

G.I.F-30 SEPT. 1976

GEOCRES No. 30M5-120DIST. 4 REGION W.P. No. 1-79-01, 03, 04, 05, 06, 07CONT. No. 79-113W. O. No. STR. SITE No. 10-161HWY. No. Q.E.W.LOCATION Q.E.W. Underpass at
Trafalgar Rd.No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

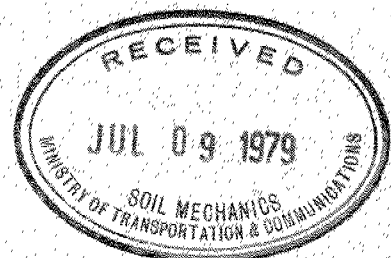
FOUNDATION INVESTIGATION REPORT

113
CONTRACT NO 79-HH

30M 5-120



Ministry of
Transportation and
Communications



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NOTE: For purposes of the Contract this report supercedes all other foundation reports done by or for the Ministry in connection with the above mentioned projects.

EXPLANATION OF TERMS USED IN REPORT

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

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

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

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

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

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

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

ROCK QUALITY: ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH DRILLED IN THAT CORING RUN.

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

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

FIELD SAMPLING

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

EARTH PRESSURE TERMS

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

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' UNIT WEIGHT OF SUBMERGED SOIL
 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} e IN LOOSEST STATE
 e_{min} e IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_p PLASTIC LIMIT
 w_s SHRINKAGE LIMIT
 I_p PLASTICITY INDEX = $w_L - w_p$
 I_L LIQUIDITY INDEX = $\frac{w - w_p}{w_L - w_p}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w}{w_L - w_p}$
 A_c ACTIVITY = $\frac{I_p \text{ of soil}}{I_p \text{ of } 2\mu m \text{ Soil Fraction}}$
 Om ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

STRENGTH PARAMETERS

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

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
 ϕ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
 σ' = EFFECTIVE NORMAL STRESS

HYDRAULIC TERMS

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

SOIL CLASSIFICATION SYSTEM

The following system was used to describe the various soils encountered at the site as determined by visual field examination and test. It was also used to classify those soils upon which a laboratory grain size determination had been made.

<u>Soil Components</u>	<u>Particle Size</u>
Clay	less than .002 mm.
Silt	from .002 mm. to .06 mm.
Sand	from .06 mm. to 2.0 mm.
Gravel	from 2.0 mm. to 2 in.
Cobbles	from 2 in. to 6 in.
Boulders	greater than 6 in.

<u>Descriptive Terms</u>	<u>Range of Proportions</u>
and	greater than 40%
with	25% to 40%
some	10% to 25%
trace	less than 10%

Example: Silt (predominant type) with (25%-40%) sand, some (10%-25%) gravel, trace (less than 10%) clay.

STANDARD PENETRATION CLASSIFICATION

Relative Density of Sands as determined by Standard Penetration Tests		
No. of Blows/foot N	Relative Density D_r	Designation on Borehole Log
0 - 4	0% - 20%	Very Loose
4 - 10	20% - 40%	Loose
10 - 30	40% - 60%	Medium Dense
30 - 50	60% - 80%	Dense
Over 50	80% - 100%	Very Dense

Shear Strengths of Clays as determined by Standard Penetration Tests		
No. of Blows/foot N	Shear Strength s psf	Designation on Borehole Log
2	250	Very soft
2 - 4	250 - 500	Soft
4 - 8	500 - 1000	Medium
8 - 15	1000 - 2000	Stiff
15 - 30	2000 - 4000	Very Stiff
Over 30	Over 4000	Hard

FOUNDATION INVESTIGATION REPORT

For

Retaining Walls at Trafalgar Road Interchange
Q.E.W. District 4, Hamilton
W.P. 1-79-07

INTRODUCTION

This report contains the results of a foundation investigation which was carried out on behalf of the Ministry by Associated Technical Services Ltd. at the site of the above mentioned project. Fieldwork was done during the period January 10 to January 23, 1979 utilizing a continuous flight auger machine equipped with 5 inch diameter solid augers and a conventional diamond drill adapted for soil sampling purposes. Bedrock was proved by obtaining BXL size (1 21/32 inch diameter) rock core samples.

SITE DESCRIPTION

The site is located in the Town of Oakville about one mile east of Oakville Creek.

The site lies within a physiographic region known as the Lake Iroquois Plain which is a nearly level terrace about two miles wide bordering Lake Ontario. The terrace was formed by wave erosion during the life of glacial Lake Iroquois and at the subject site erosion into red Queenston shale bedrock took place. Subsequent weathering of exposed bedrock resulted in a thin mantle of red silty clay or weathered shale over bedrock at the site area.

SUBSURFACE CONDITIONS

General

Surficial soils at the site were found to be relatively shallow and consisted of a red silty clay or weathered shale ranging in thickness from 3.0 to 8.5 feet. Underlying the surficial red silty clay, bedrock consisting of red shale in the northern part of the site and grey shale in the southern part was encountered.

Man-made fill was found in part of the area of the proposed North Service Road. The approach fills to the present Trafalgar Road underpass were also investigated and found to consist of red silty clay with chunks of shale bedrock.

The boundaries between the various soil types are shown on the attached Record of Borehole Sheets. The locations and elevations of the borings, along with an estimated stratigraphic profile based on borehole data, is shown on Drawing No. 2 of the Contract Drawings.

The various subsoil types encountered are briefly described in the following paragraphs.

Silty Clay (Surficial)

The primary surficial soil overlying the majority of the site consisted of a silty clay ranging in depth from 3.0 to 8.0 feet. In most boreholes, the stratum was overlain by a thin veneer of topsoil. The red silty clay is the product of in-situ weathering of the underlying shale bedrock, thus the stratum can be expected to be more soil like near ground surface and more rock like with depth. The composition of the cohesive red silty clay soil is shown on the grain size distribution chart in Figure 1. Typical moisture content and unit weight values obtained on selected representative samples are shown on the borehole logs and are summarized in the following table.

	<u>Range</u>	<u>Average</u>
Moisture Content (%)	15-26	20.6
Unit Weight (p.c.f.)	119-137	127.6

Standard Penetration Test 'N' values ranged from 6 to 82 blows per foot with an average value of 30 blows per foot. The highest values of penetration resistance were generally found close to the bedrock surface or in areas with a higher percentage of shale rock fragments.

Attempts to measure the undrained shear strength of the silt clay soil were usually frustrated by the presence of shale rock fragments. However, a few values were obtained ranging from 0.6 to

3.7 t.s.f. with an average value of 1.8 t.s.f. In consideration of the high field moisture conditions, we estimate the average value of undrained shear strength to be in the order of 1.0 t.s.f.

Existing Approach Fills

The existing approach fill embankments are approximately 20 to 22 feet high and consist of red silty clay with frequent fragments of shale rock. Standard Penetration Test 'N' values ranged from 7 to 43 blows per foot with an average of 17 blows per foot. Typical moisture content and unit weight values obtained on samples of approach fill are summarized as follows.

	<u>Range</u>	<u>Average</u>
Moisture Content (%)	7-19	11.5
Unit Weight (p.c.f.)	130-146	138.5

Bedrock

Bedrock consisted of a red shale in the northern part of the site and a grey shale in the southern part. Bedrock elevations varied from 358 in the northern most part of the site to 327 in the southern portion. These elevations indicate that the upper surface of the bedrock slopes towards the south at a gentle angle. The upper several feet of bedrock were found to be weathered along horizontal joints to form thin layers of clay. The frequency and thickness of clay layering diminished with depth.

The site lies along the boundary of two geological formations; the upper red shale of the Queenston formation and the lower grey shale of the Georgian Bay formation. The Queenston formation is a red, thinly bedded rock with occasional light grey or green bands. It is horizontally bedded and both horizontally and vertically jointed. The Georgian Bay formation consists of a grey to bluish fissile shale with interstratified hard layers of sandstone or limestone. The boundary between the formations is not abrupt but rather gradual through a thickness of about 15 feet.

Geologically, shales are formed from clays and silts through consolidation. Compaction of the clays and silts takes place due to the weight of overlying sediments and initially consists of

expulsion of water from the soil voids. As the consolidation process proceeds, more and more grain to grain contact is achieved and cementation of the solid particles begins. It may continue until the mass becomes comparatively strong and durable.

Depending upon the consolidation history, rocks of the shale type respond in various ways to exposure to the elements. Those shales formed by compaction alone will revert to their original mud after a few cycles of wetting and drying. These are known as compaction shales. Those shales which reduce to chips and mud are called semi-cemented shales, while those that are unaffected by wetting and drying cycles are known as cemented shales. The shales encountered at the site may be classified as semi-cemented shales, that is, they will be reduced from an apparently solid rock to mud and chips after a few cycles of wetting and drying. Thus, when these shales are exposed to the air, the disintegration process begins immediately and within a short period of time, the once solid rock becomes mud and chips.

Disintegration of fresh shale exposures can be prevented by immediately sealing exposed rock faces with liquid asphalt, grout, concrete, gunite or other similar material in order to prevent the occurrence of wetting and drying cycles.

Groundwater

Most of the boreholes on this project were dry on completion. Where water was encountered, it was found in granular materials overlying the silty clay soil.

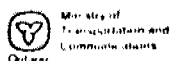
MISCELLANEOUS

The foregoing text contained under the headings 'SITE DESCRIPTION' and 'SUBSURFACE CONDITIONS' was written by J. Kilgour, P. Eng. of Associated Technical Services Ltd.

