

**FOUNDATION INVESTIGATION REPORT
SITE # 1 CULVERT REPLACEMENT
STATION 9+901
TOWNSHIP OF ARRAN
HIGHWAY 21 FROM PORT ELGIN TO ALVANLEY
G.W.P. 3059-10-00**

GEOCRES NO. 41A-235

Submitted

To

Ministry of Transportation Ontario

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PART 1: FACTUAL INFORMATION

1.0 INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the replacement of a culvert at Station 9+901 in the Township of Arran along Highway 21 between Port Elgin and Albanley, Ontario.

The purpose of this investigation was to determine the subsurface conditions at and in close proximity to the proposed culvert location and, based on this data, to provide a borehole location plan, records of boreholes, laboratory test results and a written description of the subsurface conditions. Thurber carried out the investigation under Work Item No. 4 of the MTO Agreement Nos. 3012-E-007 and 3012-E-008.

2.0 SITE DESCRIPTION

Culvert Site 1 is located at Station 9+901 in the Township of Arran, near the intersection of Craig Street and Highway 21. The existing box culvert at the site is approximately 1.7 m wide by 1.4 m high with headwalls that are approximately 2 m high and 8 m long. The culvert appears to have been installed with a bend in the middle as approximately shown on the Borehole Locations and Soil Strata drawing in Appendix D. Photographs of the culvert are presented in Appendix C. The culvert is located below a 5 m high road embankment surrounded by a heavily wooded area. There are houses located east of the culvert and a large pond to the northwest. The site was cleared for drilling investigation with an archaeological study that was carried out between approximate stations 9+850 to 9+960.

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

The scope of the field investigation for Culvert Site 1 consisted of drilling a total of 6 boreholes along two cross-sections located on either side of the culvert. The borehole investigation was carried out between May 20 and 27, 2014. The boreholes are listed as follows:

Table 3.1 Borehole Depths

Site Location	Borehole	Drilling Date	Depth of Sampled Borehole, m (elev)	DCPT Depth m (elev)
Culvert Site 1	BH 1-1	May 26, 2014	2.1 (194.5)	9.3 (187.3)
	BH 1-2	May 21, 2014	14.5 (187.1)	-
	BH 1-3	May 20, 2014	6.1 (189.5)	-
	BH 1-4	May 26, 2014	2.4 (193.7)	6.1 (190)
	BH 1-5	May 21, 2014	15.4 (186.7)	-
	BH 1-6	May 23, 2014	3.0 (193.9)	-

The approximate locations of the above boreholes are shown on the Borehole Locations and Soil Strata Drawing in Appendix D. The investigation was carried out using a D-25 track mounted drill rig and a portable tripod drill supplied and operated by Walker Drilling Limited of Utopia Ontario. The tracked rig was used to drill the boreholes from the highway shoulder, and due to the sloped heavily wooded terrain, the portable drilling equipment was used for the boreholes drilled near the toe of the highway embankment.

Borehole locations were adjusted in the field to account for trees, topography, utilities and waterways. Boreholes 1-1, 1-4 and 1-6 located near the toe of highway embankment and drilled with the portable rig met refusal at depths of 2.1 to 3.0 m. A Dynamic Cone Penetration Test (DCPT) was driven to refusal beyond the sampled depth in BH 1-1 and 1-4 to supplement the borehole data.

In these boreholes, soil drilling was carried out using hollow stem augers and all soil samples were obtained using a 50 mm outside diameter split spoon sampler advanced in accordance with the Standard Penetration Test (SPT). The SPT tests were conducted at selected intervals. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were installed in four selected boreholes for longer term water level

monitoring. The piezometers were subsequently decommissioned in general accordance with MOE Regulation 903. The borehole and piezometer completion details are shown in Table 3.2 below.

Table 3.2 – Borehole Completion Details

Borehole Location	Piezometer Tip Depth / Elevation (m)	Completion Details
BH 1-1	3.5 / 193.1	Borehole backfilled with sand filter from 3.7 m to 1.4 m, then bentonite holeplug to surface.
BH 1-2	14.4 / 187.2	Borehole backfilled with sand filter from 14.5 m to 12.2 m, then bentonite holeplug to surface.
BH 1-3	6.2 / 189.6	Borehole backfilled with sand filter from 6.1 m to 3.8 m, then bentonite holeplug to surface.
BH 1-4	2.1 / 194.0	Borehole backfilled with sand filter from 2.3 m to 0.3 m, then bentonite holeplug to surface.
BH 1-5	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 4.0 m, then bentonite holeplug to surface.
BH 1-6	None Installed	Borehole backfilled with cuttings and bentonite holeplug to surface.

The field work was supervised on a full-time basis by a member of our field staff who located the boreholes in the field, cleared borehole locations of underground utilities, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in appropriately labelled containers and transported back to Thurber's laboratory for further examination and testing. Borehole coordinates were obtained using a Differential GPS Unit and elevations were obtained from cross sections provided by MTO.

3.2 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples. Grain size distribution analysis and Atterberg Limits tests were conducted on selected samples. The laboratory test results are presented on the Record of Borehole sheets in Appendix A and the figures in Appendix B.

4.0 SUBSURFACE STRATIGRAPHY

4.1 General

The detailed subsurface soil, rock and groundwater conditions encountered in all six boreholes are presented on the Records of Boreholes in Appendix A. This section presents a generalized summary of the subsurface conditions encountered in the boreholes. The factual data presented in the Record of Borehole Sheets, however, governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered in the boreholes consist of a mixture of topsoil and silty clay or embankment fill overlying native sand and silt till which are underlain by a refusal layer which may be a layer of boulders or probable bedrock. A Borehole Locations and Soil Strata Drawing is included in Appendix D to illustrate the approximate locations of the six boreholes. Appendix D also contains stratigraphic cross sections perpendicular to the road alignment.

4.1.1 Topsoil

A layer of topsoil mixed with sand and gravel, or silty clay to clayey silt mixed with topsoil and wood fragments was encountered at the ground surface in Boreholes BH 1-1, 1-3 and 1-6. This layer is 600 to 1200 mm thick. Occasional cobbles were also noted within this layer. The elevation of the base of this layer ranges from 194.5 to 195.7 m. Topsoil or soils containing organics are anticipated to exist elsewhere in the vicinity of the site and their thickness will vary between and beyond the borehole locations.

The SPT N-values in the silt and clay mixed with topsoil range from 23 to 74 blows/0.3 m indicating a very stiff to hard consistency. The moisture content of this layer ranged from 32 to 70% with the higher moisture content indicating the presence of organics.

4.1.2 Roadway Embankment Fill

Roadway embankment fill was encountered at the ground surface in Boreholes BH 1-2 and 1-5 which were drilled from the highway platform. BH 1-5 encountered loose sand and gravel with trace silt at the surface with a thickness of 0.7 m (base elevation 201.4). At the surface of BH 1-2

and below the loose sand fill in BH 1-5, silty sand fill with trace to some gravel and trace to some clay was encountered. The thickness of the silty sand fill ranged between 4.2 m and 4.5 m (base elevation from 197.1 to 197.2 m). Asphalt fragments and clayey silt seams were noted in BH 1-2. Occasional cobbles and boulders were noted in the fill as well.

