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January 7, 1998

File No. 10950

Mr. Bruce Friesen, P.Eng.
Delcan Corporation
2001 Thurston Drive
P.O. Box 8004
Ottawa, ON K1G 3H6

Dear Mr. Friesen:

Re: Addendum to Jacques Whitford Report No. 10212 dated August 17, 1992
W.P. 374-89-00, Site 16-259 and Site 16-260
Concrete Culverts, Ramps W-N and N-W, Hwy 401/416 Interchange

This letter contains the results of additional geotechnical investigation work and revised geotechnical recommendations for the design of the above referenced concrete culverts. The additional investigative work and revised recommendations reflect newly proposed culvert locations.

This addendum letter should be read in conjunction with the original Foundation Investigation Report prepared by Jacques, Whitford Limited and dated August 17, 1992.

1.0 Background

Changes to Proposed Culvert Locations

The orientation of the concrete culvert beneath the W-N ramp, site 16-259, has been changed. The south end of the culvert has been rotated approximately 20° to the east, in order to follow the natural alignment of Johnstown Creek. The culvert will consist of a 6.0 m by 2.5 m concrete rigid frame open footing culvert, 48 m in length. The finished roadway elevation above the culvert will be approximately 93.9 m. The invert elevation will be approximately 83.0 m.

The location of the concrete box culvert beneath the N-W ramp has been moved to Station 11+302, approximately 100 m southwest of the location investigated in 1992. The culvert will be a 5.0 m by 3.0 m concrete rigid frame box culvert, 50 m in length. The finished roadway elevation above the culvert will be approximately 90.2 m. The elevation of the bed of Johnstown Creek is approximately 83.2 m at this location.



Changes to OHBDC

The geotechnical recommendations provided in the original geotechnical report (JWL Report 10204) were based on the then current edition of the Ontario Highway Bridge Design Code (OHBDC 2nd Edition). The recommendations provided in this addendum letter are in accordance with the now current, 3rd Edition of the OHBDC.

2.0 Additional Field Investigation

2.1 Methodology

The borehole locations were laid out in the field by Delcan personnel. Underground utility location clearances were obtained by Jacques, Whitford Limited prior to the onset of the drilling investigation.

One borehole, designated as 97-1, was put down at the repositioned south/east end of the culvert beneath the W-N ramp. Two boreholes, designated as 97-2 and 97-3, were put down at the east and west ends, respectively, of the culvert beneath the N-W ramp. The culvert and borehole locations are shown on Drawing 3748900-A, attached. The boreholes were put down between September 18 and 19, 1997, using a track-mounted CME 55 power auger drill rig suitably equipped for soil and bedrock sampling.

Overburden soils were sampled by means of a split spoon sampler while carrying out Standard Penetration Tests (SPT). All boreholes were put down to auger refusal on inferred bedrock. Bedrock coring was not carried out.

All soil samples recovered were stored in moisture-proof bags and returned to the JWL Ottawa laboratory for detailed classification and testing.

Standpipes were installed in Boreholes 97-2 and 97-3. The boreholes were backfilled with the augered soil.

The actual borehole elevations and locations were surveyed by Delcan personnel after completion of the drilling investigation.



2.2 Results

The subsurface conditions observed in the boreholes are presented in detail on the Record of Boreholes, attached. The ground surface elevations at the borehole locations are included on the Record of Boreholes. In addition, geological cross-sections at the proposed culvert locations are shown on Drawing 3748900-A, attached.

2.2.1 Culvert Under Ramp W-N

Borehole 97-1 was located at the east end of the proposed culvert. In general, the overburden soils observed within this borehole are very thin. A thin layer of topsoil was underlain by loose, brown sand with some silt, overlying inferred bedrock at a depth of 1.2 m below surface. The borehole was terminated upon auger refusal on inferred bedrock.

The soil conditions at the west end of the culvert alignment were assessed by Borehole 92-3, put down as part of the initial geotechnical investigation. Similarly, bedrock was encountered at a shallow depth (2.4 m).

The groundwater table in the immediate vicinity of the boreholes is estimated to be at the same elevation as the water level in Johnstown Creek, approximately 600 mm below surface.

2.2.2 Culvert Under Ramp N-W

In general, the overburden soils observed at the borehole locations consist of a surficial layer of dark brown, sandy topsoil, overlying a thin layer of sand, overlying a thick layer of silty clay, overlying glacial till, overlying inferred bedrock.

The sand generally contained trace amounts of sand and organics and extended to a depth of 800 mm.

The sand is underlain by very stiff to hard silty clay. The silty clay changed from brown to dark grey with increasing depth. The thickness of the silty clay deposit was typically 6 m. The moisture contents of eight samples tested ranged from 23 % to 36 % with an average of 29 %.

Auger refusal on inferred bedrock was encountered in Boreholes 97-2 and 97-3 at depths of 8.5 m and 7.9 m, respectively.

Water levels were measured in the standpipes on September 19, 1997. The groundwater level varied from 0.7 m to 0.6 m below ground surface at Boreholes 97-2 and 97-3, respectively. Variations in the groundwater level due to seasonal fluctuations and in response to precipitation events should be expected.



3.0 Recommendations

The conditions encountered in the boreholes drilled at the new culvert locations are consistent with those encountered at the previous culvert locations. Therefore, with the exception of reference changes from the OHBDC 2nd Edition to the OHBDC 3rd Edition, the geotechnical recommendations are unchanged from those issued in the Foundation Investigation report dated August 17, 1992.

3.1 Culvert Foundations

Culvert Under Ramp W-N

The proposed culvert may be founded on the bedrock. Spread footings placed on clean level bedrock may be designed using the following parameter:

Factored bearing capacity at ULS	3,000 kPa
----------------------------------	-----------

The bedrock is considered to be an unyielding foundation base and, hence, an SLS criteria does not apply.

Sliding resistance between the concrete and the bedrock should be calculated in accordance with Section 6-8.4.3 of the OHBDC using an unfactored friction coefficient of 0.7.

