on the Record of Borehole Sheets. Some higher water levels in the area illustrate the effect of the subartesian condition present in the heterogeneous mixture of silt, sand and gravel deposit below the cohesive heterogeneous mixture of clayey silt, sand and gravel.

Groundwater levels were not established at the borehole locations advanced on the shoulders of the Q.E.W. and the Service Roads because these boreholes were backfilled immediately for safety reasons.

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and F. Reijerse, Student Engineer, utilizing equipment owned and operated by Malone's Soil Samples.

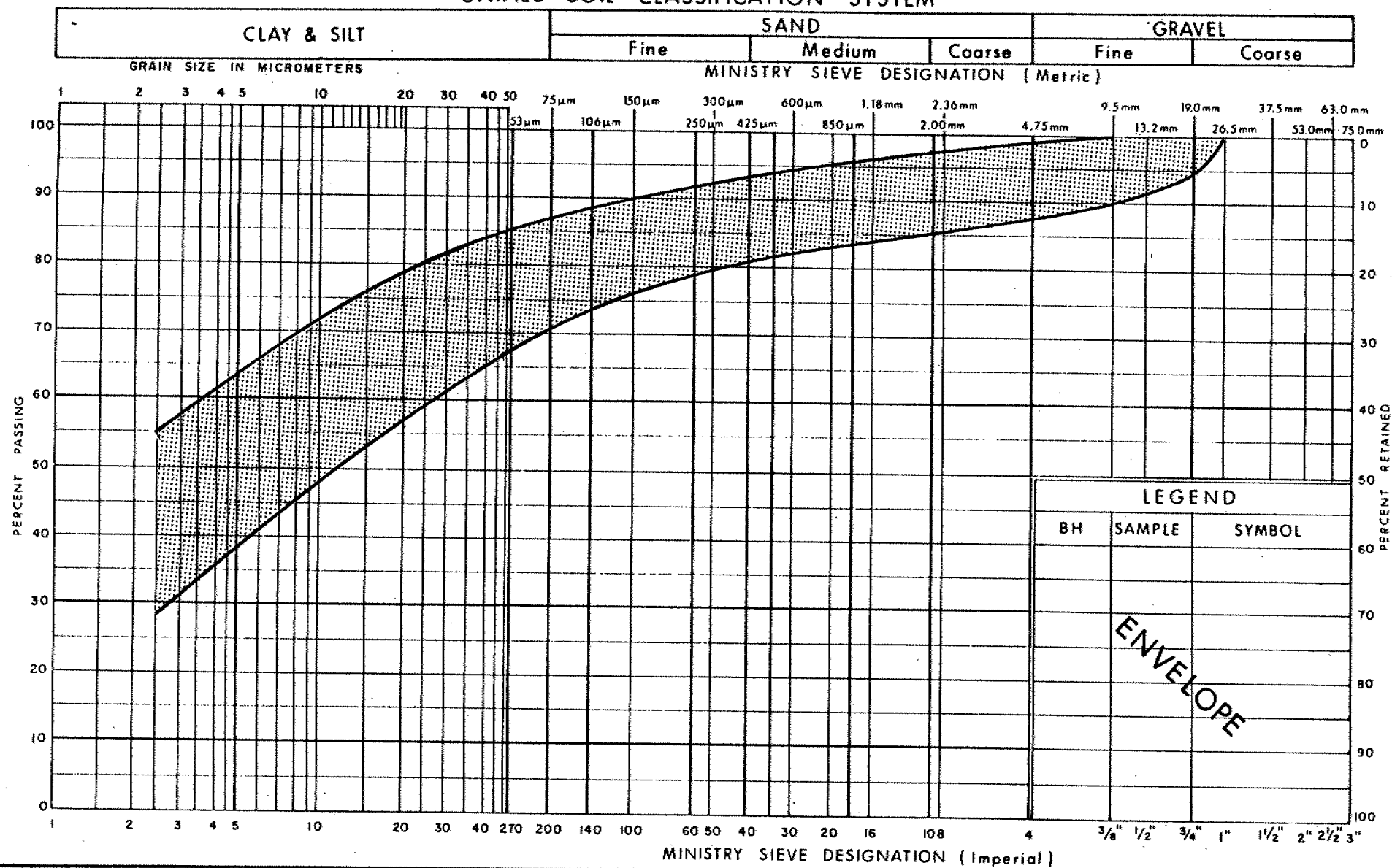
The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



