FOUNDATION INVESTIGATION AND DESIGN REPORT

DUNDAS STREET/WEST DURHAM LINK COMMUTER CARPOOL LOT BRIDGE

STATION 1+061

WHITBY, ONTARIO

GEOCRES NO.30M15-282

WSP Project No.: 141-55237-00 (SPL No. 10001315)
July 12, 2016

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DUNDAS STREET/WEST DURHAM LINK COMMUTER CARPOOL LOT BRIDGE
AT STATION 1+061, WHITBY, ONTARIO
Geocres No: 30M15-282

1 INTRODUCTION

WSP Canada (WSP) was retained by Ainley & Associates Limited (Ainley) to carry out foundation investigations to provide necessary geotechnical information and make recommendations to construct the New Commuter Carpool Lot (CCL) bridge structure (24 m single span) located about 650 m north of Halls road and Dundas Street intersection, Whitby, Ontario. The structure is located in the Region of Durham, under the Central Region of the Ministry of Transportation (MTO). These form part of the work under MTO contract No. 2081-12-00.

This report addresses pertinent geotechnical information for the design and construction of the new CCL bridge structure. As part of the work under MTO 2081-12-00 contract, the new CCL bridge structure at Sta. 1+061 will be constructed as shown on the General Arrangement (GA) Drawing (dated January 26, 2016; prepared by Planmac Engineering Inc. (Planmac)).

The purpose of the Geotechnical Investigation was to determine the sub-surface conditions at the site by means of boreholes, field and laboratory tests. Based on the information obtained, the engineering characteristics of the subsurface soils are assessed and site conditions are described to develop geotechnical recommendations regarding bridge foundation options for the proposed bridge structure.

Part A of this report presents factual information concerning the subsurface conditions based on all the subsurface information at hand and is followed by Part B wherein engineering discussion and recommendations are made for the design and construction of the proposed CCL bridge structure. Early in the investigation, this site was also referred to as 407 Commuter Carpool Lot Bridge.

2 BACKGROUND INFORMATION

2.1 GEOLOGICAL SETTING

According to surficial geology of the Oshawa area map (MNDM-3331), regionally the project site lies within the glacial lake deposits, which has been characterized mainly as a silt and clay, massive to laminate and silt and clay interbedded with diamicton and some lone stones. According to MNDM (Map 2544), bedrock underlying the site comprises Upper Ordovician age shale (Whitby formation), limestone, dolostone, and sandstone. It is typically weathered and often there is a till/shale complex at the contact of the bedrock with the overburden above. This till/shale complex contains broken pieces of the shale bedrock mixed with clayey sand till/clayey silt till.

2.2 PREVIOUS GROUND INVESTIGATIONS

The general geology of the area was evaluated using regional data collected (MOE water well records (WWR)).

The wells were reportedly used for domestic water supply purposes and were installed in the Clay silt (till-shale complex) or Sand deposits.

Well records indicate that the depth to the Till-shale complex on west side of the Halls road is approximately 3.0 m. However, on the east side of Halls road, deeper overburden soils (about 8 m thick) are present.

Recorded water levels from the water well records in the vicinity of the site area, indicated that static water levels were generally at least 4.5 mbgs. Perched water within fill material may also be encountered.

2.3 SITE DESCRIPTION

The key plan of the site location is shown on **Drawing 1a**. The bridge site lies on the east of Halls road north and it is an undeveloped and generally well vegetated and treed landscape. Photographs 1 to 6 (all photographs in **Appendix C**) give a general impression of the proposed site.

All geographic directions used in this report are with reference to the "Construction North "direction shown on the GA drawing.

2.4 PROPOSED STRUCTURE

Initially the creek crossing was proposed as a culvert structure. It was subsequently revised as a single span bridge with an extended span length.

The details of the proposed structure are given in **Table 2-1**.

Table 2-1: Details of Dundas Street/West Durham Link CCL Bridge (Based on the GA drawing)

Nearby Road	**Halls Road North, Whitby, Ontario**
Station	1 + 061
Span (m)	24.0
Number of Lanes	2
Lane width (m)	3.75 m
Skew (degrees): perpendicular to the abutment axis and road centerline	0
Abutment Height (m)	4.0 (max.)
Wing wall Length (m)	7.0
Superstructure	CPCI girders with Concrete deck

At this bridge site, the proposed road embankment is approximately 4 m high and of El. 88.5 m on the road centerline. Based on the GA drawing, and the cross-sections provided, the toe of the west side slope of the north approach embankment overlies the creek with side slopes of 2 H: 1V.

3 FIELD AND LABORATORY INVESTIGATIONS

3.1 FIELD INVESTIGATIONS

Nine (9) boreholes (C1 to C6 and A1 to A3) were drilled for the proposed bridge. The boreholes were drilled between March 18, 2015 and November 30, 2015. Boreholes BH-A1 to A3 and BH-C1 to C4 were initially carried out to address a culvert structure mentioned in Section 2.4. The conversion of the water crossing structure to a single span bridge with an extended span necessitated two additional boreholes, BH-C5 and BH-C6. At the time these two additional boreholes were carried out, the north abutment of the bridge structure was not fixed (the south abutment was as proposed previously for the culvert structure and remained the same). The locations for these additional boreholes were based on approximate locations for the north abutment, based on discussions with the structural designers.

Boreholes BH-C1 and BH-C2 were drilled at the proposed south abutment locations to depths of 9.2 m and 11.8 m respectively. Boreholes BH-C3 and BH-C4 were drilled to address the now revoked culvert north abutment to depths of 9.3 m and 8.2 m respectively. Boreholes BH-C5 and BH-C6 were drilled at the proposed north abutment location (approximate) to depths of 7.7 m and 10.2 m respectively. On the south approach embankment side, two boreholes (BH-A1 and BH-A2) were drilled to depths of 9.2 m and 6.2 m respectively whereas BH-A3 was drilled in the north approach embankment side to a depth of 7.3 m.

Prior to drilling operations, underground utilities were cleared at the borehole locations by representatives of public, private companies and MTO.

The borehole investigation results are documented in **Appendix A**. The exploratory borehole locations are shown on **Drawing 1a** following the text of the report. A summary of the borehole information is given in **Table 3-1.**

Table 3-1: Summary of Borehole Details

BH No:	*Co-ordinates (m)	Ground Elevation (m)	Drilled Depth (m)	Remarks
BH-A1	E 346322 N 4859750	87.7	9.2	South approach embankment area; SBL shoulder; Solid stem auger; terminated within inferred bedrock; split spoon sampling and rock coring
BH-A2	E 346338 N4859752	86.9	6.2	South approach embankment area; SBL; Solid stem auger; terminated within the till/shale

BH No:	*Co-ordinates (m)	Ground Elevation (m)	Drilled Depth (m)	Remarks
				complex; split spoon sampling
BH-A3	E 346395 N4859768	85.3	7.3	North approach embankment area; C/L of road; Solid stem auger; terminated within inferred Bedrock; split spoon sampling and rock coring
BH-C1	E346358 N4859741	87.7	9.2	In the vicinity of south Abutment; Offset 13.8 m Rt. from C/L; solid stem auger; terminated on inferred bedrock; split spoon sampling and piezometer installed.
BH-C2	E346346 N4859766	86.8	11.8	In the vicinity of south Abutment; Offset 13.4 m Lt. from C/L; solid stem auger; terminated within bedrock; split spoon sampling and rock coring
BH-C3	E346371 N4859749	85.0	9.3	In between south and north abutments; Offset 10.7 m Rt. from C/L; solid stem auger; terminated within bedrock; spilt spoon sampling and rock coring
BH-C4	E346363 N4859769	85.3	8.2	In between south and north abutments; Offset 11.0m Lt. from C/L solid stem auger; terminated within inferred bedrock; spilt spoon sampling and rock coring
BH-C5	E346381 N4859754	85.0	7.7	In the vicinity of north Abutment: Offset 9 m Rt. from C/L; Solid stem auger: terminated on inferred bedrock; split spoon sampling
BH-C6	E346380 N4859772	85.3	10.2	In the vicinity of north Abutment ; Offset 9 m Lt. from C/L; Solid stem auger: terminated within inferred bedrock; split spoon sampling, rock coring and piezometer installed

NBL – northbound lane; SBL – southbound lane; *based on MTM NAD 83 Zone 10 coordinates

The boreholes were drilled using a track-mounted CME 55/75 rigs (owned/operated by DBW drilling and Drilltek drilling). These boreholes were advanced using solid stem augers (150 mm diameter).

Soil samples in the boreholes were taken at frequent intervals of depth by the Standard Penetration Test Method (SPT), in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm O.D. split barrel (SS-split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance (SPT) or the N-value of the soil. This is indicative of the compactness condition of granular (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils).

In-situ shear vane tests (with a MTO 'N' vane) were carried out within the cohesive soils when the consistency of such soils allowed to obtain an indication of the shear strength of the soil.

The WSP borehole investigation was carried out under full-time supervision of WSP engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System and soil samples retrieved for subsequent laboratory identification and testing. The recovered soil samples were placed in labelled moisture-proof bags, and returned to WSP's Vaughan laboratory for further assessment.

3.2 LABORATORY INVESTIGATIONS

A laboratory testing program, consisting of natural moisture content, Atterberg Limits tests and grain size analyses, was performed on selected representative samples. The results of the laboratory tests are presented on the appropriate Record of Borehole Sheets in **Appendix A** and details of grain size distributions and Atterberg limits are given in Appendix B.

3.3 GROUNDWATER INVESTIGATIONS

Groundwater conditions in the boreholes were observed during and on completion of drilling in the open boreholes. A standpipe piezometer was installed in Boreholes BH C1 and BH C6 upon their completion to enable long term groundwater level monitoring. The rest of the boreholes were grouted using a cement/bentonite mixture as per MTO procedures. As part of the construction, the piezometers need to be decommissioned in accordance with Ontario Regulation 903 (amended to Ontario Regulation 372/07).

Table 3.2 below provides information about the piezometers installed for this investigation, including ground surface elevations, well depths, and the approximate elevations for the well screens.

Table 3-2: Piezometer Installation Details

BH ID	Ground Surface Elevation (m)	Borehole Bottom		Well Screen Interval Depth, m		Well Screen Interval Elevation, m	
		Depth (m)	Elevation (m)	From	To	From	To
BH C1	87.7	9.2	78.5	3.1	6.1	84.6	81.6

BH ID	Ground Surface Elevation (m)	Borehole Bottom		Well Screen Interval Depth, m		Well Screen Interval Elevation, m	
		Depth (m)	Elevation (m)	From	To	From	To
BH C6	85.3	10.2	75.1	4.5	6.1	80.8	79.2

4 SUBSURFACE CONDITIONS

4.1 GENERAL

The subsurface conditions encountered at the bridge location are described in the following sections. For purposes of soil description, the MTO soil classification manual was generally followed.

A borehole location plan with a subsurface profile and cross-sections are shown on **Drawing 1a** and **1b** at the end of the text. It should be noted that the subsurface conditions may vary in between and beyond the borehole locations. **Drawing 1a** and **1b** that presents inferred stratigraphic details at the bridge location are based on the borehole data. The strata boundaries shown should not be interpreted as exact planes of geological change but rather as inferred transitions from one soil type to another.

The soil descriptions are based on visual and tactile observations, and complemented by the results of field and laboratory soil test results. It should be noted that the subsurface conditions and the topsoil thicknesses encountered may vary in between and beyond the borehole locations.

An overview of subsurface conditions is described below. All depths quoted are below existing ground surface. It is to be noted that based on the borehole data, the elevations (El.) reported for strata boundaries are from the shallowest occurrence to the deepest occurrence.

4.2 OVERVIEW

In general terms, the stratigraphic sequence encountered can be described as topsoil underlain by silty clay/clayey silt/sandy silt with organics. The underlying native deposits consisted of silty clay/silty sand followed by glacial tills (silty clay/silty sand). These were underlain by a till shale complex (with explored thicknesses between 1.3 m and 5.4 m) overlying shale bedrock/inferred of the Whitby formation at shallow depths ranging from 6.1 m to 9.1 m.

The hard clayey silt till shale complex contains varying amounts of shale fragments and overlies the shale bedrock. The Bedrock was cored in three boreholes with coring advanced exceeding 3.0 m in length in BH-C2 and BH-C3 only, whilst the shale was contacted in all the boreholes except in BH-A2, within the investigated depths. The elevation on top of the bedrock varied between 80.1 m and 77.2 m across the investigated holes where shale was contacted.

A borehole at each abutment location (or in close proximity) was installed with a piezometer. The measured groundwater level generally varied from 1.0 m to 3.0 below existing ground surface at the borehole locations (i.e., elevations of 85.9 to 83.8 m). However, it must be noted that the factual data presented on the Record of Borehole Sheets would govern any interpretation of the site conditions.

The glacial deposits, due to their mode of deposition, can be expected to have cobbles and boulders.

The following paragraphs are intended to give more detailed descriptions of the data documented on the Record of Borehole Sheets (**Appendix A**).

4.3 SUBSOIL CONDITIONS

4.3.1 TOPSOIL

All boreholes (BH-A1 to BH-A3 and BH-C1 to BH-C6) encountered topsoil at the ground surface which ranged between 300 mm and 510 mm in thickness. However, it is to be noted, based on our experience, the thickness of topsoil frequently varies in between and beyond borehole locations, especially in depressed areas and near watercourses.

