



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
CULVERT REPLACEMENT NORTH OF DECEW ROAD  
SITE NO. 34-292/C  
HIGHWAY 406  
THOROLD, ONTARIO  
G.W.P. No. 2205-13-00**

**GEOCRES Number: 30M3-290**

**Report to**

**MMM Group Limited**

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**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the existing culvert located on Highway 406, north of Decew Road, in Thorold, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by WSP/MMM Group Limited (MMM) to carry out this foundation investigation under the MTO Assignment Number 2014-E0030.

**2. SITE DESCRIPTION**

The culvert site is located on Highway 406, approximately 173 m north of Decew Road in Thorold, Ontario. This culvert allows the creek to flow from east to west, under Highway 406.

The existing structure is an open footing culvert. The culvert opening is 3.66 m wide and 1.52 m high. The existing culvert spans the entire highway platform width. The highway embankment in the vicinity of the culvert is approximately 2.5 m high, and there is 1.5 m of fill above the culvert. The grade of Highway 406 at the culvert location is at approximate Elevation 172.3 m. Based on an archived drawing, the culvert inlet (east) and outlet (west) levels are at approximate Elevations 169.84 and 169.77 m, respectively.

The land surrounding the existing culvert consist of agricultural lands, with trees along the east and west sides of Highway 406. The terrain is generally flat. Gibson Lake is located approximately 250 m south of the culvert. Gibson Lake serves as a storage reservoir for the Decew generating station.

Selected photographs of the culvert area are included in Appendix D for reference.

The site is situated within the physiographic region known as the Haldimand Clay Plain, which is characterized by glacio-lacustrine deposits laid down by the glacial Lake Warren during the Wisconsinian Age. These deposits consist of silts and clays and are generally underlain by a glacial till, which in turn overlies dolomitic limestone bedrock.

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

This borehole investigation and field testing program was carried out between September 6 to 8, 2016. The program consisted of drilling and sampling 6 boreholes (numbered 406-01 to 406-06) to depths ranging from 8.2 m to 12.8 m. All the boreholes were drilled near the existing culvert alignment. Boreholes 406-01 and 406-04 were drilled at the culvert outlet and inlet areas, respectively. Boreholes 406-02, 406-03, 406-05 and 406-06 were drilled through the highway embankments. Boreholes 406-05 and 406-06 were drilled to provide subsurface information for design of roadway protection.

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The co-ordinates and elevations of the as-drilled boreholes were subsequently provided by MMM Group Limited. The approximate borehole locations are shown on a Borehole Location and Soil Strata drawing included in Appendix C.

A truck-mounted B57 drill rig was used to drill and sample the boreholes through the highway embankments, and Geoprobe equipment was used to drill and sample the boreholes at the culvert inlet and outlet. Hollow stem augers were used to advance the boreholes until the target depth was reached. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Vane shear tests (VST) using an MTO 'N' size vane were conducted in the native silty clay to measure the in-situ undrained shear strength.

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, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. The details of standpipe piezometer installations and borehole completion are summarized in Table 3.1.

The boreholes without piezometer installations were backfilled in accordance with O. Reg. 903. The piezometer installations will be decommissioned in accordance with O. Reg. 903.

**Table 3.1 Borehole Completion and Standpipe Piezometer Installation Details**

Borehole Number	Standpipe Piezometer Installations				Completion Details
	Tip Location (Depth/Elev.)	Screen Depth (m)	Screen Elevation (m)	Filter Stratum	
406-01	11.6 / 159.5	8.2 to 11.6	162.9 – 159.5	Silty Clay	Sand filter from 11.6 m to 8.2m, then bentonite holeplug from 8.6m to 7.7 m, holeplug and auger cuttings from 7.7 m to ground surface.
406-02	12.4 / 159.9	8.8 to 12.4	163.5 – 159.9	Silty Clay	Bentonite holeplug from 12.7 m to 12.4 m, sand from 12.4 m to 8.8 m, then holeplug from 8.8 m to ground surface.
406-03	-	None Installed			Borehole backfilled with bentonite holeplug and auger cuttings to 0.1 m, then asphalt to surface.
406-04	-	None Installed			Borehole backfilled with bentonite holeplug and auger cuttings to surface.
406-05	6.0 / 166.2	4.5 to 6.0	167.9 – 166.2	Silty Clay	Sand filter from 8.2 m to 4.3 m, then bentonite holeplug from 4.3m to 0.15 m, asphalt from 0.15 m to ground surface.
406-06	-	None Installed			Borehole backfilled with bentonite holeplug and auger cuttings to surface.

Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendix A.

#### 4. LABORATORY TESTING

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

#### 5. DESCRIPTION OF SUBSURFACE CONDITIONS

##### 5.1. General

Reference is made to the Record of Borehole sheets in Appendix A for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for this culvert site is presented on the Borehole Locations and Soil Strata Drawings in Appendix C for illustrative purposes. An

overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes consist of a pavement structure, or surficial topsoil, overlying silty clay embankment fill. An extensive deposit of native silty clay was contacted below the fill in all the boreholes. Groundwater levels are generally in the order of 1.8 to 2.2 m below original ground surface.

More detailed descriptions of the individual stratum are presented below.

## **5.2. Topsoil**

A 200 mm thick layer of topsoil was encountered at ground surface in Boreholes 406-01, 406-04 and 406-06, drilled near the culvert inlet and outlet areas and on the Highway 406 median.

The topsoil thickness may vary between and beyond the borehole locations, and the limited data is not suitable for estimating topsoil quantities.

## **5.3. Pavement Structure**

Boreholes 406-02, 406-03 and 406-05 were drilled from the paved platform of Highway 406. The pavement structure consisted of approximately 75 mm to 150 mm of asphalt over approximately 0.8 to 1.2 m of granular base material consisting of sand and gravel.

SPT 'N' values measured in the granular fill ranged from 12 to 25 blows per 0.3 m of penetration indicating a compact state. Measured moisture contents of the recovered granular fill samples varied from 4% to 6%.

## **5.4. Silty Clay Embankment Fill**

Embankment fill was encountered in all the boreholes below the pavement structure and topsoil. This fill typically consists of brown silty clay with trace to some sand, trace gravel and occasional organics and rootlets. In Borehole 406-05, a 0.7 m thick layer of sand fill was contacted within the silty clay fill at 2.0 m depth (Elevation 170.2). The overall thickness of the silty clay fill ranged from 1.9 m to 2.8 m. The depth to the base of the silty clay fill ranged from 2.1 m to 2.9 m (Elevations 168.3 to 169.4).

SPT 'N' values measured in the cohesive fill ranged from 3 to 16 blows per 0.3 m of penetration indicating a soft to very stiff consistency, but typically soft to firm. Measured moisture contents of the recovered silty clay fill samples ranged between 8% and 25%, with most values ranging from 15% to 24%.