For spread footings placed on bedrock, the underside of all footings should be provided with a minimum of 0.9 m of earth cover for frost protection.

Culvert Under Ramp N-W

The proposed concrete box culvert may be founded on the very stiff to hard native silty clay. The following parameters may be used for design:

Factored bearing capacity at ULS	330 kPa
Bearing capacity at SLS	200 kPa

The above recommended factored bearing capacity at ULS assumes a footing width between 2.5 m and 6 m.

Sliding resistance between the concrete and the silty clay should be calculated in accordance with Section 6-8.4.3 of the OHBDC using an unfactored friction coefficient of 0.5.



The underside of all spread footings should be provided with a minimum soil cover of 1.8 m to protect against frost action.

3.2 Backfill for Culverts and Retaining Walls

The culvert walls and associated retaining walls should be backfilled with free draining material such as OPSS Granular A or Granular B, to prevent hydrostatic pressure build-up. Backfill requirements for the box culverts should be in accordance with OPSD 803 series.

Computation of earth pressures should be in accordance with Section 6-7 of the OHBDC 3rd Edition. For abutments or retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied structures, the at-rest earth pressure should be used for design. For a structure with a horizontal backfill, the following unfactored soil parameters may be used for design.

Parameter	OPSS Granular A	OPSS Granular B
Bulk Unit Weight, γ (kN/m ³)	22.8	21.2
Effective Friction Angle, ϕ	35°	30°
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.50

Compaction of the granular backfill near the walls should be carried out using hand-operated equipment to prevent overstressing the abutment walls. Weep holes should be provided in retaining walls to drain any accumulated water within the backfill.

5.0 Closure

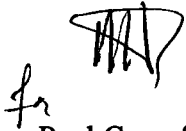
Recommendations relating to items not addressed in this addendum letter, are presented in the original Foundation Investigation Report prepared by Jacques, Whitford Limited, dated August 17, 1992. The present addendum letter should be read in conjunction with the aforementioned Foundation Investigation Report.

The recommendations made in this addendum letter are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

JACQUES, WHITFORD LIMITED



Paul Carnaffan, M.Eng., P.Eng.



J.G.A. Raymond Haché, M.Sc., P.Eng.



EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

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

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No 97-1

1 OF 1

METRIC

W.P. 374-89-00 LOCATION Hwy 401/416 Interchange, Johnstown Creek Culvert ORIGINATED BY CL
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CL
 DATUM Geodetic DATE 97.09.18 & CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
84.3 0.0	Loose, brown, SAND, some silt		1	BS													
83.1			2	SS		ref											
1.2	End of Borehole Auger Refusal on Inferred Bedrock ref = > 50 blows for 150mm																

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

RECORD OF BOREHOLE No 92-3

METRIC

W P 374-89-00 LOCATION Co-ords N 4 956 592 E 384 834 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem, N-Casing, Rock Coring COMPILED BY F.J.G.
 DATUM Geodetic DATE May 13, 1992 CHECKED BY CKK

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	VALUES		20	40	60	80	100					
84.1	Ground Surface															
84.03	Topsoil		1	SS	1	84 May 15, 1992										
83.5	Clay, sand, trace gravel, Brown, very Soft		2	SS	4											
80.6	Silty Clay Brown to Grey Firm to Hard		3	SS	10											
81.8	Sandy silt Grey, compact		4	SB	2/150mm											
82.29	Bedrock Limey Dolostone with shaley partings Excellent		5	NQ	REC 100Z											
80.1																
84.0	End of Borehole															

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 97-2

1 OF 1

METRIC

W.P. 374-89-00 LOCATION Hwy 401/416 Interchange, Johnstown Creek Culvert ORIGINATED BY CL
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CL
 DATUM Geodetic DATE 97.09.18 & CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
84.3 0.0	Loose, brown, SAND, some silt		1	BS			84							
83.5 0.8	Very stiff to hard, brownish grey to dark grey, SILTY CLAY		2	SS	14		83							
			3	SS	9		82							
			4	SS	11		81							
			5	SS	12		80							
			6	SS	17		79							
			7	SS	18		78							
			8	SS	24		77							
			9	SS	17		76							
77.5 6.8	Very dense, grey, heterogeneous mixture of silt and clay, some sand and gravel (glacial till)		10	SS	83									
			11	SS	53									
75.8 8.5	End of Borehole		12	SS		ref								
	Auger Refusal on Inferred Bedrock Standpipe Installed ref = >50 blows for 150mm													

x³ . x³ : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 97-3

1 OF 1

METRIC

W.P. 374-89-00 LOCATION Hwy 401/416 Interchange, Johnstown Creek Culvert ORIGINATED BY CL
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CL
 DATUM Geodetic DATE 97.09.18 & CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
84.0	Loose, brown, SAND		1	BS										
0.0														
83.3	Stiff to hard, brownish grey to dark grey, SILTY CLAY		2	SS	3									
0.8														
			3	SS	5									
			4	SS	10									
			5	SS	6									
			6	SS	13									
			7	SS	13									
			8	SS	11									
			9	SS	15									
77.2			Dense, grey, heterogeneous mixture of silt and clay, some sand and gravel (glacial till)		10	SS	45							
6.8														
76.2	End of Borehole		11	SS		ref								
7.9														
	Auger Refusal on Inferred Bedrock													
	Standpipe Installed													
	ref = > 50 blows for 150mm													

x³ . x³ : Numbers refer to Sensitivity

20
15 10 5 0
(%) STRAIN AT FAILURE

FOUNDATION INVESTIGATION REPORT

W.P. 374-89-00

CONCRETE CULVERTS

SITE 16-259, RAMP W-N STA. 21+338.8

SITE 16-260, RAMP N-W, STA. 11+400

HWY. 401-416 INTERCHANGE

DISTRICT 9, OTTAWA

File
GEOCRETS #31B-67

MINISTRY OF TRANSPORTATION OF ONTARIO

SUBMITTED TO

DELCAN CORPORATION

BY

JACQUES, WHITFORD LIMITED

2781 LANCASTER ROAD

SUITE 200

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PHONE: (613) 738-0708 FAX: (613) 738-0721



