

Golder Associates Ltd.

2180 Meadowvale Boulevard
Mississauga, Ontario, Canada L5N 5S3
Telephone (905) 567-4444
Fax (905) 567-6561

**REPORT ON**

**FOUNDATION INVESTIGATION AND DESIGN
EMBANKMENT SECTIONS
NORTH HALF OF QUEEN ELIZABETH WAY
AND GUELPH LINE INTERCHANGE
REGIONAL MUNICIPALITY OF HALTON
GWP: 47-88-00**

Submitted to:

McCormick Rankin Corporation
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

DISTRIBUTION:

- 5 Copies - The Ministry of Transportation, Ontario,
Downsview, Ontario
- 3 Copies - McCormick Rankin Corporation,
Mississauga, Ontario
- 2 Copies - Golder Associates Ltd.,
Mississauga, Ontario

January 2001

991-1105C

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
PART A - FOUNDATION INVESTIGATION REPORT	
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	2
3.0 INVESTIGATION PROCEDURES	3
4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY	5
4.1 Site Geology	5
4.2 Site Stratigraphy	5
4.2.1 Topsoil	6
4.2.2 Road Base Fill	6
4.2.3 Clayey Silt to Silty Clay Fill	6
4.2.4 Sand	6
4.2.5 Clayey Silt / Silty Clay Till	7
4.2.6 Bedrock	7
4.3 Groundwater Conditions	8
PART B - FOUNDATION DESIGN REPORT	
5.0 ENGINEERING RECOMMENDATIONS	10
5.1 General	10
5.2 Embankment Stability and Settlement	10
5.3 Embankment Construction	11

In Order
Following
Page No. 12

List of Abbreviations and Symbols

Record of Borehole Sheets

(Boreholes 5, 7, 9+950NSR, 10+035NSR, 10+100NW, 10+353E-N/S, 10+050WL, 10+025SW)

Drawing 1

Figures 1 through 4

TABLE OF CONTENTS (continued)**LIST OF DRAWINGS**

Drawing 1 Borehole Location Plan – Guelph Line Embankments

LIST OF FIGURES

Figure 1 Grain Size Distribution Curve – Clayey Silt (Fill)
Figure 2 Plasticity Chart - Clayey Silt (Fill)
Figure 3 Grain Size Distribution Curve - Clayey Silt (Glacial Till)
Figure 4 Plasticity Chart - Clayey Silt (Glacial Till)

PART A

**FOUNDATION INVESTIGATION REPORT
EMBANKMENT SECTIONS
NORTH HALF OF QUEEN ELIZABETH WAY
AND GUELPH LINE INTERCHANGE
REGIONAL MUNICIPALITY OF HALTON
GWP: 47-88-00**

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
PART A - FOUNDATION INVESTIGATION REPORT	
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	2
3.0 INVESTIGATION PROCEDURES	3
4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY	5
4.1 Site Geology	5
4.2 Site Stratigraphy	5
4.2.1 Topsoil	6
4.2.2 Road Base Fill	6
4.2.3 Clayey Silt to Silty Clay Fill	6
4.2.4 Sand	6
4.2.5 Clayey Silt / Silty Clay Till	7
4.2.6 Bedrock.....	7
4.3 Groundwater Conditions.....	8

1.0 INTRODUCTION

Golder Associates Ltd. has been retained by McCormick Rankin Corporation (McCormick Rankin) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation for the north half of the Queen Elizabeth Way (QEW) and Guelph Line interchange at in the Region of Halton, Ontario. The project includes two bridges on Guelph Line as well as associated high embankments and extensions of the Roseland Creek culverts. This report addresses the high embankments for Guelph Line and the associated interchange ramps.

The purpose of the foundation investigation is to determine the subsurface conditions at the site of the proposed embankments by drilling boreholes, and carrying out in-situ tests and laboratory tests on selected samples. The terms of reference for the scope of work are outlined in our Total Project Management proposal P81-1394-1, dated September 1998. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, Agreement No. 9820-7411-2715, dated January 1999. The digital plan for the Interchange was presented on profiles provided to us by McCormick Rankin on August 31, 2000.

2.0 SITE DESCRIPTION

The site is located at the existing QEW and Guelph Line interchange, and is within the MTO District 4 in the City of Burlington.

The topography of the site area is generally level and gradually slopes downwards towards the south. The existing Guelph Line has been constructed entirely in fill and the existing embankments are up to 10 m in height. The existing ramps and North Service Road are also constructed in fill to meet with Guelph Line. Within the project limits, the vegetation cover generally consists of grass and bushes. Drainage ditches run adjacent to Guelph Line at the toe of the existing embankment on the east and west side, north of the North Service Road.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between July 18 to 24, 2000. At this time eight (8) boreholes were put down at the site. Boreholes 5, 7, 9+950NSR, 10+035NSR, 10+100NW, 10+353E-N/S, 10+050WL, 10+025SW were put down at the toe of the existing Guelph Line embankment within the limits of the proposed embankment for the re-aligned Guelph Line and associated ramps.

The investigation was carried out using a bombardier-mounted CME-55 drill rig supplied and operated by Master Soil Investigations of Toronto, Ontario. In the boreholes, samples of the overburden were obtained at regular intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. The boreholes were extended to depths between 4.6 m and 12.2 m below the existing ground surface. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Piezometers were installed in two boreholes to permit monitoring of the groundwater levels at the site. The piezometers consist of a 200 mm long slotted tip threaded into 12 mm diameter PVC rigid tubing or a slotted 12 mm diameter tube. The boreholes were backfilled with either bentonite gravel or with a mixture of bentonite gravel and auger cuttings.

The field work was supervised on a full-time basis by a member of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled containers and transported back to our laboratory in Mississauga for further examination. Index and classification tests were carried out on selected samples. The results of the testing are shown on the attached Record of Borehole sheets and on Figures 1 and 2.