Three laboratory grain size distribution analyses were performed on samples of the silty clay fill and one grain size distribution analysis was performed on a sample of sand fill. The results of these tests are presented on the corresponding Record of Borehole sheets in Appendix A and the

grain size distribution curves are plotted in Figures B1 and B2 of Appendix B. Atterberg Limits tests conducted on selected samples of the silty clay fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B5 of Appendix B. The laboratory test results are summarized in the following table.

Soil Particles	Silty Clay Fill	Sand Fill
Gravel	0	1
Sand	0 to 13	81
Silt	48 to 63	11
Clay	33 to 48	7

Soil Property	Percentage (%)
Liquid Limit	36 to 43
Plasticity Index	18 to 23

The results of the limits testing indicate that the silty clay fill is of medium plasticity with a group symbol of CI.

### 5.5. Silty Clay

Native brown to grey silty clay was encountered below the silty clay fill in the six boreholes drilled on site at depths ranging from 2.1 m to 4.0 m. The silty clay contained trace sand. All the boreholes were terminated within the silty clay at depths ranging from 8.2 m to 12.8 m (Elevations 159.4 m to 164.0 m).

Within the upper 2 m of the silty clay deposit, SPT 'N' values measured in the native silty clay ranged from 4 to 9 blows per 0.3 m of penetration indicating a firm to stiff consistency. Below this upper zone, the 'N' values ranged between 0 and 5 blows per 0.3 m penetration. Vane shear tests (VST) conducted in the silty clay in Boreholes 406-02 and 406-03 measured in-situ undrained shear strength in the range of 70 kPa to 90 kPa. Based on the VST data, plasticity indices and measured moisture contents of the silty clay, the consistency of the silty clay typically ranges from soft to stiff. Measured moisture contents of the recovered silty clay samples varied from 21% and 45%.

Eight laboratory grain size distribution analyses were performed on samples of the silty clay. The results of these tests are presented on the corresponding Record of Borehole sheets in Appendix A and the grain size distribution curves are plotted in Figures B3 and B4 of Appendix B. Atterberg Limits tests conducted on selected samples of the silty clay are presented on the Record of Borehole sheets included in Appendix A and included in Figure B6 and B7 of Appendix B. The laboratory test results are summarized in the following table.

Soil Particles	%
Gravel	0
Sand	0 to 10
Silt	39 to 65
Clay	27 to 55
Soil Property	%
Liquid Limit	23 to 38
Plasticity Index	8 to 19

The results of the Atterberg Limits tests indicate that the silty clay is typically low to medium plastic with dual group symbols (CL-CI).

### 5.6. Groundwater Conditions

Water was not observed in the boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes 406-01, 406-02 and 406-05 to permit longer term monitoring. Water levels measured in the three installed standpipes are presented below.

**Table 5.1 – Groundwater Measurements**

Borehole	Date of Reading	Water Level Depth (m)	Water Level Elevation (m)
406-01	September 30, 2016	1.8	169.3
	December 8, 2016	0.9	170.2
406-02	September 30, 2016	2.2	170.1
	December 8, 2016	1.9	170.4
406-05	September 30, 2016	Not read	Not read
	December 8, 2016	2.2	170.0

The readings above indicate that the measured piezometric levels coincide with the creek water level which was estimated to be in the order of Elevations 170.2 to 170.4 m on December 8, 2016.

The groundwater level should be assumed to reflect the local creek water level. The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

## 6. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. MMM Group Limited provided the northing and easting coordinates and ground surface elevations.



Landshark Drilling of Brantford, Ontario supplied and operated a truck-mounted drill rig B57 and a Geoprobe equipment to carry out 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. Abdul Nasri of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO approved Toronto laboratory.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. R. Palomeque Reyna, P. Eng. and Dr. Pang. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



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## **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.

## EXPLANATION OF ROCK LOGGING TERMS


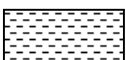

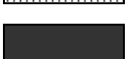

### ROCK WEATHERING CLASSIFICATION

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

### DISCONTINUITY SPACING

<b>Bedding</b>	<b>Bedding Plane Spacing</b>
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

<b>Rock Strength</b>	<b>Approximate Uniaxial Compressive Strength</b>		<b>Field Estimation of Hardness*</b>
	<b>(MPa)</b>	<b>(psi)</b>	
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 <sub>L</sub> < 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 <sub>L</sub> < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W <sub>L</sub> < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W <sub>L</sub> > 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			

# RECORD OF BOREHOLE No 406-01

1 OF 2

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 385.0 E 326 180.3 ORIGINATED BY AN  
 HWY 406 BOREHOLE TYPE Geoprobe COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.08 - 2106.09.08 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  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
171.1	GROUND SURFACE							20   40   60   80   100		W <sub>P</sub> W      W <sub>L</sub>				
0.0	TOPSOIL: (200mm)							20   40   60   80   100						
0.2	Silty <b>CLAY</b> , trace sand, trace gravel, occasional roots Stiff to Very Stiff Brown Moist (FILL)		1	SS	10		171							
			2	SS	15		170							
			3	SS	16		169							
169.0	Silty <b>CLAY</b> , trace sand Stiff to Firm Light Brown Moist		4	SS	9		169							
2.1			5	SS	4		168							
							167							
167.0	Soft to Very Soft Grey Wet		6	SS	1		166							
4.1							165							
							164							
							163							
							162							

Continued Next Page

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

# RECORD OF BOREHOLE No 406-01

2 OF 2

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 385.0 E 326 180.3 ORIGINATED BY AN  
 HWY 406 BOREHOLE TYPE Geoprobe COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.08 - 2106.09.08 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									
	Continued From Previous Page																
	Silty <b>CLAY</b> , trace sand Soft Grey Wet		10	SS	2		161										
							160										
159.5																	
11.6	END OF BOREHOLE AT 11.6m UPON REFUSAL TO AUGER ADVANCE. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.  WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.09.30 1.8 169.3 2016.12.08 0.9 170.2																



## METRIC

[illegible]

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

ONTMT4S MTO-11336.GPJ 2015TEMPLATE(MTO).GDT 12/12/16

# RECORD OF BOREHOLE No 406-02

2 OF 2

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 382.5 E 326 202.1 ORIGINATED BY AN  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.06 - 2016.09.06 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
	Silty <b>CLAY</b> , trace to some sand Very Soft to Soft Grey Wet		11	SS	1		162										
							161			3.5							
159.6			12	SS	4		160									0 10 63 27	
12.7	END OF BOREHOLE AT 12.7m UPON REFUSAL TO SPLIT SPOON SAMPLER ADVANCE. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.  WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.09.30 2.2 170.1 2016.12.08 1.9 170.4																

