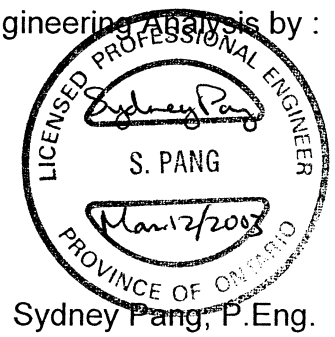
REPORT ON
FOUNDATION INVESTIGATION
PROPOSED CULVERT EXTENSIONS
HIGHWAY 401 AT HIGHWAY 77
(STATION 13+897, TILBURY NORTH)
HIGHWAY 401 AT TREMBLAY CREEK
(STATION 10+025, TILBURY WEST)
G.W.P. 61-00-00
PURCHASE ORDER NO. 3005-A-000301
GEOCRES NO. 40J2-58

Submitted

To

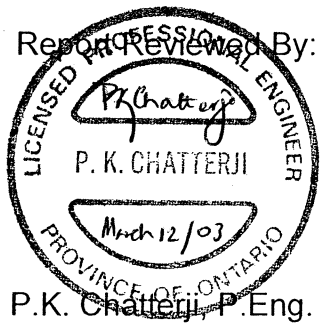
ERES Consultants

Direction of Fieldwork and
Engineering Analysis by :



Sydney Pang, P.Eng.
Project Engineer

Report Reviewed By:



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March 12, 2003
File: 19-2005-16

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1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the detailed design and construction of the proposed extensions to two culverts located on Highway 401 at Highway 77 and at Tremblay Creek, respectively. This work is part of the project involving reconstruction and widening of 10.6 km of Highway 401 from 1.2 km west of Highway 77 to 1.0 km east of Essex County Road 42 in Southwestern Ontario.

The purpose of this investigation was to determine the subsurface conditions at the existing culvert inlet and outlet locations and, based on this and other available data, to provide foundation recommendations for the design of the culvert extensions or replacement.

Prior to this investigation, relevant foundation investigation references available from the GEOCRES system for the general vicinity of the sites have been consulted. Particular reference is made to the following documents in the preparation of this report.

- Peto MacCallum Ltd. titled "Foundation Investigation and Design Report for Highway 77 Underpass, G.W.P. 60-00-00, Site 6-104, Highway 401, Comber, Ontario", PML Ref. 01TF072E, September 2002, GEOCRES No. 40J2-46 (Reference 1).

- Department of Highways, Ontario Report titled "Hwy. 401 Revision Crossing Hwy. 2, 1 Mile West of Tilbury", W.P. 159-58, April 1959, GEOCRES No. 59-F-11, (Reference 2).

2.0 SITE DESCRIPTION

The first culvert is located on Highway 401 at Station 13+897, just west of the underpass structure at Highway 77 within the Town of Lakeshore, Township of Tilbury West, Essex County, Ontario. The second culvert is located on Highway 401 at Station 10+025, at Tremblay Creek about 1 km west of the Gracie Road underpass structure within the Town of Lakeshore, Township of Tilbury West, Essex County, Ontario. Both sites are situated within the MTO District 31 and their locations are shown on Drawing 19-2005-16-3.

The general vicinity of the sites is lightly vegetated with grass and occasional shrubs and trees. The original terrain is relatively flat-lying with the bridges and approaches being the prominent features on site.

The existing culvert at Highway 77 is a 1.5 m wide by 1.5 m high open footing concrete structure.

The existing culvert at Tremblay Creek is a 5.5 m wide by 1.8 m high open footing concrete structure.

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

The borehole investigation program at the two sites were carried out from December 3 to 5, 2002, inclusive, when 4 sampled boreholes, numbered 02-40 and 02-41 (Highway 77 culvert), 02-50 and 02-51 (Tremblay Creek culvert), were

drilled and sampled near the inlet and outlet locations of the culverts. All four boreholes were drilled and sampled to 8.2 m depth below the existing ground surface.

