Foundation Investigation Report – Replacement of Highway 401 Hespeler Road Underpass, Site 33-150

Highway 401
MTO West Region

G.W.P. 3060-11-00

Geocres No. 40P8-257

Structure Location:
Latitude 43.4141°
Longitude -80.3279°

Prepared for:
Ministry of Transportation

Prepared by:
Stantec Consulting Ltd.
400 – 1331 Clyde Avenue
Ottawa, ON K2C 3G4

Project No. 165000897

May 2019

Table of Contents

LIST OF TABLES

LIST OF APPENDICES

APPENDIX A

APPENDIX B

APPENDIX C

FOUNDATION INVESTIGATION REPORT
For
G.W.P 3060-11-00

Replacement of Highway 401 Hespeler Road Underpass
City of Cambridge

1.0 INTRODUCTION

The Ministry of Transportation, Ontario (MTO) retained Stantec Consulting Ltd. (Stantec) to undertake the detailed design of the reconstruction of the Highway 401 interchange at Hespeler Road in the City of Cambridge, Ontario. This report presents the results of the foundation investigation for the replacement of the existing Hespeler Road Underpass at Highway 401 as part of the reconstruction of the interchange.

This Foundation Investigation Report has been prepared specifically and solely for the proposed bridge replacement structure.

Project Number: G.W.P.: 3060-11-00

Geocres Number: 40P8-257

Project Location: Highway 401 and Hespeler Road, Cambridge

Assignment Number: 3013-E-0005

2.0 SITE DESCRIPTION AND GEOLOGY

Site Location

The site location is shown on the Key Plan inset to Drawing No. 1, provided in Appendix A. At the project site, Highway 401 runs approximately in an east-west direction while Hespeler Road (also known as Regional Road 24) runs in a north-south direction. Chainage increases from west to east on Highway 401 and south to north on Hespeler Road.

General Site Description

At the project site, Hespeler Road is carried over Highway 401 by two four-span bridges (referred to collectively as the Hespeler Road Underpass). Highway 401 is a six-lane (three lanes in each direction) divided freeway. The spans of the existing bridges across Highway 401 are both approximately 65 m in length. Hespeler Road currently has two through lanes in each direction with an additional northbound lane for the S-W ramp and an additional southbound lane for the

N-E ramp; in total each bridge supports three lanes of traffic. Photographs 1 through 4 provided in Appendix A show the general site features.

The existing roadway drainage at this site consists of catch basins along the paved centre median leading to storm sewers, plus ditches and culverts along the outside lanes.

According to the MTO Preliminary Design Report (Draft), Highway 401 Improvements from 1 km West of Hespeler Road Easterly to the Wellington County / Halton Region Boundary dated July 2013, G.W.P. 8-00-00, prepared by McCormick Rankin, structural inspections of the bridges were performed by McCormick Rankin on October 15, 2009, and soffit delamination surveys were performed on November 19, 2009. According to the report, the southbound structure was found to be in fair to poor condition, with the soffit containing numerous areas of concrete spalling and delamination with exposed and corroded concrete. The northbound structure was found to be in good condition with minor defects in various locations, which included settlement of approaches and substandard SBGR connection to concrete barriers.

Physiographic Description

The site is located within a physiographic region known as the Guelph Drumlin Field (Chapman and Putnam, 1984). The subsurface soils are predominantly granular in nature consisting of sands and gravels with some silts and stoney tills which contain cobbles and boulders. The overburden in this area is underlain mostly by dolostones of the Amabel and Guelph Formations, which dip gently towards the southwest.

In the vicinity of the project site, the terrain is generally undulating to gently sloping with a regional slope towards the Speed River to the west of the site and is characterized as providing good natural drainage.

3.0 INVESTIGATION PROCEDURES

3.1 REVIEW OF EXISTING INVESTIGATION

Geotechnical investigation results for five boreholes in the immediate vicinity of the existing Hespeler Rod Underpass were reviewed as part of the current report. The investigation results were made available to Stantec by MTO (Geocres Report No. 40P8-94 'Highway 24 Underpass NBL'). These boreholes were designated BH1 through BH5, and their locations and the corresponding strata plots are shown on the Hwy 24 New U'Pass (NBL) Borehole Locations & Soil Strata Plan provided in Appendix A. The subsurface conditions encountered during the previous investigation typically consisted of a surficial compact to very dense sand deposit containing trace to some silt and gravel overlying a dense to very dense sand and gravel deposit.

3.2 FIELD INVESTIGATION

The geotechnical investigation for detailed design of the bridge foundations for the proposed replacement structure included eight boreholes in the vicinity of the existing Hespeler Road Underpass. Four boreholes, designated as BH14-2, BH14-3, BH14-6, and BH14-7, were advanced on both sides of Highway 401 in close proximity of the anticipated south and north abutments. Two boreholes, designated as BH14-4 and BH14-5, were advanced within the Highway 401 median on the east side of the existing Hespeler Road structure. Two boreholes, designated as BH14-1 and BH14-8, were advanced near the south and north approaches to the new structure. The locations of these boreholes are shown on the Borehole Location Plan, Drawing No. 1 in Appendix A.

Prior to carrying out the investigation for the detailed design, public utility locates for the boreholes were completed and reviewed.

The field drilling program was carried out from July 15 through 30, 2014. The boreholes were advanced using continuous flight hollow stem augers. HQ size coring equipment was used to core bedrock in BH14-5 and to advance through boulders in several boreholes. Drilling was carried out with a CME 550 rubber-tire All-Terrain Vehicle (ATV) drill rig equipped for soil sampling.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec field technician. Split spoon samples were collected at regularly spaced intervals (every 760 mm up to 10 m below existing ground surface, and every 1.5 m from 10 to 20 m depth). All samples recovered were returned to Stantec's Ottawa laboratory for detailed classification and testing.

A Dynamic Cone Penetration Test (DCPT) was carried out in two boreholes (BH14-4 and BH14-7) after encountering auger refusal.

During drilling, frequent cobbles and boulders were encountered in all boreholes advanced for this project. Drilling difficulties were encountered, due to the presence of very dense sands and gravels with frequent cobbles and boulders, occasionally requiring coring to advance through boulders during the course of the investigation.

Vibrating wire piezometers were installed in boreholes BH14-1 and BH14-7 on July 15 and 17, 2014, respectively. The piezometers were installed to depths of approximately 6.7 and 10.2 m below ground surface, respectively. The vibrating wire piezometers consist of sensors within a small diameter cylindrical housing containing a pressure transducer and a thermistor. An output cable is attached to this unit to transmit the readings to the ground surface. The installation of the vibrating wire piezometer was in accordance with the manufacturer's instructions. The collection zone consisted of a minimum 300 mm long region above and below the sensor tip and was backfilled with sand. The portion of the hole below the collection zone was backfilled with sand. The portion of the hole above the collection zone was backfilled with a mix of bentonite and drill cuttings.

Groundwater conditions were also observed in open boreholes during drilling. It is noted that except in BH14-2 and BH14-5, no groundwater was observed in the open boreholes at the end of drilling, suggesting that the groundwater level was deeper than the termination depths of the boreholes.

Groundwater level measurements using the vibrating wire piezometers were carried out on July 30, 2014, approximately two weeks after installation of the vibrating wire piezometers.

After completion of drilling, boreholes were backfilled in accordance with Ministry of the Environment Regulation 903 and sealed with cold asphalt patch when applicable.

3.3 LOCATION AND ELEVATION SURVEY

The elevation and coordinates (northing and easting) of the boreholes were determined using a Global Positioning System (GPS) apparatus, Trimble Geo XH, capable of decimeter accuracy. Summary information pertaining to the Stantec boreholes included in this report is given in Table 3.1.

Table 3.1: Borehole Information Summary

	Boreholes							
	14-1	**14-2**	**14-3**	**14-4**	**14-5**	**14-6**	**14-7**	**14-8**
MTM Zone 10 Coordinates Northing Easting	4808514 237776	4808529 237752	4808531 237778	4808574 237768	4808575 237781	4808612 237755	4808611 237782	4808623 237780
Ground Surface Elevation, m	297.3	301.1	297.2	294.7	294.9	302.1	297.9	298.3
Total Depth Drilled, m	6.7	17.4	9.5	10.1	15.5	13.6	14.3	6.7
End of Borehole Elevation, m	290.6	283.7	287.7	284.6	279.4	288.5	283.6	291.6
Depth Augered, m	6.7	17.4	9.5	6.7	10.9	13.6	14.3	6.7
Depth Cored (Bedrock), m	-	-	-	-	4.6	-	-	-
Number of Soil Samples	9	20	12	9	15	18	15	9

3.4 LABORATORY TESTING

All samples were taken to Stantec's Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer.

The geotechnical laboratory testing program for the borehole samples is summarized in Table 3.2.

Table 3.2: Geotechnical Laboratory Testing Program

Test Description	Number of Tests
Moisture Content	100
Atterberg Limits	-
Grain Size Distribution	22
Unconfined Compressive Strength (on bedrock cores)	2

Two soil samples were submitted to Parcel Laboratories of Ottawa for analysis of pH, soluble sulphate content, chloride content, and resistivity.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

4.0 SUBSURFACE CONDITIONS

4.1 GENERAL

The subsurface conditions observed in all boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix B.

Geotechnical investigation results for five boreholes from Geocres Report No. 40P8-94 are also included in Appendix B for reference. Based on this report, the subsurface soil at the site consists predominantly of a deposit of compact to very dense sand overlying dense to very dense sand and gravel containing trace amounts of fines.

In general, the subsurface stratigraphy encountered in the Stantec boreholes advanced at this site consisted of surficial asphalt or topsoil, over roadway and embankment fill material, over a deposit of sand interbedded with sand and gravel, followed by a sand and gravel till deposit with frequent cobbles and boulders; the sand was not present at all locations. Bedrock was encountered beneath the till at one borehole location.

It is noted that the subsurface profile encountered in the eight Stantec boreholes is generally consistent with the five historic boreholes briefly summarized above (Geocres Report No. 40P8-94).

A more detailed description of the subsurface conditions encountered in the Stantec boreholes is provided below. Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawing No. 1 of Appendix A.

4.2 OVERBURDEN

4.2.1 Pavement

A 200 mm thick layer of asphalt pavement was encountered in BH14-2 and BH14-6 advanced through Hespeler Road. A 250 mm thick asphalt pavement was encountered in BH14-4 and BH14-5, which were advanced through the Highway 401 median.

