



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
STRUCTURAL CULVERT No. 29-242/C1  
HIGHWAY 17 DEIL'S CREEK CULVERT  
TOWNSHIP OF HORTON, ON  
G.W.P. 4076-13-00  
AGREEMENT NUMBER: 4016-E-0014**

**GEOCRES NUMBER: 31F-202**

**SUBMITTED TO  
McINTOSH PERRY CONSULTING ENGINEERS**

**LOCATION:  
LATITUDE: 45.46873°  
LONGITUDE: -76.62259°**

**JUNE 2018  
20479**



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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 rehabilitation of Deil's Creek Culvert located on Highway 17, within the Township of Horton, Ontario. Thurber carried out the investigation as a subconsultant to McIntosh Perry Consulting Engineers (MPCE) under Agreement No. 4016-E-0014.

A base plan was provided by MPCE for the preparation of this report.

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

**2 SITE DESCRIPTION**

Culvert 29-242/C1 is located at approximate Station 23+640 on Highway 17, approximately 30 m east of the Highway 17 / County Road 6 intersection in Renfrew County, Ontario. Within the project limits County Road 6 is also known as Gillan Road to the south and Lochwinnoch Road to the north of Highway 17. For clarity County Road 6 will be used to reference the cross streets.

The location of the culvert site is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

It is noted that for project orientation purposes, Highway 17 within the project limits, will be assumed to run west-east. Flow through the culvert is from south to north. The top of streambed elevation is approximately 136.0 m.

The existing 57 m long, open footed, concrete culvert has an internal span of 3.6 m and height of 1.5 m, (see the archival construction drawing for the culvert provided in Appendix A). The asphalt surface of the highway is at approximate Elevation 138.6 m and the cover over the culvert from shoulder to the top of the culvert is approximately 0.8 m.

It is understood that several deficiencies have been noted with the culvert and that MTO would like to explore alternatives for a holding strategy, with limited expenditures and repairs to the culvert until the highway is widened and the culvert is replaced for the ultimate four lane highway configuration.

At the culvert site, Highway 17 is undivided with one through lane in each direction, tapers for a westbound right and an eastbound left turn lane and an eastbound on-ramp. There is a paved gore area present in the southeast quadrant of the intersection. The Highway 17 / County Road 6

intersection is controlled with stop signs in the north and southbound lanes of County Road 6. Based on the drawings provided, the roadway cross-section at the culvert location consists of two, 3.7 m wide through lanes, two 3.6 m wide turning lanes and gravel shoulders. Concrete curb and gutters with catchbasins are present around the paved gore area, and concrete curb and gutters are present in the northeast and southwest quadrants of the intersection.

County Road 6 has one through lane in each direction with a northbound right turn ramp to access the Highway 17 eastbound speed change lane with gravel shoulders.

The existing embankment slopes at approximately 2H:1V to 2.5H:1V (Horizontal:Vertical) and are grass and brush covered; some trees are also present. Cattails were also present at the culvert inlet. Downstream from the culvert outlet, Deil's Creek flows west under County Road 6 through two CSP culverts. The creek banks north of the outlet slope up to a flat area that is grass and tree covered.

A buried telephone company utility is present near the culvert inlet and crosses the highway to the east of the culvert.

The storm water drainage in the area is to ditches, culverts, catchbasins and Deil's Creek.

Site photographs showing the general conditions at the site, and at the inlet and outlet are presented in Appendix D.

### 3 SITE INVESTIGATION

#### 3.1 Previous Investigations

A draft preliminary GEOCREC report (31F-137, 2004) was reviewed. This investigation was carried out for the preliminary design of the proposed Highway 17 Underpass Structure at County Road 6 and included three boreholes designated CR6-1, CR6-2 and CR6-3. No reference to a final report could be found in the GEOCREC records.

#### 3.2 Field Investigation

The field investigation was carried out between January 16<sup>th</sup> and 17<sup>th</sup>, 2018, and included advancing two boreholes. The approximate MTM Zone 9 locations and ground surface elevations of the boreholes are shown on Drawing No. 1, provided in Appendix A and are summarized in Table 3-1.

**Table 3-1: Borehole Summary**

Borehole	Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Borehole Termination Depth (m)	Borehole Termination Elevation (m)
17-1	Outlet	5036558.5	295234.5	137.2	8.7	128.5
17-2	Inlet	5036511.2	295195.8	136.7	7.2	129.5

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call to provide utility locates/clearances for the intended borehole locations.

The boreholes were advanced with a portable drill rig equipped with NQ size coring equipment.

The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in all boreholes during the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. All soil samples recovered from the boreholes were placed in moisture-proof containers and the samples were transported back to Thurber's Ottawa geotechnical laboratory for further examination and testing. Bedrock was cored following ASTM Standard D6032-08 in both boreholes with NQ size coring equipment. Bedrock core samples were stored in core boxes for transport.

The boreholes were backfilled with low-permeability bentonite pellets in general accordance with Ontario MOE Regulation 903.

The as-drilled locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber. The vertical datum used was the Temporary Benchmark (TBM) provided by MPCE and located near the northeast corner of the paved gore area. The TBM has a geodetic elevation of 138.067 m. The location of the TBM is indicated on Drawing No. 1 in Appendix A.

### **3.3 Laboratory Testing**

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples in accordance with current MTO standards. Grain size distribution analyses, and Atterberg Limits testing were also carried out on selected samples to MTO and ASTM standards. All recovered bedrock core was logged and core recoveries and RQD values were measured.

The geotechnical laboratory test results are presented on the Record of Borehole sheets in Appendix B and are illustrated on the figures in Appendix C.

## **4 DESCRIPTION OF SUBSURFACE CONDITIONS**

### **4.1 Overview / General**

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert inlet and outlet areas are presented on Drawing No. 1 in Appendix A 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 stratigraphy in the area of the boreholes is characterized by clay/silt fill overlying sandy silty clay (outlet), overlying silty sand (inlet), all underlain by bedrock. This stratigraphy is generally consistent with the stratigraphy encountered in the previous, 2004 report.

Based on the OGS 1:250 000 Scale Bedrock Geology Mapping of Ontario-Revision 1 (MRD126-REV1), the regional bedrock geology includes carbonate metasedimentary rocks, marble, calc-silicate rocks, skarn and tectonic breccias.

More detailed descriptions of the individual strata are presented below.

## **4.2 Clay with Sand Fill**

A 50 mm thick rootmat layer was observed at the ground surface in Borehole 17-1.

A 600 mm thick, frozen, organic silt fill layer was observed at ground surface in Borehole 17-2. Sample recovery was poor. The moisture content of one sample was 39%.

A fill layer consisting predominantly of clay with sand was encountered in Borehole 17-1. The top of this layer was encountered at Elevation 137.1 m and the thickness of the layer was 1.4 m. The SPT 'N' values ranged from 9 to 10 however the ground was frozen at the time of the investigation which could have affected these values.

The moisture content of the samples tested ranged from 27% to 29%. The results of grain size analysis tests on a sample of the clay with sand fill indicated a gravel content of 0%, a sand content of 26%, a silt content of 53% and a clay content of 21%. Grain size analysis results are illustrated on Figure 1 in Appendix C.