The granular fill was typically in a compact to dense state as indicated by SPT N-values ranging from 11 blows/0.3 m penetration to 108 blows/0.15 m penetration, except in BH 1-5 where some loose to very loose zones with SPT N-values ranging from 2 to 9 blows/0.3 m were encountered. BH 1-2 encountered a boulder from 3.2 to 3.7 m which led to an SPT N-value of 108 blows/0.3 m. Measured moisture contents of the fill ranged from 2% to 16%.

Grain size distribution analyses were carried out on samples of the cohesionless fill. The results of these analyses are shown on Figures B1 to B2 in Appendix B. The results are also summarized in the tables below.

Soil Particles	%
SAND and GRAVEL Fill	
Gravel	43
Sand	49
Silt and Clay	8
Silty SAND Fill	
Gravel	7 to 14
Sand	42 to 65
Silt	21 to 35
Clay	6 to 16

4.1.3 Sand

A deposit of sand, some silt, and trace clay with trace organic matter was encountered at the surface of BH 1-4. The sand deposit extended to a depth of 1.7 m (Elevation 194.4 m).

Measured SPT N-values within the sand ranged from 8 to 11 blows/0.3 m indicating a loose to compact relative density. Moisture contents of the sand ranged between 10% and 15%.

A grain size distribution analysis was carried out on a sample of the sand deposit. The results of this analysis are presented in Figure B3 in Appendix B.

Soil Particles	%
SAND, some silt	
Gravel	2
Sand	69
Silt	20
Clay	9

4.1.4 Sand and Silt Till

Sand and silt till with some clay, trace to some gravel, frequent cobbles and occasional bedrock fragments was encountered below the fill in BH 1-2 and 1-5, below the surficial clays mixed with topsoil in BH 1-1, 1-3 and 1-6, and below the surficial sand in BH 1-4. Auger drilling and SPT sampling was terminated in this layer at depths ranging from 2.1 m to 15.4 m (Elevations 186.7 to 194.5). Below the base of the sampled boreholes, DCPTs were carried out in BH 1-1 and 1-4 to final depths of 9.3 m (Elev 187.3 m) and 6.1 m (Elev 190.0 m).

Measured SPT N-values within the sand and silt till deposit typically ranged between 6 and 45 blows/ 0.3 m of penetration indicating a loose to dense relative density. The SPT N-values generally indicated that the till is in a compact to dense state. An SPT N-value of 132 blows/0.15 m penetration was encountered at the base of BH 1-5 on probable bedrock or boulders. Measured moisture contents of samples of the till ranged between 8% and 20%.

Grain size distribution analyses were carried out on selected till samples. The results of these analyses are presented in Figures B4 and B5 in Appendix B. One Atterberg limit test was conducted and the results plotted on a plasticity chart shown on Figure B6 in Appendix B. The results are also summarized in the tables below.

Soil Particles	%
SAND and SILT Till	
Gravel	3 to 13
Sand	34 to 44
Silt	37 to 46
Clay	10 to 16

Index Property	%
SAND and SILT Till, with clay	
Liquid Limit	19
Plastic Limit	12
Plasticity Index	7

The above results show that the till is of low plasticity with a group symbol of CL-ML.

It should be noted that glacial tills inherently contains cobbles and boulders.

4.1.5 Refusal Layer

The native soils are underlain by a refusal layer which may indicate the presence of a layer of boulders or probable bedrock. Auger refusal or DCPT refusal was encountered in Boreholes 1-1, 1-2 and 1-5. The following table summarizes the depth to refusal encountered at the borehole locations.

Table 4.1 Depths and Elevations of Auger Refusal

Borehole Number	Depth to Auger Refusal (m)	Top of Auger Refusal Elevation (m)
BH 1-1	9.3	187.3
BH 1-2	14.5	187.1
BH 1-5	15.4	186.7

4.1.6 Groundwater Conditions

Groundwater conditions were observed during and upon completion of drilling. Standpipe piezometers were installed in four of the boreholes. The depths and elevations of water level readings observed in the open boreholes and piezometers are presented in the following table.

Table 4.2 Water Level Readings

Borehole	Installation	Date	Water Level Depth (m)	Water Level Elevation (m)
BH 1-1	Standpipe	May 27, 2014	2.1	194.5
BH 1-2	Standpipe	May 21, 2014	7.5	194.1
BH 1-3	Standpipe	May 23, 2014	0.7	194.9
BH 1-4	Standpipe	May 27, 2014	2.1	194.0
BH 1-5	Open Hole	May 21, 2014	Dry	Dry
BH 1-6	Open Hole	-	-	-

It should be noted that these observed levels are based on short term observations and groundwater levels are subject to seasonal fluctuations and severe climatic events.

5.0 MISCELLANEOUS

The borehole locations were marked in the field by Thurber. Borehole co-ordinates and elevations were measured using a Differential GPS and borehole elevations were obtained from cross section drawings provided by MTO. Thurber obtained utility clearances prior to drilling. Walker Drilling Ltd. supplied the drill rigs and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Alistair Hall of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved Oakville laboratory. Mr. Lukasz Gilarski, P.Eng. directed the field operations and Mr. Lukasz Gilarski, P.Eng. prepared this report.

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

THURBER ENGINEERING LTD.

Lukasz Gilarski, P.Eng.
Geotechnical Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 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.

EXPLANATION OF ROCK LOGGING TERMS




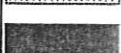
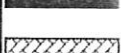
ROCK WEATHERING CLASSIFICATION

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

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
	(MPa)	(psi)	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % 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.

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			

METRIC

[illegible]

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 1-1

2 OF 2

METRIC

W.P. 3059-10-00 LOCATION N 4 931 894.8 E 158 145.9 ORIGINATED BY ADH
 HWY 21 BOREHOLE TYPE Portable Tripod COMPILED BY AN
 DATUM Geodetic DATE 2014.05.26 - 2014.05.27 CHECKED BY LPG

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 (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 27, 14 2.1 194.5																

RECORD OF BOREHOLE No BH 1-2

1 OF 2

METRIC

W.P. 3059-10-00 LOCATION N 4 931 869.6 E 158 143.6 ORIGINATED BY ADH
 HWY 21 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.21 - 2014.05.22 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								20 40 60 80 100								
201.6																
0.0	Silty SAND , trace to some gravel, trace clay Compact Brown Moist (FILL)		1	SS	13											
			2	SS	26											
	With asphalt fragments and clayey silt seams		3	SS	24											
			4	SS	30											
	Occasional cobbles, boulders from 3.2m to 3.7m		5	SS	108/ 0.150											
			6	SS	25											
197.1																
4.5	SAND and SILT , some clay, trace gravel, frequent cobbles, trace rootlets, occasional sand lenses Compact Brown Moist to Wet (TILL)		7	SS	13											
			8	SS	15											
	Loose Becoming wet		9	SS	6											
			10	SS	14											
	Becoming grey															
			11	SS	19											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 1-2

2 OF 2

METRIC

W.P. 3059-10-00 LOCATION N 4 931 869.6 E 158 143.6 ORIGINATED BY ADH
 HWY 21 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.21 - 2014.05.22 CHECKED BY LPG