Moisture content of this deposit ranged between 23% and 53%, indicating a generally wet condition (based on nine (9) SPT samples) and the higher moisture contents indicative of the organics.

4.3.2 SILTY CLAY TO CLAYEY /SANDY SILT

Below the topsoil, all boreholes encountered silty clay to clayey/sandy silt material to depths ranging from 0.8 m to 1.5 m (El. 87.3 to 83.8 m) containing organics. The explored thickness of this material ranged between 0.3 m (BH-C4 and A3) to 1.0 m (BH-C6). This material typically contained silty clay to clayey/sandy silt mixed with topsoil and rootlets and trace to some organics. It could likely be re-worked native material with a possible farming background in the past.

Moisture content of this deposit was 31%, indicative of a wet condition (based on one (1) SPT sample).

A SPT N-value of 4 blows/0.3 m was obtained in this layer indicative of a very soft consistency (based on one (1) SPT value; BH-C6/SS2).

4.3.3 SILTY CLAY

With the exception of boreholes BH-C5 and BH-C6, all boreholes encountered a soft to very stiff silty clay deposit below the deposit with an organic background at a depth of 0.8 m (elevations ranging from 87.0 m in BH-A1 to 84.2 m in BH-C3) below ground surface. The explored thickness of this deposit varied between 0.7 m (BH-C2, C3 and C4) and 4.1 m (BH-A2). A thin clayey silt (approximately 0.5 m thick) which is interlayered with the silty clay deposit was encountered in the boreholes BH-A2 and BH-A3.

The grain size distributions of two (2) representative samples from the silty clay were determined in the laboratory which gave the following grain size distribution.

Table 4-1: Grain Size Distribution Summary-Silty Clay

Sample Tested	Size Fraction	% Passing by weight	Remarks
BH-A2/SS3 **BH-C1/SS3**	Gravel	0%	Shown as Fig.1, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Sand	2%	
	Silt	40% to 48%	
	Clay	50% to 58%	

The grain size distributions of two (2) samples from the interlayered clayey silt were determined in the laboratory which gave the following grain size distribution.

Table 4-2: Grain Size Distribution Summary-Clayey Silt

Sample Tested	Size Fraction	% Passing by weight	Remarks
BH-A2/SS5 **BH-A3/SS3**	Gravel	11% to 14 %	Shown as Fig.1, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Sand	34% to 44%	
	Silt	30% to 38%	
	Clay	12% to 17%	

This deposit broadly consists of dark brown to brown silty clay with trace to some gravel and trace sand to sandy.

Atterberg Limit tests were performed on representative samples from the silty clay deposit. These tests indicate the following index values.

Table 4-3: Atterberg Limits Test Results-Silty Clay

Sample Tested	Atterberg Limits	Index Values	Remarks
BH-A2/SS3 **BH-C1/SS3**	Liquid Limit	42 % to 46 %	Shown as Fig.5, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Plastic Limit	21% to 25 %	

Sample Tested	Atterberg Limits	Index Values	Remarks
	Plasticity Index	21 %	

An Atterberg Limit test was performed on a sample from the interlayered clayey silt. This test indicates the following index values.

Table 4-4: Atterberg Limits Test Results-Clayey Silt

Sample Tested	Atterberg Limits	Index Values	Remarks
BH-A3/SS3	Liquid Limit	23%	Shown as Fig.5, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Plastic Limit	15%	
	Plasticity Index	8%	

The above values are characteristic of a cohesive soil of low plasticity (CL) to intermediate plasticity (CI).

Moisture content within this deposit ranged between 5% (BH-A2/SS7) and 37% (BH-A3/SS4a), indicating a generally moist to wet condition (based on 17 SPT samples). The plasticity indices and the moisture contents indicate a variable consolidation stress history.

SPT N-values of 2 blows/0.3 m (BH-C4/SS2) to 21 blows/0.3 m (BH-A1/SS2) were obtained in the deposit. Field vane test was also performed within this deposit and the result yielded a shear strength value of 20 kPa (BH-A2/Vane 6). Collectively, these indicate, the consistency of this material can be described as soft to very stiff consistency (based on 16 SPT values and one vane test).

4.3.4 SILTY SAND

Boreholes BH-C5 and BH-A1 encountered a silty sand deposit at depths of 0.9 m (in BH-C5) and 2.6 m (in BH-A1) respectively below ground surface with elevations of 84.1 (BH-C5) and 85.1 m (BH-A1). The explored thicknesses of this deposit were 1.2 m (BH-A1) and 1.7 m (BH-C5).

Moisture contents based on three (3) samples recovered from this layer ranged from 5 % (BH-A1/SS5) to 20 % (BH-C5/SS3) indicative of a moist condition.

SPT testing carried out in this layer gave SPT ‘N’ values ranging from 6 (BH-C5/SS2) to 20 (BH-C5/SS3) blows/0.3 m (based on 3 test results) which indicate a loose to compact relative density condition.

4.3.5 CLAYEY SILT TILL

Boreholes BH-A1, BH-C1, BH-C2, BH-C3 and BH-A3 encountered a clayey silt till deposit. The clayey silt till was encountered at depths ranging from 1.5 m (BH-C3) to 3.8 m (BH-C2 and BH-A1) below ground surface. In terms of ground elevation, this deposit was contacted at elevations ranging from El. 84.6(BH-C1) to 82.8 (BH-A3). The explored thickness of this deposit was between 1.5 m (BH-C2) and 2.3 m (BH-A1, A3 and C3). Shale rich interlayers were found within the deposit based on visual observation.

The grain size distribution of one (1) sample from the clayey silt till was determined in the laboratory which gave the following grain size distribution which reflects the presence of shale fragments in the coarser grain sizes.

Table 4-5: Grain Size Distribution Summary-Clayey Silt Till

Sample Tested	Size Fraction	% Passing by weight	Remarks
BH-C1/SS6	Gravel	21 %	Shown as Fig.2, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Sand	36%	
	Silt	30%	
	Clay	13%	

The grain size distribution of one (1) sample from the clayey silt till with shale rich interlayer was determined in the laboratory which gave the following grain size distribution which reflects the presence of an increased amount of shale fragments in the coarser grain sizes:

Table 4-6: Grain Size Distribution Summary-Clayey Silt Till (Shale Rich)

Sample Tested	Size Fraction	% Passing by weight	Remarks
BH-A3/SS4b	Gravel	34 %	Shown as Fig.2, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Sand	51%	
	Silt	11%	
	Clay	4%	

This till deposit broadly consists of dark grey clayey silt till with trace sand to sandy and trace to some shale fragments.

Moisture contents based on eleven (11) samples recovered from this deposit ranged from 5% (BH-C2/SS7) to 15% (BH-A1/SS7) indicative of a moist condition.

SPT testing carried out in this layer gave SPT ‘N’ values ranging from 14 (BH-C1/SS5) to 92 (BH-C2/SS6) blows/0.3 m (based on 12 test results) which indicate a stiff to hard consistency.

4.3.6 SANDY SILT TO SILTY SAND TILL

Boreholes BH-C2, BH-C4 and BH-C6 encountered a sandy silt to silty sand till deposit at a depth of 1.5 m below ground surface. In terms of ground elevation, this deposit was at elevations ranging from El. 85.3 (BH-C2) to 83.7 m (BH-C4). The explored thickness of this deposit was between 1.1 m (BH-C6) and 2.3 m (BH-C2).

The grain size distributions of two (2) samples from the sandy silt to silty sand till were determined in the laboratory which gave the following grain size distribution:

Table 4-7: Grain Size Distribution Summary-Sandy Silt to Silty Sand Till

Sample Tested	Size Fraction	% Passing by weight	Remarks
BH-C2/SS4 **BH-C6/SS3**	Gravel	15 % to 16 %	Shown as Fig.3, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Sand	50% to 60%	
	Silt	17% to 25%	
	Clay	7% to 10%	

This till deposit broadly consists of brown to dark grey sandy silt to silty sand till with trace to some clay and some gravel.

Moisture contents based on six (6) samples recovered from this layer ranged from 6% (BH-C4/SS4) to 20% (BH-C6/SS3) indicative of a moist condition.

SPT testing carried out in this layer gave SPT 'N' values ranging from 11 (BH-C6/SS3) to 66 (BH-C2/SS5) blows/0.3 m (based on 6 test results) which indicate a compact to very dense relative density condition. High SPT 'N' value (66 blows) was encountered only in BH-C2/SS5 due to possible influence of underlying hard clayey silt till deposit.

4.3.7 CLAYEY SILT (TILL/SHALE COMPLEX)

All boreholes encountered a clayey silt Till/Shale Complex at depths ranging from 2.6 m (in BH-C5 and C6) to 6.1 m (BH-A1) with elevations ranging from El. 82.7 (BH-C6) to El. 80.7 m (BH-A3). The explored thickness of this deposit was between 1.3 m (BH-A2) and 5.4 m (BH-C6). Borehole BH-A2 was terminated within this deposit. In Boreholes BH-C5 and BH-C6, probable shale floaters were observed within this layer resulting in more shale fragments in some horizons.

The grain size distributions of two (2) samples from the more shale horizons of this deposit were determined in the laboratory which gave the following grain size distribution.

Table 4-8: Grain Size Distribution Summary-Clayey Silt (Till/Shale Complex) –Shale Horizon

Sample Tested	Size Fraction	% Passing by weight	Remarks
BH-C5/SS5 **BH-C6/SS7**	Gravel	27% to 37%	Shown as Fig.4, in Appendix B; Summarized on the relevant Record of Borehole Sheets
	Sand	48% to 51%	
	Silt	11% to 16%	
	Clay	4% to 6%	

In general, this deposit broadly consists of grey to dark grey clayey silt (till/shale complex) with trace sand to sandy and some gravel to gravelly (shale fragments in the coarser particle sizes).

Moisture content based on thirty one (31) samples recovered from this deposit ranged from 4% (BH-C2/SS10 and BH-C3/SS6) to 14% (BH-C1/SS11) indicative of a moist condition.

SPT testing (based on 31 SPT results) carried out in this layer gave SPT ‘N’ values ranging from 20 blows/0.3 m (BH-C5/SS4) to in excess of 100 blows/0.3 m (BH-C2/SS8, C3/SS8 and C6/SS10) which indicate a very stiff to hard consistency.

4.3.8 SHALE BEDROCK

With the exception of borehole BH-A2, the presence of bedrock was inferred from auger/split spoon/rock coring in all the exploratory boreholes. The bedrock was confirmed only in two boreholes (BH-C2 and BH-C3) with a 3 m rock core as per industry standards whilst rock coring was also undertaken to a shorter length in BH-C6. The findings are given in **Table 4.9.** Photographs of rock core samples are attached in **Appendix C**.

Table 4-9: Depth/Elevation of Bedrock/ Inferred Bedrock

BH No:	Depth Below Ground Surface (m)	Top Elevation (m)	Augered / Cored Depth (m)	RQD % (RQD in core runs)	Uniaxial compressive strength based on Point Load Test, MPa (run)	Remarks
BH-A1	7.6	80.1	1.6 (augered)	N/A	N/A	SPT ‘N’ (2 SPT results) > 100 and terminated due to auger refusal
BH-A3	6.1	79.2	1.2 (augered)	N/A	N/A	SPT ‘N’ (1 SPT

BH No:	Depth Below Ground Surface (m)	Top Elevation (m)	Augered / Cored Depth (m)	RQD % (RQD in core runs)	Uniaxial compressive strength based on Point Load Test, MPa (run)	Remarks
						result) > 100 and terminated due to auger refusal
BH-C1	9.1	78.6	0.1 (augered)	N/A	N/A	SPT 'N' (1 SPT result) > 100 and terminated due to auger refusal
BH-C2	8.8	78.0	3.0 (cored)	0/39/85	19 (run 2) and 21 (run 3)	
BH-C3	6.1	78.9	3.2 (cored)	0/0/0/63	19/23/19/19	
BH-C4	6.1	79.2	2.1 (augered)	N/A	N/A	SPT 'N' (2 SPT results) > 100 and terminated due to auger refusal
BH-C5	7.6	77.4	0.1(augered)	N/A	N/A	SPT 'N' (1 SPT result) > 100 and terminated on inferred bedrock surface
BH-C6	8.1	77.2	2.1 (cored)	0/30	23 (run 2)	

RQD values measured on the recovered cores ranged from approximately 0% to 85% which is indicative of a rock mass of very poor to good quality as per Canadian Foundation Engineering Manual (Table no. 3.10). Based on the point load based uniaxial strengths ranging from 19 to 23 MPa, the encountered shale can be described as weak (as per Canadian Foundation Engineering Manual - Table no. 3.5) at the point load test locations.

4.4 GROUNDWATER OBSERVATIONS

Groundwater conditions in the open boreholes were observed during the drilling and at the completion of each borehole. A standpipe piezometer was installed in Boreholes BH-C1 and BH-C6. The observations are shown on the individual Record of Borehole Sheets in **Appendix A**.

The observed water levels in the open boreholes on completion ranged from 0.8 m (BH-C4) to 3.0 m (BH-A2) m below grade level. It should be noted that these water levels had not stabilized. In the piezometers, the water levels were measured at depths ranging from 0.95 m (approx. 1 week after installation in BH-C6) to 2.0 m (approx. 37 weeks after installation in BH-C1) below ground surface or at El. 85.7 m to 84.35 m.

