FINAL REPORT

FOUNDATION INVESTIGATION REPORT

Culvert Replacement, Highway 3, 1.89 km east of Haldimand Road 55, Jarvis

Agreement No. 3015-E-0017
Assignment No. 3
GWP 3062-14-00
Geocres No. 40I16-27

Prepared for:

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exp Services Inc.
January 23, 2017

Ministry of Transportation

Western Region – Geotechnical Section

Foundation Investigation Report

Agreement No. 3015-E-0017
Assignment No. 3
GWP 3062-14-00
Geocres No. 40I16-27

Type of Document:
Final

Project Name:
Foundation Investigation and Design Report for Culvert Replacement
Highway 3, 1.89 km East of Haldimand Road 55
Jarvis, ON

Project Number:
ADM-00235197-C0

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Appendices

PART I: FOUNDATION INVESTIGATION REPORT

1.1. Introduction

This foundation investigation report presents the results of a geotechnical investigation completed by **exp** Services Inc. (**exp**) for the replacement of an existing concrete culvert located on Highway 3 at Station 15+843, approximately 1.89 km east of Haldimand Road 55 in Jarvis, part of the Ministry of Transportation (MTO) West Region. The work was undertaken under Agreement No. 3015-E-0017, Assignment No. 3. The terms of reference (TOR) were as presented in the MTO document entitled "Foundation Engineering Terms of Reference, MTO West Region – Foundations Retainer Assignment, Assignment 3 – Culvert Replacement Hwy 3 Jarvis and Hwy 6 Dundalk" provided via e-mail on October 13, 2016.

The purpose of the investigation is to determine the subsurface conditions along the culvert alignment and to permit detailed design for the culvert replacement including temporary protection systems for culvert replacement. The site specific geotechnical investigation consisted of borings, soil and bedrock sampling, borehole logging, and field and laboratory testing.

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 culvert replacement site is located on Highway 3 at Station 15+843, approximately 1.89 km east of Haldimand Road 55 in Jarvis, Ontario. At this site, Highway 3 is a two-lane asphalt roadway and is about 8.5 m wide from edge to edge of asphalt, with narrow sand and gravel shoulders. Based on the observations at the site, the roadway embankment is less than approximately 1.8 m high with side slope not exceeding 5H:1V.

The existing culvert is an arch concrete rigid framed structure and is assumed to have an open footing foundation, but inspection was not possible due to the presence of water. It is assessed that the culvert has a span of approximately 2.8 m and rise of 1.5 m. The culvert is approximately 18.4 m long. The existing culvert is intended to be replaced with a new culvert along the same alignment. Select photographs of the site and existing culvert are presented in Appendix A. The site plan and cross-section profiles for the culvert alignment are shown on Drawings 1 and 2 in Appendix B.

The area surrounding the culvert site generally consists of flat lying fields, but a small wooded area exists to the south (outlet side) of the culvert. A mix of shrubs and long grasses were observed on the stream bank at both inlet and outlet sides, and in the path of the stream on the inlet side. However, no visible sign of flow restriction was observed due to the vegetation.

Highway 3 runs in an east-west direction and the water in culvert flows from north to south beneath the highway. At the time of investigation, the elevation of the water in the culvert was approximately 204.9 m. The elevation of highway centerline at the culvert centerline is approximately 206.4 m. Cable guide

rails are present on both sides of the highway and overhead wires are present along the north side of the roadway.

The general site conditions in the immediate vicinity of the culvert were assessed during the site reconnaissance and drilling operations on November 1, 2016 and November 8-9, 2016, respectively. The embankments were noted to be in an overall stable configuration with no obvious indications of recent slope movement. Longitudinal cracking, some transverse cracking, and wheel rutting were observed on both lanes at the site. Due to the water in the culvert, existing foundation observation was restricted. However, based on visual observation, the culvert appeared to be in satisfactory condition with no significant damage.

1.2.2. Geological Setting

The Map P.2715 (Physiography of Southern Ontario, Third Edition,1984) Bedrock Geology of Ontario, Southern Sheet, 1991) of the Ministry of Natural Resources indicates that the project area is located in a Clay Plain. The Map 2556 (Quaternary Geology of Ontario, Southern Sheet, 1991) of the Ministry of Northern Development and Mines, indicates that the surface conditions consist of glaciolaustrine deposits including silt and clay, minor sand; basin and quiet water deposits. The Map 2544 (Bedrock Geology of Ontario, Southern Sheet, 1991) of the Ministry of Northern Development and Mines, indicates that the bedrock formation in the project area consists of limestone, dolostone and shale of the Middle Devonian period.

1.3. Investigation Procedures

1.3.1. Site Investigation and Field Testing

The field investigation was performed on November 8 and 9, 2016. The field program consisted of drilling five (5) sampled boreholes, numbered BH-1 to BH-5. Three (3) boreholes were strategically located along the existing culvert alignment to provide subsurface information for the design of the proposed new culvert. Boreholes BH-1 and BH-2 were advanced at accessible locations near the inlet and outlet of the culvert, respectively. Borehole BH-4 was advanced within the travelled eastbound lane and located about 5 m west of the culvert centerline. Two (2) additional boreholes were strategically located on the embankment to provide subsurface information for the temporary roadway protection. Boreholes BH-3 and BH-5 were advanced in the eastbound travelled lane approximately 25 m west and east side of the existing culvert, respectively. The borehole locations are shown on Drawing 1 in Appendix B.

The boreholes were advanced using a rubber track mounted Mobile B57 mechanical drill rig equipped with hollow stem augers and standard soil sampling equipment, operated by a specialist drilling contractor, Landshark Drilling. The boreholes were advanced to auger refusal on the bedrock surface at depths ranging from 4.8 to 5.8 m below the ground surface. Samples of the bedrock were retrieved at Boreholes BH-3 and BH-5 using HQ coring equipment.

The borehole locations (referenced to the MTM NAD83 coordinate system) and their ground surface elevations were surveyed by **exp** personnel using a Vertical Control Point (VCP301) located approximately 50 m west of the culvert and immediately north of the Highway 3 westbound lane shoulder (258182.258 E, 4750230.749 N). The VCP was used as a temporary benchmark (TBM) and has elevation 205.707 m as was provided on the MTO document entitled “Horizontal and Vertical

Control", Highway 3 C/L Alignment – Walpole TWP, Contract No. 3014-E-0030-26, dated October 1, 2016. The TBM location is shown on Drawing 1 in Appendix B.

For the drilling program, 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) at intervals ranging from 0.75 m to 1.5 m in depth as shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (CFEM, pg. 40) and used to provide an assessment of in-situ consistency or relative density of non-cohesive soils. Field vane testing was conducted in cohesive soils to measure the *in-situ* undrained shear strength of those soils. Field vane tests were conducted in accordance with ASTM D2573-08. Two (2) shelby tube samples were obtained below the culvert invert level.

Upon completion of the boreholes, ground water level measurements were carried out in boreholes in accordance with MTO guidelines. The measured ground water levels after completion of drilling boreholes were recorded on the borehole log sheets in Appendix C. The boreholes were decommissioned by bentonite/cement mixtures in 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 an **exp** geotechnical representative who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM Standards for Soils Classification, and retrieved soil and bedrock samples. The recovered soil samples were placed in labelled moisture-proof bags; bedrock samples were placed in core boxes, and all samples were returned to **exp**'s Hamilton laboratory for additional visual, textual, olfactory examination and selective testing.

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 of all samples and particle size distribution for approximately 25% of the collected soil samples. Atterberg Limits tests were carried out on select cohesive soil samples. One soil sample was selected for corrosivity chemical analyses and was tested at AGAT Laboratories, a CALA-certified and accredited laboratory in Mississauga, Ontario. All of the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses and Atterberg Limits testing are presented graphically in Appendix D. The results of chemical analyses are also included in Appendix D.

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. 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.

A borehole location plan and stratigraphic section are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and stratigraphic section 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 granular fill overlying silty clay fill followed by the native soils, which typically consisted of silty clay, clay, and sandy clayey silt till to silty clay till. A more detailed summary of the subsurface conditions encountered in the boreholes is provided in the following sections.

1.4.1. Asphalt

Asphalt was encountered at the surface of boreholes advanced on the highway, i.e. Boreholes BH-3 to BH-5, and ranged in thickness from approximately 175 to 280 mm. Asphalt thicknesses may further vary beyond the borehole locations.

1.4.2. Topsoil

Topsoil was encountered at the surface of Boreholes BH-1 and BH-2, and ranged in thickness from approximately 50 to 100 mm. Topsoil thicknesses may further vary beyond the borehole locations.

1.4.3. Granular Fill

Granular fill was encountered below the asphalt at Boreholes BH-3 to BH-5. The granular fill layer ranged in thickness from approximately 250 to 1065 mm. The granular fill was composed of sand and crushed gravel with trace silt and was noted to contain trace amounts of coal and had a hydrocarbon odour. The SPT “N” values within this layer ranged from 9 to greater than 100 blows per 305 mm penetration, suggesting loose to very dense compactness condition.

1.4.4. Fill: Silty Clay

Silty clay fill material was encountered at all borehole locations underlying the topsoil or granular fill and extended to depths ranging from 0.9 to 2.3 m below the ground surface and elevations ranging from 204.0 to 205.0 m. The silty clay fill contained trace to some sand, trace gravel, was brown in colour, and in a moist state. The SPT “N” values ranged from 3 to 12 blows per 305 mm penetration, suggesting soft to stiff consistency. Laboratory testing consisting of seven (7) moisture content determinations, two (2) grain size analyses, and two (2) Atterberg Limits tests were carried out with the results summarized below:

Moisture Content:

- 25% to 39%

Grain Size Analysis:

- 1% to 2% gravel
- 3% to 13% sand
- 47% to 55% silt

Atterberg Limits:

- 37% to 41% liquid limit
- 17% to 20% plastic limit
- 20% to 21% plasticity index

- 31% to 48% clay

The results of the moisture content, gain size distribution and Atterberg Limits tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests and Atterberg Limits tests are also provided on Figures 3 and 7 in Appendix D.