# RECORD OF BOREHOLE No 406-03

1 OF 2

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 378.5 E 326 222.7 ORIGINATED BY AN  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.07 - 2016.09.07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  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					
172.3	GROUND SURFACE												
0.0	ASPHALT: (150mm)												
0.2	SAND and GRAVEL, trace silt Compact Brown Moist (FILL)		1	SS	20		172						
			2	SS	24								
170.9	Silty CLAY, trace sand, trace gravel, occasional organics Soft to Firm Grey Brown Wet (FILL)		3	SS	3		171						
			4	SS	7		170						
169.4	Silty CLAY, trace sand Stiff to Firm Grey Moist		5	SS	9		169						
			6	SS	5		168						
							167						
166.7	Soft to Very Soft Wet		7	SS	1		166						
5.6			8	SS	3		165						
							164						
	Firm		9	SS	5		163						

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 406-03

2 OF 2

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 378.5 E 326 222.7 ORIGINATED BY AN  
HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2016.09.07 - 2016.09.07 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
	Silty <b>CLAY</b> , trace sand Firm to Stiff Grey Wet		10	SS	4		162										
							161										
159.5			11	SS	13		160										
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m, THEN ASPHALT PATCH TO SURFACE.																

# RECORD OF BOREHOLE No 406-04

1 OF 2

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 385.0 E 326 240.9 ORIGINATED BY AN  
 HWY 406 BOREHOLE TYPE Geoprobe COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.08 - 2016.09.08 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  <b>γ</b>  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				W <sub>P</sub> W      W <sub>L</sub>								
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%)								
171.3	GROUND SURFACE							20	40	60	80	100								
0.0	TOPSOIL: (200mm)							20	40	60	80	100								
0.2	Silty <b>CLAY</b> , trace sand, trace gravel, occasional organics, occasional rootlets Firm Brown Moist (FILL)		1	SS	4		171								○					
			2	SS	4		170									○	—			
			3	SS	7		169								○					
			4	SS	4		168								○					
168.3																				
3.0	Silty <b>CLAY</b> , trace sand Stiff to Firm Brown Moist		5	SS	9		168								○					
			6	SS	5		167								○					
							166													
165.7																				
5.6	Firm to Soft Grey																			
			7	SS	2		165								—	○	—			
			8	SS	4		164										○			
							163													
			9	SS	2		162								○					

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 406-04

2 OF 2

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 385.0 E 326 240.9 ORIGINATED BY AN  
 HWY 406 BOREHOLE TYPE Geoprobe COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.08 - 2016.09.08 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W <sub>p</sub> W W <sub>L</sub>				
	Continued From Previous Page																
	Silty <b>CLAY</b> , trace sand, trace gravel Soft Grey Moist to Wet		10	SS	3		161										
159.4							160										
11.9	END OF BOREHOLE AT 11.9m UPON REFUSAL TO AUGER ADVANCE. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

# RECORD OF BOREHOLE No 406-05

1 OF 1

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 387.4 E 326 212.6 ORIGINATED BY AN  
HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2016.09.07 - 2016.09.07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
172.2	GROUND SURFACE							20	40	60	80	100						
0.0 0.1	<b>ASPHALT:</b> (75mm)																	
	<b>SAND</b> and <b>GRAVEL</b> , trace silt Compact Brown Moist (FILL)		1	SS	25		172											
171.3																		
0.9	Silty <b>CLAY</b> , trace sand, occasional organics Firm to Stiff Brown Moist (FILL)		2	SS	5		171											
170.2			3	SS	9													
2.0	<b>SAND</b> , trace gravel, some silt, trace clay Loose Reddish Brown Moist (FILL)		4	SS	9		170											1 81 11 7
169.3																		
2.9	Silty <b>CLAY</b> , trace sand Stiff to Firm Brown Wet		5	SS	15		169											
			6	SS	8		168											Split spoon sampler wet
			7	SS	5		167											
							166											
			8	SS	4		165											0 6 43 51
164.0																		
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS DATE            DEPTH(m)    ELEV.(m) 2016.12.08        2.2            170.0						164											

ONTMT4S MTO-11336.GPJ 2015TEMPLATE(MTO).GDT 12/12/16




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

# RECORD OF BOREHOLE No 406-06

1 OF 1

METRIC

GWP# 2258-15-00 LOCATION Decew Road N 4 774 373.8 E 326 212.3 ORIGINATED BY AN  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.06 - 2016.09.06 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  <b>γ</b>  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					w <sub>P</sub> w                      w <sub>L</sub>										
						○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE																	
171.5	GROUND SURFACE																						
0.0	TOPSOIL: (200mm)																						
0.2	Silty <b>CLAY</b> , some sand, occasional organics, occasional rootlets Firm to Stiff Brown Moist (FILL)		1	SS	5		171																
			2	SS	8		170																
			3	SS	10															0   13   48   39			
168.8			4	SS	10		169																
2.7	Silty <b>CLAY</b> , trace sand Firm to Soft Brown Moist     Grey Wet																						
			5	SS	5		168															0   0   63   37	
			6	SS	4		167																
			7	SS	2		165																
							</																

