

**FOUNDATION INVESTIGATION AND
DESIGN REPORTS
PROPOSED BATTEAUX RIVER BRIDGE
WBL, HIGHWAY 26,
NEAR COLLINGWOOD, ONTARIO.
G.W.P # 630-91-00
AGREEMENT # 2006-E-0002**

Delcan Corporation Geocres No. 41A-208

Project: SPT 1232

October 15, 2009

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Delcan Corporation
625 Cochrane Drive, Suite 500
Markham, Ontario
L3R 9R9

Attention: Mr. Sam Dinatolo, P.Eng.

Dear Sirs:

**RE: Final Foundation Investigation and Design Report, Proposed Batteaux River bridge WBL,
Highway 26, near Collingwood, Ontario**

Please find attached the results of our final geotechnical investigation and report relating to the above noted site.

If you have any comments or enquiries please contact the undersigned.

For and on behalf of Coffey Geotechnics Inc.



Ramon Miranda, P.Eng.
Manager, Transportation Division

Attachment A: Attachments

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**FOUNDATION INVESTIGATION REPORT
BATTEAUX RIVER BRIDGE, WBL, HIGHWAY 26
NEAR COLLINGWOOD, ONTARIO
W.P. # 630-91-00; Agreement # 2006-E0002**

1 INTRODUCTION

A new bridge is planned to be constructed to carry the proposed westbound lane (WBL) of the Highway 26 realignment over the Batteaux River at Station 22+600 near Collingwood, Ontario. Coffey Geotechnics Inc. (Coffey) was retained by Delcan Corporation (Delcan) to carry out a foundation investigation at the site of the proposed bridge.

An existing bridge was newly constructed which will carry the future eastbound traffic of the proposed Highway 26 realignment. The proposed WBL twin bridge will be constructed at about 13 m (clear distance) north of the existing EBL bridge.

The purpose of the investigation was to obtain information about the subsurface conditions at the site of the proposed WBL structure by means of boreholes, and to determine the engineering characteristics of the subsurface soils by means of field and laboratory tests.

The findings of the investigation are presented in this report.

2 SITE DESCRIPTION AND PHYSIOGRAPHY

Highway 26, in the area of the project, crosses the western extremity of the Nottawasaga Basin. According to the Physiography of Southern Ontario by L.J. Chapman and D.F. Putnam, 1984, the basin is located within the Physiographic Region known as the Simcoe Lowlands. The area contains some rolling and some broad flatlands such as the Minesing Flats. The area is drained by the Nottawasaga River and its tributaries.

The Nottawasaga Basin was covered by the Georgian Bay Lobe of the Laurentide Ice Sheet which formed the Edenvale Moraine east of the project area and the Cornhill Moraine south of the project area. This ice sheet deposited sandy, silty ground moraine till over most of the basin. Sandy, silty tills with boulders and cobbles were laid down south of the project area on the slope of the Niagara Escarpment as well as within the project area. During the occupation of the area by lake waters, sandy and gravelly beaches were formed along the shorelines and on hillsides. On the Niagara Escarpment slope, shore cliffs were formed by wave action of lake waters. The Nottawasaga River deposited a large sandy delta as it entered Glacial Lake Nipissing and the current Georgian Bay. Sand with some gravel and silt were deposited along the shore forming the current Wasaga Beach.

The project area is underlain by the Collingwood member of the Middle Ordovician Lindsay Formation, consisting of interbedded, black, organic-rich limestone and highly calcareous and fossiliferous black shale. Southwest of the project area, at the lower part of the Niagara Escarpment, a blue-grey, non-calcareous, fissile shale of the late Ordovician Blue Mountain Formation is found, which is overlain by the Georgian Bay Formation blue-grey shale with light grey to cream coloured limestone and dolostone. The deposition of

these formations occurred within an approximate time period between 550 and 500 million years before the present. During the wave erosion process of the Niagara Escarpment, rock from these formations contributed clay, boulders and cobbles to the till deposit of the project site.

The western and central part of the project area is underlain by a sandy, silty till with cobbles and boulders of mainly carbonate rocks, except near the present lakeshore, where sand and gravel beaches dominate.

3 FIELD AND LABORATORY WORK

The fieldwork for the proposed bridge was performed on November 3, 4, 5 and 6, 2008 and this consisted of drilling and sampling of eight boreholes (Boreholes B1 through B8) at the locations shown on the Boreholes Location Plan, Drawing No.1. The following table summarizes the borehole locations and drilling depths.

Table 3.1: Borehole Locations and Drilling Depths

Borehole No.	Location (Station)	Depth of Borehole Below Existing Ground Surface (m)
B1	22+592 (West Abutment)	4.7
B2	22+590 (West Abutment)	5.2
B3	22+605 (Centre Pier)	4.8
B4	22+605 (Centre Pier)	4.7
B5	22+628 (East Abutment)	4.9
B6	22+629 (East Abutment)	4.9
B7	22+578 (West Approach)	1.2
B8	22+639 (East Approach)	0.8

Eastern Soil investigations of Courtice, Ontario carried out the drilling, testing and sampling work, under the direction and supervision of a Professional Engineer from Coffey. The boreholes were advanced using track mounted drilling rig, outfitted with tools and equipment for soil sampling and testing. The boreholes were advanced using two different methods (i.e. continuous flight solid-stem augers and HQ rock coring) depending on the ground conditions.

Samples in the boreholes were taken at frequent intervals of depth by the Standard Penetration Test method (SPT), in general accordance with ASTM D1586. This test consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm O.D. split barrel (SS – split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil which is indicative of the compactness condition of cohesionless granular soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils).

Groundwater conditions in the boreholes were observed during drilling and upon completion in the open boreholes. The deep boreholes were grouted upon their completion using a cement/bentonite mixture as per MTO procedures.

The borehole locations were established in the field by Coffey engineering staff, in relation to the existing features. The locations were then tied in and the geodetic elevations of the ground at the borehole locations were determined by the client's surveyors. This survey information was provided to us.

The soil and rock samples were transported to our geotechnical laboratory in Toronto for further examination and classification. A laboratory testing programme, consisting of natural moisture content, grain size analyses, was performed on selected representative soil samples and unconfined compression tests was performed on selected rock cores. The results of the laboratory tests are presented on the appropriate Record of Borehole Sheets (Appendix A) and also in Appendix B.

4 SITE AND SUBSURFACE CONDITIONS

The subsurface conditions were explored at eight (8) boreholes (see Table 3.1 in Section 3) for this project. The plan locations of the boreholes are shown on Drawing No. 1 while a stratigraphic sections are presented on Drawing No. 2. Details of subsurface conditions encountered at each borehole location for the investigation, including the results of in-situ testing, groundwater observations and laboratory test results, are presented on the Record of Borehole Sheets in Appendix A. Detailed laboratory test results are enclosed in Appendix B.

In general, below water/topsoil and thin layer of very loose to dense silty sand till with gravel and rock fragments, the proposed bridge site is underlain by limestone bedrock.

Details of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole Sheets in appendix A. The following paragraphs are only meant to amplify and complement these data.

4.1 Topsoil

Topsoil was encountered at the ground surface in all boreholes except for Borehole B1.

It should be pointed out that in our experience at many sites the thickness of topsoil can frequently vary in between and beyond borehole locations.

4.2 Silty Sand Till with Gravel and Rock Fragments

Beneath the topsoil in Boreholes B2, B5, B6, B7 and B8, a 0.2 to 0.8 m thick silty sand till deposit with gravel and rock fragments was encountered.

Grain-size analyses were performed on four samples from the deposit and, these indicate the following grain-size distribution, as shown in Figure B-1 in Appendix B.

Gravel	42 – 66 %
Sand	26 – 37 %
Silt & Clay	8 – 21 %

The high percentage of gravel size particles in the deposit reflect the presence of rock fragments, probably derived from the underlying bedrock.

N-values recorded in the deposit range from 2 to 40 blows/0.3 m. These results indicate a very loose to dense condition but generally loose at the top of the layer and dense near the bedrock surface.

4.3 Limestone Bedrock

Light grey to dark grey slightly weathered to fresh fine-grained fossiliferous limestone bedrock was encountered in Boreholes B1, B2, B3, B4, B5 and B6 and was proven by HQ coring as presented in Table 4.3.1 Boreholes B7 and B8 encountered auger refusal probably on bedrock surface but was not proven by coring, and these are also presented in this table:

Table 4.3.1: Bedrock elevation and condition

Borehole No.	Ground Surface Elevation (m)	Depth Below Ground Surface/Elevation of the Bedrock Surface (m)	T.C.R. (%)*	R.Q.D. (%)**
B1	190.6	0.0/190.6	100	79-95
B2	190.9	1.0/189.9	92-100	76-100
B3	190.7	0.3/190.4	97-100	83-100
B4	190.4	0.1/190.3	98-100	84-87
B5	190.8	0.5/190.3	98-100	83-100
B6	190.5	1.0/189.6	96-100	70-100
B7	191.0	1.1/189.9***		
B8	191.1	0.5/190.7***		

* T.C.R.=Total Core Recovery

**R.Q.D.=Rock Quality Designation

*** Inferred bedrock depth/elevation

The boreholes were advanced into the bedrock for a vertical distance of about 3.9 to 4.6 m by HQ coring. The percentage of recovery was 92 to 100% while the RQD values vary from 70% to 100%. These results indicate a rock quality from fair to excellent. In general, RQD increases with increasing depth. Unconfined compression tests were performed on selected rock samples as shown in Table 4.3.2 and the tests yielded unconfined compressive strength of between about 76 MPa (Borehole B4) and 131 MPa (Borehole B6). These results indicate that the rock can be classified as a strong to very strong rock.

Table 4.3.2: Bedrock unconfined compressive strength

Borehole No.	Core Number	Depth of the Sample Tested (m)	Unconfined Compressive Strength (MPa)
B1	RC1	0.8	98.5
B2	RC3	1.8	119.9
B3	RC2	1.4	122.3
B4	RC1	1.6	75.6
B5	RC2	0.6	105.6
B6	RC3	1.2	131.3

At the borehole locations the surface of the bedrock was contacted at Elevations ranging from 189.6 m (Borehole B6) to 190.6 m (Borehole B1). From these results the surface of the bedrock appears to be relatively flat in this project area.

4.4 Groundwater Conditions

Groundwater conditions were observed in the open boreholes while drilling and upon completion of each borehole. The free-standing water level in Boreholes B1, B2, B3, B4, B5 and B6 upon their completion was observed at depths of 0 to 1.2 m or El.189.6 to 190.7 m while Boreholes B7 and B8 were dry upon completion. However, in the deep boreholes, where HQ coring was used (i.e. water introduced into the boreholes) the on-completion water levels may not be reliable.

It should also be pointed out that the groundwater is subject to seasonal fluctuations and fluctuation in response to major weather events. In addition, the water table at the site will be influenced by the water level in the water course.

5. CLOSURE

The Limitations of Report, as quoted in Appendix D, is an integral part of this report.

For and on behalf of Coffey Geotechnics Inc.



