



**FOUNDATION INVESTIGATION AND DESIGN REPORT
CONCERNING PIER FOUNDATIONS
REHABILITATION/WIDENING OF SCUGOG RIVER BRIDGE
HIGHWAY 7, 0.6 KM WEST OF THE HIGHWAY 7 AND
HIGHWAY 35/KAWARTHA LAKES ROAD 15 INTERSECTION
SITE NO. 32-096
G.W.P. 4264-04-00**

**for
MORRISON HERSHFIELD LIMITED**

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PML Ref.: 06HF092A
Index No. 039FIR and 040FDR
Geocres No: 31D-435
January 2, 2008



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FOUNDATION INVESTIGATION REPORT
Concerning Pier Foundations
Rehabilitation/Widening of Scugog River Bridge
Highway 7, 0.6 km West of Highway 7 and
Highway 35/Kawartha Lakes Road 15 Intersection
Site No. 32-096
G.W.P. 4264-04-00

1. INTRODUCTION

This report summarizes the results of the supplementary foundation investigation carried out for the proposed widening of the existing bridge on Highway 7 that crosses the Scugog River about 0.6 km west of the Highway 35/Kawartha Lakes Road 15 intersection near Lindsay, Ontario. The study was conducted for Morrison Hershfield Limited on behalf of the Ministry of Transportation of Ontario.

The existing bridge is an approximate 58.3 m long three span structure supported by spread footings. The piers are situated in the Scugog River and supported on three interconnected 2.7 by 5.5 m footings (one at each end and one at the centre of the bridge) founded near elevation 245.0, about 2.0 m below the river bottom.

A preliminary foundation investigation for the proposed widening of the Scugog River Bridge was conducted in the spring of 2006. Information from that study is documented in Geocres No. 31D-412 dated March 2006.

2. SITE DESCRIPTION

The Scugog River bridge on Highway 7 is located about 0.6 km west of the Highway 35/Kawartha Lakes Road 15 intersection. Land use in the vicinity of the bridge is primarily agricultural, with areas of shrub and tree growth; the river banks are vegetated by grass, shrubs and trees; cattails exist in poorly drained areas.



The Scugog River is part of the Trent-Severn waterway and flows to the north at the bridge site. The River is about 60 m wide at this location; the river water elevation at the time of the field investigation (July 30/August 3, 2007) was at elevation 249.8; the water elevation for the 25, 50 and 100 year storm events is reported to be 250.81, 250.84 and 250.88, respectively.

Selected photographs of the existing bridge are provided in Appendix A, Photographs 1 through 5.

3. GEOLOGY

The Scugog River Bridge is located within the Peterborough Drumlin Field physiographic region and is characterized by poorly developed low elongated swells and swampy valleys. The bedrock comprises limestone of the Lindsay Formation; it was identified near elevation 242.7 at the pier locations during this investigation.

4. INVESTIGATION PROCEDURES

The field investigation for this study was carried out during the period of July 30 to August 3, 2007 and comprised two boreholes advanced north of each pier at the locations shown on Drawing 1.

The borehole depths are presented in the following table:

Borehole No.	Water Depth (m)	Depth (m) ¹		
		To Surface of Bedrock ²	Rock Core ³	Total
07-1 (west pier)	2.0	7.6	7.9	15.5
07-2 (east pier)	1.9	8.7	5.3	14.0

1. Depth relative to top of drilling platform
2. Boreholes advanced by driving NW casing to refusal in the till and rock coring procedures to the bedrock surface.
3. NQ diamond rock coring equipment



The locations of the boreholes were programmed and established in the field by Peto MacCallum Ltd. The elevation of the water level in the river, the river bottom and bedrock surface were established using the following benchmark provided by Callon Dietz Inc.

BM: HCM 724. Brass cap set in concrete. North side of highway, east end of bridge where guard-rail meets concrete spillway.
Elevation 254.90.

The boreholes were advanced by a CME-55 drillrig mounted on a barge by driving NW casing to refusal in the till and NQ rock coring equipment through the remainder of the till to the bedrock surface working under the full time supervision of a member of our engineering staff. The holes were cored 7.9 and 5.3 m into bedrock in Boreholes 07-1 and 07-2 respectively with an NQ core bit. The drill and barge were supplied and operated by a specialist drilling contractor. Selected photographs of the drill and barge setup are shown in Appendix A, Photographs 6 to 8.

Representative samples of the soil were recovered at frequent depth intervals using a conventional split-spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

The soil and rock core samples were visually examined and classified in the field as the field work progressed in accordance with the MTO Soil Classification procedures. Observation of the groundwater conditions in the soil/bedrock was not possible since the boreholes were advanced over water.

Falling head permeability tests were conducted near elevation 245.0 (the founding level of the pier footings) in both boreholes. The test was conducted in accordance with the procedure suggested by Hvorslev⁽¹⁾ (case C, flush bottom, variable head) and involved:

- Driving the NW casing to near elevation 245.0 and flushing out all soil within the casing taking care to ensure that the soil at the base of the casing was not disturbed.
- Filling the casing with water and measuring the water level drop for a period of 20 minutes.

(1) M. Juul Hvorslev, Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes, Waterways Experiment Station, 1949.



Details concerning the tests are summarized on Table 1, appended.

The recovered samples were returned to our laboratory for detailed visual examination, classification and laboratory testing. The laboratory test program conducted on soil samples comprised:

- Natural water content determinations (5) (Borehole Logs)
- Particle Size analyses (4) (Figures GS-1 and GS-2)
- Atterberg Limits tests (1) (Figure PC-1)

The laboratory testing program for the rock core samples comprised:

- Unconfined Compressive Strength (8)
- Splitting Tensile Strength (5)

The splitting tensile test was conducted by the Civil Engineering Department of McMaster University (Applied Dynamics Laboratory) in accordance with ASTM D 3967-05 using a 600 kN Tinius Olsen testing machine. Photographs of the splitting tensile strength test equipment are shown in Appendix C.

The test data for both the compressive and tensile strength tests are also provided in Appendix C; the test results are summarized in Table 3.

5. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test N values, and the laboratory test results. The Grain Size Distribution and Atterberg Limits test results for the silty clay are also provided on the Borehole Logs. The results of the Grain Size Distribution tests conducted on the sand and gravel are not included on the logs since the test results are not representative of the overall gradation of the deposit.



The borehole locations as well as a stratigraphic profile prepared from the borehole data are shown on Drawing 1.

The subsurface stratigraphy revealed in the boreholes generally comprised silty clay overlying sand and gravel till mantling limestone bedrock. The drilling platform at the borehole locations was 1.1 m above the water level in the Scugog River (water level near elevation 249.8). The depth referred to in the following paragraphs is relative to the top of the drilling platform, elevation 250.9 at both borehole locations. The river bottom elevation was 247.8 and 247.9 in Boreholes 07-1 and 07-2, respectively.

The subsurface strata encountered are summarized below.

5.1 Silty Clay

Silty clay was encountered at the river bottom in Borehole 07-1; this unit was 1.3 m thick and penetrated at a depth of 4.4 m, elevation 246.5. This unit was not contacted in Borehole 07-2. The moisture content of the silty clay ranged from 36 to 38%, (the liquid limit was 45, with a plasticity index of 27). The upper 600 mm of this deposit was very soft (N = 1) and the remainder hard (N = 58).

The results of the Grain Size Distribution and Atterberg Limits tests are provided on Figures GS-1 and PC-1 respectively.

5.2 Sand and Gravel Till

Dense to very dense, grey sand and gravel till with cobbles and boulders was contacted below the silty clay at a depth of 4.4 m (elevation 246.5) in Borehole 07-1, and on the river bottom at a depth of 3.0 m (elevation 247.9) in Borehole 07-2. This unit was 3.2 and 5.7 m thick and penetrated at depths of 7.6 and 8.7 m, elevation 243.3 and 242.2, in Boreholes 07-1 and 07-2, respectively.



Refusal to driving of the NW casing was met at depths of 5.3 and 5.7 m, elevation 245.6 and 245.2 in Boreholes 07-1 and 07-2, respectively. Borehole 07-1 was advanced from 5.3 to 6.4 m (elevation 245.6 to 244.5) by 104 bl (600 mm drop) with a 160 kg hammer and coring the remaining depth (1.2 m) to bedrock. Borehole 07-2 was advanced from a depth of 5.9 m to the bedrock surface at 8.7 m by coring; 360 and 230 mm boulders were penetrated at elevation 245.0 and 243.7, respectively.

The moisture content of this unit ranged from 6 to 8%. The results of the Grain Size Distribution analyses conducted on samples of this deposit are presented on Figure GS-2. It is noteworthy that the maximum particle size that can be retrieved by the split-spoon samples is about 40 mm. Based on observations during drilling (drill chatter, grinding, rate of advancement), as well as the core samples retrieved in the till, it is considered that the gradation curves shown on Figure GS-2 are not representative of the sand and gravel deposit in situ.

