



Geotechnical Investigation
Highway 417 and Innes Road Crossing
Enbridge Pipeline Replacement
Ottawa, ON

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GEOTECHNICAL INVESTIGATION REPORT
for
Highway 417 and Innes Road Crossing – Enbridge Pipeline Replacement

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by Enbridge Gas Distribution Inc. to undertake a geotechnical investigation for the proposed replacement to the pipeline crossing of Highway 417 at Innes Road in Ottawa. The installation is to be conducted using trenchless technologies with a preferred option of Horizontal Directional Drilling (HDD).

The proposed construction will accommodate the replacement of an existing NPS 8 pipeline which crosses Highway 417 at Innes road with an NPS 12 gas pipe.

The alignment of the existing pipeline crosses Highway 417 and Innes Road ramps approximately 38 m south-east of the Innes Road Overpass Structure.

This report has been prepared specifically and solely for the project described herein. It presents the factual results of the investigation and provides geotechnical recommendations for the proposed pipeline using HDD techniques. AME Materials Engineering (AME) has carried out a geotechnical investigation at the project site titled “Geotechnical Investigation Proposed Gas Main Replacement Highway 417 and Innes Road Ottawa, ON” dated March 2013. The borehole records and laboratory test results from the AME investigation are included in this report.

2.0 Site Description and Geology

Site Location

The site of the planned service crossing is shown on the Key Plan shown on Drawing No. 1 provided in Appendix B.

General Site Description

At the planned crossing location Highway 417 is a four lane divided highway (eastbound – two main lanes and one ramp lane; westbound – two main lanes and two ramp lanes) with paved shoulders. Innes Road is a four lane divided roadway.

It is noted that there are underground utilities in the area. The contractor shall be responsible for obtaining and confirming all underground utility locates prior to the start of construction.

Physiographic Description

Published maps of the area indicate that the surficial material at the site is composition of marine deposits (clay, silt) and glacial deposits (silt, sand, gravel) underlain by shale, limestone, dolostone and siltstone of Carlsbad and Billings Formation.

Adjacent Structures

The location of the planned crossing is approximately 38 m south-east of the Innes Road Overpass Structure at Highway 417. The Innes Road structure is a two span bridge. Innes Road at the bridge is a four lane divided roadway.

3.0 Method of Investigation

3.1 DRILLING INVESTIGATION

The Stantec field investigation consisted of advancing three (3) boreholes in addition to four (4) boreholes drilled by AME. Within this Report the boreholes drilled by Stantec are identified as BH13-S1, BH13-S2 and BH13-S3. The AME boreholes are identified as BH13-1 to BH13-4. Two monitoring wells were installed by AME in boreholes to measure the groundwater table. The borehole locations are shown on Drawing No. 2 and 3 in Appendix B.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to ensure the borehole locations were clear of public utilities.

Traffic protection and signage was provided for all field work, in accordance with the Ontario Traffic Manual Book 7 – Temporary Conditions.

The field drilling program was carried out in February 2013 by AME and in June 2013 by Stantec Consulting. The boreholes were advanced using CME drilling machines fitted out with hollow stem augers and diamond bit core barrel and casing.

Standard Penetration Tests were conducted at regular intervals in all boreholes. Bedrock was cored with NQ size coring equipment. The subsurface stratigraphy encountered in each borehole was recorded in the field. All retrieved rock core samples were logged and photographed by Stantec engineers; the Rock Quality Designation (RQD) and Mohs Hardness values were estimated for all recovered samples. The hardness scale ranges from 1 (talc) to 10 (diamond). The hardness of a rock sample is estimated by trying to scratch it with an object of known hardness.

All soil samples recovered were stored in moisture-proof bags while bedrock core samples were labeled and placed in core boxes. All recovered samples were returned to the Stantec Ottawa laboratory for detailed classification and testing.

The Stantec boreholes were backfilled with grout within bedrock, and were backfilled with a mixture of auger cuttings and bentonite above bedrock to provide a low-permeability backfill,

consistent with the requirements of the Ontario Ministry of the Environment (MOE) Regulation 903.

3.2 SURVEY

The ground surface elevation at each Stantec borehole was surveyed using a Trimble GPS unit with decimeter accuracy. Accuracy may be affected by satellite coverage at the time of survey. The borehole locations, including UTM NAD83 northing and easting coordinates and respective geodetic ground surface elevations are summarized in Table 3.1 and are shown on the Borehole Locations and Soil Strata Drawing No. 2 and 3 in Appendix B.

Table 3.1: Borehole Location and Elevation Summary

	Borehole						
	13-01	13-02	13-03	13-04	13-S1	13-S2	13-S3
UTM NAD83 Zone 18							
Northing	5029017	5029084	5029119	5029190	5029058	5029101	5029152
Easting	452161	452239	452364	452483	452216	452293	452469
Ground Surface Elevation (m)	67.57	65.85	63.76	66.60	68.40	63.63	66.15
Depth Drilled (m)	16.38	20.04	20.02	16.36	22.10	15.14	16.43
End of Borehole Elevation (m)	51.2	45.8	43.7	50.2	46.3	48.5	49.7
Depth Augered (m)	5.26	4.67	4.39	7.97	7.57	4.42	7.37
Number of Soil Samples	6	6	5	10	10	6	10
Depth Cored (m)	11.12	15.37	15.63	8.89	14.53	10.72	9.06

Notes: AME survey data referenced from the 2013 AME investigation.

3.3 LABORATORY TESTING

All samples returned to the Stantec Ottawa laboratory were subjected to detailed visual examination and additional classification by a geotechnical engineer. Moisture content determination and grain size analysis were conducted on selected soil samples. Unconfined compressive strength tests were conducted on selected bedrock cores. Rock core photo logs are provided in Appendix E and a summary of unconfined strengths are provided in Table 4.2.

Results of the soil laboratory testing are shown in Appendix D and on the Borehole Records in Appendix C.

Samples will be stored for a period of one month after the issuance of this report unless otherwise directed by the client.

4.0 Subsurface Conditions

4.1 SUBSURFACE PROFILE

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix C. An explanation of the symbols and terms used to describe the Borehole Records is also provided. Photographs of the bedrock core samples are presented in Appendix E.

In general, the subsurface stratigraphy consists of topsoil or asphalt at the ground surface, underlain by a fill material, followed by a deposit of native till over bedrock. The bedrock encountered consisted of non-calcareous to slightly calcareous black shale with siltstone and limestone interbedding. Groundwater was encountered in boreholes at elevation 59.4 m and 63.0 m.

A borehole location plan and stratigraphic section of the soils encountered within the boreholes are provided on Drawing No. 2 and 3 in Appendix B.

4.1.1 Ground Surface Cover

Topsoil

Topsoil was encountered in boreholes 13-02, 13-03, and 13-04. Topsoil thickness ranged between 50 mm to 110 mm.

Asphalt

The ground surface was covered with a layer of asphalt in boreholes 13-01, 13-S1, and 13-S3. Asphalt thickness ranged from 50 mm to 60 mm.

4.1.2 Fill Material

Fill material was encountered in all boreholes. The fill consisted of variable mixtures of silty sand and sandy silt with clay or gravel. Organic material was noted in the fill at several locations. Cobbles and boulders were encountered within borehole BH13-S1. The thickness of the fill encountered ranged from 2.0 m to 6.7 m. The Standard Penetration Test (SPT) N values ranged from 4 to 81 indicating a variable compactness of loose to very dense.

Grain size analysis testing was carried out on five samples of fill and moisture content testing was completed on all samples. The laboratory testing yielded the following results:

- 0% to 52% Gravel
- 13% to 58% Sand
- 15% to 87% Fines (silt and clay size particles)
- Moisture content 3% to 22%

The fill material can be classified as ranging from silt with sand to gravelly sand.

The grain size distribution curves of the fill material are shown on Figure No. 1 in Appendix D.

4.1.3 Till

The native till was encountered in all boreholes underneath the fill. The encountered native till deposit consisted of predominantly silty sand with variable amounts of gravel. Localized layers of sand with silt was encountered in BH13-4, silty gravel in BH13-S1, and silt BH13-S3. Although not noted, cobbles and boulders are common within this deposit.

The Standard Penetration Test (SPT) N values ranged from 5 to greater than 50 indicating a loose to very dense state of compactness. Grain size analysis tests were completed on twelve samples of the till. Moisture content testing was completed on all samples. The laboratory testing yielded the following results:

- 0% to 56% Gravel
- 3% to 83% Sand
- 7% to 97% Fines (silt and clay size particles)
- Moisture Content 4% to 25%

The grain size analysis indicated the till to be of variable composition. Selected soil samples were classified as silt (ML), well-graded sand with silt (SW-SM), silty sand with gravel (SM), and silty gravel with sand (GM) in accordance with the Unified Soil Classification System (USCS). The grain size distribution curves are shown in Figure No. 2 and Figure No. 3 in Appendix D.

4.2 BEDROCK

Bedrock was proven by coring techniques in all boreholes. Depth/elevation of the bedrock encountered in the boreholes is provided in Table 4.1.

Table 4.1: Bedrock Depth and Elevations

Borehole No.	Ground surface elevation (m)	Depth to Bedrock (m)	Bedrock Elevation (m)
BH13-01	67.6	5.3	62.3
BH13-02	65.9	4.7	61.2
BH13-03	63.8	4.4	59.4
BH13-04	66.6	8.0	58.6
BH13-S1	68.4	7.6	60.8
BH13-S2	63.6	4.4	59.2
BH13-S3	66.2	7.4	58.8

The bedrock encountered within the boreholes consisted of Billings Formation black shale with subordinate interbeds of siltstone and limestone. The shale was calcareous and fossiliferous in

the majority of recovered samples. Billings Formation shale is prone to sulphatic swelling. The swelling process is the reaction triggered when the rock is exposed to air, moisture, and heat.

The Total Core Recovery (TCR) ranged from 80% to 100% and the Rock Quality Designation (RQD) ranged from 28% to 98% indicating poor to excellent quality rock mass. It should be noted that the transition between the Carlsbad and Billing Formations is near the proposed alignment.

Rock core logs are provided with the Borehole Records in Appendix C and photographs of the rock cores images are provided in Appendix E.

The following table summarizes the results of the 16 unconfined compressive strength tests carried out on selected bedrock cores.

Table 4.2: Unconfined Compressive Strength Results

Borehole	Sample No.	Ground Surface Elevation (m)	Test Core Depth (m)	Test Core Elevation (m)	Unconfined Compressive Strength (MPa)	Rock Type
BH13-01	NQ-9	67.6	7.5	60.1	108.9	Shale
BH13-01	NQ-13	67.6	13.5	54.1	97.9	Shale
BH13-02	NQ-8	65.9	7.1	58.8	83.8	Shale
BH13-02	NQ-12	65.9	13.6	52.3	109.4	Shale
BH13-03	NQ-8	63.8	6.6	57.2	62.1	Shale
BH13-03	NQ-12	63.8	13.3	50.5	92.1	Shale
BH13-04	NQ-12	66.6	8.9	57.7	94.1	Shale
BH13-04	NQ-16	66.6	15.0	51.6	110.4	Shale
BH13-S1	NQ-16	68.4	13.0	55.4	214.0	Shale
BH13-S1	NQ-19	68.4	17.6	50.8	54.7	Shale
BH13-S1	NQ-21	68.4	21.2	47.2	77.6	Shale
BH13-S2	NQ-11	63.6	10.3	53.3	69.9	Shale
BH13-S2	NQ-13	63.6	12.2	51.4	141.9	Shale
BH13-S3	NQ-12	66.2	9.1	57.1	53.4	Shale
BH13-S3	NQ-14	66.2	12.7	53.5	73.0	Shale
BH13-S3	NQ-16	66.2	15.3	50.9	56.9	Shale

4.3 GROUNDWATER

Groundwater levels were measured in boreholes BH13-02 and BH13-04 at elevations 63.0 m and 59.4 m on February 21, 2013 by AME.

5.0 Miscellaneous – Stantec Borehole

The field work was carried out under the supervision of Jason Hopwood-Jones, under the direction of Chris McGrath, P.Eng., Senior Geotechnical Engineer.

The drill rig was supplied and operated by Downing George Estate Drilling of Hawkesbury, Ontario.

Underground utility locates were carried out by Underground Service Locators USL-1.

Geotechnical laboratory testing was carried out at the Stantec Ottawa laboratory.

This report was prepared by N'eem Tavakkoli, P.Eng. and reviewed by Chris McGrath, P.Eng. and Raymond Haché, M.Sc., P.Eng.

6.0 Closure

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information obtained at specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectively Submitted;

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DESIGN REPORT

For

Highway 417 and Innes Road Crossing – Pipeline Replacement

7.0 Discussion

7.1 PROJECT DESCRIPTION & BACKGROUNDProject Purpose/Justification

Stantec Consulting Ltd. (Stantec) was retained by Enbridge Gas Distribution Inc. to undertake the geotechnical investigation for the proposed pipeline crossing of Highway 417 at Innes Road for the pipeline replacement project. The installation is to be conducted using trenchless technologies with a preferred option of Horizontal Directional Drilling (HDD).

The alignment of the proposed pipeline crosses Highway 417 and Innes Road ramps running approximately 38 m south-east of the Innes Road Overpass Structure.

Proposed Pipeline

The proposed pipeline construction will consist of replacing the Nominal Pipe Size (NPS) 8 with an NPS 12 pipeline (this corresponds to a metric nominal diameter of 300 mm). The portion of the pipeline crossing Highway 417 and the Innes Road ramps will be installed using the horizontal directional drilling approach.

The entry point will be 75 m east of the Innes Road on-ramp to Highway 417 westbound and the exit point will be 50 m west of the south-west side of the Innes Road on-ramp to Highway 417 eastbound. The proposed drilled length for the pipe crossing is approximately 575 m horizontal. The approximate location of the entry/exit pits are indicated on Drawing No. 2 and 3.

Key elevations associated with the installation are:

Approximate Invert Elevation of Pipe at Crossings:	53.5 m, over 11 m below the ground surface at Hwy 417 median
Ground Surface Elevation of Hwy 417 on-ramp (east):	68.5 m
Ground Surface Elevation of Hwy 417 on-ramp (west):	66.2 m
Ground Surface Elevation of Hwy 417:	65.4 m
Ground Surface Elevation at Borehole Locations:	68.4 to 63.6 m
Groundwater Elevation:	59.4 to 63.0 m

Construction Staging & Detours

The existing Highway 417 platform consists of a four lane divided highway (eastbound – two main lanes and one ramp lane; westbound – two main lanes and two ramp lanes). Innes Road is a four lane undivided road.

The scope of work has been planned to maintain traffic flow on the Highway 417 without disruption. The work will take place outside of traffic lanes.

7.2 SOIL SUMMARY

The soil stratigraphy at the location of the planned crossing generally consists of topsoil or asphalt underlain by fill material, underlain by a silty sand with gravel till deposit followed by black shale with subordinate interbeds of siltstone and limestone bedrock. The soil stratigraphy is presented in Drawing No. 2 and 3.

For design purposes, the soil profile shown on pipe profile can be used with Table 7.1 soil properties.

Table 7.1: Geotechnical Soil Stratigraphic Model

Soil Type	Design Properties
Topsoil	Not Applicable
FILL (mixed): silty sand to gravelly sand to silt to lean clay with sand	Bulk Unit Weight = 21.0 kN/m ³ Effective Friction Angle, $\phi' = 29^\circ$
TILL: silty sand with gravel to silt with sand to silty gravel with sand	Bulk Unit Weight = 22.5 kN/m ³ Effective Friction Angle, $\phi' = 34^\circ$
Sedimentary bedrock: Shale	Bulk Unit Weight = 24.2 kN/m ³

For design purposes, a groundwater elevation of 59.4 to 63.0 m can be considered.

7.3 SEISMIC DESIGN CONSIDERATIONS

Based on the soil conditions identified during the geotechnical investigation, the recommended site classification for seismic site response for this site is Site Class D in accordance with Table 4.1.8.4.A of the 2006 Ontario Building Code. The site class was estimated based on the soil profile and design N_{60} values outlined in Table 7.2.

Table 7.2: Parameters for Seismic Site Classification

Average Depth	Soil	N_{60} Value
0.0 m to 5.0 m	Fill	20
5.0 m to 8.0 m	Till	11
>8.0 m	Bedrock	100
Design N_{60}		37

Liquefaction of the soils at the project site is not a concern for this project due to the dense consistency of soil and shallow bedrock.

8.0 Trenchless Technology Installation

8.1 HORIZONTAL DIRECTIONAL DRILLING APPROACH

The preferred trenchless technology approach for the Highway 417 and the Innes Road ramps pipeline crossing is Horizontal Directional Drilling (HDD).

8.1.1 Suitability of Preferred Approach

The following bullets provide a brief review of the suitability of the Horizontal Directional Drilling (HDD) approach for this project.

- The work is to be carried out within the MTO Right-of-Way. Open cut excavation in the MTO Right-of-Way is not permitted therefore a trenchless approach is required.
- The fill materials encountered varied from cohesive to non-cohesive material, with significant cobbles and boulders encountered within borehole BH13-S1. It is anticipated that cobbles may be encountered during construction, the HDD alignment can be designed to avoid these materials.
- The native soils encountered within the boreholes along the majority of the alignment consist predominantly of silty sand with gravel. Penetration of this soil via HDD is not anticipated to be a concern. No significant evidence of cobbles and boulders were noted in the till during the course of investigation, however, the presence of cobbles and boulders is common in this deposit.
- The site has sufficient space for staging areas for the HDD equipment. The operation of Hwy 417 should not be disrupted during HDD operations.
- The majority of pipe alignment will be within bedrock. The rock quality of the bedrock was fair to excellent with the exception of rock quality close to the rock interface with the till which was reported as poor quality in some occasions. The quality of the bedrock below the upper layer of rock is favourable for HDD. The Tunnel Quality Index "Q" was estimated to be 1 indicating "Poor" rock classes. The Rock Mass Rating (RMR) was estimated to be 44 indicating "Fair" rock mass classifications. The estimated values of Q and RMR suggest the borehole for the HDD will be stable in the rock.
- The HDD alignment is approximately 38 m away from the Innes Road Bridge. The estimated values of Q and RMR indicated the proposed HDD boring will be stable and the bridge foundation will not be impacted by the proposed HDD crossing.

8.1.2 Constraints to the Preferred Approach

The following bullets provide a brief review of the constraints of the HDD approach for this project.

- It is noted that there are below grade utilities in the area that will need to be protected during the work. Subsurface Utility Mapping (SUM) should be reviewed to locate the existing buried infrastructure; it shall be the contractors responsibility to clear utilities for construction.

- The potential for hydraulic Fracture (i.e. “inadvertent loss of drilling fluids”) under the highway is considered to be low within the bedrock; however, the potential for inadvertent loss of drilling fluids is dependent on the type of drilling equipment, drilling and reaming methodology, down hole drilling fluid properties (density, viscosity, etc.), drill path geometry and drilling fluid pressures. The HDD variables should be assessed by an experienced contractor with reference to the soil conditions and the HDD hole geometry to mitigate the potential for this to occur.
- Cobbles and boulders were encountered within borehole BH13-S1 and could be encountered within the fill. The pipe profile should avoid the fill layer and soil in BH13-S1 as much as possible and should be founded within the bedrock.
- The use of pressure relief pits can be considered for implementation in the design on either side of Hwy 417 and Innes Road ramp crossing to dissipate high fluid pressures that may develop during drilling.
- The Billings Formation shale is prone to swelling when exposed to air, moisture and heat. To minimize the risk of swelling the pilot bore should remain submerged with water or drilling fluid. Exposure of the bedrock to air should be limited to no longer than 12 hours. The typical practice in the Ottawa area is to cover bedrock subgrades with protective mud slabs.
- The unconfined compressive strength test result carried out on samples of bedrock ranged from 53 to 214 MPa suggesting strong to very strong bedrock. The bedrock strength should be considered by the contractor when selecting the HDD equipment.
- The potential for ground surface movements which could occur above the HDD alignment beneath the footprint of the Highway 417 and Innes Road ramps is low. Although the rock quality at the bedrock surface is classified as poor, the depth of proposed alignment corresponds with the depth of fair to excellent quality rock. The bedrock is horizontally bedded which suggests a low risk of poor quality surface rock subsidence triggered by back reaming operations.