Report

on

Foundation Investigation

for

W.P. 374-89-00

Concrete Culvert

Site 16-259, Ramp W-N, Sta. 21+338.8

Site 16-260, Ramp N-W, Sta. 11+400

Hwy. 401-416 Interchange

District 9, Ottawa

Jacques, Whitford Limited

August 17, 1992



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APPENDIX 1

Explanation of Terms Used in Report
Records of Borehole
Figure 1: Grain Size Distribution
Figure 2: Plasticity Chart

APPENDIX 2

Drawing No. 3748900-A



FOUNDATION INVESTIGATION REPORT

for

W.P. 374-89-00

Concrete Culvert

Site 16-259, Ramp W-N, Sta. 21+338.8

Site 16-260, Ramp N-W, Sta. 11+400

Hwy. 401-416 Interchange

District 9, Ottawa

1.0 INTRODUCTION

This report presents the results of a foundation investigation at the above noted site in the Township of Edwardsburg, Ontario. The investigation was carried out in accordance with our proposal dated December 11, 1990. Authorization to carry out the work was provided by Ms. Colleen Conley, P.Eng., of Delcan Corporation.

This report contains factual information obtained from this investigation pertaining to the subsurface conditions.

2.0 SITE DESCRIPTION AND GEOLOGY

The sites are located at Johnstown Creek approximately 1.4 and 1.1 kilometres west of the intersection of Highways 401 and 16. The topography in the area generally slopes downward from the northeast to the southwest at about 2% grade or less. The surrounding ground consists of pasture north of Highway 401, and grassed and forested areas south of Highway 401.

Drainage in the immediate area is provided by highway ditches connected to Johnstown Creek which flows into the St. Lawrence River.

Physiographically, the site lies in the area known as the Glengarry Till Plain. The surface consists of morainic ridges and drumlins together with intervening clay flats and swamps. Bedrock underlying the overburden consists of Ordovician dolostone of the Oxford Formation.



3.0 PROCEDURE

3.1 Field Investigation

Prior to the onset of the drilling investigation, necessary utility clearances were obtained by our site personnel.

The field work for this investigation was carried out from May 11 to 13, 1992. Two (2) boreholes were drilled at each of the culvert locations. The test locations are indicated on Drawing No. 3748900-A provided in Appendix 2. One borehole at each culvert location (BH 92-1 and 92-3) proved bedrock by coring. The other borehole at each culvert location (BH 92-2 and 92-4) was put down to auger refusal on inferred bedrock.

All of the boreholes were put down using a track mounted CME 55 drill rig equipped for soil and bedrock sampling and testing. The boreholes were advanced using hollow stem augers where possible. The overburden soils were sampled at regular intervals by means of a split spoon sampler during the performance of Standard Penetration Tests (SPT) (ASTM D1586). Field vane tests were carried out in cohesive layers. Bedrock was encountered and cored using NQ sized equipment in Boreholes 92-1 and 92-3.

All soil samples recovered were stored in moisture proof containers and were returned to our laboratory for detailed classification and testing.

Standpipe piezometers 25 mm in diameter were installed in the boreholes with the exception of Borehole 92-4. The standpipe in Borehole 92-1 was sealed within the bedrock. The other boreholes were backfilled with auger cuttings to near the ground surface.

3.2 Survey

The borehole locations and ground surface elevations were surveyed by Delcan Corporation personnel prior to the field work. Boreholes relocated (if required) due to site conditions were surveyed by our personnel relative to the original surveyed locations. The actual borehole location and elevation data is summarized on Drawing 3748900-A in Appendix 2.

3.3 Laboratory Testing

The following laboratory tests were carried out on representative soil samples to determine their properties:

- Detailed visual classification of all samples,
- Natural moisture content,
- Sieve and hydrometer analyses,
- Atterberg Limits determination,

Samples remaining after testing will be stored for a period of six months after issuance of the final report. They will then be discarded unless we are otherwise directed.

4.0 RESULTS OF THE INVESTIGATION

4.1 Subsurface Conditions

The subsurface conditions observed in the boreholes are presented in detail on the Records of Borehole provided in Appendix 1. An Explanation of Terms Used in Report is also provided in Appendix 1. The laboratory test results are summarized in the Records of Borehole and also on Figures 1 and 2 in Appendix 1.

A brief discussion of the observed subsurface conditions is provided below. Specific details of the subsurface materials should be obtained from the Records of Borehole.

4.1.1 Topsoil

A layer of topsoil was observed at the ground surface in all boreholes. The topsoil ranged in thickness from 25 to 300 mm.

4.1.2 Sand and Clayey Sand

A layer of sand, trace silt or a layer of clayey sand was encountered immediately below the topsoil in all boreholes. The thicknesses of the sand or clayey sand layers vary from 0.15 m to 0.3 m. The SPT conducted yielded N values ranging from 1 to 2, indicating a denseness of very loose. Based on visual identification, the sand and clayey sand are classified as cohesionless materials.

4.1.3 Silty Clay

In Boreholes 92-1, 92-2, and 92-3 a layer of silty clay was encountered below the sand / clayey sand layer. The thickness of the silty clay varied between 1.7 and 6.6 m. Field vane tests (using a vane with dimensions of D=61 mm and H= 124 mm) were attempted at selected



locations. Due to the very stiff to hard consistency of the silty clay, the shear strength was determined as >160 kPa. The SPT conducted in the silty clay layer yielded N values ranging from 4 to 25, and generally between 10 to 15. Pocket penetration tests carried out on recovered split spoon samples indicated a shear strength for the silty clay of about 200 kPa.

The average grain size distribution obtained from laboratory sieve and hydrometer analyses on representative samples indicated 0% gravel and sand, 40% silt, and 60% clay (Figure 1 in Appendix 1). Atterberg limits tests were carried out on two representative samples of the silty clay, with liquid limits of 47% and 49%; and plasticity indices of 25% and 28% (Figure 2 in Appendix 1). Moisture contents of the silty clay samples range from 22% to 39%. Based on the above laboratory and visual identification, the silty clay is a cohesive material.