4.2.2 Topsoil

Topsoil was encountered in BH14-1, BH14-3, BH14-7 and BH14-8. The topsoil was comprised of organic material with sand and gravel. The observed thickness of topsoil ranged approximately between 150 and 900 mm. The topsoil had a moisture content of approximately 9 to 15%.

4.2.3 Roadway / Embankment Fill

Granular fill material was encountered in all boreholes (BH14-1 through BH14-8) immediately beneath the asphalt pavement or the topsoil. The thickness of the granular fill ranged from approximately 1.3 to 8.0 m, with the base of the fill encountered at elevations of 293.4 m to 295.0 m for the boreholes along Hespeler Road and to elevation 293.1 for the boreholes in the Highway 401 median (BH14-4 and BH14-5).

The fill was composed predominantly of sand and gravel-sized material with a trace amount of fines. Standard Penetration Test (SPT) blow counts (N-values) measured within the fill ranged between 4 and 80 blows per 0.3 m of penetration, indicating the fill materials are in a loose to very dense state. Typical SPT N-Values ranged from 10 to 50 blows per 0.3 m, indicating a compact to dense state.

Index tests carried out on representative samples of the fill material yielded the following results:

Gravel:	31 to 54%
Sand:	34 to 60%
Fines (silt & clay):	8 to 16%
Moisture Content:	1 to 18%

Representative grain size distribution plots for the roadway fill are given in Figure 1 of Appendix C. The Unified Soil Classification System (USCS) group symbols for the fill material range from SM (silty sand with gravel), GM (silty gravel with sand), SP-SM (poorly graded sand with silt and gravel), to GP-GM (poorly graded gravel with silt and sand).

4.2.4 Sand

A sand layer was encountered in Boreholes BH14-3 to BH14-6 immediately beneath the fill layer and within the upper portion of the till in borehole BH14-4. Where encountered, the observed thickness of the sand layer was between 1.9 and 3.7 m, extending to base elevations of between about 290.2 and 290.6 m.

This deposit was composed predominantly of sand typically with trace amounts of gravel and fines. The sand in borehole BH14-3 contained gravel and cobbles from 4.6 m to 6.0 m below ground surface. The measured SPT N-values within the sand layer ranged from 10 to greater than 100 blows per 0.3 m, indicating a compact to very dense state. Typical SPT N-Values ranged from 10 to 25 blows per 0.3 m, indicating a compact state.

Index tests carried out on representative samples from the sand layer yielded the following results:

Gravel:	2 to 4%
Sand:	90 to 93%
Fines (silt & clay):	5 to 6%
Moisture Content:	1 to 4%

Representative grain size distribution plots for the sand layer shown in Figure 2 of Appendix C. The USCS group symbol for this deposit is SP-SM (poorly graded sand with silt).

4.2.5 Sand and Gravel Till

A till deposit consisting of variable amounts of sand and gravel was encountered in all of the boreholes immediately beneath the fill and sand layers. In all but BH14-5, drilling was terminated within this deposit. This deposit was penetrated in BH14-5, in which its thickness was 6.6 m extending to base elevation of 284.0 m.

Frequent cobbles and boulders were observed in this deposit rendering drilling difficult. Boulders were cored in borehole BH14-3 between elevation 289.3 m to 287.7 m and in borehole BH14-7 between elevation 287.9 m to 287.2 m.

The SPT N-values for this deposit ranged from 9 to greater than 100 blows per 0.3 m indicating a loose to very dense state. Typical SPT N-Values ranged from 30 to 80 blows per 0.3 m, indicating a dense to very dense state of compactness. Auger refusal was encountered at elevation 288.0 m in borehole BH14-4 and elevation 287.2 m in borehole BH14-7. A Dynamic Cone Penetration Test was advanced to refusal in borehole BH14-4 at elevation 284.6 m and elevation 283.6 m in borehole BH14-7.

Index tests carried out on representative samples from this deposit yielded the following results:

Gravel:	38 to 55%
Sand:	36 to 51%
Fines (silt & clay):	8 to 16%
Moisture Content:	0 to 8%

Representative grain size distribution plots of samples obtained from this deposit are shown in Figures 3 and 4 of Appendix C. The USCS group symbols for this till deposit are SP-SM (poorly graded sand with silt and gravel), GP-GM (poorly graded gravel with silt and sand), and GM (silty gravel with sand).

4.3 BEDROCK

Grey limestone bedrock was encountered in BH14-5 at a depth of 10.9 m; this was confirmed by coring approximately 4.6 m into the rock using HQ-size coring equipment. The top of bedrock elevation was approximately 284.0 m. The bedrock was slightly weathered. The Rock Quality Designation (RQD) values of the retrieved bedrock core were between 49% and 92%, indicating a poor to excellent rock quality. The Total Core Recovery (TCR) value was 100% for all core runs. A detailed description of the rock core is provided in Field Core Log sheet in Appendix B. Rock core photographs are provided in Appendix B.

Unconfined compressive strength (UCS) tests were carried out on two bedrock samples. The results of these tests are summarized in Table 4.1.

Table 4.1: Unconfined Compressive Strength of Rock Cores

Borehole No	Test Elevation (m)	Unconfined Compressive Strength (MPa)
BH14-5	282.7	136
BH14-5	280.3	102

Based on the rock UCS test results presented above, the tested bedrock samples may be described as very strong.

4.4 GROUNDWATER

Vibrating wire piezometers were installed in BH14-1 and BH14-7 during drilling. Readings of these piezometers, which were carried approximately two weeks later, indicated that the groundwater level was beneath the tip of the vibrating wire piezometers, suggesting the groundwater level is below elevation 287.7 m.

Observations of groundwater levels within the boreholes were made at the time of drilling. These groundwater levels are not stabilized measurements and hence are deemed, “inferred”.

The groundwater levels are summarized in Table 4.2.

Table 4.2: Groundwater Levels (on July 30,2015 for VWPs; Time of Drilling at Other BHs)

Borehole No	Ground Surface Elevation (m)	Groundwater		Comments
		Depth (m)	Elevation (m)	
BH14-1	297.3	>6.7	<290.6	Vibrating Wire Piezometer
BH14-2	301.1	14.2	286.9	Inferred
BH14-3	297.2	>9.5	<287.7	Inferred
BH14-4	294.7	>10.1	<284.6	Inferred
BH14-5	294.9	7.6	287.3	Inferred
BH14-6	302.1	>13.6	<288.5	Inferred
BH14-7	297.9	>14.3	<283.6	Vibrating Wire Piezometer
BH14-8	298.3	>6.7	<291.6	Inferred

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

4.5 CHEMICAL TESTING

Two representative samples retrieved from variable depths at this site were submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphates and chloride concentrations, and resistivity. The analysis results are provided in Table 4.3. The chemical testing results provided by Paracel Laboratories Ltd. are also provided in Appendix C for reference.

Table 4.3: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
BH14-4	SS-3	1.52 to 2.13	8.21	225	31	18.8
BH14-6	SS-7	4.57 to 5.18	8.10	164	11	24.7

5.0 MISCELLANEOUS

The field work was carried out under the supervision of Mr. Zachary Popper, P.Eng., under the direction of Mr. Christopher McGrath, P.Eng.

The public utility locates for the boreholes for the detailed design were carried out by USL-1 of Ottawa, Ontario.

The CME 550 rubber tire All-Terrain Vehicle (ATV) drill rig was supplied and operated by Terex Drilling Solutions of Goodwood, Ontario.

Location and elevation survey of all the boreholes was carried out by Stantec during the course of drilling.

Traffic control service was provided by JTS Inc., of Aurora, Ontario.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory. Chemical testing for pH, soluble sulphate, and chloride content, and resistivity was carried out by Paracel Laboratories of Ottawa.

This report was prepared by Simon Gudina and Zachary Popper and reviewed by Raymond Haché, Designated Principal MTO Foundation Contact.

6.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions 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.

Respectfully Submitted;

STANTEC CONSULTING LTD.

Zach Popper, P.Eng.
Geotechnical Engineering

Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact

v:\01216\active\other_pc_projects\165000897\05_report_deliv\reports\hespeler_rd\rpt__fnl_fir_gwp_3060-11-00_hwy401_hespeler_201905.docx

APPENDIX A

Drawing No. 1 – Borehole Location Plan and Soil Strata Plot

Copies of Borehole Location Plan and Strata Plot (Geocres Report No. 40P8-94)