K.G. Selby

K.G. Selby, P. Eng.
Supervising Engineer

APPENDIX



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 25

W P 1-79-07 LOCATION Co-ords 15,792,381 N; 950,605 E. ORIGINATED BY T.L.
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 22, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
361.6	Ground Level																
0.1	Topsoil.																
	Silty clay.						360										
	Stiff to hard Red		1	SS	10		358									130.1	
356.6			2	SS	38/12" 51/6"												
5.0	Red Shale Bedrock						356										
354.8			3	SS	100/8"												
6.8	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



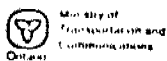
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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 26

W P 1-79-07 LOCATION Co-ords. 15,792,494 N; 950,652 E. ORIGINATED BY T.L.
 DIST Hamilton HWY O.E.W. BOREHOLE TYPE Solid Stem Auger, BXL Rock Core COMPILED BY T.L.
 DATUM Geodetic DATE January 16, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH					WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE								
363.8	Ground Level							20	40	60	80	100					
0.0	Silty clay with shale fragments. Stiff Red		1	AS													
			2	SS	18												
358.3			3	SS	11/6" 100/5"												
5.5	Shale Bedrock with several thin horizontal layers of silty clay. Decreasing in frequency with depth. Red		4	AS													
			5	RC BXL	87%												
			6	RC BXL	91%												
350.8	Shale Bedrock		7	RC BXL	100%												
13.0	Sound Red																
			8	RC BXL	100%												
344.3	End of Borehole																
19.5																	



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 29

W P 1-79-07 LOCATION Co-ords. 15,792,244 N; 950,662 E. ORIGINATED BY T.L.
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 10, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
358.8	Ground Level																
0.0 358.8 0.5	Topsoil.		1	SS	6		357										
	Fill - silty clay, occasional pocket of sand. Red		2	SS	13												
355.8 3.0	Shale Bedrock, weathered horizontal layers. Red		3	SS	138		355										
			4	SS	150		353										
352.4			5	SS	100/5"												
6.4	End of Borehole Refusal to augers																

OFFICE REPORT ON SOIL EXPLORATION



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RECORD OF BOREHOLE No 33

W P 1-79-07 LOCATION Co-ords. 15,791,722 N; 951,081 E. ORIGINATED BY T.L.
 DIST Hamilton HWY O.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 19, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			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	W _p	W	W _L		
352.6	Ground Level																
0.0	Topsoil																
0.3	Silty clay, occasional shale fragments.		1	AS			350									126.7	
	Stiff Red		2	SS	12											128.4	
			3	SS	8											130.0	
			4	SS	12											136.9	
147.1					50/4"												
5.5	Shale Bedrock, weathered horizontal layers.		5	SS	50/4"		345										
	Red		6	SS	100/5"												
343.0			7	AS													
9.6	End of Borehole																



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RECORD OF BOREHOLE No 34

W P 1-79-07 LOCATION Co-ords 15,791,785 N; 951,136 E. ORIGINATED BY T.L.
 DIST Hamilton Hwy Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 15, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH										WATER CONTENT (%)		
								0.5 1.0 1.5 2.0 2.5										10 20 30		
374.8	Ground Level																			
0.0	Asphalt.																			
373.8																				
1.0	Gravelly silty sand.		1	AS																
371.8																				
2.0	Fill - silty clay with occasional shale fragments.						370													
			2	SS	10											143.9				
			3	AS																
	Red		4	SS	8											138.0 141.1				
							360													
			5	SS	11											143.1 145.8				
352.3			6	SS	32															
21.5	Red silty clay.		7	SS	77															
	Apparent shale bedrock		8	SS	160		350													
	Red		9	SS	70/6															
348.0																				
25.9	End of Borehole																			



RECORD OF BOREHOLE No 35

W P 1-79-07 LOCATION Co-ords. 15,791,825 N; 951,163 E. ORIGINATED BY TL
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY TL
DATUM Geodetic DATE January 12, 1979 CHECKED BY _____

[illegible]

OFFICE REPORT ON SOIL EXPLORATION



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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 36

W P 1-79-07 LOCATION Co-ords 15,791,578 N; 951,141 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 18, 1979 CHECKED BY

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	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					
352.9	Ground Level																
0.0	Asphalt.		1	AS													
0.5	Concrete.		2	AS													
1.5	Limestone screenings		3	SS	42		350										
349.9	Silty clay to weathered shale.		4	SS	85/12"												
3.0	Stiff Red		5	SS	50/4"												
345.9	Shale Bedrock with occasional thin horizontal layer of weathered shale decreasing in frequency with depth.		6	SS	160/11"		345										
7.0	Red and Grey Sound		7	AS													
			8	SS	100/5"		340										
			9	RC BXL	93%												
			10	RC BXL	100%		335										
331.9	End of Borehole																
21.0																	

OFFICE REPORT ON SOIL EXPLORATION



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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 36A

W P 1-79-07 LOCATION Co-ords. 15,791.471 N; 951,173 E. ORIGINATED BY T.L.
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 23, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
353.6	Ground Level																GR SA SI CL
0.0	Asphalt.																
0.5	Concrete.																
352.1							352										
1.5	Limestone screenings		1	AS													
350.6							350										
3.0	Silty clay to weathered shale.		2	SS	12											131.8	
			3	SS	35		348									123.6	
	Stiff Red		4	SS	45/12"		346									132.6	
346.1					80/6"												
7.5	Apparent Shale Bedrock		5	SS	100/6.5"												
345.1	Red																
8.5	End of Borehole																

*3, *5: Numbers refer to
Sensitivity

20
15-20% STRAIN AT FAILURE
10



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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 37

W P 1-79-07 LOCATION Co-ords. 15,791,693 N; 951,228 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 23, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
354.5	Ground Level																
0.0	Asphalt.						354										
0.5	Concrete.																
353.0																	
1.5	Limestone screenings.		1	AS			352										
351.5																	
3.0	Gravelly silty clay to weathered shale.		2	SS	46		350										
	Red		3	SS	14												
			4	SS	74		348										
347.0																	
7.5	Apparent Shale Bedrock		5	SS	155/10"		346										
345.7	Red & Grey		6	SS	100/4"												
8.8	End of Borehole																

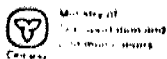


HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 38

W P 1-79-07 LOCATION Co-ords 15,791,439 N; 961,192 E. ORIGINATED BY TL
DIST Hamilton Hwy Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY TL
DATUM Geodetic DATE January 23, 1979 CHECKED BY _____

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	20 40 60 80 100					SHEAR STRENGTH								WATER CONTENT (%)				
											○ UNCONFINED + FIELD VANE												
											● QUICK TRIAXIAL × LAB VANE												
349.3	Ground Level																						
0.0	Topsoil.		1	AS																			
0.4	Asphalt.																						
0.6	Wet gravelly sand. Brown		2	AS																			
346.8																							
2.5	Silty clay.		3	SS	8																		
	Red		4	SS	28/12 40/6																		
344.8																							
4.5	Severely Weathered shale with horizontal clay seams.		5	SS	40																		
	Red and Green		6	SS	61																		
340.8			7	SS	41/61 100/100																		
8.7	Apparent Shale Bedrock																						
	End of Borehole																						



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 39

W P 1-79-07 LOCATION Co-ords. 15,791,498 N; 951,245 E. ORIGINATED BY T L
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T L
 DATUM Geodetic DATE January 11, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
372.8	Ground Level					0.5 1.0 1.5 2.0 2.5											
0.0	Gravelly clayey sand.		1	AS													
0.8	Fill - gravelly silty clay with occasional shale fragments.		2	AS													
	Red.		3	SS	43											137.2	
			4	SS	10											128.9	
			5	SS	14											135.0	
			6	SS	14											143.8	
			7	SS	20											130.4	
347.8	Gravelly sand.		8	SS	12												
321.1	Silty clay. Red																
26.7	Apparent Shale																
34.0	Bedrock Red																
30.9	End of Borehole																



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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 40

W P 1-79-07 LOCATION Co-ords. 15,791,557 N; 951,280 E. ORIGINATED BY T.L.
 DIST Hamilton Hwy Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 12, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
373.8	Ground Level																
372.8	Asphalt		1	AS													
1.0	Gravelly sand.																
	Fill - silty clay with shale fragments.		2	AS			370										
	Red		3	SS			365										
			4	SS	40		360										
			5	AS													
			6	SS	12												
			7	SS	10		355										
			8	SS	15												
			9	AS			350										
348.3			10	SS	58												
25.5	Gravelly sand. Brown																
346.7			11	SS	40/61												
27.1	Apparent Shale Bedrock				100/50												
345.9																	
27.9	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 45

W P 1-79-07 LOCATION Co-ords 15,790,577 N; 951,724 E. ORIGINATED BY TL
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Stem Auger COMPILED BY TL
DATUM Geodetic DATE January 15, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	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						WATER CONTENT (%)			
							O UNCONFINED		+ FIELD VANE								
							● QUICK TRIAXIAL		x LAB VANE								
							1.0	2.0	3.0	4.0	5.0						
333.6	Ground Level																
0.0	Asphalt.																
0.2	Crushed stone.		1	AS													
0.5	Gravelly silty clay.																
332.6																	
1.0	Silty clay with frequent shale fragments.		2	SS	48		332					o		119.0			
												o		129.8			
	Hard Red		3	SS	50		330										
			4	SS	68		328					o		132.0			
326.6																	
7.0	Apparent shale Bedrock		5	SS	100/3												
7.2	Grey																
	End of Borehole																

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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 46

W P 1-79-07 LOCATION Co-ords. 15,790,806 N; 951,650 E. ORIGINATED BY T.L.
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 15, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	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									
337.9	Ground Level																
0.0	Silty clay topsoil.		1	AS													
0.5	Silty clay. Red																
1.0	Crushed stone and Red silty clay.		2	SS	76		336										
2.0	Silty clay with frequent shale fragments		3	SS	28												
	Stiff Red		4	SS	13		334										
			5	SS	13		332										
			6	SS	9/6" 56/5"												
330.0							330										
7.9	Apparent Shale Bedrock		7	SS	100/6"												
329.4	Grey																
8.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION





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RECORD OF BOREHOLE No 61

W P 1-79-07 LOCATION Co-ords 15791932 N; 950629E ORIGINATED BY TL
 DIST Hamilton HWY D.E.W. BOREHOLE TYPE Soild Stem Auger COMPILED BY TL
 DATUM Geodetic DATE January 23, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
359.8	Ground Level													GR SA SI CL
	Silty Clay Red Brown		1	AS										
356.3														
3.5	Apparent Shale Bedrock End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION


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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 70