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

A heterogeneous mixture of sand and silt, some gravel and clay (glacial till) was encountered in Boreholes 92-1 and 92-2 underlying the silty clay. The thickness of the till layer varied between 2.6 and 3.8 m. The SPT conducted in the glacial till stratum yielded N values ranging from 22 to over 50, indicating a denseness of compact to very dense. The high N values recorded are partially attributable to the presence of cobbles within the till. Moisture contents of the glacial till samples range from 7% to 12%.

Based on previous experience with the till in the surrounding area and on visual identification of the samples, the glacial till is classified as a cohesionless material.

4.1.5 Sandy Silt

A layer of sandy silt 0.1 m in thickness was encountered underlying the silty clay in Borehole 92-3. Based on visual identification, the sandy silt is classified as a cohesionless material.

4.1.6 Bedrock

Bedrock was encountered and proven by coring for 1.6 m in Boreholes 92-1 and 92-3. The bedrock is a limey dolostone with shaley partings and some calcite. The bedrock is of excellent quality (RQD ranging from 94% to 100%). Core recovery ranged from 94% to 100%.

4.2 Groundwater

Groundwater level was observed during drilling and measured in the standpipe piezometers on August 19, 1992. The groundwater elevations are presented on the Records of Borehole. Artesian head of 1.5 m and 0.5 m above the ground surface were encountered in the bedrock and the glacial till in Boreholes 92-1 and 92-2, respectively.

Groundwater levels are subject to seasonal fluctuations and will vary from the values given in this report.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Proposed Development

One (1) culvert is proposed underneath Ramp N-W (north of Highway 401) and one (1) culvert is proposed underneath Ramp W-N (south of Highway 401) at Johnstown Creek for the proposed Highway 401-416 Interchange. The proposed culverts are to have the following details:

Culvert Under Ramp N-W

- 5.00 x 2.50 m concrete rigid frame box culvert, 51 m in length,
- Streambed elevation at approximately 83.2 m,
- Finished roadway elevation at approximately 92 m.

Culvert Under Ramp W-N

- 5.80 x 1.52 m concrete rigid frame open footing culvert, 72 m in length,
- Invert elevation at approximately 83.0 m,
- Finished roadway elevation at approximately 93.5 m.

5.2 Geotechnical Assessment

The proposed culvert under Ramp N-W may be founded on the silty clay layer. The open type culvert under Ramp W-N may be supported on spread footings placed on bedrock.

The embankment fills of up to about 9 m in height may be constructed using side slopes of 2 horizontal to 1 vertical for granular borrow, or side slopes of 2.5 horizontal to 1 vertical for fine grained borrow. A 2.0 m wide berm is recommended at mid-height of the embankment. No embankment stability problems are anticipated.

Settlement of the culvert due to the embankment loading is expected to be negligible at Ramp W-N and in the order of 50 mm at Ramp N-W.

This report contains our detailed recommendations for the culvert structures in the following areas:

- 1) Structure Foundations
- 2) Fill Stability and Settlement
- 3) Backfill
- 4) Construction Considerations



5.3 Structure Foundations

Culvert Under Ramp N-W

The proposed concrete box culvert structure at Ramp N-W may be founded within the very stiff to hard silty clay layer. The following design value is recommended for foundations placed at Elev. 83.0 m or below:

Factored Bearing Capacity at U.L.S.	330 kPa
Bearing Capacity at S.L.S. Type II	200 kPa

The above recommended U.L.S. capacity is applicable to footing widths (B) from 2.5 m to 6 m.

Sliding resistance between the concrete and the silty clay should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. assuming an unfactored coefficient of friction of 0.5.

Culvert Under Ramp W-N

The proposed open type culvert at Ramp W-N may be founded on spread footings placed on the dolostone bedrock. Spread footings founded on the bedrock at El. 83.0 m or below may be designed using the following value:

Factored Bearing Capacity at U.L.S.	3000 kPa
-------------------------------------	----------

The dolostone bedrock is considered to be an unyielding foundation base and hence a S.L.S. Type II bearing capacity would not be applicable.

For spread footings placed on bedrock, the underside of all footings should be provided with a minimum of 0.9 m of earth cover for frost protection.

Sliding resistance between the concrete and the dolostone bedrock should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. assuming an unfactored coefficient of friction of 0.7.

5.4 Embankment Fills

5.4.1 Stability

Fill placement of up to 9 m is proposed for the embankments at Ramps N-W and W-N. Side slopes of 2 horizontal to 1 vertical would be appropriate for fills constructed of granular borrow or select subgrade materials. If fine-grained borrow materials are to be used, side slopes of 2.5 horizontal to 1 vertical would be appropriate.

Where fill height is in excess of 8.0 m, it is recommended that the embankments be constructed with a 2.0 m wide berm at the mid height of the slope. The berm should be constructed as an integral part of the main embankment up to the berm height.

Any softened and organic soils should be removed within the plan limits of the embankments prior to placement.

To protect against surficial instability, normal slope vegetation should be established in accordance with MTO standards as soon as possible after construction.

5.4.2 Settlement

Ramp N-W

Settlement of the culvert under the embankment loading at Ramp N-W is expected to be in the order of 50 mm, based on consolidation test results obtained in the foundation investigation for the Ramp N-W over Cedar Grove Road structure, W.P.: 374-89-03, Site 16-307.

Ramp W-N

For culvert and retaining structure footings founded on bedrock at Ramp W-N, settlement under the embankment loading is expected to be negligible.

5.5 Backfill for Culverts

To prevent hydrostatic pressure buildup, backfill to culvert walls should consist of free draining materials such as OPSS Granular 'A' or Granular 'B'. Backfill requirement for the box culverts should be in accordance with OPSD 803 series.

