

**FOUNDATION INVESTIGATION REPORT
MURDOCK RIVER BRIDGE REPLACEMENT
HIGHWAY 607, TOWNSHIP OF BIGWOOD, SUDBURY AREA
W.P. 33-78-01, SITE: 46-208**

Geocres Number: 41A-266

Report to

MMM Group

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of the proposed replacement bridge that will carry a re-aligned Highway 607 over Murdock River in the Township of Bigwood, Ontario. The existing bridge is located to the west of the proposed alignment and consists of a single-span steel bailey bridge that carries a single lane of traffic.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile and cross-sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group, under the Ministry of Transportation Ontario (MTO) Agreement Number 5008-E-0013.

2 SITE DESCRIPTION

The site is located approximately 5 km south of the intersection of Highway 64 and Highway 607 near Alban, Ontario. At the site, Murdock River flows on a relatively gentle gradient towards the east in a channel that is approximately 15 m wide at the existing bridge and 35 m wide at the location of the proposed bridge. The water level in the river was recorded as Elevation 182.50 in May 2009.

The south river bank consists mainly of bedrock outcrops and some small swamp areas vegetated with shrubs and trees. The north river bank is vegetated with shrubs and trees and there is a pile of rock fill east of the proposed alignment on the north river bank.

Geologically, the site lies within the Canadian Shield, which is characterized by Pre-Cambrian bedrock. Locally, however, Murdock River flows across deposits of sand and silt overlying the

bedrock. There are several private residences set back from the south bank of the river, both east and west of the proposed alignment.

Photographs of the site are included in Appendix D and show the existing bridge, the approaches and the site terrain.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field-testing for this project was carried out on March 8 and from May 31 to June 3, 2010 and consisted of drilling ten boreholes identified as MR10-03 to MR10-8 and MR10-11 to MR10-14. Proposed Boreholes MR10-01 and MR10-02 (located at the south abutment) could not be drilled due to cobbles and boulders at the surface. However, bedrock was observed at surface approximately 2.5 m northeast of the proposed location of MR10-02. Proposed Boreholes MR10-09 and MR10-10 (located at the north abutment) could not be drilled due to the proximity of overhead power lines. At the location of Borehole MR10-13 (located along the south approach) bedrock is at surface.

Four boreholes were drilled at the approximate locations of each of the proposed north and south abutments and one borehole was drilled along each of the south approach (MR10-13) and north approach (MR10-14). The depths of the boreholes ranged from 0.7 m to 14.8 m, with the deeper boreholes located at the north abutment due to thicker overburden deposits. The Record of Borehole sheets for these boreholes are included in Appendix A. The approximate locations of the boreholes, are shown on the Borehole Locations and Soil Strata Drawing included in Appendix E.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area.

A combination of hollow-stem auger drilling and NQ-sized coring techniques were used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

At least 3 m of bedrock was cored in Boreholes MR10-04 to MR10-08, MR10-11, and MR10-12. The rock cores were logged and total core recovery, solid core recovery and Rock Quality Designation (RQD) was determined for each core.

A standpipe piezometer consisting of 19 mm PVC pipe with a slotted screen was installed in Borehole MR10-12 and enclosed in filter sand to permit groundwater level monitoring. The locations and completion details of the piezometer and all other boreholes are shown in Table 3.1.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

Table 3.1 – Borehole Completion Details

Borehole Location	Borehole ID	Piezometer Tip Depth/ Elevation (m)	Completion Details
South Approach	MR10-13	None Installed	Borehole not drilled. Bedrock at surface.
South Abutment	MR10-03	None Installed	Borehole caved to surface.
	MR10-04	None Installed	Borehole backfilled with bentonite to surface.
	MR10-05	None Installed	Borehole backfilled with bentonite to surface.
	MR10-06	None Installed	Borehole backfilled with bentonite to surface.
North Abutment	MR10-07	None Installed	Borehole backfilled with bentonite to 1.8 m, then cuttings to surface.
	MR10-08	None Installed	Borehole backfilled with bentonite to 1.8 m, then cuttings to surface.
	MR10-11	None Installed	Borehole backfilled with bentonite to 2.3 m, then cuttings to surface.
	MR10-12	11.6 / 168.9	Piezometer with 1.5 m slotted screen installed with sand filter to 9.3 m, bentonite seal from 9.3 m to 0.2 m, then cuttings to surface.
North Approach	MR10-14	None Installed	Borehole caved to 1.2 m, then backfilled with bentonite to surface.

4 LABORATORY TESTING

All of the recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination in the laboratory. Selected samples were also subjected to gradation analysis (hydrometer and sieve), the results of which are summarized on the Record of Borehole Sheets in Appendix A. Grain size distribution curves for these samples are presented on the figures included in Appendix B.

Point load tests were carried out in the laboratory on selected samples of intact bedrock to assist in evaluation of the compressive strength of the bedrock. The results of the point load tests are tabulated in Table 1 in Appendix B and on the Record of Borehole sheets in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

A detailed description of the soil stratigraphy encountered at each borehole location is presented in Appendix A and on the “Borehole Locations and Soil Strata” drawing in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets (Appendix A) governs any interpretation of the site conditions.

In general, the site is underlain by organic material overlying cohesionless deposits of sand and silt and silty sand till overlying granite bedrock.

5.1 Organic Material

Fibrous, peaty, organic material mixed with sand, gravel and roots was encountered surficially in Boreholes MR10-03 to MR10-06, MR10-11 and MR10-12 and was encountered below a surficial layer of fill in Borehole MR10-08. The thickness of the organic material ranged from 200 to 600 mm (underside elevation 180.3 to 180.9 m). Natural moisture contents of the organic material samples ranged from 8 to 254%. The thickness of organic material may vary between and beyond the boreholes.

SPT N-values recorded in the organic material generally ranged from 6 to 10 blows per 0.3 m penetration, indicating a loose condition. An SPT N-value of 53 blows for 0.225 m of penetration was recorded in the organic material overlying bedrock in Borehole MR10-04.

5.2 Sand Fill

Sand fill was encountered surficially in Boreholes MR10-07 and MR10-08. The sand fill contained some gravel and occasional cobbles and boulders and was brown and moist. The thickness of the granular fill ranged from 0.6 m in Borehole MR10-08 to 0.7 m in Borehole MR10-07 (underside elevation 180.6 to 180.9 m).

5.3 Sand to Sand and Silt

A layer of wet water bearing sand to sand and silt was encountered below the organic material in Boreholes MR10-03, MR10-05, MR10-08, MR10-11, and MR10-12, below the sand fill in Borehole MR10-07, and below the ice and water in Borehole MR10-14. The sand and silt also contains trace clay, trace gravel, and occasional cobbles and is brown to grey. This layer encountered in Boreholes MR10-03 and MR10-05 (located at the south abutment) was 100 to 200 mm thick (underside elevations 180.6 and 180.7 m, respectively), overlying bedrock. The sand and silt layer encountered in Boreholes MR10-07, MR10-08, MR10-11, MR10-12, and MR10-14 (located at the north abutment and north approach) was 5.2 to 10.9 m thick (underside elevations 169.4 to 175.8 m).