A plan of the proposed Guelph Line Interchange was provided to us in digital format by McCormick Rankin. The borehole locations were surveyed and staked in the field by Bennet Young Limited, professional land surveyors. Based on the information provided, the northing and easting co-ordinates of the borehole locations are given in UTM, and the borehole elevations are referenced to Geodetic Datum. The co-ordinates of the boreholes are indicated on the Record of Borehole sheets and the locations of the boreholes are shown on Drawing 1.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

The site is located in the physiographic region known as the Iroquois Plain. The Iroquois Plain is generally composed of a shallow cover of sand and till covering portions between Hamilton and Toronto (Chapman and Putnam, "The Physiography of Southern Ontario", 3rd Edition, 1984). The surface topography slopes gradually and fairly uniformly towards Lake Ontario. The native overburden at the site area is a silty clay till which is underlain by bedrock comprised of red shale with limestone interbeds of the Queenston Formation. The depth to bedrock at this site is shallow, varying typically between 2 m to 5 m below original ground surface.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets following the text of this report. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

In summary, the surficial subsoils at the site generally consist of a layer of topsoil underlain by silty clay to clayey silt fill material. The boreholes drilled through the existing Guelph Line embankment encountered asphalt and granular road base fill below the roadway surface. The fills are underlain by about 1 m to 3 m of very stiff to hard clayey silt / silty clay or dense to very dense silty sand till which is in turn underlain by shale bedrock of the Queenston Formation.

The location of the borings are shown on the attached Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided in the following sections.

4.2.1 Topsoil

A surficial layer of topsoil was encountered in four of the boreholes. The topsoil was measured between about 100 mm and 450 mm in thickness in Boreholes 10+025SW, 10+035NSR, 10+353E-N/S, and 10+050WL.

4.2.2 Road Base Fill

A 0.9 m to 1.0 m thick layer of compact to dense, crushed gravel with sand and gravel fill was encountered beneath the asphalt road surface in Boreholes 5 and 7, which were drilled through the existing Guelph Line embankment.

4.2.3 Clayey Silt to Silty Clay Fill

In general, a 1.4 m to 2.1 m thick layer of silty clay to clayey silt fill exists below the topsoil or road base fill in all boreholes except Borehole 10+050WL. In Boreholes 5 and 7, which were extended through the existing Guelph Line embankment, the fill is between 6.3 m and 7.6 m deep. The clayey silt fill is typically red-brown to brown to grey in colour and contains variable proportions of sand and gravel. The silty clay fill is typically dark brown to red-brown in colour and contains variable proportions of sand, gravel and organics. The measured Standard Penetration (SPT) 'N' values for the clayey silt / silty clay fill were between 8 blows and 54 blows per 0.3 m of penetration indicating a stiff to hard consistency.

Atterberg limits testing carried out on one sample of the clayey silt fill gave a liquid limit of 24.5 percent and a plasticity index of 5.8 percent. This classifies the fill sample as inorganic and of low plasticity. A grain size distribution for this sample is shown in Figure 1 and the result of the Atterberg limits test is shown on Figure 2. The natural water content for selected samples of the clayey silt / silty clay fill ranged from about 9 percent to 20 percent, with an average of about 15 percent.

4.2.4 Sand

In Borehole 10+100NW, a 0.7 m thick layer of moist to wet, red-brown, sand containing some silt was encountered below the fill. The measured SPT 'N' value was 53 blows per 0.3 m of

penetration indicating a very dense state of packing. The measured water content on the one sample obtained was about 13 percent.

In Borehole 10+050WL, a 1.5 m thick layer of red-brown silty sand containing trace clay and gravel and trace shale and limestone fragments was encountered below the topsoil and above the silty clay till. The SPT 'N' values were between 43 blows and greater than 100 blows per 0.3 m of penetration indicating a dense to very dense state of packing.

4.2.5 Clayey Silt / Silty Clay Till

A deposit of red-brown clayey silt to silty clay till was encountered in all boreholes. Some shale and limestone fragments were noted within the till. A grain size distribution curve for a selected sample of the clayey silt till is shown on Figure 3. The SPT 'N' values within the till deposit range from 19 blows to greater than 50 blows per 0.3 m of penetration, indicating a very stiff to hard consistency. In general, the till is hard.

Atterberg limit testing carried out on two selected samples of the clayey silt / silty clay till gave liquid limits of about 18 percent and 23 percent, and a plasticity index of about 4 percent and 8 percent, respectively. This classifies the till as inorganic and of low plasticity. The results of the Atterberg limits testing are shown on Figure 4. The natural water content for selected samples of the till ranged from about 7 percent to 13 percent. The water contents were less than the plastic limit.

4.2.6 Bedrock

Shale bedrock was encountered in all of the boreholes. Hard limestone layers between 25 mm and 150 mm thick were encountered throughout the shale, inferred from augering through the bedrock. Limestone layers up to 200 mm in thickness were encountered throughout the shale in boreholes where bedrock coring was carried out for other aspects of this project. A minimum of 1.4 m of the bedrock was penetrated through augering except in Borehole 9+950NSR where the borehole was extended to the bedrock surface only. The following table summarizes the bedrock surface elevations.

<i>Borehole</i>	<i>Elevation of Surface of Weathered Shale Bedrock (m)</i>
5	103.3
7	106.3
10+025SW	105.2
9+950NSR	104.9
10+035NSR	106.2
10+353E-N/S	106.6
10+100NW	102.5
10+050WL	104.7

4.3 Groundwater Conditions

Water levels were noted in the open boreholes during and upon completion of the drilling operation. All boreholes were dry upon completion of drilling except Borehole 10+353NSR which had a water level at Elevation 105.5 m in the open borehole. Piezometers were installed in two boreholes and the water levels are summarized in the table below.

<i>Borehole</i>	<i>Water Levels in Piezometers</i>			
	<i>July 25, 2000</i>		<i>August 16, 2000</i>	
	<i>Depth (m)</i>	<i>Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>
10+035NSR	2.7	106.4	2.7	106.4
10+353E-N/S	1.1	109.4	0.9	109.6

Based on these measurements, and on water level measurements in boreholes for other aspects of this project, the groundwater table slopes downward toward the south and the east. The groundwater table seems to be controlled by the bedrock surface topography and by the water bearing sand deposits which are present sporadically across the site.

It should be noted that groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year. It is also expected that water levels could be higher in areas adjacent to the drainage channels on either side of Guelph Line north of the existing North Service Road.


GOLDER ASSOCIATES LTD.



Sarah E.M. Poot, P.Eng.



