



**Final
FOUNDATION INVESTIGATION
REPORT
UNKNOWN CREEK # 5
CULVERT REPLACEMENT
HWY 540
TOWNSHIP OF HOWLAND
AGREEMENT NO.: 5010-E-0007
WP: 5057-07-01
GWP: 5057-07-00
GEOCRES NO.: 41G-12**

**January 4, 2012
GS-TB-012143**

Prepared for:

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NorthEastern Region
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Table of Contents

1. INTRODUCTION	1
2. SITE DESCRIPTION	2
3. INVESTIGATION PROCEDURES AND LABORATORY TESTING.....	5
4. DESCRIPTION OF SUBSURFACE CONDITIONS	7
4.1 Top Soil	7
4.2 Asphalt.....	7
4.3 Embankment Fill	7
4.4 Silt - Sandy	8
4.5 Silt	8
4.6 Groundwater.....	9
5. REFERENCES	10
6. LIMITATIONS OF REPORT	11

APPENDICES

LIMITATIONS OF REPORT	'A'
DESCRIPTIVE TERMS FOR SOIL CLASSISFICATION	'B'

DRAWINGS

BOREHOLE LOCATION PLAN AND CROSS SECTIONS.....	1 - 4
------------------------------------------------	-------

ENCLOSURES

LOG OF BOREHOLES	1 - 3
GRAINSIZE ANALYSIS AND PARTICLE SIZE ANALYSIS.....	4 - 6
ATTERBERG LIMITS TEST RESULTS	7 - 8

List of Tables

Table 3.1	Detail of borehole locations	5
Table 4.1	Depths and elevations of auger refusals.....	7
Table 4.2	Probable depth of water table at Borehole Locations.....	9

List of Figures

Figure 2.1	Corrugated Steel Pipe (CSP) culvert (looking south)	3
Figure 2.2	Minor erosion and loss of embankment (looking north)	3
Figure 2.3	Outlet of the existing culvert (looking west)	4
Figure 2.4	Inlet of the existing culvert (looking west)	4

**FOUNDATION INVESTIGATION AND DESIGN REPORT
UNKNOWN CREEK # 5 CULVERT REPLACEMENT
HIGHWAY 540
TOWNSHIP OF HOWLAND
AGREEMENT NO.: 5010-E-0007
WP: 5057-07-01
GWP: 5057-07-00
GEOCRES NO.: 41G-12**

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

DST Consulting Engineers Inc. (DST) has been subcontracted by Genivar who was retained by Ministry of Transportation (MTO), NorthEastern Region, to conduct a geotechnical investigation for the replacement a culvert on Highway 540 near Township of Howland. This work was carried out under Agreement No.: 5010-E-0007, Detailed Design for the Replacement/Rehabilitation of various Culverts.

This report addresses the field investigation, laboratory test program, factual report on conditions (Part 1) and recommendations for the design and construction for the proposed culvert replacement (Part 2).

2. SITE DESCRIPTION

The site is located on Highway 540, approximately 12.0 km west of junction Highway 6, in Howland Township, Sudbury Area. The structural site number is 49-066.

It is understood that the proposed replacement will involve the replacement of the existing corrugated steel pipe (CSP) culvert (Figure 2.1) which has approximately 0.5 m of cover with pre cast box structure. The existing steel ellipse culvert has dimensions of 3.0 m x 2.1 m x 24.7 m and was identified by MTO in the RFQ to be in fair to poor condition with a minor corrosion and deterioration of the barrel. Buckling was observed along the structure and some moderate flaking and section loss close to the inlet was also identified. Minor erosion and loss of embankment fill were identified around this the existing culvert at this site (Figure 2.2).

The outlet and inlet of the existing culvert are grassed and wooded (Figures 2.3 and 2.4). The embankment slopes at this location vary from 2H:1V to 3H:1V. The photographs shown in Figures 2.1 to 2.4 were taken by MTO.

Physiographic information is available from published, *Map 2223; The Physiography of Southern Ontario* by the *Department of Mines and Northern Affairs Ontario Research Foundation* for the Manitoulin area, Southern Ontario. The map indicates limestone plains are dominant in the Highway 540 region which is surrounded by escarpments and bevelled till plains with beaches and shore cliffs.



Figure 2.1 Corrugated Steel Pipe (CSP) culvert (looking south)



Figure 2.2 Minor erosion and loss of embankment (looking north)



Figure 2.3 Outlet of the existing culvert (looking west)



Figure 2.4 Inlet of the existing culvert (looking west)

3. INVESTIGATION PROCEDURES AND LABORATORY TESTING

Site work was carried out in the period of four days (October 17, 2010 to October 20, 2010) utilizing a CME 750 drill rig that was operated by DST personnel. A total of three (3) hydraulically drilled boreholes using hollow stem augers were put down for the purpose of foundation design at this site.

One borehole was advanced through the road structure at Station 10+002 offset 4.3 m right. Two boreholes were advanced near the existing culvert inlet and outlet at Station 9+997 offset 12.5 m left and Station 9+985 offset 11.5 m right respectively. The minimum number of boreholes, and depths and locations of boreholes were chosen according to the given specification in Request for Quotation (RFQ) by MTO.

The borehole locations are referenced to the MTO Station numbering system as indicated in the RFQ. The centreline of the existing culvert was assumed as Station 10+000. The ground surface elevations at the borehole locations were surveyed by DST personnel. At approximately Station 9+980 offset 12 m left a benchmark with an assigned elevation of 180.95 m was placed in a hydro pole near culvert. Borehole locations, stationing and benchmark location are shown on the Borehole Location Plan, Drawings 1. Table 3.1 summarizes the detail of borehole locations and depths.

Table 3.1 Detail of borehole locations

Borehole ID	Station	Elevation (m)	Depth (m)	Offset (m)
BH1	10+002	181.60	7.3	4.3 Lt
BH2	9+997	179.68	5.2	12.5 Rt
BH3	9+985	179.65	5.1	11.5 Lt

The fieldwork was supervised on a full-time basis by DST personnel who located the boreholes in the field, performed sampling and in-situ testing and logged the boreholes. In-situ tests included standard penetration test (SPT). The soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analysis.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests

included moisture contents, particle size analyses and Atterberg limits including plastic limit and liquid limit. A total of twenty three (23) moisture contents, four (4) sieve analyses, five (5) particle analyses, and six (6) Atterberg limits have been carried out for this assignment. Laboratory test results are presented in the Boreholes Logs (Enclosures 1 to 3), and Plots (Enclosures 4 to 8).

4. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions are presented based on the information obtained during field and laboratory testing.

The generalized stratigraphy of the existing embankment, based on the conditions encountered in boreholes, consists of asphalt overlying a fill material that is underlain by a sandy silt material followed by a clayey silt layer. The fill consists of a gravel and sand material underlying a base course of sandy crushed gravel. Auger refusals on boulders or possible bedrock were encountered at different elevations in each borehole (Table 4.1).

Table 4.1 Depths and elevations of auger refusals

Borehole ID	Depth of auger refusal (m)	Elevation of auger refusal (m)
BH1	7.3	174.3
BH2	5.2	174.5
BH3	5.1	174.6

4.1 Top Soil

The Top soil was encountered in Borehole 2 and 3 with thickness of 0.08 and 0.07 m respectively.

4.2 Asphalt

Asphalt was encountered in Borehole 1. The thickness of the asphalt is about 35 mm.

4.3 Embankment Fill

Embankment fill layer was encountered in Borehole 1 below the asphalt layer. Embankment fill layer was encountered at depth of 0.03 m for Borehole 1 with thickness of approximately 2.6 m, with corresponding elevation of 181.6 m respectively. Within the sand fill cobbles were noted during the drilling process. Grain size distributions of the fill material are reported in borehole logs (Enclosures 1) and plots (Enclosure 4).

Directly below the asphalt, a fill of predominantly sandy crushed gravel material was encountered at Boreholes 1 from 35 mm below surface to depths up to 0.3 m, corresponding to elevations of between 181.6 to 181.3 m respectively. This layer is roadbed granular layer.

Gradation analyses conducted on a sample from Borehole 1 indicates gravel, sand and fines contents of approximately 52%, 37% and 10% respectively. Moisture content was found to be 3%. This material does not classify as Granular A meeting SSP 110S13 requirements.

Directly below this sandy crushed gravel, a fill of predominantly gravel and sand materials was encountered at Boreholes 1 from 0.3 m below surface to the depths of 2.6 m corresponding to elevations of between 181.3 to 179.1 m respectively. Gradation analyses conducted on samples from Borehole 1 indicate gravel, sand, and fines contents of approximately 48%, 36% and 16% respectively. This material does not classify as Granular B, Type I meeting SSP 110S13 requirements. The moisture content of samples was between 4 and 9%.

4.4 Silt - Sandy

Soft to firm sandy silt material was encountered in Borehole 1, 2 and 3 at depths of 2.6, 0.08 and 0.07 m with thickness of 2.6, 3.1 and 3.1 m, corresponding to elevations of 179.1, 179.6 and 179.6 m respectively. Cobbles were noted within this stratum during drilling process. Gradation analyses conducted on the samples from Borehole 1 and 3 indicate gravel, sand, silt and clay contents of approximately 8 to 9%, 35 to 43%, 38 to 47% and 10 to 11% respectively. Gradation analyses conducted on samples from Borehole 2 indicate gravel, sand, and fines contents of approximately 11 to 12%, 47 to 50% and 39 to 41% respectively.

Atterberg limit test carried out on samples from Boreholes 1 and 3 indicate this material has a low plasticity with liquid limits and plasticity indexes from 13 to 18 and 3 to 6 respectively. The moisture content of samples was between 8 and 19%.

4.5 Silt

Very soft to soft silt was encountered in Boreholes 1, 2 and 3 at depth of 5.2, 3.7 and 3.7 m, with corresponding elevations of 176.4, 176.0 and 176.0 m respectively. The thickness of this stratum is 2.1, 1.5 and 1.4 m for Borehole 1, 2 and 3 respectively. Gradation analyses conducted on the samples from Borehole 1 and 3 indicate gravel, sand, silt and clay contents of approximately 0 to 7%, 16 to 29%, 60 to 76% and 4 to 7% respectively. The moisture content of samples was between 14 and 22%. Atterberg limit test carried out on a sample from Borehole 3 indicate this material has a low plasticity with liquid limit and plasticity index of 20 and 3 respectively.

4.6 Groundwater

The groundwater table was identified below the ground surface during the field investigation and visual identification of soil samples. The estimated depth of groundwater level below the ground surface elevation is given in Table 4.2. The water level in the creek at the culvert was at an elevation of approximately 178.7 m during the field investigation. The groundwater levels and water level at the culvert can be expected to vary with season and precipitation events.

Table 4.2 Probable depth of water table at Borehole Locations

Borehole ID	Borehole elevation (m)	Water table elevation (m)	Depth of water table below the ground surface (m)
BH1	181.60	178.5	3.1
BH2	179.68	178.18	1.5
BH3	179.65	178.15	1.5

5. REFERENCES

Canadian Highway Bridge Design Code (2006), CAN/CSA-S6-06, A National Standard of Canada, Canadian standards Association.

Special Provisions, Ontario Provincial Standards, SSP110S13.

6. LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

Prepared by:

Reviewed by:



Deep Bansal, M.Eng
Jr. Project Manager



Dr. M W Bo, PhD., P. Eng, P.Geo, Int PE,
C.Geol, C. Eng, Eur Geol, Eur Eng
Principal / Director (GeoServices)

Reviewed by:



Wesley Saunders, P. Eng.
Project Manager

APPENDIX 'A'
LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

GEOTECHNICAL STUDIES

The data, conclusions and recommendations which are presented in this report, and the quality thereof, are based on a scope of work authorized by the Client. Note that no scope of work, no matter how exhaustive, can identify all conditions below ground. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. Conditions can also change with time. It is recommended practice that DST Consulting Engineers be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

Any results from an analytical laboratory or other subcontractor reported herein have been carried out by others, and DST Consulting Engineers Inc. cannot warranty their accuracy. Similarly, DST cannot warranty the accuracy of information supplied by the client.