The table below summarizes the ground water observations.

Table 4-10: Summary of Groundwater Observations

BH No.	Ground Elevation (m)	Top of Screen Depth/Elevation (m)	Water Level Measurements		Remarks
			Depth (m)	Elevation (m)	
BH-A1	87.7	N/A	2.2*	85.5	Wet spoon @ 2.3 m & Borehole Open
BH-A2	86.9	N/A	3.0*	83.9	Wet spoon @ 4.6 m & Caved @ 5.2 m
BH-A3	85.3	N/A	1.2*	84.12	Wet spoon @ 2.4 m & Caved @ 4.6 m
BH-C1	87.7	3.1/84.6	3.0*	84.7	Wet spoon and Caved @ 6.1 m
			3.0 (Mar.18,2015)	84.7	
			2.0 (Mar.26,2015)	85.7	
			2.0 (Dec.07, 2015)	85.7	
BH-C2	86.8	N/A	0.9*	85.9	Wet spoon @ 3.9 m & Caved @ 4.6 m
BH-C3	85.0	N/A	0.9*	84.1	Wet spoon @ 1.6 m & Caved @ 4.6 m
BH-C4	85.3	N/A	0.8*	84.5	Wet spoon @ 1.6 m & Caved @ 6.0 m

BH-C5	85.0	N/A	1.2*	83.8	Wet spoon @ 1.5 m & Caved @ 6.1 m
BH-C6	85.3	4.6 / 80.7	1.5*	83.8	Wet spoon @ 2.5 m & Caved @ 6.1 m
			0.95 (Dec.07,2015)	84.4	

*water level measurement upon completion of borehole

It should be pointed out that groundwater levels would be subject to seasonal fluctuations in response to major weather events. The groundwater levels observed at the site may also be influenced by the water level in the watercourse.

SIGNATURES

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MTO Designated Contact

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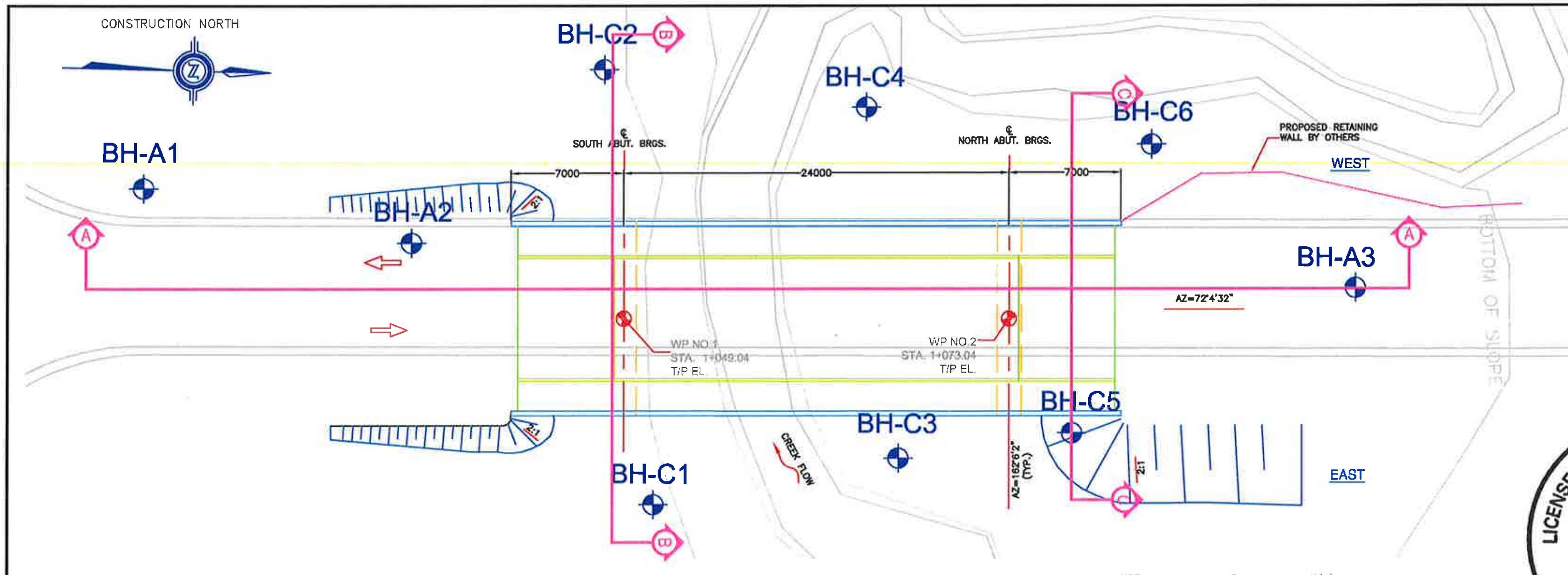
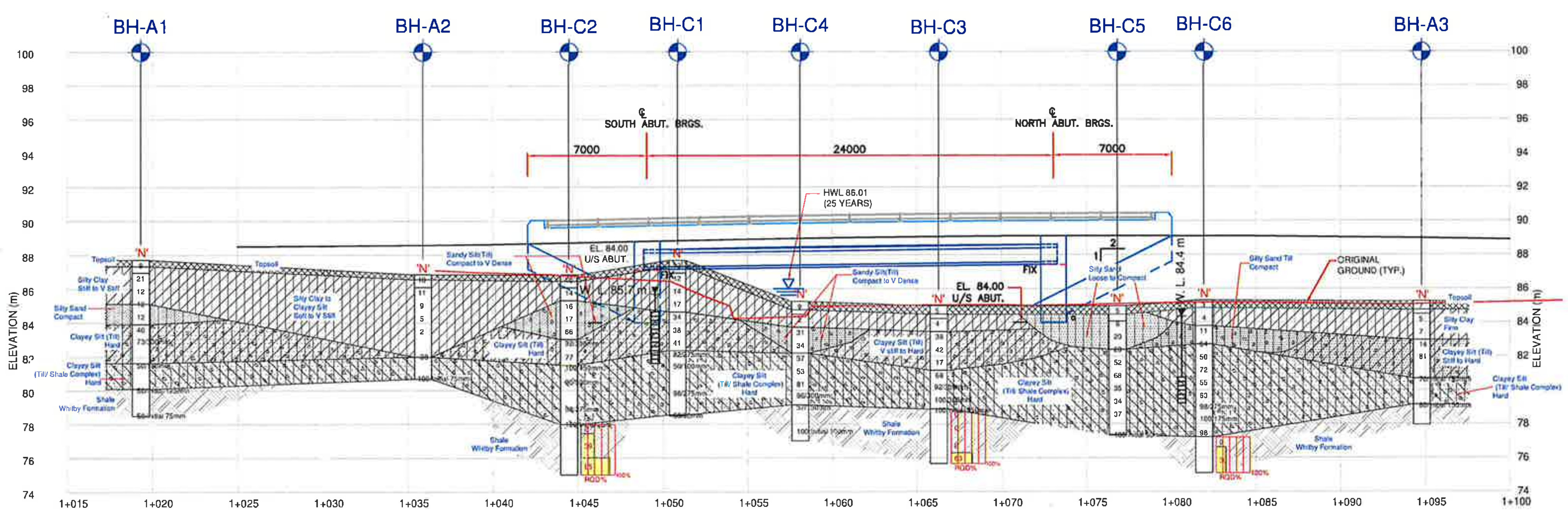
Drawings



PLAN



CROSS SECTION A-A

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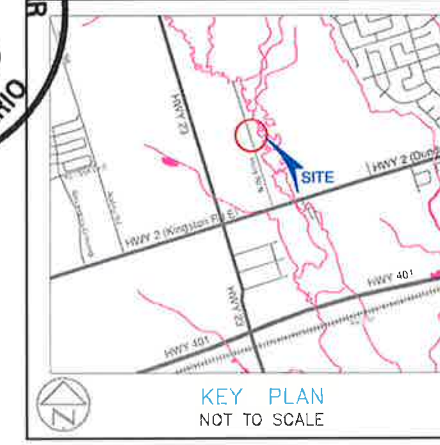
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No: 2081–12–00

HIGHWAY 407 EAST
BOREHOLE LOCATIONS & SOIL STRATA

WSP
51 Constellation Court
Toronto, Ontario
M9W 1K4



KEY PLAN
NOT TO SCALE

LEGEND

- Borehole
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL in Piezometer (Dec 07, 2015)
- Piezometer

SOIL STRATA SYMBOLS

- Topsoil
- Silty Clay/ Clayey Silt
- Silty Sand/ Sandy Silt
- Clayey Silt Till
- Silty Sand Till
- Clayey Silt (Till/ Shale Complex)
- Shale Whitby Formation

BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTH (m)	EAST (m)
BH-A1	87.7	4859750	346322
BH-A2	86.9	4859752	346338
BH-A3	85.3	4859768	346395
BH-C1	87.7	4859741	346358
BH-C2	86.8	4859766	346346
BH-C3	85.0	4859749	346371
BH-C4	85.3	4859769	346363
BH-C5	85.0	4859754	346381
BH-C6	85.3	4859772	346380

— NOTES —

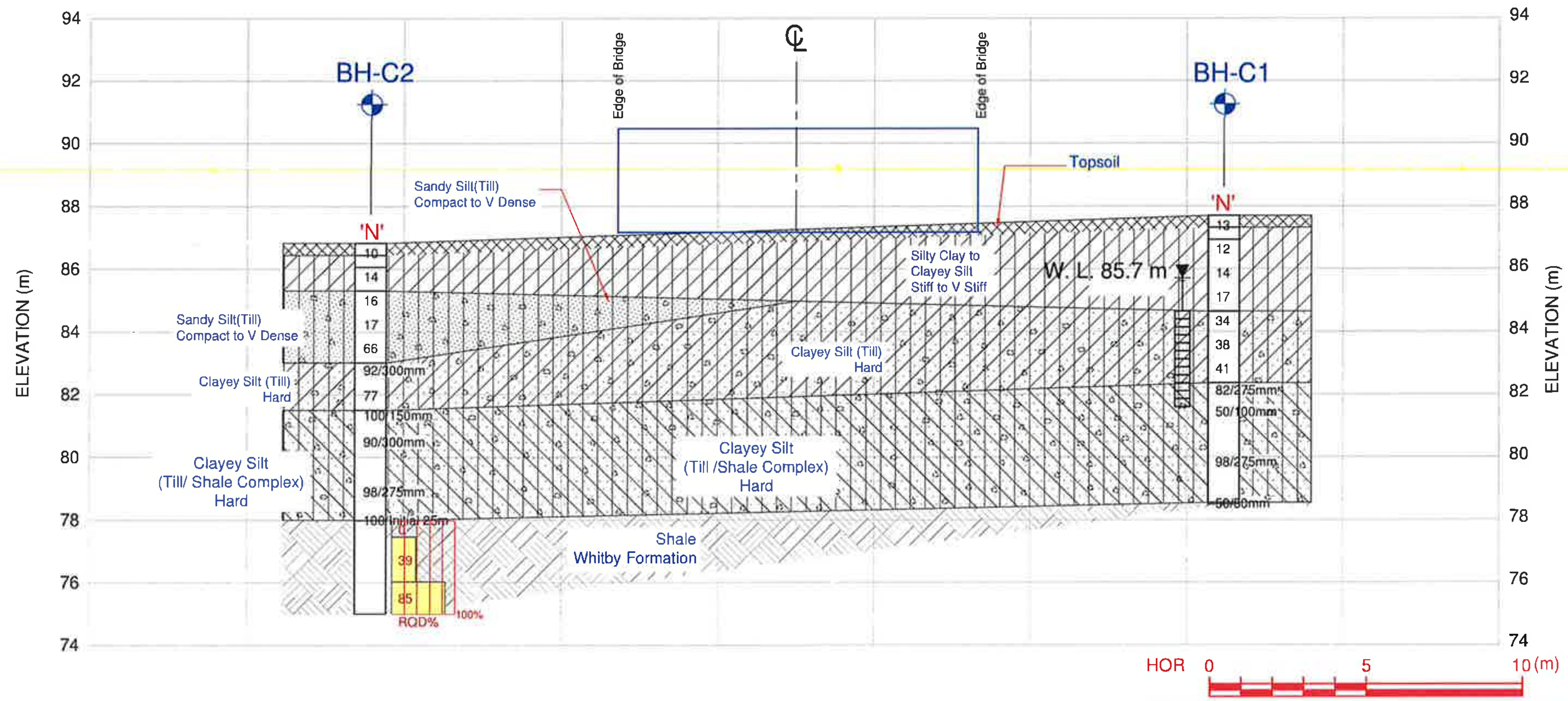
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

Borehole Location plan and profile are based on drawing "1-GA.dwg" received on February 3, 2016.