The approximate locations of all four boreholes are shown on Drawing 19-2005-16-3. The investigation was carried out using track and truck mounted drill rigs supplied and operated by specialist drilling contractors.

In the boreholes, all soil samples were obtained with a 50 mm outside diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT). It was not possible to carry out any field vane test due to the stiffness of the silty clay till foundation soils. Pocket penetrometer readings were obtained on selected cohesive samples for qualitative strength correlation purposes. Groundwater conditions in the open boreholes were observed throughout the drilling operations. One standpipe piezometer was installed in each of the Boreholes 02-40 and 02-50 to permit longer term groundwater level monitoring.

The field work was supervised on a full-time basis by one of our field technicians who located the boreholes in the field, cleared borehole locations of underground utilities, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in appropriately labelled containers and transported back to Thurber's laboratory in Oakville for further examination and testing.

Upon completion of drilling, the boreholes were backfilled with drill cuttings. Once the last set of piezometer readings was taken, the piezometers were decommissioned with cement and bentonite.

All as-drilled borehole locations were established in the field by Thurber's drilling supervisor in relation to surface features on site. The ground surface elevations

and plan co-ordinates (northings and eastings) at the borehole locations have been estimated based on plans and profiles originated from MTO and forwarded to Thurber by ERES. Results of the field sampling and testing are presented on Drawing 19-2005-16-3 and on the Records of Boreholes in Appendix A.

3.2 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content, visual classification and description of all soil samples in accordance with the current MTO standards. Grain size distribution analysis and Atterberg Limits tests were conducted on selected samples. Results of these tests are presented in Appendices A, B and C.

4.0 GENERAL SITE GEOLOGY AND SUBSURFACE STRATIGRAPHY

4.1 General Site Geology

Based on published geological information, the general area of the project is located within the physiographic sub-region named Essex Clay Plain of the St. Clair Clay Plains. This is a till plain with lacustrine clay deposits which settled in the depressions while the knolls were lowered by wave action of past glacial lakes. The till deposits consist mainly of a silty clay to clayey silt matrix. Below the extensive till deposits lies bedrock of the Dundee Formation (Chapman and Putnam, "The Physiography of Southern Ontario", Third Edition, Ontario Geological Survey, 1984). The bedrock reportedly consists of limestone, dolostone and shale.

4.2 Subsurface Stratigraphy

This section contains generalized summary of the subsurface conditions at this site. The detailed subsurface soil and groundwater conditions encountered in the boreholes are presented on the Records of Borehole sheets in Appendix A.

In general, the subsurface conditions encountered in the boreholes consist of a deposit of silty clay till. Topsoil overlies the till at some locations. Groundwater levels at 5.9 m and 3.3 m depths were measured in the piezometers installed in two selected boreholes.

4.2.1 Topsoil

Topsoil was encountered in Boreholes 02-40 and 02-41. At the borehole locations, topsoil thickness varied between 75 mm and 100 mm.

4.2.2 Silty Clay Till

A deposit of silty clay till was encountered below the topsoil or at ground surface in all four boreholes drilled during this investigation. This deposit was not fully penetrated in any of these boreholes.

The upper zone of the silty clay till is dessicated and is brown to mottled brown and grey in colour. The stiff crust extends below this upper zone into the underlying grey portion of the till, and is generally greater than 6 m in thickness. Correlations with SPT 'N' values which typically varied from 14 blows to greater than 32 blows, and with pocket penetrometer test results, indicated that the crust has a typically very stiff to hard consistency. The upper 0.6 m of the till was apparently disturbed by past activities on site and had a generally firm consistency as indicated by SPT 'N' values of between 6 blows and 9 blows. No successful field vane test was carried out within this crust due to its stiffness.

