

**FOUNDATION INVESTIGATION AND  
DESIGN REPORTS  
PROPOSED CULVERT EXTENSION  
AT HIGHWAY 26 AND MOSLEY STREET,  
WASAGA BEACH, ONTARIO  
G.W.P. 630-91-00, SITE 30-520C  
GEOCRES 41A-214**

Delcan Corporation

TRANETOB01232AA-AC  
February 18, 2010

February 18, 2010

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

**Attention: Mr. Sam Dinatolo, P. Eng.**

Dear Sir:

**RE: Foundation Investigation and Design Report, Proposed Mosley Street Culvert Extension at Highway 26, Wasaga Beach, Ontario, G.W.P. 630-91-00, SITE 30-520C, GEOCRETS 41A-214**

Please find attached the Foundation Investigation and Design Reports 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

**FOUNDATION INVESTIGATION REPORT  
PROPOSED CULVERT EXTENSION  
AT HIGHWAY 26 AND MOSLEY STREET,  
WASAGA BEACH, ONTARIO  
G.W.P. 630-91-00, SITE 30-520C  
GEOCRE 41A-214**

Delcan Coperation

Project: TRANETOB01232AA-AC  
February 18, 2010

# CONTENTS

<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
<b>2</b>	<b>SITE DESCRIPTION AND PHYSIOGRAPHY</b>	<b>1</b>
<b>3</b>	<b>FIELD AND LABORATORY WORK</b>	<b>2</b>
<b>4</b>	<b>SUMMARIZED SUBSURFACE CONDITIONS</b>	<b>3</b>
<b>4.1</b>	<b>Topsoil</b>	<b>4</b>
<b>4.2</b>	<b>Surficial Silty Sand</b>	<b>4</b>
<b>4.3</b>	<b>Silty Clay</b>	<b>4</b>
<b>4.4</b>	<b>Sandy Silt to Silty Sand Till</b>	<b>5</b>
<b>4.5</b>	<b>Silty Fine Sand</b>	<b>5</b>
<b>4.6</b>	<b>Groundwater Conditions</b>	<b>6</b>

## **Drawing**

Drawing 1: Borehole Location Plan and Soil Strata

## **Appendices**

Appendix A: Record of Borehole Sheets

Appendix B: Laboratory Test Results

Appendix C: Site Photographs

Appendix D: Golder Associates Foundation Investigation Report

Appendix E: Explanation of Terms Used in Report

**FOUNDATION INVESTIGATION REPORT  
PROPOSED MOSLEY STREET CULVERT EXTENSION AT HIGHWAY 26  
WASAGA BEACH, ONTARIO  
G.W.P. 630-91-00, SITE 30-520C**

## **1 INTRODUCTION**

As part of the realignment of Highway 26, from the Town of Wasaga Beach to Collingwood, Coffey Geotechnics Inc. (Coffey) was retained by Delcan Corporation (Delcan) to carry out a foundation investigation at the site of proposed Mosley Street culvert extension (Site 30-520C) and the associated retaining wall in the Town of Wasaga Beach, Ontario.

The existing structure is an about 71.9 m long concrete box culvert (4267x2438 mm inner dimension) under the junction of the existing Highway 26 and Mosley Street. The 24.5 m long culvert extension is planned toward the south end (inlet) of the culvert.

The purpose of the investigation was to obtain information about the subsurface conditions at the site 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**

The location of the Mosley Street Culvert falls within Nottawasaga Basin which belongs to the physiographic region of Simcoe Lowlands (The Physiography of Southern Ontario, Chapman and Putnam, 1984). Nottawasaga Basin is named for the river which drains it. For the most part, the basin was one time part of the floor of Lake Algonquin, therefore, its surface beds are therefore deposits of deltaic lacustrine origin and not glacial outwash.

According to the Quaternary Geology of Ontario, Collingwood-Nottawasaga Area (Map P.919) and Quaternary Geology of Ontario, Southern Sheet (Map P.2715), the project area lies between two major units of paleozoic deposits, one of which, on the west side, is a glaciolacustrine deposit of gravel, sand, silt and clay of post-Nippissing Age. Till deposit that correlates with the Newmarket Till deposited during the Port Bruce Stadial was mapped on the east side. This till deposit, which consists predominantly sand silt to silt, is rich in clasts and often high in total matrix carbonate content.

Bedrock from the Middle and Upper Ordovician and Lower and Middle Silurian ages underlie the project area (Bedrock Geology of Ontario, Southern Sheet, Map 2544). Bedrock may consists of limestone dolostone, shale, arkose and sandstone. The topography of bedrock is said to dip approximately 8 m per kilometer southwesterly.

The topography at the site is relatively flat. No significant signs of instability or erosion of the existing embankment at culvert location were identified at the time of our investigation.

### 3 FIELD AND LABORATORY WORK

The fieldwork for this project was conducted on September 24 and 25, 2009. Four (4) boreholes (Boreholes 101, 102, 103 and 104) were drilled and sampled for the proposed culvert extension at the existing culvert inlet area (south end of the culvert) to the proposed depth of 10.5 m. The locations of the boreholes at the sites are given on the Borehole Location Plan in Drawing No 1.

Table 3.1: Borehole Locations and Drilling Depths

Borehole No.	Coordinate (Northing / Easting)	Existing Ground Surface Elevation (m)	Depth of Borehole Below Existing Ground Surface (m)	Piezometer
101	4925343.8/256431.0	183.8	10.5	No
102	4925329.0/256439.0	183.7	10.5	Yes
103	4925327.7/256427.1	183.5	10.5	No
104	4925320.9/256440.4	183.5	10.5	No

The boreholes were advanced using a track-mounted drilling rig owned and operated by Walker Drilling Limited of Barrie, Ontario, under the full-time supervision of a technical staff (Mr. Gem Jiang, EIT) from Coffey. These boreholes were advanced using continuous flight hollow-stem augers.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test method (SPT), in general accordance with ASTM D1586. The 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 granular (cohesionless) soils (gravels, sands and coarse silts) or the consistency of cohesive soils (clays and clayey silts).

Dynamic Cone Penetration Tests (DCPT) were performed from the ground surface adjacent to Boreholes 101, 102, and 103, as well as from the bottom of Boreholes 102 and 104 to refusal. In this test, a 51 mm diameter, 60-degree apex cone, screw attached to the tip of an A-size rod, is driven into the ground, using the same driving energy as the SPT method. By recording the number of blows of the hammer to drive the cone/rod assembly, into the soil every 0.3 m, a qualitative record of soil compactness condition is obtained. Although the interpretation of the test results is difficult because no samples are obtained by the DCPT and the penetration resistances are not necessarily equal to the N-values, useful information is gained by the continuity of the results and by the elimination of unbalanced hydrostatic force effects which in some cases (such as the present cases of soil back up at the bottom of the boreholes during the drilling) affect the SPT results.

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 by Delcan.

Water level observations in the open boreholes were made during the drilling and at completion of each borehole.

A piezometer was installed to a depth of 10.0 m in Borehole 102 to determine the groundwater levels over a prolonged period of time, without interference from surface water.

Upon completion, each borehole was backfilled with bentonite/cement mixture, as per MTO procedures. The piezometer in Borehole 102 was not decommissioned, as it may provide useful information prior and/or during the construction of the culvert extension. The decommissioning should be carried out during the construction.

The soil samples were transported to our geotechnical laboratory in Toronto for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations, Atterberg Limits tests and grain size analyses, was performed on selected representative samples. The results of the laboratory tests are presented on the appropriate Record of Borehole Sheets.