D. Dundas
D. Dundas, P.Eng.
Senior Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



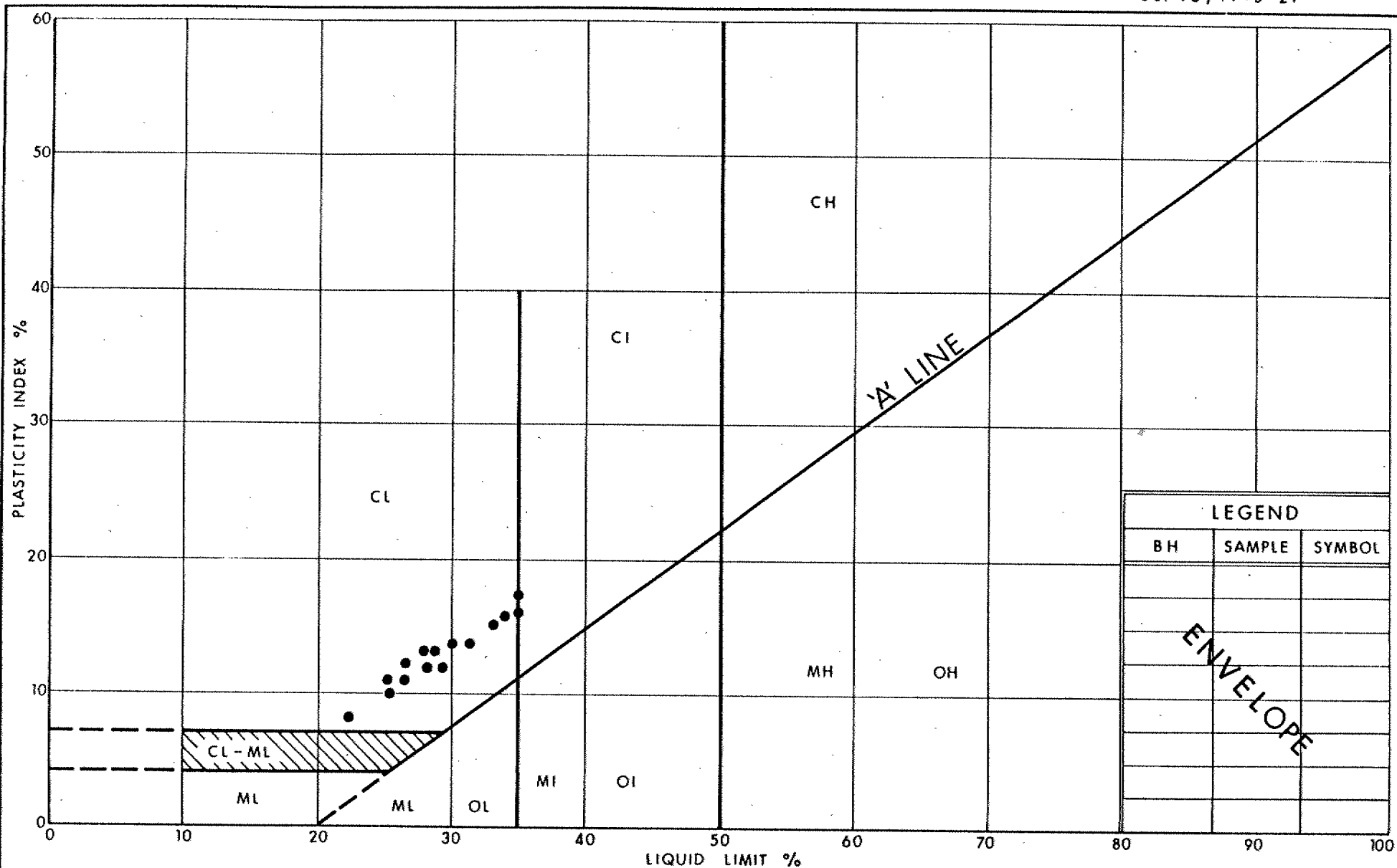
Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF CLAYEY SILT
SAND & GRAVEL (Glacial Till)

FIG No 1

W P 434-92-01



Ministry of
Transportation

Ontario

PLASTICITY CHART HET MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 434-92-01

RECORD OF BOREHOLE No G-1

1 OF 1

METRIC

W.P. 434-92-01 LOCATION Co-ords: N 4 787 460; E 289 623 ORIGINATED BY PC
DIST 4 HWY G.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
DATUM Ceodetic DATE 91 11 06 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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							W _p	W	W _L
								SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE								
								• QUICK TRIAXIAL	* LAB VANE								
80.1	Ground Surface							20 40 60 80 100		WATER CONTENT (%)							
0.0										10 20 30							
			1	SS	30												
			2	SS	33												
			3	SS	24		78										
	Brown		4	SS	14								21.4	11 15 43 31			
	Grey		5	SS	13		76										
			6	SS	13												
			7	SS	23		74						22.2	48 33 15 4			
	Het. Mixt. of Silt, Sand and Gravel (Glacial Till)		8	SS	54												
			9	SS	23		72										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		10	SS	28		70										
69.4	Stiff to Very Stiff																
10.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		11	SS	98	/15cm											
67.5	Red, Very Dense		12	SS	95		68										
12.6	End of Borehole • 91 11 07																

RECORD OF BOREHOLE No G-2

1 OF 1

METRIC

W.P. 434-92-01

LOCATION Co-ords: N 4 787 520; E 289 623

ORIGINATED BY TS

DIST 4 HWY Q.E.W.