The permeability of the soil, computed using the variable head flush bottom formula suggested by Hvorslev, is:

Borehole No.	Bottom of Casing ² Elevation (m)	Computed Permeability cm/sec (k)
07-1	244.9	8×10^{-4}
07-2	245.6	9×10^{-4}

1. Test conducted in NW casing, flush bottom.

5.3 **Bedrock**

Bedrock was contacted at depths of 7.6 and 8.7 m (elevation 243.3 and 242.2 m) in Boreholes 07-1 and 07-2, respectively.



The bedrock comprised limestone of the Lindsay Formation that was judged to be low to medium strength and unweathered. A detailed description of the rock core samples is presented in Table 2. Photographs of the rock core are shown in Appendix B.

The measured core recovery varied from 88 to 100%, typically 100%. The Rock Quality Designation (RQD) determined from the rock core was 66% in the upper 1.5 m in Borehole 07-1 indicating a fair quality rock, and ranged from 82 to 100% below that depth indicating a good to excellent quality rock. The RQD value ranged from 91 to 100% in the rock core samples retrieved from Borehole 07-2 indicating excellent quality rock.

The unconfined compressive strength of eight core samples ranged from 28.9 to 65.8 MPa with an average of 41.8 MPa which indicates a medium strong rock. It is noted however, with the exception of the two core samples retrieved in Borehole 07-1 within 2 m of the rock surface, the unconfined compressive strength ranged from 28.9 to 42.6 MPa. The results of the five splitting tensile tests ranged from 6.0 to 9.3 MPa. The results of the rock core testing are provided in Table 3.

5.4 Groundwater

Observation of the groundwater conditions in the soil and rock was not possible since the boreholes were advanced over water.

6. CLOSURE

The field work was carried out under the supervision of Mr. M. Rapsey and direction of Mr. P.A. Lyall, P.Eng. The equipment was supplied by Canadian Soil Drilling.

This report was prepared by Mr. P.A. Lyall, P.Eng., Project Engineer, and reviewed by Mr. D.W. Kerr, MEng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, MEng., P.Eng., MTO Designated Contact, carried out an independent review of the report.

Sincerely

Peto MacCallum Ltd.



Dennis W. Kerr, MEng., P.Eng.
Chief Foundation Engineer



Brian R. Gray, MEng., P.Eng.
MTO Designated Principal Contact



PL/DWK-lad



Table 1

Falling Head Permeability Test Details

Borehole No.	Bottom of Casing ¹ Elevation (m)	Head ² (m)	Duration (minutes)	Water Level Drop (mm)
07-1	244.9	1.36	0	0
			1	60
			2	90
			3	130
			4	160
			5	200
			6	230
			7	260
			8	280
			9	300
			10	320
			15	420
			20	510
07-2	245.6	1.90	0	0
			1	60
			2	120
			3	160
			4	215
			5	265
			6	310
			7	350
			8	380
			9	420
			10	460
			15	860
			20	785

1. Test conducted in NW casing, 'flush bottom' using the Hvorslev test procedure; inside diameter of NW casing is 7.62 mm.
2. Water level in river 249.8; water level in casing at start of the test in Boreholes 07-1 and 07-2 was 251.16 and 251.70, respectively.

Table 2

Rock Core Description

CORE RECOVERY					CORE DESCRIPTION	
BH	RC	DEPTH (m)	Rec (%)	RQD (%)	DEPTH (m)	DESCRIPTION
07-1	6	6.4 – 7.6			6.4 – 7.6	TILL: Sand and gravel with cobbles and boulders.
	7	7.6 – 9.1	95	66	7.6 – 15.5	LIMESTONE: Grey, fine crystalline, with numerous thin irregular shaley seams, occasional shale layers to 100 mm, medium strength, unweathered, close to moderate spaced flat partings (bedding layers), generally smooth to rough planar, locally smooth undulating, generally tight with occasional clay infilling (5 to 10 mm), occasional vertical cross joints, fair to excellent quality. (Lindsay Formation)
	8	9.1 – 9.4	100	82		
	9	9.4 – 10.9	100	100		
	10	10.9 – 12.5	100	100		
	11	12.5 – 14.0	100	82		
	12	14.0 – 15.5	88	87		

RQD = Rock Quality Designation
 Drilled: July 30 and 31, 2007
 Logged: August 1, 2007

Table 2
 Rock Core Description

CORE RECOVERY					CORE DESCRIPTION	
BH	RC	DEPTH (m)	Rec (%)	RQD (%)	DEPTH (m)	DESCRIPTION
07-2	5	5.9 – 7.4			5.9 – 8.7	TILL: Sand and gravel with cobbles and boulders. 360 and 230 mm boulders encountered at 5.9 and 7.2 m depth.
	6	7.4 – 7.9				
	7	7.9 – 9.4	100	92	8.7 – 14.0	LIMESTONE: Grey, fine crystalline, with numerous thin irregular shaley seams, occasional shale layers to 10 mm, medium strength, unweathered, close to moderate spaced flat partings (bedding layers), generally smooth to rough planar, locally smooth undulating, generally tight with occasional openings to 0.5 mm, excellent quality. (Lindsay Formation)
	8	9.4 – 10.9	100	100		
	9	10.9 – 12.5	100	93		
	10	12.5 – 14.0	100	91		

RQD = Rock Quality Designation
 Drilled: August 1 and 3, 2007
 Logged: August 2, 2007



Table 3

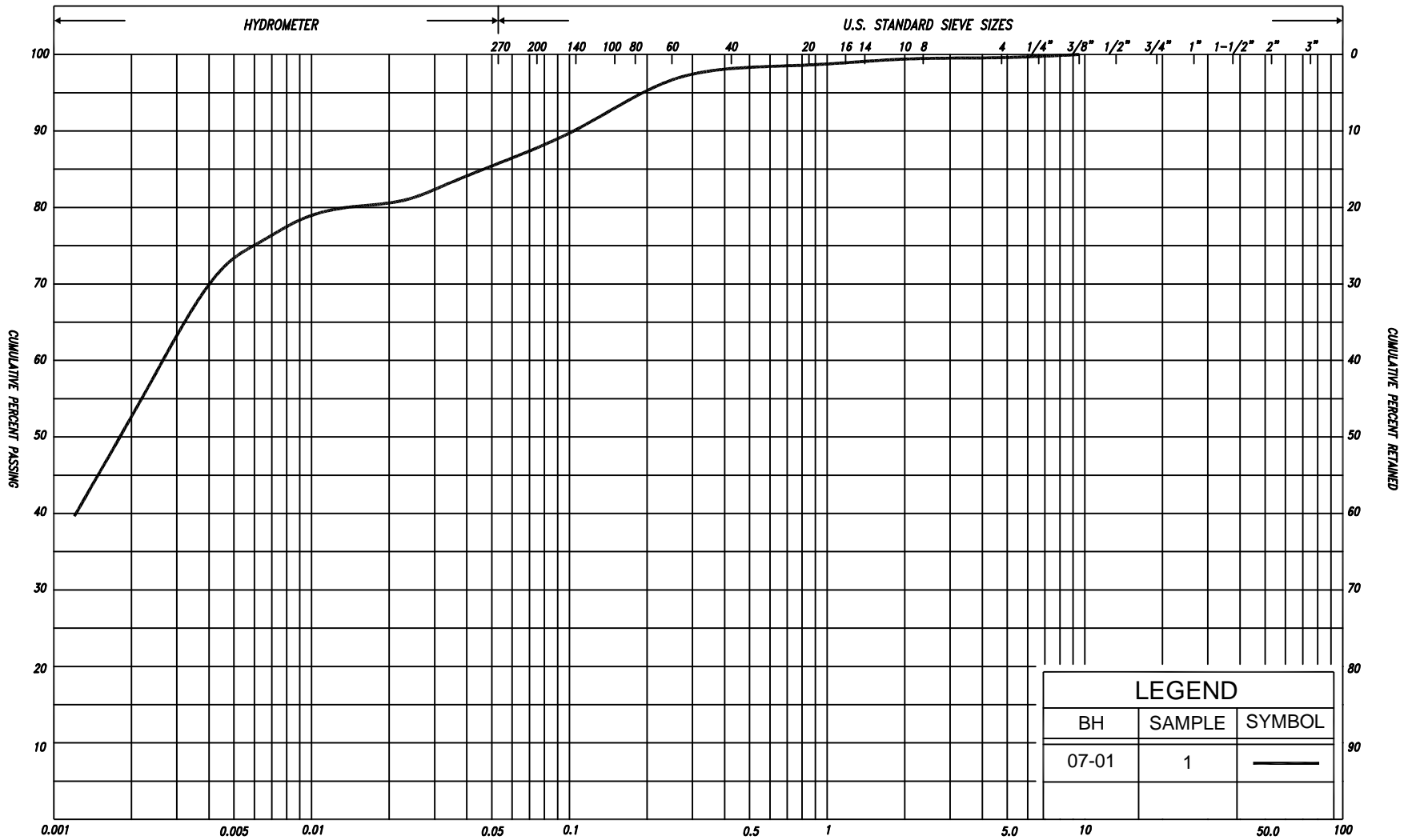
Compressive Strength Test Results

Borehole No.	Elevation of Core Sample	Unconfined Compressive Strength (MPa)
07-1	242.9	56.5
07-1	241.1	65.8
07-1	239.2	35.9
07-1	237.5	33.5
07-1	235.7	34.1
07-2	241.7	36.8
07-2	239.7	28.9
07-2	237.4	42.6