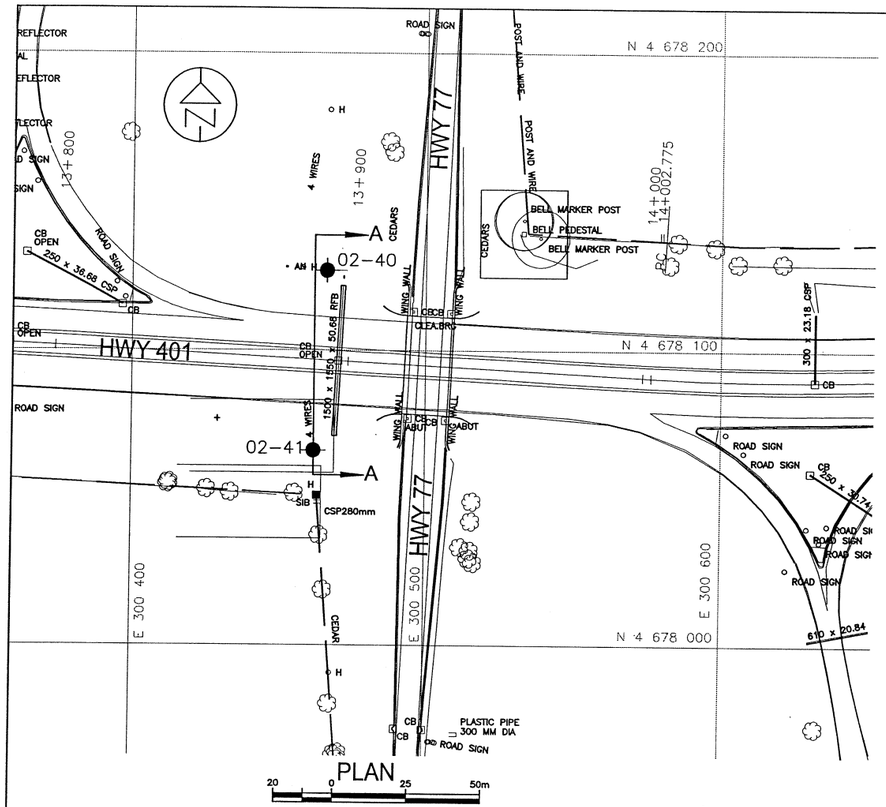
Below the crust is the main body of the grey silty clay till. Correlation with SPT 'N' values, ranging between 22 blows and 16 blows, and pocket penetrometer results, indicated that this grey till has a typically very stiff consistency. In Borehole 02-51, however, 'N' values of 12 blows were obtained near the bottom of the hole indicating that the till became stiff with depth.

