FINAL REPORT

FOUNDATION INVESTIGATION REPORT

Locking Creek Culvert Replacement, Hwy 602, Township of Lash

Agreement No. 6014-E-0017
Assignment No. 1
GWP 6919-12-00
Geocres No. 52C-39

Prepared for:

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exp Services Inc.
February 27, 2015

Ministry of Transportation

Foundation Investigation Report
Agreement No. 6014-E-0017
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Project Name:
Foundation Investigation Report for Locking Creek Culvert Replacement
HWY 602, Township of Lash

Project Number:
ADM-00223648-A0

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Date Submitted:
February 27, 2015

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Appendices

1. FOUNDATION INVESTIGATION REPORT

1.1 Introduction

This foundation investigation report presents the results of a geotechnical investigation completed by **exp** Services Inc. for the replacement of Locking Creek Culvert on Highway 602, located approximately 8.2 km south of the junction of Highway 602 and Highway 11 at Locking Creek, in the Township of Lash, the Ministry of Transportation (MTO) Northwestern Region. The work was undertaken under Agreement # 6014-E-0017, Assignment No. 1 (GWP 6919-12-00). The terms of reference (TOR) were as presented in the MTO letter dated December 2, 2014.

As noted in the TOR, the existing culvert is a rigid frame open footing concrete structure with a span of 3 m, depth of 1.8 m and a length of about 22 m. It is understood that the existing culvert constructed in 1935 is intended to be replaced with a new culvert along the same alignment.

The purpose of the investigation is to evaluate the subsurface conditions along the alignment, to permit detailed design for the culvert replacement. The site specific geotechnical investigation consisted of borings, soil sampling, borehole logging, and field and laboratory testing. It is noted that a Preliminary Foundation Investigation and Design Report was previously completed, by others, in November 2014, as referenced in Section 1.3.3.

This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the investigation and the laboratory testing completed for this project.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The Locking Creek Culvert replacement site is located on Hwy 602, approximately 8.2 km south of the junction of Hwy 602 and Hwy 11, in the Township of Lash. At the site, Hwy 602 is a two lane roadway with a speed limit of 80 km/h and is about 7 m wide from edge of pavement to edge of pavement, with narrow sand and gravel shoulders. Based on drawings provided, the roadway embankment is about 5 to 6 m high with side slopes of about 2H:1V.

During the fieldwork between December 17 and 20, 2014, the general site conditions were assessed; however, the site was generally snow covered which limited observations possible. Hwy 602 runs in a north to south direction and Locking Creek, flows from east to west towards the Rainy River, which is about 75 m west from Hwy 602. The Locking Creek Culvert location is located in a "valley" of the roadway. At the time of this investigation, Locking Creek was frozen and the approximate creek elevations at the inlet and outlet were 326.41 m and 326.32 m, respectively. The elevation of highway centerline pavement is 331.98 m.

The vicinity of the inlet and outlet of the culvert is heavily vegetated with trees and wild bushes. Fallen trees and branches at the inlet side were observed; however, the flow of the water did not appear to be restricted by the fallen trees.

Select photographs are provided in Appendix A.

1.2.2 Geological Setting

According to the MNR Northern Ontario Engineering Geology Terrain Data Base Map, Ontario Geological Survey Map 5069. Scale 1:100,000, dated 1978, the underlying native soil at the sites consists of clay and silt glaciolacustrine plain deposits with a subordinate landform consisting of bedrock knob; mainly low local relief, undulating to rolling and dry surface conditions.

1.3 Investigation Procedures

1.3.1 Site Investigation and Field Testing

The field investigation was performed between December 17 and 20, 2014. The field program consisted of drilling two (2) sampled boreholes (BH101 and BH102). The boreholes were strategically located about 3 m from the existing culvert; BH101 was located about 3 m north of the culvert within the southbound lane, and BH102 was located about 3 m south of the culvert within the northbound lane. The borehole locations are shown on Drawing 1 in Appendix B.

The boreholes were advanced using a rubber tire mounted CME-750 drill rig, equipped with a hollow stem continuous flight augers, standard soil sampling equipment (includes 51 mm outside diameter split spoon samplers and *in situ* shear vane testing equipment) and rock coring equipment, NQ size, operated by a specialist drilling contractor, RPM Drilling Inc. However, no rock coring equipment was used.

The boreholes BH101 and BH102 were advanced to depths of about 40.2 m and 40.1 m, respectively, at which point they were terminated.

The borehole locations were referenced to the MTM NAD83 coordinate system and their ground surface elevations were surveyed by **exp** personnel. The ground surface elevations, including top of culvert and top of water/ice at the upgradient and downgradient sides of the highway, were referenced to a temporary geodetic benchmark provided by the client (top of asphalt at Hwy 602 centreline at the culvert centerline). The elevation of the TBM was 331.98 m, and location of the TBM is detailed on Drawing 1, in Appendix B. The elevation of the TBM is based on a historical Preliminary Foundation Investigation and Design report dated, November 2014 (referenced below).

During the drilling of the boreholes, soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586), and were generally performed at intervals of about 0.75 m within the critical foundation zone (upper 15 m), 1.5 m intervals in the upper 21 m, and 3.0 m intervals thereafter. The original field (uncorrected) SPT “N” values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual and used to provide an assessment of *in-situ* compactness (cohesionless) or consistency (cohesive) soils. In addition, twelve (12) i*n situ* shear field vane tests were conducted within the cohesive soils, and four (4) thin-walled, Shelby Tube samples were also collected.

Upon completion of the boreholes, ground water level measurements were carried out in boreholes in accordance with the Ministry of Transportation guidelines. The measured ground water levels after completion of drilling boreholes were recorded on borehole log sheets in Appendix C. The boreholes were backfilled with a mixture of bentonite and auger cuttings and cold patch was used to repair the asphalt surface damaged by the augers. The borehole decommissioning was in general accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the *Ontario Water Resources Act)*.

The fieldwork was supervised by a member of **exp**'s engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM Standards for Soils Classification, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags and were brought to **exp**'s Thunder Bay laboratory for additional visual, textual and olfactory examination.

1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content and particle size distribution for approximately 25% of the collected soil samples. Atterberg limits tests were carried out for cohesive soils. In addition, one consolidation test and a specific gravity test were performed on a representative cohesive sample within the critical foundation zone. All of the laboratory tests were carried out in accordance with MTO and/or ASTM Standards as appropriate at the **exp** laboratory in Thunder Bay, ON, with the exception of the consolidation test, which was performed by the **exp** laboratory in Brampton, ON. A summary of the laboratory testing is presented in Table 1.2 below.

The laboratory test results are provided on the attached borehole log sheets in Appendix C as well as graphically in Appendix D.

1.3.3 Previous Investigations

The following previous/historical investigations were provided by the client.

1. Preliminary Foundation Investigation and Design Report, Replacement of Locking Creek Culvert, Highway 602, Station 10+640, Township of Lash – Site No. 45-161/C; GWP 6919-12-00; Geocres No. 52C-36; Stantec Consulting Ltd; November 2014; Stantec Project No. 165000873.
2. Structural Design Report, Locking Creek Culvert, Site 45-161/C, Highway 602; GWP 6919-12-00; MTO Agreement No. 6012-E-0049; Stantec Consulting Ltd; November 2014

1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in Appendix D. Figure 6 in Appendix D shows moisture content, total unit weight, undrained shear strength and stress history profiles with depth. The "Explanation of Terms Used in Report" preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report. The historical borehole logs from the 2014 Preliminary Foundation

Investigation and Design Report, are presented in Appendix E and included in our drawings (Appendix B).

A borehole location plan and stratigraphic sections are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and stratigraphic sections are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be interpreted as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions along the proposed culvert alignment consist of a layer of poorly graded sand with silt and gravel fill underlain by a fat clay fill. The fill layers are followed consecutively by native deposits of a lean clay with sand, underlain by a fat clay and underlain by a poorly graded sand with silt near the borehole termination depths of about 40 m below the pavement surface. A more detailed summary of the subsurface conditions encountered in the boreholes is provided in the following sections.

1.4.1 **Poorly Graded Sand with Silt and Gravel (SP-SM) Fill**

Poorly graded sand with silt and gravel was encountered beneath the asphalt. The asphalt thickness was about 25 mm at BH101 and BH102. The fill was generally described as frozen (in the upper zones) and brown. At BH102, asphalt treatment, about 75 mm in thickness, was observed beneath the sand with silt and gravel fill. Beneath the asphalt treatment, silty sand with gravel fill was encountered, and was described as frozen, brown and containing trace clay at depth. No SPT sampling was conducted within the fill due to frozen ground conditions; the samples were collected from the augers. This fill at BH101 and BH102 extended to about 0.5 m (331.6 m elevation) and 0.8 m (331.2 m elevation) below ground surface, respectively.

Laboratory testing performed on selected samples consisted of grain size distribution tests. The test results are as follows:

Grain size distribution:

- 12% to 34% gravel;
- 57% to 68% sand; and
- 9% to 20% silt and clay size.

The results of the grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 1 in Appendix D.

1.4.2 **Fat Clay (CH) Fill**

Fat clay fill was encountered underlying the sand with silt and gravel fill. The clay fill was generally described as stiff to soft at depth, grey, moist, containing trace to some peat. Trace wood pieces were noted at BH102 at about 2.3 m depth. Lean clay with sand fill was encountered beneath the fat clay fill at BH102. The SPT "N" values ranged between about 10 and 4 blows per 300 mm penetration, generally decreasing at depth. The clay fill extended to about 6.9 m below ground surface and about 325.2 m elevation and 325.1 m elevation at BH101 and BH102, respectively. The thickness of this layer is between 6.1 m and 6.4 m.

Laboratory testing performed on selected samples consisted of moisture content, grain size distribution tests and Atterberg limit testing. The test results are as follows:

Moisture content:

- 21.5% to 41.3%

Grain size distribution:

- 0 % gravel,
- 5% to 27% sand,
- 30% to 42% silt, and
- 35% to 64% clay size.

Total unit weights have been calculated based on the moisture contents and are estimated to range from about 18.5 to 19.5 kN/m^3.

In addition, Atterberg limit testing was performed three representative samples of the clay fill (BH101-S10, BH102-S7, BH102-S11) and indicated that the soil is of medium to high plasticity. The data is shown on the plasticity chart, Figure 4, in Appendix D. The liquid limits ranged from about 46 to 63, plastic limits from 18 to 19 with corresponding plasticity index ranging from 27 to 45. The results of the moisture content, grain size distribution and Atterberg limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution and Atterberg limit tests are also provided on Figure 2 and Figure 4, respectively, in Appendix D.

1.4.3 **Lean Clay with Sand (CL)**

Lean clay with sand was encountered beneath the fill. The lean clay with sand was generally described as firm to hard, grey, and moist to wet. At BH102, gravel and / or cobbles were noted during augering at about 17.7 m to 18.3 m depth. The SPT "N" values ranged between about 2 and 12 blows per 300 mm penetration. Four Shelby Tube samples were collected. In addition, *in situ* shear vane tests were performed and field results ranged between about 111 kPa to greater than 330 kPa (maximum instrument reading). The corrected values (based on Bjerrum, considering plasticity) ranged from about 105 kPa to greater than 310 kPa. The values of undrained shear strength of this soil layer with depth are shown on Figure 6 in Appendix D.

The lean clay with sand at BH101 and BH102 extended to about 33.6 m (298.5 m elevation) and 32.0 m (299.9 m elevation) below ground surface, respectively. The thickness of this layer is between 25.1 m and 26.7 m.

Laboratory testing performed on selected samples consisted of moisture content, grain size distribution tests, Atterberg limit testing, consolidation testing and specific gravity. The test results are as follows:

Moisture content:

- 20.0% to 28.6%

Grain size distribution:

- 0 % gravel,
- 20% to 28% sand,
- 34% to 41% silt, and
- 33% to 46% clay size.

Total unit weights have been calculated based on the moisture contents and are estimated to range from about 19.2 to 20.6 kN/m^3. A single unit weight determination on a sample from between 11.4 m and 12.0 m in BH-101 yielded a value of about 20.4 kN/m^3.

In addition, Atterberg limit testing was performed on representative samples of the lean clay with sand (BH101-S12, BH101-S17, BH101-S23, BH102-S13, BH102-S19, BH102-S24, BH102-S27, BH102-S29) and indicated that the soil is of medium plasticity. The data is shown on the plasticity chart in Figure 5, Appendix D. The liquid limits ranged from about 37 to 49, plastic limits from 14 to 16 with corresponding plasticity index ranging from 22 to 33.