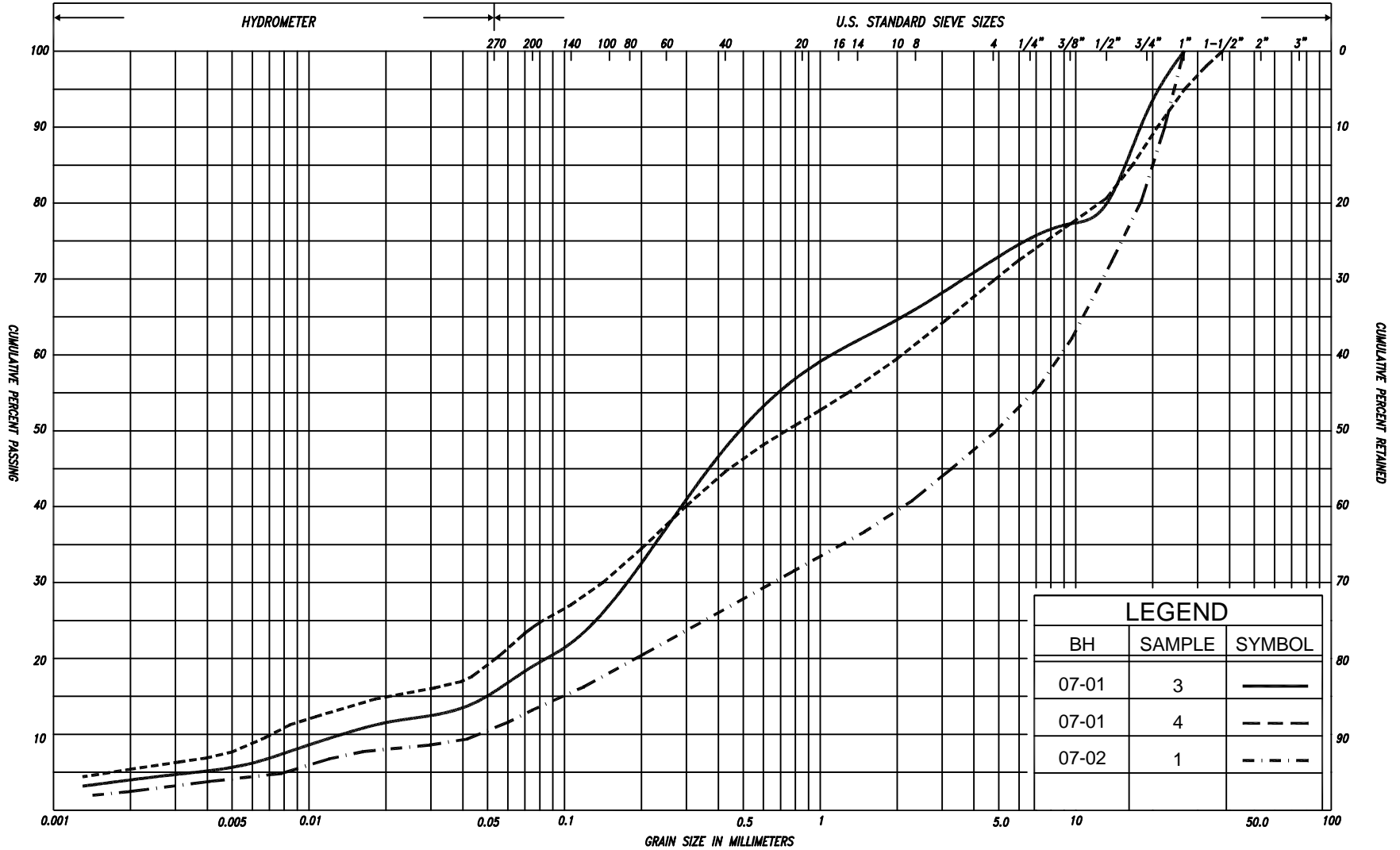
Tensile Splitting Test Results¹

Borehole No.	Elevation of Core Sample	Tensile Strength (MPa)
07-1	242.7	6.0
07-1	239.0	9.3
07-1	236.0	6.9
07-2	240.9	8.7
07-2	238.4	6.1

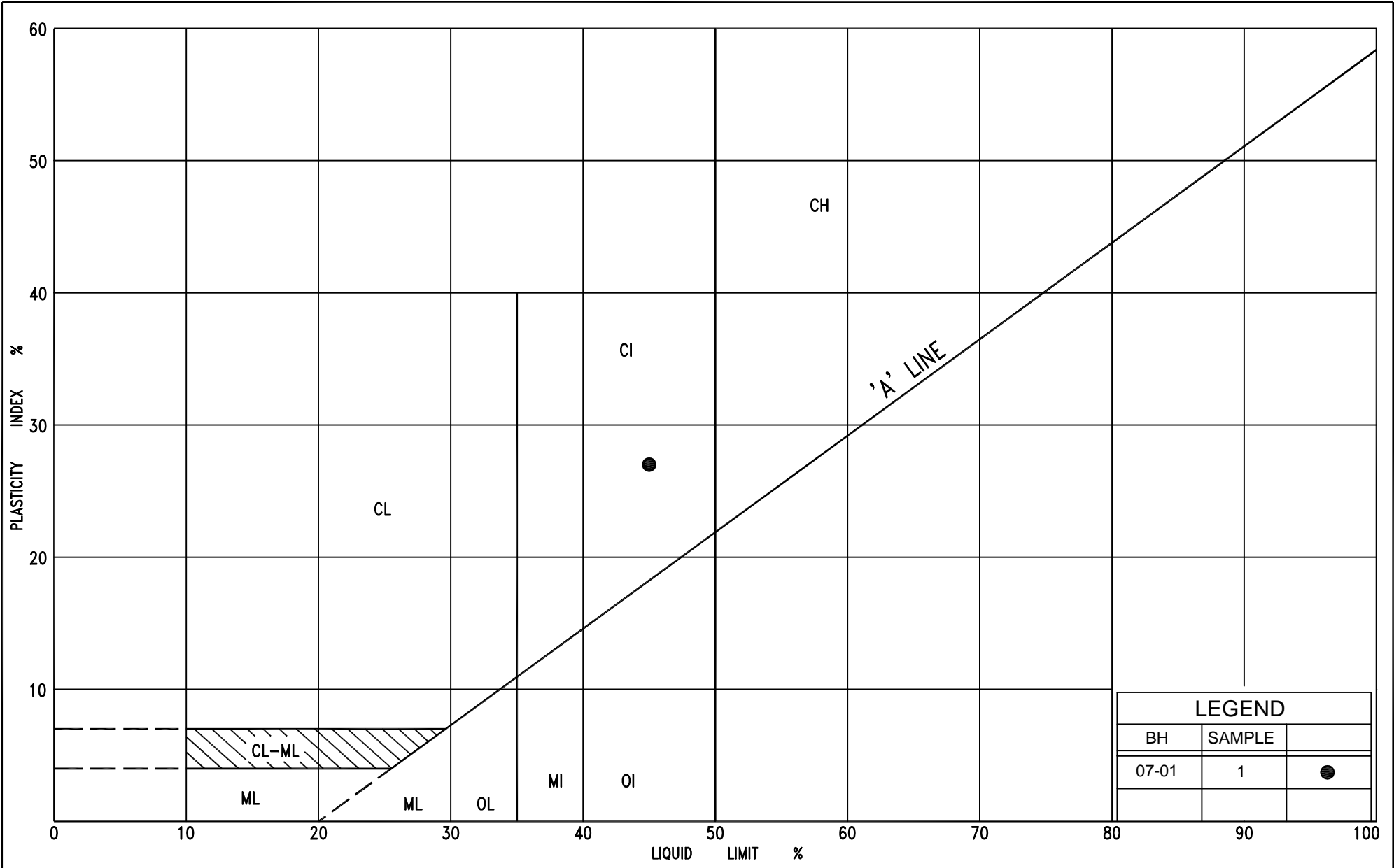
1. Test conducted at McMaster University in accordance with ASTM D3967-05 using a 600 kN Tinius Olsen Testing machine.
2. Refer to Appendix C for photographs of test equipment and laboratory test data.



