

G.I.-30 SEPT. 1976

GEOCRES No. 30 M3-202DIST. 4 REGION W.P. No. 333-89-01CONT. No. 94-83W. O. No. STR. SITE No. HWY. No. Q.E.W.

LOCATION Q.E.W. - from Victoria St.
to Jordan Rd. (4 Retaining Walls
No of PAGES - & Culvert Extension)

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 94-83



Ontario

**Ministry of
Transportation**

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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.

EXPLANATION OF TERMS USED IN REPORT

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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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	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

Jordan Harbour (Twenty Mile Creek)

QEW WB and EB Structures

W.P.334-89-01, Site 18-19

District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at QEW - Twenty Mile Creek crossing. The investigation was carried out at the proposed structure foundation locations and also within the approach areas extending from approximately stations 11+370 to 12+070.

SITE DESCRIPTION AND GEOLOGY

The site is confined between Lake Ontario to the north and the Jordan Harbour to the south in the Town of Lincoln, Regional Municipality of Niagara. The site is situated between Victoria Ave and Jordan Road approximately ten kilometres west of the City of St. Catharines. The Jordan Harbour is present south of the site and its waters flow into Lake Ontario via the Twenty Mile Creek.

The site conditions have undergone significant changes within the time period in which the foundation investigation has taken place. Originally, the shoreline immediately north of the site was populated with tall deciduous trees but as a result of recent construction activity at the site, these trees have been removed. New fill material including shoreline protection materials (armour stone, rip rap) have been recently constructed along the proposed North Service Road/Twenty Mile Creek crossing. Previous armour stone placed along the Twenty Mile Creek is also evident at the site. In addition, a pronounced breakwater rockfill wall is located within Lake Ontario northeast of the site area. This breakwater structure apparently has been recently constructed by the Beacon Hotel management to safeguard the hotel which is located north of the existing North Service Road just east of the site area.

The two existing QEW-Twenty Mile Creek structures are three span steel structures that carry two lane WBL and EBL respectively. Both structures have undergone considerable deterioration. It is understood that the existing structures are founded on concrete caissons bearing on bedrock.

The land surrounding the site is generally flat with grade increases in both west and east directions. The approach embankment fills to the existing structures reveal their slopes superimposed on the natural ground surface at the site.

The primary industry within the site area is agricultural and the area is reknown for its fruit growing. Orchards and vineyards are present within the generally site area, although not at the specific site location. Soil conditions and the regional climate allow grapes, peaches, cherries and pears to be grown extensively in the area. Motel accommodations and restaurants are also located within the area.

Physiographically, the site is located within the region known as the "Iroquois Plain". The Iroquois Plain is the product of the advance and retreat of the Wisconsinan ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). The lowland bordering Lake Ontario, was inundated by the glacial lake called Lake Iroquois when the last glacier was receding at the site. Conditions in the old lake plain vary greatly within the Iroquois Plain. At the site location, the former lake bottom consisted of an organic silty clay to clay deposit which is underlain by undulating till plains and overlain by glaciofluvial sands to silty sands.

The overburden at the site is underlain by shale bedrock of the Queenston Formation at an elevation ranging from approximately 56 m to 67.9 m suggesting a highly variable and irregular bedrock surface. The overburden thickness ranges from approximately 7.8 m to 22.5 m.

INVESTIGATION PROCEDURE

General

The subsurface investigation conducted at the site was executed during several different mobilizations spanning time periods between 1965 and 1994. The borehole identification number groups that signify the five separate mobilizations that occurred at the site are summarized in Table 1 below. In each case, the physical and mechanical properties of the soil and/or rock were obtained both by in situ and laboratory testing as discussed below.

Table 1 - Investigation Time Periods			
BH Group #	BH	# of BH's	Time Period
1	1-10 incl.	10	65 11 02-19
2	101-104 incl.	4	92 06 29-92 07 03
3	105-114 incl.	10	93 06 10-29
4	301-302 incl.	4	93 08 12-13
5	501-508 incl.	8	94 01 17-94 02 01

The original field investigation at the site occurred in 1965, when a total of twenty-one boreholes were advanced for the proposed widening of the QEW structures at that time. Ten of these boreholes were advanced in the vicinity of the QEW EB and WB structures and have therefore been included in this report.

Since the original field investigation, four further investigations have been conducted between June 1992 and January 1994. Boreholes within Group #2 and #3 were advanced in an attempt to further define the properties and plan limits of organic materials at the site. Boreholes within Group #4 were advanced to retrieve specific subsoil data within the organic silty clay to clay stratum at the site and boreholes within Group #5 were advanced to retrieve subsurface information at the proposed structure foundation locations. A total of 26 boreholes have been advanced during the more recent investigations.

Field Investigation

The fieldwork for the original investigation in 1965 was carried out using both a diamond drill unit adapted for soil sampling purposes, and a Pennsylvania continuous flight drill auger which were conventional at the time. The more recent investigations were carried out employing track mounted diesel drilling units equivalent to a CME 55 and equipped with hollow stem augers to advance the boreholes. The fieldwork consisted of the advancement of several sampled boreholes ranging in depth from 9.6 m to 22.9 m.

Samples were retrieved at 0.7, 1.5 and 3 m intervals. Disturbed subsoil samples were retrieved using a standard 50.8 mm O.D. split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). Relatively undisturbed samples of the

organic silty clay to clay at the site were also retrieved using 57 mm and 73 mm diameter thin wall samples. The thin wall sampler was pushed either manually or hydraulically in accordance with the procedures outlined in ASTM D1587.

All subsoil samples were identified in the field and then properly sealed to preserve natural moisture contents in the soil. Disturbed samples were placed in sealed plastic containers and thin wall samples were capped and waxed. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted (see Laboratory Analyses).

In situ vane tests were also carried out to determine the undrained shear strength at selected intervals between the subsoil sample retrieval. The test was carried out in accordance with ASTM D2573 employing the standard MTO 'N' vane. Remoulded shear strengths were also obtained allowing the determination of soil sensitivity. Two boreholes (301B and 302B) were advanced strictly to conduct in situ vane tests.

Rock core was also retrieved at the proposed structure foundation locations using conventional rock coring techniques and a NXL core barrel. The rock core was identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory for detailed rock logging (see Laboratory Analyses).

Groundwater levels were determined by monitoring the water 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 elevation of the individual boreholes was provided by Central Region Survey and Plans and MTO Construction staff.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation and other pertinent physical properties and the mechanical properties of the soil (strength, compressibility) were determined by conducting the appropriate laboratory tests on representative samples. These tests are tabulated in Table 2 below.

Table 2 - Physical/ Mechanical Property Testing	
Physical Property Tests	Mechanical Property Tests
1) Atterberg Limit Tests	1) Consolidation Test
2) Particle Size Analysis	2) Unconfined Compression
3) Natural Moisture Contents	
4) Bulk Unit Weights	
5) Organic Content	

Sample preparation and laboratory tests were conducted in accordance with the respective procedures outlined in the MTO Laboratory Testing Manual and as described in Chapter 3 of the MTO Soil Classification Manual.

As mentioned earlier, detailed rock core logs were produced by an in-house resident geologist and "Rock Core Descriptions" for all rock core retrieved are contained in the Appendix to this report. The descriptions include rock colour, strength, jointing, bedding and composition.

Laboratory test results on subsoil samples 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. Rock core recoveries and rock quality designations are summarized both in the Rock Core Descriptions and on individual borehole logs.

SUBSURFACE CONDITIONS

General

Within the proposed structure foundation area and adjacent approaches, the subsurface conditions consist of a surficial fill material comprised of an irregular mixture of a silty sand with gravel of thickness ranging from 0.6 m to 4.3 m. The fill material, which also contains random zones of clayey silt is underlain by subsoils consisting of an uppermost deposit of sand to silty sand with traces to some gravel. This deposit is brown to grey in colour

and has a thickness ranging from 3.5 m to 10.7 m but generally is within approximately 5.5 to 8 m. The deposit has a very loose to dense range of denseness but is generally loose to compact.

The cohesionless sand to silty sand with gravel deposit is underlain by an organic silty clay to clay deposit. The organic silty clay to organic clay has a thickness ranging upto 11.8 m with thicknesses increasing in an easterly direction. As shown on Dwg. No. 3348901-B,* however, the organic silty clay to organic clay stratum eventually disappears in both easterly and westerly directions (at stations 11+960 and 11+440 respectively). Based on in situ and laboratory testing of the organic silty clay to clay, this material can be categorized as having a firm to very stiff consistency.

The organic silty clay to clay is underlain by glacial till deposits consisting of either a heterogeneous mixture of silt, sand and gravel or a heterogeneous mixture of clayey silt, sand and gravel or at some locations both. These deposits are of a thickness ranging from 1.1 m to 4.9 m. The consistency/ denseness of these deposits is generally hard and very dense respectively.

The glacial till deposits are underlain by bedrock of the Queenston Shale Formation. This bedrock consists of greyish-red shale with interbedded grey siltstone. The bedrock, which is generally a very weak to weak rock, exists at depths ranging from 20.3 m to 7.8 m or equivalently at elevations ranging from 56 m to 67.9 m .

* Dwg. No. 2A, (Sheet 471-I) of the Contract Drawings.

Boreholes 105 to 109 inclusive and 110 to 114 inclusive reveal that the subsurface conditions change at a distance beyond the west and east abutment respectively. At both locations, the thickness of the organic silty clay to organic clay deposit decreases and eventually disappears as mentioned earlier. At the west approach location, the sand to silty sand deposit is overlain by a cohesive clayey silt stratum ranging in thickness from 1.9 m to 3.6 m. The clayey silt is grey and of firm to stiff consistency. It appears, however, that both the clayey silt and sand to silty sand deposit also disappear in a westerly direction. At BH 105, the surficial native deposit is the heterogeneous mixture of clayey silt, sand and gravel.

At the east approach, the sand to silty sand deposit is overlain by a silt deposit that contains random layers of clayey silt. The thickness of this stratum ranges from 5 to 5.7 metres and the clayey silt layers have a thickness up to approximately 0.45 metres. The cohesionless silt can be described as having a very loose to compact state of denseness.

A plan of the site illustrating the locations and elevations of the boreholes is shown on Dwg. Nos. 3348901-A&B* in the Appendix. A subsoil stratigraphical profile and stratigraphical sections at the structure foundation locations that illustrate the subsurface conditions at the site are also provided. The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the

* Dwg. Nos. 2 & 2A, (Sheets 471 & 471-I) of the Contract Drawings.

time of investigation are shown on the stratigraphical profile and sections and also on the individual Record of Borehole sheets in the Appendix. A detailed description of the subsurface conditions is given below.

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

Fill material consisting of silty sand with/ traces of gravel has been placed across the existing QEW corridor at the site in conjunction with the roadway construction. Random zones of clayey silt are also present within the fill material. The material is brown to grey in colour and of thickness ranging from 0.6 m to 4.3 m. The fill material is generally in a compact state of denseness.

Clayey Silt

A stratum of grey clayey silt with random zones of silt underlies the fill material in the area of BH's 106 to 109 inclusive. The thickness of this stratum ranges from 1.9 m to 3.6 m. In addition, the stratum also occurs surficially for thicknesses upto 11.6 metres at both the western and eastern extremes of the site. Atterberg Limit tests conducted on representative samples of the soil revealed liquid limits ($W_L\%$) ranging from 19% to 31% and plasticity indices ($I_p\%$) ranging from 4% to 16%. The results reveal that the soil has a low plasticity and can be categorized as a clayey silt with random zones of silt.

The 'N' values derived from the SPT conducted in this stratum ranged from as low as 3 blows/ 0.3 m to as high as 125 blows/ 0.15 m. Based on these 'N' values, the soil can be described as having a firm to hard consistency.

Silt with random layers of Clayey Silt

A deposit of silt with random layers of clayey silt exists surficially at the extreme eastern limits of the site. The deposit has a thickness ranging from 5.0 to 5.8 metres with clayey silt layers upto 0.45 metres in thickness. The stratum is brown to grey in colour and based on 'N' values derived from the SPT ranging from 2 blows/ 0.3 m to 15 blows/ 0.3 m can be described as having a very loose to compact state of denseness.

Sand to Silty Sand, trace/ some Gravel

Underlying the fill material, the clayey silt stratum; the silt with random layers of clayey silt where these deposits exist and present surficially elsewhere at the site exists a cohesionless sand to silty sand with traces to some gravel. The thickness of this deposit ranges from 3.5 m to 10.7 m, but generally the deposit has a thickness ranging from 5.5 m to approximately 8 m. The deposit has been oxidized to varying depths ranging from being completely unoxidized and hence completely grey in colour to partially oxidized and brown to depths ranging from approximately 1.5 m to 6 m.

Figure 1 in the Appendix illustrates a grain size distribution envelope of the deposit derived from mechanical sieve analysis of representative samples across the site. As the envelope reveals, the main component of the deposit is the sand that ranges from fine to coarse. The envelope also illustrates traces/ some fine to coarse gravel sizes ranging from approximately 1 to 28% of the deposit. Silt percentages range from approximately 6% (traces) to 50% (silty sand to sandy silt).

This cohesionless deposit is for the most part submerged below the groundwater table and hence during the drilling and sampling process was subjected to conditions of unbalanced hydrostatic head. To prevent soil cave-in and sloughing at the base of the borehole, a constant hydrostatic force was required. This was achieved by supplying a constant head of water using pumps and hoses.

The 'N' values derived from the SPT conducted in this deposit ranged from 2 blows/ 0.3 m to 80 m blows/ 0.3 m indicating a very loose to a very dense state of denseness. However, in general, 'N' values were in the 5 blows/ 0.3 m to 25 blows/ 0.3 m suggesting a loose to compact state of denseness. The larger 'N' values may have been a product of the coarser gravel sizes in the deposits.

Organic Silty Clay to Organic Clay

The surficial native sand to silty sand deposit is underlain by an organic silty clay to organic clay stratum which is present across most of the site. The organic silty clay to organic clay stratum extent was defined between approximate stations 11+960 and 11+440. The surface of this stratum was encountered at an elevation ranging from 66.7 m to 71 m and its thickness ranged from 2.9 m to 11.8 m within the structure location and immediate vicinity. The stratigraphical profile shown on Dwg. No. 3348901-B* illustrates the diminishing thickness of the organic silty clay to clay stratum beyond the proposed structure.

A grain size distribution envelope produced by mechanical sieve and hydrometer analysis for this stratum is shown on Figure 2 in the Appendix. The envelope clearly illustrates that the material is fine grained with particle sizes less than 75 micrometres. The clay fraction ranges from approximately 10% to 20% but generally, the clay fraction ranges between 10% and 15%. Silt percentages range from approximately 78% to 90%.

Occasional layers of peat and organic inclusions of partially decomposed timber are also present within the soil matrix of this stratum. The organic content varies between 6.3 and 14.3% by weight. The organic inclusions and soil material are dark grey to blackish grey in colour.

* Dwg. No. 2A, (Sheet 471-I) of the Contract Drawings.

In accordance with the MTO Soil Classification system, a deposit with gradations of this nature is categorized by its behaviour and hence Atterberg Limit Tests were conducted to evaluate the plasticity of the soil. The results of these tests are illustrated on Figure 3 and summarized in Table 3 below. Natural moisture contents and unit weights of the soil are also included in Table 3 below. Natural moisture contents were determined by oven drying whereas Atterberg Limits were determined by air drying the samples prior to testing. Table 3 also includes the test results conducted on representative samples of the organic silty clay to clay retrieved from the NSR/Twenty Mile Creek project (WP 325-89-01) immediately north of the site.

Table 3 - Organic Silty Clay to Clay		
	Range	# of Tests
Plastic Limit ($w_p\%$)	32-45	27
Liquid Limit ($w_L\%$)	36-71	27
Plasticity Index ($I_p\%$)	6-30	27
Liquidity Index ($I_L\%$)	0.8-1.4	27
Natural Moisture Content ($w\%$)	45-117	37
Unit Weight (kN/m^3)	13-19.5	14

Table 4 below provides the results of Atterberg Limit Tests in which sample air drying was compared to sample oven drying.

Table 4 - Air Drying vs. Oven Drying						
Sample	Plastic Limit (w_p %)		Liquid Limit (w_L %)		Plasticity Index (I_p %)	
	Air	Oven	Air	Oven	Air	Oven
BH 301A, TW5	50	44	80	65	30	21
BH 302A, TW5	60	52	85	70	25	18

The results tabulated in Table 3 and 4 and illustrated on Figure 3 clearly reveal that the soil exhibits an intermediate to high plasticity and behaves as an organic silty clay to an organic clay. Atterberg Limits were smaller for the oven dried samples than for the air dried samples confirming the presence and influence of the organic material in the soil.

The liquidity index for the soil ranges from 0.8 to 1.4 but in general, the liquidity index exceeds unity. This indicates that the natural moisture content of the soil exceeds the liquid limit. Natural moisture contents range from 45% to 117%.

The unit weight of the soil ranges from 13 kN/m^3 to 19.5 kN/m^3 , but generally the unit weights are less than 16 kN/m^3 .

The undrained shear strength of the organic silty clay to organic clay was determined by in situ vane tests and laboratory unconfined compression tests and the results are tabulated in Table 5. Test results on representative samples of this deposit obtained for the NSR/ Twenty Mile Creek project (WP 325-89-01) have also been included in Table 5.

Table 5 - Undrained Shear Strength (c_u) (kPa)		
	Range	# of Tests
Vane Test	70->100	50
Unconfined Compression Test	30-58	14

The results reveal an undrained shear strength ranging from 30 kPa to in excess of 100 kPa. It is believed that the lower undrained shear strength values observed in the unconfined compression test may be a reflection of sample disturbance induced. An undrained shear strength of 60 kPa to 100 kPa is considered as an accurate representative range of the undrained shear strength of this material and consequently the material can be described as having a stiff to very stiff consistency.

The sensitivity of the soil ranged from 2 to 3 indicating a soil of low sensitivity.

SPT 'N' values recorded in this material ranged from 1 blow/ 0.3 m to 14 blows/ 0.3 m. However, in general, there was very little resistance offered by the soil to the split spoon sampler penetration and 'N' values were usually less than 5 blows/ 0.3 m.

The compressibility characteristics of the organic silty clay to organic clay stratum were determined by conducting one dimensional consolidation tests on representative samples of the material. The samples tested were retrieved from boreholes BH 101, BH 103 and BH 301A which were advanced in conjunction with the NSR/ Twenty Mile Creek project but applicable to the QEW/ Twenty Mile Creek structures. Figures 4a and 4b illustrate the results of oedometer tests in which samples were subjected to an external loading with a load increment ratio of one and double drainage. The consolidation curves are plotted on semi-logarithmic paper with the void ratio (e) plotted against the applied load ($\log p$). This form of plotting the load-deformation properties of the soil has the advantage of enabling the determination of the preconsolidation pressure (p_c) which is defined as the maximum pressure that the soil has experienced in its stress history. Considerable consolidation settlements can occur once the threshold preconsolidation pressure is exceeded.

The consolidation curves reveal preconsolidation pressures ranging from 128 kPa to 157 kPa. The effective overburden pressures of the samples tested ranged from approximately 57 kPa to 67 kPa. It can therefore be concluded that the soil has been

preconsolidated in the past to an effective pressure approximately 60 to 85 kPa in excess of the existing overburden pressure. Compression indices of the material ranged from approximately 0.5 to 1.5.

Attempts were made to compute the coefficient of consolidation (c_v) using Taylor's Root time method and oedometer dial gauge readings. However, this method produced irregular and inconsistent results. The results have therefore been considered as unacceptable for application in engineering calculations.

Deposits of Glacial Till Origin

General

The organic silty clay to clay is underlain by deposits of glacial till origin, namely a heterogeneous mixture of clayey silt, sand and gravel or a cohesionless heterogeneous mixture of silt, sand and gravel. Both deposits are irregular and unstratified and occur randomly across the site, generally overlying the bedrock. Detailed descriptions of these deposits are given below.

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

The heterogeneous mixture of clayey silt, sand and gravel has a thickness ranging from 0.2 m to 13.8 m but generally has a thickness ranging from approximately 4 to 7 metres. The colour of the soil varies from brown to grey to red. Figure 5 in the Appendix illustrates a grain size distribution envelope of this deposit revealing that the deposit is

broadly graded containing a wide range of particle sizes. The main component of this unsorted deposit is the clayey silt material. The envelope reveals that the fine grained portions (less than 75 micrometres) contribute up to 85% of the deposit. This material essentially binds the coarser sands and gravels within the deposit. Boulders and cobbles, although not encountered, are characteristic components of glacial till deposits and hence can occur in this deposit.

Atterberg Limit Tests were carried out to define the behaviour and plasticity of the fine grained portion of the soil (less than 425 micrometres) and the results are plotted on Figure 6. A summary of the indices is provided in Table 6 below. Natural Moisture Contents have also been included in the table.

Table 6 - Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		
	Range %	# of Tests
Natural Moisture Content (w%)	10-25	6
Liquid Limit (w_L %)	20-37	6
Plastic Limit (w_p %)	3-21	6
Plastic Index (I_p %)	4-16	6

The test results reveal that the fine grained portion of the deposit is predominantly of low plasticity and hence is classified as clayey silt. The test results also reveal that zones of heterogeneous mixture of silt, sand and gravel are also present within the deposit. 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 Tests (SPT) carried out in this deposit revealed 'N' values ranging from 8 blows/ 0.3 m to 131 blows/ 0.15 and hence the material can be categorized as having a stiff to hard consistency.

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

The heterogeneous mixture of silt, sand and gravel has a thickness of approximately 1.9 m and generally is red in colour. The deposit is unsorted, unstratified and broadly graded containing a wide range of particle sizes ranging from silt to gravel. Boulders and cobbles although not encountered during the investigation are characteristic components of glacial till deposits and hence can exist in this deposit. This cohesionless deposit is generally underlain by bedrock.

Standard Penetration Tests (SPT) carried out in this deposit revealed 'N' values ranging from 95 blows/ 0.3 m to 100 blows/ 0.05 m indicating a very dense state of denseness.

Bedrock

The overburden at the site is underlain by bedrock of the Queenston Shale Formation at an Elevation ranging from 56 m to 67.9 m. The bedrock surface appears to be irregular and varies across the site.

The bedrock consists of a greyish red shale with interbedded greenish grey siltstone. In general, the surficial metre or so has been slightly to moderately weathered. Occasional clay seams of 50 to 100 mm thickness were present within the weathered zone. The weathered rock is underlain by sound, competent and unweathered rock.

Samples of the rock were retrieved by conventional rock coring techniques using an NXL core barrel. Up to 3.5 metres of rock core was retrieved at various borehole locations across the site. Split spoon samples were also retrieved albeit with considerable penetration resistance at some locations where augering techniques were used to penetrate the weathered rock.

Physical and mechanical properties of the rock were determined by physical examination and by core recovery and rock quality designation (RQD) measurement conducted in situ. Detailed rock core designations produced by our resident geologist provide a summary of these properties and are located within the Appendix under the heading "Rock Core Descriptions".

The shale bedrock with interbedded siltstone is very fine grained and contains very thin to thin horizontal bedding. The rock contains moderately close to extremely close spaced fractures that are flat, dipping to near vertical, planar to undulating and smooth. The rock is an extremely friable material with a very low slaking durability. Rock strength as determined by index property examination in the laboratory is generally very weak to weak.

Rock core recoveries in the slightly to moderately weathered rock ranged from 85% to 100% and RQD's ranged from 7% to 77%. In the unweathered rock, recoveries were generally 100% and RQD's ranged from 33% to 77%. The 7% RQD reflects the weathered state of the bedrock. Based on these observations, it can be concluded that the weathered rock is of very poor quality and the unweathered rock ranges from poor to good quality. In general, however, the unweathered rock can be considered to have a fair quality.

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. Particular attention was given to avoiding non-representative water levels produced by the drilling water.

At the time of the most recent investigation, the groundwater elevation ranged from approximately 73 m to 75 m which for all practical purposes can be assumed to be approximately equal to the lake level.

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 several different mobilizations as summarized below.

BH's	Time Period	Supervisor(s)	Contractor
1-4	November, 1965	R. Magi, F. Wang	Domion Soil Inc.
101-104	June/July 1992	M. Vasavithasan	Malone's Soil Samples
105-114	June 1993	M. Vasavithasan	Malone's Soil Samples
301-302	August 1993	M. Vasavithasan	Malone's Soil Samples
501-508	January/February 1994	T. Sangiuliano, D. Rothwell	Malone's Soil Samples

Logging of rock core in the laboratory was carried out by D. Williams, Petreographer.

The project was carried out by T. Sangiuliano and M. Vasavithasan under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by D. Dundas, Chief Foundation Engineer (acting).