8.1.3 Entry Point and Exit Pit

Two HDD entry/exit pits are proposed for the crossings. The location of the pits is shown on the Plan on Drawing No. 2 and 3 in Appendix B. The pits are within close proximity to Innes Road. The pits should be supported with a trench box or shoring system.

The trench box design (or any alternative shoring design) should be carried out by a Professional Engineer retained by the Contractor, licensed to practice in the Province of Ontario. Signed and sealed drawings must be available prior to commencement of the HDD operations.

A static groundwater elevation in the range of Elevation 59.4 m to 63.0 m should be considered in the design.

Upon completion of the HDD installation, the trench box (or any alternative shoring) shall be removed and the excavation backfilled and compacted. The disturbed area shall be restored to an equivalent or better condition than existed prior to the commencement of construction. Trenching, backfilling and compacting for entry and exit pits or other locations along the pipe path should be in accordance with OPSS 514.

8.2 RECOMMENDATIONS

It is recommended that the profile of the pipe be designed so the obvert elevation of the pipe is at least 2.0 m below the bedrock surface for the crossing of the Highway 417 and Innes Road. The proposed alignment exceeds the recommended minimum 2 m bedrock cover.

Non Standard Special Provision

The tender for the proposed utility plant relocation service installation should include the document titled "Pipe Installation by Trenchless Method, Non Standard Special Provision (NSSP)", dated February 2009; a copy of this document is provided in Appendix F.

The NSSP includes the general requirements relating to the installation of pipes by trenchless methods including specifications for directional drilling and instrumentation monitoring.

The contractor should provide a complete submission consistent with the requirements of the NSSP.

Monitoring Points

Monitoring points should be installed along the alignment of the pipe. Additional comments regarding the monitoring points is provided in "Instrumentation and Monitoring Plan for Horizontal Directional Drilling" in a separate volume as well as Section 9.3.

9.0 Construction Considerations

9.1 UNWATERING

The groundwater elevations were measured at 59.4 m and 63.0 m within the two monitoring wells. It should be practical to undertake unwatering in the entry/exit pits using conventional sump and pump techniques. Provided the base of the pits are above the groundwater level. References should be made to OPSS 517 and OPSS 518 for unwatering requirements. Construction stage unwatering is expected to have a negligible impact on existing infrastructure, given the soil/bedrock condition encountered.

9.2 SITE PREPARATION

Given the existing conditions observed and recorded via the geotechnical investigation, clearing and grubbing should not be required as a component of site preparation activities.

Reference is given to OPSS 201, OPSS 503 and OPSS 565 for the specifications associated with site preparation and related activities.

9.3 MONITORING

Typically, the most common type of distress for trenchless technology applications is settlement caused by loss of ground around the tunnel. Heave of the ground surface and/or inadvertent drilling fluid returns are also possible depending on the type of installation. Distortions of this nature would be a serious safety concern and could lead to serviceability issues of the highway.

Distress at the ground surface is generally prevented or minimized by planning and good construction practices. The preparation of an installation plan that includes appropriate mitigation measures and contingencies is typically required for these applications. To lay the groundwork for the contractor to prepare a suitable installation plan, the following measures are set forth.

A condition survey of the pavement and bridge structure should be carried out prior to the commencement of construction and documented for the purpose of requirement of restoration, if necessary. The condition survey should be completed during the installation of the in-ground monitoring points and after completion of the HDD installation. Interim surveys should be completed if movement is detected in the in-ground monitoring points.

An array of three in ground measurement points installed at the pipe centerline and off-set a lateral distance of 1.5 m on either side of the pipe centerline is recommended. The in-ground measurement points should be grouted 2.0 m below ground surface (below the depth of frost penetration). Arrays of measurement points are detailed in separate volume "Instrumentation & Monitoring Plan for Horizontal Directional Drilling" specifically prepared for this project by Stantec.

A licensed Ontario Land Surveyor should be engaged for the purpose of monitoring the in-ground and surface monitoring points during construction. Surface monitoring points should be identified and located at 5.0 m intervals along the tunnel alignment and with 5.0 m offsets to the right and left at each interval, consistent with the requirements of the NSSP.

Consistent with the requirements of the NSSP, the surveyor should compile the following:

- Three (3) sets of readings prior to construction to establish "base-line" data.
- One (1) set of readings during each day of construction presuming that movements remain within the anticipated limits. If movements are recorded, the frequency of monitoring will be adjusted consistent with the NSSP.
- Weekly readings after completion of the work for one month, or until a time when all parties agree that further movements have stopped.

The NSSP referenced above includes specifics on: in-ground monitoring points; surface monitoring points; reading frequency; and criteria for assessment, and specify a maximum acceptable surface settlement (or heave) of 15 mm.

The baseline reading, alert level, and review level are described as follows:

- **Baseline Reading** – The baseline readings will be reviewed by the surveyor and Stantec to confirm consistency and reliability in the initial readings. The readings will be conveyed to all parties for the record, prior to commencement of the work.
- **Review Level** – A movement of 10 mm relative to the baseline readings will be established for this purpose. If this level is reached, the Contractor will be advised accordingly and changes to the installation method, rate/progress of installation, or sequence of construction, will be required for implementation to mitigate further ground displacement.
- **Alert Level** – A movement of 15 mm relative to the baseline readings will be established for this purpose. If this level is reached, the Contractor shall cease construction operations and execute pre-planned measures to secure the site, to mitigate further displacement, to assure public safety, and to maintain traffic flow on the Highway.

The reporting process for issue of the survey data should be as follows:

- If the surveyed displacement is below the Review Level, the data obtained should be forwarded within 24 hours of collection to MTO's project contact, Stantec's Project Engineer, the General Contractor's Project Manager, and the earth boring Contractor's Representative.
- If the surveyed displacement is above the Review Level, the General Contractor's Project Manager and the earth boring Contractor's Representative should be notified immediately to request an adjustment to the construction process (see comments provided above), and the survey data should be forwarded within 1 hour of collection to MTO's project contact, Stantec's Project Engineer, the General Contractor's Project Manager, and the Earth Boring Contractor's Representative.
- If the surveyed displacement is above the Alert Level, the General Contractor's Project Manager and the earth boring Contractor's Representative should be notified immediately to stop work and implement contingencies to mitigate any displacements and/or damages incurred. The survey data should be forwarded within 1 hour of collection to MTO's project contact, Stantec's Project Engineer, the General Contractor's Project Manager, and the earth boring Contractor's Representative. A site meeting should be scheduled to review the data and the conditions observed to discuss the nature of the Alert Level, with a view to revising the construction approach and to coordinate the requirement for design and implementation of the remedial measures.

A data distribution list, identifying all parties with the appropriate contact information, should be established prior to commencement of the work.

9.4 EXCAVATION

Temporary excavations must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA).

All fill and till materials encountered in this investigation should be classified as Type 3 soils. The maximum excavation side slope for a Type 3 soil is 1:1 (Horizontal:Vertical) in accordance with the OHSA regulation. Excavations in bedrock can be carried out with a vertical side slopes.

9.5 TRENCH BOX REQUIREMENTS

It is anticipated that temporary shoring will be used at the location of the entry/exit pits in the form of a trench box. The trench box system should be designed in accordance with the methods described in the Canadian Foundation Engineering Manual (2006 Edition). The recommended soil parameters to be used in the design are provided below in Table 9.1. The earth pressures recommended are based on the assumption that a permanent horizontal back slope will be utilized behind the wall.

For walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied structures, the at rest pressure should be used for design, unless the wall can deflect enough (approximately 0.05% of the wall height) to establish the active pressure.

Table 9.1: Soil Parameters

Material	K_o (at rest)	K_a (active)	K_p (passive)	ϕ (friction angle)	Unit Weight
Fill Materials	0.51	0.35	2.88	29	21 kN/m ³
Silty Sand with Gravel Till	0.44	0.28	3.54	34	22.5 kN/m ³

The design of the trench box should be carried out by a professional engineer specialized in shoring design. The design should consider load effects from the adjacent embankment, existing infrastructure, and construction equipment.

The contract documents should reference OPSS 538 and OPSS 539 which pertains to excavation support and protection systems.

9.6 REMOVAL OF PROTECTION SYSTEMS

The protection systems should be removed from the right-of-way after the completion of construction.

All disturbed areas should be restored to an equivalent or better condition than prior to the start of construction.

The contract documents should reference OPSS 538 and OPSS 539 which pertains to excavation support and protection systems.

10.0 Specifications

The following specifications apply to the content of this report:

Table 10.1: Specifications Referenced in Report

Document	Title
NSSP	Pipe Installation by Trenchless Method, February 2009
OPSS 565	Construction Specification for the Protection of Trees
OPSS 539	Construction Specification for Temporary Protection System
OPSS 538	Construction Specification for Shoring and Bracing
OPSS 518	Construction Specifications for Control of water from Dewatering Operations
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility and Associated Structure Excavation
OPSS 503	Construction Specification for Site Preparation for Pipelines, Utilities, and Associated Structures
OPSS 201	Construction Specification for Clearing, Close Cut Clearing, Grubbing, and Removal of Surface and Piled Boulders

11.0 References

ASTM 4.08. Standard D1586-99: Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM 4.08. Standard D2487-00: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

Canadian Geotechnical Society. Canadian Foundation Engineering Manual, 4th Edition. Richmond: BiTech Publisher Ltd, 2006.

CHBDC, 2006. Canadian Highway Bridge Design Code. Canadian Standards Association, Mississauga, Ontario.

Ministry of Labour. Occupational Health and Safety Act and Regulations for Construction Projects. Toronto, Ontario: Publications Ontario, 2002.

Ministry of Transportation. Ontario Provincial Standards for Roads and Municipal Services. Downsview, Ontario: Ministry of Transportation, 1998.

MTO LS-701: Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

MTO LS-702. Standard D422-63: Standard Test Method for Particle-Size Analysis of Soils.

Ministry of Transportation. Guideline for Foundation Engineering Tunnelling Specialty for Corridor Encroachment Permit Application.

12.0 Closure

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Respectfully submitted,

STANTEC CONSULTING LTD.

N'eem Tavakkoli, P. Eng.
Geotechnical Engineering



Christopher McGrath, P. Eng.
Associate – Senior Geotechnical Engineer



Raymond Haché, M.Sc., P. Eng.
Senior Principal – Senior Geotechnical Engineer
Designated Principal MTO Foundation Contact



APPENDIX A

Statement of General Conditions

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or subsurface conditions are present upon becoming aware of such conditions.

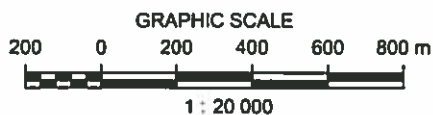
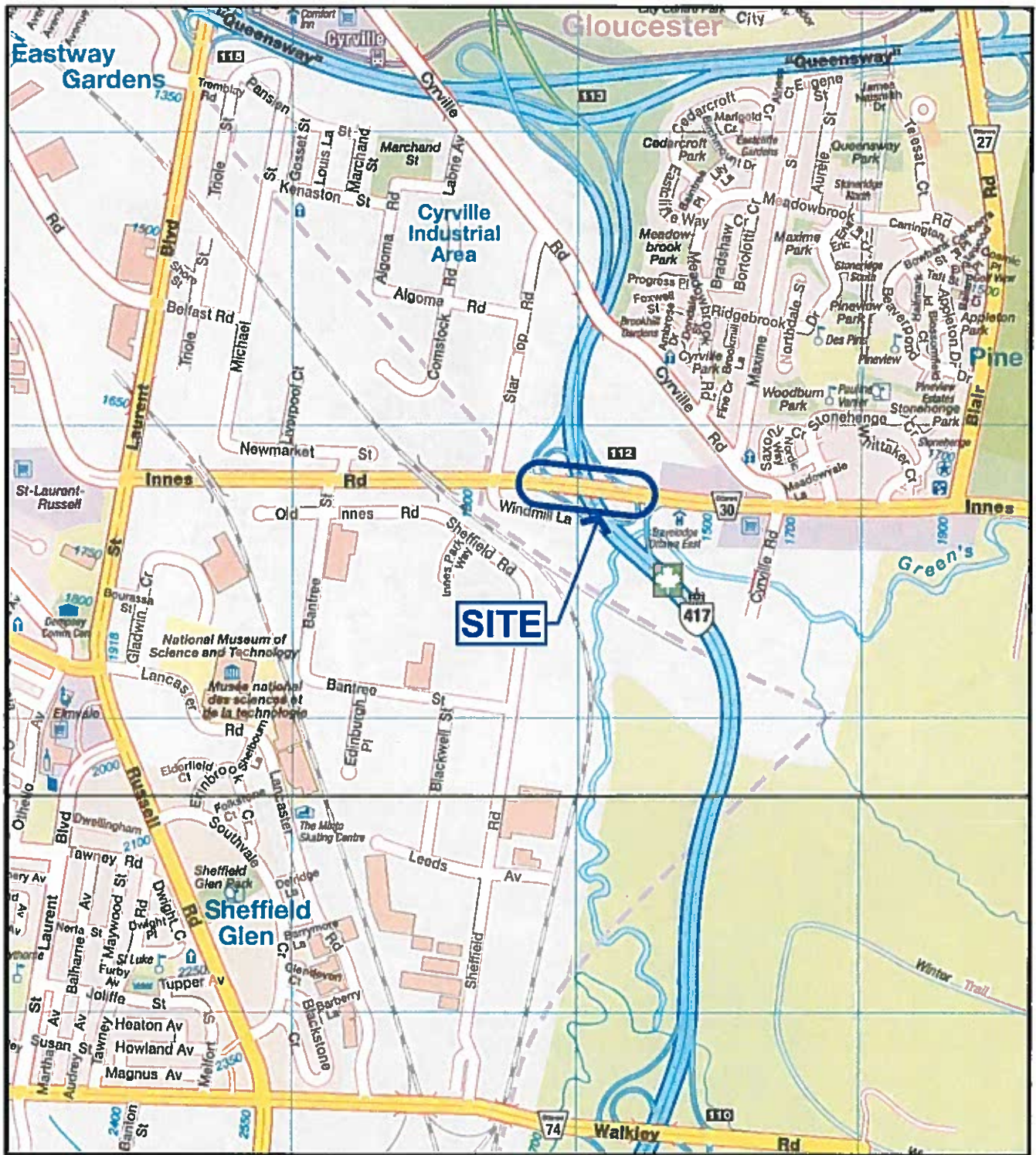
PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

APPENDIX B

Drawing No. 1 – Key Plan

Drawing No. 2 – Borehole Location Plan and Profile (South-West)

Drawing No. 3 – Borehole Location Plan and Profile (North-East)



REFERENCE: MAPART

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

KEY PLAN

GEOTECHNICAL INVESTIGATION, ENBRIDGE PIPELINE REPLACEMENT
HIGHWAY 417 AND INNES ROAD CROSSING, OTTAWA, ONTARIO

Client: ENBRIDGE GAS DISTRIBUTION INC.

Job No.: 122410935

Scale: 1 : 20 000

Date: 13/07/04

Dwn. By: GBB

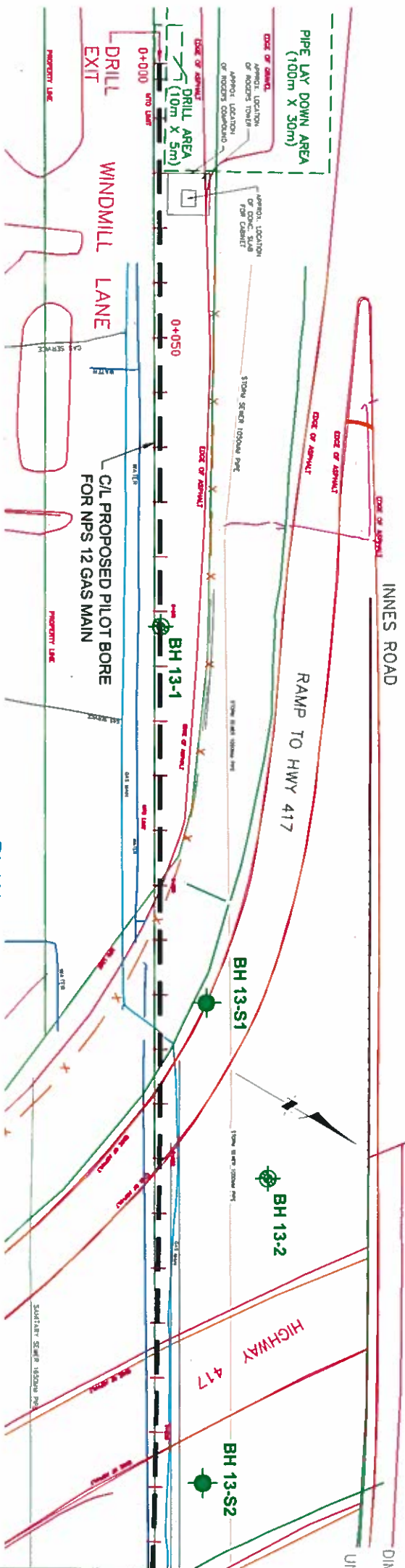
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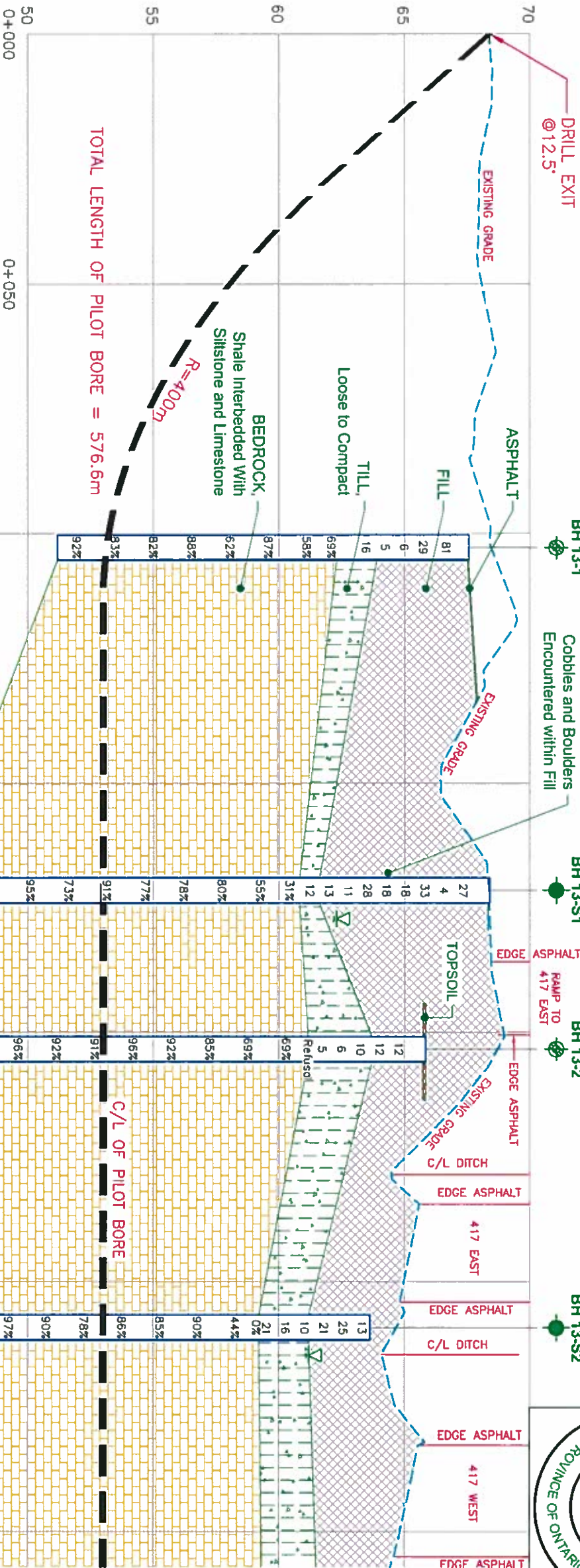
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SCALE
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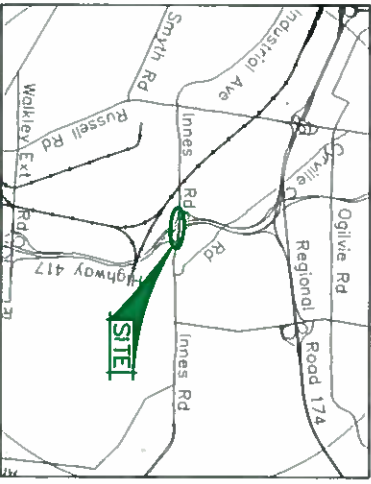
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UNLESS OTHERWISE SHOWN