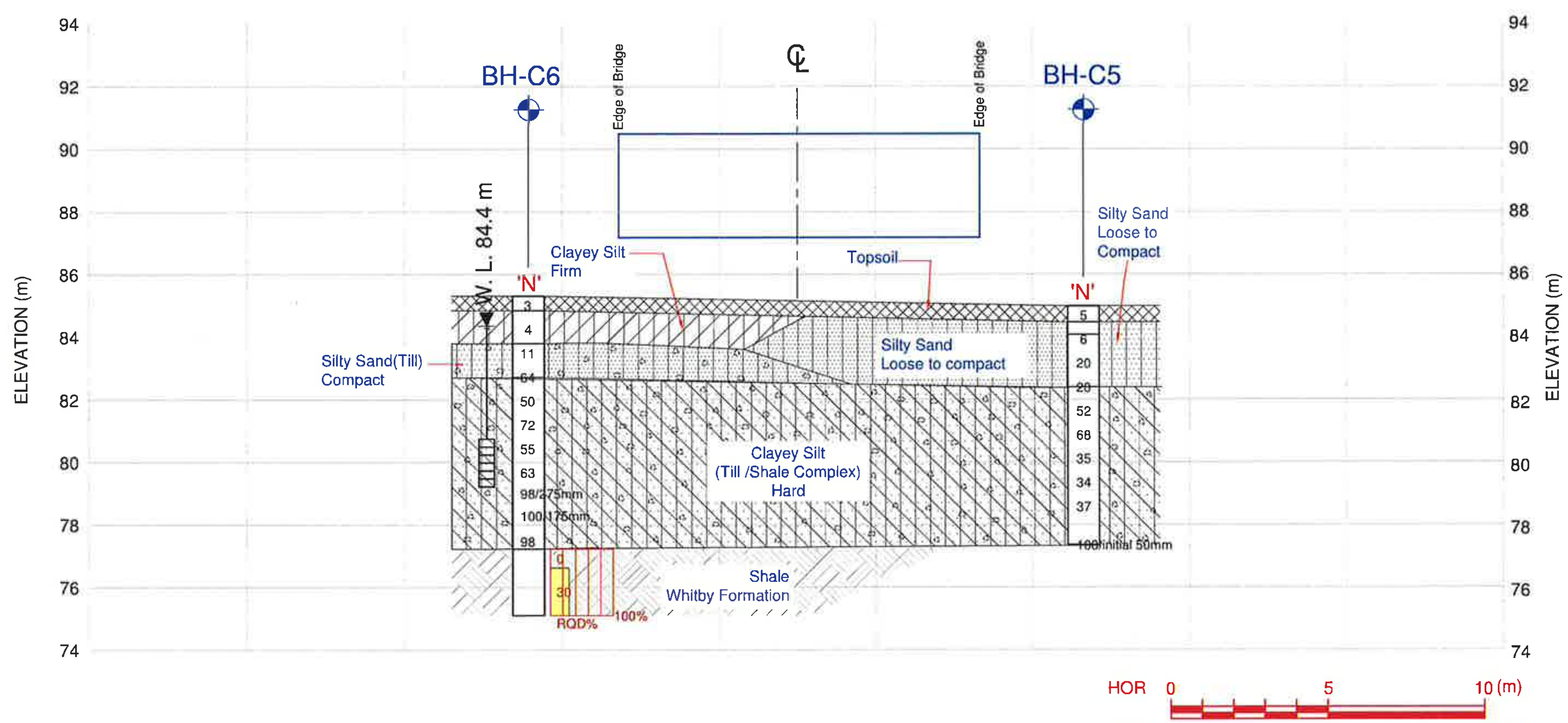
REVISIONS		
Mar 30/16	ZMO	Submission for MTO review
DATE	BY	DESCRIPTION

GEOCRES No : 30M15-282

HWY No			DIST
SUBM'D	CHECKED MP	DATE Mar 30/16	SITE
DRAWN ZMO	CHECKED MP	APPROVED VW	DWG 1a



CROSS SECTION B-B



CROSS SECTION C-C

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

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100186910
July 8, 2016
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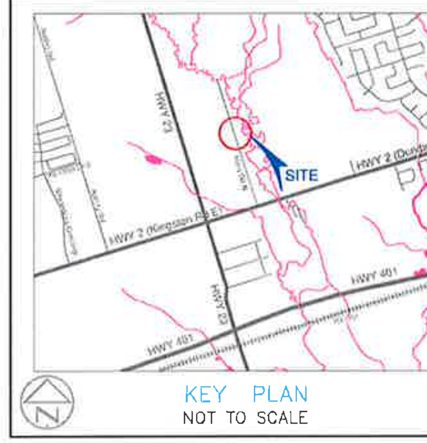
SOIL STRATA SYMBOLS

- Topsoil
- Silty Clay/ Clayey Silt
- Silty Sand/ Sandy Silt
- Clayey Silt Till
- Silty Sand Till
- Clayey Silt (Till/ Shale Complex)
- Shale Whitby Formation

CONT No:
2081–12–00

HIGHWAY 407 EAST
BOREHOLE LOCATIONS & SOIL STRATA

WSP
51 Constellation Court
Toronto, Ontario
M9W 1K4



KEY PLAN
NOT TO SCALE

LEGEND

- Borehole
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL in Piezometer
- Piezometer

BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTH (m)	EAST (m)
BH–A1	87.7	4859750	346322
BH–A2	86.6	4859752	346338
BH–A3	85.3	4859768	346395
BH–C1	87.7	4859741	346358
BH–C2	86.8	4859766	346346
BH–C3	85.0	4859749	346371
BH–C4	85.3	4859769	346363
BH–C5	85.0	4859754	346381
BH–C6	85.3	4859772	346380

— NOTES —

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

Borehole Location plan and profile are based on drawing "1–GA.dwg" received on February 3, 2016.

REVISIONS		
Mar 30/16	ZMO	Submission for MTO review
DATE	BY	DESCRIPTION

GEOCRES No : 30M15–282

HWY No			DIST
SUBM'D	CHECKED MP	DATE Mar 30/16	SITE
DRAWN ZMO	CHECKED MP	APPROVED VW	DWG 1b

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Appendix A: Record of Borehole Sheets

Ministry of Transportation Ontario

RECORD OF BOREHOLE No BH-A1

METRIC

W.P. 2081-12-00 LOCATION MTM NAD 83 Zone 10, E 346322, N 4859750 ORIGINATED BY AT

DIST HWY 407 CCL BOREHOLE TYPE Solid Stem Auger COMPILED BY AT

DATUM Geodetic DATE Mar/17/2015 to Mar/17/2015 CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS
87.7 / 0.0	**TOPSOIL:** 380mm					
87.3 / 0.4	**SILTY CLAY:** mixed with topsoil, trace rootlets, dark brown to brown, moist, stiff.	1	SS	9	○	
87.0 / 0.8	**SILTY CLAY:** trace gravel, brown, moist, stiff to very stiff.	2	SS	21	○	
		3	SS	12	○	
						wet spoon
85.1 / 2.6	**SILTY SAND:** trace clay, trace gravel, brown, wet, compact.	4	SS	12	○	
		5	SS	12	○	
83.9 / 3.8	**CLAYEY SILT (TILL):** trace sand, trace shale fragments, dark grey, moist, hard.	6	SS	40	○	
		7	SS	73/ 300mm	○	
81.6 / 6.1	**CLAYEY SILT (TILL/SHALE COMPLEX):** trace sand, some shale fragments, dark grey, moist, hard.	8	SS	50/ 100mm	○	
80.1 / 7.6	**WHITBY FORMATION:** shale, dark grey.	9	SS	50/ Initial 125mm	○	
78.5		10	SS	50/ Initial 75mm	○	
9.2	**END OF THE BOREHOLE** Note: 1) Borehole was open and water at 2.15m below ground surface upon completion. 2) Auger refusal at 9.2m					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (87, 86, 85, 84, 83, 82, 81, 80, 79); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m³) γ; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

10001315

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

$+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No BH-A2

METRIC

W.P. 2081-12-00 LOCATION MTM NAD 83 Zone 10, E 346338, N 4859752 ORIGINATED BY AT

DIST HWY 407 CCL BOREHOLE TYPE Solid Stem Auger COMPILED BY AT

DATUM Geodetic DATE Mar/18/2015 to Mar/18/2015 CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa / DCPT	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.9								
0.0	**TOPSOIL:** 300mm							
86.6 / 0.3	**SILTY CLAY:** mixed with topsoil, trace rootlets, dark brown to brown, moist, stiff.	1	SS	10			○	
86.1 / 0.8	**SILTY CLAY:** trace sand, brown, moist, firm to stiff.	2	SS	11	86		○	
		3	SS	9	85		○ wp–wL (42)	0 2 48 50
		4	SS	5	84		○	
	clayey silt, soft	5	SS	2			○	11 34 38 17
		6	VANE		83	+ 4.0		
82.3 / 4.5	**CLAYEY SILT (TILL/SHALE COMPLEX):** trace sand, some shale fragments, grey, moist, hard.	7	SS	38	82		○	wet spoon
					81			
80.7 / 6.2	**END OF THE BOREHOLE** Note: 1) Borehole caved at 5.2m and water at 3m below ground surface upon completion.	8	SS	100/ Initial 75mm				

ON-MTO-2015 DUNDAS CROSSING DEC. 18,2015.GPJ ON_MOT.GDT 3/29/16

10001315

+3, ×3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

Ministry of Transportation Ontario

RECORD OF BOREHOLE No BH-A3

METRIC

W.P. 2081-12-00	LOCATION MTM NAD 83 Zone 10, E 346395, N 4859768		ORIGINATED BY AT
DIST	HWY 407 CCL	BOREHOLE TYPE Solid Stem Auger	COMPILED BY AT
DATUM Geodetic		DATE Mar/19/2015 to Mar/19/2015	CHECKED BY RM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT / PLASTIC–LIQUID LIMIT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.3 / 0.0	**TOPSOIL:** 510mm	1	SS	7		85		
84.7 / 0.5	**SILTY CLAY:** sandy, mixed with topsoil, trace rootlets, dark brown to brown, moist, firm							
84.5 / 0.8	**SILTY CLAY:** sandy, trace gravel, trace shale fragments, brown, moist, firm to stiff.	2	SS	5		84		
	grey below 1.5m	3	SS	7				14 44 30 12
	clayey silt	4a	SS			83		wet spoon
82.8 / 2.5	**CLAYEY SILT (TILL):** trace sand to sandy, trace to some shale fragments, dark grey, moist, stiff to hard.	4b	SS	14				34 51 11 4
		5	SS	81		82		
80.7 / 4.6	**CLAYEY SILT (TILL/SHALE COMPLEX):** trace sand, some shale fragments, dark grey, moist, hard.	6	SS	70/ Initial 50mm		81, 80		
79.2 / 6.1	**WHITBY FORMATION:** shale, dark grey.	7	SS	80/ Initial 50mm		79		
78.0 / 7.3	**END OF THE BOREHOLE**					78		

Note:
1) Borehole caved at 4.6m and water at 1.2m below ground surface upon completion.
2) Auger refusal at 7.3m

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30
POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m³)

10001315

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

○ ε=3% Strain at Failure

Ministry of Transportation Ontario

RECORD OF BOREHOLE No BH-C1

METRIC

W.P. 2081-12-00 LOCATION MTM NAD 83 Zone 10, E 346358, N 4859741 ORIGINATED BY AT

DIST ____ HWY 407 CCL BOREHOLE TYPE Solid Stem Auger COMPILED BY AT

DATUM Geodetic DATE Mar/18/2015 to Mar/18/2015 CHECKED BY RM

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
87.7 / 0.0	**TOPSOIL:** 380mm
87.3 / 0.4	**SILTY CLAY:** mixed with topsoil, trace rootlets, dark brown to brown, moist, stiff.
86.9 / 0.8	**SILTY CLAY:** trace sand, brown, moist, stiff to very stiff.
84.6 / 3.1	**CLAYEY SILT (TILL):** trace sand to sandy, some shale fragments, dark grey, moist, hard.
82.4 / 5.3	**CLAYEY SILT (TILL/SHALE COMPLEX):** trace sand, some shale fragments, dark grey, moist, hard.
78.6 / 9.1	**WHITBY FORMATION:** shale, dark grey
78.5 / 9.2	**END OF THE BOREHOLE**

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	13	
2	SS	12	
3	SS	14	0 2 40 58
4	SS	17	
5	SS	34	
6	SS	38	21 36 30 13
7	SS	41	
8	SS	82/ 275mm	
9	SS	50/ 100mm	wet spoon
10	SS	98/ 275mm	
11	SS	50/ 50mm	

Sample 3: liquid limit 46.

GROUND WATER CONDITIONS: Concrete; Holeplug; W. L. 85.7 m Mar 26, 2015; Sand; W. L. 84.7 m Mar 18, 2015; Screen; Caved

ELEVATION SCALE: 87, 86, 85, 84, 83, 82, 81, 80, 79

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

POCKET PEN. (Cu) (kPa) γ NATURAL UNIT WT (kN/m³)

1) 50mm dia. monitoring well was installed upon completion, screened at 3m to 6.1m.
2) Auger refusal at 9.2m
3) Caved-in at 6.1 m
Water level measured in monitoring well:

Date	W. L. Depth (m)
Mar 18, 2015	3.0
Mar 26, 2015	2.0
Dec 07, 2015	2.0

ON-MTO-2015 DUNDAS CROSSING DEC. 18,2015.GPJ ON_MOT.GDT 3/29/16

10001315

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

$+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Ministry of Transportation Ontario

RECORD OF BOREHOLE No BH-C2

METRIC

W.P. 2081-12-00 LOCATION MTM NAD 83 Zone 10, E 346346, N 4859766 ORIGINATED BY AT

DIST ___ HWY 407 CCL BOREHOLE TYPE Solid Stem Auger and Diamond Drilling COMPILED BY AT

DATUM Geodetic DATE Mar/18/2015 to Mar/18/2015 CHECKED BY RM

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.8	Ground Surface				
0.0	**TOPSOIL:** 380mm	1	SS	10	
86.5 / 0.4	**SILTY CLAY:** mixed with topsoil, trace rootlets, dark brown to brown, moist, stiff.				
86.1 / 0.8	**SILTY CLAY:** trace gravel, brown, moist, stiff	2	SS	14	
85.3 / 1.5	**SANDY SILT (TILL):** trace clay, trace to some gravel, dark grey, moist, compact to very dense.	3	SS	16	
		4	SS	17	16 60 17 7
		5	SS	66	
83.0 / 3.8	**CLAYEY SILT (TILL):** sandy, trace shale fragments, dark grey, moist, hard.	6	SS	92/ 300mm	wet spoon
		7	SS	77	
81.5 / 5.3	**CLAYEY SILT (TILL/SHALE COMPLEX):** sandy, some shale fragments, dark grey, moist, hard.	8	SS	100/ 150mm	
		9	SS	90/ 300mm	
		10	SS	98/ 275mm	
78.0 / 8.8	**WHITBY FORMATION:** shale, dark grey. Refer to Rock Core Log.	11	SS	100/ Initial 25m	
		1	RC		
		2	RC		

Other columns: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (86 to 76); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3) γ.