A 0.6 m thick layer of gravel and cobbles was encountered within the sand to sand and silt layer in Borehole MR10-14 at 0.6 m depth (elevation 180.7 m).

SPT N-values recorded in the sand and silt layer generally ranged from 1 to 44 blows per 0.3 m of penetration, indicating a very loose to dense relative density. An SPT N-value of 100 blows for 0.08 m of penetration was recorded in Borehole MR10-03 at 0.6 m, just above bedrock. Typically, the sand and silt layer had a very loose to compact relative density. Natural moisture contents of samples collected from the sand and silt layer ranged from 10 to 36%.

Selected samples from the sand to sand and silt layer were subjected to gradation analysis, the results of which are summarized below.

Soil Particles	Percentage
Gravel	0 to 8
Sand	33 to 91
Silt	21 to 65
Clay	2
Silt and Clay	2 to 14

The grain size distribution curves for these samples are presented in Figures B1 and B2 of Appendix B and the results are summarized on the corresponding Record of Borehole sheet in Appendix A.

5.4 Silty Sand Till

In Boreholes MR10-07, MR10-11, MR10-12, and MR10-14 a layer of silty sand till was encountered below the sand and silt layer. The silty sand till contained trace to some gravel and trace clay and was grey. Although not recovered in the SPT samples, glacial tills inherently contain cobbles and boulders. The thickness of the silty sand till layer ranged from 0.6 to 1.5 m (underside elevation 168.8 to 174.5 m).

SPT N-values recorded in the silty sand till ranged from 48 blows for 0.3 m of penetration to 100 blows for 0.275 m penetration, indicating a dense to very dense relative density. Natural moisture contents of samples of the silty sand till ranged from 11 to 13%.

Selected silty sand till samples were subjected to gradation analysis, the results of which are summarized below. The grain size distribution curves for these samples are presented in Figure B3 of Appendix B and the results are summarized on the appropriate Record of Borehole sheet in Appendix A.

Soil Particles	Percentage
Gravel	3 to 11
Sand	56 to 82
Silt	29
Clay	4
Silt and Clay	15

5.5 Bedrock

The overburden soils described above are underlain by granite bedrock. The bedrock was generally grey with occasional pink and white bands visible in most cores. Occasional mechanical breaks and sub-vertical fractures were observed in the rock cores.

Bedrock was encountered at various depths and was proved by coring in a number of boreholes. Table 5.1 summarizes the depths and elevations to the top of bedrock in the boreholes. Where coring was not carried out, bedrock was inferred from auger refusal.

Table 5.1 – Depths and Elevations of Top of Bedrock

Borehole	Location	Top of Bedrock	
		Depth (m)	Elevation (m)
MR10-03	South Abutment	0.7*	180.6
MR10-04		0.4	180.8
MR10-05		0.5	180.7
MR10-06		0.3	180.8
MR10-07	North Abutment	8.8	172.5
MR10-08		10.4	171.1
MR10-11		10.0	Not surveyed
MR10-12		11.7	168.8
MR10-13	South Approach	0.0	Not surveyed
MR10-14	North Approach	6.8*	174.5

* Auger refusal on probable bedrock.

Core recovery in the bedrock generally ranged from 85% to 100%. The RQD values generally ranged from 65% to 100%, indicating fair to excellent rock quality. RQD values of 0% were recorded in Borehole MR10-05 Run 2 and MR10-12 Run 1. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, generally ranged from 0 to 5. In some bedrock cores the Fracture Index ranged from 5 to 10.

The estimated unconfined compressive strength of the rock cores generally ranges from 76 MPa to 287 MPa, indicating a strong to extremely strong rock. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results is presented in Table 1 immediately following the text of this report.

5.6 Groundwater Conditions

A 19 mm standpipe piezometer was installed in Borehole MR10-12, located at the north abutment. A water level of 0.13 m below ground surface (elevation 180.4 m) was measured

on June 3, 2010. This is a short-term water level reading only and the water table will fluctuate seasonally. The river level was at Elevation 182.5 in May 2009.

6 MISCELLANEOUS

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied a track mounted CME 55 drill rig and conducted the drilling, sampling and in-situ testing operations for Boreholes MR10-03 to MR10-08, MR10-11, and MR10-12. OGS Inc. of Almonte, Ontario supplied portable drilling equipment and conducted the drilling, sampling and in-situ testing operations for Borehole MR10-14.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger and Mr. Jason Mei of Thurber, under the direction of Mr. Tony Harte, M.Sc..

The coordinates for the boreholes and the ground surface elevations were provided by MMM Group Limited.

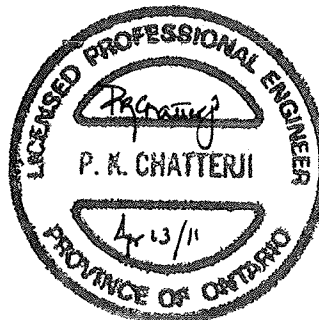
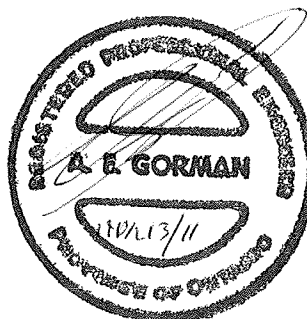
Mrs. Lindsey Blaine, E.I.T. and Mr. Alastair E. Gorman, P.Eng prepared the Foundation Investigation Report.

Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

Thurber Engineering Ltd.
Lindsey Blaine, E.I.T.

L. Blaine Apr. 13/11

Alastair E. Gorman, P.Eng.,
Senior Foundations Engineer



Report Reviewed by:
P.K. Chatterji, P.Eng.,
Review Principal, Designated MTO Contact

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

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	12 or less	Less than 2
Soft	12 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 RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$



Water Level

C_{pen}






Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

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			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail


<u>TERMS</u>	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No MR10-03

1 OF 1

METRIC

W.P. 33-78-00 LOCATION N 5 103 851.1 E 218 791.3 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2010.06.03 - 2010.06.03 CHECKED BY LRB

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE						
181.3 0.0	ORGANICS, mixed with clayey silt, trace cobbles, with roots and rootlets Stiff Black Wet		1	SS	10	181								
180.7 180.6 0.7	SAND, trace gravel, occasional cobbles Very Dense Brown Wet END OF BOREHOLE AT 0.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE CAVED TO SURFACE AND WATER LEVEL AT SURFACE.		2	SS	100									
					0.075									

UNIM14S 0158-GF-3 106710

ONTM4S 6158.CPJ 10/2/10

RECORD OF BOREHOLE No MR10-04

1 OF 1

METRIC

W.P. 33-78-00 LOCATION N 5 103 853.7 E 218 793.7 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2010.06.03 - 2010.06.03 CHECKED BY LRS