The results of Atterberg Limits testing completed on a sample of the clay with sand fill indicated a liquid limit of 33, a plastic limit of 18, and a plasticity index 15. Atterberg Limits analysis results are illustrated on Figure 2 in Appendix C and indicate a low plastic clay (CL).

## **4.3 Sandy Silty Clay**

A brown to grey sandy silty clay deposit was encountered beneath the fill layer in Borehole 17-1. The top of this layer was encountered at Elevation 135.6 m and the layer had a thickness of 1.5 m. The SPT N-values were 19 and 17 suggesting that this unit is very stiff.

The moisture content of the samples tested was 16% and 19%. The results of a grain size analysis test indicated a gravel content of 1%, sand content of 38%, a silt content of 43% and a clay content of 18%. Grain size analysis results are illustrated on Figure 3 in Appendix C.

The results of Atterberg Limits testing completed on a sample of this material indicated a liquid limit of 16, a plastic limit of 12, and a plasticity index 4. Atterberg Limits analysis results are illustrated on Figure 4 in Appendix C, and indicate a low plastic silty clay (CL-ML).

## **4.4 Silty Sand with Gravel**

A sand deposit with varying amounts of silt and gravel was encountered beneath the sandy silty clay layer in Borehole 17-1 and beneath the fill layer in Borehole 17-2. The top of this layer was encountered at Elevations 134.1 m and 136.1 m. The thickness of this layer was 2.2 m and 3.6 m in Boreholes 17-1 and 17-2. The SPT 'N' values ranged from 7 to greater than 100; indicating a loose to very dense condition, but typically compact. Occasional cobbles were noted in both boreholes in this layer.

The moisture content of the samples tested ranged from 10% to 17%. The results of two grain size analysis tests indicated a gravel content of 29% and 32%, sand content of 47% and 58%, and a fines content (combined silt and clay size particles) of 13% and 21%. Grain size analysis results are illustrated on Figure 5 in Appendix C.

#### 4.5 Marble Bedrock

The overburden materials were underlain by a white marble bedrock. Both boreholes were advanced into bedrock by coring with NQ-size coring equipment. Photographs of the bedrock core are provided in Appendix B.

A summary of the bedrock surface elevation is provided in Table 4-1.

**Table 4-1: Bedrock Summary**

<b>Borehole</b>	<b>Location</b>	<b>Ground Surface Elevation (m)</b>	<b>Depth Below Existing Grade (m)</b>	<b>Top of Bedrock Elevation (m)</b>
17-1	Outlet	137.2	5.2	132.0
17-2	Inlet	136.7	4.2	132.5

The total core recovery ranged from 70% to 100%, the solid core recovery ranged from 0% to 100% and the Rock Quality Designation (RQD) ranged from 0% to 78%. Based on the RQD value the bedrock is classified as poor to good quality. A vertical fracture was encountered throughout the first run of bedrock core in Borehole 17-2 and the SCR and RQD values were measured as 0% for this run.

#### 4.6 Groundwater Conditions

Groundwater levels measured in the open boreholes were not considered representative due to the introduction of water into the borehole during coring operations.

The water level in the Deil's Creek Culvert was measured at the time of Thurber's field investigation at a depth of 1.5 m below the top of the culvert at the inlet; corresponding to Elevation 136.1 m.

Seasonal fluctuations of the water level in the culvert is to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

Standpipe piezometers were installed in all three boreholes advanced for the Highway 17 Underpass investigation and the final groundwater levels were measured in the piezometers in October 2003. The measured water level ranged from Elevation 136.3 m to 135.0 m from south to north.

## 5 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole locations, and determined the ground surface elevations based on a temporary benchmark provided by McIntosh Perry Consulting Engineers. Forage M3 Drilling Services Inc. of Hawkesbury, Ontario supplied and operated the drilling equipment to carry out the drilling, sampling, and in-situ testing. Traffic control consisting of signs and cones was provided by Thurber. The drilling, and sampling operations in the field were supervised on a full-time basis by Nick Weil of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Kenton C. Power, P.Eng.  
Geotechnical Engineer



Fred J. Griffiths, Ph.D., P.Eng.  
Senior Associate



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



**APPENDIX A**

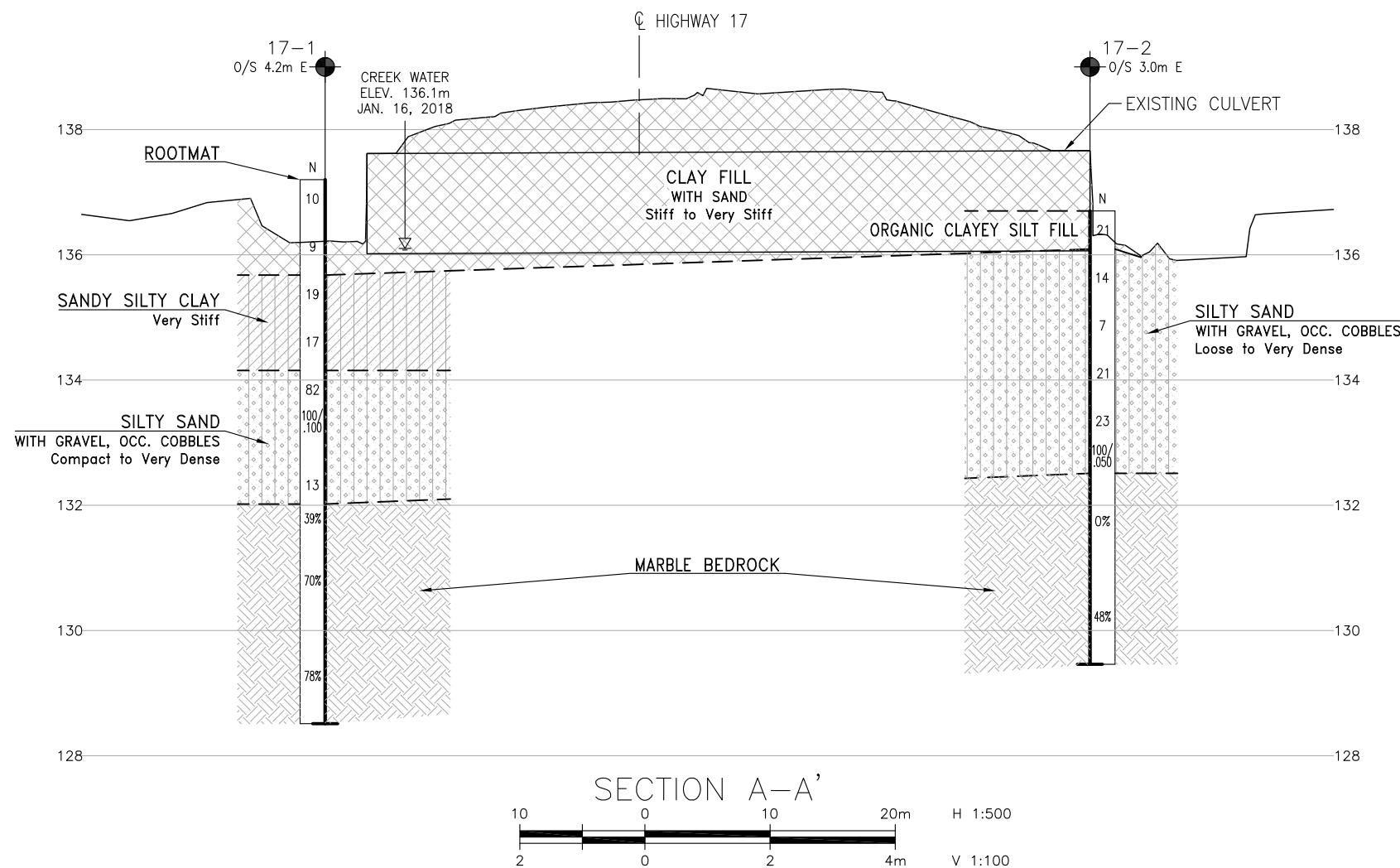
**BOREHOLE LOCATIONS AND SOIL STRATA DRAWING, JUNE 2018  
CULVERT DRAWING, CONTRACT 73-186  
BOREHOLE LOCATIONS AND SOIL STRATA DRAWING, MAY 2004**