JOB NUMBER
122410935

SHEET
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BOREHOLE LOCATIONS & SOIL STRATA
HIGHWAY 417
SOUTH - WEST



LICENSED PROFESSIONAL ENGINEER
C. McGRATH
PROVINCE OF ONTARIO
13/02/05

LICENSED PROFESSIONAL ENGINEER
J.G.A.R. HACHE
PROVINCE OF ONTARIO
13/02/05

LEGEND

- Borehole By Stantec
- Borehole By Others
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- Wt. at time of investigation Feb 2013

No	ELEVATION	UTM ZONE 18 COORDINATES
13-1	67.57	5 029 017 452 161
13-S1	68.40	5 029 058 452 216
13-2	65.85	5 029 084 452 239
13-S2	63.63	5 029 101 452 293

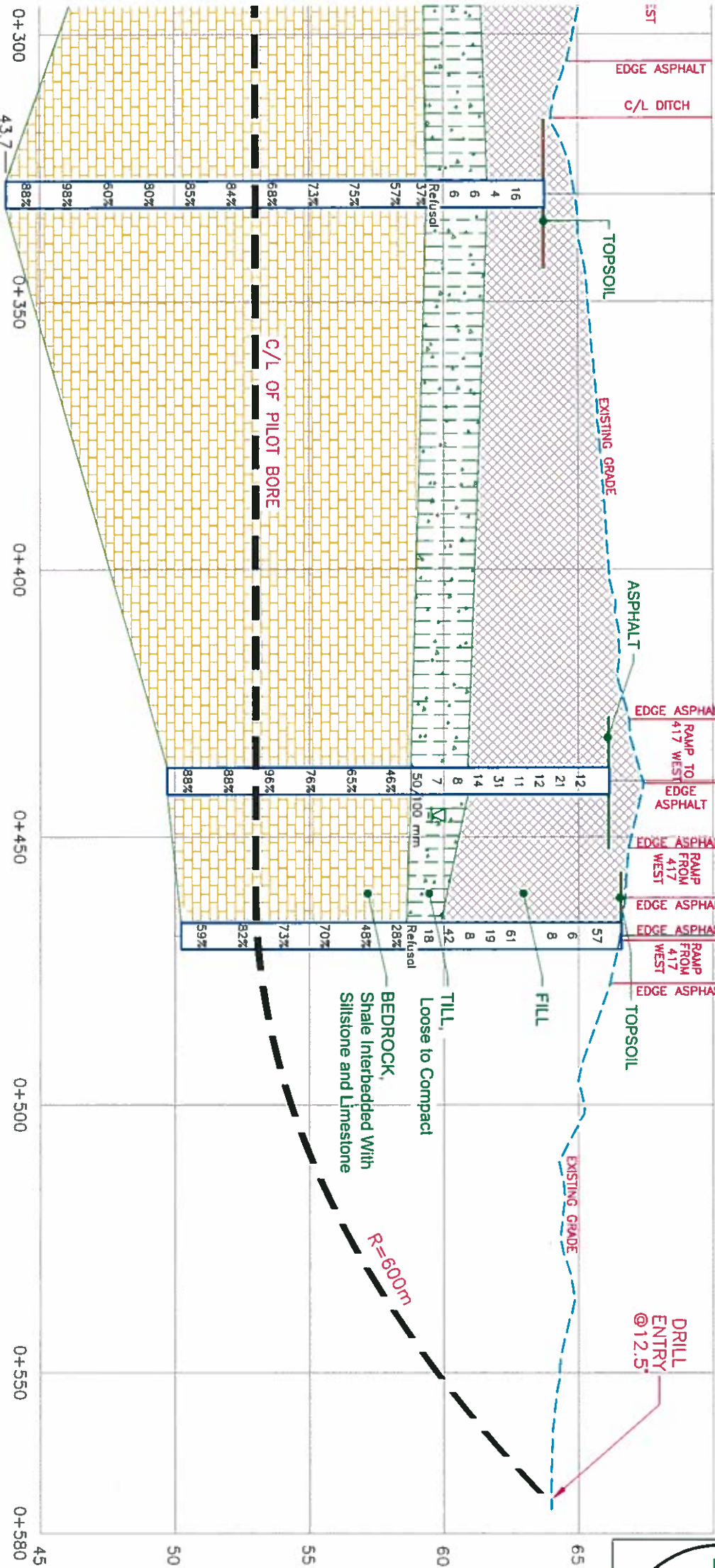
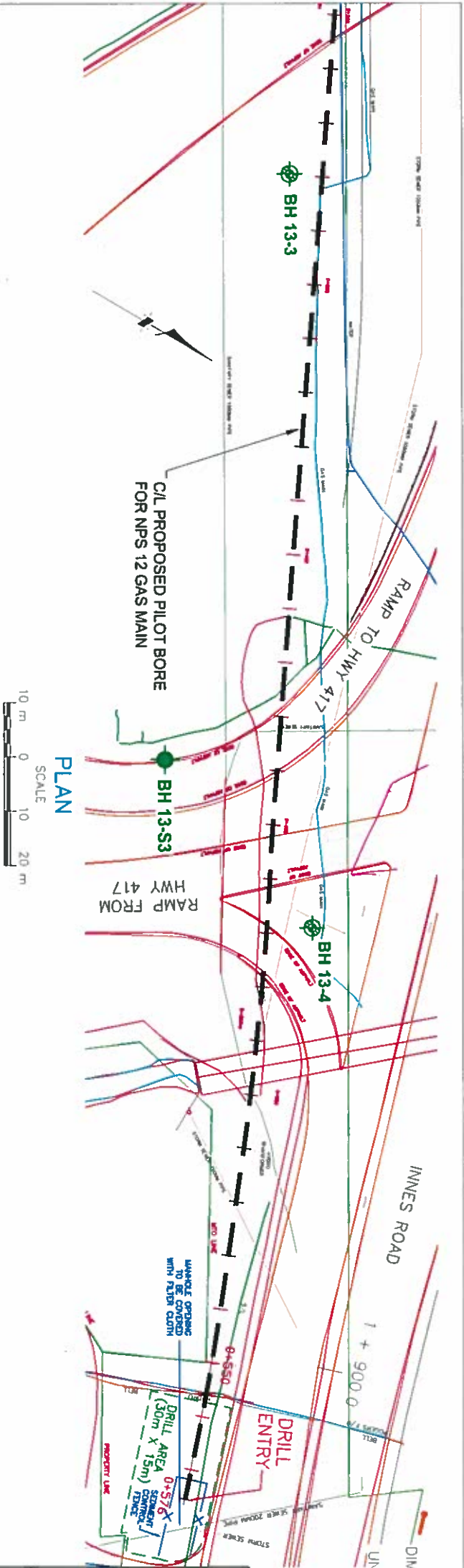
NOTES

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

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS		
DATE	BY	DESCRIPTION

HWY No 417	CHECKED	DATE 2013-07-05	DWG NO
SUBD NIT			
DRAWN: CBB	CHECKED		2



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UNLESS OTHERWISE SHOWN

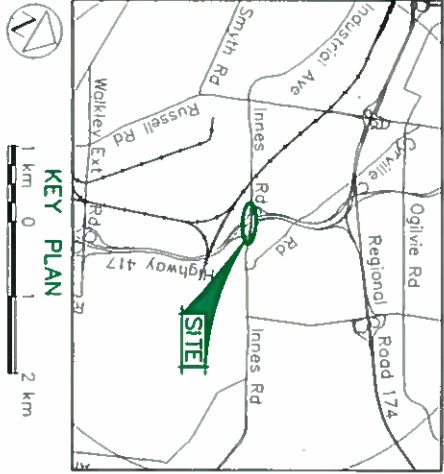
JOB NUMBER

122410935

HIGHWAY
NORTH - EAST

BOREHOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Borehole By Stantec
- Borehole By Others
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- Wt. at time of investigation Feb 2013

No	ELEVATION	UTM ZONE 18 COORDINATES
13-3	63.76	5 209 119 452 36.4
13-S3	66.15	5 029 152 452 469
13-4	66.60	5 029 190 452 483

NOTES

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

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Council of Ontario, 1055-2010, in accordance with the provisions of Section 105.2 of the Act.

REVISIONS	DATE	BY	DESCRIPTION
1			

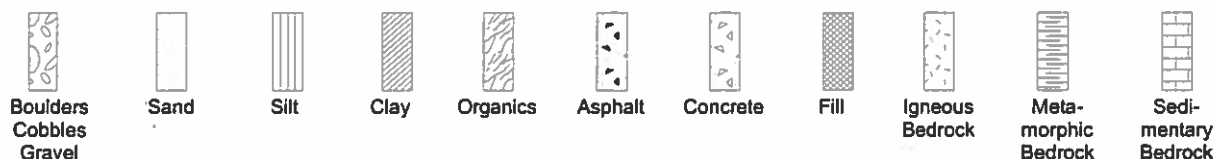
HWY 417	CHECKED	DATE 2013-07-05	DWG NO
SUBD. INT			
DRAWN GBB	CHECKED		3

APPENDIX C

Symbols and Terms Used on Borehole Records
Borehole Records and Field Bedrock Core Logs

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.



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



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)

1	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



SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

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

Terminology describing soil structure:

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

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 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
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>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
<i>Very Soft</i>	<0.25	<12.5
<i>Soft</i>	0.25 - 0.5	12.5 - 25
<i>Firm</i>	0.5 - 1.0	25 - 50
<i>Stiff</i>	1.0 - 2.0	50 - 100
<i>Very Stiff</i>	2.0 - 4.0	100 - 200
<i>Hard</i>	>4.0	>200



ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	<i>Very Poor</i>
25-50	<i>Poor</i>
50-75	<i>Fair</i>
75-90	<i>Good</i>
90-100	<i>Excellent</i>

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	<i>Extremely Wide</i>	-
2000-6000	<i>Very Wide</i>	<i>Very Thick</i>
600-2000	<i>Wide</i>	<i>Thick</i>
200-600	<i>Moderate</i>	<i>Medium</i>
60-200	<i>Close</i>	<i>Thin</i>
20-60	<i>Very Close</i>	<i>Very Thin</i>
<20	<i>Extremely Close</i>	<i>Laminated</i>
<6	-	<i>Thinly Laminated</i>

Terminology describing rock strength:

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

Terminology describing rock weathering:

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



CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-01

LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON

PROJECT No. 122410935

DATES: BORING February 4, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m 10 20 30 40 50 60 70 80 90									
0	67.57																	
1	67.5	50 mm ASPHALT																
		FILL: Brown sand with gravel trace silt																
1	66.4	FILL: Brown silt with sand			SS	1	600	81										
2	65.4	FILL: Dark brown silty sand			SS	2	600	29										
3					SS	3	600	6										
4	63.9	Compact brown silty sand (SM) with gravel TILL			SS	4	600	5										
5					SS	5	600	16										
6	62.3	Fair to good quality black calcareous SHALE (refer to field bedrock core log)			SS	6	300	Refusal										
7					NQ	7	94%	69%										
8					NQ	8	95%	58%										
9	58.8	Fair to good quality black calcareous SHALE interbedded with medium grey LIMESTONE and SILTSTONE (refer to field bedrock core log)			NQ	9	100%	87%										
10					NQ	10	97%	62%										
11					NQ	11	100%	88%										
12																		

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe

Field Vane Test, kPa
 Remoulded Vane Test, kPa App'd _____
 Pocket Penetrometer Test, kPa Date _____

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. _____ BH13-01

LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON

PROJECT No. 122410935

DATE: BORING February 4, 2013 WATER LEVEL

DATUM _____ Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD	WATER CONTENT & ATTERBERG LIMITS									
									<div><div><div>50100150200</div><div><div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><div></div><div></div><div></div></div></div><div><div><div></div><div></div><div></div></div><div><div><d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Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc. Project No.: 122410935
Project: Proposed Gas Main Replacement - Highway 417 and Innes Road Date: April 30, 2013
Contractor: - Borehole No.: BH13-01
Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
5.26	NQ-7	94%	69%	5.66	Non-calcareous to slightly calcareous, fossiliferous black shale		U	1	B	F	C	RP	-	T	Mohs Hardness: H<3
5.66	NQ-8	95%	58%	7.24	Non-calcareous to slightly calcareous, fossiliferous black shale		U	1	B	F	VC-C	SP/RP	-	T	Mohs Hardness: H<3
7.24	NQ-9	100%	87%	8.76	Non-calcareous to slightly calcareous, fossiliferous black shale	VS	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
8.76	NQ-10	97%	62%	10.29	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey limestone and siltstone 10-60 mm thick		U	2	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
									J	V	-	SP	-	T	

STRENGTH (MPa)
EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

DISCONTINUITY TYPE
B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

SPACING
VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

ORIENTATION
F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

FILLING
T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay



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								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
10.29	NQ-11	100%	88%	11.81	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of siltstone and limestone 10-20 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
11.81	NQ-12	97%	82%	13.33	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of siltstone and limestone 10-70 mm thick		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
13.34	NQ-13	100%	83%	14.86	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of siltstone and limestone 20-60 mm thick	S	U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
14.86	NQ-14	100%	92%	16.38	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of siltstone and limestone 10-100 mm thick		U	2	B	F	C-M	SP	-	T	Mohs Hardness: H<3

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BOREHOLE RECORD

N: 5 029 084 E: 452 239

BH13-02

1 of 2

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-02

LOCATION Highway 417 and Innes Road - Gas Main Replacement, Ottawa, ON

PROJECT No. 122410935

DATES: BORING February 13, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR QD	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m 10 20 30 40 50 60 70 80 90									
0	65.85																	
	65.7	110 mm TOPSOIL																
1		FILL: Brown silty sand with gravel			SS	1	600	12										
2					SS	2	600	12										
	63.7	Compact brown silt (ML)			SS	3	600	10										
3					SS	4	600	6										
	62.9	Loose brown silty sand (SM) TILL			SS	5	600	5										
4					SS	6	200	Refusal										
5		Fair to good quality black non-calcareous SHALE interbedded with medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	7	98%	69%										
6					NQ	8	98%	69%										
7					NQ	9	100%	85%										
8					NQ	10	100%	92%										
9					NQ	11	98%	96%										
10																		
11																		
12																		
	61.2																	
	56.5	Excellent quality black non-calcareous SHALE interbedded with medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)																

▽ Inferred Groundwater Level
 ▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa
 □ Remoulded Vane Test, kPa App'd _____
 ▲ Pocket Penetrometer Test, kPa Date _____

DATUM _____ Geodetic



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Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc. **Project No.:** 122410935
Project: Proposed Gas Main Replacement - Highway 417 and Innes Road **Date:** April 30, 2013
Contractor: **Borehole No.:** BH13-02
Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
4.67	NQ-7	98%	69%	6.27	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-40 mm thick		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
6.27	NQ-8	98%	69%	7.85	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-30 mm thick	S	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
7.85	NQ-9	100%	85%	9.37	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-50 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
9.37	NQ-10	100%	92%	10.90	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-70 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3

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Project: Proposed Gas Main Replacement - Highway 417 and Innes Road Date: April 30, 2013
Contractor: Borehole No.: BH13-02
Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% ROD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
10.90	NQ-11	98%	96%	12.42	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-50 mm thick		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
12.42	NQ-12	100%	91%	13.94	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-60 mm thick	VS	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
13.94	NQ-13	98%	92%	15.47	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-70 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
15.47	NQ-14	96%	96%	16.99	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-30 mm thick		U	1	B	F	C-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)
EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

SPACING
VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

DISCONTINUITY TYPE
B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

ORIENTATION
F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING
T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
SI = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay



Client: Enbridge Gas Distribution Inc.

Client: Enbridge Gas Distribution Inc.

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Date: April 30, 2013Borehole No.: BH13-02

HS

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE		
16.99	NQ-15	100%	90%	18.52	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-30 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
18.52	NQ-16	100%	93%	20.04	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-70 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)

EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

VW = Very Weak = 1-5
EW = Extremely Weak = < 1

WEATHERING

U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Silty, Minor Clay
NC = Non-swelling Clay
SC = Swelling, Soft Clay

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-03

LOCATION Highway 417 and Innes Road - Gas Main Replacement, Ottawa, ON

PROJECT No. 122410935

DATES: BORING February 6, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa	
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR ROD	50	100
0	63.76									
0.75	63.7	75 mm TOPSOIL								
1.0		FILL: Brown gravelly sand trace silt			SS	1	600	16		
2.0	61.6				SS	2	600	4		
2.5		Loose brown silty sand (SM) TILL			SS	3	600	6		
3.5					SS	4	600	6		
4.5	59.4				SS	5	500	Refusal		
5.0		Fair to good quality black non-calcareous to slightly calcareous SHALE interbedded with medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	6	87%	37%		
6.5					NQ	7	94%	57%		
7.5					NQ	8	90%	75%		
8.5					NQ	9	98%	73%		
9.5					NQ	10	100%	68%		
10.5					NQ	11	100%	84%		

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

Field Vane Test, kPa

Remoulded Vane Test, kPa

Pocket Penetrometer Test, kPa

App'd _____

Date _____

DATUM _____ Geodetic



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc. Project No.: 122410935
Project: Proposed Gas Main Replacement - Highway 417 and Innes Road Date: May 1, 2013
Contractor: Borehole No.: BH13-03
Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	NO. OF SETS	DISCONTINUITIES					OCCASIONAL FEATURES	DRILLING OBSERVATIONS
									TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
4.39	NQ-6	87%	37%	4.78	Non-calcareous to slightly calcareous, fossiliferous black shale		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
4.78	NQ-7	94%	57%	6.30	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-40 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
6.30	NQ-8	90%	75%	7.82	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-20 mm thick	S	U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
7.82	NQ-9	98%	73%	9.35	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-40 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)

EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING

U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

SPACING

VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc.