The results of the moisture content, grain size distribution and Atterberg limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution are also provided on Figure 3 in Appendix D, and Atterberg limit tests are provided on Figure 5 in Appendix D.

Sample BH101-S17 was tested for specific gravity, and the laboratory testing results yielded a specific gravity of 2.69.

The results of the consolidation test performed on a sample of the lean clay (BH-101, Sample 16, elevation 320.3 m) are included in Appendix D. The results are summarized below:

- Moisture content (MC) = 22.7%
- Initial void ratio (e_0) = 0.659; unit weight = 20.39 kN/m^3
- Effective overburden pressure p'_0 = 164 kPa
- Pre-consolidation pressure (p'_C)= 240 kPa
- Recompression Index (C_r) = 0.025
- Compression Index (C_c) = 0.19

1.4.4 **Fat Clay (CH)**

Fat clay was encountered underlying the lean clay with sand. The fat clay was generally described as firm to hard, grey, and moist to wet. The SPT "N" values ranged between about 4 and 8 blows per 300 mm penetration. In addition, *in situ* shear vane tests were performed and field results ranged between about 109 kPa to greater than 277 kPa. The corrected values (based on Bjerrum, considering plasticity) ranged from about 78 kPa to 199 kPa. The undrained shear strength of this layer with depth is shown on Figure 6 in Appendix D.

The fat clay at BH101 and BH102 extended to about 39.7 m (292.4 m elevation) and 39.5 m (292.5 m elevation) below ground surface, respectively. The thickness of this layer is between 6.1 m to 7.5 m.

Laboratory testing performed on selected samples consisted of moisture content, grain size distribution tests and Atterberg limit testing. The test results are as follows:

Moisture content:

- 37.2% to 64.4%

Grain size distribution:

- 0% gravel,
- 0% to 3% sand,
- 16% to 31% silt, and
- 66% to 84% clay size.

Total unit weights have been calculated based on the moisture contents and are estimated to range from about 15.9 to 18.2 kN/m^3.

In addition, Atterberg limit testing was performed on two representative of the fat clay (BH101-S28, BH102-S32) and indicated that the soil is of high plasticity. The data is shown on the plasticity chart, Figure 4. The liquid limits ranged from about 55 to 91, plastic limits from 17 to 27 with corresponding plasticity index ranging from 38 to 64.

The results of the moisture content, grain size distribution and Atterberg limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution are also provided on Figure 2 in Appendix D, and Atterberg limit tests are provided on Figure 4 in Appendix D.

1.4.5 **Poorly Graded Sand with Silt (SP-SM)**

Poorly graded sand with silt was encountered beneath the fat clay. The poorly graded sand with silt was generally described as loose to compact, grey and wet. At BH102, at the sand and clay interface, about 610 mm of blowing sand was encountered within the augers. The SPT “N” values at BH101 and BH102 were 10 and 11 blows, respectively, per 300 mm penetration. The poorly graded sand with silt at BH101 and BH102 extended to about 40.3 m (291.8 m elevation) and 40.1 m (291.9 m elevation) below ground surface, respectively.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture content:

- 14.3% to 22.5%

Grain size distribution:

- 0% to 4% gravel,

- 89% to 92% sand, and
- 7% to 8% silt and clay size

Total unit weights have been calculated based on the moisture contents and are estimated to range from about 20.1 to 21.9 kN/m^3.

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheet in Appendix C. The result of the grain size distribution tests also provided on Figure 1 in Appendix D.

1.5 Groundwater and Surface Water Conditions

Information of groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The groundwater levels encountered in the boreholes are shown on the borehole logs and presented below in Table 1.1. In addition, historical groundwater and surface water elevations are indicated below.

Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods. Some perched water over clayey silt layers could exist in the embankment fill as well.

Table 1.1. Groundwater data

Borehole	Date Completed	Date Measured	Ground Surface Elevation[2]	Depth to Water[3]	Groundwater Elevation
BH101[4]	Dec. 20/14	Dec. 20/14	332.04	2.35	329.69
BH102[4]	Dec. 18/14	Dec. 18/14	331.97	4.27	327.70
BH14-1	May 21/14	May 21/14	332.1	5.9	326.2
BH14-2	May 22/14	May 22/14	331.9	5.7	326.2
BH14-3	May 26/14	May 26/14	327.9	1.7	326.2
BH14-4	May 26/14	May 26/14	328.8	2.5	326.3
Locking Creek wl Upstream Side	--	Dec. 20/14	--	--	326.41
Locking Creek wl Downstream Side	--	Dec. 20/14	--	--	326.32

Notes:
1) All units in metres.
2) Elevations surveyed are referenced to a geodetic temporary benchmark (TBM) provided by the client (top of asphalt at Hwy 602 centreline at the culvert centerline). The elevation of the TBM is 332.0 m,
3) Depths are relative to ground surface.
4) **Artesian groundwater conditions appear to be encountered from the underlying sand with silt layer at the bottom of the boreholes**.

In addition to the groundwater depths/elevations indicated above, the recent Stantec's Preliminary Foundation Investigation and Design Report, indicates that the water level at the Locking Creek on July 20, 2012, was 326.4 m.

1.6 Closure

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation Report has been prepared by Ahileas Mitsopoulos, P.Eng., Demetri N. Georgiou, MASc. P.Eng., and Silvana Micic, Ph.D., P.Eng. It is reviewed by TaeChul Kim, M.E.Sc., P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Elwin Farkas.

Yours truly,

exp Services Inc.

Demetri N. Georgiou, MASc., P.Eng.
Senior Geotechnical Engineer
Project Manger

Stan E. Gonsalves, M.Eng., P.Eng.
Principal Engineer
Designated MTO Foundation Contact

Encl.

Appendix A – Photographs

Photo 1. Inlet of existing culvert at east side of highway

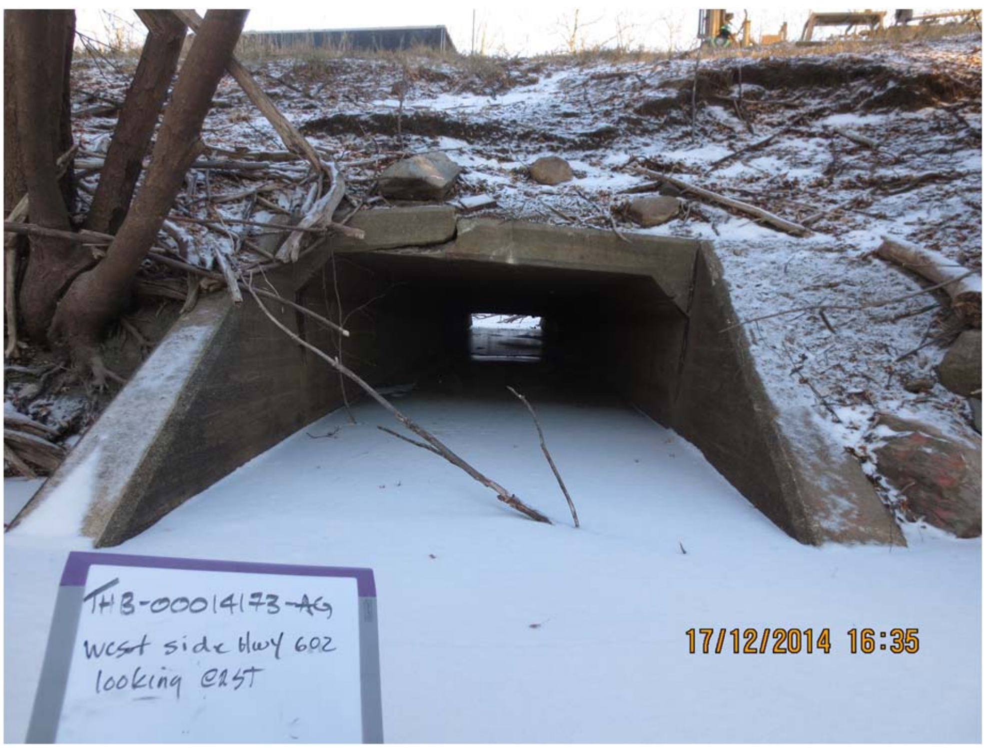


Photo 2. Outlet of existing culvert on west side of highway. Fractuing is noted.

Photo 3. Facing north on Hwy 602 before the existing culvert

Photo 4. Facing south on Hwy 602 from the existing culvert

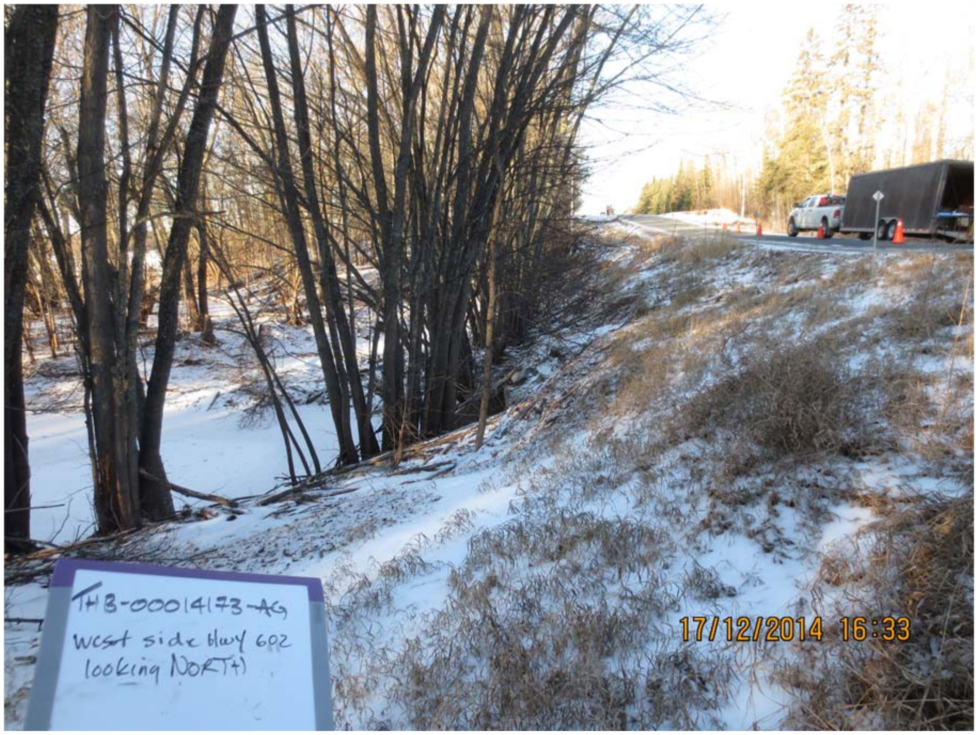
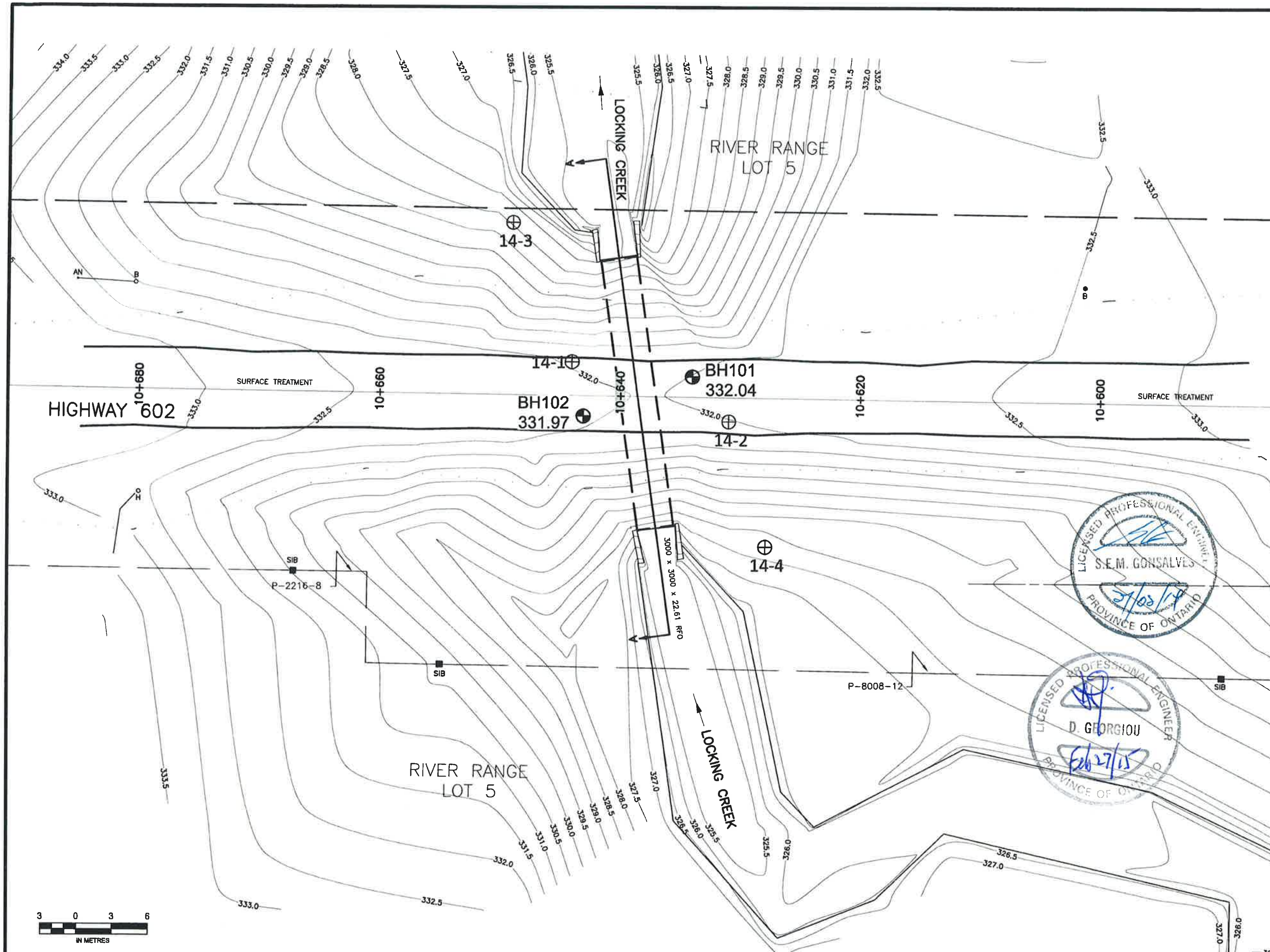