ONTMT4S MTO-11336.GPJ 2015TEMPLATE(MTO).GDT 12/12/16

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

20  
15  
10

(%) STRAIN AT FAILURE



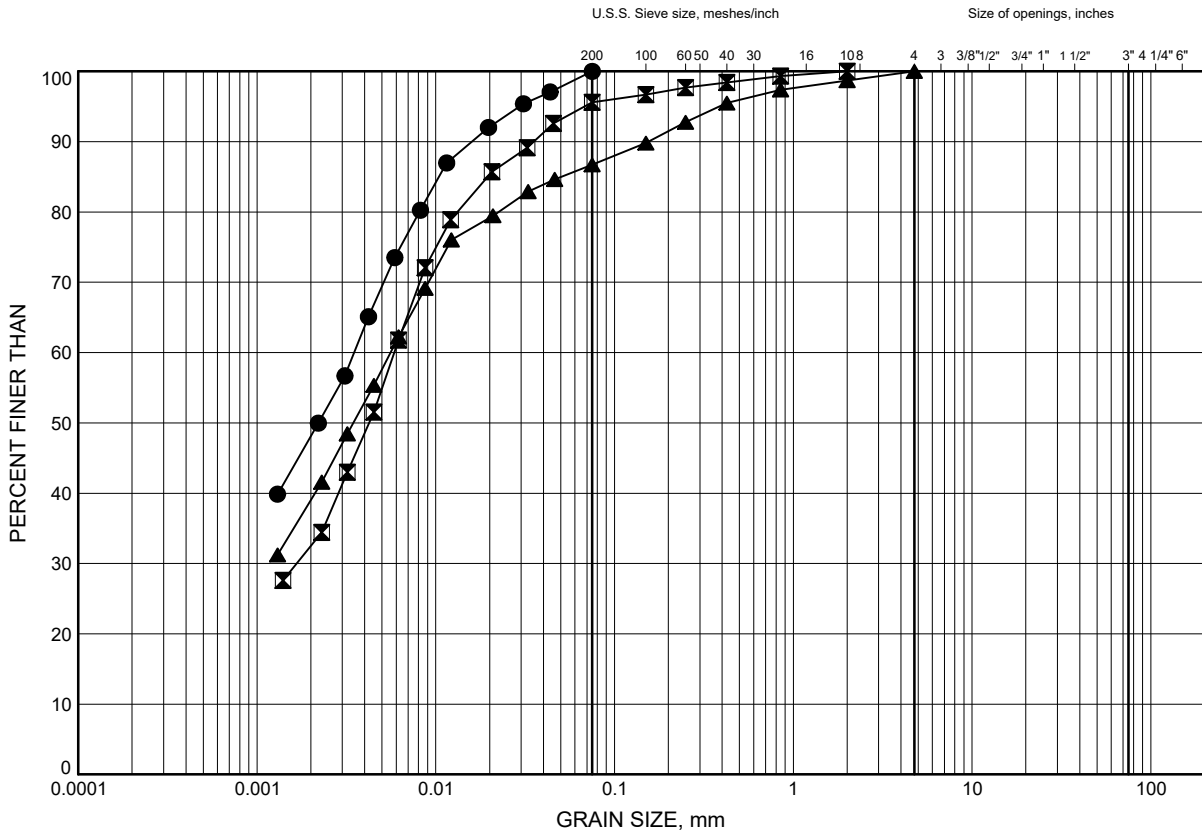
## **Appendix B**

### **Laboratory Test Results**

# Decew Road 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)
●	406-01	1.83	169.27
⊠	406-04	1.07	170.23
▲	406-06	1.83	169.67

