

**FOUNDATION INVESTIGATION REPORT  
CLOUD RIVER CULVERT REPLACEMENT  
HIGHWAY 61  
CLOUD BAY COMMUNITY, NEEBING MUNICIPALITY  
DISTRICT OF THUNDER BAY, ONTARIO**

**G.W.P. 6936-10-00, SITE No. 48W/184C**

**Geocres Number: 52A-156**

**Report to**

**Hatch Mott MacDonald**

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the location of a replacement culvert that will carry Highway 61 over the Cloud River in the Cloud Bay Community in the District of Thunder Bay, Ontario.

The purpose of this 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, a stratigraphic profile, 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 Hatch Mott MacDonald, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0010.

**2 SITE DESCRIPTION**

The Cloud River culvert is located on Highway 61, between Cloud River Road and Little Trout Bay Road in the Cloud Bay Community, Neebing Municipality in the District of Thunder Bay, Ontario. The site is approximately 40 km south of Thunder Bay, Ontario.

The existing Cloud River culvert is a one-cell concrete box culvert. The length and width of the culvert are 46.1 m and 6.1 m, respectively. The water flows through the culvert from west to east. Part of a previously abandoned culvert exists just to the south of the existing culvert. The length of the abandoned culvert has not been confirmed.

The surrounding lands are undeveloped and heavily treed. A few residential dwellings are located near the existing culvert on both sides of Highway 61.

Photographs in Appendix C show the general nature of the site and the existing culvert structure.

Photographs 7 and 8 in Appendix C indicate presence of rock fill on the side slopes of the highway embankments.

The region is characterized by Precambrian meta-volcanic and meta-sedimentary rocks intruded by later stage mafic dikes. At this site, the native soils primarily consist of silts and clays.

### **3 SITE INVESTIGATION AND FIELD TESTING**

The original scope of work consisted of drilling four boreholes along the existing culvert alignment, two boreholes on Highway 61 lanes/shoulder and two boreholes near the inlet and outlet of the existing culvert. However, due to existing site conditions (steep and heavily treed embankment slopes below the highway and presence of standing water near the embankment toes, it was not possible to drill the boreholes at the ends of the existing culvert. Therefore, only two boreholes were drilled at this site, both through the shoulders of Highway 61.

The site investigation and field testing for this project was carried out on October 13 to 16, 2011 and consisted of drilling and sampling two boreholes (identified as CLD-02 and CLC-03), the locations of which are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

Boreholes CLD-02 and CLD-03 were drilled and sampled to 26.5 m depth (elevations 180.3 to 181.0). A Dynamic Cone Penetration Test (DCPT) was conducted below borehole termination in each borehole. The DCPTs were terminated upon refusal at depths of 33.5 m and 33.8 m (elevations 173.3 and 173.7) in Boreholes CLD-02 and CLD-03, respectively.

Subsequently, on March 28 and 29, 2012, at the request of MTO and Hatch Mott McDonald, three more boreholes (numbered 01 to 03) were drilled at this site to investigate for obstructions in the ground that would indicate the presence of the abandoned culvert which could impede the installation of sheet piles. The three boreholes were drilled between the existing and the abandoned culverts, 2.0 m south of the proposed south sheet pile wall. Boreholes 01 to 03 were augered to depths ranging from 12.2 m to 15.2 m (elevations 191.8 to 195.0). No sampling or laboratory testing were conducted on the 3 boreholes.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

Borehole locations were selected and established in the field by Thurber Engineering Ltd. Surveyors retained by Hatch Mott MacDonald provided site contour drawings from which the co-ordinates and the ground surface elevations for the boreholes were estimated. Boreholes 01 to 03 were marked on site by the surveyors.

Drilling on the highway shoulders was carried out using a truck-mounted CME 75 drill rig and the boreholes were advanced with hollow-stem augers and casing techniques. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the embankment fill and native soils.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. A standpipe piezometer consisting of 19 mm PVC pipe with slotted screen was installed in Borehole CLD-03 and enclosed in filter sand to permit longer term groundwater level monitoring. The boreholes were backfilled with bentonite holeplug in general accordance with O.Reg. 903 upon completion. The location and completion details of the piezometer and boreholes are shown in Table 3.1.

**Table 3.1 – Borehole Abandonment Details**

<b>Foundation Unit</b>	<b>Borehole</b>	<b>Piezometer Tip Depth/ Elevation (m)</b>	<b>Abandonment Details</b>
North wall	CLD-02	None installed	Borehole backfilled with holeplug to 3.7 m, sand and gravel to 0.1 m, then asphalt to surface.
South wall	CLD-03	25.5/182.0	Sand from 25.5 m to 22.0 m, holeplug from 22.0 m to 4.3 m, auger cuttings from 4.3 m to 0.3 m, sand from 0.3 m to 0.15 m, then asphalt to surface.

#### **4 LABORATORY TESTING**

All recovered soil samples were subjected to Visual Identification (VI) and natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are summarized on the Record of Borehole sheets included in Appendix A and on the figures presented in Appendix B.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the "Borehole Locations and Soil Strata" drawing included in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

In general terms, the soil stratigraphy encountered at this site consists of pavement structure overlying sand and gravel fill and silty clay fill. A layer of native sand and silt was contacted below the silty clay fill in one borehole. A native deposit of silt was contacted below the silty clay fill and the native sand and silt. Silty clay was encountered below the silt. DCPT were terminated upon refusal at 33.5 m and 33.8 m depth (elevations 174.0 and 173.7).

### **5.1 Pavement structure**

Pavement structure was encountered in the two boreholes drilled through the existing Highway 61 shoulders. The pavement structure in the shoulders consists of approximately 40 mm to 50 mm of asphalt overlying granular fill.

### **5.2 Sand Fill**

Brown sand fill containing some gravel was contacted below the pavement structure in both boreholes. The thickness of the fill was 1.3 m and 2.0 m in Boreholes CLD-02 and CLD-03, respectively.

The depths to the base of the sand fill were 1.3 m and 2.0 m (elevation 205.5).

SPT N-values recorded in the sand fill ranged from 6 to 21 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The moisture content of the sand and gravel fill ranged from 5% to 19%.