Anne S. Poschmann, P.Eng.
Principal



Fintan J. Heffernan, P.Eng.
Designated MTO Contact



SEMP/ASP/FJH/clg

S:\FINAL\DATA\PROJECTS\1999\991-1105\2000\991105CRPTL01.DOC

PART B

**FOUNDATION DESIGN REPORT
EMBANKMENT SECTIONS
NORTH HALF OF QUEEN ELIZABETH WAY
AND GUELPH LINE INTERCHANGE
REGIONAL MUNICIPALITY OF HALTON
GWP: 47-88-00**

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of design of proposed embankments based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

It is understood that the QEW and Guelph Line Interchange (north half) will consist of several on / off ramps as well as links to the North Service Road and Guelph Line where the embankments will be greater than 4.5 m in height. The existing Guelph Line has been constructed entirely in fill with embankment heights of 7 m to 10 m. It is understood that a grade raise of about 3 m is proposed on Guelph Line. This will increase the embankment height to as much as 13 m. The ramps and links will be constructed to tie into the existing fill embankments (including the existing North Service Road embankment). Two ramps will tie into the existing embankment on the west side of Guelph Line – the Northwest QEW ramp (NW) and the west link to the North Service Road (WL). Four ramps will tie into the existing embankment on the east side of Guelph Line – the Southwest QEW ramp (SW), the East to North / South ramp (E-N/S), the east link to the North Service Road (EL) and the North Service Road to Guelph Line link. The east link and the North Service Road to Guelph Line link will be constructed with one side as a retaining wall. These two retaining walls have been addressed in a separate report by Golder Associates Ltd., 991-1105B, dated September 2000.

5.2 Embankment Stability and Settlement

The embankment subgrade soils consist generally of very stiff to hard clayey silt / silty clay till underlain by shale bedrock. Very dense wet sand deposits overlie the bedrock at some locations. Providing that the subgrade below the embankment is properly prepared and the embankment fills

are properly placed and compacted, embankments up to about 13 m in height with side slopes maintained at 2 horizontal to 1 vertical will have an adequate factor of safety against deep seated slope instability.

Settlement of the founding soils below the embankment is expected to be less than 12 mm. Settlement of the embankment fills will occur and the settlement of the widened portions of the embankment will be differential with respect to the existing embankment. If granular fills are utilized, the full settlement of the fill will occur essentially during placement and there will therefore be not be any long-term differential settlement. If cohesive (clayey) or silty fill soils are used for the embankment widening, the majority of the settlement will occur after completion of the embankment. For embankment heights of up to 13 m, there is potential for as much as 50 mm of settlement, about half of which will take place within six months. It is recommended that final paving be delayed as long as possible to accommodate this settlement.

Mid-height benches, 2 m in width, should be provided to all embankments with height greater than 8 m.

5.3 Embankment Construction


Topsoil and loose fill should be stripped from below the proposed new fill embankment areas and all subgrade soils proof-rolled to aid fill placement. The newly placed embankment fill should be keyed into the existing embankment side slopes by benching in accordance with OPSD 208.01. Construction of the embankment above the prepared subgrade may be carried out using clean earth fill meeting the specifications of OPSS 212 or Select Subgrade Material meeting the specifications of OPSS 1010, depending on material availability. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 percent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 percent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. The permanent soil slopes of the embankment should be maintained not steeper than 2 horizontal to 1 vertical (2H:1V).

Keying of the new fill into the existing embankments helps to minimize abrupt differential settlement. The differential settlement generally has greatest impact where it occurs within the travelled lanes. It is understood that there will ^{be} an increase in embankment height of about 2 m to 3 m due to the grade raise of Guelph Line. This grade raise will help to even out the differential settlement. The potential impact of the grade raise and the differential settlements should be assessed as part of the pavement design.

Vegetation cover should be established on all soil slopes to protect embankment fill against surficial erosion, as per OPSS 572.

GOLDER ASSOCIATES LTD.


Sarah E.M. Poot, P.Eng.


Anne S. Poschmann, P.Eng.
Principal




Fintan J. Heffernan, P.Eng.
Designated MTO Contact

SEMP/ASP/FJH/clg
S:\FINAL\DAT\PROJECTS\1999\991-1105\2001\9911105CRPTA01.DOC



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Consistency

	kPa	C _u , S _u	psf
Very soft	0 to 12		0 to 250
Soft	12 to 25		250 to 500
Firm	25 to 50		500 to 1,000
Stiff	50 to 100		1,000 to 2,000
Very stiff	100 to 200		2,000 to 4,000
Hard	over 200		over 4,000

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I GENERAL

π	= 3.1416
$\ln x$	natural logarithm of x
$\log_{10} x$ or $\log x$	logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio = σ'_p / σ'_{vo}

(e) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

PROJECT 991-1105 (3000)			RECORD OF BOREHOLE No 5		1 OF 1		METRIC				
W.P. 47-88-00			LOCATION N 4801219.0; E 280105.5		ORIGINATED BY SEP						
DIST 4 HWY QEW			BOREHOLE TYPE 114mm SOLID STEM AUGERS		COMPILED BY SEP						
DATUM Geodetic			DATE July 19, 2000		CHECKED BY ASP						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID 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	W _p W W _L	γ	GR SA SI CL
113.79	GROUND SURFACE										
119.89	Asphalt										
0.20	Crushed Gravel, some sand Light brown Dry (Fill)										
112.79	Clayey Silt with sand, some gravel Firm to hard Red-brown to grey Moist (Fill)		1	SS	40		113				
1.00			2	SS	27		112				
			3	SS	5		111				18 45 28 8
			4	SS	8		110				
			5	SS	15		109				
			6	SS	8		108				
			7	SS	33		107				
105.19	Clayey Silt, some sand, trace gravel, shale and limestone fragments Hard Red-brown Dry (Glacial Till)		8	SS	80/12		106				
8.60							105				
103.29	Red-brown SHALE bedrock (Queenston Formation), with hard limestone layers inferred from auger resistance during drilling from 10.7 m to 12.2 m depth.		9	SS	100/0.1		104				
10.50							103				
101.59	END OF BOREHOLE						102				
12.20	Note: 1. Open Borehole dry upon completion of drilling.										