Computation of earth pressures should be in accordance with Section 6-6.1.2.1 of the O.H.B.D.C. The active pressure should be used if the structure is yielding. For rigidly tied structures, the at-rest earth pressure should be used for design, unless enough deflection (approximately 0.05 percent of the wall height) is allowed to establish active conditions.

For a horizontal backfill the following soil parameters are recommended for design:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Unit Weight (kN/m ³)	22.8	21.2
Effective Friction Angle, ϕ	35°	30°
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_0)	0.43	0.50



Compaction of the granular backfill near the walls should be carried out using hand-operated equipment to prevent overstressing the culvert and retaining walls. Weep holes should be provided in retaining walls to drain any accumulated water within the backfill.

5.6 Construction Considerations

5.6.1 Dewatering

Dewatering during construction will likely be required at both culvert locations. Dewatering may be achieved by utilizing perimeter ditches within a gravity system in conjunction with a sump pump discharge system to drain accumulated water. Alternatively, dewatering may be achieved by carrying out the excavation from within interlocking steel sheetings. Other dewatering alternatives may also be considered. The most economical and practically feasible dewatering alternative should be selected. It is the responsibility of the contractor to lower the groundwater below the excavation base, and to construct the structure foundations in the dry without disturbing the underlying foundation soils.

5.6.2 Temporary Excavation

Temporary excavations in the cohesive silty clay layer may be carried out using vertical side slopes in the bottom 1.2 m of the excavation. The side slopes should be no steeper than 1H:1V for the portion of the excavation higher than 1.2 m from the bottom. Where excavations are made in cohesionless deposits, the side slopes should be no steeper than 1H:1V throughout the excavation. In cohesionless deposits where seepage is encountered, flatter side slopes will likely be required, or alternatively a shoring system may be utilized.

5.7 Groundwater/Soil Chemistry

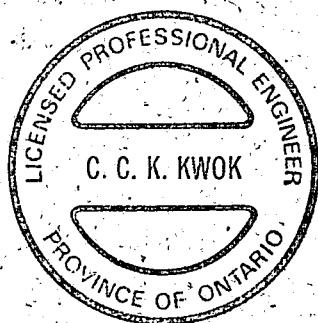
Representative samples of the groundwater and overburden soils have been tested for pH, sulphate and chloride contents for several other foundation investigations in the vicinity for the Hwy. 401-416 Interchange project (W.P. 374-89-00, 374-89-02, 374-89-03). All test results indicate that the potential degree of sulphate attack on concrete and the potential degree of attack on exposed steel are both negligible. However, corrosion potential resulting from the use of road salts in winter seasons should be considered in the design.

6.0 MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Y. Larochelle, P. Eng., utilizing equipment owned and operated by Marathon Drilling Company Limited. The report was written by both undersigned.

Respectfully submitted,

JACQUES WHITFORD LIMITED



A handwritten signature in cursive script, appearing to read 'C. C. K. Kwok'.

Charles C.K. Kwok, M.Sc., P.Eng.



A handwritten signature in cursive script, appearing to read 'F. J. Griffiths'.

Fred J. Griffiths, Ph.D., P.Eng.



EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

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

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No 92-1

METRIC

W P 374-89-00 LOCATION Co-ords: N 4 956 604 E 384 655 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock Coring COMPILED BY F.J.G.
 DATUM Geodetic DATE May 11, 1992 CHECKED BY CLK

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					
84.7	Ground surface																
0.1	Topsoil		1	SS	2		Seal										
0.4	Sand, some silt Brown Very Loose		2	SS	8		84										
			3	SS	15		83										
	Silty Clay Brown to Grey Very Stiff to Hard		4	SS	13		82										
			5	SS	10		81										
			6	SS	12	Native Backfill	80										
			7	SS	17		79										
			8	SS	17		78										
			9	SS	15		77										
77.7							76										
7.0	Het, Mixture of Sand and Silt, some Gravel and Clay		10	SS	54		75										
	Grey (Glacial Till) Very Dense						74										
75.1			11	SS	150mm		73										
9.6	Bedrock Limey Dolostone Excellent		12	NQ	94%		72										
73.5							71										
11.2	End of Borehole						70										
	Artesian Conditions 1.5m, Aug. 19, 1992						69										

RECORD OF BOREHOLE No 92-2

METRIC

W P 374-89-00 LOCATION Co-ords N 4 956 587 E 384 691 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem, N-Casing, Rock Coring COMPILED BY F.J.G.
 DATUM Geodetic DATE May 11, 1992 CHECKED BY CLK

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					
84.3	Ground Surface																
0.1	Topsoil																
0.25	Sand, some silt Brown, loose		1	SS	3		84										
	Silty clay Grey Very Stiff to Hard		2	SS	7		83										
			3	SS	9		82										
			4	SS	11		81										
			5	SS	12		80										
			6	SS	12		79										
77.6			7	SS	25		78										
6.7	Het, Mixture of Sand and Silt, some Gravel and Clay (Glacial Till) Grey Compact to Very Dense		8	SS	22		77										
			9	SS	74		76										
73.8							75										
10.5	End of Borehole Auger Refusal ▽* Artesian Conditions 0.5m, Aug. 19, 1992						74										

RECORD OF BOREHOLE No 92-3

METRIC

W P 374-89-00 LOCATION Co-ords N 4 956 592 E 384 834 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem, N-Casing, Rock Coring COMPILED BY F.J.G.
 DATUM Geodetic DATE May 13, 1992 CHECKED BY CKK

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					
84.1	Ground Surface																
84.03	Topsoil		1	SS	1		84 May	15, 1992									
83.5	Clay, sand, trace gravel, Brown, very Soft		2	SS	4		83										
81.8	Silty Clay Brown to Grey Firm to Hard		3	SS	10		82										
82.29	Sandy silt Grey, compact		4	SS	2/15		81										
2.4	Bedrock Limey Dolostone with shaley partings Excellent		5	NQ	REC 100%												RQD 100%
80.1																	
4.0	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 92-4