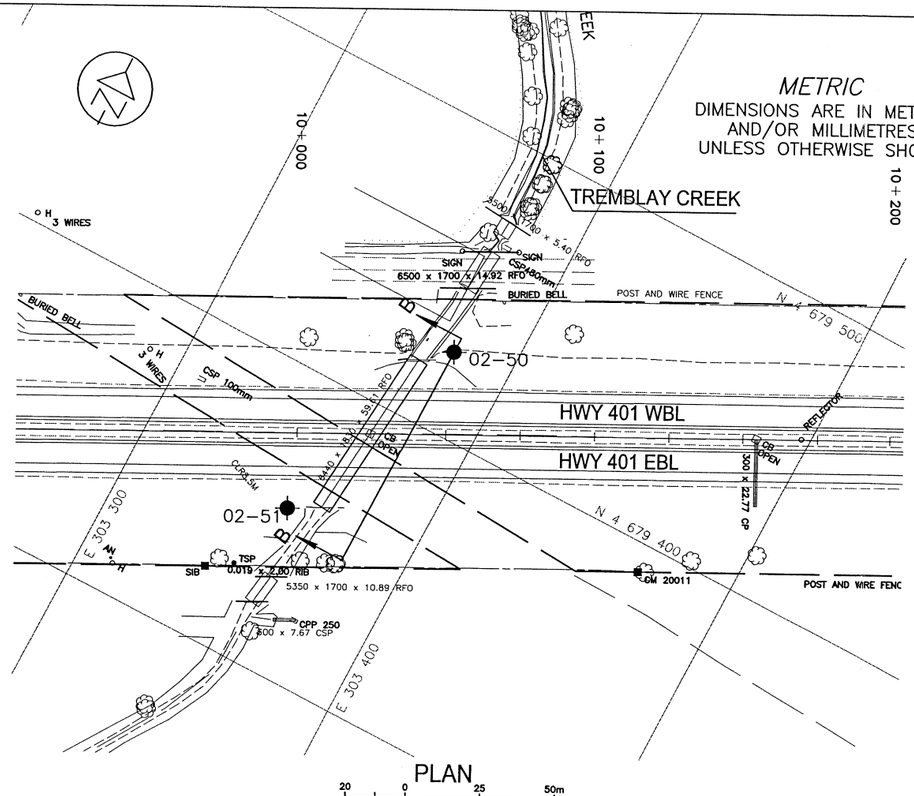
Atterberg limits tests carried out on selected samples of this till yielded liquid limits varying from 36% to 38%, and corresponding plasticity indices varying from 17% to 19%. Figures B1 shows Atterberg limits test results plotted on a plasticity chart which indicated that this till has a medium plasticity (group symbol of CI). Figure C1 shows grain size distribution curves of selected samples indicating clay contents of 48% to 49%. Measured moisture contents of samples of the till ranged between approximately 19% and 22%.

4.2.3 Groundwater Conditions

During drilling, no free water was observed in any of the open boreholes. One piezometer was installed at the bottom of each of the Boreholes 02-40 and 02-50. Piezometric levels of 5.9 m depth (Elevation 175.6 m) and 3.3 m depth (Elevation 174.2 m) were measured in Boreholes 02-40 and 02-50, respectively, on January 9, 2003.

It should be noted that groundwater levels are subject to seasonal fluctuations and may also be influenced by the water level in the creek.





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

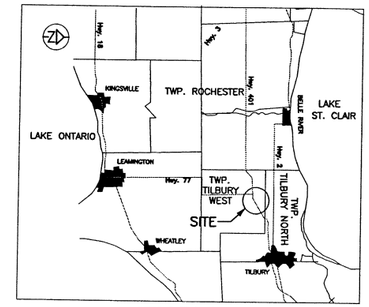
DIST NO. 31,HWY.401
GWP NO. 61-00-00

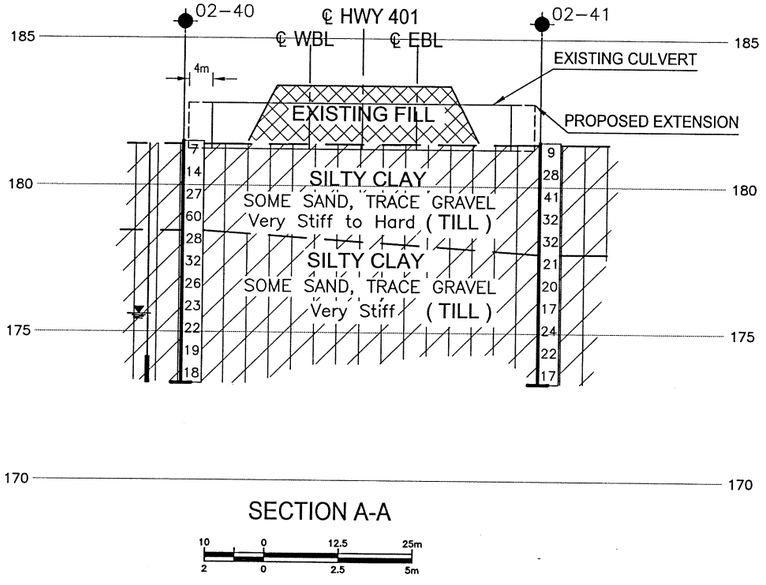
HWY 77 CULVERT (TILBURY WEST)
TREMBLAY CREEK (TILBURY NORTH)
BORE HOLE LOCATION & SOIL STRATA