SILT & CLAY					FINE		MEDIUM		COARSE	GRAVEL				COBBLES	UNIFIED	
CLAY	FINE		MEDIUM		COARSE	FINE		MEDIUM		COARSE	GRAVEL				COBBLES	M.I.T.
	SILT					SAND					GRAVEL				COBBLES	U.S. BUREAU
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL					COBBLES	U.S. BUREAU



SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COBBLES	UNIFIED
CLAY	SAND			FINE		MEDIUM		COARSE	GRAVEL		COBBLES	M.I.T.
	SAND			V. FINE		FINE		COARSE	GRAVEL		COBBLES	U.S. BUREAU



LEGEND		
BH	SAMPLE	
07-01	1	●

TERMS USED IN REPORT



N Value: the standard penetration test (SPT) N value is the number of blows required to cause a standard 51 mm O.D. split barrel sampler to penetrate 0.3 m into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kg. Falling freely a distance of 0.76 m. For penetrations of less than 0.3 m N values are indicated as the number of blows for the penetration achieved. Average N value is denoted thus N.

Dynamic cone penetration test: continuous penetration of a conical steel point (51 mm 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 0.3 m 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/0.3 m)	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, 100 mm + 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	50 mm	50 - 300 mm	0.3 m - 1 m	1 m - 3 m	> 3 m
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	RC	Rock Core
BS	Block Sample	PH	T W Advanced Hydraulically
CS	Chunk Sample	PM	T W Advanced Manually
TW	Thinwall Open	FS	Foil Sample

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
α_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'	$^\circ$	Effective Angle of Internal Friction
c_u	kPa	Apparent Cohesion Intercept
ϕ_u	$^\circ$	Apparent Angle of Internal Friction
τ_R	kPa	Residual Shear Strength
τ_r	kPa	Remoulded Shear Strength
s_t	1	Sensitivity

STRESS AND STRAIN

U_w	kPa	Pore Water Pressure
γ_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
e	%	Linear Strain
e_1, e_2, e_3	%	Principal Strain
ε	kPa	Modulus of Linear Deformation
G	kPa	Modulus of Shear Deformation
μ	1	Coefficient of Friction

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	Density of Solid Particles	w_p	%	Plastic Limit
γ_s	kN/m^3	Unit Weight of Solid Particles	w_s	%	Shrinkage Limit
ρ_w	kg/m^3	Density of Water	I_p	%	Plasticity Index = $w_L - w_p$
γ_w	kN/m^3	Unit Weight of Water	I_L	1	Liquidity Index = $\frac{w - w_p}{I_p}$
ρ	kg/m^3	Density of Soil	I_C	1	Consistency Index = $\frac{w_L - w}{I_p}$
γ	kN/m^3	Unit Weight of Soil	e_{\max}	1, %	Void Ratio in Loosest State
ρ_d	kg/m^3	Density of Dry Soil	e_{\min}	1, %	Void Ratio in Densest State
γ_d	kN/m^3	Unit Weight of Dry Soil	I_D	1	Density Index = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_{sat}	kg/m^3	Density of Saturated Soil	D	mm	Grain Diameter
γ_{sat}	kN/m^3	Unit Weight of Saturated Soil	D_n	mm	n Percent - Diameter
ρ'	kg/m^3	Density of Submerged Soil	C_u	1	Uniformity Coefficient
γ'	kN/m^3	Unit Weight of Submerged Soil	h	m	Hydraulic Head or Potential
e	1, %	Void Ratio	q	m	Rate of Discharge
n	1, %	Porosity	v	m/s	Discharge Velocity
w	1, %	Water Content	i	1	Hydraulic Gradient
s_r	%	Degree of Saturation	k	m/s	Hydraulic Conductivity
w_L	%	Liquid Limit	J	kN/m^3	Seepage Force

RECORD OF BOREHOLE No 07-1

1 of 2

METRIC

G.W.P. 4264-04-00 LOCATION Co-ords: 4 910 044 N : 366 184 E ORIGINATED BY M.R.
DIST Eastern HWY 7 BOREHOLE TYPE NW Casing and NQ Rock Coring COMPILED BY P.L.
DATUM Geodetic DATE July 30 and 31, 2007 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N° VALUES			SHEAR STRENGTH kPa						
250.9 0.0	Top of Drilling Platform							20 40 60 80 100						
249.8 1.1	Water							20 40 60 80 100						
247.8 3.1	Silty clay some sand, trace gravel Very soft Mottled Moist to hard brown		1	SS	1			20 40 60 80 100						1 11 35 53
246.5 4.4	Sand and gravel with cobbles and boulders Dense to Grey Saturated very dense (TILL) drove NW casing from El. 248.6 to El. 246.5 took 104 blows with a 160kg hammer with 0.60m drop.		2	SS	58			20 40 60 80 100						
			3	SS	32			20 40 60 80 100						
			4	SS	60*			20 40 60 80 100						
			5	SS	85/15cm			20 40 60 80 100						
			6	RC NQ				20 40 60 80 100						
243.3 7.6	Limestone bedrock Medium strength Unweathered Fair to excellent quality		7	RC NQ	REC = 95%			20 40 60 80 100						RQD = 66%
			8	RC NQ	REC = 100%			20 40 60 80 100						RQD = 82%
			9	RC NQ	REC = 100%			20 40 60 80 100						RQD = 100%
			10	RC NQ	REC = 100%			20 40 60 80 100						RQD = 100%
			11	RC NQ	REC = 100%			20 40 60 80 100						RQD = 62%
			12	RC NQ	REC = 98%			20 40 60 80 100						RQD = 87%

Cont'd

RECORD OF BOREHOLE No 07-1

2 of 2

METRIC

G.W.P. 4264-04-00 LOCATION Co-ords: 4 910 044 N : 366 184 E ORIGINATED BY M.R.
DIST Eastern HWY 7 BOREHOLE TYPE NW Casing and NW Rock Coring COMPILED BY P.L.
DATUM Geodetic DATE July 30 and 31, 2007 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
235.9								20	40	60	80	100					
235.4																	
15.5	End of borehole																
	NOTE: Drove NW Casing to refusal in Fill with 160kg hammer with 600cm fall.																
	* 2007 07 31																
	▽ Water level observed during drilling																
	▼ Water level measured after drilling																

RECORD OF BOREHOLE No 07-2

1 of 2

METRIC

G.W.P. 4254-04-00 LOCATION Co-ords: 4 910 055 N : 366 205 E ORIGINATED BY M.R.
DIST Eastern HWY 7 BOREHOLE TYPE NW Casing and HQ Rock Coring COMPILED BY P.L.
DATUM Geodetic DATE August 1 to 3, 2007 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
250.0 0.0	Top of Drilling Platform							20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	GR SA SI CL
249.6 1.1	Water						250								
							249								
247.8 3.0	Sand and gravel with cobbles and boulders some silt Dense to Grey Saturated very dense (TILL) 360mm boulder encountered at El. 245.0 210mm boulders encountered at El. 243.7		1	SS	47		248								
			2	SS	63		247								
			3	SS	56		246								
			4	SS	70/8cm		245								
			5	RC NQ			244								
			6	RC NQ			243								
243.2 8.1	Limestone bedrock Medium strength Unweathered Excellent quality		7	RC NQ	REC = 100%		242								RQD = 92%
			8	RC NQ	REC = 100%		241								RQD = 100%
			9	RC NQ	REC = 100%		240								RQD = 93%
			10	RC NQ	REC = 100%		239								RQD = 91%
236.9 14.5	End of borehole						237								
Cont'd															

