FOUNDATION INVESTIGATION AND DESIGN REPORT
PROPOSED CULVERT REPLACEMENT
ONAPING LAKE ROAD NEAR SUDBURY, ONTARIO
SITE NO. 46-411/C
G.W.P. 5022-10-00
MTO GEOCRES NO. 41I-287

Prepared for:

ONTARIO MINISTRY OF TRANSPORTATION

By:

SPL CONSULTANTS LIMITED

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

Project: 1067-710 (Onaping Lake Road)
February 2013

146 Colonnade Road
Ottawa, Ontario K2E 7Y1
Tel: 613.228.0065 Fax: 613.228.0045

FOUNDATION INVESTIGATION REPORT
PROPOSED CULVERT REPLACEMENT
ONAPING LAKE ROAD NEAR SUDBURY, ONTARIO
SITE NO. 46-411/C
G.W.P. 5022-10-00
MTO GEOCRES NO. 41I-287

Prepared for:

ONTARIO MINISTRY OF TRANSPORTATION

By:

SPL CONSULTANTS LIMITED

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

Project: 1067-710 (Onaping Lake Road)
February 2013

146 Colonnade Road
Ottawa, Ontario K2E 7Y1
Tel: 613.228.0065 Fax: 613.228.0045

Table of Contents

Site Photographs

Drawings No.

Appendices

1. INTRODUCTION

SPL Consultants Limited (SPL) was retained by the Ontario Ministry of Transportation (MTO) to conduct a foundation investigation as part of a proposed culvert replacement on Onaping Lake Road approximately 300 m east of Highway 144 near Sudbury, Ontario.

The terms of reference (TOR) for this investigation are outlined in the Request for Quotation (RFQ) issued by the MTO under Agreement No. 5011-E-0023 dated November 2011 and SPL's subsequent Proposal No. P11.12.011 dated December 2011.

The purpose of the foundation investigation was to obtain subsurface information at the site by means of exploratory boreholes. This report presents the findings of the foundation investigation carried out at the site, as well as general comments and recommendations for the design and construction of the proposed culvert replacement.

2. SITE DESCRIPTION

The site is located on Onaping Lake Road approximately 300 mm east of Highway 144, near Sudbury, Ontario (see Drawing 1). The topography in the general area is generally flat to gently sloping. The area is heavily vegetated with trees and forest in the upland areas and small shrubs and grasses along the floodplain of the watercourse. Rock outcrops are visible in the stream bed to the south (downstream) of the culvert crossing.

Flow in the watercourse is from north to south, and based on information provided to us the estimated flow velocity during a 5 year storm is 4.65 m/s corresponding to a flow rate of 34.36 m^3/s. At the time of the investigation the water level in the creek was at approximately 96.3 m elevation, or 3.4 m below the top of the existing culvert.

The existing structure is an approximately 4 m diameter by 23 m long, round, Structural Plate Corrugated Steel Pipe (SPCSP). The culvert has approximately 300 mm of soil cover. The existing road is gravel surfaced and approximately 7.5 m wide.

The elevation of the road in the general vicinity of the crossing is approximately 100.2 m (a local datum has been established by others for this project) and the top of the existing culvert outlet is 99.7 m (again, in the local datum). The existing embankment is approximately 4 m to 4.5 m high at the crossing.

3. INVESTIGATION PROCEDURES

The initial foundation investigation was carried out in March and December 2012. The scope of work for this assignment included a desk study, field investigations, laboratory testing, analysis and preparation of this report.

3.1 Desk Study

Surficial geology in the area comprises glaciofluvial outwash (coarse-grained) deposits, as well as exposed bedrock. These deposits generally would be expected to include silt, sand and gravel, as well as potentially cobbles and boulders.

Bedrock geology maps of the general area indicate the bedrock in the area to be foliated to gneissic tonalite and granodiorite.

3.2 Field Investigation

The field investigation was carried out between March 1 and March 8, 2012. The field investigation included drilling a total of 5 boreholes at the crossing location (BH-1 through BH-5).

The boreholes were advanced using a truck-mounted drill rig supplied and operated by Landcore Drilling of Chelmsford, ON. The boreholes were drilled using a combination of hollow-stem auger drilling and rock coring to depths ranging from 9.7 m to 15.8 m below the existing ground surface. During drilling, sampling and in-situ testing including Standard Penetration (SPT) Testing and Dynamic Cone Penetration Testing (DCPT) Testing, were carried out at regular intervals.

A standpipe piezometer was installed in Borehole BH-4 to allow for measurement of groundwater levels at the site. All boreholes were backfilled with bentonite and soil cuttings and were sealed at the ground surface.

A supplementary field investigation was completed in December 2012. During this supplementary investigation an additional two boreholes were advanced at the site. Due to difficult access, the boreholes were drilled by SPL using hand-portable equipment. At BH12-2 the drilling was carried out using driven casing, wash boring and regular sampling with a standard SPT sampler. SPT sampling was completed using a non-standard 31.8 kg hammer; all other aspects of the test were completed in the standard manner. SPT “N” values presented on borehole logs and on the foundation drawings have been corrected for this reduced driving energy.

At Borehole BH12-1 SPT sampling could not be carried out due to difficulties retrieving the samples and heaving of the base of the borehole below the water table. At this location the borehole was advanced by wash boring and visual observation of the general nature of the returned material in the cuttings stream. A DCPT test was also completed at this location to supplement the borehole information (using the non-standard hammer as discussed above, and corrected for the reduced driving energy).

Borehole locations are shown in Drawing 2. Borehole logs are included in Appendix A of this report.

3.3 Laboratory Testing

During drilling and in-situ testing, soil samples were retained for further examination and classification. A laboratory testing program, including determination of natural water content, grain size distribution (sieve and hydrometer) and chemical analyses, was carried out on selected representative soil samples.

The results of natural water content testing are included on the relevant borehole logs in Appendix A. The results of grain size distribution testing are summarized on the individual borehole logs and are presented in Drawings 5 and 6.

Chemical testing to determine sulphate content, chloride content, pH and soil resistivity was also carried out on selected soil samples obtained during drilling. The results of these tests are included in Appendix B.

4. SUBSURFACE CONDITIONS

The subsurface conditions at the site are discussed in the following sections. Detailed descriptions of the soil and groundwater conditions encountered at each of the borehole locations are included in the individual borehole logs in Appendix A.

4.1 Soil Conditions

4.1.1 Fill

Five of the boreholes drilled as part of this investigation (BH-1 through BH-5) were drilled on the existing gravel-surfaced (unpaved) road. At all locations granular fill was encountered which forms the road structure, as well as the existing embankment.

The granular fill is primarily sand and gravel, with a trace of silt. Cobbles and boulders were also encountered at various locations within the fill layer (see Borehole records in Appendix A).

The grain size curves for several samples of the fill are presented in Drawing 5. A summary of the grain size distribution of these samples is also presented in Table 1 below. It should be noted that these grain size distribution tests were carried out on samples obtained through SPT testing which does not recover coarse gravel, cobble and boulder sized particles. Because of this the grain size distributions shown on Drawing 5 and Table 1 may be finer than portions of the materials in the field.

Table 1 – Results of Grain Size Analyses for Compact to Dense Sand and Gravel Fill Material

Borehole No.	Sample No.	Grain Size Distribution		
		% Gravel	% Sand	% Silt & Clay
BH-1	2	48	46	6
BH-1	1	15	71	14
BH-3	2	39	55	6
BH-3	5	38	55	7
BH-4	1	18	74	8
BH-4	3	32	63	5
BH-5	2	51	45	4
Range		15 – 51	45 – 74	4 - 14

The density of the fill material (as interpreted based on SPT “N” values) ranged from compact to very dense. Very high “N” values often reflect the presence of cobbles and boulders, rather than a very high density of the soil matrix itself.

The fill material extended to a depth of 3.0 m to 4.6 m below the existing road surface in the boreholes drilled as part of this investigation. This corresponds to local elevations of 95.2 m to 96.9 m.

4.1.2 Native Sand and Gravel Soils

The granular fill layer was underlain by native soils which include a variable mixture of sands with trace to some gravel and trace silt. These predominantly sandy soils extended from the base of the fill embankment to the depth of drilling in all boreholes.

The grain size distributions of several samples of the native soils are presented in Drawing 6, and are summarized in Table 2 below.

Table 2 – Results of Grain Size Analyses for Loose to Compact Native Sand Soils

Borehole No.	Sample No.	Grain Size Distribution		
		% Gravel	% Sand	% Silt & Clay
BH-1	8	2	93	5
BH-2	9	3	96	1
BH-2	7	5	94	1
BH-2	9	21	77	2
BH-2	11	2	94	4
BH-3	9	18	80	2
BH-4	6	13	85	2
BH-4	8	19	80	1
BH-4	10	26	71	3
BH-4	12	13	83	4
BH-5	5	30	64	6
BH-5	6	31	68	1
BH-5	8	24	75	1
BH12-5	6	2	94	4
Range		2 - 31	64 – 96	1 - 6

The sandy soils are typically described as loose to compact (as interpreted based on SPT “N” values), with localized areas being described as dense. SPT “N” values and DCPT resistance values are presented on the borehole logs included in Appendix A as well as on the cross-sections presented as Drawings 3 and 4.

4.1.3 Bedrock/Auger Refusal

Neither bedrock, nor auger refusal were encountered in any of the boreholes drilled at the site.

4.2 Groundwater Conditions

The water level in the creek at the time of the investigation was approximately 96.3 m elevation (in the local datum). Seepage was noted beginning near this elevation within the sandy soils during drilling.

A standpipe piezometer was installed in BH-4 during drilling. The groundwater level at the site was found to be at 96.5 m elevation (or approximately coincident with the level of the creek at the time of drilling). This would generally be expected given the sandy (permeable) nature of the soils at the site. Soil samples were noted to be wet/saturated in all boreholes below approximately this elevation.

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations as well as fluctuations in response to major weather events, and in particular for this site, in response to changes in the level of the creek. If construction is carried out at a time when the creek level is higher than the level in March 2012, a corresponding increase in groundwater levels should be anticipated.

4.3 Summary

A summary of the soil and groundwater conditions encountered at the crossing location is presented in Table 3 below.

Table 3 – Simplified Stratigraphy and Groundwater Elevations

Borehole No.	Ground Surface Elevation (local datum)	Simplified Soil Stratigraphy		Measured Groundwater Elevation (local datum)
		Sand and Gravel Fill	Native Sand and Gravel	
BH-1	100.2 m	0.0 – 3.6 m	3.6 – 9.7 m	--
BH-2	100.2 m	0.0 – 4.5 m	4.5 – 12.8 m	--
BH-3	99.8 m	0.0 – 4.6 m	4.6 – 12.8 m	--
BH-4	100.2 m	0.0 – 4.5 m	4.5 – 15.8 m	96.5
BH-5	99.9 m	0.0 – 3.0 m	3.0 – 9.7 m	--
BH12-1	97.2 m	0.0 – 1.2 m	1.2 – 6.1 m	--
BH12-2	96.7 m	0.0 – 1.8 m	1.8 – 6.1 m	--

5. CLOSURE

The field investigations were supervised by Mr. Naeem Ehsan, P.Eng. This report was prepared by Mr. Chris Hendry, P.Eng. Mr. Fanyu Zhu, P.Eng., who is the project manager and SPL's designated MTO contact and Mr. Shaheen Ahmad, P.Eng., who is the project quality control auditor, provided quality control and independent review of the technical aspects of this report.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

SPL CONSULTANTS LIMITED

Chris Hendry, M.Eng., P.Eng.

Fanyu Zhu, Ph.D., P.Eng.

Shaheen Ahmad, M.A.Sc., P.Eng.