In 2002 – 2003, Golder Associates Limited (Golder) carried out a geotechnical investigation at the site of the proposed culvert extension. The findings of the investigation were presented in a report entitled "Foundation Investigation Report, Proposed New Culverts, Highway 26, G.W.P. 630-91-00, Agreement Number 3005-A-000164", dated February 2006. The investigation included two boreholes at the proposed Mosley Street Culvert Extension site (Boreholes 7 and 8). The boreholes put down by Golder at the site were used to supplement the boreholes by Coffey at this site. The locations of these boreholes are shown on the Borehole Location Plan, Drawing No 1.

#### **4 SUMMARIZED SUBSURFACE CONDITIONS**

Boreholes 101, 102, 103 and 104 were advanced at the proposed culvert extension site, adjacent to the south end of the exiting Mosley Street Culvert. Boreholes 101 and 102 were put down in the middle of the proposed extension (about 6 and 11 m away from the existing culvert inlet southerly on each side of the proposed culvert extension) from the existing ground surface (El. 183.7 and 183.8 m) level, while Boreholes 103 and 104 were drilled at the end of the proposed extension (about 25 m away from the existing culvert inlet southerly on each side of the proposed culvert extension) also from the existing ground surface (El. 183.5 m) level.

All boreholes drilled at the site encountered a 0.2 to 0.3 m thick topsoil at the ground surface. Underlying the topsoil, Boreholes 101, 102 and 103 contacted a 0.7 to 1.1 m thick surficial silty sand. Below this silty sand cap, Boreholes 101, 102 and 103 encountered a 0.4 to 1.0 m thick silty clay layer. Below this silty clay in Boreholes 101, 102 and 103 and underlying the topsoil in Borehole 104, all boreholes contacted a sandy silt to silty sand glacial till deposit at depths of 0.3 to 2.0 m (or El. 181.7 to 183.2 m). The glacial till deposit was found to extend to a depth of 4.4 m or El. 179.1 to 179.4 m and is further underlain by a silty fine sand deposit. The boreholes were terminated within this deposit at the proposed borehole depth of 10.5 m (El. 173.0 to 173.3 m). Some soil back-up (about 0.2 to 0.3 m) due to the hydrostatic uplift within the silty fine sand deposit was noted during the drilling.

Dynamic Cone Penetration tests (DCPT) were performed from the bottom of Boreholes 102 and 104 and refusal was encountered at 14.2 m (or El. 169.5 m) and 11.3 m (or El. 172.2 m), respectively. DCPT from the original ground surface adjacent to the drilled boreholes was also carried out in Boreholes 101, 102 and 103 and refusal was encountered at depths of 3.3 m, 5.8 m and 4.9 m or El., 180.5, 177.9 and 178.6 m, respectively.

Subsurface conditions at the site are discussed in the following sections. Details of the stratigraphy encountered in the boreholes are presented on the Records of Borehole Sheets (including boreholes by Golder Associates Limited). The locations of the boreholes along with an inferred subsurface profile (based on Coffey boreholes) are given in Drawing No. 1. Photographs of the proposed culvert extension site are included in Appendix C. The following paragraphs are only meant to complement these data. Appropriate portions of the previous investigation report for this proposed culvert extension (prepared by Golder in 2006) is also included in Appendix D of this report.

#### **4.1 Topsoil**

A layer of topsoil ranging from 0.2 to 0.3 m in thickness was contacted in all boreholes at ground surface.

#### **4.2 Surficial Silty Sand**

Underlying the topsoil in Boreholes 101, 102 and 103, a 0.7 to 1.1 m thick surficial silty sand was encountered at depths of 0.2 to 0.3 m below the ground surface and found to extend to depths of 0.9 to 1.4 m or El. 182.1 to 182.9 m. This deposit contains traces of rootlets, as well as clay and gravel size particles.

The surficial silty sand is a granular (non-cohesive) soil. The grain-size distribution of a sample recovered from the deposit is presented in Figure B-1, in Appendix B which indicates following grain-size distribution:

Gravel:	0 %
Sand:	63 %
Silt:	29 %
Clay:	8 %

Standard Penetration Tests conducted in the silty sand yielded N-values between 4 to 14 blows/0.3 m. These results indicate that the relative density of the silty sand can be described as very loose to compact.

#### **4.3 Silty Clay**

Below the surficial silty sand, Boreholes 101, 102 and 103 contacted a 0.4 to 1.0 m thick silty clay deposit, extending to El. 181.7 to 181.9 m. This deposit contains traces to some sand and gravel, traces of rootlets, occasional silt pockets and sand seams.

The grain-size distribution of two samples from this deposit was determined in the laboratory and the resulting curves are given in Figure B-2 in Appendix B. The following grain-size distribution is indicated.

Gravel:	6-15 %
Sand:	5-17 %
Silt:	36-38 %
Clay:	41-42 %



The results of Atterberg Limits tests performed on two samples recovered from this deposit are given on the individual Record of Borehole Sheets and also on the plasticity chart presented in Figure B-3 in Appendix B. The following index values were obtained:

Liquid Limit:	35-36 %
Plastic Limit:	17-18 %
Plasticity Index:	17-18

These results are characteristic of cohesive soils of low to intermediate plasticity.

Standard Penetration tests, performed in this cohesive deposit, yielded N-values of between 3 and 13 blows/0.3 m, indicating soft to stiff consistency.

#### **4.4 Sandy Silt to Silty Sand Till**

Underlying the silty clay in Boreholes 101, 102 and 103, and the topsoil in Borehole 104, a glacial deposit consisting of a heterogeneous mixture of sandy silt to silty sand with traces to some gravel and clay was encountered at depths ranging from 0.3 to 2.0 m or El. 181.7 to 183.2 m. This sandy silt to silty sand till deposit was found to extend to a depth of 4.4 m below the ground surface or El. 179.1 to 179.4 m. Grain-size analysis conducted on five samples, retrieved from this deposit, gave the following grain size distribution (see Figure B-4 in Appendix B):

Gravel:	3-11 %
Sand:	36-49 %
Silt:	34-52 %
Clay:	7-10 %

N-values obtained from Standard Penetration Tests performed in this granular (i.e. non-cohesive) deposit are between 3 and 54 blows/0.3 m. This indicates that the deposit is in a very loose to very dense compactness condition, but typically compact to dense.

It should also be mentioned that owing to their mode of deposition, the presence of cobbles and boulders should always be anticipated in the glacial till deposits.

#### **4.5 Silty Fine Sand**

All boreholes contacted a silty fine sand deposit below the glacial till at a depth of 4.4 m or at El. 179.1 to 179.4 m. The boreholes were terminated within this deposit at a depth of 10.5 m or El. 173.0 to 173.3 m.

The silty fine sand was identified as a dilatant material.

The grain-size distribution of four samples from this deposit was determined in the laboratory and the resulting curves are given in Figure B-5 in Appendix B. The following grain-size distribution is indicated.

Gravel:	0 %
---------	-----

Sand:	57-89 %
Silt:	10-40 %
Clay:	1-5 %

N-values obtained from Standard Penetration Tests performed in this granular (i.e. non-cohesive) deposit are between 4 and 55 blows/0.3 m. This indicates that the deposit is in a very loose to very dense compactness condition, but typically compact to dense.

It is noted that an about 0.2 to 0.3 m soil back-up into the hollow stem augers was recorded during the investigation within the deposit where very low N-values were recorded, due to the hydrostatic uplift and therefore, these recorded low N-values may not be reliable.

## 4.6 Groundwater Conditions

Groundwater conditions in the open boreholes were observed during the drilling and at the completion of each borehole. One piezometer was installed in Borehole 102 to a depth of 10.0 m. The observations made in the boreholes are summarized in Table 4.5.1 and presented on the Record of Borehole Sheets in Appendix A.