Cont'd

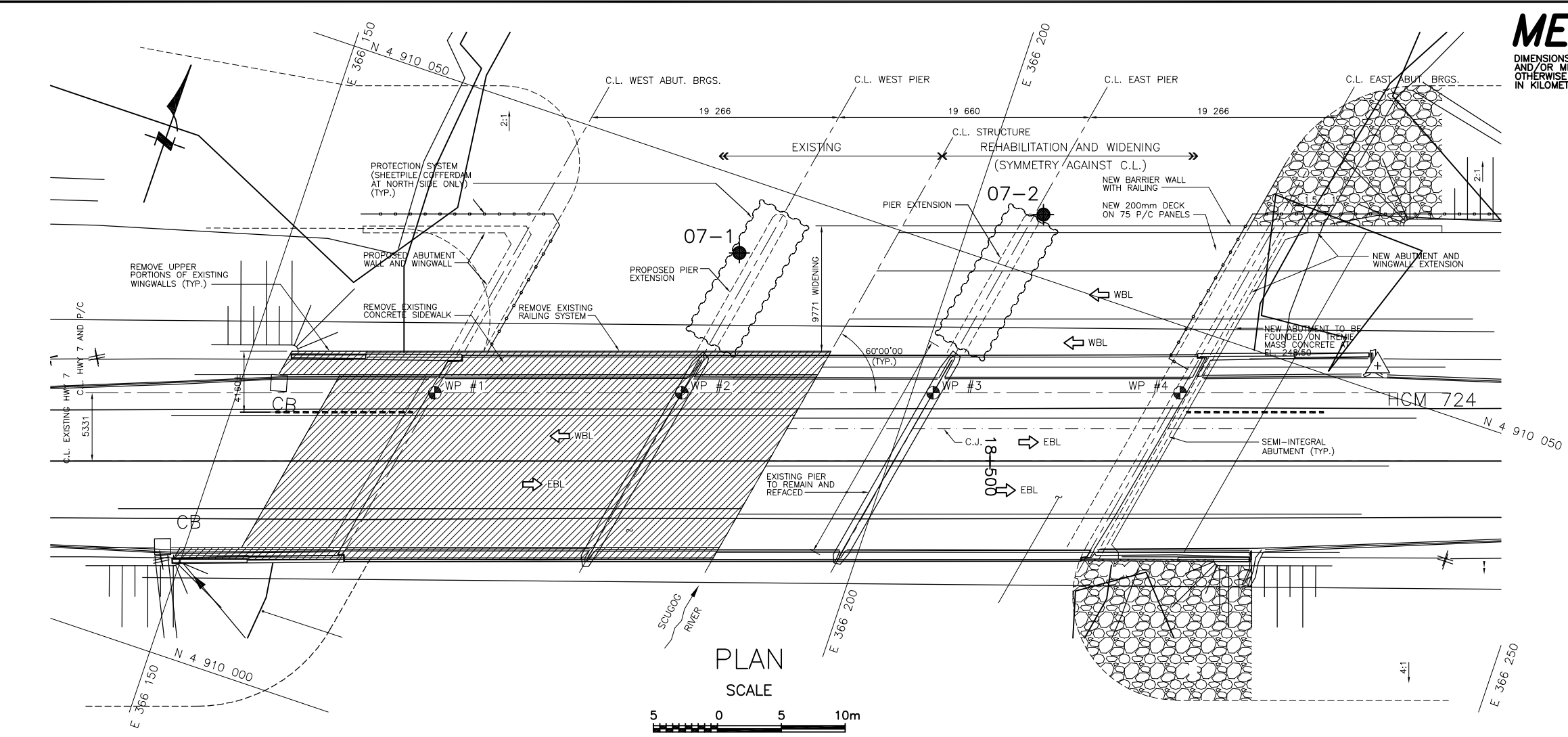
RECORD OF BOREHOLE No 07-2

2 of 2

METRIC

G.W.P. 4264-04-00 LOCATION Co-ords: 4 910 055 N + 366 205 E
DIST Eastern HWY 7 BOREHOLE TYPE NW Casing and NQ Rock Coring
DATUM Geodetic DATE August 1 to 3, 2007
ORIGINATED BY M.R.
COMPILED BY P.T.
CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L		
235.9	NOTE Drove NW casing to refusal in Till with 180kg hammer with 600mm fall. + 2007 07 J1 ▽ Water level observed during drilling ▼ Water level measured after drilling							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60	kn/m ³	GR SA SI CL
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL X LAB VANE						

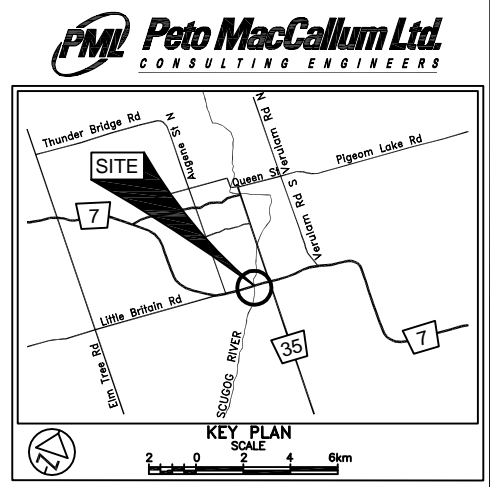


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

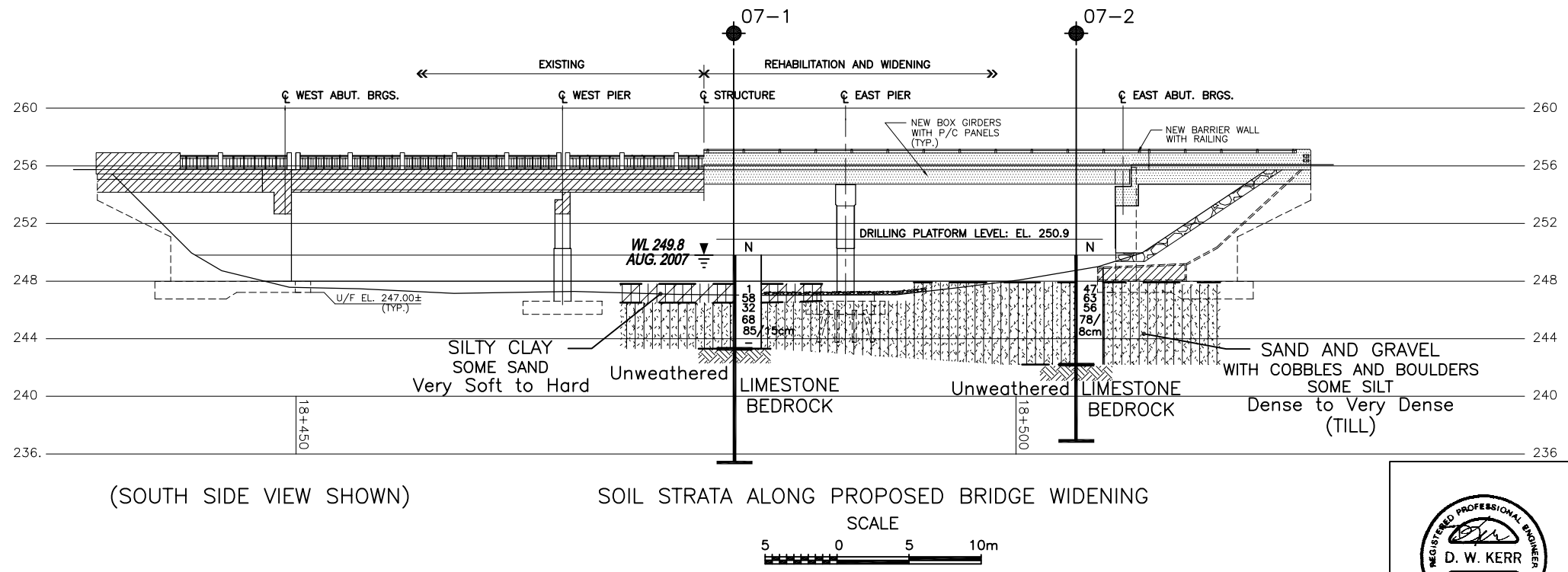
CONT No
GWP No 4264-04-00

REHABILITATION/WIDENING OF
SCUGOG RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
51



LEGEND			
	Borehole		
	Dynamic Cone Penetration Test (Cone)		
	Borehole & Cone		
N	Blows/0.3m (Std. Pen Test, 475 J / blow)		
CONE	Blows/0.3m (60° Cone, 475 J / blow)		
	W L at time of investigation July-Aug. 2007		
	Head		
	ARTESIAN WATER Encountered		
	PIEZOMETER		
BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
07-1	250.9	4 910 044	366 184
07-2	250.9	4 910 055	366 205



- NOTES:
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - REFER TO GEOCREs No. 31D-412, DRAWING No. 11378-1 DATED MARCH 24, 2006 FOR ADDITIONAL BOREHOLE AND SOIL STRATA INFORMATION.

REF No.: MORRISON AND HERSHFIELD DRAWING 1061047\STRUCTURE\Drawings\32069S01.dwg; Dated: JUNE 2007

— NOTE —

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. XXX-XXX

HWY No 7	DIST EASTERN
SUBM'D PL	CHECKED PL
DRAWN NA	CHECKED DWK
DATE JAN. 02, 2008	APPROVED BRG
SITE 32-096	DWG 1



Appendix A

Site Photographs of Existing Bridge, Photographs 1 through 5

Photographs of Drill and Barge Setup, Photographs 6 to 8



Photograph 1 – View west along north side of bridge.



Photograph 2 – View west from east end of bridge (north side).



Photograph 3 – View west from east end of bridge (south side).



Photograph 4 – View east from west end of bridge.



Photograph 5 – View west from east end of bridge.



Photograph 6 – View of drill and barge set up in the river.