Raid Khamis, P.Eng.
Geotechnical Engineer



Ramon Miranda, P.Eng.
Manager, Transportation Division



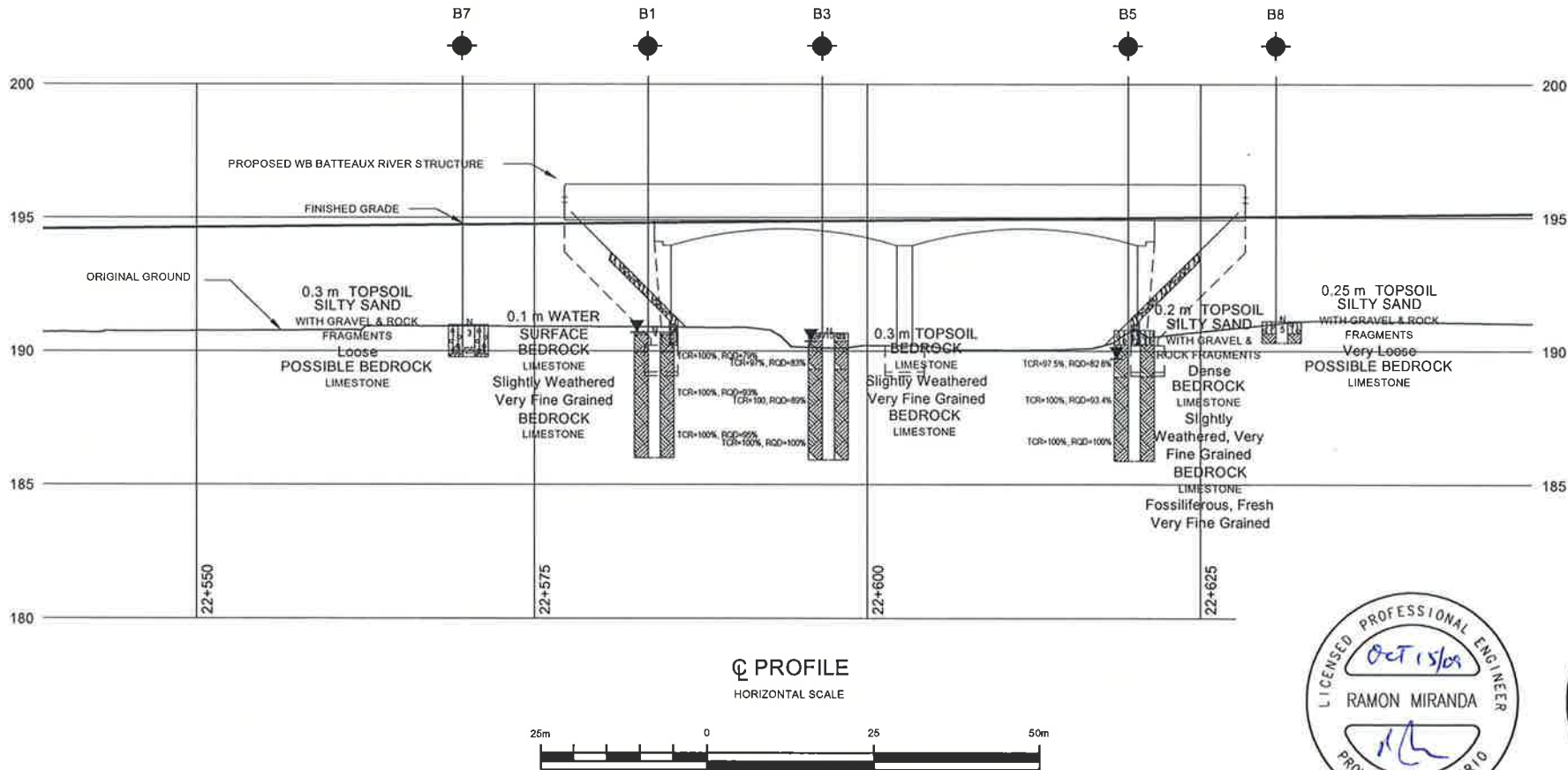
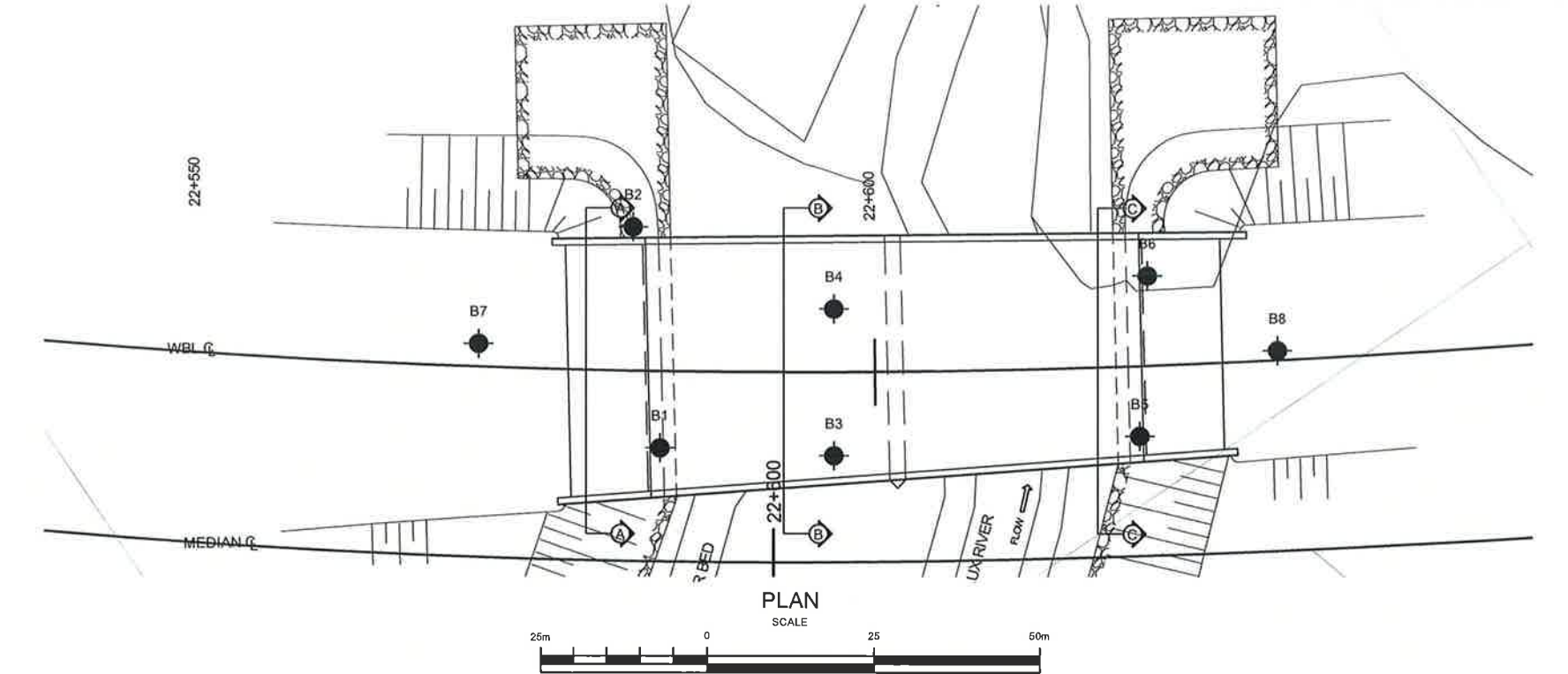
Z.S. Ozden, P.Eng.
Senior Principal



Drawings

METRIC

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



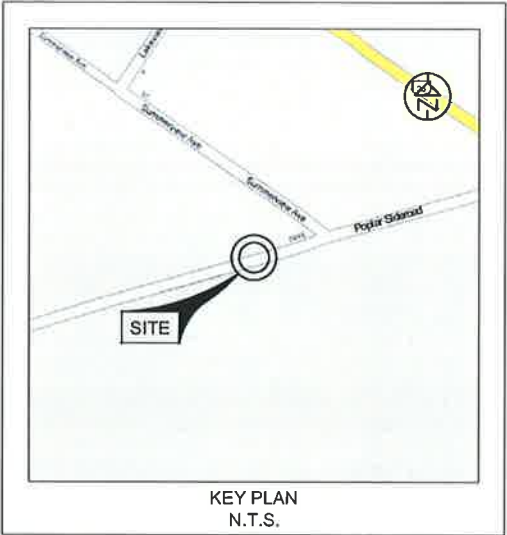
CONT No.
GWP: 630-91-00

HIGHWAY 26
BATTEAUX RIVER BRIDGE
BOREHOLE LOCATION PLAN AND
STRATIGRAPHY



SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



LEGEND			
	Borehole		
	Blows/0.3m (Std. Pen. Test, 475 J/blow)		
	Water Level at Time of Investigation (W. L. NOT STABILIZED)		
	Water Level in Piezometer		
	Piezometer		

No.	ELEVATION	STATION	OFFSET
B1	190.7	22+592	8.5m Lt Median C/L
B3	190.7	22+605	8.0m Lt Median C/L
B5	190.8	22+628	9.0m Lt Median C/L
B7	191.0	22+578	16.0m Lt Median C/L
B8	191.1	22+639	15.0m Lt Median C/L

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 41A-208			
TRANETOBO1232AA		DIST	
SUBM'D	CHECKED	DATE	Oct. 2009
DRAWN	PHK	CHECKED	RM
APPROVED		ZO	DWG
1		1	



METRIC

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS
REFER TO RECORD OF BOREHOLE SHEETS.

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

CONT No.
GWP: 630-91-00

HIGHWAY 26
BATTEAUX RIVER BRIDGE
CROSS SECTIONS

SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



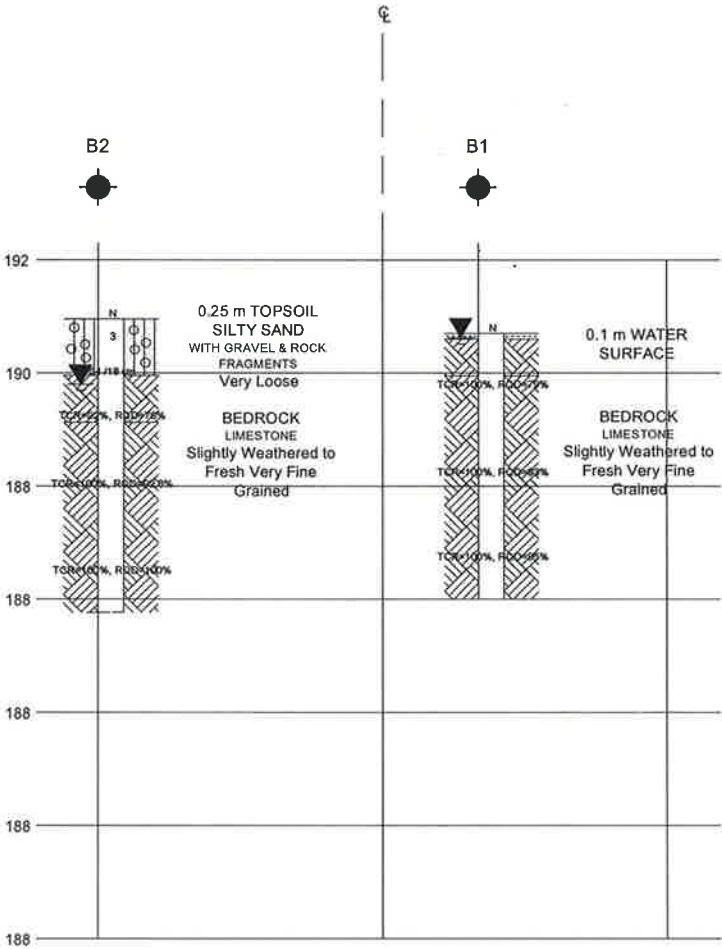
LEGEND			
	Borehole		
	Blows/0.3m (Std. Pen. Test, 475 J/blow)		
	Water Level at Time of Investigation (W. L. NOT STABILIZED)		
	Water Level in Piezometer		
	Piezometer		
No.	ELEVATION	STATION	OFFSET
B1	190.7	22+592	8.5m Lt C/L
B2	190.9	22+590	25.0m Lt C/L
B3	190.7	22+605	8.0m Lt C/L
B4	190.4	22+605	19.0m Lt C/L
B5	190.8	22+628	9.0m Lt C/L
B6	190.5	22+629	21.0m Lt C/L