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			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						WATER CONTENT (%) W P W W L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
181.2	ORGANICS, mixed with sand, trace gravel, with roots and rootlets Very Dense Brown Wet GRANITE BEDROCK, with quartzite veins, very strong to extremely strong Start coring at 0.4m 100mm vertical joints at 0.7m 50mm rubble zone at 1.1m 100mm sub-vertical joints at 0.8m		1	SS	53/ 0.226																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	

RECORD OF BOREHOLE No MR10-05

1 OF 1

METRIC

W.P. 33-78-00 LOCATION N 5 103 847.9 E 218 794.9 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2010.08.02 - 2010.08.02 CHECKED BY LRB

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			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE				W _p	W	W _L
181.2						20	40	60	80	100	20	40	60		
0.0	ORGANICS, peaty, fibrous		1	SS	6										
180.9															
180.9	SAND, trace gravel, occasional cobbles Loose Wet		1	RUN											
0.5	GRANITE BEDROCK, with pink quartzite, strong to extremely strong Start coring at 0.5m 100mm rubble zone at 1.2m Vertical joints at: 100mm at 1.1m 500mm at 1.3m		2	RUN											
			3	RUN											
			4	RUN											
177.6															
3.6	END OF BOREHOLE AT 3.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.														



ONTM74S 6158.GPJ 10/8/10

RECORD OF BOREHOLE No MR10-06

1 OF 1

METRIC

W.P. 33-78-00 LOCATION N 5 103 650.5 E 218 797.2 ORIGINATED BY SLL
 HWY 607 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2010.06.02 - 2010.06.02 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
181.1							20	40	60	80	100	20	40	60				
0.0	ORGANICS, with roots and rootlets, trace gravel		1	SS	10													
180.8																		
0.3	GRANITE BEDROCK, with micaceous layers and quartzite veins, strong to extremely strong Start coring at 0.3m		1	RUN														

RECORD OF BOREHOLE No MR10-07

1 OF 2

METRIC

W.P. 33-78-00 LOCATION N 5 103 873.5 E 218 805.2 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2010.06.01 - 2010.06.02 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W _p	W	W _L		
181.3							20	40	60	80	100	20	40	60		
0.0	SAND, some gravel, occasional cobbles Dense Brown Moist (FILL)															
180.6																
0.7	SAND and SILT, trace clay Loose to Compact Brown to Grey Wet		1	SS	14											
			2	SS	5											
			3	SS	6											0 53 45 2
			4	SS	8											
			5	SS	5											
			6	SS	9											0 33 65 2
174.0																
7.3	Silty SAND, trace gravel Very Dense Grey Moist (TILL)		7	SS	77											
172.5																
8.8	GRANITE BEDROCK, very strong Start coring at 8.8m															
			1	RUN												

Continued Next Page

+ 3 . x 3 : Numbers refer to
Sensitivity

20
15 5 5
10 (%) STRAIN AT FAILURE

ONTM14S 6158 GPJ 10/8/10

RUN 1#
TCR=100%,
SCR=100%,
ROD=100%
UCS=198MPa

RECORD OF BOREHOLE No MR10-07

2 OF 2

METRIC

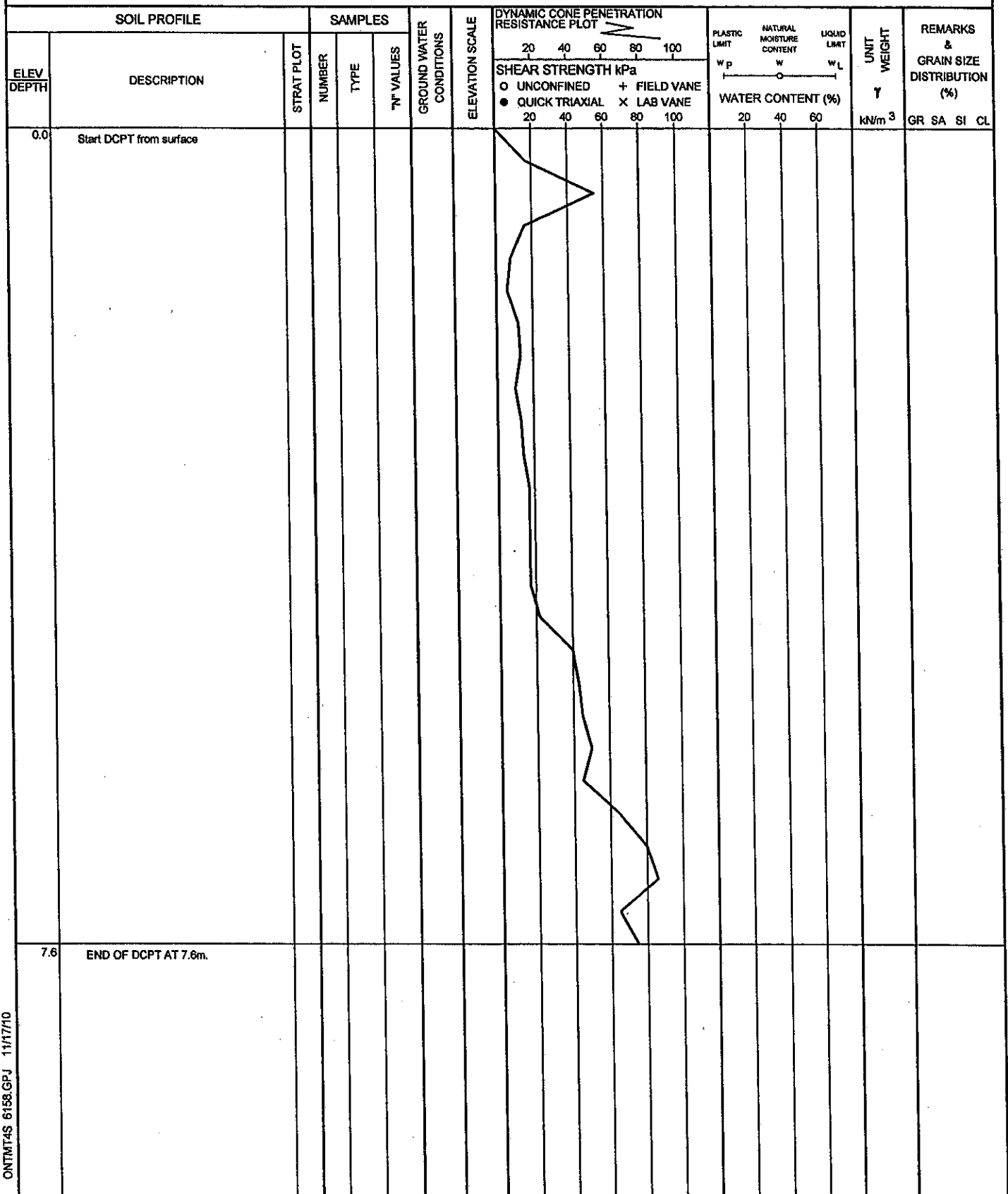
W.P. 33-78-00 LOCATION N 5 103 873.5 E 218 805.2 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2010.08.01 - 2010.06.02 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa	WATER CONTENT (%)	W _p	W		
	Continued From Previous Page												
			2	RUN		171						0	RUN 2# TCR=100%, SCR=100%, RQD=96% UCS=190MPa
						170						0	
			3	RUN								1	
169.0 12.3	END OF BOREHOLE AT 12.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, THEN CUTTINGS TO SURFACE.												RUN 3# TCR=100%, SCR=100%, RQD=86% UCS=235MPa