A P P E N D I X 'B'

**DESCRIPTIVE TERMS FOR SOIL
CLASSIFICATION**

Descriptive Terms for soil classification:

As per the soil classification manual by MTO, the descriptive terms based on percent by mass of the whole sample, are described as per following table

Descriptive Term	Example	Percent by Mass of Sample
And (with two major soil types)	Sand and gravel	40-60
Adjective (silty)	Silty	30-40
With	Silt with fine sand	20-30
Some	Silt, some fine sand	10-20
Trace	Sand, trace of gravel	0-10

DRAWINGS

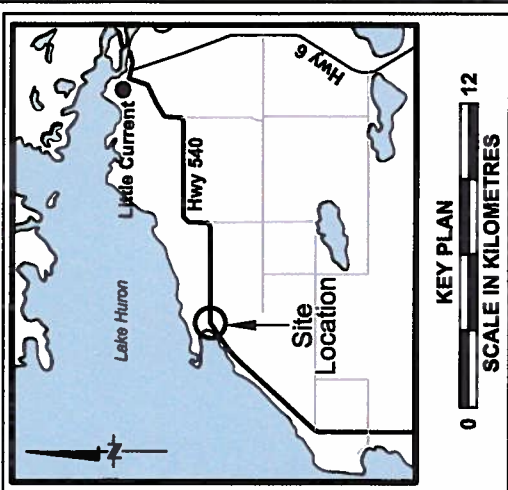
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METERS

CONT

No 5010-E-0007
GWP No 5057-07-00
Site No 49-066
Geocres No 41G-12

CULVERT REPLACEMENT
UNKNOWN CREEK CULVERT #5
Highway 540 - Howland Twp.
BOREHOLE LOCATION PLAN

SHEET



LEGEND

Borehole

Borehole with DCPT

Dynamic Cone Penetration Test (DCPT)

Rock Probe

Blows/0.3m (Std. Pen Test, 475 J/Blow)

Water level at time of investigation

Benchmark

Fill

Organics

Topsoil

Till

Bedrock

Sand

Silt

Clay

Sand & Gravel

Boulders

No.	Elevation	Northing	Eastings	Station	Offset
BH1	181.685	5885101	418533	10+002	4.3 m RT
BH2	178.685	5885124	418536	9+987	12.5 m LT
BH3	178.685	5885835	418533	9+985	11.5 m RT

Note:
Auger refusal was encountered on possible
boulders or bedrock at all borehole locations

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NOTES:

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

LOT 25
CON 6

Scale in Metres
0 50

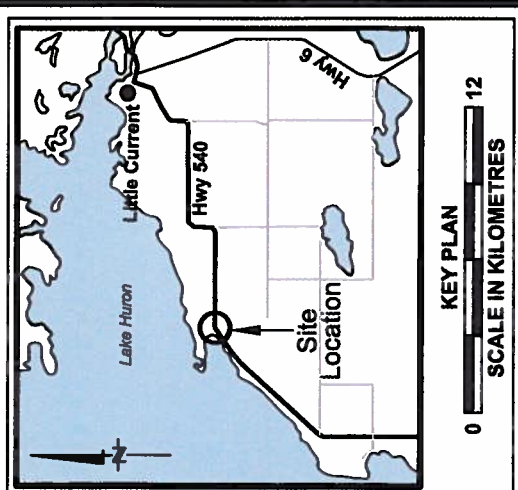
DRAWING 1

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETERS + METERS

CONT No 5010-E-0007
GWP No 5057-07-00
Site No 49-066
Geocres No 41G-12

SHEET

CULVERT REPLACEMENT
UNKNOWN CREEK CULVERT #5
Highway 540 – Howland Twp.
BOREHOLE LOCATION &
SOIL STRATIGRAPHY



LEGEND

Borehole

Borehole with DCPT

Dynamic Cone Penetration Test (DCPT)

Rock Probe

'N' Blows/0.3m (Std. Pen Test, 475 J/Blow)

Water level at time of investigation.

Benchmark

Fill

Organics

Topsoil

Till

Bedrock

Sand

Silt

Clay

Sand & Gravel

Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	181.805	5083101	418333	19+002	4.3 m RT
BH2	179.885	5089124	418336	9+997	12.5 m LT
BH3	179.855	5089685	418333	9+985	11.6 m RT

Note:
Auger refusal was encountered on possible boulders or bedrock at all borehole locations

NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

DST

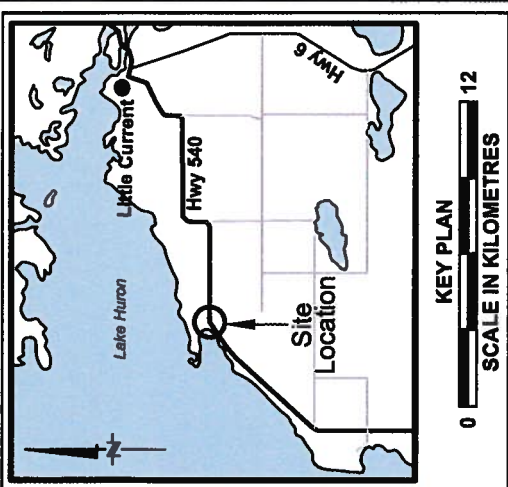
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Fx: (807) 623-1792
consulting engineers Email: thunderbay@dstgroup.com

Distance H:1 to V:1

DRAWING 2

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETERS + METERS

CONT	No 5010-E-0007	SHEET
GWP	No 5057-07-00	
Site	No 49-066	
Geocres	No 41G-12	
CULVERT REPLACEMENT UNKNOWN CREEK CULVERT #5 Highway 540 - Howland Twp. BOREHOLE LOCATION & SOIL STRATIGRAPHY		