Site Photographs

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

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

PLATE No
CONT WP 3060-11-00

HWY 401 WIDENING, HESPELER RD UNDERPASS REPLACEMENT
BOREHOLE LOCATIONS & SOIL STRATA

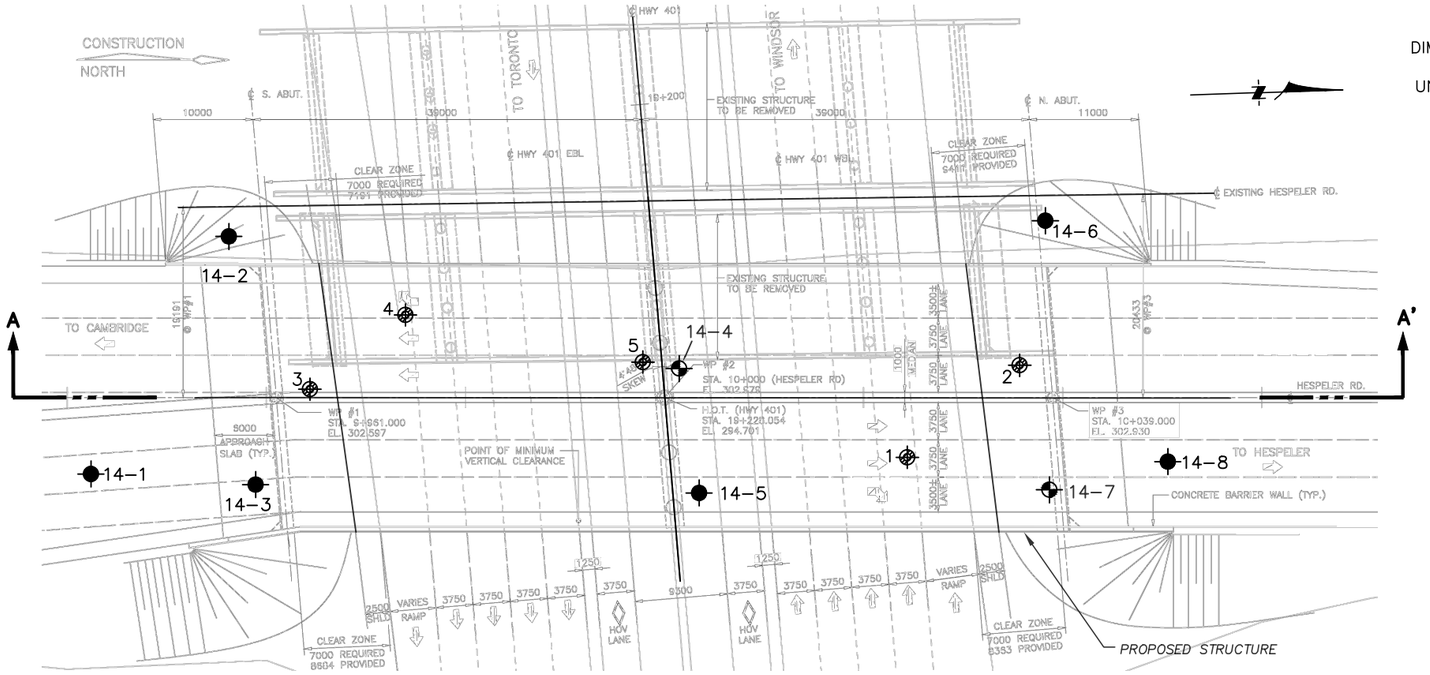
SHEET

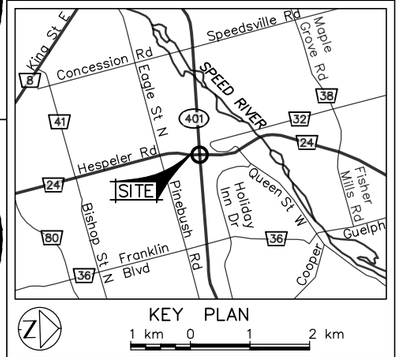
Stantec

LICENSED PROFESSIONAL ENGINEER
Z. POPPER
2019-05-07
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
J.G.A.R. HACHÉ
2019-05-07
PROVINCE OF ONTARIO

PLAN
SCALE
6 m 0 6 12





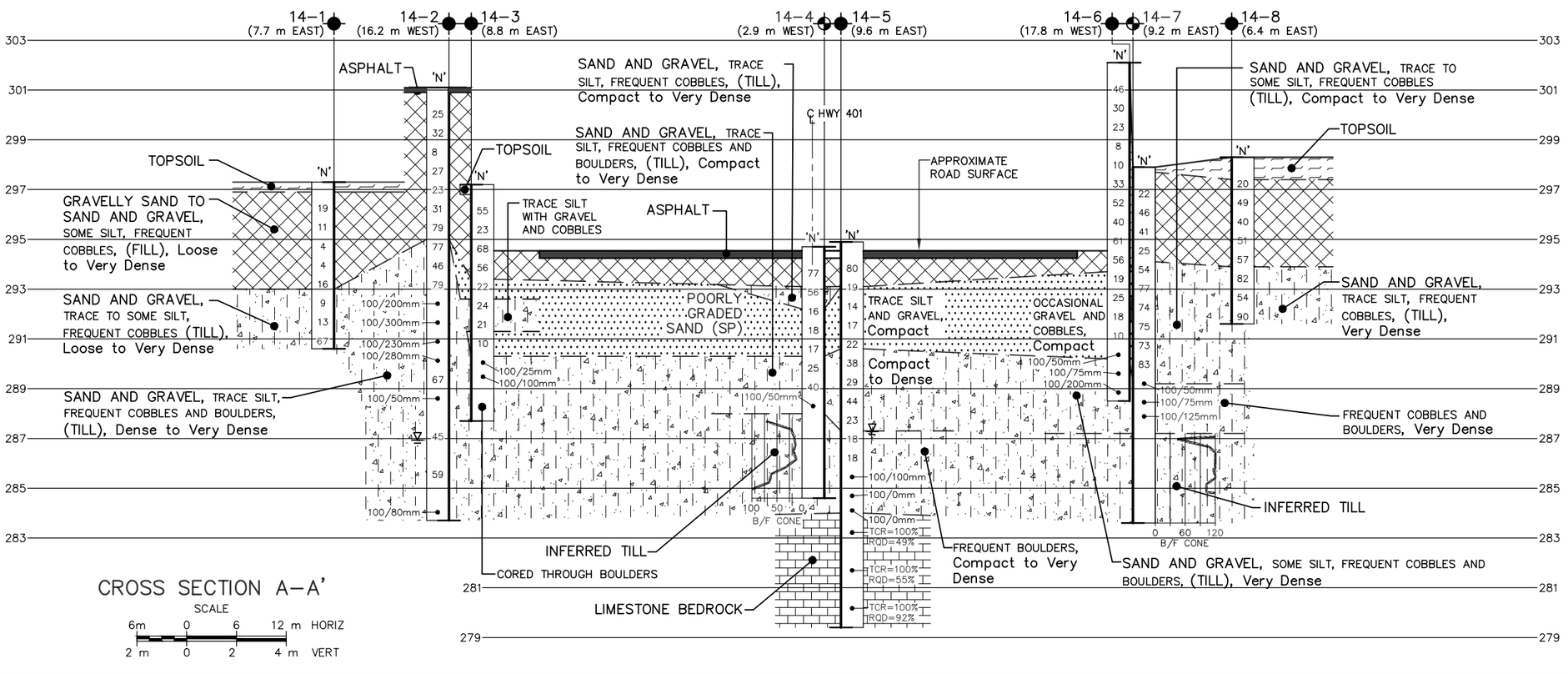
KEY PLAN
1 km 0 1 2 km

LEGEND

●	Borehole (July 2014)
⊕	Borehole & Cone (July 2014)
⊗	Borehole & Cone (Sept 1987)
(x.x m)	Offset from Cross Section Line in meters
N	Blows/0.3m (Std Pen Test, 475 J/blow)
▽	WL at time of investigation July 2014

No	ELEVATION	MTM ZONE 10 COORDINATES NORTH	EAST
14-1	297.3	4 808 514	237 776
14-2	301.1	4 808 529	237 752
14-3	297.2	4 808 531	237 778
14-4	294.7	4 808 575	237 768
14-5	294.9	4 808 575	237 781
14-6	302.1	4 808 612	237 755
14-7	297.9	4 808 611	237 782
14-8	298.3	4 808 623	237 780
1	294.6	4 808 597	237 778
2	298.4	4 808 608	237 769
3	297.2	4 808 537	237 769
4	295.2	4 808 547	237 761
5	294.5	4 808 570	237 767

CROSS SECTION A-A'
SCALE
6m 0 6 12 m HORIZ
2 m 0 2 4 m VERT



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 Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS	DATE	BY	DESCRIPTION

GEOCRES No 40P8-257

HWY No 401				DIST
SUBM'D SG	CHECKED	DATE 2019-01-24	SITE	33-150
DRAWN GBB	CHECKED	APPROVED	DWG	1

DRAWING NAME: 165008897_Hespeler.dwg
CREATED BY: GBB MODIFIED:
T:\Autocad\Drawings\Project Drawings\2019\165008897\165008897_Hespeler.dwg (2019-01-21) Printed: Jan 24, 2019

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-0-207 82 04

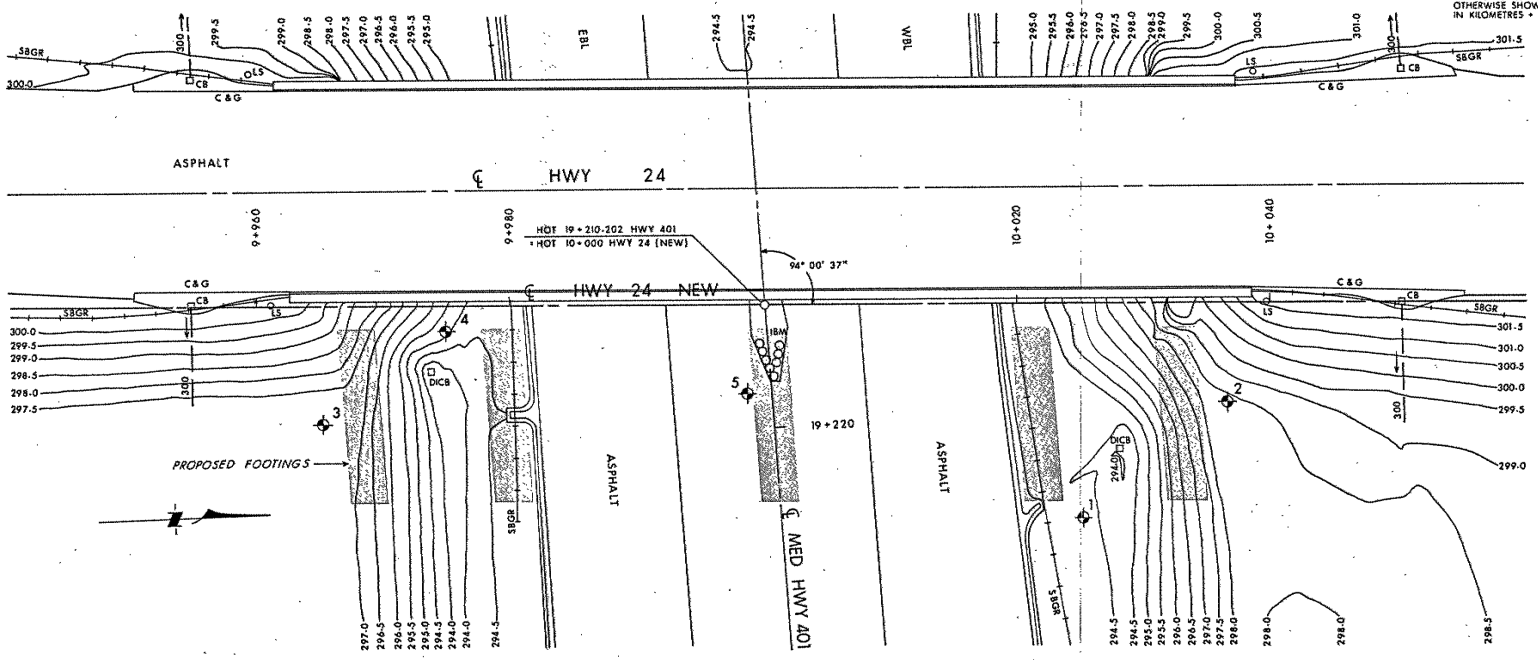
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