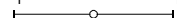
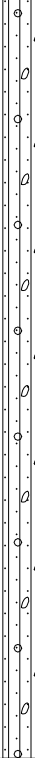
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																	
	Continued From Previous Page						20	40	60	80	100						
187.1	SAND and SILT , some clay, trace gravel, frequent cobbles, trace roots, occasional sand lenses Dense Brown Wet (TILL) <																

RECORD OF BOREHOLE No BH 1-3

1 OF 1

METRIC

W.P. 3059-10-00 LOCATION N 4 931 847.3 E 158 145.9 ORIGINATED BY ADH
 HWY 21 BOREHOLE TYPE Portable Tripod COMPILED BY AN
 DATUM Geodetic DATE 2014.05.20 - 2014.05.20 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)													
195.6	0.0		1	SS	25			20	40	60	80	100		PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	12	34	40	14					
194.5	1.1		2	SS	23																194	193	192	191	190
189.5	6.1		3	SS	33																194	193	192	191	190
			4	SS	7																193	192	191	190	
			5	SS	45																192	191	190		
			6	SS	30																191	190			
			7	SS	43																190				
			8	SS	45																190				
END OF BOREHOLE AT 6.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																									
WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 23, 14 0.7 194.9																									

ONTMT4S 15-64-31.GPJ 2012TEMPLATE(MTO).GDT 7/9/14

RECORD OF BOREHOLE No BH 1-4

1 OF 1

METRIC

W.P. 3059-10-00 LOCATION N 4 931 898.7 E 158 175.7 ORIGINATED BY ADH
 HWY 21 BOREHOLE TYPE Portable Tripod COMPILED BY AN
 DATUM Geodetic DATE 2014.05.26 - 2014.05.26 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)	
196.1 0.0	SAND, some silt, trace clay, trace gravel, trace organic matter Loose to Compact Brown Dry		1	SS	8		196								2	69	20	9
			2	SS	11		195											
194.4								194										
1.7 193.7	SAND and SILT, some clay, some gravel, frequent cobbles Compact Brown Wet (TILL)		3	SS	10		194											
2.4																		
	Start DCPT at 2.4m upon encountering refusal to advance with bi-cone						193											
							192											
							191											
190.0 6.1	END OF DCPT AT 6.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 27, 14 2.1 194.0																	

RECORD OF BOREHOLE No BH 1-5

1 OF 2

METRIC

W.P. 3059-10-00 LOCATION N 4 931 884.8 E 158 173.1 ORIGINATED BY ADH
 HWY 21 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.21 - 2014.05.21 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
202.1													
0.0	SAND and GRAVEL , trace silt Loose Brown Moist (FILL)		1	SS	9		202						43 49 8 (SI+CL)
201.4													
0.7	Silty SAND , trace gravel, some clay Compact to Loose Black to Brown Moist (FILL)		2	SS	11		201						
			3	SS	9		200						
			4	SS	17		199						7 42 35 16
			5	SS	13		198						
	Very Loose		6	SS	2		197						
197.2			7	SS	10		196						
4.9	SAND and SILT , some clay, trace gravel Compact to Dense Brown Moist (TILL)(CL-ML)		8	SS	16		195						3 39 42 16
			9	SS	20		194						
			10	SS	32		193						
			11	SS	21								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC



+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BH 1-6

1 OF 1

METRIC

W.P. 3059-10-00 LOCATION N 4 931 852.4 E 158 165.3 ORIGINATED BY ADH
 HWY 21 BOREHOLE TYPE Portable Tripod COMPILED BY AN
 DATUM Geodetic DATE 2014.05.23 - 2014.05.23 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
196.9	0.0	Clayey SILT , some fibrous organic material, occasional cobble fragments Very Stiff to Hard Brown Saturated		1	SS	23														
195.7	1.2	SAND and SILT , some clay, trace to some gravel Compact Brown Moist (TILL)		2	SS	74														
				3	SS	16														
		Grey		4	SS	14														
193.9	3.0	END OF BOREHOLE AT 3.0m UPON BI-CONE AND SPT REFUSAL ON COBBLES AND BOULDERS. BOREHOLE BACKFILLED WITH CUTTINGS AND BENTONITE HOLEPLUG TO SURFACE.																		

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

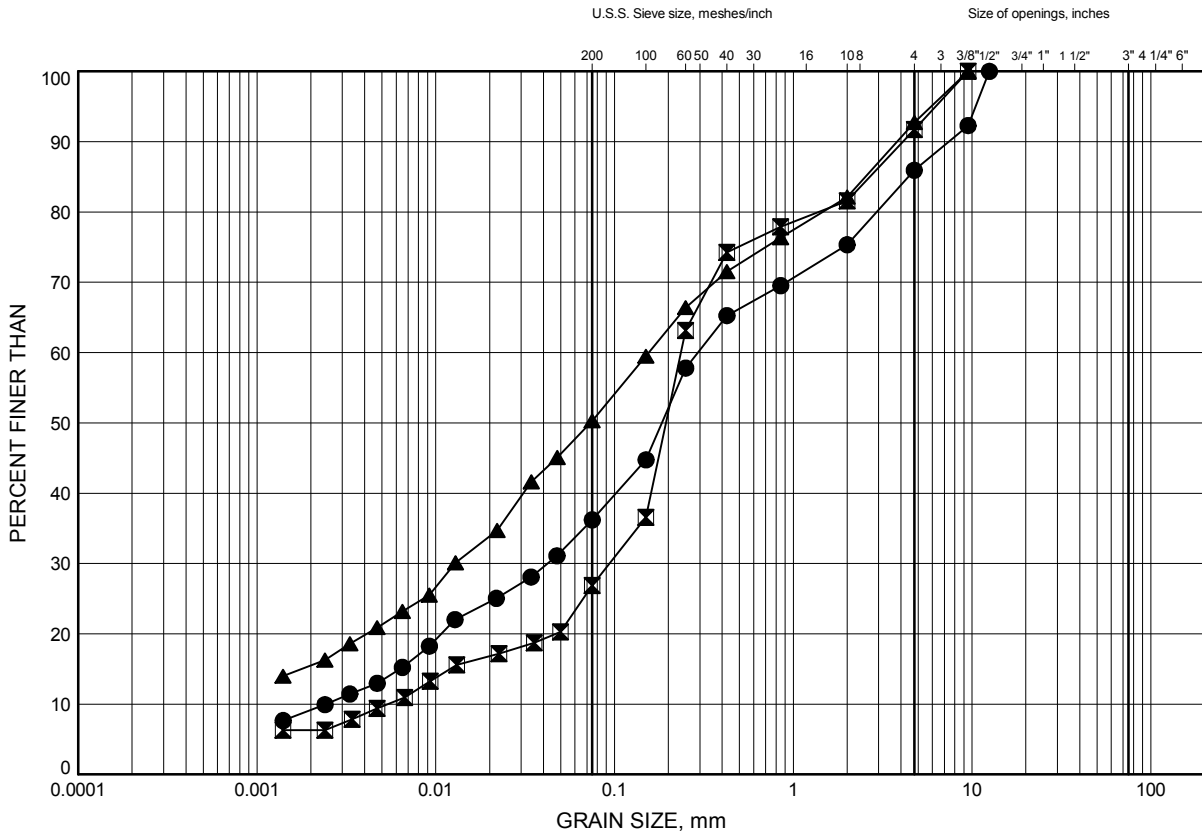
Appendix B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty SAND FILL, Some Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH 1-2	1.83	199.77
⊠	BH 1-2	4.11	197.49
▲	BH 1-5	2.59	199.51