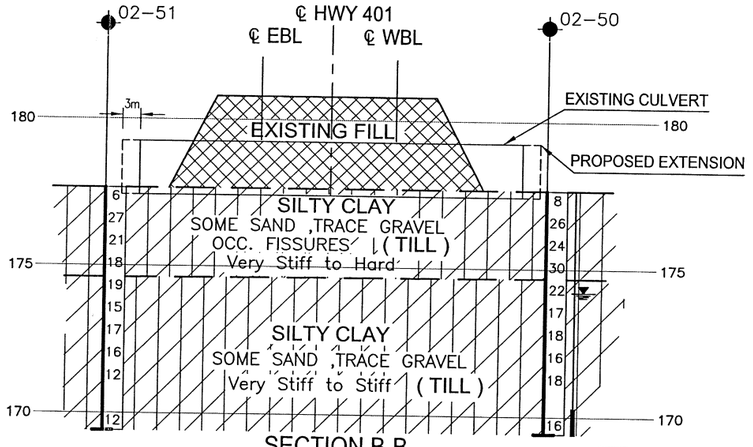
SHEET

RES CONSULTANTS
A Division of Applied Research Associates, Inc.

THURBER ENGINEERING LTD.







LEGEND	
⊕	Bore Hole
⊕	Dynamic Cone penetration Test (cone)
⊕	Bore Hole & Cone
N	Blow / 0.3m (std pen Test,475 J / blow)
CONE	Blows /0.3m (60° Cone ,475J/blow)
PH	Pressure, Hydraulic
▼	WL on January 9, 2003
	Head Artesian Water
	Piezometer

NO	ELEVATION	NORTHING	EASTING
02-40	181.5	4678127	300467
02-41	181.5	4678066	300462
02-50	177.6	4679427	303380
02-51	177.6	4679355	303355

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

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
March 12/03
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. PANG
March 12/2003
PROVINCE OF ONTARIO

REVISIONS		
MAR.2003	SP	FINAL
DEC.2002	SP	ISSUED AS DRAFT FOR REVIEW
DATE	BY	DESCRIPTION

DESIGN	SP	CHK PKC	CHBDC 2000	LOAD	DATE MAR.2003
DRAWN	SS	CHK SP	SITE	STRUCT	DWG. 19-2005-16-3

APPENDIX A

Records of Boreholes

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] "N" VALUE
Very Soft	Less than 10	Less than 2
Soft	10 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR TEST HOLE LOGS

SYMBOLS FOR SAMPLE TYPE

- Shelby Tube
- SPT
- No Recovery
- A - Casing
- Grab/Auger sample
- Core

- MC – Moisture Content (% by Weight) as determined by sample

Water Level

C_{vane} Shear Strength Determination by Field Insitu Vane

C_{pen} Shear Strength Determination by Pocket Penetrometer

C_{lab} Shear Strength Determination using a Laboratory Vane Apparatus

C_U Undrained Shear Strength determined by Unconfined Compression Test

(1) SPT Standard Penetration Test – refers to the number of blows from a 63.5kg hammer falling through 0.76m to advance a 60 degree truncated cone 0.3m.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 02-40 1 OF 1 METRIC