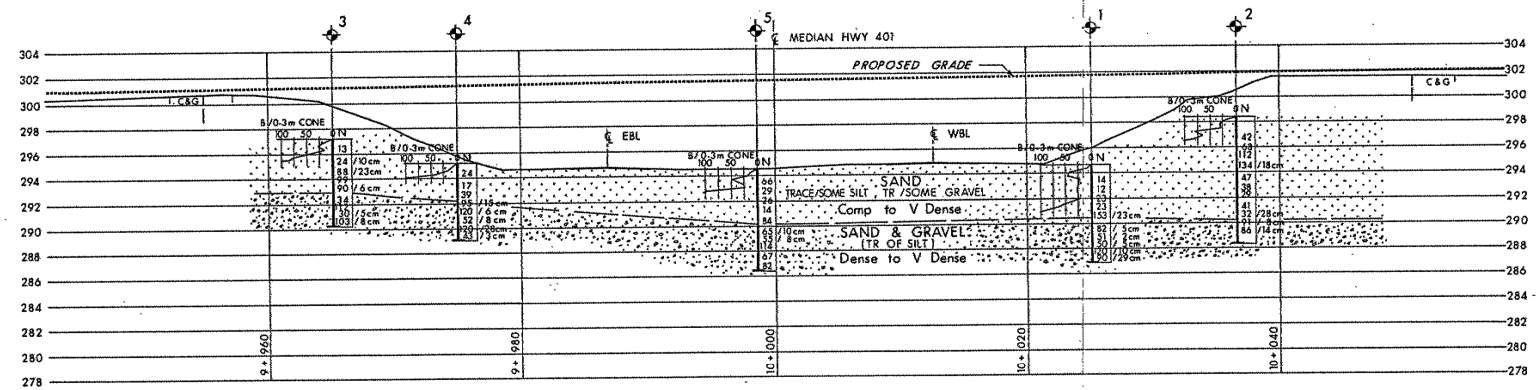
CONT No
WP No 239-87-01

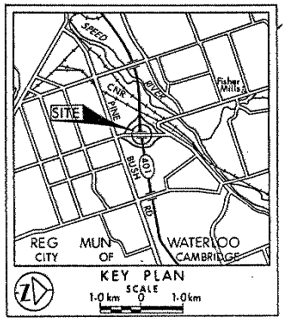
HWY 24 NEW U'PASS (NBL)

BORE HOLE LOCATIONS & SOIL STRATA

SHEET







LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- WL at time of investigation
  WL not observed in bore holes 1 to 5

No	ELEVATION	STATION	OFFSET
1	294·6	10+025·2	17·0m Lt
2	298·4	10+036·6	7·9m Lt
3	297·2	9+965·0	9·3m Lt
4	295·2	9+975·0	2·0m Lt
5	294·5	9+998·8	7·1m Lt

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 40P8-94

HWY No 401			DIST 3
SUBM'D PP	CHECKED	DATE 87 10 02	SITE 33-150
DRAWN DT	CHECKED	APPROVED	DWG 2398701-A

REF No E-10027-1, 86 09

Stantec	Project No.: 165000897	GWP: 3060-11-00	Site Photographs
	Project Name: Highway 401 Replacement of Hespeler Road Underpass, Cambridge, ON		Date: August 2013

Site Photo No.: 1	Hespeler Road Bridge over Highway 401 looking northwest

Site Photo No.: 2	Looking south at BH14-8 location

Stantec	Project No.: 165000897	GWP: 3060-11-00	Site Photographs
	Project Name: Highway 401 Replacement of Hespeler Road Underpass, Cambridge, ON		Date: August 2013

Site Photo No.: 3	Looking south from Hespeler Road Bridge near BH14-9

Site Photo No.: 4	Looking east from Hespeler Road Bridge at BH14-2

APPENDIX B

Symbols and Terms Used on Borehole Records

Borehole Records

Field Core Log

Rockcore Photographs

Borehole Records from a Previous Investigation (Geocres Report No. 40P8-94)

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

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

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. 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 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

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

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

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

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

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

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

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

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

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

Boulders Cobbles Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Igneous Bedrock | Meta-morphic Bedrock | Sedi-mentary Bedrock

SAMPLE TYPE

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

WATER LEVEL MEASUREMENT

measured in standpipe, piezometer, or well

inferred

RECOVERY

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

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. 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-values 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 (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

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

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

Stantec

RECORD OF BOREHOLE No BH14-1

1 OF 1 **METRIC**

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 514 E: 237 776 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler, Vibrating Wire Piezometer COMPILED BY ZP

DATUM Geodetic DATE 2014 07 15 - 2014 07 15 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
297.3											
0.0	410 mm sandy TOPSOIL		1	GS			297				
296.9											
0.4	FILL: Gravelly sand to sand and gravel, some silt Loose to compact - frequent cobbles		2	SS	19						
			3	SS	11		296				
			4	SS	4		295				
			5	SS	4		294				
293.6	- organic matter noted from 3.5 to 3.7 m										
3.7	SAND and GRAVEL, trace to some silt, frequent cobbles (till) Loose to very dense Brown		6	SS	16						43 48 (9)
			7	SS	9		293				
			8	SS	13		292				
			9	SS	67		291				
290.6											
6.7	End of Borehole Vibrating Wire Piezometer Installed at 6.7 m No water observed in open borehole Water level below Vibrating Wire Piezometer (6.7m) on July 30, 2014										

$\times^3$, $\times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

ONTARIO MTO STANTEC 165000897 - HIGHWAY 401 CAMBRIDGE.GPJ ONTARIO MOT.GDT 1/21/19

Stantec

RECORD OF BOREHOLE No BH14-2 1 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 529 E: 237 752 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler COMPILED BY ZP

DATUM Geodetic DATE 2014 07 18 - 2014 07 18 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ✖ FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.1											
0.0 / 300.9	200 mm ASPHALT						301				
0.2	FILL: Gravelly sand to sand and gravel, some silt Loose to very dense - frequent cobbles		1	GS					○		
			2	SS	25		300		○		
			3	SS	32				○		37 47 (16)
			4	SS	8		299		○		
	- silty between 2.6 and 2.9 m		5	SS	27		298		○		
			6	SS	23		297		○		
	- silty between 4.1 and 4.4 m - trace organics		7	SS	31				○		
295.0			8	SS	79		296		○		
6.1	SAND and GRAVEL, trace silt, frequent cobbles and boulders (till) Dense to very dense Brown		9	SS	77		295		○		
			10	SS	46		294		○		45 46 (9)
			11	SS	79		293		○		
			12	SS	100/ 200mm				○		
			13	SS	100/ 300mm		292		○		
291.1											

Continued Next Page

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

Stantec

RECORD OF BOREHOLE No BH14-2 2 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 529 E: 237 752 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler COMPILED BY ZP

DATUM Geodetic DATE 2014 07 18 - 2014 07 18 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL ✖ FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	SAND and GRAVEL, trace to some silt, frequent cobbles and boulders (till) Dense to very dense Brown		14	SS	100/ ,230mm		291		○		
			15	SS	100/ ,280mm		290		○		44 48 (8)
			16	SS	67		289		○		
			17	SS	100/ ,50mm		288		○		
			18	SS	45	▽	287		○		
			19	SS	59		286		○		38 51 (11)
							285				
	- boulders		20	SS	100/ ,80mm		284		○		
283.7 17.4	End of Borehole										

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

ONTARIO MTO STANTEC 165000897 - HIGHWAY 401 CAMBRIDGE.GPJ ONTARIO MOT.GDT 1/21/19

Stantec

RECORD OF BOREHOLE No BH14-3 1 OF 1 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 531 E: 237 778 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler, HQ Rock Core COMPILED BY ZP

DATUM Geodetic DATE 2014 07 15 - 2014 07 15 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
297.2							297				
0.0	400 mm sandy TOPSOIL		1	GS							
296.8							296				
0.4	FILL: Gravelly sand to sand and gravel, some silt Compact to very dense - frequent cobbles		2	SS	55						
			3	SS	23		295				31 60 (9)
			4	SS	68						
			5	SS	56		294				
293.4											
3.8	Poorly graded SAND (SP), trace silt and gravel Compact Brown		6	SS	22		293				
292.6											
4.6	- with gravel and cobbles from 4.6 m to 5.9 m		7	SS	24						
			8	SS	21		292				
291.3											
5.9			9	SS	10		291				2 93 (5)
290.3											
6.9	SAND and GRAVEL, trace silt, frequent cobbles and boulders (till) Very dense Light brown		10	SS	100/ ,25mm		290				
			11	SS	100/ 100mm						
	- Advanced HQ core through boulder		12	HQ			289				
287.7							288				
9.5	End of Borehole No water observed in open borehole										

ONTARIO MTO STANTEC 165000897 - HIGHWAY 401 CAMBRIDGE.GPJ ONTARIO MOT.GDT 1/21/19

✖^{3}, ×^{3}: Numbers refer to Sensitivity O$^{3\%}$ STRAIN AT FAILURE

Stantec

RECORD OF BOREHOLE No BH14-4 1 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 575 E: 237 768 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler COMPILED BY ZP

DATUM Geodetic DATE 2014 07 28 - 2014 07 29 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ✖ FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.7								20 40 60 80 100	10 20 30		
0.0 / 294.5	250 mm ASPHALT										
0.3	FILL: Sand and gravel, some silt Very dense - frequent cobbles		1	GS			294		○		
			2	SS	77				○		46 41 (13)
293.1											
1.6	SAND and GRAVEL, trace silt, frequent cobbles (till) Compact to very dense Brown		3	SS	56		293		○		
292.2											
2.5	Poorly graded SAND (SP) Compact Brown		4	SS	16		292		○		
			5	SS	18				○		
			6	SS	17		291		○		
290.4											
4.4	SAND and GRAVEL, trace silt, frequent cobbles (till) Compact to very dense Brown		7	SS	25		290		○		
			8	SS	40		289		○		
	- boulders		9	SS	100/ ,50mm				○		52 39 (9)
288.0							288				
6.7	Auger Refusal at 6.7 m Dynamic Cone Penetration Test - Inferred till						287				
							286				
							285				

Continued Next Page

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

Stantec

RECORD OF BOREHOLE No BH14-4 2 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 575 E: 237 768 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler COMPILED BY ZP

DATUM Geodetic DATE 2014 07 28 - 2014 07 29 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
284.6 10.1	End of Borehole Refusal of Dynamic Cone Penetration Test No water observed in open borehole										

$\times^3$, $\times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Stantec

RECORD OF BOREHOLE No BH14-5 1 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 575 E: 237 781 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler, HQ Rock Core COMPILED BY ZP