BOREHOLE TYPE SS Auger

COMPILED BY TS

DATUM Geodetic

DATE 91 11 08

CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
80.1	Ground Surface															
0.0			1	SS	32											
			2	SS	40											
	Hard		3	SS	30		78								22.3	1 14 45 40
	Brown		4	SS	24											
	Grey		5	SS	13		76									
			6	SS	11											
			7	SS	12											
			8	SS	17		74								21.7	0 14 46 40
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	17											
	Stiff to Very Stiff		10	SS	17		72									
			11	SS	24		70									
67.5			12	SS	25		68									
12.6	End of Borehole • 91 11 11															

RECORD OF BOREHOLE No G-3

1 OF 1

METRIC

W.P. 434-92-01

LOCATION Co-ords: N 4 787 475 E 289 627

ORIGINATED BY PC

DIST 4 HWY Q.E.W.

BOREHOLE TYPE SS Auger

COMPILED BY TS

DATUM Geodetic

DATE 91 11 05

CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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 80 100		10 20 30			
80.2	Ground Surface														
0.0	<div><div></div><div>Brown</div><div>Grey</div><div>Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff</div><div>Red, Hard</div></div>														
			1	SS	17										
			2	SS	28										
			3	SS	27										
			4	SS	13										
			5	SS	14										
			6	SS	12										
			7	SS	14										
			8	SS	17										
			9	SS	17										
			10	SS	31										
			11	SS	36										
67.6			12	SS	68										
12.6	End of Borehole														
	• 91 11 07														

RECORD OF BOREHOLE No H-1 1 OF 1 METRIC

W.P. 434-92-01 LOCATION Co-ords: N 4 787 966; E 291 092 ORIGINATED BY FR
 DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Ceodetic DATE 91 11 12 CHECKED BY PP

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
81.4	Ground Surface															
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	10											
79.3	Brown, Firm to Stiff		2	SS	8											
2.1			3	SS	18											
			4	SS	18											
			5	SS	22											
	Brown		6	SS	14											
	Grey		7	SS	15											
			8	SS	13											
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Hard		9	SS	16											
			10	SS	22											
			11	SS	36											
68.8			12	SS	35											
12.6	End of Borehole • Dry Upon Completion															

RECORD OF BOREHOLE No H-3

1 OF 1

METRIC

W.P. 434-92-01

LOCATION Co-ords: N 4 787 011; E 291 111

ORIGINATED BY TS

DIST 4 HWY Q.E.W.

BOREHOLE TYPE SS Auger

COMPILED BY FR

DATUM Geodetic

DATE 91 11 11

CHECKED BY PP

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 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
80.7	Ground Surface					20 40 60 80 100			10 20 30				
0.0			1	SS	29								
			2	SS	27								
			3	SS	22								
			4	SS	31								
			5	SS	20								
			6	SS	15								
			7	SS	15								
			8	SS	14								
			9	SS	16								
			10	SS	12								
			11	SS	24								
68.1			12	SS	28								
12.6	End of Borehole • Dry Upon Completion												

RECORD OF BOREHOLE No H-4

1 OF 1

METRIC

W.P. 434-92-01 LOCATION Co-ords: N 4 787 045; E 291 107 ORIGINATED BY TS
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY FR
 DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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									
								20 40 60 80 100									
80.1	Ground Surface																
0.0	<div>Hard</div> <div>Brown</div> <div>Gray</div> <div>Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff</div>		1	SS	30	DRY *	78										
			2	SS	32												
			3	SS	26												
			4	SS	27												
			5	SS	17												
			6	SS	15												
			7	SS	16												
			8	SS	17												
			9	SS	15												
			10	SS	17												
			11	SS	29												
67.5			12	SS	25												
12.6	End of Borehole • Dry Upon Completion																