ONTMT4S 6158.GPJ 10/8/10

METRIC

W.P.	33-78-00	LOCATION		ORIGINATED BY	SLL
HWY	607	BOREHOLE TYPE	DCPT	COMPILED BY	AN
DATUM	Geodetic	DATE	2010.11.17 - 2010.11.17	CHECKED BY	TH



DNMT4S 6158.GPJ 11/17/10

+³, ×³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MR10-08

1 OF 2

METRIC

W.P. 33-78-00 LOCATION N 5 103 876.2 E 218 807.6 ORIGINATED BY SLL
 HWY 607 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2010.06.01 - 2010.06.01 CHECKED BY LRB

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					
181.5							20 40 60 80 100	20 40 60					
0.0	SAND, some gravel, occasional cobbles and boulders (FILL)												
180.9													
0.6	ORGANICS, with roots and rootlets Black												
180.7													
0.8	SAND and SILT, trace clay Very Loose to Dense Brown to Grey Moist to Wet		1	SS	4								
			2	SS	1								0 57 41 2
			3	SS	2								
			4	SS	2								
			5	SS	7								
			6	SS	15								
			7	SS	38								2 66 30 2
	Trace gravel		8	SS	26								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MR10-08

2 OF 2

METRIC

W.P. 33-78-00 LOCATION N 5 103 876.2 E 218 807.8 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2010.06.01 - 2010.06.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
171.1	SAND and SILT, trace clay													
10.4	Compact Grey Moist													
	GRANITE BEDROCK, with thin quartz seam, very strong Start coring at 10.4m		1	RUN			171						1	RUN 1# TCR=100%, SCR=100%, RQD=100% UCS=221MPa
			2	RUN			170						0	RUN 2# TCR=100%, SCR=100%, RQD=100% UCS=195MPa
			3	RUN			169						0	RUN 3# TCR=100%, SCR=100%, RQD=100% UCS=189 (Average)MPa
168.0														
13.5	END OF BOREHOLE AT 13.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, THEN CUTTINGS TO SURFACE.													

ONTMT4S 6158.GPJ 10/8/10

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MR10-11

1 OF 2

METRIC

W.P. 33-78-00 LOCATION ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2010.05.31 - 2010.05.31 CHECKED BY LRB

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						
180.3								20 40 60 80 100						
0.0	ORGANICS, with roots and rootlets							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE						
0.2	SAND and SILT, trace clay, occasional cobbles Very Loose to Compact Grey Moist to Saturated		1	SS	13		180							
			2	SS	1		179							
			3	SS	1		178							
			4	SS	2		177							0 77 21 2
			5	SS	1		176							
			6	SS	22		174							
			7	SS	4		173							
			8	SS	82		171							11 56 29 4
171.5	Silty SAND, trace to some gravel, trace clay Very Dense Grey Moist (TILL.)													
170.3														

Continued Next Page

+ 3 . X 3 : Numbers refer to
Sensitivity 20
15 10 6 5
(%) STRAIN AT FAILURE

ONTMT4S 6158.GPJ 4/6/11

RECORD OF BOREHOLE No MR10-11

2 OF 2

METRIC

W.P. 33-78-00 LOCATION _____ ORIGINATED BY SLL
 HWY 607 BOREHOLE TYPE Hollow Stem Augers/INQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2010.05.31 - 2010.05.31 CHECKED BY LRB

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 (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE
							20	40	60	80	100						
10.0	Continued From Previous Page GRANITE BEDROCK, thinly bedded, strong to very strong Start coring at 10.0m Sub-vertical joints at: 87.5mm at 10.5m 75mm at 11.3m		1	RUN											FI	RUN 1# TCR=100%, SCR=100%, RQD=100% UCS=120MPa	
			2	RUN												1	
																2	
																4	RUN 2# TCR=100%, SCR=98%, RQD=90% UCS=108 (Average)MPa
																3	
																2	
															0		
															0		
															0	RUN 3# TCR=100%, SCR=100%, RQD=96% UCS=73 (Average)MPa	
															1		
167.1															2		
13.2	END OF BOREHOLE AT 13.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.3m, THEN CUTTINGS TO SURFACE.																

RECORD OF BOREHOLE No MR10-12

1 OF 2

METRIC

W.P. 33-78-00 LOCATION N 5 103 869.8 E 218 814.7 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2010.06.01 - 2010.06.01 CHECKED BY LRS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
180.5								20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L				
0.0	ORGANICS, with roots and rootlets Black							20 40 60 80 100	○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE					
0.2	SAND and SILT, trace clay, occasional cobbles Loose to Dense Brown to Grey Wet		1	SS	15										
			2	SS	6								0 58 40 2		
			3	SS	14										
			4	SS	17								0 60 38 2		
			5	SS	13										
			6	SS	44										
			7	SS	43										
			8	SS	36										

ONTM4S 6158.GPJ 10/8/10

Continued Next Page

+ 3 x 3: Numbers refer to
Sensitivity

20
15 10 5
10 (%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No MR10-13

1 OF 1

METRIC

W.P. 33-78-00 LOCATION N 5 103 832.6 E 218 774.5 ORIGINATED BY SLL
HWY 607 BOREHOLE TYPE Visual Inspection COMPILED BY AN
DATUM Geodetic DATE 2010.03.08 - 2010.03.08 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE					WATER CONTENT (%) 20 40 60				
184.3 0.0	Bedrock at surface															

ONTM4S 6158.GPJ 10/8/10

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MR10-14

1 OF 1

METRIC

W.P. 33-78-00 LOCATION N 5 103 882.5 E 218 826.2 ORIGINATED BY JM
HWY 607 BOREHOLE TYPE Continuous Sampling/BW Casing COMPILED BY AN
DATUM Geodetic DATE 2010.03.06 - 2010.03.06 CHECKED BY TH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
181.3														
0.0	ICE and WATER													
181.0														
0.3	SAND, some gravel, occasional silt, trace rootlets, occasional fibrous		1	SS	19		181							
180.7	Compact Dark Brown Wet													
0.6														
180.1	GRAVEL, trace cobble Gray Wet		2	SS	10		180							
1.2	SAND, trace to some silt and clay, trace gravel Compact Dark Brown to Gray Wet		3	SS	12									7 91 2 (SI+CL)
			4	SS	10		179							
			5	SS	15		178							8 78 14 (SI+CL)
			6	SS	13		177							
							176							
175.8														
5.5	Silty SAND, trace clay, trace gravel Dense to Very Dense Gray Moist to Wet (TILL)		7	SS	48		175							
			8	SS	100/ 0.275									
174.5														
6.8	END OF BOREHOLE AT 6.8m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE CAVED TO 1.2m, THEN BENTONITE HOLEPLUG TO SURFACE.													