1.4.5. Fill: Gravelly Sand with Some Silt and Clay

Gravelly sand with some silt and clay fill material was encountered at Borehole BH-4 underlying the silty clay fill at a depth of 2.3 m below the ground surface and extended to the native clay at a depth of 3.1 m below the ground surface (elevation 203.4 to 204.1 m). The gravelly sand fill contained some silt, some clay, was grey in colour and in a moist state. A single SPT "N" value of 5 blows per 305 mm penetration was obtained within the gravelly sand fill layer, suggesting loose compactness condition. Laboratory testing consisting of one (1) moisture content determination, one (1) grain size analysis, and one (1) Atterberg Limits test were carried out with the results summarized below (i.e. Atterberg Limits tests were carried out on the silty clay portion of the sample):

Moisture Content:

- 16%

Grain Size Analysis:

- 26% gravel
- 41% sand
- 20% silt
- 13% clay

Atterberg Limits:

- 48% liquid limit
- 29% plastic limit
- 19% plasticity index

The results of the moisture content, gain size distribution and Atterberg Limits tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests and Atterberg Limits tests are also provided on Figures 4 and 8 in Appendix D.

1.4.6. Silty Clay

Native silty clay was encountered below the silty clay fill at Boreholes BH-1, BH-2, and BH-5 at depths ranging from 0.9 to 1.5 m (elevations 204.3 to 205.0 m) and extended to the underlying clay stratum at 1.5 to 3.2 m below the ground surface. The silty clay was varved, contained trace sand, was brown in colour, and in a moist state. The SPT "N" values ranged from 7 to 12 blows per 305 mm penetration and undrained shear strengths obtained from in-situ shear vane tests ranged from 91 to 95 kPa, classifying the silty clay as firm to stiff in consistency. Laboratory testing consisting of four (4) moisture content determinations, one (1) grain size analysis, and one (1) Atterberg Limits test were carried out with the results summarized below:

Moisture Content:

- 22% to 28%

Grain Size Analysis:

- 0% gravel
- 1% sand

Atterberg Limits:

- 33% liquid limit
- 21% plastic limit
- 12% plasticity index

- 56% silt
- 43% clay

The results of the moisture content, gain size distribution and Atterberg Limits tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests and Atterberg Limits tests are also provided on Figures 1 and 5 in Appendix D.

1.4.7. **Clay**

Native clay was encountered at all borehole locations underlying the silty clay fill or native silty clay at depths ranging from 1.5 to 3.2 m below the ground surface (elevations 202.3 to 204.2 m) and extended to the sandy silty clay till or silty clay till at depths ranging from 3.4 to 4.6 m below the ground surface. The clay was silty, brown in colour, and in a moist state. The SPT "N" values ranged from 3 to 16 blows per 305 mm penetration and undrained shear strengths obtained from in-situ shear vane tests ranged from 43 to 107 kPa, classifying the clay as firm to very stiff in consistency. Laboratory testing consisting of eight (8) moisture content determinations, two (2) grain size analyses, and two (2) Atterberg Limits tests were carried out with the results summarized below:

Moisture Content:

- 27% to 36%

Grain Size Analysis:

- 0% gravel
- 0% to 1% sand
- 24% to 26% silt
- 73% to 76% clay

Atterberg Limits:

- 64% liquid limit
- 27% plastic limit
- 37% plasticity index

The results of the moisture content, gain size distribution and Atterberg Limits tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests and Atterberg Limits tests are also provided on Figures 1 and 5 in Appendix D.

1.4.8. **Sandy Clayey Silt Till / Silty Clay Till**

Native sandy clayey silt till or silty clay till was encountered at all borehole locations underlying the clay at depths ranging from 3.4 to 4.6 m below the ground surface (elevations 201.3 to 202.5 m) and extended to the bedrock surface at depths ranging from 4.8 to 5.8 m below the ground surface. The till contained trace gravel, was brown in colour, and in a moist state. The SPT "N" values ranged from 4 to 10 blows per 305 mm penetration, classifying the till as firm to stiff in consistency. Laboratory testing consisting of eight (8) moisture content determinations, two (3) grain size analyses, and two (3) Atterberg Limits tests were carried out with the results summarized below:

Moisture Content:

- 7% to 24%

Grain Size Analysis:

- 5% to 8% gravel

Atterberg Limits:

- 21% to 42% liquid limit
- 13% to 20% plastic limit
- 8% to 22% plasticity index

- 13% to 30% sand
- 35% to 44% silt
- 20% to 46% clay

The results of the moisture content, gain size distribution and Atterberg Limits tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests and Atterberg Limits tests are also provided on Figures 2 and 6 in Appendix D.

1.4.9. Limestone Bedrock

Bedrock or auger refusal on assumed bedrock was encountered at all borehole locations at depths ranging from 4.8 to 5.8 m below the ground surface (Elev. 200.0 to 201.3 m). The bedrock was confirmed by retrieving 0.3 to 3.2 m long HQ rock cores from Boreholes BH-5 and BH-3, respectively. The bedrock surface depth and elevation encountered at the drilled borehole locations are listed in Table 1.1 below. Photographs of the rock cores are included in Appendix E.

Table 1.1 Depth and elevation of bedrock surface

Borehole	Depth Below Ground Surface (m)	Elevation (m)	Comments
BH-1	5.5	200.0	Auger refusal on assumed bedrock surface
BH-2	4.8	200.4	Auger refusal on assumed bedrock surface
BH-3	5.8	200.5	Bedrock cored for depth of 3.2 m
BH-4	5.6	200.8	Auger refusal on assumed bedrock surface
BH-5	5.2	201.3	Bedrock cored for depth of 0.3 m

Based on the rock cores recovered, the bedrock consists of limestone. In general, the rock samples are described as light grey in colour, with narrow to wide joint spacing. The joints are flat to vertical in orientation and the joint surfaces are rough undulating to rough planar. The Rock Quality Designation (RQD) measured on the rock core samples ranged from approximately 0% to 77%, indicating a rock mass of very poor to good quality, but based on the limited sampling, was typically of fair to good quality.

1.5. Groundwater & Surface Water Conditions

Groundwater conditions were monitored in the open boreholes during and upon completion of the drilling operations. Groundwater was encountered at Boreholes BH-1, BH-2, and BH-4 at depths ranging from 4.1 to 5.5 m below grade upon completion of the drilling operations. Boreholes BH-3 and BH-5 remained dry prior to advancing the rock coring equipment. Since the soil encountered at the site is low permeable (i.e. silty clay/clay) the groundwater levels are not considered to have stabilized during the short term of the investigation.

At the time of investigation surficial flow of creek water through the culvert was observed to be at approximately Elev. 204.9 m.

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.

1.6. Chemical Analyses

One soil sample was selected for chemical analyses and was sent via courier, in a secure cooler under chain of custody, to AGAT Laboratories, a CALA-certified and accredited laboratory in Mississauga, Ontario. The analytical laboratory results are presented in Appendix D, and are summarized in Table 1.2 below.

Table 1.2. Corrosivity chemical analysis

Sample Identification	pH (unitless)	Soluble Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (mS/cm)	Redox Potential (mV)
BH-1 SS3 Native Silty Clay	8.31	255	51	1,770	0.565	264

PART II: 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 and Design Report has been prepared by Jeffrey Golder, P.Eng., Nimesh Tamrakar, M.Eng., EIT. and Silvana Micic, Ph.D., P.Eng. It was reviewed by TaeChul Kim, P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Aziz Abdelmessih.

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PART III: LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of **exp** may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by exp. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and exp's recommendations. Any reduction in the level of services recommended will result in exp providing qualified opinions regarding the adequacy of the work. exp can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to exp to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to exp by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. exp has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or

inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to exp.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to exp by its client ("Client"), communications between exp and the Client, other reports, proposals or documents prepared by exp for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. exp is not responsible for use by any party of portions of the Report.

USE OF REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of exp. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. exp is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

REPORT FORMAT

Where exp has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by exp have utilize specific software and hardware systems. exp makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are exp's instruments of professional service and shall not be altered without the written consent of exp.