RECORD OF BOREHOLE No 1-1

1 OF 1

METRIC

W.P. 434-92-01 LOCATION Co-ords: N 4 786 590; E 292 183 ORIGINATED BY FR
DIST 4 HWY Q.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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 (%)		
								20	40	60	80	100						10	20	30
83.0	Ground Surface																			
0.0	Brown ----- Grey Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		1	SS	17															
			2	SS	25															
			3	SS	23															
			4	SS	15															
			5	SS	18															
			6	SS	16															
			7	SS	21															
			8	SS	23															
			9	SS	23															
			10	SS	17															
72.3			11	SS	70	/15cm														
10.7	Bedrock - Shale																			
	Red, Unweathered to, slightly																			
70.8	Weathered, Weak to Very Weak					/3cm														
12.2	End of Borehole																			
	• CWL not established																			

RECORD OF BOREHOLE No 1-2

1 OF 1

METRIC

W.P. 434-92-01 LOCATION Co-ords: N 4 786 606; E 292 193 ORIGINATED BY FR
DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY FR
DATUM Ceodetic DATE 91 11 11 CHECKED BY PP

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
82.1	Ground Surface						82								
0.0			1	SS	54									22.8	4 20 43 33
	Brown		2	SS	29		80								
	Grey		3	SS	19										
			4	SS	13										
			5	SS	15		78							21.5	5 20 43 32
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		6	SS	18										
	(Glacial Till)		7	SS	23										
	Stiff to Very Stiff		8	SS	27		76								
			9	SS	22									21.8	2 18 41 39
72.3			10	SS	23		74								
9.8	Bedrock - Shale with interbedded siltstone		11	RC	REC 100%		72								RQD = 52%
	Red, Unweathered to Slightly Weathered, Weak to Very Weak		12	RC	REC 100%		70								RQD = 74%
69.7															
12.4	End of Borehole - 91 11 12 GWL not established														

RECORD OF BOREHOLE No 1-4

1 OF 1

METRIC

W.P. 434-92-01 LOCATION Co-ords: N 4 786 670; E 292 215 ORIGINATED BY TS
 DIST 4 HWY O.E.W. BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 11 08 CHECKED BY PP

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80					
81.5	Ground Surface															
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	7											
80.3			2	SS	13											
1.2	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		3	SS	22											
			4	SS	25											
			5	SS	22											
			6	SS	19											
			7	SS	20											
			8	SS	18											
			9	SS	20											
			10	SS	18											
70.5			11	SS	111											
11.0	Bedrock - Shale															
69.3	Red, Unweathered to slightly Weathered, Weak to Very Weak															
12.2	End of Borehole															
	* GWL not established															
	** Sampler bouncing															

FOUNDATION INVESTIGATION REPORT**for****Culvert Replacement****W.P. 434-92-02****Queen Elizabeth Way****Fifty Road to Casablanca Boulevard****Stoney Creek and Grimsby****1.0 INTRODUCTION**

This report presents the results of a foundation investigation carried out at proposed culvert replacement sites in the City of Stoney Creek, and Town of Grimsby, Ontario. The investigation was carried out in accordance with our proposal dated 94/08/06. Authorization to carry out the work was provided by the Foundation Design Section, Ministry of Transportation, Ontario (MTO).

This report contains factual information pertaining to the subsurface conditions.

2.0 SITE DESCRIPTION AND GEOLOGY

The culvert replacement sites are located along the Queen Elizabeth Way (QEW) between Fifty Road in Stoney Creek and Casablanca Boulevard in Grimsby. Sheets No. 371-2 and 371-3 in the Contract Drawings show the site locations. The terrain surrounding the sites is generally flat and consists of mixed residential, agricultural and industrial land uses. The existing ground surface generally slopes downward gently from south to north, towards Lake Ontario.

At the time of the investigation, the QEW is a four-lane divided highway with gravel shoulders. A North Service Road and South Service Road is located parallel to the QEW on the north and south sides, respectively. Both the North and South Service Roads are two-lane paved roads with gravel shoulders.

Drainage of the existing QEW is provided by highway ditches located on both the north and south sides and in between the QEW and the two service roads. The culverts investigated during this study facilitate drainage of these ditches beneath the QEW towards the north into Lake Ontario.

Physiographically, the sites lie in the area known as the Halton Till Plain, which consists of glacial till with clayey silt to silty clay size particles and little to no cobbles and boulders. Bedrock underlying the overburden consists of Ordovician shale of the Queenston Formation throughout the study area.

3.0 PROCEDURE

3.1 Field Investigation

Prior to the onset of the drilling investigation, the necessary utility check clearances were obtained by our site personnel. Traffic control for this project was provided by Barricade Traffic Services Inc., who were coordinated by MTO.

The field work for this investigation was carried out between August 16 and 25, 1994. Three (3) boreholes were put down at each culvert location. The test locations are indicated on Drawings No. 4349202-A and 4349202-B (Refer to Sheets 371-2 & 371-3 in the Contract Drawings). One dynamic cone penetration test was also conducted at each culvert location.