W P 1-79-07 LOCATION Co-ords. 15,792,052 N; 950,816 E. ORIGINATED BY T.L.
 DIST Hamilton, HWY 0.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 10, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
361.8	Ground Level													
0.0	Fill - mixture of gravelly silty sand, silty clay and shale fragment. Brown		1	SS	112									
350.8														
1.0			2	SS	83		360							
			3	SS	102									
	Fill - grey angular shale fragments and silty sand matrix.		4	SS	92		358							
			5	SS	120									
355.1	Shale Bedrock Grey						356							
6.7	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 71

W P 1-79-07 LOCATION Co-ords. 15,791,857, N; 950,803 E. ORIGINATED BY T.L.
DIST Hamilton Hwy Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 11, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
358.9	Ground Level																
0.0	Silty clay topsoil.		1	SS	26		358										
357.9	Fill - silty clay with grey shale fragments		2	SS	79		356										
1.0																	
355.4	End of borehole Refusal to augers Apparent Bedrock		3	AS													
3.5																	

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to
Sensitivity

20
15
10
5
0
5
10
15
20
% STRAIN AT FAILURE



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RECORD OF BOREHOLE No 71A

W P 1-79-07 LOCATION Co-ords 15,791,863 N; 950,800 E. ORIGINATED BY T.L.
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 10, 1979 CHECKED BY

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	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
358.9	Ground Level																GR SA SI CL
0.0	Silty clay topsoil.																
357.9							358										
1.0	Fill - red silty clay with grey shale fragments.		1	SS	49/10"		357										
355.9																	
3.0	End of Borehole Refusal to augers Apparent Bedrock																

OFFICE REPORT ON SOIL EXPLORATION

TYPICAL RED SILTY CLAY

FIG No 1

W P 1-79-07

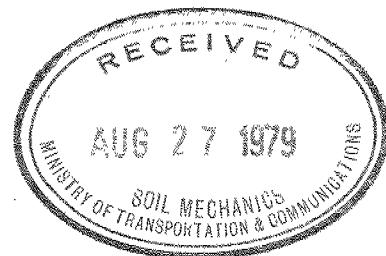
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INDEX

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1	Index
2	Abbreviations and Symbols
3	Soil Classification System
4	Standard Penetration Classification
5-	Foundation Investigation Report For Q.E.W. Underpass at Trafalgar Road W.P. 1-79-04
	Trafalgar Road Overpass at Shopping Centre Access Road W.P. 1-79-05
	North Service Road Overpass at Shopping Centre Exit W.P. 1-79-06

* NOTE: Since the fieldwork for this foundation investigation was carried out, a contract has been awarded for the construction of Retaining Walls 1, 2 & 3 (see Dwg. 10-161-3). The conditions described in this report and as shown on Dwg. 10-161-3 are those which prevailed prior to any construction activities being carried out for Retaining Walls 1, 2 & 3.

NOTE: For purposes of the Contract these reports supercede all other foundation reports prepared by or for the Ministry in connection with the above mentioned projects.



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

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

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

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

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

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

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

ROCK QUALITY: ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 1/4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

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

FIELD SAMPLING

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

EARTH PRESSURE TERMS

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

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' UNIT WEIGHT OF SUBMERGED SOIL
 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} e IN LOOSEST STATE
 e_{min} e IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_p PLASTIC LIMIT
 w_s SHRINKAGE LIMIT
 I_p PLASTICITY INDEX = $w_L - w_p$
 I_L LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
 A_c ACTIVITY = $\frac{I_p \text{ of soil}}{2 \mu m \text{ Soil Fraction}}$
 O_m ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u (\text{undisturbed})}{S_u (\text{remoulded})}$

STRENGTH PARAMETERS

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

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
 ϕ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
 σ' = EFFECTIVE NORMAL STRESS

HYDRAULIC TERMS

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

SOIL CLASSIFICATION SYSTEM

The following system was used to describe the various soils encountered at the site as determined by visual field examination and test. It was also used to classify those soils upon which a laboratory grain size determination had been made.

<u>Soil Components</u>	<u>Particle Size</u>
Clay	less than .002 mm.
Silt	from .002 mm. to .06 mm.
Sand	from .06 mm. to 2.0 mm.
Gravel	from 2.0 mm. to 2 in.
Cobbles	from 2 in. to 6 in.
Boulders	greater than 6 in.

<u>Descriptive Terms</u>	<u>Range of Proportions</u>
and	greater than 40%
with	25% to 40%
some	10% to 25%
trace	less than 10%

Example: Silt (predominant type) with (25%-40%) sand, some (10%-25%) gravel, trace (less than 10%) clay.

STANDARD PENETRATION CLASSIFICATION

Relative Density of Sands as determined by Standard Penetration Tests		
No. of Blows/foot N	Relative Density D_r	Designation on Borehole Log
0 - 4	0% - 20%	Very Loose
4 - 10	20% - 40%	Loose
10 - 30	40% - 60%	Medium Dense
30 - 50	60% - 80%	Dense
Over 50	80% - 100%	Very Dense

Shear Strengths of Clays as determined by Standard Penetration Tests		
No. of Blows/foot N	Shear Strength s psf	Designation on Borehole Log
2	250	Very soft
2 - 4	250 - 500	Soft
4 - 8	500 - 1000	Medium
8 - 15	1000 - 2000	Stiff
15 - 30	2000 - 4000	Very Stiff
Over 30	Over 4000	Hard

FOUNDATION INVESTIGATION REPORT

For

- (1) Q.E.W. U/Pass at Trafalgar Rd.
Site #10-161
- (2) Trafalgar Rd. O/Pass at Shopping Centre Access Rd.,
Site #10-313
- (3) North Service Rd. O/Pass at Shopping Centre Exit
Site #10-314
Q.E.W., District 4, Hamilton
W.P. 1-79-04/05/06
-

INTRODUCTION

This report contains the results of a foundation investigation which was carried out on behalf of the Ministry by Associated Technical Services Ltd. at the site of the above mentioned project. Fieldwork was done during the period January 10 to January 23, 1979 utilizing a continuous flight auger machine equipped with 5 inch diameter solid augers and a conventional diamond drill adapted for soil sampling purposes. Bedrock was proved by obtaining BXL size (1 21/32 inch diameter) rock core samples.

* SITE DESCRIPTION

The site is located in the Town of Oakville about one mile east of Oakville Creek.

The site lies within a physiographic region known as the Lake Iroquois Plain which is a nearly level terrace about two miles wide bordering Lake Ontario. The terrace was formed by wave erosion during the life of glacial Lake Iroquois and at the subject site erosion into red Queenston shale bedrock took place. Subsequent weathering of exposed bedrock resulted in a thin mantle of red silty clay or weathered shale over bedrock at the site area.

* SUBSURFACE CONDITIONS

General

Surficial soils at the site were found to be relatively shallow and consisted of a red silty clay or weathered shale ranging in thickness from 3.0 to 8.5 feet. Underlying the surficial red silty clay, bedrock consisting of red shale in the northern part of the site and grey shale in the southern part was encountered.

* See Note on Page 1

Man-made fill was found in part of the area of the proposed North Service Road. The approach fills to the present Trafalgar Road underpass were also investigated and found to consist of red silty clay with chunks of shale bedrock.

The boundaries between the various soil types are shown on the attached Record of Borehole Sheets. The locations and elevations of the borings, along with an estimated stratigraphic profile based on borehole data, is shown on Drawing No. 2 of the Contract Drawings.

The various subsoil types encountered are briefly described in the following paragraphs.

Silty Clay (Surficial)

The primary surficial soil overlying the majority of the site consisted of a silty clay ranging in depth from 3.0 to 8.0 feet. In most boreholes, the stratum was overlain by a thin veneer of topsoil. The red silty clay is the product of in-situ weathering of the underlying shale bedrock, thus the stratum can be expected to be more soil like near ground surface and more rock like with depth. The composition of the cohesive red silty clay soil is shown on the grain size distribution chart in Figure 1. Typical moisture content and unit weight values obtained on selected representative samples are shown on the borehole logs and are summarized in the following table.

	<u>Range</u>	<u>Average</u>
Moisture Content (%)	15-26	20.6
Unit Weight (p.c.f.)	119-137	127.6

Standard Penetration Test 'N' values ranged from 6 to 82 blows per foot with an average value of 30 blows per foot. The highest values of penetration resistance were generally found close to the bedrock surface or in areas with a higher percentage of shale rock fragments.

Attempts to measure the undrained shear strength of the silt clay soil were usually frustrated by the presence of shale rock fragments. However, a few values were obtained ranging from 0.6 to

3.7 t.s.f. with an average value of 1.8 t.s.f. In consideration of the high field moisture conditions, we estimate the average value of undrained shear strength to be in the order of 1.0 t.s.f.

Existing Approach Fills

The existing approach fill embankments are approximately 20 to 22 feet high and consist of red silty clay with frequent fragments of shale rock. Standard Penetration Test 'N' values ranged from 7 to 43 blows per foot with an average of 17 blows per foot. Typical moisture content and unit weight values obtained on samples of approach fill are summarized as follows.

	<u>Range</u>	<u>Average</u>
Moisture Content (%)	7-19	11.5
Unit Weight (p.c.f.)	130-146	138.5

Bedrock

Bedrock consisted of a red shale in the northern part of the site and a grey shale in the southern part. Bedrock elevations varied from 358 in the northern most part of the site to 327 in the southern portion. These elevations indicate that the upper surface of the bedrock slopes towards the south at a gentle angle. The upper several feet of bedrock were found to be weathered along horizontal joints to form thin layers of clay. The frequency and thickness of clay layering diminished with depth.

The site lies along the boundary of two geological formations; the upper red shale of the Queenston formation and the lower grey shale of the Georgian Bay formation. The Queenston formation is a red, thinly bedded rock with occasional light grey or green bands. It is horizontally bedded and both horizontally and vertically jointed. The Georgian Bay formation consists of a grey to bluish fissile shale with interstratified hard layers of sandstone or limestone. The boundary between the formations is not abrupt but rather gradual through a thickness of about 15 feet.

Geologically, shales are formed from clays and silts through consolidation. Compaction of the clays and silts takes place due to the weight of overlying sediments and initially consists of

expulsion of water from the soil voids. As the consolidation process proceeds, more and more grain to grain contact is achieved and cementation of the solid particles begins. It may continue until the mass becomes comparatively strong and durable.