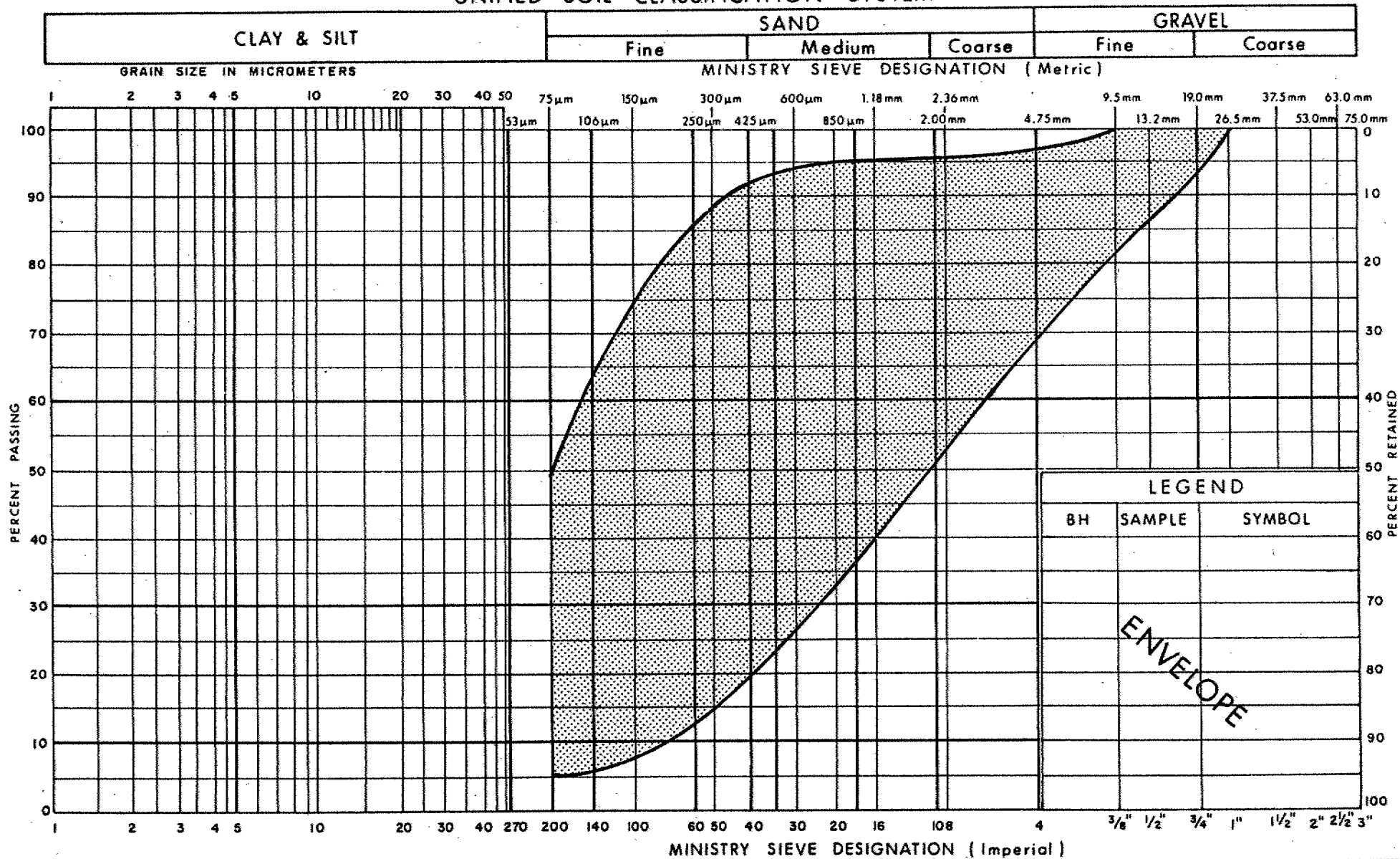


D. Dundas
D. Dundas, P.Eng.

Senior Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

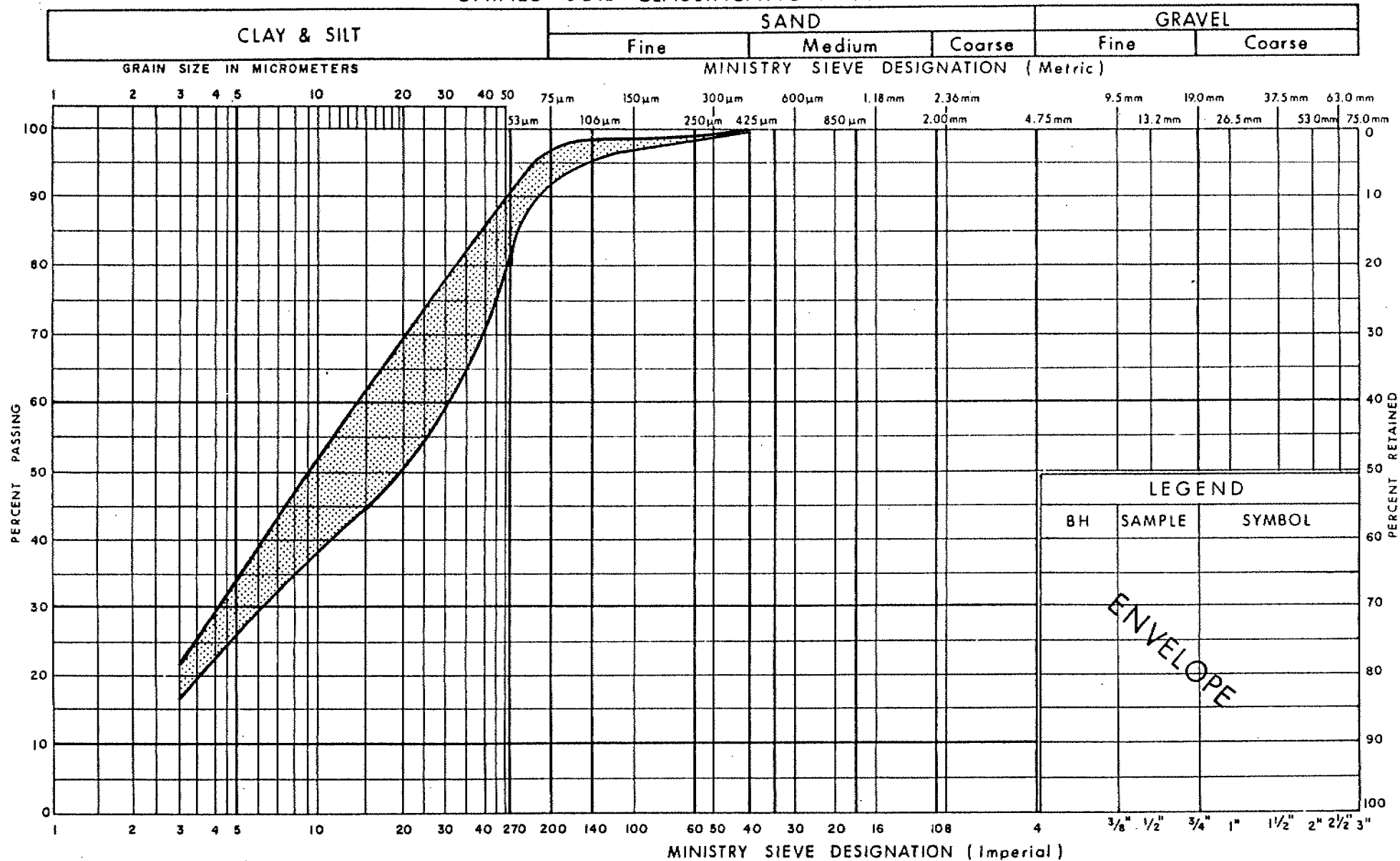
GRAIN SIZE DISTRIBUTION

SAND TO SILTY SAND, TRACE / SOME GRAVEL

FIG No 1

W P 334-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



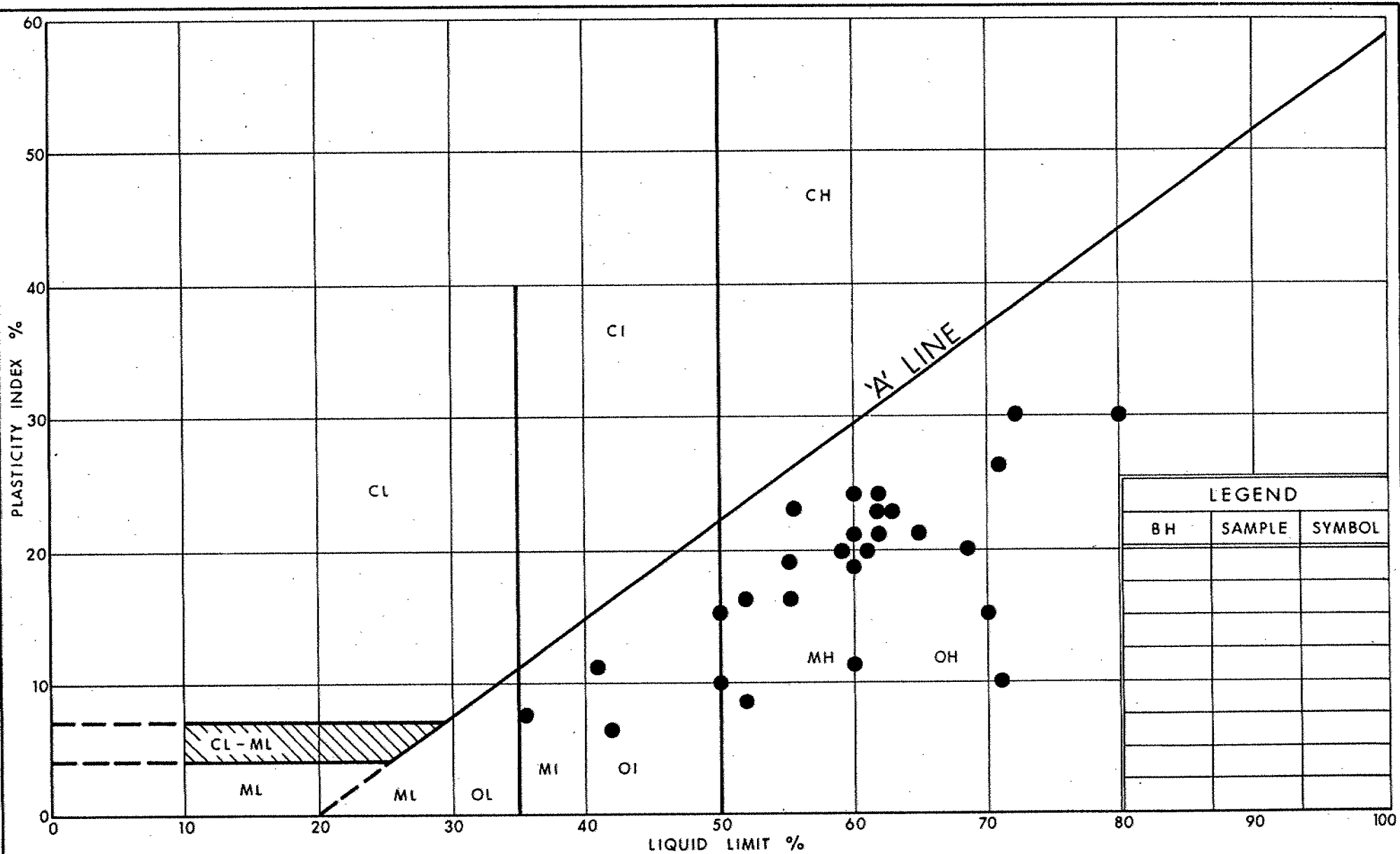
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

ORGANIC SILTY CLAY TO ORGANIC CLAY

FIG No 2

W P 334 -89-01



VOID RATIO - PRESSURE CURVES

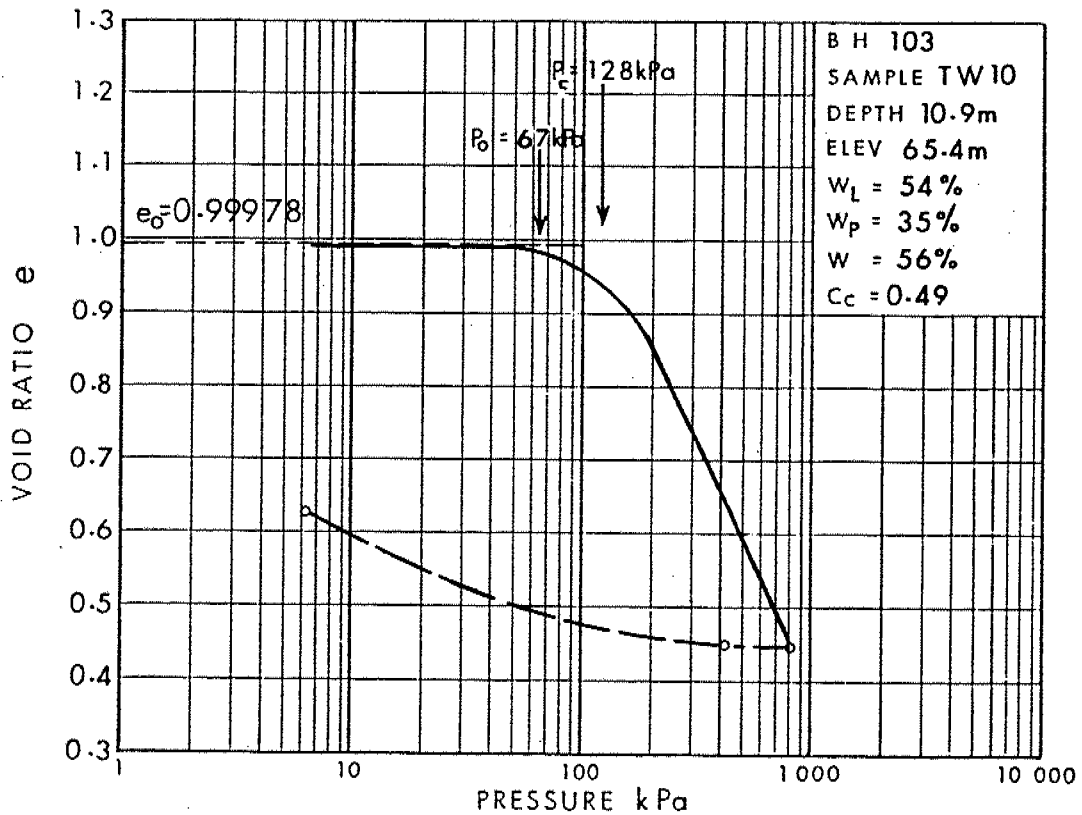
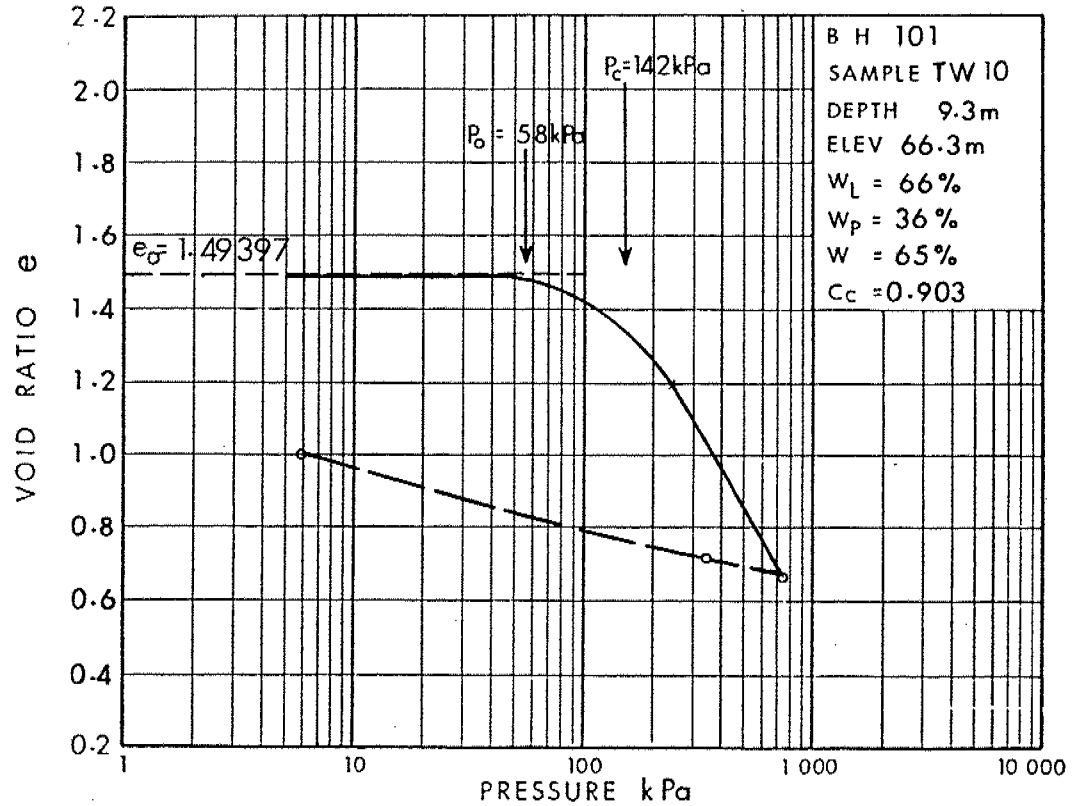


Fig 4a

W P 334-89-01

VOID RATIO - PRESSURE CURVES

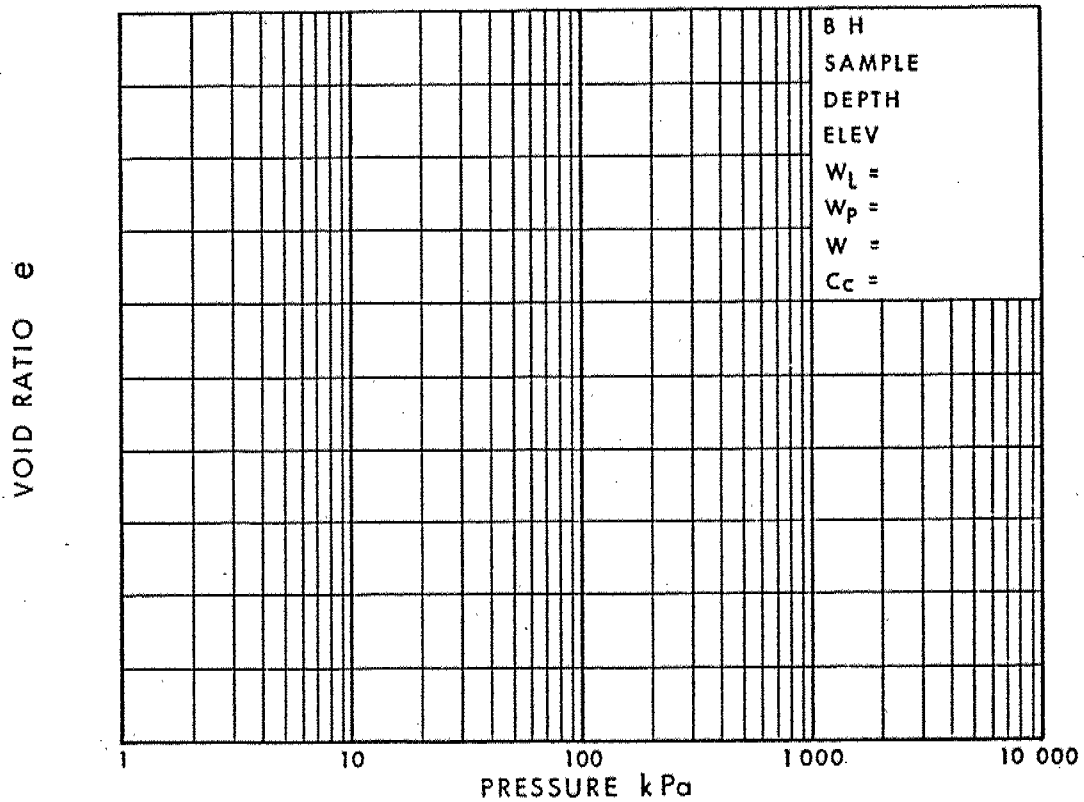
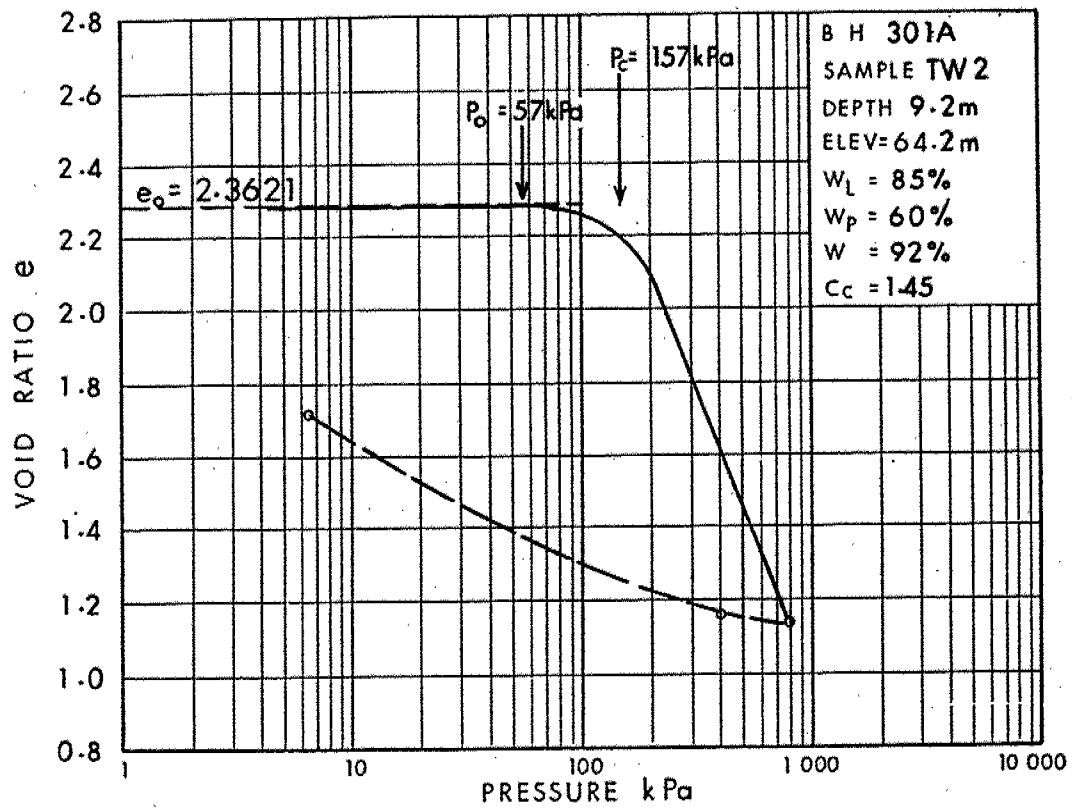
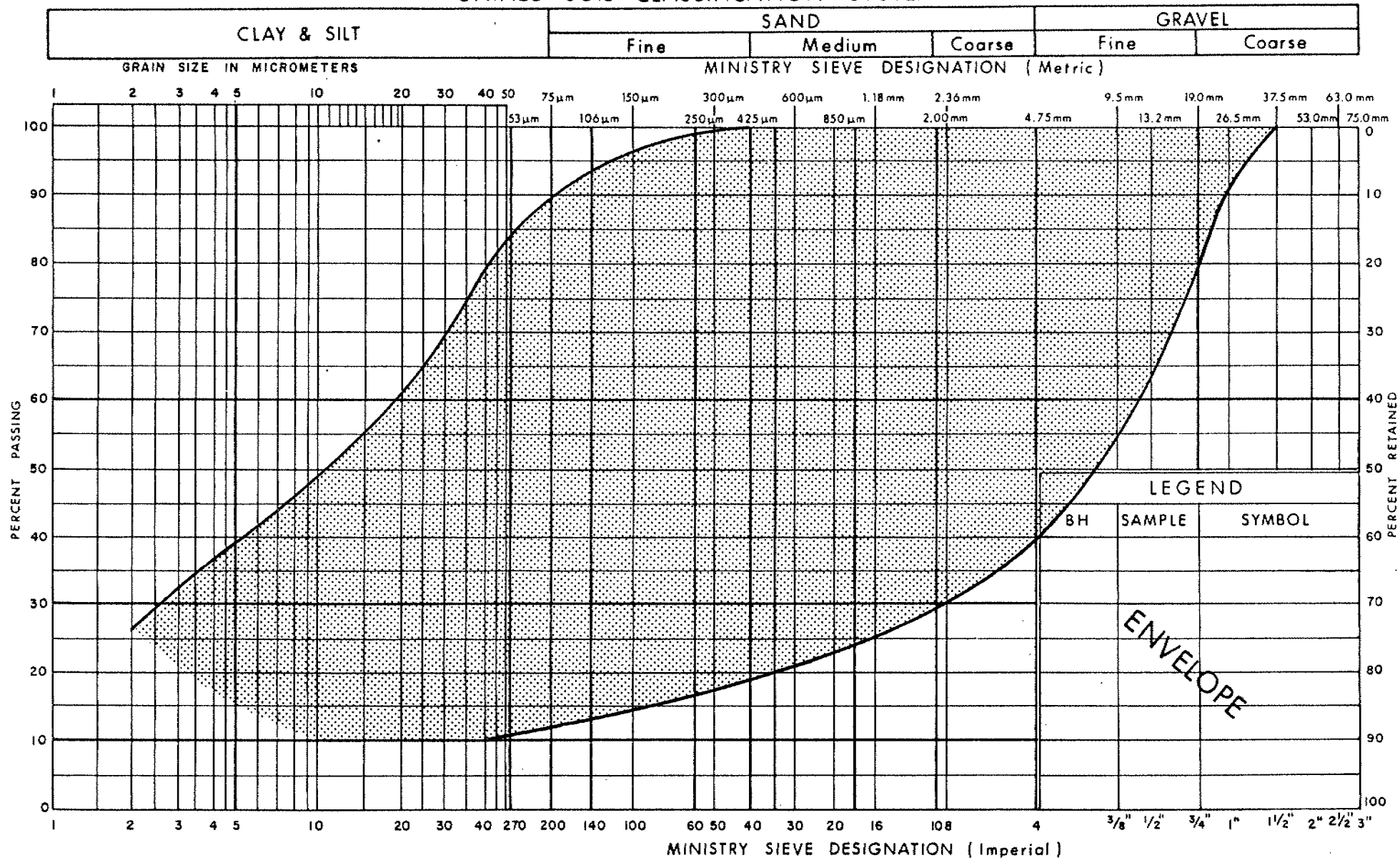


Fig 4b

W P 334-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM

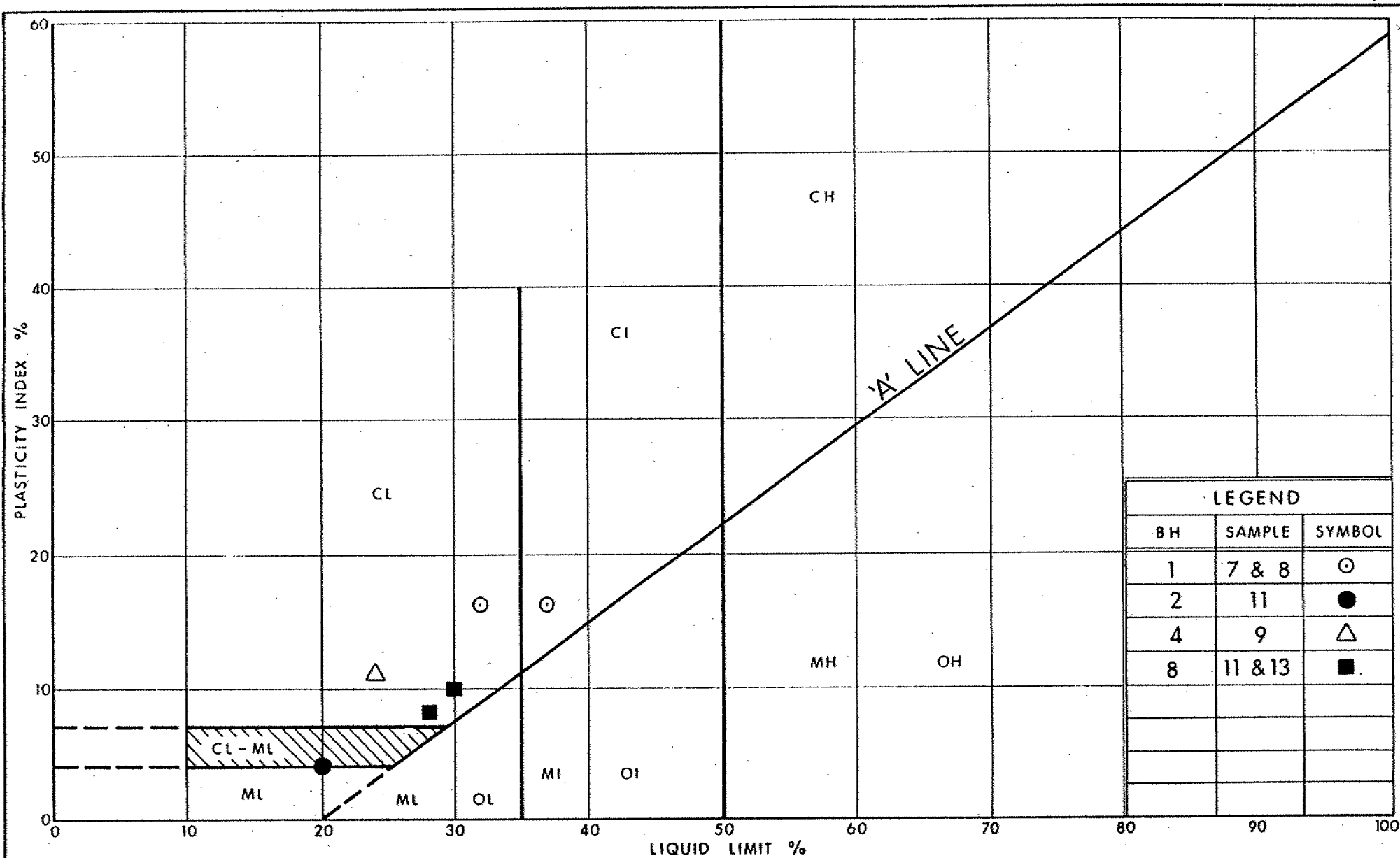


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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 5

W P 334 -89-01



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

FIG No 6

W P 334-89-01

RECORD OF BOREHOLE No 1
(Formerly BH No 9 of 65-F-113)

1 OF 1

METRIC

W.P. 334 30-89-01 LOCATION CO - ORDS: N 4 782 671.0 ; E 314 876.0 ORIGINATED BY R M
DIST 4 HWY QEW BOREHOLE TYPE PENNDRIILL COMPILED BY M V
DATUM GEODETIC DATE 65 11 09 CHECKED BY P P

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					
76.5	Ground Surface																
0.0			1	SS	8		76										
			2	SS	16		74										
	SILTY SAND, Occasional Gravel, Loose to Dense		3	SS	33		72										
			4	SS	31		70										
			5	SS	10		68										
68.6			6	SS	15		66										
7.9			7	SS	76												
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL Hard (Glacial Till)		8	SS	92	/10cm											
64.3			9	SS	100	/3cm											
12.2	End of Borehole																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 334 88-89-01 LOCATION CD - ORDS: N 4 782 607.0 ; E 315 020.0 ORIGINATED BY R M
 DIST 4 HWY QEW BOREHOLE TYPE WASHBORING COMPILED BY M V
 DATUM GEODETIC DATE 65 11 02 CHECKED BY P P

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		
76.1	Ground Surface													
0.0			1	SS	37									
			2	SS	36									
			3	SS	26									
			4	SS	36									
			5	SS	14									
70.0														
6.1			6	TW	PM									
			7	TW	PM									
			8	TW	PM									
65.4														
10.7			9	SS	26									
			10	SS	95	/15cm								
			11	SS	100	/8cm								
			12	SS	100	/8cm								
60.5														
15.6	End of Borehole													

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

334

(Formerly BH No 4 of 65-F-113)

W.P. 384-89-01

LOCATION CO - ORDS: N 4 782 552.0 ; E 315 127.0

ORIGINATED BY R.M.

DIST 4 HWY QEW

BOREHOLE TYPE PENNDRIILL

COMPILED BY M.V.

DATUM GEODETIC

DATE 65 11 04

CHECKED BY P.P.

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					
76.2	Ground Surface																
0.0			1	SS	18		76										
			2	SS	15		74										
			3	SS	13		72										
	SILTY SAND, Occasional Gravel, Compact		4	SS	20		70										
			5	SS	26		68										
			6	SS	16		66										
66.9			7	SS	9		64										
9.3			8	SS	11		62										
	Organic Silty Clay to Clay Occasional Gravel, Stiff to Very Stiff		9	SS	12		60										
			10	SS	14		58										
60.4			11	SS	18												
15.8			12	SS	100	/13cm											
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard		13	SS	100	/10cm											
	(Glacial Till)		14	SS	100	/3cm											
56.1																	
20.1	End of Borehole																

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

334

W.P. 304-89-01

LOCATION CO - ORDS: N 4 782 479.0 : E 315 266.0

ORIGINATED BY R M

DIST 4 HWY QEW

BOREHOLE TYPE PENNDRIILL

COMPILED BY M V

DATUM GEODETIC

DATE 65 11 08

CHECKED BY P P

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							
76.2	Ground Surface							20 40 60 80 100							
0.0	SILTY SAND With Gravel (Fill Material)						76								
0.6			1	SS	17		74								
	SILTY SAND, Occasional Gravel, Loose to Compact		2	SS	24		72								
			3	SS	23		70								
			4	SS	8		68								
70.1			5	SS	5		66								
6.1	Organic Silty Clay to Clay Firm to Stiff		6	SS	9		64								
			7	TW	PM		62								
64.6			8	SS	10										
11.6	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, (Glacial Till) Hard		9	SS	130 /15cm										
			10	SS	148 /15cm										
60.5			11	SS	115 /15cm										
15.7	End of Borehole														

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

(Formerly BH No 15 of 65-F-113)

334

W.P. 334-89-01

LOCATION CO - ORDS: N 4 782 376.0 ; E 315 385.0

ORIGINATED BY R M

DIST 4 HWY QEW

BOREHOLE TYPE PENNDRIILL

COMPILED BY

DATUM GEODETIC

DATE 65 11 11

CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W _P	W	W _L		
81.1	Ground Surface															
0.0																
			1	SS	12											
			2	SS	11											
			3	SS	27											
			4	SS	38											
			5	SS	49											
			6	SS	44											
			7	SS	72											
			8	SS	125	/15cm										
69.5			9	SS	100	/15cm										
11.6			10	SS	101	/18cm										
			11	SS	131	/13cm										
			12	SS	146	/20cm										
			13	SS	126	/15cm										
61.2			14	SS	108	/5cm										
19.9	End of Borehole															
	* GWL not established.															

+3, x5: Numbers refer to Sensitivity

20
15-0-5 (%) STRAIN AT FAILURE
10

334		RECORD OF BOREHOLE No 6 (Formerly BH No 14 of 65-F-113)				1 OF 1		METRIC					
W.P. 304-89-01		LOCATION CO - ORDS: N 4 782 448.0 : E 315 250.0				ORIGINATED BY R.M.							
DIST 4 HWY QEW		BOREHOLE TYPE PENNDRILL				COMPILED BY MV/TS							
DATUM GEODETIC		DATE 65 11 10				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	W _P W W _L			WATER CONTENT (%)
77.4	Ground Surface												
0.0	SILTY SAND With Gravel, Loose to Compact (Fill Material)		1	SS	12								
			2	SS	7								
73.4			3	SS	7								
4.0	SILTY SAND, Occasional Gravel, Loose to Compact		4	SS	20								
			5	SS	31								
			6	SS	9								
67.6													
9.8	ORGANIC SILTY CLAY TO CLAY Firm to Very Stiff		7	TW	PM								
			8	TW	PM								
			9	TW	PM								
			10	TW	PM								
59.4			11	TW	PM								
18.0	Heterogeneous Mixture of GRAVEL, SAND and SILT, (Glacial Till) Very Dense		12	SS	173	/38cm							
57.5													
19.9	End of Borehole												
	* GWL not established.												