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

$+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

10001315

ON-MTO-2015 DUNDAS CROSSING DEC. 18,2015.GPJ ON_MOT.GDT 7/6/16

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No BH-C2

METRIC

W.P. 2081-12-00 LOCATION MTM NAD 83 Zone 10, E 346346, N 4859766 ORIGINATED BY AT

DIST HWY 407 CCL BOREHOLE TYPE Solid Stem Auger and Diamond Drilling COMPILED BY AT

DATUM Geodetic DATE Mar/18/2015 to Mar/18/2015 CHECKED BY RM

ELEV DEPTH	SOIL PROFILE: DESCRIPTION (Continued)	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: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3) γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
75.0	**WHITBY FORMATION:** shale, dark grey. Refer to Rock Core Log. *(continued)*		3	RC								
11.8	**END OF THE BOREHOLE** Note: 1) Borehole caved at 4.6m and water at 0.9m below ground surface upon completion.											

ON-MTO-2015 DUNDAS CROSSING DEC. 18,2015.GPJ ON_MOT.GDT 7/6/16

10001315

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

O ε=3% Strain at Failure

Ministry of Transportation Ontario

LOG of ROCK CORE BH-C2

METRIC

W.P. 2081-12-00 | LOCATION MTM NAD 83 Zone 10, E 346346, N 4859766 | ORIGINATED BY AT

DIST ___ HWY 407 CCL | BOREHOLE TYPE Solid Stem Auger and Diamond Drilling | COMPILED BY AT

DATUM Geodetic | DATE Mar/18/2015 to Mar/18/2015 | CHECKED BY RM

(m) ELEV / DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE NUMBER	SIZE	TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES	Weathering Index	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cm³) E (GPa)
78.0	Rock Surface															
78.0 / 8.8	**WHITBY FORMATION** (UPPER ORDOVICIAN) Moderately weathered to fresh, laminated to thinly bedded, grey and black, weak to strong, slightly bituminous **SHALE** (90%~95%), occasionally with thinly laminated to very thin bedded, slightly weathered to fresh, light grey, medium strong to strong **SHALY LIMESTONE** (5%~10%).		1	NQ	100	38	10	0	12 / 4	Moderately weathered (W3): Fragmented zone: 8.84m-8.97m Fracture: 8.97m-9.09m, θ = 0°						
77.5 / 9.4			2	NQ	100	80	5	39	14 / 3 / 6 / 4 / 2	Slightly weathered (W2): Fragmented zone: 9.5m-9.6m Fracture: 9.37m-9.63m, θ = 15°			58 / 47	21 / 16		
76.0 / 10.8			3	NQ	100	100	8	85	2 / 2 / 3	Slightly weathered to Fresh (W1/W2):			60	16		
75.0 / 11.8	**END OF BOREHOLE**															

10001315

Weathering Index: W1-Fresh, W2-Slightly weathered, W3-Moderately weathered, W4-Highly weathered, W5-Completely weathered θ = angle to the core axis

E = Modulus of Elasticity

*: UCS [Mpa] ≈ 24 $I_{S(50)}$

Ministry of Transportation Ontario

RECORD OF BOREHOLE No BH-C3

METRIC

W.P. 2081-12-00 LOCATION MTM NAD 83 Zone 10, E 346371, N 4859749 ORIGINATED BY AT

DIST HWY 407 CCL BOREHOLE TYPE Solid Stem Auger and Diamond Drilling COMPILED BY AT

DATUM Geodetic DATE Mar/19/2015 to Mar/19/2015 CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS
85.0 / 0.0	**TOPSOIL:** 500mm	1	SS	5	53	
84.5 / 0.5	**SILTY CLAY:** mixed with topsoil, trace rootlets, dark brown to brown, moist, stiff.					
84.2 / 0.8	**SILTY CLAY:** some sand, trace gravel, brown, moist, firm	2	SS	4		
83.5 / 1.5	**CLAYEY SILT (TILL):** sandy, trace shale fragments, dark grey, moist, very stiff to hard.	3	SS	38		wet spoon
		4	SS	42		
		5	SS	17		
81.2 / 3.8	**CLAYEY SILT (TILL/SHALE COMPLEX):** some sand to sandy, some shale fragments, dark grey, moist, hard.	6	SS	68		
		7	SS	92/ 300mm		
		8	SS	100/ 300mm		
78.9 / 6.1	**WHITBY FORMATION:** shale, dark grey. Refer to Rock Core Log.	9	SS	100/ Initial 150mm		
		1	RC			
		2	RC			
		3	RC			
		4	RC			
75.7 / 9.3	**END OF THE BOREHOLE**					

Note:
1) Borehole caved at 4.6m and water at 0.9m below ground surface upon completion.

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (84, 83, 82, 81, 80, 79, 78, 77, 76); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3) γ; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

LOG of ROCK CORE BH-C3

METRIC

W.P.	2081-12-00	LOCATION	MTM NAD 83 Zone 10, E 346371, N 4859749	ORIGINATED BY	AT
DIST		HWY	407 CCL		
		BOREHOLE TYPE	Solid Stem Auger and Diamond Drilling	COMPILED BY	AT
DATUM	Geodetic	DATE	Mar/19/2015 to Mar/19/2015	CHECKED BY	RM

(m) ELEV / DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE NUMBER	CORE SAMPLE SIZE	TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES	Weathering Index	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cm³) E (GPa)
78.9	Rock Surface															
78.7 / 6.1																
6.3 / 78.4	**WHITBY FORMATION** (UPPER ORDOVICIAN) Highly weathered to slighly weathered, laminated to thinly bedded, grey and black, weak to strong, slightly bituminous **SHALE** (92%~100%), occasionally with thinly laminated to very thin bedded, slightly weathered to fresh, light grey, medium strong to strong **SHALY LIMESTONE** (0%~8%).		1	NQ	100	38	0	0	10	Highly to Moderately weathered (W4/W3): Fragmented zone: 6.25m-6.4m			36	19		
6.6 / 77.1			2	NQ	76	24	6	0	>25 20 20 7	Loss zone: 6.58m-6.86m Fragmented zone: 6.86m-6.91m, 7.19m-7.21m, 7.47m-7.54m Broken zone: 7.34m-7.47m			55	23		
7.9 / 76.3			3	NQ	100	42	6	0	14 12 5	Fragmented zone: 7.85m-7.9m, 7.98m-8.05m Broken zone: 8.18m-8.33m, 8.56m-8.69m			37	19		
8.7 / 75.7			4	NQ	100	92	8	63	7 2	Slightly weathered (W2): Fracture: 8.97m-9.02m, θ= 40°			56	19		
9.3	**END OF BOREHOLE**															

ON MTO ROCK CORE-2014 DUNDAS CROSSING DEC. 18,2015.GPJ SPL.GDT 3/31/16

10001315

Weathering Index: W1-Fresh, W2-Slightly weathered, W3-Moderately weathered, W4-Highly weathered, W5-Completely weathered

θ = angle to the core axis

E = Modulus of Elasticity

*: UCS [Mpa] ≈ 24 $I_{S(50)}$

Ministry of Transportation Ontario

RECORD OF BOREHOLE No BH-C4

METRIC

W.P. 2081-12-00 | LOCATION MTM NAD 83 Zone 10, E 346363, N 4859769 | ORIGINATED BY AT

DIST ____ HWY 407 CCL | BOREHOLE TYPE Solid Stem Auger | COMPILED BY AT

DATUM Geodetic | DATE Mar/19/2015 to Mar/19/2015 | CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
85.3 / 0.0	**TOPSOIL:** 500mm	1	SS	9	~25	
84.8 / 0.5	**SILTY CLAY:** mixed with topsoil, trace rootlets, dark brown to brown, moist, stiff.					
84.5 / 0.8	**SILTY CLAY:** trace sand, trace gravel, brown, moist, soft.	2	SS	2	~24	
83.7 / 1.5	**SANDY SILT (TILL):** trace clay, trace shale fragments, dark grey, moist, dense.	3	SS	31	~13	wet spoon
		4	SS	34	~6	
82.2 / 3.1	**CLAYEY SILT (TILL/SHALE COMPLEX):** sandy, some shale fragments, dark grey, moist, hard.	5	SS	57	~7	
		6	SS	53	~5	
		7	SS	81	~6	
		8	SS	96/300mm	~5	
79.2 / 6.1	**WHITBY FORMATION:** shale, dark grey.	9	SS	57/150mm	~4	
		10	SS	100/Initial 100mm	~6	
77.0 / 8.2	**END OF THE BOREHOLE**					

Notes:
1) Borehole caved at 6m and water at 0.8m below ground surface upon completion.
2) Auger refusal at 8.23m

Chart legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3) γ; GR SA SI CL

+3, ×3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

10001315

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No BH-C5

METRIC

W.P. 2081-12-00 | LOCATION MTM NAD 83 Zone 10, E 346381, N 4859754 | ORIGINATED BY AT

DIST | HWY 407 CCL | BOREHOLE TYPE Solid Stem Auger | COMPILED BY AT

DATUM Geodetic | DATE Nov/27/2015 to Nov/27/2015 | CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.0 / 0.0	**TOPSOIL:** 510mm	1	SS	5	
84.5 / 0.5	**SANDY SILT :** mixed with topsoil, trace to some organics, some clay, trace rootlets, dark brown to brown, wet, loose				
84.1 / 0.9	**SILTY SAND:** trace clay, trace shale fragments, dark grey, wet, loose to compact.	2	SS	6	
		3	SS	20	Wet Spoon
82.4 / 2.6	**CLAYEY SILT (TILL/SHALE COMPLEX):** sandy, some shale fragments, dark grey, moist, hard.	4	SS	20	
		5	SS	52	37 48 11 4
		6	SS	68	
		7	SS	35	
		8	SS	34	
		9	SS	37	
77.4 / 77.3 / 7.6 / 7.7	**WHITBY FORMATION:** shale, dark grey	10	SS	100/ initial 50mm	
	END OF THE BOREHOLE				

Note:
1) Borehole caved at 6.1m and water at 1.22m below ground surface upon completion.

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (84, 83, 82, 81, 80, 79, 78); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3); REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ON-MTO-2015 DUNDAS CROSSING DEC. 18,2015.GPJ ON_MOT.GDT 3/29/16

10001315

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

○ ε=3% Strain at Failure

Ministry of Transportation Ontario

RECORD OF BOREHOLE No BH-C6

METRIC

W.P. 2081-12-00 | LOCATION MTM NAD 83 Zone 10, E 346380, N 4859772 | ORIGINATED BY AT

DIST ____ HWY 407 CCL | BOREHOLE TYPE Solid Stem Auger and Diamond Drilling | COMPILED BY AT

DATUM Geodetic | DATE Nov/27/2015 to Nov/30/2015 | CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.3 / 0.0	**TOPSOIL:** 460mm	1	SS	3	~24	
84.9 / 0.5	**CLAYEY SILT:** mixed with topsoil, trace to some organics, trace rootlets, dark brown to brown, moist, firm	2	SS	4	~32	
83.8 / 1.5	**SILTY SAND(TILL):** some gravel, trace to some clay, trace shale fragments, dark grey, moist, compact.	3	SS	11	~20	15 50 25 10
82.7 / 2.6	**CLAYEY SILT (TILL/SHALE COMPLEX):** sandy, some shale fragments, dark grey, moist, hard.	4	SS	64	~8	Wet Spoon
		5	SS	50	~6	
		6	SS	72	~5	
		7	SS	55	~6	27 51 16 6
		8	SS	63	~7	
		9	SS	98/ 275mm	~7	
		10	SS	100/ 175mm	~5	
77.2 / 8.1		11	SS	98	~7	
77.2 / 8.1	**WHITBY FORMATION:** shale, dark grey. Refer to Rock Core Log.	1	RC			
		2	RC			
75.1 / 10.2	**END OF THE BOREHOLE** 1) 50mm dia. monitoring well was installed upon completion, screened at 4.6m to 6m. 2) Caved-in at 6.1 m 3)Water leve upon completion at 1.5 m Water level measured in monitoring well:					

Ground water conditions / elevation scale: Concrete, 85, W. L. 84.4 m Dec 07, 2015, 84, Holeplug, 83, 82, Sand, Screen, 79, 78, Caved, 77, 76