Depending upon the consolidation history, rocks of the shale type respond in various ways to exposure to the elements. Those shales formed by compaction alone will revert to their original mud after a few cycles of wetting and drying. These are known as compaction shales. Those shales which reduce to chips and mud are called semi-cemented shales, while those that are unaffected by wetting and drying cycles are known as cemented shales. The shales encountered at the site may be classified as semi-cemented shales, that is, they will be reduced from an apparently solid rock to mud and chips after a few cycles of wetting and drying. Thus, when these shales are exposed to the air, the disintegration process begins immediately and within a short period of time, the once solid rock becomes mud and chips.

Disintegration of fresh shale exposures can be prevented by immediately sealing exposed rock faces with liquid asphalt, grout, concrete, gunite or other similar material in order to prevent the occurrence of wetting and drying cycles.

Groundwater

Most of the boreholes on this project were dry on completion. Where water was encountered, it was found in granular materials overlying the silty clay soil.

MISCELLANEOUS

The foregoing text contained under the headings 'SITE DESCRIPTION' and 'SUBSURFACE CONDITIONS' was written by J. Kilgour, P. Eng. of Associated Technical Services Ltd.

K.G. Selby

K.G. Selby, P. Eng.
Supervising Engineer

APPENDIX



RECORD OF BOREHOLE No 25

W.P. 1-79-04/05/06 LOCATION Co-ords 15,792,381 N; 950,605 E. ORIGINATED BY TL
 DIST. Hamilton Hwy. Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY TL
 DATUM Geodetic DATE January 22, 1979 CHECKED BY TL

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					
361.6	Ground Level																
0.1	Topsoil																
	Silty clay.						360										
	Stiff to hard Red		1	SS	10											130.1	
356.6							358										
					38/12"												
			2	SS	51/6"												
5.0	Red Shale Bedrock						356										
354.8																	
					100/2"												
6.8	End of Borehole		3	SS													

*3, *5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 26

W.F. 1-79-04/05/06 LOCATION Co-ords. 15,702,494 N; 940,652 E. ORIGINATED BY T.L.
 DISTANCE 11.0 M.V. C.E.M. BOREHOLE TYPE Solid Stem Auger, BXL Rock Core COMPILED BY T.L.
 DATUM Geodetic DATE January 16, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONFINEMENT RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
363.8	Ground Level																
0.0	Silty clay with shale fragments.		1	AS													
	Stiff Red		2	SS	18												
358.3			3	SS	11/6"												
			4	AS	100/5"												
5.5	Shale Bedrock with several thin horizontal layers of silty clay.																
	Decreasing in frequency with depth.		5	RC BXL	87%												
	Red		6	RC BXL	91%												
350.8																	
13.0	Shale Bedrock		7	RC BXL	100%												
	Sound Red		8	RC BXL	100%												
344.3																	
19.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



MINISTRY OF TRANSPORT
HIGHWAY ENGINEERING DIVISION

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SC. MECHANICS SECTION

RECORD OF BOREHOLE No 29

W.P. 1-79-04/05/06 LOCATION Co-ords. 15,792,244 N, 950,662 E. ORIGINATED BY
 DIST Hamilton Hwy Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY
 DATUM Geodetic DATE January 10, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
358.8	Ground Level																GR 5A 51 CI
0.0 358.1	Topsoil.		1	SS	6		357										
0.5	Fill - silty clay, occasional pocket of sand. Red		2	SS	13												
355.8							355										
3.0	Shale Bedrock, weathered horizontal layers. Red		3	SS	138												
			4	SS	150		353										
352.2			5	SS	102												
6.4	End of Borehole Refusal to augers																

*3, *5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 33

W.P. 1-79-04/05/06 LOCATION Co-ords. 15,721,722 N, 951,081 E. ORIGINATED BY T.L.
 DIST HAMILTON HWY Q.E.W. BOREHOLE TYPE Solid Stem Pump COMPILED BY T.L.
 DATUM Geodetic DATE January 19, 1979 CHECKED BY

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	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					
352.6	Ground Level																
0.0	Topsoil																
0.3	Silty clay, occasional shale fragments.		1	AS			350									126.7	
			2	SS	12											128.4	
	Stiff Red		3	SS	8											130.0	
			4	SS	12											136.9	
347.1					50/4"												
5.5	Shale Bedrock, weathered horizontal layers.		5	SS	50/4"		345										
	Red		6	SS	100/5"												
343.0			7	AS													
9.6	End of borehole		8	SS	65/7"												

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to
Sensitivity

20
15 \diamond 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 34

W.F. 1-79-04/05/06 LOCATION Co.ords 15,791,785 N., 951,136 E. ORIGINATED BY T.
 DIST Hamilton Hwy. Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.
 DATUM Geodetic DATE January 15, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE - PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
374.8	Ground Level																
373.8	Asphalt																
371.8	Gravelly silty sand.		1	AS													
2.0	Fill - silty clay with occasional shale fragments.		2	SS	10		370									143.9	
			3	AS												138.0	
	Red		4	SS	8											141.1	
							360										
			5	SS	11											143.1	
																145.8	
352.3			6	SS	32												
21.5	Red silty clay.		7	SS	77												
	Apparent shale bedrock		8	SS	160												
	Red		9	SS	70/6		350										
348.9																	
25.9	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

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

5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 35

W P 1-79-04/05/06 LOCATION Co-ords. 15,791,825 N. 951,163 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 12, 1979 CHECKED BY

[illegible]

20
13-5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 36

W.P. 1-79-04/05/06 LOCATION Co-ords 15,791,578 N; 951,141 E. ORIGINATED BY T.L.
 DIST Hamilton Hwy O.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 18, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
352.9	Ground Level																
0.0	Asphalt																
0.5	Concrete		1	AS													
1.5	Limestone screenings		2	AS													
349.9							350										
3.0	Silty clay to weathered shale.		3	SS	42												
345.9	Stiff Red		4	SS	95/12" 60/8"												
7.0	Shale Bedrock with occasional thin horizontal layer of weathered shale decreasing in frequency with depth.		5	SS	95		345										
			6	SS	60/11"												
			7	AS													
	Red and Grey		8	SS	100/6"		340										
	Sound		9	RC BXL	93%												
			10	RC BXL	100%		335										
331.8	End of Borehole																
21.0																	

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 36A

W.P. 1-79-04/05/06 LOCATION Co-ords. 15,791.121 N; 951,173 E. ORIGINATED BY T.C.
 DIST. Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.C.
 DATUM Geodetic DATE January 23, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
353.6	Ground Level																
0.0	Asphalt.																
0.5	Concrete.																
352.1							352										
1.5	Limestone screenings		1	AS													
350.6							350										
3.0	Silty clay to weathered shale.		2	SS	12											131.8	
	Stiff Red		3	SS	35		348									123.6	
346.1			4	SS	45/12" 80/6"		346									132.6	
7.5	Apparent Shale Bedrock Red		5	SS	100/5.5"												
345.1																	
8.5	End of Borehole																

+3, x5 : Numbers refer to Sensitivity 20
 15 5 (%) STRAIN AT FAILURE
 10



RECORD OF BOREHOLE No. 37

W.P. 1-79-04/05/06 LOCATION Co-ords. 15,791,403 N. 951,208 E. ORIGINATED BY _____
 DIST. Hamilton Hwy. Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY _____
 DATUM Geodetic DATE January 23, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE (PLC)					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES			20	40	60	80	100					
354.5	Ground Level																
0.0	Asphalt						354										
0.5	Concrete																
353.0																	
1.5	Limestone screenings		1	AS			352										
351.5																	
3.0	Gravelly silty clay to weathered shale.		2	SS	46		350										
	Red		3	SS	14												
			4	SS	74		348										
347.0																	
7.5	Apparent Shale Bedrock		5	SS	155/10"		346										
345.0	Red & Grey		6	SS	100/4												
8.8	End of Borehole																

*3, *5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 30

W.F. 1-79-04/05/06 LOCATION LD-0005 15,791.43' N 401.192 E. ORIGINATED BY J.L.
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY J.L.
 DATUM Geodetic DATE January 23, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT CONTENT LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION %
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
349.3	Ground Level																
0.6	Toussaint, Ardèche.																
0.6	Wet gravelly sand. Brown		2	AS			348										
346.8																	
2.5	Silty clay. Red		3	SS	8		346										
344.8			4	SS	28/12 40/6		344										
4.5	Severely weathered shale with horizontal clay seams. Red and Greer		5	SS	40		342										
341.8			6	SS	61		340										
341.8	Apparent Shale Bedrock		7	SS	47/6 120/2												
8.7	End of borehole																

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to Sensitivity

20
15
10
*5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 39

W.P. 1-79-04/05/06 LOCATION Co-ords. 15,791,498 N; 951,245 E. ORIGINATED BY _____
 (Post Hamilton) Hwy. U.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY _____
 DATUM Geodetic DATE January 11, 1979 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	'N' VALUES		70	40	60	80	100	W _p	W	W _L		
372.8	Ground Level															
370.0	Gravelly clayey sand.		1	AS												
368.8	Fill - gravelly silty clay with occasional shale fragments.		2	AS												
	Red.		3	SS	43										137.2	
			4	SS	10										128.9	
			5	SS	14										135.0	
			6	SS	14										143.6	
			7	SS	20										130.4	
347.0	Gravelly sand.		8	SS	12											
321.1	Silty clay. Red															
287.7	Apparent Shale															
286.0	Bedrock Red															
30.9	End of Borehole															

* 3, * 5 : Numbers refer to Sensitivity.