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Contractor:

Project No.: 122410935

Date: May 1, 2013

Borehole No.: BH13-03

Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
9.35	NQ-10	100%	68%	10.87	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-50 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
10.87	NQ-11	100%	84%	12.40	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-60 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
12.40	NQ-12	100%	85%	13.92	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-60 mm thick	S	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
13.92	NQ-13	92%	80%	15.44	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-50 mm thick		U	3	B J J	F D V	C-M VC-C -	SP SP SP	- - -	T T T	Mohs Hardness: H<3

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DISCONTINUITY TYPE

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J = Cross Joint
F = Fault
S = Shear Plane

SPACING

VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ORIENTATION

F = Flat = 0-20°
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Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc.

Project No.: 122410935

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Date: May 1, 2013

Contractor:

Borehole No.: BH13-03

Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
15.44	NQ-14	100%	60%	16.97	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-50 mm thick		U	2	B J	F V	VC-M -	SP SP	- -	T T	Mohs Hardness: H<3
16.97	NQ-15	100%	98%	18.49	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-60 mm thick		U	2	B J	F D	C-W -	SP SP	- -	T T	Mohs Hardness: H<3
18.49	NQ-16	100%	88%	20.02	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-40 mm thick		U	2	B J	F D	C-M -	SP SP	- -	T T	Mohs Hardness: H<3

STRENGTH (MPa)

EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING

U = Unweathered = No Signs
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M = Moderately = Discoloured
H = Highly = Friable
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DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

ORIENTATION

F = Flat = 0-20°
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V = n-Vertical = >50°

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O = Oxidized
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VC = Very Close = <5 cm

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-04

LOCATION Highway 417 and Innes Road - Gas Main Replacement, Ottawa, ON

PROJECT No. 122410935

DATES: BORING February 5, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR QD	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m 10 20 30 40 50 60 70 80 90									
0	66.60																	
	66.6	50 mm TOPSOIL																
		FILL: Brown sand with gravel trace silt																
1	65.4				SS	1	600	57										
		FILL: Grey silty sand trace gravel																
2					SS	2	600	6										
					SS	3	600	8										
3	63.7																	
	63.5	FILL: Grey silt and sand			SS	4	600											
		FILL: Brown silty sand with gravel some clay																
4					SS	5	600	61										
5					SS	6	600	19										
	60.9				SS	7	600	8										
6		FILL: Brown sand some silt trace organics																
					SS	8	600	42										
7	59.9																	
	59.1	Compact brown well graded sand (SW-SM) with silt TILL			SS	9	600	18										
8	58.6	Compact brown silty sand (SM) with gravel TILL			SS	10	300	Refusal										
		Poor to fair quality black non-calcareous to slightly calcareous SHALE interbedded with medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	11	80%	28%										
9																		
					NQ	12	95%	48%										
10																		
11					NQ	13	97%	70%										
12																		

▽ Inferred Groundwater Level
 ▼ Groundwater Level Measured in Standpipe

☐ Field Vane Test, kPa
☐ Remoulded Vane Test, kPa App'd _____
☐ Pocket Penetrometer Test, kPa Date _____

DATUM _____ Geodetic



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc. Project No.: 122410935
 Project: Proposed Gas Main Replacement - Highway 417 and Innes Road Date: April 30, 2013
 Contractor: - Borehole No.: BH13-04
 Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
7.98	NQ-11	80%	28%	8.74	Non-calcareous to slightly calcareous, fossiliferous black shale		U	1	B	F	VC-C	SP/SU	-	T	medium grey siltstone bed 10 mm thick Mohs Hardness: H<3
8.74	NQ-12	95%	48%	10.26	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-20 mm thick	S	U	2	B J	F D	VC-C VC0C	SP SP	- -	T T	Mohs Hardness: H<3
10.26	NQ-13	97%	70%	11.79	Non-calcareous to slightly calcareous, fossiliferous black shale with subordinate interbeds of medium grey siltstone and limestone 10-50 mm thick		U	2	B J	F D-V	VC-C C	SP SP	- -	T T	Mohs Hardness: H<3
11.79	NQ-14	100%	73%	13.31	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-40 mm thick		U	2	B J	F D	C-M VC-M	SP SP	- -	T T	Mohs Hardness: H<3

STRENGTH (MPa)

EH = Extremely Strong = > 250
 VS = Very Strong = 100-250
 S = Strong = 50-100
 MS = Medium Strong = 25-50
 W = Weak = 5 - 25

WEATHERING

U = Unweathered = No Signs
 S = Slightly = Oxidized
 M = Moderately = Discoloured
 H = Highly = Friable
 C = Completely = Soil-like

DISCONTINUITY TYPE

B = Bedding Joint
 J = Cross Joint
 F = Fault
 S = Shear Plane

ORIENTATION

F = Flat = 0-20°
 D = Dipping = 20-50°
 V = n-Vertical = >50°

FILLING

T = Tight, Hard
 O = Oxidized
 SA = Slightly Altered, Clay Free
 S = Sandy, Clay Free
 Si = Sandy, Silty, Minor Clay
 NC = Non-softening Clay
 SC = Swelling, Soft Clay

SPACING

VW = Very Wide = >3m
 W = Wide = 1-3 m
 M = Moderate = 0.3-1 m
 C = Close = 5-30 cm
 VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
 RP = Rough Planar
 SU = Smooth Undulating
 SP = Smooth Planar
 LU = Slickensided Undulating
 LP = Slickensided Planar



Client: Enbridge Gas Distribution Inc.

Client: Enbridge Gas Distribution Inc.

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Date: April 30, 2013

Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
13.31	NQ-15	100%	82%	14.83	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-40 mm thick		U	1	B	F	VC-M	SP	-	T		Mohs Hardness: H<3
14.83	NQ-16	100%	59%	16.36	Non-calcareous to slightly calcareous, fossiliferous black shale with interbeds of medium grey siltstone and limestone 10-90 mm thick	VS	U	2	B	F	VC-M	SP	-	T	40 mm thick clay seam at 15.6 m / vertical fracture at 15.8 m	Mohs Hardness: H<3

STRENGTH (MPa)

EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

ORIENTATION

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D = Dipping = 20-50°
V = n-Vertical = >50°

FILLING

T = Tight, Hard
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WEATHERING

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SPACING

VW = Very Wide = >3m
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M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
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SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-S1

LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON

PROJECT No. 122410935

DATES: BORING May 27/June 13, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m 10 20 30 40 50 60 70 80 90									
0	68.40																	
	68.3	60 mm ASPHALT			BS	1	-	-										
		FILL: greyish-brown silty sand with gravel																
1					SS	2	400	27										
	66.7																	
2		FILL: brown to blue sand with gravel and silty clay			SS	3	300	4										
		-rock fragments (2.3 to 2.9 m)																
					SS	4	300	33										
3																		
		-occasional cobbles (3.1 to 3.7 m)			SS	5	600	18										
4																		
					SS	6	500	18										
5																		
		-occasional cobbles (5.3 to 6.7 m)			SS	7	450	28										
6																		
		-rock fragments (6.5 to 6.7 m)			SS	8	550	11										
7	61.6																	
		Compact brown to blue silty gravel (GM) with sand TILL			SS	10	300	12										
	60.8																	
		-trace clay and rock fragments																
8					NQ	12	100%	31%										
		Poor to fair quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)																
9					NQ	13	98%	55%										
10	58.5																	
		Good to excellent quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	14	93%	80%										
11																		
12																		

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

App'd _____

△ Pocket Penetrometer Test, kPa

Date _____

CLIENT Enbridge Gas Distribution Inc. BOREHOLE No. BH13-S1
 LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON PROJECT No. 122410935
 DATES: BORING May 27/June 13, 2013 WATER LEVEL _____ DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa	
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD	50	100
									WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m	
									10 20 30 40 50 60 70 80 90 W _p W W _L	
-12		Good to excellent quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log) (Cont.)			NQ	15	100%	78%		
-13					NQ	16	100%	77%		
-14										
-15					NQ	17	96%	91%		
-16										
-17					NQ	18	100%	73%		
-18										
-19		-5 mm thick clay seam at 18.85 m			NQ	19	100%	95%		
-20					NQ	20	98%	95%		
-21										
-22	46.3	-25 mm thick clay seam at 22.02 m			NQ	21	100%	73%		
-23		End of Borehole								
-24										

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

☐ Field Vane Test, kPa

☐ Remoulded Vane Test, kPa App'd _____

☐ Pocket Penetrometer Test, kPa Date _____



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc.

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Contractor: George Downing Estate Drilling Ltd.

Project No.: 122410935

Date: June 25, 2013

Borehole No.: BH13-S1

Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
7.57	NQ-12	100%	31%	8.38	Black fossiliferous shale		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
8.38	NQ-13	98%	55%	9.91	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-50 mm thick		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
9.91	NQ-14	93%	80%	11.43	Black fossiliferous shale with interbeds of grey siltstone and limestone 5-10 mm thick		U	2	B J	F V	VC-M -	SP RP	- -	T	Mohs Hardness: H<3
11.43	NQ-15	100%	78%	12.95	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-60 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)
EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

DISCONTINUITY TYPE
B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

SPACING
VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

ORIENTATION
F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

FILLING
T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
SI = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc.

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Contractor: George Downing Estate Drilling Ltd.

Project No.: 122410935

Date: June 25, 2013

Borehole No.: BH13-S1

Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
12.95	NQ-16	100%	77%	14.48	Black fossiliferous shale with interbeds of grey siltstone and limestone 5-150 mm thick	VS	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
14.48	NQ-17	96%	91%	16.00	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-50 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
16.00	NQ-18	100%	73%	17.53	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-50 mm thick		U	2	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
17.53	NQ-19	100%	95%	19.05	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-50 mm thick	S	U	1	B	F	C-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)
EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
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SPACING
VW = Very Wide = >3m
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DISCONTINUITY TYPE
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ROUGHNESS
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RP = Rough Planar
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LP = Slickensided Planar



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc.

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Contractor: George Downing Estate Drilling Ltd.

Project No.: 122410935

Date: June 25, 2013

Borehole No.: BH13-S1

Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
19.05	NQ-20	98%	95%	20.57	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-60 mm thick		U	1	B	F	VC-M	SP	-	T-SC	5 mm thick clay seam at 18.85 m	Mohs Hardness: H<3
20.57	NQ-21	100%	73%	22.10	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-40 mm thick	S	U	1	B	F	C-M	SP	-	T-SC	25 mm thick clay seam at 20.02 m	Mohs Hardness: H<3

STRENGTH (MPa)

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VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25
VW = Very Weak = 1-5
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O = Oxidized
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SC = Swelling, Soft Clay

ROUGHNESS

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RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar
RW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-S2

LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON

PROJECT No. 122410935

DATES: BORING June 18, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m 10 20 30 40 50 60 70 80 90									
0	63.63	FILL: Silty clayey sand with gravel			SS	1	500	13										
1					SS	2	450	25										
2					SS	3	450	21										
3	61.2	Compact brown to grey silty sand (SM) TILL			SS	4	450	10										
4					SS	5	400	16										
5	59.2	-gravelly and with occasional rock fragments (3.8 to 4.4 m)			SS	6	600	21										
6		Very poor to poor quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	7	87%	0%										
7					NQ	8	98%	44%										
8	57.5	Good to excellent quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	9	100%	90%										
9					NQ	10	96%	85%										
10					NQ	11	100%	86%										
11					NQ	12	100%	78%										
12																		

▽ Inferred Groundwater Level
▼ Groundwater Level Measured in Standpipe

☐ Field Vane Test, kPa
☐ Remoulded Vane Test, kPa App'd _____
☐ Pocket Penetrometer Test, kPa Date _____

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-S2


LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON


PROJECT No. 122410935

DATES: BORING June 18, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa	
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD	50	100
									WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m	
									10 20 30 40 50 60 70 80 90 W _p W W _L	
-12		Good to excellent quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log) (Cont.)			NQ	13	100%	90%		
-13					NQ	14	98%	97%		
-14										
-15	48.5	End of Borehole								
-16										
-17										
-18										
-19										
-20										
-21										
-22										
-23										
-24										

 Inferred Groundwater Level

 Groundwater Level Measured in Standpipe

☐ Field Vane Test, kPa

☐ Remoulded Vane Test, kPa App'd _____

☐ Pocket Penetrometer Test, kPa Date _____



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc.

Project: Proposed Gas Main Replacement - Highway 417 and Innes Road

Contractor: George Downing Estate Drilling Ltd.

Project No.: 122410935

Date: June 25, 2013

Borehole No.: BH13-S2

Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
4.42	NQ-7	87%	0%	4.62	Black fossiliferous shale		U	0							Mohs Hardness: H<3
4.62	NQ-8	98%	44%	6.12	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-60 mm thick		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
6.12	NQ-9	100%	90%	7.62	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-40 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
7.62	NQ-10	96%	85%	9.12	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-70 mm thick		U	1	B	F	C-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)
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S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

DISCONTINUITY TYPE
B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

SPACING
VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

ORIENTATION
F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

FILLING
T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc. **Project No.:** 122410935
Project: Proposed Gas Main Replacement - Highway 417 and Innes Road **Date:** June 25, 2013
Contractor: George Downing Estate Drilling Ltd. **Borehole No.:** BH13-S2
Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
9.12	NQ-11	100%	86%	10.64	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-60 mm thick	S	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
10.64	NQ-12	100%	78%	12.14	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-60 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
12.14	NQ-13	100%	90%	13.64	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-150 mm thick	VS	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
13.64	NQ-14	98%	97%	15.14	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-30 mm thick		U	1	B	F	C-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)

EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25
VW = Very Weak = 1-5
EW = Extremely Weak = < 1

WEATHERING

U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

SPACING

VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-S3

LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON

PROJECT No. 122410935

DATES: BORING June 12/June 14, 2013 WATER LEVEL

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR QD	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS DYNAMIC PENETRATION TEST, BLOWS/0.3m STANDARD PENETRATION TEST, BLOWS/0.3m 10 20 30 40 50 60 70 80 90									
0	66.15																	
	66.1	60 mm ASPHALT			BS	1	-	-										
1		FILL: brown silty sand with gravel			SS	2	300	12										
2					SS	3	200	21										
	63.9	FILL: silty clayey sand with gravel and bedrock fragments			SS	4	200	12										
3					SS	5	200	11										
4					SS	6	400	31										
5					SS	7	350	14										
	60.9	Loose greyish blue silt (ML)			SS	8	300	8										
6		-wood fragments (6.1 to 6.5 m)			SS	9	450	7										
	59.6	Compact greyish-blue silty sand (SM) with gravel TILL			SS	10	300	50										
7		-occasional cobbles																
8		Poor to fair quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	11	86%	46%										
9					NQ	12	96%	65%										
10																		
	55.8	Good to excellent quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log)			NQ	13	96%	76%										
11																		
12																		

Inferred Groundwater Level
 Groundwater Level Measured in Standpipe

Field Vane Test, kPa
 Remoulded Vane Test, kPa App'd _____
 Pocket Penetrometer Test, kPa Date _____

CLIENT Enbridge Gas Distribution Inc.

BOREHOLE No. BH13-S3

LOCATION Highway 417 and Innes Road - Gas Main Replacemenet, Ottawa, ON

PROJECT No. 122410935

DATES: BORING June 12/June 14, 2013 WATER LEVEL _____

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES				UNDRAINED SHEAR STRENGTH - kPa									
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR QD	<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
12		Good to excellent quality black fossiliferous SHALE with interbeds of medium grey SILTSTONE and LIMESTONE (refer to field bedrock core log) (Cont.)			NQ	14	100%	96%	<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
13																		
14																		
15					NQ	15	100%	88%	<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
16					NQ	16	96%	88%	<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
17	49.7	End of Borehole							<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
18									<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
19									<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
20									<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
21									<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
22									<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
23									<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									
24									<div style="display: flex; justify-content: space-between;"> 50 100 150 200 </div> <div style="display: flex; justify-content: space-between;"> 10 20 30 40 50 60 70 80 90 </div>									

Inferred Groundwater Level

Groundwater Level Measured in Standpipe

☐ Field Vane Test, kPa

☐ Remoulded Vane Test, kPa App'd _____

☐ Pocket Penetrometer Test, kPa Date _____



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc. Project No.: 122410935
 Project: Proposed Gas Main Replacement - Highway 417 and Innes Road Date: June 25, 2013
 Contractor: George Downing Estate Drilling Ltd. Borehole No.: BH13-S3
 Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE		
7.34	NQ-11	86%	46%	8.81	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-20 mm thick		U	1	B	F	VC-C	SP	-	T	Mohs Hardness: H<3
8.81	NQ-12	96%	65%	10.34	Black fossiliferous shale with interbeds of grey siltstone and limestone 10 mm thick	S	U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
10.34	NQ-13	96%	76%	11.86	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-50 mm thick		U	1	B	F	VC-M	SP	-	T	Mohs Hardness: H<3
11.86	NQ-14	100%	96%	13.39	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-60 mm thick	S	U	1	B	F	C-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)

EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

WEATHERING

U = Unweathered = No Signs
S = Slightly = Oxidized
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C = Completely = Soil-like

SPACING

VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
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Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
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 S = Shear Plane

ORIENTATION

F = Flat = 0-20°
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 V = n-Vertical = >50°

FILLING

T = Tight, Hard
 O = Oxidized
 SA = Slightly Altered, Clay Free
 S = Sandy, Clay Free
 Si = Sandy, Silty, Minor Clay
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ROUGHNESS

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 SU = Smooth Undulating
 SP = Smooth Planar
 LU = Slickensided Undulating
 LP = Slickensided Planar

SPACING

VW = Very Wide = >3m
 W = Wide = 1-3 m
 M = Moderate = 0.3-1 m
 C = Close = 5-30 cm
 VC = Very Close = <5 cm



Stantec

Field Bedrock Core Log

Client: Enbridge Gas Distribution Inc. **Project No.:** 122410935
Project: Proposed Gas Main Replacement - Highway 417 and Innes Road **Date:** June 25, 2013
Contractor: George Downing Estate Drilling Ltd. **Borehole No.:** BH13-S3
Logger: SH

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	NO. OF SETS	DISCONTINUITIES					OCCASIONAL FEATURES	DRILLING OBSERVATIONS
									TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
13.39	NQ-15	100%	88%	14.91	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-50 mm thick		U	2	B J	F V	VC-M -	SP SP	- -	T T	Mohs Hardness: H<3
14.91	NQ-16	96%	88%	16.43	Black fossiliferous shale with interbeds of grey siltstone and limestone 10-30 mm thick	S	U	1	B	F	C-M	SP	-	T	Mohs Hardness: H<3