W.P. G.W.P. 61-00-00 LOCATION N 4 678 127 E 300 467 ORIGINATED BY GA

DIST 31 HWY 401 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 03.12.02 - 03.12.02 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.5											
181.4 / 0.0	**TOPSOIL** (100mm)										
0.1	Silty **CLAY**, some sand, trace gravel, occasional rootlets, occasional iron oxide staining, occasional black organics Firm to Hard Brown-Grey (TILL)(CI)			SS	7		181				
				SS	14						
				SS	24		180				
				SS	60		179				
178.5											
3.1	Silty **CLAY**, some sand, trace gravel Hard to Very Stiff Grey (TILL)(CI)			SS	28		178				
				SS	32						
				SS	20		177				
				SS	23		176				
				SS	22		175				
				SS	19						
173.3				SS	18		174				
8.2	END OF BOREHOLE AT 8.23m. BOREHOLE OPEN TO 8.23m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) 05/12/02 Dry 09/01/03 5.9										

+ 3 , × 3 : Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 02-41 1 OF 1 METRIC

W.P. G.W.P. 61-00-00 LOCATION N 4 678 066 E 300 462 ORIGINATED BY GA

DIST 31 HWY 401 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 04.12.02 - 04.12.02 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.5											
181.4 0.0	**TOPSOIL** (75mm)										
0.1	Silty **CLAY**, some sand, trace gravel, occasional rootlets, occasional iron oxide staining Stiff to Hard Brown to Brown-Grey (TILL)(CI)			SS	9		181				
				SS	28						
				SS	41		180				
				SS	32		179				
178.5											
3.1	Silty **CLAY**, some sand, trace gravel Hard to Very Stiff Grey (TILL)(CI)			SS	32		178				0 13 37 49
				SS	21						
				SS	20		177				
				SS	17		176				
				SS	24		175				
				SS	22						
173.3							174				
				SS	17						
8.2	END OF BOREHOLE AT 8.23m. BOREHOLE OPEN TO 8.23m. BOREHOLE DRY ON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.										

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

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 02-50 1 OF 1 METRIC

W.P. G.W.P. 61-00-00 LOCATION N 4 679 427 E 303 380 ORIGINATED BY GA

DIST 31 HWY 401 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 05.12.12 - 05.12.12 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.5											
0.0	Silty **CLAY**, some sand, trace gravel, occasional rootlets, occasional iron oxide staining, occasional grey silt fissures Stiff to Hard Brown-Grey (TILL)(Cl)			SS	8		177				
				SS	26		176				
				SS	24		175				
174.5				SS	30						
3.1	Silty **CLAY**, some sand, trace gravel Very Stiff Grey (TILL)(Cl)			SS	22		174				
				SS	17		173				
				SS	18		172				
				SS	16		171				
				SS	18		170	>>			
169.3				SS	16						
8.2	END OF BOREHOLE AT 8.23M. BOREHOLE OPEN TO 8.23m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)
05/12/02	Dry
09/01/03	3.3

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

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 02-51 1 OF 1 METRIC

W.P. G.W.P. 61-00-00 LOCATION N 4 679 355 E 303 355 ORIGINATED BY GA

DIST 31 HWY 401 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 05.12.02 - 05.12.02 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.5											
0.0	Silty **CLAY**, some sand, trace gravel, occasional black organics, occasional iron oxide staining Firm to Very Stiff Brown-Grey (TILL)(CI)			SS	6		177		○		
				SS	27		176		○		
175.2				SS	21				○		
2.3	Silty **CLAY**, some sand, trace gravel Very Stiff to Stiff Grey (TILL)(CI)			SS	18		175		○		2 13 36 48
				SS	19		174		○		
				SS	15				○		
				SS	17		173		○ ○		
				SS	16		172				
				SS	12		171		○		
169.3				SS	12		170		○		
8.2	END OF BOREHOLE AT 8.23m. BOREHOLE DRY ON COMPLETION. BOREHOLE OPEN TO 8.23m. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.										