Date December 2016

GWP# 2258-15-00



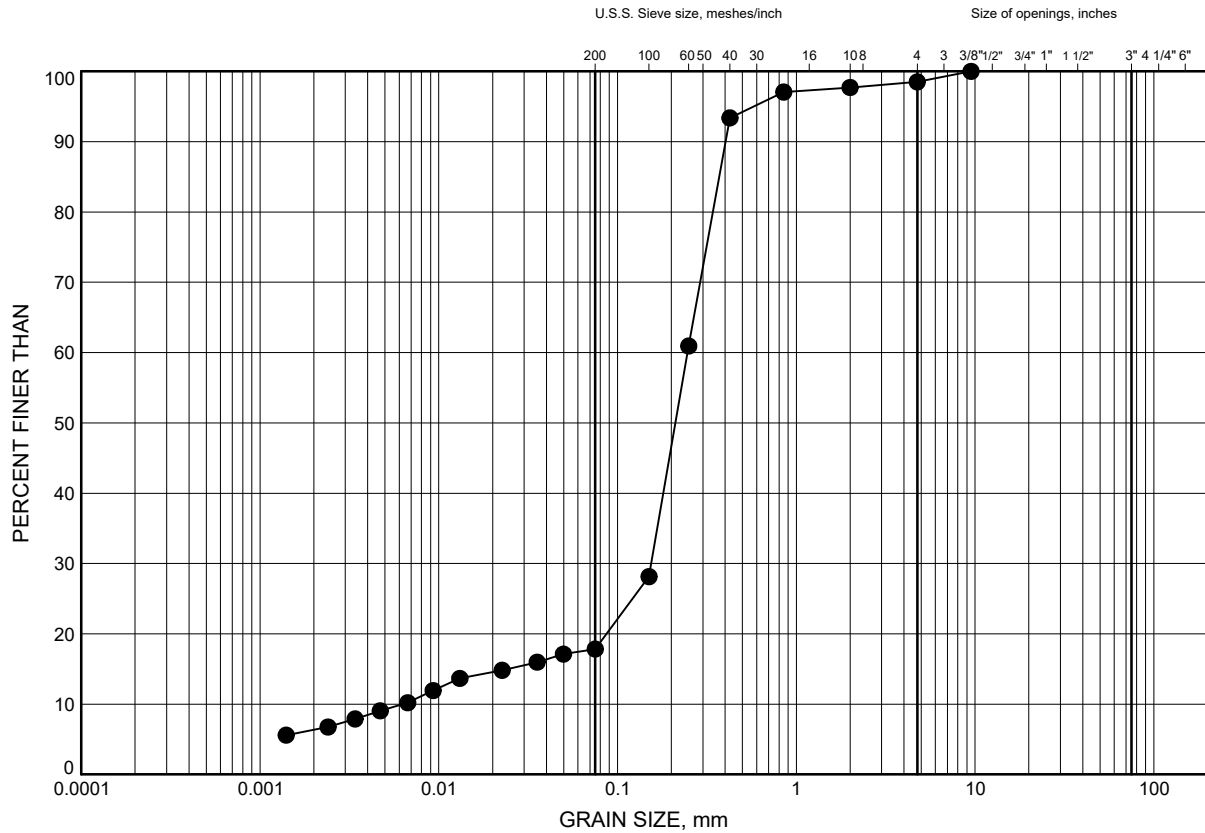
Prep'd AN

Chkd. RPR

# Decew Road GRAIN SIZE DISTRIBUTION

FIGURE B2

## SAND FILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	406-05	2.44	169.76

Date December 2016  
GWP# 2258-15-00

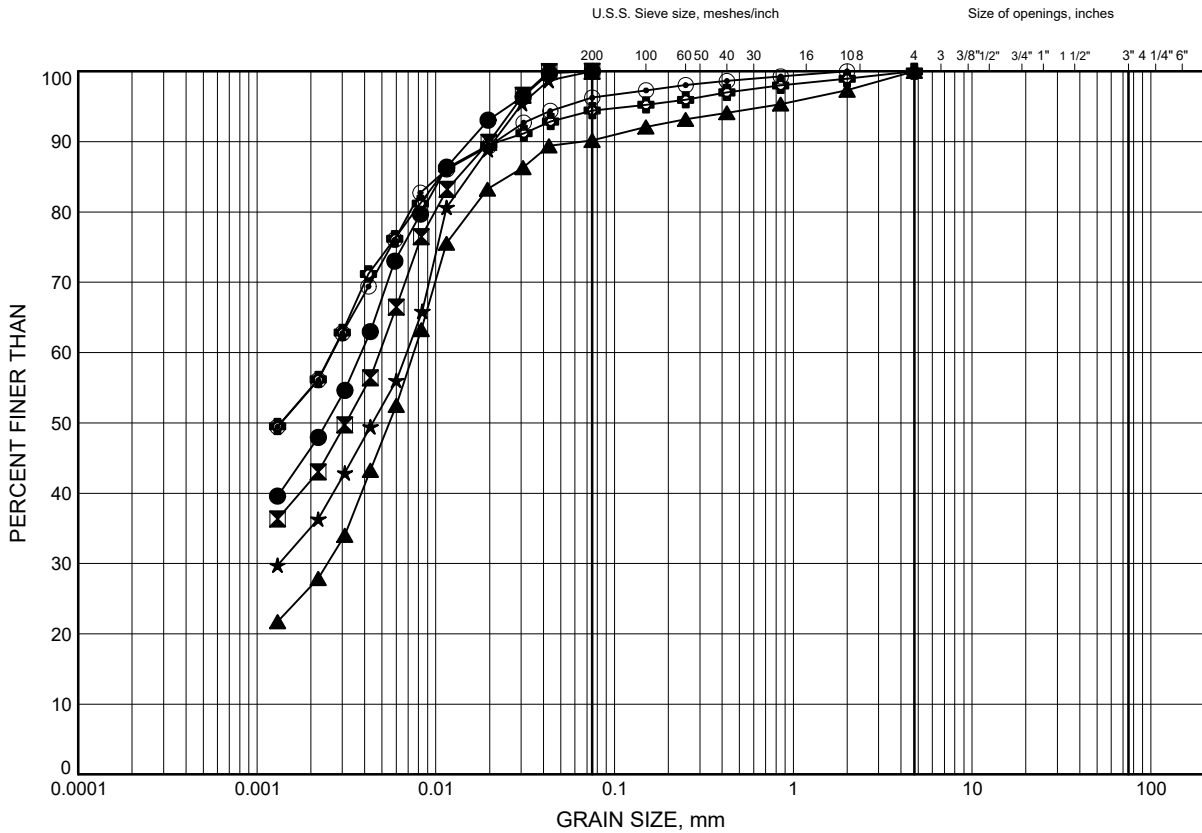


Prep'd AN  
Chkd. RPR

# Decew Road GRAIN SIZE DISTRIBUTION

FIGURE B3

## Silty CLAY



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	406-01	3.35	167.75
⊠	406-02	4.11	168.19
▲	406-02	12.50	159.80
★	406-03	4.88	167.42
⊙	406-03	7.92	164.38
⊕	406-04	6.40	164.90