Table 4.6.1.: Groundwater Conditions

Borehole	Ground Elevation (m)	Depth / Elevation of the Tip of Piezometer (m)	Date	Water Level Depth / Elevation (m)
101	183.8	-	Upon completion	4.6/179.2
102	183.7	10.0/173.7	A day after installation	4.4/179.3
103	183.5	-	Upon completion	4.0/179.5
104	183.5	-	Upon completion	4.2/179.3

In Boreholes 7 and 8 advanced by Golder Associates, the water level was measured in July and August 2003 at about El. 179 m.

Based on these results, the ground water level at the time of our investigation and in July and August 2003 was between El. 179.0 and 179.5 m, at the site.

It should, however, be pointed out that the groundwater at the site would be subject to seasonal fluctuations as well as fluctuations due to weather events and the water level in the water course. In addition a perched water table may occur due to accumulation of the surface water in the upper more pervious zones of the soil overlying the less pervious silty clay and the dense to very dense till. As well, the groundwater can be expected to be influenced by the water level in the existing creek.

For and on behalf of Coffey Geotechnics Inc.

**Gwangha Roh, Ph.D.**

**Ramon Miranda, P.Eng**  
Manager, Transportation Division



**Zuhtu Ozden, P.Eng.**  
Senior Principal



**Drawing**

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 REALIGNMENT  
MOSLEY ST. CULVERT EXTENSION  
BOREHOLE LOCATION PLAN  
AND SOIL STRATA



SHEET

coffey geotechnics  
SPECIALISTS MANAGING THE EARTH



KEY PLAN  
N.T.S.

LEGEND

- Borehole & Cone (Coffey)
- Borehole (Golder)
- 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	NORTHING	EASTING
101	183.8	4925343.8	256431.1
102	183.7	4925329.0	256439.0
103	183.5	4925327.7	256427.1
104	183.5	4925321.0	256440.4
7	183.7	4925346.6	256425.5
8	184.5	4925353.1	256449.3

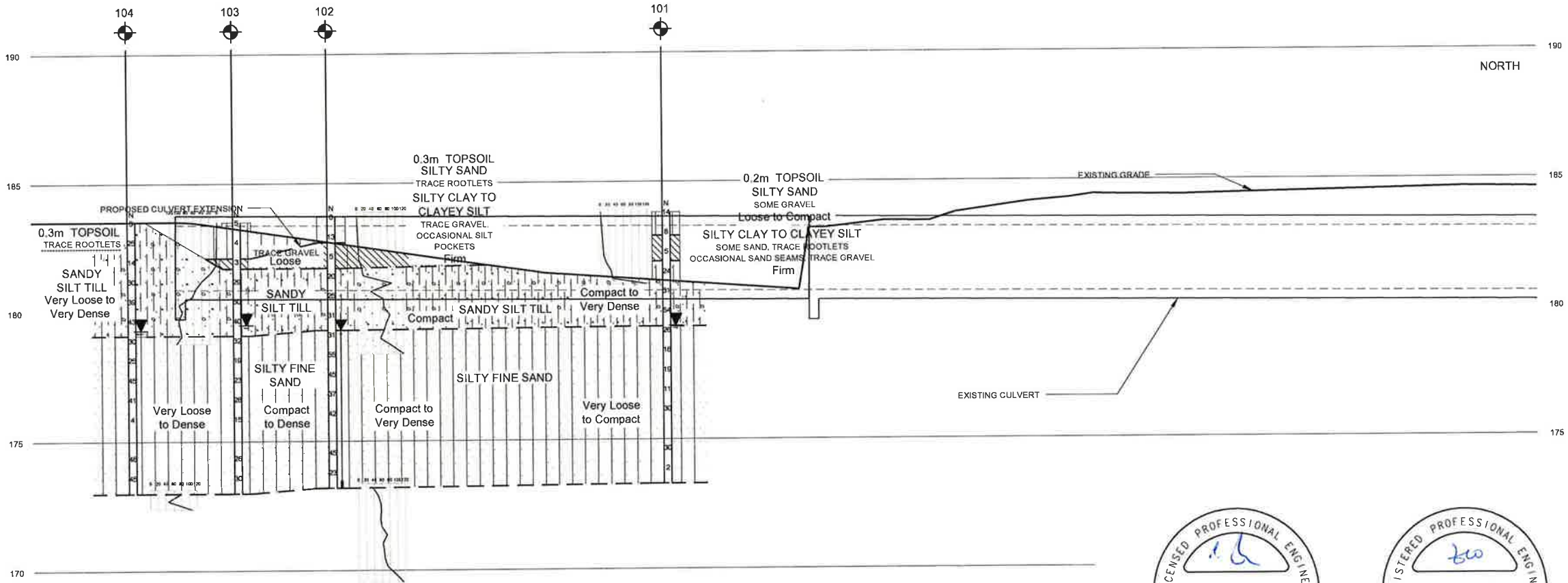
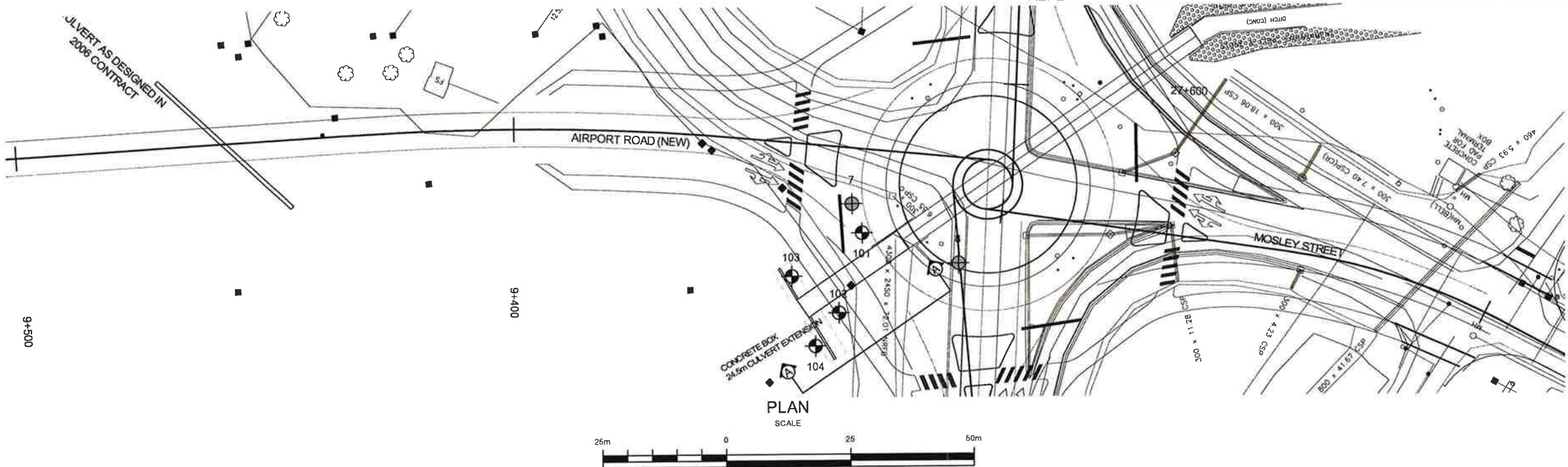
-NOTE-

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-214	TRANETO01232AA	DIST
SUBMD	CHECKED	DATE Jan. 27, 2010
DRAWN	PHK	CHECKED RM
APPROVED	ZO	DWG
1		