Date June 2014
W.P. 3059-10-00

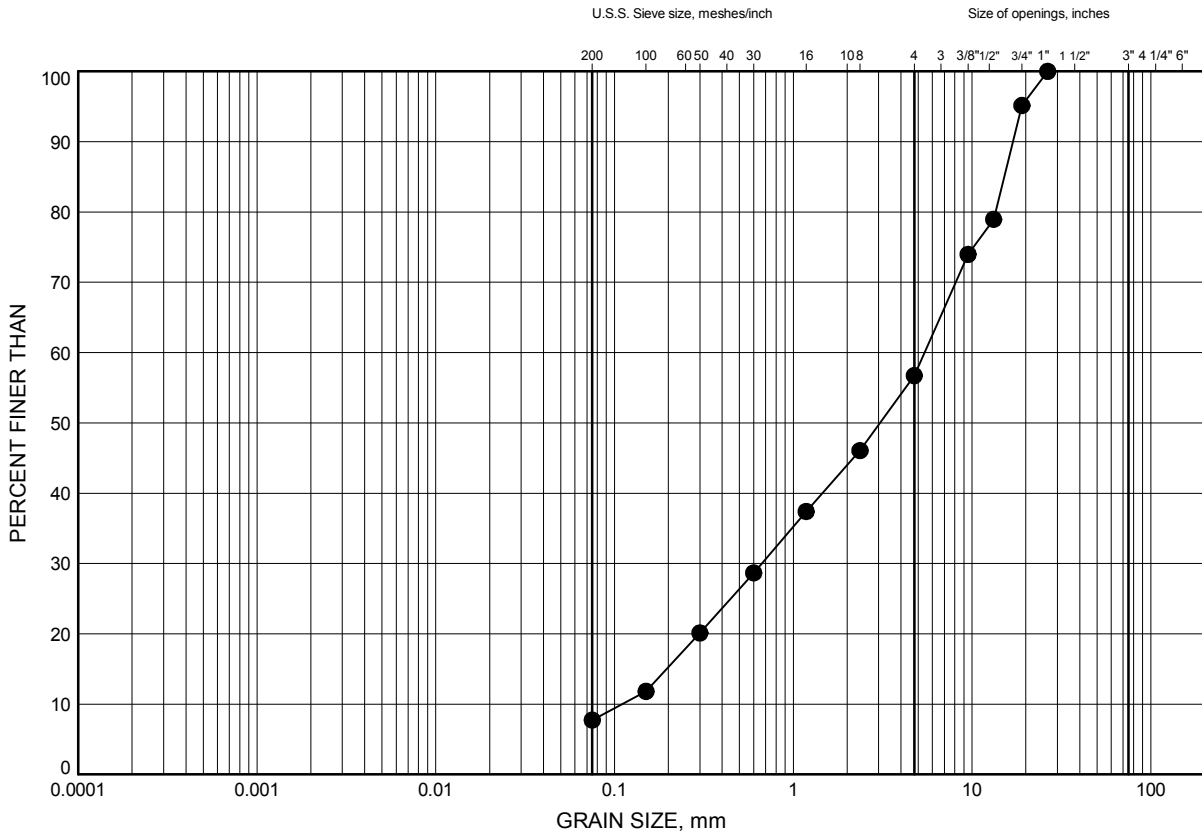


Prep'd AN
Chkd. MEF

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND & GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH 1-5	0.30	201.80

Date June 2014
W.P. 3059-10-00

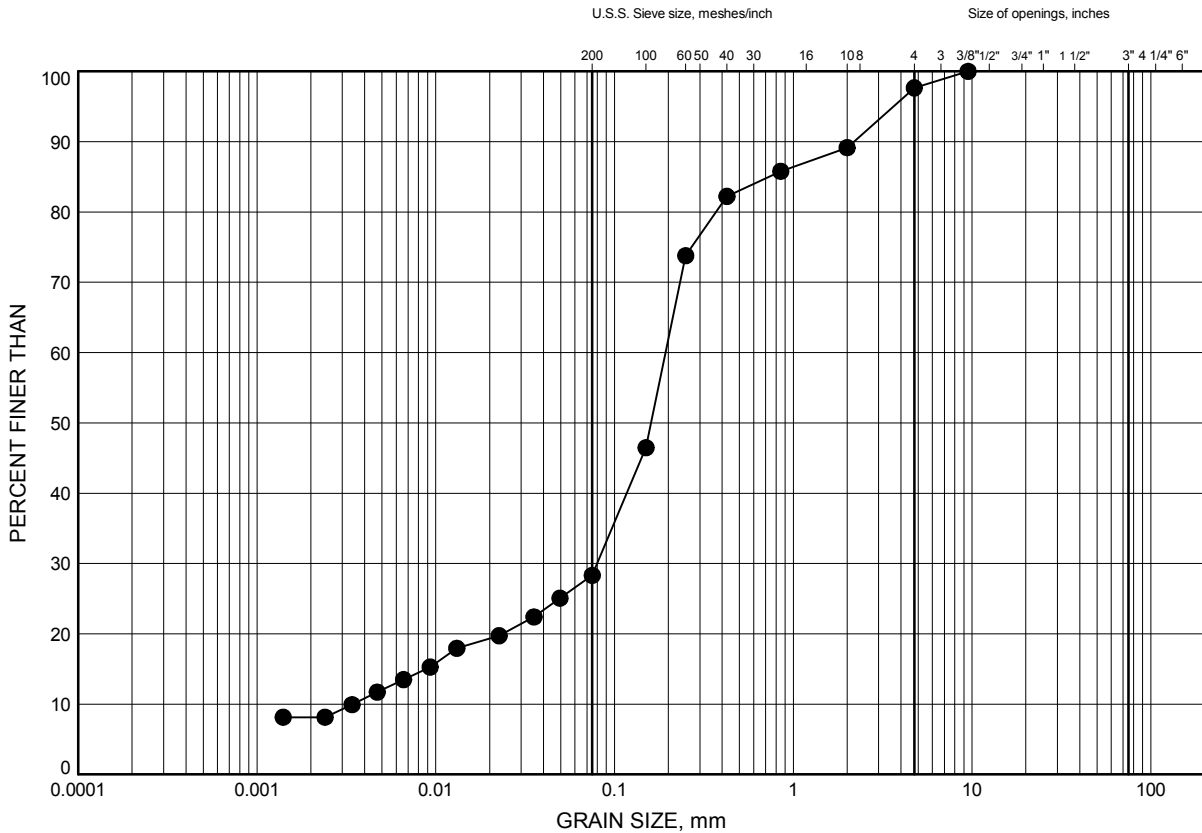


Prep'd AN
Chkd. MEF

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND, Some Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH 1-4	1.07	195.03