334		RECORD OF BOREHOLE No 7		1 OF 1		METRIC											
W.P. <u>304-89-01</u>		LOCATION <u>CO - ORDS: N 4 782 521.0 ; E 315 111.0</u>		ORIGINATED BY <u>R.M.</u>													
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>PENNDRIILL</u>		COMPILED BY <u>MV/TS</u>													
DATUM <u>GEODETIC</u>		DATE <u>65 11 09</u>		CHECKED BY <u>PP</u>													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _P	W	W _L	γ	GR SA SI CL			
76.9	Ground Surface																
0.0	SILTY SAND With Gravel, Some Clayey Silt, Loose to Compact (Fill Material)		1	SS	18		76										
			2	SS	7		74							1 93 (6)			
72.6			3	TW	PM									0 3 88 9			
4.3	SILTY SAND, Occasional Gravel, Compact		4	SS	23		72										
			5	SS	24		70										
69.1			6	TW	PM									19.5			
7.8	ORGANIC SILTY CLAY TO CLAY Firm to Very Stiff		7	TW	PM		68							15.4			
			8	TW	PM		66							16.0			
			9	TW	PM		64							15.7			
			9A	TW	PM		62							13.7			
			10	TW	PM		60							16.0			
			11	TW	PM		58							15.9			
			12	TW	PM												
			13	SS	95												
			14	SS	100												
58.9			Heterogeneous Mixture of GRAVEL, SAND and SILT, Very Dense (Glacial Till)		13	SS	95									60 26 (14)	
57.0	14	SS			100												
19.9	End of Borehole																

334		RECORD OF BOREHOLE No 8				1 OF 1		METRIC				
W.P. <u>384-89-01</u>		LOCATION <u>CO - ORDS: N 4 782 577.0 ; E 315 004.0</u>				ORIGINATED BY <u>R.M.</u>						
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>PENNDRILL</u>				COMPILED BY <u>WV/TS</u>						
DATUM <u>GEODETIC</u>		DATE <u>65 11 02</u>				CHECKED BY <u>PP</u>						
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		
77.3	Ground Surface											
0.0	SILTY SAND With Gravel, (Fill Material) Loose to Compact		1	SS	11							
			2	SS	7							
74.3			3	SS	11							
3.0	SILTY SAND, Occasional Gravel, Compact		4	SS	15							
			5	SS	28							
			6	SS	30							
			7	SS	26							
68.5			8	SS	12							
8.8	ORGANIC SILTY CLAY TO CLAY Occasional Gravel Stiff to Very Stiff		9	SS	10							
			10	SS	16							
63.4			11	SS	125							
13.9	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, (Glacial Till)		12	SS	100	/5cm						
60.5	Hard		13	SS	100	/5cm						
15.8	End of Borehole											

334		RECORD OF BOREHOLE No 9		1 OF 1		METRIC					
W.P. <u>384-89-01</u>		LOCATION <u>CO - ORDS: N 4 782 639.0 : E 314 863.0</u>		ORIGINATED BY <u>R M</u>							
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>PENNDRIILL</u>		COMPILED BY <u>MV/TS</u>							
DATUM <u>GEODETIC</u>		DATE <u>65 11 03</u>		CHECKED BY <u>PP</u>							
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		
77.7	Ground Surface										
0.0	SILTY SAND With Gravel, Loose to Compact (Fill Material)		1	SS	18						
			2	SS	7						
73.9			3	SS	15						
3.8			4	SS	80						
			5	SS	48						
	SILTY SAND, Occasional Gravel, Compact to Very Dense		6	SS	16						
			7	SS	15						
66.7			8	SS	14						
11.0			9	TW	PM						
	ORGANIC SILTY CLAY TO CLAY		10	TW	PM						
	Occasional Gravel, Firm to stiff		11	SS	11						
			12	SS	10						
58.8			13	SS	18						
18.9	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, (Glacial Till)		14	SS	100	/15cm					
56.3	Hard		15	SS	100	/10cm					
21.4	End of Borehole										

<div style="display: flex; justify-content: space-between;"> 334 RECORD OF BOREHOLE No 10 1 OF 1 METRIC </div> <div style="display: flex; justify-content: center; margin-top: -10px;"> <small>(Formerly BH No 19 of 65-F-113)</small> </div>														
W.P. <u>304-89-01</u>		LOCATION <u>CO - ORDS: N 4 782 675.0 : E 314 756.0</u>		ORIGINATED BY <u>R M</u>										
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>PENNDRIILL</u>		COMPILED BY <u>MV/TS</u>										
DATUM <u>GEODETIC</u>		DATE <u>65 11 19</u>		CHECKED BY <u>PP</u>										
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	WATER CONTENT (%)	20 40 60			
79.2	Ground Surface													
0.0	CLAYEY SILT, Stiff to Hard		1	SS	10		78						19.5	
			2	SS	19		76							
			3	SS	90		74							
			4	SS	40		72							
			5	SS	43		70							
			6	SS	68		68							
			7	SS	68									
			8	SS	125									
11.3	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		9	SS	139	/20cm								
66.8														
12.4	End of Borehole													

334		RECORD OF BOREHOLE No 101 (Formerly BH No 101 of WP 325-89-01)		1 OF 1 METRIC												
W.P. 384-89-01		LOCATION CO - ORDS: N 4 782 565.0 ; E 315 178.0		ORIGINATED BY M.V.												
DIST 4 HWY QEW		BOREHOLE TYPE HOLLOW STEM AUGER, NW CASING & CONE TEST		COMPILED BY M.V.												
DATUM GEODETIC		DATE 92 06 29		CHECKED BY P.P.												
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
75.8	Ground Surface															
0.0	Cobbles		1	SS	8											20 71 (9)
	SAND to SILTY SAND, Some Gravel Loose to Compact		2	SS	4											
			3	SS	7											
			4	SS	12											
			5	SS	12											
			6	SS	16											22 68 (10)
	Sandy Silt		7	SS	6											
			8	SS	5											
68.4			9	SS	3											Org.= 7.2%
7.2			10	TW	PH											Org.= 9.6%
	Organic Silty Clay to Clay Occasional Layers of Peat and Partially decomposed Timber, Stiff		11	SS	3											
			12	SS	5											Org.= 18.2%
			13	SS	4											
60.0	Some Sand, Tr. of Gravel		14	SS	10											
15.6	Heterogeneous Mixture of GRAVEL, SAND & SILT Very Dense (Glacial Till)		15	SS	106	13cm										
58.4																
17.2	QUEENSTON SHALE															
57.2	Highly Weathered															
18.4	End of Borehole															

334		RECORD OF BOREHOLE No 102 (Formerly BH No 102 of WP 325-89-01)				1 OF 1		METRIC							
W.P. <u>384-89-01</u>		LOCATION <u>CO - ORDS: N 4 782 608.0; E 315 036.0</u>				ORIGINATED BY <u>M.V.</u>									
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>HOLLOW STEM AUGER, NW CASING & CONE TEST</u>				COMPILED BY <u>M.V.</u>									
DATUM <u>GEODETIC</u>		DATE <u>92 06 30</u>				CHECKED BY <u>P.P.</u>									
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					
77.1	Ground Surface														
0.0	Organics		1	SS	5										
	SAND to SILTY SAND, Trace of Gravel, Loose to Compact		2	SS	10										
			3	SS	23										
	Sandy Silt		4	SS	12										
70.1															
7.0	Organic Silty Clay to Clay Occasional Layers of Peat, Stiff		5	SS	4										
			6	SS	3										
66.1			7	TW	PH										
11.0	Het. Mix. of GRAVEL, SAND & SILT Compact (Glacial Till)		8	SS	18										
65.1			9	SS	88										
12.0	QUEENSTON SHALE, Highly Weathered		10	SS	100										
63.2															
13.9	End of Borehole * Water Level Not Established														

334		RECORD OF BOREHOLE No 103 (Formerly BH No 103 of WP 325-89-01)		1 OF 1 METRIC						
W.P. 384 -89-01		LOCATION CO - ORDS: N 4 782 656.0 : E 314 942.0		ORIGINATED BY M.V.						
DIST 4 HWY QEW		BOREHOLE TYPE HOLLOW STEM AUGER, NW CASING & CONE TEST		COMPILED BY M.V.						
DATUM GEODETIC		DATE 92 07 02		CHECKED BY P.P.						
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	WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER							
76.3	Ground Surface									
0.0	Gravelly Sand, Some Silt SAND to SILTY SAND, Trace of Gravel Loose to Compact		1	SS	18					5 45 (50)
			2	SS	18					
			3	SS	10					
			4	SS	12					
			5	SS	13					
			6	SS	27					
			7	SS	28					
			8	SS	10					
67.8	Organic Silty Clay to Clay Occasional Layers of Peat, Decomposed Timber Stiff		9	SS	3					15.4 Org. = 10.0% Org. = 6.0% Org. = 8.2%
			10	TW	PH					
			11	SS	4					
			12	SS	4					
			13	SS	3					
			14	SS	4					
			15	SS	3					
			16	SS	35					
56.0	QUEENSTON SHALE, Highly Weathered									
20.3	End of Borehole									

<div style="display: flex; justify-content: space-between;"> 334 RECORD OF BOREHOLE No 104 1 OF 1 METRIC </div> <div style="display: flex; justify-content: center; margin-top: 5px;"> (Formerly BH No 104 of WP 325-89-01) </div>														
W.P. 384-89-01		LOCATION CO - ORDS: N 4 782 698.0 ; E 314 849.0				ORIGINATED BY M.V.								
DIST 4 HWY QEW		BOREHOLE TYPE HOLLOW STEM AUGER & CONE TEST				COMPILED BY M.V.								
DATUM GEODETIC		DATE 92 07 03				CHECKED BY P.P.								
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					
75.7	Ground Surface													
0.0	SAND to SILTY SAND, Some Gravel,		1	SS	7									
			2	SS	23									
	Gravelly Sand, Some Silt		3	SS	22									
			4	SS	8									
71.7	Loose to Compact													
4.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		5	SS	6									
	Firm to Stiff		6	SS	8									
67.9			7	SS	109									
7.8	QUEENSTON SHALE, Highly Weathered		8	SS	147									
65.1														
9.6	End of Borehole													

RECORD OF BOREHOLE No 105

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION Co-ords: N 4 782 652.7; E 314 797.3 ORIGINATED BY MV
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 93 06 10-11 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					
76.3	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Very Stiff to Hard		1	SS	17		76										
			2	SS	26		74										
			3	SS	29												
			4	RC	38%		72										RQD = 0%
			5	SS	29												
			6	SS	33		70										
			7	SS	73		68										
			8	SS	51												
66.2							66										
10.3 65.5	Shale Bedrock - Weathered		9	SS	106	13cm											
10.8	End of Borehole																
	* 93 06 11 ** Sampler Bouncing																

RECORD OF BOREHOLE No 106

1 OF 1

METRIC

334

W.P. 334-89-01 LOCATION Co-ords: N 4 782 645.6; E 314 832.1 ORIGINATED BY MV
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 93 06 23 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	WATER CONTENT (%) W	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						
76.5	Ground Surface																	
0.0	Silty Sand, trace Gravel (Fill Material)						76											
75.4	Grey, Compact																	
1.1	Clayey Silt Grey, Firm to Stiff		1	SS	6		74											
73.1			2	SS	5													
3.4	Sand to Silty Sand trace Gravel Grey, Loose to Compact		3	SS	6		72											
70.3			4	SS	17													
6.2	Organic Silty Clay to Clay		5	SS	2		70											
69.0	Blackish Grey, Stiff		6	SS	2													
7.5	Stiff Hard Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey		7	SS	8		68											
65.0			8	SS	30													
64.2			9	SS	74	/15cm	66											
11.5	Shale Bedrock - Weathered		10	SS	126	/9cm												
12.3	End of Borehole																	
	* 93 06 23																	

RECORD OF BOREHOLE No 107

1 OF 1

METRIC

W.P. 334 384-89-01 LOCATION Co-ords: N 4 782 651.0; E 314 817.1 ORIGINATED BY MV
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 93 06 23 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 76.0	Silty Sand, trace Gravel (Fill Material)																
0.8	Clayey Silt Grey, Firm to Stiff		1	SS	6		76										
			2	SS	5		74										
72.4																	
4.4 71.5	Sand to Silty Sand Grey, Compact		3	SS	18		72										
5.3	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		4	SS	17												
			5	SS	20		70										
			6	SS	39												
			7	SS	27		68										
85.4	Very Stiff to Hard		8	SS	124	/28cm	66										
11.4 64.5	Shale Bedrock - Weathered		9	SS	100	/9cm											
12.3	End of Borehole																
	* 93 06 23																

RECORD OF BOREHOLE No 108

1 OF 1

METRIC

334

W.P. 304-89-01 LOCATION Co-ords: N 4 782 648.4; E 314 824.2 ORIGINATED BY MV
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 93 06 24 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					
76.6	Ground Surface																
0.0	Silty Sand, trace Gravel (Fill Material)						76										
75.6																	
1.0	Clayey Silt Grey, Stiff		1	SS	5		74										
73.2			2	SS	5												
72.8	Organic Silty Clay to Clay		3	SS	9												
3.8	Sand to Silty Sand, trace Gravel		4	SS	24		72										
71.3	Grey, Loose to Compact		5	SS	21												
5.3	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Very Stiff to Hard		6	SS	37		70										
			7	SS	30												
			8	SS	34		68										
			9	SS	25												
			10	SS	64		66										
65.1			11	SS	100												
11.5	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Very Weak to Weak		12	RC	REC 96%		64										RQD = 45%
62.0			13	RC	REC 96%												RQD = 36%
14.6	End of Borehole * 93 06 24																

RECORD OF BOREHOLE No 109

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION Co-ords: N 4 782 646.6; E 314 829.0 ORIGINATED BY MV
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 93 06 24 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					
76.5	Ground Surface																
0.0	Silty Sand, trace Gravel (Fill Material)						76										
75.1	Brown, Compact																
1.4	Clayey Silt		1	SS	3		74										
73.2	Grey, Firm																
3.3	trace Organics		2	SS	3												
	Sand to Silty Sand		3	SS	9												
	trace Gravel		4	SS	15		72										
70.6	Grey, Loose to Compact		5	SS	6												
69.7	Organic Silty Clay to Clay Blackish Grey, Stiff		6	SS	4		70										
6.8	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		7	SS	21												
			8	SS	29												
66.9	Grey, Very Stiff		9	SS	17		68										
9.6	End of Borehole																
	* 93 06 24																

RECORD OF BOREHOLE No 110

1 OF 1

METRIC

334

W.P. 304-89-01 LOCATION Co-ords: N 4 782 405.6; E 315 324.1 ORIGINATED BY MV
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 93 06 25 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																
0.0	Silt with random layers of Clayey Silt Very Loose to Compact Brown Grey		1	SS	3		78										
			2	SS	2		76										
			3	SS	3												
73.9			4	SS	16		74										
5.7	Very Stiff Hard Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey		5	SS	15		72										
			6	SS	29		70										
			7	SS	27												
			8	SS	71	/15cm	68										
67.1			9	SS	66	/15cm											
12.5	End of Borehole * GWL not established																

RECORD OF BOREHOLE No 111

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION Co-ords: N 4 782 427.7; E 315 282.7 ORIGINATED BY MV
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 93 06 28 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					
78.7	Ground Surface																
0.0	Silt with random layers of Clayey Silt Brown Grey Very Loose to Compact		1	SS	10		78										
			2	SS	4		76										
			3	SS	1												
73.7			4	SS	2		74										
5.0	Sand to Silty Sand Grey, Very Loose to Loose		5	SS	2												
			6	SS	5												
			7	SS	4		72										
70.9			8	SS	17												
7.8	Very Stiff Hard Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey		9	SS	98		70										
			10	SS	93		68										
			11	SS	53		66										
64.8			12	SS	76	/15cm											
13.9	End of Borehole * 93 06 28																

<div style="display: flex; justify-content: space-between;"> 334 RECORD OF BOREHOLE No 112 1 OF 1 METRIC </div>													
W.P. 304-89-01		LOCATION		Co-ords: N 4 782 437.3; E 315 265.0		ORIGINATED BY MV							
DIST 4 HWY QEW		BOREHOLE TYPE HS Auger				COMPILED BY TS							
DATUM Geodetic		DATE 93 06 28				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	Silt with random layers of Clayey Silt Brown, Very Loose to Compact		1	SS	11								
			2	SS	2								
			3	SS	2								
73.2			4	SS	5								
5.0	Silt to Silty Sand Grey, Very Loose to Loose ----- trace Organics		5	SS	4								
			6	SS	6								
			7	SS	4								
69.3			8	SS	2								
8.9	Organic Silty Clay to Clay Blackish Grey, Firm to Very Stiff		9	SS	2								
			10	SS	3								
			11	SS	2								
			12	SS	5								
			13	SS	4								
65.3			14	SS	29								
12.9	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		15	SS	20								
			16	SS	72	/10cm							
61.3	Grey ----- Red		17	SS	103	/15cm							
16.9	End of Borehole												
	* 93 06 28												

RECORD OF BOREHOLE No 113

1 OF 1

METRIC

W.P. 334 384-89-01 LOCATION Co-ords: N 4 782 432.5; E 315 273.9 ORIGINATED BY MV
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 93 06 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					
78.6	Ground Surface																
0.0	Brown Silt with random layers of Clayey Silt Very Loose to Compact		1	SS	15		78										
			2	SS	3		76										
73.6			3	SS	3		74										
5.0	Sand to Silty Sand Grey, Very Loose to Loose		4	SS	5		72										
71.0			5	SS	2		70										
7.6	Organic Silty Clay to Clay Blackish Grey, Stiff to Very Stiff		6	SS	4												
68.8			7	SS	3												
9.8	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	71		68										
			9	SS	53												
			10	SS	69		66										
	Grey Hard		11	SS	106		64										
			12	SS	96	/15cm	62										
61.7			13	SS	78	/15cm											
16.9	End of Borehole • 93 06 29																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 114

1 OF 1

METRIC

W.P. 334 384-89-01 LOCATION Co-ords: N 4 782 430.5; E 315 278.2 ORIGINATED BY MV
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 93 06 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					
78.7	Ground Surface																
0.0	Silt with random layers of Clayey Silt Brown, Very Loose to Compact		1	SS	14		78										
			2	SS	3		76										
73.7			3	SS	3		74										
5.0	Sand to Silty Sand Grey, Loose trace Organics		4	SS	4		72										
			5	SS	4												
			6	SS	5												
70.0			7	SS	11		70										
8.7	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		8	SS	81												
			9	SS	75		68										
			10	SS	58		66										
			11	SS	113		64										
			12	SS	81	/15cm	62										
			13	SS	71	/15cm	60										
			14	SS	99	/15cm	58										
			15	SS	77	/15cm											
			16	SS	69	/15cm											
			17	SS	131	/15cm											
56.2			18	SS	100	/8cm	56										
55.8	Shale Bedrock - Weathered																
22.9	End of Borehole																
	* 93 06 30																

<div style="display: flex; justify-content: space-between;"> 334 RECORD OF BOREHOLE No 301A (Formerly BH No 301A of WP 325-89-01) 1 OF 1 METRIC </div>														
W.P. <u>384-89-01</u>		LOCATION <u>Co-ords: N 4 782 565.0 ; E 315 179.5</u>		ORIGINATED BY <u>MV</u>										
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>HS Auger</u>		COMPILED BY <u>TS</u>										
DATUM <u>Geodetic</u>		DATE <u>93 08 11</u>		CHECKED BY <u>PP</u>										
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
75.6	Ground Surface													
0.0	Sand to Silty Sand, some Gravel Grey, Very Loose to Compact		1	SS	5									
			2	SS	5									
			3	SS	2									
67.2			4	SS	2									
8.4	Organic Silty Clay to Clay Blackish Grey, Stiff to Very Stiff		5	TW	PH									
			6	TW	PH									
			7	SS	3									
			8	TW	PH									
60.1	Silt, Very Loose		9	SS	2									
59.9														
15.7	End of Borehole													
	* 93 08 11													

RECORD OF BOREHOLE No 301B*
(Formerly BH No 301B of WP 325-89-01)

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION CO-ORDS: N 4 782 565.0 : E 315 180.0 ORIGINATED BY MY
DIST 4 HWY QEW BOREHOLE TYPE HS Auger. Vane Testing COMPILED BY TS
DATUM Geodetic DATE 93 08 11 CHECKED BY PP

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Testing COMPILED BY TS

DATUM Geodetic DATE 93 08 11 CHECKED BY PP

DATUM Geodetic DATE 93 08 11 CHECKED BY PP

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 302A (Formerly BH No 302A of WP 325-89-01)

1 OF 1

METRIC

W.P. 334-89-01 LOCATION CO-ORDS: N 4 782 654.0 ; E 314 946.0 ORIGINATED BY MV
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 93 08 13 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					
76.3	Ground Surface																
0.0	Sand to Silty Sand, some Gravel Grey, Loose																
67.3			1	SS	9												
9.0			2	SS	6												
	Organic Silty Clay to Clay		3	SS	2												
	Blackish Grey, Stiff to Very Stiff		4	TW	PH												
			5	TW	PH												
			6	TW	PH												
			7	TW	PH												
			8	TW	PH												
			9	TW	PH												
			10	SS	3												
			11	SS	3												
			12	SS	1												
58.9			13	SS	4												
58.3	Silt, Very Loose		14	SS	1												
18.0	End of Borehole • 93 08 13																

RECORD OF BOREHOLE No 302B*
(Formerly BH No 302B of WP 325-89-01)

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION CO-ORDS: N 4 782 655.0 ; E 314 943.0 ORIGINATED BY MV
DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Testing COMPILED BY TS
DATUM Geodetic DATE 93 08 16-17 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 80 100	20 40 60 80 100					
76.3	Ground Surface													
0.0	Probable Sand to Silty Sand, some Gravel													
67.3			1	SS	4									
9.0	Probable Organic Silty Clay to Clay													
	Suff to Very Suff													
58.3			2	SS	3									
18.0	End of Borehole													
	*See BH No 302A for detailed soils information													

RECORD OF BOREHOLE No 501

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION Co-ords: N 4 782 570.0 E 315 018.4 ORIGINATED BY DR
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NXL Core COMPILED BY TS
 DATUM Geodetic DATE 94 02 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	40	60	80	100					
77.4	Roadway Surface																
0.0	Irregular Mixture of Clayey Silt, Sand & Gravel (Fill Material)					*											
75.4	Brown, Very Stiff		1	SS	19		76										
2.0	Sand to Silty Sand Grey, Loose to Compact		2	SS	9		74										
			3	SS	14		72										
							70										
							68										
66.7							66										
10.7	Organic Silty Clay to Clay Blackish Grey to Grey, Stiff to Very Stiff		4	SS	5		64										
			5	SS	3		62										
			6	SS	4		60										
59.1							58										
18.3	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)																
57.6	Hard																
19.8	Shale Bedrock with interbedded Siltstone		7	RC	REC												
56.1	Very Weak to Weak, Unweathered				88%												RQD = 70%
21.3	End of Borehole																
	* GWL not established																

RECORD OF BOREHOLE No 502

1 OF 1

METRIC

334

W.P. 334-89-01 LOCATION Co-ords: N 4 782 602.0, E 315 033.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NXL Core COMPILED BY TS
DATUM Geodetic DATE 94 01 20 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	WATER 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						
78.9	Ground Surface																	
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material)						76											
74.9	Brown, Very Loose		1	SS	3													
2.0	Sand to Silty Sand, some Gravel		2	SS	14		74											
	Grey, Compact						72											
69.1			3	SS	2		70											
7.8	Organic Silty Clay to Clay Grey, Stiff to Very Stiff						68											
66.2			4	SS	4		66											
10.7	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)						64											
63.0	Red, Soft		5	SS	60													
13.9	Slightly to Moderately Weathered Unweathered		6	RC	REC 100%		62											RQD = 41%
60.0	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Very Weak to Weak		7	RC	REC 100%													RQD = 33%
16.9	End of Borehole * 94 01 21																	

RECORD OF BOREHOLE No 503

1 OF 1

METRIC

334

W.P. 334-89-01

LOCATION Co-ords: N 4 782 560.3, E 315 040.0

ORIGINATED BY DR

DIST 4 HWY QEW

BOREHOLE TYPE HS Auger, NXL Core

COMPILED BY TS

DATUM Geodetic

DATE 94 02 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					
77.4	Ground Surface																
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material)					*											
75.4	Brown, Loose		1	SS	6		76										
2.0	Sand to Silty Sand, trace/some Gravel						74										
	Grey, Loose		2	SS	7		72										
							70										
			3	SS	8		68										
66.7							66										
10.7	Organic Silty Clay to Clay		4	SS	1		64										
	Grey, Stiff to Very Stiff						62										
			5	SS	3		60										
							58										
59.1							56										
18.3	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)																
57.9	Hard																
19.5	Shale Bedrock with Interbedded Siltstone		7	RC	REC 95%												RQD = 58%
	Red with interbedded Grey, Very Weak to Weak, Unweathered		8	RC	REC 100%												RQD = 63%
54.9																	
22.5	End of Borehole																
	* GWL not established.																

RECORD OF BOREHOLE No 504

1 OF 1

METRIC

W.P. 334 354-89-01 LOCATION Co-ords: N 4 782 591.6; E 315 057.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NW Casing, NXL Core COMPILED BY TS
DATUM Geodetic DATE 94 01 21 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		
77.1	Ground Surface																
0.0	Sand to Silty Sand, trace Gravel Grey, Loose to Compact		1	SS	6		76										
			2	SS	12		74										
							72										
							70										
69.5			3	SS	2		68										
7.6	Organic Silty Clay to Clay Grey, Stiff to Very Stiff		4	SS	3		66										
							64										
63.4	Het Mix of Clayey Silt, Sand & Gravel (Glacial Till)		5	SS	60	/15cm	62										
13.9	Shale Bedrock with interbedded Siltstone Red with interbedded Grey Very Weak to Weak Weathered Unweathered		6	RC	REC 85%		82							RQD = 7%			
60.2			7	RC	REC 100%									RQD = 85%			
16.9	End of Borehole																

RECORD OF BOREHOLE No 505

1 OF 1

METRIC

334

W.P. 334-89-01

LOCATION Co-ords: N 4 782 580.0 E 315 090.0

ORIGINATED BY DR

DIST 4 HWY QEW

BOREHOLE TYPE HS Auger, NW Casing, NXL Core

COMPILED BY TS

DATUM Geodetic

DATE 94 01 17

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	WATER CONTENT (%) W	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						
76.2	Ground Surface																	
0.0	Irregular Mixture of Silt, Sand, Gravel, Cobbles (Fill Material) Brown, Loose																	
74.7																		
1.5	Sand to Silty Sand, trace Gravel Grey, Very Loose to Compact		1	SS	15													
			2	SS	4													
68.6																		
7.6	Organic Silty Clay to Clay Grey, Stiff to Very Stiff		3	SS	4													
			4	SS	4													
			5	SS	4													
59.0			6	SS	6													
17.2	Het. Mixture of Clayey Silt, Sand and Gravel (Glacial Till)																	
58.1																		
18.1	Unweathered Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Very Weak to Weak		7	SS	60	/8cm												
			8	RC	REC 92%													RQD = 56%
54.8			9	RC	REC 100%													RQD = 73%
21.4	End of Borehole																	

RECORD OF BOREHOLE No 506

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION Co-ords: N 4 782 558.8 E 315 104.8 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NW Casing, NXL Core COMPILED BY TS
DATUM Geodetic DATE 94 01 19 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					
77.1	Ground Surface															
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material) Brown, Firm		1	SS	12											
75.1																
2.0	Sand to Silty Sand, trace Gravel Gey, Very Loose		2	SS	2											
69.2			3	SS	4											
7.9	Organic Silty Clay to Clay Grey, Stiff to Very Stiff		4	SS	4											
59.9			5	SS	4											
17.2	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Red, Hard		6	SS	1											
58.4			7	SS	36											
18.7	Weathered Unweathered Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Very Weak to Weak		8	RC	REC 100%											RQD = 65%
55.3			9	RC	REC 100%											RQD = 60%
21.8	End of Borehole * GWL not established.															

RECORD OF BOREHOLE No 507

1 OF 1

METRIC

334

W.P. 384-89-01 LOCATION Co-ords: N 4 782 539.5 ; E 315 077.0 ORIGINATED BY TS
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NX Core COMPILED BY TS
 DATUM Geodetic DATE 94 02 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					
77.3	Ground Surface																
0.0	Silty Sand to Silt Grey, Very Loose to Compact		1	SS	18		76										
			2	SS	3		74										
			3	SS	7		72										
							70										
							68										
66.6			4	SS	3		66										
10.7	Organic Silty Clay to Clay Grey, Stiff to Very Stiff		5	SS	8		64										
			6	SS	5		62										
							60										
59.0							58										
18.3	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)																
57.8																	
19.5	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Very Weak to Weak, Unweathered		7	RC	REC 100%												RQD = 77%
56.3																	
21.0	End of Borehole																

ROCK CORE DESCRIPTION

WP 334-89-01

Page 1 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
501	7	19.81-21.34	88	70	19.81-21.34	SHALE , greyish red, with interbedded greenish grey SILTSTONE (24%); very fine grained; very weak to weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
502	6	13.89-15.42	100	41	13.89-16.94	SHALE , greyish red, with interbedded greenish grey SILTSTONE (5%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 13.89-14.17 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	7	15.42-16.94	100	33		
503	7	19.48-21.01	95	58	19.48-19.61	OVERBURDEN (till).
	8	21.01-22.53	100	63	19.61-22.53	SHALE , greyish red, with interbedded greenish grey SILTSTONE (11%); very fine grained; very weak to weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to dipping, planar to undulating, smooth.
504	6	13.87-15.39	85	7	13.87-16.92	SHALE , greyish red, with interbedded greenish grey SILTSTONE (5%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 13.87-15.90 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	7	15.39-16.92	100	65		

*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

ROCK CORE DESCRIPTION

WP 334-89-01

Page 2 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
505	8	18.34-19.86	92	56	18.34-21.39	SHALE, greyish red, with interbedded greenish grey SILTSTONE (9%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 19.37-19.86 m); fractures moderate to extremely close spaced, flat to dipping, planar to undulating, smooth.
	9	19.86-21.39	100	73		
506	8	18.75-20.27	100	65	18.75-21.79	SHALE, greyish red, with interbedded greenish grey SILTSTONE (21%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 18.75-19.07 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	9	20.27-21.79	100	60		
507	7	19.51-21.03	100	77	19.51-21.03	SHALE, greyish red, with interbedded greenish grey SILTSTONE (19%); very fine grained; very weak to weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
508	7	19.51-21.03	100	63	19.51-22.56	SHALE, greyish red, with interbedded greenish grey SILTSTONE (10%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 19.51-19.81 m); fractures moderate to extremely close spaced, flat to dipping, planar to undulating, smooth.
	8	21.03-22.56	100	60		

*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

FOUNDATION INVESTIGATION REPORT
FOR
Proposed Retaining Walls and Culvert Extension
QEW Widening from Victoria Street to Jordan Road
W.P. 333-89-01
District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted in conjunction with proposed retaining walls and a culvert extension related to the QEW Widening from Victoria Street to Jordan Road. The limits of the retaining walls and culvert extension were provided by the Central Region Structural Section and are shown on Dwg. Nos S-3 & S-4, (Sheets 452 & 453) of the Contract Drawings. A total of six sites were investigated within the contract limits and are identified as Sites #1 to #6 respectively for the purposes of this report. However, site #5a is not applicable to this contract.

SITE DESCRIPTION AND GEOLOGY

The site is located within and adjacent to the QEW corridor between Victoria Street and approximately 0.5 kilometres east of Jordan Road. Situated approximately ten kilometres west of St. Catharines, the site is within the Town of Lincoln, Regional Municipality of Niagara.

In general, the land within the area is used primarily for agriculture. Orchards and vineyards populate this land often referred to as the Niagara Fruit Belt area. However, site conditions vary from site to site within the limits mentioned above. A meandering creek adjacent to orchards is situated south of the existing South Service Road at Site #1. Restaurant and motel accommodations are located along the northwestern limits of the general site area (Site #2). A marina is situated at the southwestern limits of the site adjacent to the Jordan Harbour (Sites #3 and #4). The Twenty Mile Creek exists within the plan limits of the site and flows into Lake Ontario immediately north of the existing QEW or North Service Road (adjacent to Site #6). Construction of the new North Service Road - Twenty Mile Creek structure was in progress at the time of the investigation. At Site #5a, the proposed retaining wall is situated within a buried valley. The valley, approximately 70 m in width and approximately 5-6 metres in depth, has been filled between the North Service Road and South Service Road and a culvert transmits the waters of an existing creek beneath the QEW.