Appendix A –
Site Photographs

Photo 1: Looking south from centreline of culvert on eastbound lane shoulder

Photo 2: Looking north at culvert from south of Highway 3

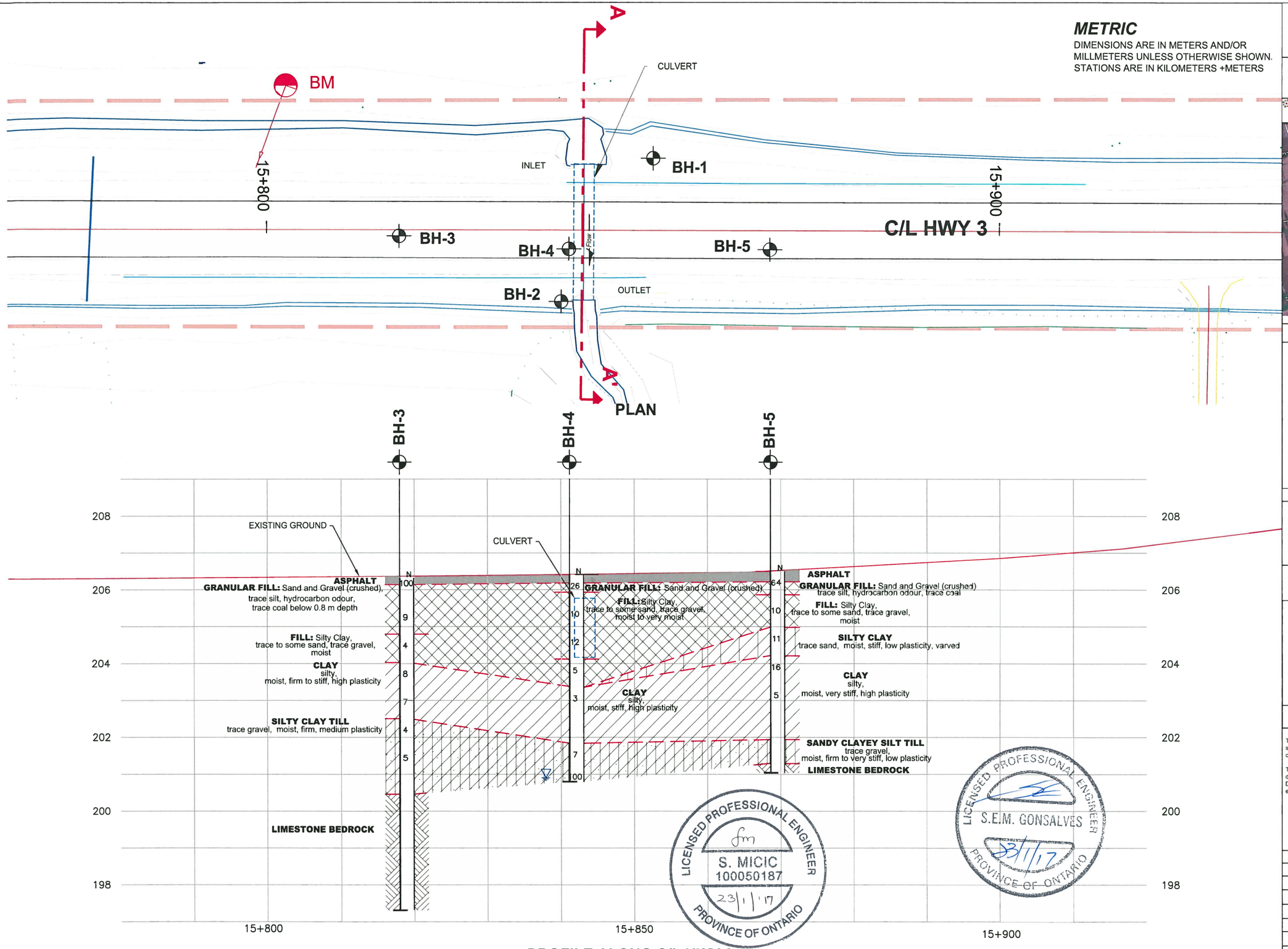
Photo 3: Looking east toward culvert

Photo 4: Looking south at culvert location from shoulder of westbound lane

Photo 5: Looking south at culvert from north of Highway 3

Photo 6: Looking west toward culvert

Appendix B – Drawings



PROFILE ALONG C/L HWY 3

METRIC

DIMENSIONS ARE IN METERS AND/OR MILLMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS

Agreement No. 3015-E-0017
Assignment No. 3
GWP - 3062-14-00

CULVERT REPLACEMENT
HWY 3, JARVIS
BOREHOLE LOCATION PLAN AND PROFILE

SHEET

exp Services Inc.

LEGEND

- Location of Drilled Boreholes
- N — Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Bench Mark (EL. 205.707m)

SOIL STRATA SYMBOLS

ASPHALT · CLAY · LIMESTONE BEDROCK · TOPSOIL · SILTY CLAY · FILL · SANDY SILTY CLAY TILL

BH No.	APPROX. ELEV.	MTM CO-ORDINATES NORTH	EAST
BH-1	205.5	4750241.5	258235.4
BH-2	205.2	4750220.2	258226.4
BH-3	206.3	4750225.0	258203.1
BH-4	206.4	4750227.4	258226.1
BH-5	206.5	4750232.1	258253.2

NOTE

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

HOR 0 5 15 m
VERT 0 2

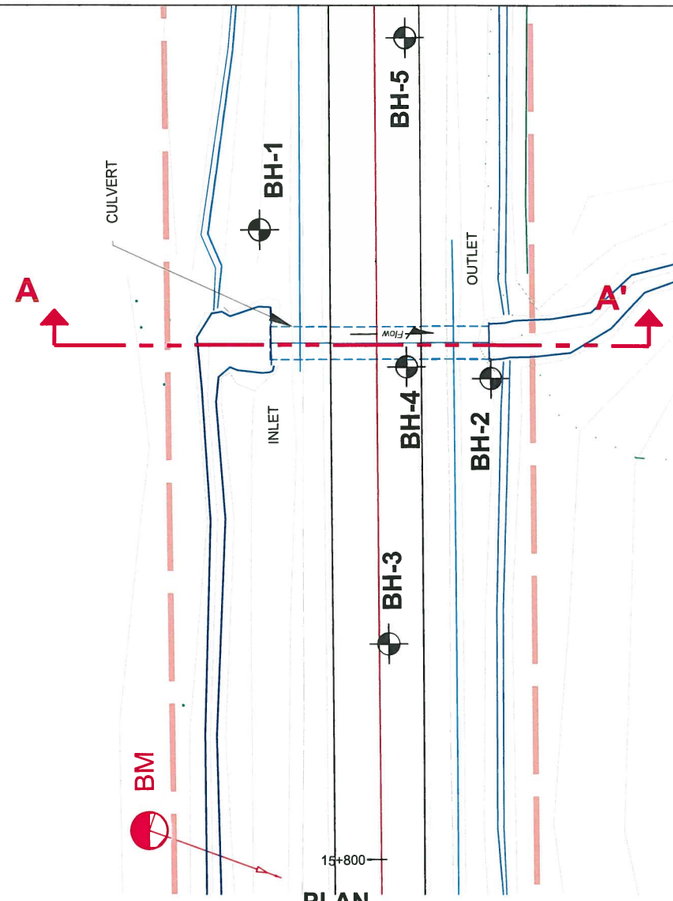
LICENSED PROFESSIONAL ENGINEER S. MICIC 100050187 23/1/17 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S.E.M. GONSALVES 23/1/17 PROVINCE OF ONTARIO

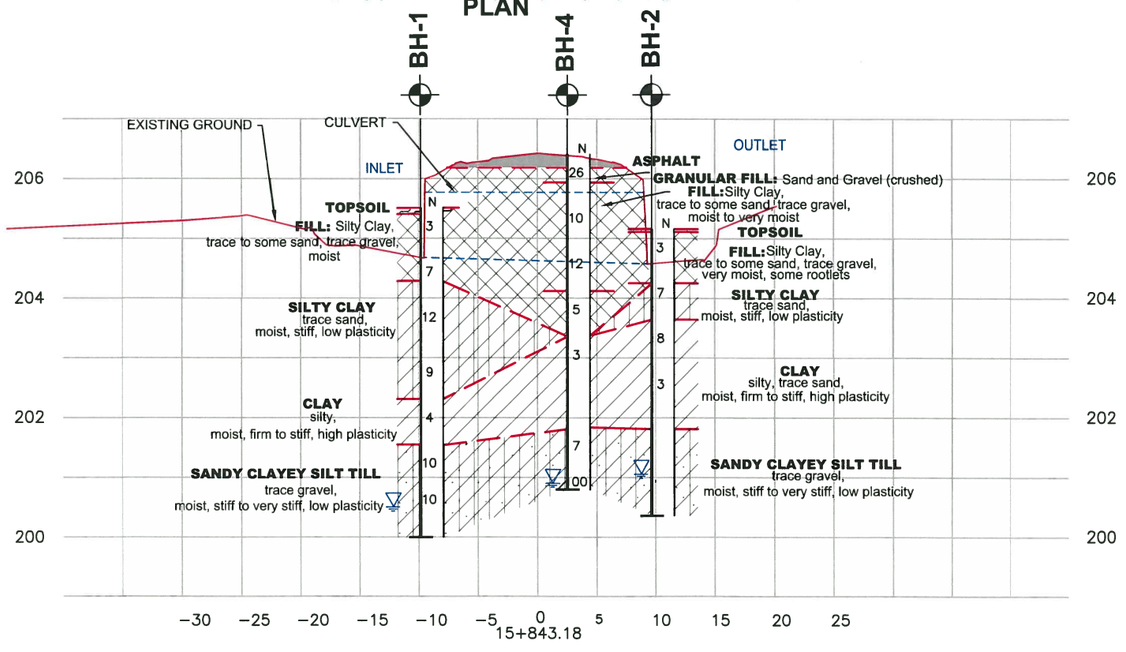
DATE	BY	DESCRIPTION
18/01/2017	SM	SUBMISSION FOR MTO REVIEW
		GEOCRES NO.. 40I16-27
		PROJECT NO. ADM-00235197-C0

SUBM'D SM	CHECKED SM	DATE	18/01/2017
DRAWN SH	CHECKED SG	APPROVED SG	DWG. 1

CON 8
LOT 10



PLAN



SECTION A-A' ALONG C/L CULVERT STA. 15+843.18

METRIC

DIMENSIONS ARE IN METERS AND/OR MILLMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS

Agreement No. 3015-E-0017
Assignment No. 3
GWP - 3062-14-00

**CULVERT REPLACEMENT
HWY 3, JARVIS
BOREHOLE LOCATION PLAN
AND SECTION A-A'**

SHEET

exp Services Inc.