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

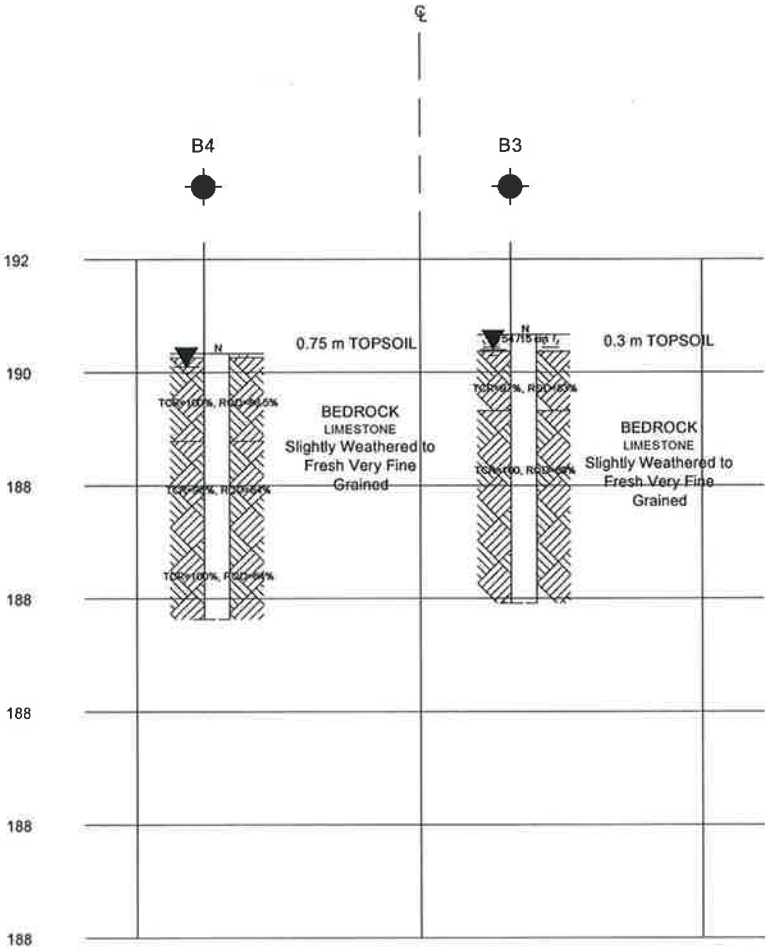
NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

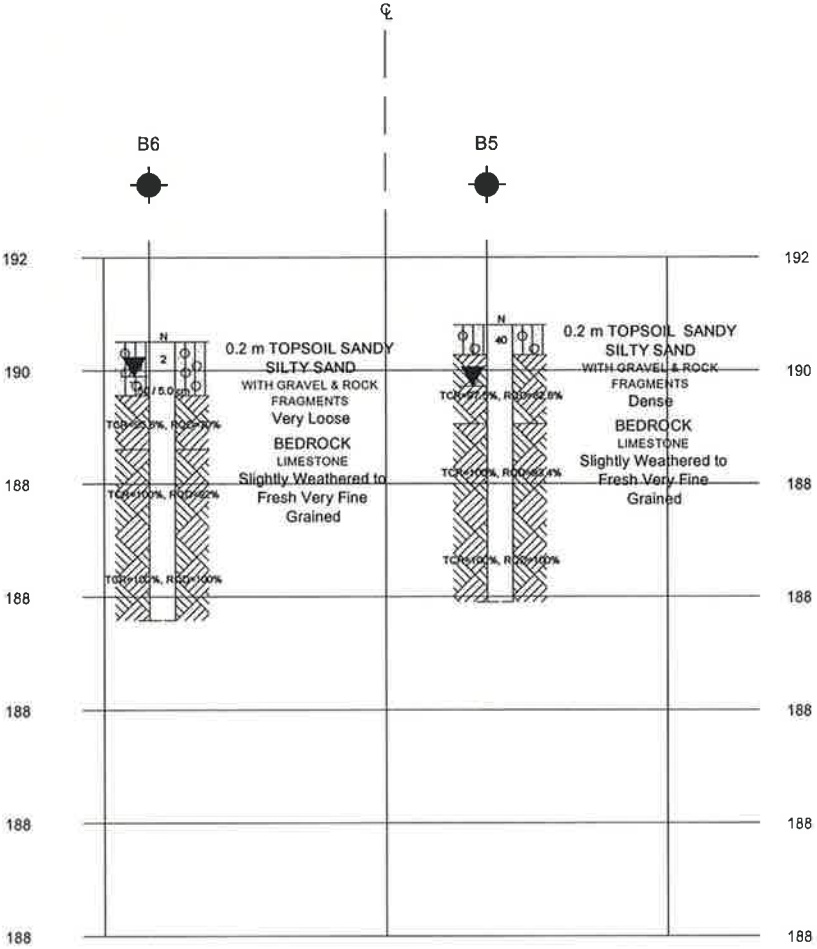
Geocres No 41A-208			
TRANETOB01232AA		DIST	
SUBMD	CHECKED	DATE	Ocl. 2009
DRAWN	PHK	CHECKED	RM
APPROVED		ZO	DWG
			2



SECTION A-A
HORIZONTAL SCALE



SECTION B-B
HORIZONTAL SCALE



SECTION C-C
HORIZONTAL SCALE



Appendix A

Borehole Logs

SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B1

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+592, 8.5 m Lt C/L of New Hwy 26 ORIGINATED BY RK
 DIST HWY 26 BOREHOLE TYPE Solid Stem Auger/HQ Coring COMPILED BY RK
 DATUM DATE 11/4/2008 CHECKED BY RM

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					
190.7 190.6 0.1	WATER SURFACE 0.1 m WATER						20 40 60 80 100				W _P W W _L		
190.0 0.8	LIMESTONE BEDROCK slightly weathered, very fine grained light to dark grey		1	RCTCR=100% RQD=75%			190						UCS = 98.5 MPa
	LIMESTONE BEDROCK fossiliferous, fresh, very fine grained, light to dark grey		2	RCTCR=100% RQD=93%			189						
			3	RCTCR=100% RQD=95%			188						
							187						
186.0 4.7	End of borehole Water level at 0.1m(not stabilized)* above ground surface UCS = Unconfined Compressive Strength						186						

+³, ×³ Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE




SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B2

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+590, 25.0 m Lt C/L of New Hwy26 ORIGINATED BY RK
 DIST HWY 26 BOREHOLE TYPE Solid Stem Auger/HQ Coring COMPILED BY RK
 DATUM DATE 11/4/2008 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● POCKET PENETR.	× LAB VANE	W _P	W		
190.9 0.0	GROUND SURFACE					20	40	60	80	100	10	20	30	kN/m ³	GR SA SI CL
189.9 1.0	0.25 m TOPSOIL SILTY SAND TILL with gravel and rock fragments dark brown, v.loose,wet		1	SS	3										
189.1 1.8	LIMESTONE BEDROCK slightly weathered,very fine grained light to dark grey		2	SS	54 / 18 cm										
			3	RC	TCR=92% RQD=76%										
	LIMESTONE BEDROCK fossiliferous, fresh,very fine grained light to dark grey		4	RC	TCR=100% RQD=93%										
			5	RC	TCR=100% RQD=100%										
185.8 5.2	End of borehole Water level at 1.2 m (not stabilized)* upon completion UCS = Unconfined Compressive Strength														

+³, ×³ : Numbers refer to
Sensitivity

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15 10 5
(%) STRAIN AT FAILURE

SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B3

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+605, 8.0 m Lt C/L of New Hwy26 ORIGINATED BY RK
 DIST HWY 26 BOREHOLE TYPE Solid Stem Auger/HQ Coring COMPILED BY RK
 DATUM DATE 11/4/2008 CHECKED BY RM

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 ● POCKET PENETR. × LAB VANE						WATER CONTENT (%) w _p w w _L
190.7 0.0 190.4 0.3	GROUND SURFACE 0.3 m TOPSOIL		1	SS	54 / 15 cm									
189.3 1.4	LIMESTONE BEDROCK slightly weathered, very fine grained light to dark grey		2	RC	TCR=97% RQD=83%		190							UCS = 122.3 MPa
			3	RC	TCR=100 RQD=89%		189							
	LIMESTONE BEDROCK fossiliferous fresh, very fine grained light to dark grey		4	RC	TCR=100% RQD=100%		188							
							187							
185.9 4.8	End of borehole Water level @ 0.3 m (not stabilized)* upon completion UCS = Unconfined Compressive Strength						186							

+³, ×³: Numbers refer to
Sensitivity

20
15
10
5
(%) STRAIN AT FAILURE

SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B4

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+605, 19.0 m Lt C/L of New Hwy 26 ORIGINATED BY RK
DIST HWY 26 BOREHOLE TYPE Solid Stem Auger/HQ Coring COMPILED BY RK
DATUM DATE 11/3/2008 CHECKED BY RM

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 ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE			WATER CONTENT (%) w _p w w _L				
190.4	GROUND SURFACE						20	40	60	80	100				
190.3	75 mm TOPSOIL						20	40	60	80	100				
188.8	LIMESTONE BEDROCK slightly weathered, very fine grained light to dark grey		1	RC	TCR=100% RQD=86.5%										UCS = 75.6 MPa
188.8			2	RC	TCR=98% RQD=84%										
185.7	LIMESTONE BEDROCK fossiliferous, fresh, very fine grained dark grey		3	RC	TCR=100% RQD=84%										
4.7	End of borehole Water level @ 0.3 m (not stabilized)* upon completion UCS = Unconfined Compressive Strength														

+ 3 . x 3 Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B5

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+628, 9.0 m Lt C/L of New Hwy 26 ORIGINATED BY RK
 DIST HWY 26 BOREHOLE TYPE Solid Stem Auger/HQ Coring COMPILED BY RK
 DATUM DATE 11/5/2008 CHECKED BY RM

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	20 40 60 80 100	20 40 60 80 100	W _P	W		
190.8	GROUND SURFACE												
0.0	0.2 m TOPSOIL		1	SS	40								
190.3	SILTY SAND TILL												
0.5	with gravel and rock fragments brown, dense, wet												
189.0	LIMESTONE BEDROCK		2	RC	TCR=98% RQD=83%	190							
1.8	slightly weathered, very fine grained light to dark grey												
189.0	LIMESTONE BEDROCK		3	RC	TCR=100% RQD=93%	189							
1.8	fossiliferous, fresh, very fine grained light to dark grey												
185.9	LIMESTONE BEDROCK		4	RC	TCR=100% RQD=100%	187							
4.9	End of borehole					186							
	Water level @ 1.1 m(not stabilized)* upon completion UCS = Unconfined Compressive Strength												

+³, ×³ Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE




SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B6

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+629, 21.0 m Lt C/L of New Hwy 26 ORIGINATED BY RK
 DIST HWY 26 BOREHOLE TYPE Solid Stem Auger/HQ Coring COMPILED BY RK
 DATUM DATE 11/5/2008 CHECKED BY RM

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 ● POCKET PENETR. x LAB VANE	20 40 60 80 100	w _p w w _L	10 20 30			
190.5	GROUND SURFACE													
0.0	0.2 m TOPSOIL SILTY SAND TILL with gravel & rock fragments dark brown, v.loose, wet		1	SS	2									66 26 (8)
189.6			2	SS50	20.0 cm									
1.0	LIMESTONE BEDROCK moderately to slightly weathered very fine grained light grey		3	RC	TCR=96% RQD=70%									UCS = 131.3 MPa
188.6			4	RC	TCR=100% RQD=92%									
1.9	LIMESTONE BEDROCK fossiliferous, fresh, very fine grained light to dark grey		5	RC	TCR=100% RQD=100%									
185.6	End of borehole Water level @ 0.9 m (not stabilized)* upon completion UCS = Unconfined Compressive Strength													
4.9														

SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B7

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+578, 16.0 m Lt C/L of New Hwy 26 ORIGINATED BY RK
 DIST HWY 26 BOREHOLE TYPE Solid Stem Auger COMPILED BY RK
 DATUM DATE 11/5/2008 CHECKED BY RM

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					
191.0	GROUND SURFACE												
0.0	0.3 m TOPSOIL SILTY SAND TILL with gravel and rock fragments brown, loose, moist		1	SS	3								
189.9			2	SS	58 / 25 cm	190							54 31 (15)
189.8	POSSIBLE BEDROCK												
1.2	End of borehole Borehole is dry(not stabilized) & open, upon completion Auger refusal @ 1.2 m depth												

+ 3 . x 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

SPT1232 :Batteaux River Bridge

RECORD OF BOREHOLE No B8

1 OF 1

METRIC

GWP 630-91-00 LOCATION Station : 22+639, 15.0 m Lt C/L of New Hwy 26 ORIGINATED BY RK
 DIST HWY 26 BOREHOLE TYPE Solid Stem Auger COMPILED BY RK
 DATUM DATE 11/6/2008 CHECKED BY RM

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			20 40 60 80 100	20 40 60 80 100	W _P	W	W _L		
191.1	GROUND SURFACE													
0.0	0.25 m TOPSOIL		1	SS	5	191								
190.7	SILTY SAND TILL													
0.5	with gravel and rock fragments													
190.3	dark brown, v.loose, moist													
0.8	POSSIBLE BEDROCK													
	End of borehole Borehole is dry (not stabilized) & open, upon completion Auger refusal @ 0.8m depth													

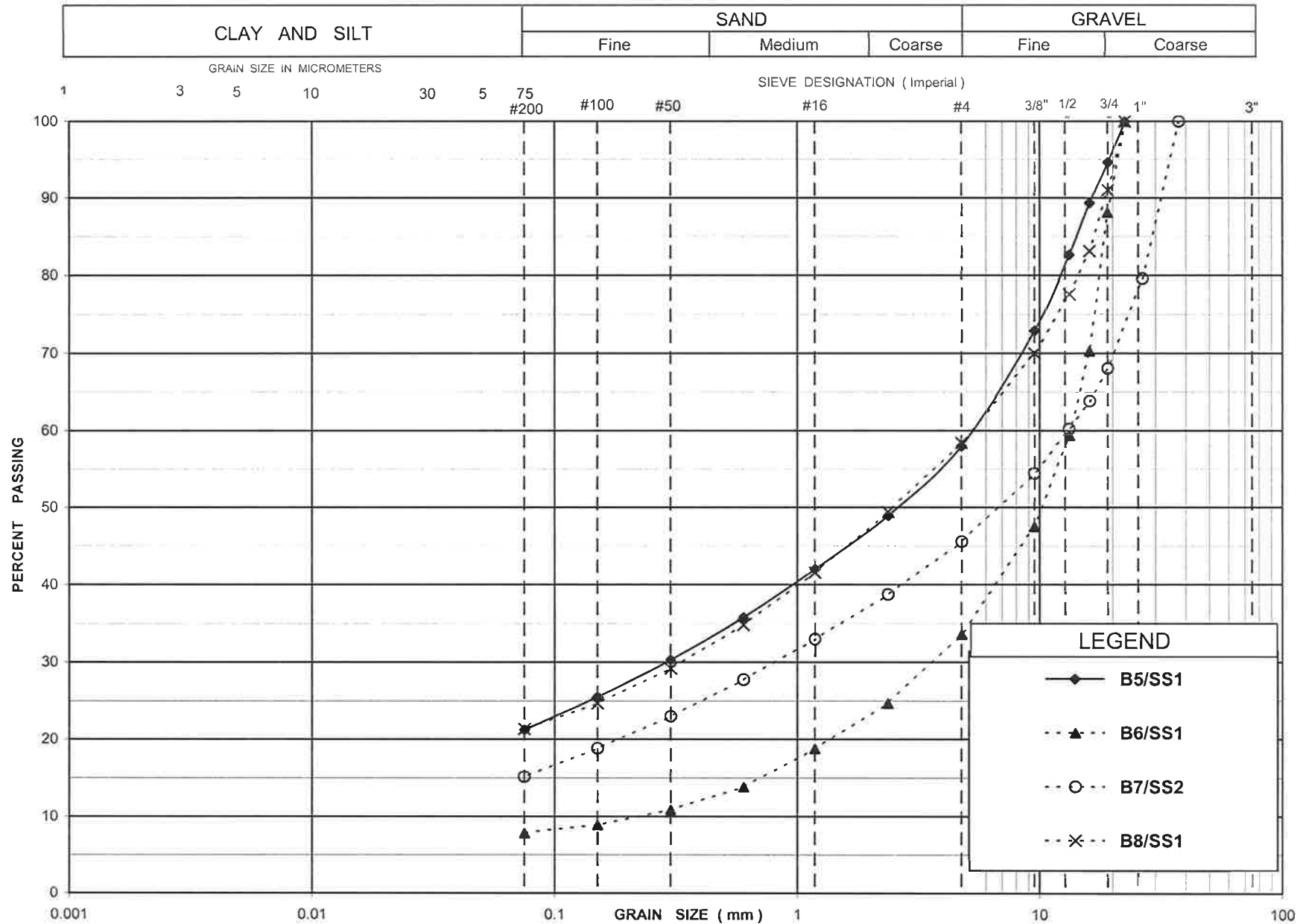
+³, ×³ Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

Appendix B

Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM



UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-04

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1116-0001	SAMPLE NUMBER	RC1
BOREHOLE NUMBER	B1	SAMPLE DEPTH, m	-

TEST CONDITIONS

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.05

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	12.90	WATER CONTENT, (specimen) %	0.35
SAMPLE DIAMETER, cm	6.30	UNIT WEIGHT, kN/m ³	26.13
SAMPLE AREA, cm ²	31.17	DRY UNIT WT., kN/m ³	26.03
SAMPLE VOLUME, cm ³	402.13	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	1071.70	VOID RATIO	0.02
DRY WEIGHT, g	1067.96		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	98.5
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REMARKS:

DATE:

1/20/2009

Test Result (Borehole B1)

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-04

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1116-0001	SAMPLE NUMBER	RC3
BOREHOLE NUMBER	B2	SAMPLE DEPTH, m	-

TEST CONDITIONS

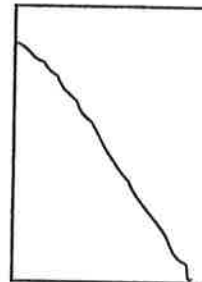
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.08

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.10	WATER CONTENT, (specimen) %	0.30
SAMPLE DIAMETER, cm	6.30	UNIT WEIGHT, kN/m ³	25.88
SAMPLE AREA, cm ²	31.17	DRY UNIT WT., kN/m ³	25.81
SAMPLE VOLUME, cm ³	408.36	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	1078.20	VOID RATIO	0.03
DRY WEIGHT, g	1074.98		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	119.9
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REMARKS:

DATE:

1/20/2009

Test Result (Borehole B2)

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-04

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1116-0001	SAMPLE NUMBER	RC2
BOREHOLE NUMBER	B3	SAMPLE DEPTH, m	-

TEST CONDITIONS

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.08

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.15	WATER CONTENT, (specimen) %	0.22
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m ³	25.80
SAMPLE AREA, cm ²	31.27	DRY UNIT WT., kN/m ³	25.74
SAMPLE VOLUME, cm ³	411.22	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	1082.20	VOID RATIO	0.03
DRY WEIGHT, g	1079.82		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	122.3
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REMARKS:

DATE:

1/20/2009

Test Result (Borehole B3)

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-04

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1116-0001	SAMPLE NUMBER	RC1
BOREHOLE NUMBER	B4	SAMPLE DEPTH, m	-

TEST CONDITIONS

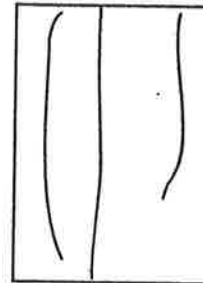
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.07

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.05	WATER CONTENT, (specimen) %	0.57
SAMPLE DIAMETER, cm	6.30	UNIT WEIGHT, kN/m ³	26.09
SAMPLE AREA, cm ²	31.17	DRY UNIT WT., kN/m ³	25.94
SAMPLE VOLUME, cm ³	406.80	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	1082.50	VOID RATIO	0.02
DRY WEIGHT, g	1076.36		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	75.6
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REMARKS:

DATE:

1/20/2009

Test Result (Borehole B4)

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-04

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1116-0001	SAMPLE NUMBER	RC2
BOREHOLE NUMBER	B5	SAMPLE DEPTH, m	-

TEST CONDITIONS

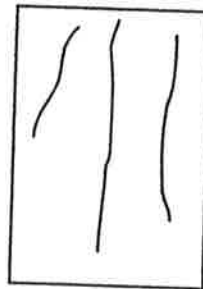
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	1.99

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	12.55	WATER CONTENT, (specimen) %	0.33
SAMPLE DIAMETER, cm	6.30	UNIT WEIGHT, kN/m ³	24.78
SAMPLE AREA, cm ²	31.17	DRY UNIT WT., kN/m ³	24.70
SAMPLE VOLUME, cm ³	391.22	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	988.90	VOID RATIO	0.07
DRY WEIGHT, g	985.65		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	105.6
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REMARKS:

DATE:

1/20/2009

Test Result (Borehole B5)

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-04

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1116-0001	SAMPLE NUMBER	RC3
BOREHOLE NUMBER	B6	SAMPLE DEPTH, m	-

TEST CONDITIONS

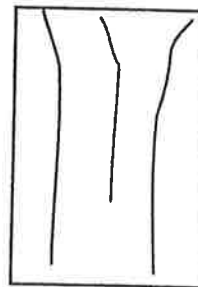
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.08

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.10	WATER CONTENT, (specimen) %	0.30
SAMPLE DIAMETER, cm	6.30	UNIT WEIGHT, kN/m ³	25.95
SAMPLE AREA, cm ²	31.17	DRY UNIT WT., kN/m ³	25.87
SAMPLE VOLUME, cm ³	408.36	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	1080.90	VOID RATIO	0.02
DRY WEIGHT, g	1077.67		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	131.3
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REMARKS:

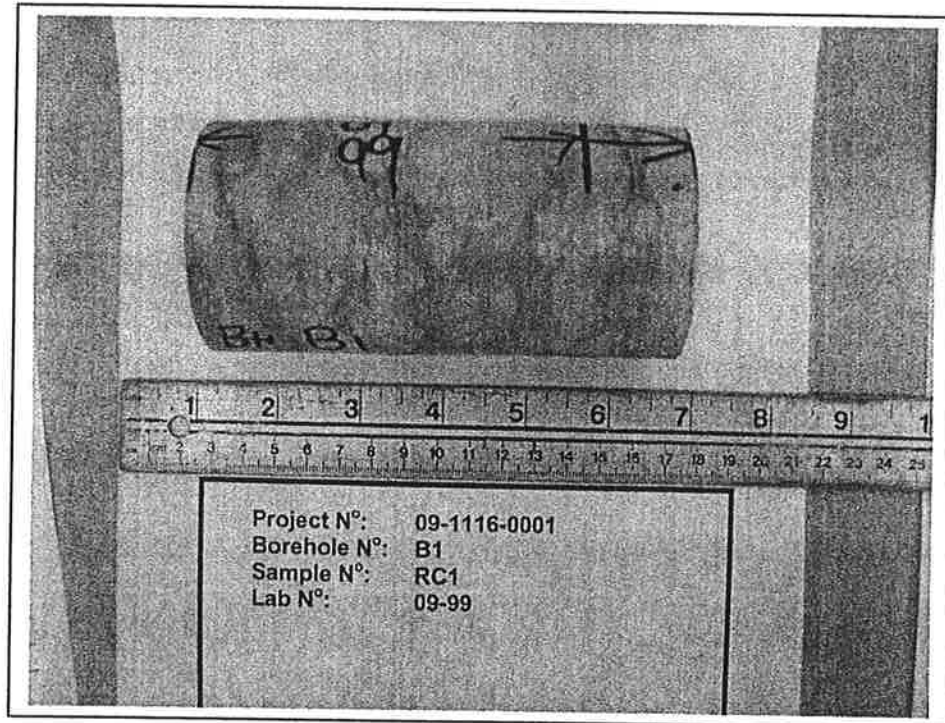
DATE:

1/20/2009

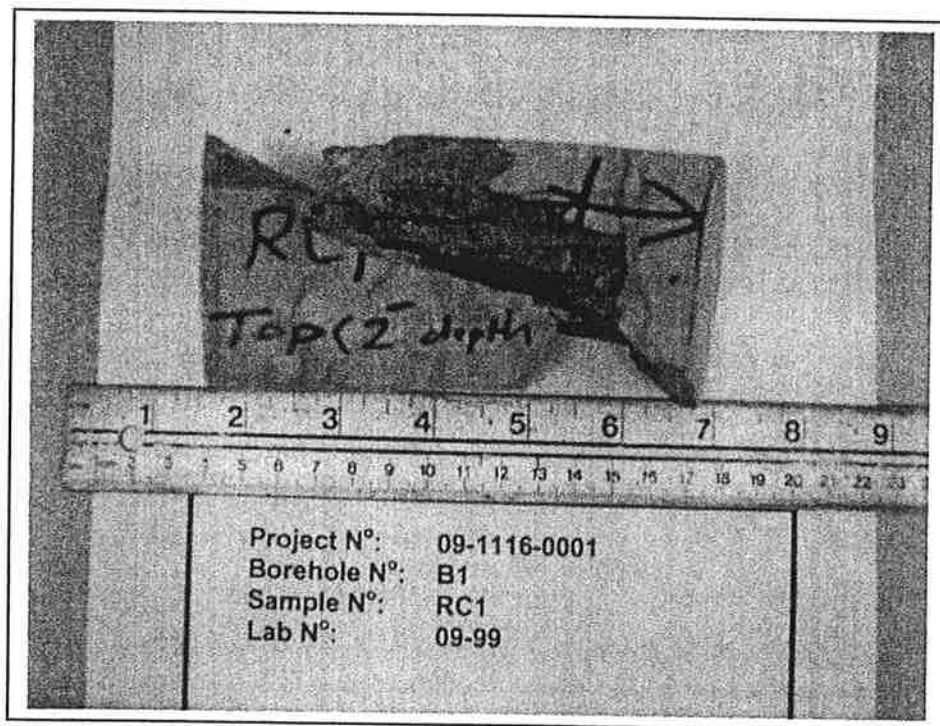
Test Result (Borehole B6)

UNCONFINED COMPRESSION TEST
ASTM D2166-98A

FIGURE



BEFORE COMPRESSION



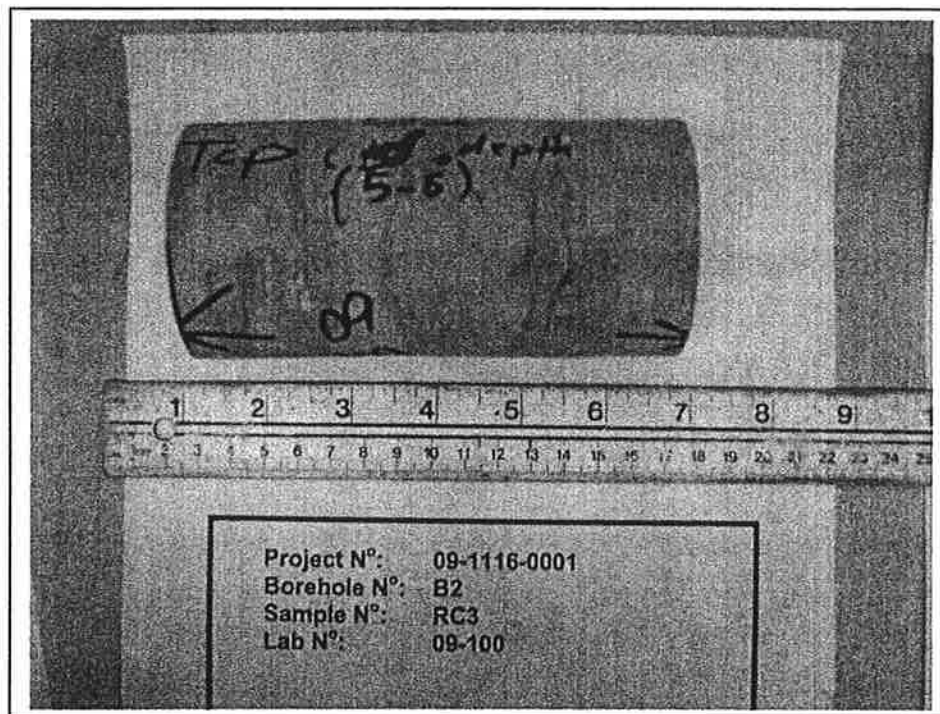
AFTER COMPRESSION

Test Specimen (Borehole B1)

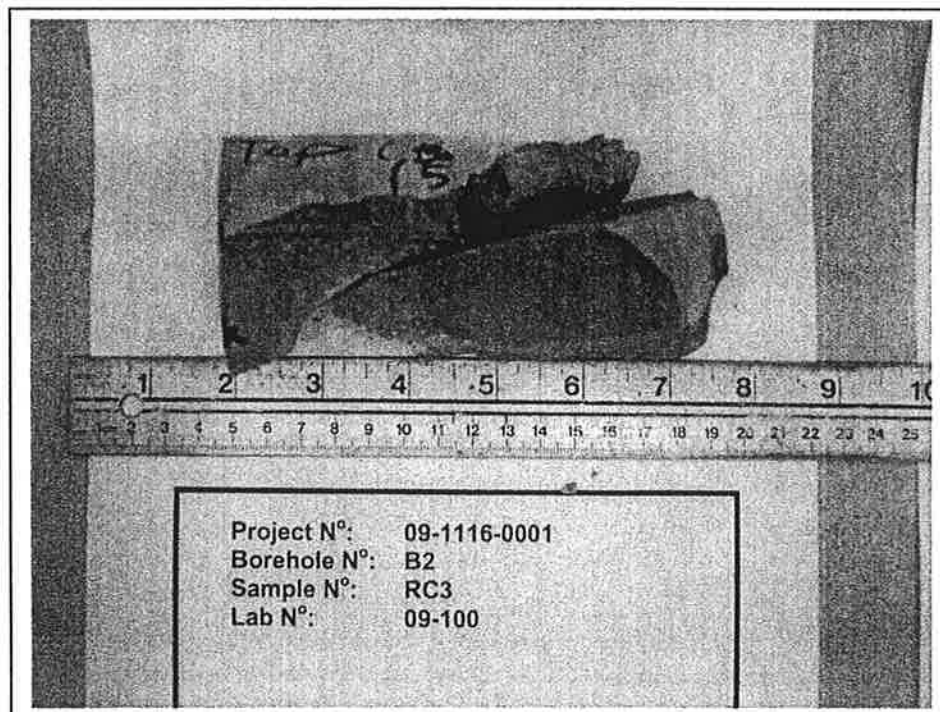
Drawn AH
Chkd. *ah*

UNCONFINED COMPRESSION TEST
ASTM D2166-98A

FIGURE



BEFORE COMPRESSION



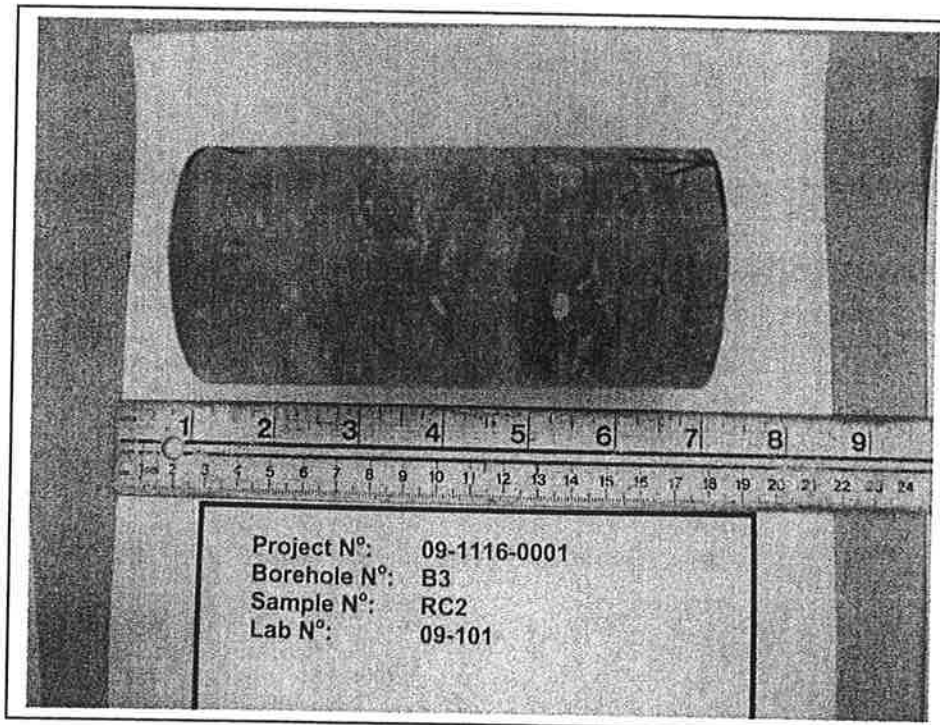
AFTER COMPRESSION

Test Specimen (Borehole B2)

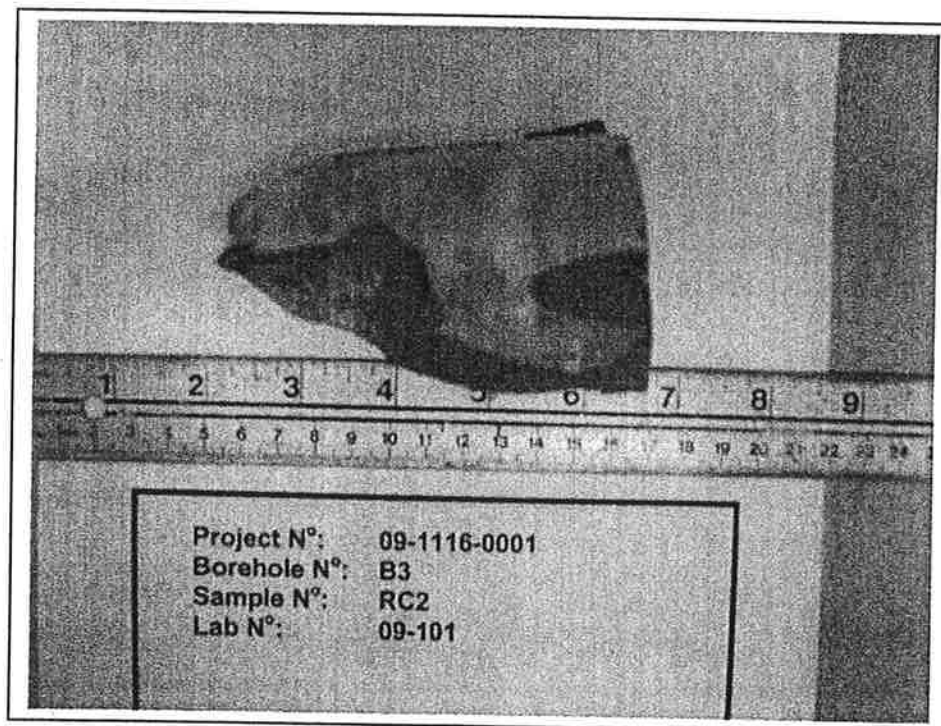
Drawn AH
Chkd. [Signature]