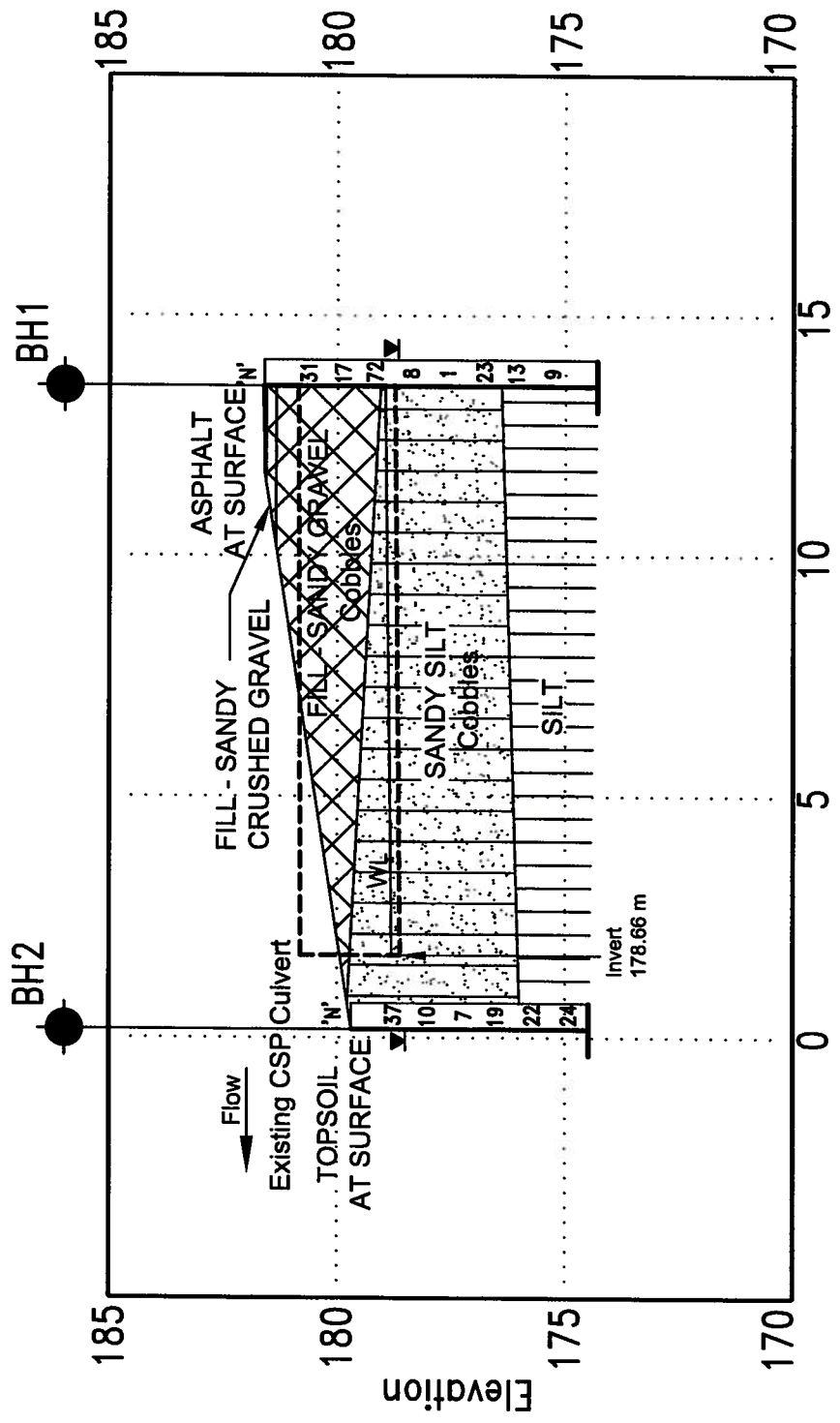
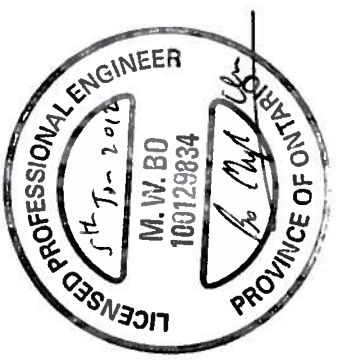
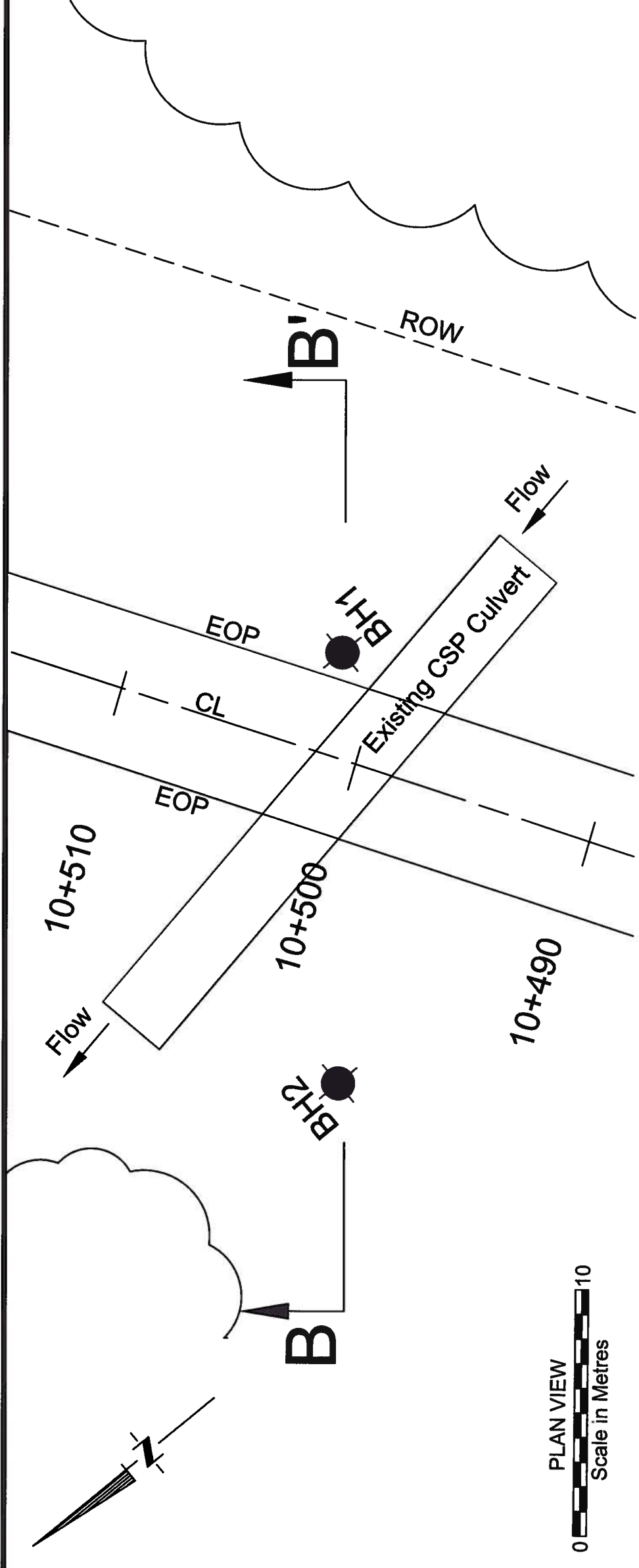