DATUM Geodetic DATE 2014 07 28 - 2014 07 30 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ✖ FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.9											
0.0 / 294.7	250 mm ASPHALT										
0.3	FILL: Gravelly sand to sand and gravel Compact to very dense - frequent cobbles		1	GS					○		
			2	SS	80		294		○		
293.1			3	SS	19		293		○		
1.8	Poorly graded SAND trace silt and gravel (SP) Compact Brown		4	SS	14				○		
			5	SS	17		292		○		4 90 (6)
290.6			6	SS	22		291		○		
4.3	SAND and GRAVEL, trace to some silt, frequent cobbles (till) Compact to very dense Brown		7	SS	38		290		○		
			8	SS	29		289		○		
			9	SS	44				○		55 37 (8)
			10	SS	23	▽	288		○		
			11	SS	18		287		○		
			12	SS	18				○		48 36 (16)
	- boulders below 9.0 m						286				
			13	SS	100/ 100mm				○		
284.9							285				

Continued Next Page

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

ONTARIO MTO STANTEC 165000897 - HIGHWAY 401 CAMBRIDGE.GPJ ONTARIO MOT.GDT 1/21/19

Stantec

RECORD OF BOREHOLE No BH14-5 2 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 575 E: 237 781 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler, HQ Rock Core COMPILED BY ZP

DATUM Geodetic DATE 2014 07 28 - 2014 07 30 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	SAND and GRAVEL, trace to some silt, frequent cobbles and boulders (till)		14	SS	100/ ,0mm						
			15	SS	100/ ,0mm		284				
284.0											
10.9	Limestone BEDROCK - very strong - poor to excellent quality - grey - slightly weathered - moderately fractured and bedded - close to medium joint spacing (Refer to Field Bedrock Core Log)		16	HQ	-		283				TCR = 100% RQD = 49% UCS = 136 MPa
			17	HQ	-		282				TCR = 100% RQD = 55%
			18	HQ	-		281				TCR = 100% RQD = 92% UCS = 102 MPa
279.4							280				
15.5	End of Borehole										

$\times^3$, $\times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Stantec

RECORD OF BOREHOLE No BH14-6

1 OF 2 **METRIC**

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 612 E: 237 755 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler COMPILED BY ZP

DATUM Geodetic DATE 2014 07 17 - 2014 07 17 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ✖ FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
302.1											
0.0 / 301.9	200 mm ASPHALT						302				
0.2	FILL: Gravelly sand to sand and gravel, some silt Loose to very dense - frequent cobbles		1	GS							
			2	SS	46		301				
			3	SS	30						31 58 (11)
			4	SS	23		300				
			5	SS	8		299				
			6	SS	10		298				
			7	SS	33		297				
			8	SS	52						
			9	SS	40		296				
			10	SS	61		295				43 46 (11)
			11	SS	56						
293.9							294				
8.2	Poorly graded SAND (SP) Compact Brown - occasional cobbles		12	SS	19						
			13	SS	25		293				
292.1											

Continued Next Page

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

Stantec

RECORD OF BOREHOLE No BH14-6 2 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 612 E: 237 755 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler COMPILED BY ZP

DATUM Geodetic DATE 2014 07 17 - 2014 07 17 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL ✖ FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	Poorly graded SAND (SP) Compact Brown - occasional cobbles		14	SS	18		292		○		2 92 (6)
			15	SS	10		291		○		
290.2			16	SS	100/ ,50mm				○		
11.9	SAND and GRAVEL, some silt, frequent cobbles and boulders (till) Very dense Brown		17	SS	100/ ,75mm		290		○		
288.5			18	SS	100/ ,200mm		289		○		47 40 (13)
13.6	End of Borehole No water observed in open borehole										

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

Stantec

RECORD OF BOREHOLE No BH14-7 1 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 611 E: 237 782 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler, HQ Rock Core, Vibrating Wire Piezometer COMPILED BY ZP

DATUM Geodetic DATE 2014 07 16 - 2014 07 17 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL ✖ FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
297.9											
297.8 0.0	150 mm sandyTOPSOIL										
0.2	FILL: Gravelly sand to sand and gravel, some silt Compact to dense - frequent cobbles		1	GS							
			2	SS	22		297				
			3	SS	46		296				
			4	SS	41						54 34 (12)
			5	SS	25		295				
294.1											
3.8	SAND and GRAVEL, trace to some silt, frequent cobbles (till) Compact to very dense Brown		6	SS	54		294				40 49 (11)
			7	SS	77		293				
			8	SS	74		292				
			9	SS	75						
			10	SS	73		291				
	- boulders below 8.0 m		11	SS	83		290				41 50 (9)
			12	SS	100/ ,50mm		289				
			13	SS	100/ ,75mm						
287.9	- auger refusal at 9.9 m				100/		288				

Continued Next Page

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

ONTARIO MTO STANTEC 165000897 - HIGHWAY 401 CAMBRIDGE.GPJ ONTARIO MOT.GDT 1/21/19

Stantec

RECORD OF BOREHOLE No BH14-7 2 OF 2 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 611 E: 237 782 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler, HQ Rock Core, Vibrating Wire Piezometer COMPILED BY ZP

DATUM Geodetic DATE 2014 07 16 - 2014 07 17 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	SAND and GRAVEL, trace silt, frequent cobbles and boulders (till)		14	SS	125mm						
			15	HQ							
287.2											
10.7	Dynamic Cone Penetration Test - Inferred TILL						287 286 285 284				
283.6											
14.3	End of Borehole Refusal of Dynamic Cone Penetration Test Vibrating Wire Piezometer Installed to 10.16 m No water observed in open borehole Water level below Vibrating Wire Piezometer (10.16 m) on July 30, 2014										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100

WATER CONTENT (%): 10 20 30

$\times^3$, $\times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

Stantec

RECORD OF BOREHOLE No BH14-8 1 OF 1 METRIC

W.P. GWP 3060-11-00 LOCATION Hwy 401 Hespeler Rd Underpass, Cambridge, ON N: 4 808 623 E: 237 780 ORIGINATED BY ZP

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Auger - Split spoon Sampler COMPILED BY ZP

DATUM Geodetic DATE 2014 07 16 - 2014 07 16 CHECKED BY SG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.3											
0.0	900 mm sandy TOPSOIL trace gravel		1	GS			298		o		
297.4											
0.9	FILL: Gravelly sand to sand and gravel, trace silt Compact to very dense - frequent cobbles		2	SS	20		297		o		45 47 (8)
			3	SS	49						
			4	SS	40		296		o		
			5	SS	51		295		o		
			6	SS	57				o		43 48 (9)
293.9							294				
4.4	SAND and GRAVEL, trace silt, frequent cobbles (till) Very dense Brown		7	SS	82				o		
			8	SS	54		293		o		
			9	SS	90		292		o		49 41 (10)
291.6											
6.7	End of Borehole No water observed in open borehole										

$\times^3$, $\times^3$: Numbers refer to Sensitivity $o^{3\%}$ STRAIN AT FAILURE

ONTARIO MTO STANTEC 165000897 - HIGHWAY 401 CAMBRIDGE.GPJ ONTARIO MOT.GDT 1/21/19

Stantec

Field Bedrock Core Log

Client: Ministry of Transportation Ontario
Project: Hespeler Road Underpass
Contractor: Terex Drilling

Project No.: 165000897
Date: July 30, 2014
Borehole No.: BH14-5
Logger: Z. Popper

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		
10.92	HQ16	100	49	12.44	Limestone, grey, medium to fine grained texture	R5	W2	1	BD	F	C	RP	C	O		
12.44	HQ17	100	55	13.96	Limestone, grey, medium to fine grained texture	R5	W2	2	BD JN	F V	C N/A	RP RP	C C	O O		
13.96	HQ18	100	92	15.49	Limestone, grey, medium to fine grained texture	R5	W2	1	BD	F	C	SP	C	SA		

STRENGTH (MPa)

Grade/Classification	Est. Strength (MPa)
R0 Extremely Week	0.25 - 1.0
R1 Very Weak	1.0 - 5.0
R2 Weak	5.0 - 25.0
R3 Medium Strong	25.0 - 50.0
R4 Strong	50.0 - 100.0
R5 Very Strong	100.0 - 250.0
R6 Extremely Strong	>250.0

JOINT TYPE

BD = Bedding
JN = Joint
FOL = Foliation
CON = Contact
FLT = Fault
VN = Vein

ORIENTATION

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

JOINT APERTURE

C = Closed = < 0.5 mm
G = Gapped = 0.5 to 10 mm
O = Open = > 10 mm

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

WEATHERING

Grade/Classification	Description
W1 Fresh	No Visible Signs of Weathering
W2 Slightly	Discoloration, Weathering on Discontinuities
W3 Moderately	<50% of Rock Material is Decomposed, Fresh Core Stones
W4 Highly	>50% Decomposed to soil: Fresh Core Stones
W5 Completely	100% Decomposed to Soil: Original Structure Intact
W6 Residual Soil	All Rock Converted to Soil, Structure and Fabric Destroyed

DISCONTINUITY SPACING

Spacing (mm)	
EW = >6000	Extremely Wide
VW = 2000 - 6000	Very Wide
W = 600 - 2000	Wide
M = 200 - 600	Moderate
C = 60 - 200	Close
VC = 20 - 60	Very Close
EC = <20	Extremely Close

JOINT ROUGHNESS

Jr	Description
4	DJ = Discontinuous Joints
3	RU = Rough, Irregular, Undulating
1.5	SU = Smooth, Undulating
1.5	LU = Slickensided, Undulating
1.0	RP = Rough or Irregular, Planar
0.5	SP = Smooth, Planar
2	LP = Slickensided, Planar

V:\01216\active\other_pc_projects\165000897\05_report_deliv\Reports\Hespeler_Rd\Appendix B\BH14-5_hespeler_field_bedrock_core_log.xlsx

Stantec	Project No.: 165000897	GWP: 3060-11-00	Rockcore Photographs Date: July 30, 2014
	Project Name: Highway 401 - Replacement of Hespeler Road Underpass, Cambridge, ON		

Rock Core Photo No. 1	Borehole: BH14-5 (Site No. 33-150)	Depth: 10.92 to 13.51 m

Rock Core Photo No. 2	Borehole: BH14-5 (Site No. 33-150)	Depth: 13.51 to 15.49 m

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1 METRIC

W P 239-87-01 LOCATION STA: 10 + 025.2; O/S 17m LT (℄ New Hwy #24) ORIGINATED BY IR
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 08 to 87 08 11 CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.6	Ground Level										
0.0	Sand		1	SS	14	*	294				9 86 (5)
	Trace of Silt		2	SS	12						
			3	SS	23		292				5 90 (5)
	Trace of Gravel		4	SS	23						
290.5	Compact		5	SS	153/23cm			120/29cm			4 87 (7)
4.1			6	SS	82/5cm		290				
	Sand and Gravel		8	SS	51/2cm						53 37 (10)
	Trace of Silt		9	SS	50/5cm						
			10	SS	120/10cm		288				42 54 (4)
286.9	Very Dense		12	SS	90/29cm						
7.7	END OF BOREHOLE										

*Note:
Groundwater was not observed.