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

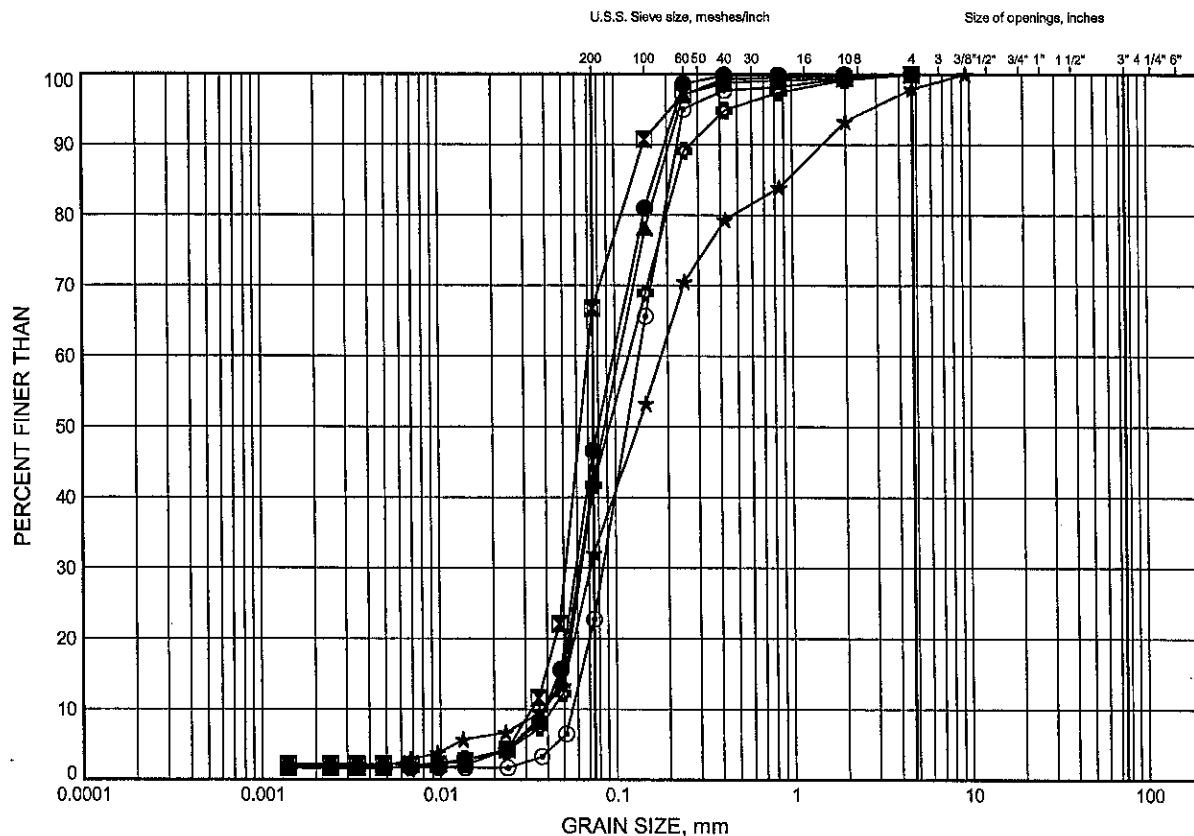
Appendix B

Laboratory Test Results

Murdock River and Grassy Lake Bridges GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND to SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MR10-07	2.59	178.71
⊠	MR10-07	6.40	174.90
▲	MR10-08	1.83	179.67
★	MR10-08	7.92	173.58
⊙	MR10-11	3.35	176.95
⊕	MR10-12	1.83	178.67

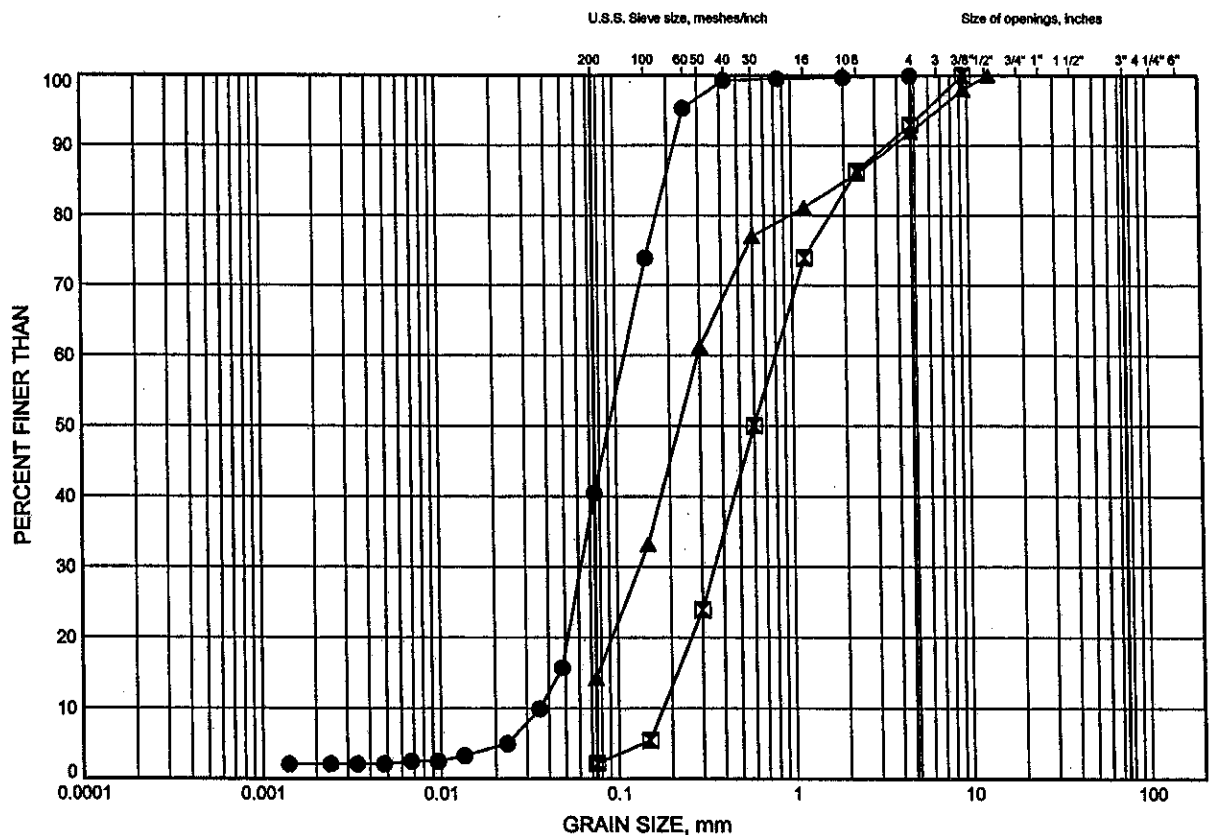


W.P.# 33-78-00
Prepared By AN
Checked By LRB

Murdock River GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND to SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MR10-12	3.35	177.15
◻	MR10-14	1.47	179.83
▲	MR10-14	3.35	177.95