LEGEND			
	Borehole		Fill
	Borehole with DCPT		Organics
	Dynamic Cone Penetration Test (DCPT)		Topsoil
	Rock Probe		Till
	Blows/0.3m (Std. Pen Test, 475 J/Blow)		Bedrock
	Water level at time of investigation		Sand
	Benchmark		Silt
	Sand & Gravel		Clay
	Boulders		Sand & Gravel Boulders


Note:
Auger refusal was encountered on possible
boulders or bedrock at all borehole locations

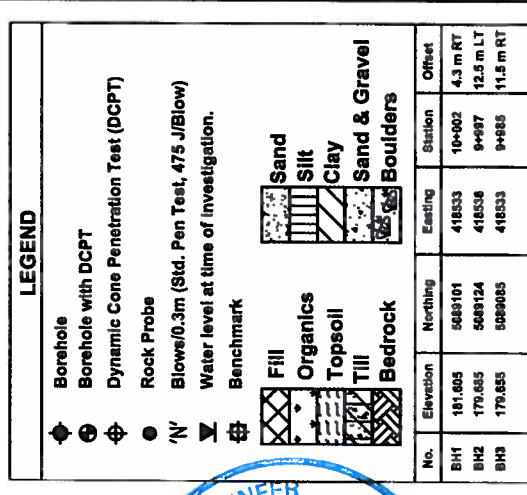
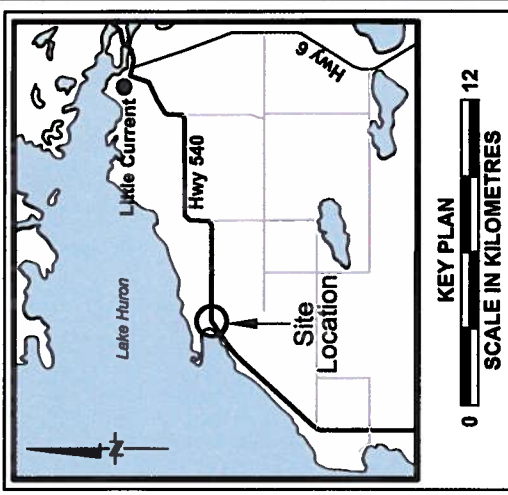
NOTE:
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locations. Between boreholes the boundaries are assumed by interpolation
and may not represent actual conditions.

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Distance H:1 to V:1

CONT No 5010-E-0007 GWP No 5057-07-00 Site No 49-066 Geocres No 41G-12	
CULVERT REPLACEMENT UNKNOWN CREEK CULVERT #5 Highway 540 - Howland Twp. BOREHOLE LOCATION & SOIL STRATIGRAPHY	SHEET



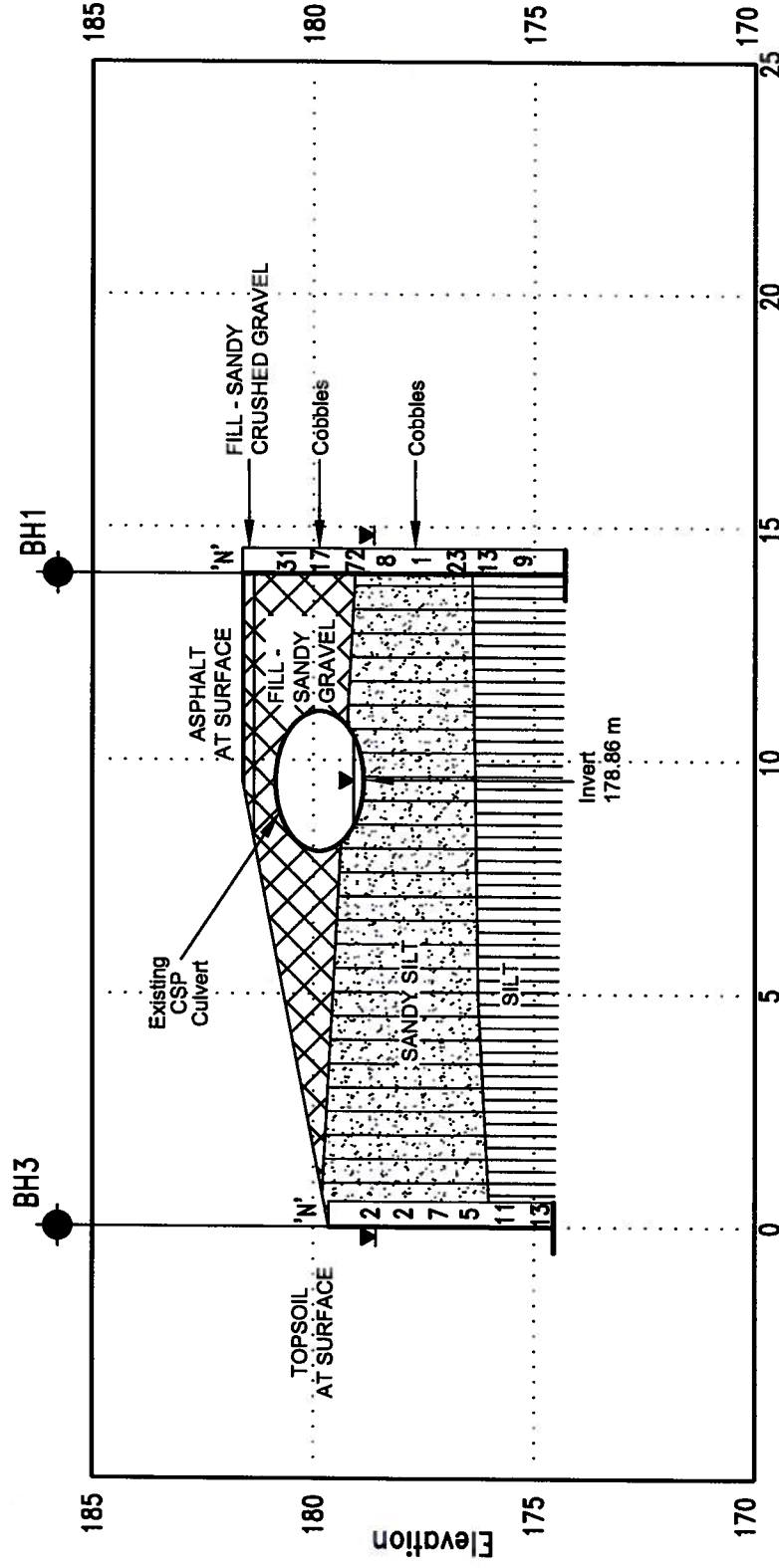
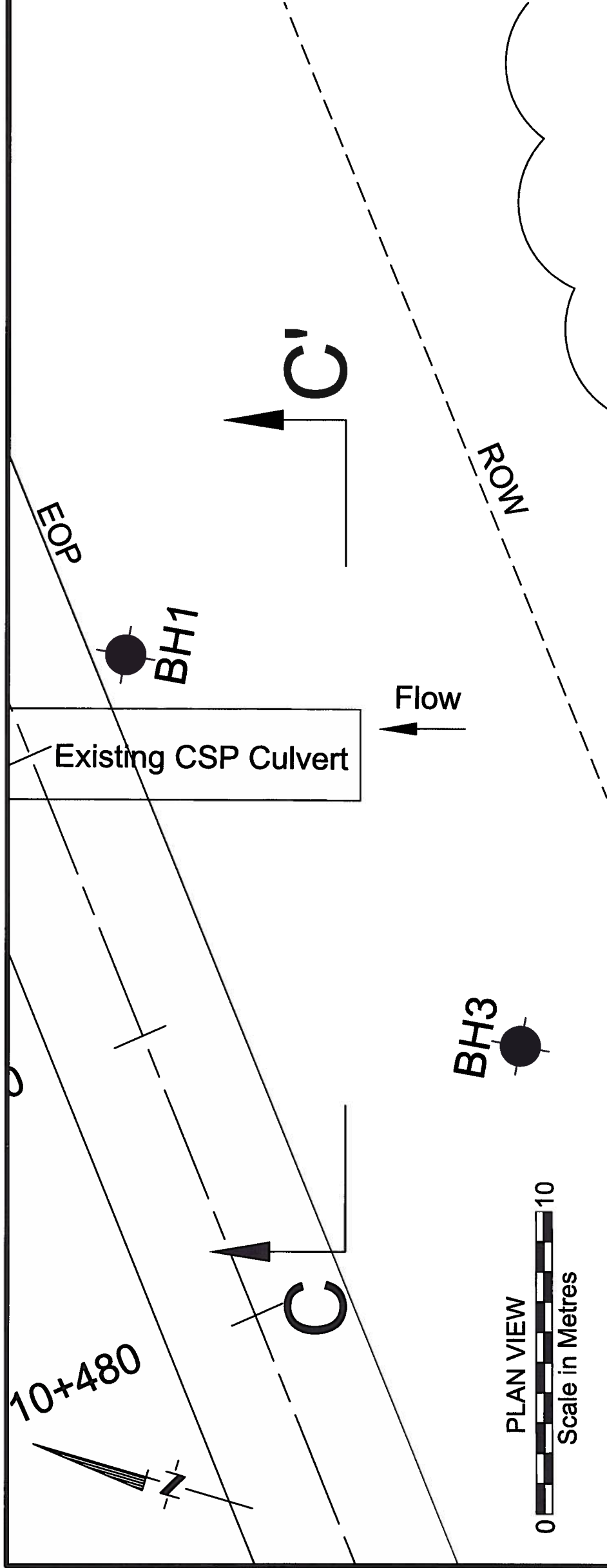
Note: Auger refusal was encountered on possible boulders or bedrock at all borehole locations