All boreholes were put down using either a track-mounted or truck-mounted power auger drill suitably equipped for soil and bedrock sampling. Continuous flight solid stem augers and NQ-sized rock coring techniques (where required) were employed during the course of the investigation to advance the boreholes.

The overburden soils encountered were sampled by means of a split spoon sampler during the performance of Standard Penetration Tests (SPT) (ASTM D1586). Where soft to firm cohesive soils were encountered, field vane tests were conducted at selected locations. Sampling was generally conducted on a near continuous basis (intervals of 0.76 m) at the top 4.6 m of the borehole. Below this depth, sampling was conducted in intervals of about 1.5 m.

All soil samples recovered together with bedrock core samples were stored in moisture-proof bags or core boxes, and were returned to our Markham laboratory for detailed classification and testing.

Water levels, where observed, were obtained in the open boreholes upon completion of the drilling. All boreholes were backfilled with auger cuttings and sealed with a minimum 500 mm thick bentonite layer at the ground surface. Boreholes put down at the median where the surface consists of asphaltic concrete were surfaced with a minimum of 50 mm of cold mix asphalt.

3.2 Survey

The borehole and cone penetration test locations and ground surface elevations were surveyed by Jacques Whitford Environment Limited (JWEL) personnel after completion of the field work. The elevations were referenced to existing culvert invert elevations shown on the site plans, provided by MTO. These elevations are assumed to be referenced to the Geodetic datum.

3.3 Laboratory Testing

To identify the properties of the samples collected during the field investigation, the following laboratory tests were carried out on selected samples:

- Detailed visual classification,
- Natural moisture content,
- Sieve and hydrometer analyses,
- Atterberg Limits determination,
- Natural unit weight determination.

4.0 RESULTS OF THE INVESTIGATION

The subsurface conditions observed in the boreholes are presented in detail on the Record of Boreholes provided in the Appendix.

A brief discussion of the observed subsurface conditions is provided below.

4.1 W.P. 434-92-02

4.1.1 Topsoil

Topsoil was encountered at the ground surface in most boreholes except the boreholes located in the median of the QEW. The thickness of the topsoil ranges from 50 mm to 600 mm.

4.1.2 Asphaltic Concrete

Asphaltic concrete was encountered at the ground surface in Boreholes 135-41-2, and 136-04-2 (QEW median locations). The thickness of the asphaltic concrete ranged from 50 mm to 100 mm at the time of the investigation with an average thickness of about 75 mm.

4.1.3 Sand, Silt and Gravel (Fill) / Silt (Fill)

A loose to compact mixture of sand, silt and gravel (fill) layer was encountered at the ground surface or underlying the asphaltic concrete in all QEW median boreholes. The thickness of the fill layer ranged from 0.5 m to 1.8 m. In general, this material was observed to be compact. Based on visual identification and laboratory tests, this fill can be classified as inorganic and cohesionless.

A compact silt (fill) with varying amounts of sand, clay and gravel was encountered underlying the sand, silt and gravel (fill) mentioned above, in Boreholes 135-40-2, 136-01-2, and 136-05-2. The thickness of the fill layer ranged from 1.4 m to 1.5 m. The SPT conducted in this fill layer yielded N values ranging from 9 to 14. The visual observations and laboratory test results indicate that this material is cohesionless.

4.1.4 Heterogeneous Mixture of Silt and Clay, some Sand, trace Gravel (Glacial Till)

This till material can generally be classified as an inorganic, cohesive silt and clay of low to medium plasticity. Seams of cohesionless materials, generally consisting of sands and gravels, are noted at random depths and locations throughout the deposit. Grain size analysis of glacial till samples is limited to the maximum size of the SPT sampling methods that were employed (38 mm). Cobbles and/or boulders can be encountered in a glacial till deposit. Large cobbles or boulders were not detected in any of the boreholes put down as part of this investigation.

Vane shear testing was not possible due to the stiffness of this material. Based on laboratory observations and SPT correlations, the till is typically in the very stiff to hard range.

4.1.5 Bedrock

Based on tests at other locations, the bedrock is a reddish brown to grey, weathered to unweathered shale of the Queenston Formation. The bedrock is of poor to good quality (RQD of the unweathered shale ranging from 65% to 88%). Core recoveries varied between 97% and 100%. The average RQD over 5.8 m of rock cored was 74%, indicating an overall rock mass quality of fair.

4.1.6 Groundwater

The groundwater conditions encountered during the investigation are shown on the Record of Borehole Sheets. Artesian conditions were not encountered in any of the boreholes.