STRENGTH (MPa)
EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

DISCONTINUITY TYPE
B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

SPACING
VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

ORIENTATION
F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

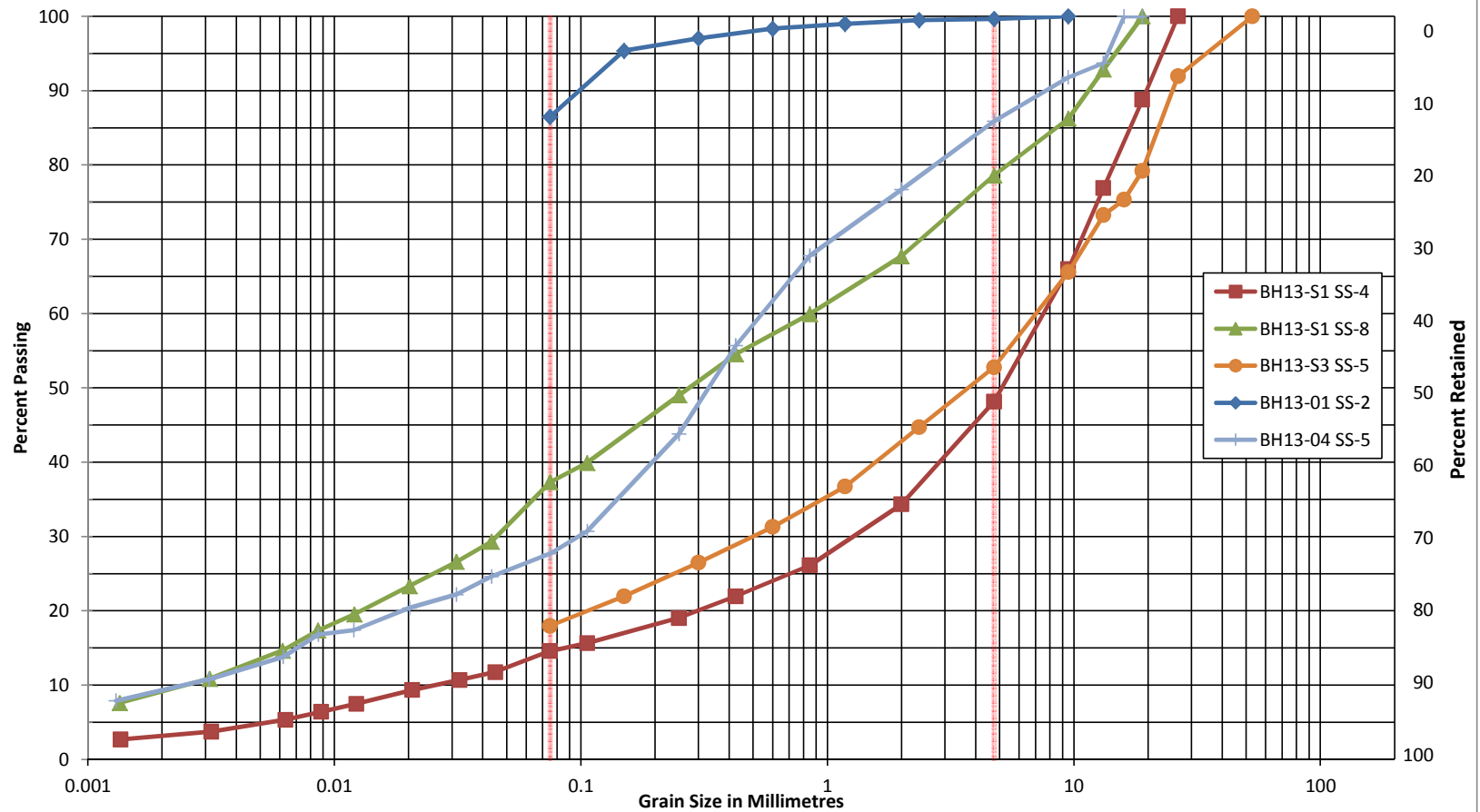
FILLING
T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

APPENDIX D

Laboratory Test Results

Unified Soil Classification System

	SAND			Gravel			
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse		
U.S. Std. Sieve No.	200	100	50	30	16	8	4



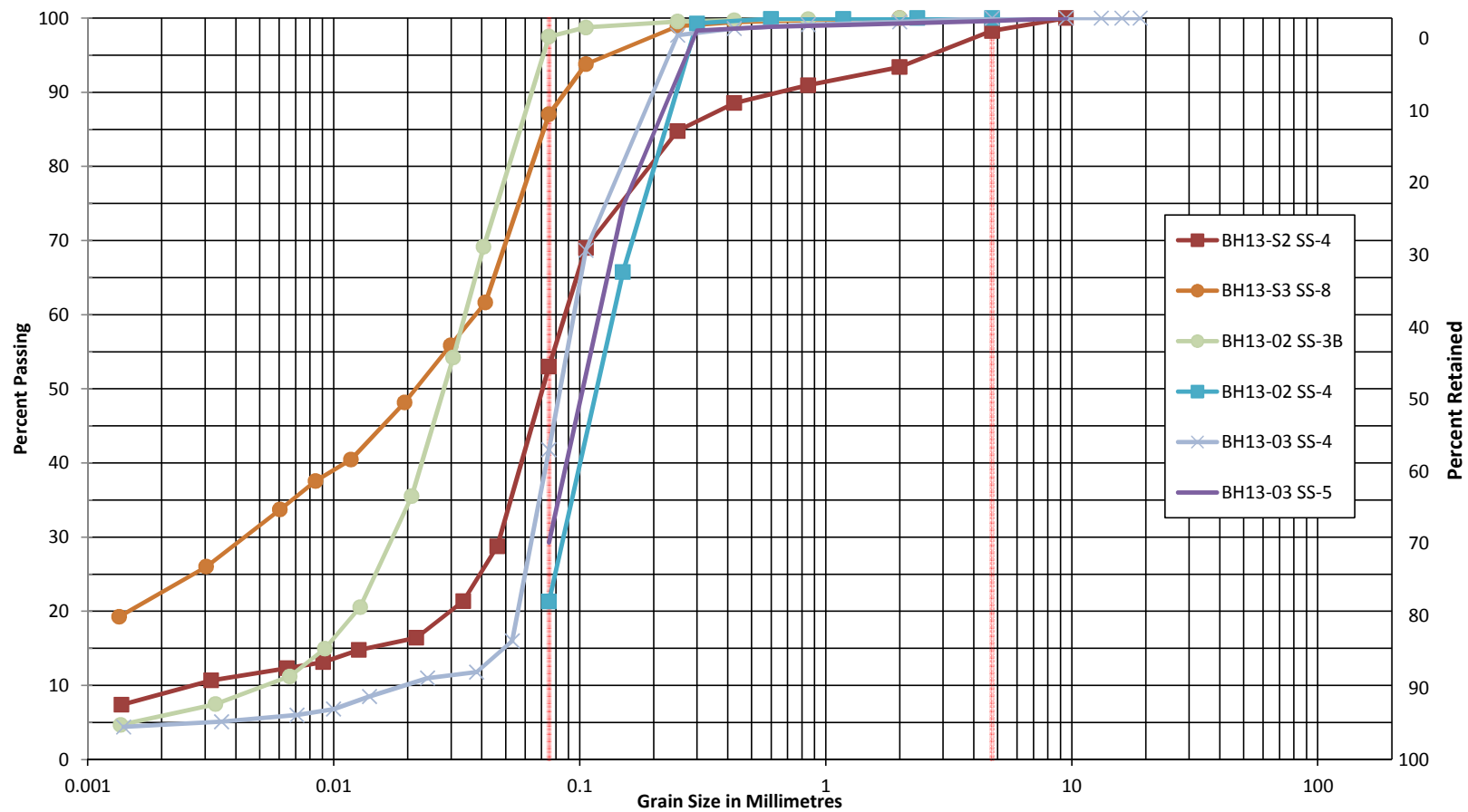
GRAIN SIZE DISTRIBUTION FILL

Figure No. 1

Project No. 122410935

Unified Soil Classification System

	SAND			Gravel			
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse		
U.S. Std. Sieve No.	200	100	50	30	16	8	4



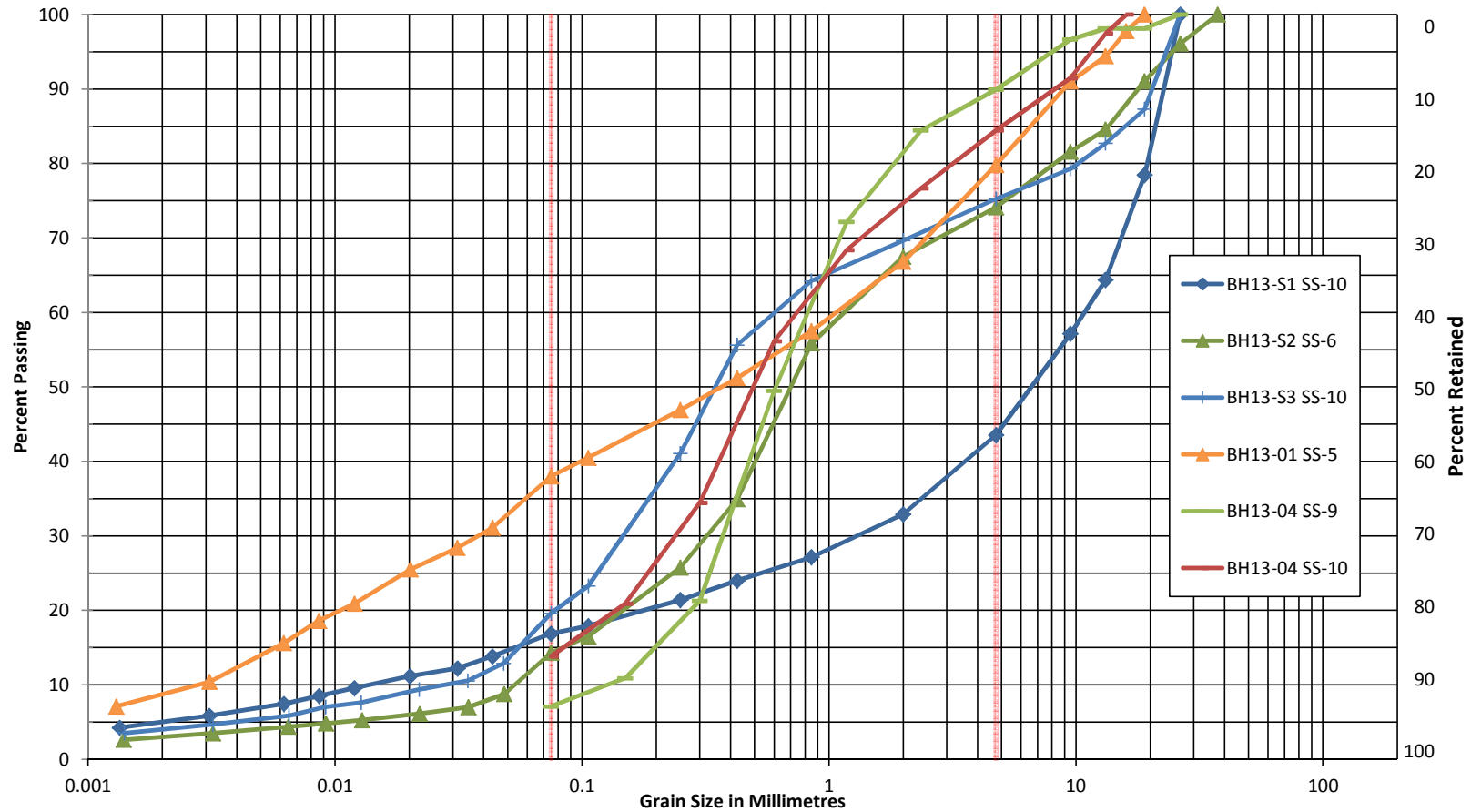
GRAIN SIZE DISTRIBUTION
Silty Sand and Sandy Silt TILL

Figure No. 2

Project No. 122410935

Unified Soil Classification System

	SAND			Gravel			
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse		
U.S. Std. Sieve No.	200	100	50	30	16	8	4



GRAIN SIZE DISTRIBUTION
Silty Sand with Gravel TILL

Figure No. 3

Project No. 122410935

APPENDIX E

Rock Core Photo



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

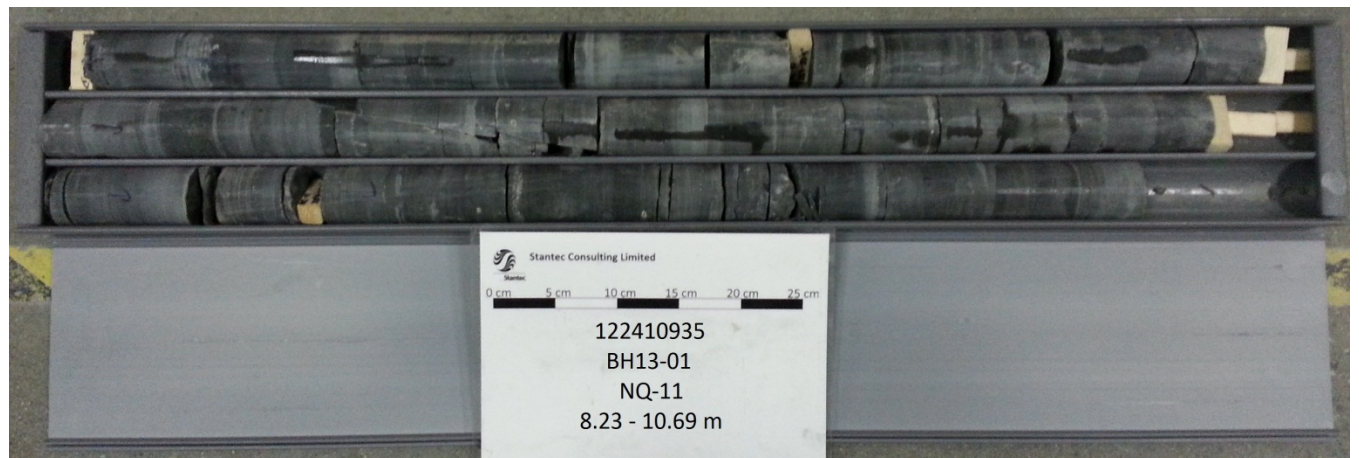
Rockcore
Photographs



Rock Core Photo No.: 1

Borehole: BH13-01 (AME Samples)

Depth: 5.26 – 8.23 m



Rock Core Photo No.: 2

Borehole: BH13-01 (AME Samples)

Depth: 8.23 – 10.69 m

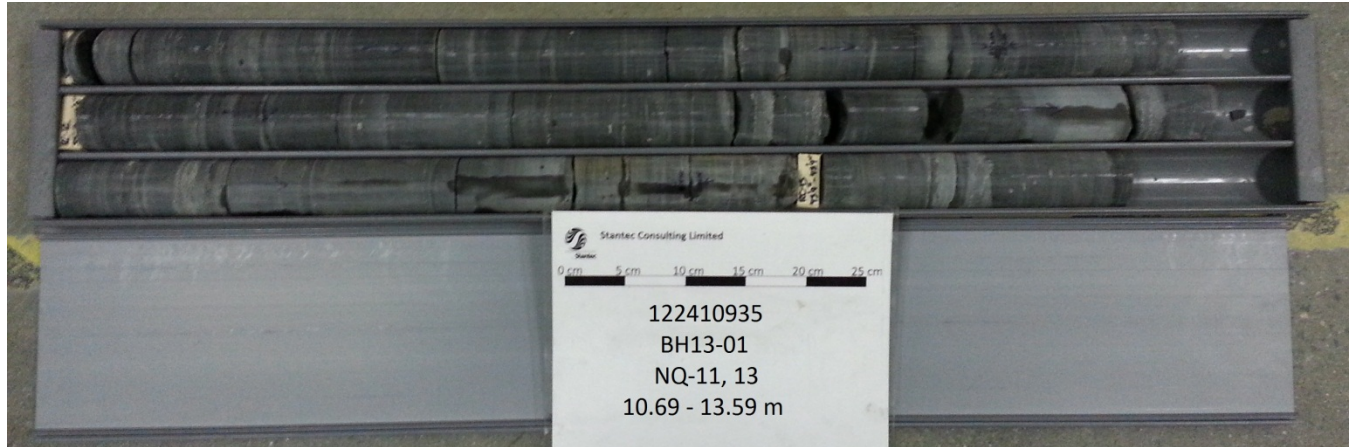


Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

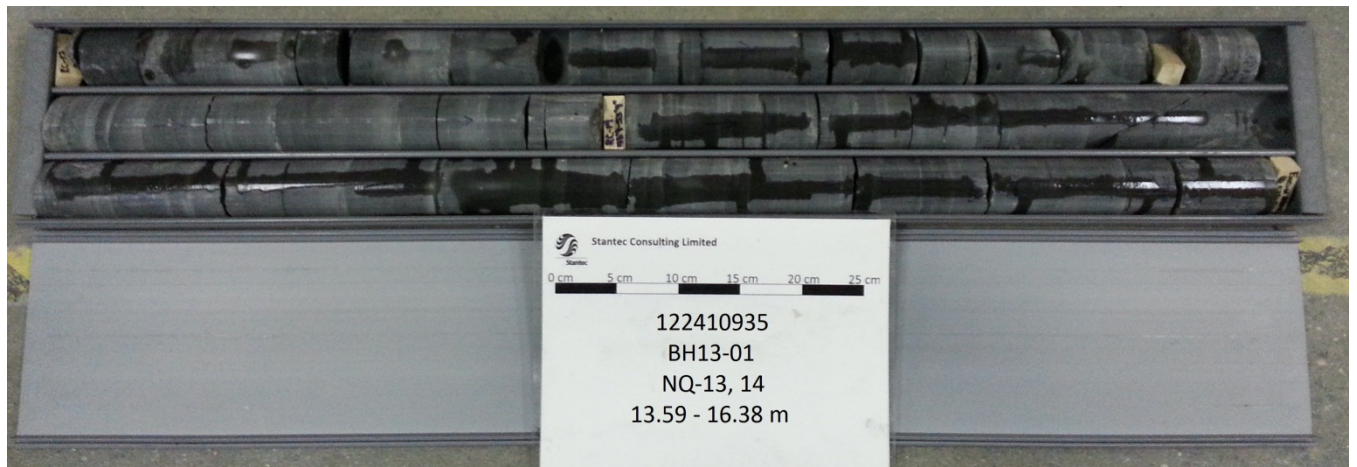
Rockcore
Photographs



Rock Core Photo No.: 3

Borehole: BH13-01 (AME Samples)

Depth: 10.69 – 13.59 m



Rock Core Photo No.: 4

Borehole: BH13-01 (AME Samples)

Depth: 13.59 – 16.38 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 5

Borehole: BH13-02 (AME Samples)

Depth: 4.67 – 7.44 m



Rock Core Photo No.: 6

Borehole: BH13-02 (AME Samples)

Depth: 7.44 – 10.24 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

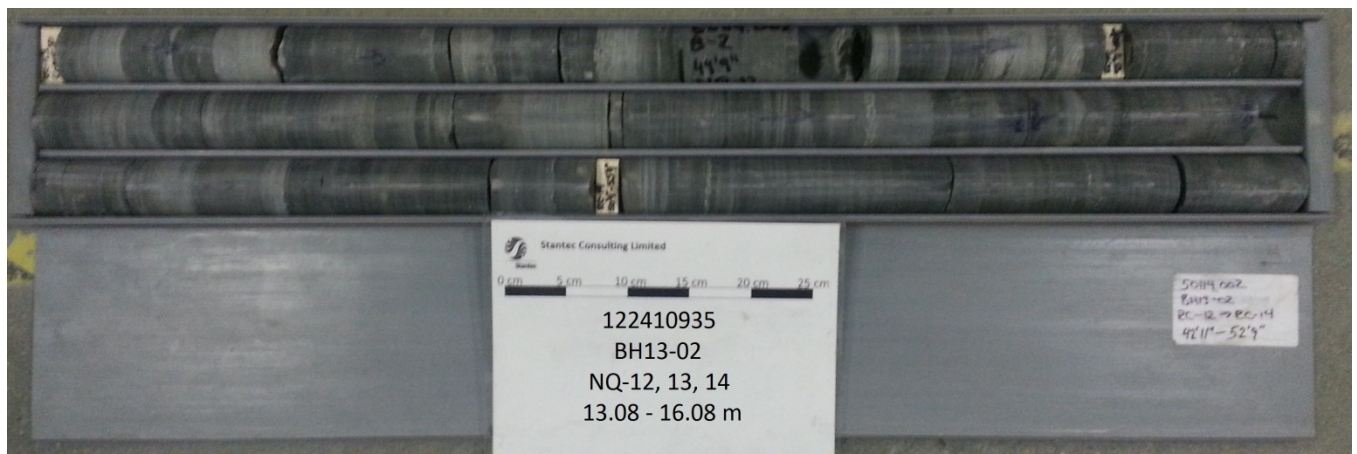
Rockcore
Photographs



Rock Core Photo No.: 7

Borehole: BH13-02 (AME Samples)