+3, x5 : Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2 METRIC

W P 239-87-01 LOCATION STA: 10 + 036.6; O/S 7.9m LT(℄ New Hwy #24) ORIGINATED BY DM
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 11 to 87 09 15 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
298.4	Ground Level										
0.0	Sand		1	SS	--	*	298				
	Trace/some Silt		3	SS	42				○		35 51 (14)
			4	SS	68		296	120 / 23cm			
	Some Gravel		5	SS	112				○		44 49 (7)
			6	SS	134/ 18cm						
			7	SS	47		294				
	Compact		8	SS	38						
	to		9	SS	29		292		○		9 86 (5)
	Very dense		10	SS	41				○		1 94 (5)
290.2			11	SS	32/ 28cm				○		1 91 (8)
8.2	Sand & Gravel Trace of Silt Very Dense		12	SS	91/ 8cm		290				
288.3			13	SS	86/ 14cm				○		
10.1	Refusal END OF BOREHOLE										
	*Note: Groundwater was not observed.										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 3 METRIC

W P 239-87-01 LOCATION STA: 9 + 965; O/S 9.3m LT (℄ New Hwy #24) ORIGINATED BY IR

DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (S.S.) & Bx Casing COMPILED BY PP

DATUM Geodetic DATE 87 09 15 to 87 09 17 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
297.2	Ground Level										
0.0	Sand					*					
	Traces/some Silt		1	SS	13		296				
	Some Gravel		2	SS	24/10cm						28 57 (15)
	Compact to Very Dense		3	SS	88/23cm						
292.9			4	SS	99		294				33 56 (11)
			6	SS	907/6cm						
4.3	Sand & Gravel Trace of Silt		8	SS	34						65 28 (6)
	Dense to Very Dense		10	SS	112		292				49 44 (7)
290.2			11	SS	307/5cm						
			12	SS	103/8cm						
7.0	END OF BOREHOLE										
	*Note: Groundwater was not observed.										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 4 METRIC

W P 239-87-01 LOCATION STA: 9 + 975; O/S 2m LT(℄ New Hwy.#24) ORIGINATED BY DM
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 17 to 87 09 21 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
295.2	Ground Level										
0.0	Sand Trace of Silt Some Gravel Compact to Dense		1	SS	24	*	294	100/15cm	○		
			2	SS	17				○		30 63 (.7)
292.2			3	SS	39				○		
3.0	Sand & Gravel Trace of Silt		4	SS	95/15cm		292		○		49 46 (5)
			5	SS	120/6cm						
			6	SS	52/8cm				○		48 45 (7)
289.0	Very Dense		7	SS	120/28cm		290				
			8	SS	43/3cm						
6.2	END OF BOREHOLE										

* Note:
Groundwater was not observed.

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 5 METRIC

W P 239-87-01 LOCATION STA: 9 + 998.8; O/S 7.1 m LT (℄ New Hwy #24) ORIGINATED BY IR
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
294.5	Ground Level										
0.0	Sand					*	294				
	Trace/some Silt		1	SS	66						32 54 (14)
	Trace/some Gravel		2	SS	29			75/3cm			
	Compact		3	SS	26		292				9 85 (6)
	to		4	SS	14						
290.1	Very Dense		5	SS	84						34 58 (8)
4.4	Sand & Gravel		6	SS	65/10cm		290				
	Trace of Silt		7	SS	55/8cm						53 40 (7)
			8	SS	114		288				
	Very Dense		9	SS	67						52 36 (12)
286.4			10	SS	82						
8.1	END OF BOREHOLE										
	*Note: Groundwater was not observed.										

+3, ×5 : Numbers refer to Sensitivity

15 20 5 (%) STRAIN AT FAILURE 10

OFFICE REPORT ON SOIL EXPLORATION

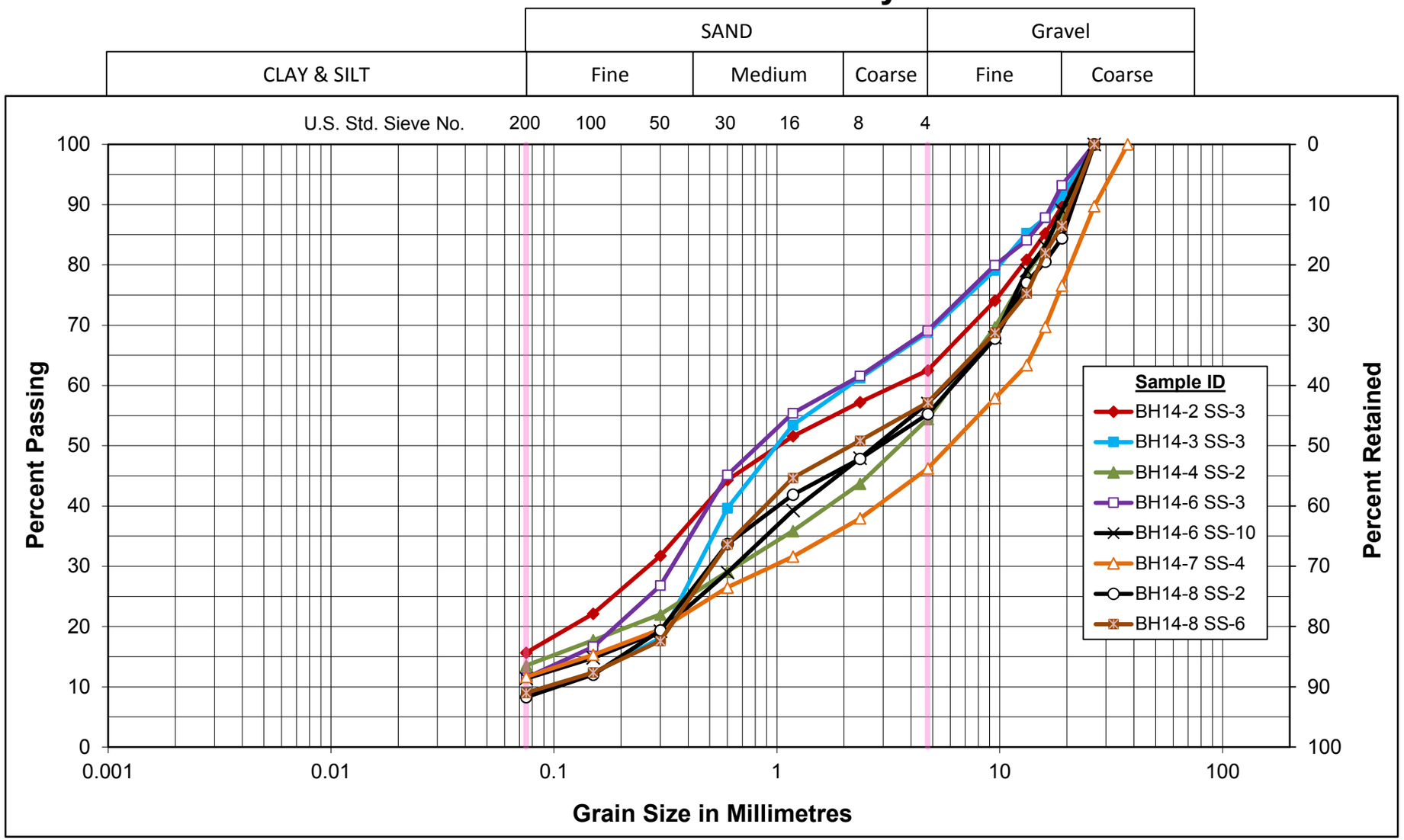
APPENDIX C

Laboratory Test Results

Figures 1 – 4: Grain Size Distribution Plots

Chemical Test Results – Paracel Laboratories Ltd.