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



CONT No	(
GWP No 4076-13-00	

HIGHWAY 17  
DEIL'S CREEK  
CULVERT REHABILITATION  
BOREHOLE LOCATIONS AND SOIL STRATA

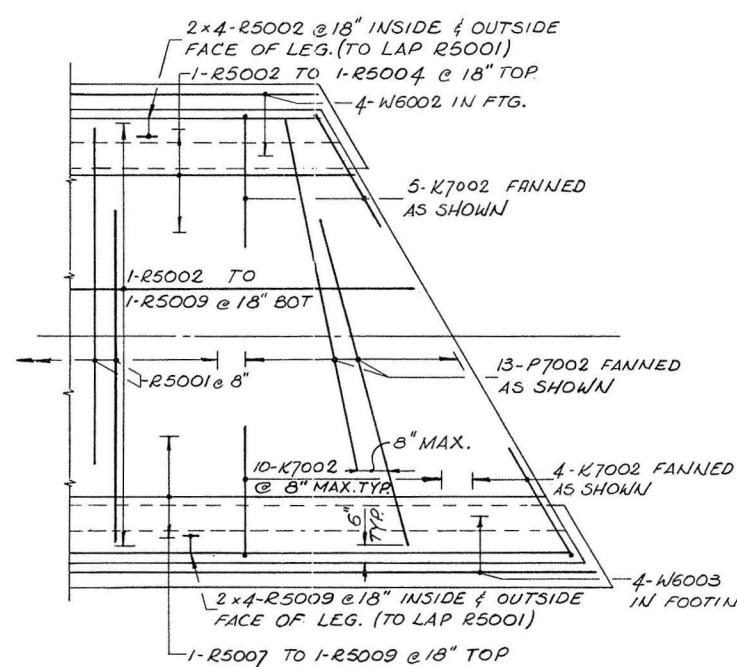
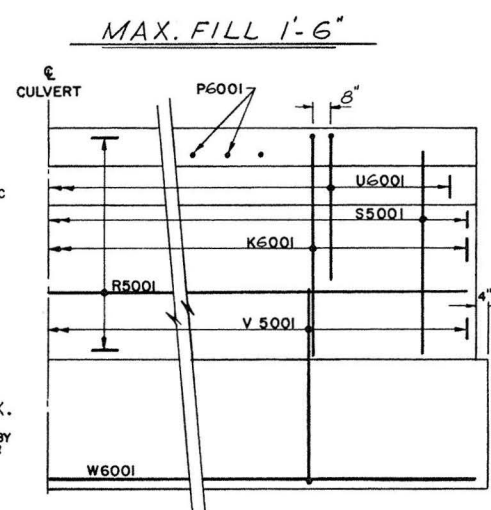
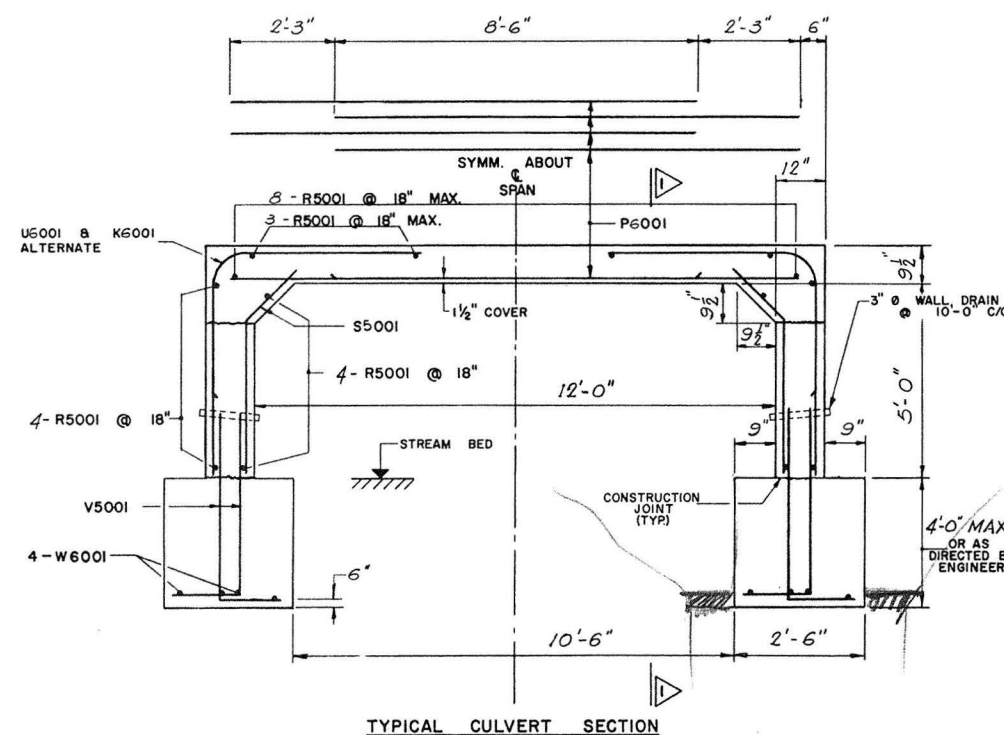
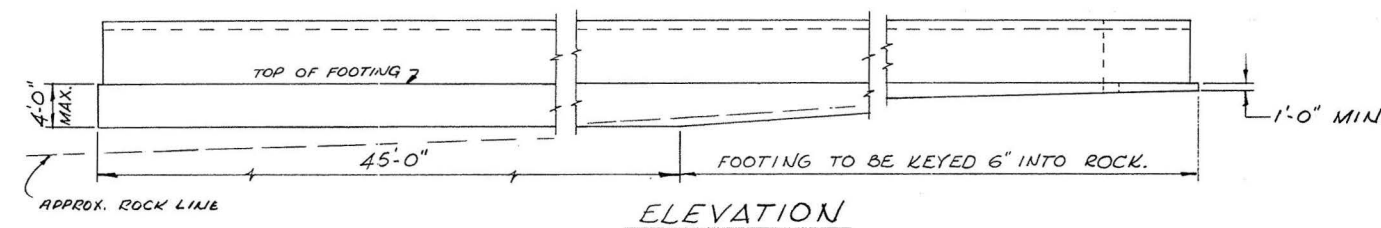
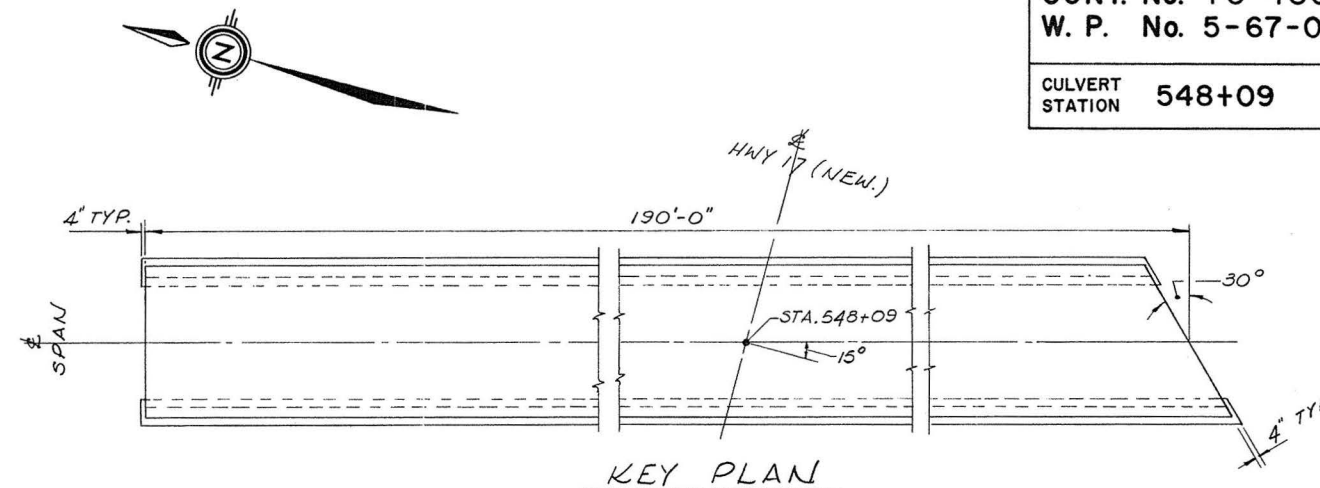