As indicated earlier, rockfill is visible on the side slopes of the highway embankments. It is not confirmed if this rockfill is for erosion protection purposes or whether the existing embankment contains rockfill. No boreholes were drilled in these areas, where rockfill is visible in the sideslopes. It must be recognized that embankments fills are heterogeneous in nature and may contain obstructions such as boulders or rockfill.

### **5.3 Silty Clay Fill**

Reddish brown silty clay fill containing some sand to sandy and trace gravel and occasional cobbles was contacted below the sand fill in both boreholes. The thickness of the silty clay fill was in the two boreholes were 6.5 m and 7.7 m.

The depth to the base of the silty clay fill was 7.8 m and 9.7 m (elevations 199.0 and 197.8) in Boreholes CLD-02 and CLD-03, respectively.

SPT N-values recorded in the silty clay fill were 2 to 12 blows per 0.3 m of penetration, indicating a soft to stiff consistency.

The moisture content of the silty clay fill samples ranged from 20% to 41%.

Grain size distribution curves for selected silty clay fill samples are presented in Appendix B, Figure B1. The results are also summarized on the Record of Borehole sheets included

in Appendix A. Atterberg Limit test results are presented in Figures B5 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	1
Sand	14 to 25
Silt	37 to 41
Clay	33 to 48

Index Property	Percentage (%)
Liquid Limit	42 to 48
Plastic Limit	20 to 21

The above results show that the silty clay fill is of medium plasticity with a group symbol of CI.

#### 5.4 Sand and Silt

Native grey sand and silt containing some clay, trace gravel and occasional wood fibres was contacted below the silty clay fill at 7.8 m depth (elevation 199.0) in Borehole CLD-02.

The depth to the base of the sand and silt was 9.4 m (elevation 197.4). The layer is 1.6 m in thickness.

SPT N-values recorded in the sand and silt were 11 and 21 blows per 0.3 m of penetration, indicating compact relative density.

The moisture content of the sand and silt was 36%.

Grain size distribution curve for a sand and silt sample is presented in Appendix B, Figure B2. The results are also summarized on the Record of Borehole sheets included in Appendix A. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	3
Sand	44
Silt	43
Clay	10

#### 5.5 Silt

Grey silt containing trace clay to clayey, trace sand, trace gravel and occasional cobbles and wood fibres was contacted below the native sand and silt layer at 9.4 m depth (elevation 197.4) in Borehole CLD-02 and below the silty clay fill at 9.7 m depth

(elevation 197.8) in Borehole CLD-03. The thickness of the silt layer was 11.6 m and 11.9 m in Boreholes CLD-02 and CLD-03, respectively.

The depth to the base of the silt layer was 21.0 m and 21.6 m (elevations 185.8 and 185.9) in Boreholes CLD-02 and CLD-03, respectively.

SPT N-values recorded in the silt ranged from 0 to 16 blows for 0.3 m of penetration, indicating a very loose to compact relative density.

The moisture content of samples collected from the silt layer generally varies between 21% and 36%.

Grain size distribution curves for selected silt samples are presented in Appendix B, Figure B3. The results are also summarized on the Record of Borehole sheets included in Appendix A. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	0 to 1
Sand	0 to 9
Silt	79 to 92
Clay	8 to 21

## 5.6 Silty Clay

Native reddish brown silty clay containing trace sand was encountered below the silt at 21.0 m and 21.6 m depth (elevations 185.8 and 185.9) in both boreholes.

Boreholes CLD-02 and CLD-03 were both terminated within the silty clay layer at 26.5 m depth (elevations 181.0).

DCPTs were conducted below borehole termination depths and extended to refusal encountered at 33.5 m and 33.8 m depth (elevations 173.3 and 173.7) in Boreholes CLD-02 and CLD-03, respectively.

SPT 'N' values recorded in the silty clay ranged from 2 to 6 blows for 0.3 m of penetration, indicating a very soft to firm consistency.

The moisture content of samples collected from the silty clay layer generally varies between 21% and 43%.

Grain size distribution curves for selected silty clay samples are presented in Appendix B, Figures B4. The results are also summarized on the Record of Borehole sheets included in Appendix A. Atterberg Limits test results are presented in Figures B6 of Appendix B. The results of the laboratory tests are summarized as follows:



Soil Particles	Percentage (%)
Gravel	0
Sand	0
Silt	52
Clay	48

Index Property	Percentage (%)
Liquid Limit	43
Plastic Limit	19

The above results show that the silty clay is of medium plasticity with a group symbol of CI.

### 5.7 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole CLD-03 to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.1, along with the measurements in the boreholes upon completion of drilling.

**Table 5.1 – Water Level Measurements**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
CLD-02	October 16, 2011	8.2	198.6	Open borehole
CLD-03	November 30, 2011	4.8	202.7	Piezometer
	March 28, 2012	5.1	202.4	

Piezometric reading indicates that the water level at this site varies from 4.8 m to 5.1 m below the top of highway embankment, at elevations 202.7 to 202.4.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

Information provided by Hatch Mott MacDonald indicates that the water level along the edge of the river was near elevation 199.5 when the site was surveyed.

### **5.8 Boreholes drilled to investigate the presence of obstructions near proposed sheet piles**

Boreholes 01 to 03 were drilled on the south side of the proposed culvert, to determine if there are any obstructions that would indicate the presence of the abandoned culvert which could impede the installation of the sheet piles.

The borehole locations were positioned on site by surveyors approximately 2.0 m south of the proposed south sheet pile wall.

A review of the Boreholes 01 to 03 indicates that, with the exception of some grinding of drill augers at 1.8 m and 2.1 m depth in Boreholes 02 and 03, no major obstructions were noted during drilling the boreholes to depths of 12.2 m to 15.2 m (elevations 191.8 to 195.0.).

## **6 MISCELLANEOUS**

Borehole locations were selected and established in the field by Thurber Engineering Ltd. Surveyors retained by Hatch Mott MacDonald provided site contour drawings so that the co-ordinates and the ground surface elevations for the boreholes may be estimated from the contour drawings. Boreholes 01 to 03 were established on site by surveyors.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a truck mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The field program was supervised by Ms. Eckie Siu of Thurber.

Overall supervision of the field program was conducted by Mr. Mark Farrant, P. Eng. Interpretation of the data and preparation of the report were carried out by Ms. R. Palomeque Reyna, P.Eng.