METRIC

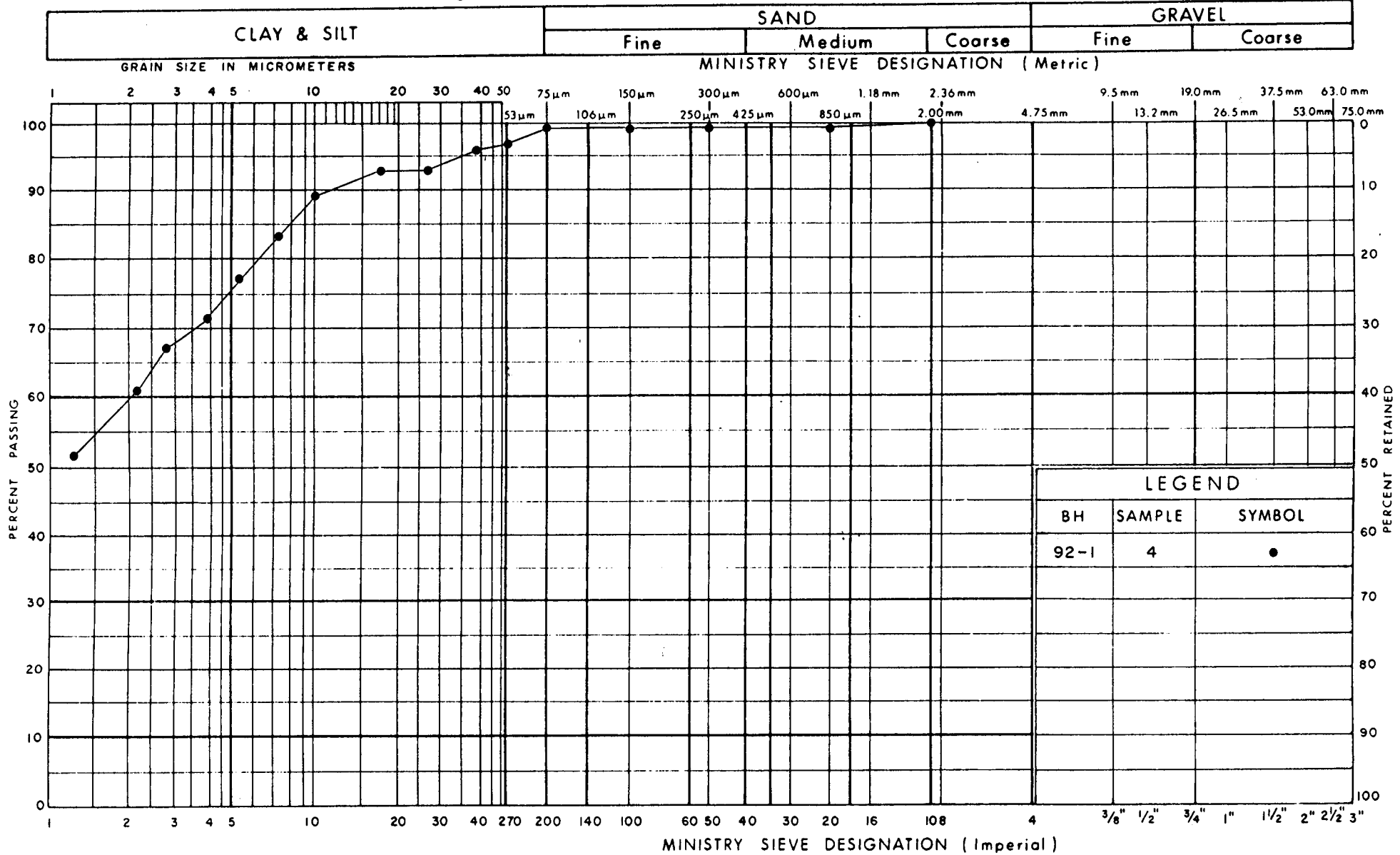
W P 374-89-00 LOCATION Co-ords: N 4 956 557 E 384 875 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem, COMPILED BY F.J.G.
 DATUM Geodetic DATE May 13, 1992 CHECKED BY CLK

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	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
84.2	Ground Surface															
83.9	Topsoil		1	SS	1	84										
0.3 83.6	Sand trace silt to silty sand trace to some clay Brown, Very Loose															
0.6																
	End of Borehole Auger Refusal on Inferred Bedrock Groundwater not Encountered															