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

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

APPENDIX B

Laboratory Test Results

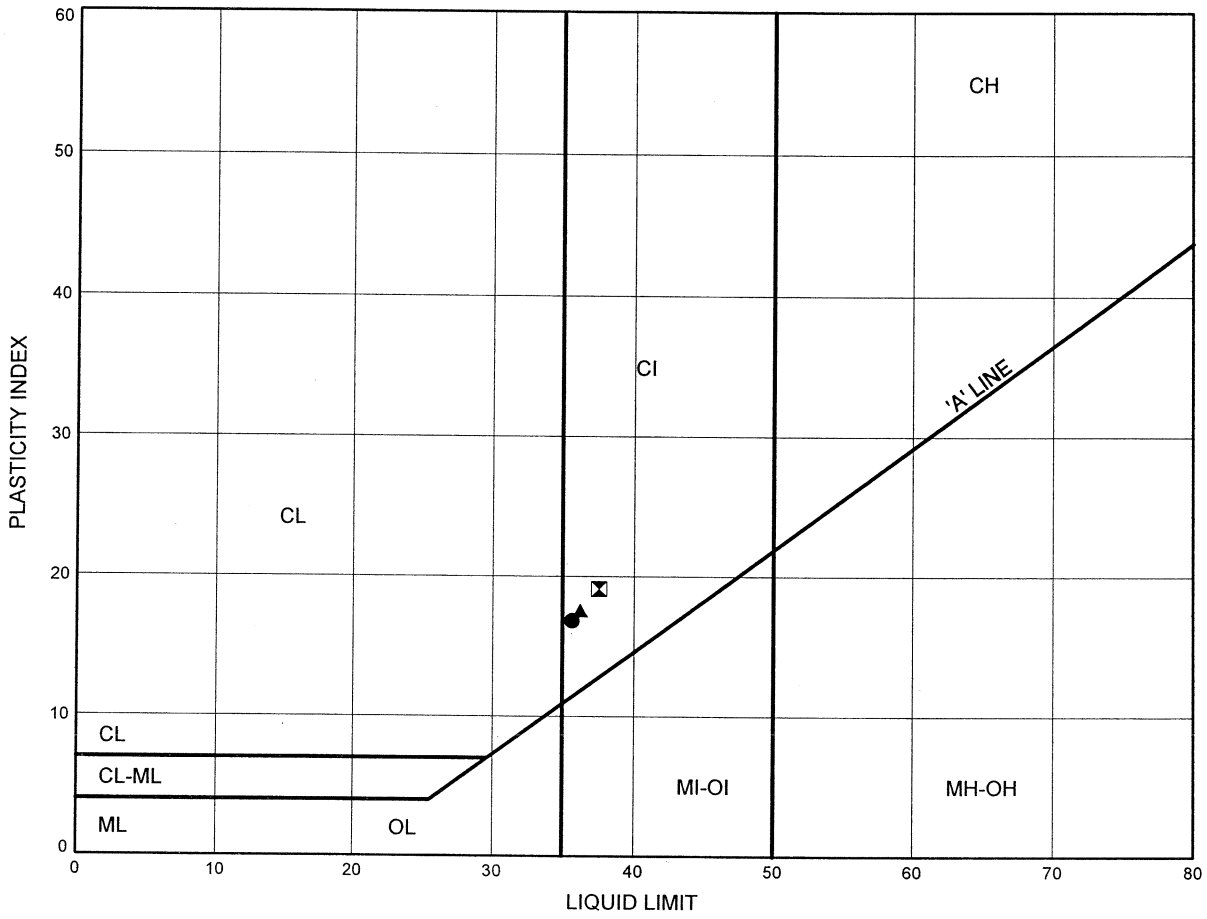
Plasticity Charts

Hwy 401 Culverts and Embankments

ATTERBERG LIMITS TEST RESULTS

SILTY CLAY (TILL)

FIGURE B1



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-40	3.35	178.15
⧓	02-50	1.83	175.67
▲	02-50	3.35	174.15