Physiographically, the site is located within the region known as the "Iroquois Plain". The Iroquois Plain is the product of the advance and retreat of the Wisconsinan ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). The lowland bordering Lake Ontario, was inundated by the glacial lake called Lake Iroquois when the last glacier was receding at the site. Conditions in the old lake plain vary greatly within the Iroquois Plain. At the site location, the former lake bottom consisted of an organic silty clay to clay deposit, undulating till plains or glaciofluvial sands to silty sands. Overburden at the site is underlain by shale bedrock with interbedded siltstone of the Queenston Formation.

INVESTIGATION PROCEDURE

General

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analysis. Details of the field investigation and laboratory testing program are discussed below.

Field Investigation

The recent fieldwork for this project was conducted between 94 03 09 and 94 03 16 and consisted of a total of thirteen(13) new boreholes (BH's 1, 2, 4-14 incl.). In addition, borehole information obtained from previous investigations has also been included. Borehole information from BH's 102-103; 201-203; 502 and 502A (Formerly BH #2) were obtained from boreholes advanced in conjunction with the Twenty Mile Creek/NSR (WP 325-89-01) and Twenty Mile Creek/QEW (WP 334-89-01) structures. These boreholes were advanced on 92-06-30 to 92-07-02, 93 09 20-21, 94-01-20 and 65-11-02 respectively and ranged in depth from 13.9 m to 20.3 m.

In general, boreholes advanced during the most recent fieldwork ranged in depth from 12.2 m to 14.2 m below the ground surface. However, because of varying conditions at the various sites, some boreholes were advanced to shallower depths and others to larger depths. All boreholes were advanced using conventional track mounted Central Mining Equipment (CME) 55 equivalent drilling units. In general, solid stem or hollow ste

augering techniques were used to penetrate the overburden at the site. In general, disturbed subsoil samples were retrieved across the site. Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). An automatic hydraulic tripping hammer mechanism was used to impart the standard driving energy. Samples were generally retrieved at 0.76 m intervals within the surficial 6 metres or so and at 1.5 m intervals beyond this depth.

Relatively undisturbed subsoil samples were retrieved within weaker cohesive soils where encountered using a 57 mm diameter thin wall sampler. The thin wall sampler was pushed hydraulically in accordance with procedures outlined in ASTM D1587.

All subsoil samples were identified in the field and then properly sealed to preserve natural moisture contents in the soil. Disturbed samples were placed in sealed plastic containers and thin wall samples were capped and waxed. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

In situ vane tests were also carried out within cohesive soils of weaker consistency to determine the undrained shear strength at selected intervals between the subsoil sample retrieval. The test was carried out in accordance with ASTM D2573 employing the standard MTO 'N' vane. Remoulded shear strengths were also obtained allowing the determination of soil sensitivity.

Rock core was retrieved using conventional rock coring techniques and a NXL core barrel. Rock core samples were identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory for detailed rock core logging (see Laboratory Analyses).

Groundwater levels were determined by monitoring the water levels in the open boreholes. All boreholes were backfilled upon completion of the fieldwork.

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

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation and other pertinent physical properties of the soil were determined by conducting the appropriate laboratory tests on representative samples. These tests are tabulated in Table 1 below. Mechanical property testing was conducted to evaluate the strength and compressibility characteristics of an organic silty clay deposit at Site #6 and consisted of unconfined compression testing and consolidation testing respectively.

Table 1 - Physical Property Testing
Atterberg Limit Tests
Particle Size Analysis
Natural Moisture Contents
Bulk Unit Weights
Organics Content

Laboratory test results on subsoil samples are illustrated on the corresponding boreholes and figures included in the Appendix of this report. Rock core recoveries and rock quality designations are summarized both in the "Rock Core Descriptions" and on individual borehole logs.

SUBSURFACE CONDITIONS

As mentioned above, several independent sites were investigated. Figures 1 and 2 in the Appendix illustrate the Atterberg Limit test results for a clayey silty with random interbedded layers of sandy silt stratum and a heterogeneous mixture of clayey silt, sand and gravel (glacial till) encountered at many of the sites. Figures 3a-d and 4a-f provide the gradations of the clayey silt with random interbedded layers of sandy silt and of a heterogeneous mixture of clayey silt, sand and gravel encountered at the various sites respectively. Figures 5-7 provide the results of sieve analysis conducted on a sand to silty sand, trace/some gravel deposit and an organic silty clay to clay deposit and Atterberg Limit testing on the organic silty clay to clay deposit respectively encountered at site no. 6.

Plans of the sites illustrating the locations and elevations of the boreholes and proposed structure foundation locations and stratigraphical sections are shown on Dwg. Nos. S-3 & S-4, (sheets 452 & 453) of the Contract Drawings. 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 individual Record of Borehole sheets in the Appendix.

A summary of the subsurface conditions encountered at each site is described below.

Site #1 - Culvert Extension

The ground surface at the existing creek channel is approximately 78 m and slopes on either side rise at approximately 2H:1V to elevation 83 m (see Groundwater Conditions). The one borehole advanced at the southern culvert inlet revealed a surficial thickness of fill material consisting of an irregular mixture of clayey silt, sand and gravel. This material is brown and stiff and approximately 1.5 m in thickness. The fill material is underlain by a grey heterogeneous mixture of clayey silt, sand and gravel of glacial till origin and extended for a thickness of 10.7 m. Shale bedrock with interbedded siltstone underlies the overburden at an elevation of 65.8 m. Based on 'N' values ranging from 14 blows/0.3 m to 26 blows/0.3 m, the heterogeneous mixture of clayey silt, sand and gravel deposit can be described as having a very stiff consistency to approximately 69 m. Below elevation 69 m, the deposit is hard with 'N' values ranging from 60 blows/5 cm to 100 blows/25 cm.

Site #2 - Retaining Wall - Plain and Fancy Restaurant/North Service Road

The ground surface elevation at the site ranges between elevation 83 m and elevation 84 m. The two boreholes advanced at the site indicate very uniform subsoil conditions. Underlying a shallow thickness (0.8 m) of fill material consisting of an irregular mixture of silt, sand and gravel, the native deposit across the site consists of a cohesive clayey silt with random interbedded layers of upto 100 mm of cohesionless sandy silt. The stratum, approximately 7.6 m in thickness is brown in colour for the surficial 4.5 metres or so and then becomes grey in colour. The colour change also coincides with a noticeable reduction in the SPT 'N' values. Within the surficial oxidized, brown zone, 'N' values ranged from 8 blows/0.3 m to 19 blows/0.3 m. Within the underlying grey zone, 'N' values ranged from 1 blow/0.3 m to 7 blows/0.3 m. In situ vane tests were conducted within the weaker, grey material but the vanes could not shear the soil within the limits of the test indicating a shear strength exceeding 120 kPa. The stratum can be described as having a stiff to very stiff consistency.

The clayey silt with random interbedded layers of sandy silt stratum is underlain by a stiff to hard heterogeneous mixture of clayey silt, sand and gravel of glacial till origin. SPT 'N' values ranged from 7 blows/0.3 m to 50 blows/0.3 m within the 5 metre thickness explored.

Site #3 - Retaining Wall - QEW EB/Marina Access Road

The ground surface varies from elevation 83.9 m at the western extreme and gradually slopes to elevation 75.8 m at the eastern extreme. The subsurface conditions are generally uniform apart from the fill material located between BH's 4 and 5 and the changing

subsurface conditions at BH 8, the most easterly limit of the retaining wall. Up to 3 metres of fill material consisting of brown clayey silt of very stiff consistency exists at the crest of the Marina Access Road. This material is underlain by a native stratum consisting of a clayey silt with random interbedded layers of sandy silt of up to 100 mm thickness. This stratum is predominantly grey, but at some locations the soil has been oxidized up to approximately 3 metres and hence is brown in colour. The thickness of this stratum varies between 3.8 m and 6.1 m. Based on 'N' values ranging from 4 blows/0.3 m to 17 blows/0.3 m and the fact that the results of in situ vane tests reveal undrained shear strengths exceeding 100 kPa, this material can be described as having a stiff to very stiff consistency.

At BH #8, the clayey silt with random interbedded layers of sandy silt was not encountered. The surficial overburden at this location consists instead of a surficial deposit of organic silt of 1.5 m thickness underlain by a further 3.1 m thickness of silty sand, which in turn is underlain by an organic silty clay of 1.6 m thickness. All these soils are weak materials and are generally very loose to loose cohesionless soils or stiff cohesive soils.

A heterogeneous mixture of clayey silt, sand and gravel of glacial till origin is present across the site underlying the soils described above. The deposit has a thickness ranging from 9.1 m at the crest of the slope to 2.1 m at the bottom of the slope adjacent to the Jordan Harbour (BH#8). The main component of this deposit is the cohesive clayey silt binder. Boulders and cobbles, although not encountered during the investigation, are characteristic components of these deposits of glacial till origin and hence can exist.

'N' values derived from the SPT ranged from 8 blows/0.3 m to 106 blows/0.3 m. In general, 'N' values ranged between 20 blows/0.3 m and 40 blows/0.3 m suggesting a very stiff to hard consistency.

The overburden at the site is underlain by shale bedrock with interbedded siltstone of the Queenstone Shale Formation. The bedrock surface is relatively flat ranging from 67.2 m to 67.9 m. The bedrock is red with interbedded grey, very thin to thinly bedded, weak to very weak and generally of poor quality. The bedrock has been weathered at some locations approximately 0.3 m in thickness. Detailed rock core descriptions are provided in the Appendix.

Site #4 - Retaining Wall (Marina Access Road/Campbell Property)

The ground surface elevation at the site varies from approximately elevation 85 m at the crest of the slope to approximately elevation 77 metres at the toe of the slope. The slope is approximately 1H:1V. The native subsoil conditions at the proposed retaining wall are similar to the conditions described for the western portion of the retaining wall at Site #3. The surficial native deposit consists of a clayey silt stratum within random interbedded layers of sandy silt extending for a thickness of 7.6 m to 9.1 m (Elevation 77.4 m to 75.7 m). The thickness of the interbedded layers of sandy silt are in the order of 100 mm. In contrast to the clayey silt at the retaining wall #2 location, the consistency of this stratum is noticeably weaker ranging from soft to very stiff. In situ vane tests revealed undrained shear strengths ranging from 20 kPa to 50 kPa. 'N' values ranged from 2 blows/0.3 m to

25 blows/0.3 m at the top of the existing slope (see BH's 9 and 10). The stratum is brown for the surficial 3.8 m to 4.5 m and grey beneath this depth.

The clayey silt with random interbedded layers of sandy silt is underlain by the heterogeneous mixture of clayey silt, sand and gravel (glacial till) present in the general area. This deposit is grey and extended to elevation 66.6 m, approximately 9.2 m in thickness at the crest of the slope. Based on 'N' values ranging from 18 blows/0.3 m to 126/23 cm, this deposit with the cohesive clayey silt binder can be described as having a consistency of stiff to hard, but generally very stiff to hard. As is characteristic of all glacial till deposits, boulders and cobbles can exist in this deposit.

Shale bedrock with interbedded siltstone as described above exists beneath the heterogeneous mixture of clayey silt, sand and gravel.

Site #5a - Retaining Wall (QEW W/NSR) Not Applicable to this Contract.

The ground surface at the site is approximately at elevation 86 m. Situated within a buried valley, up to 6.1 metres of fill material was encountered at the site. The fill material consisted of (1) silt with traces/some sand and with random layers of clayey silt and (2) clayey silt. The cohesionless silt with layers of clayey silt has been placed up to a thickness of 3 metres. The clayey silt underlying the surficial fill material has a thickness of approximately 3.1 metres. The cohesionless silt with clayey silt layers is brown for the surficial 1.5 m to 2.3 m and grey thereafter. The underlying clayey silt fill material is grey.

Based on 'N' values ranging from 2 blows/0.3 m to 15 blows/0.3 m, the cohesionless silt fill material can be described as having a denseness ranging from very loose to compact. In general, however, 'N' values exceed 10 blows/0.3 m and hence the cohesionless fill material can be described as compact. The cohesive clayey silt fill material has a consistency ranging from firm to very stiff based on in situ vane tests conducted in the material. Undrained shear strengths ranged from 40 kPa to in excess of 120 kPa.

A native grey clayey silt material is also present at the site underlying the fill material. This stratum has a thickness of 1.6 m to 3.1 m and has a consistency ranging from firm to stiff. Undrained shear strengths determined from in situ vane tests were as low as 38 kPa. SPT 'N' values ranged from 3 blows/0.3 m to 10 blows/0.3 m.

A heterogeneous mixture of clayey silt, sand and gravel (glacial till) underlies the clayey silt (fill) or clayey silt (native) at a depth ranging from 4.6 m to 6.1 m (Elevation 81.2 m to 79.9 m). This deposit has an extensive thickness of approximately 22.9 m and was explored to a depth of 29 m. The main portion of this deposit is the clayey silt binder. Boulders and cobbles are also characteristic components of this deposit. The surficial thickness of this deposit up to as deep as Elevation 74 m has a stiff consistency. In situ vane tests conducted within this zone revealed undrained shear strengths ranging from approximately 60 kPa to 85 kPa. Beneath this depth, the deposit strengthens. The 'N' values ranged generally between 12 blows/0.3 m to 22 blows indicating a stiff to very stiff consistency.

The heterogeneous mixture of clayey silt, sand and gravel deposit is underlain by a very dense deposit consisting of a silty sand to sand and gravel. The thickness of this deposit was not explored.

Site #6 - Retaining Wall Adjacent QEW WB Structure

In general subsurface conditions are uniform across the site. The ground surface is approximately at elevation 77 m. However at the NSR, a surcharged embankment at elevation 81.5 exists. The native subsoils consist of an uppermost deposit of sand to silty sand with traces to some gravel. This deposit is brown to grey in colour and has a thickness ranging from 6.1 m to 8.5 m. The deposit has a very loose to dense range of denseness but is generally loose to compact. SPT 'N' values generally range from 5 blows/0.3 m to 25 blows/0.3 m. This cohesionless deposit is for the most part submerged below the groundwater table and hence during the drilling and sampling process was subjected to conditions of unbalanced hydrostatic head. To prevent soil cave-in and sloughing at the base of the borehole, a constant hydrostatic force supplied by a head of water was required.

The surficial native sand to silty sand deposit is underlain by an organic silty clay to organic clay stratum. The thickness of this stratum between stations 11+600± and the eastern limit of the wall is in the order of 3.7 m to 5.5 m. The thickness increases west of station 11+600±. Organic contents range from 6 to 10%. Undrained shear strengths for this material as determined by in situ vane tests and unconfined compression tests range from approximately 30 kPa to in excess of 100 kPa. An undrained shear strength of 60 kPa to

100 kPa, however, is considered as a representative range for this material and consequently the material can be described as having a stiff to very stiff consistency.

The compressibility characteristics of the organic silty clay to organic clay stratum were determined by conducting one dimensional consolidation tests on representative samples of the material. The test results reveal that the soil has been preconsolidated in the past to an effective pressure approximately 60 to 85 kPa in excess of the existing overburden pressure.

A heterogeneous mixture of silt to clayey silt, sand and gravel underlies the organic silty clay to clay stratum across the site. The main component of the deposit varies from silt to clayey silt and hence the deposit exhibits either cohesionless or cohesive characteristics respectively. The thickness of the deposit ranges up to 1.7 m and generally is very dense or hard.

The overburden at the site is underlain by shale bedrock with interbedded siltstone of the Queenston Formation present at an Elevation ranging between 63 m to 65 m. Borehole information at BH 103 reveals however, that the bedrock surface elevation decreases to as low as Elevation 56 m at the western limit of the retaining wall. In general, the surficial metre or so of the bedrock has been slightly to moderately weathered. This rock contains occasional clay seams of 50 to 100 mm thickness and is of poor quality. The weathered rock is underlain by sound, competent and unweathered rock of fair to excellent quality.

GROUNDWATER CONDITIONS

The groundwater conditions at each site is summarized in Table 2 below. 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 subject to seasonal fluctuations and hence can vary from the values given in this report.

Table 2 - Groundwater Levels			
Site		Depth (m)	Elevation (m)
#	Description		
1	Culvert	0.3	77.7
2	Retaining Wall (NSR/Plain & Fancy)	4.5-5	78.8-79.3
3	Retaining Wall (QEW E/Marina)	7.6-9.1	76.3-74.6
4	Retaining Wall (Marina/Campbell)	10.6-10.9	74.4-74
5a	Retaining Wall (QEW W/NSR)	6.1	79.7-80.1
6	Retaining Wall (QEW WB Structure/NSR)	1-2.5	73-75

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and D. Rothwell, utilizing equipment owned and operated by Malones Soil Samples. Logging of the rock core in the laboratory was carried out by D. Williams, Petrographer.

The project was carried out by T. Sangiuliano and Dan Rothwell under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by D. Dundas, (Acting) Chief Foundation Engineer.

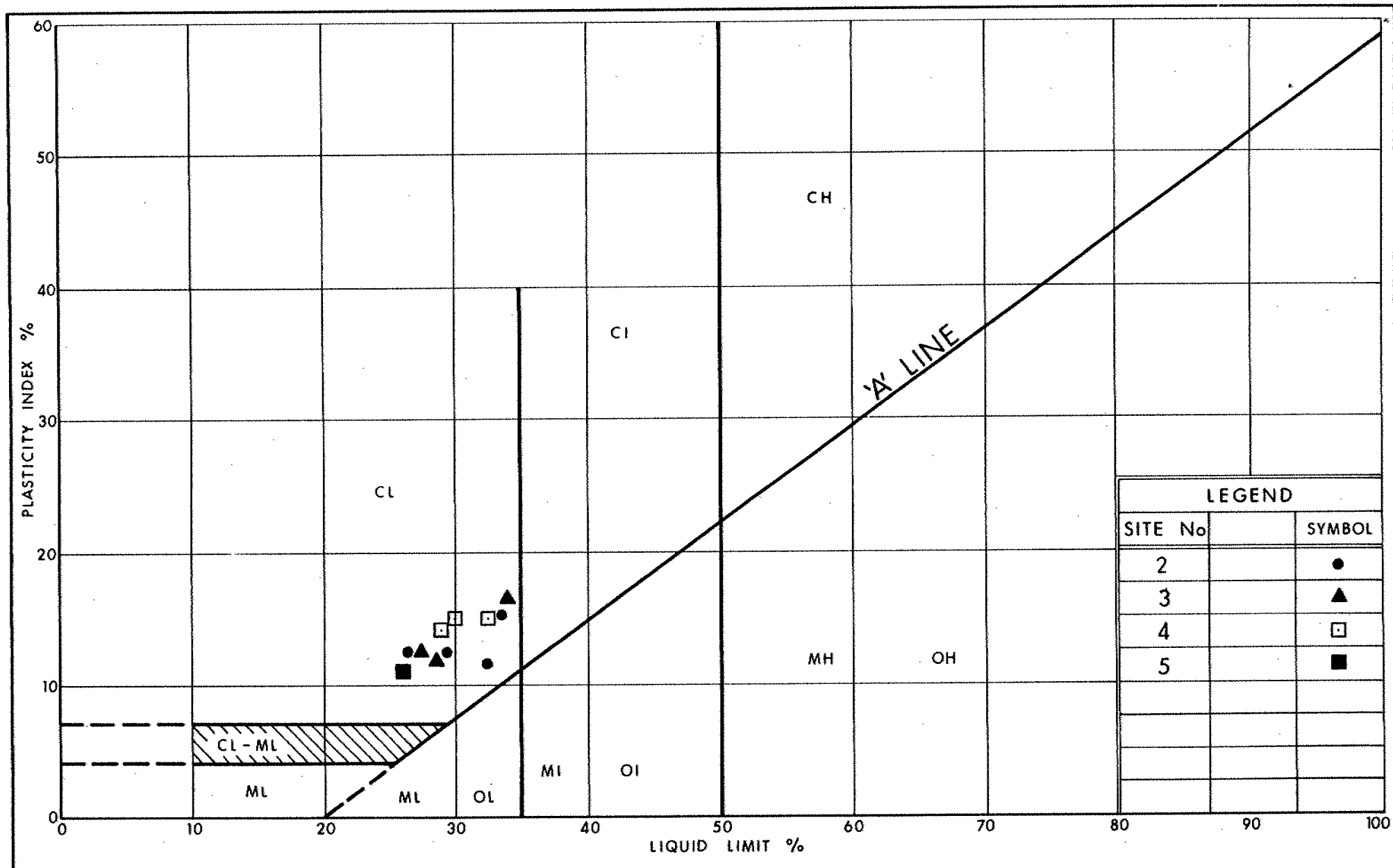


D. Dundas

D. Dundas, P.Eng.

Senior Foundation Engineer

APPENDIX

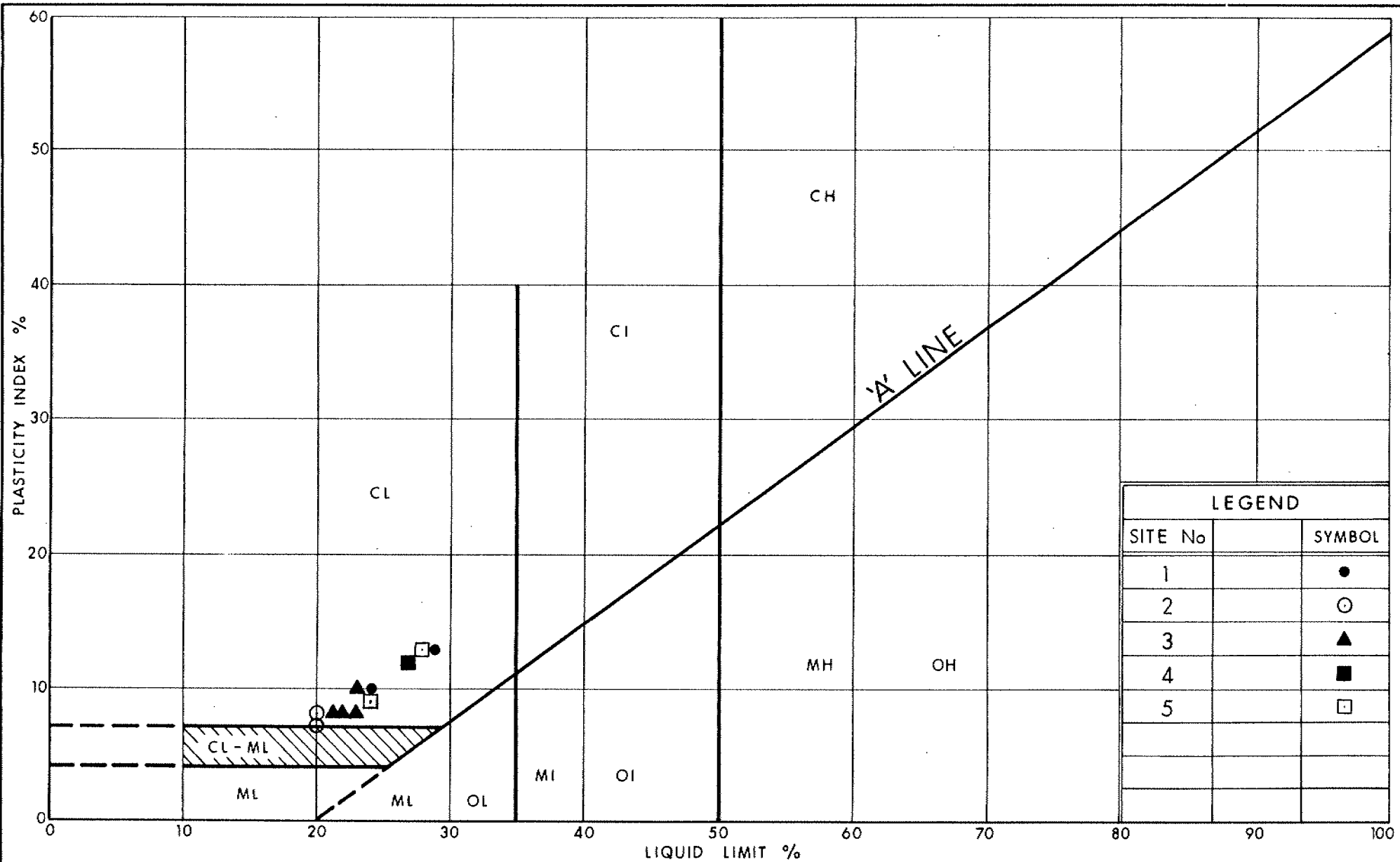


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PLASTICITY CHART CLAYEY SILT WITH RANDOM INTERBEDDED LAYERS OF SANDY SILT

FIG No 1

W P 333-89-01



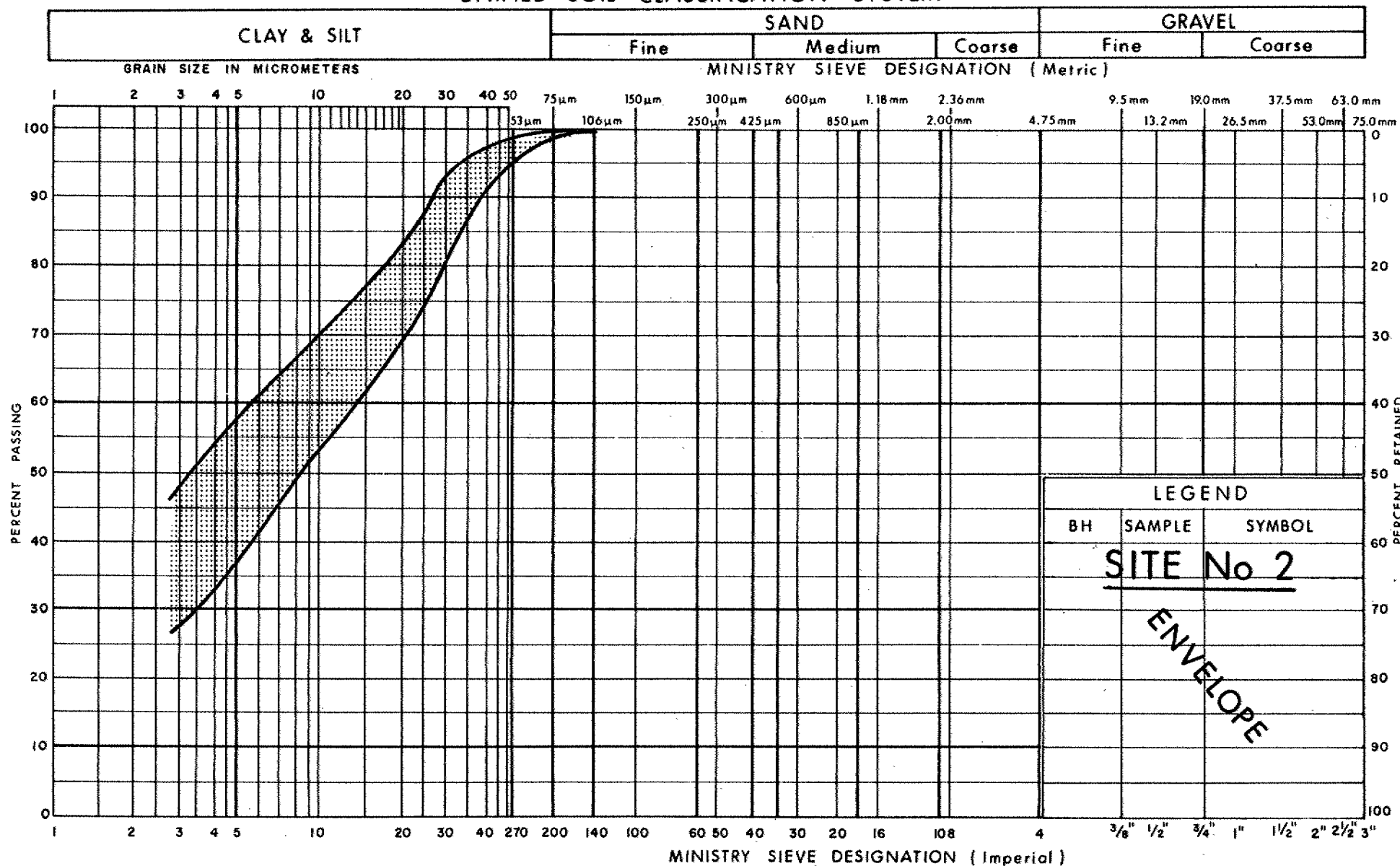
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PLASTICITY CHART
HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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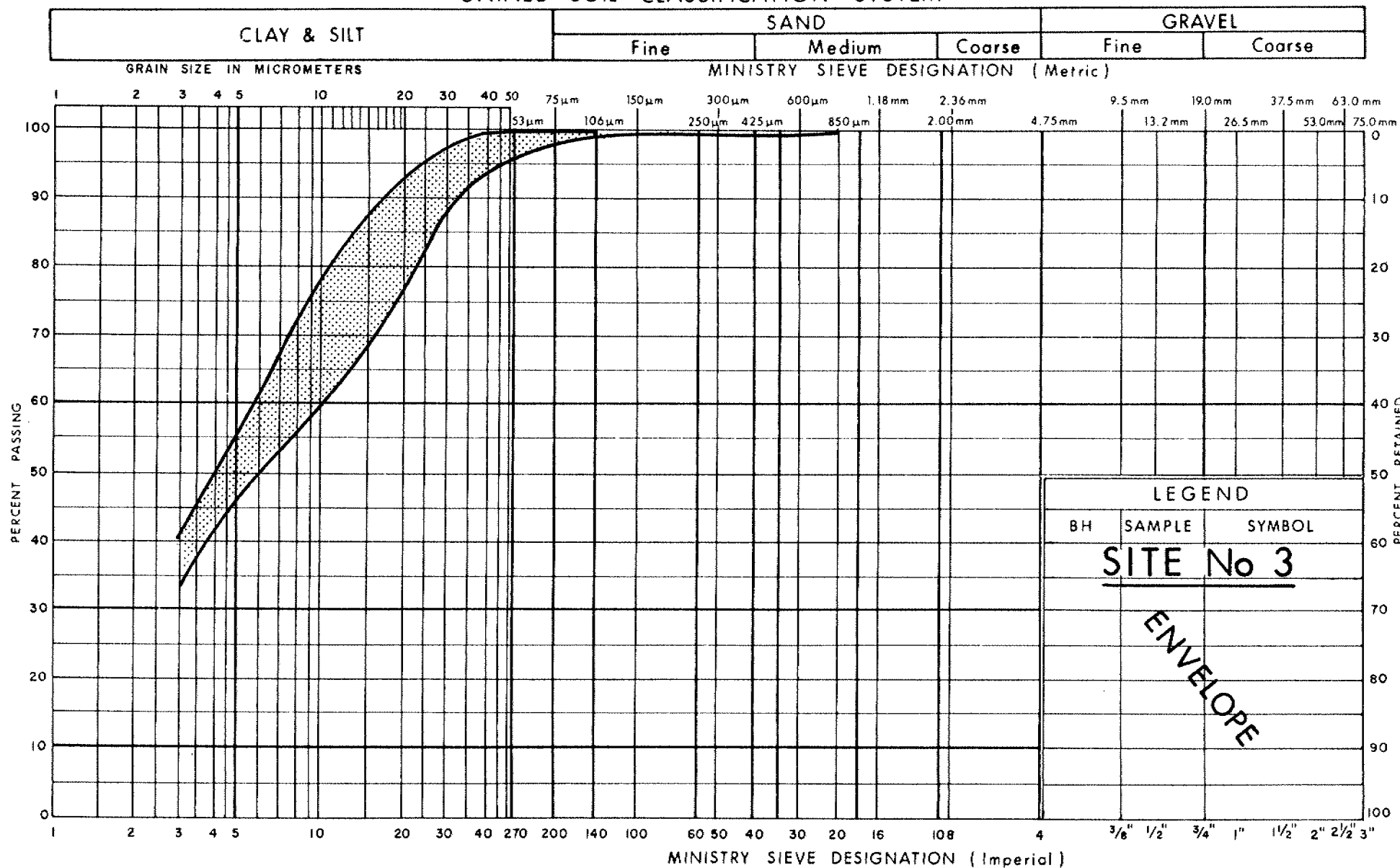
GRAIN SIZE DISTRIBUTION