UNCONFINED COMPRESSION TEST
ASTM D2166-98A

FIGURE



BEFORE COMPRESSION



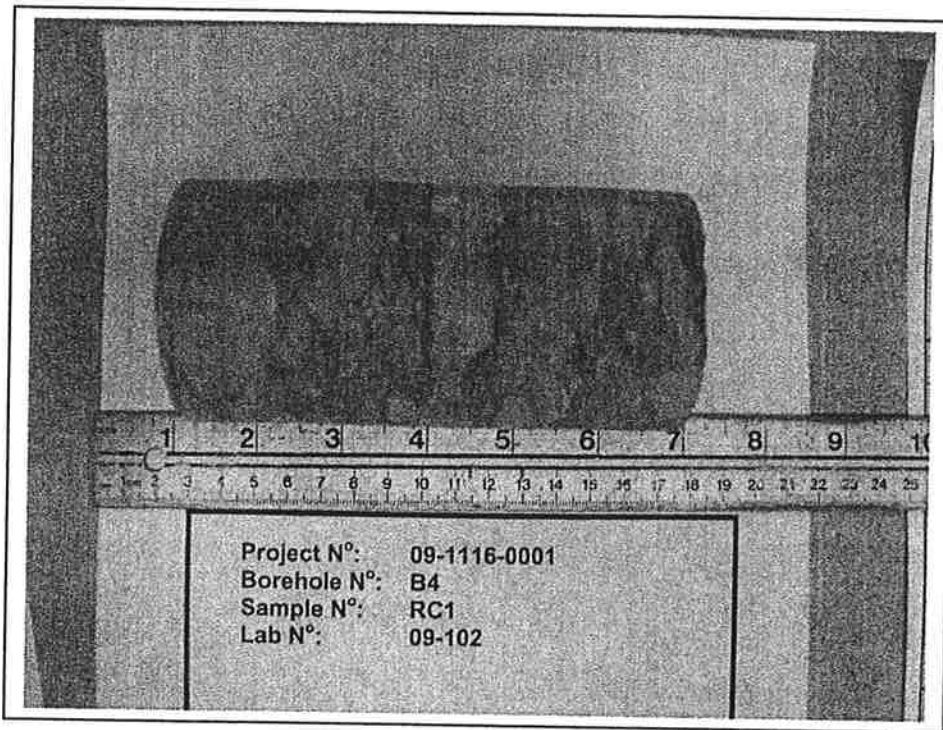
AFTER COMPRESSION

Test Specimen (Borehole B3)

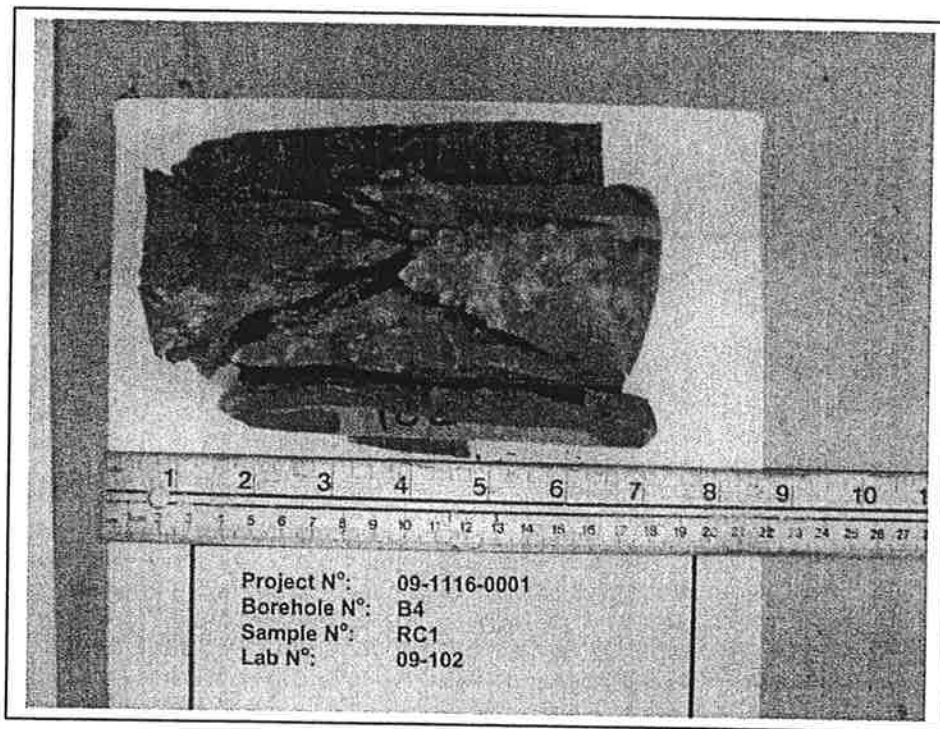
Drawn AH
Chkd. My

UNCONFINED COMPRESSION TEST
ASTM D2166-98A

FIGURE



BEFORE COMPRESSION



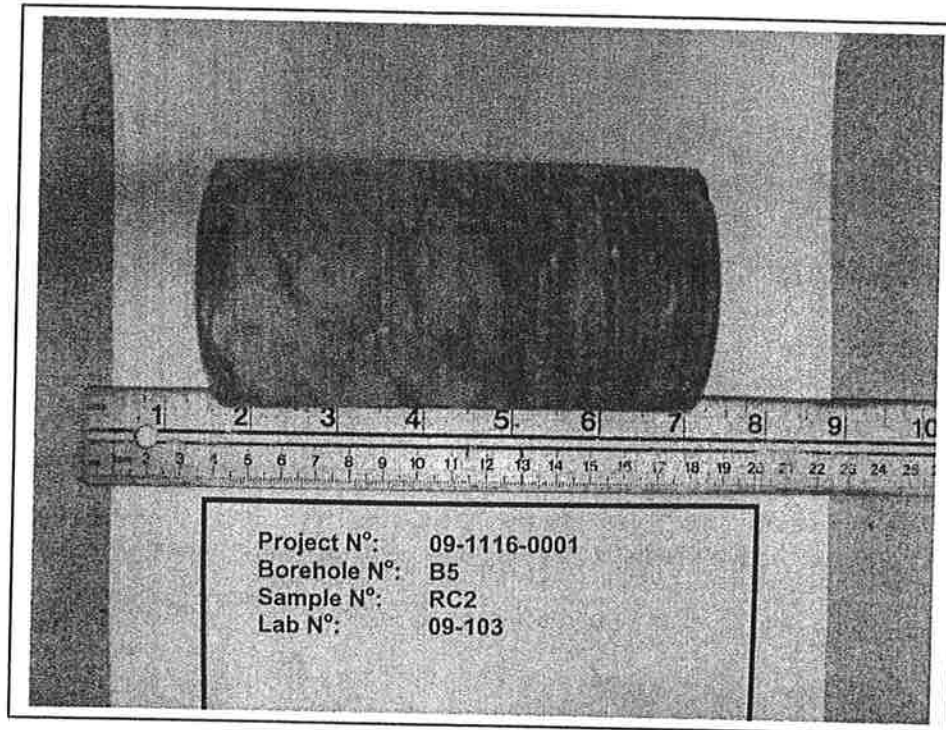
AFTER COMPRESSION

Test Specimen (Borehole B4)

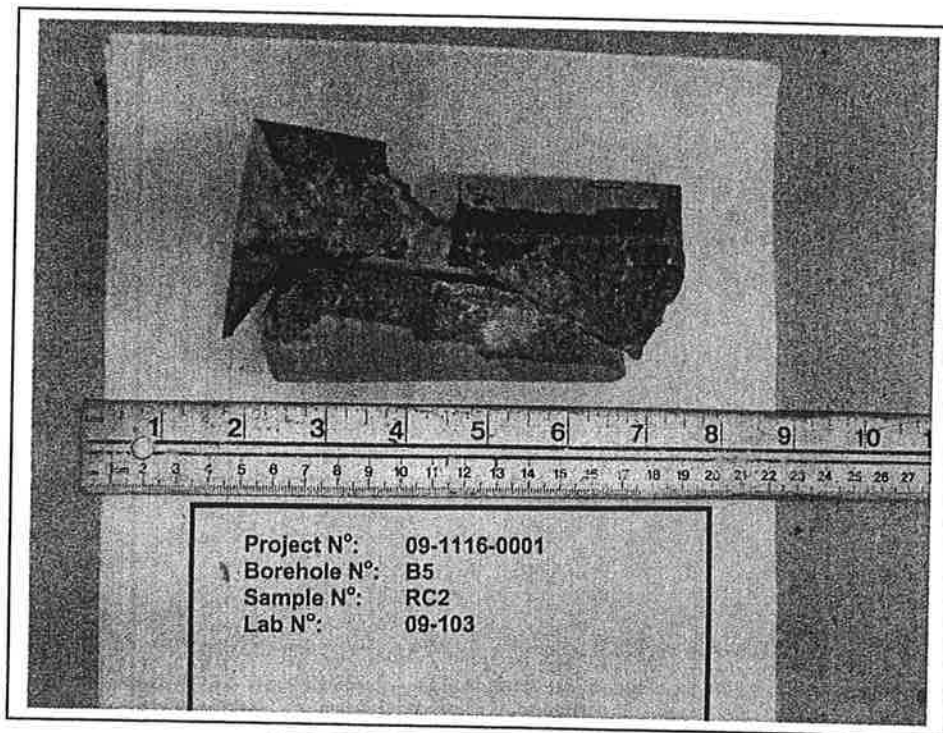
Drawn AH
Chkd. *[Signature]*

UNCONFINED COMPRESSION TEST
ASTM D2166-98A

FIGURE



BEFORE COMPRESSION



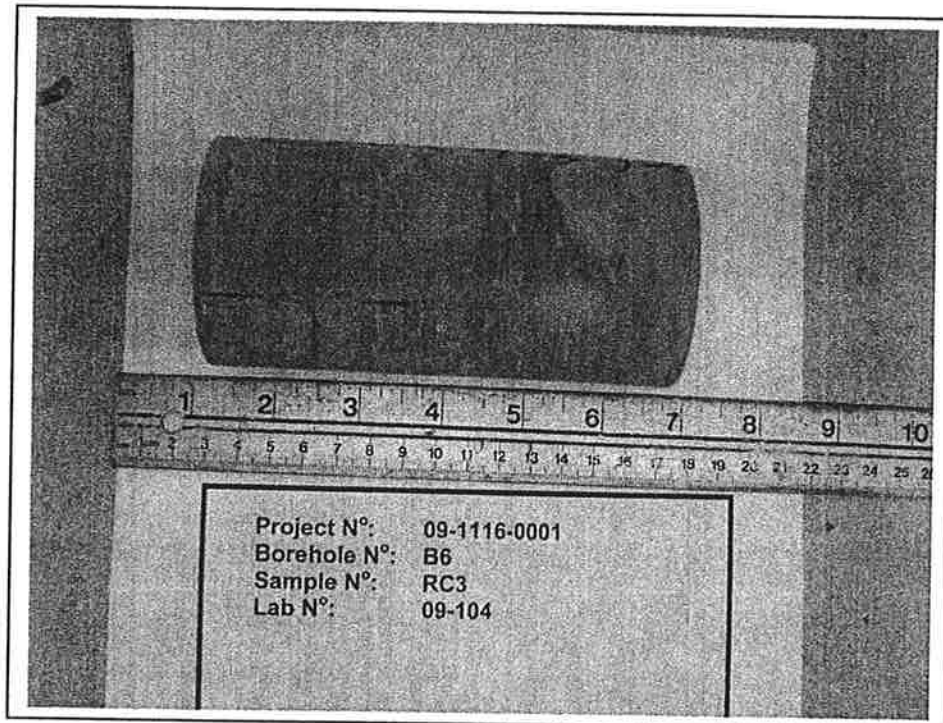
AFTER COMPRESSION

Test Specimen (Borehole B5)