Date March 2003

Project G.W.P. 61-00-00

THURBER

Prep'd WM

Chkd. SKP

THURBALT 00516.GPJ 12/03/03

APPENDIX C

Laboratory Test Results

Grain Size Distribution Curves

19-2005-16

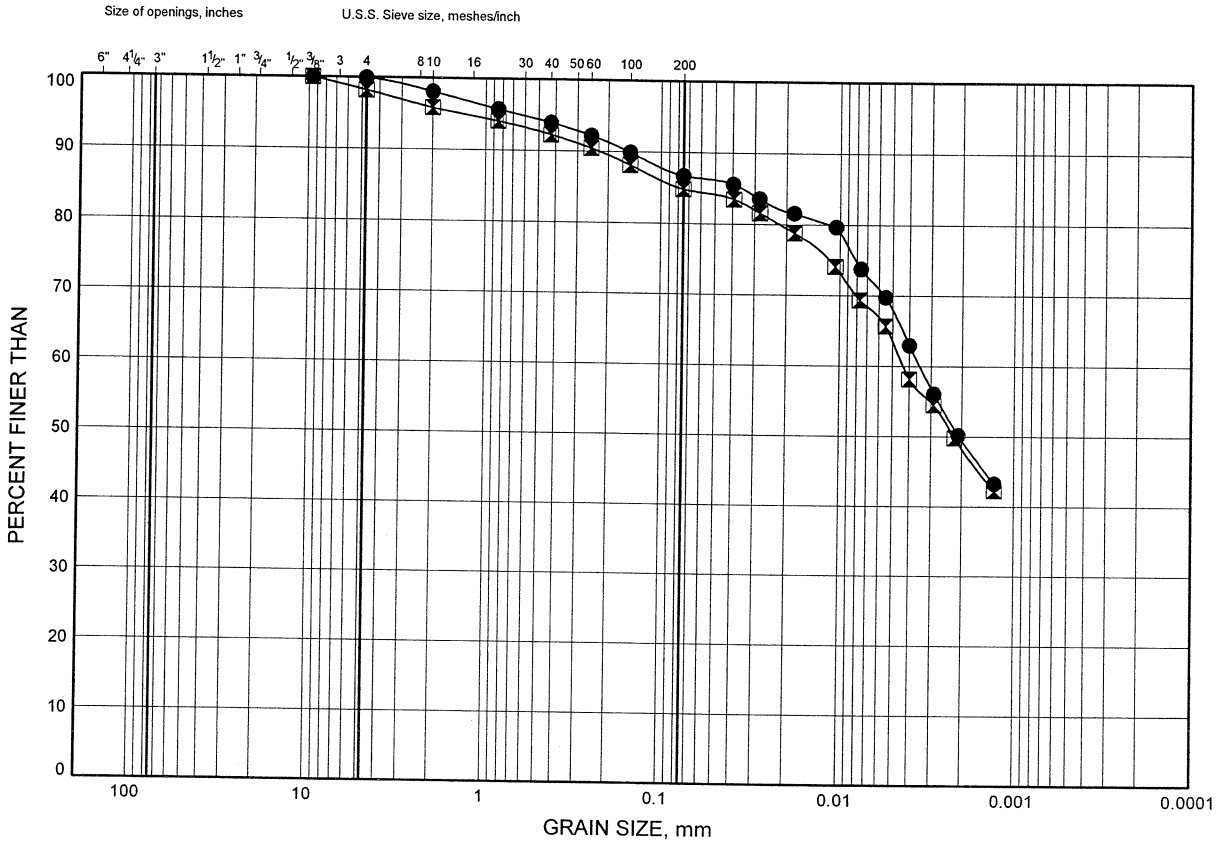
March, 2003

Hwy 401 Culverts and Embankments

GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)

FIGURE C1



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-41	3.35	178.15
⧓	02-51	2.59	174.91

Date March 2003

Project G.W.P. 61-00-00

THURBER

Prep'd WM

Chkd. SKP

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