Site Photographs

Looking North at Outlet

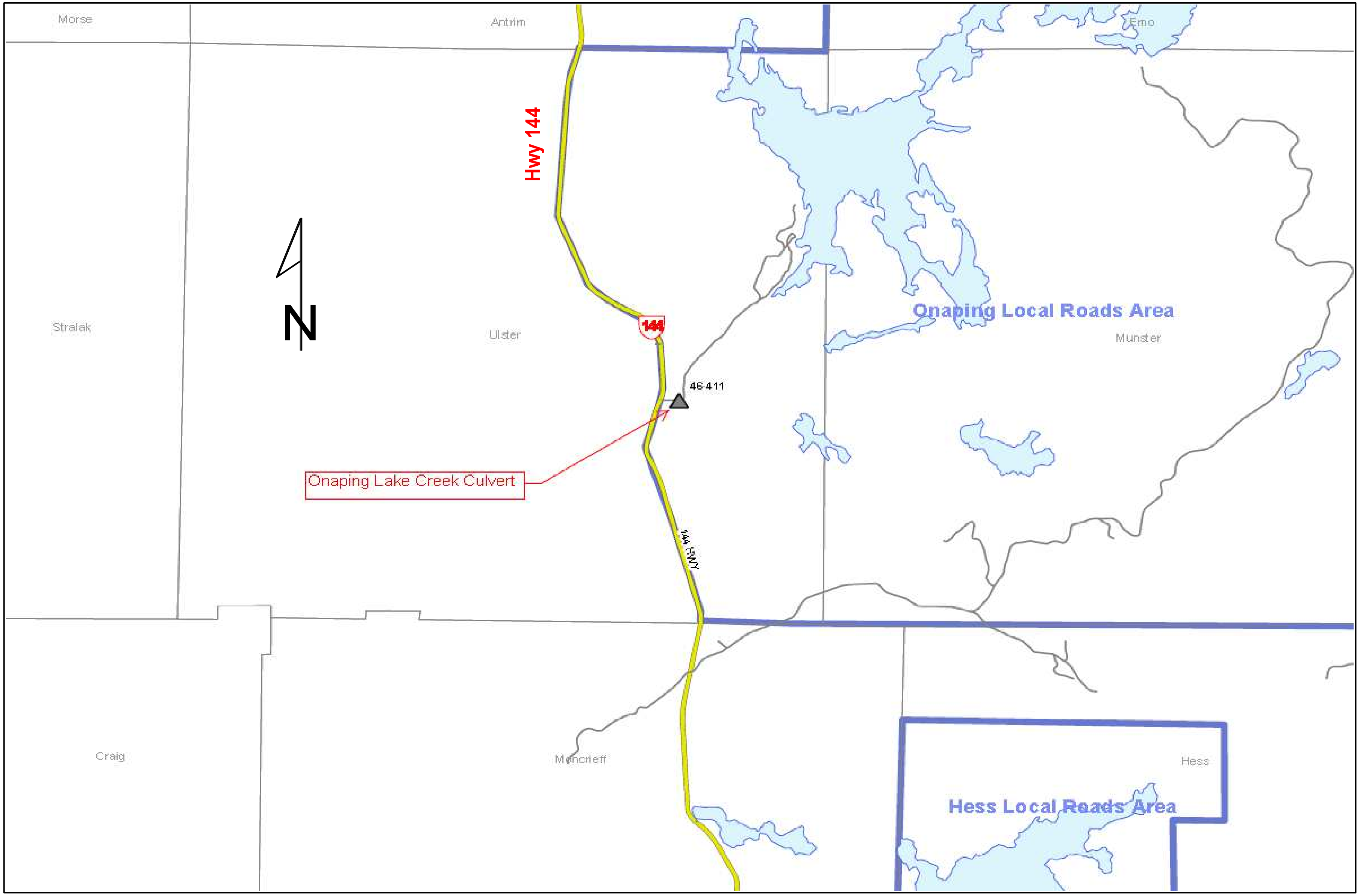
Looking North at Upstream River

Looking South over Culvert

Looking West along Roadway (February 2012)

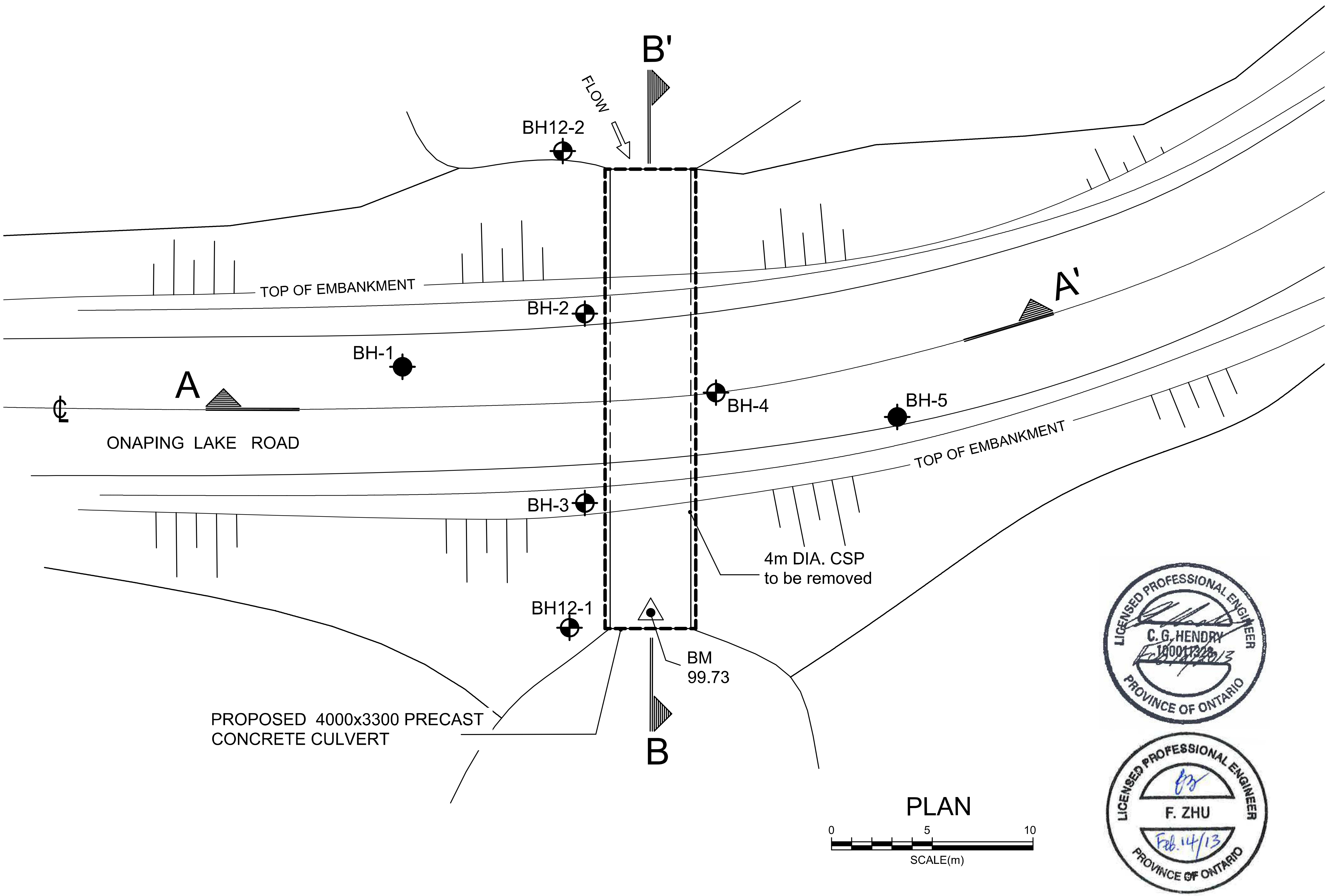
Looking Southwest at Roadway and Culvert Inlet (February 2012)

Drawings



Client:	Ministry of Transportation Ontario			Title:	SITE PLAN
Project#:	1067-710	DWG #:	1	Project:	Geotechnical Investigation - Onaping Lake Road Culvert Replacement
Drawn:	NT	Approved:	CH		
Date:	March 2012	Scale:	N. T. S.		SPL Consultants Limited Geotechnical Environmental Materials Hydrogeology
Size:	Letter	Rev:	0		

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

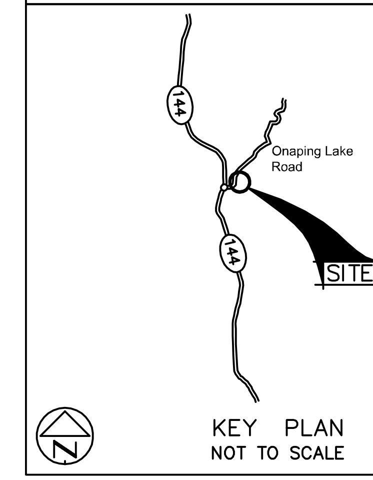


CONT No 2013–5601
WP No 5019–10–01

ONAPING LAKE ROAD
CULVERT REPLACEMENT
BORE HOLE LOCATIONS

SHEET
14

SPL Consultants Limited
Geotechnical • Environmental • Materials • Hydrogeology



KEY PLAN
NOT TO SCALE

LEGEND

Bore Hole
Bore Hole & Cone
Benchmark = 99.73 m
(to of culvert at outlet)

No	ELEVATION	NORTHING	EASTING
BH–1	100.2	5187005	453501
BH–2	100.2	5187004	453509
BH–3	99.8	5186999	453506
BH–4	100.2	5187000	453513
BH–5	99.9	5186998	453521
BH12–1	97.2	5186988	453506
BH12–2	96.7	5187012	453505

NOTES–

Borehole elevations are based on local datum.

REVISIONS		
JAN 2013	ZMO	Revision 03 – Final Report
DEC 2012	TJC	Revision 02 – Revised Draft – Issued for Exec. Review
MAR 2012	NT	Revision 01 – Draft Reprt
DATE	BY	DESCRIPTION

GEOCRES No 411–287

HWY No – –	–		DIST – – –
SUBM'D CH	CHECKED CH	DATE March 2012	SITE 46–411/C
DRAWN NT	CHECKED CH	APPROVED – – –	DWG 2

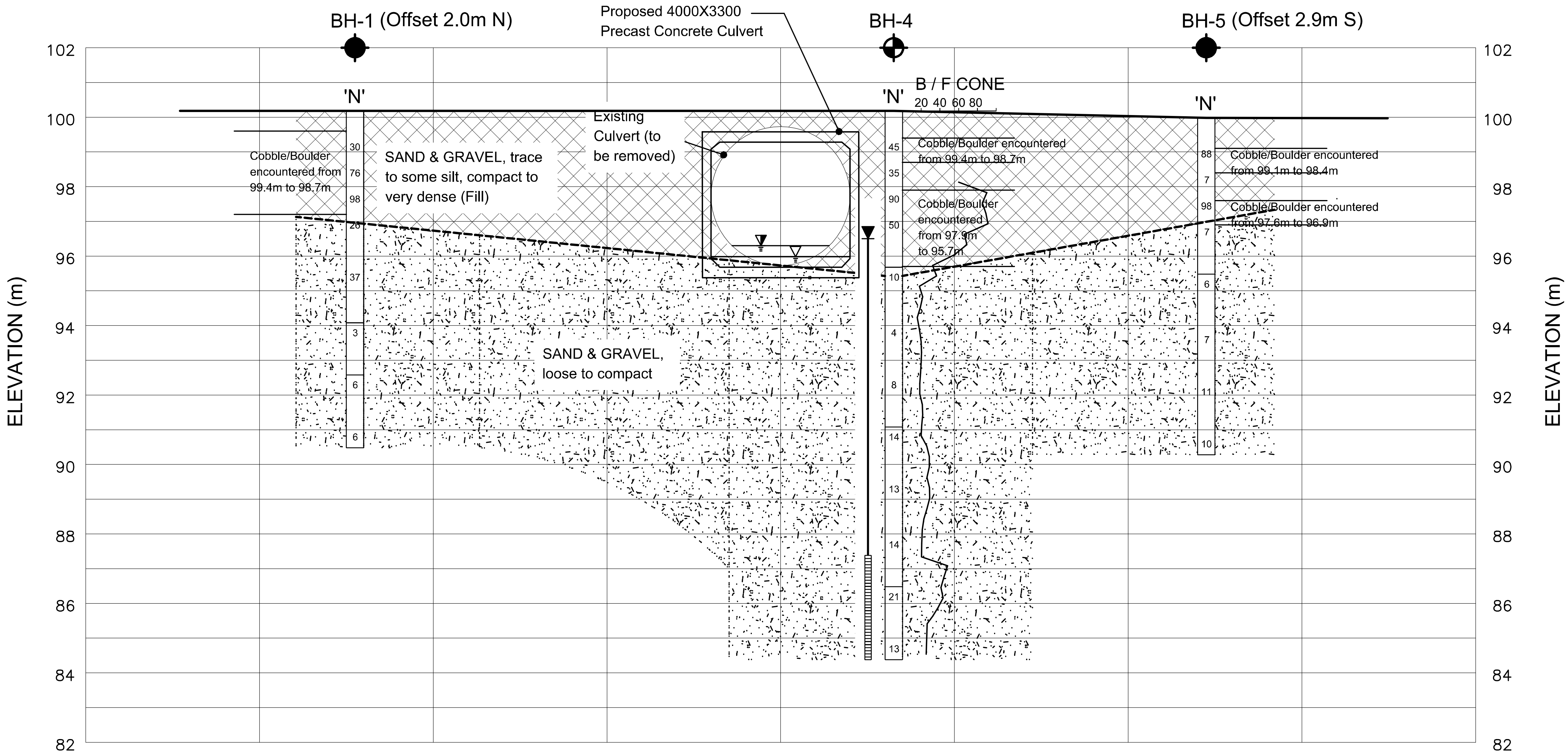
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No 2013–5601
WP No 5019–10–01

ONAPING LAKE ROAD CULVERT REPLACEMENT
BORE HOLE LOCATIONS & SOIL STRATA

SHEET 15

SPL Consultants Limited
Geotechnical • Environmental • Materials • Hydrogeology



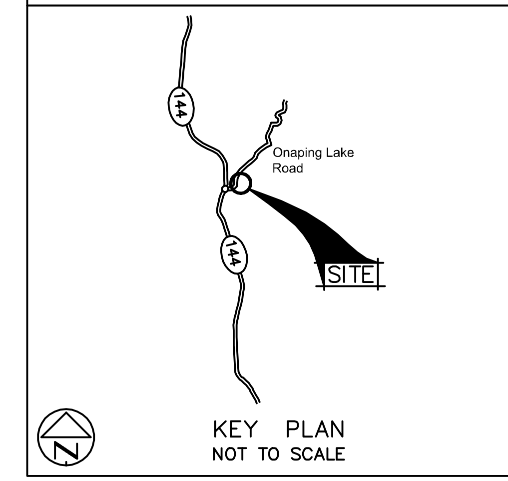
CROSS SECTION A-A'

HOR 0 5 10(m)
VERT 0 5 10(m)
SCALE(m)

SOIL STRATA SYMBOLS

SAND & GRAVEL FILL

SAND, GRAVELLY SAND, SAND & GRAVEL, SANDY GRAVEL



KEY PLAN
NOT TO SCALE

LEGEND

- Bore Hole
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation (MAR–2012)
- WL at time of Survey (AUG–2011)
- WL in Piezometer (MAR–2012)
- Piezometer

No	ELEVATION	NORTHING	EASTING
BH–1	100.2	5187005	453501
BH–2	100.2	5187004	453509
BH–3	99.8	5186999	453506
BH–4	100.2	5187000	453513
BH–5	99.9	5186998	453521
BH12–1	97.2	5186988	453506
BH12–2	96.7	5187012	453505

— NOTES —

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

Borehole elevations are based on local datum.