The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd



Rocío Palomeque Reyna, P.Eng.  
Geotechnical Engineer



P. K. Chatterji, P.Eng.  
Review Principal

## **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 <sup>(1)</sup> '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

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

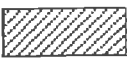




 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (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 (MPa)	Field Estimation of Hardness*
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	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	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m			
Very thinly bedded	20 to 60mm	Strong	50-100	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	Breaks under single blow of geological hammer.
<u>TERMS</u>		Weak	5.0 to 25.0	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	Indented by thumbnail
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 CLD-02

1 OF 4

METRIC

W.P. 6936-10-00 LOCATION Cloud River Culvert ORIGINATED BY ES  
HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
DATUM Geodetic DATE 2011.10.15 - 2011.10.16 CHECKED BY RPR

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 <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   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE							w <sub>p</sub> w   w <sub>L</sub>		
206.8							20	40	60	80	100	20	40	60			
0.8	ASPHALT: (40mm)																
	SAND, some gravel Loose Brown Moist (FILL)		1	GS													
			1	SS	8												
205.5																	
1.3	Silty CLAY, some sand, trace gravel, occasional cobbles Stiff to Soft Reddish Brown (FILL)		2	SS	11												
			3	SS	2												
		4	SS	2													

Continued Next Page

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

20  
15 10 5  
(%) STRAIN AT FAILURE



## METRIC

[illegible]

(%) STRAIN AT FAILURE

## METRIC

[illegible]

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

RECORD OF BOREHOLE No CLD-02

4 OF 4

METRIC

W.P. 6936-10-00 LOCATION Cloud River Culvert ORIGINATED BY ES  
 HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.15 - 2011.10.16 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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	Wp W WL	20 40 60			
	Continued From Previous Page												
173.3													
33.5	END OF DCPT AT 33.5m UPON REFUSAL. WATER LEVEL AT 8.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 3.7m, SAND AND GRAVEL TO 0.1m THEN ASPHALT TO SURFACE.												

ONTMT4S 5121.GPJ 5/8/12

# RECORD OF BOREHOLE No CLD-03

1 OF 4

METRIC

W.P. 6936-10-00 LOCATION Cloud River Culvert ORIGINATED BY ES  
HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.10.13 - 2011.11.15 CHECKED BY RPR

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 (%)					
207.5	ASPHALT: (50mm)		1	GS										
	SAND, some gravel Compact to Loose Brown Damp (FILL)		1	SS	21									
205.5			2	SS	6									
2.0	Silty CLAY, some sand to sandy, trace gravel Firm Reddish Brown (FILL)		3	SS	4									
	Soft to Firm		4	SS	3									
			5	SS	5									
			6	SS	4									
			7	SS	12									
	Stiff		8	SS	9									
197.8														
9.7	SILT, trace to some clay													

Continued Next Page

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

RECORD OF BOREHOLE No CLD-03

2 OF 4

METRIC

W.P. 6936-10-00 LOCATION Cloud River Culvert ORIGINATED BY ES  
HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.10.13 - 2011.11.15 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ 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 (%)	W <sub>P</sub>	W	W <sub>L</sub>		
	Continued From Previous Page													
	SILT, trace clay Very Loose Grey Wet		9	SS	0									
			10	SS	1									
			11	SS	0									0 0 92 8
			12	SS	3									
	Loose		13	SS	4									
	Compact		14	SS	14									
	Some clay to clayey													

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup> Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

## METRIC

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup> Numbers refer to Sensitivity

RECORD OF BOREHOLE No CLD-03

4 OF 4

METRIC

W.P. 6936-10-00 LOCATION Cloud River Culvert ORIGINATED BY ES  
HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.10.13 - 2011.11.15 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w <sub>p</sub> w w <sub>L</sub> WATER CONTENT (%)	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							
	Continued From Previous Page																	
173.7																		
33.8	<p>END OF DCPT AT 33.8m UPON REFUSAL.</p> <p>Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.</p> <p>WATER LEVEL READINGS:</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH (m)</th> <th>ELEV. (m)</th> </tr> </thead> <tbody> <tr> <td>Nov.30/11</td> <td>4.8</td> <td>202.7</td> </tr> <tr> <td>Mar.28/12</td> <td>5.1</td> <td>202.4</td> </tr> </tbody> </table>	DATE	DEPTH (m)	ELEV. (m)	Nov.30/11	4.8	202.7	Mar.28/12	5.1	202.4								
DATE	DEPTH (m)	ELEV. (m)																
Nov.30/11	4.8	202.7																
Mar.28/12	5.1	202.4																

## METRIC

ONTMT4S 5121.GPJ 5/8/12

[illegible]

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

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No BH-01

2 OF 2

METRIC

W.P. 6936-10-00 LOCATION N 5 330 939.8 E 345 610.3 Cloud River Culvert ORIGINATED BY RK  
 HWY 61 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2012 03 28 - 2012 03 29 CHECKED BY MEF

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 <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		
	Continued From Previous Page															
	No sampling done from 8.2m to 12.2m No obstructions noted															
194.0	Very Loose		3	SS	2											
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, DRY CONCRETE TO 0.15m THEN ASPHALT PATCH TO SURFACE.															

METRIC

W.P.	6936-10-00	LOCATION	N 5 330 939.1 E 345 611.8 Cloud River Culvert	ORIGINATED BY	RK
HWY	61	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012 08 28 - 2012 08 29	CHECKED BY	MEF

[illegible]

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>; Numbers refer to Sensitivity

## METRIC

ELEV DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT  NATURAL MOISTURE CONTENT  LIQUID LIMIT	$w_p \quad w \quad w_L$	UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20    40    60    80   100 20    40    60				GR SA SI LI

[illegible]

## METRIC

[illegible]

RECORD OF BOREHOLE No BH-03

2 OF 2

METRIC

W.P. 6936-10-00 LOCATION N 5 330 938.0 E 345 613.7 Cloud River Culvert ORIGINATED BY RK  
HWY 61 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2012.03.28 - 2012.03.29 CHECKED BY RPR

SOIL PROFILE		SAMPLES				ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100		
	Continued From Previous Page						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE						
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w <sub>p</sub> w w <sub>L</sub>						
							WATER CONTENT (%) 20 40 60						
195.0	No sampling No obstructions noted/encountered					197							
						196							
12.2	END OF BOREHOLE AT 12.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, DRY CONCRETE TO 0.15m THEN COLD PATCH TO SURFACE.												