Date June 2014
W.P. 3059-10-00

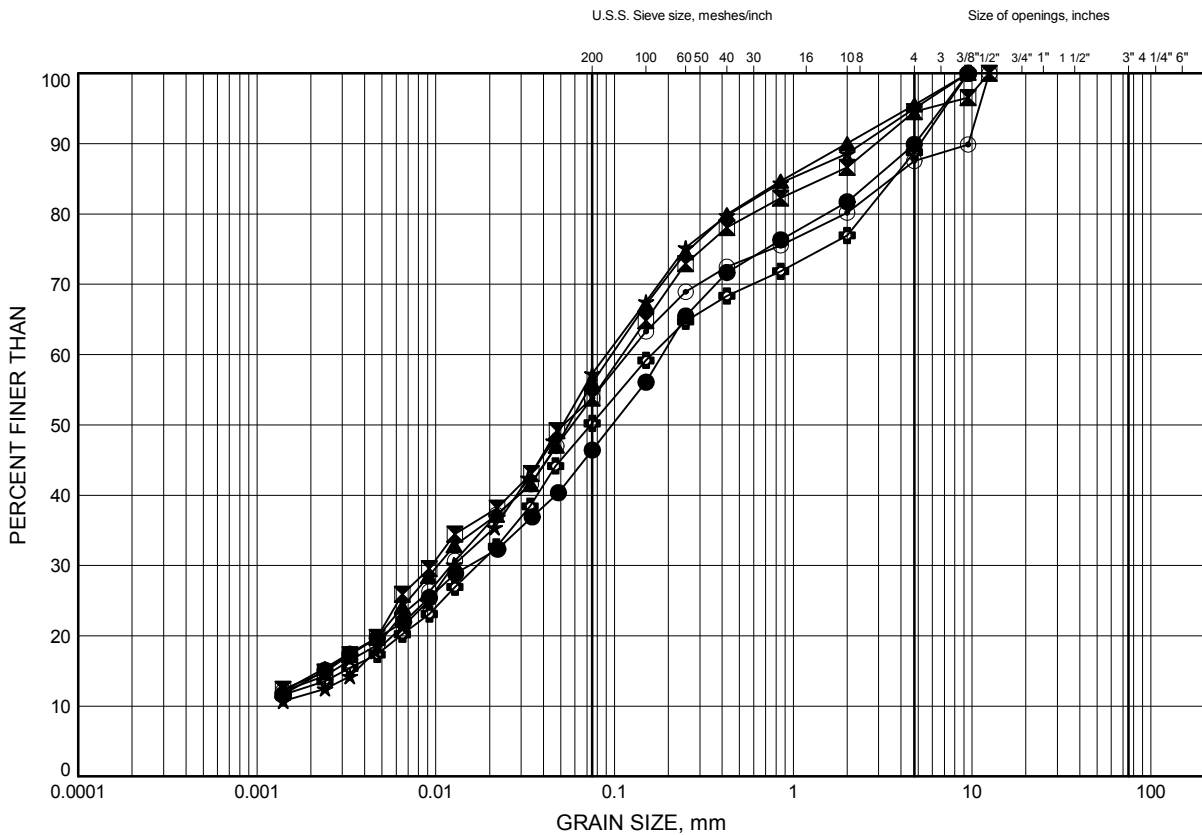


Prep'd AN
Chkd. MEF

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND & SILT TILL, Some Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH 1-1	1.07	195.53
⊠	BH 1-2	4.88	196.72
▲	BH 1-2	6.40	195.20
★	BH 1-2	12.50	189.10
⊙	BH 1-3	1.83	193.77
⊕	BH 1-3	3.35	192.25

Date June 2014
W.P. 3059-10-00

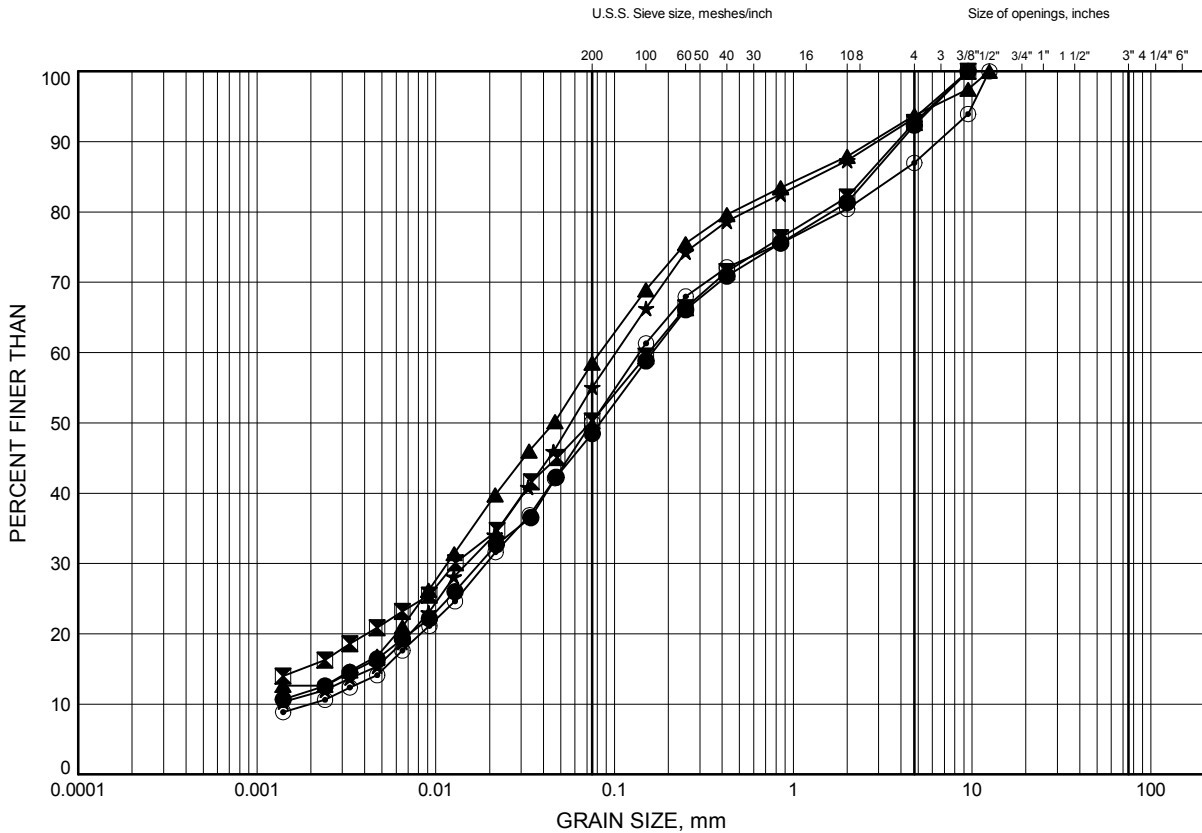


Prep'd AN
Chkd. MEF

GRAIN SIZE DISTRIBUTION

FIGURE B5

SAND & SILT TILL, Some Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH 1-3	5.79	189.81
⊠	BH 1-5	2.59	199.51
▲	BH 1-5	10.97	191.13
★	BH 1-6	2.03	194.87
⊙	BH 1-6	2.59	194.31