Date December 2016

GWP# 2258-15-00



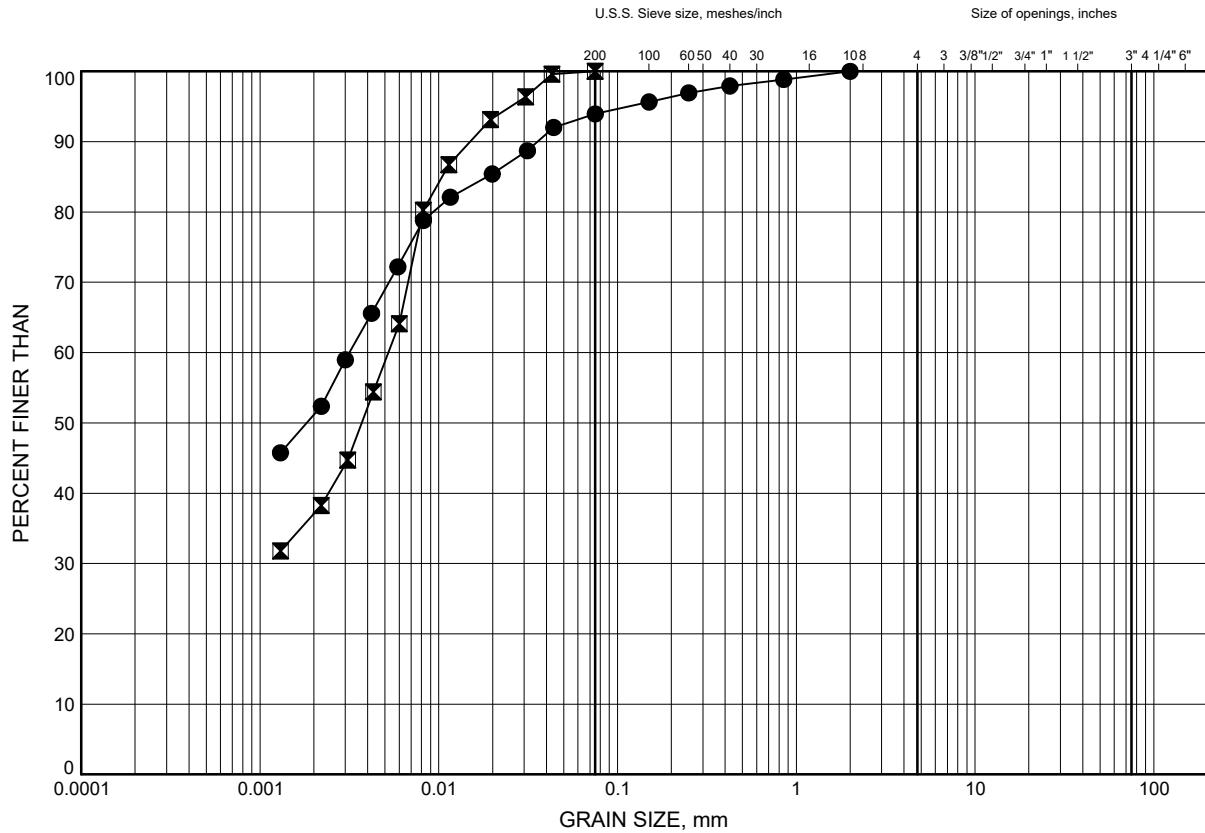
Prep'd AN

Chkd. RPR

# Decew Road 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)
●	406-05	7.92	164.28
⊠	406-06	3.35	168.15

Date December 2016

GWP# 2258-15-00



Prep'd AN

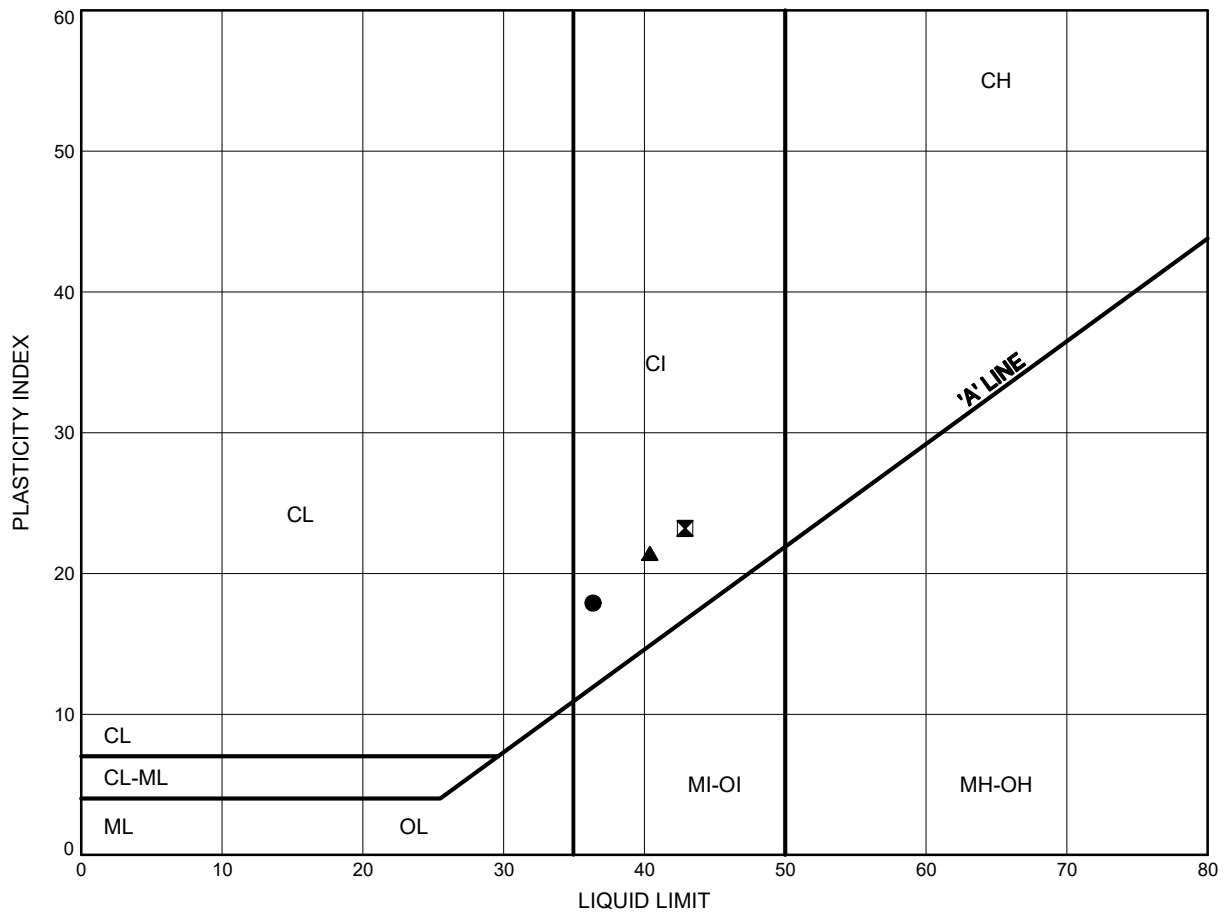
Chkd. RPR

Decew Road

# ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY FILL



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	406-01	1.83	169.27
⊠	406-04	1.07	170.23
▲	406-06	1.83	169.67

Date December 2016

GWP# 2258-15-00



Prep'd AN

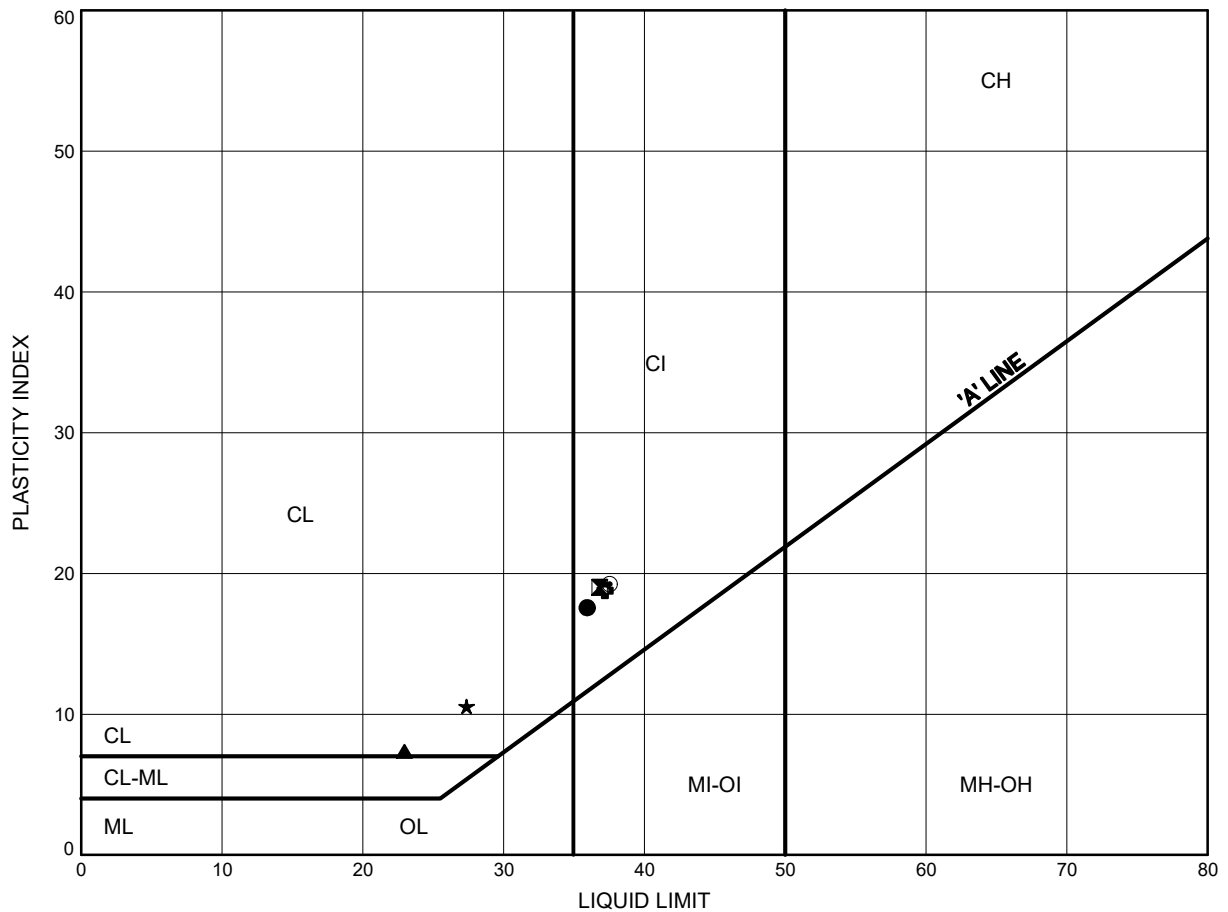
Chkd. RPR

Decew Road

# ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty CLAY



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	406-01	3.35	167.75
⊠	406-02	4.11	168.19
▲	406-02	12.50	159.80
★	406-03	4.88	167.42
⊙	406-03	7.92	164.38
⊕	406-04	6.40	164.90