The groundwater levels noted on the Borehole Records were recorded immediately after drilling. Due to the relatively low permeability of the overburden soils, these groundwater levels may not represent the static water levels which would approximately correspond to an adjacent creek level draining into Lake Ontario. Groundwater levels are subject to seasonal fluctuations.

5.0 MISCELLANEOUS

The field work for this investigation was carried out under the supervision of R. Rintjema, P.Eng., N. Lobo and C. Reynolds. Drilling equipment was provided by Master Soil Investigations Ltd. and Eastern Soil Investigation Ltd.

This report was prepared by C. Kwok and T. Olson, Project Engineer, and approved by G. Kack, Project Manager.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Jacques Whitford Environment Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the MTO Foundation Design Section.



D. Dundas

D. Dundas, P.Eng.
Sr. Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 135-40-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 135-40; Sta. 31+688, O-S 25m Lt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.24 & 94.09.24

CHECKED BY TO

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			20	40	60					
81.8	Ground Surface														
0.0	Topsoil		1	SS	12										
81.4															
0.5	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		2	SS	37										
			3	SS	21										
			4	SS	10										
			5	SS	13										
			6	SS	22										
75.1			7	SS	35										
6.7	END OF BOREHOLE Borehole dry upon completion														

RECORD OF BOREHOLE No 135-40-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 135-40; Sta. 31+888, O-S 4m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY IK

DATUM SEE TEXT

DATE 84.08.10 & 84.08.10

CHECKED BY TO

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
83.5	Ground Surface													
0.0	Mixture of Sand, Silt and Clay, trace gravel, (Fill) Stiff		1	AS										
			2	SS	12									
82.0														
1.5	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Brown Grey		3	SS	21									
			4	SS	30									
			5	SS	26									
			6	SS	29									
			7	SS	34									
			8	SS	37									
			9	SS	49									
75.3														
8.2	END OF BOREHOLE Borehole dry upon completion													

x³, x³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 135-40-3

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 135-40; Sta. 31+688, O-S 28m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT & kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
82.0	Ground Surface													
0.0	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		1	SS	18									
			2	SS	29									
			3	SS	19									
			4	SS	20									
			5	SS	21									
			6	SS	24									
			7	SS	34									
75.3			8	SS	30									
6.7	END OF BOREHOLE													

RECORD OF BOREHOLE No 135-41-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 135-41; Sta. 32+102, O-S 30m Lt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.23 & 94.08.23

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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						
								20 40 60 80 100						
79.9	Ground Surface													
0.0	Topsoil		1	SS	2									
79.3														
0.6	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		2	SS	21		79							
			3	SS	32		78							
			4	SS	27		77							
			5	SS	22		76							
			6	SS	24		75							
							74							
73.2			7	SS	19									
6.7	END OF BOREHOLE Borehole dry upon completion													

RECORD OF BOREHOLE No 135-41-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 135-41; Sta. 32+102, O-S 3m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.10 & 94.08.10

CHECKED BY TO

[illegible]

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

RECORD OF BOREHOLE No 135-41-3

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 135-41; Sta. 32+102, O-S 36m Rt.

ORIGINATED BY JK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY JK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

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			20	40					
80.5	Ground Surface													
80.4	50mm Topsoil		1	SS	8									
0.1	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		2	SS	27									
			3	SS	33									
			4	SS	24									
			5	SS	27									
			6	SS	32									
75.0														
5.6	Shale Bedrock Poor to Fair		7	SS	50	100mm								
73.8														
6.7	END OF BOREHOLE Borehole dry upon completion													

RECORD OF BOREHOLE No 136-01-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-01; Sta. 10+419, O-S 23m Lt.

ORIGINATED BY IK

DIST 4 HWY OEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.23 & 94.08.23

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
80.2	Ground Surface													
79.9	Topsoil		1	SS	13		80							
0.3	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Gray		2	SS	26		79						20.7	
			3	SS	35		78							
			4	SS	63		78							
			5	SS	68	283mm	77							
			6	SS	26		76							
	-gray shale seam (75mm)						75							
							74							
73.5			7	SS	28									
6.7	END OF BOREHOLE Borehole dry upon completion													

RECORD OF BOREHOLE No 136-01-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-01; Sta. 10+419, O-S 4m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	10 20 30		
82.0	Ground Surface											
0.0												
81.7	Mixture of Sand, Silt and Gravel (Fill)		1	SS	8							
0.3	Mixture of Silt and Sand, trace clay (Fill), loose		2	SS	9							
80.3												
1.7	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		3	SS	33							
			4	SS	45							
			5	SS	59							
			6	SS	69							
			7	SS	35							
			8	SS	49							
			9	SS	36							
73.8												
8.2	END OF BOREHOLE Borehole dry upon completion											

RECORD OF BOREHOLE No 136-01-3

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-01; Sta. 10+419, O-S 22m Rt.