CLAYEY SILT WITH RANDOM INTERBEDDED LAYERS OF SANDY SILT

FIG No 3a

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



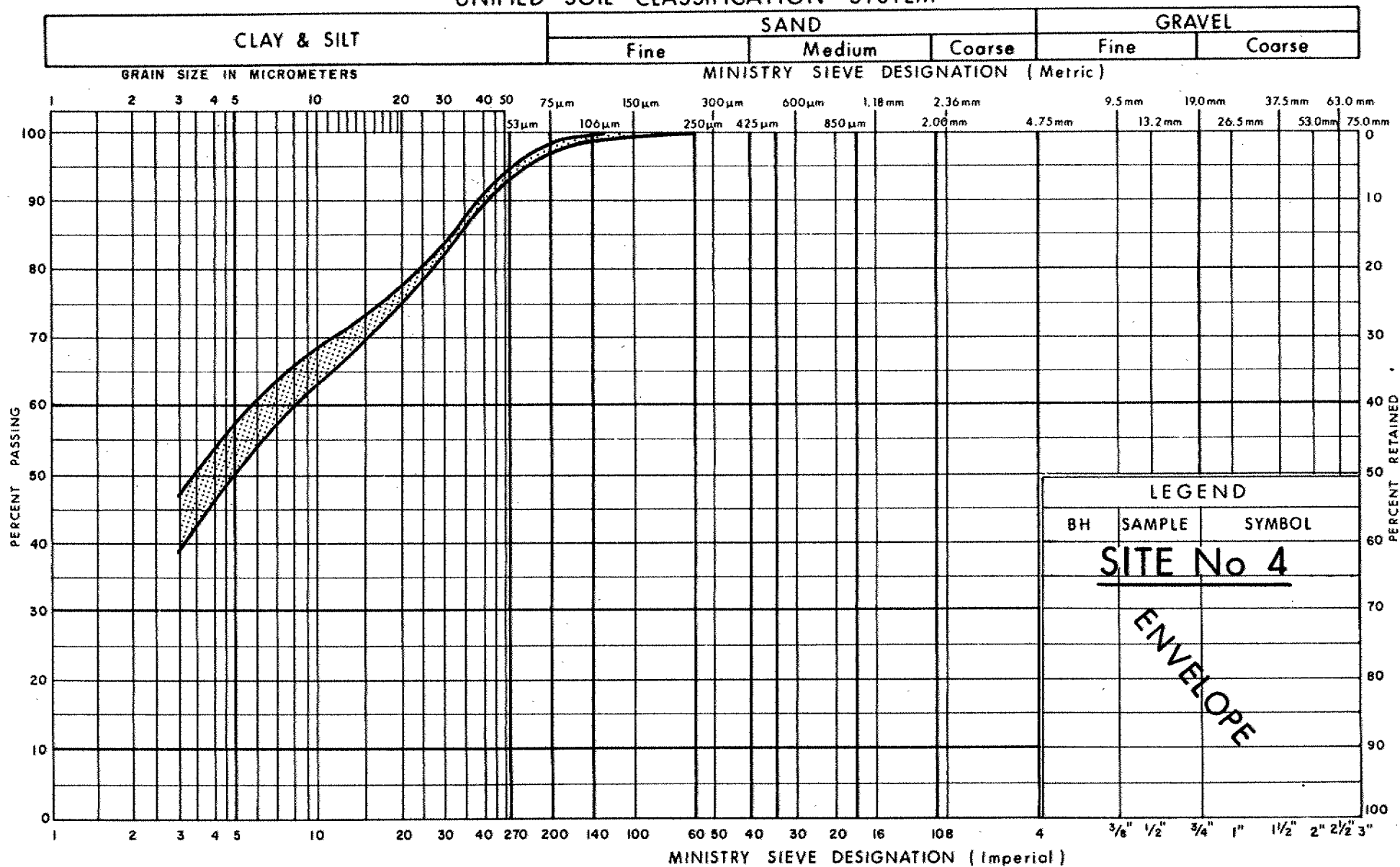
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GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH RANDOM INTERBEDDED LAYERS OF
SANDY SILT

FIG No 3b

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



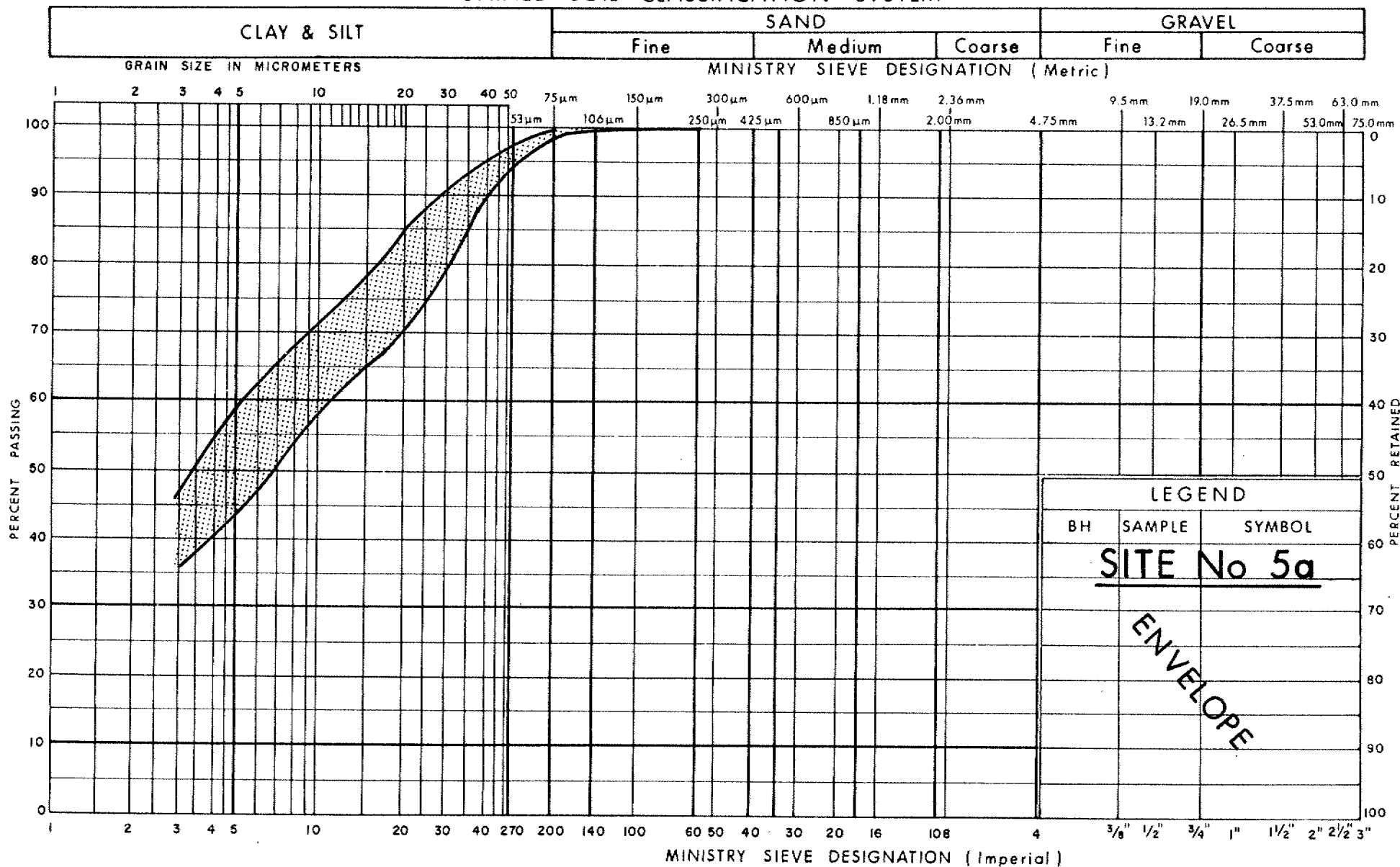
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Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH RANDOM INTERBEDDED LAYERS OF
SANDY SILT

FIG No 3c

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



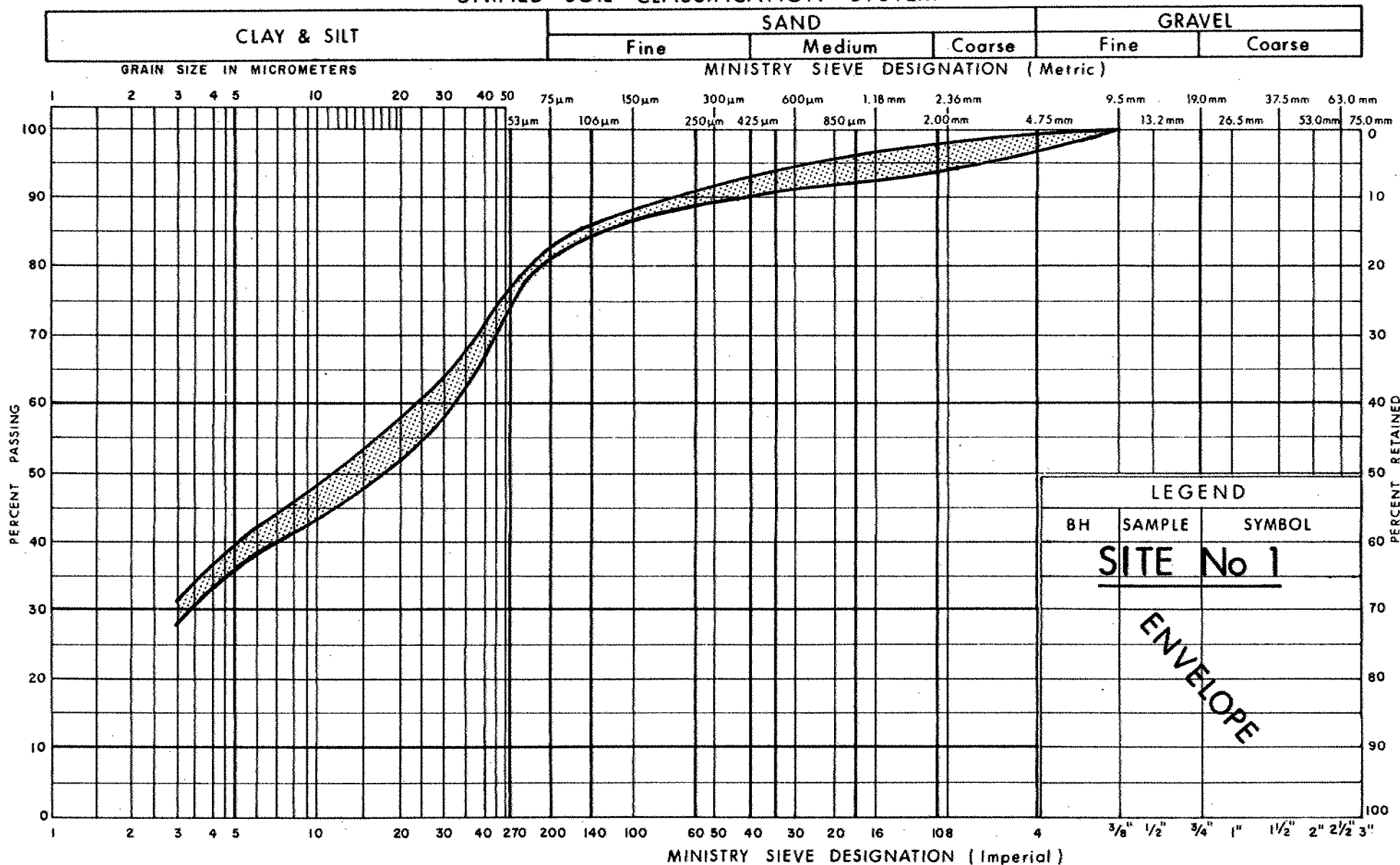
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GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH RANDOM INTERBEDDED LAYERS OF
SANDY SILT

FIG No 3d

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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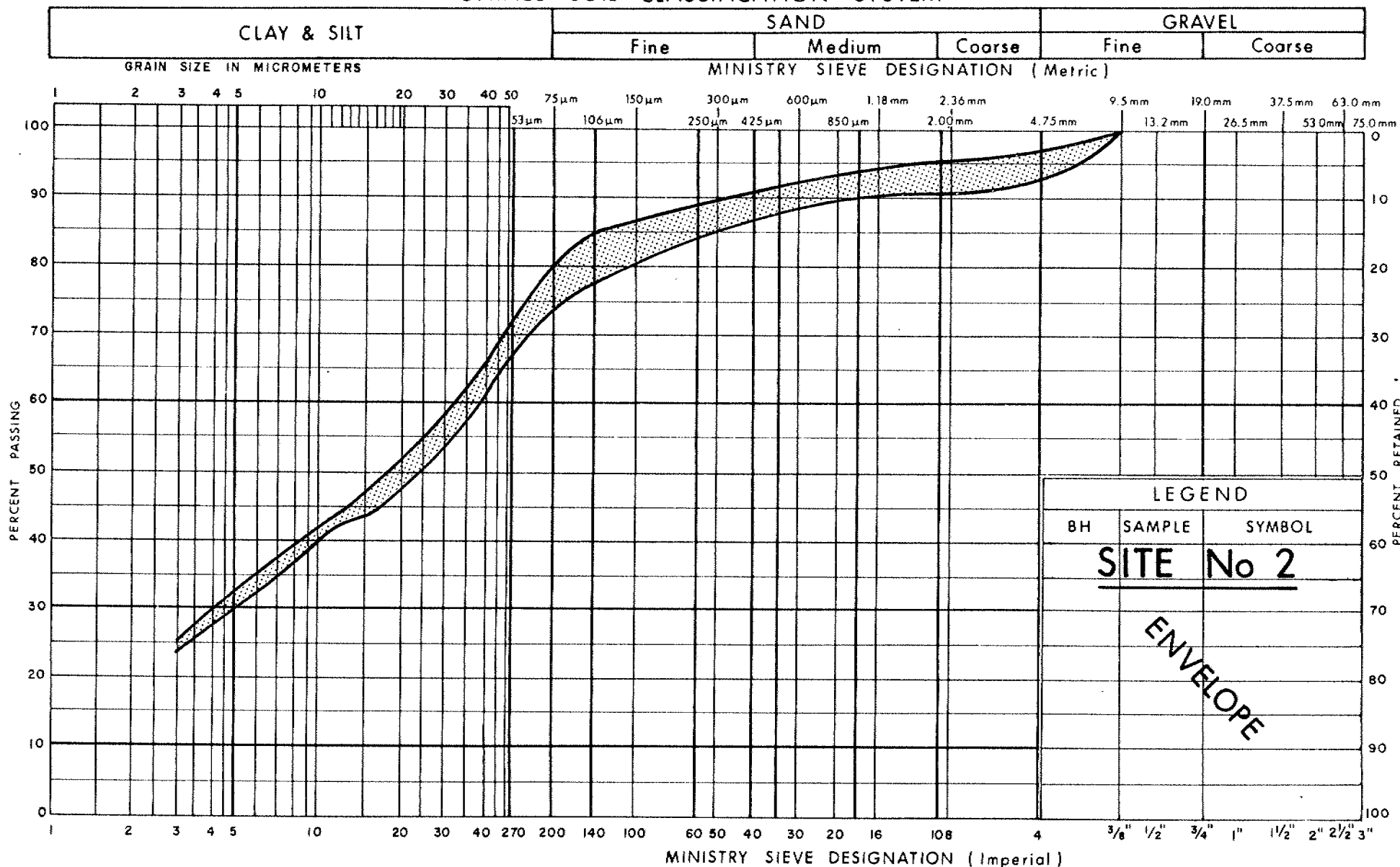
GRAIN SIZE DISTRIBUTION

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

FIG No 4a

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



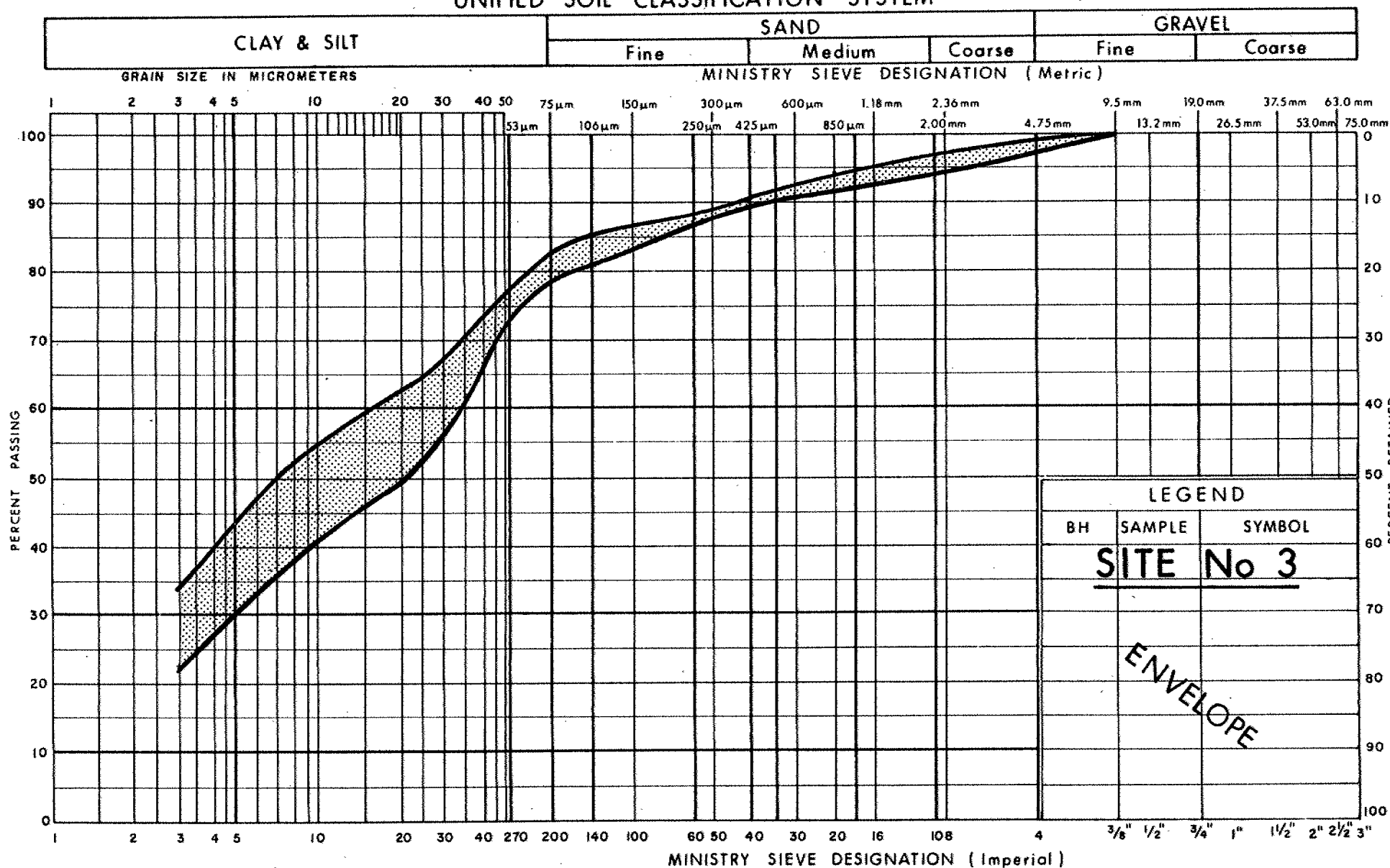
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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4b

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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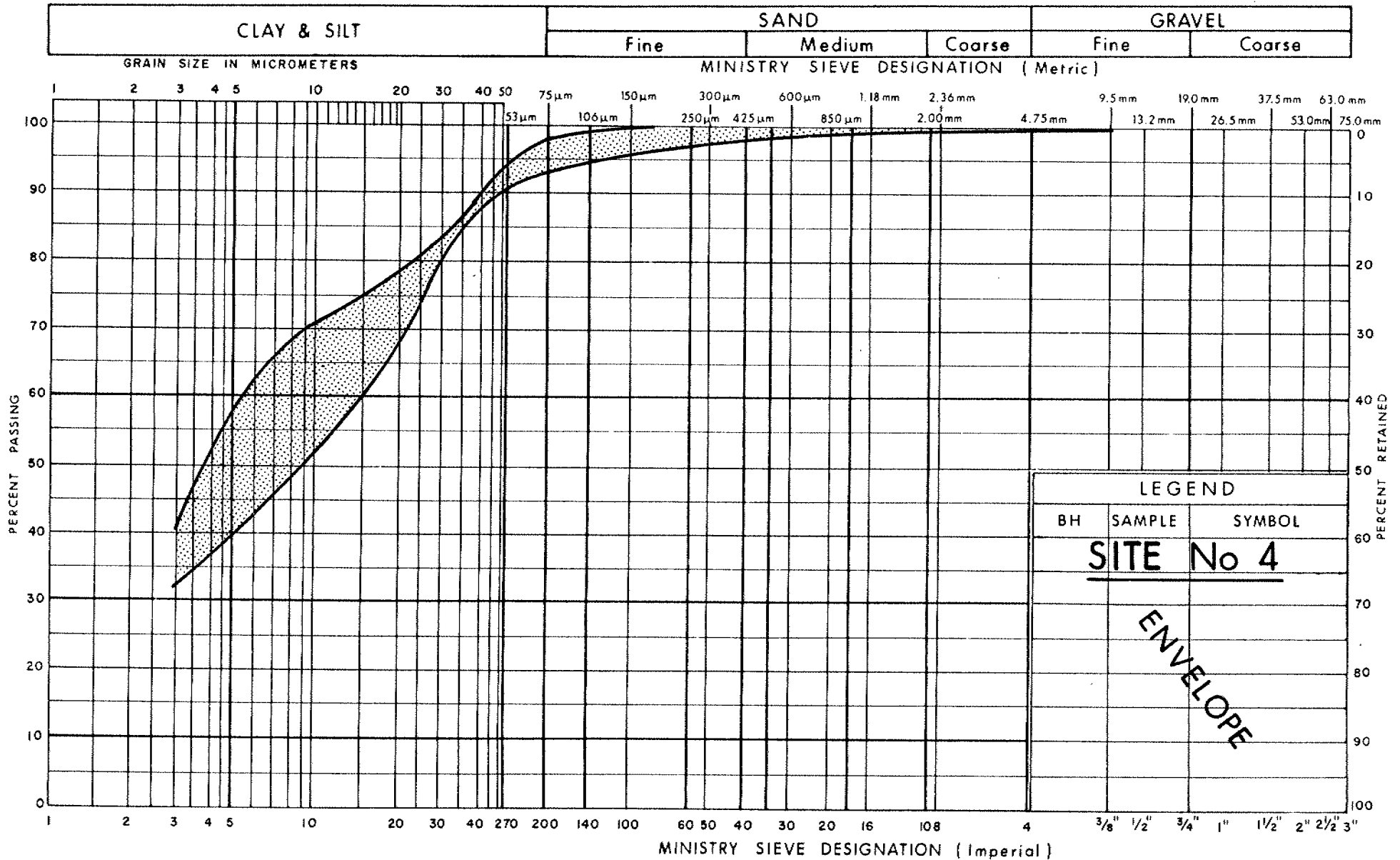
GRAIN SIZE DISTRIBUTION

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

FIG No 4c

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



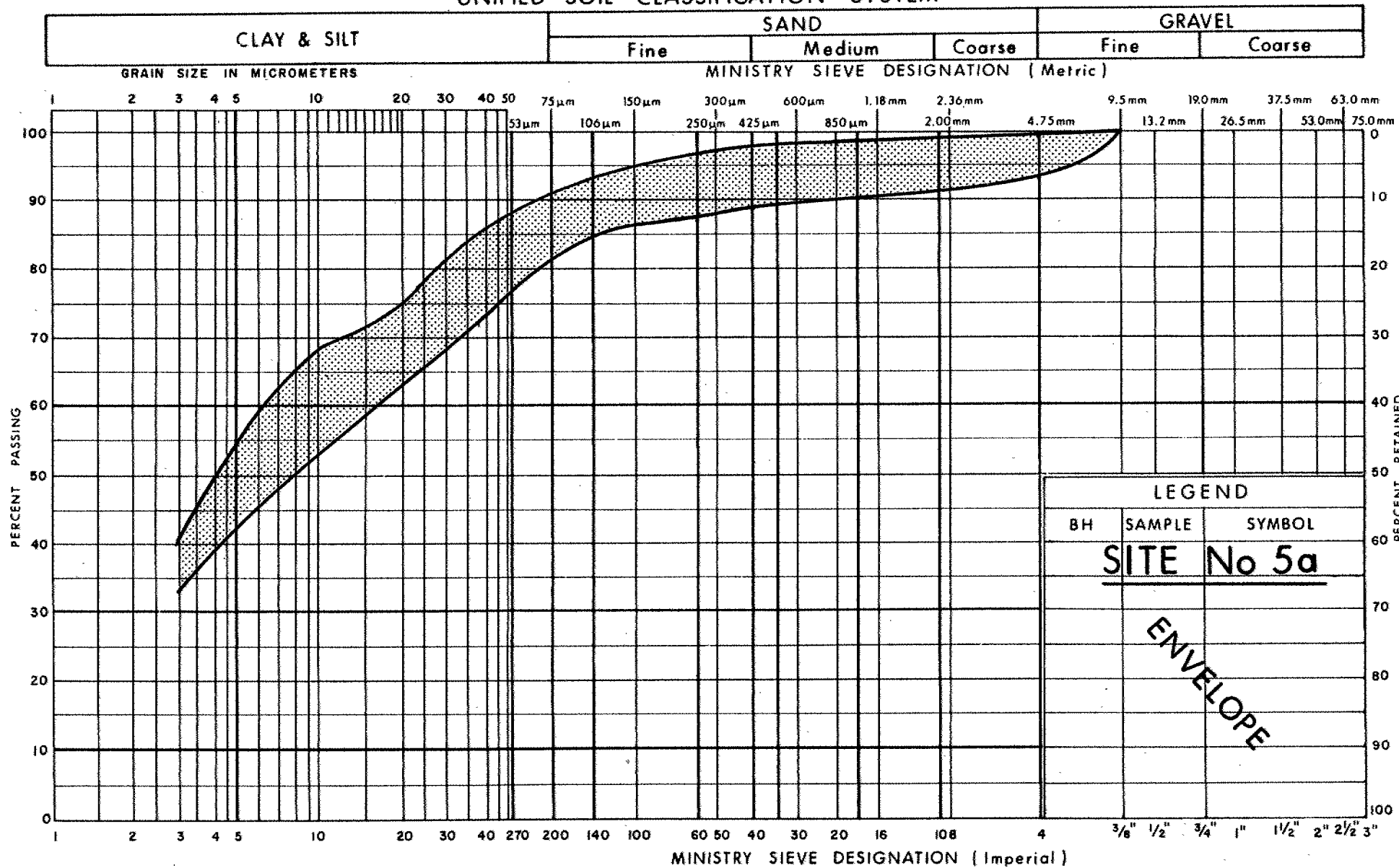
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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4d

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



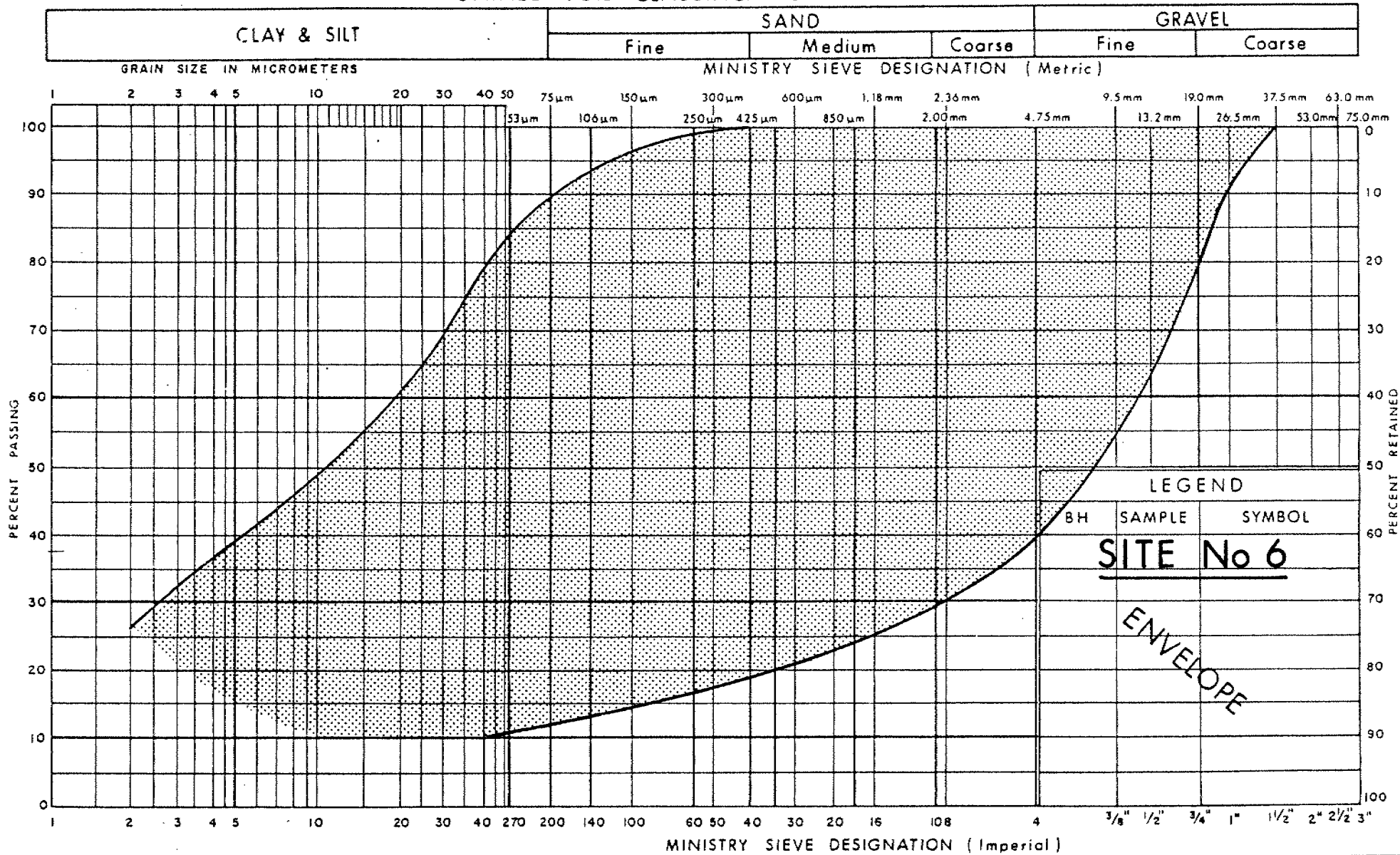
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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4e