### **-NOTES-**

- 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.
- 3) Boreholes are shown in MTM Zone 9 coordinates.

**GEOCRES No. 31F-202**

REVISIONS									
	DATE	BY				DESCRIPTION			
DESIGN	KP	CHK	—	CODE		LOAD	DATE	JUN 2018	
DRAWN	MFA	CHK	KP	SITE		STRUCT	DWG	1	



# GENERAL NOTES

- CLASS OF CONCRETE 3000 PSI.
- CLEAR COVER TO REINFORCING STEEL 3" EXCEPT AS NOTED.
- ALL EXPOSED CORNERS TO BE CHAMFERED 3/4".
- NO CONCRETE SHALL BE PLACED FOR ANY FOOTING, UNTIL THE DEPTH OF THE EXCAVATION AND CHARACTER OF THE FOUNDATION MATERIAL HAVE BEEN APPROVED BY THE ENGINEER.
- FILL SHALL BE PLACED AT BOTH SIDES OF CULVERT SIMULTANEOUSLY.
- CULVERT AND WINGWALLS SHALL BE BUILT IN ACCORDANCE WITH M.T.C. FORM 9.
- REINFORCING STEEL SHALL BE HARD GRADE.
- STEEL FOR THIS CULVERT (INCLUDING WINGWALLS WHERE APPLICABLE) SHALL BE BUNDLED SEPARATELY AND MARKED WITH STATION NUMBER.
- WALL DRAINS SHALL BE BITUMINIZED FIBRE PIPE. VERTICAL LOCATION OF WALL DRAINS SHALL BE DETERMINED IN FIELD BY THE ENGINEER.
- I.F. DENOTES INSIDE FACE.
- O.F. DENOTES OUTSIDE FACE.
- E.F. DENOTES EACH FACE.
- FOR GRANULAR BACKFILL REQUIREMENTS SEE DD809 A, B & C.

REINFORCING STEEL SCHEDULE FOR CULVERT				
MARK	Nº	SPAC.	LENGTH	DETAIL
P6001	276	8"	10'-9"	STRAIGHT
K6001	276	16"	9'-3 1/4"	IN SLAB AND LEG
U6001	276	16"	7'-11 3/4"	U6001 ALTERNATE WITH K6001
S5001	286	16"	5'-10 1/2"	INSIDE FACE OF LEG
R5001	240	18"	22'-6"	STRAIGHT 30 LINES, 3 PER LINE
V5001	572	16"	6'-9"	FOOTING DOWELS
W6001	64	—	22'-9"	STRAIGHT 8 LINES, 8 PER LINE
P7002	13	—	12'-0"	STR.
K7002	19	8"	9'-7 3/4"	SEE DETAIL
R5002	10	18"	22'-6"	STR.
R5003	2	18"	23'-7"	STR.
R5004	2	18"	24'-8"	STR.
R5005	1	18"	25'-9"	STR.

R5006	1	18"	26'-10"	STR.	DISTRIBUTION STEEL
R5007	2	18"	27'-11"	STR.	
R5008	2	18"	29'-0"	STR.	
R5009	10	18"	30'-0"	STR.	LONGITUDINAL IN FOOTING.
W6002	4	—	22'-0"	STR.	
W6003	4	—	30'-0"	STR.	

DRAWING NOT TO SCALE

CULVERT & WINGWALL QUANTITIES		
	CULVERT	WINGWALLS
WT. OF REINF. STEEL	13.52 TONS	TONS
VOLUME OF CONCRETE	253.55 CU. YDS.	CU. YDS.