LICENSED PROFESSIONAL ENGINEER C. G. HENDRY 100017328 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER F. ZHU PROVINCE OF ONTARIO Feb. 14/13

REVISIONS

DATE	BY	DESCRIPTION
JAN 2013	ZMO	Revision 03 – Final Report
DEC 2012	TJC	Revision 02 – Revised Draft – Issued for Exec. Review
MAR 2012	NT	Revision 01 – Draft Reprt

GEOCRES No 41I–287

HWY No – – | DIST – – –
SUBM'D CH | CHECKED CH | DATE March 2012 | SITE 46–411/C
DRAWN NT | CHECKED CH | APPROVED – – – | DWG 3

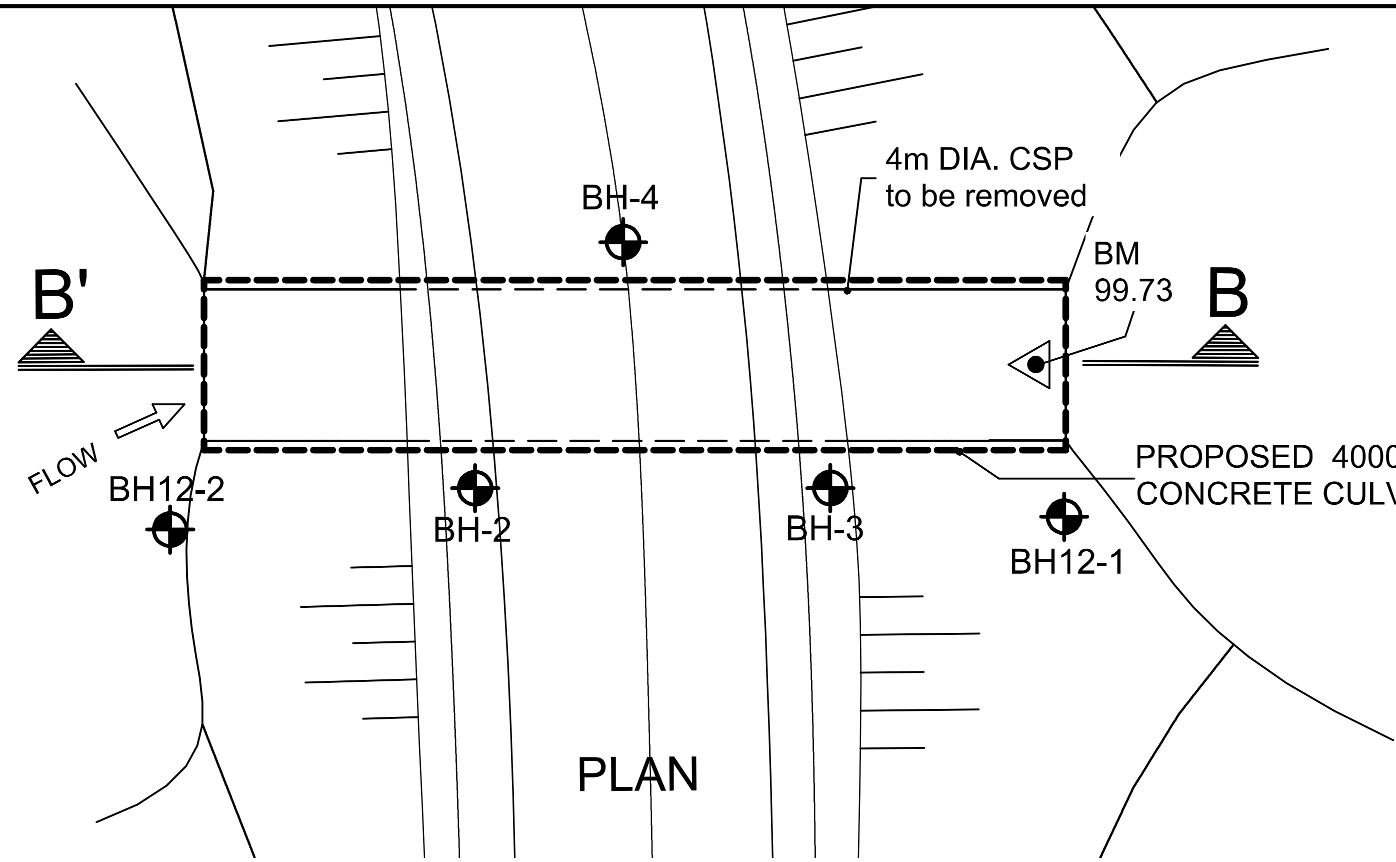
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

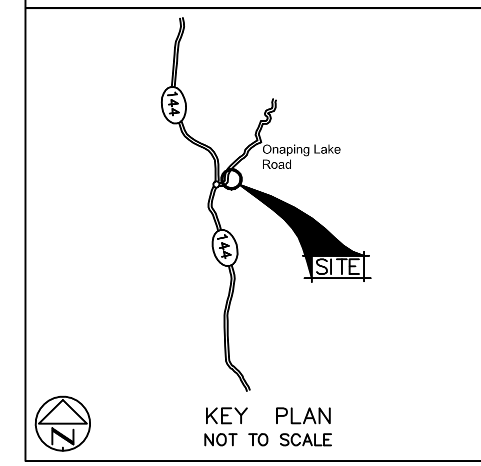
CONT No 2013–5601
WP No 5019–10–01

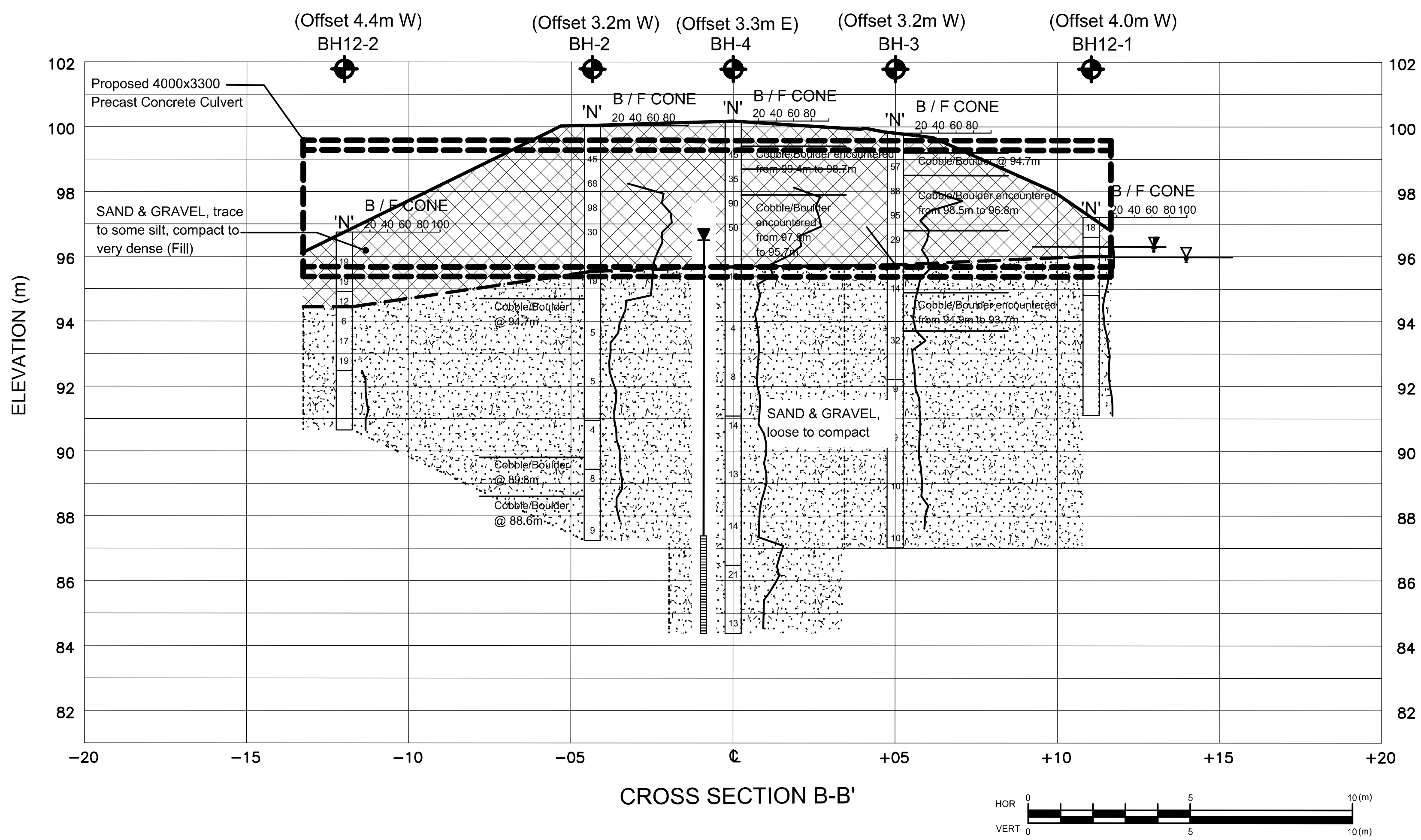
ONAPING LAKE ROAD CULVERT REPLACEMENT
BORE HOLE LOCATIONS & SOIL STRATA

SHEET 16

SPL Consultants Limited
Geotechnical • Environmental • Materials • Hydrogeology







LEGEND

- Bore Hole
- Bore Hole & Cone
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation (MAR–2012)
- WL at time of Survey (AUG–2011)
- WL in Piezometer (MAR–2012)
- Piezometer

No	ELEVATION	NORTHING	EASTING
BH–1	100.2	5187005	453501
BH–2	100.2	5187004	453509
BH–3	99.8	5186999	453506
BH–4	100.2	5187000	453513
BH–5	99.9	5186998	453521
BH12–1	97.2	5186988	453506
BH12–2	96.7	5187012	453505

— NOTES —

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

Borehole elevations are based on local datum.