Photograph 7 – Drill and barge setup prior to drilling at east pier.



Photograph 8 – Prior to drilling at west pier.



Appendix B

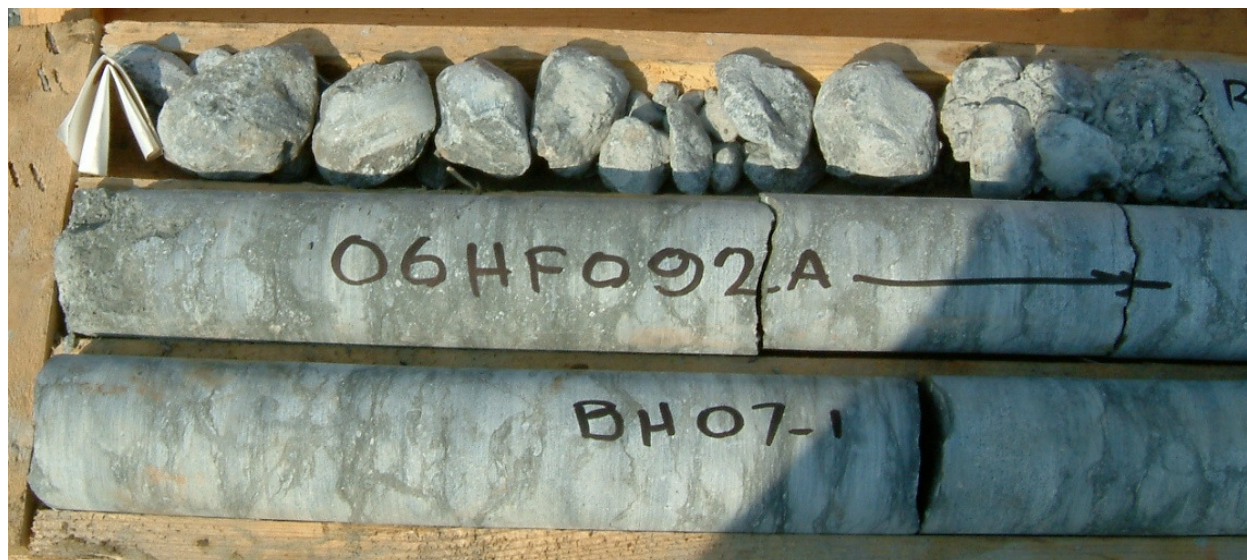
Rock Core Photographs

Borehole 07-1, 7.6 to 15.5 m

Borehole 07-02, 8.7 to 14.0 m

Borehole 07-1 – 7.6 to 15.5 m

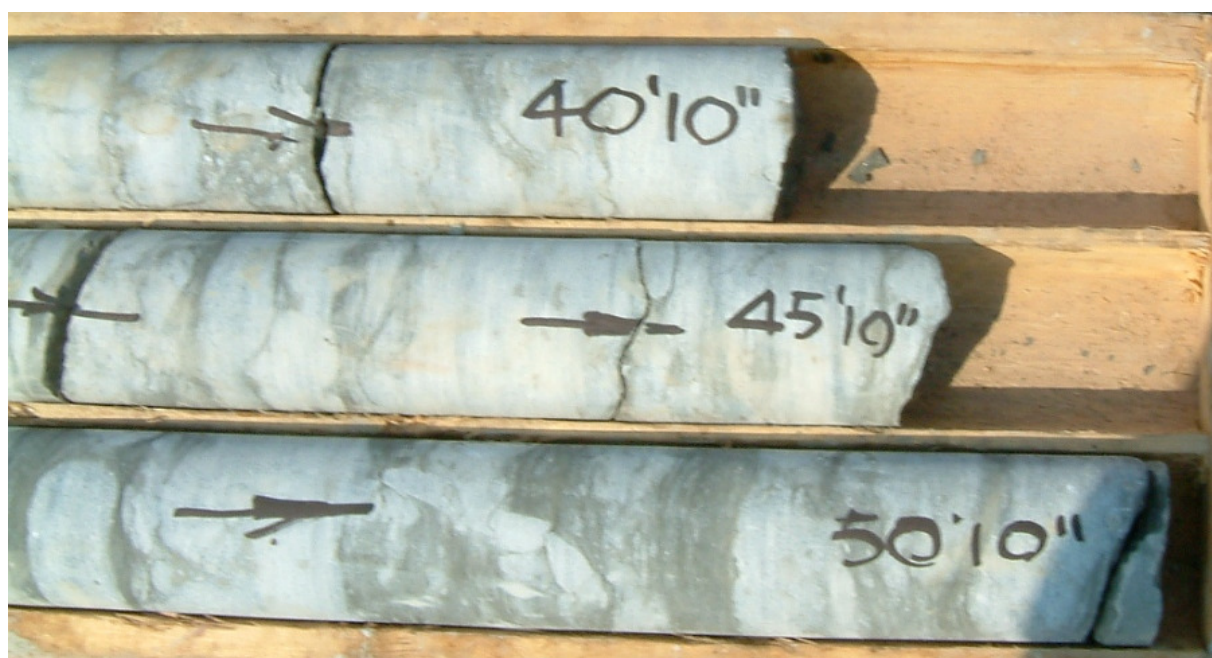






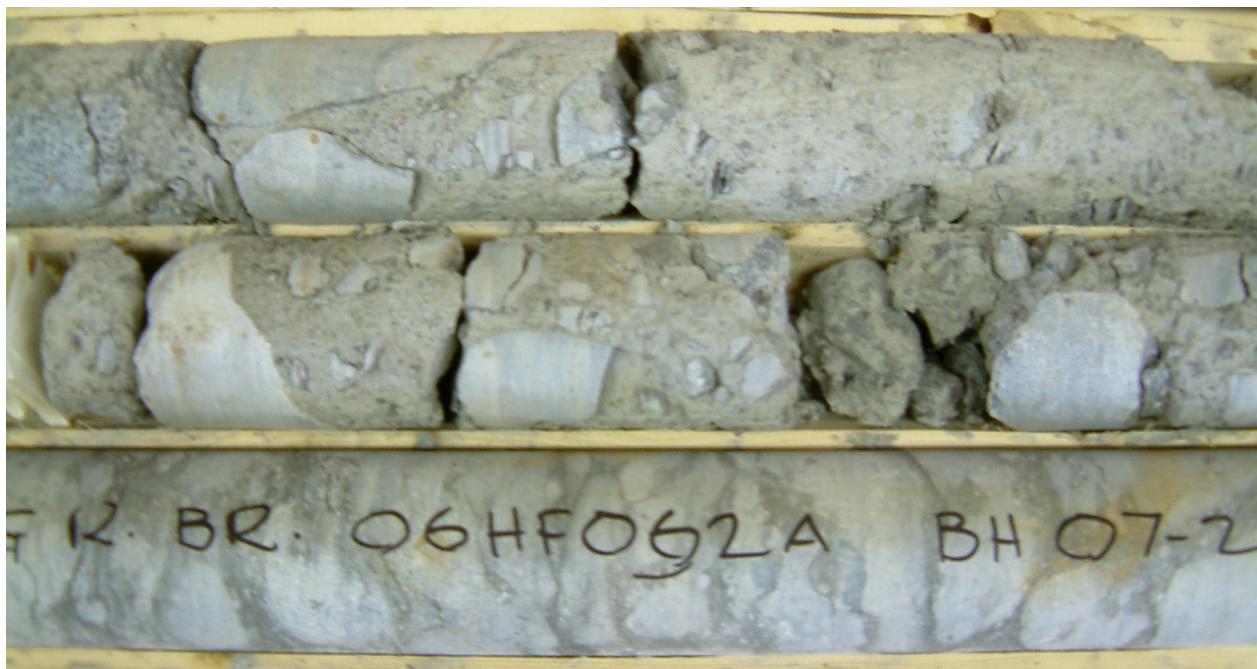






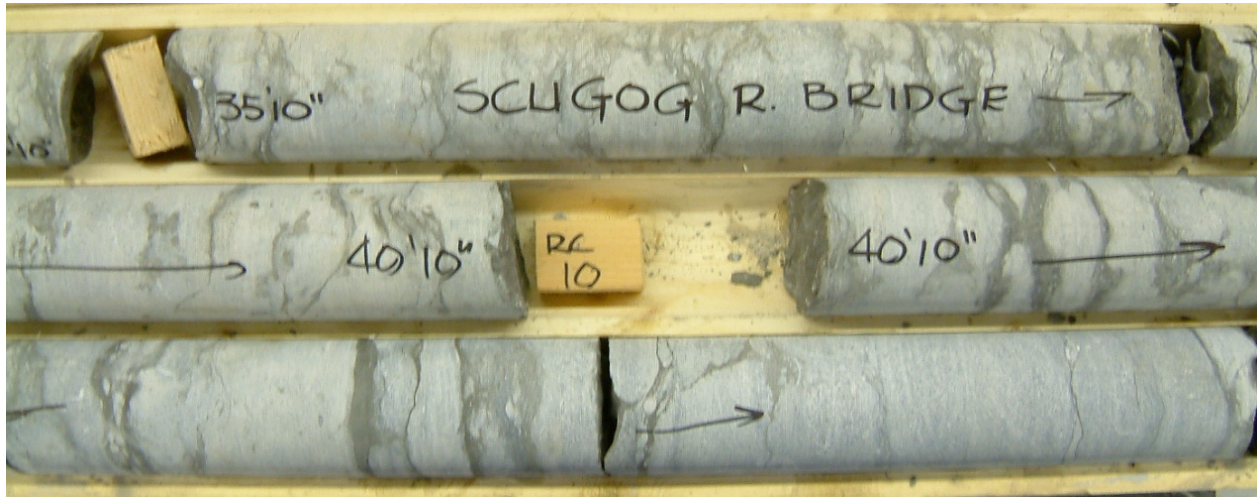
Borehole 07-2, 8.7 to 14.0 m













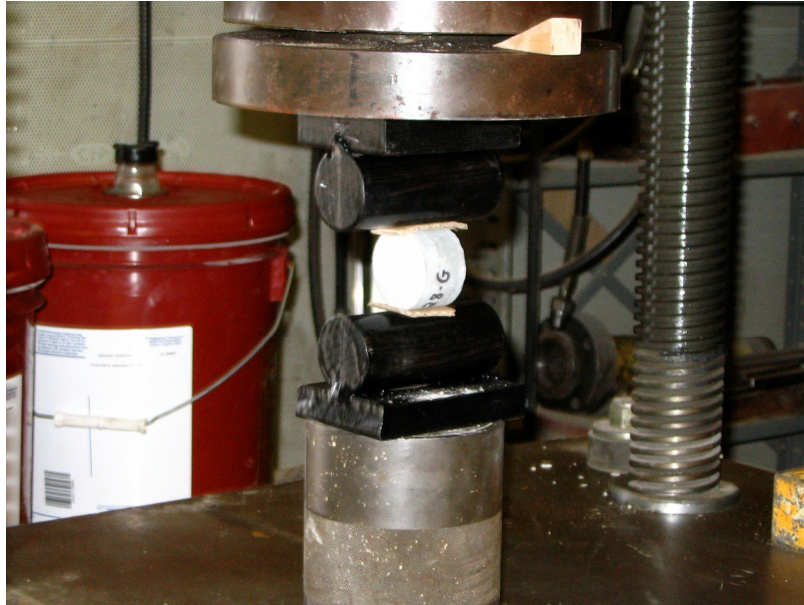


Appendix C

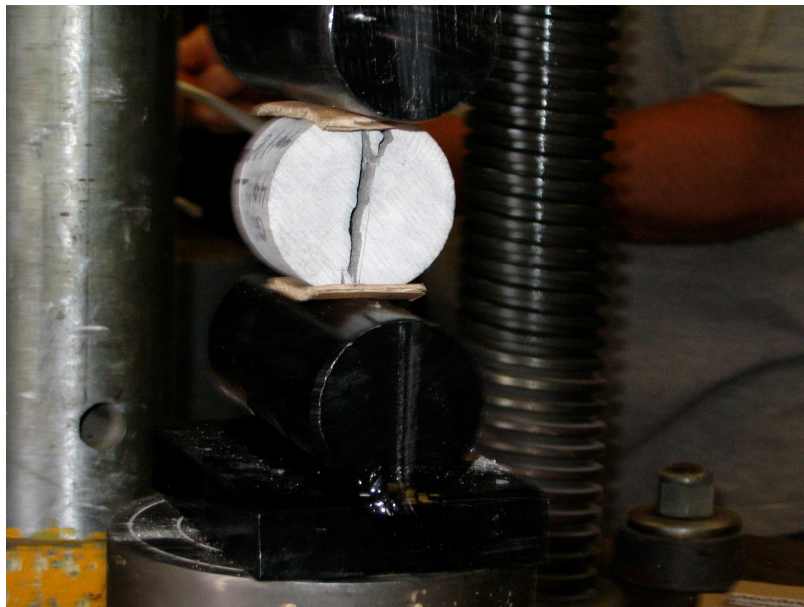
Photographs of Rock Core Tensile Test Equipment

Tensile and Compressive Strength Laboratory Test Data

600 kN Tinius Olsen Test Equipment



Commencement of test.



After failure.

Mr. David Doodnauth, C.E.T.
Peto MacCallum Ltd.
165 Cartwright Avenue,
Canada M6A 1V5,
Toronto, Ontario

Dear Mr. Doodnauth

Below please find the results of the 5 rock core samples for the Splitting Tensile Test (ASTM D 3967-05) conducted using the 600 kN *Tinius Olsen* universal testing machine (Serial no. 66712) located in the Applied Dynamics Laboratory of McMaster University.

The tests were conducted on August 14th and 15th 2007 at a loading rate of 0.005 in/min and the machine was last calibrated on January 18, 2007 by *Cal-Check Canada* to ASTM E-4.

Specimen designation	Diameter (mm)	Length (mm)	Maximum load (kN)	Recorded weight (g)	Dry weight (g)	Moisture content (%)	Strength (Mpa)	Comments
06HFO92A HOLE 07-1, SAMPLE 7, DEPTH 27' 0"	47.4	27.89	12,500	119	117	1.7	6.0	Air voids in sample
06HFO92A HOLE 07-2, SAMPLE 10, DEPTH 41' 0"	47.49	29.38	13,400	127	126	0.8	6.1	Different layers along failure line
06HFO92A HOLE 07-1, SAMPLE 12, DEPTH 49' 0"	47.4	29.53	15,250	129	128	0.8	6.9	
06HFO92A HOLE 07-2, SAMPLE 8, DEPTH 33' 0"	47.53	29.22	18,950	132	131	0.8	8.7	