+ 3, X 3 Numbers refer to Sensitivity

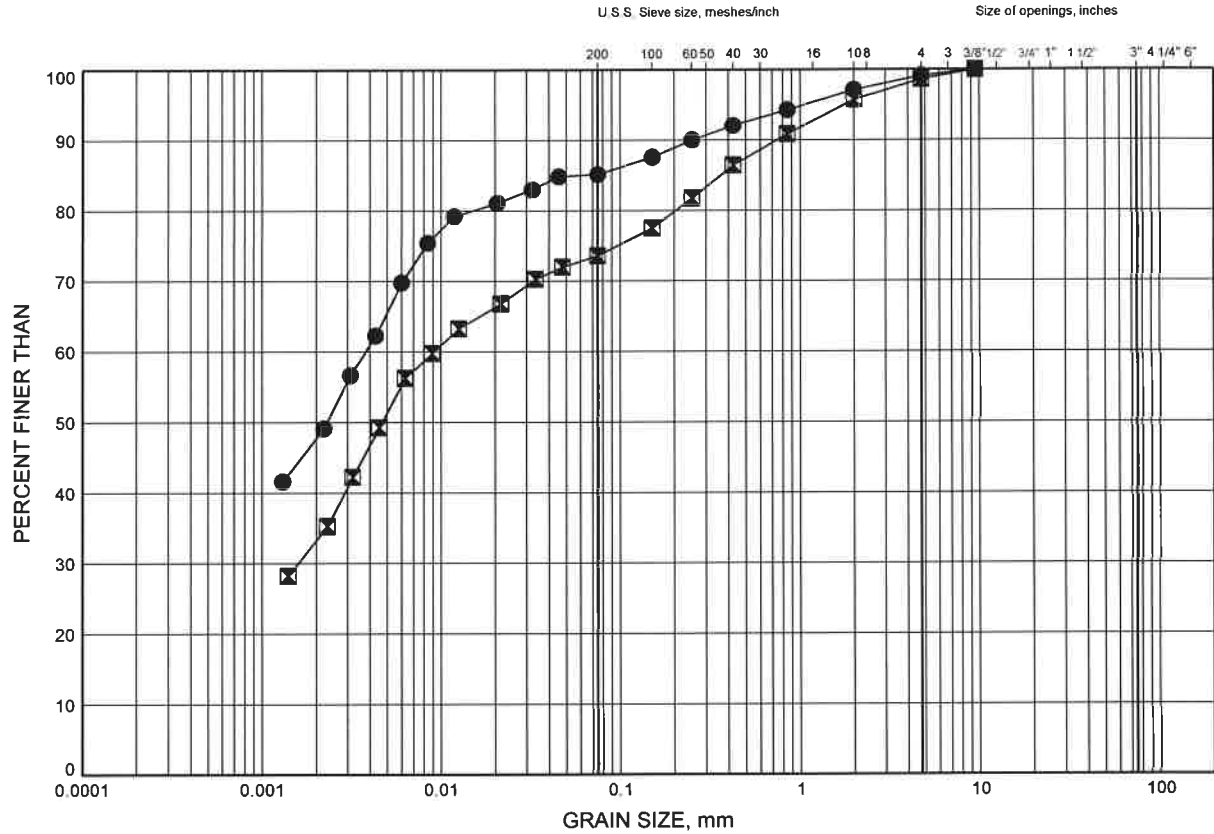
20  
15 10 5 0  
(%) STRAIN AT FAILURE

**Appendix B**  
**Laboratory Test Results**

# Cloud River Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1

## SILTY CLAY FILL



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

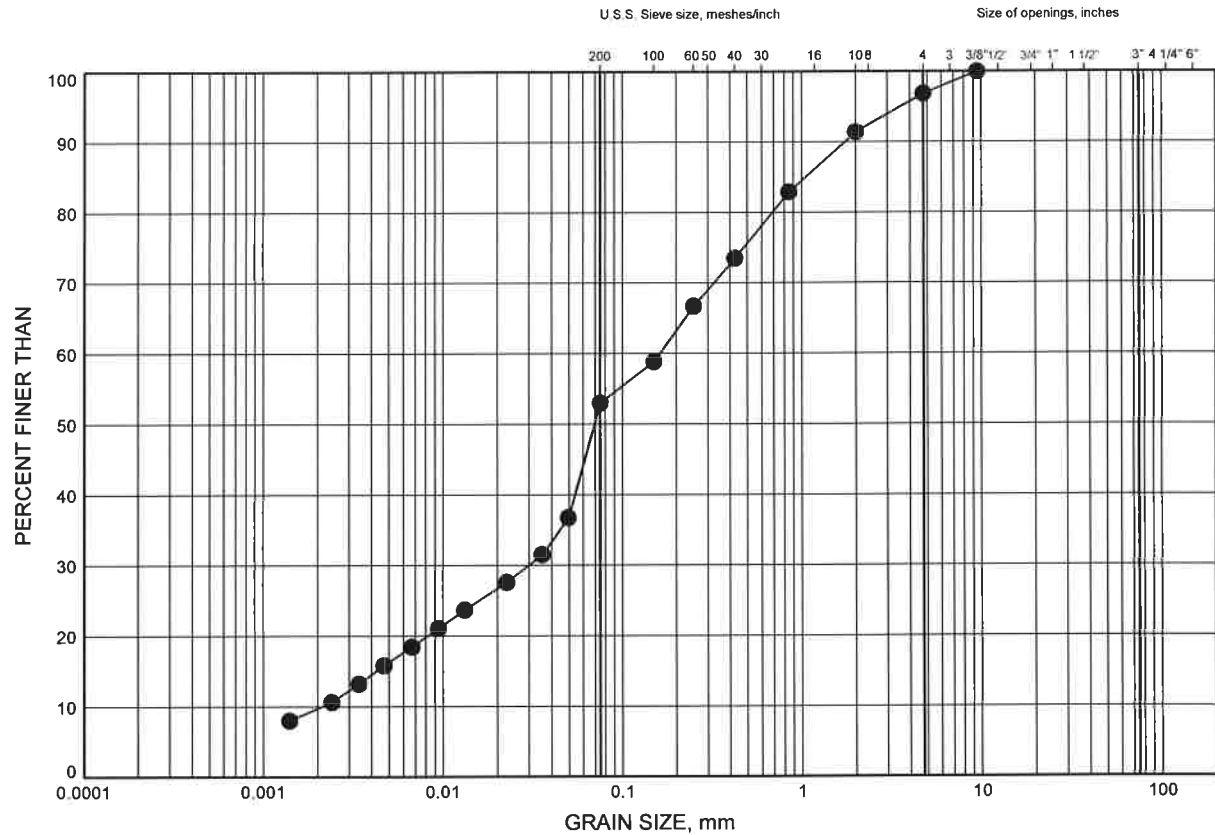
### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLD-02	6.40	200.40
■	CLD-03	2.59	204.91