SECTION A-A  
HORIZONTAL SCALE



# Appendix A

## **Borehole Logs**

TRANETOBO1232AA

# RECORD OF BOREHOLE No 101

1 OF 1

METRIC

GWP 630-91-00 LOCATION Intersection of Hwy 26 and Mosley Street ORIGINATED BY G.J.  
DIST HWY HWY 26 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test (DCPT) COMPILED BY W.C.  
DATUM Geodetic DATE 9/24/2009 9/25/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)						
183.8	GROUND SURFACE							20 40 60 80 100						
0.0	0.2 m TOPSOIL SILTY SAND some gravel, brown loose to compact, moist		1	SS	14		183	○ UNCONFINED + FIELD VANE ● POCKET PENETR. X LAB VANE						
182.9			2	SS	8		182							
0.9	SILTY CLAY some sand, tr. gravel, tr. rootlets occ. sand seams, brown, firm		3	SS	5		181							15 5 38 42
181.9			4	SS	24		180							
1.9	SANDY SILT TO SILTY SAND TILL grey, compact to v. dense		5	SS	31		179							
			6	SS	54		178							
179.4			7	SS	26		177							
4.4	SILTY FINE SAND grey, loose to compact, dilatant, wet		8	SS	18		176							0.2 m soil back up (N-value may not be reliable) wet spoon 0 57 40 3
			9	SS	19		175							
			10	SS	11		174							
			11	SS	30									
			12	SS	30									
			13	SS	2*									*0.3 m soil back up (N-value is not reliable)
173.3	End of Borehole. Borehole caved in @ 4.4 m. Water level @ 4.6 m (not stabilized)* upon completion. Dynamic Cone Penetration Test (DCPT) performed adjacent to the borehole from ground surface to 3.3 m.													

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE



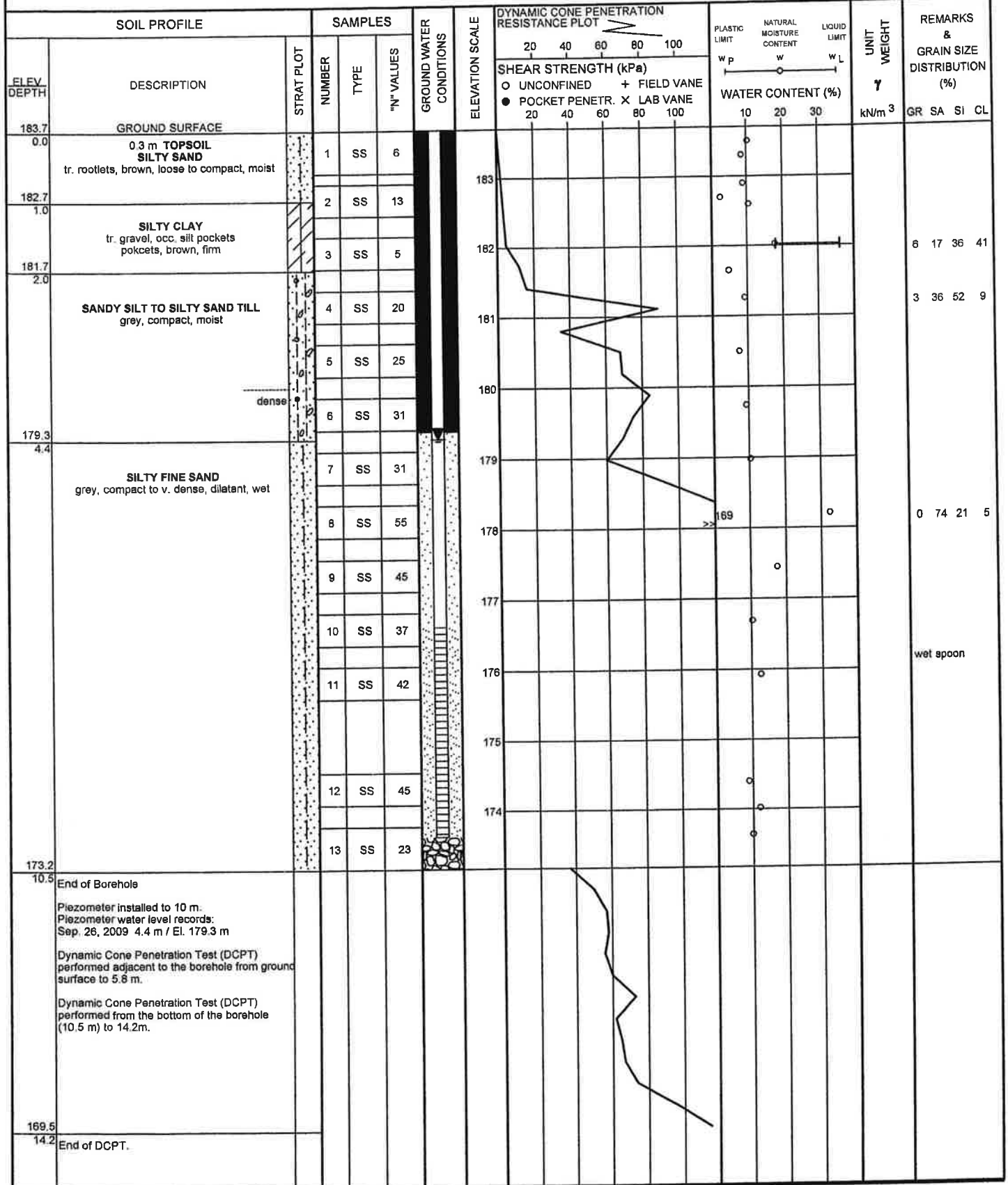
TRANETOB01232AA

# RECORD OF BOREHOLE No 102

1 OF 1

METRIC

GWP 630-91-00 LOCATION Intersection of Hwy 26 and Mosley Street ORIGINATED BY G.J.  
DIST HWY HWY 26 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test (DCPT) COMPILED BY W.C.  
DATUM Geodetic DATE 9/25/2009 CHECKED BY Z.O.



+ 3, X 3, Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE



TRANET0801232AA

# RECORD OF BOREHOLE No 103

1 OF 1

METRIC

GWP 630-91-00 LOCATION Intersection of Hwy 26 and Mosley Street ORIGINATED BY G.J.  
 DIST HWY HWY 26 BOREHOLE TYPE Hollow Stem Augers, Dynamic Cone Penetration Test (DCPT) COMPILED BY W.C.  
 DATUM Geodetic DATE 9/24/2009 9/25/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)							
								○ UNCONFINED	+ FIELD VANE						
								● POCKET PENETR.	x LAB VANE						
								20	40	60	80	100	10	20	30
183.5	GROUND SURFACE														
0.0	0.3 m TOPSOIL SILTY SAND tr. rootlets, tr. gravel brown, v. loose, moist		1	SS	5		183								0 63 29 8
			2	SS	4										
182.1							182								
1.4	SILTY CLAY tr. gravel, brown, soft, moist		3	SS	3										
181.7															
1.8	SANDY SILT TO SILTY SAND TILL grey, v. loose to dense, dilatant		4	SS	29		181								auger grinding @ 3.0 m
			5	SS	50										
			6	SS	40		180								10 49 34 7
179.1															
4.4			7	SS	32		179								
	SILTY FINE SAND grey, compact to dense, dilatant, wet		8	SS	19		178								wet spoon 0.2 m soil back up (N-value may not be reliable)
			9	SS	23		177								
			10	SS	28		176								
			11	SS	15		175								
							174								0 89 10 1
			12	SS	26										
			13	SS	30										
173.0							173								
10.5	End of borehole Borehole caved in @ 4.0 m. Water level @ 4.0 m upon completion (not stabilized). Dynamic Cone Penetration Test (DCPT) performed adjacent to the borehole from ground surface up to 4.9 m.														