LEGEND

- Location of Drilled Boreholes
- N — Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Bench Mark (EL. 205.707m)

SOIL STRATA SYMBOLS

ASPHALT, TOPSOIL, FILL, CLAY, SILTY CLAY, SANDY SILTY CLAY TILL, LIMESTONE BEDROCK

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-1	205.5	4750241.5	258235.4
BH-2	205.2	4750220.2	258226.4
BH-3	206.3	4750225.0	258203.1
BH-4	206.4	4750227.4	258226.1
BH-5	206.5	4750232.1	258253.2

NOTE

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

HOR 0 5 15 m
VERT 0 2

LICENSED PROFESSIONAL ENGINEER
S. MICIC
100050187
23/1/17
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
23/1/17
PROVINCE OF ONTARIO

DATE	BY	DESCRIPTION
18/01/2017	SM	SUBMISSION FOR MTO REVIEW
		GEOCRES NO.. 40I16-27
		PROJECT NO. ADM-00235197-C0

SUBM'D SM	CHECKED SM	DATE	18/01/2017
DRAWN SH	CHECKED SG	APPROVED SG	DWG. 2

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 generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. 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:

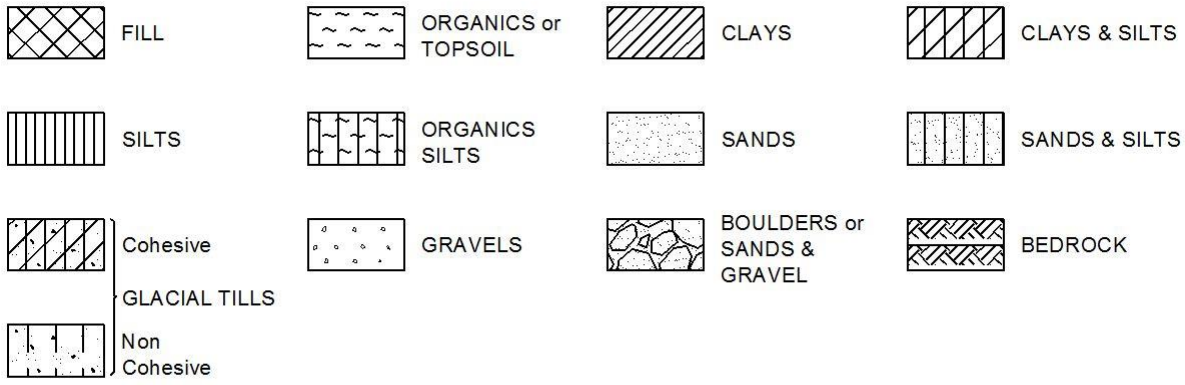
Table c: Consistency of Cohesive Soil

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

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

RECORD OF BOREHOLE No BH-1

1 OF 1

METRIC

W. P. 3062-14-00 LOCATION Jarvis, ON, 258235.4 E, 4750241.5 N (MTM 10) ORIGINATED BY AA

DIST Haldimand HWY 3 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY JG

DATUM Geodetic DATE 2016/11/09 - 2016/11/09 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH: Cu, KPa (○ UNCONFINED, × QUICK TRIAXIAL, + FIELD VANE, LAB VANE)	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
205.5	Ground Surface										
205.4	**TOPSOIL:** (~100 mm thick)										
0.1	**FILL:** silty clay, trace to some sand, trace gravel, brown, moist		1	SS	3		205				
204.3			2	SS	7						
1.2	**SILTY CLAY:** trace sand, brown, moist, stiff, low plasticity, varved		3	SS	12		204				
			4	SS	9		203	+2.7			0 1 56 43
202.3								+4.6	64		0 0 24 76
3.2	**CLAY:** silty, brown, moist, firm to very stiff, high plasticity		5	SS	4		202	+4.5			
201.6											
4.0	**SANDY CLAYEY SILT TILL:** trace gravel, brown, moist, stiff , low plasticity		6	SS	10						5 30 44 21
	grey, increasingly sandy and gravelly below 4.6 m depth		7	SS	10	▽	201				
200.0							200				
5.5	**Borehole terminated at 5.5 m depth due to auger refusal on assumed bedrock.**										

Notes:
1. This borehole log is to be read with the subject report and project numbers as presented above.
2. Groundwater level at 5.0 m depth upon completion of drilling.

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

EXP RECORD OF BOREHOLE BHLOGS MTO HWY 3.GPJ ONTARIO MOT.GDT 1/18/17

RECORD OF BOREHOLE No BH-2

1 OF 1

METRIC

W. P. 3062-14-00 LOCATION Jarvis, ON, 258226.4 E, 4750220.2 N (MTM 10) ORIGINATED BY AA

DIST Haldimand HWY 3 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY JG

DATUM Geodetic DATE 2016/11/09 - 2016/11/09 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: Cu, KPa (○ 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.2	Ground Surface										
205.1 / 0.1	**TOPSOIL:** (~50 mm thick)										
	FILL: silty clay, trace to some sand, trace gravel, dark brown, very moist, some rootlets		1	SS	3		205				
204.3											
0.9	**SILTY CLAY:** trace sand, brown, moist, firm, low plasticity, varved		2	SS	7		204				
203.6											
1.5	**CLAY:** silty, trace sand, brown, moist, firm to stiff, high plasticity		3	SS	8						0 1 26 73
			4	SS	3		203				
201.8											
3.4	**SANDY CLAYEY SILT TILL:** trace gravel, brown, moist, stiff to very stiff, low plasticity		5	TW		▽	202	+3.7			
							201				
200.4											
4.8	**Borehole terminated at 4.8 m depth due to auger refusal on assumed bedrock.**										

Notes:
1. This borehole log is to be read with the subject report and project numbers as presented above.
2. Groundwater level at 4.1 m depth upon completion of drilling.

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

EXP RECORD OF BOREHOLE BHLOGS MTO HWY 3.GPJ ONTARIO MOT.GDT 1/18/17

RECORD OF BOREHOLE No BH-3

1 OF 1

METRIC

W. P. 3062-14-00 | LOCATION Jarvis, ON, 258203.1 E, 4750225.0 N (MTM 10) | ORIGINATED BY AA

DIST Haldimand HWY 3 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers/ HQ Coring | COMPILED BY JG

DATUM Geodetic | DATE 2016/11/08 - 2016/11/08 | CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: Cu, 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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
206.3	Road Surface										
206.1	**ASPHALT:** (~175 mm thick)		1	SS	100		206				
0.2	**GRANULAR FILL:** sand and gravel (crushed), trace silt (~1065 mm thick)										
	hydrocarbon odour, trace coal below 0.8 m depth		2	SS	9		205				
204.8											
1.5	**FILL:** silty clay, trace to some sand, trace gravel, brown, moist		3	SS	4						1 13 55 31
204.0							204				
2.3	**CLAY:** silty, brown, moist, firm to stiff, high plasticity		4	SS	8						
			5	SS	7		203				
202.5											6 13 35 46
3.8	**SILTY CLAY TILL:** trace gravel, brown, moist, firm, medium plasticity		6	SS	4						
			7	SS	5		202				
200.5							201				
5.8	**LIMESTONE BEDROCK:** light grey, bedding joints with flat orientation, joint spacing is narrow to wide (2 to 32 cm), joint surfaces are rough undulating to rough planar RUN 1 (5.84-6.25 m): recovery 100%, RQD 70% (fair) RUN 2 (6.25-7.77 m): recovery 100%, RQD 68% (fair) RUN 3 (7.77-8.99 m): recovery 100%, RQD 77% (good)		8	HQ							
			9	HQ			200				
			10	HQ			199				
197.3							198				
9.0	**Borehole terminated at 9.0 m depth in bedrock.** Notes: 1. This borehole log is to be read with the subject report and project numbers as presented above. 2. Borehole remained dry upon completion of auger drilling.										

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

EXP RECORD OF BOREHOLE BHLOGS MTO HWY 3.GPJ ONTARIO MOT.GDT 1/18/17

RECORD OF BOREHOLE No BH-4

1 OF 1 **METRIC**

W. P. 3062-14-00 LOCATION Jarvis, ON, 258226.1 E, 4750227.4 N (MTM 10) ORIGINATED BY AA

DIST Haldimand HWY 3 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY JG

DATUM Geodetic DATE 2016/11/08 - 2016/11/08 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: Cu, 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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
206.4	Road Surface										
206.2	**ASPHALT:** (~225 mm thick)										
0.2 / 205.9	**GRANULAR FILL:** sand and gravel (crushed), trace silt, hydrocarbon odour, trace coal (~250 mm thick)		1	SS	26		206				
0.5	**FILL:** silty clay, trace to some sand, trace gravel, grey, moist to very moist		2	SS	10						
			3	SS	12		205		48		
204.1											
2.3	**FILL: GRAVELLY SAND with some silt and some clay** grey, moist, hydrocarbon odour mixed with silty clay below 2.6 m depth		4	SS	5		204				26 41 20 13
203.3											
3.1	**CLAY:** silty, brown, moist, stiff, high plasticity		5	SS	3		203	+2.4			
201.8											
4.6	**SANDY CLAYEY SILT TILL:** trace gravel, brown, moist, firm, low plasticity		6	SS	7		202				
			7	SS	100	▽	201				8 30 42 20
200.8											
5.6	**Borehole terminated at 5.6 m depth due to auger refusal on assumed bedrock.**										

Notes:
1. This borehole log is to be read with the subject report and project numbers as presented above.
2. Groundwater level at 5.5 m depth upon completion of drilling.