# Cloud River Culvert GRAIN SIZE DISTRIBUTION

FIGURE B2

## SAND & SILT



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

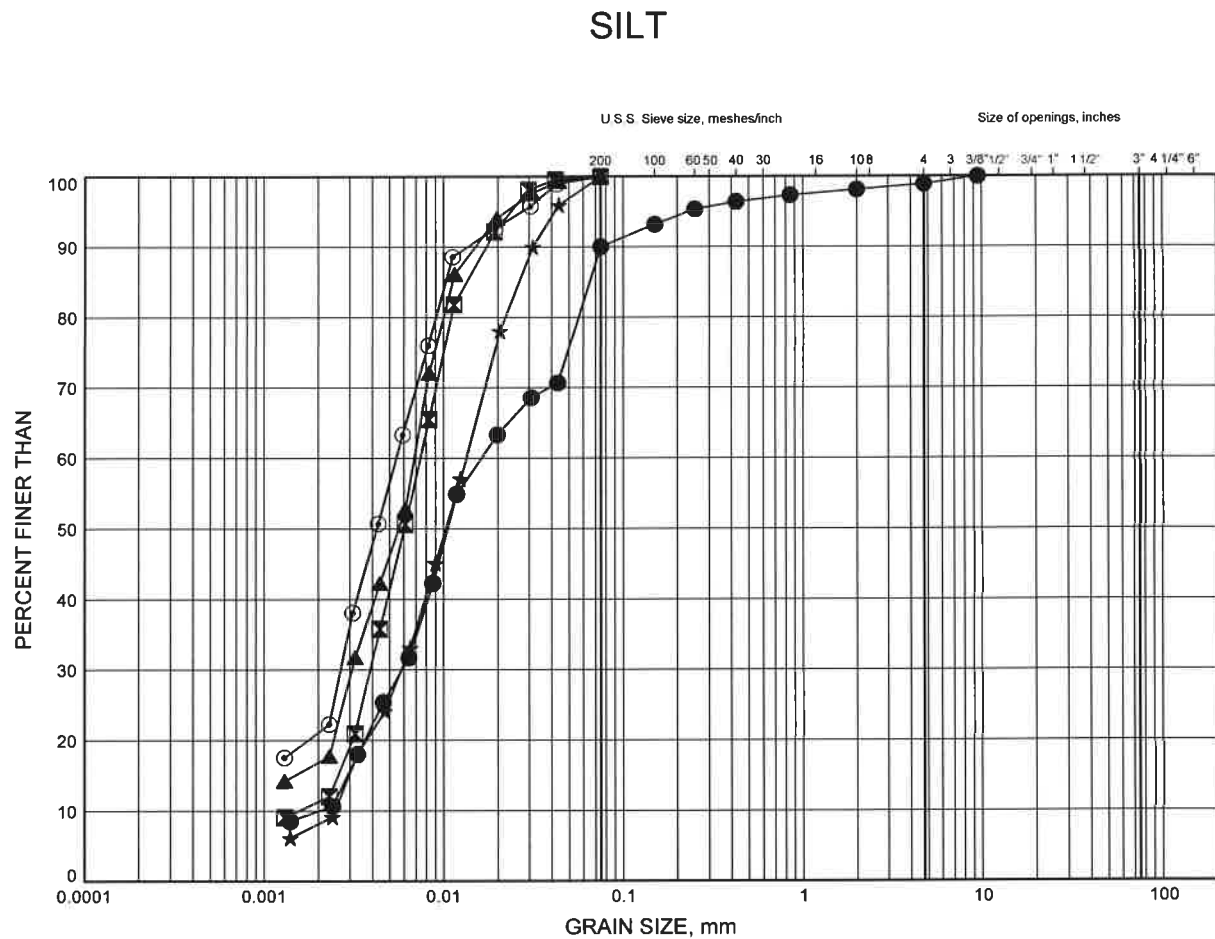
### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLD-02	7.92	198.88