Depth: 10.24 – 13.08 m



Rock Core Photo No.: 8

Borehole: BH13-02 (AME Samples)

Depth: 13.08 – 16.08 m

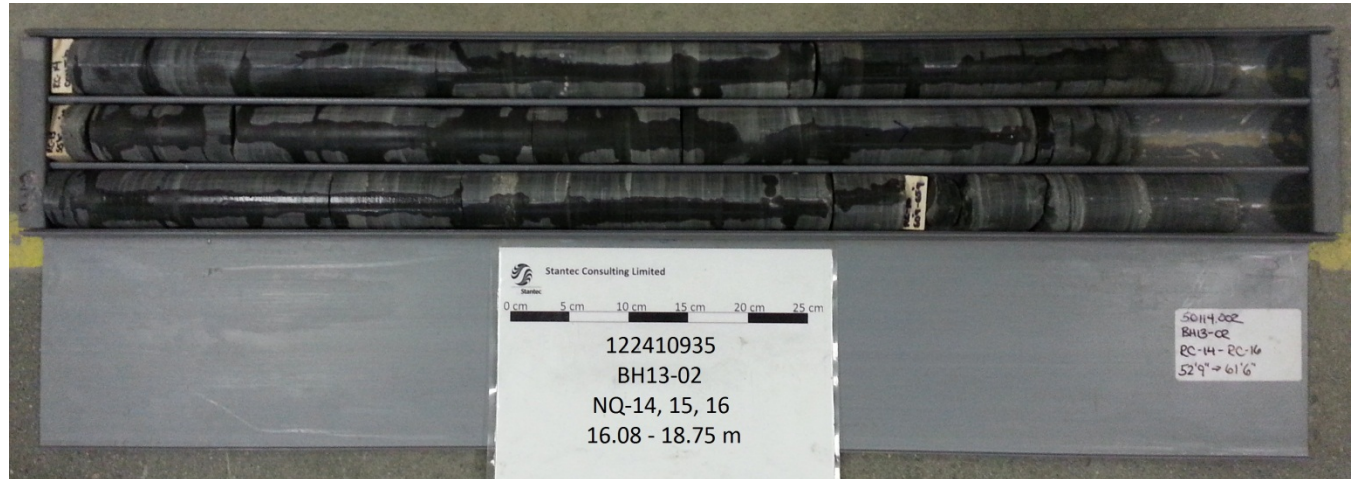


Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

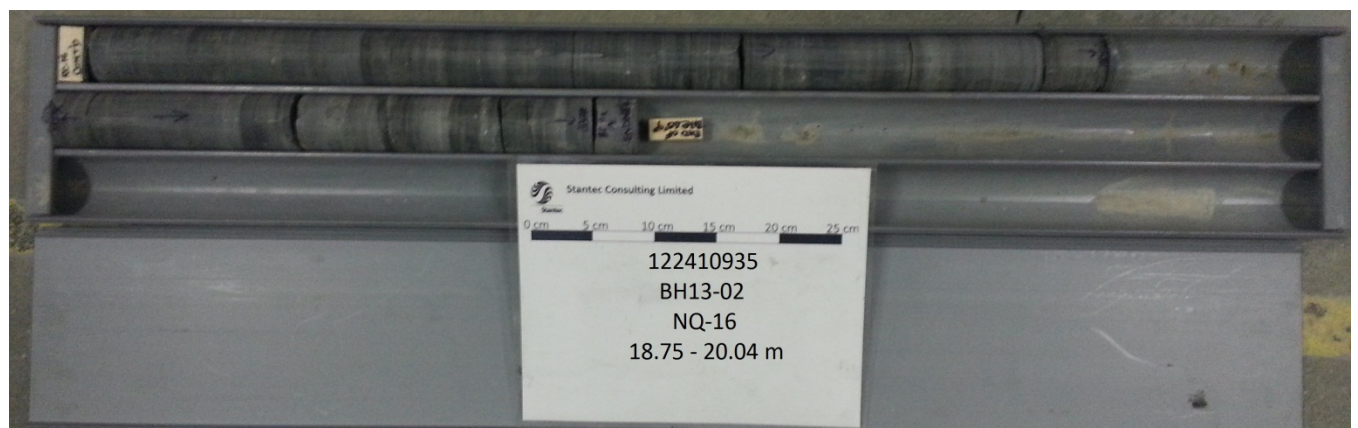
Rockcore
Photographs



Rock Core Photo No.: 9

Borehole: BH13-02 (AME Samples)

Depth: 16.08 – 18.75 m



Rock Core Photo No.: 10

Borehole: BH13-02 (AME Samples)

Depth: 18.75 – 20.04 m

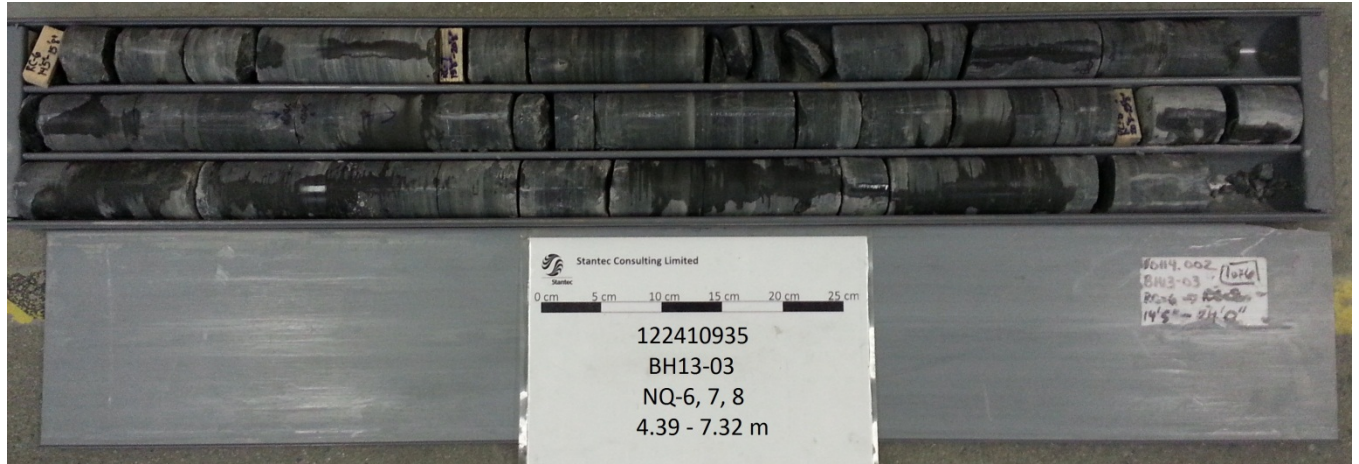


Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

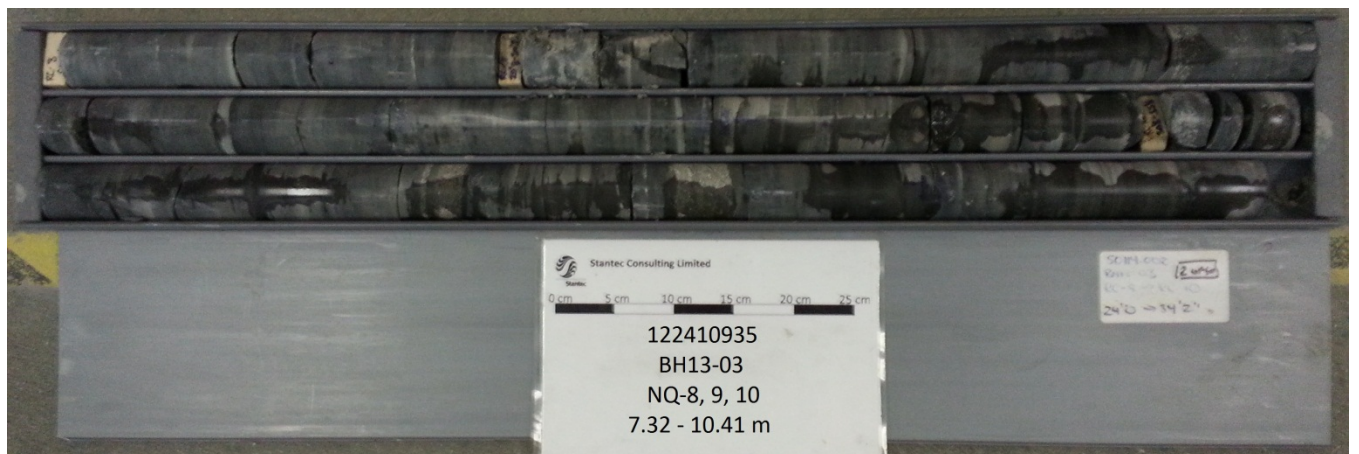
Rockcore
Photographs



Rock Core Photo No.: 11

Borehole: BH13-03 (AME Samples)

Depth: 4.39 – 7.32 m



Rock Core Photo No.: 12

Borehole: BH13-03 (AME Samples)

Depth: 7.32 – 10.41 m

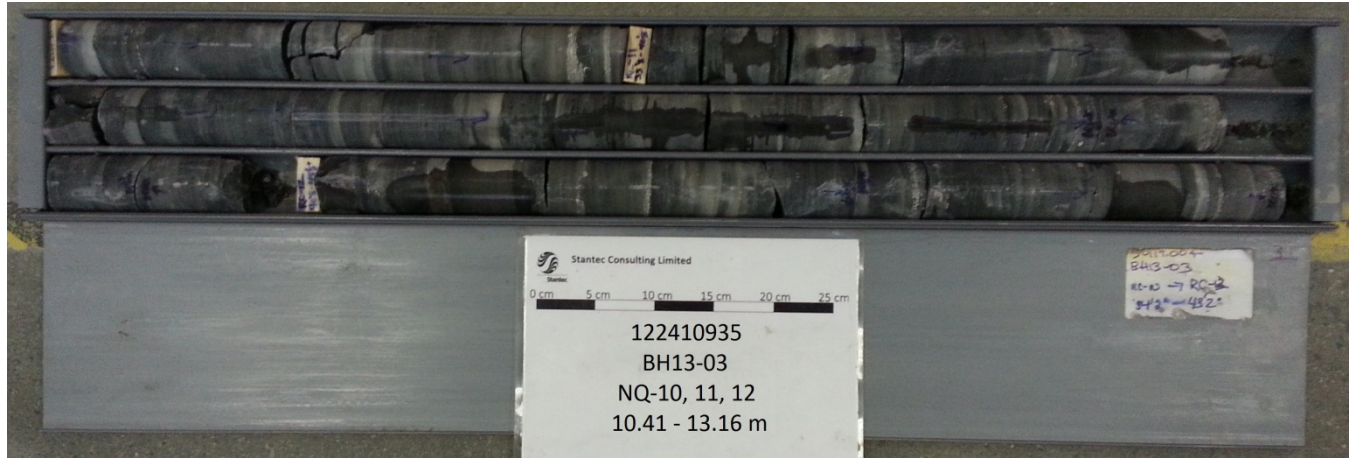


Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

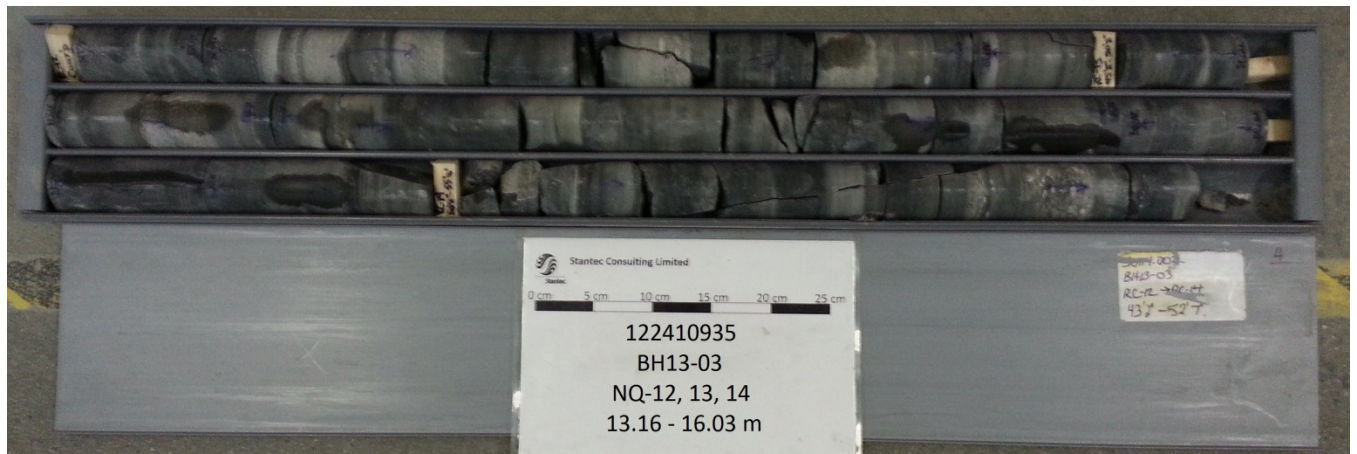
Rockcore
Photographs



Rock Core Photo No.: 13

Borehole: BH13-03 (AME Samples)

Depth: 10.41 – 13.16 m



Rock Core Photo No.: 14

Borehole: BH13-03 (AME Samples)

Depth: 13.16 – 16.03 m

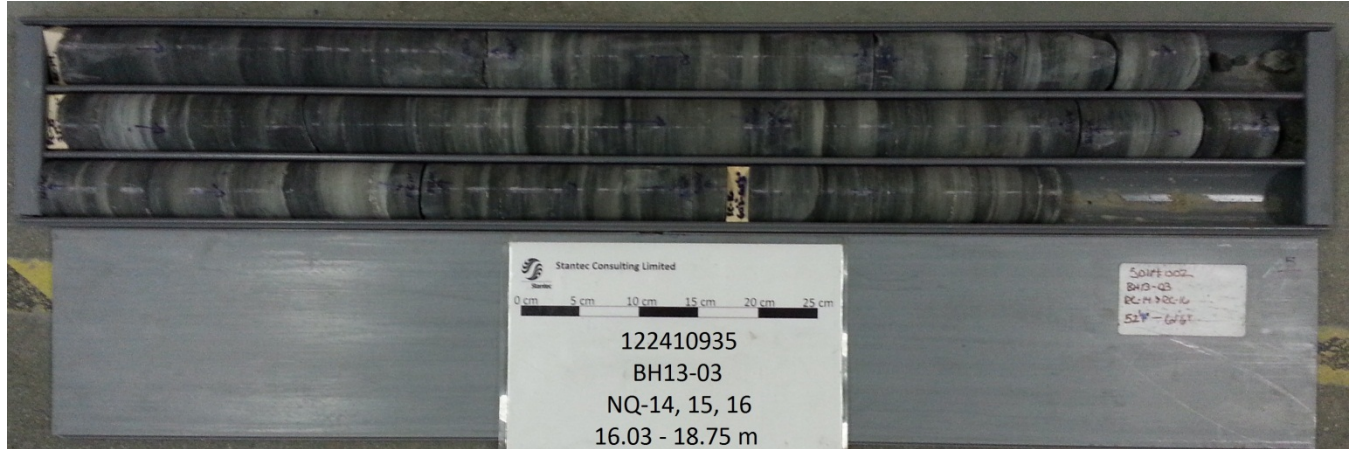


Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

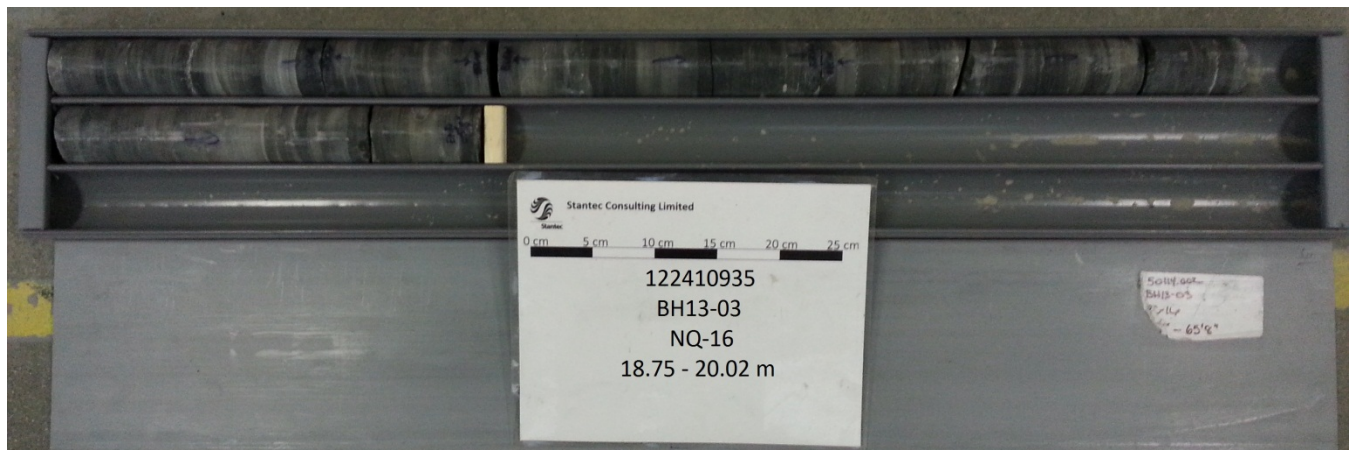
Rockcore
Photographs



Rock Core Photo No.: 15

Borehole: BH13-03 (AME Samples)

Depth: 16.03 – 18.75 m



Rock Core Photo No.: 16

Borehole: BH13-03 (AME Samples)

Depth: 18.75 – 20.02 m



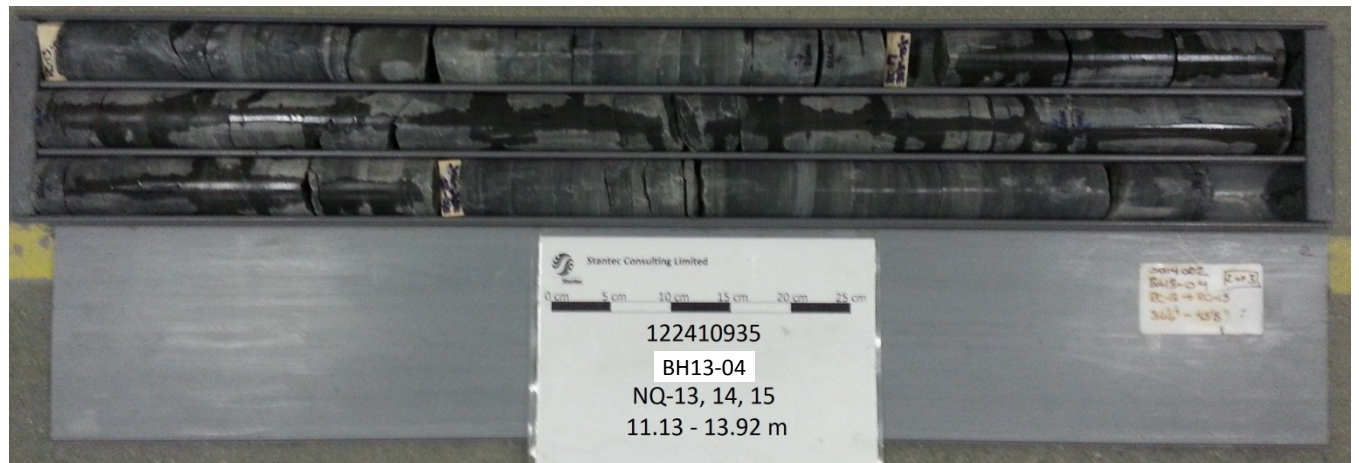
Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 17 Borehole: BH13-04 (AME Samples) Depth: 7.98 – 11.13 m