NOTE: The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

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DRAWING 4



ENCLOSURES

RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 5057-07-01 LOCATION STA. 10+002 4.3 m RT (17T 5089101 m N, 418533 m E) ORIGINATED BY PR
 DIST HWY 540 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
 DATUM Assumed DATE 2010 10 19 CHECKED BY LP/MWB

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 (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
181.6	GROUND SURFACE							20	40	60	80	100					
180.0	ASPHALT - 35 mm		1	AS													Water level at 3.1 m on completion. Cave at 4.5 m. 52 38 (10)
184.3	FILL - CRUSHED GRAVEL - Sandy, trace silt, brown		2	SS	31												
	FILL - GRAVEL - Sandy, some silt, brown, compact to very dense		3	SS	17												48 36 (16)
	- COBBLES																
179.1	SILT - Sandy, some clay, trace gravel, grey, very soft to very stiff		4	SS	72												8 35 46 11
2.6	- COBBLES		5	SS	8												
			6	SS	1												0 16 77 7
			7	SS	23												
176.4	SILT - some sand, trace clay, layered, grey, very soft to stiff		8	SS	13												
5.2			9	SS	9												
			10	SS	1												
174.3	End of Borehole at 7.3 m Auger Refusal																
7.3																	

\times^3, \star^3 : Numbers refer to Sensitivity \bigcirc 3% STRAIN AT FAILURE

ENCLOSURE 1

ON MOT CS-TB-012143 - GENIVAR - #5010-E-0007 - HWY 540 - UNKNOWN CREEK #5.GPJ DST_MIN GDT 4/1/12

RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 5057-07-01 LOCATION STA. 9+997 12.5 m LT (17T 5089124 m N, 418536 m E) ORIGINATED BY PR
DIST HWY 540 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
DATUM Assumed DATE 2010 10 19 CHECKED BY LP/MWB

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
179.7	GROUND SURFACE							20	40	60	80	100					GR SA SI CL
178.9	TOPSOIL - 80 mm SILT - Sandy, some gravel, trace clay, brown, loose to dense		1	AS		▽	179										Anticipated water level at 1.5 m. Cave at 4.0 m. 12 47 (41)
	- COBBLES		2	SS	37		178										
			3	SS	10		177										
			4	SS	7		176										
			5	SS	19		175										
176.0																	11 50 (39)
3.7	SILT - with sand, trace gravel and clay, layered, grey, compact, firm		6	SS	22		176										
			7	SS	24		175										7 29 60 4
174.5																	
5.2	End of Borehole at 5.2 m Auger Refusal																

\times^3, \star^3 : Numbers refer to Sensitivity \bigcirc 3% STRAIN AT FAILURE

ENCLOSURE 2

ON_MOT_CS-TB-012143 - GENIVAR - #5010-E-0007 - HWY 540 - UNKNOWN CREEK #5.GPJ_DST_MIN.GDT 4/1/12

RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

W.P. 5057-07-01 LOCATION STA. 9+985 11.5 m RT (17T 5089085 m N, 418533 m E) ORIGINATED BY PR
DIST HWY 540 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
DATUM Assumed DATE 2010 10 19 CHECKED BY LP/MWB