ON MOT 991-1105.GPJ ON MOT.GDT 13/12/00

PROJECT 991-1105 (3000)		RECORD OF BOREHOLE No 7		1 OF 1		METRIC							
W.P. 47-88-00		LOCATION N 4801275.0; E 280033.9		ORIGINATED BY SEP									
DIST 4 HWY QEW		BOREHOLE TYPE 114mm SOLID STEM AUGERS		COMPILED BY SEP									
DATUM Geodetic		DATE July 18, 2000		CHECKED BY ASP									
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					
115.08	GROUND SURFACE												
8.98 0.90	Asphalt Crushed Gravel, some sand Light Brown Dry (Fill)												
114.18 0.90	Clayey Silt with sand, some gravel Stiff to hard Red-brown to grey Moist (Fill)		1	SS	10								
			2	SS	10								
			3	SS	18								
			4	SS	54/28								
	Asphalt pieces at 4.6 m depth (Elev. 110.48 m)		5	SS	33								
			6	SS	14								
107.88 7.20	Clayey Silt, some sand, trace gravel Very stiff Brown to red-brown Moist (Glacial Till) Cobble inferred from drilling at 7.3 m.		7	SS	19								
106.28 8.80	Red-brown SHALE bedrock (Queenston Formation), with hard limestone layers inferred from auger resistance during drilling.		8	SS	50/05								
104.18 10.90	END OF BOREHOLE Note: 1. Open borehole dry upon completion of drilling.		9	SS	60/07								

ON_MOT_991-1105.GPJ ON_MOT.GDT 13/12/00

PROJECT 991-1105 (3000)		RECORD OF BOREHOLE No 9+950 (NSR)		1 OF 1		METRIC							
W.P. 47-88-00		LOCATION N 4801304.0; E 279931.1		ORIGINATED BY SEP									
DIST 4 HWY QEW		BOREHOLE TYPE 114mm SOLID STEM AUGERS		COMPILED BY SEP									
DATUM Geodetic		DATE July 19, 2000		CHECKED BY ASP									
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					
109.43	GROUND SURFACE						20 40 60 80 100	20 40 60 80 100	10 20 30				
0.00	Silty Clay, some sand and organics, trace gravel Dark brown Moist (Fill)												
108.53			1	SS	8								
0.90	Clayey Silt, trace sand and gravel, trace organics Stiff Brown Moist (Fill)		2	SS	50								
108.03													
1.40	Clayey Silt with sand, some gravel Hard Red-brown Moist (Glacial Till)		3	SS	100/0/0								
			4	SS	100/0/0								
104.88													
4.60	Red-brown SHALE bedrock (Queenston Formation). END OF BOREHOLE		5	SS	100/0/0								
	Note: 1. Open Borehole dry upon completion of drilling.												

ON MOT 991-1105.GPJ ON MOT.GDT 13/12/00




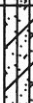

PROJECT <u>991-1105 (3000)</u>		RECORD OF BOREHOLE No 10+035 (NSR)		1 OF 1		METRIC	
W.P. <u>47-88-00</u>		LOCATION <u>N 4801367.0; E 279986.8</u>		ORIGINATED BY <u>SEP</u>			
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>114mm SOLID STEM AUGERS</u>		COMPILED BY <u>SEP</u>			
DATUM <u>Geodetic</u>		DATE <u>July 18, 2000</u>		CHECKED BY <u>ASP</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			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED								+ FIELD VANE		● QUICK TRIAXIAL
110.50	GROUND SURFACE						20	40	60	80	100	10	20	30				
0.00	Topsoil																	
0.15	Silty Clay, trace sand and gravel, trace organics Stiff Brown Moist (Fill)		1	SS	10													
109.30	Clayey Silt, some sand, trace gravel hard Red-brown Moist (Fill)		2	SS	54													
108.40	Clayey Silt with sand, trace gravel, limestone fragments Hard Red-brown Moist (Glacial Till)		3	SS	73													
2.10			4	SS	99/15													
106.20	Red-brown SHALE bedrock (Queenston Formation), with hard limestone layers inferred from auger resistance during drilling.		5	SS	109/15													
4.30																		
104.40	END OF BOREHOLE																	
6.10	Note: 1. Open Borehole dry upon completion of drilling. 2. Water level measured in piezometer at 1.15 m depth (Elev. 109.35 m) on July 25, 2000. 3. Water level measured in piezometer at 0.92 m depth (Elev. 109.58 m) on August 16, 2000.																	

PROJECT <u>991-1105 (3000)</u>		RECORD OF BOREHOLE No 10+100 (NW)		1 OF 1		METRIC	
W.P. <u>47-88-00</u>		LOCATION <u>N 4801150.0; E 280065.9</u>		ORIGINATED BY <u>SEP</u>			
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>114mm SOLID STEM AUGERS</u>		COMPILED BY <u>SEP</u>			
DATUM <u>Geodetic</u>		DATE <u>July 24, 2000</u>		CHECKED BY <u>ASP</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	SHEAR STRENGTH kPa		WATER CONTENT (%)			
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
105.74	GROUND SURFACE												
0.00	Silty Clay with sand and gravel, with organics												
105.34	Dark brown Moist (Fill)												
0.40	Clayey Silt with sand, trace gravel												
104.34	Stiff Brown Moist (Fill)		1	SS	14								
1.40	Sand, some silt												
103.64	Very dense Red-brown Moist to wet		2	SS	53								
2.10	Clayey Silt with sand, trace gravel, limestone fragments		3	SS	50/05								
102.54	Hard Red-brown Moist (Glacial Till)		4	SS	60/07								
3.20	Red-brown SHALE bedrock (Queenston Formation), hard limestone layers inferred from auger resistance during drilling from 3.5 m to 4.4 m depth.												
101.14	END OF BOREHOLE												
4.60	Note: 1. Open borehole dry upon completion of drilling.												