Unified Soil Classification System



Stantec

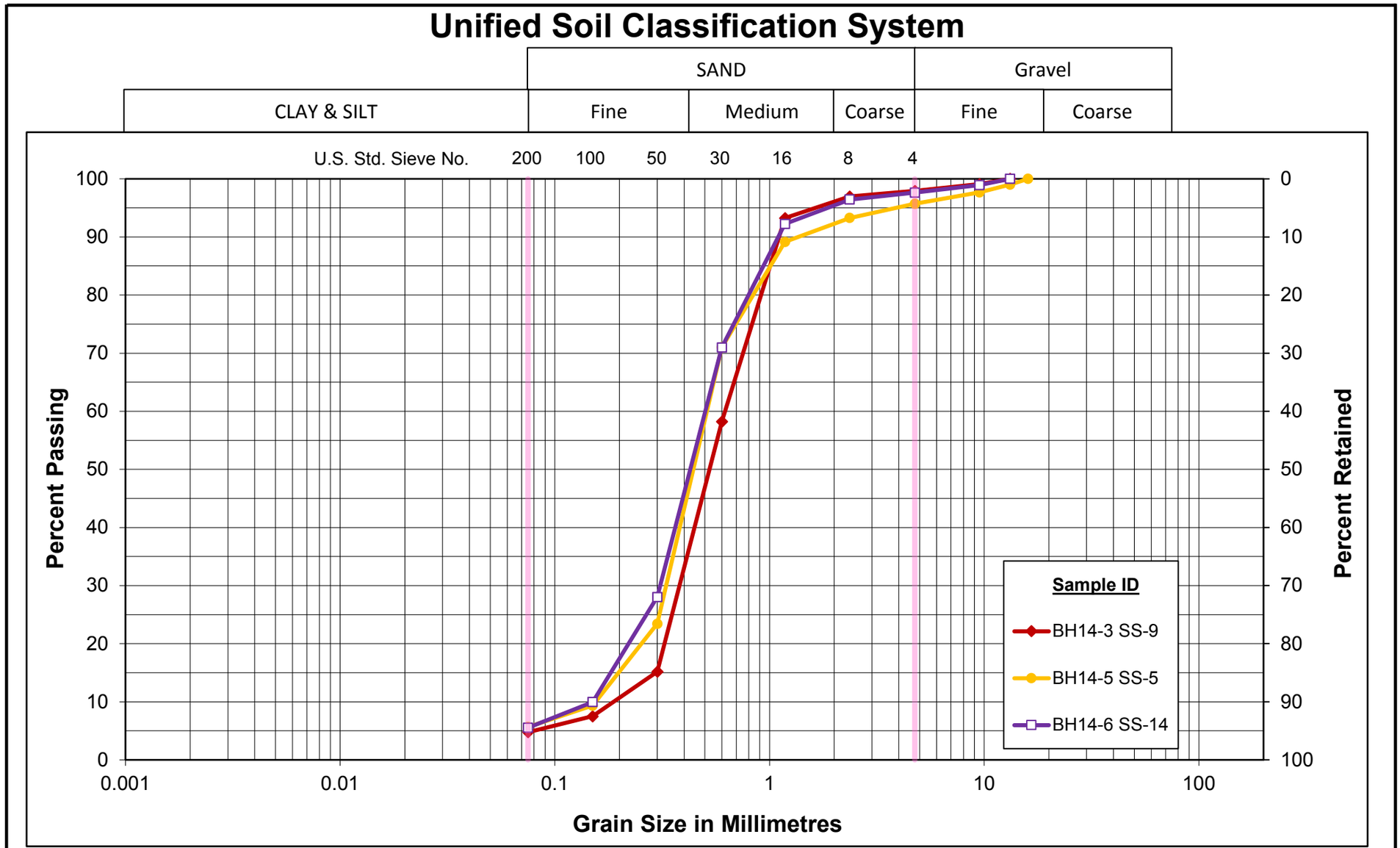
GRAIN SIZE DISTRIBUTION

FILL: Gravelly sand to sand and gravel, trace to some silt (SP-SM to GP-GM)

Figure No. 1

Project No. 165000897

GWP: 3060-11-00



Stantec

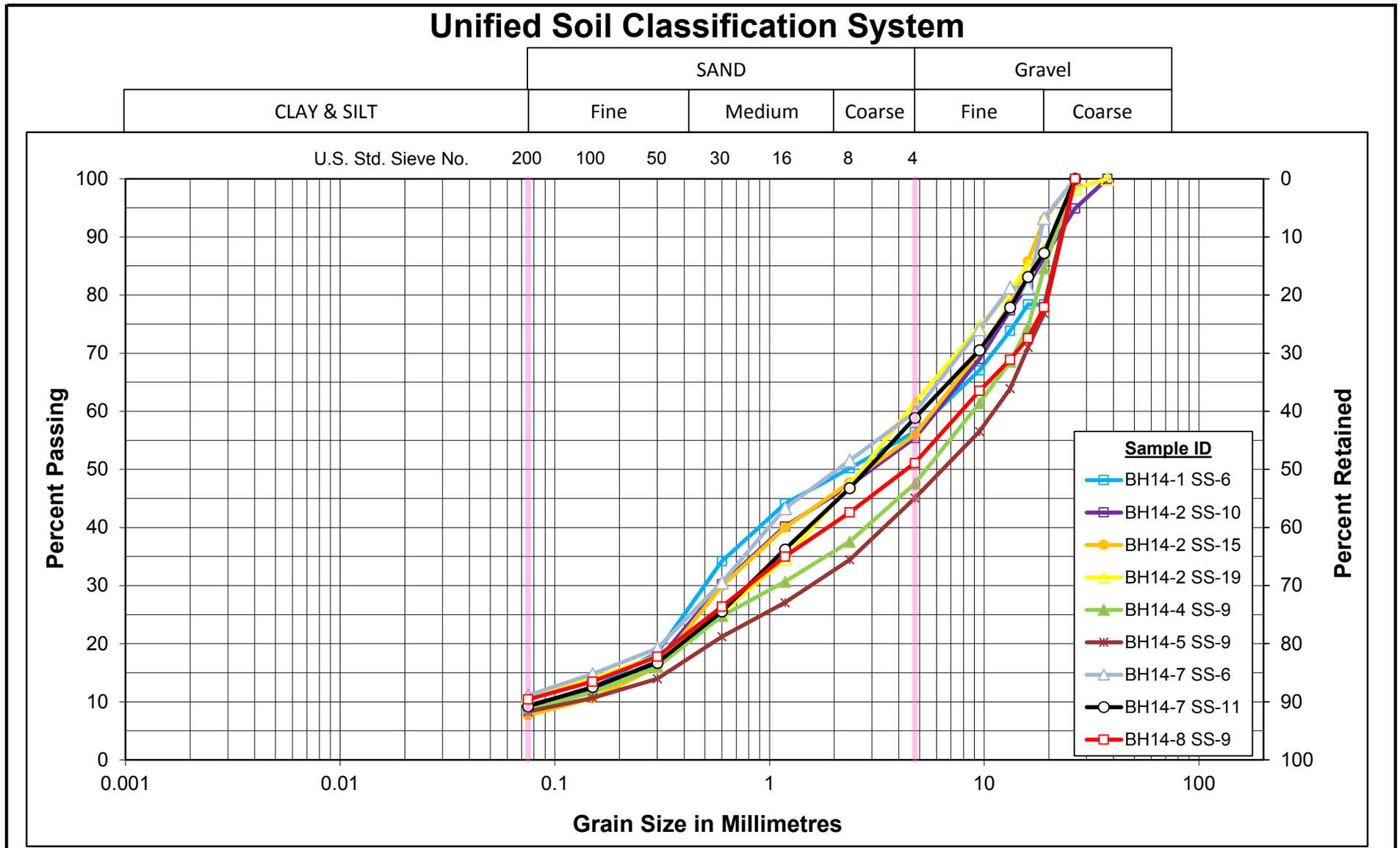
GRAIN SIZE DISTRIBUTION

Poorly graded sand with silt (SP-SM)

Figure No. 2

Project No. 165000897

GWP: 3060-11-00



Stantec

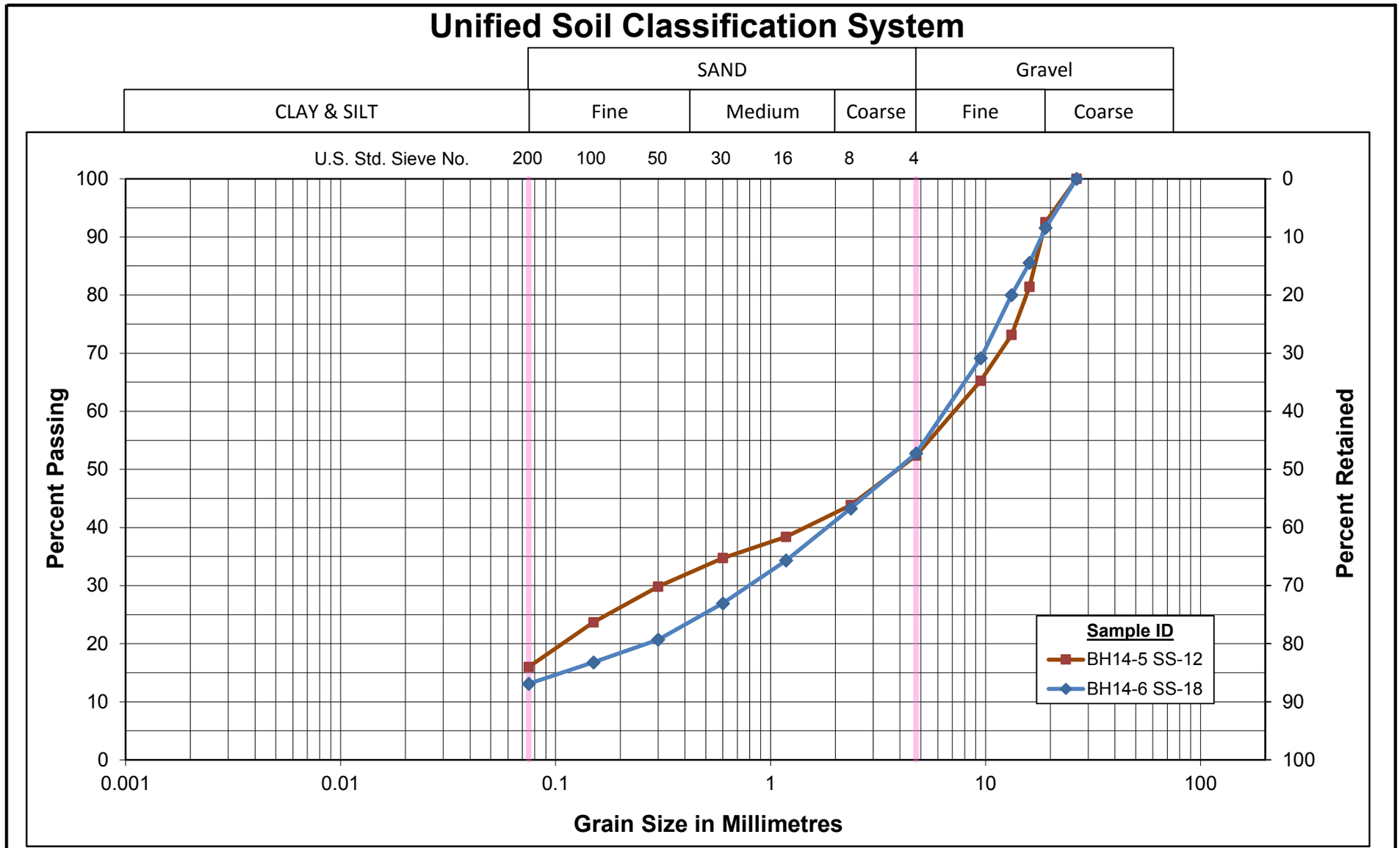
GRAIN SIZE DISTRIBUTION

TILL: Sand and gravel, trace to some silt
(SP-SM to GP-GM)

Figure No. 3

Project No. 165000897

GWP 3060-11-00



Stantec

GRAIN SIZE DISTRIBUTION

TILL: Sand and gravel, some silt (GM)

Figure No. 4

Project No. 165000897

GWP: 3060-11-00

PARACEL LABORATORIES LTD. | TRUSTED. RESPONSIVE. RELIABLE.