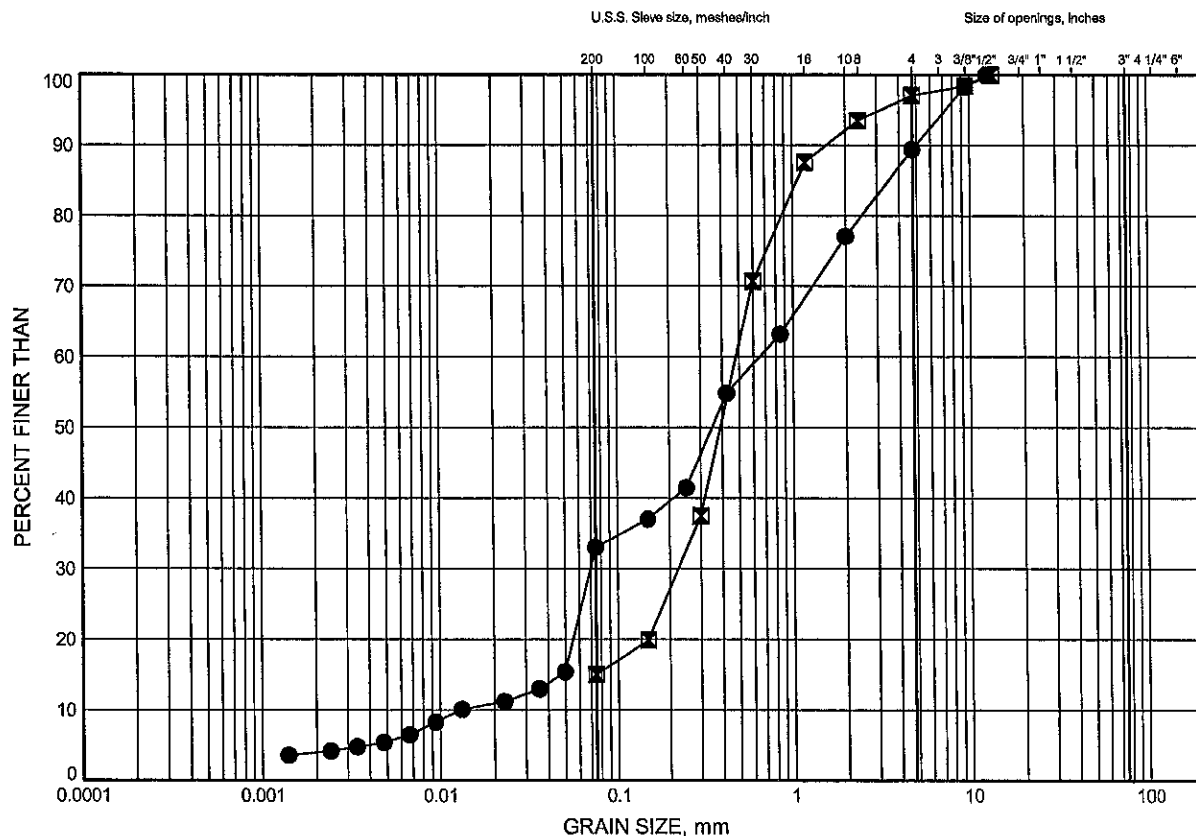


W.P.# .33-78-00.....
Prepared By .AN.....
Checked By .LRB.....

Murdock River and Grassy Lake Bridges GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MR10-11	9.45	170.85
⊠	MR10-12	11.20	169.30

Appendix C

Site Photographs

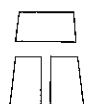




Photo 1. South approach to the Murdock River Bridge



Photo 2. Looking north along the Murdock River Bridge

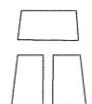
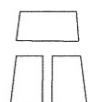




Photo 3. Murdock River Bridge from the southwest showing cobbles and boulders

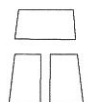


Photo 4. Rockfill pile located northeast of the existing bridge



Appendix D

Drawings



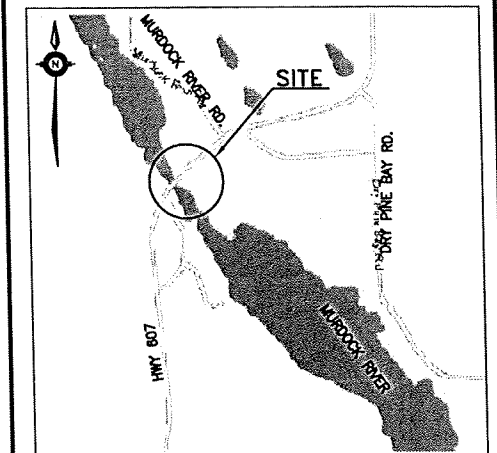
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 33-78-00