PROJECT 991-1105 (3000)		RECORD OF BOREHOLE No 10+353 (E-N/S)		1 OF 1		METRIC							
W.P. 47-88-00		LOCATION N 4801309.0; E 280044.7		ORIGINATED BY SEP									
DIST 4 HWY QEW		BOREHOLE TYPE 114mm SOLID STEM AUGERS		COMPILED BY SEP									
DATUM Geodetic		DATE July 18, 2000		CHECKED BY ASP									
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	SHEAR STRENGTH kPa		WATER CONTENT (%)		γ	
109.75	GROUND SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED		W _p W W _L 10 20 30		GR SA SI CL	
0.00	Topsoil												
109.29													
0.46	Clayey Silt with sand, trace gravel Hard Red-brown Moist (Fill)		1	SS	50		109						
			2	SS	38		108						
107.65													
2.10	Clayey Silt with sand, trace gravel Very stiff to hard Red-brown Moist (Glacial Till)		3	SS	25		107						
106.55			4	SS	50/23		106						
3.20	Red-brown SHALE bedrock (Queenston Formation), with hard limestone layers inferred from auger resistance during drilling.												
105.05			5	SS	131/15								
4.70	END OF BOREHOLE												
Note: 1. Water level measured in open borehole at 4.3 m depth (Elev. 105.45 m).													

PROJECT 991-1105 (3000)		RECORD OF BOREHOLE No 10+050 (WL)		1 OF 1		METRIC				
W.P. 47-88-00		LOCATION N 4801251.0; E 279992.5		ORIGINATED BY SEP						
DIST 4 HWY QEW		BOREHOLE TYPE 114mm SOLID STEM AUGERS		COMPILED BY SEP						
DATUM Geodetic		DATE July 24, 2000		CHECKED BY ASP						
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT  WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
107.50	GROUND SURFACE									
8.98 0.10	Topsoil Silty Sand, trace clay, trace gravel, trace shale and limestone fragments Dense to very dense Red-brown Dry		1	SS	43					
106.00										
1.50	Silty Clay with sand, trace gravel, trace shale fragments Hard Red-brown Dry (Glacial Till)		2	SS	70/07					
			3	SS	50/07					
104.70										
2.80	Red-brown SHALE bedrock (Queenston Formation), with hard limestone layers inferred from auger resistance during drilling at 3.6 m and 4.0 m depth.		4	SS	100/15					
102.90										
4.60	END OF BOREHOLE Notes: 1. Open borehole dry upon completion of drilling.									

PROJECT		RECORD OF BOREHOLE		No 10+025 (SW)		1 OF 1		METRIC													
W.P.		LOCATION		N 4801283.0; E 280085.9		ORIGINATED BY		SEP													
DIST		HWY		BOREHOLE TYPE		COMPILED BY		SEP													
DATUM		DATE		July 21, 2000		CHECKED BY		ASP													
SOIL PROFILE		SAMPLES		GROUND WATER		ELEVATION SCALE		DYNAMIC CONE PENETRATION		RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER	ELEVATION SCALE	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	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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	
109.03	GROUND SURFACE																				
8.98 0.10	Topsoil Silty Clay, some to with sand, trace gravel, trace organics Very stiff Red-brown Moist (Fill)		1	SS	21		108														
106.93			2	SS	21		107														
2.10	Silty Clay, trace to some sand, trace gravel Hard Red-brown Moist (Glacial Till)		3	SS	33		106														
	Limestone gravel in tip of spoon at 3.3 m depth.		4	SS	62/15		105														
105.23							104														
3.80	Red-brown SHALE bedrock (Queenston Formation), with 0.03 m to 0.15 m thick hard limestone layers inferred from auger resistance during drilling at 3.9 m, 4.9 m, 5.2 m and 5.8 m depth.						103														
102.93																					
6.10	END OF BOREHOLE Note: 1. Open Borehole dry upon completion of drilling. 2. Water level measured in piezometer at 2.68 m depth (Elev. 106.35 m) on July 25, 2000 and August 16, 2000.																				

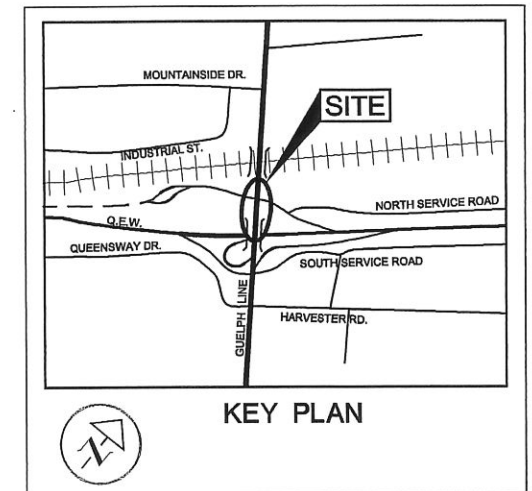
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST No. 4
CONT No.
WP No.