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM

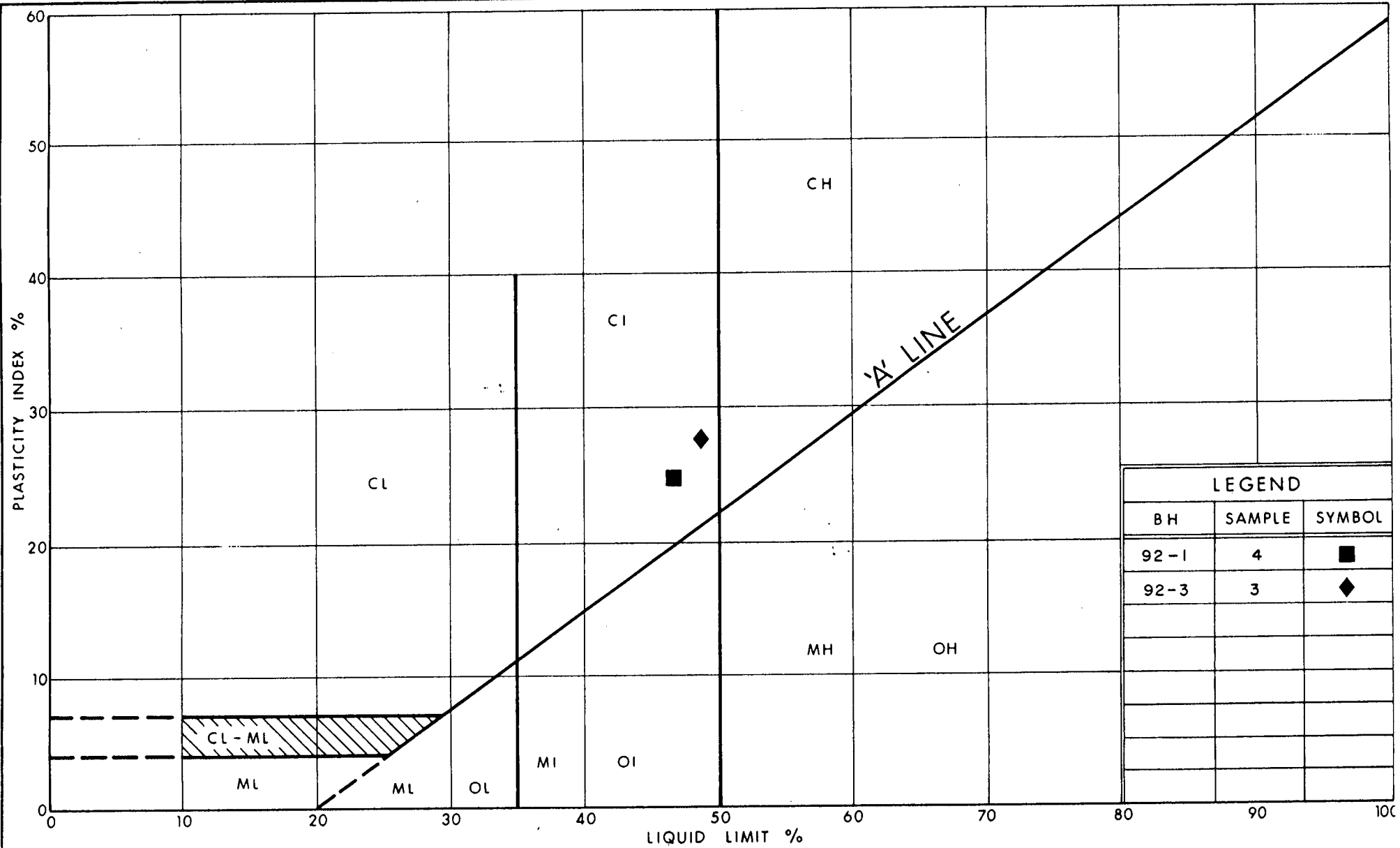


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIG No 1

W P 374-89-00



LEGEND		
BH	SAMPLE	SYMBOL
92-1	4	■
92-3	3	◆



Ministry of
Transportation

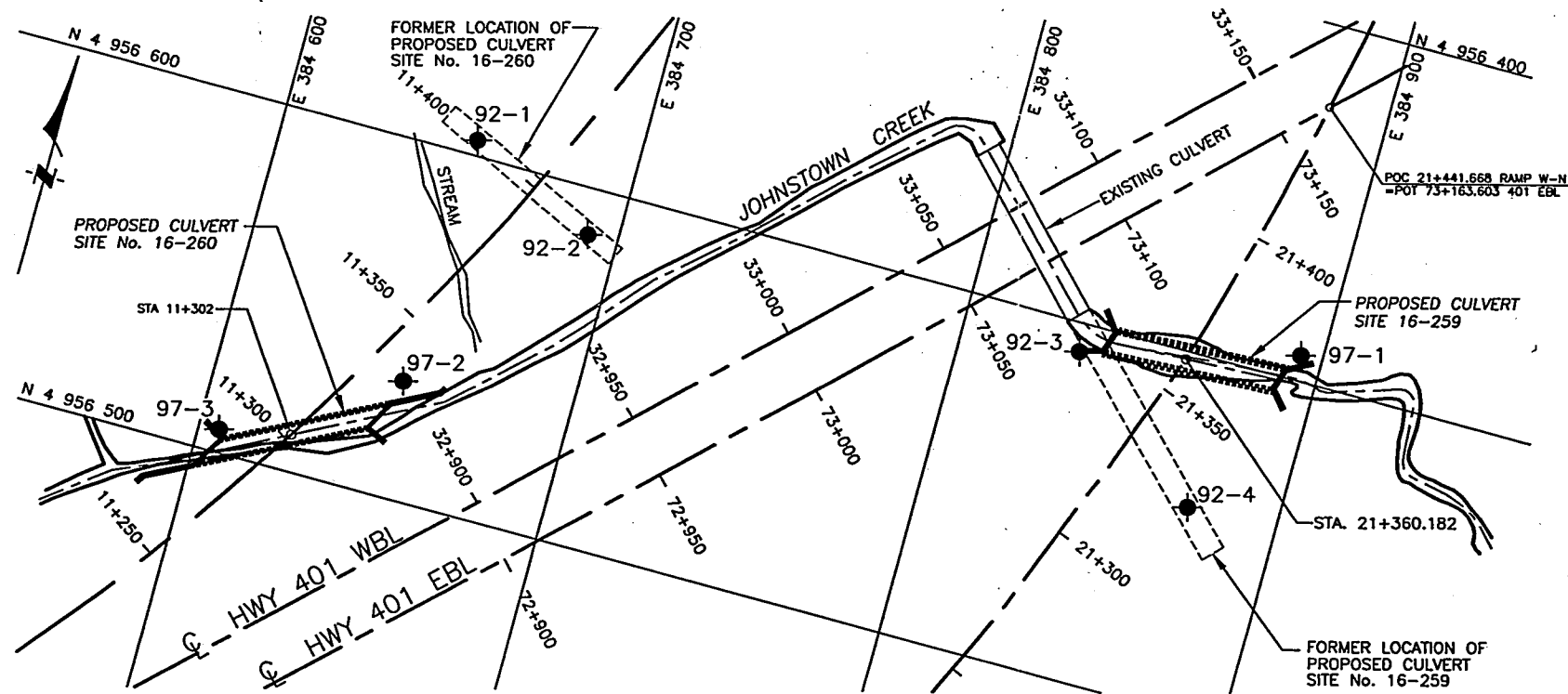
Ontario

PLASTICITY CHART SILTY CLAY

FIG No. 2

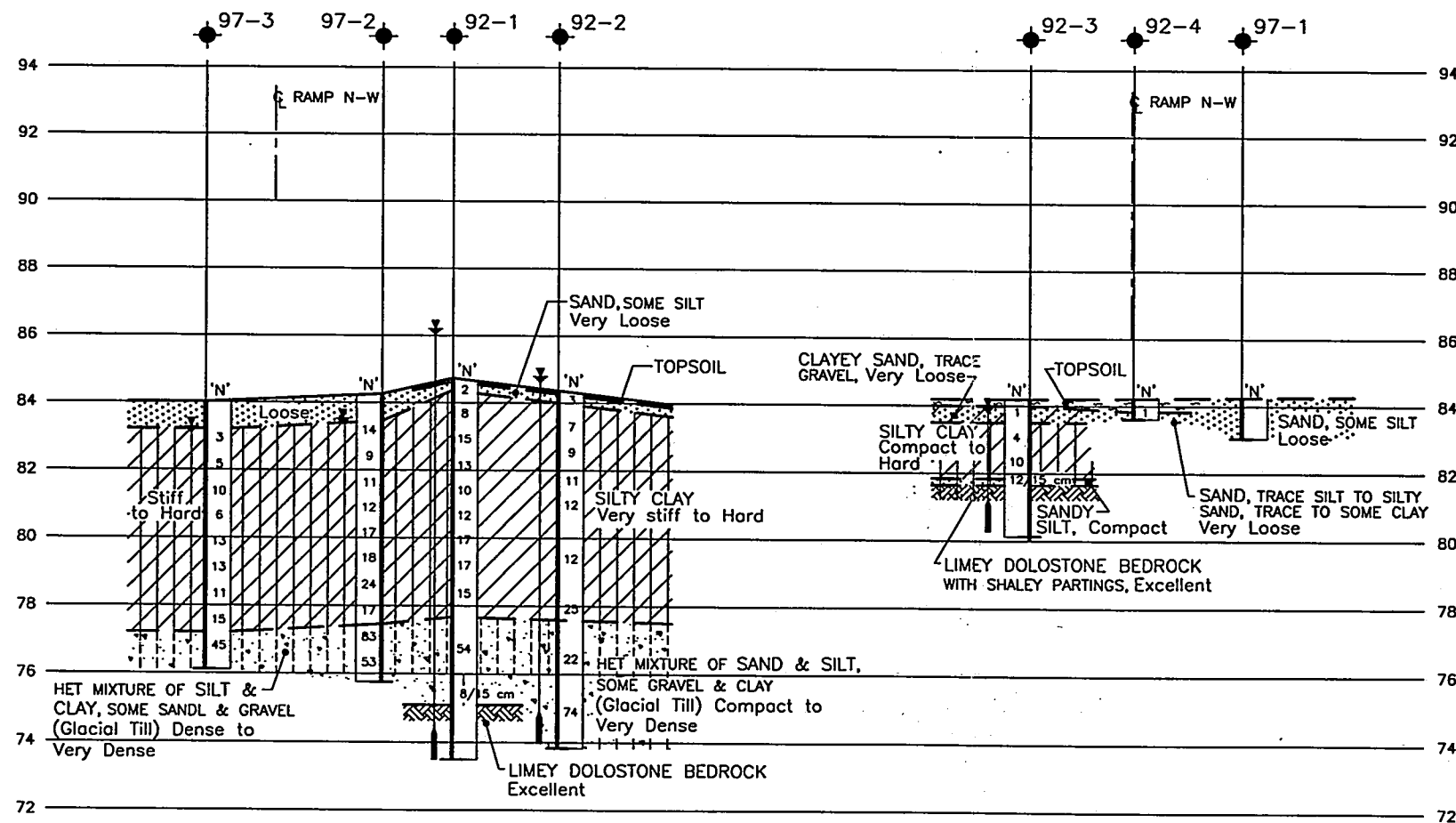
W P 374-89-00





PLAN

SCALE
20m 10 0 20m



PROFILE ALONG CULVERT

SCALE
20m 10 0 20m HOR
2m 1 0 2m VERT

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

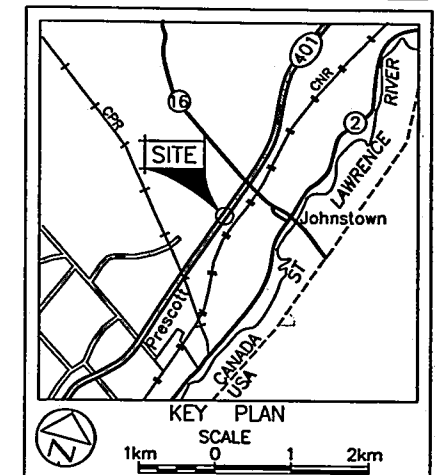
CONT No
WP No 374-89-00

CULVERTS UNDER
RAMP N-W & RAMP W-N
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

JACQUES, WHITFORD LIMITED



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- ↓ WL at time of investigation 97 05
- ↓ WL in Piezometer 91 05
- ⊕ Piezometer

No	ELEVATION	COORDINATES	
		NORTH	EAST
92-1	84.7	4 956 604	384 655
92-2	84.3	4 956 587	384 691
92-3	84.1	4 956 592	384 834
92-4	84.2	4 956 557	384 875
97-1	84.3	4 956 607	384 894
97-2	84.3	4 956 533	384 652
97-3	84.0	4 956 507	384 606

NOTE

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

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

REV.	DATE	BY	DESCRIPTION
GEOCRE No 31B-67			
HWY No 401		DIST 9	
SUBM'D	PC	CHECKED	DATE NOV 10, 1997
DRAWN	GBB	CHECKED	APPROVED
SITE 16-259/260		DWG 3748900-A	

LATEST
COPY of Nov. 10. 97
DWG

Jan 29/98 This Dwg was pulled
from orig. Report to prepare
Cont Package 97-68.
For the cont was used a 8 1/2 x 11"
copy.