# Cloud River Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3



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

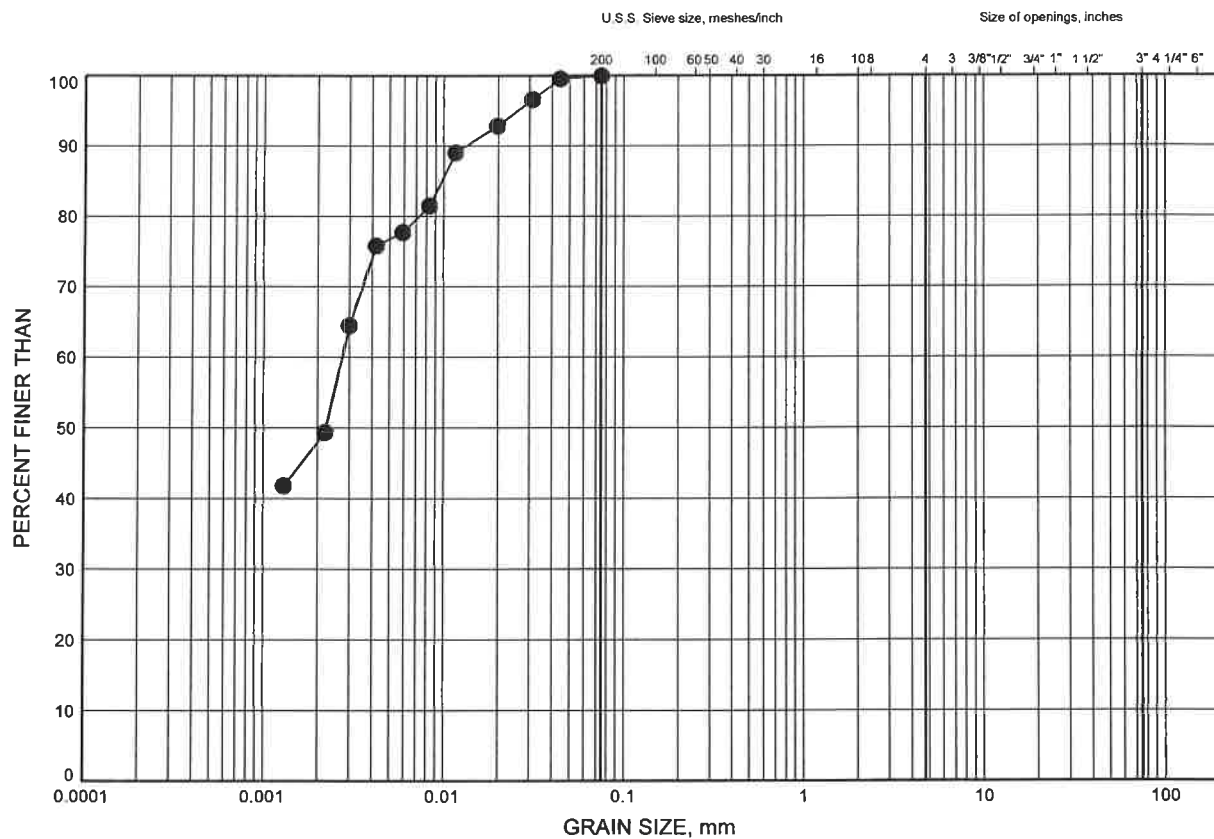
## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLD-02	12.50	194.30
■	CLD-02	15.54	191.26
▲	CLD-02	20.12	186.68
★	CLD-03	14.02	193.48
⊙	CLD-03	20.12	187.38

# Cloud River Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4

## SILTY CLAY



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

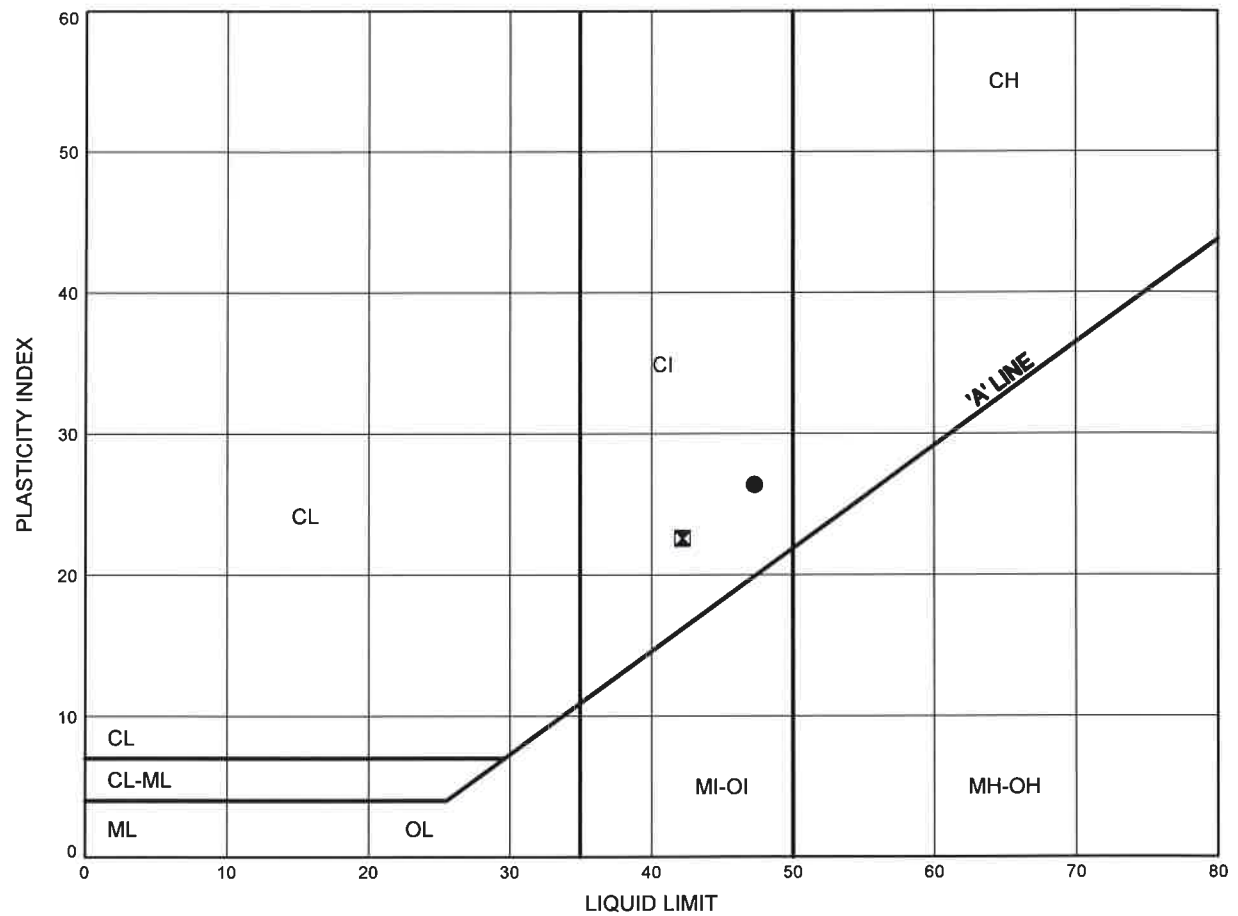
## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLD-03	23.16	184.34