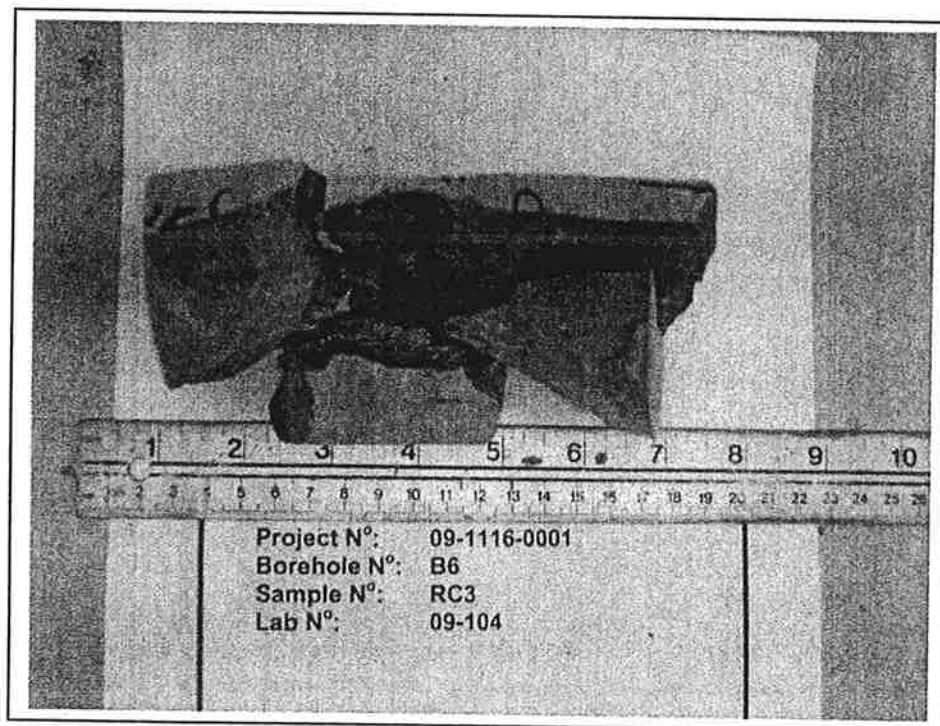
Drawn AH
Chkd. *ah*

UNCONFINED COMPRESSION TEST
ASTM D2166-98A

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Test Specimen (Borehole B6)

Drawn AH
Chkd. *ah*

Appendix C

Site Photographs



West bank of Batteaux River, looking towards north



East bank of Batteaux River, looking towards north



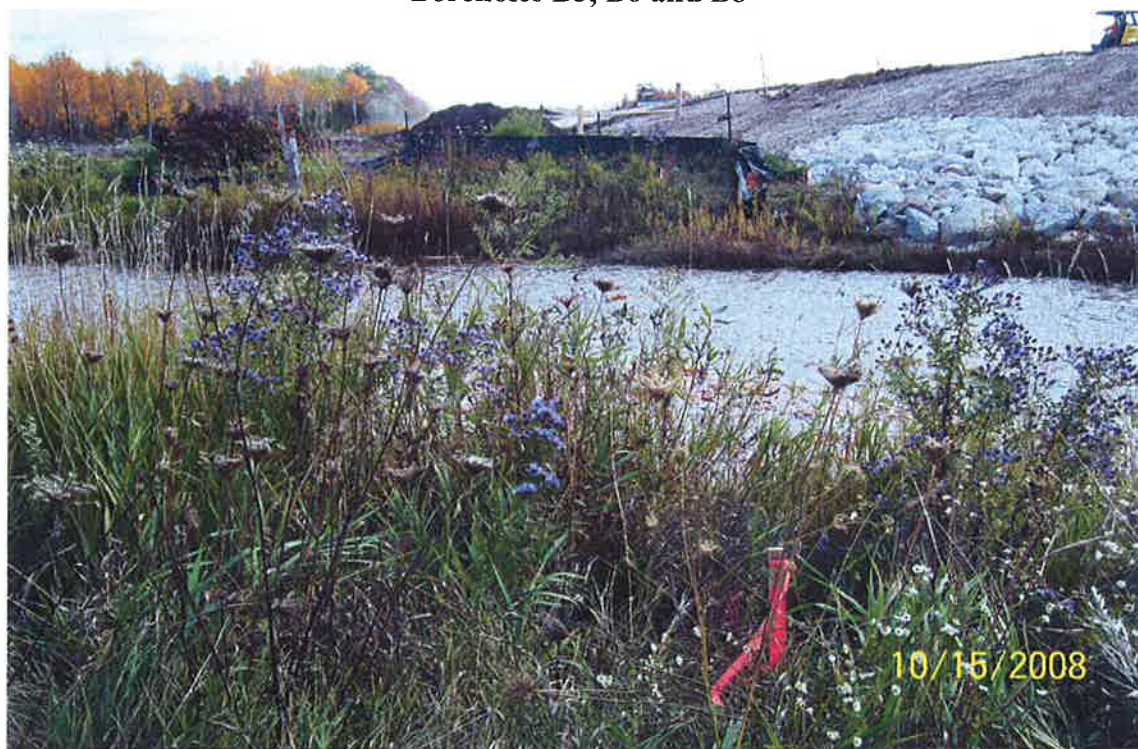
Batteaux River Bridge, looking towards east



Borehole B2 (left) and Borehole B4 (right)