Photo 5. Embankment slope on west side facing north

Photo 6. Embankment slope on east side facing north

Appendix B – Drawings



Agreement No. 6014-E-0017
Assignment No. 1
GWP 6919-12-00

LOCKING CREEK CULVERT
(Highway 602, Township of Lash)
PLAN

DWG 1

exp Services Inc.

KEY PLAN

LEGEND

- BH101 332.04 — BOREHOLE LOCATION GROUND SURFACE ELEVATION IN METRES
- 14-1 — HISTORICAL BOREHOLE LOCATION

BH No.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTH	EAST
BH101	332.04	5,381,407	245,688
BH102	331.97	5,381,396	245,693
14-1	332.1	5,381,392	245,689
14-2	331.9	5,381,405	245,694
14-3	327.9	5,381,388	245,676
14-4	328.8	5,381,409	245,703

NOTES

1. ALL DIMENSIONS ARE IN METRES.
2. BASE MAP PROVIDED BY CLIENT.
3. REFERENCE: THE HISTORICAL BOREHOLE LOCATIONS ARE BASED ON THE STANTEC, PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT FOR THE LOCKING CREEK CULVERT REPLACEMENT, DATED NOVEMBER 2014.
4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. THE PROPOSED STRUCTURE DETAILS/WORKS ARE SHOWN FOR ILLUSTRATION PURPOSES ONLY.

REVISIONS

DATE	BY	DESCRIPTION

GEOCRES No. 52C-39	Project No. ADM-00223648-A0
Date: February 25, 2014	Scale : 1:300
Drawn By: RM	Checked By: AM
	Checked By: DG

Agreement No. 6014-E-0017
Assignment No. 1
GWP 6919-12-00

LOCKING CREEK CULVERT

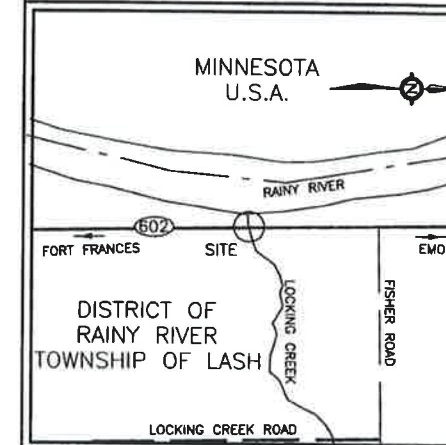
(Highway 602, Township of Lash)

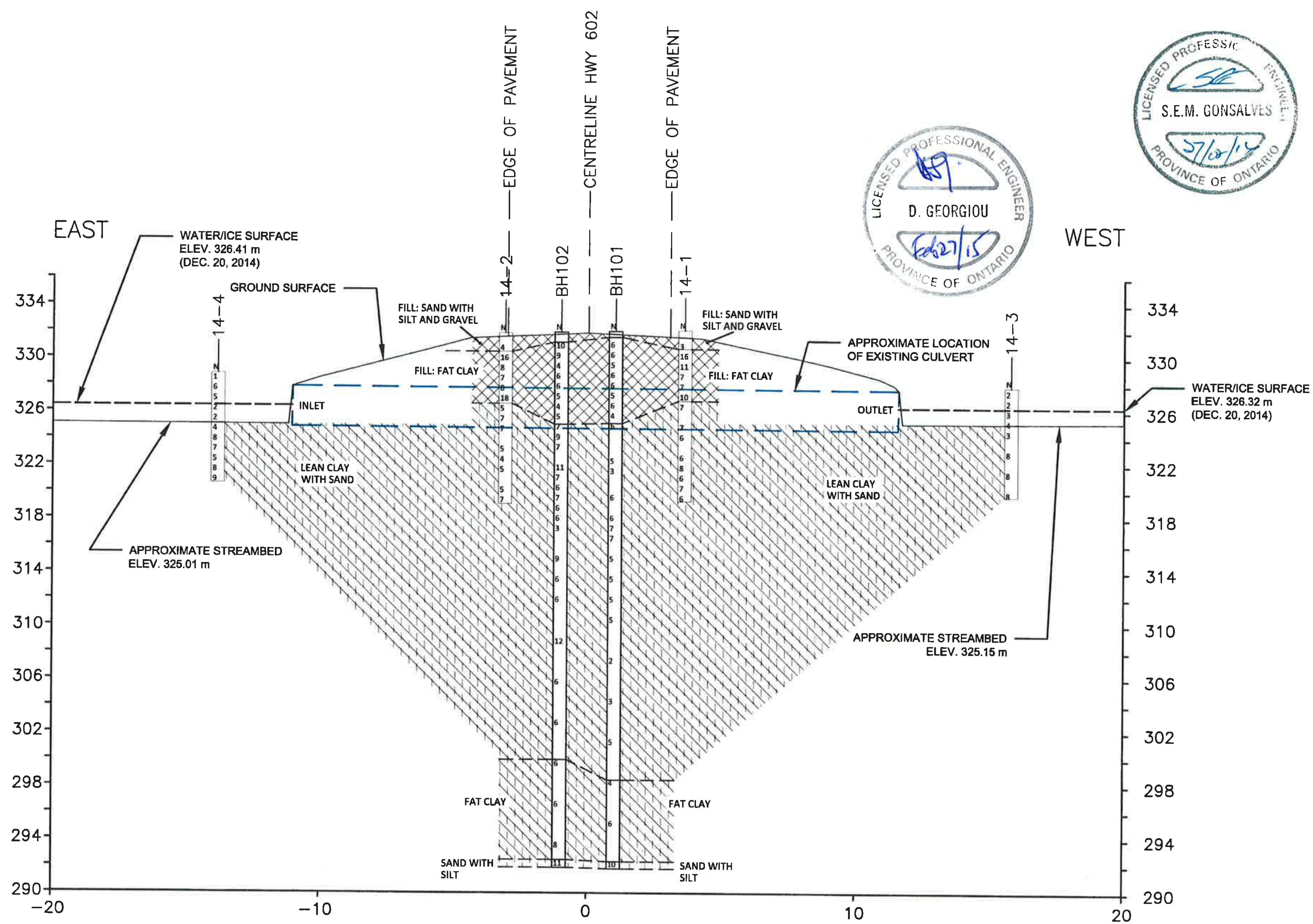
CROSS SECTION

DWG 2

exp Services Inc.

KEY PLAN





A–A
PROFILE OF LOCKING CREEK CULVERT

LEGEND

N STANDARD PENETRATION TEST (BLOWS/0.3 m)

BH No.	APPROX. ELEV. (m)	MTM COORDINATES NORTH	MTM COORDINATES EAST
BH101	332.04	5,381,407	245,688
BH102	331.97	5,381,396	245,693
14-1	332.1	5,381,392	245,689
14-2	331.9	5,381,405	245,694
14-3	327.9	5,381,388	245,676
14-4	328.8	5,381,409	245,703

NOTES

1. ALL DIMENSIONS ARE IN METRES.
2. ELEVATIONS OF THE CULVERT AND STREAMBED ARE DETERMINED FROM CLIENT PROVIDED DRAWINGS.
3. REFERENCE: THE HISTORICAL BOREHOLE LOCATIONS AND DETAILS ARE BASED ON THE STANTEC, PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT FOR THE LOCKING CREEK CULVERT REPLACEMENT, DATED NOVEMBER 2014.
4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. THE PROPOSED STRUCTURE DETAILS/WORKS ARE SHOWN FOR ILLUSTRATION PURPOSES ONLY.

REVISIONS

DATE	BY	DESCRIPTION

GEOCRES No. 52C-39	Project No. ADM-00223648-A0
Date: February 25, 2015	Scale 1:150 H 1:300 V
Drawn By: RM	Checked By: AM
	Checked By: DG

Appendix C – Borehole Logs

Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil: mixture of soil and humus capable of supporting good vegetative growth.

Peat: fibrous fragments of visible and invisible decayed organic matter.

Fill: where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

Till: the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

Desiccated: having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

Stratified: alternating layers of varying material or color with the layers greater than 6 mm thick.

Laminated: alternating layers of varying material or color with the layers less than 6 mm thick.

Fissured: material breaks along plane of fracture.

Varved: composed of regular alternating layers of silt and clay.

Slickensided: fracture planes appear polished or glossy, sometimes striated.

Blocky: cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Lensed: inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

Seam: a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

Homogeneous: same color and appearance throughout.

Well Graded: having wide range in grain sized and substantial amounts of all predominantly on grain size.

Uniformly Graded: predominantly on grain size.