# Cloud River Culvert ATTERBERG LIMITS TEST RESULTS

FIGURE B5

## SILTY CLAY FILL



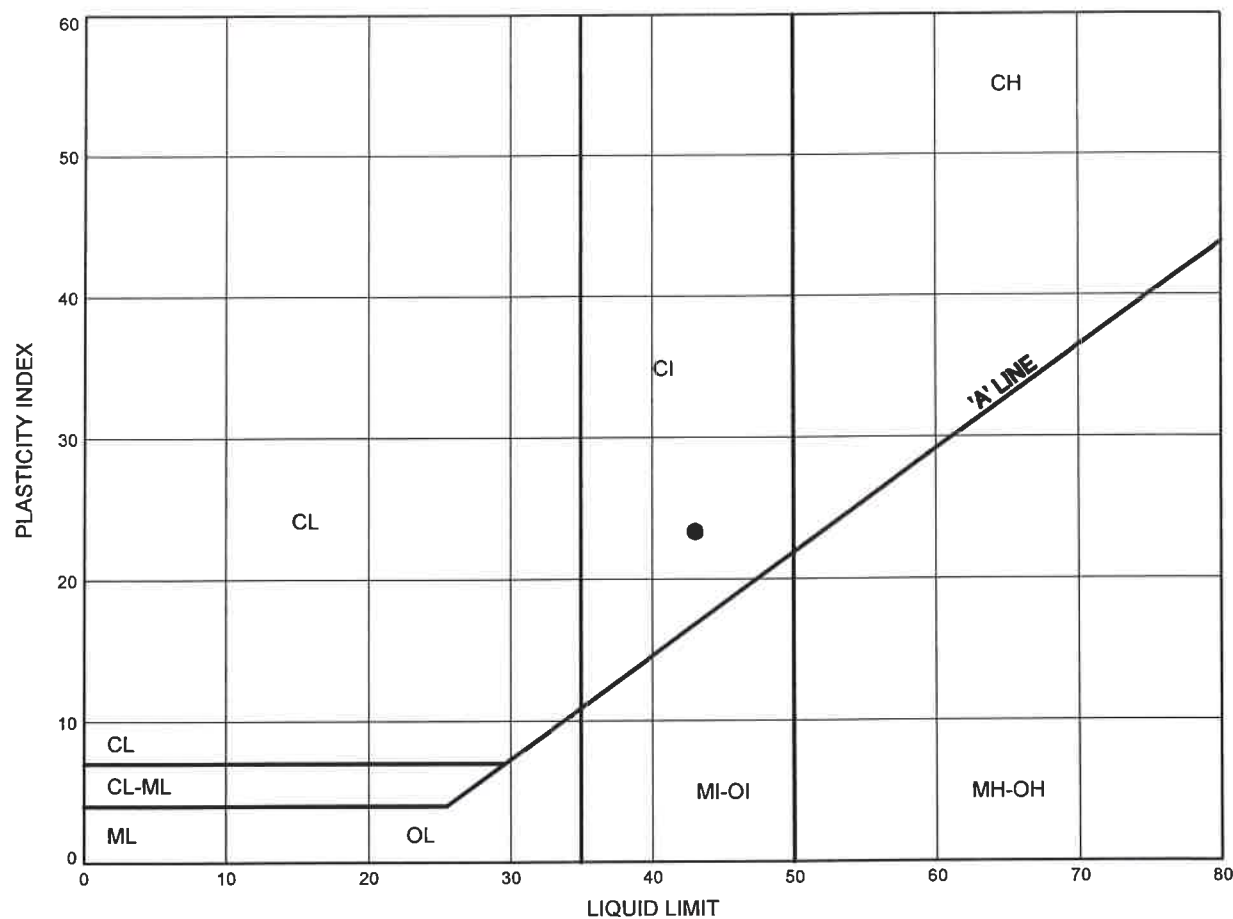
SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CLD-02	6.40	200.40
⊠	CLD-03	2.59	204.91