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

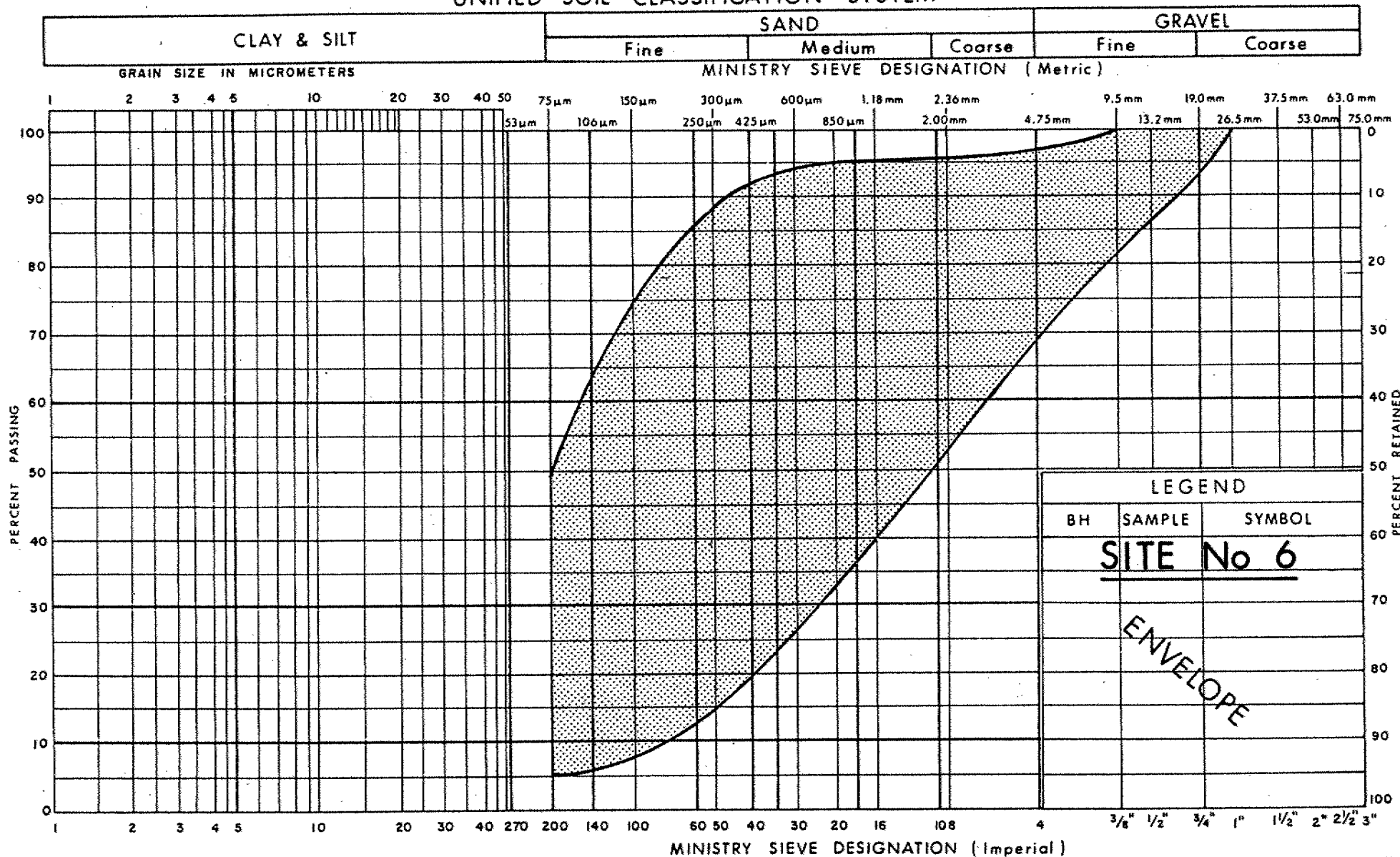
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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4f

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



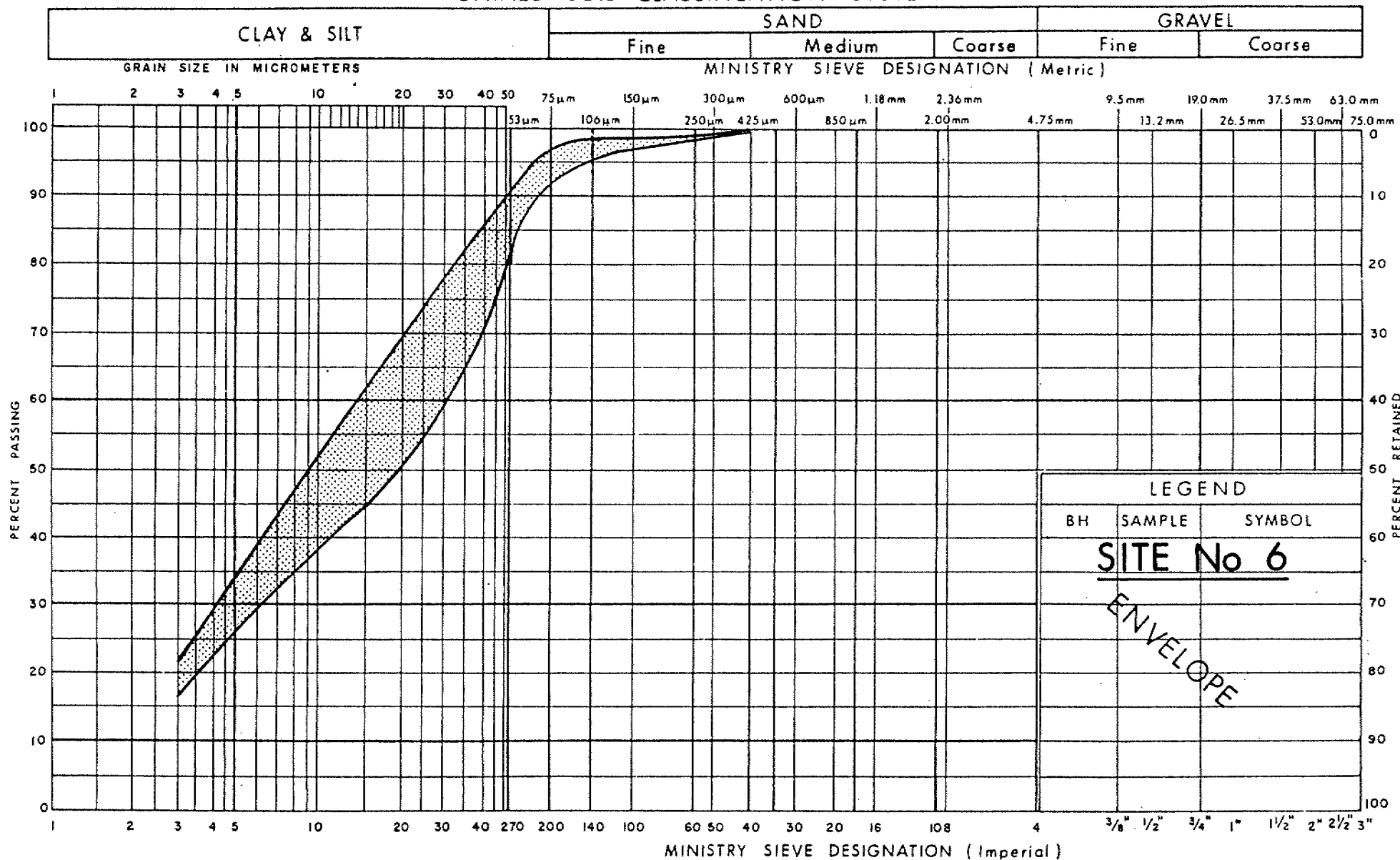
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GRAIN SIZE DISTRIBUTION
SAND TO SILTY SAND, TRACE / SOME GRAVEL

FIG No 5

W P 333-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



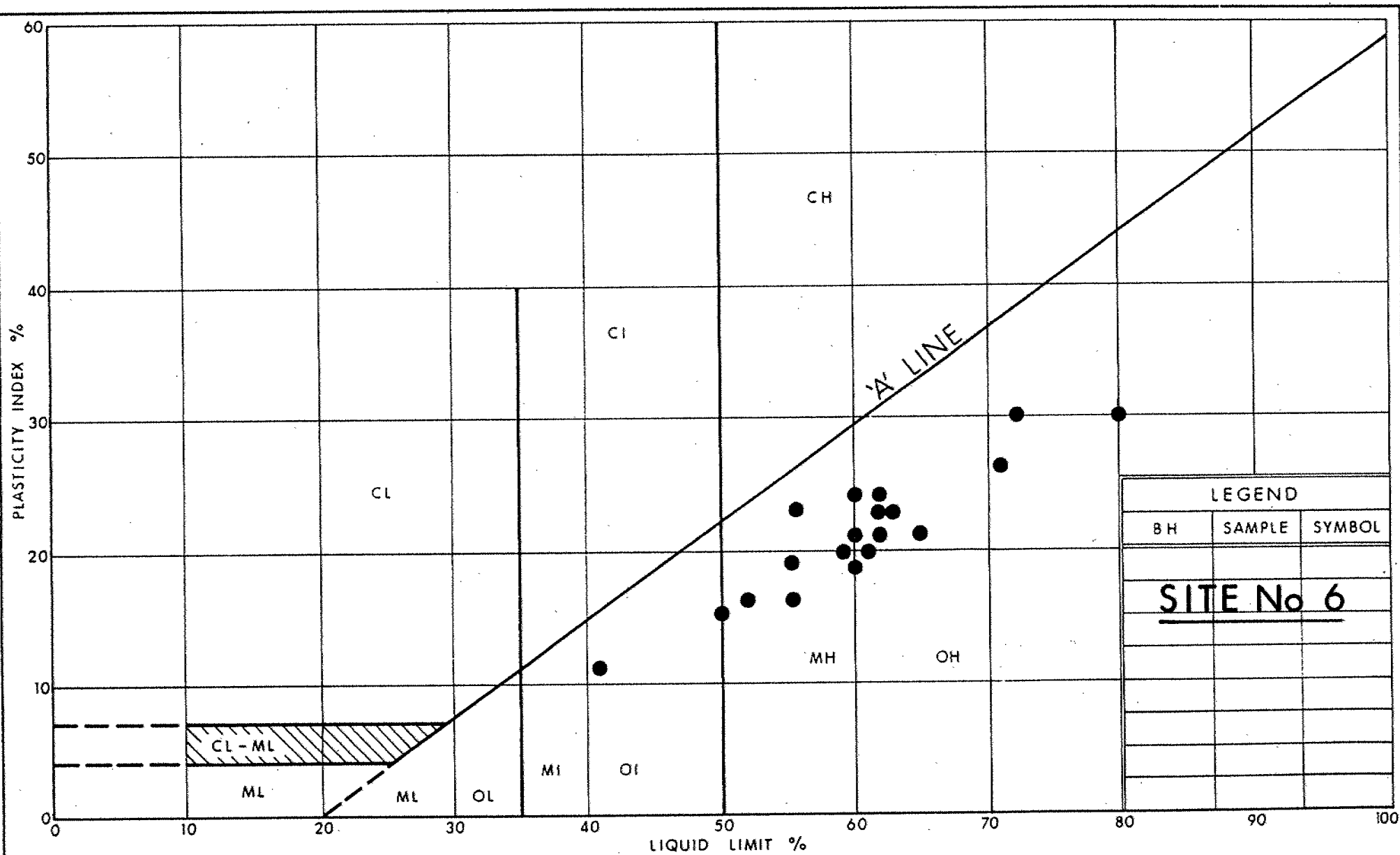
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GRAIN SIZE DISTRIBUTION

ORGANIC SILTY CLAY TO ORGANIC CLAY

FIG No 6

W P 333-89-01



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PLASTICITY CHART ORGANIC SILTY CLAY TO ORGANIC CLAY

FIG No 7





W P 333-89-01

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 782 768.5 ; E 314 560.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 94 03 09 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 (%)
								UNCONFINED		FIELD VANE		QUICK TRIAXIAL						
83.3	Ground Surface						20	40	60	80	100	20	40	60				
82.5	Irregular Mixture of Silt, Sand and Gravel (Fill Material)		1	SS	14													
0.8	Clayey Silt with random interbedded layers of Sandy Silt Brown ----- Grey Stiff to Very Stiff		2	SS	11										21.4	0 0 60 40		
			3	SS	16													
			4	SS	17													
			5	SS	16													
			6	SS	1											21.5	0 2 70 28	
			7	SS	7													
			75.7															
7.6	Stiff to Very Stiff Hard Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		8	SS	12													
			9	SS	8											7 18 54 21		
			10	SS	50													
70.7	Grey		11	SS	41													
12.6	End of Borehole * 94 03 10																	

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 782 753.7 : E 314 632.8 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 94 03 09 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					
84.3	Ground Surface																
0.0	Clayey Silt with random interbedded layers of Sandy Silt Stiff to Very Stiff Brown ----- Grey		1	SS	9		84									22.1	7 3 62 28
			2	SS	19		82									19.8	0 1 77 22
			3	SS	12												
			4	SS	12												
			5	SS	8		80										
			6	SS	3												
			7	SS	7		78									0 1 79 20	
76.7			8	SS	7		76										
7.6	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Very Stiff		9	SS	9		74										
			10	SS	17												3 17 63 17
71.7			11	SS	22		72										
12.6	End of Borehole * 94 03 10																

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-Ords N 4 782 679.4 E 314 659.6 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE SS Auger NX Core COMPILED BY TS
DATUM Geodetic DATE 94 03 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					
83.9	Ground Surface																
0.0	Clayey Silt (Fill Material) Brown, Stiff to Very Stiff		1	SS	8		82									18.1	0 7 63 30
80.9			2	SS	7												
3.0			3	SS	18												
	Clayey Silt with random interbedded layers of Sandy Silt Grey, Very Stiff		4	SS	9		80									20.3	0 0 60 40
			5	SS	8												
			6	SS	13		78										0 0 67 33
			7	SS	10												
76.3			8	SS	8		76										
7.6			9	SS	10												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Very Stiff to Hard		10	SS	53		74										2 18 55 25
			11	SS	39		72										2 17 61 20
			12	SS	36		70										
67.2			13	SS	70	/8cm	68										
16.7	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Unweathered Very Weak to Weak		14	RC	REC 100%		66										RQD = 50%
65.6																	
18.3	End of Borehole • 94 03 11																

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 333-89-03 LOCATION Co-ords: N 4 782 665.0 : E 314 698.0 ORIGINATED BY DR
 DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 94 03 11 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							
83.7	Ground Surface							20 40 60 80 100							
82.9	Sand, trace Silt (Fill Material)														
82.8	Clayey Silt (Fill Material) Brown, Very Stiff		1	SS	17										
1.5	Brown ----- Grey Clayey Silt Stiff to Very Stiff		2	SS	26		82								
			3	SS	9										
			4	SS	5								0 2 74 24		
			5	SS	13										
			6	SS	17								0 0 75 25		
			7	SS	17										
			8	SS	14										
			9	SS	25										
74.8	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Very Stiff to Hard		10	SS	38		74								
			11	SS	34								3 12 55 30		
			12	SS	40										
69.5															
14.2	End of Borehole * 94 03 11														

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 782 655.0 ; E 314 738.0 ORIGINATED BY DR
 DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 94 03 14 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			SHEAR STRENGTH kPa										WATER CONTENT (%)																																																																																																																			
								20 40 60 80 100																																																																																																																													
81.6	Ground Surface																																																																																																																																				
0.0	Clayey Silt with random interbedded layers of Sandy Silt Grey, Very Stiff		1	SS	4	*	80																																																																																																																														
2			SS	5	78																																																																																																																																
3			SS	4																								76																																																																																																									
4			SS	11																																				74																																																																																													
5			SS	7																																																72																																																																																	
6.1	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Very Stiff to Hard		6	SS																																																												11	/10cm	68									3 14 69 14																																																										
7			SS	23																																																												70																																																																					
8			SS	54																																																																																			66																																														
9			SS	23																																																																																															64																																		
10			SS	23																																																																																																											62																						
67.9	Weathered ----- Unweathered		11	SS																																																																																																																							70	60									
13.7			Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Very Weak to Weak																																																																																																																								12										
65.0	End of Borehole								56																																																																																																																												
16.6			* GWL not established																54																																																																																																																		
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RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 782 636.0 ; E 314 787.0 ORIGINATED BY DR
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 94 03 14 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					
77.8	Ground Surface																
0.0	Clayey Silt with random interbedded layers of Sandy Silt		1	SS	11		76										
			2	SS	16												
			3	SS	16												
	Brown		4	SS	7		74										
74.0	Stiff to Very Stiff		5	SS	9												
3.8			6	SS	16												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		7	SS	25		72										
			8	SS	27												
	Grey, Very Stiff to Hard		9	SS	23		70										
			10	SS	106	/10cm	68										
67.1			11	SS	76	/15cm											
10.7	Shale Bedrock with interbedded Siltstone		12	RC	REC		66										
65.5	Red with interbedded Grey, Very Weak to Weak, Unweathered				100%												RQD = 78%
12.3	End of Borehole * GWL not established																

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 333-89-03 LOCATION Co-ords: N 4 782 634.4 ; E 314 820.9 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 94 03 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					
75.8	Ground Surface																
0.0	Organic Silt Black, Very Loose		1	SS	2												
74.3			2	SS	4												
1.5	some Organics, Black-Grey, Loose		3	SS	16												
	Silty Sand, some Gravel		4	SS	7												
	Grey, Loose to Compact		5	SS	6												
71.2			6	SS	2												
4.6	Organic Clayey Silt Grey, Stiff		7	SS	2												
69.7			8	SS	12												
6.1	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		9	SS	60												
	Grey, Very Stiff		10	SS	60												
67.6	Red, Hard		11	RC	REC												
8.2	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Unweathered, Very Weak to Weak				100%												
65.9																	
9.9	End of Borehole																
	* 94 03 11																

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-Ords: N 4 782 653.0 E 314 709.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NX Core COMPILED BY TS
DATUM Geodetic DATE 94 03 14 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					
84.9	Ground Surface																
0.0			1	SS	7		84									20.4	0 3 67 30
	Clayey Silt with random interbedded layers of Sandy Silt		2	SS	20												
			3	SS	25												
	Brown, Stiff to Very Stiff		4	SS	13		82									20.2	
			5	SS	4												
	Grey, Soft to Firm		6	SS	4		80	2									
			7	SS	9		78	+2									
	Stiff to Very Stiff		8	SS	12												
75.8			9	SS	13		76									22.3	0 7 67 26
9.1			10	SS	33		74										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		11	SS	35		72										
	Grey, Hard		12	SS	30		70										
			15	SS	41												
66.6			16	SS	126	/23cm	68										
18.3			17	SS	151	/30cm	66										
	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Very Weak to Weak		18	RC	REC 100%												RQD = 21%
64.7																	
20.2	End of Borehole * 94 03 14																

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-Ords N 4 782 635.0 E 314 760.0 ORIGINATED BY DR
 DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 94 03 15 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		
85.0	Ground Surface													
0.0	Clayey Silt with random interbedded layers of Sandy Silt		1	SS	17		84							
	Stiff to Very Stiff		2	SS	10		82							0 1 58 41
	Brown													
	Grey		3	SS	2		80							
77.4							78							
7.6	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		4	SS	18		76							0 1 72 27
	Grey, Stiff to Very Stiff		5	SS	18									
			6	SS	25									
72.4			7	SS	32		74							
12.6	End of Borehole * 94 03 15													

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 781 981.4 : E 316 453.3 ORIGINATED BY DR
 DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
 DATUM Geodetic DATE 94 03 09 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							20 40 60				
85.8	Ground Surface																		
0.0	Silt, Some/Trace Sand, with random layers of Clayey Silt (Fill Material) Brown Grey Compact		1	SS	12		84							0 18 64 18					
82.8			2	SS	15									0 7 84 9					
3.0	Clayey Silt		4	SS	8		82							0 1 62 37					
81.2	Grey, Stiff to Very Stiff		5	SS	10														
4.6	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Stiff to Very Stiff		6	SS	10		80							1 12 63 24					
			7	SS	8														
			8	SS	8		78												
			9	SS	9														
			10	SS	9		76							3 9 58 30					
			11	SS	10														
73.2			12	SS	9		74												
12.6	End of Borehole * 94 03 10																		

RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 781 974.2 : E 316 526.8 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 94 03 10 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					
86.1	Ground Surface													
0.0	Silt, some Sand with random layers of Clayey Silt (Fill Material) Compact		1	SS	15									0 12 71 17
	Brown		2	SS	13									
83.1	Grey		3	SS	14									0 1 66 33
3.0	Clayey Silt Grey, Firm to Stiff		4	SS	11									
			5	SS	7									
			6	SS	3									
80.1														
6.1	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Stiff to Very Stiff		7	SS	2									0 9 60 31
			8	SS	3									
			9	SS	20									
			10	SS	11									
73.5			11	SS	13									
12.6	End of Borehole • 94 03 11													

RECORD OF BOREHOLE No 13

1 OF 2

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 781 977.0 ; E 316 491.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 94 03 10 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		
85.0	Ground Surface													
0.0	Silt, Trace Sand with random layers of Clayey Silt (Fill Material) Very Loose to Compact		1	SS	11									
	Brown		2	SS	12									
	Grey		3	SS	2									
83.0			4	SS	3									
3.0	Clayey Silt (Fill Material) Firm Stiff to Very Stiff		5	TW	PH									
	Grey		6	SS	9									
79.9			7	SS	9									
6.1	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey		8	TW	PH									
	Stiff Very Stiff		9	SS	13									
			10	SS	22									
			11	SS	13									
			12	SS	17									
			13	SS	16									
			14	SS	12									
			15	SS	17									
			16	SS	65	/15cm								
57.0	Hard		17	SS	1									
29.0	Silty Sand to Sand and Gravel Grey, Very Dense													
55.5														
30.5														

Continued

+3, x⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 13

2 OF 2

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 781 977.0 ; E 316 491.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 94 03 10 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		
55.5	Continued		18	SS	66	15cm										
30.5	Silty Sand to Sand and Gravel Grey, Very Dense															
52.0			19	SS	66											0 66 (34)
34.0	End of Borehole * GWL not established ** Disturbed (Soil Cave-in)															

RECORD OF BOREHOLE No 14

1 OF 1 METRIC

W.P. 333-89-01 LOCATION Co-Ords N 4 782 723.0 E 314 267.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 94 03 16 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		
78.0	Ground Surface													
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material) Brown, Stiff		1	SS	9									
76.5			2	SS	24									
1.5			3	SS	17									
			4	SS	24									
			5	SS	14									
			6	SS	23									
			7	SS	26									
			8	SS	20									
			9	SS	100									
			10	SS	60									
			11	SS	60									
65.8	Shale Bedrock with interbedded Siltstone, Red to Grey, Weathered													
12.4	End of Borehole.													
	* 94 03 16													

RECORD OF BOREHOLE No 102
(Formerly BH No 102 of WP 325-89-01)

1 OF 1

METRIC

W.P. 333-89-01 LOCATION CO - ORDS: N 4 782 608.0; E 315 036.0 ORIGINATED BY M.V.
DIST 4 HWY QEW BOREHOLE TYPE HOLLOW STEM AUGER, NW CASING & CONE TEST COMPILED BY M.V.
DATUM GEODETIC DATE 92 06 30 CHECKED BY P.P.

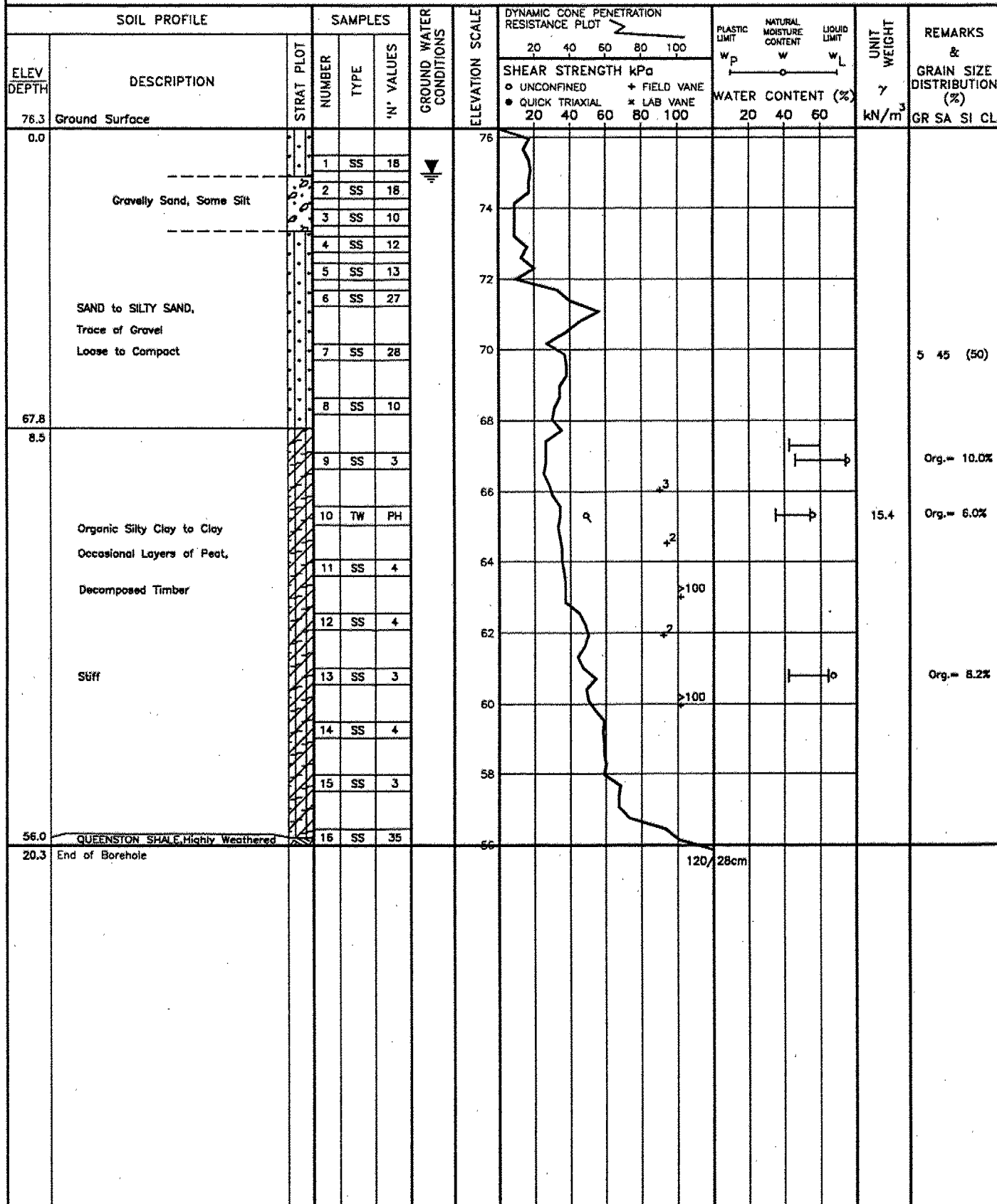
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L	WATER CONTENT (%)			
77.1	Ground Surface													
0.0	Organics		1	SS	5		76							
	SAND to SILTY SAND, Trace of Gravel, Loose to Compact		2	SS	10		74							
			3	SS	23		72							
	Sandy Silt		4	SS	12		70							4 83 (13)
70.1	Organic Silty Clay to Clay Occasional Layers of Peat, Stiff		5	SS	4		68							Org. = 6.4%
7.0			6	SS	3		66							
66.1			7	TW	PH		64							
11.0	Het. Mix. of GRAVEL, SAND & SILT Compact (Glacial Till)		8	SS	18									
65.1			9	SS	88									
12.0	QUEENSTON SHALE, Highly Weathered		10	SS	100									
63.2														
13.9	End of Borehole													
	* Water Level Not Established													

RECORD OF BOREHOLE No 103
(Formerly BH No 103 of WP 325-89-01)

1 OF 1

METRIC

W.P. 333-89-03 LOCATION CO - QRS: N 4 782 656.0 : E 314 942.0 ORIGINATED BY M.V.
DIST 4 HWY QEW BOREHOLE TYPE HOLLOW STEM AUGER, NW CASING & CONE TEST COMPILED BY M.V.
DATUM GEODETIC DATE 92 07 02 CHECKED BY P.P.