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

RECORD OF BOREHOLE No BH-5

1 OF 1 **METRIC**

W. P. 3062-14-00 LOCATION Jarvis, ON, 258253.2 E, 4750232.1 N (MTM 10) ORIGINATED BY AA

DIST Haldimand HWY 3 BOREHOLE TYPE Continuous Flight Hollow Stem Augers/ HQ Coring COMPILED BY JG

DATUM Geodetic DATE 2016/11/08 - 2016/11/08 CHECKED BY SM

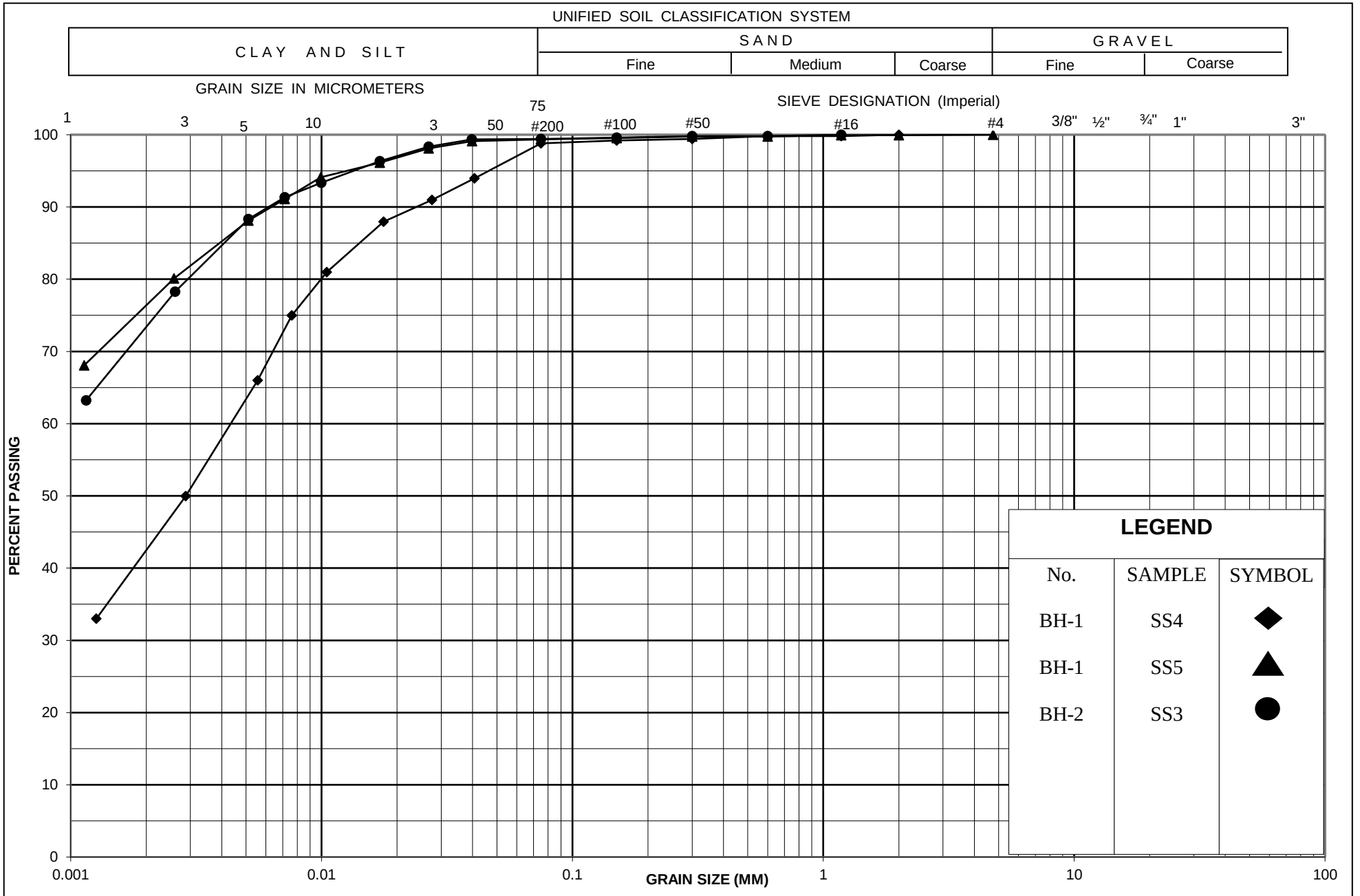
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH: Cu, KPa (○ UNCONFINED, × QUICK TRIAXIAL, + FIELD VANE, LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
206.5	Road Surface										
206.2	**ASPHALT:** (~280 mm thick)										
0.3 / 205.9	**GRANULAR FILL:** sand and gravel (crushed), trace silt, hydrocarbon odour, trace coal (~355 mm thick)		1	SS	64						
0.6	**FILL:** silty clay, trace to some sand, trace gravel, grey, moist		2	SS	10						2 3 47 48
205.0											
1.5 / 204.2	**SILTY CLAY:** trace sand, brown, moist, stiff, low plasticity, varved		3	SS	11						
2.3	**CLAY:** silty, brown, moist, very stiff, high plasticity		4	SS	16						
			5	SS	5						
201.9								+2.9			
4.6 / 201.3	**SANDY CLAYEY SILT TILL:** trace gravel, brown, moist, firm to very stiff, low plasticity		6	TW							
5.2 / 201.0	**LIMESTONE BEDROCK:** light grey, bedding joints with flat and near vertical orientation, joint spacing is narrow to moderately wide (1 to 9 cm), joint surfaces are rough undulating to rough planar		7	HQ							
5.5	RUN 1 (5.2-5.48 m): recovery 100%, RQD 0% (very poor) **Borehole terminated at 5.5 m depth in bedrock.**										

Notes:
1. This borehole log is to be read with the subject report and project numbers as presented above.
2. Borehole remained dry upon completion of auger drilling.

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

EXP RECORD OF BOREHOLE BHLOGS MTO HWY 3.GPJ ONTARIO MOT.GDT 1/18/17

Appendix D – Laboratory Data



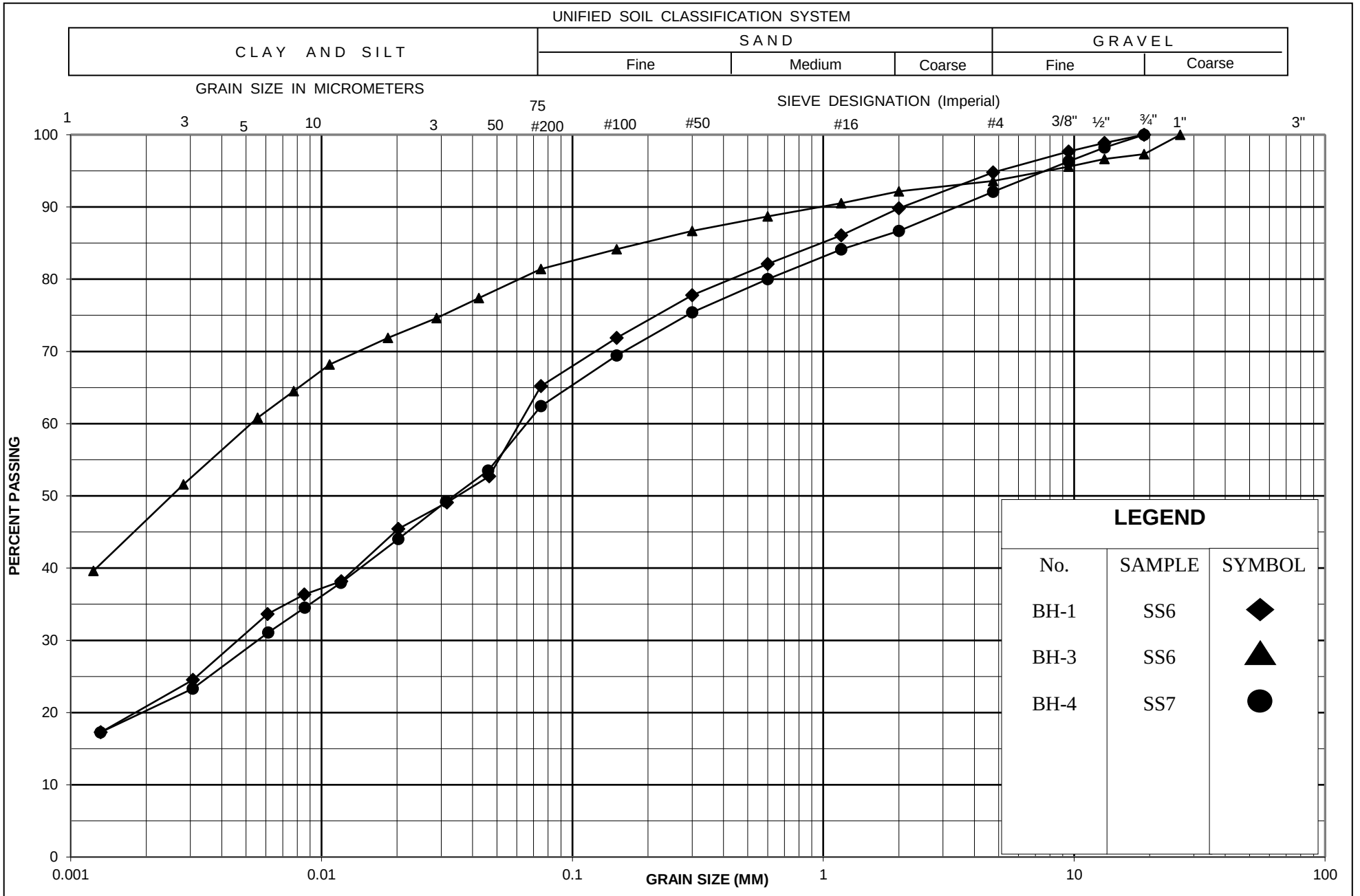
GRAIN SIZE DISTRIBUTION

CLAY (CH), SILTY CLAY (CL)

FIGURE NO.: 1

PROJECT: ADM-00235197-C0

DATE: NOVEMBER 2016



GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL (CI), SANDY CLAYEY SILT TILL (CL)