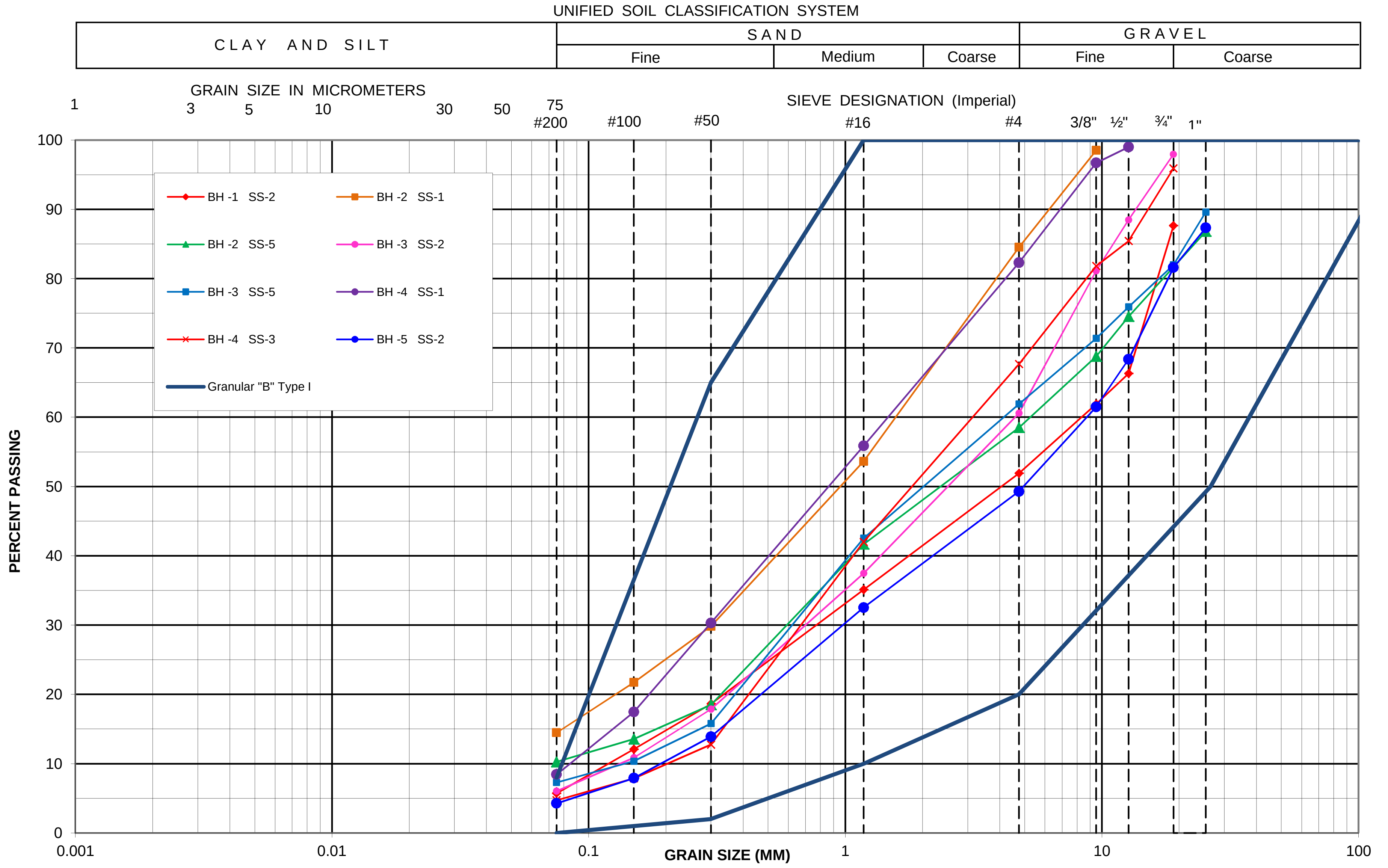
SOIL STRATA SYMBOLS

- SAND & GRAVEL FILL
- SAND, GRAVELLY SAND, SAND & GRAVEL, SANDY GRAVEL

REVISIONS DATE	BY	DESCRIPTION
JAN 2013	ZMO	Revision 03 – Final Report
DEC 2012	TJC	Revision 02 – Revised Draft – Issued for Exec. Review
MAR 2012	NT	Revision 01 – Draft Reprt

GEOCRES No 411–287

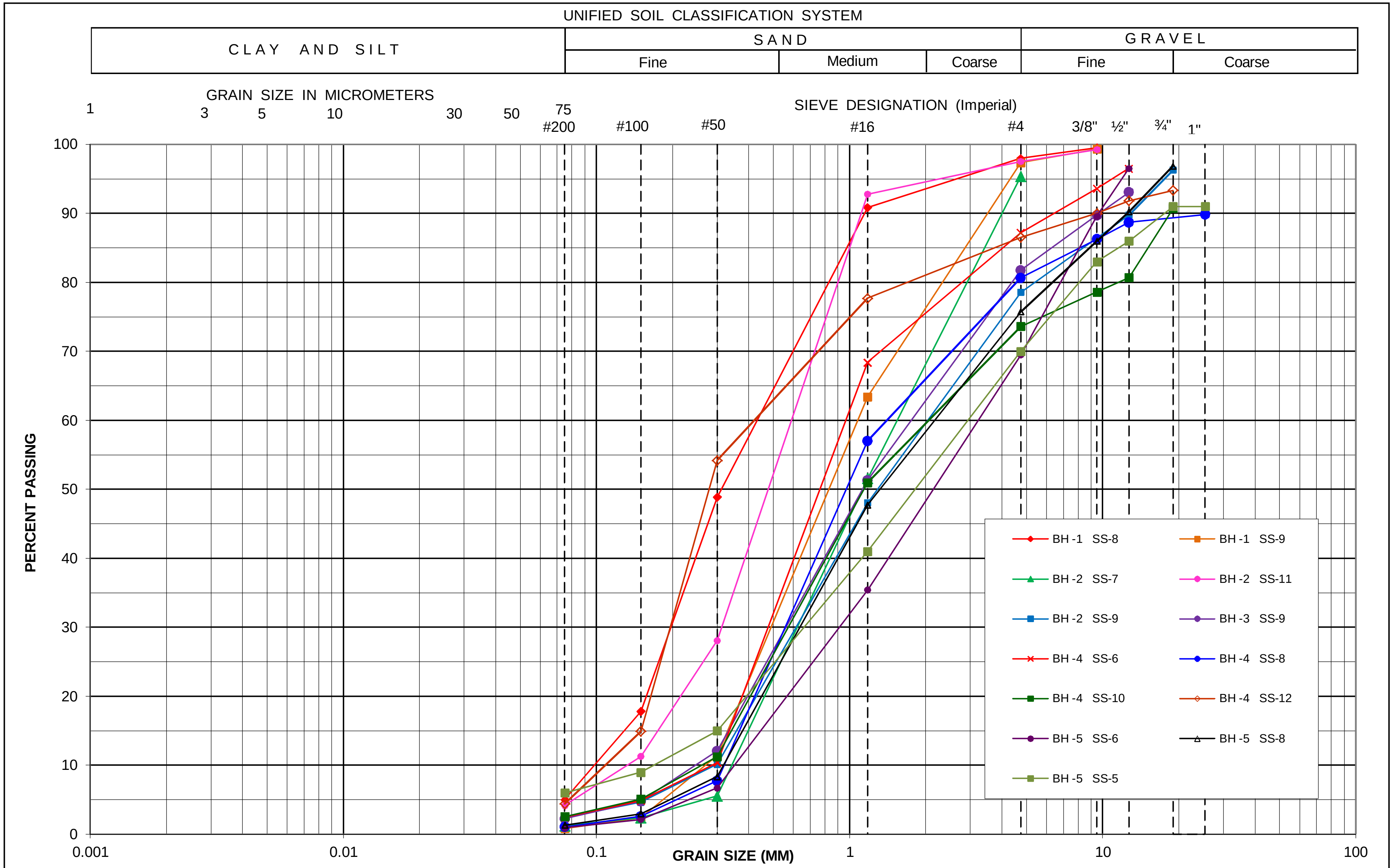
HWY No – –	–		DIST – – –
SUBM'D CH	CHECKED CH	DATE March 2012	SITE 46–411/C
DRAWN NT	CHECKED CH	APPROVED – – –	DWG 4



SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

GRAIN SIZE DISTRIBUTION - SAND & GRAVEL FILL
Onaping Lake Road Culvert Replacement

Drawing No:	5
Project No.	1067-710
Date :	March 2012



SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

GRAIN SIZE DISTRIBUTION - NATIVE SAND & GRAVEL
Onaping Lake Road Culvert Replacement

Drawing No:	6
Project No.	1067-710
Date :	March 2012

Appendix A

Borehole Logs (Record of Borehole Sheets)

Ministry of Transportation Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH-1

METRIC

W.P. 5019-10-01	LOCATION Onaping Lake Road, E 453501 - N 5187005 (see borehole location plan)	ORIGINATED BY NE
DIST ___ HWY ___	BOREHOLE TYPE Hollow Stem Auger & NW Coring	COMPILED BY NT
DATUM Local	DATE Mar/07/2011	CHECKED BY CH

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
100.2 / 0.0	**Sand and Gravel,** trace to some silt, brown, moist, compact to dense (Fill)	1	AS					
	- cobbles/boulders encountered between 0.6m and 1.5m	2	SS	30	48	46	(6)	
	- cobbles/boulders encountered from 1.5m to 3.0m	3	SS	76/ 175mm				
		4	SS	98/ 175mm				
		5	SS	26				
96.6 / 3.6	**Sand,** trace to some gravel, trace organics, brown to grey, saturated, dense	6	SS	37				
94.1	- switched to NW coring at 6.1m							
6.1	**Sandy Gravel,** trace silt, brown, saturated, loose	7	SS	3				
92.6 / 7.6	**Sand,** trace gravel, trace silt, brown, saturated, loose	8	SS	6	2	93	(5)	
		9	SS	6	3	96	(1)	
90.5 / 9.7	**END OF BOREHOLE**							

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (100 to 91); DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

ON-MTO-LARGE SCALE 1067-710 ONAPING OLD-FEB11-2013.GPJ ON_MOT.GDT 13/2/13

Ministry of Transportation Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH-2

METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453509 - N 5187004 (see borehole location plan) ORIGINATED BY NE

DIST ____ HWY ____ BOREHOLE TYPE Hollow Stem Auger & NW Coring COMPILED BY NT

DATUM Local DATE Mar/07/2011 CHECKED BY CH

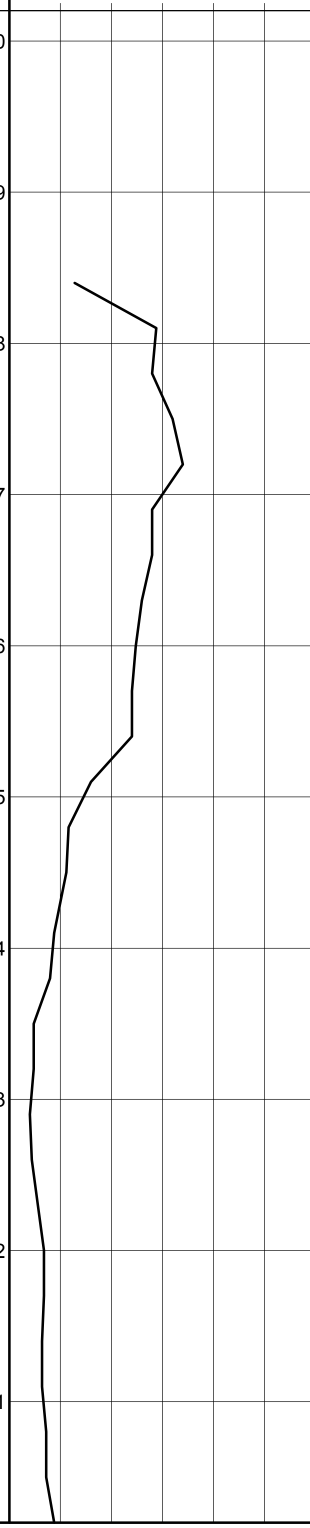
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
100.2 / 0.0	**Gravelly Sand,** some silt, brown, moist, dense to very dense (Fill)	Fill	1	AS			100	○		15	71	(14)	
	- cobbles/boulders encountered from 0.8m to 3.0m		2	SS	45		99	○					
			3	SS	68			○					
			4	SS	98/ 175mm		98	○					
			5	SS	30		97	○		42	48	(10)	
95.7	- switched to NW coring at 4.5m						96						
95.7 / 4.5	**Sand,** trace gravel, brown, wet, compact to loose	Sand	6	SS	19		95						
	- boulder at 5.5m						94						
			7	SS	5		93	○		5	94	(1)	
			8	SS	5		92	○					
91.1 / 9.1	**Gravelly Sand,** trace silt, brown, wet, loose	Gravelly sand	9	SS	4		91	○		21	77	(2)	

DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125)

SHEAR STRENGTH kPa (20, 40, 60, 80, 100): ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20, 40, 60

REMARKS & GRAIN SIZE DISTRIBUTION (%)



Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH-2

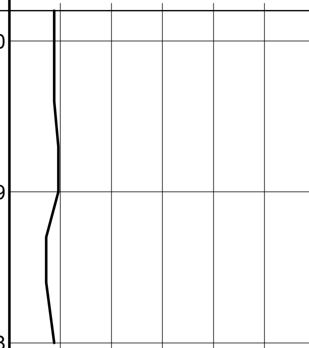
METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453509 - N 5187004 (see borehole location plan) ORIGINATED BY NE

DIST ____ HWY ____ BOREHOLE TYPE Hollow Stem Auger & NW Coring COMPILED BY NT

DATUM Local DATE Mar/07/2011 CHECKED BY CH

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Gravelly Sand, trace silt brown, wet loose *(continued)* - cobbles/boulders at 10.4m						90				
89.6 10.6	**Sand,** trace gravel, trace silt brown, wet loose		10	SS	8				○		
							89				
	- cobble / boulder at 11.6m										
							88				
			11	SS	9				○		2 94 (4)
87.4 12.8	**END OF BOREHOLE**										



+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH-3

METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453506 - N 5186999 (see borehole location plan) ORIGINATED BY NE

DIST HWY BOREHOLE TYPE Hollow Stem Auger & NW Coring COMPILED BY NT

DATUM Local DATE Mar/08/2011 CHECKED BY CH

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
99.8 / 0.0	**Gravelly Sand,** trace silt, brown, moist, very dense to compact (Fill)
	- cobble/boulder at 0.6m
	- cobbles/boulders encountered from 1.5m to 3.0m
	- switched to NW coring at 4.6m
95.2 / 4.6	**Sand and Gravel,** trace organics / wood, brown, saturated, compact to dense
	- cobbles/boulders inferred from 4.9m to 6.1m
92.2 / 7.6	**Sand,** trace to some gravel, trace silt, brown, wet, loose to compact