All soil sample descriptions included in this report follow the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002 0.006 0.02 0.06 0.2 0.6 2.0 6.0 20 60 200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5≤Pp≤10%
Little	15≤Pp≤25%
Some	30≤Pp≤45%
Mostly	50≤Pp≤100%

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test ‘N’ value:

Table b: Apparent Density of Cohesionless Soil

	‘N’ Value (blows/0.3 m)
Very Loose	N<5
Loose	5≤N<10
Compact	10≤N<30
Dense	30≤N<50
Very Dense	50≤N

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test ‘N’ values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

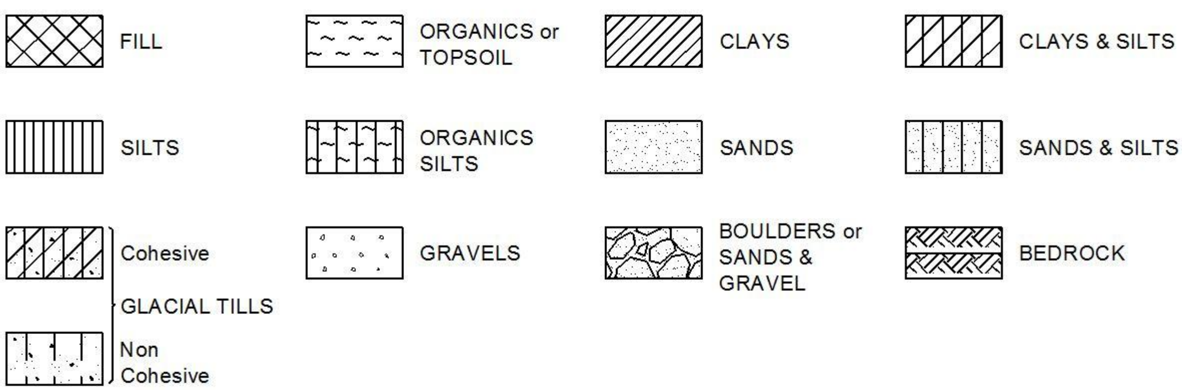
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	‘N’ Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT

Open Borehole or Test Pit   Monitoring Well, Piezometer or Standpipe

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

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
$\sigma_1, \sigma_2, \sigma_3$	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 PROPERIES OF SOIL

m_v	kPa^{-1}	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m^2/s	Coefficient of consolidation
H	m	Drainage path
T_V	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	kPa	Effective overburden pressure
σ'_P	kPa	Preconsolidation pressure
τ_f	kPa	Shear strength
c'	kPa	Effective cohesion intercept
ϕ'	$-^\circ$	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	$-^\circ$	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

P_s	kg/m^3	Density of solid particles
γ_s	kN/m^3	Unit weight of solid particles
ρ_w	kg/m^3	Density of water
γ_w	kN/m^3	Unit weight of water
ρ	kg/m^3	Density of soil
γ	kN/m^3	Unit weight of soil
ρ_d	kg/m^3	Density of dry soil
γ_d	kN/m^3	Unit weight of dry soil
ρ_{sat}	kg/m^3	Density of saturated soil
γ_{sat}	kN/m^3	Unit weight of saturated soil
ρ'	kg/m^3	Density of submerged soil
γ'	kN/m^3	Unit weight of submerged soil
e	1, %	Void ratio
n	1, %	Porosity
w	1, %	Water content
S_r	%	Degree of saturation
W_L	%	Liquid limit
W_P	%	Plastic limit
W_s	%	Shrinkage limit
I_P	%	Plasticity index = $(W_L - W_P)$
I_L	%	Liquidity index = $(W - W_P)/I_P$
I_C	%	Consistency index = $(W_L - W)/I_P$
e_{max}	1, %	Void ratio in loosest state
e_{min}	1, %	Void ratio in densest state
I_D	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
D_n	mm	N percent - diameter
C_u	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m^3/s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m^3	Seepage force

exp.

RECORD OF BOREHOLE No BH101

METRIC

W.P. GWP No. 6919-12-00 LOCATION **Locking Creek Culvert (Site No. 45-161/C) MTM ON-16 5,381,406 N 245,688 E** ORIGINATED BY EF

DIST 61 HWY 602 BOREHOLE TYPE CME 750 Rubber Tire Mount / HSA COMPILED BY AM

DATUM **Geodetic** DATE 12.19.14 - 12.20.14 CHECKED BY DG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
332.0	Asphalt					
332.0 / 0.0	**ASPHALT** - about 25 mm	S1	AUGER			34 57 (9)
331.6 / 0.5	**Poorly Graded SAND with Silt and Gravel (SP-SM) Fill** - frozen, brown	S2	AUGER			
	Fat CLAY (CH) Fill - frozen in upper 0.8 m, grey - becoming firm, moist, trace peat at about 0.8 m depth	S3	AUGER			
		S4	SS	6		
		S5	SS	6	∇	
		S6	SS	5		0 6 30 64
		S7	SS	6		
		S8	SS	6		
		S9	SS	5		
		S10	SS	6		0 5 42 53
325.2	- becoming firm to soft, grey to brown at about 6.1 m depth	S11	SS	4		
6.9	**Lean CLAY with Sand (CL)** - very stiff to hard, grey, moist to wet	S12	SS	6		0 23 41 36
			VANE			Field Vane = 105 kPa
		S13	SH			
		S14	SS	5		
		S15	SS	3		
			VANE			Field Vane = 187 kPa
		S16	SH			Unit weight 20.4 kN/m³
		S17	SS	6		0 24 40 36
			VANE			Field Vane = 196 kPa
		S18	SS	6		
		S19	SS	7		
		S20	SS	7		
			VANE			Field Vane = 153 kPa
		S21	SS	5		
		S22	SS	5		
			VANE			Field Vane = 235 kPa
		S23	SS	5		0 21 39 40
		S24	SS	5		
			VANE			Field Vane = 105 kPa
		S25	SS	2		

Elevation scale: 330, 328, 326, 324, 322, 320, 318, 316, 314, 312, 310, 308

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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 BH101

METRIC

W.P.	GWP No. 6919-12-00	LOCATION	Locking Creek Culvert (Site No. 45-161/C) MTM ON-16 5,381,406 N 245,688 E	ORIGINATED BY	EF
DIST	61 HWY 602	BOREHOLE TYPE	CME 750 Rubber Tire Mount / HSA	COMPILED BY	AM
DATUM	Geodetic	DATE	12.19.14 - 12.20.14	CHECKED BY	DG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (sensitivity)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Lean CLAY with Sand (CL) continued			VANE				Field vane >>, 1			Field Vane = 126 kPa
							306				
			S26	SS	3				o		
				VANE			304	+ 1			Field Vane = 116 kPa
							302				
			S27	SS	5				o		
				VANE				Field vane >>, 1			Field Vane = 145 kPa
							300				
298.5 / 33.6	**Fat Clay (CH)**- stiff to hard, grey, moist to wet		S28	SS	4		298		wP–w–wL (wL 91)		0 0 16 84
				VANE				+ 1			Field Vane = 78 kPa
							296				
			S29	SS	6				o		
				VANE				Field vane >>, 2			Field Vane = 199 kPa
							294				
292.4 / 39.7	**Poorly Graded SAND with Silt (SP-SM)** - loose to compact, grey, wet		S30	SS	10		292		o		0 92 (8)
291.8 / 40.3	**End of Borehole**										

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O 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   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH102

METRIC

W.P.	GWP No. 6919-12-00	LOCATION	Locking Creek Culvert (Site No. 45-161/C) MTM ON-16 5,381,395 N 245,693 E
ORIGINATED BY	EF		
DIST	61	HWY	602
BOREHOLE TYPE	CME 750 Rubber Tire Mount / HSA	COMPILED BY	AM
DATUM	Geodetic	DATE	12.17.14 - 12.18.14
CHECKED BY	DG		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
332.0	Asphalt
332.0 / 0.0	**ASPHALT** - about 25 mm
331.9 / 0.1	**Poorly Graded SAND with Silt and Gravel (SP-SM) Fill** - frozen, brown
331.8 / 0.2	**ASPHALT TREATMENT** about 75 mm
331.2 / 0.8	**SILTY SAND with Gravel (SM) Fill** - frozen, brown - trace clay at about 0.4 m depth
	Fat CLAY (CH) Fill - stiff to firm, grey, moist, trace to some peat - becoming soft to firm, trace wood pieces at about 2.3 m depth
325.9 / 6.1	**Lean CLAY with Sand (CL) Fill** - firm, grey, moist, trace to some peat
325.1 / 6.9	**Lean CLAY with Sand (CL)** - firm to stiff, grey, moist to wet - gravel and/or cobbles encountered during augering at about 17.7 m to 18.3 m depth - hard at about 20.8 m depth - becoming stiff at about 22.9 m depth

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
S1	AUGER			
S2	AUGER			12 68 (20)
S3	AUGER			
S4	SS	10		
S5	SS	9		
S6	SS	4		
S7	SS	6		0 14 30 56
S8	SS	6	∇	
S9	SS	5		
S10	SS	4		
S11	SS	5		0 27 38 35
S12	SS	7		
S13	SS	9		0 26 40 34
S14	SS	7		
S15	SH			
S16	SS	11		
S17	SS	7		
S18	SS	6		
S19	SS	7		0 23 38 39
S20	SS	6		
S21	SS	6		
S22	SS	3		
S23	SH			
S24	SS	9		0 28 39 33
S25	SS	6		
S26	SS	6		
	SH			Field Vane was greater than 314 kPa
S27	SS	12		0 26 38 36

ELEVATION SCALE: 330, 328, 326, 324, 322, 320, 318, 316, 314, 312, 310, 308

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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 BH102

METRIC

W.P. GWP No. 6919-12-00 | LOCATION Locking Creek Culvert (Site No. 45-161/C) MTM ON-16 5,381,395 N 245,693 E | ORIGINATED BY EF

DIST 61 HWY 602 | BOREHOLE TYPE CME 750 Rubber Tire Mount / HSA | COMPILED BY AM

DATUM Geodetic | DATE 12.17.14 - 12.18.14 | CHECKED BY DG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Lean CLAY with Sand (CL) continued					
	- becoming firm at about 25.9 m depth	S28	SS	6	306	
					304	
		S29	SS	6		0 20 34 46
					302	
299.9 / 32.0	**Fat CLAY (CH)**- firm to stiff, grey, moist to wet	S30	SS	6	300	
					298	
		S31	SS	6	296	
					294	
		S32	SS	8		0 3 31 66
292.5 / 39.5	- about 610 mm of blowing sand in augers at about 39.4 m depth					
291.9 / 40.1	**Poorly Graded SAND with Silt (SP-SM)** - compact, grey, wet	S33	SS	11	292	4 89 (7)
	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

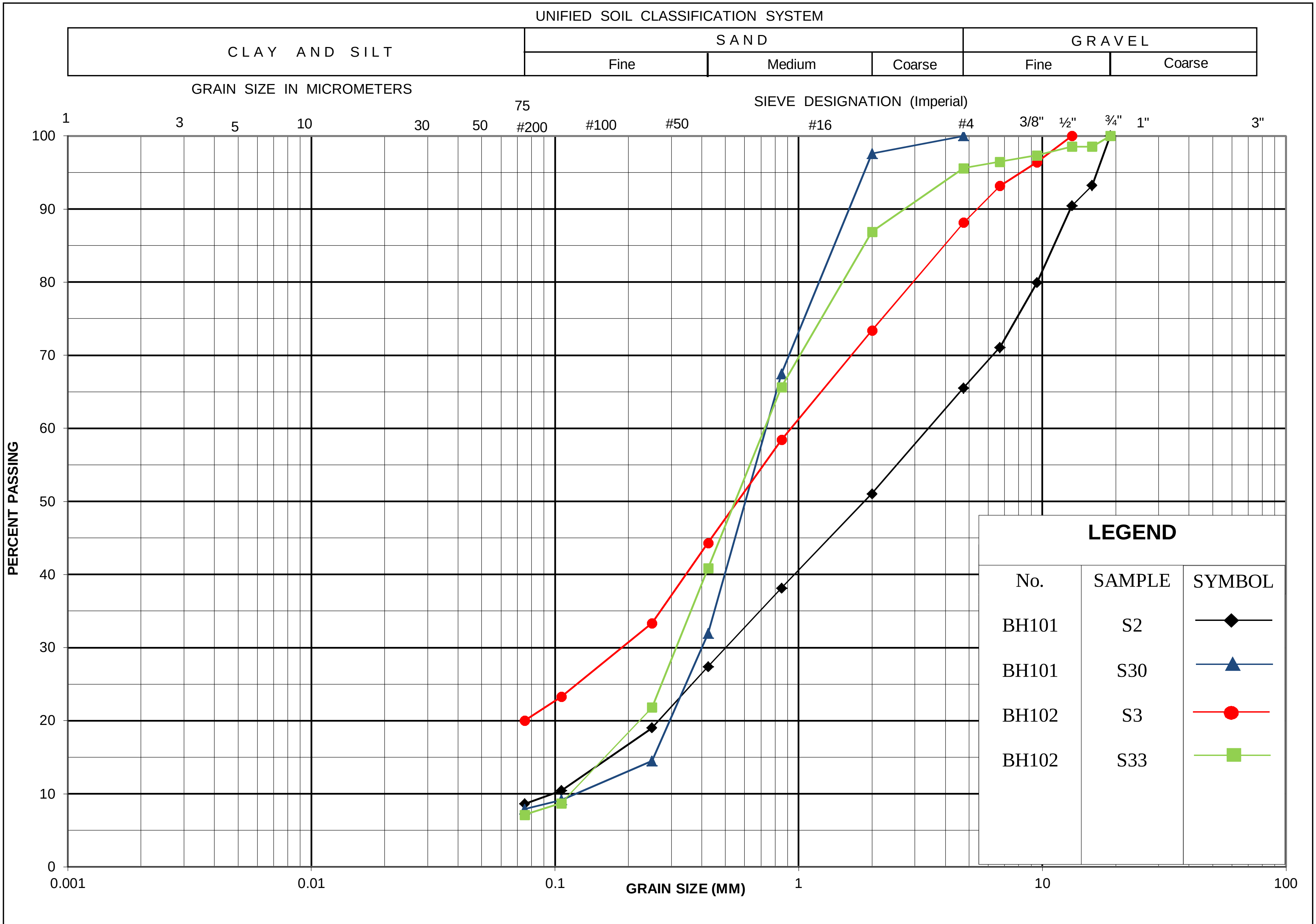
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