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3) γ

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

$+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

10001315

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No BH-C6

METRIC

W.P. 2081-12-00 LOCATION MTM NAD 83 Zone 10, E 346380, N 4859772 ORIGINATED BY AT

DIST HWY 407 CCL BOREHOLE TYPE Solid Stem Auger and Diamond Drilling COMPILED BY AT

DATUM Geodetic DATE Nov/27/2015 to Nov/30/2015 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3) γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES							
	Date W. L. Depth (m) Dec 07, 2015 0.95m											

ON-MTO-2015 DUNDAS CROSSING DEC. 18,2015.GPJ ON_MOT.GDT 3/29/16

10001315

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

○ ε=3% Strain at Failure

Ministry of Transportation Ontario

LOG of ROCK CORE BH-C6

METRIC

W.P. 2081-12-00 | LOCATION MTM NAD 83 Zone 10, E 346380, N 4859772 | ORIGINATED BY AT

DIST ____ HWY 407 CCL | BOREHOLE TYPE Solid Stem Auger and Diamond Drilling | COMPILED BY AT

DATUM Geodetic | DATE Nov/27/2015 to Nov/30/2015 | CHECKED BY RM

(m) ELEV / DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE NUMBER	CORE SAMPLE SIZE	TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES	Weathering Index	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cm³) E (GPa)
77.2	Rock Surface															
77.2 / 8.1	**WHITBY FORMATION** (UPPER ORDOVICIAN) Highly to moderately weathered, laminated to thinly bedded, grey and black, weak to medium strong, slightly bituminous **SHALE** (100%)		1	NQ	50	15	0	0	25 20	Highly to moderately weathered (W4/W3): Soft layer/Missing zone: 8.1-8.3m Fragmented zone: 8.3m-8.6m						
76.6 / 8.7			2	NQ	87	55	0	30	25 25 12 11 5	Fragmented zone: 8.7m-8.95m; 9.1m-9.3m; 9.4m-9.5m; 9.65m-9.75m			47	23		
75.1 / 10.2	**END OF BOREHOLE**															

10001315

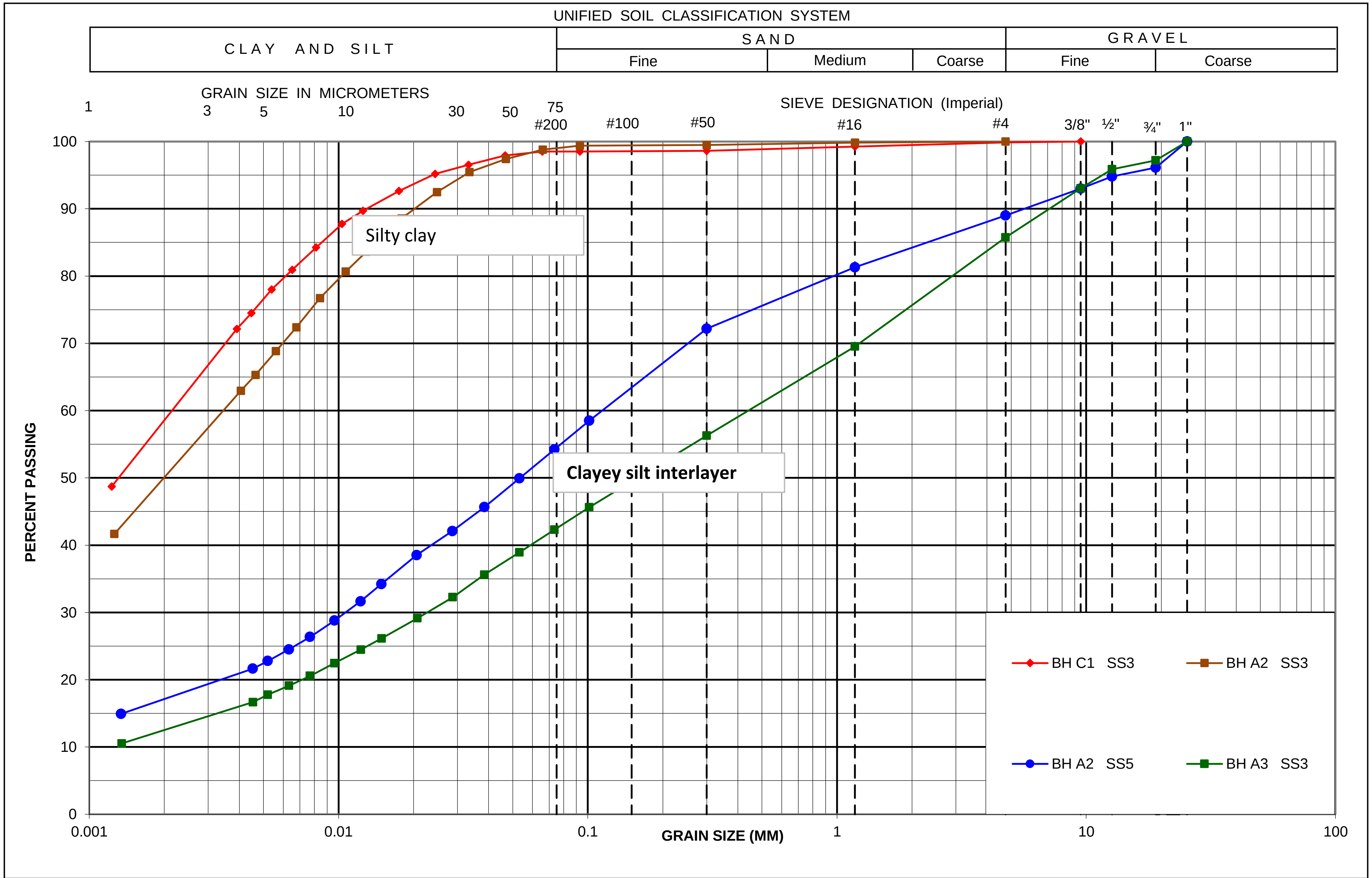
Weathering Index: W1-Fresh, W2-Slightly weathered, W3-Moderately weathered, W4-Highly weathered, W5-Completely weathered