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS		
2	SS	57	39 55 (6)
3	SS	88/225mm	
4	SS	95/175mm	
5	SS	29	38 55 (7)
6	SS	14	
7	SS	32	
8	SS	9	
9	SS	9	18 80 (2)

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (99, 98, 97, 96, 95, 94, 93, 92, 91, 90); DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-3

METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453506 - N 5186999 (see borehole location plan) ORIGINATED BY NE

DIST HWY BOREHOLE TYPE Hollow Stem Auger & NW Coring COMPILED BY NT

DATUM Local DATE Mar/08/2011 CHECKED BY CH

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sand, trace to some gravel, trace silt brown, wet loose to compact *(continued)*										
			10	SS	10		89				
							88				
			11	SS	10				○		
87.0 12.8	**END OF BOREHOLE**						87				

$+^3, \times^3$: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-4

METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453513 - N 5187000 (see borehole location plan) ORIGINATED BY NE

DIST HWY BOREHOLE TYPE Hollow Stem Auger & NW Coring COMPILED BY NT

DATUM Local DATE Mar/06/2011 CHECKED BY CH

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
100.2 / 0.0	**Gravelly Sand,** trace silt, brown, moist, dense (Fill)	1	AS		18	74	(8)	
	- cobbles/boulders encountered from 0.8m to 1.5m	2	SS	45				
		3	SS	35	32	63	(5)	
	- cobbles/boulders below 2.3m	4	SS	90/ 200mm				
		5	SS	50/ 25mm				
95.7 / 4.5	**Sand,** some gravel, trace silt, brown, wet, loose to compact	6	SS	10	13	85	(2)	
	- switched to NW coring at 6.1m	7	SS	4				
		8	SS	8	19	80	(1)	
91.1 / 9.1	**Gravelly Sand,** trace silt, brown, wet, compact	9	SS	14				

W. L. 96.5 m

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Elevation scale: 100, 99, 98, 97, 96, 95, 94, 93, 92, 91

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ministry of Transportation Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH-4

METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453513 - N 5187000 (see borehole location plan) ORIGINATED BY NE

DIST ______ HWY ______ BOREHOLE TYPE Hollow Stem Auger & NW Coring COMPILED BY NT

DATUM Local DATE Mar/06/2011 CHECKED BY CH

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Gravelly Sand, trace silt, brown, wet, compact *(continued)*	10	SS	13	○	26 71 (3)
		11	SS	14	○	
86.5 / 13.7	**Sand,** some gravel, trace silt, brown, wet, compact	12	SS	21	○	13 83 (4)
		13	SS	13	○	
84.4 / 15.8	**END OF BOREHOLE**					

Elevation scale: 90, 89, 88, 87, 86, 85

DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100)

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Notes:

1) 25mm standpipe piezometer installed upon completion.
2) Water levels in piezometer;

Date	Depth (m)	Elevation (m)
07/03/2012	3.75	96.5
08/03/2012	3.70	96.5

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH-5

METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453521 - N 5186998 (see borehole location plan) ORIGINATED BY NE

DIST HWY BOREHOLE TYPE Hollow Stem Auger COMPILED BY NT

DATUM Local DATE Mar/01/2011 CHECKED BY CH

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.9 0.0	**Sandy Gravel,** trace silt brown, moist very dense (Fill)	Fill	1	AS				
	- cobbles/ boulders encountered between 0.8m and 1.5m	Fill	2	SS	88		99	51 45 (4)
98.4 1.5	**Gravelly Sand,** trace silt brown, moist loose to very dense (Fill)	Fill	3	SS	7		98	
	- cobbles/boulders encountered between 2.3m and 3.0m	Fill	4	SS	98/ 175mm			
96.9 3.0	**Gravelly Sand,** trace silt brown, saturated loose to compact	Gravelly sand	5	SS	7		97	30 64 (6)
							96	
			6	SS	6		95	31 68 (1)
							94	
			7	SS	7		93	
	- Sand heaving in hollow-stem augers below 7.6m		8	SS	11		92	24 75 (1)
							91	
			9	SS	10			
90.2 9.7	**END OF BOREHOLE**							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 25 50 75 100 125

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

ON-MTO-LARGE SCALE 1067-710 ONAPING OLD-FEB11-2013.GPJ ON_MOT.GDT 13/2/13

Ministry of Transportation
Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH-5

METRIC

W.P. 5019-10-01 LOCATION Onaping Lake Road, E 453521 - N 5186998 (see borehole location plan) ORIGINATED BY NE

DIST ___ HWY ___ BOREHOLE TYPE Hollow Stem Auger COMPILED BY NT

DATUM Local DATE Mar/01/2011 CHECKED BY CH

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20, 40, 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	Notes: 1) Water at 2.4m depth in borehole at the end of drilling. 2) Borehole caved to 4.3 m when removing augers.										

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON-MTO-LARGE SCALE 1067-710 ONAPING OLD-FEB11-2013.GPJ ON_MOT.GDT 13/2/13

Ministry of Transportation Ontario

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

1067-710

RECORD OF BOREHOLE No BH12-1

METRIC

W.P. 5019-10-01 LOCATION South Side of Onaping Lake Road - See Borehole Location Plan ORIGINATED BY PD

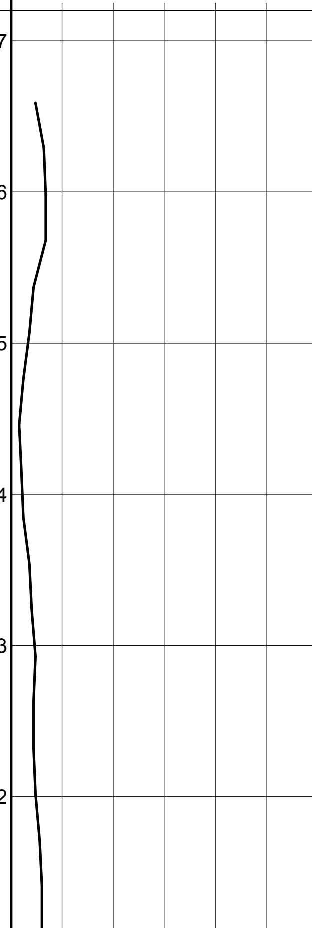
DIST ____ HWY ____ BOREHOLE TYPE Hand Drilling COMPILED BY ZO

DATUM Local DATE Dec/03/2012 CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.2										
0.0	**SAND AND GRAVEL:** saturated, compact (FILL)	Fill	1	SS	18		97	○		
96.6 0.6	**SAND AND GRAVEL (Inferred)** (FILL)	Fill								
96.0 1.2	**SAND AND GRAVEL (Inferred)**	Sand and gravel					96, 95, 94, 93, 92			
91.1 6.1	**END OF BOREHOLE AND DCPT**									

Notes:
1) Spoon sampling ended at 0.6m due to extensive heaving condition, further sampling was impossible. Borehole advanced by wash boring.
2) DCPT perfomed from 0.6m to 6.1m.

DYNAMIC CONE PENETRATION RESISTANCE PLOT (25, 50, 75, 100, 125)
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20, 40, 60, 80, 100)
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT W_L; WATER CONTENT (%) 20, 40, 60



+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH12-2

METRIC

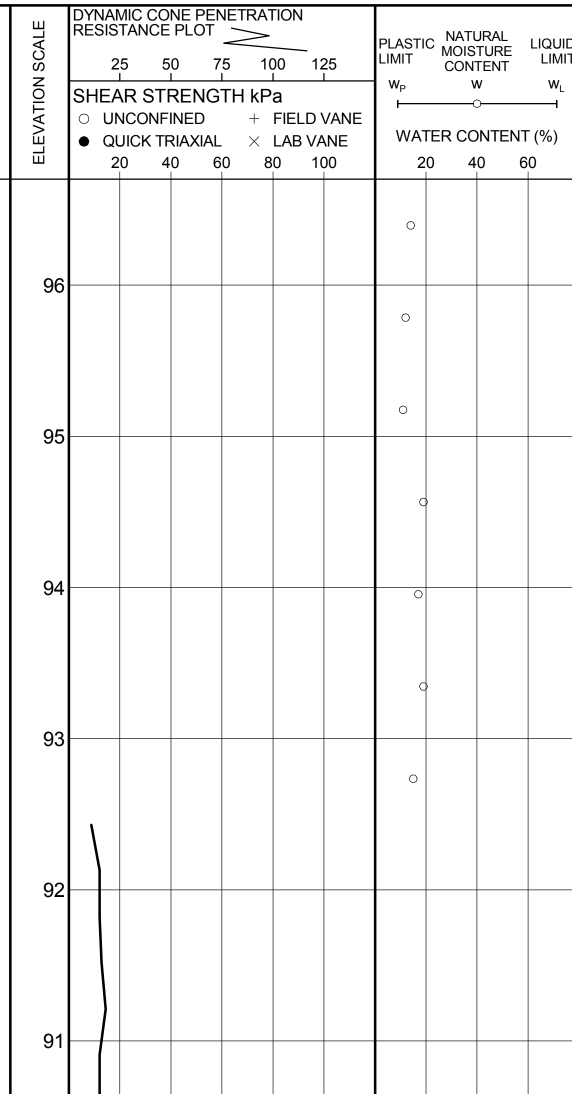
W.P. 5019-10-01 LOCATION North Side of Onaping Lake Road - See Borehole Location Plan ORIGINATED BY PD

DIST ____ HWY ____ BOREHOLE TYPE Hand Drilling COMPILED BY ZO

DATUM Local DATE Dec/03/2012 CHECKED BY RM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.7 0.0	**SANDY GRAVEL:** brown, wet, compact (FILL)	1	AS			
		2	SS	19		
	grey from 1.2m	3	SS	19		
94.9 1.8	**GRAVELLY SAND:** grey, wet, compact (FILL)	4	SS	12		
94.4 2.3	**SAND:** trace silt, trace gravel, grey, wet, loose to compact	5	SS	6		
		6	SS	17		96 3 1
		7	SS	19		
92.4 4.3						
90.6 6.1	**END OF BOREHOLE AND DCPT**					

Notes:
1) Spoon sampling ended at 4.3m. Borehole advanced by wash boring.
2) DCPT performed from 4.3m to 6.1m.



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Appendix B

Chemical Test Results

Certificate of Analysis

Client:	SPL Consultants Ltd. 146 Colonnade Rd., Unit 17 Ottawa, ON K2E 7Y1	Report Number:	1204614
		Date Submitted:	2012-03-15
Attention:	Mr. Neem Tavakkoli	Date Reported:	2012-03-19
PO#:	VISA	Project:	1067-710-ONAPING
COC#	156561		

Dear Neem Tavakkoli:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call.

Report Comments:

APPROVAL: ______________________________

Lorna Wilson
Inorganic Laboratory Supervisor

Exova (Ottawa) is certified and accredited for specific parameters by:
CALA, Canadian Association for Laboratory Accreditation (to ISO 17025), OMAF, Ontario Ministry of Agriculture, Food and Rural Affairs(for farm soils), Licensed by Ontario MOE for specific tests in drinking water.

Certificate of Analysis

Client:	SPL Consultants Ltd. 146 Colonnade Rd., Unit 17 Ottawa, ON K2E 7Y1	Report Number:	1204614
Attention:	Mr. Neem Tavakkoli	Date Submitted:	2012-03-15
PO#:	VISA	Date Reported:	2012-03-19
COC#	156561	Project:	1067-710-ONAPING

Group	Analyte	MRL	Units	Guideline	946134	946135
				Lab I.D.	946134	946135
				Sample Matrix	Soil	Soil
				Sampling Date	2012-03-07	2012-03-07
				Sample I.D.	BH-3/SS-5	BH-4/SS-7
Agri. - Soil	Electrical Conductivity	0.05	mS/cm		0.12	<0.05
	pH	2.0			7.0	7.5
General Chemistry	Cl	0.002	%		<0.002	<0.002
	Resistivity	1	ohm-cm		8330	>20000
	SO4	0.01	%		0.06	0.05

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective.

Appendix C

Explanation of Terms used in Report

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS $\overline{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSION AND STRUCUTRAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINT AND BEDDING:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_l, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
Φ'	$-^o$	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
Φ_u	$-^o$	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $(W_L – W_L)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W – W_P)/ I_P$	i	1	HYDAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(W_L – W) / 1_P$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERED SOIL	$e_{,max}$	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION DESIGN REPORT
PROPOSED CULVERT REPLACEMENT
ONAPING LAKE ROAD NEAR SUDBURY, ONTARIO
SITE NO. 46-411/C
G.W.P. 5022-10-00
MTO GEOCRES NO. 41I-287

Prepared for:

ONTARIO MINISTRY OF TRANSPORTATION

By:

SPL CONSULTANTS LIMITED

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

Project: 1067-710 (Onaping Lake Road)
February 2013

146 Colonnade Road
Ottawa, Ontario K2E 7Y1
Tel: 613.228.0065 Fax: 613.228.0045

Table of Contents

Appendices

6. DISCUSSION AND RECOMMENDATIONS

6.1 General

The subsurface conditions encountered in the boreholes drilled at the site include a layer of fill 3.0 m to 4.6 m in thickness (from the road surface) which corresponds to elevations of 94.4 m to 96.9 m. This fill forms the road structure, embankment and backfill around the existing culvert. This fill material is underlain by a variable mixture of sand, gravelly sand, sand and gravel and sandy gravel with a trace of silt which would typically be described loose to compact. Bedrock was not encountered during the investigations at the site.