Date June 2014
W.P. 3059-10-00

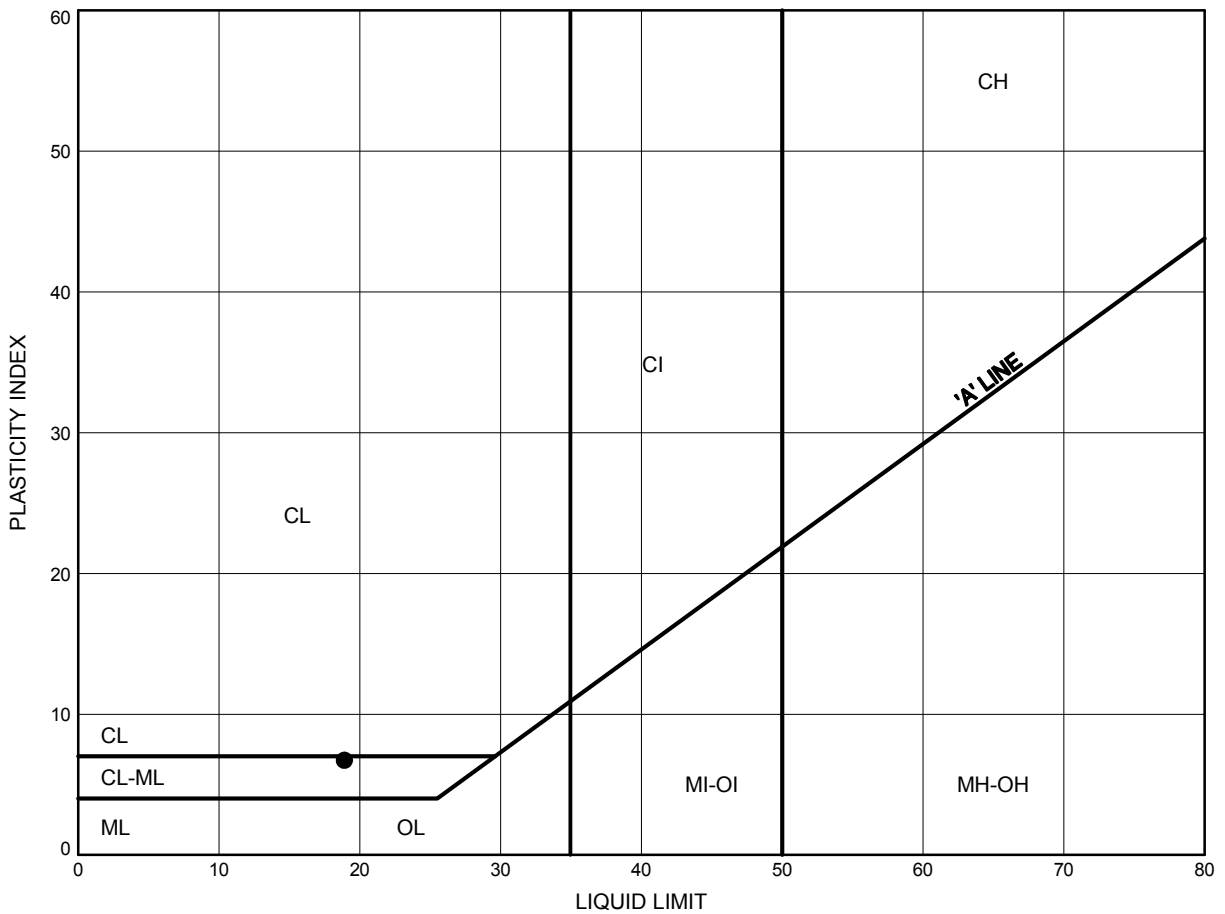


Prep'd AN
Chkd. MEF

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

SAND & SILT TILL, Some Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH 1-5	5.64	196.46

Date June 2014
W.P. 3059-10-00



Prep'd AN
Chkd. MEF

Appendix C

Site Photographs



Photograph 1: South culvert headwall looking west.



Photograph 2: North end of culvert looking down-slope.

Appendix D

Borehole Locations and Soil Strata Drawings

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

CONT No
WP No 3059-10-00

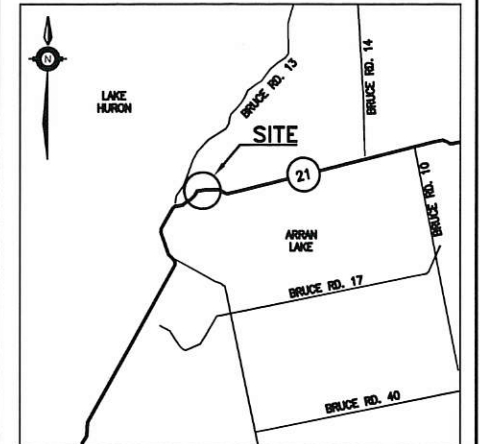


CULVERT SITE 1
SECTION 9+902 & 9+922
TOWNSHIP OF ARRAN
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1



THURBER ENGINEERING LTD.



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
- W Water Level
- HA Head Artesian Water
- P Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BH1-1	196.6	4 931 894.8	158 145.9
BH1-2	201.6	4 931 869.6	158 143.6
BH1-3	195.6	4 931 847.3	158 145.9
BH1-4	196.1	4 931 898.7	158 175.7
BH1-5	202.1	4 931 884.8	158 173.1
BH1-6	196.9	4 931 852.4	158 165.3