Q.E.W.
47-88-00

Q.E.W./GUELPH LINE
HIGH FILL EMBANKMENTS
BOREHOLE LOCATIONS

Golder Associates
MISSISSAUGA, ONTARIO, CANADA

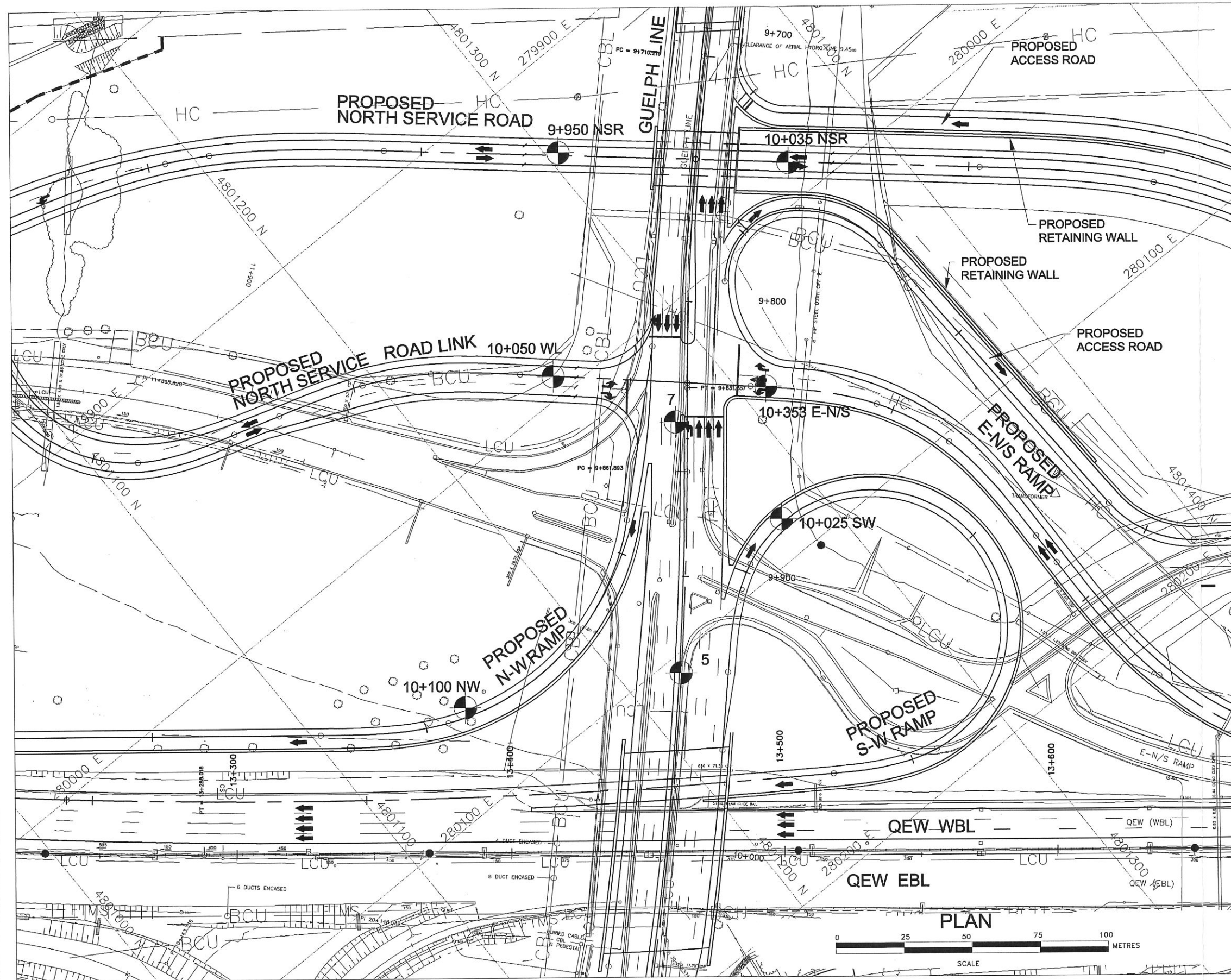


LEGEND			
Borehole			
No.	ELEVATION	LOCATION	
		NORTHING	EASTING
5	113.79	4801219	280106
7	115.08	4801275	280034
9+950 NSR	109.43	4801304	279931
10+035 NSR	110.50	4801367	279987
10+353 E-N/S	109.75	4801309	280045
10+050 WL	107.30	4801251	279993
10+100 NW	105.74	4801150	280066
10+025 SW	109.03	4801283	280086

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

REFERENCE
This drawing was created from digital file "PLAN1117.dwg" titled "QEW/GUELPH LINE NORTH HALF OF INTERCHANGE W.P. 47-88-00" provided by McCormick Rankin Corp. on August 31, 2000

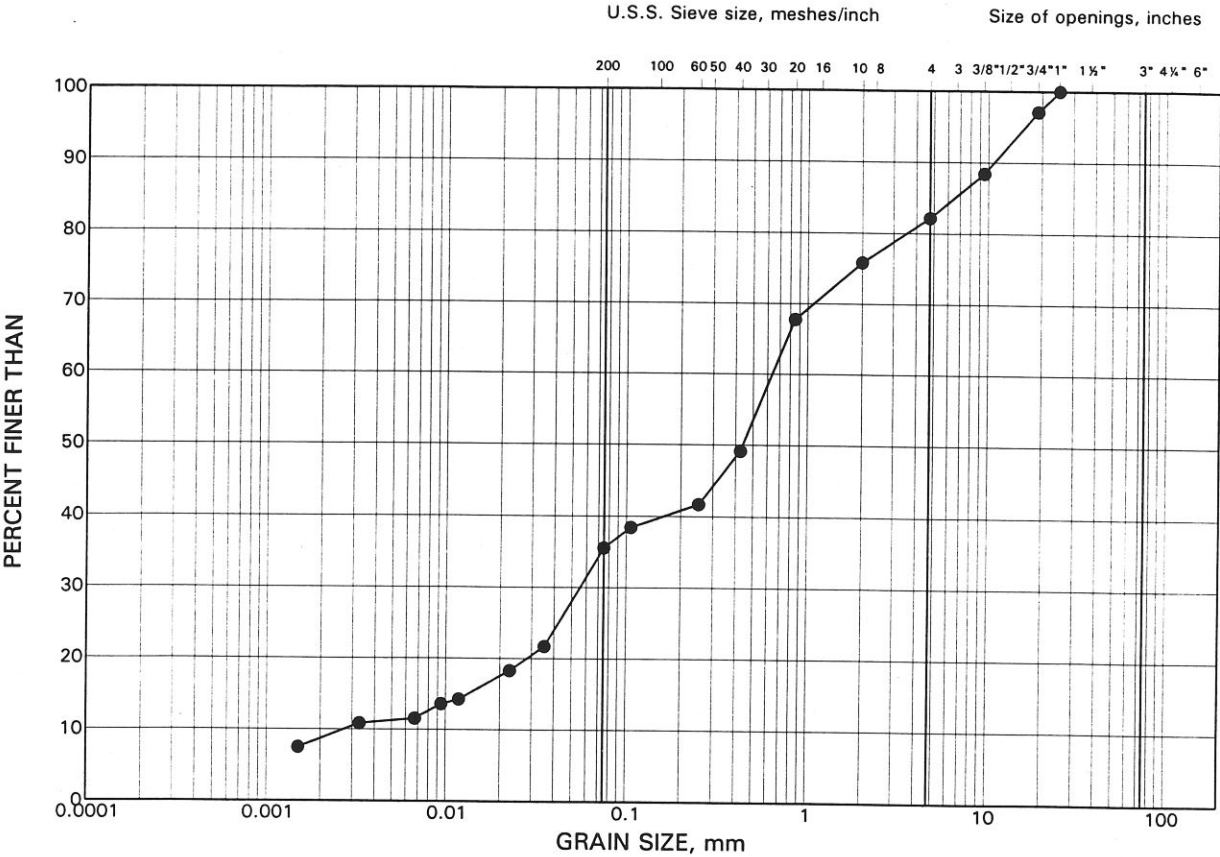
NO.	DATE	BY	REVISION
Geocres No.			
Q.E.W.	PROJECT NO.: 991-1105	DIST.	
SUBM'D. SEP	CHKD: ASP	DATE: 2000 09 26	SITE
DRAWN: JFC	CHKD. SEP	APPD.	DWG. 1