Groundwater levels in the native soils were found to be at an elevation of approximately 96.5 m (in the local datum), which is similar to the water level in the creek at the time of the investigation.

The proposed culvert structure is (based on preliminary General Arrangement drawings provided to us) is a 4.0 m wide by 3.3 m high precast concrete box culvert. The invert of the new culvert will be at approximately 95.5 m, which is slightly lower than the invert of the existing culvert. The replacement culvert will be located at approximately the same location (in plan) as the existing culvert (see Drawing 2).

Based on the borehole information, the existing soils and granular fill are expected to be adequate to support the proposed new culvert.

6.2 Frost Protection

The depth of frost penetration for the Onaping Lake Road site may be assumed to be 2.0 m. The fill within the frost zone is sand and gravel which would be considered to have a low susceptibility to frost heave. The existing road is a gravel-surfaced rural road, and it is assumed that there are no plans to pave the road in the future. For these reasons, it is considered that installation of a frost taper is not required, as the soils are not highly frost susceptible, and the road will require seasonal maintenance and re-grading anyway.

6.3 Seismic Performance

The site is located in an area of relatively low seismic activity. The Peak Horizontal Ground Acceleration (PHA) for an earthquake with a 10% chance of exceedance in 50 years (475 year return period event) is 0.02 g. Based on the Canadian Highway Bridge Design Code (CHBDC) this corresponds to a Seismic Performance Zone 1 (assuming the crossing would be classified as an Emergency Route Bridge), and Zonal Acceleration Ratio of A = 0 (CHBDC Section 4.4).

For the purposes of assessing the effects of site conditions under seismic loading, the site may be assumed to be Soil Profile Type III, which corresponds to a Site Coefficient S = 1.5 (CHBDC Section 4.4.6).

6.4 Foundations and Bearing Resistance

6.4.1 Foundation Options

The culvert will be replaced with a rigid frame concrete box culvert. This structure could be either a closed-bottom pre-cast concrete culvert or an open bottom culvert with cast-in-place foundations. The existing soils are considered adequate to support either option. Deep foundations are technically feasible, but are not required. A comparison of shallow foundation options (pre-cast or cast-in-place) is presented in Table 6 below.

6.4.2 Bearing Resistance and Settlement

The new culvert will be founded at an elevation of approximately 95.5 m. At this depth the culvert will be founded on either native sand soils or a thin layer of the existing granular fill, underlain by the native sandy soils. The proposed new culvert is a 4.0 m wide by 3.2 m high pre-cast concrete box culvert.

For individual footings or strip footings (such as the cut-off walls) which have are approximately 0.4 m and are founded below 95.5 m elevation on native soils or the existing compacted granular fill:

The unfactored ultimate geotechnical bearing resistance can be taken as 300 kPa. A resistance factor of 0.5 should be applied to this value, yielding a factored bearing resistance of 150 kPa at ULS (Ultimate Limit States).

The geotechnical resistance at the Serviceability Limit State (SLS) can be taken as 100 kPa.

For the main culvert which is approximately 4.0 m wide and founded at 95.5 m elevation or lower on undisturbed native soils or compacted granular fill:

The unfactored ultimate geotechnical bearing resistance can be taken as 400 kPa. A resistance factor of 0.5 should be applied to this value, yielding a factored bearing resistance of 200 kPa at ULS (Ultimate Limit States).

The geotechnical resistance at the Serviceability Limit State (SLS) can be taken as 100 kPa.

Provided that the subgrade is not disturbed during construction the total and differential settlments associated with the above SLS resistance values are expected to be less than 25 mm and 20 mm, respectively.

All bearing surfaces should be checked, evaluated and approved at the time of construction to ensure that the conditions encountered are as anticipated in the preparation of these recommendations.

Table 4: Summary of Foundation Alternatives
Foundation Investigation and Design Report
Proposed Onaping Lake Road Culvert Replacement, Site No. 46-411/C

Foundation Option	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Precast Concrete Box Culvert	• Routine excavation and construction procedure • Single stage excavation, excavation support, dewatering, etc. (no separate excavations for footings) • Rapid installation due to pre-cast structure, resulting in less time on site • Wide base distributes load over larger bearing area, reducing the potential for differential settlement • Final culvert may be more tolerant of differential settlement between segments	• May require excavation and replacement of unsuitable material below bedding. • Requires larger excavation volumes and placement of bedding and levelling layers • Will not result in a natural bottom, and therefore the invert may need to be covered with additional material	• Possibly higher for the culvert, but may be offset somewhat by ease of construction	• Risk of difficulties with dewatering and excavation and disturbance of subgrade • Risk of requiring removal of unsuitable soils and replacement with additional engineered fill
Open Bottom Culvert with Cast-in-Place Footings	• Reduces sub-excavation area and eliminates requirements for bedding and levelling layers • Provides a natural soil substrate within the culvert	• Requires additional excavations below frost depth for footings in granular soils below the water table, which will be complicated in terms of excavation support and dewatering	• Structure may be cheaper, but the site work will typically take longer and may be more expensive	• Risk of difficulties with dewatering and excavation and disturbance of subgrade • Risk of requiring removal of unsuitable or disturbed soils below the footings

6.5 Bedding and Backfilling

Bedding for the new culvert should consist of 300 mm of Granular A or Granular B Type II, compacted to 98% SPMDD. Additional Granular A may be used as a levelling course prior to installing the culvert if required.

Backfill for the culvert and any retaining walls should consist of suitable free-draining granular fill (OPSS 1010 Granular A or Granular B) material placed and compacted in accordance with relevant standards, such as OPSS 901 and OPSS 501. The majority of the sand and gravel fill encountered in the embankment during drilling meets the requirements of OPSS 1010 for Granular B Type I and would be expected to be suitable for re-use as backfill. A significant portion of the lower native sand and gravel soil also meets the requirements of OPSS 1010 Granular B Type I.

Excavated soils should be reviewed during construction and any suitable material stockpiled for re-use. It should be noted that any materials excavated from below the water table will be too wet for immediate re-use and will require drying before being re-worked and re-used. In addition, cobbles and boulders were noted during the field investigation, as were layers of organic soils. These would need to be removed prior to re-use of the on-site soils as engineered fill.

Fill material should be placed in shallow lifts, not exceeding 200 mm loose thickness. Fill immediately below the roadway should be compacted to a minimum of 100% of Standard Proctor Maximum Dry Density (SPMDD). Remaining fill may be compacted to a minimum of 98% of SPMDD. All compaction should be carried out in accordance with OPSS 501.

To avoid damaging or laterally displacing the structures, care should be exercised when compacting fill adjacent to and immediately on top of the culvert and any retaining wall structures. Compaction equipment should be restricted in size as per MTO convention to prevent damage to the structures. Backfilling should be carried out on both sides of the culvert simultaneously.

6.6 Earth Pressures and Backfilling

Computation of earth pressures acting against culvert walls and retaining structures should be in accordance with the Canadian Highway Bridge Design Code (CHBDC). For design purposes, the following properties can be assumed for the backfill:

Compacted Granular 'A' or Granular 'B' Type II

Angle of Internal Friction (ϕ) = 35 degrees (unfactored)
Unit Weight = 22 kN/m^3

Coefficients of Lateral Earth Pressure:

Earth Pressure Coefficient	Level Backfill	Sloping Backfill 3H:1V	Sloping Backfill 2H:1V
K_a	0.27	0.34	0.40
K_b	0.35	0.44	0.50
K_0	0.43	0.56	0.62
K*	0.45	0.60	0.66

Compacted Granular 'B' Type I

Angle of Internal Friction (ϕ) = 30 degrees (unfactored)
Unit Weight = 21 kN/m^3

Coefficients of Lateral Earth Pressure:

Earth Pressure Coefficient	Level Backfill	Sloping Backfill 3H:1V	Sloping Backfill 2H:1V
K_a	0.33	0.42	0.54
K_b	0.41	0.52	0.64
K_0	0.50	0.66	0.76
K*	0.57	0.74	0.86

Notes:

K_a is the coefficient of active earth pressure;
K_b is the coefficient of active earth pressure for an unrestrained structure including compaction efforts;
K_0 is the coefficient of earth pressure at rest;
K* is the coefficient of earth pressure at rest for a fully restrained structure including compaction efforts.

The above values assume that the backfill behind the structure is free-draining granular fill, and that proper drainage is provided. Where this is not the case then water pressures should also be accounted for and the submerged soil unit weight used below the water table. It will not be feasible to maintain the culvert in a drained condition when the structure is partially submerged by the creek.

The appropriate earth pressure coefficient for design will depend upon whether the retaining structure is restrained or some movement can occur such that the active earth pressure state can develop. The effect of compaction should also be taken into account when selecting the appropriate earth pressure coefficients.

According to the method outlined in the CHBDC and Commentaries Section 4.6.4, for a Zonal Acceleration Ratio of A = 0 the earth pressure under the design seismic event is essentially equal to the earth pressure under static conditions (because A = 0).

6.7 Roadway Widening

Based on staging drawings provided to us, the currently proposed construction staging is as follows:

- A protection system will be installed approximately along the road centreline. The south section of the existing culvert will be removed and replaced with the proposed culvert. The embankment will be widened as required to accommodate traffic. Traffic will be diverted to the north side of the existing road.

- Traffic will be diverted to the south side of the road, and the north section of the existing culvert will be removed and replaced;

Copies of staging drawings for the culvert replacement are included in Appendix D.

The widened portion of the embankment will involve new slopes with normal (2H:1V) slopes. Foundation failures are not anticipated assuming that all organic and unsuitable materials are removed as per MTO standards and procedures for stripping and benching prior to placing the embankment fills.

All unsuitable materials should be removed and the approved embankment subgrade should be proof rolled. The construction of the new embankment may require dewatering and/or groundwater control as discussed in Section 6.9 below where the base of the embankment is below the water table.

The sides of the existing embankment should be benched prior to placing fill material for the embankment widening, as per OPSD 208.01. Fill material should be placed and compacted in accordance with OPSS 206 and OPSS 501. Borrow material should consist of select suitable inorganic earth, free of objectionable inclusions such as cobbles, boulder, frozen materials, organic soil, etc. Portions of the existing fill material and site soils may be suitable for this purpose provided they are properly moisture conditioned (either dried or wetted). Borrow material should be approved prior to installation from both a geotechnical and environmental perspective.

All embankment construction (including review of stripping, exposed subgrade, approval of fill materials, etc.) should be carried out under the review and supervision of a qualified person.

6.8 Erosion Protection

The native sandy soils and granular fill at the site are expected to be susceptible to erosion. Erosion and scour protection (such as rip rap treatment similar to OPSD 810.919) will likely be required at the culvert inlet and outlet. The design of erosion protection should be carried out by a specialist who is familiar with the site and the findings of this investigation.

It should also be noted that appropriate cut-off walls, head walls, aprons, etc. will be required to ensure that the flow in the channel is through the culvert and to limit the potential for piping of the bedding, backfill and native soils.

6.9 Construction Considerations

Construction Dewatering

Seepage was encountered during drilling below the level of the creek at the time of the investigation. Given the relatively permeable nature of the embankment fill and the native soils, it should be anticipated that the groundwater level will be very sensitive to changes in the water level in the creek (i.e. if the creek is higher at the time of construction a corresponding increase in groundwater levels should be expected). For this reason it is recommended that if possible construction be carried out in a dry period when the creek would be expected to be at its lowest level. It is also recommended that where possible the water flow in the existing watercourse be diverted away from the construction zone to help maintain sufficiently dry conditions for construction.

Even with these measures, dewatering will likely be required to stabilize the native soils, to maintain a dry working area and to minimize disturbance of the native soils during construction. Depending upon the creek level and groundwater conditions at the time of construction, closely spaced filtered sumps may be used for excavations which extend only a short distance below the groundwater table (say 0.5 m or so). Deeper excavations will likely require an active dewatering system including well points and/or deep wells.

Given the granular nature of the soils at the site, it is expected that in addition to an above-ground diversion (coffer dam), an underground impervious barrier (such as a sheet pile wall) may also need to be constructed to control groundwater flows into the excavation.

Temporary Excavations

All excavations should be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). Part III of Ontario Regulation 213/91 deals with excavations. In addition, the following Ontario Provincial Standard Specifications (OPSS) also deal with temporary excavations:

OPSS 539 – Construction Specification for Temporary Protection Systems
OPSS 902 – Construction Specification for Excavating and Backfilling - Structures

The soils at the site include primarily granular fill in the embankment and pavement structure, as well as loose to compact native soils. The granular fill material can be classified as Type 3 Soil. The native soils encountered in the boreholes can be classified as Type 3 Soil above water table and as Type 4 Soil below water table. These classifications should be reviewed and, if necessary adjusted during construction by a qualified person familiar with the requirements for temporary excavations.