RECORD OF BOREHOLE No 201

1 OF 1

METRIC

W.P. 333-89-01

LOCATION

Co-ords: N 4 782 637.4 E 314 988.3

ORIGINATED BY TS

DIST 4 HWY QEWBOREHOLE TYPE HS Auger, NW Casing, NXL Core

COMPILED BY TS

DATUM Geodetic

DATE _____

93 09 20

CHECKED BY PP

[illegible]

RECORD OF BOREHOLE No 202

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 782 625.4 E 315 005.4 ORIGINATED BY TS
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NW Casing, NXL Core COMPILED BY TS
 DATUM Geodetic DATE 93 09 21 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		
77.4	Ground Surface													
0.0	Sand and Gravel (Fill Material)													
75.9	Brown, Compact													
1.5	Sand to Silty Sand some Gravel		1	SS	14									28 66 (6)
			2	SS	32									
	Brown, Compact to Dense													
	Grey, Very Loose		3	SS	4									
69.8														
7.6	Organic Silty Clay to Clay		4	SS	2									
	Grey, Firm to Very Stiff		5	SS	2									
			6	SS	2									
65.2														
12.2	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		7	SS	10									
63.5	(Glacial Till) Red, Hard		8	SS	80									
13.9	Shale Bedrock with interbedded Siltstone		9	RC	REC									0 1 78 21
	Slightly to Moderately Weathered				100%									RQD = 0%
	Unweathered													
	Red with interbedded Grey, Very Weak to Weak		10	RC	REC									RQD = 0%
80.4					100%									
17.0	End of Borehole													
	• 93 09 22													

RECORD OF BOREHOLE No 203

1 OF 1

METRIC

(Formerly BH No 203 of WP 325-89-01)

W.P. 333-89-01 LOCATION Co-ords: N 4 782 618.6 E 315 028.1 ORIGINATED BY TS
 DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NW Casing, NXL Core COMPILED BY TS
 DATUM Geodetic DATE 93 09 20-21 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT 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		
78.0	Ground Surface																
0.0	Sand to Silty Sand, some Gravel																
	Brown																
	Grey		1	SS	23												
	Compact																
69.9																	
6.1	Organic Silty Clay to Clay Grey, Firm to Very Stiff		2	SS	2												
			3	SS	2												
54.4																	
11.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		4	SS	119												
63.0	Red, Very Dense		5	SS	81												
13.0	Shale Bedrock with interbedded Siltstone		6	RC	REC												
	Red with interbedded Grey, Very Weak to Weak																
	Slightly Weathered		7	RC	REC												
59.8	Unweathered				100%												
16.2	End of Borehole																
	* 93 09 22																

RECORD OF BOREHOLE No 502

1 OF 1

METRIC

W.P. 333-89-01 LOCATION Co-ords: N 4 782 602.0, E 315 033.0 ORIGINATED BY DR
DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NXI Core COMPILED BY TS
DATUM Geodetic DATE 94 01 20 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					
75.9	Ground Surface																
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material)																
74.9	Brown, Very Loose		1	SS	3												
2.0	Sand to Silty Sand, some Gravel																
	Grey, Compact		2	SS	14												
69.1																	
7.8	Organic Silty Clay to Clay Grey, Stiff to Very Stiff		3	SS	2												
66.2																	
10.7	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		4	SS	4												
	Red, Soft																
63.0			5	SS	60												
13.9	Slightly to Moderately Weathered Unweathered																
	Shale Bedrock with Interbedded Siltstone		6	RC	REC 100%												RQD = 41%
	Red with interbedded Grey, Very Weak to Weak		7	RC	REC 100%												RQD = 33%
60.0																	
16.9	End of Borehole																
	* 94 01 21																

RECORD OF BOREHOLE No 502A

1 OF 1

METRIC

W.P. 333-89-01 LOCATION CO - ORDS: N 4 782 607.0 ; E 315 020.0 ORIGINATED BY R M
DIST 4 HWY QEW BOREHOLE TYPE WASHBORING COMPILED BY M V
DATUM GEODETIC DATE 65 11 02 CHECKED BY P P

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					
76.1	Ground Surface																
0.0	SILTY SAND, Occasional Gravel, Compact to Dense		1	SS	37		74										
			2	SS	36												
			3	SS	26												
			4	SS	36												
			5	SS	14												
70.0	Organic Silt Clay to Clay Firm to Stiff		6	TW	PM		70									19.2	
6.1			7	TW	PM												
			8	TW	PM												
65.4	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		9	SS	26		68										
10.7			10	SS	95												
			11	SS	100												
			12	SS	100												
60.5	End of Borehole						66										
15.6																	

ROCK CORE DESCRIPTION **WP 333-89-01**

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
4	14	16.78-18.30	100	50	16.78-18.30	SHALE , greyish red, with interbedded greenish grey SILTSTONE (30%); minor gypsum nodules up to 2 cm in diameter; very fine grained; very weak to weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
6	12	15.06-16.59	100	27	15.06-16.59	SHALE , greyish red, with interbedded greenish grey SILTSTONE (8%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 15.06-15.29 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
7	12	10.82-12.34	100	76	10.82-12.34	SHALE , greyish red, with interbedded greenish grey SILTSTONE (3%); minor gypsum nodules up to 2 cm in diameter; very fine grained; very weak to weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to dipping, planar to undulating, smooth.
8	11	8.41-9.93	100	23	8.41-9.93	SHALE , greyish red, with interbedded greenish grey SILTSTONE (16%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 8.41-8.66 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
9	18	18.72-20.24	100	21	18.72-20.24	SHALE , greyish red, with interbedded greenish grey SILTSTONE (10%); minor gypsum nodules up to 3 cm in diameter; very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 18.72-18.85 m and 19.35-19.56 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.

*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

ROCK CORE DESCRIPTION **WP 333-89-01**

Page 1 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
201	5	12.65-14.17	90	45	12.65-15.70	SHALE , greyish red, with interbedded greenish grey SILTSTONE (9%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 12.65-13.82 m); fractures moderate to extremely close spaced, flat to dipping, undulating to planar, smooth.
	6	14.17-15.70	100	84		
202	9	13.94-15.47	100	0	13.94-16.99	SHALE , greyish red, with interbedded greenish grey SILTSTONE (6%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 13.94-15.14 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	10	15.47-16.99	100	0		
203	6	13.11-14.63	98	15	13.11-16.15	SHALE , greyish red, with interbedded greenish grey SILTSTONE (4%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 13.11-14.20 m); fractures wide to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	7	14.63-16.15	100	93		
502	6	13.89-15.42	100	41	13.89-16.94	SHALE , greyish red, with interbedded greenish grey SILTSTONE (5%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 13.89-14.17 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	7	15.42-16.94	100	33		

*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

FOUNDATION INVESTIGATION REPORT

For

Culvert Replacement

W.P. 333- 89-00

Queen Elizabeth Way

Jordan Road

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out at 2 proposed culvert replacement sites in the City of St. Catharines, 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 condition.

2.0 SITE DESCRIPTION AND GEOLOGY

Two (2) culvert replacement sites are located along the QEW at Jordan Road in St. Catharines. 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. At each culvert location beneath the QEW, there is an additional two separate culverts constructed beneath the North Service Road and the South Service Road.

Physiographically, the sites in St. Catharines lie in the glacial Lake Iroquois stratified sands and silts. 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 of the culvert locations. The test locations are indicated on Drawings 3338900-A and 3338900-B provided in Appendix. 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 suitable 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 D 1586). 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.

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. The 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 Appendix.

A brief discussion of the observed subsurface conditions is provided below. Specific details of the subsurface materials at a particular culvert location should be obtained from the Record of Boreholes.

4.2 W.P. 333-89-00

4.2.1 Topsoil

Topsoil was encountered at the ground surface in all boreholes except the boreholes located in the median of the QEW. The thickness of the topsoil ranges from 100 mm to 300 mm.

4.2.2 Fill

A mixture of sand, silt and gravel (fill) layer was encountered at the ground surface in Boreholes 138-06-2 and 138-07-2. The thickness of the fill layer ranged from 0.2 m to 0.3 m. Based on visual identification and laboratory tests, this fill can be classified as inorganic and cohesionless.

A silt (fill) with some sand and clay was observed in Boreholes 138-06-01, 139-06-02, and 138-07-02. The thickness of the fill layer ranged from 3.0 m to 3.4 m. The SPT conducted in this fill layer yielded N values ranging from 7 to 30, indicating a relative density of loose to compact. Laboratory analysis carried out on a sample of the fill indicated a grain size distribution of 0% gravel, 10% sand, 76% silt and 14% clay. The moisture content of the fill ranged from 12% to 20% with an average of about 15%. Based on visual observation and laboratory tests, this material can be classified as inorganic and cohesionless.

4.2.3 Silt

A silt with some sand and clay was encountered underlying the fill or topsoil in all boreholes except Boreholes 138-07-2 and 138-07-3. Where present, the silt surface was encountered at elevations ranging from El. 82.3 m to El. 85.5 m (depths of 0.3 m to 3.0 m).

The SPT conducted in the silt layer yielded N values ranging from 3 to 26, indicating a relative density of loose to compact. Laboratory analyses carried out on a representative sample of the silt indicated a grain size distribution of 0% gravel, 18% sand, 71% silt and 11% clay. The moisture content of the silt ranged from 13% to 19%, with an average of about 17%. This material is classified as cohesionless. Non-cohesive deposits such as this silt material are susceptible to base disturbance or boiling if an unbalanced piezometric head is introduced during construction.

4.2.4 Silt and Clay

A lacustrine deposit of silt and clay with some sand was encountered underlying the fill or silt in the boreholes. The silty clay surface was encountered at elevations ranging from El. 79.2 m to El. 84.0 m.

Field vane tests indicated shear strengths exceeding 120 kPa. Based on laboratory observations and SPT correlations, the silt and clay has a general consistency in the stiff to very stiff range.

Laboratory analyses carried out on a representative sample of the silt and clay indicated a grain size distribution of 0% gravel, 34% sand, 53% silt and 13% clay. The moisture content of the silt and clay ranged from 12% to 28%, with an average of about 17%.

Based on the above testing and visual identification, this silt and clay material can generally be classified as inorganic, cohesive and of low plasticity.

4.2.5 Groundwater

Groundwater was encountered in all boreholes except Borehole 138-07-2, as noted in the Borehole Records, which caved in at 4.9 m. Groundwater levels at these locations ranged between El. 77.7 m and El. 81.5 m, or from 4.6 m to 9.2 m below ground surface prior to backfilling. Artesian conditions were not encountered in any of the boreholes.

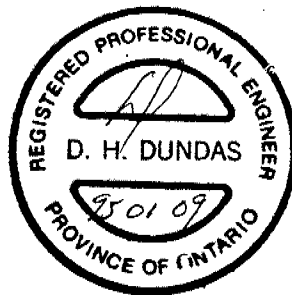
The groundwater levels noted on the Borehole Records were recorded immediately after drilling. Due to the relatively low permeability of the overburden soils, these groundwater levels may not represent the static water levels which would approximately correspond to an adjacent creek level draining into 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 Investigation Ltd. and Eastern Soil Investigation Ltd.

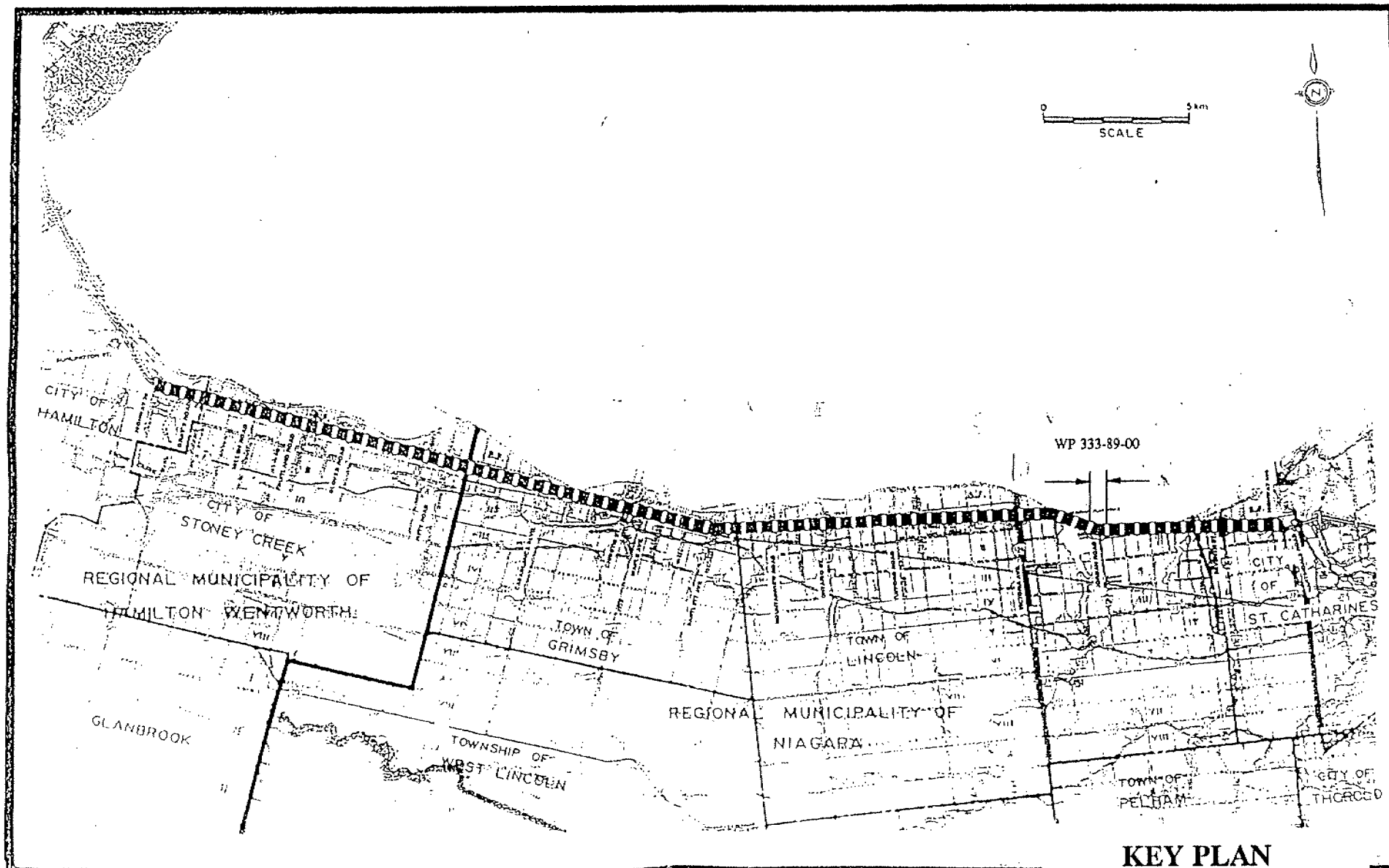
The report was prepared by C. Kwok and T. Olson, Project Engineer, and approved by G. Kack, Project Manager.

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 M.T.O. Foundation Design Section.

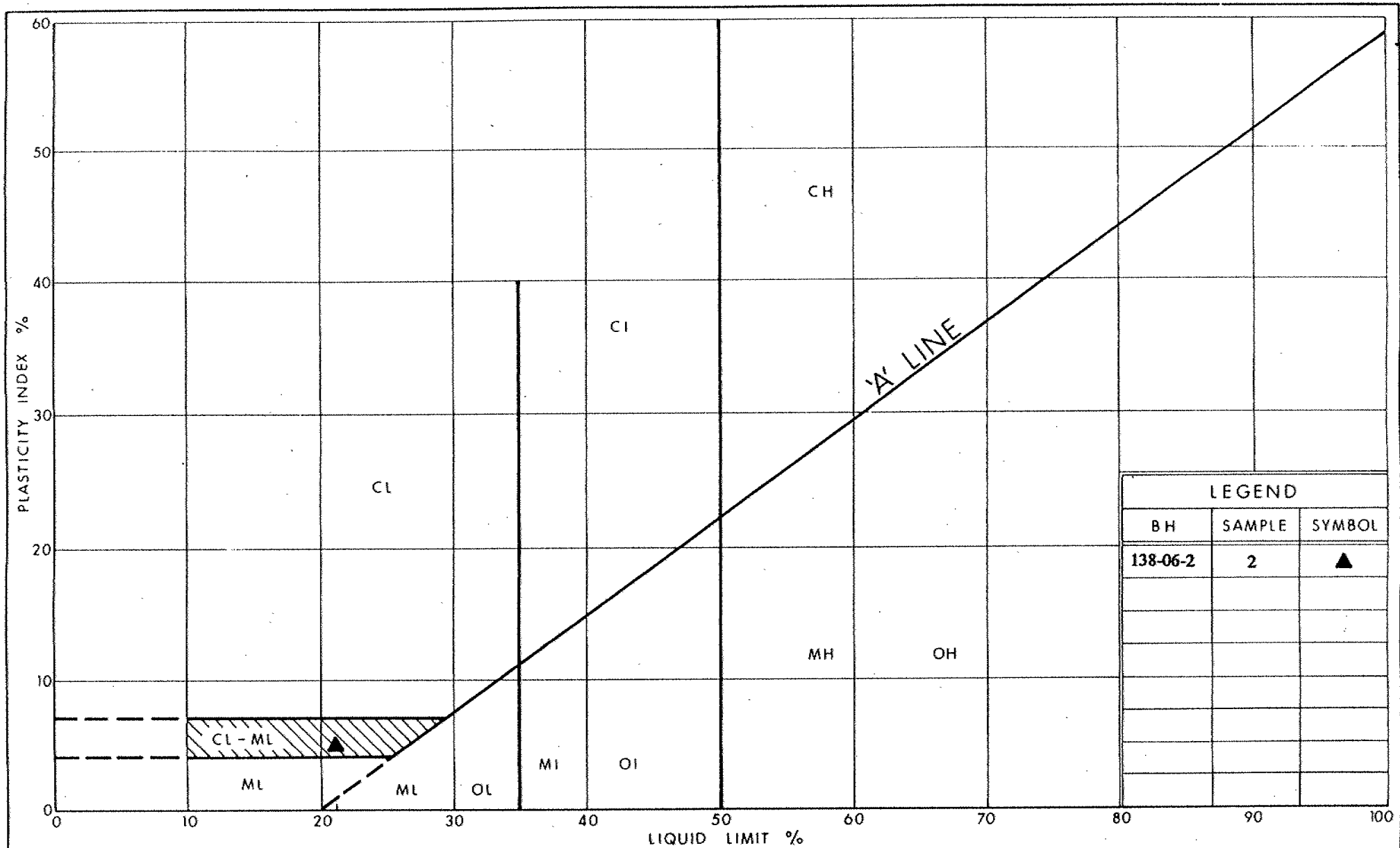


D. Dundas
D. Dundas, P.Eng.
Sr. Foundation Engineer

APPENDIX



KEY PLAN
FIGURE 1



Ministry of
Transportation

PLASTICITY CHART SILT (FILL), SOME SAND & CLAY

FIG No 6

W P 333-89-00

RECORD OF BOREHOLE No 138-06-1

1 OF 1

METRIC

W.P. 333-89-00 LOCATION WC 138-06; Sta. 12+489, O-S 42m Lt. ORIGINATED BY IK
DIST 4 HWY QEW BOREHOLE TYPE Solid Stem COMPILED BY IK
DATUM SEE TEXT DATE 94.08.25 & 94.08.25 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			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								20 40 60 80 100							
						○ UNCONFINED ✕ FIELD VANE ● QUICK TRIAXIAL ✕ LAB VANE					WATER CONTENT (%) w _p w w _L				
85.7	Ground Surface														
85.0	Topsoil		1	SS	28									0 18 71 12	
0.1	Silt (Fill), some sand and clay, trace gravel		2	SS	26										
	Compact		3	SS	30										
	Brown		4	SS	20										
82.7															
3.0	Silt, some sand and clay		5	SS	23										
	Compact		6	SS	18										
	Brown		7	SS	17										
79.6															
6.1	Silt and Clay, some sand		8	SS	11										
	Stiff to Very Stiff														
			9	SS	18										
			10	SS	20										

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

RECORD OF BOREHOLE No 138-06-2

1 OF 1

METRIC

W.P. 333-89-00 LOCATION WC 138-06; Sta. 12+489, O-S 3m Rt. ORIGINATED BY IK
DIST 4 HWY QEW BOREHOLE TYPE Solid Stem, Cone Test COMPILED BY IK
DATUM SEE TEXT DATE 94.08.17 & 94.08.17 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	WATER CONTENT (%)					
87.0	Ground Surface													
88.8	Mixture of Sand, Silt and Gravel (Fill)		1	SS	14									
0.2	Silt (Fill), some sand and clay		2	SS	10									
	Loose to Compact		3	SS	8									
	Brown		4	SS	8									
84.0	Silt, some sand and clay		5	SS	17									
	Compact		6	SS	26									
	Brown		7	SS	19									
			8	SS	18									
80.0	Silt and Clay, some sand		9	SS	7									
7.0	Firm to Very Stiff		10	SS	30									
	Grey		11	SS	21									
			12	SS	27									
74.2														
12.8	END OF BOREHOLE													

Numbers refer to Sensitivity
20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 138-06-3

1 OF 1

METRIC

W.P.	333-89-00	LOCATION	WC 138-06; Sta. 12+489, O-S 38m Rt.	ORIGINATED BY	IK
DIST	4	HWY	QEW	BOREHOLE TYPE	Solid Stem
DATUM	SEE TEXT	DATE	94.08.24 & 94.08.24	COMPILED BY	IK
				CHECKED BY	TO

[illegible]

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

RECORD OF BOREHOLE No 138-07-1

1 OF 1

METRIC

W.P. 333-89-00 LOCATION WC 138-07; Sta. 13+248, 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 & 94.08.24 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			20	40	60	80	100	
85.8	Ground Surface											
85.0	Topsoil		1	SS	11							
0.3	Sandy Silt, trace clay											
	Loose to Compact		2	SS	16							
	Brown		3	SS	10							
			4	SS	3							
			5	SS	10							
82.0												
3.8	Silt and Clay, sandy		6	SS	3							
	Very Stiff											
	Grey											
			7	SS	16							
			8	SS	11							
			9	SS	23							
76.1												
9.8	END OF BOREHOLE											

*³ . x³ . Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 138-07-2

1 OF 1

METRIC

W.P. 333-89-00 LOCATION WC 138-07; Sta. 13+248, O-S 3m Rt. ORIGINATED BY IK
DIST 4 HWY QEW BOREHOLE TYPE Solid Stem, Cone Test COMPILED BY IK
DATUM SEE TEXT DATE 94.08.18 & 94.08.18 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	40					
86.2	Ground Surface													
85.9	Mixture of Sand Silt and Gravel (Fill)		1	SS	16									
0.3	Compact													
	Silt (Fill), some sand, trace clay and gravel		2	SS	15									
	Loose to Compact		3	SS	14									
	Brown		4	SS	7									
82.8			5	SS	8									
3.4	Silt and Clay, some sand													
	Soft		6	SS	3									
	Brown Grey		7	SS	3									
	Very Stiff													
			8	SS	27									
			9	SS	20									
			10	SS	16									
76.5														
9.8	END OF BOREHOLE													

RECORD OF BOREHOLE No 138-07-3

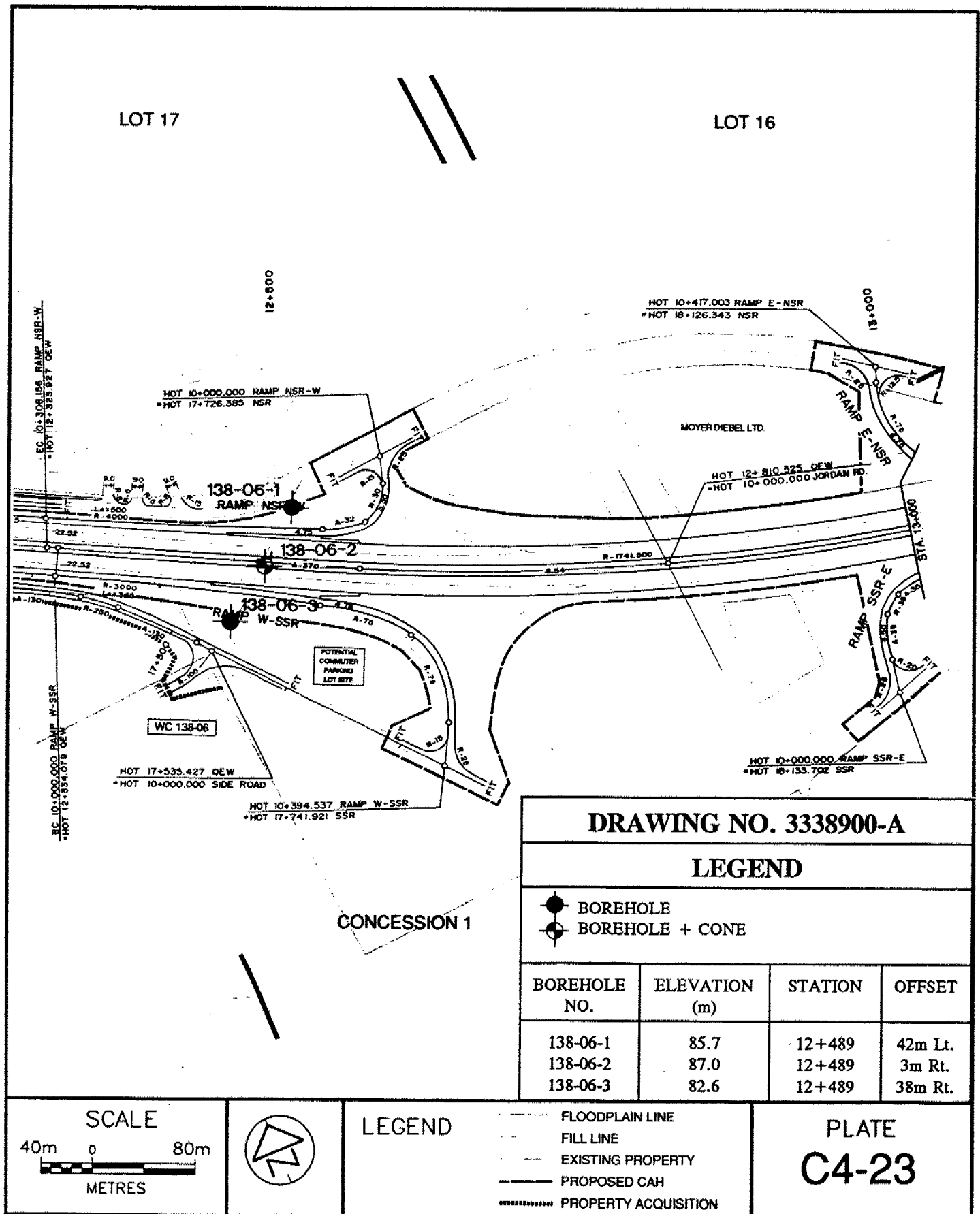
1 OF 1

METRIC

W.P. 333-89-00 LOCATION WC 138-07; Sta. 13+248, O-S 24m Rt. ORIGINATED BY JK
DIST 4 HWY QEW BOREHOLE TYPE Solid Stem COMPILED BY JK
DATUM SEE TEXT DATE 94.08.24 & 94.08.24 CHECKED BY TO

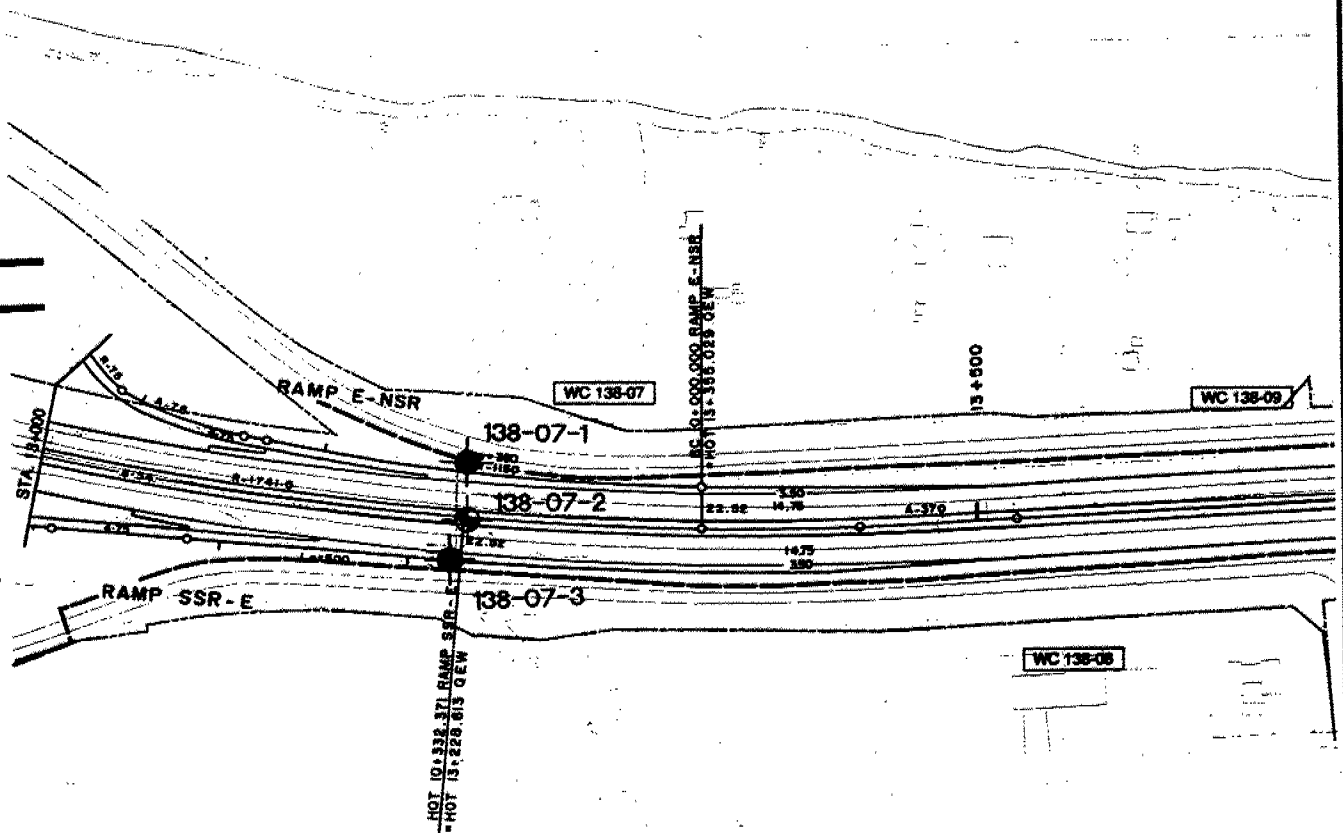
[illegible]

*³, X³: Numbers refer to Sensitivity



LOT 16

LOT 15



DRAWING NO. 3338900-B

LEGEND

- BOREHOLE
 ● BOREHOLE + CONE

BOREHOLE NO.	ELEVATION (m)	STATION	OFFSET
138-07-1	85.8	13+248	25m Lt.
136-07-2	86.2	13+248	3m Rt.
136-07-3	86.4	13+248	24m Rt.