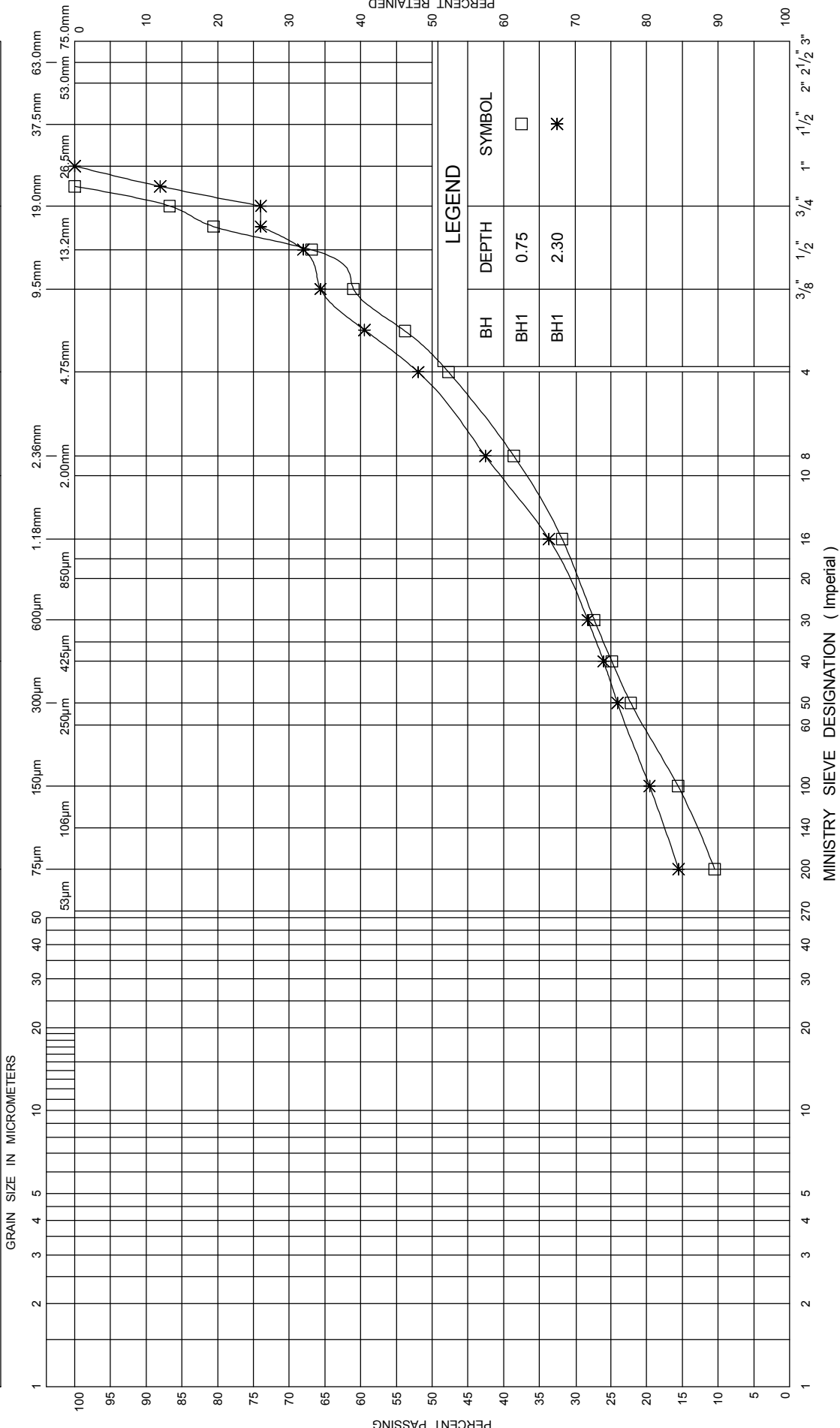
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20	40	60	80	100						20	40	60
179.7	GROUND SURFACE																GR SA SI CL			
178.9	TOPSOIL - 70 mm SILT - Sandy, trace gravel and clay, trace organics, grey, soft to firm		1	AS													Anticipated water level at 1.5 m. Cave at 5.0 m.			
			2	SS	2															
			3	SS	2															
			4	SS	7											9 43 38 10				
			5	SS	5															
176.0																				
3.7	SILT - trace clay, some sand, grey, stiff		6	SS	11															
			7	SS	13												0 18 76 6			
174.6	End of Borehole at 5.1 m Auger Refusal																			
5.1																				

✕³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 3

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine		Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION
SANDY GRAVEL