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

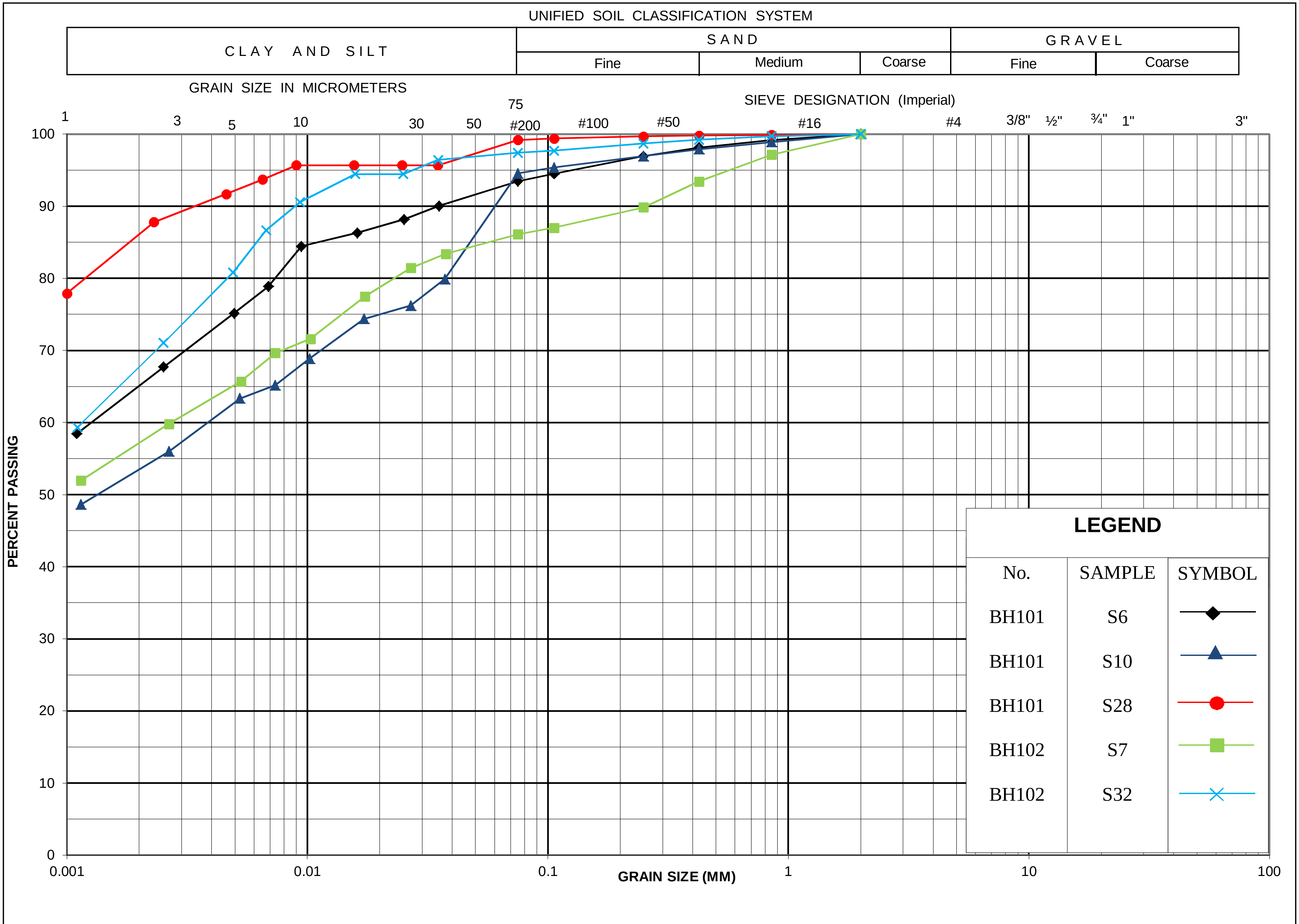
UNIT WEIGHT γ kN/m³

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

Appendix D –
Laboratory Data



exp.	GRAIN SIZE DISTRIBUTION ***SAND (SP-SM)*** - EXISTING CULVERT	FIGURE : No. 1 GWP : 6919-12-00 DATE : February 10, 2015



exp.

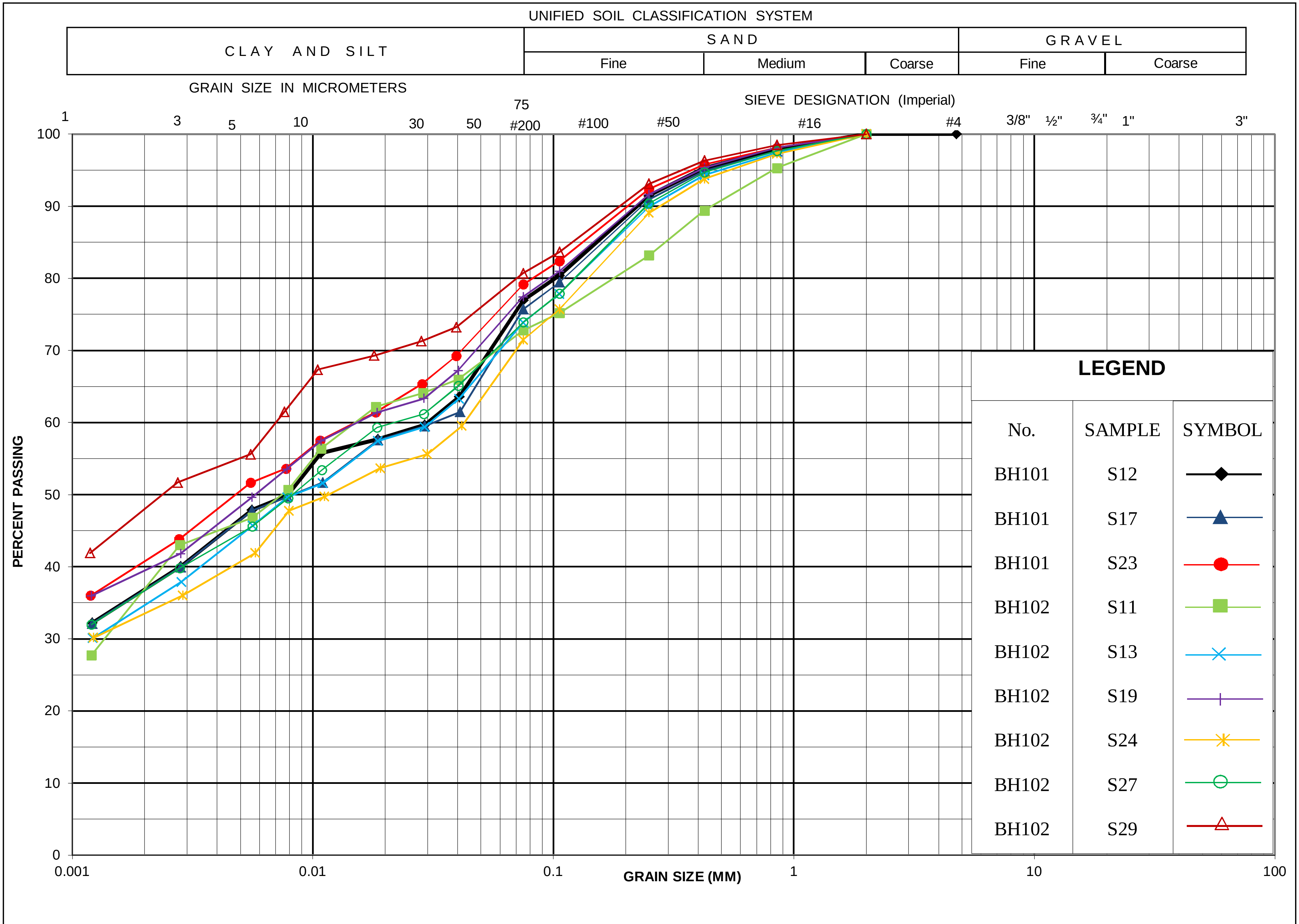
GRAIN SIZE DISTRIBUTION

FAT CLAY (CH) - EXISTING CULVERT

FIGURE : No. 2

GWP : 6919-12-00

DATE : February 10, 2015



exp.