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 40

W.P. 1-79-04/05/06 LOCATION Co-ords 15,791,447 N; 951,280 E. ORIGINATED BY T. J.
 Dist. Hamilton Hwy. O.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T. J.
 DATUM Geodetic DATE January 12, 1979 CHECKED BY T. J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					W _p	W	W _L		
								SHEAR STRENGTH									
373.8	Ground Level																
372.8	Asphalt		1	AS													
1.0	Gravelly sand.																
	Fill - silty clay with shale fragments.		2	AS													
	Red		3	SS													
			4	SS	40												
			5	AS													
			6	SS	12												
			7	SS	10												
			8	SS	15												
			9	AS													
348.3																	
25.5	Gravelly sand. Brown		10	SS	58												
346.7																	
27.1	Apparent Shale Bedrock		11	SS	40/6												
346.9					100/												
27.9	End of Borehole																

*3, *5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 45

W.P. 1-79-04/05/06 LOCATION Co-ords 15,790,577 N, 951,724 E. ORIGINATED BY _____
 DIST Hamilton Hwy D.F.W. BOREHOLE TYPE Stem Auger COMPILED BY _____
 DATUM Geodetic DATE January 15, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
333.6	Ground level																
0.0	Asphalt																
0.2	Crushed stone		1	AS													
0.5	Gravelly silty clay																
332.6																	
1.0																	
	Silty clay with frequent shale fragments		2	SS	48		332							o		119.0	
														o		129.8	
	Hard Red		3	SS	50		330										
			4	SS	68		328				o			o		132.0	
326.6	Apparent shale Bedrock		5	SS	100/3												
7.2	Grey																
	End of Borehole																

+3, +5: Numbers refer to Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 48

W.P. 1-79-04/05/06 LOCATION Co-ords. 15,790,496 N. 851,650 E. ORIGINATED BY T.L.
 DIST. Hamilton Hwy. Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 15, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
337.9	Ground Level																
0.0	Silty clay topsoil.		1	AS													
0.5	Silty clay. Red																
1.0	Crushed stone and Red silty clay.		2	SS	76		336										
2.0	Silty clay with frequent shale fragments		3	SS	28											126.6	
	Stiff Red		4	SS	13		334									120.6	
			5	SS	13		332									126.1	
			6	SS	9/6"											119.9	
330.0					56/5"											130.7	
7.9	Apparent Shale Bedrock		7	SS	100/6"		330										
329.4	Grey																
8.5	End of Borehole																

*3, *5: Numbers refer to
Sensitivity

20
15-20 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No. 61

DATE: 1-79-04/05/06 LOCATION: Co-ords 15791832 N, 951624 E ORIGINATED BY: _____
 DIST: Hamilton Hwy. C.E.W. BOREHOLE TYPE: Solid Stem Auger COMPILED BY: _____
 DATUM: Geodetic DATE: January 23, 1979 CHECKED BY: _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTICITY LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			20	40	60	80	100		
359.8	Ground Level						SHEAR STRENGTH		WATER CONTENT (%)				
							○ UNCONFINED + FIELD VANE						
							● QUICK TRIAXIAL x LAB VANE						
356.2	Silty Clay Red Brown		1	AS									
3.5	Apparent Shale Bedrock End of Borehole												

FIELD REPORT ON SOIL EXPLORATION

+3, x5 Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 70

W. S. 1-7-04/05/06 LOCATION Co-ords. 15,792.052 N; 956,416 E. ORIGINATED BY _____
 DIST. Hwy 0.F.B. BOREHOLE TYPE Solid Stem Auger COMPILED BY _____
 DATUM GEDDOLLE DATE January 10, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
361.8	Ground Level																GR SA SI CL
0.0	Fill - mixture of gravelly silty sand, silty clay and shale fragment. Brown			SS	112												
360.8																	
1.0	Fill - grey angular shale fragments and silty sand matrix.		2	SS	83		360										
			3	SS	102		358										
			4	SS	92												
			5	SS	120		356										
355.1	Shale Bedrock Grey				100/2"												
6.7	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No. 71

W.F. 1-79-04/05/06 LOCATION Co-ords. 15,791,857, N. 955,803 E. ORIGINATED BY _____
 St. Hamilton Hwy. D.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY _____
 DATUM Geodetic DATE January, 11, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
358.9	Ground Level		1	SS	26		358										
357.9	Fill - silty clay with grey shale fragments		2	SS	79		356										
355.4	End of borehole Refusal to augers Apparent Bedrock		3	AS													

3, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 71A

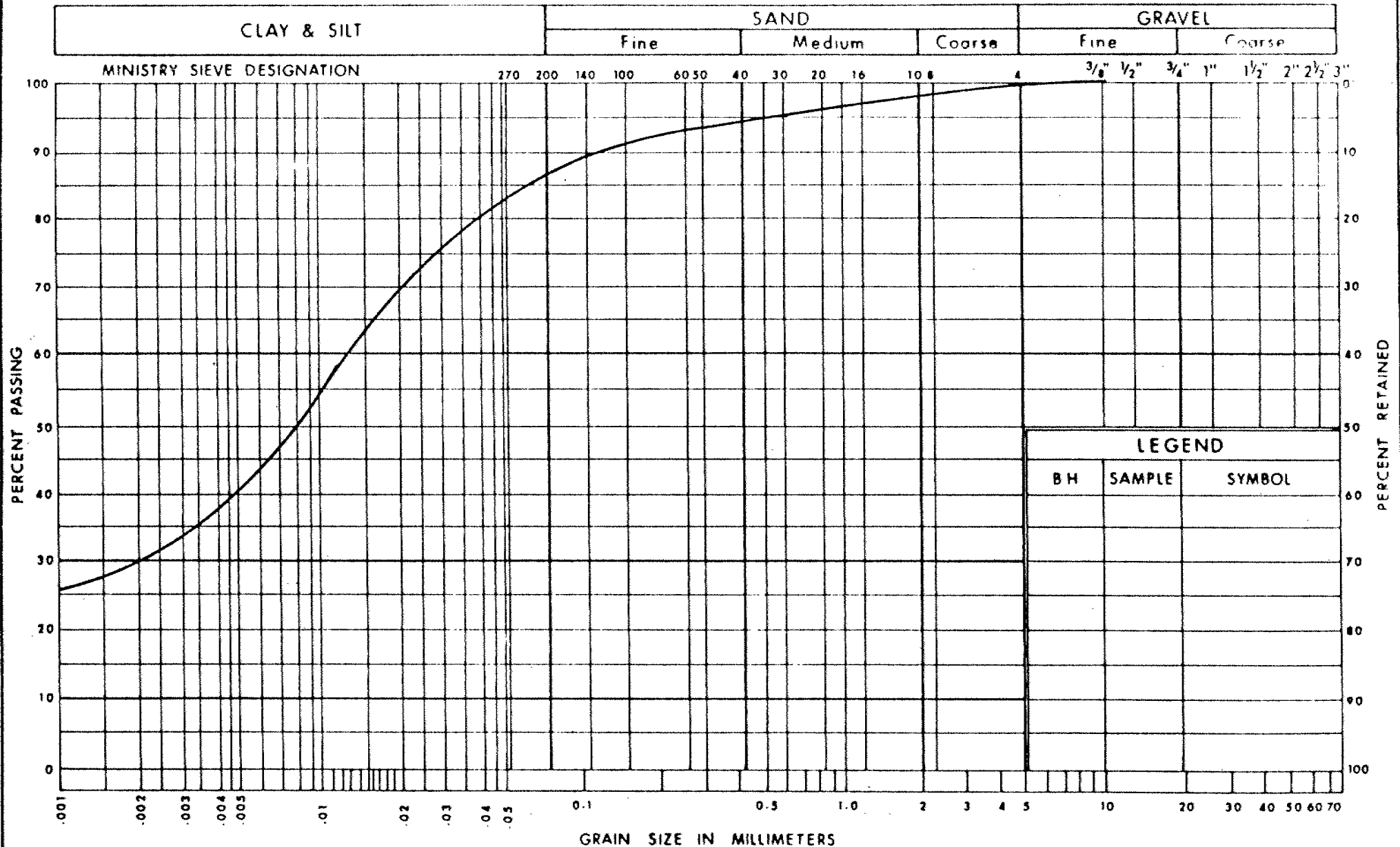
W P 1-79-04/05/06 LOCATION Co-ords 15,291,863 N, 956,800 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 10, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
358.9	Ground Level																
0.0	Silty clay topsoil.																
357.9							358										
1.0	Fill - red silty clay with grey shale fragments.		1	SS	49/10"		357										
355.9																	
3.0	End of Borehole Refusal to augers Apparent Bedrock																

*3, *5: Numbers refer to
Sensitivity

20
15 * 5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation and
Communications

Ontario

ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION

TYPICAL RED SILTY CLAY

FIG No 1

W P 1-79-04/05/06

ASSOCIATED GEOTECHNICAL SERVICES LTD.



CAMBRIDGE LEASEHOLDS LIMITED

FOUNDATION INVESTIGATION REPORT
TRAFALGAR ROAD INTERCHANGE
WP 1-79-~~07~~07
HWY Q.E.W. DISTRICT 4, HAMILTON

CONTRACT 79-113

Ministry of Transportation and Communications

Damas and Smith Limited
Consulting Engineers

submitted by

ASSOCIATED TECHNICAL SERVICES LIMITED
756 Gordon Baker Road
WILLOWDALE, Ontario M2H 3B4
Telephone #416-499-5355

February 1979

GEO. 30 M 5-120

ENGINEERING MATERIALS OFFICE
SOIL MECHANICS SECTION

W.P. 1-79-01 07

Dist. 4

Hwy. Q.E.W.

Str. Site

Trafalgar Road Interchange

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APPENDIX

Plan and Profiles

Borehole Logs

Figure 1

FOUNDATION INVESTIGATION REPORT
for
Trafalgar Road Interchange
W.P. 1-79-01 ~~107~~ Site
Hwy. Q.E.W., District 4, Hamilton

1. INTRODUCTION

This report contains the results of a foundation investigation carried out in January, 1979 to provide information for the design and construction of an underpass structure and approach fills, a subway, several retaining walls and a culvert for the above listed site. The field work consisted of 17 sampled boreholes advanced by means of a continuous flight auger machine equipped with solid stem augers. In addition, diamond drilling techniques were employed to obtain BXL size core of bedrock. The boreholes ranged in depth from 3 to 31 feet below ground surface.

2. SITE DESCRIPTION AND GEOLOGY

The site is located in the Town of Oakville about 1 mile east of Oakville Creek.