Cloud River Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE B6

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CLD-03	23.16	184.34



**Appendix C**  
**Site Photographs**



**Photograph 1** – Highway 61 and Cloud River Culvert crossing



**Photograph 2** – Highway 61 west embankment at Cloud River Culvert





**Photograph 3 –** West end Cloud River Culvert - Inlet





**Photographs 4 and 5 – Cloud River**



**Photograph 6 – East end Cloud River Culvert - Outlet**

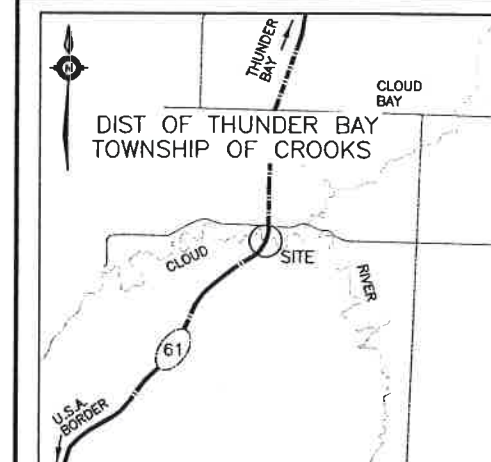




**Photographs 7 and 8 – Highway 61 embankment at Cloud River Culvert**






**Appendix D**  
**Borehole Locations and Soil Strata**





## KEYPLAN

### LEGEND

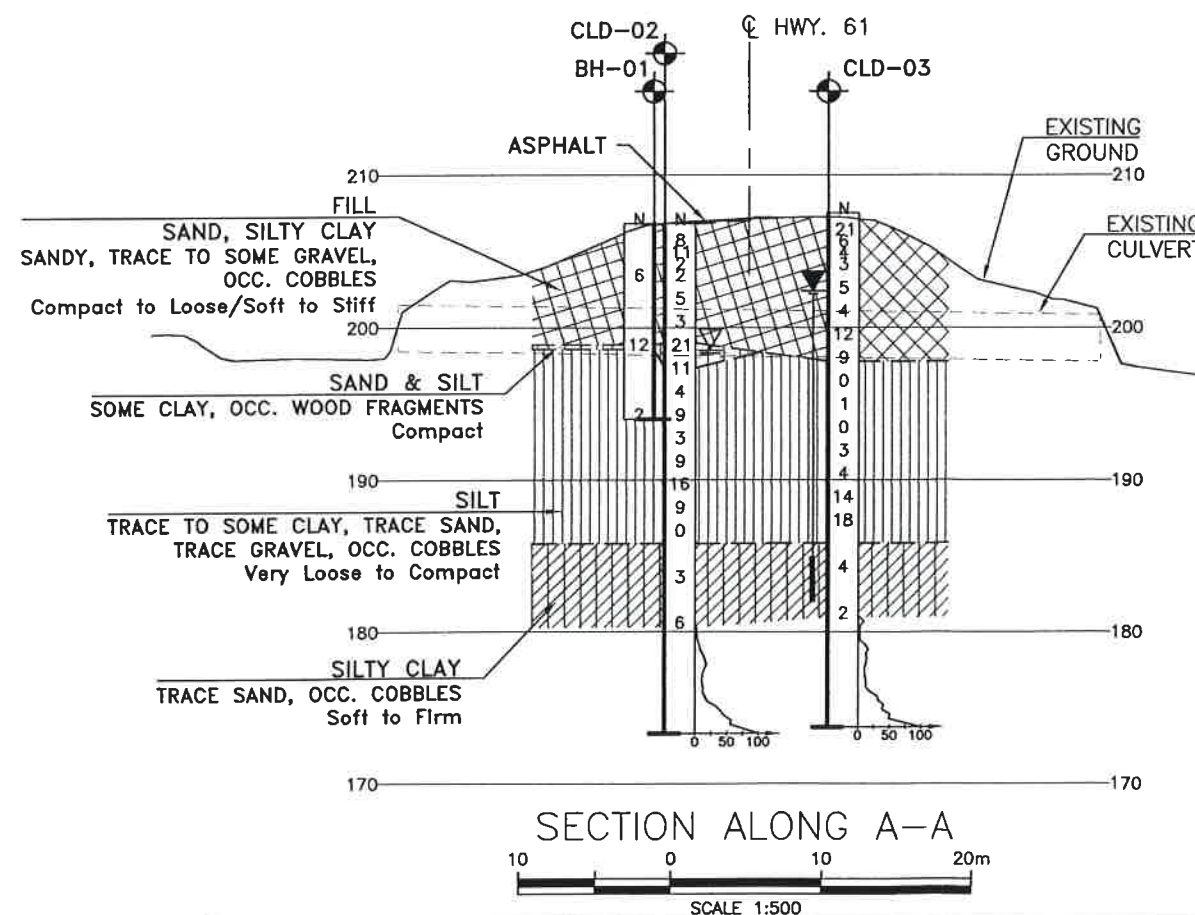
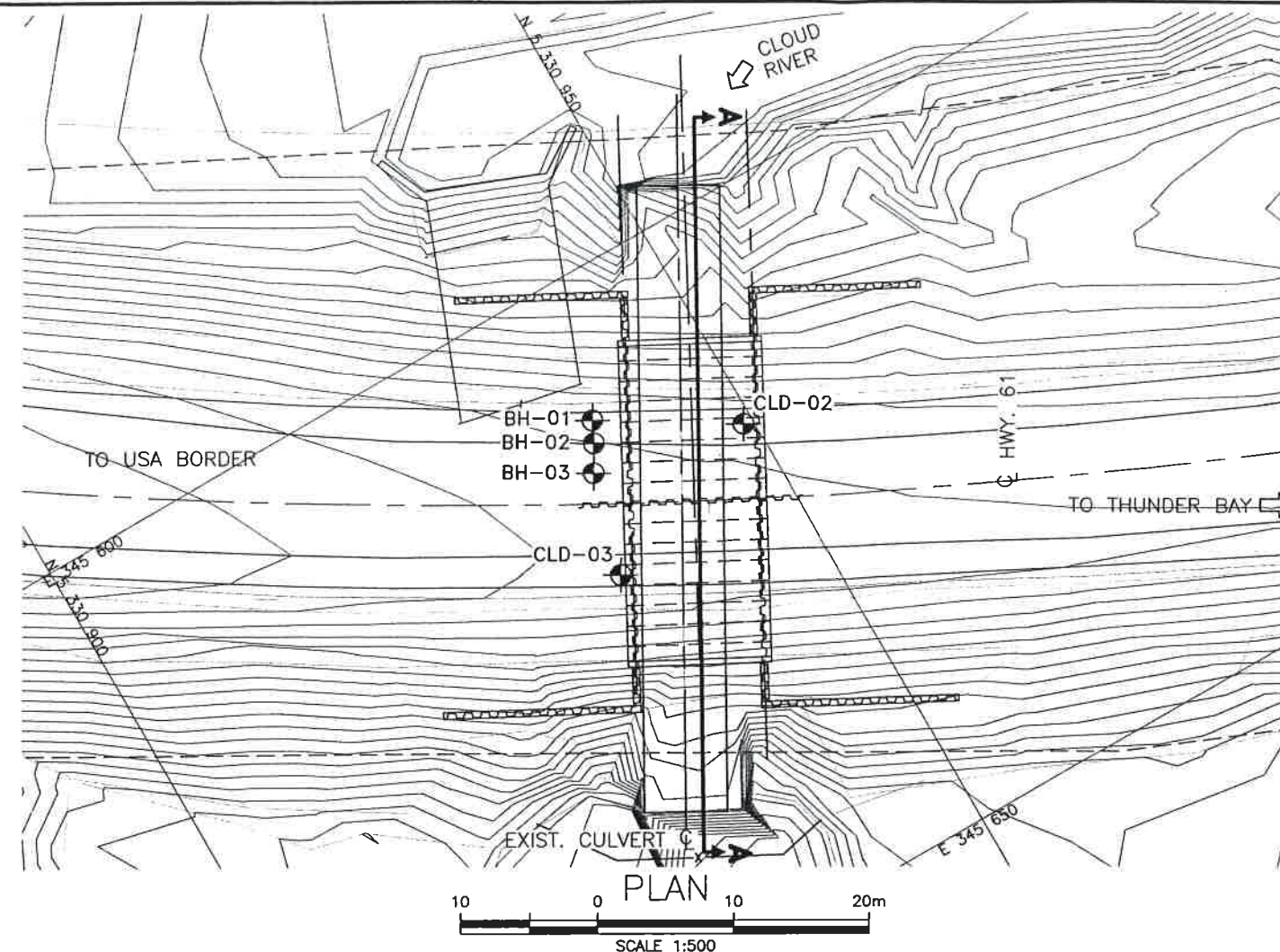
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

**-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. 52A-156



BOREHOLES BH-01 TO BH-03 (AUGER PROBES) WERE DRILLED TO DETERMINE IF ANY OBSTRUCTION (ABANDONED CULVERT) EXISTS IN PROXIMITY TO THE PROPOSED CULVERT. NO SAMPLING WAS CONDUCTED IN THESE BOREHOLES.

[illegible]