ORIGINATED BY JK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY JK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

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 20 40 60 80 100 ○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%) 10 20 30					
78.9	Ground Surface													
78.8	75mm Topsoil		1	SS	9									
0.1	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		2	SS	4									0 16 61 33
			3	SS	26									
			4	SS	77	225mm								
			5	SS	45									
			6	SS	64									
73.2			7	SS	31									
6.7	END OF BOREHOLE Borehole dry upon completion													

RECORD OF BOREHOLE No 136-02-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-02; Sta. 10+622, O-S 23m Lt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.23 & 94.08.23

CHECKED BY TO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100		
81.3	Ground Surface												
81.0	Topsoil												
0.3	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		1	SS	14	81							
			2	SS	27	80							
			3	SS	24	79							
			4	SS	38	78							
			5	SS	36	77							
			6	SS	26	76							
			7	SS	22	75							
74.6	END OF BOREHOLE												
6.7	Borehole dry upon completion												

x³.x³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 136-02-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 138-02; Sta. 10+822, O-S 3m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY IK

DATUM SEE TEXT

DATE 84.08.11 & 84.08.11

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT & kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L		
82.2	Ground Surface											
0.0	Mixture of Sand, Silt and Gravel (Fill), compact		1	SS	7		82					
81.6							81					
0.6	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till)		2	SS	6		80					
	Very Stiff to Hard		3	SS	32		79					
			4	SS	34		78					
			5	SS	31		77					
			6	SS	43		76					
			7	SS	42		75					
			8	SS	30							
			9	SS	30							
74.6	END OF BOREHOLE											
7.6	Borehole dry upon completion											

RECORD OF BOREHOLE No 136-02-3

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 135-02; Sta. 10+822, O-S 23m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY _____ TO _____

[illegible]

*³, X³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 136-03-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-03; Sta. 10+825, O-S 22m Lt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 84.08.23 & 94.08.23

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT α 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 (%)						
81.8	Ground Surface													
81.5	Topsoil		1	SS	2									
0.3	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard		2	SS	13									
			3	SS	34									
			4	SS	26									
			5	SS	25									
			6	SS	28									
			7	SS	30									
75.1														
6.7	END OF BOREHOLE Borehole dry upon completion													

RECORD OF BOREHOLE No 136-03-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-03; Sta. 10+825, O-S 3m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ _s kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L			
82.3	Ground Surface													
0.0	Mixture of Sand, Silt and Gravel, (Fill), compact		1	AS										
81.5														
0.8	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey -100mm sand seam		2	SS	16									
			3	SS	36									
			4	SS	45									
			5	SS	55									
			6	SS	36									
			7	SS	30									
			8	SS	28									
74.1			9	SS	33									
8.2	END OF BOREHOLE Borehole dry upon completion													

RECORD OF BOREHOLE No 136-03-3

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-03; Sta. 10+825, O-S 22m Rt.

ORIGINATED BY JK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY JK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
81.6	Ground Surface													
81.6	Topsoil		1	SS	14		81							
0.1	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard		2	SS	36		80						21.0	0 15 55 30
			3	SS	45		79							
			4	SS	50		78							
			5	SS	31		77							
			6	SS	28		76							
			7	SS	27		75							
74.9	END OF BOREHOLE													
6.7	Borehole dry upon completion													

*³ X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 136-04-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-04; Sta. 11+101, O-S 23m Lt.

ORIGINATED BY IK

DIST 4 HWY QEWBOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.23 & 94.08.23

CHECKED BY _____ TO _____

[illegible]

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

RECORD OF BOREHOLE No 136-04-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-04; Sta. 11+101, O-S 3m Rt.

ORIGINATED BY JK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY JK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	× FIELD VANE						
82.7	Ground Surface							20 40 60 80 100							
82.6	75mm ASPHALT														
0.1	Brown Sand and Gravel (Fill)		1	SS	7										
82.2	Het. mixture of Silt and Clay, some sand, trace gravel		2	SS	7										
0.5	(Glacial Till)		3	SS	22										
	Very Stiff to Hard		4	SS	32										
			5	SS	28										
			6	SS	50										
			7	SS	48										
			8	SS	34										
			9	SS	36										
75.1															
7.6	END OF BOREHOLE														