Date December 2016  
GWP# 2258-15-00

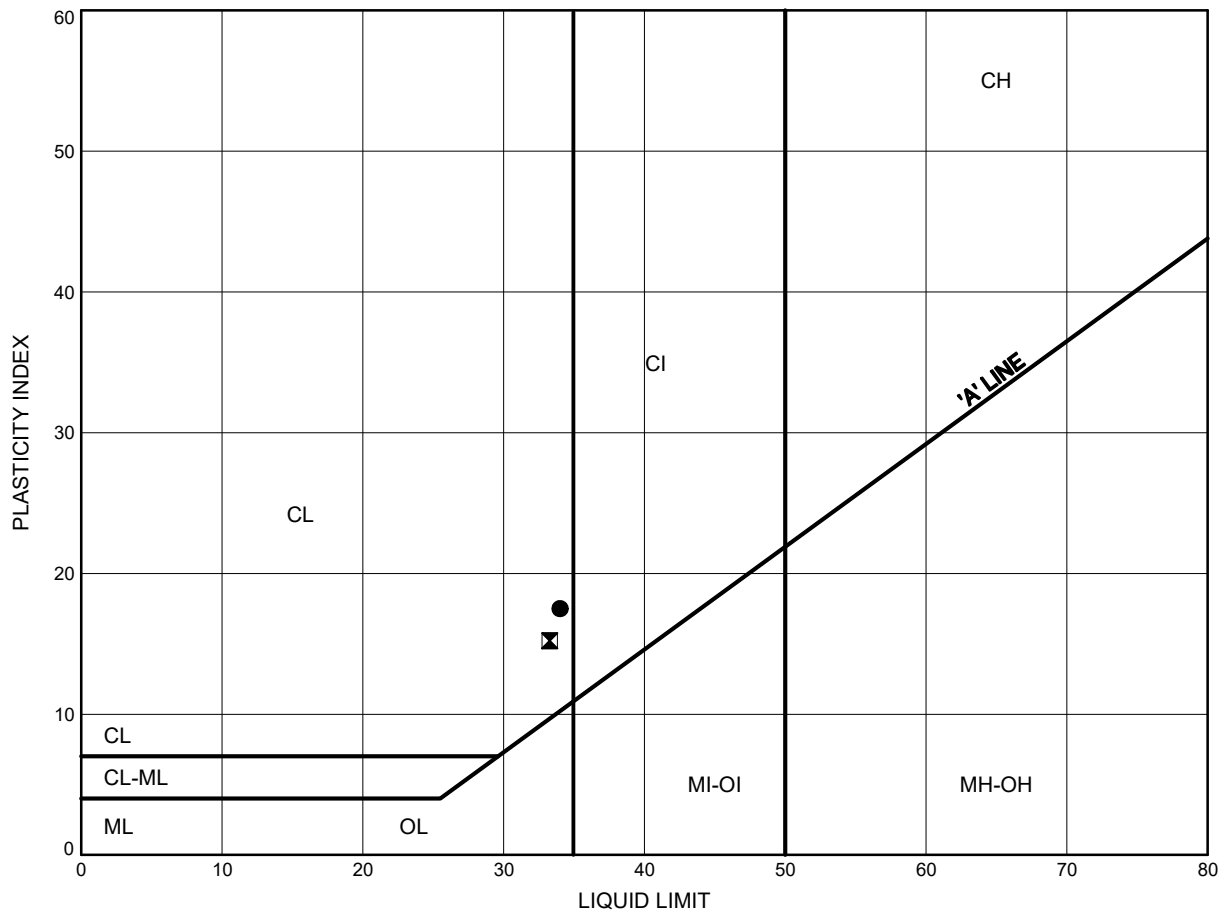


Prep'd AN  
Chkd. RPR

# Decew Road ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Silty CLAY



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	406-05	7.92	164.28
⊠	406-06	3.35	168.15