O1105001C.DWG

GRAIN SIZE DISTRIBUTION CLAYEY SILT (FILL)

FIGURE 1

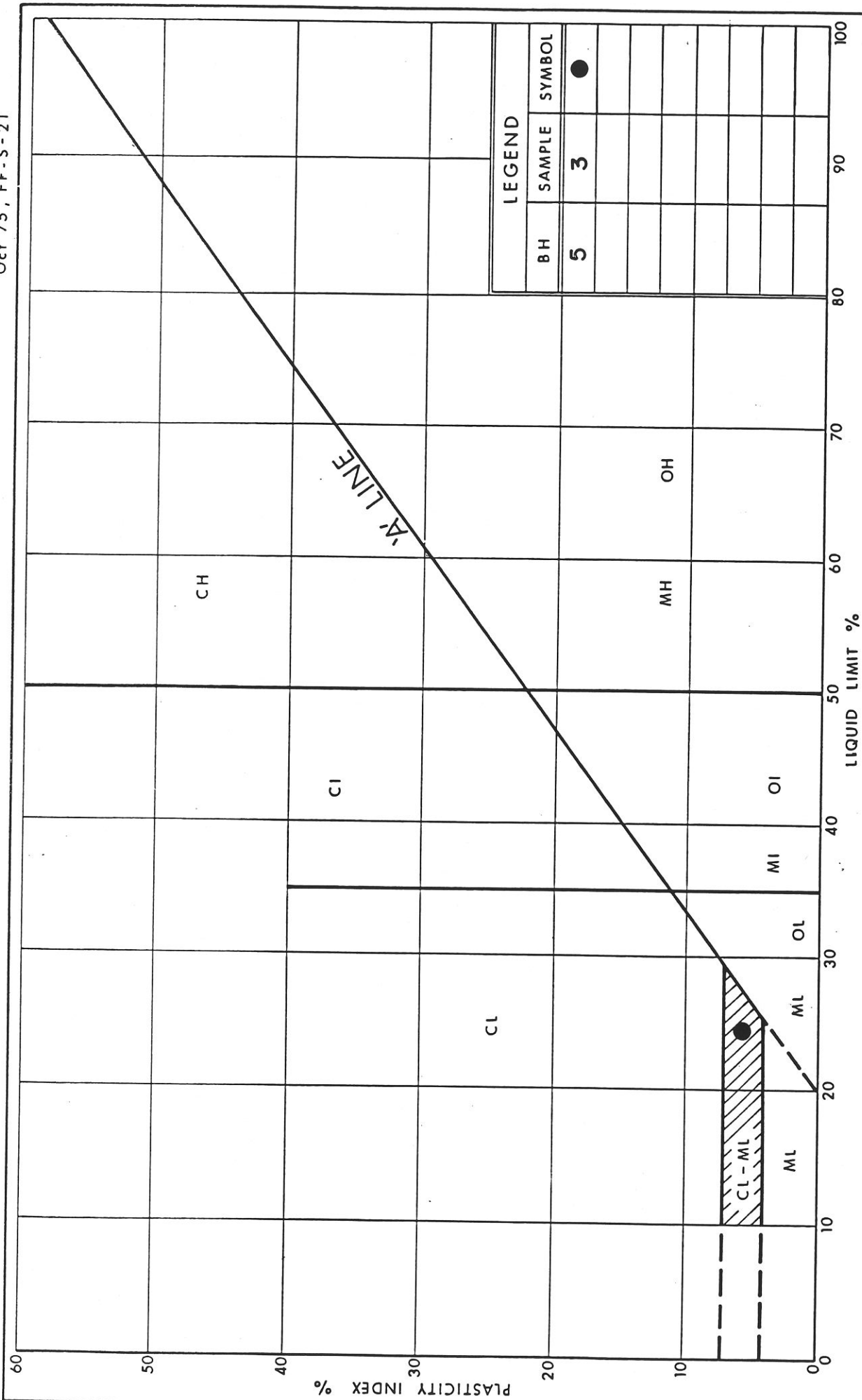


SILT AND CLAY SIZES			FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED			SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