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

TRANETOB01232AA

# RECORD OF BOREHOLE No 104

1 OF 1

METRIC

GWP 630-91-00 LOCATION Intersection of Hwy 26 and Mosley Street ORIGINATED BY G.J.  
DIST HWY HWY 26 BOREHOLE TYPE Hollow Stem Augers COMPILED BY W.C.  
DATUM Geodetic DATE 9/24/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)							WATER CONTENT (%)
								○ UNCONFINED ● POCKET PENETR.	+ FIELD VANE x LAB VANE						
183.5 0.0	GROUND SURFACE						20 40 60 80 100	20 40 60 80 100	10 20 30						
	0.3 m TOPSOIL	tr. rootlets	1	SS	5	1	183								
	SANDY SILT TO SILTY SAND TILL grey, compact to dense		2	SS	25									9 45 36 10	
			3	SS	14										
			4	SS	30										
			5	SS	39										
			6	SS	43									4 48 40 8	
179.1 4.4	SILTY FINE SAND grey, loose to dense, dilatant, wet	moist wet	7	SS	30			179							
			8	SS	25			178							
			9	SS	45			177						0 83 15 2	
			10	SS	41			176						wet spoon *0.3 m soil back up (N-value may not be reliable)	
			11	SS	4*			175							
			12	SS	48			174							
			13	SS	45			173							
173.0 10.5	End of borehole. Water level @ 4.2 m upon completion (not stabilized)*.														
172.2 11.3	Dynamic Cone Penetration Test (DCPT) performed from the bottom of the borehole (10.5 m) to 11.3 m.														
	End of DCPT														

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

PROJECT <u>001-3232-4-4</u>		<b>RECORD OF BOREHOLE No 7</b>		1 OF 1	<b>METRIC</b>
G.W.P. <u>630-91-00</u>	LOCATION <u>N 4925346.6 E 256425.5</u>	ORIGINATED BY <u>MR</u>			
DIST <u>30</u> HWY <u>26</u>	BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM)</u>	COMPILED BY <u>WDF</u>			
DATUM <u>GEODETIC</u>	DATE <u>8 July 2003</u>	CHECKED BY <u>AMH</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										
								20 40 60 80 100										
183.69	TOPSOIL, silty Brown																	
0.00	FILL, sandy silt with topsoil layers																	
0.23	Loose Brown																	
182.78	SILTY CLAY, trace sand, trace gravel Stiff Mottled brown and grey		1	SS	8													
0.91																		
181.86			2	SS	11													
1.83	SANDY SILT, trace gravel, trace clay, with cobbles (TILL) Compact Brown to Grey at 2.1m		3	SS	28													
180.79																		
2.90	SILTY FINE SAND, Very dense Grey		4	SS	76													
180.49																		
3.20	SANDY SILT, trace gravel, trace clay, with cobbles (TILL) Very dense Grey		5	SS	62									4 45 45 6				
179.27																		
4.42	SANDY SILT, with silty fine sand layers Dense Grey		6	SS	42													
178.51																		
5.18	SILTY FINE SAND, Very dense Grey		7	SS	62													
			8	SS	59									0 65 35 0				
			9	SS	39													
176.37	END OF BOREHOLE																	
7.32	Groundwater encountered at elev. 179.12m during drilling July 8, 2003.																	
	Groundwater measured at elev. 179.15m July 10, 2003.																	
	Groundwater measured at elev. 178.81m July 14, 2003.																	
	Groundwater measured at elev. 178.81m July 17, 2003.																	
	Groundwater measured at elev. 178.72m Aug. 20, 2003																	

ON MTO 001-3232-4-4.GPJ ON MOT.GOT 26/11/03 DATA INPUT:

# RECORD OF BOREHOLE No 8

1 OF 1

METRIC

PROJECT 001-3232-4-4

G.W.P. 630-91-00

LOCATION

N 4925353.1 ; E 256449.3

ORIGINATED BY MR

DIST 30

HWY 26

BOREHOLE TYPE POWER AUGER (HOLLOW STEM)