Temporary protection systems (Performance Level 2) are indicated on the design drawings and will be required to accommodate the construction excavations while maintaining traffic on the road. Protection systems typically consist of interlocking sheet piles, soldier piles and lagging or a similar system. Protection systems will need to be designed to resist earth pressures which are controlled by the type and flexibility of the shoring system chosen. The design of the protection system will be the responsibility of the contractor, however, for preliminary design and evaluation the earth pressure parameters provided in Section 6.6 can be assumed to apply to the granular soils behind the protection system. The deflections associated with a Performance Level 2 would be expected to be sufficient to allow the active earth pressure condition to develop, however, this assumption will need to be verified by the shoring designer based on the proposed shoring system.

It should be noted that cobbles and boulders were encountered during the investigation (particularly in the fill material which forms the embankment) which should be considered when selecting shoring systems and installation methods.

<u>Foundation Excavations</u>

The bearing capacities provided in Section 6.4 above assume that the subgrade is not unduly disturbed during construction. Given the fact that the foundations for the proposed structure will be below the groundwater table in loose to compact sandy soils, it will require careful construction control to achieve this condition. Installation and operation of an adequate dewatering system, as discussed above, will be critical to the construction of the foundations.

It is also recommended that allowance be made for the need to pour a layer of lean concrete (mud slab) on foundation bearing surfaces immediately after excavation and inspection (before placement of bedding and levelling layers) to minimize foundation disturbance. All excavated surfaces should be kept free of frost, water, etc. during the course of construction.

All excavated surfaces should be inspected and approved prior to placing engineered fill and/or foundations. If disturbed or unsuitable soils are identified in the base of the excavation they may be over-excavated and replaced with additional compacted granular fill.

6.10 Corrosion and Cement Type

Two soil samples were submitted to Exova Accutest for testing related to soil corrosivity and potential exposure of concrete elements to sulphate attack. The results of these tests are included in Appendix B.

The test results indicate that the sulphate content of the native soils is relatively low, and sulphate-resistant Portland cement is not required.

The test results (soil resistivity) indicate that there is a low to moderate potential for corrosion of buried steel elements. Appropriate care should be taken in designing the corrosion protection system for any buried steel structures.

7. CLOSURE

The field investigations were supervised by Mr. Naeem Ehsan, P.Eng. This report was prepared by Mr. Chris Hendry, P.Eng. Mr. Fanyu Zhu, P.Eng., who is the project manager and SPL's designated MTO contact and Mr. Shaheen Ahmad, P.Eng., who is the project quality control auditor, provided quality control and independent review of the technical aspects of this report.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

SPL CONSULTANTS LIMITED

LICENSED PROFESSIONAL ENGINEER
C.G. HENDRY
100011329
Feb 14/2013
PROVINCE OF ONTARIO

Chris Hendry, M.Eng., P.Eng.

LICENSED PROFESSIONAL ENGINEER
F. ZHU
Feb. 14/13
PROVINCE OF ONTARIO

Fanyu Zhu, Ph.D., P.Eng.

Shaheen Ahmad, M.A.Sc., P.Eng.

8. REFERENCES

The following section provides a general list of references, as well as a list of Ontario Provincial Standard Specifications which are expected to be relevant to the Foundations portion of the proposed work.

General References

CAN/CSA-S6-06 Canadian Highway Bridge Design Code, 2011

Canadian Foundation Engineering Manual, 2006. 4th Edition. Canadian Geotechnical Society

Relevant Ontario Provincial Standard Specifications

OPSS NO.	TITLE
128	Supply of Pre-Qualified Materials and Products
182	Environmental Protection for Construction in Waterbodies and on Waterbody banks.
201	Clearing, Close Cut Clearing, Grubbing, and Removal of Surface and Piled Boulders
206	Grading
401	Trenching, Backfilling, and Compacting
404	Support Systems
422	Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
501	Compacting
504	Preservation, Protection and Reconstruction of Existing Facilities
506	Dust Suppressants
510	Removals
511	Rip-Rap, Rock Protection, and Granular Sheeting
514	Trenching, Backfilling, and Compacting
518	Control of Water from Dewatering Operations
539	Temporary Protection Systems
805	Temporary Erosion and Sediment Control Measures
902	Excavating and Backfilling – Structures
1001	Aggregates - General
1010	Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
1860	Geotextiles

Relevant CDED Special Provisions

Provision No.	Title
100S60	Amendment to MTO General Conditions of Contract, April 2010 – use of unlicensed vehicles…
104S04	Amendment to OPSS 401, November 2010
105S21	Amendment to OPSS 501, November 2010
110S13	Amendment to OPSS 1010, April 2004
199S55	Record Drawings for Structures and Foundations
422S01	Precast Concrete Box Culvert
511S01	Rip Rap
539S02	Protection System – Amendment to OPSS 512, April 2011
805F01	Light-Duty Sediment Barriers, etc.

Relevant OPSD's

OPSD No.	Title
803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3 m
810.010	Rip-Rap Treatment for Sewer and Culvert Inlets
810.020	Rip-Rap Treatment for Ditch Inlets
3090.100	Foundation, Frost Penetration Depths for Northern Ontario

Relevant MTOD's

MTOD No.	Title
803.021	Bedding and Backfill for Precast Concrete Box Culverts

Appendix D

Preliminary Staging Drawings

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

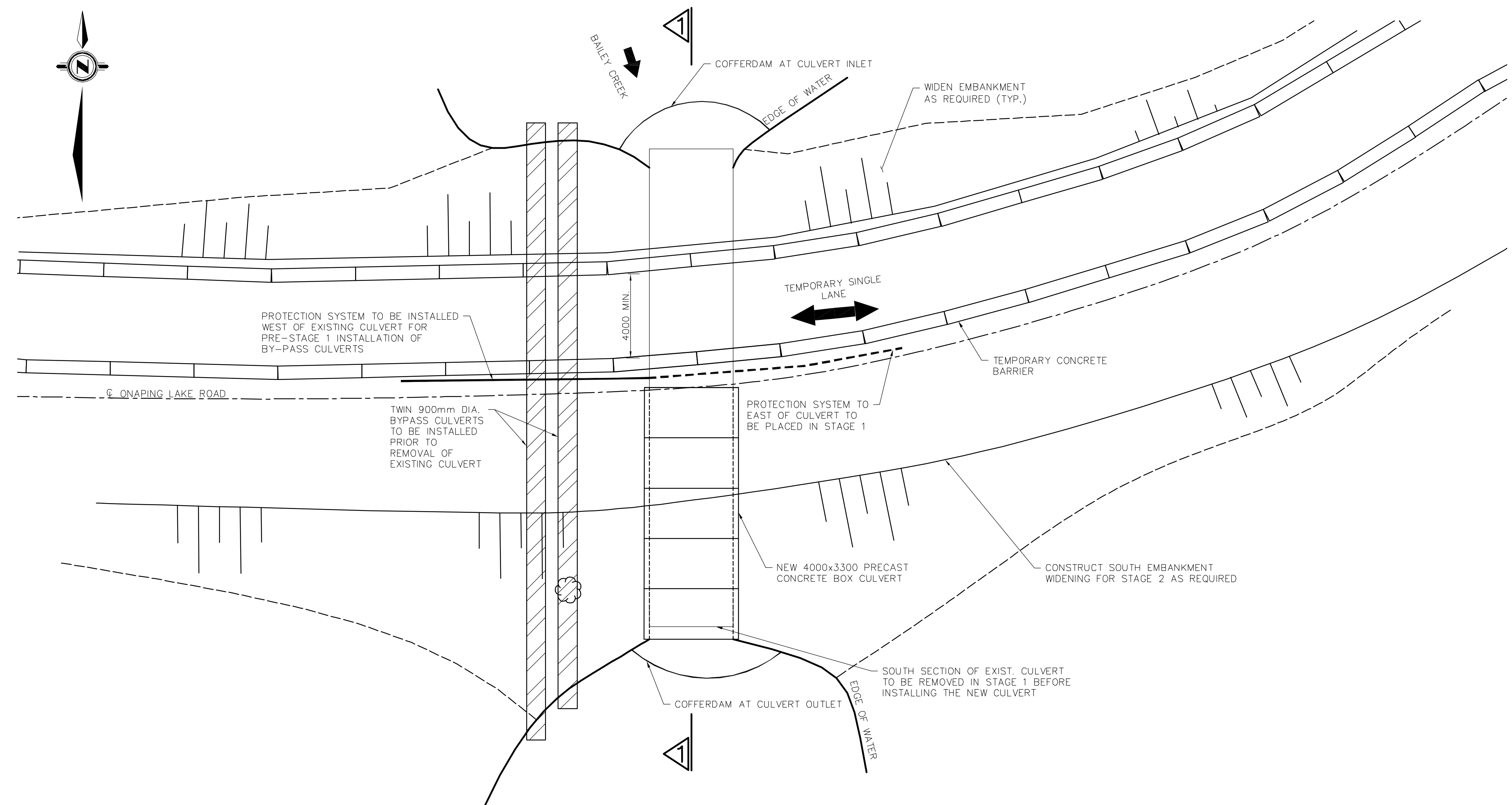
CONT No 2013-5601
WP No 5019-10-01

ONAPING LAKE RD.
CULVERT REPLACEMENT

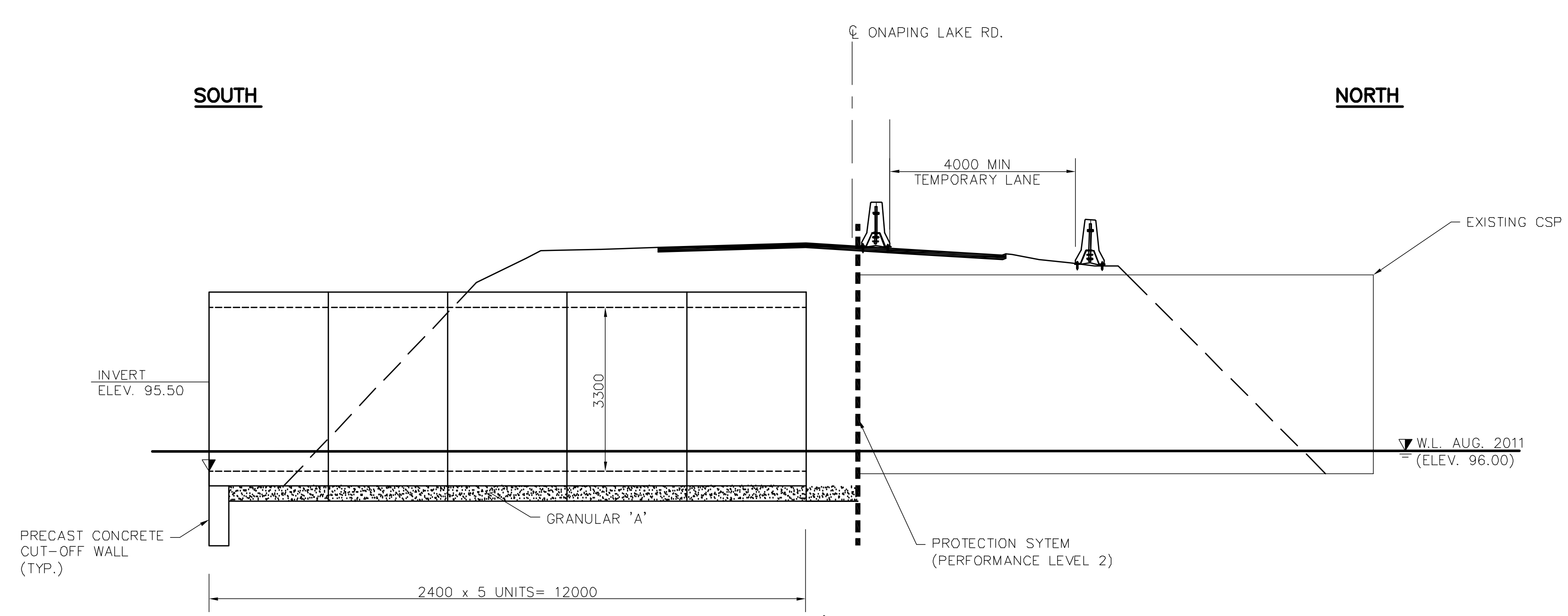
STAGE 1

SHEET 11

D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario
Canada, K9J 0B9
P. 705.742.2297
F. 705.741.3568
E. wills@dmwills.com



STAGE 1
1:125



SECTION 1
1:75

PRE-STAGE 1:

1. REMOVE STEEL BEAM GUIDE RAIL FROM NORTH SIDE OF ROADWAY;
2. INSTALL PROTECTION SYSTEM WEST OF EXISTING CULVERT;
3. CONSTRUCT COFFER DAM AT NORTH WHERE BY-PASS CULVERTS ARE TO BE INSTALLED;
4. EXCAVATE AND INSTALL NORTH HALF OF TWIN BY-PASS CULVERTS; AND
5. BACKFILL EXCAVATION AND RESTORE GRANULAR ROADWAY.