PLATE
C4-24

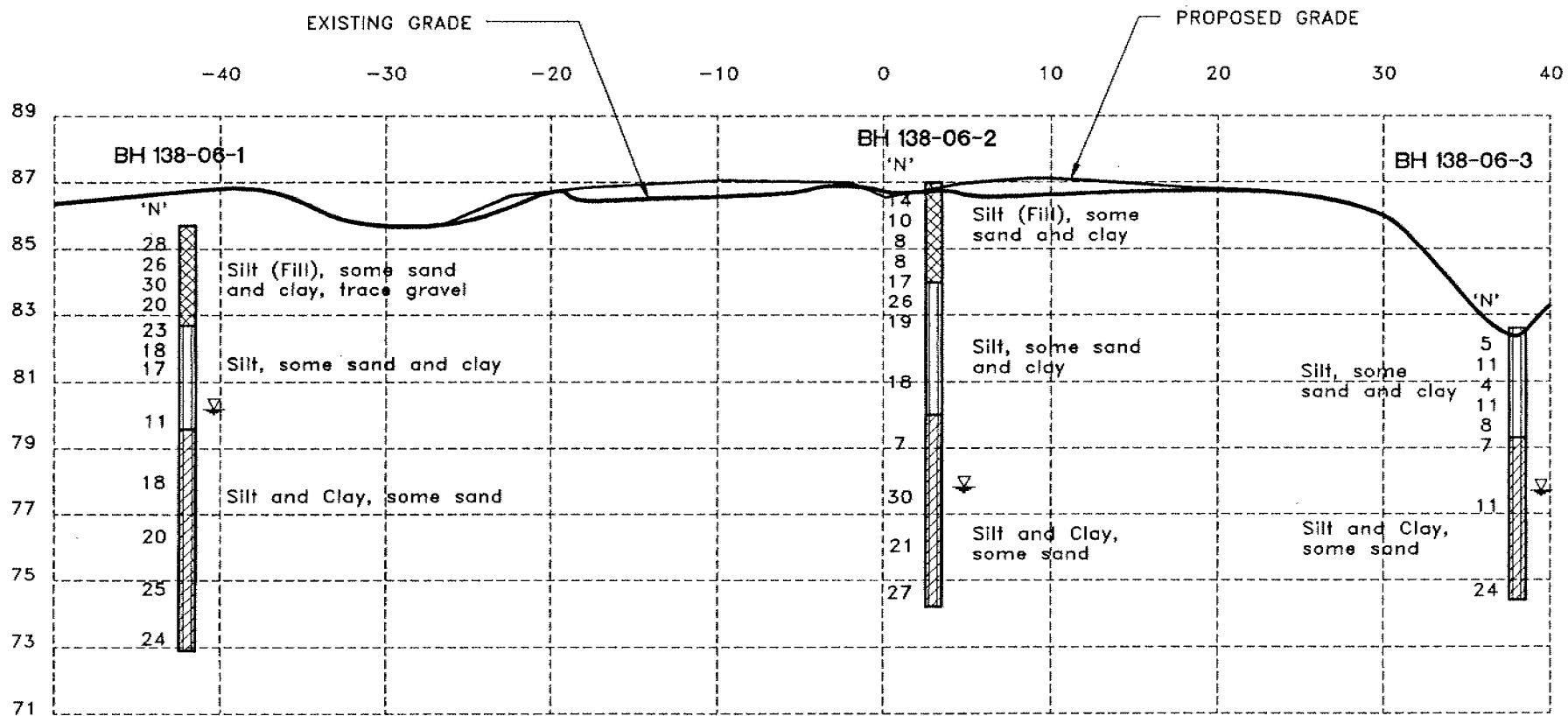
LEGEND

- FLOODPLAIN LINE
 --- FILL LINE
 --- EXISTING PROPERTY
 --- PROPOSED CAH
 --- PROPERTY ACQUISITION



SCALE





WC 138-06 - C PROFILE STATION 12+489

Job No.:
WP 333-89-00

Dwg. No.:
3338900-C

Date:
94/09/06

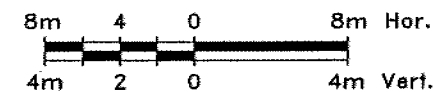
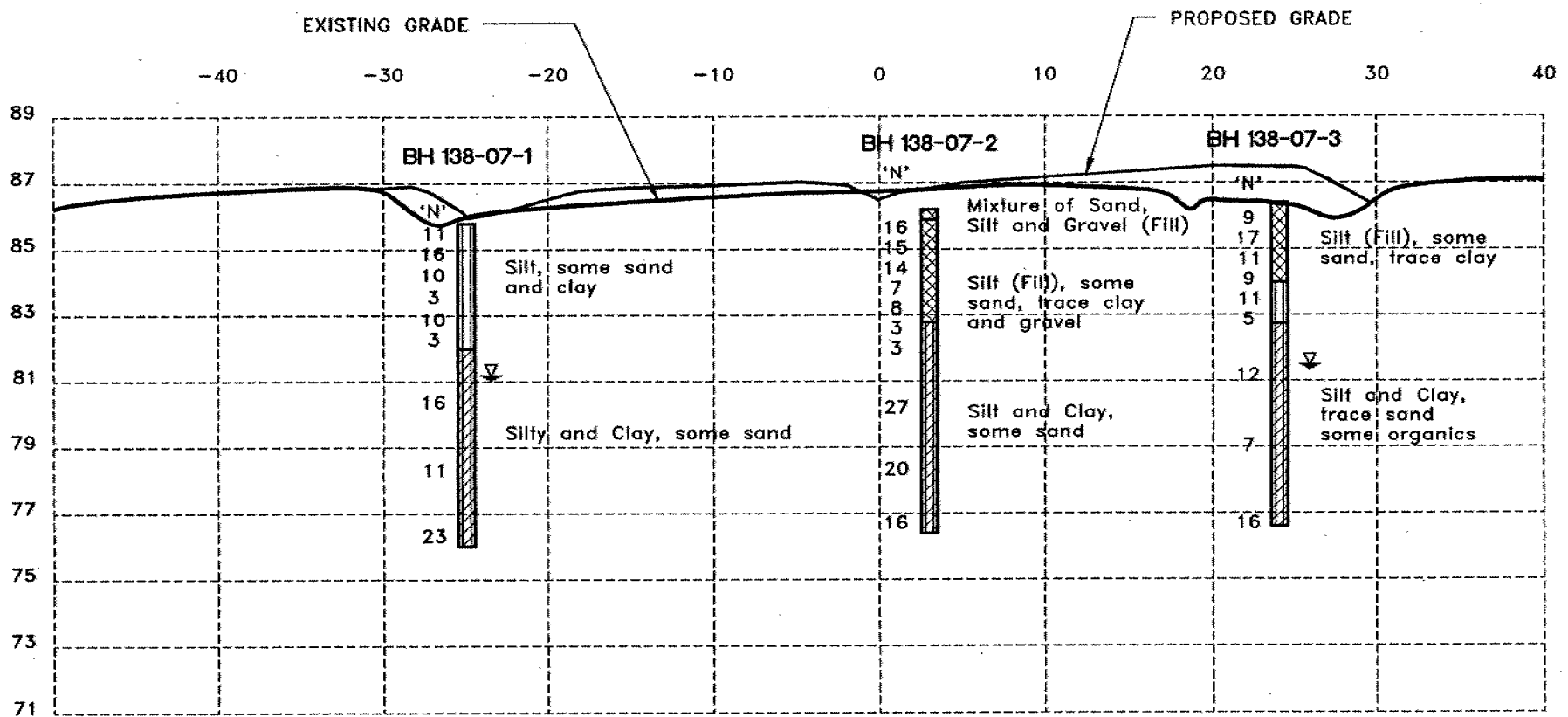
Dwn. by:
TA

Appd.:
TO



Jacques
Whitford

146



WC 138-07 - C PROFILE STATION 13+248

Job No.:
WP 333-89-00

Dwg. No.:
3338900-D

Date:
94/09/06

Dwn. by:
TA

Appd.:
TO



Jacques Whitford

147

3338900-D

FOUNDATION INVESTIGATION - Temporary Shoring
QEW Widening from Victoria Street to Jordan Road
Station 12+705 to Station 12+804
W.P. 392-85-01
District 4, Burlington

INTRODUCTION

Our office has undertaken and completed a foundation investigation planned to acquire subsurface information at the site. This fieldwork was carried out on June 16, 1994 and consisted of two sampled boreholes advanced to depths of 14.6 m and 15.7 (see borehole logs S1, S2). Subsoil samples were retrieved using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (ASTM D1586) at 1.5 m intervals. In situ vane tests were conducted in cohesive soils of weaker consistency in accordance with ASTM D2573 employing the Standard MTO 'N' vane. The samples were examined in the field, placed in sample jars to preserve moisture contents and then transported to the laboratory for further examination and classification. Physical property testing including Atterberg Limit testing, grain size distribution testing, unit weight determination and moisture content determination were then conducted in the laboratory. Groundwater levels were obtained by measurement in the open boreholes at the time of the investigation. All boreholes were backfilled upon completion.

A description of the subsurface conditions encountered at the site is given below.

SUBSURFACE CONDITIONS

The existing ground surface at the site varies between approximately 88 m and 82.3 m. Jordan Road, located at the eastern limit of the proposed shoring is situated primarily in an excavation cut with side slopes approximately 2H:1V.

The subsurface conditions at the site consists of a surficial fill material comprised of a brown sand and gravel. This material which is in a compact state of denseness and serves as a base for QEW, has a thickness of approximately 0.9 m.

The sand and gravel fill material is underlain by a native stratum of Silt to Sandy Silt that contains random interbedded layers of Clayey Silt and has a thickness ranging between 7 m and 8.2 m. The silt material ranges from a plastic silt to a non-plastic silt depending on the composition. The Clayey Silt layers have a thickness ranging from 25 mm to 500 mm. This stratum has been oxidized at some locations and is brown for the surficial 2.0 m or so at BH S2. The stratum is grey below the surficial oxidized material. Standard Penetration Test 'N' values ranged from 4 blows/0.3 m to 34 blows/0.3 m indicating a very loose to dense state of denseness. In general, however, the stratum is in a compact state of denseness. The interbedded layers of Clayey Silt can be considered as stiff.

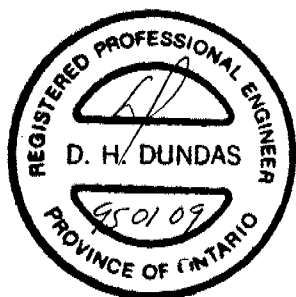
A layer of a grey, stiff cohesive Clayey Silt underlies the Silt to Sandy Silt with random interbedded layers of Clayey Silt. This layer has a thickness ranging from approximately 0.9 m to 1.6 m.

A heterogeneous mixture of Clayey Silt, Sand and Gravel of glacial till origin in turn underlies the clayey silt layer at an Elevation ranging between 77.1 m and 78.4 m. The thickness of this deposit was not determined during this investigation but previous investigations (64-F-13) indicate that this deposit has a thickness of approximately 21 to 24 m. 'N' values in this deposit ranged between 1 blow/0.3 m to 9 blows/0.3 m. In Situ Vane Tests revealed undrained shear strengths ranging from 76 kPa to in excess of 120 kPa indicating a stiff to very stiff consistency.

Groundwater levels measured in the open boreholes at the time of the investigation ranged from 3 to 4 m below the ground surface (Elevation 84.8 to 84.1). Groundwater levels, however are subject to seasonal fluctuation.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and T. Barlow, utilizing equipment owned and operated by Malones 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 D. Dundas, Senior Foundation Engineer.



D. Dundas

D. Dundas, P.Eng.

Senior Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No S 1

1 OF 1

METRIC

W.P. 392-85-01 LOCATION Co - ords: N 4 782 084.4 ; E 315 945.9 ** ORIGINATED BY T.S.
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY T.B.
DATUM Geodetic DATE 94 06 16 CHECKED BY P.P.

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					
87.8	Ground Surface																
0.0	SAND and GRAVEL (Fill Material)																
86.9																	
0.9																	
			1	SS	24		86										
			2	SS	34		84										0 65 (35)
	SILT to SANDY SILT, with Random Interbeds of Clayey Silt Grey, Compact to Dense/Stiff		3	SS	12		82									18.9	0 2 56 42
			4	SS	22		80										
			5	SS	13		78										0 22 (78)
78.7			6	SS	1		76										0 0 53 47
9.1	CLAYEY SILT, Grey, Stiff		7	SS	1		74										
77.1			8	SS	3												
10.7			9	SS	6												
	Heterogeneous Mixture of CLAYEY SILT, Sand and Gravel (Glacial Till) Grey, Stiff															22.4	1 6 66 27
73.2																	
14.6	End of Borehole * 94 06 16 ** Sta. 12+705, o/s 3m Rt of Median QEW																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S 2

1 OF 2

METRIC

W.P. 392-85-01 LOCATION Co - Ords: N 4 782 076.2 : E 315 992.2 ** ORIGINATED BY T.B.
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY T.B.
DATUM Geodetic DATE 94 06 16 CHECKED BY P.P.

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					
88.1	Ground Surface																
0.0	SAND and GRAVEL (Fill Material)						88										
87.2																	
0.9	SILT to SANDY SILT, with Random Interbeds of Clayey Silt, Very Loose to Compact/Stiff Brown ----- Grey		1	SS	4		86									21.3	0 11 69 20
			2	SS	14		84										0 11 (89)
			3	SS	29												
			4	SS	7		82										
80.2			5	SS	4		80										
7.9	CLAYEY SILT, Grey, Stiff		6	SS	2		78										5 1 50 44
78.3			7	SS	7		76										
9.8	Heterogeneous Mixture of CLAYEY SILT, Sand and Gravel (Glacial Till) Grey, Stiff to Very Stiff		8	SS	7		74									20.3	1 14 57 28
72.9			9	SS	7												
15.2																	

Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No S 2

2 OF 2

METRIC

W.P. 392-85-01 LOCATION Co - Ords: N 4 782 076.2 ; E 315 992.2 ** ORIGINATED BY T.B.
DIST 4 HWY QEW BOREHOLE TYPE HS Auger COMPILED BY T.B.
DATUM Geodetic DATE 94 06 16 CHECKED BY P.P.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W _p	W	W _L		
72.9	Continued															
15.2 72.4			10	SS	9											
15.7	End of Borehole * 94 06 16 ** Sta. 21+755, o/s 3m Rt of Median QEW															

MEMORANDUM



To: V. Boehnke, P. Eng.
Head, Structural Section
Central Region

Date: 94 04 29

Attn: K. Wong, P. Eng., Sr. Structural Eng.

From: Foundation Design Section
Room 315, Central Bldg.

Re: Preliminary Foundation Recommendations
Retaining Walls at Campbell's Property

Further to our meeting on April 13, 1994, Table 1 attached summarizes the foundation design options and corresponding foundation elevations for the retaining walls on Campbell's property (sites #3 and #4). Site #3 pertains to the retaining wall separating the QEW EB and the realigned Marina Access Rd. and site #4 is the retaining wall proposed south of the Marina Access Rd. As discussed, these advanced preliminary recommendations are intended to facilitate a cost estimate for these projects.

Table 2 attached provides shoring design recommendations and parameters required at Site #4. Active earth pressure coefficients can be used and the shoring wall should be designed to resist lateral earth pressures using an appropriate rectangular or trapezoidal envelope.

The shoring system must be designed to satisfy earth pressure equilibrium. This can be achieved by using rock anchors to support the wall. A grout/rock bond stress of 100 kPa can be used for a grouted anchor in the bedrock.

Attached please find drawings illustrating prefabricated concrete panels used adjacent to a temporary shoring wall on a previous GO-ALERT project. This type of facing can be considered at site #4.

The interim foundation report that will include the text component of the report for all the retaining walls is scheduled to be forwarded by May 4, 1994.

If you have questions regarding these projects, please do not hesitate to contact this office.

A handwritten signature in black ink, appearing to read "T. Sangiuliano".

T. Sangiuliano, P. Eng.
Foundation Engineer
for

D. Dundas, P. Eng.
Chief Foundation Engineer
(Acting)

DD/TS/jb

TABLE 1 - FOUNDATION RECOMMENDATIONS						
SITE	OPTION	FOUNDATION	EXTENT	ELEVATION(m)	ULS	SLS
#3	a	Shallow	11+263 to 11+358	≤81	225kPa	150kPa
			11+358 to 11+400	≤77	225kPa	150kPa
		Deep-Caissons - Piles	>11+400	67	3500kPa 1600 kN	N/A 1150kN
	b	Deep-Caissons	11+263 to 11+400	67	3500kPa 1600kN	N/A 1150kN
			>11+400	67	3500kPa 1600kN	N/A 1150kN
#4		Deep-Caissons - Piles	Full	66	3500kPa 1600kN	N/A 1150kN


Table 2 - Shoring Design Parameters				
Soil	Elevation (m)	Unfactored Angle of Internal Friction (ϕ)	Bulk Unit Weight (γ) (kN/m ³)	Coefficient of Active Earth Pressure (K_a)
Clayey Silt with random layers of sandy silt	85 - 76	30	20	0.33
Het. Mixture of clayey silt, sand and gravel (Glacial Till)	76 - bedrock	32	21	0.31

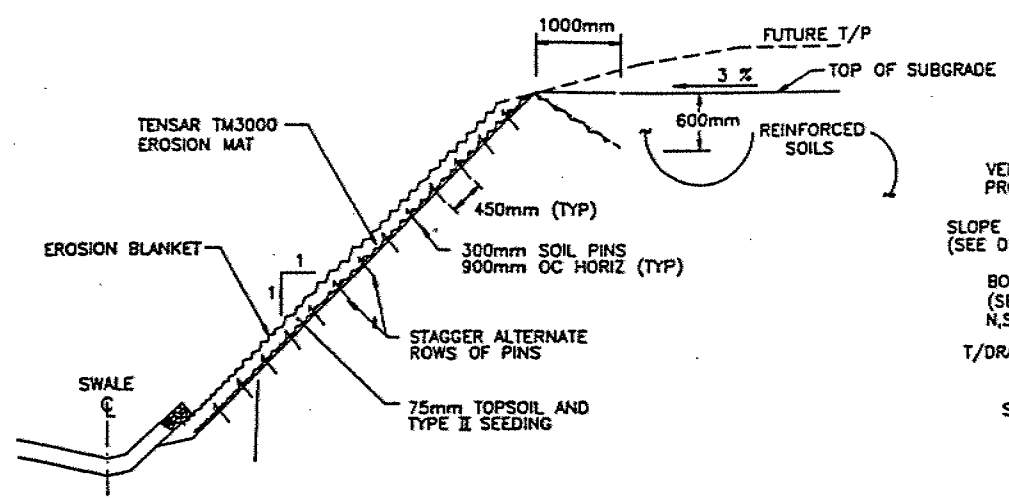
Buoyant unit weights (γ') are to be used below the groundwater table. The groundwater table at the time of the investigation was approximately 74 m.

93-103
 87-00
 SLOPES
 WALL
 sar
 16A AVENUE
 128 688
 2323

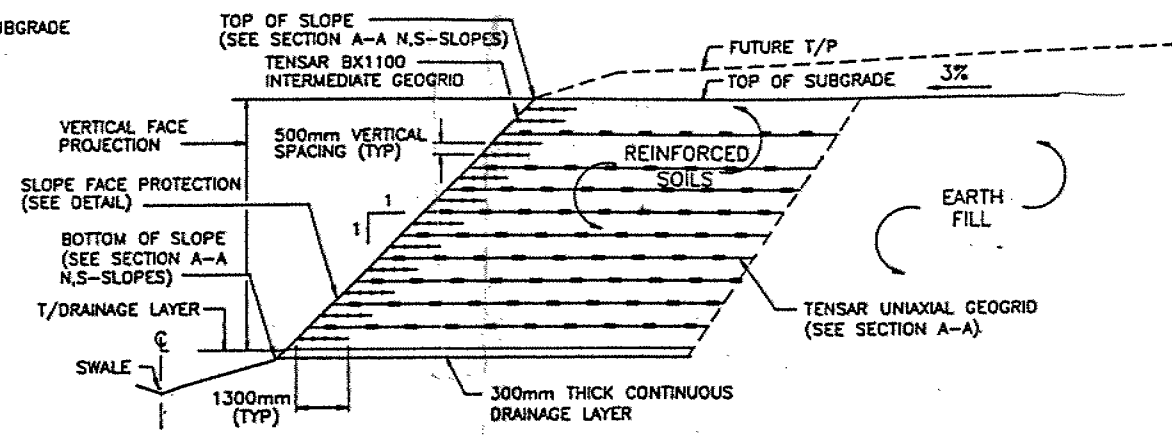
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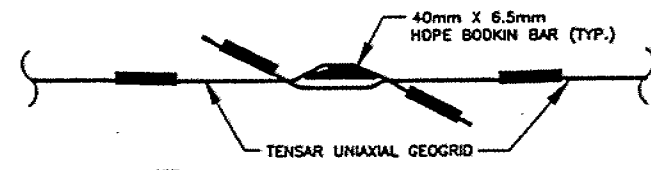
PROJECT No. 93-103 WP No. 139-87-00	SHEET 18
REINFORCED SOILS SLOPES TYPICAL SECTIONS AND DETAILS	Designed by JFK Drawn by LAA Checked by TLR
 Tensar 205, 4500 16th AVENUE CALGARY, ALBERTA T2B 0M8 403 - 240 - 2323	



SLOPE FACE PROTECTION
 NOT TO SCALE

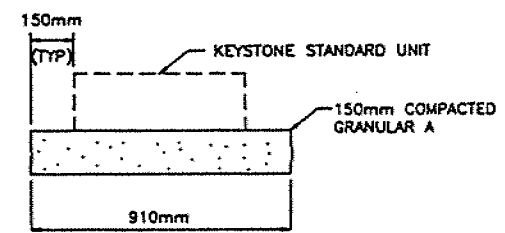


TYPICAL SLOPE SECTION
 NOT TO SCALE

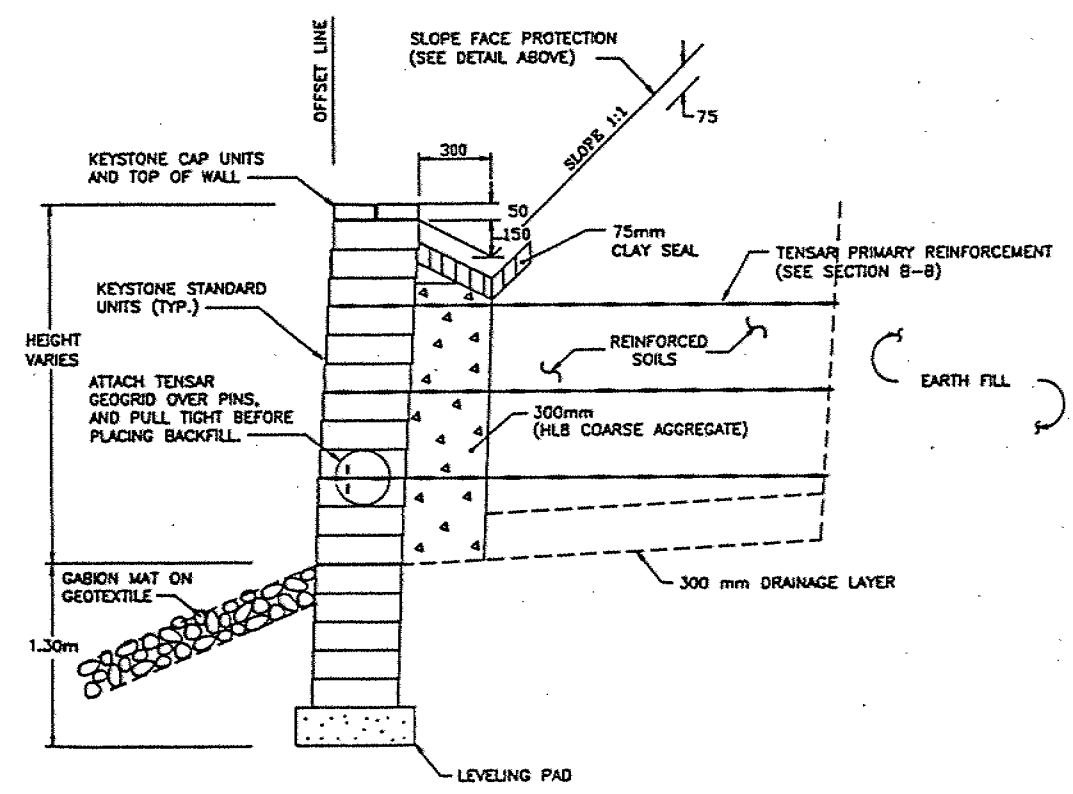


NOTE:
 THIS CONNECTION SHOULD NOT BE USED
 TO SPlice GEOGRIDS LESS THAN 2 METERS IN LENGTH

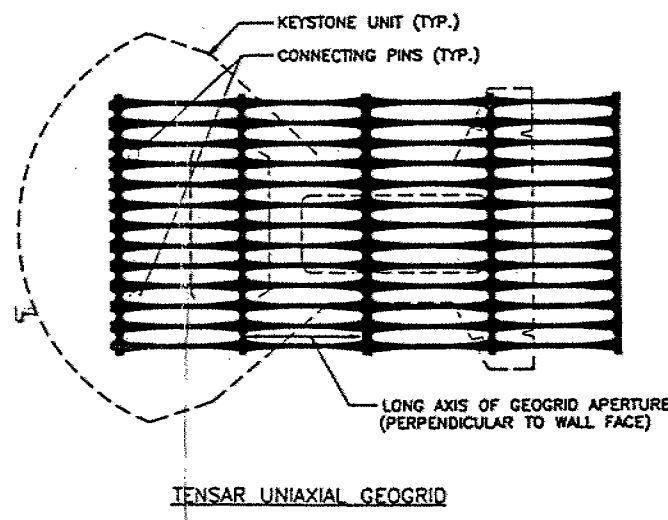
BODKIN CONNECTION
 NOT TO SCALE



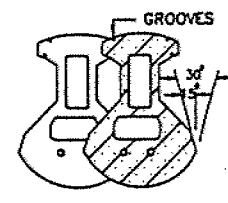
LEVELING PAD
 NOT TO SCALE



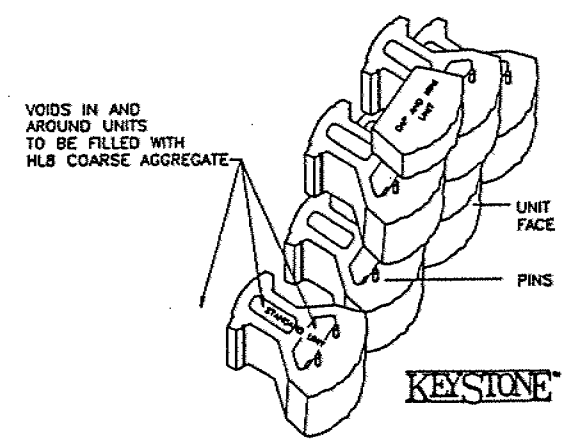
KEYSTONE WALL
 NOT TO SCALE



TENSAR GEOGRID ORIENTATION
 NOT TO SCALE



PLAN
 NOT TO SCALE

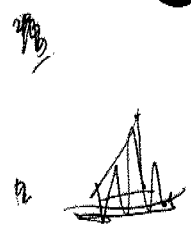


KEYSTONE UNIT
 NOT TO SCALE

RETAINING WALLS - FOUNDATION RECOMMENDATIONS

WALL	OPTION	STRUCTURE FOUNDATIONS	EXTENT	FOUNDING EI ^a (m)	BEARING CAPACITY	
					ULS	SLS
#1		Shallow	Full	82-80.5	300 kPa	200 kPa
#2	a	Shallow	11+263 to 11+358	≤81	225 kPa	150 kPa
			11+358 to 11+400	≤77 <i>stepping</i>	225 kPa	150 kPa
		Deep - Caissons - Piles	>11+400	67	3500 kPa 1600 kN	N/A 1150 kN
<i>eliminate</i>	b	Deep - Caissons - Piles	11+263 to 11+400	67	3500 kPa 1600 kN	N/A 1150 kN
			>11+400	67	3500 kPa 1600 kN	N/A 1150 kN
#3	Shallow	Deep - Caissons - Piles	Full	66	3500 kPa 1600 kN	N/A 1150 kN
#4	Deep	i-(0.76mø Caisson)	Full	75.5	1200 kN	800 kN
		ii -Steel H-piles	Full	75.5	375 kN	250 kN
	Shallow	Shallow	Full	<85	120 kPa	80 kPa

modify
General
ultrafine
reinforced earth
gabions
soil nail

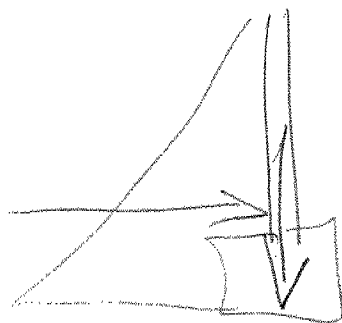


rock anchors

gabions
 6.1
 4.6
 2.6
 6.6
 9.1
 2.1

RETAINING WALLS - FOUNDATION RECOMMENDATIONS
HORIZONTAL CAPACITY/CONSTRUCTION CONSIDERATIONS

WALL	Foundation	EI ^a (m)	HORIZONTAL CAPACITY			CONST'N
			ϕ (°)	c_u (kPa)	q_u (MPa)	
#1	Shallow		30			■ Isolation Joint at Centre ■ OPSD 3504(Cut) ■ Septic Tank Removal
#2	Shallow		30			■ OPSD 3504(Cut)<11+358
	Deep	81-75		100		■ OPSD 3504(Fill)>11+358
		75-67		150		■ Liner/slurry to control
		<67			25	cave-in @ eastern extreme
	Deep	74-71.5	28			■ Liner/slurry to control cave-in @ eastern extreme
		71.5-69		50		
		69-67		150		
		<67			25	
#3	Deep (caisson/pile)	85-79		40		■ Raker/anchor soldier pile timber lagging wall
		79-74		100		
		74-67		200		■ Settlement Monitoring
		<67			25	■ Water well Monitoring
#4	Deep	83-80		40		
		80-75.5		60		
	Shallow		28			■ Isolation Joint



$K_a \gamma H$

$$3 \times 235 \text{ kN/m}^3$$

$$= 70.5$$

$$\frac{1}{2} K_a \gamma H^2 = \frac{1}{2} (0.3) (20)^3$$

$$3^3 = 27$$

memorandum

235-3696



To: D. Dundas
Chief Foundation Engineer (Acting)
Foundation Design Section
Central Building, Room 315

Date: 94 03 22

Attn: T. Sangiuliano

From: Soils and Aggregates Section
Engineering Materials Office
Central Building, Room 311

File No: 3162-2-4-113

Re: **Borehole Core Description**
QEW/20 Mile Creek, Jordan Harbour
W.P. 333-89-00

As requested by you, core from five (5) boreholes was logged. A description is appended. Bedrock is **SHALE** and interbedded **SILTSTONE** of the Queenston Formation. Depth to bedrock and depth to unweathered to slightly weathered bedrock in each borehole are tabulated below:

Borehole number	Depth to bedrock in metres below ground surface (*based on split spoon samples)	Depth to unweathered to slightly weathered bedrock in metres below ground surface
4	16.7*	16.8
6	13.7*	15.3
7	10.7*	10.8
8	8.4*	8.7
9	18.3*	18.9

If you have any questions, please contact me.

D. A. Williams.

David A. Williams,
Petrographer.

DAW/jlp
Attachment

ROCK CORE DESCRIPTION

WP 333-89-00

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
4	14	16.78-18.30	100	50	16.78-18.30	SHALE , greyish red, with interbedded greenish grey SILTSTONE (30%); minor gypsum nodules up to 2 cm in diameter; very fine grained; very weak to weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
6	12	15.06-16.59	100	27	15.06-16.59	SHALE , greyish red, with interbedded greenish grey SILTSTONE (8%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 15.06-15.29 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
7	12	10.82-12.34	100	76	10.82-12.34	SHALE , greyish red, with interbedded greenish grey SILTSTONE (3%); minor gypsum nodules up to 2 cm in diameter; very fine grained; very weak to weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to dipping, planar to undulating, smooth.
8	11	8.41-9.93	100	23	8.41-9.93	SHALE , greyish red, with interbedded greenish grey SILTSTONE (16%); very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 8.41-8.66 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
9	18	18.72-20.24	100	21	18.72-20.24	SHALE , greyish red, with interbedded greenish grey SILTSTONE (10%); minor gypsum nodules up to 3 cm in diameter; very fine grained; very weak to weak; unweathered to slightly weathered (moderately weathered, 18.72-18.85 m and 19.35-19.56 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.

*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