The site lies within a physiographic region known as the Lake Iroquois plain which is a nearly level terrace about 2 miles wide bordering Lake Ontario. The terrace was formed by wave erosion during the life of glacial Lake Iroquois and at the subject site erosion into red Queenston shale bedrock took place. Subsequent weathering of exposed bedrock resulted in a thin mantle of red silty clay or weathered shale over bedrock at the site area.

3. SUBSURFACE CONDITIONS

3.1 General

Surficial soils at the site were found to be relatively shallow and consisted of a red silty clay or weathered shale ranging in thickness from 3.0 to 8.5 feet. Underlying the surficial red silty clay, bedrock consisting of red shale in the northern part of the site and grey shale in the southern part was encountered.

Man-made fill was found in part of the area of the proposed north Service Road. The approach fills to the present Trafalgar Road underpass were also investigated and found to consist of red silty clay with chunks of shale bedrock.

The boundaries between the various soil types are shown on the attached Record of Borehole Sheets. The locations and elevations of the borings, along with an estimated stratigraphic profile based on borehole data, is shown on Drawing No. 17901.

The various subsoil types encountered are briefly described in the following paragraphs.

3.2 Silty Clay (Surficial)

The primary surficial soil overlying the majority of the site consisted of a silty clay ranging in depth from 3.0 to 8.0 feet. In most boreholes, the stratum was overlain by a thin veneer of topsoil. The red silty clay is the product of insitu weathering of the underlying shale bedrock thus the stratum can be expected to be more soil-like near ground surface and more rock-like with depth. The composition of the cohesive red silty clay soil is shown on the grain size distribution chart in Figure 1. Typical moisture content and unit weight values obtained on selected representative samples are shown on the borehole logs and are summarized in the following table.

	<u>Range</u>	<u>Average</u>
Moisture Content(%)	15-26	20.6
Unit Weight (p.c.f.)	119-137	127.6

Standard Penetration Test 'N' values ranged from 6 to 82 blows per foot with an average value of 30 blows per foot. The highest values of penetration resistance were generally found close to the bedrock surface or in areas with a higher percentage of shale rock fragments.

Attempts to measure the undrained shear strength of the silt clay soil were usually frustrated by the presence of shale rock fragments. However, a few values were obtained ranging from 0.6 to 3.7 T.S.F. with an average value of 1.8 T.S.F. In consideration of the high field moisture conditions, we estimate the average value of undrained shear strength to be in the order of 1.0 T.S.F.

3.3 Existing Approach Fills

The existing approach fill embankments are approximately 20 to 22 feet high and consist of red silty clay with frequent fragments of shale rock. Standard Penetration Test 'N' values ranged from 7 to 43 blows per foot with an average of 17 blows per foot. Typical moisture content and unit weight values obtained on samples of approach fill are summarized as follows.

	<u>Range</u>	<u>Average</u>
Moisture Content (%)	7-19	11.5
Unit Weight (p.c.f.)	130-146	138.5

3.4 Bedrock

Bedrock consisted of a red shale in the northern part of the site and a grey shale in the southern part. Bedrock elevations varied from 358 in the northern most part of the site to 327 in the southern portion. These elevations indicate that the upper surface of the bedrock slopes towards the south at a gentle angle. The upper several feet of bedrock were found to be weathered along horizontal joints to form thin layers of clay. The frequency and thickness of clay layering diminished with depth.

The site lies along the boundary of two geological formations; the upper red shale of the Queenston formation and the lower grey shale of the Georgian Bay formation. The Queenston formation is a red, thinly bedded rock with occasional light grey or green bands. It is horizontally bedded and both horizontally and vertically jointed. The Georgian Bay formation consists of a grey to bluish fissile shale with interstratified hard layers of sandstone or limestone. The boundary between the formations is not abrupt but rather gradual through a thickness of about 15 feet.

Geologically, shales are formed from clays and silts through consolidation. Compaction of the clays and silts takes place due to the weight of overlying sediments and initially consists of expulsion of water from the soil voids. As the consolidation process proceeds, more and more grain to grain contact is achieved and cementation of the solid particles begins. It may continue until the mass becomes comparatively strong and durable.

Depending upon the consolidation history, rocks of the shale type respond in various ways to exposure to the elements. Those shales formed by compaction alone will revert to their original mud after a few cycles of wetting and drying. These are known as compaction shales. Those shales which reduce to chips and mud are called semi-cemented shales, while those that are unaffected by wetting and drying cycles are known as cemented shales. The shales encountered at the site may be classified as semi-cemented shales, that is, they will be reduced from an apparently solid rock to mud and chips after a few cycles of wetting and drying. Thus when these shales are exposed to the air, the disintegration process begins immediately and within a short period of time, the once solid rock becomes mud and chips.

Disintegration of fresh shale exposures can be prevented by immediately sealing exposed rock faces with liquid asphalt, grout, concrete, gunite or other similar material

in order to prevent the occurrence of wetting and drying cycles.

3.5 Groundwater

Most of the boreholes on this project were dry on completion. Where water was encountered, it was found in granular materials overlying the silty clay soil.

4. DISCUSSION AND RECOMMENDATIONS

4.1 Discussion

The proposed construction of the new Trafalgar Road Interchange presently contemplates the following elements:

- 1) Underpass and approach fills
- 2) Subway on Trafalgar Road North
- 3) Retaining Wall in the south-east quadrant of the interchange.
- 4) Retaining Walls and culvert in the north-west quadrant.

4.2 Underpass

A twin two span post-tensioned concrete underpass structure is proposed to carry Trafalgar Road over the Q.E.W. The planned structure will have a combined span length of 280 feet and a deck width in excess of 100 feet. Approach embankments will be approximately 22 to 25 feet high.

4.2.1 Spread Footings

The structure may be founded on spread footings taken down to sound bedrock with an allowable loading of 10 tons per square foot. Founding levels are expected to be suitable at the following elevations

North Abutment - 342.0
Centre Pier - 339.0
South Abutment - 339.0

In order to resist lateral forces acting on the abutment foundations, frictional forces between the footing bases and the shale bedrock can be calculated using a coefficient of friction of 0.45. Backfill behind the abutments should be composed of well compacted free-draining granular material with provisions made for adequate drainage.

The lateral earth pressure exerted on the abutment walls by the granular backfill can be computed using a unit weight of 130 pcf for the backfill and a coefficient of earth pressure of:

$K_a = 0.35$ for the "active" case where
rotation about the base is allowed

$K_o = 0.5$ for the "at rest" case where
no rotation or translation about the
base is permitted.

4.2.2 Perched Pier and Abutments

Alternatively, the structure may be built on perched foundations supported on end bearing steel H-piles driven to sound bedrock at the following elevations:

North Abutment - 340 ±

Centre Pier - 337 ±

South Abutment - 337 ±

Piles driven to sound bedrock can be designed for the allowable structural capacity of the pile (i.e. 12,000 p.s.i. for steel 'H' section pile). In order to minimize damage during driving to bedrock and to facilitate penetration of weathered bedrock, all pile tips should be reinforced with welded steel flange plates as per current M.T.C. standards.

4.3 Approach Fill Embankments

It is intended to raise the existing embankments by about 3 feet and to widen the existing embankment to accommodate new traffic lanes. No stability problems are anticipated with the embankment fills if 2:1 slopes are employed. It should be realized, however, that some post construction settlement of the new embankment will take place. The amount of settlement will vary between 0.2 and 1.0 percent (or more) of the embankment height depending upon the placement moisture content and degree of compaction of the new fill.

4.4 Subway

It is proposed to construct a subway beneath Trafalgar Road to provide access to a proposed shopping centre. According to the available information, the subway will provide 9 feet of vertical clearance below the Trafalgar Road structure with an access road profile grade at elevation 355 beneath the centreline of Trafalgar Road.

Excavation for the subway will be through 5 feet of silty clay above elevation 358 and through weathered shale to about elevation 351.

The abutments for the Trafalgar Road bridge may rest on spread footings placed at elevation 350 with an allowable bearing capacity of 10 tons per square foot. For computation of sliding resistance, a coefficient of friction of 0.45 may be assumed between the base of the footing and the shale bedrock. Granular backfill should be used with the same assumptions given in section 4.2.1.

Cut slopes in soil and weathered shale may be constructed safely with standard 2:1 side slopes.

4.5 Retaining Walls

Several retaining walls are proposed in connection with the new interchange which vary in height from 3 feet to 13 feet above present ground surface. At most retaining wall locations, the upper surface of shale bedrock is located within 5 feet of ground surface. However, the upper portion of shale bedrock is weathered along horizontal joints into thin clay layers. These layers decrease in thickness and frequency with depth and disappear at a depth of about 6 feet below the upper rock surface. Considering the retaining walls founded on spread footings at the upper rock surface, we recommend a maximum allowable bearing capacity of 5 tons per square foot at this level in order to limit settlement in the clay layers. For computation of sliding resistance, a coefficient of friction of .30 along a clay seam beneath the base of the footing may be used. If greater

sliding resistance is required, it may be obtained by the use of dowels or a key.

Alternatively bin type walls may be designed using a foundation clay shear strength of 1 ton per square foot. Where the bins are placed on shale or weathered shale, the factor of safety against sliding should be computed using an angle of friction of 24 degrees between the bottom of the bin and shale bedrock. Sliding along a potential bedrock clay layer should also be considered using a shearing resistance of 1500 p.s.f. along the clay layer.

4.6 General

The shale bedrock weathers rapidly on exposure to air and water thus a concrete working slab should be poured as soon as possible after rock is exposed in order to protect it in the footing excavation.

Concentrated water flow can cause severe erosion of the shale in the bottom and sides of a water course, therefore, it is important that the water channel be lined in areas where this type of erosion will be detrimental.

Spread footings and pile caps should be protected against frost heaving by a minimum depth of cover of 4 feet.

Prior to the placement of earth fills, topsoil should be excavated for a minimum distance of 50 feet behind the abutments.

No major dewatering problems are envisaged for footings excavations at this site. Any seepage into the excavations can be handled by pumping from open sumps.

Respectfully submitted



J. Kilgour, P. Eng.

Designated Consulting Engineer



APPENDIX

SOIL CLASSIFICATION SYSTEM

The following system was used to describe the various soils encountered at the site as determined by visual field examination and test. It was also used to classify those soils upon which a laboratory grain size determination had been made.