COMPILED BY WDF

DATUM GEODETIC

DATE

10 July 2003

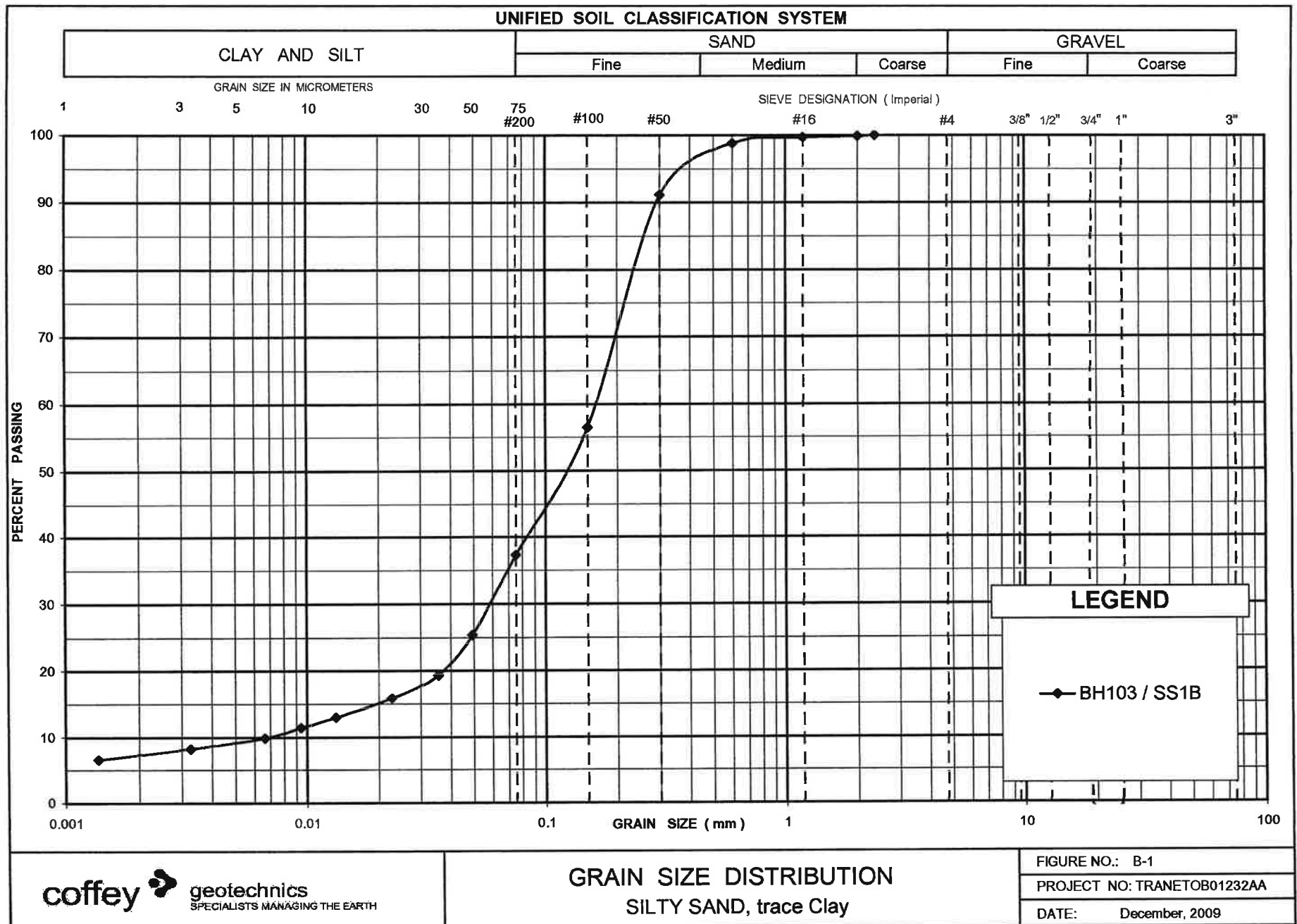
CHECKED BY AMH

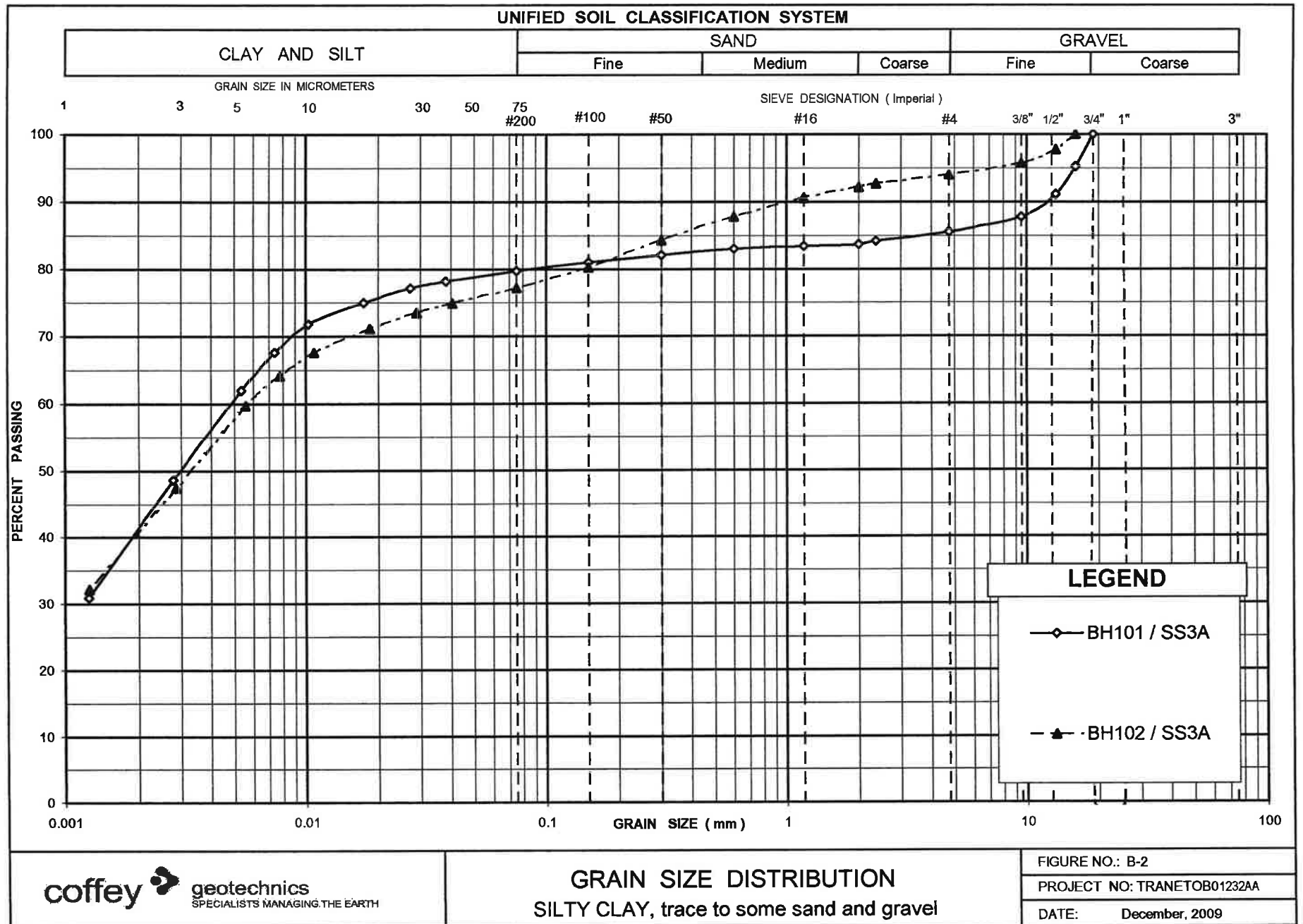
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
184.47							20 40 60 80 100								
0.05	FILL, sand, medium to coarse (25mm) Brown														
183.91	ASPHALT (25mm)														
0.56	FILL, sand and gravel Brown														
	SANDY SILT, trace gravel, trace clay, with cobbles (TILL) Compact to very dense Brown to Grey at 2.9m		1	SS	17										
			2	SS	16										
			3	SS	90										
			4	SS	55										
180.36			5	SS	100/225mm										
4.11	SILTY FINE SAND, Very dense														
180.05	Grey														
4.42	SANDY SILT, trace gravel, with silty fine sand layers, with cobbles (TILL) Very dense		6	SS	64										4 43 47 6
179.29	Grey														
5.18	SAND, fine to medium, trace to some silt Dense to very dense Grey		7	SS	89										
			8	SS	53										
			9	SS	42										
177.31	SILT, trace fine sand														
7.16	Dense														
7.32	Grey END OF BOREHOLE														
	Groundwater encountered at elev. 179.14m during drilling July 10, 2003.														
	Groundwater measured at elev. 178.89m July 14, 2003.														
	Groundwater measured at elev. 178.89m July 17, 2003.														
	Groundwater measured at elev. 178.56m Aug. 20, 2003														

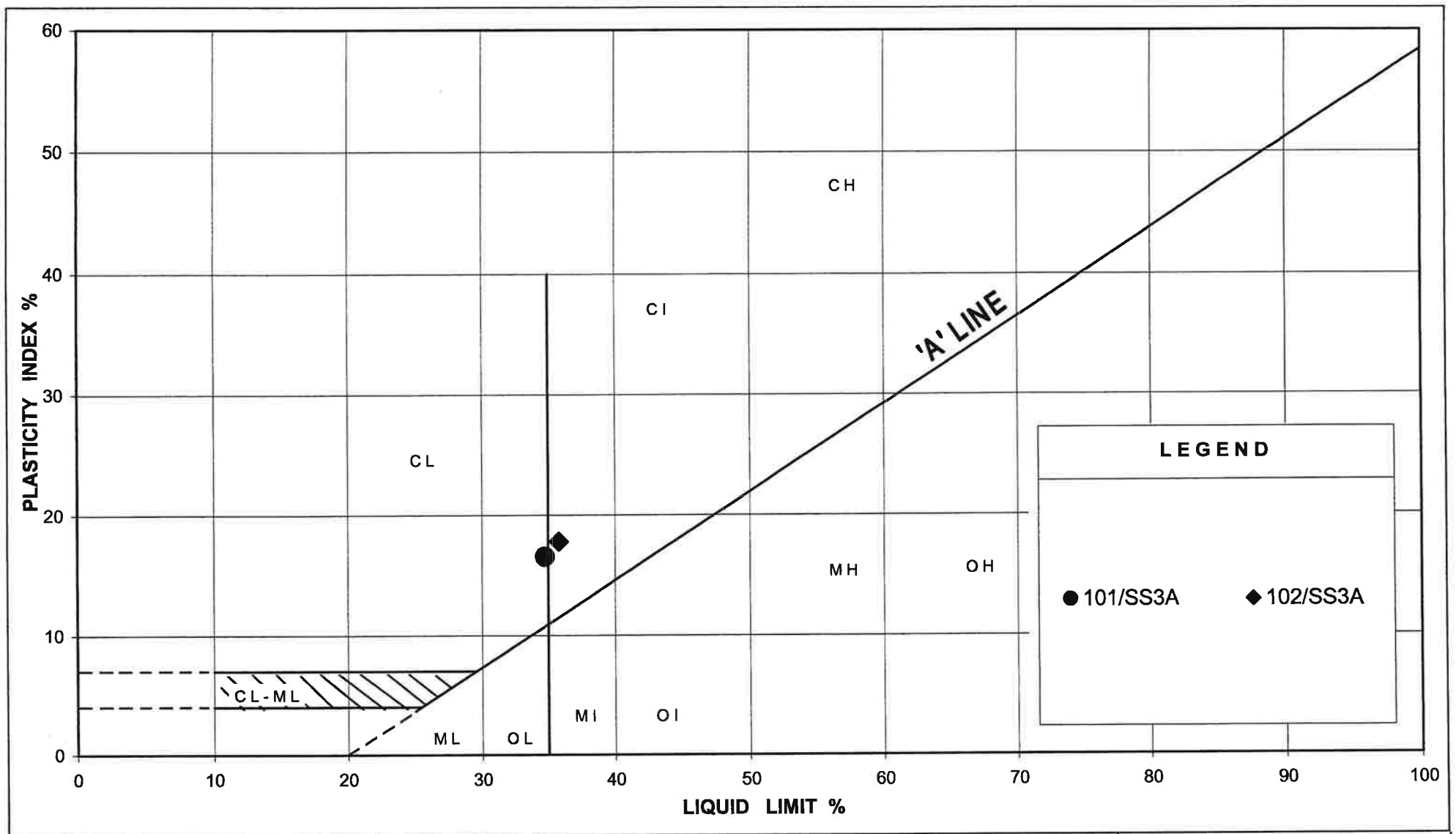
ON MTO 001-3232-4-4.GPJ ON MOT.GDT 28/11/03 DATA INPUT:

# Appendix B

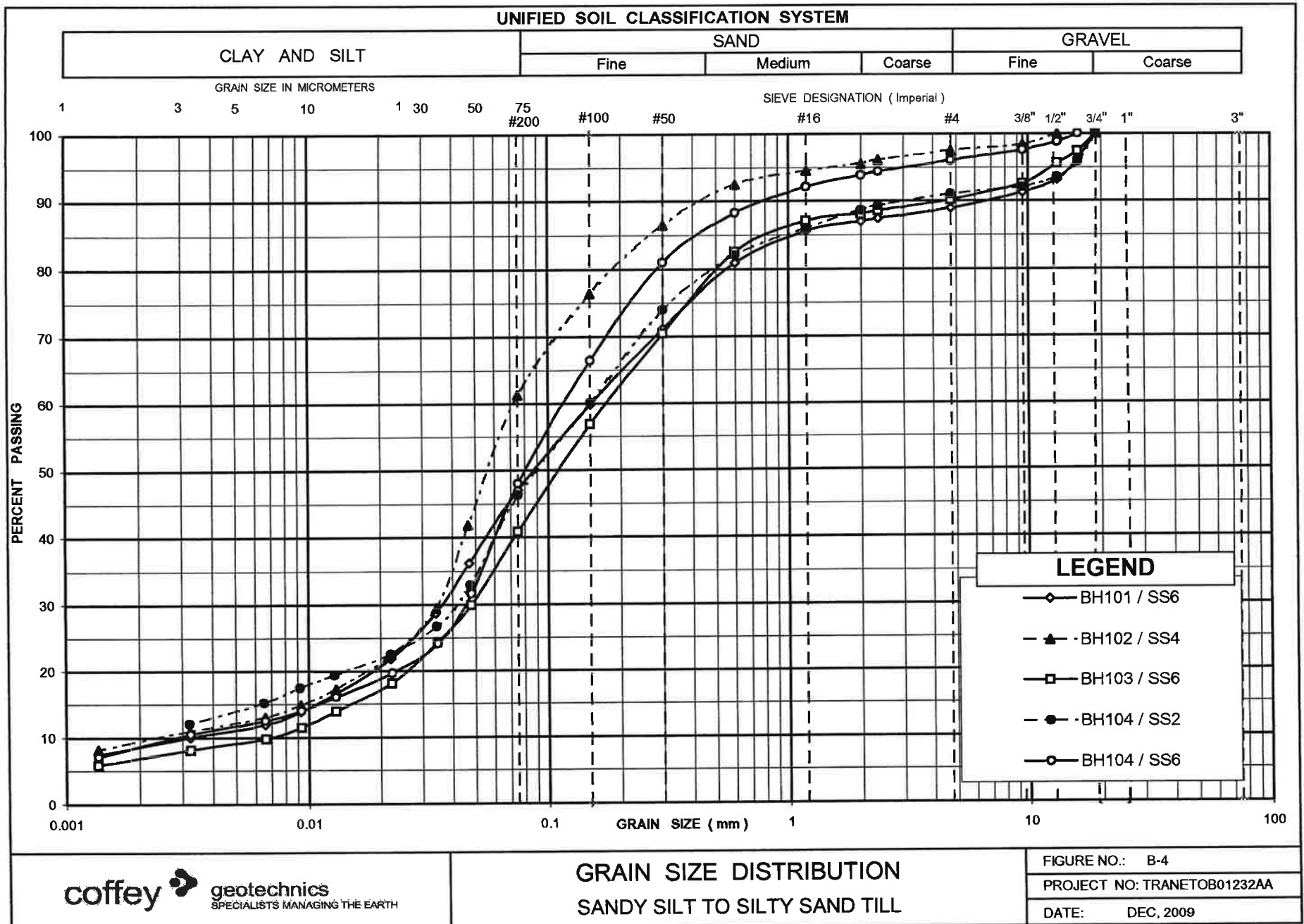
## Test Results

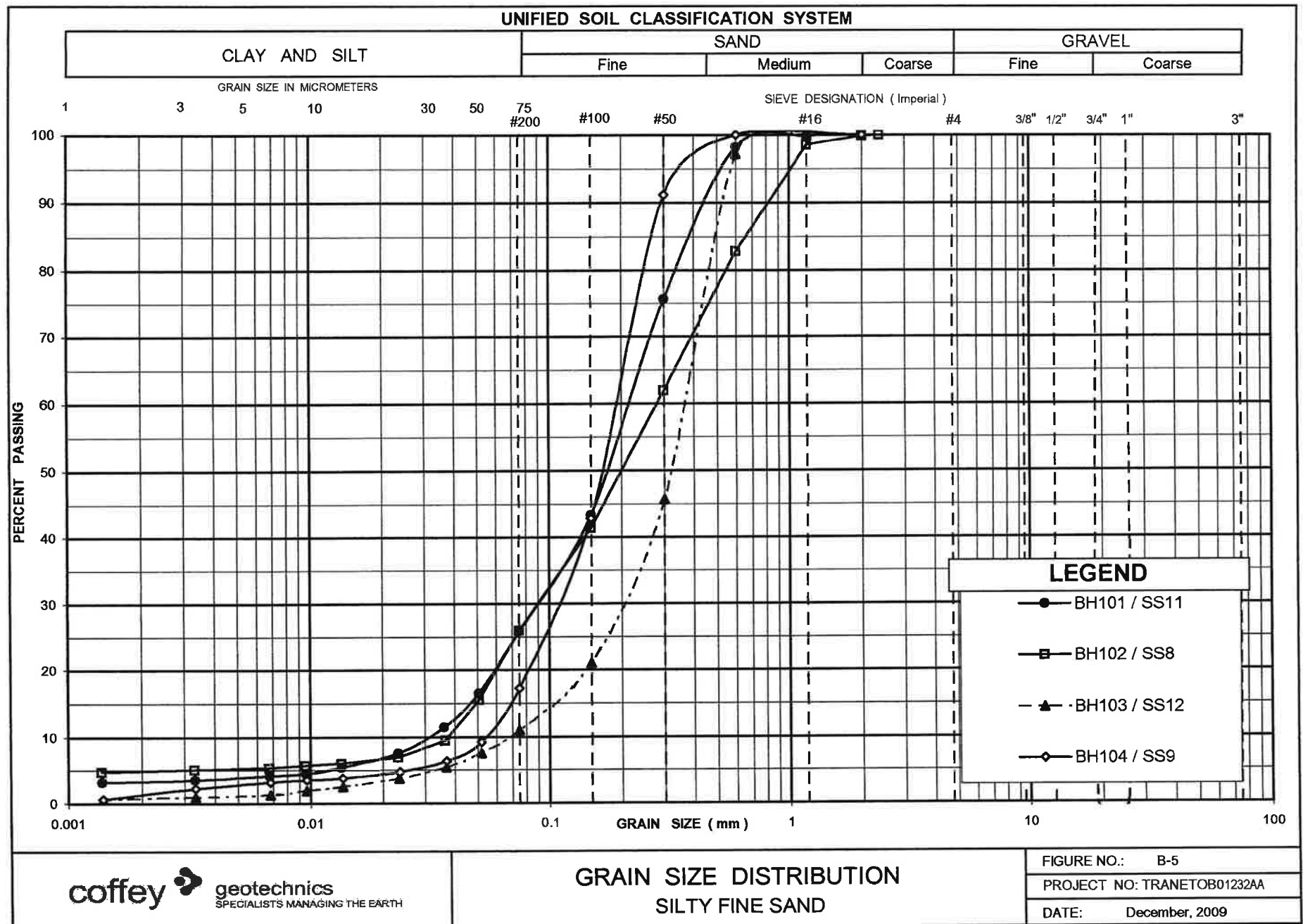












# Appendix C

## **Site Photographs**



Photograph 1. Retaining wall at the existing culvert inlet and embankment



Photograph 2. Existing culvert inlet and concrete slab





Photograph 3. Mosley Street Culvert (South End), Looking Towards South



Photograph 4. Mosley Street Culvert (South End), Looking Towards East

# Appendix D

**Golder Associates Foundation Investigation Report**

#### **4.1.4 Mosley Street Culvert**

##### Topsoil and Fill

Borehole 7, drilled near the southeast end of the existing Mosley Street culvert, encountered 230 millimetres of silty topsoil over 0.7 metres of loose sandy silt fill materials. The fill had a standard penetration test N value of 8 blows per 300 millimetres penetration and the water content of the fill sample collected from the borehole was about 7 per cent.

Borehole 8 was drilled at the edge of Airport Road near the southwest end of the existing Mosley Street culvert and encountered 25 millimetres of sand over a 25 millimetre thick layer of asphalt. The asphalt was underlain by 510 millimetres of sand and gravel roadbase.

##### Silty Clay

Borehole 7 encountered a deposit of stiff silty clay beneath the fill materials at elevation 182.8 metres. The deposit was about 0.9 metres thick and contained varying amounts of sand and gravel. The silty clay deposit had standard penetration test N values of 8 and 11 blows per 300 millimetres penetration and water contents of about 22 to 29 per cent.

##### Sandy Silt Till

Beneath the silty clay in borehole 7 and the roadbase materials in borehole 8, a deposit of compact to very dense sandy silt till was encountered at elevations 181.9 to 183.9 metres. The till deposit was about 2.6 to 4.6 metres thick and extended to between elevations 183.9 and 179.3 metres. A 0.3 metre thick layer of silty fine sand material was encountered within the till in both boreholes. The till had standard penetration test N values between 11 blows per 300 millimetres penetration and 100 blows per 225 millimetres penetration. The water contents of the till samples collected from the boreholes were between about 4 and 6 per cent, with an average of about 10 per cent.

Figure A-3 in Appendix A shows gradation curves for samples recovered from the sandy silt till deposit in boreholes 7 and 8. The deposit consists mainly of sand and silt size material with a trace of gravel and clay size particles. Cobbles and boulders should be expected in the till.

##### Sandy Silt

A 0.8 metre thick pocket of dense sandy silt was encountered beneath the till deposit in borehole 7. The sandy silt pocket had a standard penetration test N value of 42 blows per 300 millimetres penetration and a water content of about 19 per cent.