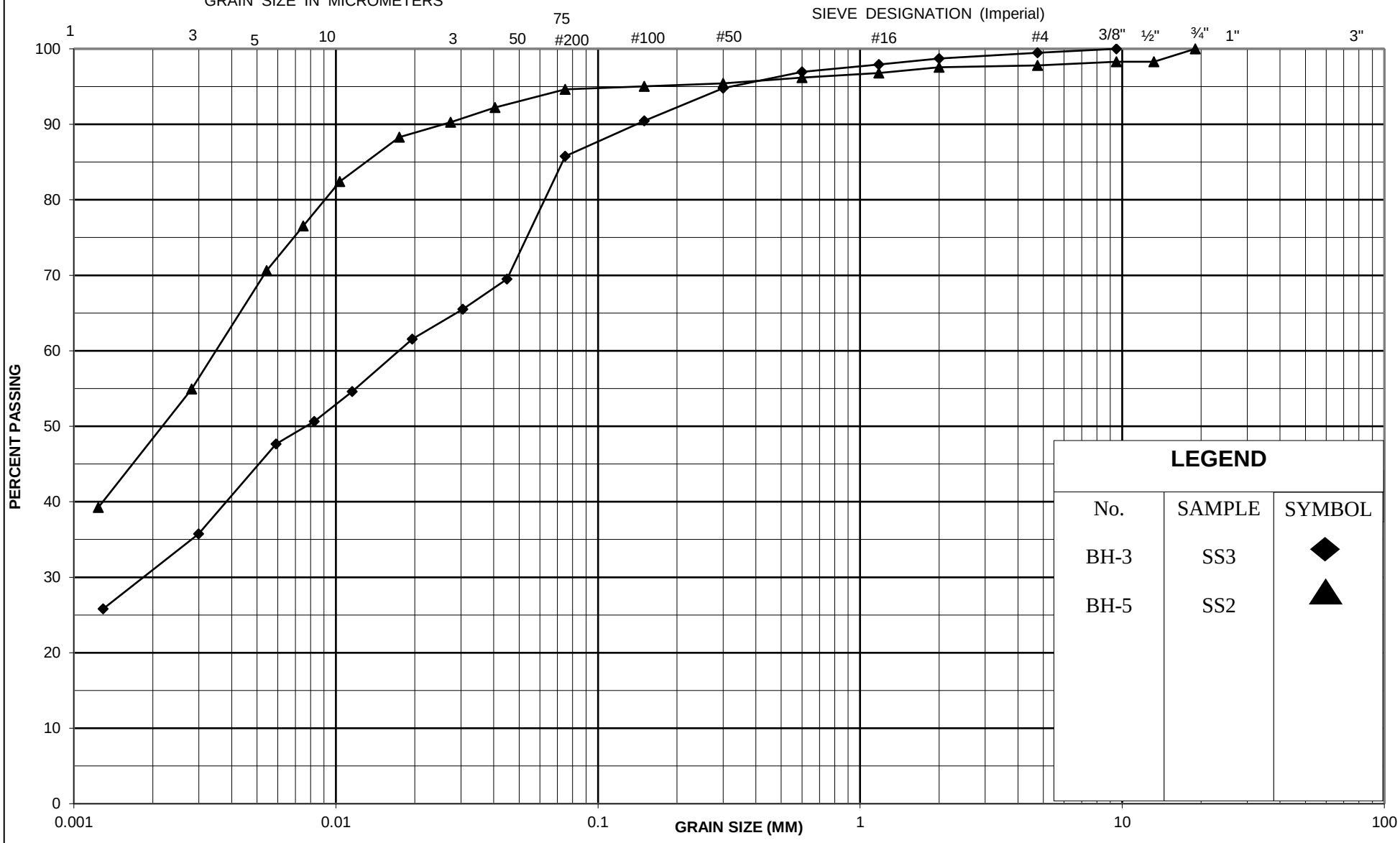
FIGURE NO.: 2

PROJECT: ADM-00235197-C0

DATE: NOVEMBER 2016

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



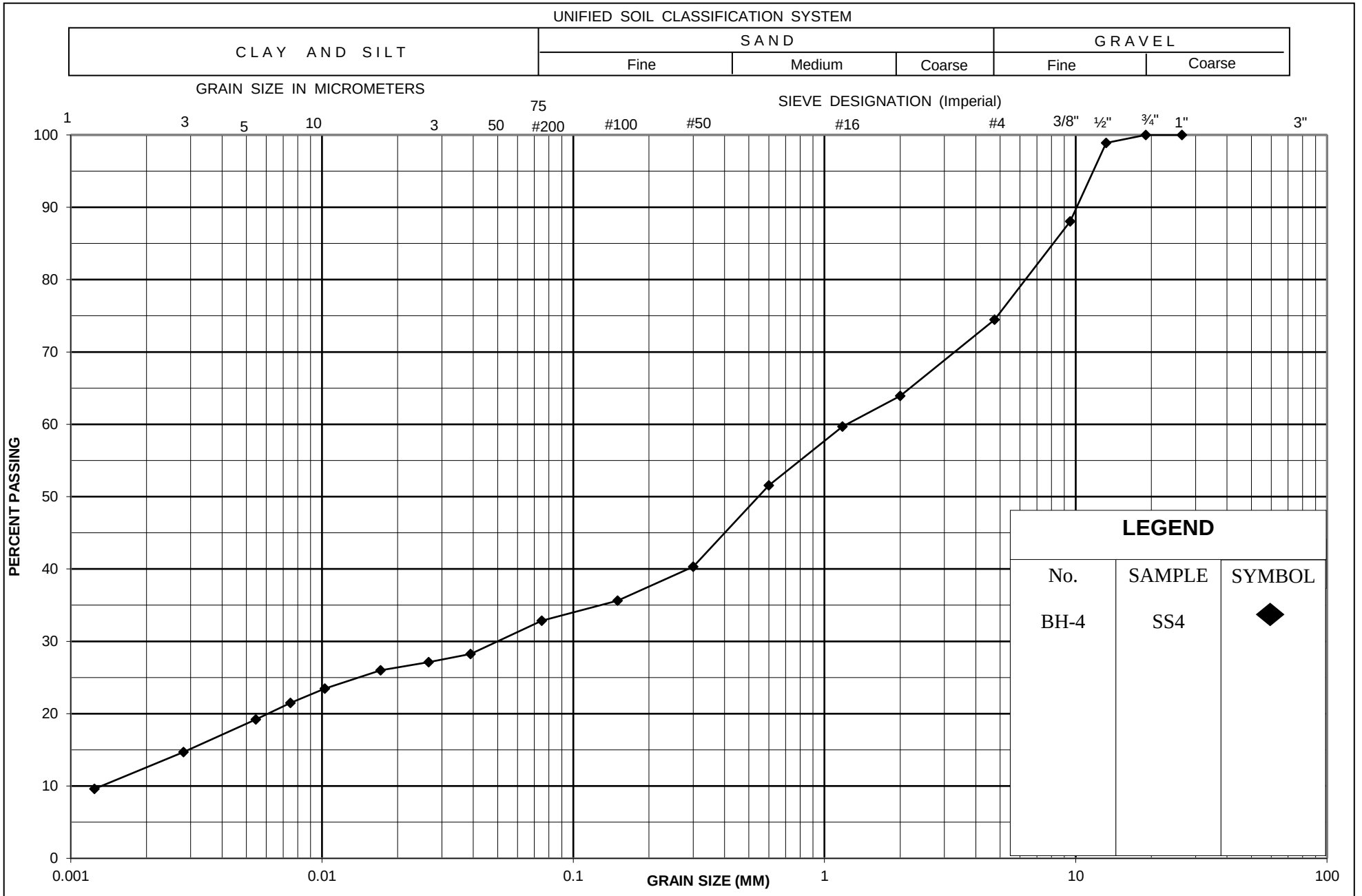
GRAIN SIZE DISTRIBUTION

FILL: SILTY CLAY (CI)

FIGURE NO.: 3

PROJECT: ADM-00235197-C0

DATE: NOVEMBER 2016



GRAIN SIZE DISTRIBUTION

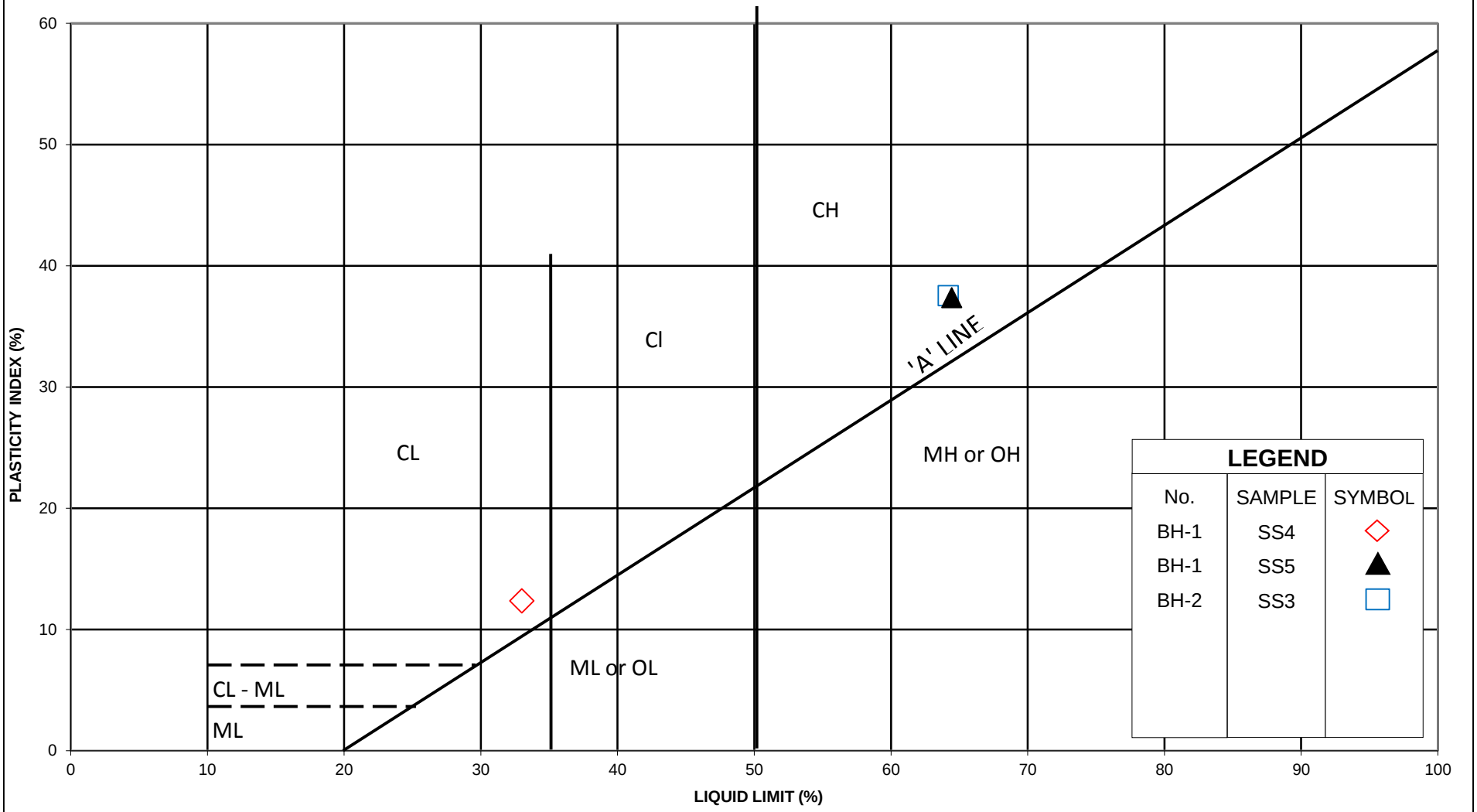
FILL: GRAVELLY SAND with some silt and some clay (SC)