<u>Soil Components</u>	<u>Particle Size</u>
Clay	less than .002 mm.
Silt	from .002 mm. to .06 mm.
Sand	from .06 mm. to 2.0 mm.
Gravel	from 2.0 mm. to 2 in.
Cobbles	from 2 in. to 6 in.
Boulders	greater than 6 in.

<u>Descriptive Terms</u>	<u>Range of Proportions</u>
and	greater than 40%
with	25% to 40%
some	10% to 25%
trace	less than 10%

Example: Silt (predominant type) with (25%-40%) sand, some (10%-25%) gravel, trace (less than 10%) clay.

STANDARD PENETRATION CLASSIFICATION

Relative Density of Sands as determined by Standard Penetration Tests		
No. of Blows/foot N	Relative Density D_r	Designation on Borehole Log
0 - 4	0% - 20%	Very Loose
4 - 10	20% - 40%	Loose
10 - 30	40% - 60%	Medium Dense
30 - 50	60% - 80%	Dense
Over 50	80% - 100%	Very Dense

Shear Strengths of Clays as determined by Standard Penetration Tests		
No. of Blows/foot N	Shear Strength s psf	Designation on Borehole Log
2	250	Very soft
2 - 4	250 - 500	Soft
4 - 8	500 - 1000	Medium
8 - 15	1000 - 2000	Stiff
15 - 30	2000 - 4000	Very Stiff
Over 30	Over 4000	Hard



RECORD OF BOREHOLE No 25

W P 1-79 LOCATION Co-ords 15,792,381 N; 950,605 E. ORIGINATED BY T.L.
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
 DATUM Geodetic DATE January 22, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL x LAB VANE						
							WATER CONTENT (%)							
							Wp W WL							
							10 20 30							
361.6	Ground Level													
0.1	Topsoil.													
	Silty clay.						360							
	Stiff to hard Red		1	SS	10								130.1	
							358							
356.6			2	SS	38/12"									
5.0	Red Shale Bedrock				51/6"		356							
354.8			3	SS	100/3"									
6.8	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 26

W P 1-79-01 LOCATION Co-ords. 15,792,494 N; 950,652 E. ORIGINATED BY T L
DIST Hamilton HWY O.E.W. BOREHOLE TYPE Solid Stem Auger, BXL Rock Core COMPILED BY T L
DATUM Geodetic DATE January 16, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
363.8	Ground Level																
0.0	Silty clay with shale fragments.		1	AS													
	Stiff Red		2	SS	18												
358.3			3	SS	11/6"												
5.5			4	AS	100/5"												
	Shale Bedrock with several thin horizontal layers of silty clay. Decreasing in frequency with depth.		5	RC BXL	87%												
	Red		6	RC BXL	91%												
350.8																	
13.0	Shale Bedrock		7	RC BXL	100%												
	Sound Red		8	RC BXL	100%												
344.3																	
19.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 29

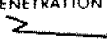


W P 1-79-01 LOCATION Co-ords. 15,792,244 N; 950,662 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 10, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
358.8	Ground Level																
0.0 358.8 0.5	Topsoil.		1	SS	6		357										
	Fill - silty clay, occasional pocket of sand. Red		2	SS	13												
355.8																	
3.0	Shale Bedrock, weathered horizontal layers. Red		3	SS	138		355										
			4	SS	150		353										
352.4			5	SS	100/5"												
6.4	End of Borehole Refusal to augers																



RECORD OF BOREHOLE No 33

W P 1-79-01 LOCATION Co-ords. 15,791,722 N; 951,081 E. ORIGINATED BY T.L.
DIST Hamilton HWY O.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 19, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH					WATER CONTENT (%)				
								○ UNCONFINED		+ FIELD VANE			● QUICK TRIAXIAL		x LAB VANE		
352.6	Ground Level					0.5	1.0	1.5	2.0	2.5	10	20	30				
0.0	Topsoil																
0.3	Silty clay, occasional shale fragments. Stiff Red		1	AS													
			2	SS	12											126.7	
			3	SS	8											128.4	
			4	SS	12											130.0	
347.1	Shale Bedrock, weathered horizontal layers. Red				50/4"										136.9		
5.5			5	SS	50/4"												
			6	SS	100/6"												
			7	AS													
343.0			8	SS	65/4"												
9.6	End of Borehole																



RECORD OF BOREHOLE No 34

W P 1-79-01 LOCATION Co-ords 15,791,785 N; 951,136 E. ORIGINATED BY T.L.
Dist Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 15, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
374.8	Ground Level																
0.0	Asphalt.																
373.8																	
1.0	Gravelly silty sand.		1	AS													
371.8																	
2.0	Fill - silty clay with occasional shale fragments.						370										
			2	SS	10											143.9	
			3	AS													
	Red		4	SS	8											138.0	
							360									141.1	
			5	SS	11												
																143.1	
																145.8	
			6	SS	32												
352.3																	
21.5	Red silty clay.		7	SS	77												
			8	SS	160												
	Apparent shale bedrock Red		9	SS	70/6		350										
348.9																	
25.9	End of Borehole																



RECORD OF BOREHOLE No 35

W P 1-79-01 LOCATION Co-ords. 15,791,825 N; 951,163 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 12, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							0.5 1.0 1.5 2.0 2.5					WATER CONTENT (%) 10 20 30					
374.4	Ground Level																
0.0	Asphalt																
1.0	Gravelly silty sand. Fill - silty clay with shale fragments. Stiff Red		1	AS													
371.4																	
3.0			2	AS													
			3	SS	11												
			4	AS													
			5	SS	7												
			6	AS													
			7	SS	12												
			8	AS													
			9	SS	18												
		10	SS	36													
349.4			11	SS	100/2"												
25.2	Apparent Shale Bedrock																
	End of Borehole																



RECORD OF BOREHOLE No 36

W P 1-79-01 LOCATION Co-ords 15,791,578 N; 951,141 E. ORIGINATED BY T L
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T L
DATUM Geodetic DATE January 18, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
352.9	Ground Level																
0.0	Asphalt		1	AS													
0.5	Concrete																
1.5	Limestone screenings		2	AS													
349.9																	
3.0	Silty clay to weathered shale.		3	SS	42												
345.9	Stiff Red		4	SS	85/12" 50/4"												
7.0	Shale Bedrock with occasional thin horizontal layer of weathered shale decreasing in frequency with depth.		5	SS	95												
			6	SS	160/11"												
			7	AS													
			8	SS	100/6"												
	Red and Grey Sound		9	RC BXL	93%												
			10	RC BXL	100%												
331.0																	
21.0	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (% STRAIN AT FAILURE

RECORD OF BOREHOLE No 36A

W P 1-79-01 LOCATION Co-ords, 15,791,621 N; 951,173 E. ORIGINATED BY TL
Dist Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY TL
DATUM Geodetic DATE January 23, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
353.6	Ground Level																
0.0	Asphalt.																
0.5	Concrete.																
352.1							352										
1.5	Limestone screenings		1	AS													
350.6																	
3.0	Silty clay to weathered shale.		2	SS	12		350									131.8	
			3	SS	35		348									123.6	
	Stiff Red		4	SS	45/12" 80/6"		346									132.6	
346.1																	
7.5	Apparent Shale Bedrock Red		5	SS	100/5.5"												
345.1																	
8.5	End of Borehole																

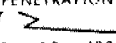
RECORD OF BOREHOLE No 37

W P 1-79-01 LOCATION Co-ords, 15,791,693 N; 951,228 E. ORIGINATED BY T L
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T L
 DATUM Geodetic DATE January 23, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
354.5	Ground Level																
0.0	Asphalt.						354										
0.5	Concrete.																
353.0																	
1.5	Limestone screenings.		1	AS			352										
351.5																	
3.0	Gravelly silty clay to weathered shale.		2	SS	46		350										
	Red		3	SS	14												
			4	SS	74		348										
347.0																	
7.5	Apparent Shale Bedrock		5	SS	155/10"		346										
345.7	Red & Grey		6	SS	100/4"												
8.8	End of Borehole																

RECORD OF BOREHOLE No 38

W P 1-79-01 LOCATION Co-ords 15,791,439 N; 951,192 E. ORIGINATED BY TL
 DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY TL
 DATUM Geodetic DATE January 23, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
349.3	Ground Level																
0.0	Topsoil.		1	AS													
0.4	Asphalt.																
0.6	Wet gravelly sand.		2	AS			348										
	Brown																
346.8																	
2.5	Silty clay.		3	SS	8		346										
	Red																
344.8			4	SS	28/12 40/6		344										
4.5	Severely Weathered shale with horizontal clay seams.		5	SS	40		344										
	Red and Green		6	SS	61		342										
340.8			7	SS	41/6 100/2		340										
8.5	Apparent Shale Bedrock																
8.7	End of Borehole																

³, ⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 39

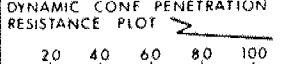






W P 1-79-01 LOCATION Co-ords. 15,791,498 N; 951,245 E. ORIGINATED BY T L
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T L
DATUM Geodetic DATE January 11, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
372.8	Ground Level																
0.0	Gravelly clayey sand.		1	AS			370									137.2	
0.8	Fill - gravelly silty clay with occasional shale fragments.		2	AS													
	Red.		3	SS	43		365									128.9	
			4	SS	10		360									135.0	
			5	SS	14		355									143.8	
			6	SS	14		350									130.4	
			7	SS	20												
347.8	Gravelly sand.		8	SS	12		345										
25.0	Silty clay. Red																
321.1	Apparent Shale Bedrock Red		9		40/6" 100/5"												
26.7																	
344.0																	
28.0																	
30.5																	
30.9	End of Borehole																



RECORD OF BOREHOLE No 40

W P 1-79-01 LOCATION Co-ords. 15,791,557 N; 951,280 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 12, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH										
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×	LAB VANE					WATER CONTENT (%)
373.8	Ground Level							0.5	1.0	1.5	2.0	2.5						
372.8	Asphalt		1	AS														
1.0	Gravelly sand.		2	AS														
	Fill - silty clay with shale fragments.		3	SS														
	Red		4	SS	40													
			5	AS														
			6	SS	12													
			7	SS	10													
			8	SS	15													
			9	AS														
348.3			10	SS	58													
25.5	Gravelly sand. Brown		11	SS	40/6"													
346.7																		
27.1	Apparent Shale Bedrock				100/5"													
345.0																		
27.9	End of Borehole																	