HIGHWAY 607
MURDOCK RIVER
BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

- ◆ Borehole
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

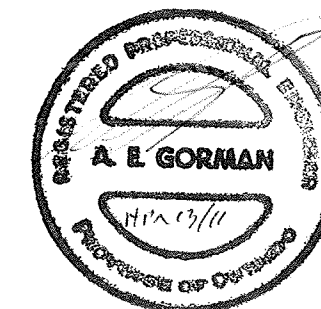
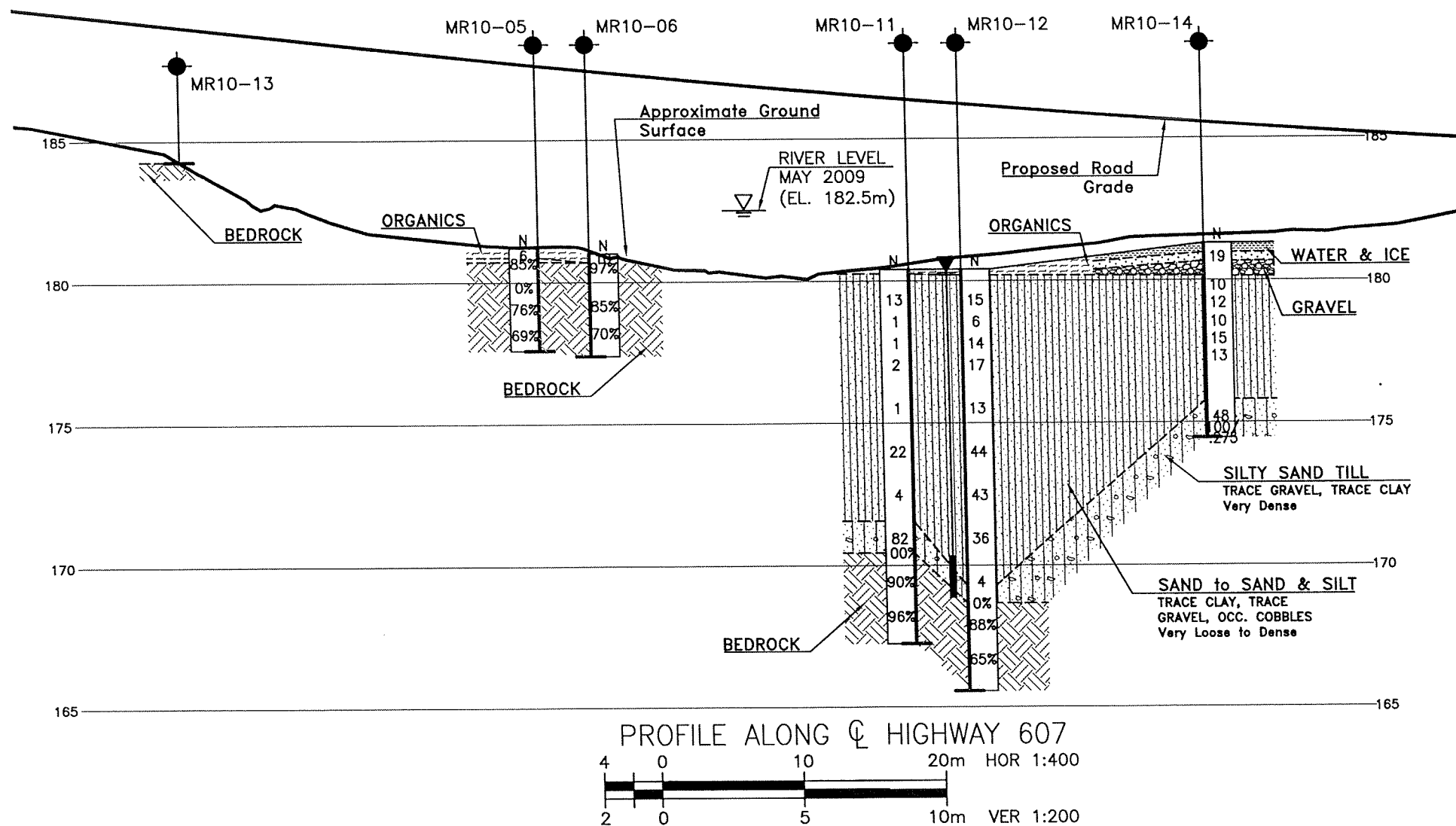
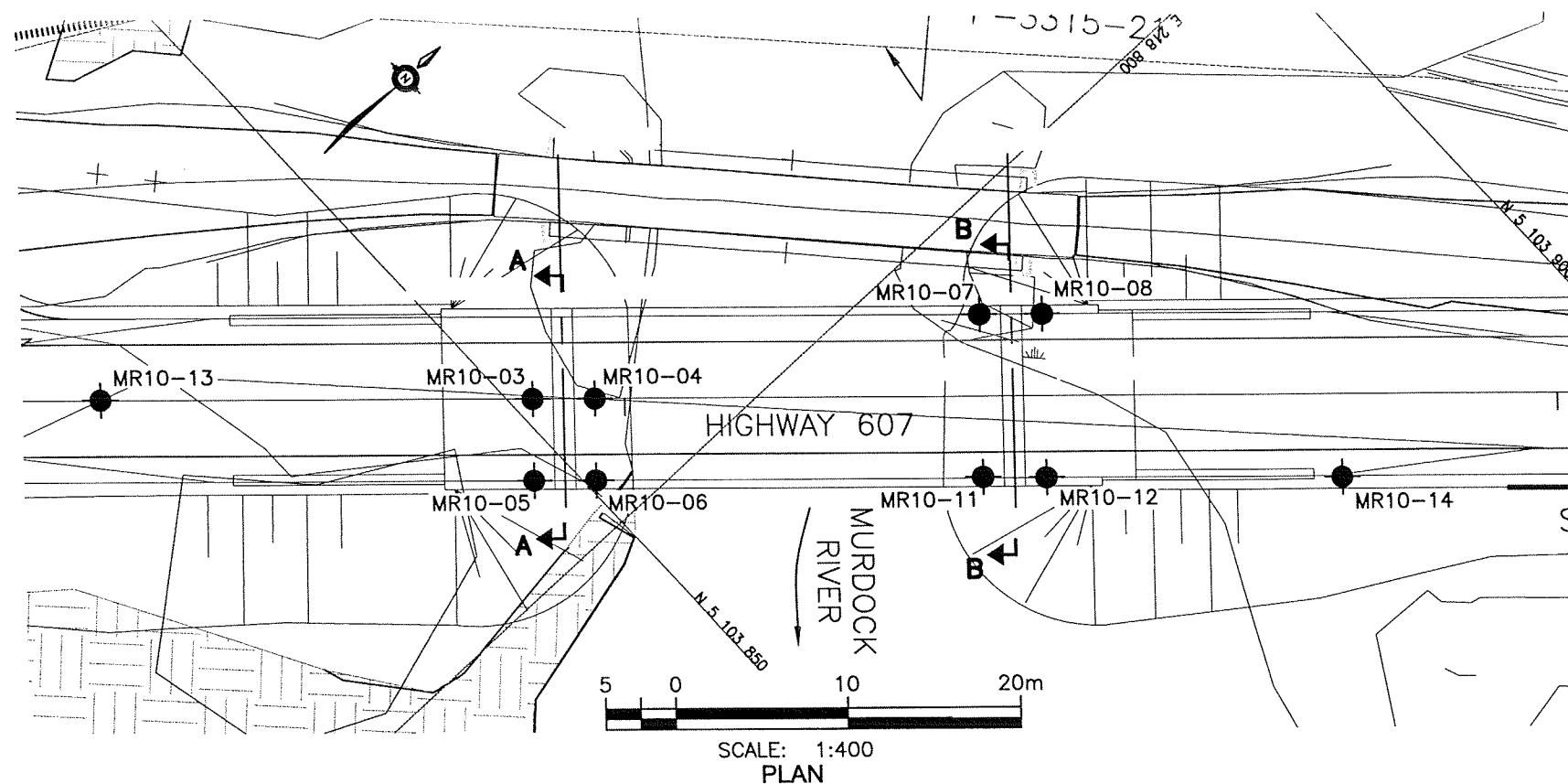
NO	ELEVATION	NORTHING	EASTING
MR10-03	181.3	5 103 851.1	218 791.3
MR10-04	181.2	5 103 853.7	218 793.7
MR10-05	181.2	5 103 847.9	218 794.8
MR10-06	181.1	5 103 850.5	218 797.2
MR10-07	181.3	5 103 873.5	218 805.2
MR10-08	181.5	5 103 876.2	218 807.6
MR10-11	180.3	5 103 867.2	218 812.2
MR10-12	180.5	5 103 869.8	218 814.7
MR10-13	184.3	5 103 832.6	218 774.5
MR10-14	181.3	5 103 882.5	218 826.2

NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41A-266

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LRB	CHK	CODE
DRAWN	AN	CHK	SITE
			LOAD
			STRUCT
			DWG 1
			DATE APR. 2011