GRAIN SIZE DISTRIBUTION

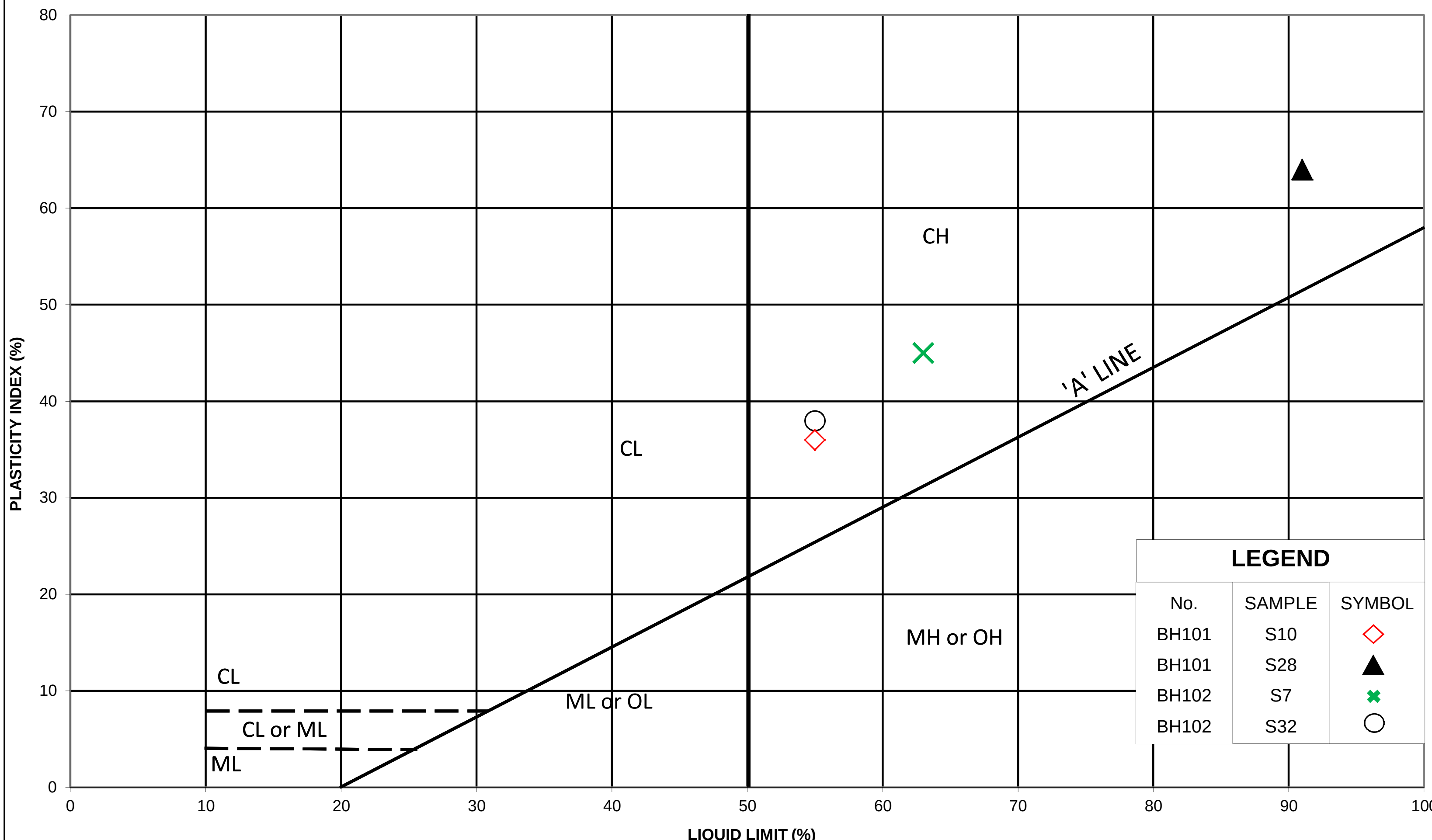
LEAN CLAY (CL) - EXISTING CULVERT

FIGURE : No. 3

GWP : 6919-12-00

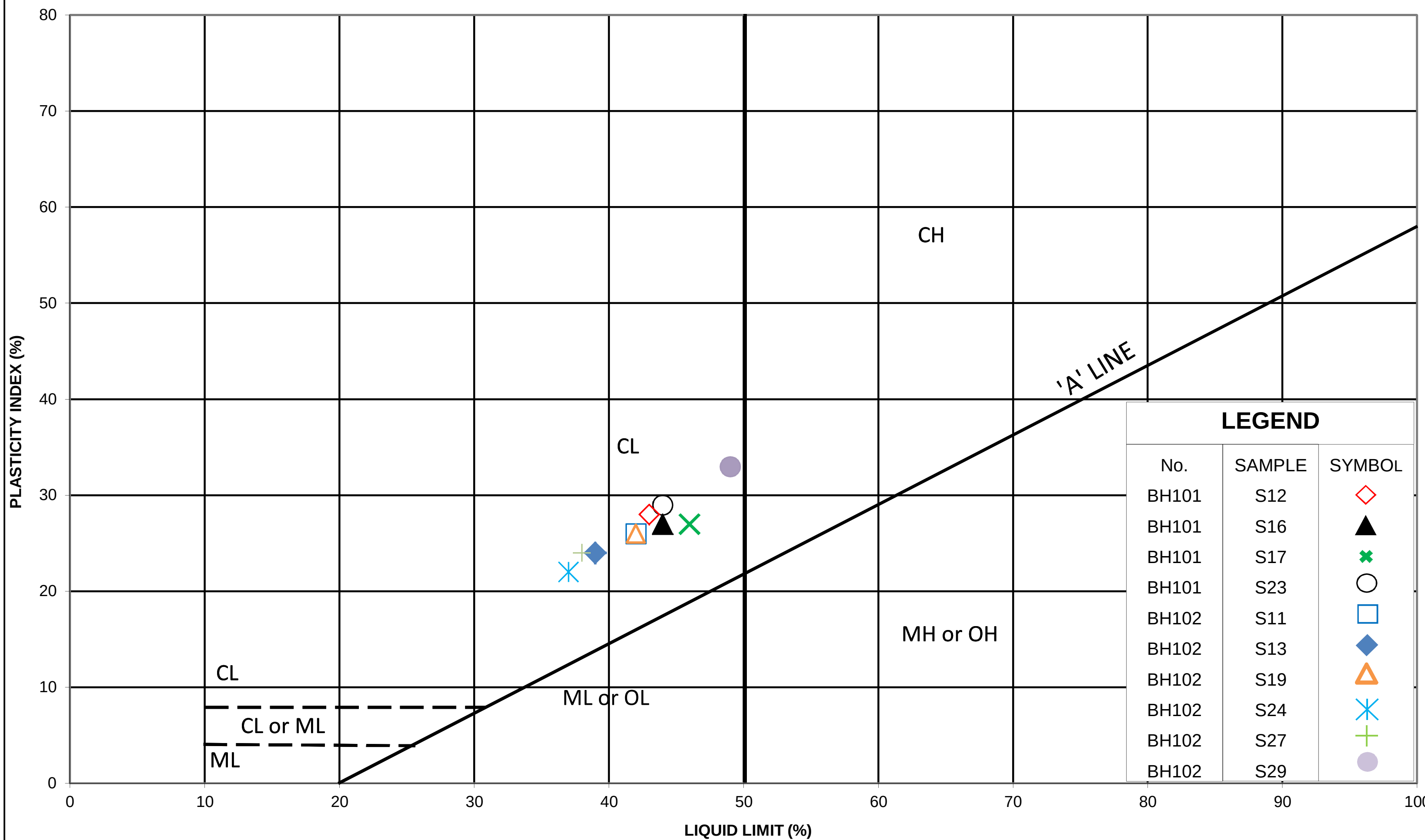
DATE : February 10, 2015

Locking Creek Culvert (Site No. 45-161/C)
GWP No. 6919-12-00, Highway 602, Township of Lash, Ontario



exp.	PLASTICITY CHART ***FAT CLAY (CH)***	FIGURE 4 ADM-00223648-A0 DATE February 25, 2015

Locking Creek Culvert (Site No. 45-161/C)
GWP No. 6919-12-00, Highway 602, Township of Lash, Ontario



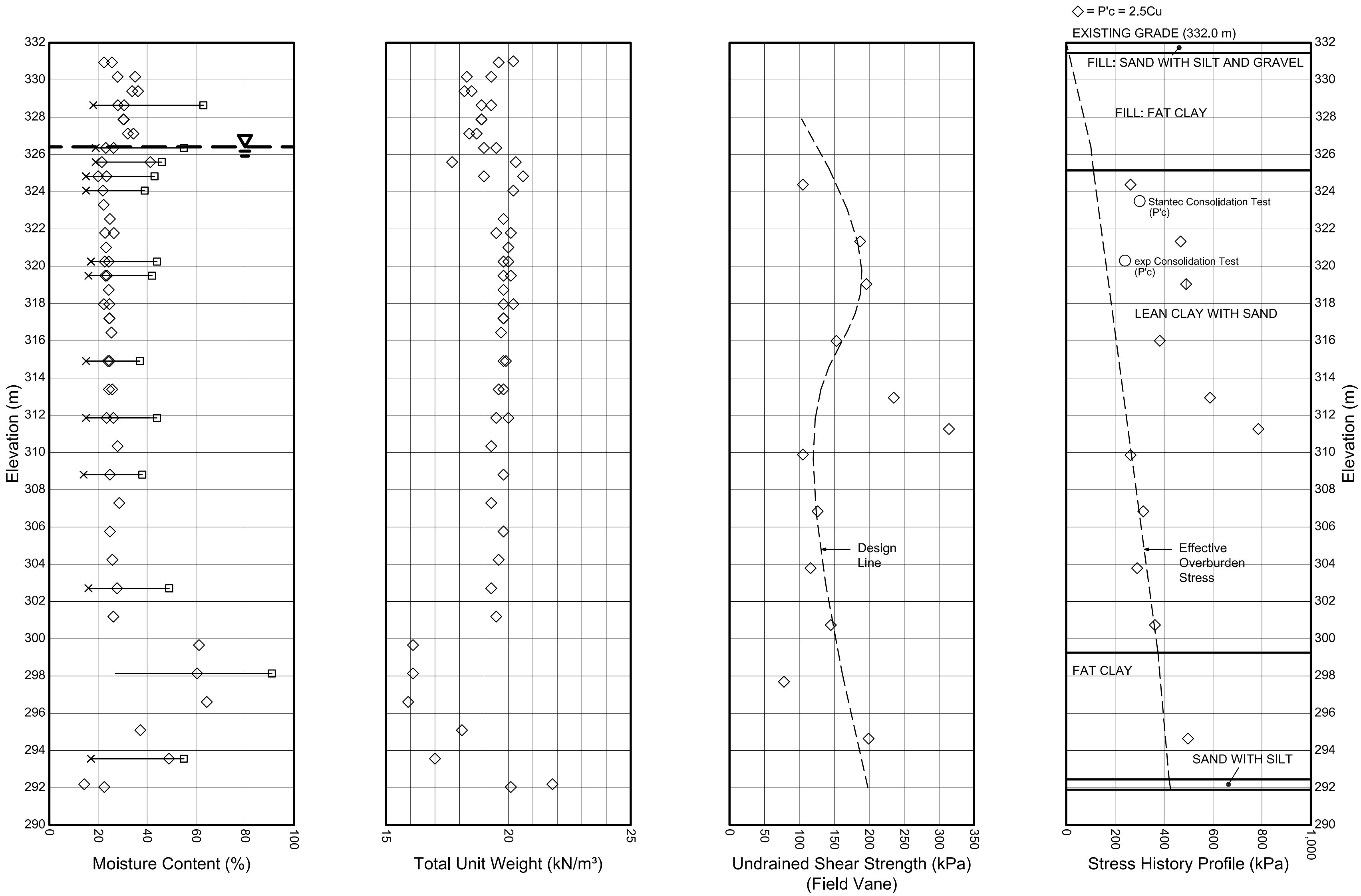
PLASTICITY CHART

LEAN CLAY (CL)

FIGURE 5

ADM-00223648-A0

DATE February 25, 2015



exp.

Thunder Bay, Ontario

FIGURE 6

SOIL PROPERTIES

Locking Creek Culvert, Site No. 45-161/C
Highway 602, Township of Lash, Ontario

PROJECT NO.:	ADM-00223648-A0
SCALE:	N/A
DRAWN BY:	RM
CHECKED BY:	DG
DATE:	February 25, 2015

exp Services Inc.

1595 Clark Boulevard
Brampton, ON
L6T 4V1
Tel.: 905-793-9800
Fax: 905-793-0641

Consolidation Test Summary Data Sheet (ASTM: D 2435-96)

Project No.:	adm-00223648-a0 geo-200 200-100		
Project Name:	Lab	Borehole No.	BH 101
Client Job No.:		Sample No.	TW-16
Sample Location:	MTO Hwy 602	Depth:	11.4 - 12.0m
Sample Description:	Silty Clay Brown		

Water Content Determination	Before Test		After Test
	Specimen	Trimmings	Specimen
Wt. of wet sample + Ring (tare) - g	225.64	91.47	225.1
Wt. of dry sample + Ring (tare) - g	200.75	74.5	200.75
Wt. of water (W_w) - g	24.89	16.97	24.35
Wt. of Ring - g	96.17	2.09	96.17
Wt. of dry soil (Ws) - g	104.58	72.41	104.58
Water Content (W) - %	23.8	23.4	23.3
Average (W) - %	23.6		23.3

Apparatus:

Machine No.	3
Cell No.	3
Ring No.	3
Diameter of Ring (in) :	2.5
Height of Ring - H_1 (in):	0.784
Area of Ring (in^2) :	4.9087

Load Factor:

1.55	lb. on Hanger
500	lb/ft2 on Sample

Test Data

Initial Dial Reading (in) :	0.03
Final Dial Reading (in) :	0.0577
Difference (in) :	0.0277
Machine Correction 0 to 0 (in) :	0.0043
Change in Ht., specimen, delta H (in) :	0.0234
Final Ht. of specimen, H_2=H_1-delta H :	0.7606

Spec. Gr.of Solids (G) :	(estimated)	2.75
Spec. Gr.of Solids (G) :	(determined)	
Initial Height of Specimen, H_1(in):		0.7840

Calculations	Before Test	After Test
Height of Specimen, H_1, H_2 (in):	0.7840	0.7606
Ht of Solids, H_s (in):	0.4726	0.4726
Ht. of Voids, H_v (in):	0.3114	0.2880
Ht. of Water, H_w (in):	0.3093	0.3026
Saturation, Sr (%):	99.3	100.0
Void ratio (e):	0.659	0.609

Comments:

Reported By: Willie Rodych

Date Reported: 19/01/2015

exp Services Inc.