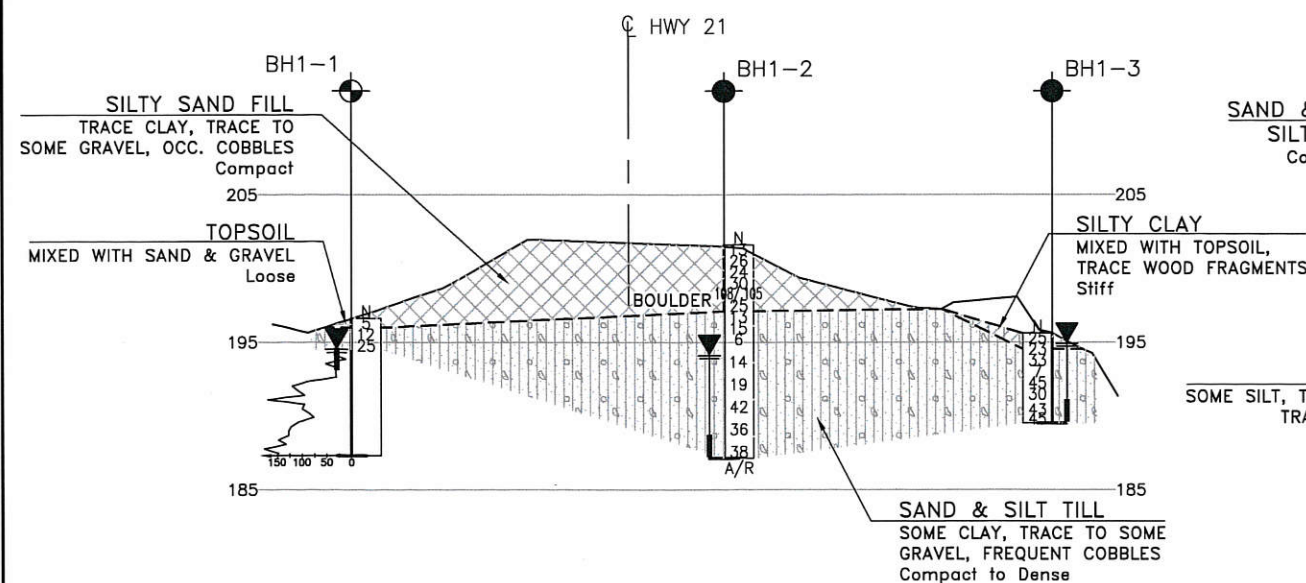
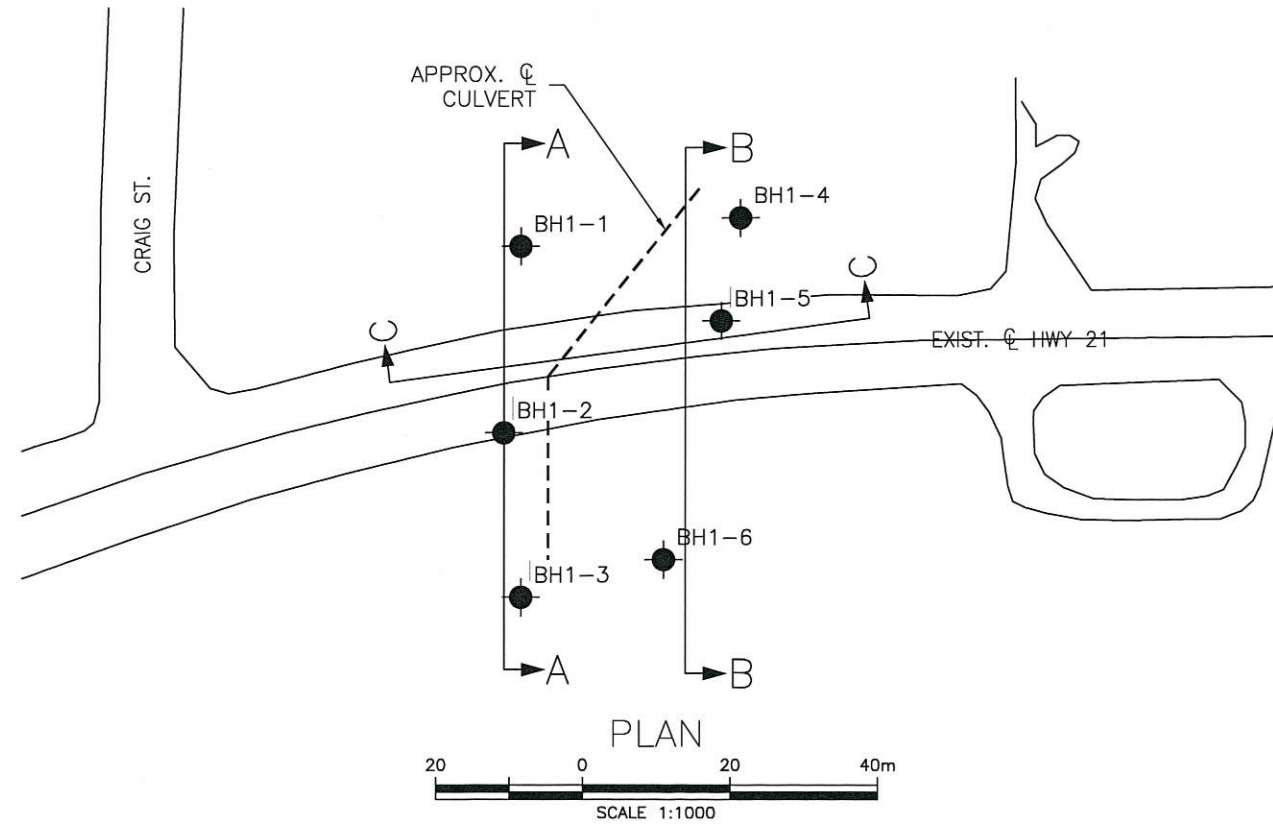
-NOTES-

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

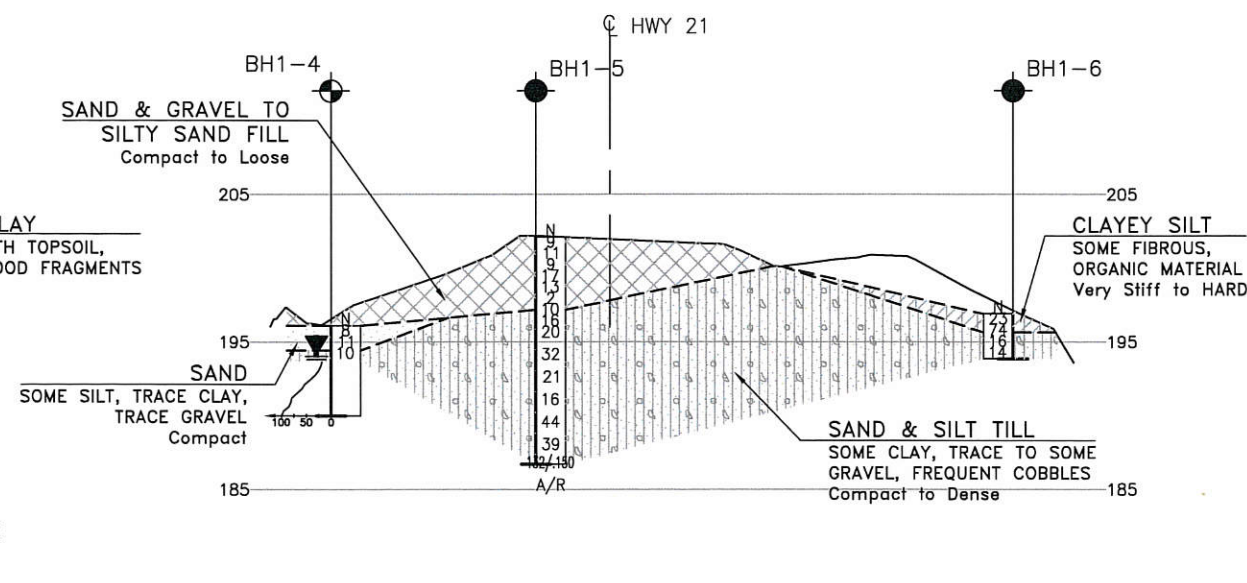
GEOCRES No. 41A-235

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LPG	CHK	PK
DRAWN	AN	CHK	SITE
LOAD	DATE	JUL 2014	
STRUCT	DWG	1	

FILENAME: H:\Drafting\15\64\31\156431-BoreholePlan&Profile.dwg
PLOTDATE: 7/9/2014 1:22 PM



SECTION A-A
(STN. 9+902)



SECTION B-B
(STN. 9+922)

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

CONT No
WP No 3059-10-00

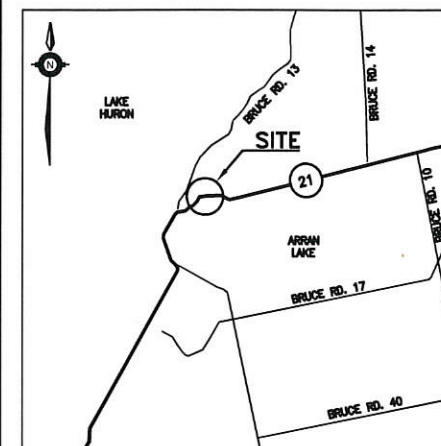


CULVERT SITE 1
SECTION 9+902 & 9+922
TOWNSHIP OF ARRAN
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
2