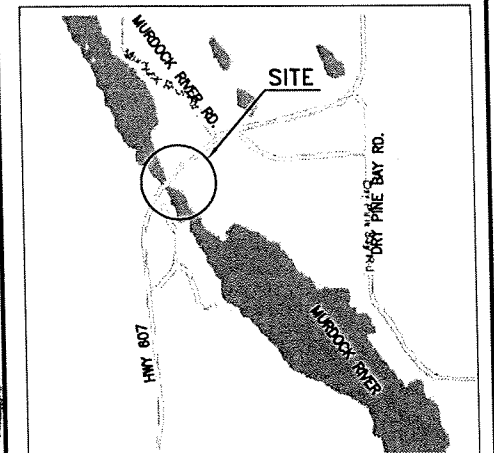
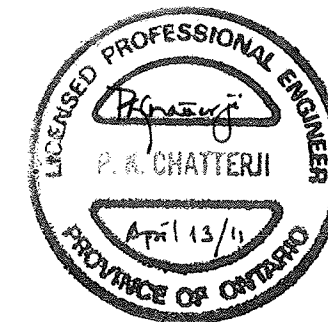
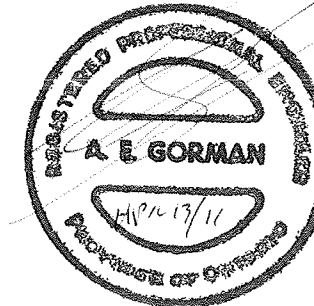
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 33-78-00

HIGHWAY 607
MURDOCK RIVER
BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

◆	Borehole
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

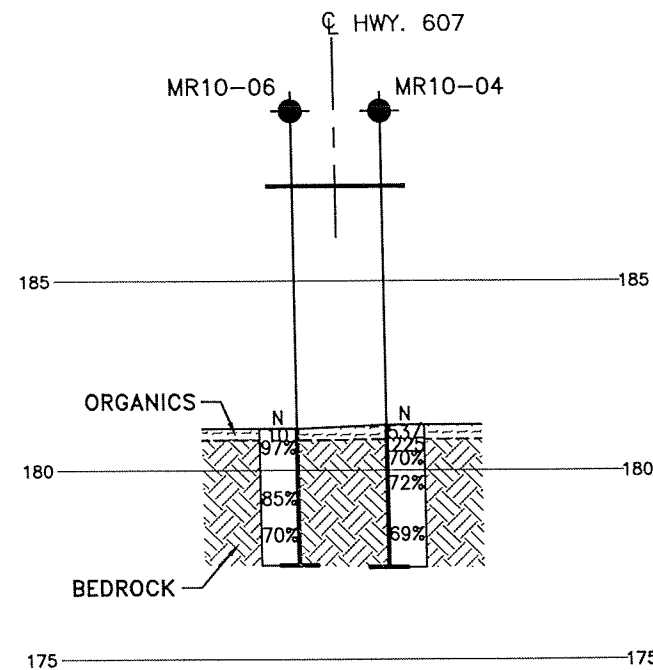
NO	ELEVATION	NORTHING	EASTING
MR10-04	181.2	5 103 853.7	218 793.7
MR10-06	181.1	5 103 850.5	218 797.2
MR10-08	181.5	5 103 876.2	218 807.6
MR10-12	180.5	5 103 869.8	218 814.7

-NOTES-

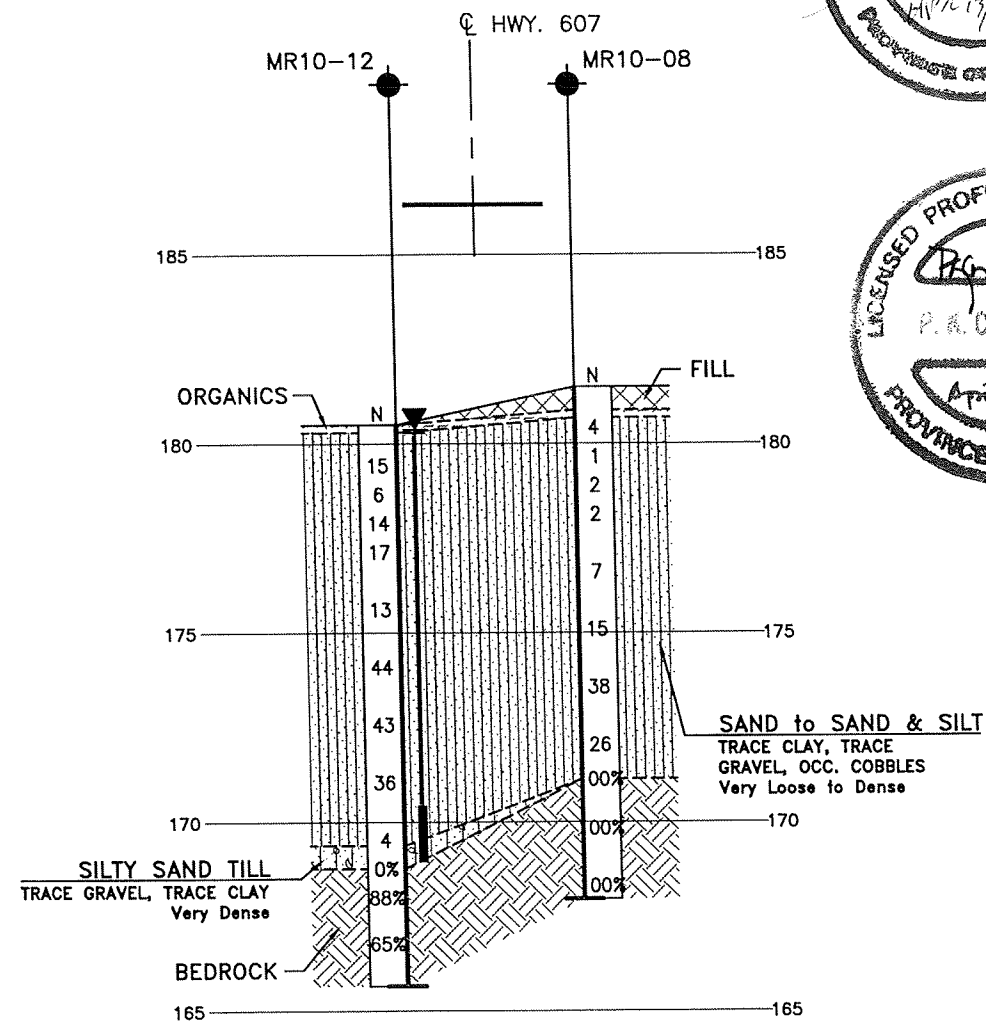
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41A-266

REVISIONS				DATE				DESCRIPTION			
DESIGN	LRB	CHK	CODE	LOAD	DATE	APR. 2011					
DRAWN	AN	CHK	SITE	STRUCT	DWG	2					



SECTION A-A
SOUTH ABUTMENT



SECTION B-B
NORTH ABUTMENT