1595 Clark Boulevard
Brampton, ON
L6T 4V1
Tel.: 905-793-9800
Fax: 905-793-0641

Consolidation Test
Determination of Void Ratio
(ASTM: D 2435-96)

Project No.	adm-00223648-a0 geo-200 200-100
Project Name	Lab
Client Job No.:	
Sample No.	BH 101 TW-16 11.4 - 12.0m
Sample Location	

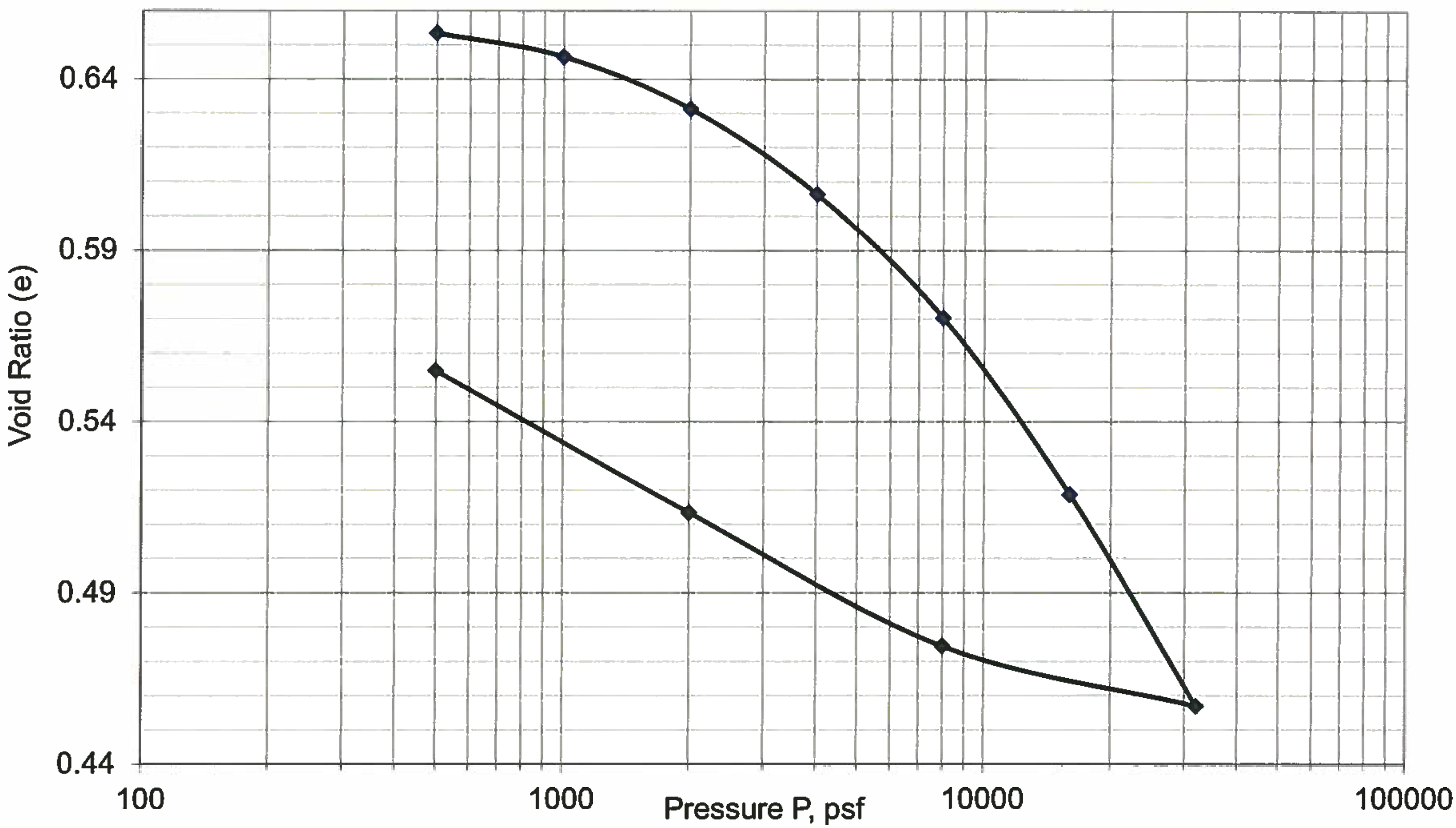
Height of Solids (in):	0.473
Initial Height of Voids (in):	0.311
Initial Void Ratio (e_o):	0.659
Initial Dial Reading:	0.030

Load No.	Hanger Load (lbs.)	Pressure on sample (lb/ft^2)	Final Dial Reading	Decrease in Height of Voids (in)	Machine Deflection (in)	Net Decrease in Height of Voids (in)	Height of Voids (in)	Void Ratio (e)
1	1.55	500	0.0340	0.0040	0.0014	0.0026	0.3088	0.653
2	3.1	1000	0.0382	0.0082	0.0023	0.0059	0.3055	0.646
3	6.2	2000	0.0467	0.0167	0.0036	0.0131	0.2983	0.631
4	12.4	4000	0.0599	0.0299	0.0050	0.0249	0.2865	0.606
5	24.8	8000	0.0789	0.0489	0.0070	0.0419	0.2695	0.570
6	49.6	16000	0.1057	0.0757	0.0094	0.0663	0.2451	0.519
7	99.2	32000	0.1373	0.1073	0.0118	0.0955	0.2159	0.457
8	24.8	8000	0.1266	0.0966	0.0094	0.0872	0.2242	0.474
9	6.2	2000	0.1059	0.0759	0.0071	0.0688	0.2426	0.513
10	1.55	500	0.0848	0.0548	0.0056	0.0492	0.2622	0.555
11								
12								
13								
14								
15								

Tested By: Willie Rodych
Date: 19/01/2015

Graph - e vs log P

Sample Test No.: 219686-6



exp Services Inc.
1595 Clark Boulevard
Brampton, ON
L6T 4V1
Tel.: 905-793-9800
Fax: 905-793-0641

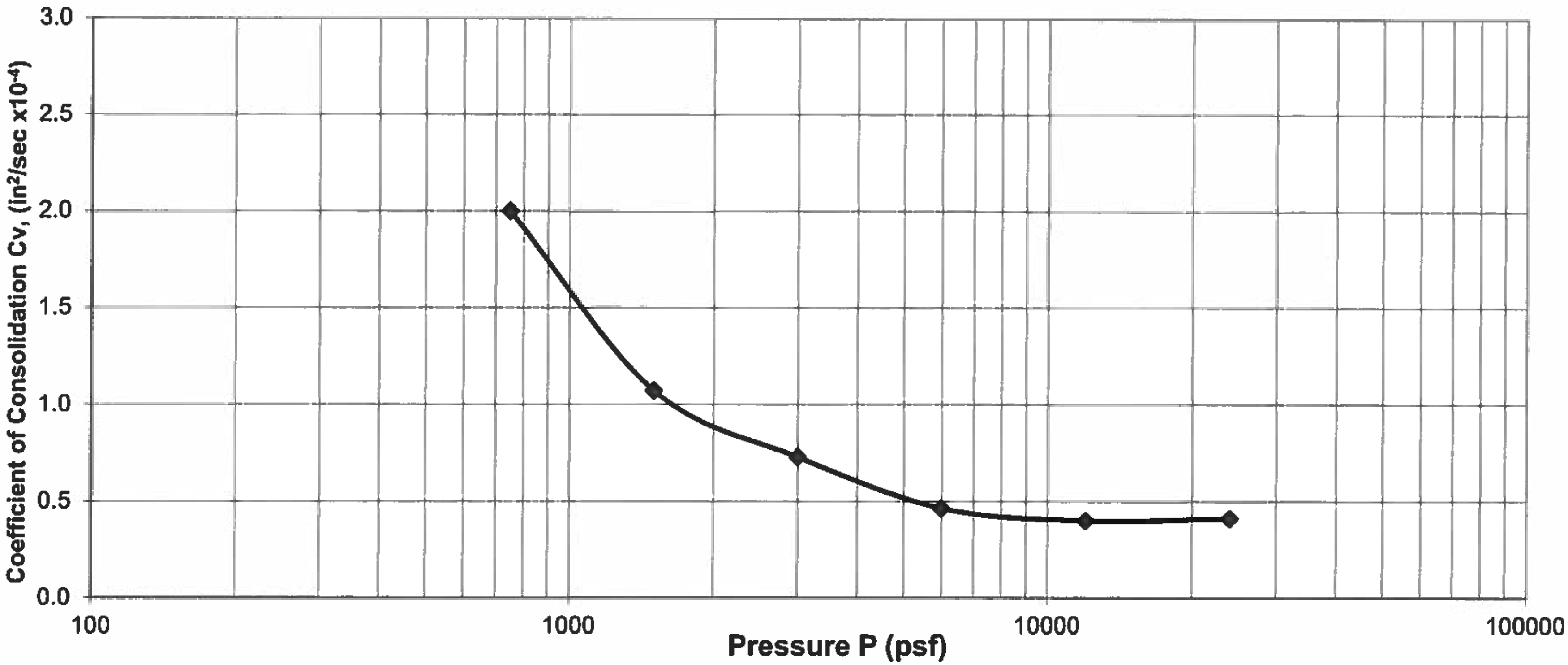
Consolidation Test
Coefficient of Consolidation
(ASTM: D 2435-96)

Project No.: adm-00223648-a0 geo-200 200-100
Project Name: Lab
Client Job No.:
Site Location:
Sample No. BH 101 TW-16 11.4 - 12.0m

Initial Height of Sample (in):	0.7840
Initial Dial Reading:	0.0300

Load No.	Pressure on sample (lb/ft^{2})	Dial Reading at 50% Consolidation	Decrease in Height of Sample (in)	Machine Deflection (in)	Net Decrease in Height of Voids (in)	Height of Sample $2H_{dr}$ (in)	Length of Drainage (in) H_{dr} (in)	Length of Drainage (in) $(H_{dr})^2$ (in)	t_{50} seconds	C_v (in^2/sec)
1	500									
2	1000	0.0361	0.0061	0.0023	0.0038	0.7802	0.3901	0.1522	150	2.0E-04
3	2000	0.0421	0.0121	0.0036	0.0085	0.7755	0.3878	0.1504	276	1.1E-04
4	4000	0.0534	0.0234	0.0050	0.0184	0.7656	0.3828	0.1465	396	7.3E-05
5	8000	0.0694	0.0394	0.0070	0.0324	0.7516	0.3758	0.1412	600	4.6E-05
6	16000	0.0918	0.0618	0.0094	0.0524	0.7316	0.3658	0.1338	660	4.0E-05
7	32000	0.1197	0.0897	0.0118	0.0779	0.7061	0.3531	0.1246	600	4.1E-05
8										
9										
10										
11										
12										
13										
14										
15										

Graph - Cv vs log P



SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

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

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index). A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
Very Soft	<0.25	<12.5
Soft	0.25 - 0.5	12.5 - 25
Firm	0.5 - 1.0	25 - 50
Stiff	1.0 - 2.0	50 – 100
Very Stiff	2.0 - 4.0	100 - 200
Hard	>4.0	>200

ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor*
25-50	*Poor*
50-75	*Fair*
75-90	*Good*
90-100	*Excellent*

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

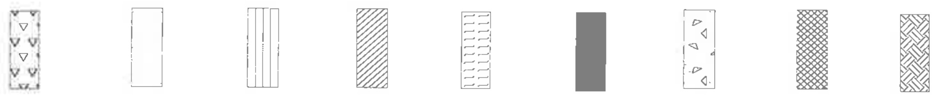
Strength Classification	Unconfined Compressive Strength (MPa)
Extremely Weak	< 1
Very Weak	1 – 5
Weak	5 – 25
Medium Strong	25 – 50
Strong	50 – 100
Very Strong	100 – 250
Extremely Strong	> 250

Terminology describing rock weathering:

Term	Description
Fresh	No visible signs of rock weathering. Slight discolouration along major discontinuities
Slightly Weathered	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
Moderately Weathered	Less than half the rock is decomposed and/or disintegrated into soil.
Highly Weathered	More than half the rock is decomposed and/or disintegrated into soil.
Completely Weathered	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.