RECORD OF BOREHOLE No 136-04-3

1 OF 1

METRIC

W.P. 434-92-02 LOCATION WC 136-04; Sta. 11+101, O-S 23m Rt. ORIGINATED BY IK
DIST 4 HWY QEW BOREHOLE TYPE Solid Stem COMPILED BY IK
DATUM SEE TEXT DATE 94.08.12 & 94.08.12 CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
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		
81.5	Ground Surface												
81.2	Topsoil		1	SS	34		81						
0.3	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard - medium to coarse gravel Brown Grey		2	SS	26		80						
			3	SS	38		79						
			4	SS	74	225mm	78						
			5	SS	44		77						
			6	SS	42		76						
75.0			7	SS	80	275mm	75						
6.5	END OF BOREHOLE Borehole dry upon completion												

RECORD OF BOREHOLE No 136-05-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-05; Sta. 11+262, O-S 22m Lt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.23 & 94.08.23

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
81.7	Ground Surface													
81.0	Topsoil		1	SS	11									
0.3	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Grey		2	SS	47		81							
			3	SS	50		80							
			4	SS	47		79							
			5	SS	39		78							
			6	SS	24		77							
							76							
76.0			7	SS	33		75							
6.7	END OF BOREHOLE Borehole dry upon completion													

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

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 136-05-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-05: Sta. 11+262, O-S 3m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.12

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT WP	NATURAL MOISTURE CONTENT W	LIQUID LIMIT WL	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
82.9	Ground Surface													
82.9	Brown Sand (Fill)		1	SS	23									
0.3	Brown Silt (Fill), some sand, trace clay and gravel		2	SS	14									
	Compact													
81.1	Het. mixture of Silt and Clay, some sand, trace gravel		3	SS	34									
1.8	(Glacial Till)		4	SS	32									
	Very Stiff to Hard		5	SS	28									
			6	SS	52									
			7	SS	37									
			8	SS	28									
74.7			9	SS	42									
8.2	END OF BOREHOLE													
	Borehole dry upon completion													

RECORD OF BOREHOLE No 136-05-3

1 OF 1

METRIC

W.P. 434-92-02 LOCATION WC 136-05; Sta. 11+262, O-S 22m Rt. ORIGINATED BY IK
DIST 4 HWY QEW BOREHOLE TYPE Solid Stem COMPILED BY IK
DATUM SEE TEXT DATE 84.08.12 & 84.08.12 CHECKED BY TO

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 DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20					
82.2	Ground Surface												
82.1	75mm Topsoil		1	SS	12								0 15 59 25
0.1	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard - seams of silty sand Brown Grey		2	SS	25								
			3	SS	34								
			4	SS	50								
			5	SS	46								
			6	SS	32								
75.5			7	SS	32								
6.7	END OF BOREHOLE												

RECORD OF BOREHOLE No 136-06-1

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-06; Ste. 11+446, O-S 23m Lt.

ORIGINATED BY JK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY JK

DATUM SEE TEXT

DATE 94.08.23 & 94.08.23

CHECKED BY TO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
81.8	Ground Surface													
81.8	Topsoil		1	SS	8									
0.3	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard Brown Gray		2	SS	35		81						22.0	
			3	SS	34		80							
			4	SS	54		79							
			5	SS	47		78							
			6	SS	32		77							
			7	SS	31		76							
75.1	END OF BOREHOLE													
6.7	Borehole dry upon completion													

x³, x²: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 136-06-2

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-06; Sta. 11+446, O-S 3.0m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem, Cone Test

COMPILED BY IK

DATUM SEE TEXT

DATE 94.08.11 & 94.08.11

CHECKED BY TO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
82.9	Ground Surface											
0.0	Mixture of Sand, Silt and Gravel (Fill), compact		1	SS	11							
82.3	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till)		2	SS	10							
0.6	Very Stiff to Hard		3	SS	20							
			4	SS	28							
			5	SS	27							
			6	SS	40							
			7	SS	46							
			8	SS	38							
			9	SS	31							
75.3												
7.6	END OF BOREHOLE											
	Borehole dry upon completion											

RECORD OF BOREHOLE No 136-06-3

1 OF 1

METRIC

W.P. 434-92-02

LOCATION WC 136-06; Sta. 11+446, O-S 23m Rt.

ORIGINATED BY IK

DIST 4 HWY QEW

BOREHOLE TYPE Solid Stem

COMPILED BY IK

DATUM SEE TEXT

DATE 84.08.12 & 84.08.12

CHECKED BY TO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20					
82.1	Ground Surface												
82.0	Topsoil		1	SS	2								
0.1	Het. mixture of Silt and Clay, some sand, trace gravel (Glacial Till) Very Stiff to Hard		2	SS	25								
			3	SS	31								
			4	SS	70	290mm							
			5	SS	35								
			6	SS	50	125mm							
	Brown Grey												
75.4			7	SS	28								
6.7	END OF BOREHOLE												

* X³ X³: Numbers refer to Sensitivity 20 15-10-5 (%) STRAIN AT FAILURE