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

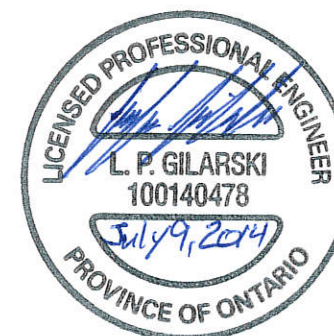
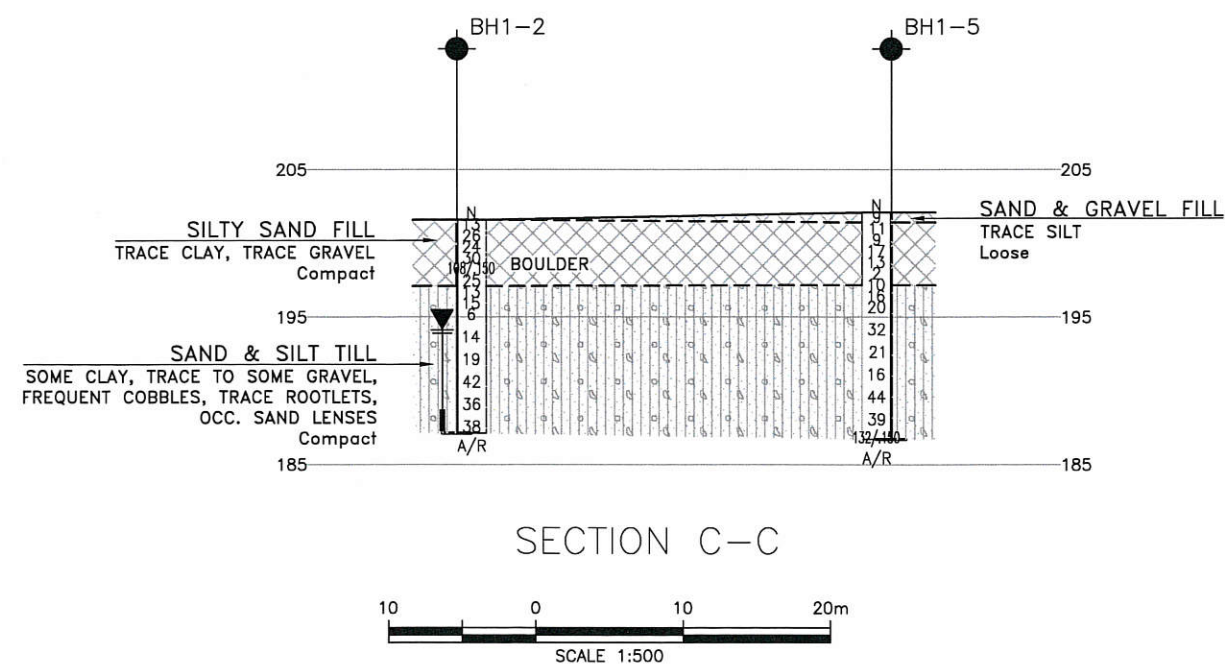
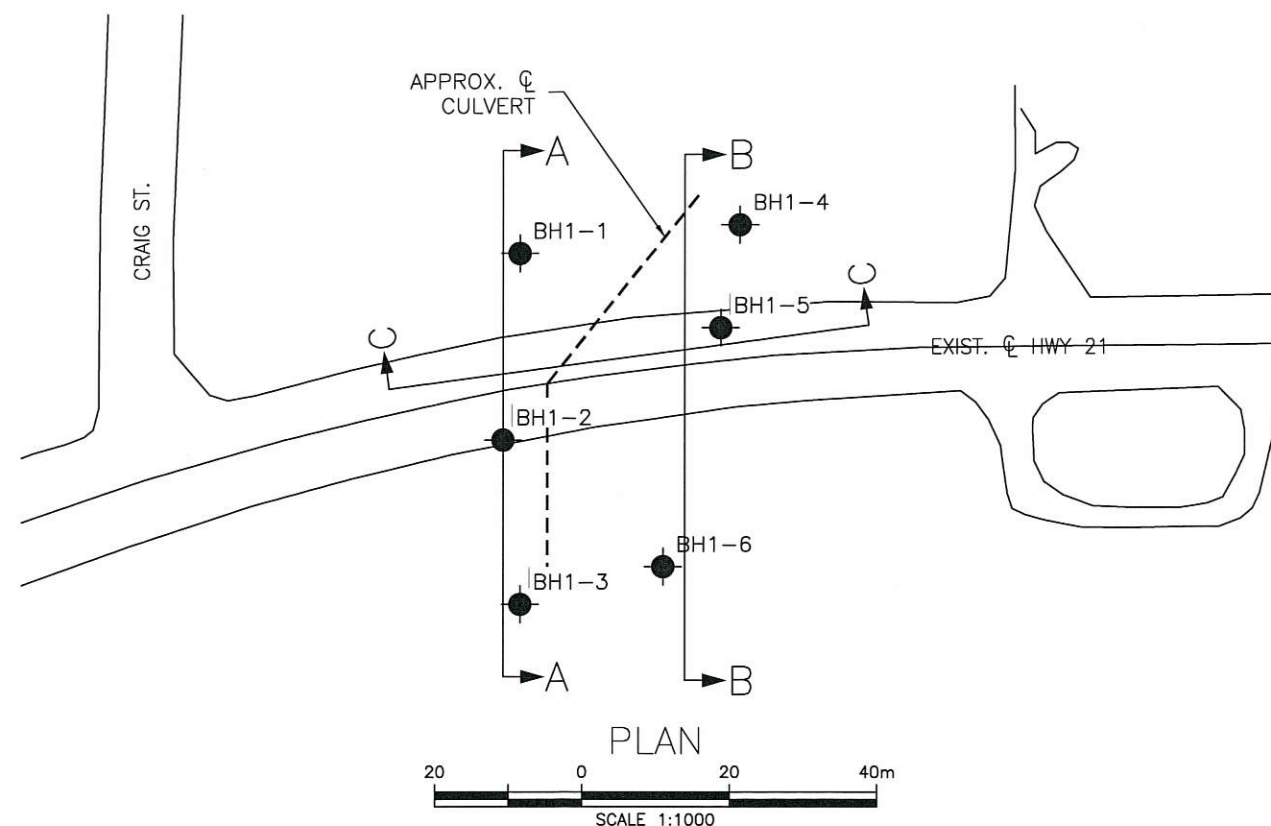
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BH1-1	196.6	4 931 894.8	158 145.5
BH1-2	201.6	4 931 869.6	158 143.3
BH1-3	195.6	4 931 847.3	158 145.5
BH1-4	196.1	4 931 898.7	158 175.5
BH1-5	202.1	4 931 884.8	158 173.5
BH1-6	196.9	4 931 852.4	158 165.5

-NOTES-

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

GEOCRES No. 41A-235

[illegible]