SS 114-1

B.S. - H. 12

HWY.17
GWP NO. 647-92-00

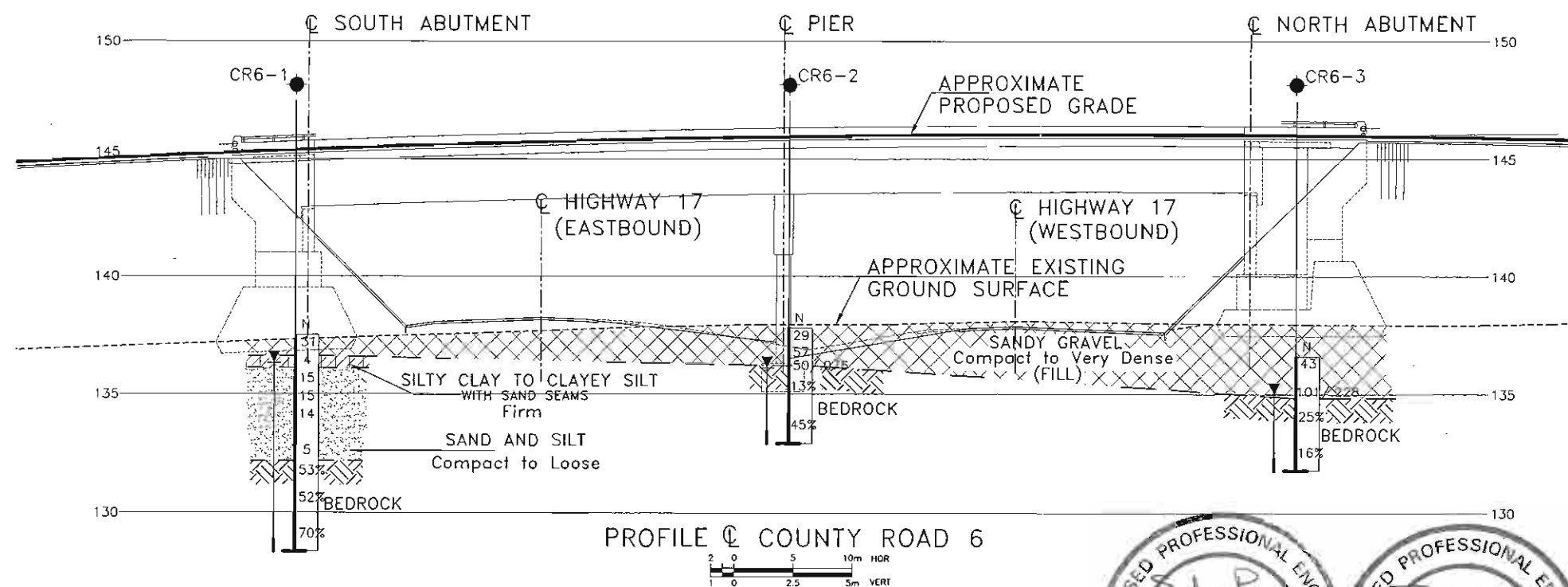
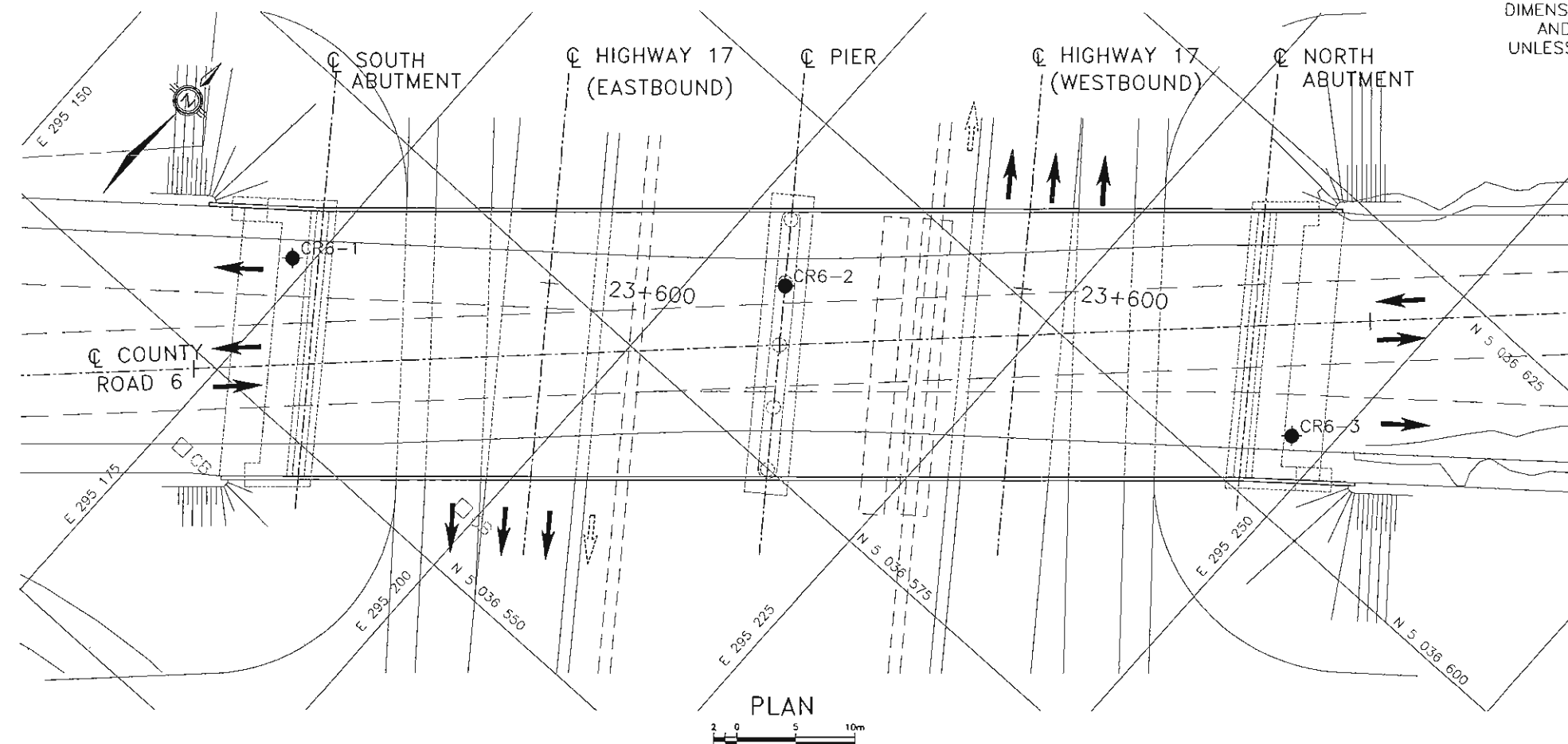
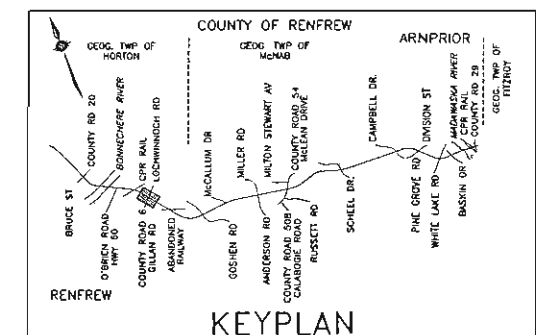


HIGHWAY 17 TWINNING  
COUNTY ROAD 6 UNDERPASS  
BOREHOLE LOCATIONS AND SOIL STRATA







SHEET



THURBER ENGINEERING LTD.



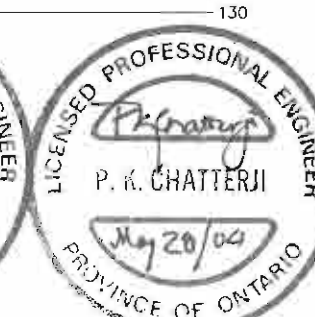
### LEGEND

- |   |   |
|---|---|
|  | Bore Hole                               |
|  | Dynamic Cone Penetration Test (cone)    |
|  | Bore Hole & Cone                        |
| N   | Blows/ 0.3m (Std Pen Test, 475 J/blow ) |
| CONE  | Blows/ 0.3m (60° Cone, 475 J/blow)      |
| PH  | Pressure, Hydraulic                     |
|  | WL at Time of Investigation             |
|  | Head Artesian Water                     |
|  | Piezometer                              |
| 90%   | Rock Quality Designation (RQD)          |
| A/R   | Auger Refusal                           |

[illegible]

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.



REVISIONS								
	MAY. 04	SP	ISSUED AS DRAFT FOR REVIEW					
	DATE	BY	DESCRIPTION					
	DESIGN	SP	CHK	PKC	CHBDC	2000	LOAD	DATE MAY.2004
	DRAWN	SS	CHK	SP	SITE	28-408	STRUCT	DWG.