Boreholes B5, B6 and B8



Borehole B3, looking towards east



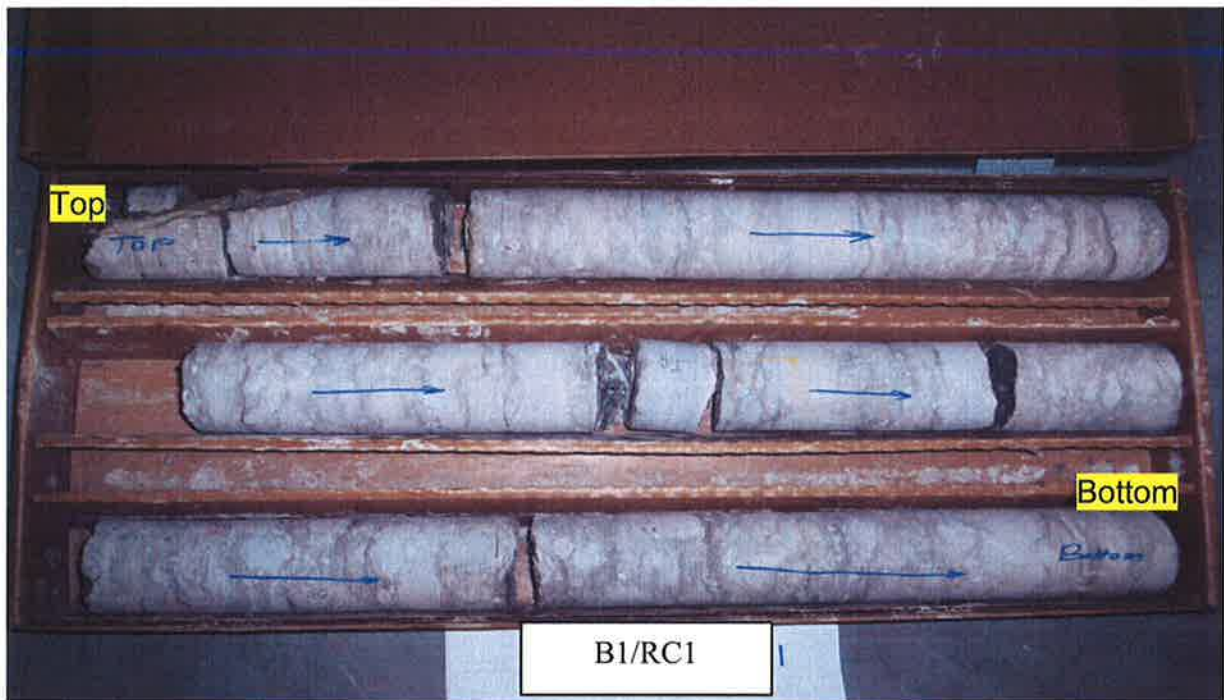
Borehole B1, looking towards north



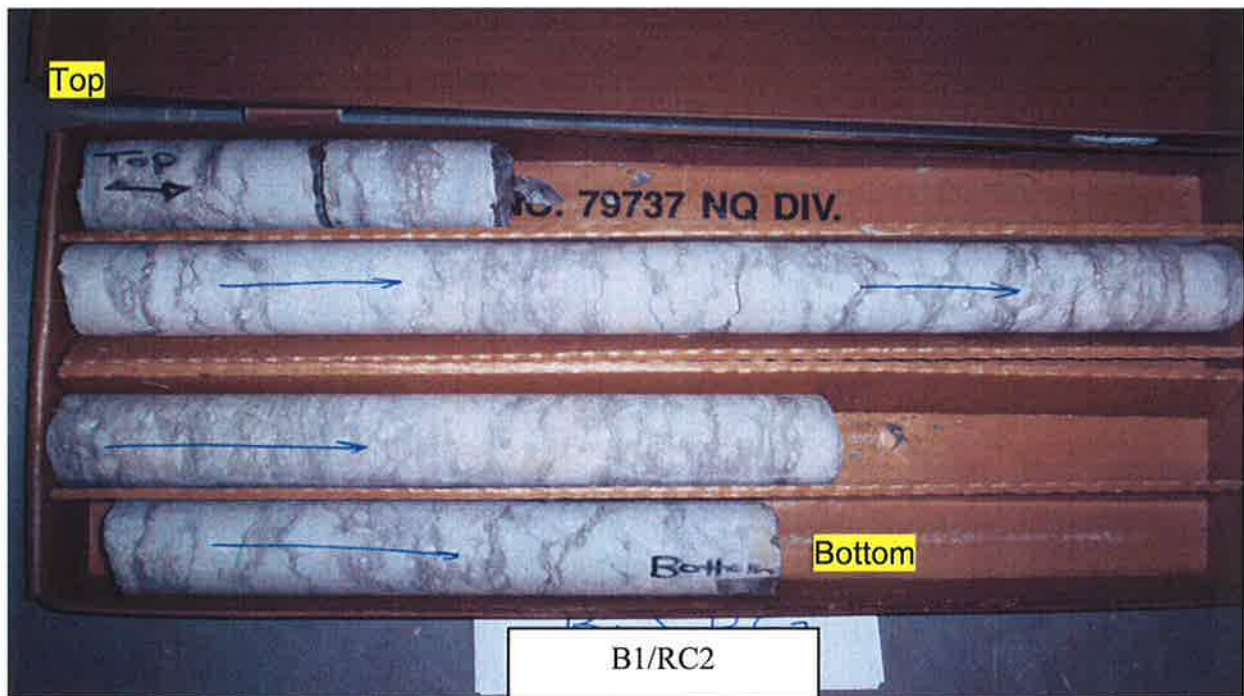
Borehole B7, looking towards west

Appendix D

Rock Core Photographs



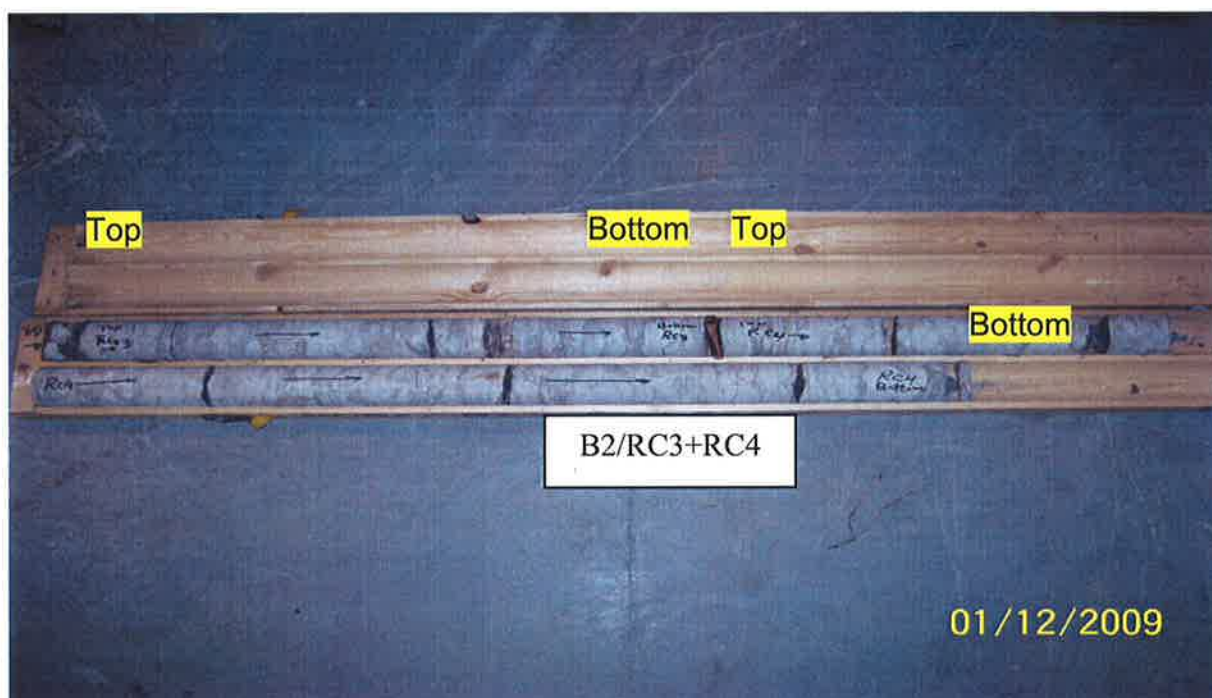
Borehole B-1/ Core # RC1



Borehole B-1/ Core # RC2



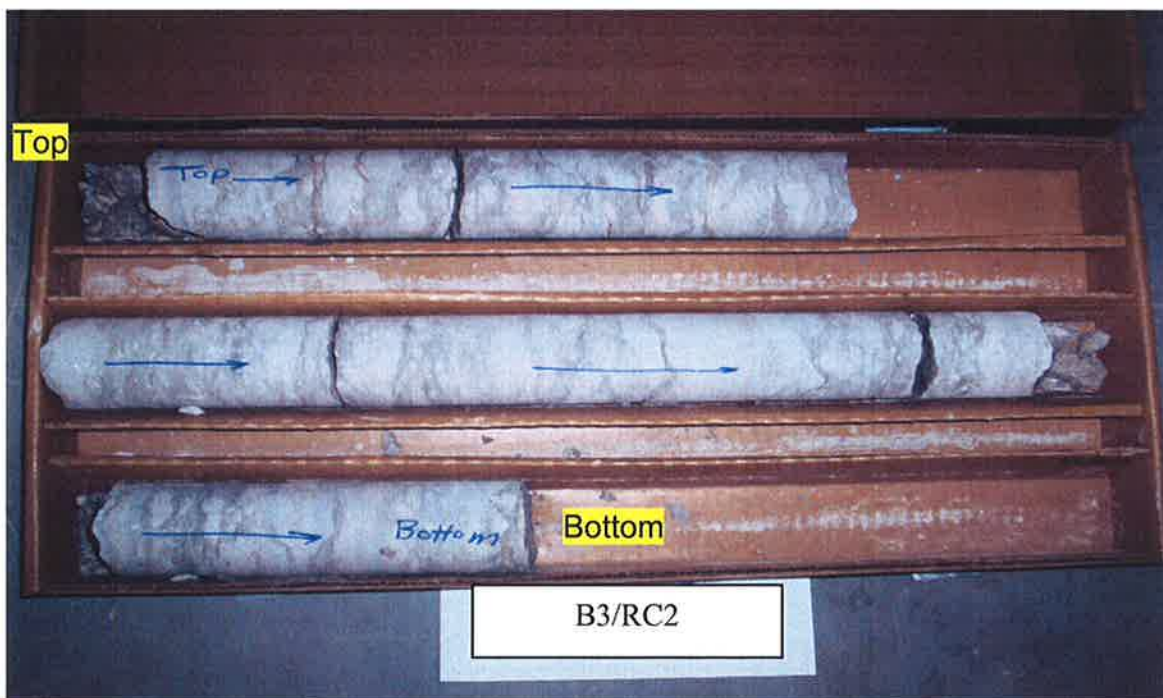
Borehole B-1/ Core # RC3



Borehole B-2/ Core # RC3 + RC4



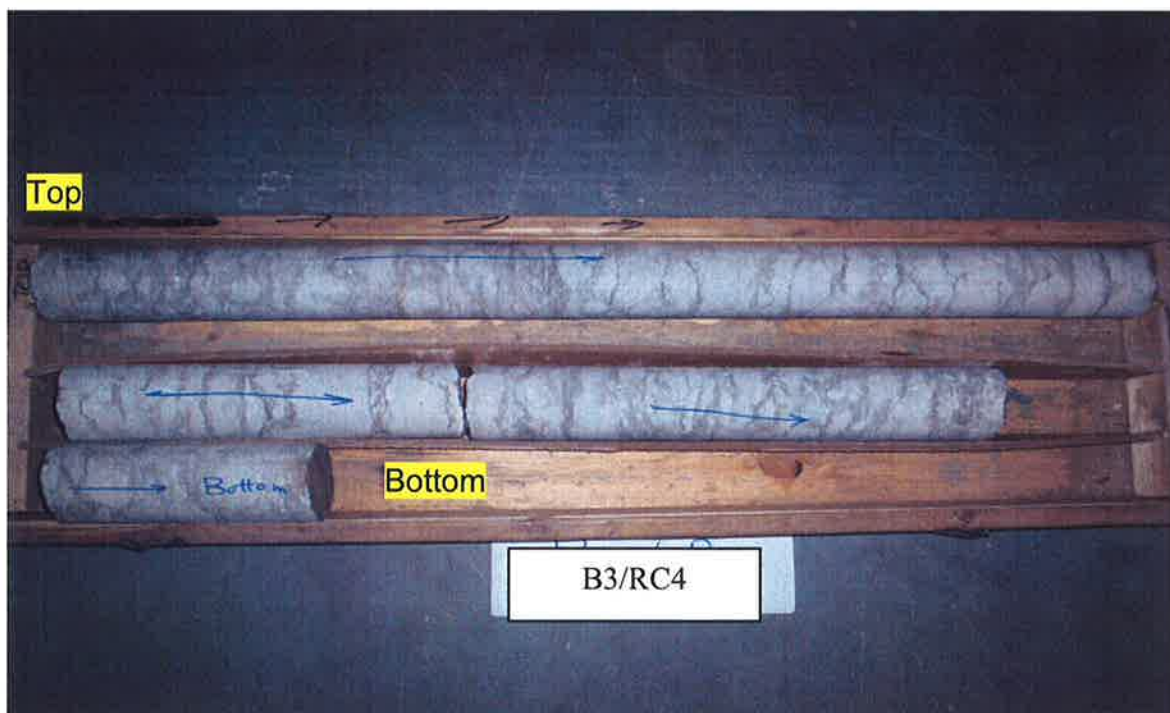
Borehole B-2/ Core # RC5



Borehole B-3/ Core # RC2



Borehole B-3/ Core # RC3



Borehole B-3/ Core # RC4



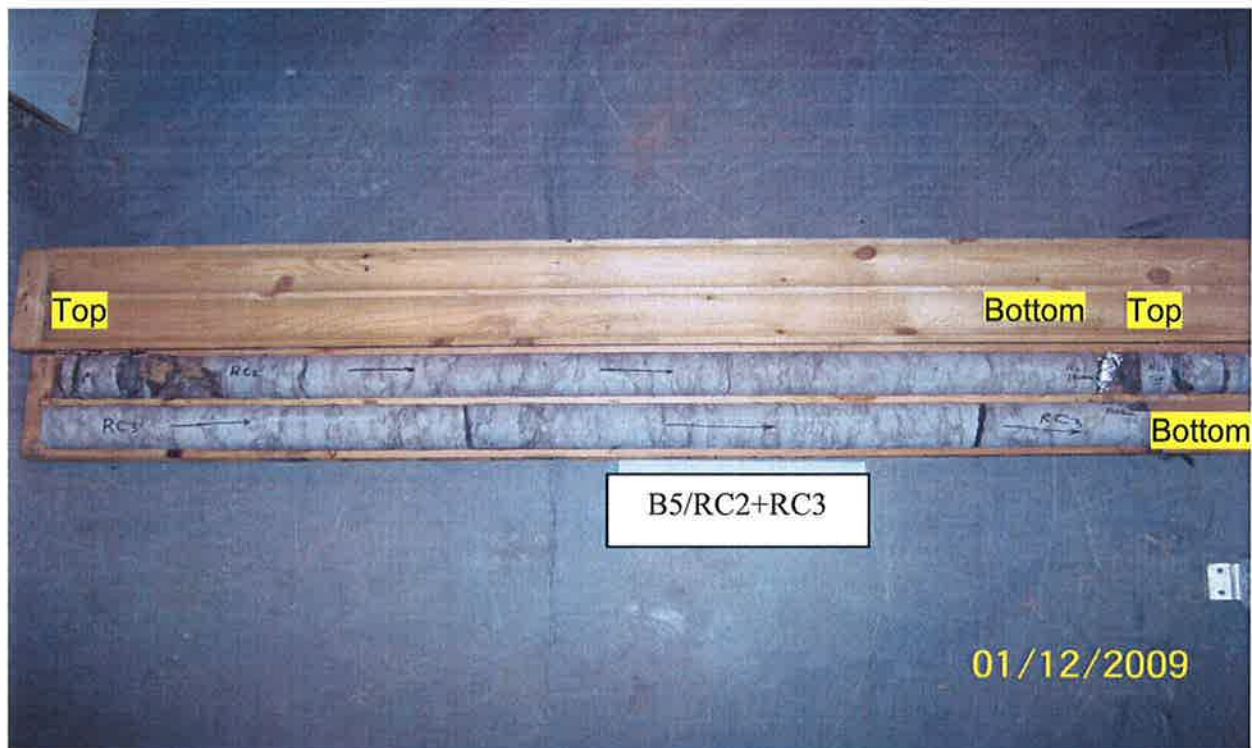
Borehole B-4/ Core # RC1



Borehole B-4/ Core # RC2



Borehole B-4/ Core # RC3



Borehole B-5/ Core # RC2+RC3



Borehole B-5/ Core # RC4



Borehole B-6/ Core # RC3



Borehole B-6/ Core # RC4+ RC5

Appendix E

Explanation of Terms Used in the Report

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

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

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

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

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

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

JOINT AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICALL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
j_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
P_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
j_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
P	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
j	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
P_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
j_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(W_L - W_p) / I_p$	v	m/s	DISCHARGE VELOCITY
P_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_p) / I_p$	i	1	HYDAULIC GRADIENT
j_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(W_L - W) / 1_p$	k	m/s	HYDRAULIC CONDUCTIVITY
P'	kg/m^3	DENSITY OF SUBMERED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
j'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						