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 45

W P 1-79-01 LOCATION Co-ords 15,790,577 N; 951,724 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 15, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
333.6	Ground Level																
0.0	Asphalt																
0.2	Crushed stone		1	AS													
0.5	Gravelly silty clay																
332.6																	
1.0	Silty clay with frequent shale fragments		2	SS	48		332							o		119.0	
														o		129.8	
	Hard Red		3	SS	50		330										
			4	SS	68		328				a			o		132.0	
326.6																	
7.0	Apparent shale Bedrock		5	SS	100/3												
7.2	Grey																
	End of Borehole																

RECORD OF BOREHOLE No 46

W P 1-79-01 LOCATION Co-ords. 15,790,806 N; 951,650 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 15, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
337.9	Ground Level																
0.0	Silty clay topsoil.		1	AS													
0.5	Silty clay. Red																
1.0	Crushed stone and Red silty clay.		2	SS	76		336										
2.0	Silty clay with frequent shale fragments		3	SS	28											126.6	
	Stiff Red		4	SS	13		334									120.6	
			5	SS	13		332									126.1	
			6	SS	9/6"											119.9	
			7	SS	56/5"		330									130.7	
330.0	Apparent Shale Bedrock Grey																
7.9	End of Borehole																
329.4																	
8.5																	

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

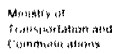


RECORD OF BOREHOLE No 61

W P 1-79-01 LOCATION Co-ords 15791932. N; 950629E ORIGINATED BY TL
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY TL
DATUM Geodetic DATE January 23, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
359.8	Ground Level																
356.3	Silty Clay Red Brown		1	AS													
3.5	Apparent Shale Bedrock End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 70

W P 1-79-01 LOCATION Co-ords. 15,792,052 N; 950,816 E. ORIGINATED BY TL
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY TL
DATUM Geodetic DATE January 10, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	Liquid LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		WATER CONTENT (%)				
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
361.8	Ground Level													
0.0	Fill - mixture of gravelly silty sand, silty clay and shale fragment. Brown		1	SS	112	360								
360.8			2	SS	83									
1.0			3	SS	102		358							
			4	SS	92									
	Fill - grey angular shale fragments and silty sand matrix.		5	SS	120	356								
					100/2"									
355.1	Shale Bedrock Grey													
6.7	End of Borehole													

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 71



W P 1-79-01 LOCATION Co-ords. 15,791,857, N; 950,803 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Solid Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 11, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N ^o VALUES			20	40	60	80	100	W _p	W	W _L		
358.9	Ground Level																GR SA SI CL
0.0	Silty clay topsoil.		1	SS	26		358										
357.9	Fill - silty clay with grey shale fragments		2	SS	79												
1.0							356										
355.4	End of borehole Refusal to augers Apparent Bedrock		3	AS													
3.5																	



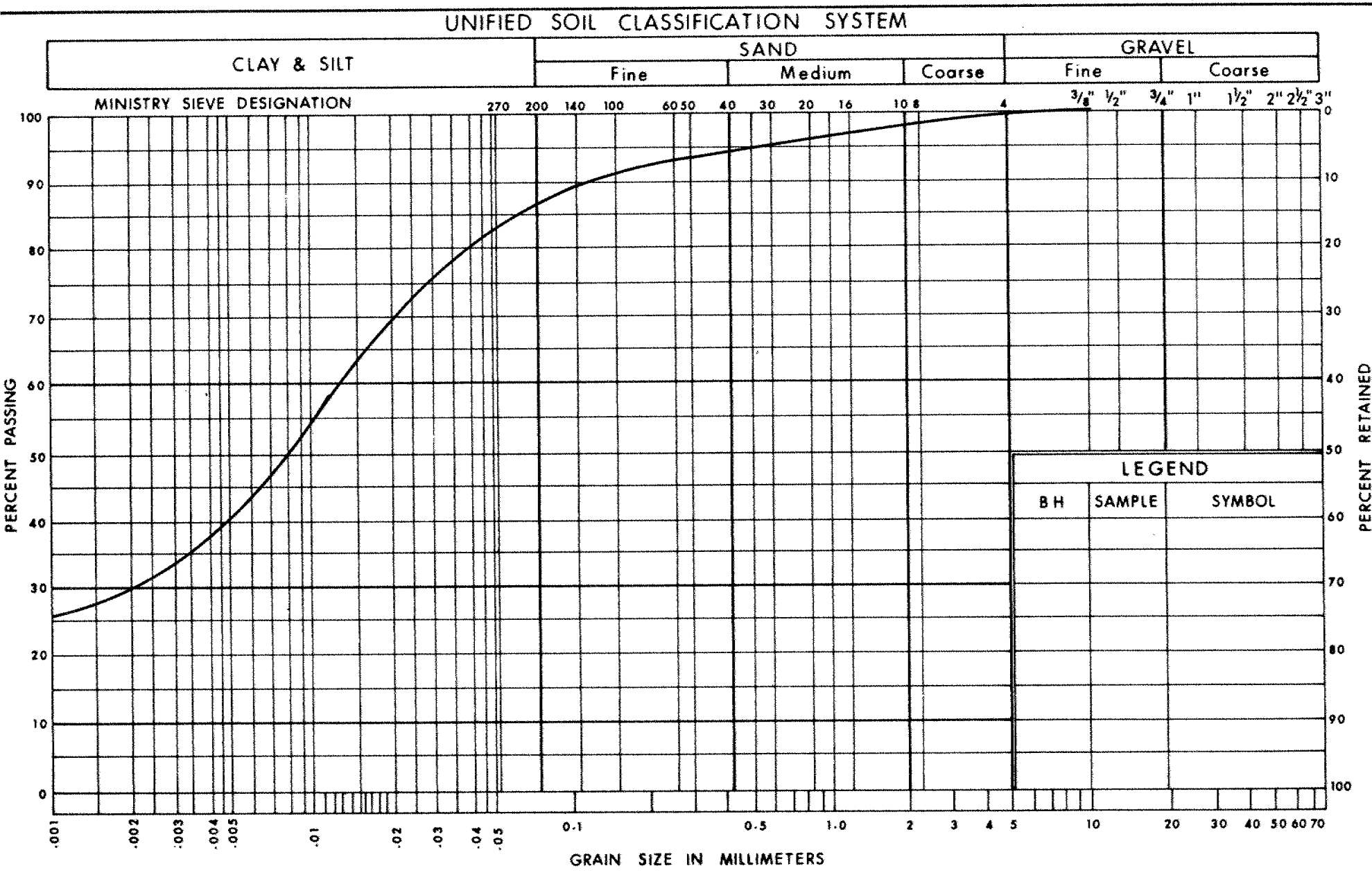
RECORD OF BOREHOLE No 71A

W P 1-79-01 LOCATION Co-ords 15,791,863 N; 950,800 E. ORIGINATED BY T.L.
DIST Hamilton HWY Q.E.W. BOREHOLE TYPE Stem Auger COMPILED BY T.L.
DATUM Geodetic DATE January 10, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH									
358.9	Ground Level																
0.0	Silty clay topsoil.						358										
357.9																	
1.0	Fill - red silty clay with grey shale fragments.		1	SS	49/10"		357										
355.9																	
3.0	End of Borehole Refusal to augers Apparent Bedrock																

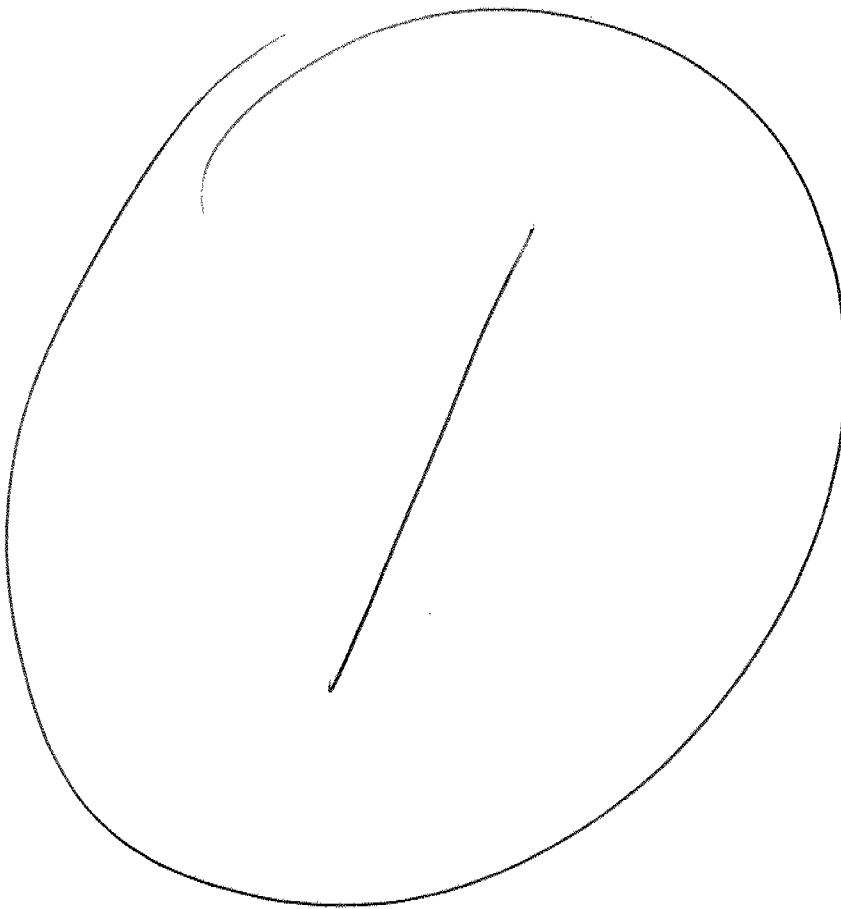
+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



35MM

DRAWING



OVERSIZE DRAWING(S)