FIGURE NO.: 4

PROEJCT: ADM-00235197-C0

DATE: NOVEMBER 2016

CULVERT REPLACEMENT
Highway 3, Jarvis, ON



PLASTICITY CHART

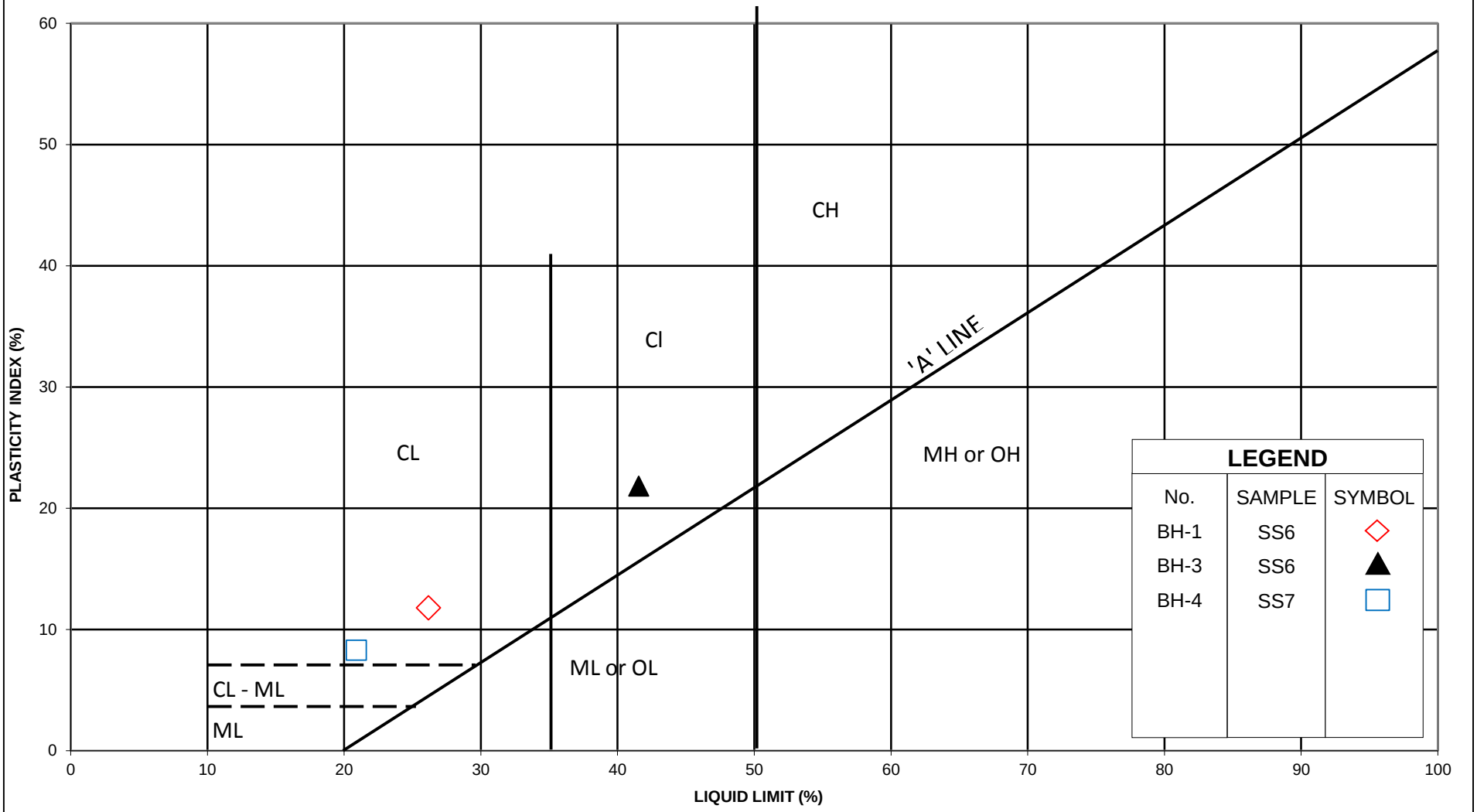
CLAY (CH), SILTY CLAY (CL)

FIGURE NO.: 5

PROJECT: ADM-00235197-C0

DATE: NOVEMBER 2016

CULVERT REPLACEMENT
Highway 3, Jarvis, ON



PLASTICITY CHART

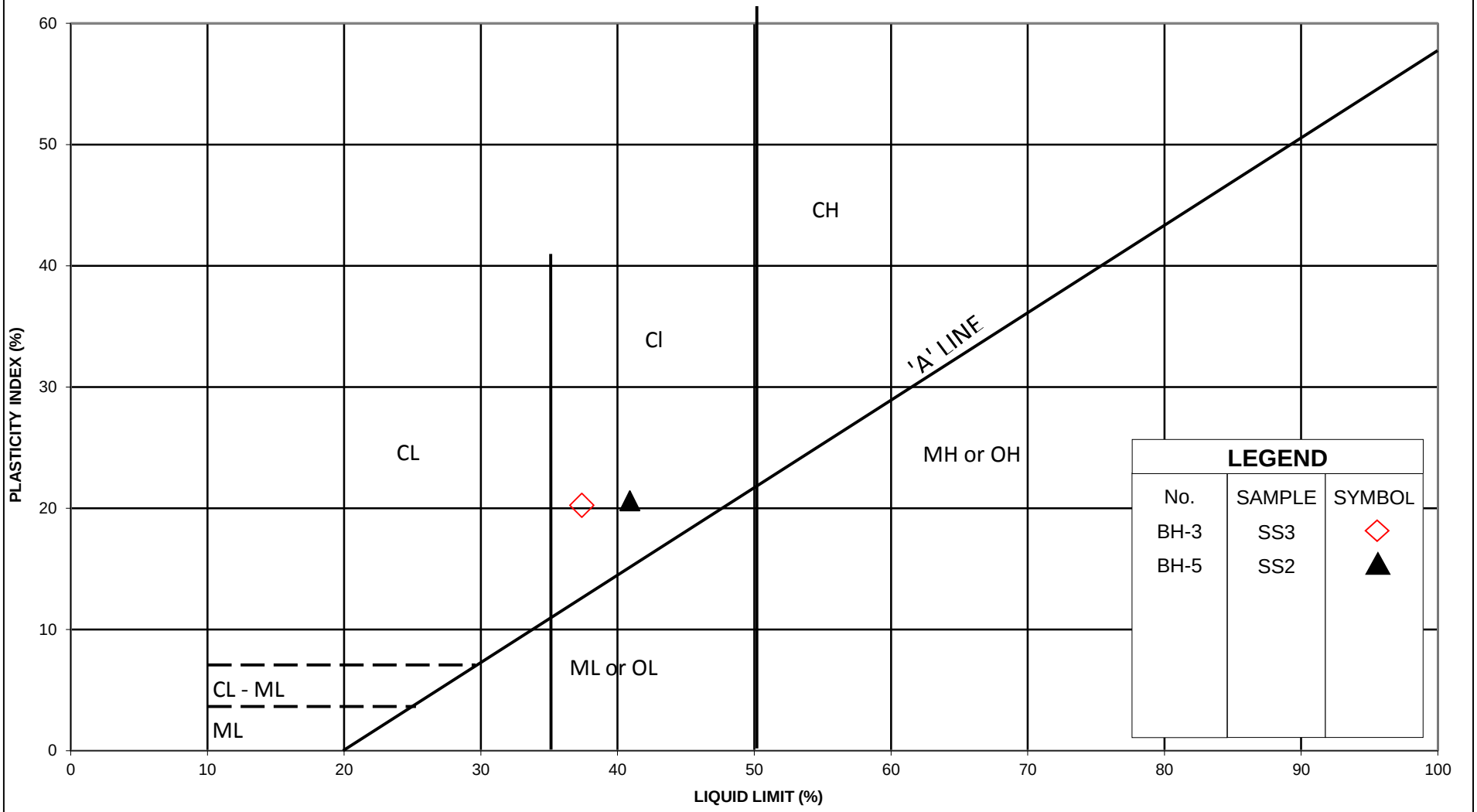
SILTY CLAY TILL (CI), SANDY CLAYEY SILT TILL (CL)