06HFO92A HOLE 07-1, SAMPLE 10, DEPTH 39' 0"	47.52	27.66	19,100	126	124	1.6	9.3	

Please let me know if I can be of any further assistance
Regards,

Wael W. El-Dakhakhni, Ph.D., P.E.
Martini, Mascarin and George Chair in Masonry Design,
Assistant Professor
Center for Effective Design of Structures
Civil Engineering Dept., McMaster University
Hamilton, ON, L8S 4L7, Canada
Tel: 905-525-9140 Ext. 26109,
Fax: 905-529-9688,
e-mail: eldak@mcmaster.ca

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
PROJECT Rehabilitation of Scugog River Bridge
SAMPLE IDENTIFICATION BH 07-2, Sample 10, 44' 4" - 44' 8"

PML REF 06HF092A
LAB NO. 34328 M
DATE SAMPLED

DATE TESTED 8/10/2007
TESTED BY BM / RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8690	TEST TIME (min) (spec. 2 to 15)	5:13
SPECIMEN LENGTH (in.)	3.867	MAXIMUM LOAD APPLIED (kN)	75.44
	3.866		
	3.864	COMPRESSIVE STRENGTH (MPa)	42.6
AVE.	3.866	TYPE OF FAILURE	B
SURFACE AREA (sq mm)	1770	LENGTH TO DIAMETER RATIO	2.07

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	570.09	WEIGHT OF DRY SAMPLE IN AIR (g)	465.86
WEIGHT OF DRY SAMPLE + TARE (g)	566.25	VOLUME OF SAMPLE (cu m)	0.000174
WEIGHT OF WATER (g)	1.84	UNIT WEIGHT (kg/cu m)	2680
WEIGHT OF TARE (g)	105.24		
WEIGHT OF DRY SAMPLE (g)	463.01		
MOISTURE CONTENT (%)	0.4		
REMARKS	ASTM: D 2938-95 / D 7012-07 TYPE OF FAILURE: ASTM C 39/C 38 M		

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
PROJECT Rehabilitation of Scugog River Bridge
SAMPLE IDENTIFICATION BH 07-1, Sample 12, 49' 10" - 50' 3"

PML REF 06HF092A
LAB NO. 34328 H
DATE SAMPLED

DATE TESTED 8/10/2007
TESTED BY BM/RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8707	TEST TIME (min) (spec. 2 to 15)	5.22
SPECIMEN LENGTH (in.)	4.073	MAXIMUM LOAD APPLIED (kN)	60.54
	4.069		
	4.068	COMPRESSIVE STRENGTH (MPa)	34.1
	AVE. 4.07	TYPE OF FAILURE	A
SURFACE AREA (sq mm)	1773	LENGTH TO DIAMETER RATIO	2.18