Date December 2016

GWP# 2258-15-00



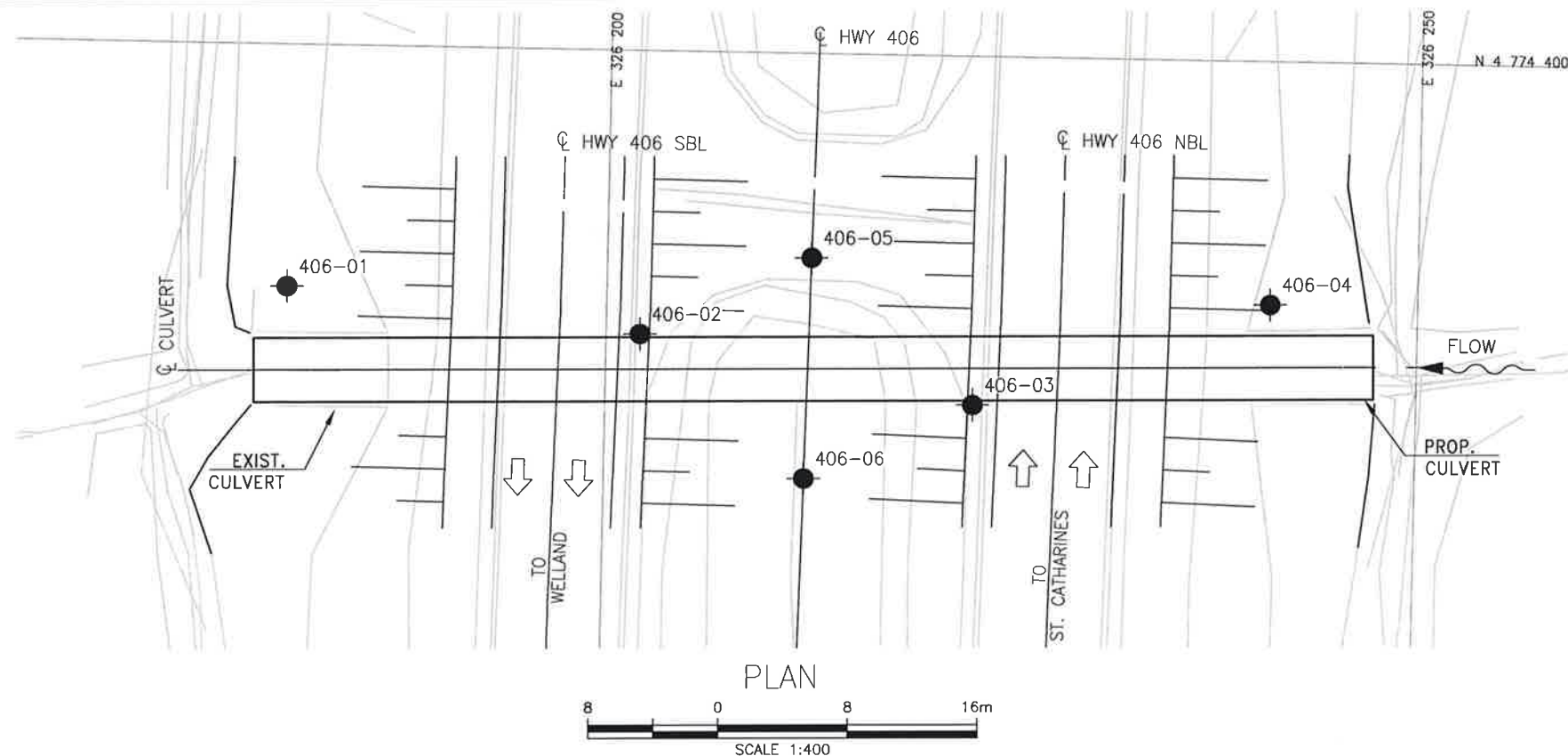
Prep'd AN

Chkd. RPR



## **Appendix C**

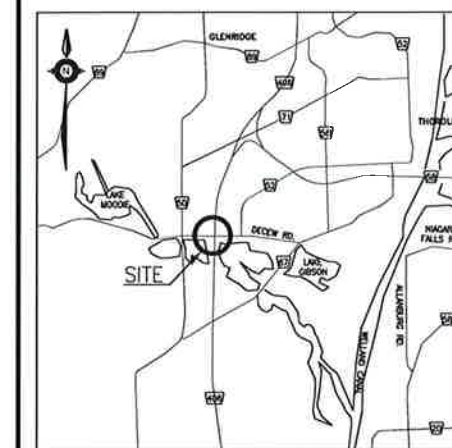
### **Borehole Locations and Soil Strata Drawings**



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






CONT No  
WP No 2258-15-00

HIGHWAY 406  
CULVERT NORTH OF DECEW RD.  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA



## KEYPLAN

### LEGEND

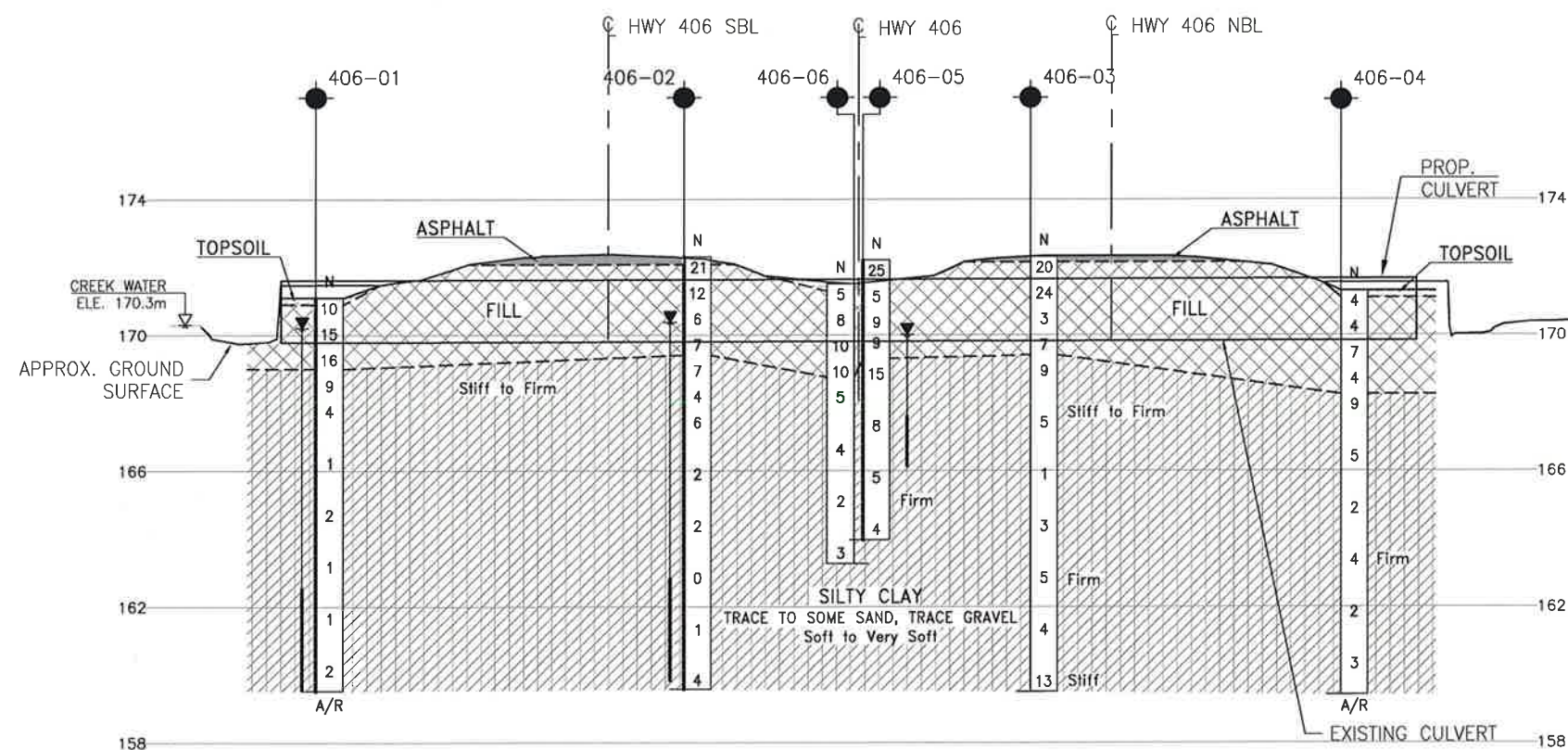
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
406-01	171.1	4 774 385.0	326 180.3
406-02	172.3	4 774 382.5	326 202.1
406-03	172.3	4 774 378.5	326 222.7
406-04	171.3	4 774 385.0	326 240.9
406-05	172.2	4 774 387.4	326 212.6
406-06	171.5	4 774 373.8	326 212.3

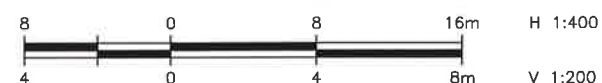
-NOTES-

- 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. 30M3-290**



## SECTION ALONG CULVERT

[illegible]

## **Appendix D**

### **Selected Photograph of Culvert Site**

Decew Road Culvert Replacement  
Highway 406



**Photo 1.- Culvert, looking north**



**Photo 2.- Culvert, looking south**



Decew Road Culvert Replacement  
Highway 406



**Photo 3.- Culvert, east side**



**Photo 4.- Culvert, west side**