### Sands

Layers of very dense silty fine sand were encountered within and beneath the till deposit in boreholes 7 and 8. Where fully penetrated, the sand layers were between 0.3 and 2.0 metres thick. Borehole 7 was terminated in the sand deposit at a depth of 7.3 metres, or elevation 176.4 metres, after exploring it for some 2.1 metres. The sand layers had standard penetration test N values of 39 blows per 300 millimetres penetration to 100 blows per 225 millimetres penetration. The water contents of the sand samples ranged between about 7 and 24 per cent, with an average of about 16 per cent.

Figure A-4 in Appendix A shows a gradation curve for a sample recovered from the sand deposit in borehole 7.

A 2 metre thick layer of fine to medium sand was encountered beneath the sandy silt till at elevation 179.3 metres with borehole 8. The sand had standard penetration test N values of 53 and 89 blows per 300 millimetres and water contents of 7 to 18 per cent.

### Silt

Borehole 8 encountered and was terminated in a silt deposit. The deposit was explored for 0.1 metres before terminating the borehole at a depth of 7.3 metres below ground surface, or elevation 177.2 metres. The silt had a standard penetration test N value of 42 blows per 300 millimetres penetration and a water content of about 10 per cent.

## **4.2 Groundwater Conditions**

Water levels were noted in the open boreholes during drilling and piezometers were installed in selected boreholes upon completion of the drilling operations. The water levels encountered in the boreholes during drilling and measured in August 2002 and July and August 2003 are summarized in the following table together with the relevant surface water elevation at the existing Service Road and Mosley Street culverts. There are no existing water courses at the other two culvert locations and it should be noted that the groundwater levels are subject to seasonal fluctuations.



BOREHOLE	GROUND	SURFACE	ENCOUNTERED	<u>MEASURED GROUNDWATER ELEVATION (m)</u>				
	SURFACE	WATER	GROUNDWATER	2002		2003		
	<u>ELEVATION</u>	<u>ELEVATION</u>	<u>ELEVATION</u>	<u>August 22</u>	<u>August 27</u>	<u>July 14</u>	<u>July 17</u>	<u>August 20</u>
	(m)	(m)	(m)					
Service Road								
1	194.31	191.47	Dry	185.47	189.86	-	-	190.41
2	193.77		Dry	-	-	-	-	-
28+420								
3	190.37	N/A*	183.36	182.69	182.45	-	-	-
4	190.38		181.85	182.91	182.88	-	-	-
28+050								
5	188.75	N/A*	180.22	-	181.37	-	-	181.50
6	188.95		181.74	-	-	-	-	181.33
Mosley Street								
7	183.69	180.77	179.12	-	-	178.81	178.81	178.72
8	184.47		179.14	-	-	178.89	178.89	178.56

\* No existing channel at proposed culvert location.

# 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 STRUCTURAL FEATURES AND/OR STRENGTH.

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

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

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

**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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$c_c$	1	COMPRESSION INDEX
$c_s$	1	SWELLING INDEX
$c_a$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $c_u / \tau_r$

## PHYSICAL PROPERTIES OF SOIL

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