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	577.88	WEIGHT OF DRY SAMPLE IN AIR (g)	489.20
WEIGHT OF DRY SAMPLE + TARE (g)	575.42	VOLUME OF SAMPLE (cu m)	0.000183
WEIGHT OF WATER (g)	2.46	UNIT WEIGHT (kg/cu m)	2669
WEIGHT OF TARE (g)	88.67		
WEIGHT OF DRY SAMPLE (g)	486.75		
MOISTURE CONTENT (%)	0.5		
REMARKS	ASTM D 2938-95 / D 7012-07 TYPE OF FAILURE: ASTM C 39/C 39 M		

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
PROJECT Rehabilitation of Scugog River Bridge
SAMPLE IDENTIFICATION BH 07-1, Sample 9, 32' - 32' 4"

PML REF 06HF092A
LAB NO. 34328 C
DATE SAMPLED

DATE TESTED 8/9/2007
TESTED BY BM / RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8693	TEST TIME (min) (spec. 2 to 15)	7.29
SPECIMEN LENGTH (in.)	3.899	MAXIMUM LOAD APPLIED (kN)	116.45
	3.901		
	3.900	COMPRESSIVE STRENGTH (MPa)	65.8
	AVE. 3.9	TYPE OF FAILURE	B
SURFACE AREA (sq mm)	1771	LENGTH TO DIAMETER RATIO	2.09

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	563.02	WEIGHT OF DRY SAMPLE IN AIR (g)	459.26
WEIGHT OF DRY SAMPLE + TARE (g)	561.01	VOLUME OF SAMPLE (cu m)	0.000175
WEIGHT OF WATER (g)	2.01	UNIT WEIGHT (kg/cu m)	2618
WEIGHT OF TARE (g)	104.89		
WEIGHT OF DRY SAMPLE (g)	456.12		
MOISTURE CONTENT (%)	0.4		
REMARKS	ASTM D 2938-85 / D 7012-07 TYPE OF FAILURE: C 39/C 39 M		

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
PROJECT Rehabilitation of Scugog River Bridge
SAMPLE IDENTIFICATION BH 07-2, Sample 9, 36' 7" - 36' 11"

PML REF 06HF092A
LAB NO. 34328 K
DATE SAMPLED

DATE TESTED 8/10/2007
TESTED BY BM/RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8690	TEST TIME (min) (spec. 2 to 15)	6.14
SPECIMEN LENGTH (in.)	3.941	MAXIMUM LOAD APPLIED (kN)	51.24
	3.943		
	3.444	COMPRESSIVE STRENGTH (MPa)	28.9
	AVE. 3.776	TYPE OF FAILURE	B
SURFACE AREA (sq mm)	1770	LENGTH TO DIAMETER RATIO	2.02

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	572.15	WEIGHT OF DRY SAMPLE IN AIR (g)	471.86
WEIGHT OF DRY SAMPLE + TARE (g)	569.81	VOLUME OF SAMPLE (cu m)	0.000170
WEIGHT OF WATER (g)	2.34	UNIT WEIGHT (kg/cu m)	2780
WEIGHT OF TARE (g)	101.79		
WEIGHT OF DRY SAMPLE (g)	468.02		
MOISTURE CONTENT (%)	0.5		
REMARKS	ASTM: D 2938-95 / D 7012-07 TYPE OF FAILURE: ASTM C 39/C 39M		

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
PROJECT Rehabilitation of Scugog River Bridge
SAMPLE IDENTIFICATION BH 07-1, Sample 11, 43'11"-44'3"

PML REF 06HF092A
LAB NO. 34328 F
DATE SAMPLED

DATE TESTED 8/10/2007
TESTED BY BM/RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8715	TEST TIME (min) (spec. 2 to 15)	6.59
SPECIMEN LENGTH (in.)	3.974	MAXIMUM LOAD APPLIED (kN)	59.43
	3.971		
	3.972	COMPRESSIVE STRENGTH (MPa)	33.5
	AVE. 3.972	TYPE OF FAILURE	B
SURFACE AREA (sq mm)	1775	LENGTH TO DIAMETER RATIO	2.12

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	579.89	WEIGHT OF DRY SAMPLE IN AIR (g)	477.55
WEIGHT OF DRY SAMPLE + TARE (g)	576.21	VOLUME OF SAMPLE (cu m)	0.000179
WEIGHT OF WATER (g)	3.68	UNIT WEIGHT (kg/cu m)	2667
WEIGHT OF TARE (g)	105.74		
WEIGHT OF DRY SAMPLE (g)	470.47		
MOISTURE CONTENT (%)	0.8		
REMARKS	ASTM: D 2938-95 / D 7012-07 TYPE OF FAILURE: ASTM: C 39/C 39M		

Peto MacCallum Ltd.

CONSULTING ENGINEERS

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
 PROJECT Rehabilitation of Scugog River Bridge
 SAMPLE IDENTIFICATION BH 07-1, Sample 7, 26' 3" - 26' 7"

PML REF 06HF092A
 LAB NO. 34328 A
 DATE SAMPLED

DATE TESTED 8/10/2007
 TESTED BY BM/RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8670	TEST TIME (min) (spec. 2 to 15)	6.09
SPECIMEN LENGTH (in.)	3.959	MAXIMUM LOAD APPLIED (kN)	99.77
	3.962		
	3.964	COMPRESSIVE STRENGTH (MPa)	56.5
	AVE. 3.962	TYPE OF FAILURE	B
SURFACE AREA (sq mm)	1766	LENGTH TO DIAMETER RATIO	2.12

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	600.90	WEIGHT OF DRY SAMPLE IN AIR (g)	474.34
WEIGHT OF DRY SAMPLE + TARE (g)	599.80	VOLUME OF SAMPLE (cu m)	0.000178
WEIGHT OF WATER (g)	1.10	UNIT WEIGHT (kg/cu m)	2669
WEIGHT OF TARE (g)	126.86		
WEIGHT OF DRY SAMPLE (g)	472.94		
MOISTURE CONTENT (%)	0.2		
REMARKS	ASTM: D 2938-96 / D 7012-07 TYPE OF FAILURE: ASTM C 39/C 39M		

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
PROJECT Rehabilitation of Scugog River Bridge
SAMPLE IDENTIFICATION BH 07-2, Sample 7, 30' 0" - 30' 4"

PML REF 06HF092A
LAB NO. 34328 I
DATE SAMPLED

DATE TESTED 8/10/2007
TESTED BY BM/RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8717	TEST TIME (min) (spec. 2 to 15)	5.43
SPECIMEN LENGTH (in.)	4.026	MAXIMUM LOAD APPLIED (kN)	65.34
	4.035		
	4.035	COMPRESSIVE STRENGTH (MPa)	36.8
	AVE. 4.032	TYPE OF FAILURE	B
SURFACE AREA (sq mm)	1775	LENGTH TO DIAMETER RATIO	2.15

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	616.60	WEIGHT OF DRY SAMPLE IN AIR (g)	484.93
WEIGHT OF DRY SAMPLE + TARE (g)	615.10	VOLUME OF SAMPLE (cu m)	0.000182
WEIGHT OF WATER (g)	1.50	UNIT WEIGHT (kg/cu m)	2667
WEIGHT OF TARE (g)	131.89		
WEIGHT OF DRY SAMPLE (g)	483.21		
MOISTURE CONTENT (%)	0.3		
REMARKS ASTM D 2938-95 / D 7012-07 TYPE OF FAILURE: ASTM C 39/C 39 M			

ROCK CORE TESTING

CLIENT Morrison Hershfield Limited
PROJECT Rehabilitation of Scugog River Bridge
SAMPLE IDENTIFICATION BH 07-1, Sample 10, 38' 2.5"-38' 6.5"

PML REF 06HF092 A
LAB NO. 34328 D
DATE SAMPLED

DATE TESTED 8/10/2007
TESTED BY BM/RS

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	1.8690	TEST TIME (min) (spec. 2 to 15)	7.07
SPECIMEN LENGTH (in.)	3.876	MAXIMUM LOAD APPLIED (kN)	63.52
	3.879		
	3.879	COMPRESSIVE STRENGTH (MPa)	35.9
	AVE. 3.878	TYPE OF FAILURE	A
SURFACE AREA (sq mm)	1770	LENGTH TO DIAMETER RATIO	2.07

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	574.03	WEIGHT OF DRY SAMPLE IN AIR (g)	467.04
WEIGHT OF DRY SAMPLE + TARE (g)	571.93	VOLUME OF SAMPLE (cu m)	0.000174
WEIGHT OF WATER (g)	2.10	UNIT WEIGHT (kg/cu m)	2679
WEIGHT OF TARE (g)	108.45		
WEIGHT OF DRY SAMPLE (g)	463.48		
MOISTURE CONTENT (%)	0.5		
REMARKS	ASTM D 2938-96 / D 7012-07 TYPE OF FAILURE: ASTM C 39/C 39M		