## **APPENDIX B**

### **RECORD OF BOREHOLE SHEETS BEDROCK CORE PHOTOGRAPHS**



## **SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS**

### **TERMINOLOGY DESCRIBING COMMON SOIL GENESIS**

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

### **TERMINOLOGY DESCRIBING SOIL STRUCTURE:**

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

### **RECOVERY:**

For soil samples, the recovery is recorded as the length of the soil sample recovered.

### **N-VALUE:**

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

### **DYNAMIC CONE PENETRATION TEST (DCPT):**

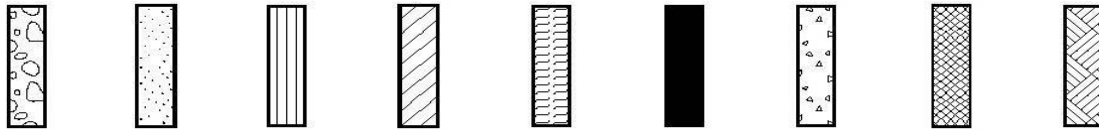
Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.





### STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Bedrock
-------------------------------	------	------	------	----------	---------	----------	------	---------

### TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

### TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

### SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

### TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

### MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note -  $W_L$  = Liquid Limit





## EXPLANATION OF ROCK LOGGING TERMS

### ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
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 structures are preserved.

### 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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

### DISCONTINUITY SPACING

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

### STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

# RECORD OF BOREHOLE No 17-1

1 OF 1

METRIC

GWP# 4076-13-00 LOCATION Site 29-242/C1 Deil's Creek Culvert, MTM Zone 9: N 5 036 558.5 E 295 234.5 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY CM  
 DATUM Geodetic DATE 2018.01.16 - 2018.01.17 CHECKED BY KP

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 (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P			W			W L				GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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ONTMT4S 20479 DEIL'S CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 5/6/18




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

# RECORD OF BOREHOLE No 17-2

1 OF 1

METRIC

GWP# 4076-13-00 LOCATION Site 29-242/C1 Deil's Creek Culvert, MTM Zone 9: N 5 036 511.2 E 295 195.8 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY CM  
 DATUM Geodetic DATE 2018.01.17 - 2018.01.17 CHECKED BY KP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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						
								20 40 60 80 100						
								20 40 60 80 100						
136.7														
0.0	Organic clayey silt - frozen Brown FILL		1	SS	21									
136.1														
0.6	SILTY SAND (SM) with gravel Loose to very dense Brown to grey		2	SS	14		136							
			3	SS	7		135							29 58 13 (SI+CL)
			4	SS	21		134							
			5	SS	23									
			6	SS	100/ 50mm		133							
132.5	- 175 mm Cobble at 4.0 m													
4.2	MARBLE BEDROCK Slightly weathered Poor to good quality Medium grained White		1	RUN			132							RUN #1 TCR=97% SCR=0% RQD=0%  *vertical fracture throughout Run#1
			2	RUN			131							RUN #2 TCR=70% SCR=67% RQD=48%
							130							
129.5														
7.2	End of Borehole													

ONTMT4S 20479 DEIL'S CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 5/6/18

**Borehole 17-1**  
**Box 1 (of 2)**  
**Elevation 132.0 m to 129.6 m**



**Borehole 17-1**  
**Box 2 (of 2)**  
**Elevation 129.6 m to 128.5 m**





**Borehole 17-2**  
**Box 1 (of 1)**  
**Elevation 132.6 m to 129.5 m**

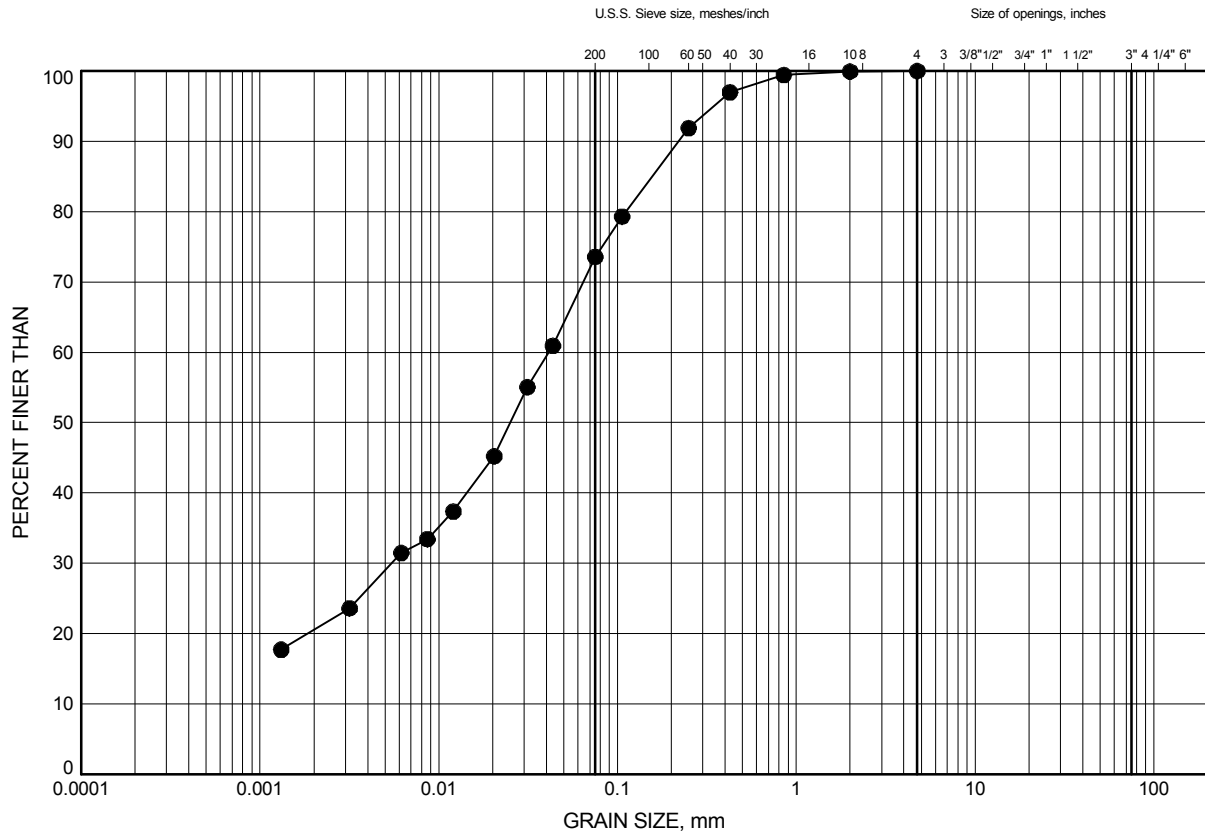


**APPENDIX C**  
**LABORATORY TEST RESULTS**

Site 29-242/C1 Deil's Creek Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 1