θ = angle to the core axis

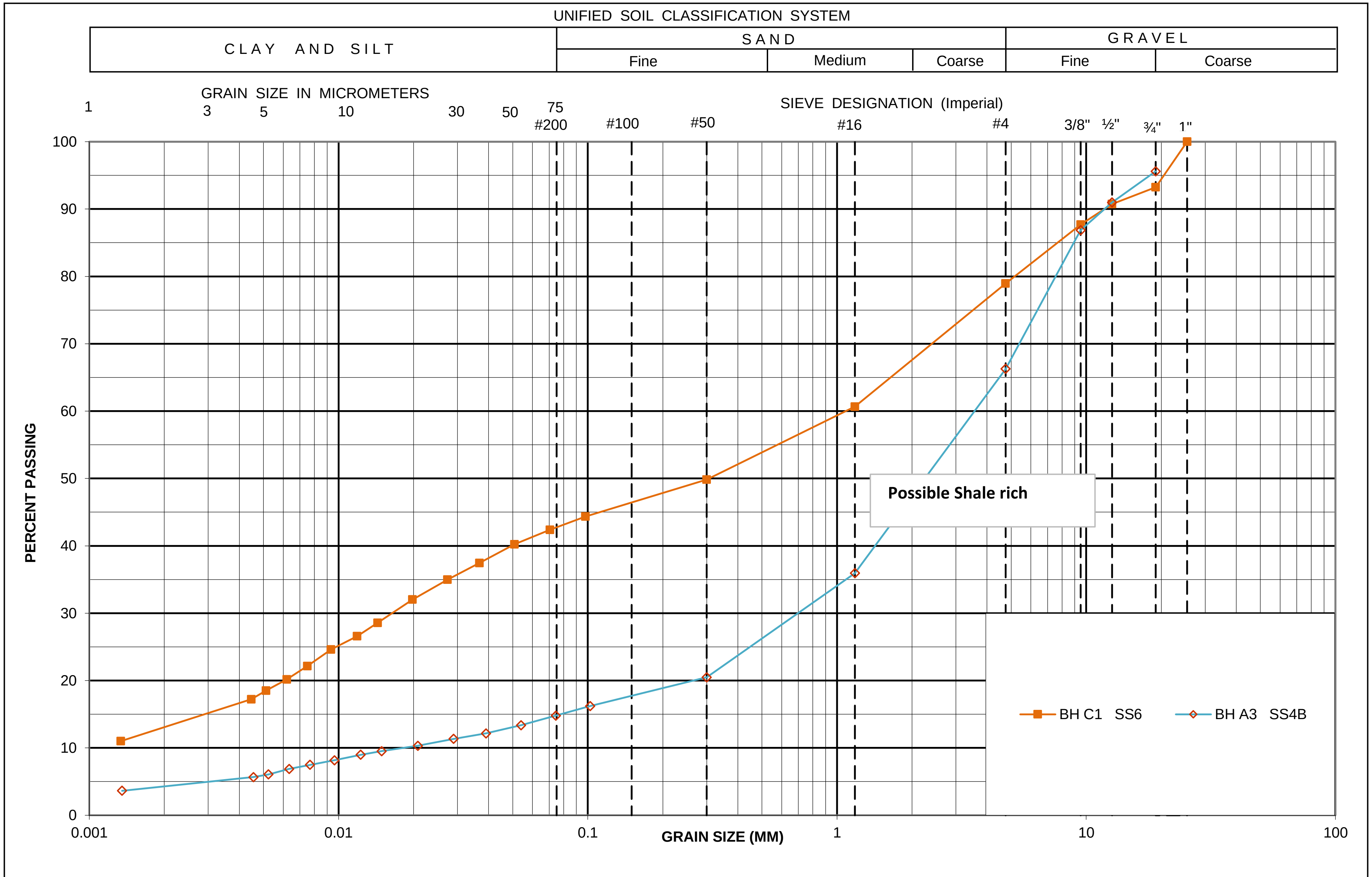
E = Modulus of Elasticity

*: UCS [Mpa] ≈ 24 $I_{S(50)}$

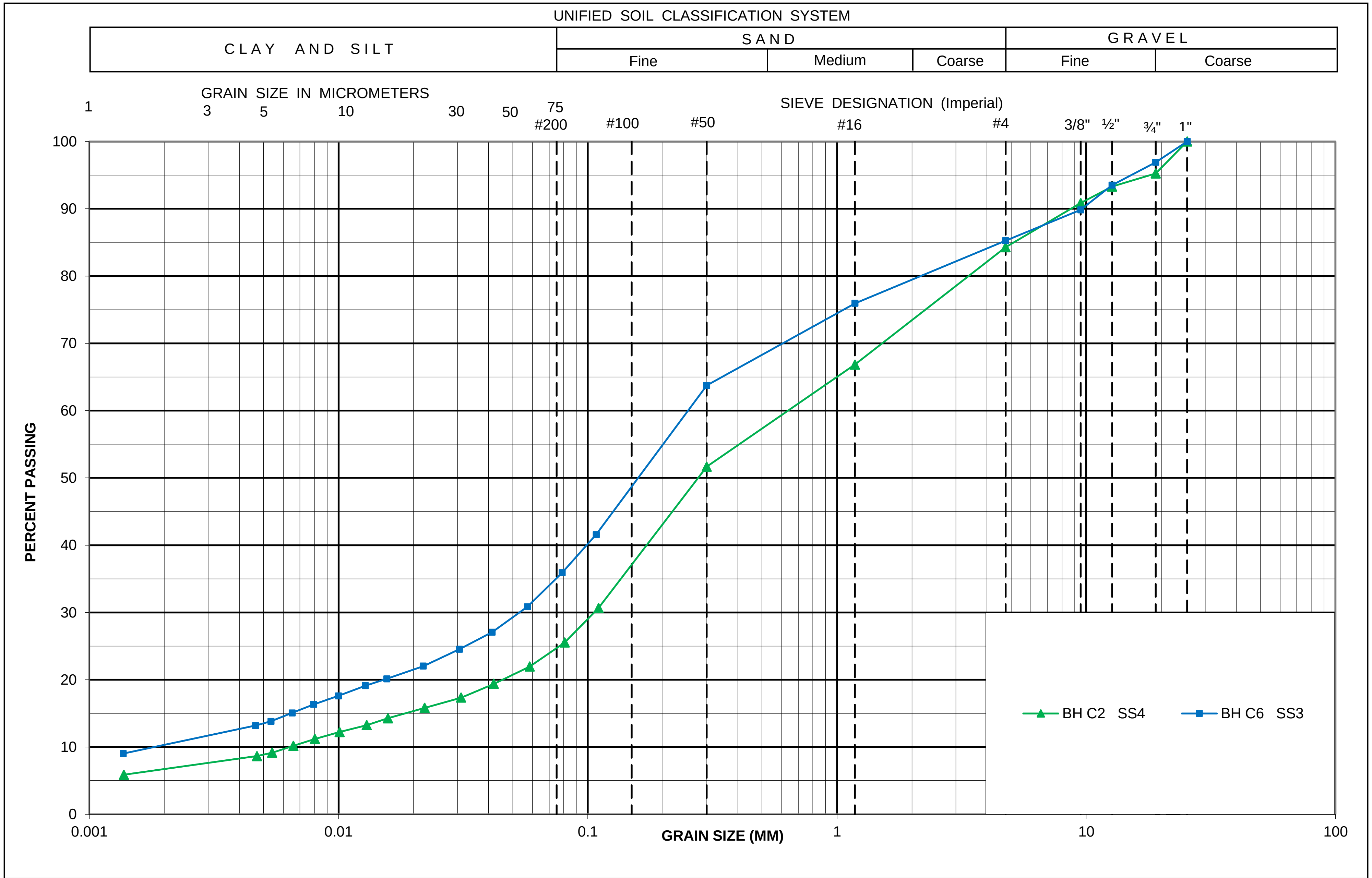
Appendix B: Laboratory Test Results



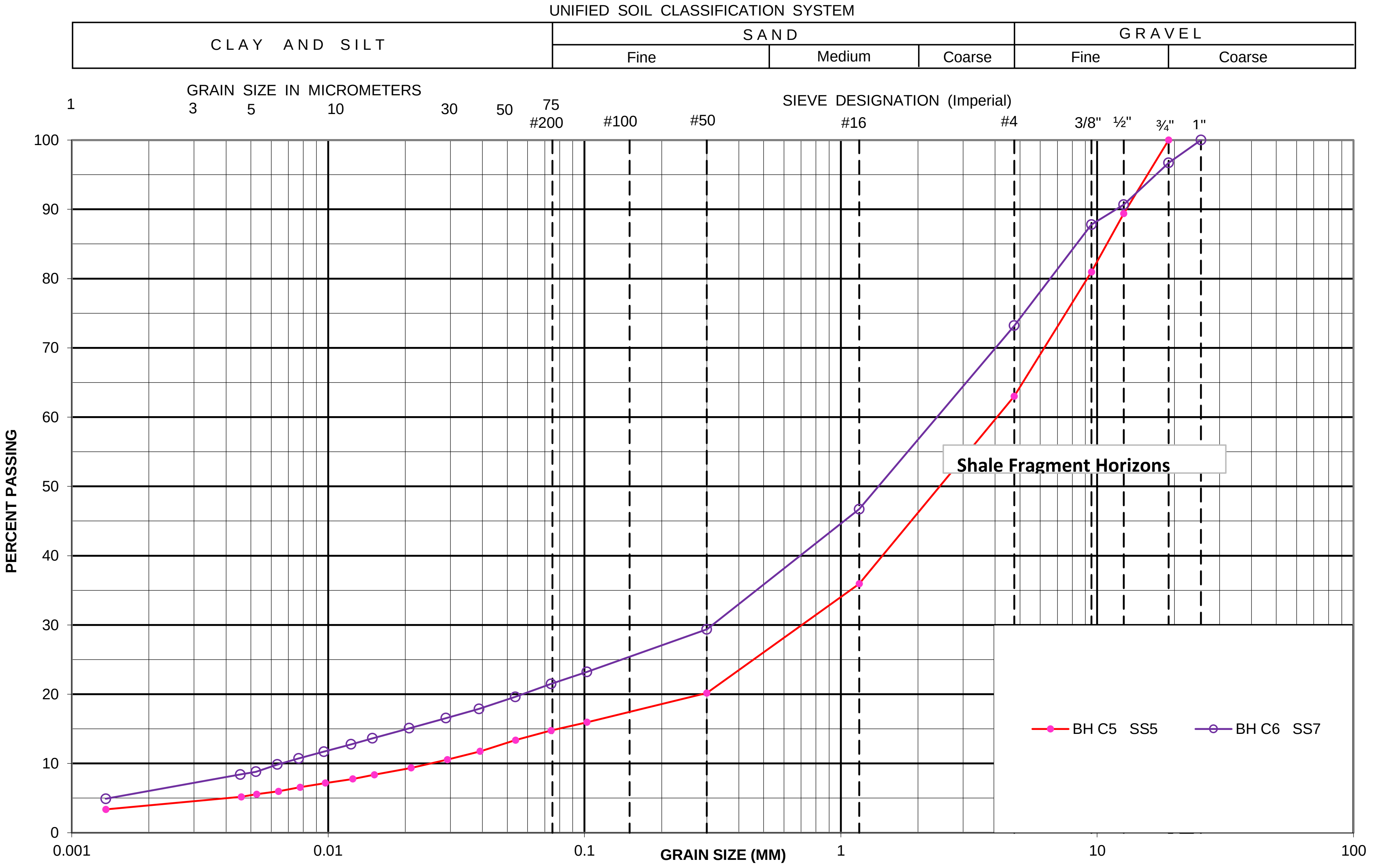
	GRAIN SIZE DISTRIBUTION SILTY CLAY	Figure No: 1 Project No. 10001315 Date : December 14,2015



WSP	GRAIN SIZE DISTRIBUTION CLAYEY SILT (TILL)	Figure No: 2 Project No. 10001315 Date : December 14,2015



GRAIN SIZE DISTRIBUTION SILTY SAND (TILL)	Figure No:	3
	Project No.	10001315
	Date :	December 14,2015

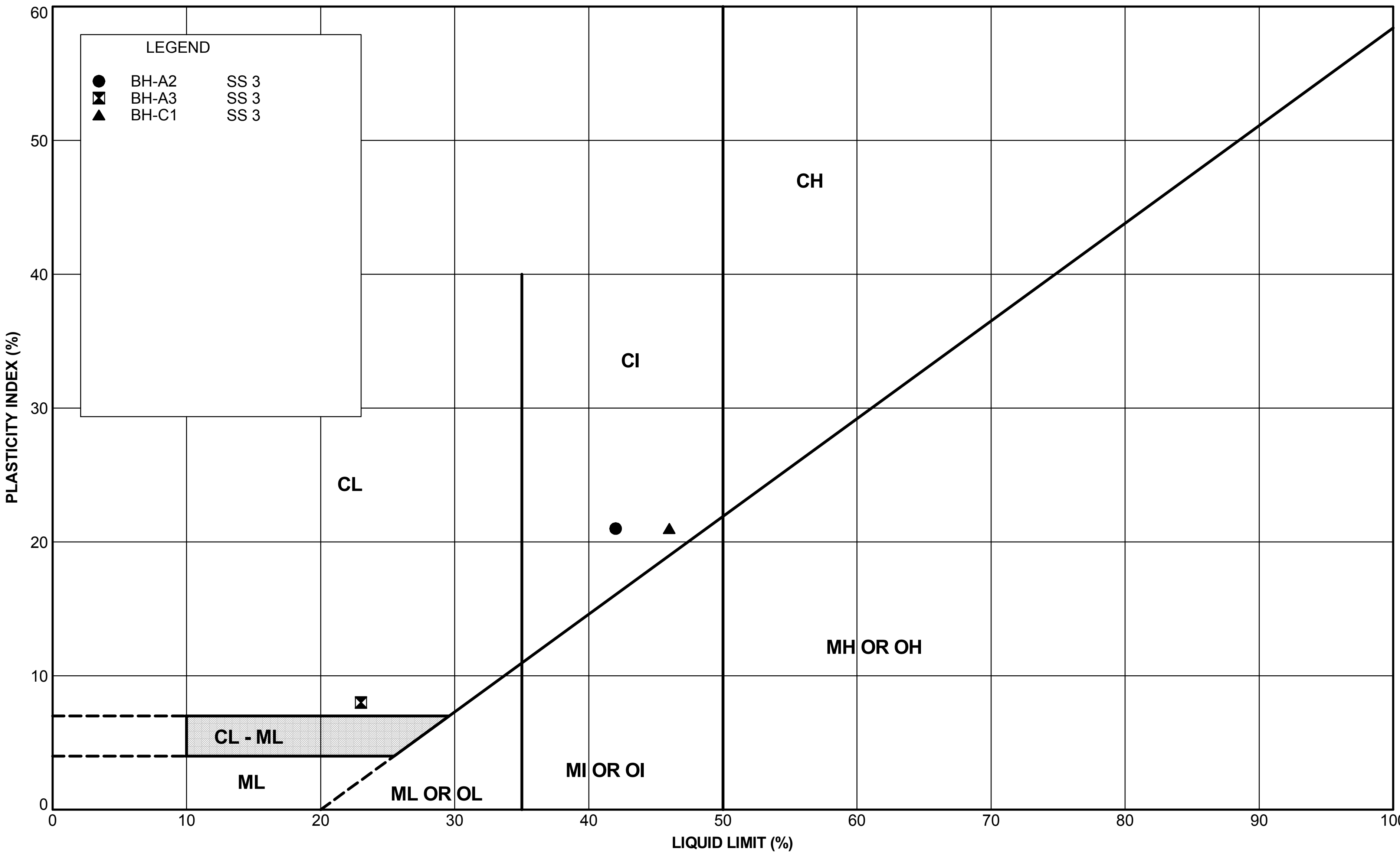


WSP

GRAIN SIZE DISTRIBUTION
CLAYEY SILT(TILL SHALE COMPLEX)

Figure No:	4
Project No.	10001315
Date :	December 14,2015

Ministry of Transportation
Ontario



WSP	PLASTICITY CHART	FIGURE NO.	Fig 5
		JOB NO.	10001315
		DATE	Feb 19, 2016

Appendix C: Site Photographs

Photo 1: Looking North West, Creek Crossing

Photo 2: Looking East, West Side of Creek

Photo 3: Looking West, West Approach Near BH A1 and A2

Photo 4: Looking North-West, South-West Corrner of Structure Near BH-C1

Photo 5: Looking East, North-West Corrner of Structure Near BH-C2

Photo 6: Looking West, South-East Corrner of Structure Near BH-C5

Photo 7: Looking West, North-East Corrner of Structure Near BH-C6

Photo 8: Looking Eest, East Approach near BH-A3

BH-C2

Rock Core Photo: Run 1, Run 2 and Run 3

Run 1: 29’ 0’’ – 30’ 9’’ (8.84m – 9.47m)   Run 2: 30’ 9’’ – 35’ 5’’ (9.47m – 10.8m)

Run 3: 35’ 5” – 38’ 9’’ (10.8m – 11.82m)

BH-C3

Rock Core Photo: Run 1 to Run 4

Run 1: 20’ 6’’ – 21’ 7’’ (6.25m – 6.58m) Run 2: 21’ 7’’ – 25’ 9’’ (6.58m – 7.85m)

Run 3: 25’ 9” – 28’ 6’’ (7.85m – 8.7m) Run 4: 28’ 6” – 30’ 6’’ (8.7m – 9.32m)

BH-C6

Rock Core Photo: Run 1 to Run 2

Run 1: 26’ 6’’ – 28’ 6’’ (8.1m – 8.7m) Run 2: 28’ 6’’ – 33’ 6’’ (8.7m – 10.2m)

FOUNDATION DESIGN REPORT

DUNDAS STREET/WEST DURHAM LINK COMMUTER CARPOOL LOT BRIDGE

STATION 1 + 061

WHITBY, ONTARIO

Geocres No. 30M15-282

Prepared For:
Ainley & Associates Limited
280 Pretty River Parkway, Collingwood, Ontario L9Y 4J5

WSP Project No: 141-55237-00 (SPL No. 10001315)
Date: July 12, 2016

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Toronto, ON M9W 1K4 Canada

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Fax: +1 416-798-0518
www.wspgroup.com

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APPENDIX D:EMBANKMENT STABILITY RESULTS

APPENDIX E: FOUNDATION AND RETAINING WALL ALTERNATIVES

APPENDIX F: LIST OF SPS, OPSSS, OPSDS AND NSSPS

APPENDIX G: LIMITATIONS

[illegible]

DISCUSSION AND RECOMMENDATIONS

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[illegible]

[illegible]

[illegible] site for the proposed structure can be classified as 'Class [illegible]' for seismic site response according to [illegible]

[illegible]

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5.3.2.1 [illegible]

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5.3.2.2 [illegible]

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5.3.2.3 [illegible]

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5.3.2.4 [illegible]

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5.5.1.1 [illegible]

[illegible] drock ("100 blow material") to reach practical refusal. The [illegible]

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[illegible] resistance of the pile will be predominantly in end bearing in the “100 blow” or better [illegible]

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5.5.2.1 [illegible]

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[illegible] and this should be “[illegible]” and a suggested wording for an [illegible] be reinforced with flange plates as per OPSD 3000.100 or driving shoes such as Titus Standard “H” Bearing Pile [illegible]

[illegible]

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		[illegible]				
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	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]

[illegible] – [illegible]

[illegible] draining backfill (Granular 'A' or Granular 'B' Type I or Type [illegible]

[illegible]

[illegible]	Compacted Granular 'A' and Granular 'B' Type II [illegible] φ [illegible]° [illegible] 22 [illegible] [illegible]		Compacted Granular 'B' Type I [illegible] φ [illegible] 2° [illegible] 21 [illegible] [illegible]	
	[illegible]		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible] – [illegible]

5.6.3.1 [illegible]

[illegible]

[illegible]

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[illegible]

[illegible]

[illegible]

[illegible]	Compacted Granular 'A' and Granular 'B' Type II [illegible] φ [illegible]° [illegible] 22 [illegible]		Compacted Granular 'B' Type I [illegible] φ [illegible]2° [illegible] 21 [illegible]	
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

5.6.3.2 [illegible]

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5.7.2.1 [illegible]

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[illegible]	[illegible]	[illegible]	[illegible] (c' = [illegible] Φ' (degrees)	[illegible]	[illegible] E' [illegible] v'
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible] (c' = [illegible] Φ' (degrees)	[illegible]	[illegible] E' M [illegible] v'
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

- [illegible] *In-situ Testing in Geomechanics* [illegible]

5.7.2.2 [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

5.7.2.3 [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

5.7.4.1 [illegible]

[illegible]

[illegible]

5.7.4.2 [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

5.7.4.3 [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Granular 'A' as excavation backfill [illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Granular 'A' [illegible] 'B' Type II [illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Geosynthetic manufacturer's instructions should [illegible]

[illegible]

[illegible]

[illegible]

[illegible] *performance level* [illegible]

[illegible]

[illegible]

[illegible]	[illegible]			
	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible] more demanding dewatering and potential hydraulic blow out. These aspects should be '[illegible]' in the

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] requirements is outside WSP’s scope. There is no guarantee as to whether or not excavated soils will be [illegible]

[illegible]

CLOSURE

The "Limitations of Report" as presented in Appendix G are an integral part of this report.