STRATA PLOT

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



Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

▼ measured in standpipe, piezometer, or well

▽ inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

Stantec RECORD OF BOREHOLE No BH14-1 — METRIC

W.P. 6919-12-00 LOCATION Highway 602 Locking Creek (Site 45-161/C) N: 5 381 392 E: 245 689 ORIGINATED BY JHJ

DIST ____ HWY 602 BOREHOLE TYPE Hollow-stem Augers, Splitspoon Sampler COMPILED BY KF

DATUM Geodetic DATE 2014 05 21 - 2014 05 21 CHECKED BY SG

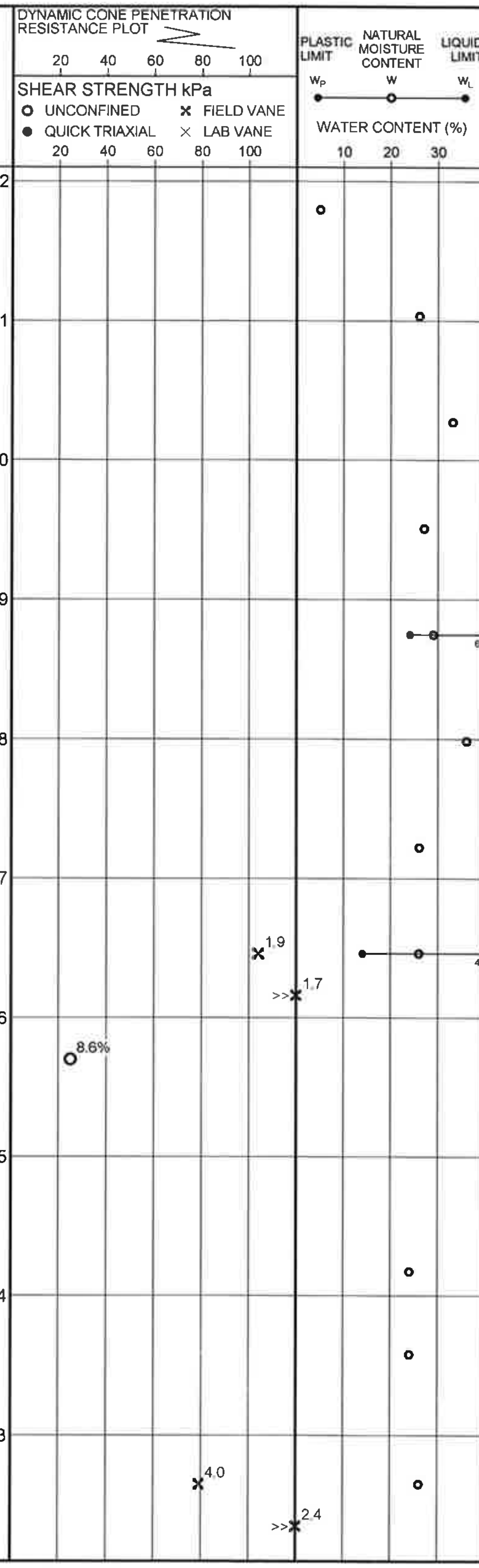
Soil Profile

ELEV / DEPTH	DESCRIPTION
332.1	Asphalt
[illegible]	25 mm Asphalt
	FILL: silty sand with gravel, dark brown to black
330.7 / 1.4	FILL: silty clay, trace wood, roots, sand and gravel, grey
326.8 / 5.3	SILTY CLAY (CI) Stiff to very stiff Grey
	- cobbles encountered at 7.6 m depth
	- trace gravel below 8 m depth

Samples

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)	UNIT WEIGHT γ (kN/m³)
1	BS	-		
2	SS	3	PP=62 kPa	
3	SS	16		
4	SS	11	PP=62 kPa	
5	SS	7	5 16 28 51; PP=100 kPa	
6	SS	7	PP= 62 kPa	
7	SS	10	PP= 62 kPa	
8	SS	7	0 21 44 35; S_u = 167 kPa	
9	ST			
10	SS	7		
11	SS	6	PP=50 kPa	
12	ST			20.1
13	SS	6	S_u = 154 kPa	

GROUND WATER CONDITIONS: ∇ (water level at approx. elev. 326.2)



PP = Pocket penetrometer
S_u = Undrained shear strength

Continued Next Page

✖3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

W.P. 6919-12-00 LOCATION Highway 602 Locking Creek (Site 45-161/C) N: 5 381 392 E: 245 689 ORIGINATED BY JHJ

DIST HWY 602 BOREHOLE TYPE Hollow-stem Augers, Splitspoon Sampler COMPILED BY KF

DATUM Geodetic DATE 2014 05 21 - 2014 05 21 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY (CI) Stiff to very stiff Grey *(continued)*	14	SS	8	322			PP=62 kPa
		15	SS	6	321	>> 4.1		S_u = 146 kPa
						>> 2.1		S_u = 159 kPa
		16	SS	7				1 27 36 36
		17	SS	6	320			
319.3 / 12.8	End of Borehole							

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; UNIT WEIGHT γ kN/m³

×3, ×3 Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH14-2

Stantec METRIC

W.P. 6919-12-00	LOCATION Highway 602 Locking Creek (Site 45-161/C)	N: 5 381 405 E: 246 694	ORIGINATED BY JHJ
DIST ___ HWY 602	BOREHOLE TYPE Hollow-stem Augers, Splitspoon Sampler		COMPILED BY KF
DATUM Geodetic	DATE 2014 05 22 - 2014 05 22		CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.9	Granular Fill					
0.0	FILL: clayey sand and gravel, brown to black - occasional wood pieces	1	BS			
		2	SS	4		
330.5 / 1.4	FILL: silty clay, some sand, trace gravel, grey	3	SS	16		1 18 41 40
		4	SS	8		
		5	SS	7		PP=75 kPa
		6	SS	8		
	- wood encountered at 5.0 m deep	7	SS	18		0 12 35 53
326.6 / 5.3	SILTY CLAY (CI), trace gravel Very stiff Grey	8	SS	5	▽	PP=50 kPa
		9	SS	7		1 35 32 32
		10	SS	7		PP=75 kPa
		11	ST			
		12	SS	5		PP=75 kPa
		13	SS	4		S_u = 134 kPa
						S_u = 123 kPa

Plot annotations: liquid limit values 52 (sample 3), 50 (sample 7), 46 (sample 9); 13.9% strain at failure (sample 11); field vane >>3.2, >>1.7.

Elevation scale: 331, 330, 329, 328, 327, 326, 325, 324, 323, 322

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE — 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

PP = Pocket penetrometer
S_u = Undrained shear strength

Continued Next Page

✖3, ×3: Numbers refer to Sensitivity   O3% STRAIN AT FAILURE

Stantec

RECORD OF BOREHOLE No BH14-2

METRIC

W.P. 6919-12-00 LOCATION Highway 602 Locking Creek (Site 45-161/C) N: 5 381 405 E: 246 694 ORIGINATED BY JHJ

DIST ____ HWY 602 BOREHOLE TYPE Hollow-stem Augers, Splitspoon Sampler COMPILED BY KF

DATUM Geodetic DATE 2014 05 22 - 2014 05 22 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L (WATER CONTENT %)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY (CI), trace gravel Very stiff Grey *(continued)*		14	SS	5				o		PP=62 kPa
			15	SS	-		321	>>× 3.7 >>× 2.8	o		S_u = 147 kPa S_u = 158 kPa
			16	SS	5		320		•—o—• 41		3 25 36 36 PP=62 kPa
			17	SS	7				o		
319.1 / 12.8	Start Dynamic Cone Penetrometer Test						319				
	Inferred SILTY CLAY						318 317 316 315 314				
313.6 / 18.3	End of Borehole										

Legend: UNCONFINED (o); QUICK TRIAXIAL (●); FIELD VANE (×); LAB VANE (×)

×³, ×³ Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH14-3

METRIC

Stantec

W.P. 6919-12-00	LOCATION Highway 602 Locking Creek (Site 45-161/C) N: 5 381 388 E: 245 676
DIST ___ HWY 602	BOREHOLE TYPE Portable Drilling Equipment, Splitspoon Sampler
DATUM Geodetic	DATE 2014 05 26 - 2014 05 26
ORIGINATED BY JHJ	COMPILED BY KF
CHECKED BY SG	

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.9	Peat						
327.8 0.1	PEAT SILTY SAND (SM), with clay, some gravel, trace organics Very loose Dark brown to grey	1	BS	2			
		2	SS	2		327	
		3	SS	3	▽	326	
325.6 2.3	SILTY CLAY (CI), with sand, some gravel and cobbles Firm to very stiff Grey	4	SS	4		325	PP=38 kPa
		5	SS	3			2 28 36 34 PP=50 kPa
	- Shelby tube refusal - Soil strength exceeded capacity of vane (200 kPa) at 4.1 m	6	BS	-		324	
		7	SS	8		323	PP=50 kPa
						322	
		8	SS	8		321	2 25 35 38 PP=75 kPa
	- Soil strength exceeded capacity of vane (200 kPa)	9	SS	8		320	PP=50 kPa
319.7 8.2	End of Borehole						

Water content plot (%): Sample 5 — w_P ≈ 17, w ≈ 22, w_L = 44; Sample 8 — w_P ≈ 16, w ≈ 21, w_L = 42.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O 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 (%) 10 20 30
UNIT WEIGHT γ kN/m³

PP = Pocket penetrometer

✖3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

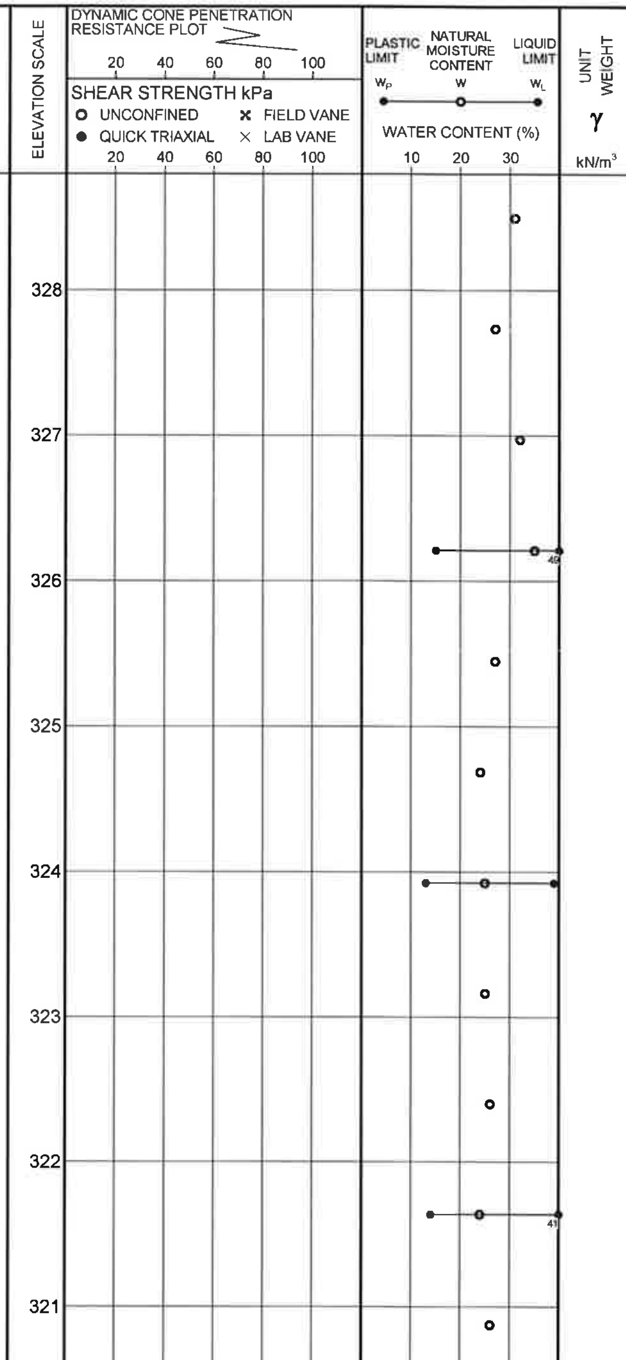
Stantec — **RECORD OF BOREHOLE No BH14-4** — 1 OF 1 — **METRIC**

W.P. 6919-12-00 | LOCATION Highway 602 Locking Creek (Site 45-161/C) N: 5 381 409 E: 245 703 | ORIGINATED BY JHJ

DIST ___ HWY 602 | BOREHOLE TYPE Portable Drilling Equipment, Splitspoon Sampler | COMPILED BY KF

DATUM Geodetic | DATE 2014 05 26 - 2014 05 26 | CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
328.8	Peat					
328.9 / 0.1	PEAT; SILTY CLAY (CI), with sand, trace gravel. Firm. Brown to Grey	1	SS	1		
		2	SS	6		PP=50 kPa
		3	SS	5		PP=50 kPa
		4	SS	2	▽	0 39 28 33
325.7 / 3.1	SILTY CLAY (CI), with sand, trace gravel. Very stiff. Grey	5	SS	2		PP=75 kPa
	- Soil strength exceeded capacity of vane (200 kPa) vane at 4.1 m	6	SS	4		PP=75 kPa
		7	SS	8		1 24 37 38 PP=62 kPa
		8	SS	7		PP=62 kPa
		9	SS	5		PP=38 kPa
		10	SS	8		1 25 36 38 PP=38 kPa
		11	SS	9		
320.6 / 8.2	End of Borehole. Note: 63.6 kg at 762 mm drop					



PP = Pocket penetrometer

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

Appendix E –
Historical Borehole Logs