**Clay with Sand Fill**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	1.07	136.09

Date June 2018  
 GWP# 4076-13-00



Prep'd KCP  
 Chkd. FG

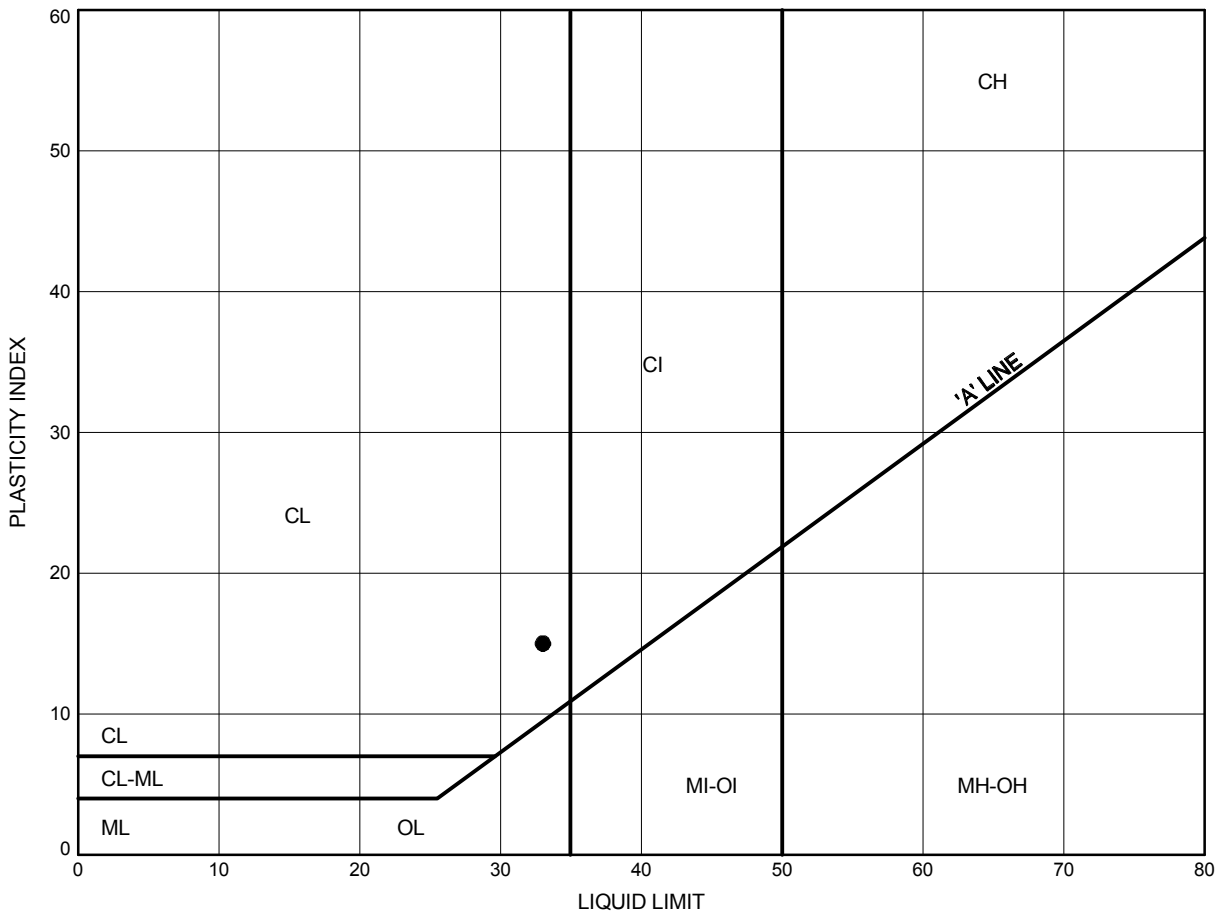


Site 29-242/C1 Deil's Creek Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE 2

Clay with Sand Fill



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	1.07	136.09

Date June 2018  
GWP# 4076-13-00

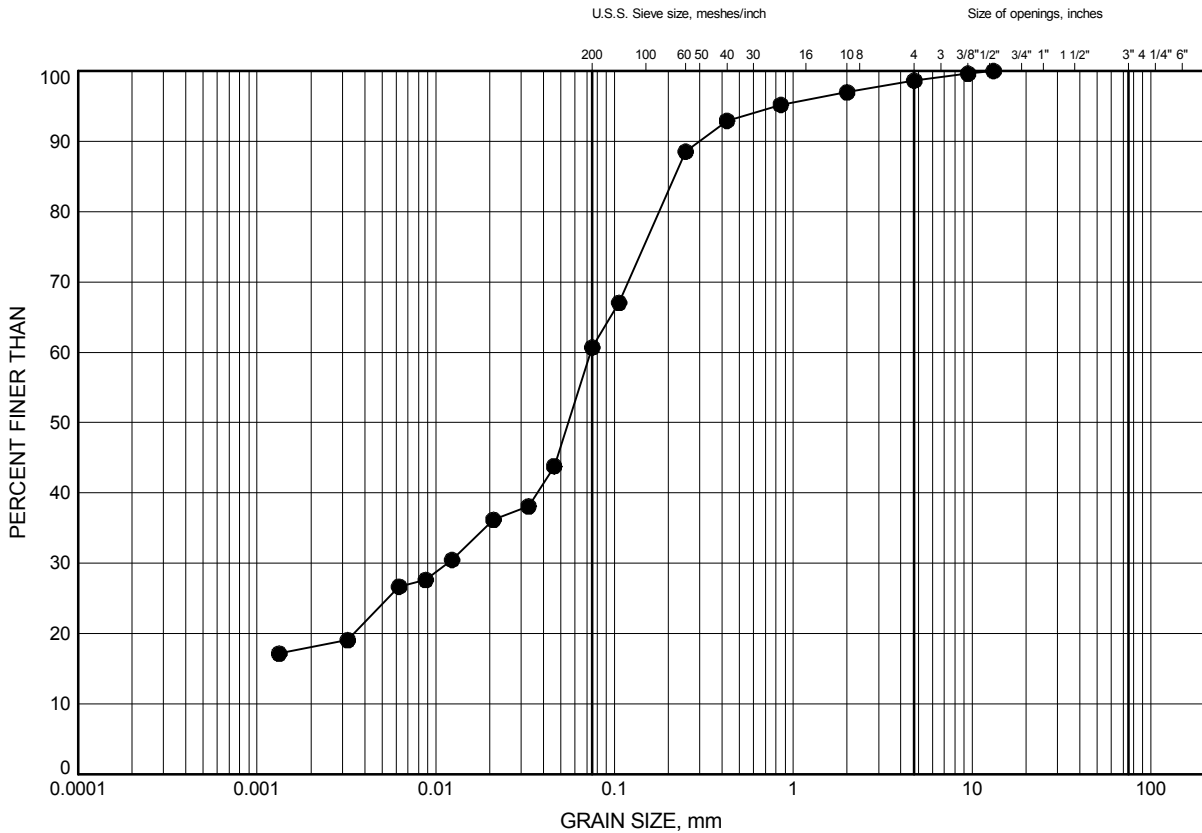


Prep'd KCP  
Chkd. FG

Site 29-242/C1 Deil's Creek Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 3