OTTAWA • KINGSTON • NIAGARA • MISSISSAUGA • SARNIA

Head Office
300-2319 St. Laurent Blvd.
Ottawa, Ontario K1G 4J8
p: 1-800-749-1947
e: paracel@paracellabs.com
www.paracellabs.com

Certificate of Analysis

Stantec Consulting Ltd. (Ottawa)

1331 Clyde Avenue Suite 400
Ottawa, ON K2C 3G4
Attn: Chris McGrath

Phone: (613) 722-4420
Fax: (613) 738-0721

Client PO: 165000897
Project: 165000897.260
Custody:

Report Date: 16-Sep-2014
Order Date: 12-Sep-2014

Order #: 1437293

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1437293-01	BH14-6 SS7 15'-17'
1437293-02	BH14-9 SS7 15'-17'
1437293-03	BH14-9 SS21 55'-57'
1437293-04	BH14-12 SS4 7'.6-9'.6
1437293-05	BH14-12 SS19 50'-52'

Approved By:

Mark Foto, M.Sc. For Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Report Date: 16-Sep-2014
Order Date:12-Sep-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	15-Sep-14	15-Sep-14
pH	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	15-Sep-14	15-Sep-14
Resistivity	EPA 120.1 - probe, water extraction	15-Sep-14	16-Sep-14
Solids, %	Gravimetric, calculation	15-Sep-14	15-Sep-14

PARACEL LABORATORIES LTD.

Order #: 1437293

Certificate of Analysis

Report Date: 16-Sep-2014
Order Date:12-Sep-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897

Project Description: 165000897.260

	Client ID:	BH14-6 SS7 15'-17'	BH14-9 SS7 15'-17'	BH14-9 SS21 55'-57'	BH14-12 SS4 7'.6-9'.6
	Sample Date:	17-Jul-14	17-Jul-14	17-Jul-14	17-Jul-14
	Sample ID:	1437293-01	1437293-02	1437293-03	1437293-04
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	97.1	89.9	92.5	97.4
General Inorganics					
pH	0.05 pH Units	8.10 [1]	8.09 [1]	8.13 [1]	8.20 [1]
Resistivity	0.10 Ohm.m	24.7	11.1	7.22	26.2
Anions					
Chloride	5 ug/g dry	164 [1]	409 [1]	822 [1]	112 [1]
Sulphate	5 ug/g dry	11 [1]	19 [1]	31 [1]	13 [1]

	Client ID:	BH14-12 SS19 50'-52'	-	-	-
	Sample Date:	17-Jul-14	-	-	-
	Sample ID:	1437293-05	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	87.6	-	-	-
General Inorganics					
pH	0.05 pH Units	8.09 [1]	-	-	-
Resistivity	0.10 Ohm.m	6.82	-	-	-
Anions					
Chloride	5 ug/g dry	913 [1]	-	-	-
Sulphate	5 ug/g dry	31 [1]	-	-	-

Certificate of Analysis

Report Date: 16-Sep-2014
Order Date:12-Sep-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Report Date: 16-Sep-2014
Order Date:12-Sep-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	52.8	5	ug/g dry	49.9			5.6	20	
Sulphate	215	5	ug/g dry	202			6.5	20	
General Inorganics									
pH	7.58	0.05	pH Units	7.59			0.1	10	
Resistivity	374	0.10	Ohm.m	419			11.3	20	
Physical Characteristics									
% Solids	87.2	0.1	% by Wt.	87.6			0.5	25	

Certificate of Analysis

Report Date: 16-Sep-2014
Order Date:12-Sep-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	149	5	ug/g	49.9	99.3	78-113			
Sulphate	304	5	ug/g	202	102	78-111			

Certificate of Analysis

Report Date: 16-Sep-2014
Order Date:12-Sep-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Qualifier Notes:

Sample Qualifiers :

1 : Holding time had been exceeded upon sample receipt.

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

PARACEL LABORATORIES LTD. | TRUSTED. RESPONSIVE. RELIABLE.

Head Office
300-2319 St. Laurent Blvd.
Ottawa, Ontario K1G 4J8
p: 1-800-749-1947
e: paracel@paracellabs.com
www.paracellabs.com

OTTAWA · KINGSTON · NIAGARA · MISSISSAUGA · SARNIA

Chain of Custody
(Lab Use Only)

Client Name:	Stantec Consulting Ltd.	Project Reference:	165000897
Contact Name:	Chris McGrath	Task #:	260
Address:	2781 Lancaster Road., Suite 101. Ottawa ON. K1B-1A7	PO #	165000897
Telephone:	613-738-6075	Email Address:	christopher.mcgrath@stantec.com

TAT: [X] Regular [ ] 3 Day [ ] 2 Day [ ] 1 Day

Date Required: _____

Criteria: [ ] O. Reg. 153/04 Table __ [ ] O. Reg. 153/11 (Current) Table __ [ ] RSC Filing [ ] O. Reg. 558/00 [ ] PWQO [ ] CCME [ ] SUB (Storm) [ ] SUB (Sanitary) Municipality: _____ [ ] Other: _____

Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)

Paracel Order Number: 1437293

	Sample ID/Location Name	Matrix	Air Volume	# of Containers	Sample Taken Date	Sample Taken Time	Resistivity	PH	Sulphates & Chlorides								
1	BH14-6 SS7 15'-17'	S		1	Jul 17/14		X	X	X						ZIPLOCK	BAG	
2	BH14-9 SS7 15'-17'	S		1			X	X	X								
3	BH14-9 SS21 55'-57'	S		1			X	X	X								
4	BH14-12 SS4 7'.6-9'.6	S		1			X	X	X								
5	BH14-12 SS19 50'-52'	S		1			X	X	X								
6																	
7																	
8																	
9																	
10																	

Comments:

Method of Delivery: Swift

Relinquished By (Print & Sign): Beth Frank	Received by Driver/Depot:	Received at Lab: SUNNYPORN DOKMAI	Verified By: MJC
Beth Frank	Date/Time:	Date/Time: SEP 12, 2014 01:27	Date/Time: Sept 12/14 1:36
Date/Time: Sept 12 2014	Temperature: _____ °C	Temperature: 24.3 °C	pH Verified [ ] By: N/A

PARACEL LABORATORIES LTD. | TRUSTED. RESPONSIVE. RELIABLE.

OTTAWA • KINGSTON • NIAGARA • MISSISSAUGA • SARNIA

Head Office
300-2319 St. Laurent Blvd.
Ottawa, Ontario K1G 4J8
p: 1-800-749-1947
e: paracel@paracellabs.com
www.paracellabs.com

Certificate of Analysis

Stantec Consulting Ltd. (Ottawa)

1331 Clyde Avenue Suite 400
Ottawa, ON K2C 3G4
Attn: Chris McGrath

Phone: (613) 722-4420
Fax: (613) 738-0721

Client PO: 165000897
Project: 165000897.260
Custody:

Report Date: 30-Oct-2014
Order Date: 27-Oct-2014

Order #: 1444034

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1444034-01	BH14-4 SS3 5'-7'

Approved By: Mark Foto

Mark Foto, M.Sc. For Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Report Date: 30-Oct-2014
Order Date:27-Oct-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	28-Oct-14	28-Oct-14
pH	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	28-Oct-14	28-Oct-14
Resistivity	EPA 120.1 - probe, water extraction	28-Oct-14	29-Oct-14
Solids, %	Gravimetric, calculation	28-Oct-14	28-Oct-14

Certificate of Analysis

Report Date: 30-Oct-2014
Order Date:27-Oct-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897

Project Description: 165000897.260

	Client ID:	BH14-4 SS3 5'-7'	-	-	-
	Sample Date:	24-Oct-14	-	-	-
	Sample ID:	1444034-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	95.8	-	-	-
General Inorganics					
pH	0.05 pH Units	8.21	-	-	-
Resistivity	0.10 Ohm.m	18.8	-	-	-
Anions					
Chloride	5 ug/g dry	225	-	-	-
Sulphate	5 ug/g dry	31	-	-	-

Certificate of Analysis

Report Date: 30-Oct-2014
Order Date:27-Oct-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Report Date: 30-Oct-2014
Order Date:27-Oct-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	9.7	5	ug/g dry	9.7			0.2	20	
Sulphate	ND	5	ug/g dry	ND			0.0	20	
General Inorganics									
pH	9.21	0.05	pH Units	9.18			0.3	10	
Resistivity	7.26	0.10	Ohm.m	7.16			1.4	20	
Physical Characteristics									
% Solids	83.1	0.1	% by Wt.	82.8			0.3	25	

Certificate of Analysis

Report Date: 30-Oct-2014
Order Date:27-Oct-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	9.9		mg/L	1.0	89.5	78-113			
Sulphate	10.0		mg/L	0.23	98.2	78-111			

Certificate of Analysis

Report Date: 30-Oct-2014
Order Date:27-Oct-2014

Client: **Stantec Consulting Ltd. (Ottawa)**
Client PO: 165000897 Project Description: 165000897.260

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

PARACEL LABORATORIES LTD. | TRUSTED. RESPONSIVE. RELIABLE.

Head Office
300-2319 St. Laurent Blvd.
Ottawa, Ontario K1G 4J8
p: 1-800-749-1947
e: paracel@paracellabs.com
www.paracellabs.com

OTTAWA · KINGSTON · NIAGARA · MISSISSAUGA · SARNIA

Chain of Custody
(Lab Use Only)

Client Name:	Stantec Consulting Ltd.	Project Reference:	165000897
Contact Name:	Chris McGrath	Task #:	260
Address:	101-2781 Lancaster Road., Suite 101. Ottawa ON. K1B-1A7	PO #	165000897
		Email Address:	christopher.mcgrath@stantec.com
Telephone:	613-738-6070 ; 613-791-9136		

TAT: [X] Regular [ ] 3 Day [ ] 2 Day [ ] 1 Day

Date Required: _____

Criteria: [ ] O. Reg. 153/04 Table __ [ ] O. Reg. 153/11 (Current) Table __ [ ] RSC Filing [ ] O. Reg. 558/00 [ ] PWQO [ ] CCME [ ] SUB (Storm) [ ] SUB (Sanitary) Municipality: _____ [ ] Other: _____

Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)

Paracel Order Number: 1444034

	Sample ID/Location Name	Matrix	Air Volume	# of Containers	Sample Taken Date	Sample Taken Time	Resistivity	PH	Sulphates & Chlorides								
							Required Analyses										
1	BH14-4 SS3 5'-7'	S		1			X	X	X				ZIPLOCK BAG				
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Comments:

Method of Delivery: COURIER

Relinquished By (Print & Sign): Dan Boateng	Received by Driver/Depot:	Received at Lab: COURIER DROP	Verified By: MJC
Date/Time: 27-Oct-14	Date/Time:	Date/Time: OCT 27, 2014 09:43	Date/Time: Oct 27/14 2:50
	Temperature: _____ °C	Temperature: 24.5 °C	pH Verified [ ] By: _____ N/A