FIGURE NO.: 6

PROJECT: ADM-00235197-C0

DATE: NOVEMBER 2016

CULVERT REPLACEMENT
Highway 3, Jarvis, ON



PLASTICITY CHART

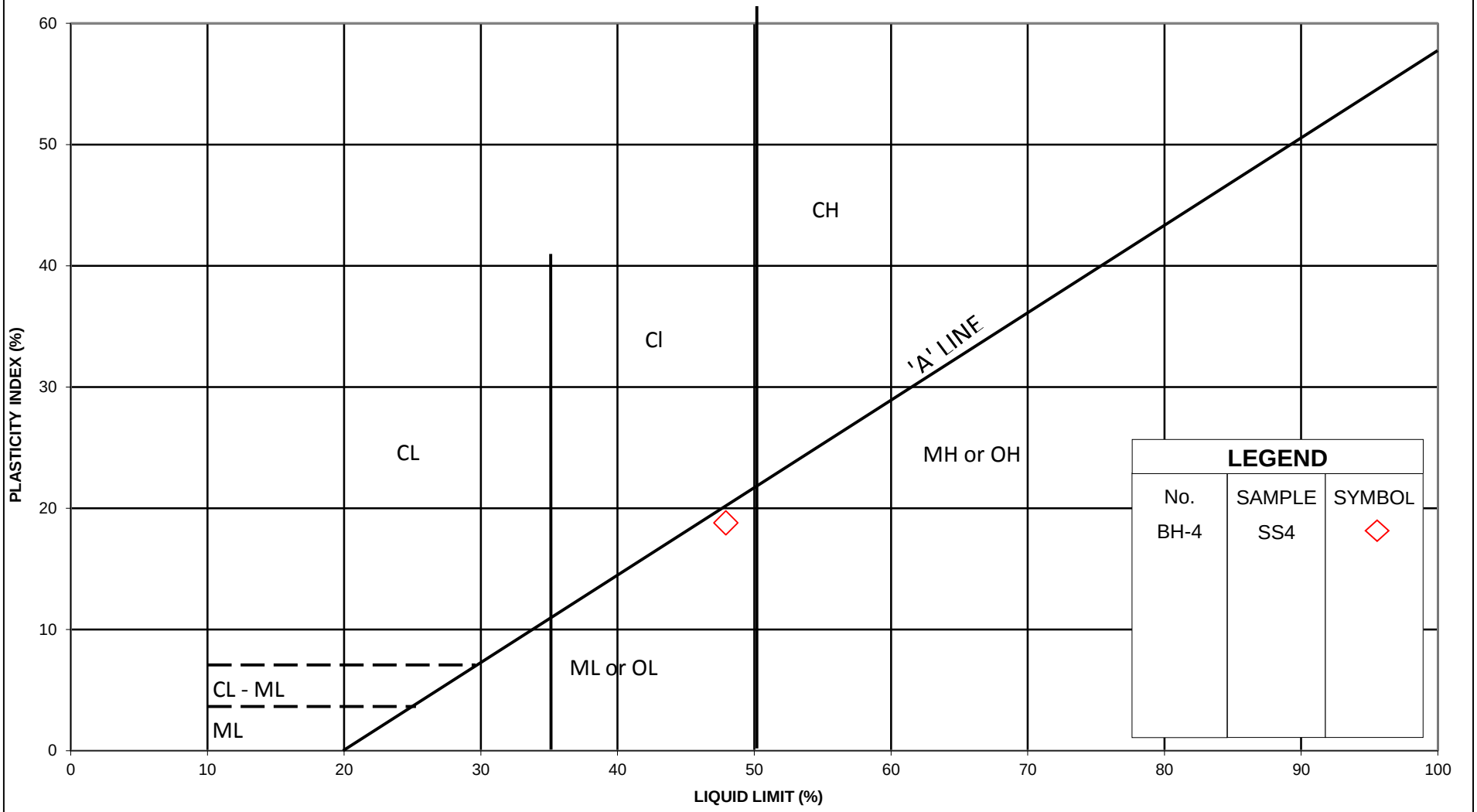
FILL: SILTY CLAY (CI)

FIGURE NO.: 7

PROJECT: ADM-00235197-C0

DATE: NOVEMBER 2016

CULVERT REPLACEMENT
Highway 3, Jarvis, ON



PLASTICITY CHART

FILL: GRAVELLY SAND with some silt and some clay (SM)

FIGURE NO.: 8

PROJECT: ADM-00235197-C0

DATE: NOVEMBER 2016

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: EXP. SERVICES INC.
80 BANCROFT STREET
HAMILTON, ON L8E2W5
(905) 573-4000

ATTENTION TO: Jeff Golder

PROJECT: ADM-00235197-C0

AGAT WORK ORDER: 16T159963

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Coordinator

DATE REPORTED: Nov 18, 2016

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Member of: Association of Professional Engineers and Geoscientists of Alberta (APEGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

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Results relate only to the items tested and to all the items tested
All reportable information as specified by ISO 17025:2005 is available from AGAT Laboratories upon request

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 16T159963

PROJECT: ADM-00235197-C0

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2016-11-14

DATE REPORTED: 2016-11-18

		SAMPLE DESCRIPTION:		BH-1 SS3 (5-7')
		SAMPLE TYPE:		Soil
		DATE SAMPLED:		2016-11-08
Parameter	Unit	G / S	RDL	8012972
Sulfide	%		0.01	0.01
Chloride (2:1)	µg/g		2	255
Sulphate (2:1)	µg/g		2	51
pH (2:1)	pH Units		NA	8.31
Electrical Conductivity (2:1)	mS/cm		0.005	0.565
Resistivity (2:1)	ohm.cm		1	1770
Redox Potential (2:1)	mV		5	264

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

8012972 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Sulfide analysis performed by AGAT Burnaby.

Certified By: Amanjot Bhela

Results relate only to the items tested and to all the items tested

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Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 16T159963

PROJECT: ADM-00235197-C0

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Nov 18, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Sulfide	8014293		0.03	0.03	NA	< 0.01	100%	80%	120%						
Chloride (2:1)	8014326		72	72	0.0%	< 2	94%	80%	120%	104%	80%	120%	96%	70%	130%
Sulphate (2:1)	8014326		70	72	2.8%	< 2	92%	80%	120%	103%	80%	120%	98%	70%	130%
pH (2:1)	8014326		8.12	8.17	0.6%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	8016096		0.042	0.042	0.0%	< 0.005	99%	90%	110%	NA			NA		
Redox Potential (2:1)	8014326		276	274	0.7%	< 5	102%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.
Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By: Amanjot Bhela

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Results relate only to the items tested and to all the items tested

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
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Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 16T159963

PROJECT: ADM-00235197-C0

ATTENTION TO: Jeff Golder

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulfide	INOR-181-6027	modified from ASTM E1915-11	COMBUSTION
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Laboratory Use Only
Work Order #: 16T159963

Cooler Quantity:
Arrival Temperatures: 20.7 | 21.0 | 21.0
19.7 | 15.0 | 15.0
Custody Seal Intact: ☐ Yes ☐ No ☐ N/A
Notes: TCC

Report Information:

Company: exp Services Inc.
Contact: Jeffrey Golder
Address: 80 Bancroft Street
Hamilton, ON L8E 2W5
Phone: 905.573.4000 x5022 Fax:
Reports to be sent to:
1. Email: jeffrey.golder@exp.com
2. Email:

Regulatory Requirements:

☐ No Regulatory Requirement
(Please check all applicable boxes)

☐ Regulation 153/04
Table (Indicate One) ☐ Ind/Com ☐ Res/Park ☐ Agriculture
Soil Texture (Check One) ☐ Coarse ☐ Fine

☐ Sewer Use
☐ Sanitary ☐ Storm
Region (Indicate One)

☐ Regulation 558
☐ CCME
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
(Indicate One)

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)
☐ 3 Business Days ☐ 2 Business Days ☐ 1 Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

Project Information:

Project: ADM-00235197-C0
Site Location: HWY CULVERT
Sampled By: AA
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐
Company:
Contact:
Address:
Email:

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI (Please Circle) Y / N	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	(Check Applicable) ORPs: ☐ B-HWS ☐ Cl⁻ ☐ CN⁻ ☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ NO_3/NO_2 ☐ Total N ☐ Hg ☐ pH ☐ SAR	(Check Applicable) Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	(Check Applicable) Volatiles: ☐ VOC ☐ BTEX ☐ THM	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	Corrosivity Package
BH-1 SS3 (5-7')	Nov. 8	N/A	1	S																	☑

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Jeffrey Golder 2016/11/14	Nov. 14, 2016	10:00	2016/11/14 12:05		
Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
2016/11/14		7:40			
Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time

Page ____ of ____
No:

Pink Copy - Client | Yellow Copy - AGAT | White Copy- AGAT

Appendix E –
Rock Core Photographs

Borehole BH-3
Run No. 1
Sample Depth: 5.84 – 6.25 m
Sample Elevation: 199.58 – 199.17 m)
Recovery 100%, RQD 70% (fair quality)

Photo 1. Core Sample for BH3 from Elevation 199.58 m to 199.17 m

Borehole BH-3
Run No. 2
Sample Depth: 6.25 – 7.77 m
Sample Elevation: (199.17 – 197.65 m)
Recovery 100%, RQD 68% (fair quality)

Photo 2. Core Sample for BH3 from Elevation 199.17m to 197.65 m

Borehole BH-3
Run No. 3
Sample Depth: 7.77 – 8.99 m
Sample Elevation: (197.65 – 196.43 m)
Recovery 100%, RQD 77% (good quality)

Photo 3. Core Sample for BH3 from Elevation 197.65 m to 196.43 m

Borehole BH-5
Run No. 1
Sample Depth: 5.84 – 6.25 m
Sample Elevation: (199.77 – 199.36 m)
Recovery 100%, RQD 0% (very poor quality)

Photo 4. Core Sample for BH1 from Elevation 199.77 m to 199.36 m