ENCLOSURE 4

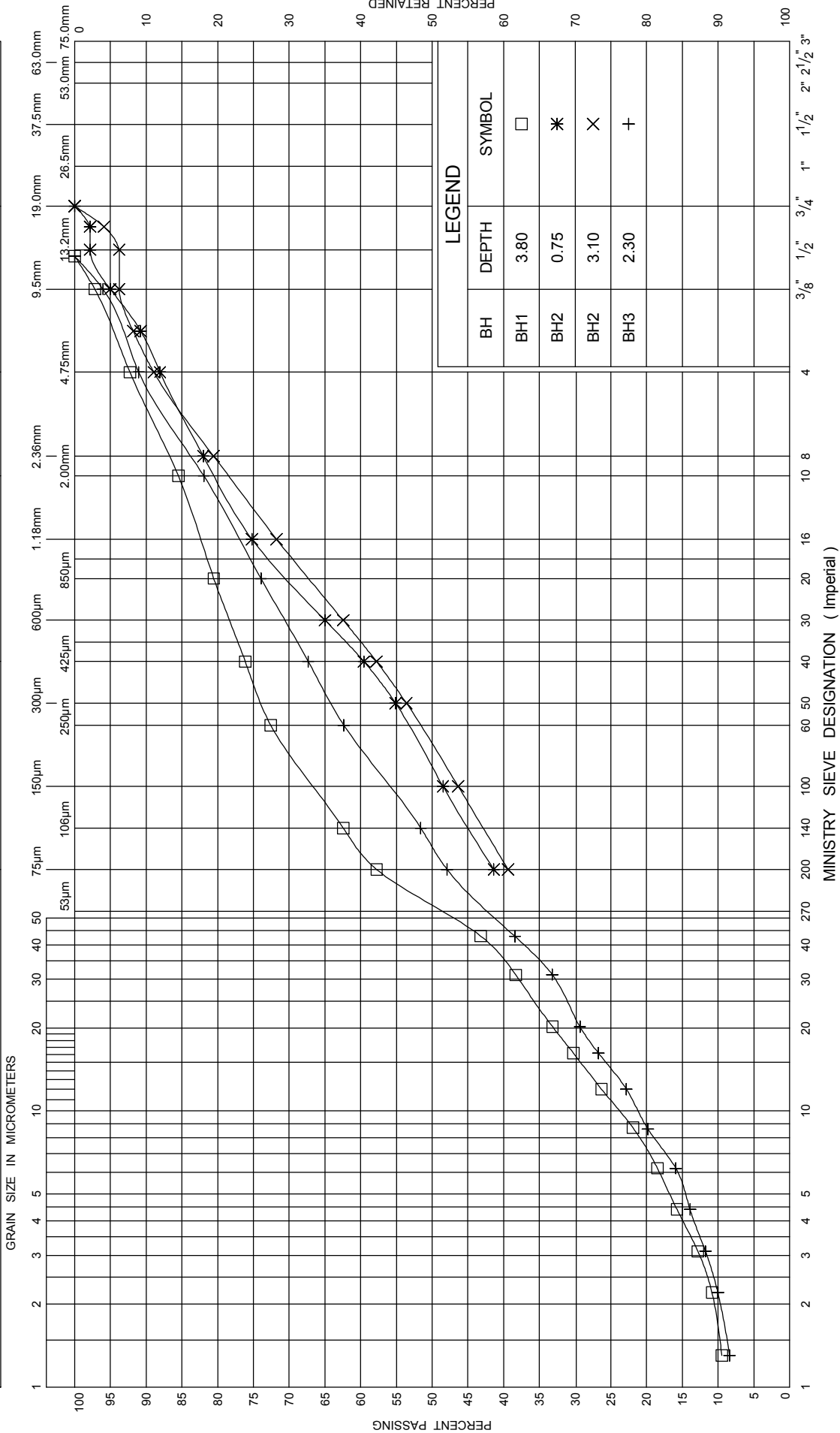
5010-E-0007 - Unknown Creek #5

HIGHWAY 540



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine		Medium	Coarse	Fine	Coarse



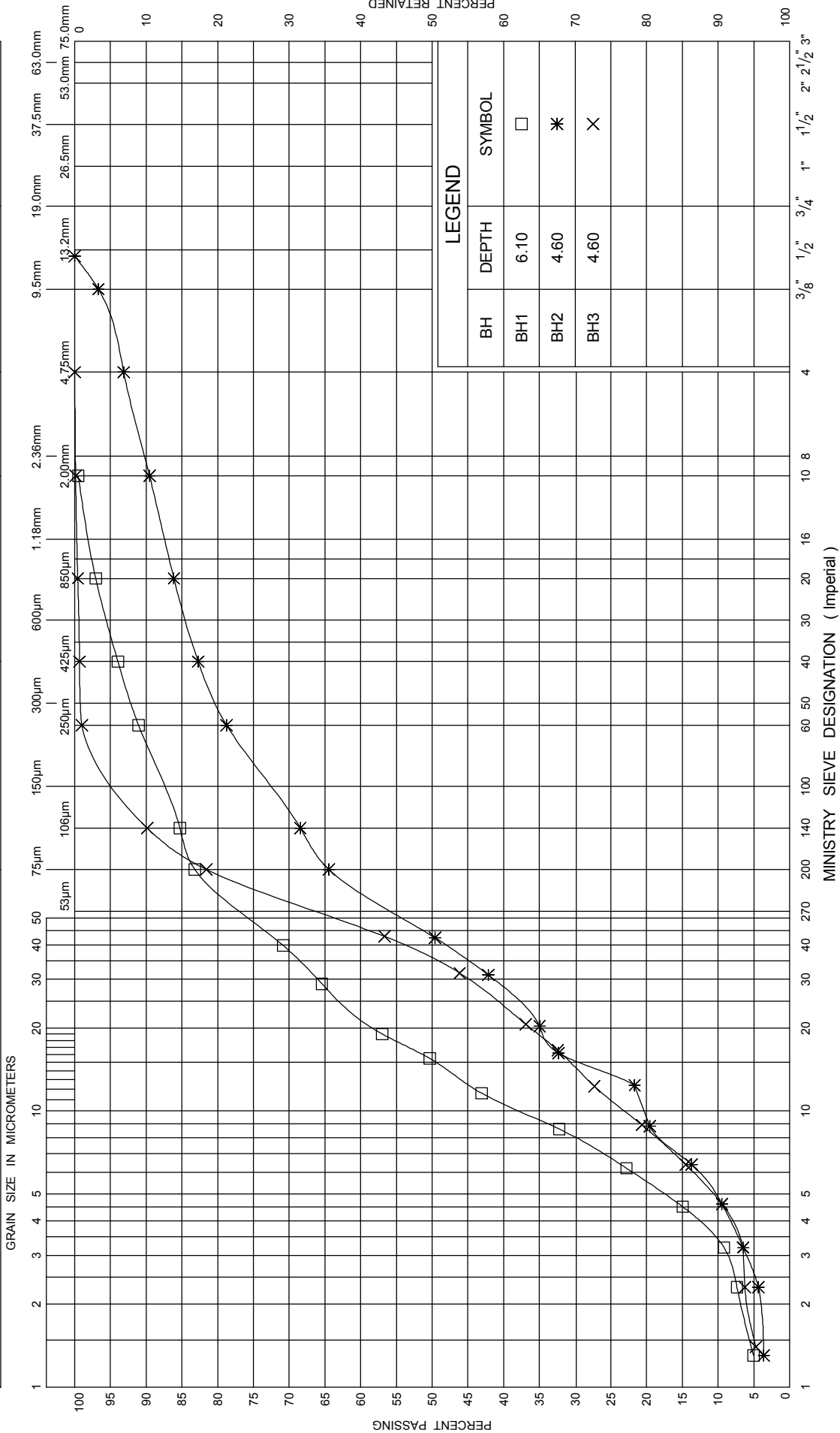
GRAIN SIZE DISTRIBUTION
SANDY SILT

ENCLOSURE 5
W P 5057-07-01
HIGHWAY 540



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION
SILT

ENCLOSURE 6
W P 5057-07-01
HIGHWAY 540