Rock Core Photo No.: 18 Borehole: BH13-04 (AME Samples) Depth: 11.13 – 13.92 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 19

Borehole: BH13-04 (AME Samples)

Depth: 13.92 – 16.36 m



Rock Core Photo No.: 20

Borehole: BH13-S1

Depth: 7.57 – 9.83 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 21

Borehole: BH13-S1

Depth: 9.83 – 11.99 m



Rock Core Photo No.: 22

Borehole: BH13-S1

Depth: 11.99 – 13.46 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 23

Borehole: BH13-S1

Depth: 13.46 – 15.37 m



Rock Core Photo No.: 24

Borehole: BH13-S1

Depth: 15.37 – 17.53 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 25

Borehole: BH13-S1

Depth: 17.53 – 19.48 m



Rock Core Photo No.: 26

Borehole: BH13-S1

Depth: 19.48 – 22.10 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 27

Borehole: BH13-S2

Depth: 4.42 – 9.12 m



Rock Core Photo No.: 28

Borehole: BH13-S2

Depth: 9.12 – 12.14 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 29

Borehole: BH13-S2

Depth: 12.14 – 15.14 m



Rock Core Photo No.: 30

Borehole: BH13-S3

Depth: 7.34 – 9.75 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 31

Borehole: BH13-S3

Depth: 9.75 – 11.86 m



Rock Core Photo No.: 32

Borehole: BH13-S3

Depth: 11.86 – 13.92 m



Stantec

Project No.: 122410935

Project Name: Hwy 417 at Innes Road

Rockcore
Photographs



Rock Core Photo No.: 33

Borehole: BH13-S3

Depth: 13.92 – 15.90 m



Rock Core Photo No.: 34

Borehole: BH13-S3

Depth: 15.90 – 16.43 m

APPENDIX F

Pipe Installation By Trenchless Method

GEOTECHNICAL INVESTIGATION

APPENDIX F - PIPE INSTALLATION BY TRENCHLESS METHOD

Non Standard Special Provision

July 2013

1. SCOPE

This specification covers the general requirements for the installation of pipes by trenchless methods for the Enbridge pipeline crossing located at Innes Road and Highway 417.

The Contractor is to determine the most appropriate method of installation. Specifications for Jack & Bore, Pipe Ramming, Directional Drilling, and Tunneling are provided herein, and are to be applied to the installation method recommended by the Contractor.

The following specifications is to not be used to do the work for the above tender item: OPSS 415 (Construction Specification for Pipeline and Utility Installation by Tunneling), OPSS 416 (Construction Specification for Pipeline and Utility Installation by Jacking and Boring), and OPSS 450 (Construction Specification for Pipeline and Utility Installation in Soil by Horizontal Directional Drilling).

2. REFERENCES

This specification refers to the following standards, specifications, or publications:

Geotechnical Investigation Report

Highway 417 and Innes Road Crossing
 Enbridge Pipeline Replacement
 Ottawa, ON
 Stantec Project No. 122410935

Instrumentation and Monitoring Plan for Horizontal Directional Drilling

Highway 417 and Innes Road Crossing
 Enbridge Pipeline Replacement
 Ottawa, ON
 Stantec Project No. 122410935

Ontario Provincial Standard Specifications, General

OPSS 180 Management and Disposal of Excess Material

Ontario Provincial Standard Specifications, Construction

OPSS 504 Preservation, Protection, and Reconstruction of Existing Facilities
 OPSS 507 Site Restoration Following Installation of Pipelines, Utilities and Associated Structures in Open Cut
 OPSS 514 Trenching, Backfilling, and Compaction
 OPSS 517 Dewatering of Pipeline, Utility, and Associated Structure Excavation
 OPSS 538 Support Systems
 OPSS 539 Protection Schemes

Ontario Provincial Standard Specifications, Material

OPSS 1004	Aggregates - Miscellaneous
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1802	Smooth Walled Steel Pipe

MTO Specifications

OPSS 1820	Material Specification for Circular Concrete Pipe
OPSS 1840	Material Specification for Non-Pressure Polyethylene Plastic Pipe Products

American Society for Testing and Materials (ASTM) International Standards

ASTM A252-93	Welding and Seamless Steel Pipe Piles
ASTM D2657-03	Standard Practice for Heat Fusion Joining of Polyelofin Pipe and Fittings
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM F894	Polyethylene Large Diameter Profile Wall Sewer and Drain Pipe

Canadian Standards Association Standards:

CSA B182.6	Profile Polyethylene Sewer Pipe and Fittings.
CAN/CSA A5-93	Portland Cement
CSA W59	Welded Steel Construction (Metal Arc Welding)

3. DEFINITIONS

For the purpose of this specification, the following definitions apply:

Back reamer: a cutting head suitably designed for the subsurface conditions that is attached to the end of a drill string to enlarge the pilot bore during a pullback operation.

Bore Path: a drilled path according to the grade and alignment tolerances specified in the Contract Documents.

Design Engineer: means the Engineer retained by the Contractor who produces the original design and working drawings. The design engineer is to be licensed to practice in the Province of Ontario.

Design Checking Engineer: means the Engineer retained by the Contractor who checks the original design and working drawings. The design checking engineer is to be licensed to practice in the Province of Ontario.

Digger Shield/Hand Mining: a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead while tunnelling advances using hand-mining (man-entry operation or “Jack and Mine) or a “digger” type shield with a hydraulic excavator arm to remove materials from inside the liner pipe.

Drilling Fluids: a mixture of water and additives, such as bentonite, polymers, surfactants, and soda ash, designed to block the pore space on a bore wall, reduce friction in the bore, and to suspend and carry cuttings to the surface.

Drilling Fluid Fracture or Frac Out: a condition where the drilling fluid's pressure in the bore is sufficient to overcome the in situ confining stress, thereby fracturing the soil and/or rock materials and allowing the drilling fluids to migrate to the surface at an unplanned location.

Engineer: a Professional Engineer licensed by the Professional Engineers of Ontario to practice in the Province of Ontario.

Excavation: includes all materials encountered regardless of type and extent. Excavation is to include removal of natural soil, large boulders, cobbles, wood and fill regardless of means necessary to break consolidated materials for removal.

Environmentally Sensitive Area (ESA): areas adjacent to construction that are off limits to the Contractor as specified elsewhere in the Contract.

Fill: man-made mixture of previously placed/handled materials such as sand, clay, silt, gravel, broken rock, sometimes containing organic and/or deleterious materials, placed in an excavation or other area to raise the surface elevation.

Grouting: injection of grout into voids.

Guidance System: an electronic system capable of locating the position, depth and orientation of the drill head during the directional drilling process.

Directional Drilling (DD): directional boring or guided boring.

HDPE: high density polyethylene.

Inadvertent Returns: the flow of unexpected fluids, saturated materials (or running soil) towards the drilling rig that typically originated from an artesian aquifer encountered during the drilling process.

Jack & Bore: a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead and rotating a cutter head, followed by removal of material from inside the bore.

Loss of Circulation: the discontinuation of the flow of drilling fluid in the bore back to the entry or exit point or other planned recovery points.

Pilot Bore: the initial bore to set directional controlled horizontal and vertical alignment between the connecting points.

Pipe Jacking: a method for installing steel casing or concrete pipe in the subsurface utilizing hydraulically operated jacks of adequate number and capacity to ensure smooth and uniform advancement without overstressing the liner/pipe.

Pipe Ramming: a method for installing steel casings utilizing the energy from a percussion hammer to advance a steel casing with a cutting shoe attached at the front end of the casing.

Primary Liner (Support): system installed prior to or concurrent with excavation, to maintain stability of an excavation and to support earth or rock and any structure utilities or other facilities in or on the supported earth or rock mass, until the excavation is completed.

Product: pipe culverts, pipe sewers, watermain pipe and sanitary pipe.

Pullback: that part of the DD method in which the drill string is pulled back through the bore path to the entry point.

Quality Verification Engineer (QVE): an Engineer who has a minimum of five (5) years of experience in the field of pipe installation using trenchless methods or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the contract. The Quality Verification Engineer is to be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificate(s) of Conformance.

Reaming: a process for pulling a tool attached to the end of the drill string through the bore path to enlarge the bore and mix the cuttings with the drilling fluid. This typically includes multiple passes.

Rock: natural beds or massive fragments, or the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin, which may or may not be weathered and includes boulders having a size equivalent to 0.3 m in diameter or greater.

Secondary Liner: concrete pipe, HDPE pipe or un-reinforced cast-in-place concrete, installed subsequent to tunnel excavation.

Shaft: vertically sided excavation used as entry and/or exit points from which the trenchless method is initiated or directed for the installation of product.

Strike Alert: a system that is intended to alert and protect the operator in the case of inadvertent drilling into an electrical utility cable. The strike alert system consists of a sensor and an alarm connected to the drill rig and a grounding stake. The alarm may be audio or visual or both.

Slurry: a mixture of soil and/or rock cuttings, and drilling fluid.

Soil: all materials except those defined as rock, and excludes stone masonry, concrete, and other manufactured materials; includes rock fragments having an equivalent size less than 0.3 m in diameter.

Tunnelling: an underground method of constructing a passage open at both ends that involves installing a pipe.

4. DESIGN AND SUBMISSION REQUIREMENTS

4.01 General

The Contractor's documentation, submission requirements, and installation methods must specifically consider and address the subsurface conditions at each pipe crossing as identified in the Foundation Investigation Report and Instrumentation and Monitoring Plan.

4.02 Working Drawings

Three copies of stamped working drawings for portal or shaft construction, primary liner, excavation, secondary lining, dewatering and groundwater control, and grouting is to be submitted to the Contract Administrator (CA) at least one (1) week prior to the commencement of the work for reference purposes. All submissions are to bear the seal and signature of the Design Engineer and Design Checking Engineer. The

Contractor is to have a copy of the stamped working drawings at the site during construction.

As a minimum, working drawings/details pertaining to the tunnel design and construction are to include the following (as appropriate):

a) Plans, Elevations, and Details:

- A work plan outlining the materials, procedures, methods, and schedule to be used to execute the work;
- A list of personnel, including backup personnel, and their qualifications and experience;
- A safety plan, including the company safety manual and emergency procedures;
- The work area layout;
- An erosion and sediment control plan that includes a contingency plan in the event the erosion and sediment control measures fail;
- A drilling fluid management plan, if applicable, that addresses control of frac-out pressures and any potential environmental impacts, and includes a contingency plan detailing emergency procedures in the event that the fluid management plan fails;
- Lighting, ventilation, and fire safety details as may be required by applicable occupational health and safety regulations; and
- Excavated materials disposal plan.

b) Design Criteria:

- Primary liner design details, if applicable;
- Design assumption and material data when materials other than those specified are proposed for use; and
- Drill path design, details of alignment and alignment control, maximum curvature, and reaming stages;

c) Materials:

- Certification from the manufacturer that the product furnished on the contract meets the specifications cited in the manufacturer's product specification and that the materials supplied are suitable for the application; and
- Material mixture for filling voids and installation procedures.

d) Upstream/Downstream Portal Installation Procedure:

- The access shaft or entry/exit pit details designed and stamped/signed by the Design Engineer, as applicable; and
- Face support and other temporary support details, if applicable.

e) Primary Liner/Secondary Liner Installation and Grouting Procedure:

- Excavation and pipe jacking procedures, including methodology to handle obstructions and preventing soil cave-in; and
- Details of tunnelling equipment/methods to be used for the works.

f) Excavation and Dewatering:

- Ground control/dewatering details, as applicable, describing the proposed method for control, handling, treatment, and disposal of water.

g) Alignment Monitoring Method

- The methods to be employed to monitor and maintain the alignment of the installation;

4.03 Site Survey

Prior to commencing the work, the Contractor is to lay out the alignment and confirm locations of entry and exit pits. Stantec will only lay out the alignment of settlement monitoring points at road crossings within the road right-of-way.

4.04 Certificate of Conformance

The Contractor is to submit details of the sequence and method of construction to the Quality Verification Engineer for review, which has already been prepared and stamped by the Design Engineer. The Contractor is to submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate is to state that the construction procedures are in conformance with the requirements and specifications of the contract documents.

The Contractor is to submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer upon completion of each of the following operations and prior to commencement of each subsequent operation for each pipe installation:

- Site surveying (as noted in Section 4.03)
- Excavation for pits including dewatering of excavation
- Jacking/Ramming/Directional Drilling of Casing/Liner
- Excavation and Dewatering
- Installation of the Product
- Grouting Operations

Each Certificate of Conformance is to state that the work has been carried out in general conformance with the contract documents, specifications, and/or stamped working drawings.

In addition, upon completion of the installation of the pipe at each location, the Contractor is to submit to the Contract Administrator a **final** Certificate of Conformance sealed and signed by the Quality Verification Engineer. The Certificate is to state that the pipe has been installed in general conformance with the Contractor's Submission and Design Requirements, stamped working drawings, and contract documents.

The Design Engineer is not permitted to carry out the work of the Quality Verification Engineer.

5. MATERIALS

5.01 Product

The product is to be concrete pipe or high density polyethylene pipe as specified.

5.02 Concrete

Concrete is to be according to OPSS 1350. The concrete strength is to be as specified in the Contractor's design submission.

5.03 Concrete Reinforcement

Steel reinforcing for concrete work is to be according to OPSS 1440.

5.04 Timber

Timber is to be sound, straight, and free from cracks, shakes, and large or loose knots.

5.05 Grout

The Contractor is to submit the proposed grout mix design for grouts to be used for lubricating jacking pipe and for filling of voids and annular spaces. Purging grout is to consist of a mixture of one part Portland cement conforming to the requirements of CAN/CSA A5-93 and two parts mortar sand conforming to OPSS 1004, wetted with only sufficient water to make the mixture plastic.

5.06 Jack & Bore Materials

5.06.01 Pipe Materials

Steel pipe is to conform to ASTM A252-95 welded joints suitable for jacking operations. The Contractor is to select pipe class for pipe jacking.

Concrete pipe must conform with OPSS 1820.

Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.

5.07 Pipe Ramming Materials

5.07.01 Pipe Materials

The following is a list of materials for pipe ramming:

- Steel pipe is to conform with ASTM A 252-93 welded joints.
- New steel casing is to be smooth wall carbon steel pipe according to ASTM A252-93 Grade 2 (when specified).
- Used steel casing can be used provided that the steel casing can resist the applicable static and dynamic loadings.
- Pipe wall thickness is to be determined by the Contractor based on static and dynamic loads from traffic loading and anticipated ramming forces for selected pipe and driven pipe lengths. The wall thickness is to be increased as required to ensure the casing is not damaged during handling and installation. A minimum wall thickness of 50 mm and minimum yield strength of 240 MPa is required.
- Pipe segments are to be determined by the Contractor.
- Steel pipe joints are to be pressure fit type or welded.
- All steel casing pipe is to be square cut.
- Steel casing pipe is to have roundness such that the difference between the major and minor outside diameters is to not exceed 6 mm or 1% of the specified nominal outside diameter, whichever is less.

- Steel casing pipe is to have a minimum allowable straightness of 1.5 mm maximum per metre of length.

5.07.02 Mill Certificates

For permanent casing, the Contractor is to submit to the Contract Administrator at the time of delivery one copy of the mill certificate, indicating that the steel meets the requirements for the appropriate standards for casings.

Where mill test certificates originate from a mill outside Canada or the U.S., the Contractor is to have the information on the mill certificate verified by testing by a Canadian laboratory. The laboratory is to be accredited by a Canadian National Accreditation Body to comply with the requirements of ISO/IEC Guide 25 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates is to be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp is to include the appropriate material specification number, the date and the signature of an authorized officer of the Canadian testing laboratory.

5.08 Directional Drilling Materials

5.08.01 Drilling Fluids

The drilling fluids are to be mixed according to the manufacturer's recommendations and be appropriate for the anticipated subsurface conditions.

5.08.02 Pipe Materials

The following is a list of material requirements for directional drilling piping:

- High Density Polyethylene (HDPE) pipe as per OPSS 1840 is to be used in accordance with ASTM D3350.
- The requirements for fittings are to be suitable for and compatible with the class and type of pipe with which they will be used and in according to CAN/CSA-B182.6 or ASTM F894.
- The Contractor is to determine the required dimensional ratio (DR) of the HDPE pipe to support all subsurface conditions and hydrostatic pressures, and to withstand the grouting pressure and installation forces. The Contractor is to identify these forces in his submission requirements.
- The Contractor's submission is to demonstrate, in conjunction with the manufacturer's specifications, that the heat resistance of the pipe material is sufficient to tolerate without damage the heat of hydration generated by grout curing.
- Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.
- Jointing of HDPE piping is to be completed by thermal butt fusion in accordance with manufacturer's recommended procedures and as outlined in the latest revision of ASTM D2657. All manufacturer's recommendations and procedures is to be followed during the jointing process.

- Jointing of HDPE piping to other piping materials or appurtenances is to be completed using flanged connections.

5.09 Tunnelling Materials

5.09.01 Primary Liner

Tunnelling methods will require installation of a primary liner to provide support and stability to the excavation.

5.09.02 Secondary Liner

Concrete or High Density Polyethylene Pipe is to be used according to the following requirements.

5.09.02.01 Concrete Pipe

Concrete pipe as per OPSS 1820 is to be used. The Contractor is to select the pipe class to withstand grouting pressure and installation forces. The Contractor is to identify these forces in his submission requirements.

Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.

5.09.02.02 High Density Polyethylene (HDPE)

High Density Polyethylene (HDPE) pipe as per OPSS 1840 is to be used in accordance with ASTM D3350.

The requirements for fittings are to be according to CAN/CSA-B182.6 or ASTM F894.

The Contractor is to determine the required dimensional ratio (DR) to withstand the grouting pressure and installation forces. The Contractor is to identify these forces in his submission requirements.

Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.

Jointing of HDPE piping is to be completed by thermal butt fusion in accordance with manufacturer's recommended procedures and as outlined in the latest revision of ASTM D2657. All manufacturer's recommendations and procedures is to be followed during the jointing process.

Jointing of HDPE piping to other piping materials is to be completed using flanged connections.

6. EQUIPMENT

6.01 Jack & Bore Equipment

The selection of jack & bore equipment is to be determined by the Contractor and is to be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner is to be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.02 Pipe Ramming Equipment

Pipe ramming equipment is to be determined by the Contractor and is to be identified in the submission requirements specified herein.

The pipe ramming hammer(s) is to be capable of driving the pipe casing from the drive pit through the existing subsurface conditions at the site.

Specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the pipe is to be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.03 Directional Drilling Equipment

6.03.01 General

The directional drilling equipment is to consist of a directional drilling rig and a drilling fluid mixing and delivery system of sufficient capacity to successfully complete the product installation without exceeding the maximum tensile strength of the product being installed.

6.03.02 Drilling Rig

The directional drilling rig is to:

- consist of a leak free hydraulically powered boring system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head;
- contain a guidance system to accurately guide boring operations;
- be anchored to the ground to withstand the rotating, pushing, and pulling forces required to complete the product installation; and
- be grounded during all operations unless otherwise specified by the drilling rig manufacturer.

6.03.03 Drill Head

The drill head is to be steerable by changing its rotation, be equipped with the necessary cutting surfaces and drilling fluid jets, and be of the type for the anticipated subsurface conditions,

6.03.04 Guidance System

The guidance system is to be setup, installed, and operated by trained and experienced personnel. The operator is to be aware of any magnetic or electromagnetic anomalies and is to consider such influences in the operation of the guidance system when a magnetic or electromagnetic system is used.

6.03.05 Drilling Fluid Mixing System

The drilling fluid mixing system is to be of sufficient size to thoroughly and uniformly mix the required drilling fluid.

6.03.06 Drilling Fluid Delivery System

The delivery system is to have a means of measuring and controlling fluid pressures and be of sufficient flow capacity to ensure that all slurry volumes are adequate for the length and diameter of the final bore and the anticipated subsurface conditions. Connections between the delivery pump and drill pipe is to be leak-free.

6.04 Tunnelling Equipment

Tunnelling equipment is to be determined by the Contractor and is to be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the tunnel face is to be submitted to the Contract Administrator information purposes. Use of explosives or rock fracturing chemicals is to only be considered subject to a field demonstration satisfactory to the Ministry prior to its use.

7. CONSTRUCTION

7.01 General

The Contractor is to notify the Contract Administrator at least 48 hours in advance of starting work. The proposed method of pipe installation is to be subject to the limitations presented in the following subsections.

7.01.01 Layout, Alignment and Depth Control

The location of the installation is to be established from the lines, elevations and tolerances specified in the Contract Documents. The pipe installation is to be to the horizontal and vertical alignments specified in the Contract Drawings. Deviations from location, alignment, grades and/or invert levels are to be corrected by the Contractor at no cost to the Ministry.

All reference points necessary to construct the pipe installation and appurtenances is to be laid out.

The Contractor is to calibrate tracking and locating equipment at the beginning of each work day, and is to monitor and record the alignment and depth readings provided by the tracking system at every 5 m in normal conditions and every 2 m where precise alignment control is necessary;

The Contract Administrator is to be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

All excavations are to be carried out in accordance with the Occupational Health and Safety Act (OHSA) of Ontario.

For directional drilling, the contractor is to ensure that during pilot hole drilling the maximum degree of deviation or “dog-leg” is to be 2.5 degrees per 9m drill pipe length. Any deviation exceeding 2.5 degrees will necessitate a pull-back and straightening of the alignment at the Contractor’s sole expense. The pilot hole exit location is to be within 0.5m of the target location.

7.01.02 Shafts

Shafts are to be specified in the Contractor's submission. The boundaries and protection of these is to be as required to contain all disturbances to areas outside of the ESA limits.

Shafts are to be maintained in a drained condition.

A minimum 2.4 m high secure fencing is to be installed around the perimeter of the construction shaft area with gates and truck entrances. The fence is to be removed on completion of the work.

7.01.03 Protection Systems

The construction of all protection systems is to be according to OPSS 539. Where the stability, safety, or function of an existing roadway, watercourse, other works, proposed works or ESA's may be impaired due to the method of operation, protection is to be provided. Protection systems include primary liner and portal excavation support systems. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works.

7.01.04 Settlement or Heave

Any disturbance to the ground surface (settlement or heave) as a result of the pipe installation is to be immediately corrected by the Contractor, at no additional cost.

7.01.05 Stability of Excavation

The construction methods, plant, procedures, and precautions employed is to ensure that excavations are stable, free from disturbance, and maintained in a drained condition.

The construction methods, plant, and materials employed is to prevent the migration of soil and/or rock material into the excavation from adjacent ground.

7.01.06 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities is to be according to OPSS 504.

Subsurface Utility Mapping (SUM) should be reviewed as a part of contractors' responsibility to locate existing buried infrastructure. Existing underground facilities is to be exposed to verify its horizontal and vertical locations when the outlet pipe path comes within 1.0 m horizontally or vertically of the existing facility. Existing facilities is to be exposed by non-destructive methods.

7.01.07 Transporting, Unloading, Storing and Handling Materials

Manufacturer's handling and storage recommendations is to be followed.

7.01.08 Trenching, Backfilling and Compacting

Trenching, backfilling, and compacting for entry and exit points or other locations along the pipe path is to be according to OPSS 514.

7.01.09 Dewatering

The work of this Section includes control, handling, treatment, and disposal of groundwater. The Contractor is to review the Foundation Investigation Report for reference to soil and groundwater conditions on the project site and plan a dewatering scheme accordingly.

The Contractor is to control groundwater inflows to excavations to maintain stability of surrounding ground, to prevent erosion of soil, to prevent softening of ground exposed in the excavation, and to avoid interfering with execution of the work.

The Contractor is to maintain excavations free of standing water at all times during excavation, including while concrete is curing.

Should water enter the excavation in amounts that could adversely affect the performance of the work or could cause loss of ground, the Contractor is to take immediate steps to control the inflow.

The Contractor is alerted that seepage zones of perched water within the fill materials should be expected, particularly where granular materials are excavated.

Dewatering is to be performed according to OPSS 517.

7.01.10 Removal of Boulders

The Contractor is alerted that cobbles and boulders should be anticipated in the soil deposits at the site. Accordingly, the Contractor is to address the removal of cobbles and boulders in the proposed method of construction. The Contractor immediately informs the Contract Administrator of any obstruction encountered.

7.01.11 Record Keeping

Verification record requirements of the alignment and depth of the installation is to be as specified in the Contract Documents. A copy of the verification records is to be given to the Contract Administrator at the completion of the installation.

7.01.12 Testing

Testing of the product installation is to consist of verifying the specified grade between the two ends of the pipe and passing of water from the median end of the pipe to the outlet end to confirm gravity flow conditions.

7.01.13 Management and Disposal of Excess Material

Management and disposal of excess material is to be according to OPSS 180. Satisfactory re-usable excavated material required for backfill is to be separated from unsuitable excavated material.

7.01.14 Site Restoration

Site restoration is to be according to OPSS 507.

7.01.15 Supervision

A qualified individual, who is experienced in the pipe installation by trenchless methods, is to supervise the work at all times.

7.02 Jack & Bore Installation

7.02.01 Method of Installation Procedure

The installation procedure to be used is to be subject to the following limitations:

- Hydraulically operated jacks of adequate number and capacity are to be provided to ensure smooth and uniform advancement without over-stressing of the pipe.
- A suitably padded jacking head or collar is to be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.
- The jacking pipe is to be fully supported in the jacking pit at the specified line and grade.
- Selection of the excavation method and jacking equipment is to take into consideration the conditions at each pipe crossing.

7.02.02 Pipe Installation

Concrete pipe joints are to be water tight and according to OPSS 1820 and must withstand jacking forces, determined by the Contractor.

During the jacking of the liner the space between the liner and the wall of the excavation is to be kept filled with bentonite slurry. Upon completion of jacking, the space between the liner and the wall of the excavation is to be filled with grout.

The annular space between the liner and the product is to be fully grouted with a water tight, expandable and stable grout.

7.03 Pipe Ramming Installation

For pipe ramming installation the following requirements apply:

Only smooth walled steel pipe is to be used. But welding of pipe joints is to conform to CAS W59.

Ramming equipment of adequate capacity is to be provided to ensure smooth and uniform advancement without overstressing of the pipe. Delays are to be avoided between ramming operations.

A ramming head is to be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.

Two or more lubricated guide rails or sills is to be provided of sufficient length to fully support the pipe at the specified line and grade in the ramming pit. Pipe is to be installed to the line and grade specified.

Following installation of the liner pipe, all material is to be removed from the pipe to the satisfaction of the Contract Administrator. Any voids remaining between the pipe and the excavation wall is to be grouted as soon as the pipe is rammed. The annular space between the liner pipe and the product is to be fully grouted with a water tight, expandable and stable grout.

7.04 Directional Drilling Installation

7.04.01 General

When strike alerts are provided on a drilling rig, they are to be activated during drilling and maintained at all times. This is the responsibility of contractor to maintain the strike alert system and stop the process upon any strike incident.

7.04.02 Site Preparation

The work site is to be graded or filled to provide a level working area for the drilling rig. No alterations beyond what is required for DD operations are to be made. All activities are to be confined to designated work areas.

7.04.03 Pilot Bore

The pilot bore is to be drilled along the bore path in accordance with the grade, alignment, and tolerances as indicated on the Contractor's submitted drilling plan to ensure that the product is installed to the line and grade shown on the Contract Drawings. The Contractor's methods must take into consideration the conditions at each crossing within the pipe alignment, and are to be suitable to advance through such obstructions such as cobbles and boulders and address the potential for deflection off these obstruction and/or soil conditions.

In the event the pilot bore deviates from the submitted path, the Contractor is to notify the Contract Administrator. The Contract Administrator may require the Contractor to pullback and re-drill from the location along the bore path before the deviation.

In the event that a drilling fluid fracture, inadvertent returns, or loss of circulation occurs during pilot bore drilling operations, the Contract Administrator is to be advised of the event and action is to be taken in accordance with the Contractor's submitted contingency plan.

At the entry and exit points, there is potential for ravelling of the existing soil, fill and or weathered rock areas along the alignment. This is conventionally addressed by the use of drilling fluid. However, casing may be required. The Contractor's methods must take into consideration the potential need to install sections of casing to manage ravelling at or near ground surface.

If a drill hole beneath the highway must be abandoned, the hole is to be backfilled with grout or bentonite to prevent future subsidence.

The Contractor is to maintain drilling fluid pressure and circulation throughout the DD process, including during the initial pilot bore and during the reaming process.

The Contractor is to at all times and for the entire length of the installation alignment be able to demonstrate the horizontal and vertical position of the alignment, the fluid volume used, return rates and pressures.

Stantec will install and monitor settlement points at traversed road crossings within the road right of way. If in any case the settlement reaches the alert level, the Contract Administrator will be advised of the event and action is to be taken in accordance with the Contractor's submitted contingency plan.

7.04.04 Drilling Fluid Fracture (Frac-Out)

In order to reduce the potential for hydraulic fracturing of the hole during directional drilling, a minimum depth

of cover of 5m is normally maintained between the pipe and the ground surface. Sections of the pipe close to the exit pit with less than 5m cover is to be cased. The Contractor is to ensure that drilling fluid pressures are properly set and controlled to prevent frac-out, for the depth of cover available between the bottom of the pavement structure (bottom of the subbase material) and the top of the bore.

Since fluid loss normally occurs in fault zones, fracture zones, or seams of coarse material, fluid migration does not always gravitate to the surface, thus making detection difficult. Once a fluid loss is detected, the Contractor is to halt operations immediately and conduct a detailed examination of the drill path and implement measures to mitigate fluid loss. If no surface migration is evident, resume operation while paying particular attention to fluid monitoring.

In the event of a fluid migration to the surface occurring, the Contractor is to halt all operations immediately, isolate the migration site, and recover fluids. Once the fracture is controlled, continue drilling operations with the operator paying particular attention to the fracture points

7.04.05 Reaming

The bore is to be reamed using the appropriate tools to a diameter at least 50% greater than the outside diameter of the product.

7.04.06 Product Installation

7.04.06.01 General

The product is to be jointed according to manufacturer's recommendations. The length of the product to be pulled is to be jointed as one length before commencement of the continuous pulling operation.

The product is to be protected from damage during the pullback operation.

The minimum allowable bending radius for the product must not be exceeded.

Product must be allowed to recover before connections to new or existing facility are made. Product recovery time is to be according to the manufacturer's recommendations.

7.04.06.02 Pullback and Grouting

After successfully reaming the bore to the required diameter, the product is to be pulled through the bore path. Once the pullback operation has commenced, it is to continue without interruption until the product is completely pulled into bore unless otherwise approved by the Contract Administrator.

A swivel is to be used between the reamer and the product being installed to prevent rotational forces from being transferred to the product. When specified in the Contract Documents, a weak link or breakaway connector is to be used to prevent excess pulling force from damaging the product.

The product is to be inspected for damage where visible at excavation pits and where it exits the bore. Any damage noted is to be rectified to the satisfaction of the Contract Administrator,

The pull back and reaming operations cannot exceed the fluid circulation rate capabilities. Reaming and back pulling operations is to be planned to insure that, once started, all reaming and back pulling operations are completed without stopping and within the permitted work hours.

The space between the pipe and the excavation walls is to be filled with grout.

7.05 Tunnelling Installation

7.05.01 General

The method of tunneling is to be selected by the Contractor and submitted to the Contract Administrator prior to commencement of the work for information purposes.

Excavation of native soil and fill is to be done in a manner to control groundwater inflow to the excavation and to prevent loss of ground into the excavation.

Methods of excavating the tunnel are to be capable of fully supporting the face and must accommodate the removal of boulders and other oversize objects from the face. Continuous ground support is to be maintained during excavation.

As the excavation progresses, the Contractor is to continuously monitor (every 2m) indications of support distress, such as cracking, deflection or failure of support system and subsidence of ground near the excavation.

The Contractor is to advance the ventilation system as a regular part of the normal excavation cycle.

The Contractor is to provide lighting in accordance with OHSA requirements for the entire length of the tunnel.

The tunnel is to be kept sufficiently dry at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor is to maintain clean working conditions at all times in tunnels.

In the event that excavation threatens to endanger personnel, the Work, or adjacent property, the Contractor is to cease excavation. The Contractor must then evaluate methods of construction and revise as necessary to ensure the safe continuation of the work.

The Contractor is to maintain tunnel excavation line and grade to provide for construction of final lining within specified tolerances.

7.05.01 Tunnelling Method

The tunnelling method is to be suitable to provide face support in changing ground conditions that may be encountered during the progress of the work. The selection of the tunnelling method should consider the soil conditions at each pipe crossing and the presence of obstructions, such as cobbles and boulders, with respect to the tunnel alignment.

7.05.02 Primary Liner (Support System)

Primary support systems are to prevent deterioration, loosening, or unravelling of ground surfaces exposed by excavation.

The primary liner support system is to be designed and installed to achieve the intended performance requirements.

The primary liner support system must maintain the safety of personnel, minimize ground movement into the excavation, ensure stability, and maintain strength of ground surrounding the excavation.

The primary liner is to be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting, and is to ensure that no ground loading or other loading will be placed on the new work until after design strength has been reached.

The primary liner is to be installed so that the exterior is as tight as possible to the excavated surface of the tunnel and allows the placement of the full design thickness of the secondary lining.

Primary support systems are to be compatible with the encountered ground conditions, with the method of excavation, with methods for control of water, and with placement of the permanent lining.

All voids between the primary lining and the surface of the excavation are to be filled with cement grout. If an unexpanded liner is used, the space outside the liner plates is to be grouted at least daily.

7.05.03 Secondary Liner

7.05.03.01 Placing of Grout

The void outside the finished secondary liner is to be filled with cement grout according to the Contractor's submission.

Grout is to not be placed until the lining has achieved 85% of its specified strength or 30 MPa. Grouting is to be limited to such sequences and programs as are necessary to avoid damaging any part of the works or any other structure or property.

7.06 Instrumentation and Monitoring

Stantec will install instrumentation and provide ground surface monitoring services at road crossings along the pipeline alignment during the HDD operation. The scope of this service will be as outlined in Stantec document "Instrumentation and Monitoring Plan for Horizontal Directional Drilling, Highway 417 and Innes Road Crossing, Enbridge Pipeline Replacement, Ottawa, ON".

The Contractor should provide Stantec with Site Access and Traffic Control during installation and monitoring.

7.07 Condition survey

Prior to commencement of the construction Stantec will perform and document a road condition survey based on MTO Manual for Condition Rating, Distress Manifestation, SP-024 for the purpose of requirement of restoration. During the condition survey all visible defects such as cracks, distortions and deviations, heaves and depressions will be documented. Stantec will repeat the condition survey two weeks after the construction is completed or until such time at which all parties agree that further movement has stopped.

The Contractor should provide Stantec with Traffic Control services during the initial and final Road Condition Survey. Contractor will be held liable for any occurred damages to the pavement. All suffered damages should be remediated by the Contractor in conformance to applicable MTO Standards.

7.08 Criteria for Assessment of Roadway Subsidence/Heave

Based on the monitoring of ground movement as specified in Subsection 4.02, the following represents trigger levels that define magnitude of movement and corresponding action:

- **Review Level:** If a maximum value of 10 mm relative to the baseline readings is reached, the Contractor is to review or modify the method, rate of sequence of construction, or ground stabilization measures to mitigate further ground displacement.

If the Review Level is exceeded, Stantec is to immediately notify the CA and the contractor to review and discuss response actions. The Contractor is to submit a plan of action to prevent Alert Levels from being reached. All construction work is to be continued such that the Alert Level is not reached.

- **Alert Level:** If a maximum value of 15 mm relative to the baseline readings is reached, the Contractor is to cease construction operations upon Stantec notification, inform the Contract Administrator, and execute pre-planned measures to secure the site, to mitigate further movements, and to assure safety of public and maintain traffic.

No construction is to take place until all the following conditions are satisfied:

- The cause of the settlement has been identified.
- The Contractor submits a corrective/preventive plan.
- Any corrective and/or preventive measure deemed necessary by the Contractor is implemented.
- The CA deems it is safe to proceed.

The Contractor is to avoid damaging instrumentation during construction. Instrumentation that is damaged as a result of the Contractor's operation is to be repaired or replaced by the Contractor within one business day. The costs for replacement/repair are to be borne by the Contractor.

At the completion of the job, the Contractor is to abandon all instrumentations installed during the course of the Work.

9. MEASUREMENT FOR PAYMENT

Measurement is to be by Plan Quantity Payment as may be revised by Adjusted Plan Quantity Payment in metres, following along the centre line of the pipes from centre to centre of maintenance holes or chambers (catch basins) or from/to the end of the pipe where no maintenance hole or chamber is installed, of the actual length of pipe installed by trenchless methods.

10. BASIS OF PAYMENT

Payment at the contract price is to be full compensation for providing all labour, equipment, and materials required for excavation (regardless of material encountered), dewatering, sheathing and shoring, supply and installation of pipe liners, site restoration, and for all other work necessary to complete the installation as specified.

Payment for the rigid or flexible pipe conduits installed inside the pipe liners are to be paid separately under the appropriate tender items.

Where a protection system is made necessary because of the Contractor's operations (e.g. choice of trenchless installation method), the cost is to be included in this item and is to be full compensation for all labour, equipment, and materials required to carry out the work including subsequently removing the temporary protection system and performing any necessary restoration work.

Payment for connecting intercepted drains and service connections is to be made on the following basis:

- (a) Where such drains and service connections are shown on the contract drawings the cost of connections is to be included in the contract price for pipe installation.
- (b) Where such drains and service connections are not shown on the contract drawings, the cost of connections will be considered an allowable extra to the contract.

Payment for removal of boulders/obstructions greater than an equivalent 0.3 m in diameter is to be on a time and materials basis. The Contractor is to inform the Contract Administrator when boulders/obstructions are encountered and prior to removal to allow for proper and accurate tracking of time and material charges.