STAGE 1:

1. EXTEND ROADWAY PROTECTION FOR EXCAVATION OF EXISTING CULVERT;
2. INSTALL TEMPORARY TRAFFIC SIGNALS, TEMPORARY CONCRETE BARRIERS AND TRAFFIC STAGING FOR STAGE 1;
3. REMOVE STEEL BEAM GUIDE RAIL ON SOUTH SIDE OF ROAD;
4. CONSTRUCT COFFER DAM AT SOUTH WHERE BY-PASS CULVERTS ARE TO BE INSTALLED;
5. EXCAVATE AND INSTALL SOUTH HALF OF TWIN BY-PASS CULVERTS;
6. REMOVE COFFER DAMS FROM BY-PASS CULVERTS AND ESTABLISH FLOW THROUGH BY-PASS CULVERTS. CONSTRUCT COFFER DAMS AT INLET AND OUTLET OF EXISTING CULVERT;
7. EXCAVATE AND REMOVE SOUTH HALF OF EXISTING CULVERT. INSTALL SOUTH 5 UNITS OF NEW PRECAST CONCRETE BOX CULVERT;
8. APPLY WATERPROOFING OVER TOP OF CULVERT;
9. BACKFILL SOUTH PORTION OF NEW CULVERT; AND
10. CONSTRUCT ROADWAY WIDENING FOR STAGE 2 TRAFFIC.

INLET COFFERDAM DESIGN ELEVATION = 97.00

BY-PASS CULVERTS INLET ELEV. = 95.60
OUTLET ELEV. = 95.30

BY-PASS SYSTEM DESIGN FLOW RATE = 2.9 m^3/s

LICENSED PROFESSIONAL ENGINEER
T.M.H. CAMPBELL
100132234
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
D. S. BONSALL
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN TC	CHK DB	CODE CHBDC-2006	LOAD CL-625-ONT	DATE 11/2012
DRAWN KC	CHK DB	SITE 46-411/C	STRUCT	SCHEME / DWG 2

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

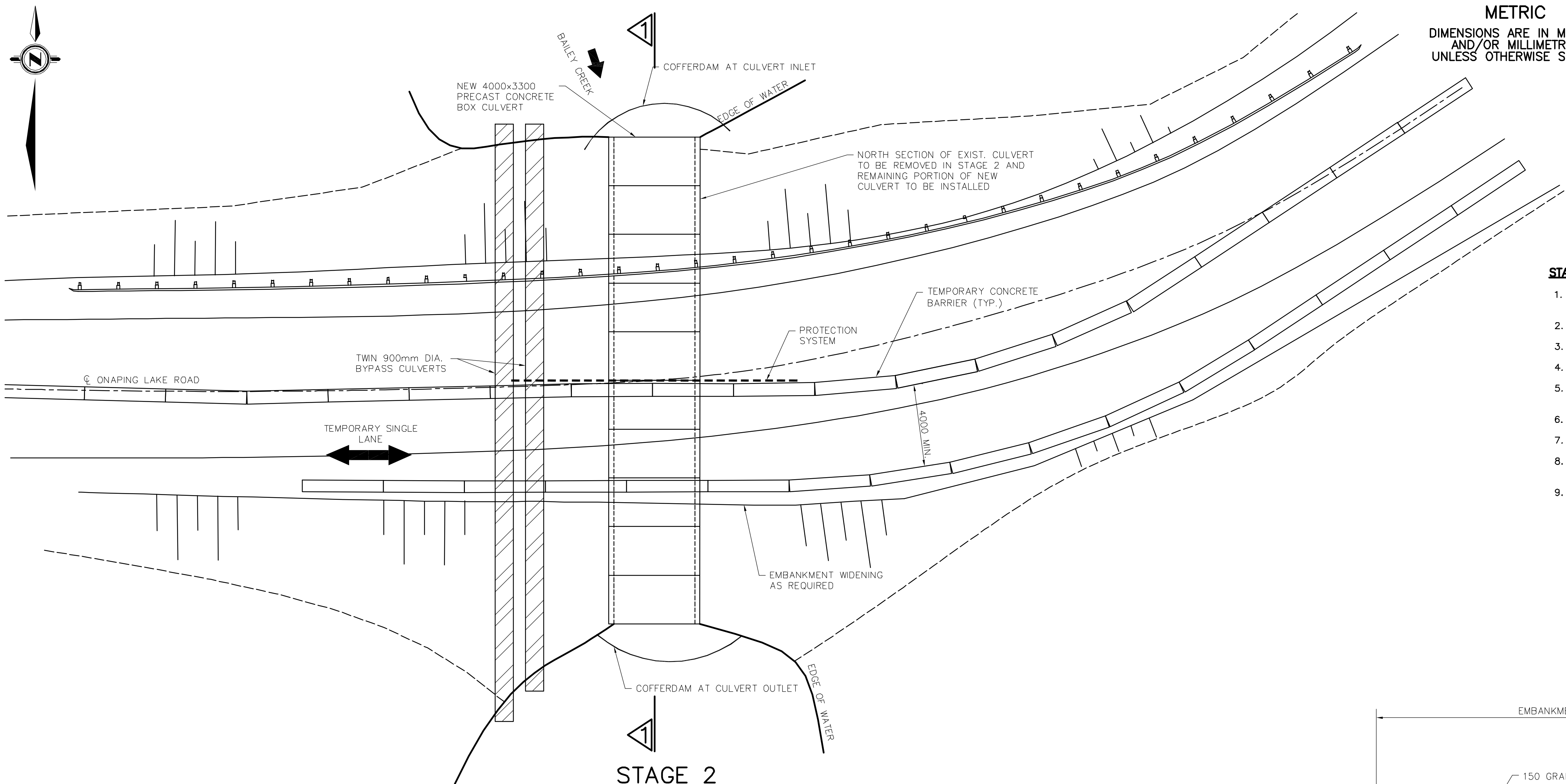
CONT No 2013-5601
WP No 5019-10-01

ONAPING LAKE RD. CULVERT REPLACEMENT

STAGE 2

SHEET 12

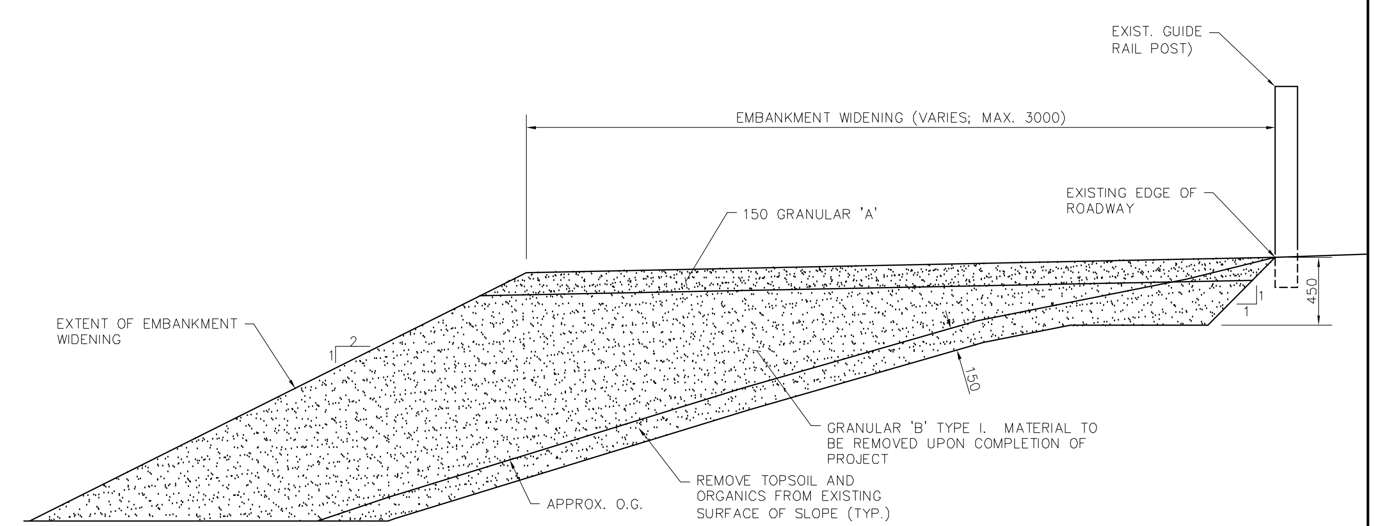
WILLS
D.M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario
Canada, K9J 0B9
P. 705.742.2297
F. 705.741.3568
E. wills@dmwills.com



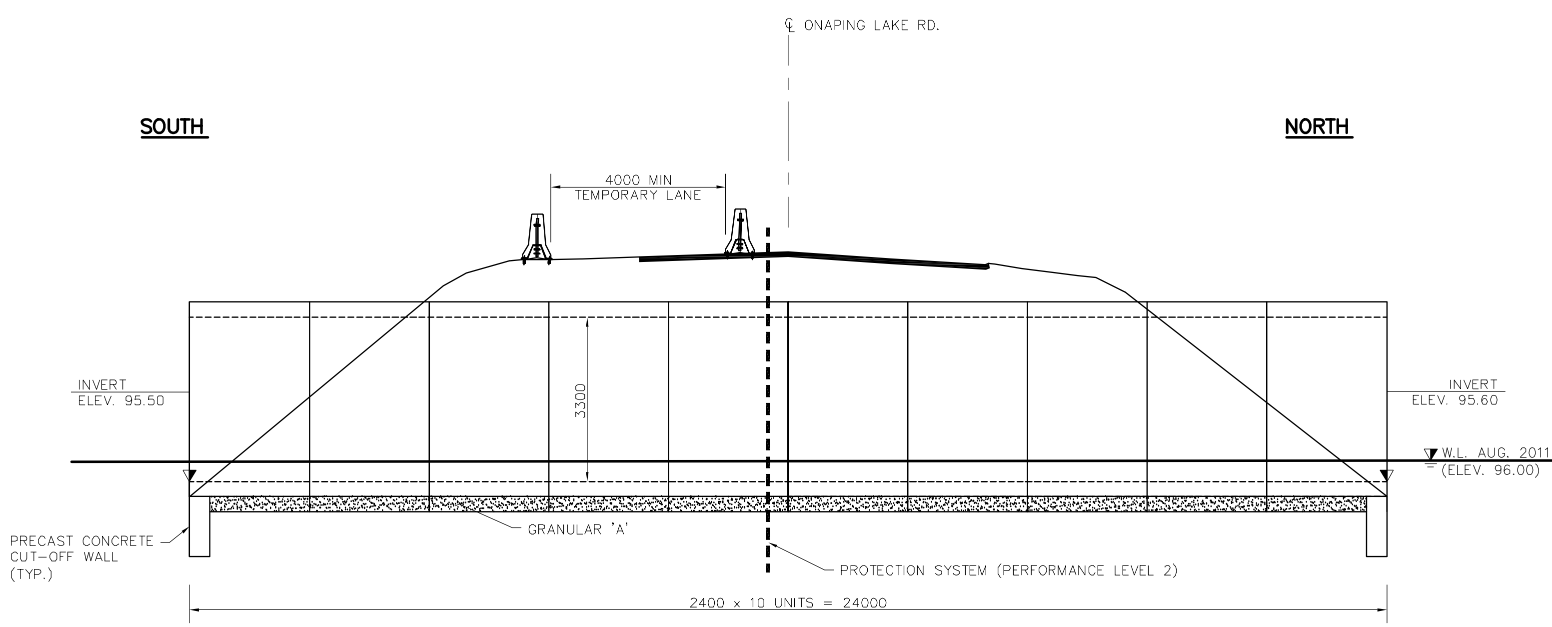
STAGE 2
1:125

STAGE 2:

1. RELOCATE TEMPORARY CONCRETE BARRIERS AND TEMPORARY TRAFFIC SIGNALS FOR STAGE 2 TRAFFIC;
2. EXCAVATE AND INSTALL NORTH 5 UNITS OF NEW CULVERT;
3. APPLY WATERPROOFING OVER TOP OF CULVERT;
4. BACKFILL NORTH PORTION OF NEW CULVERT;
5. REMOVE COFFERDAMS FROM ENDS OF CULVERT AND RESUME FLOW THROUGH CULVERT;
6. RECONSTRUCT THE NORTH PORTION OF THE ROADWAY;
7. REINSTATE STEEL BEAM GUIDE RAIL;
8. REMOVE ROADWAY PROTECTION, TEMPORARY CONCRETE BARRIERS AND TEMPORARY TRAFFIC SIGNALS; AND
9. PLACE SURFACE TREATMENT ON DISTURBED AREAS OF ROAD.



SOUTH EMBANKMENT WIDENING
1:25



SECTION 1
1:75

LICENSED PROFESSIONAL ENGINEER
T.M.H. CAMPBELL
100132234
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
D. S. BONSALL
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION			
DESIGN TC	CHK DB	CODE CHBDC-2006	LOAD CL-625-ONT	DATE 11/2012		
DRAWN KC	CHK DB	SITE 46-411/C	STRUCT	SCHEME	DWG 3	

F:\9000\9000 - 9099\9072 Retainer - Local Roads Boards\02 Drawings\Onaping Culvert\Contract Drawings\(5009-E-0075)-46-411C-Onaping Rd. Culvert-Stage 2.dwg DATE MODIFIED: Dec 12, 2012 - 2:49pm