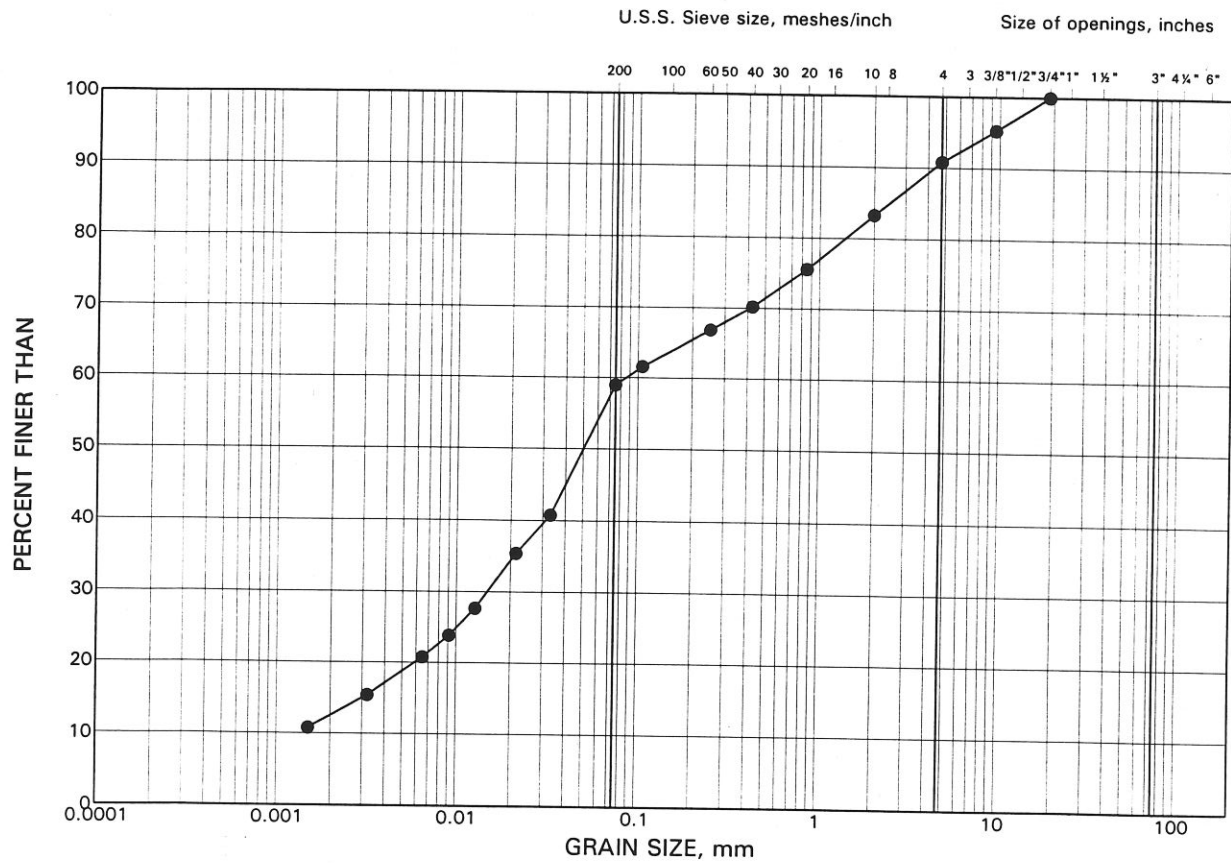
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
•	5	3	111.1

Oct 75, FF-S-21



GRAIN SIZE DISTRIBUTION CLAYEY SILT (GLACIAL TILL)

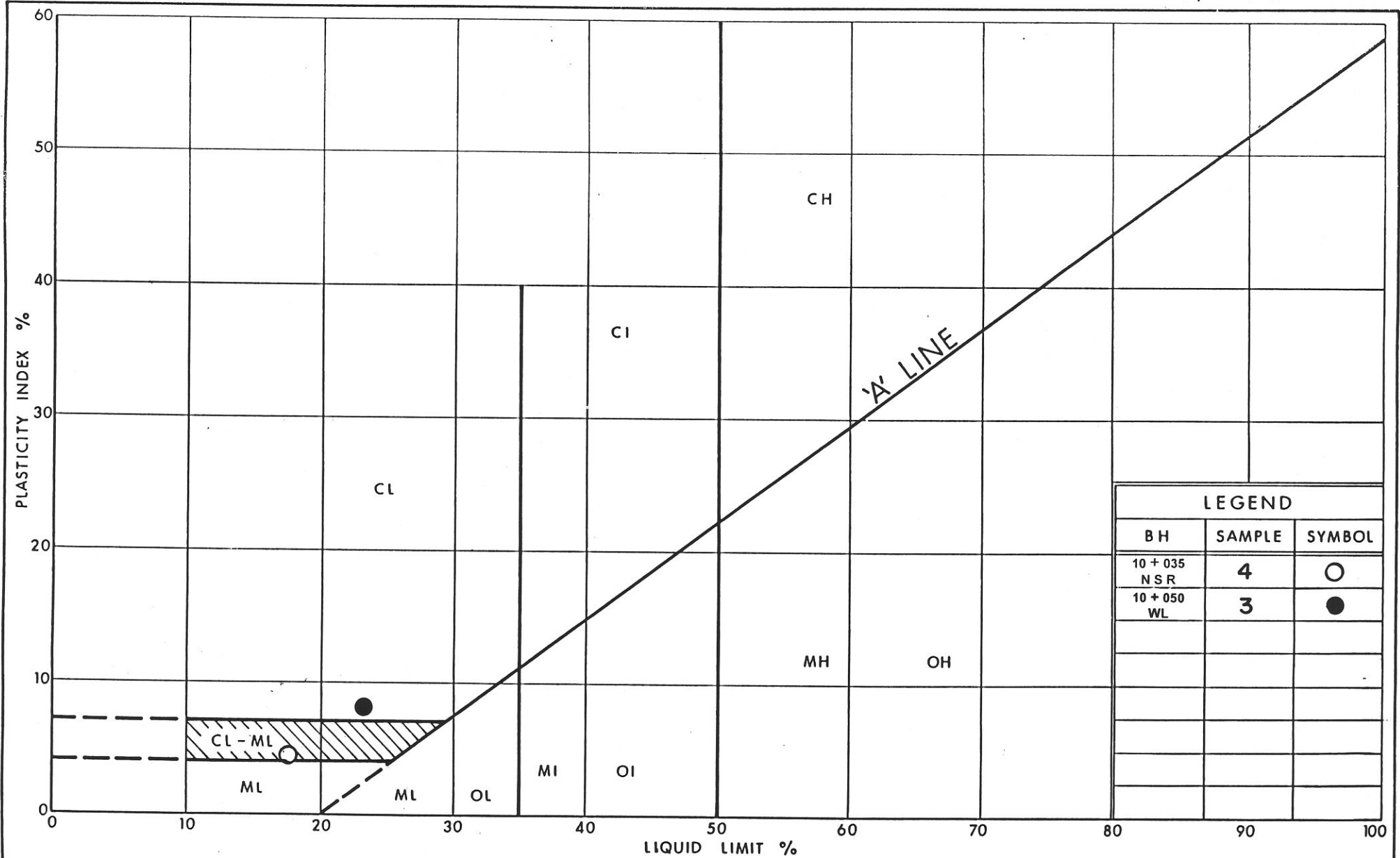
FIGURE 3



SILT AND CLAY SIZES		FINE		MEDIUM	COARSE	FINE		COARSE	COBBLE
FINE GRAINED		SAND SIZE				GRAVEL SIZE			SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
•	10+035 NSR	4	107.5



Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT (GLACIAL TILL)

FIG No

4

GWP

47-88-00