**Sandy Silty Clay**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	2.59	134.57

Date March 2018  
 GWP# 4076-13-00



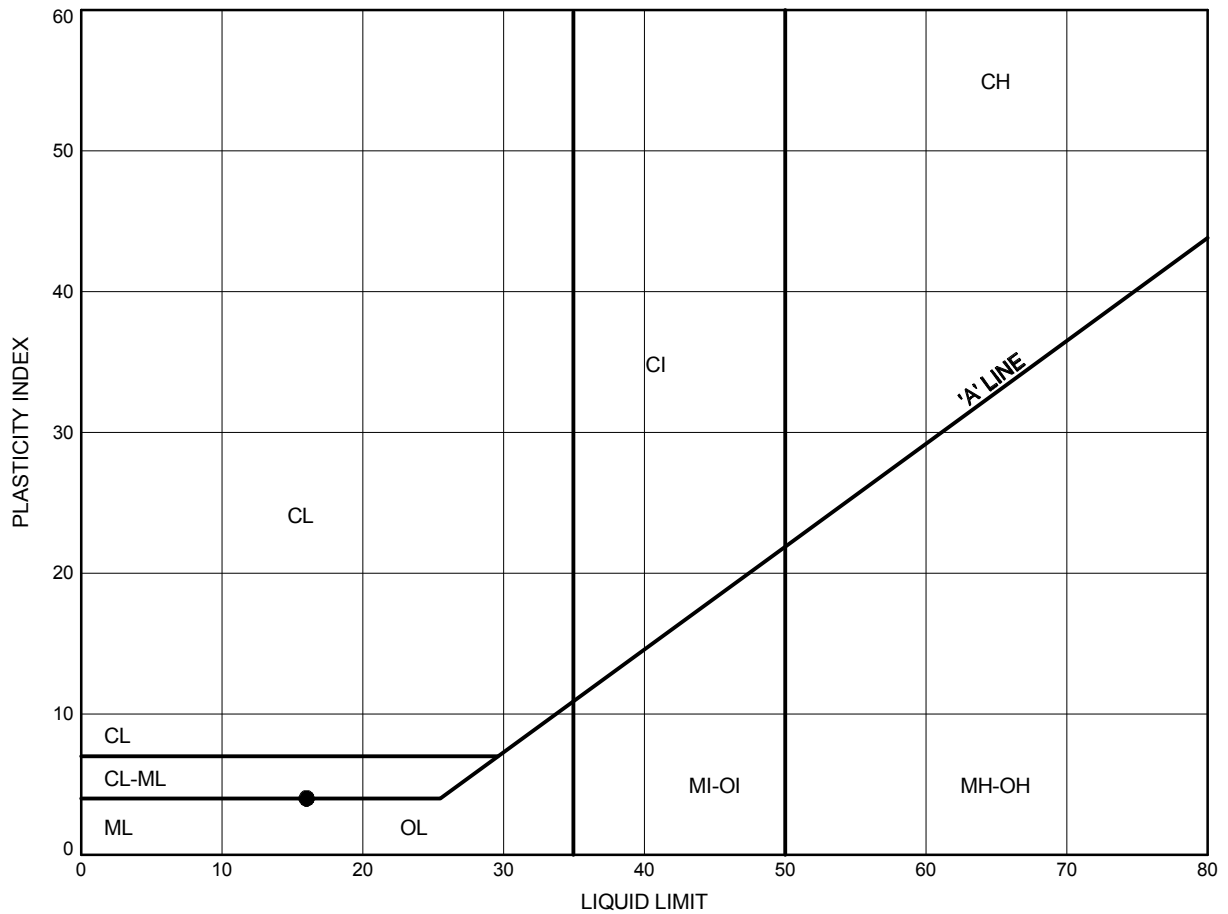
Prep'd KCP  
 Chkd. FG

Site 29-242/C1 Deil's Creek Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE 4

Sandy Silty Clay



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	2.59	134.57

Date June 2018  
GWP# 4076-13-00

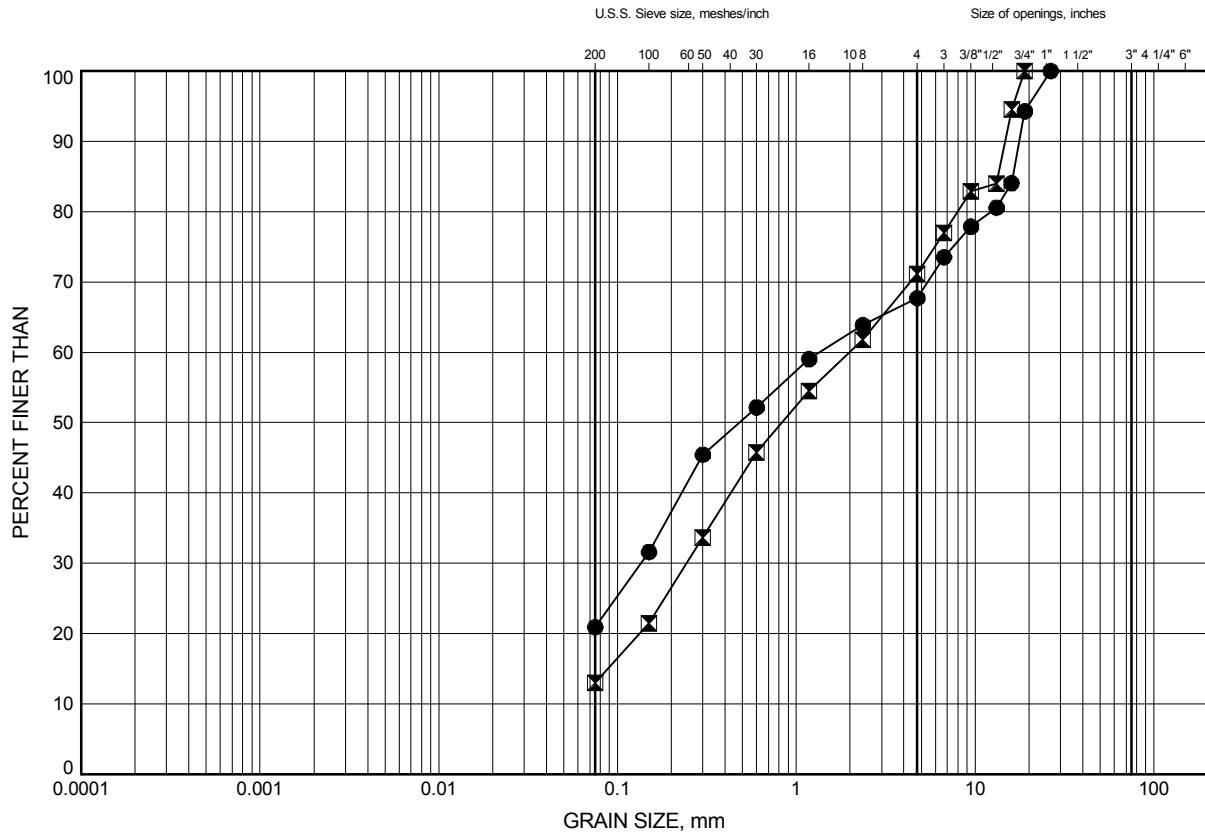


Prep'd KCP  
Chkd. FG

Site 29-242/C1 Deil's Creek Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE 5

**Silty Sand with Gravel**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	3.35	133.81
⊠	17-2	1.83	134.92

Date March 2018  
 GWP# 4076-13-00



Prep'd KCP  
 Chkd. FG

**APPENDIX D**  
**SITE PHOTOGRAPHS**



**Photograph 1: Roadway platform and embankment at culvert inlet looking southwest**



**Photograph 2: Looking upstream from culvert inlet**





**Photograph 3: Looking west along ditchline towards the existing culvert outlet**



**Photograph 4: Looking downstream from culvert outlet**





**Photograph 5: Looking southeast from County Road 6 towards culvert outlet**