SIGNATURES

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

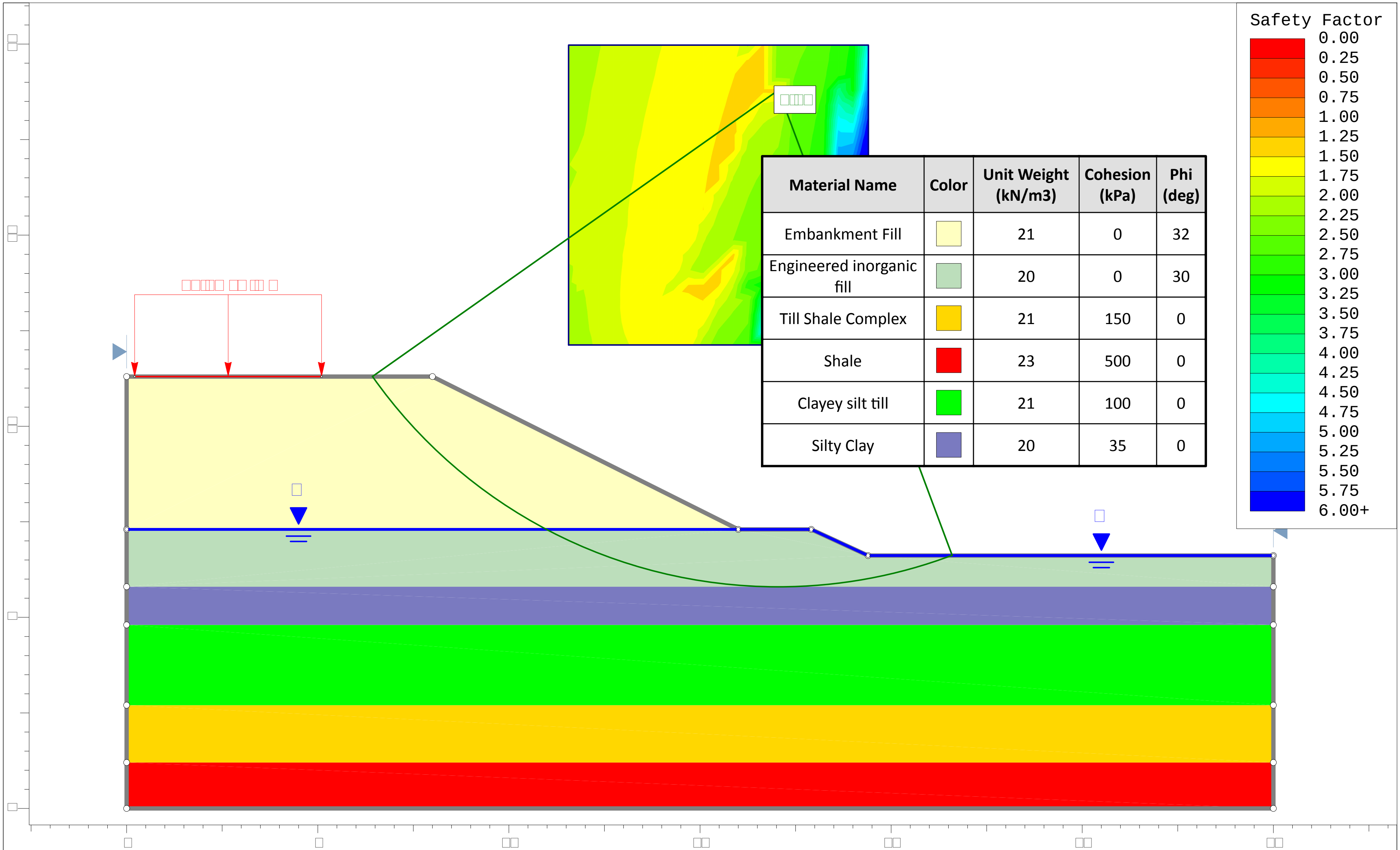
[illegible] *Geotechnical Earthquake Engineering* [illegible]

[illegible] *Pilling Engineering* [illegible]

[illegible] *Soil liquefaction during earthquakes* [illegible]

[illegible] *In-situ Testing in Geomechanics* [illegible]

Appendix D:Embankment Stability Results



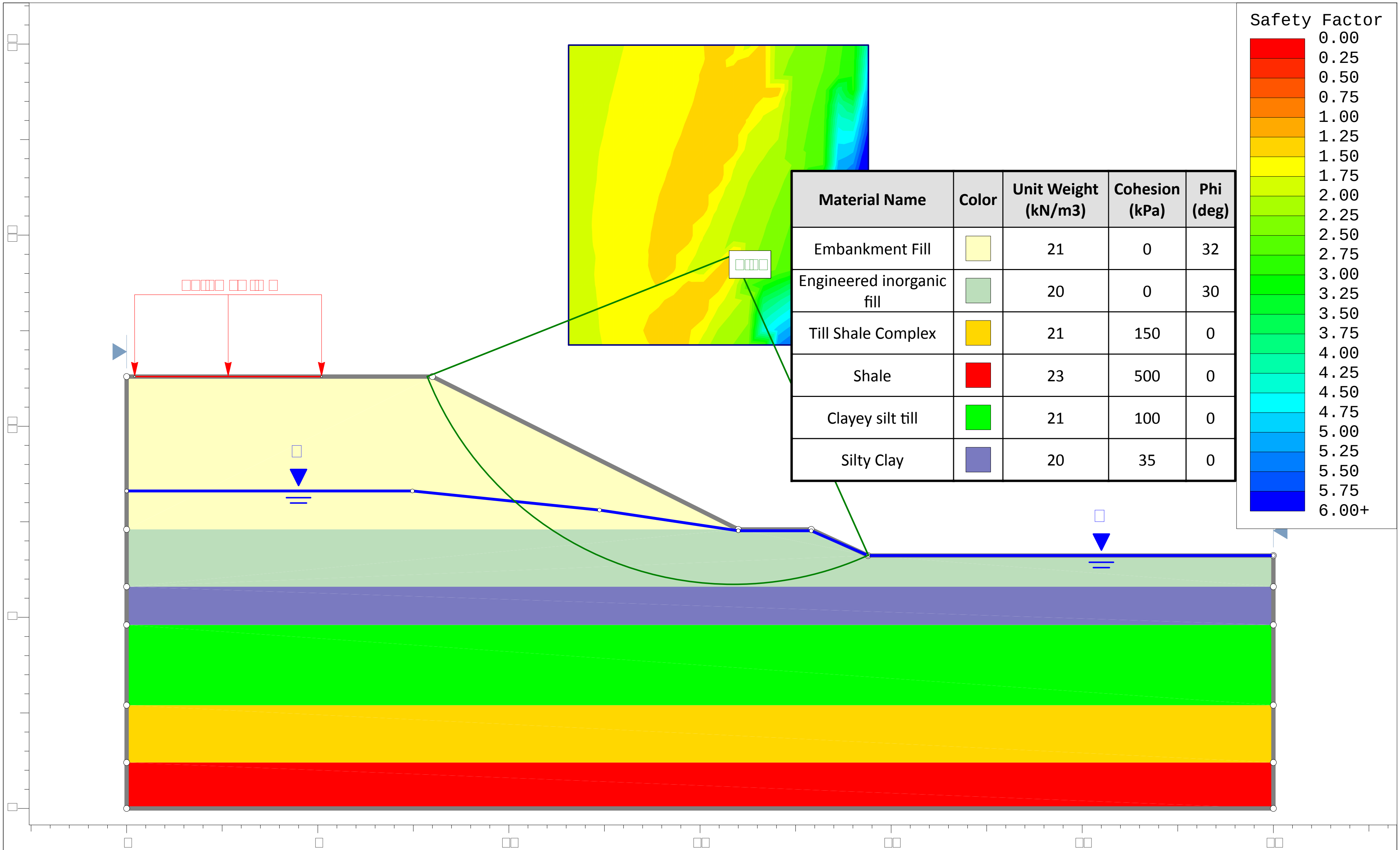
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Embankment Fill		21	0	32
Engineered inorganic fill		20	0	30
Till Shale Complex		21	150	0
Shale		23	500	0
Clayey silt till		21	100	0
Silty Clay		20	35	0

WSP

SLIDEINTERPRET 6.020

Project	407 Commuter Car Pool Lot Bridge		
Analysis Description	End of construction-East side slope of Northern approach embankment		
Drawn By	MP	*Scale*	1:141
Company	WSP Canada		
Date		*File Name*	407 ccl - east side slope at sta.1+095 -eoc.slim

Figure No. 1



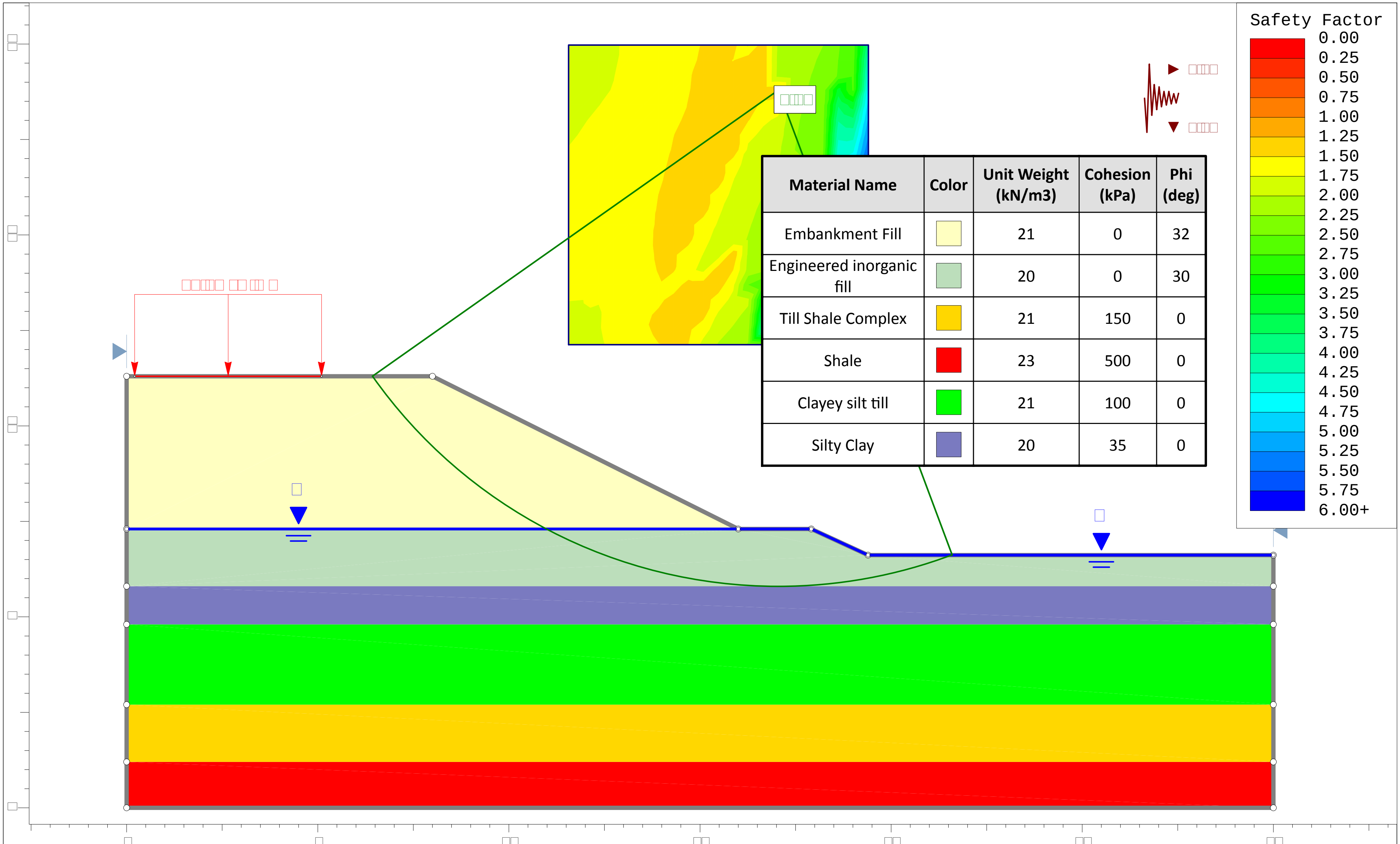
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Embankment Fill		21	0	32
Engineered inorganic fill		20	0	30
Till Shale Complex		21	150	0
Shale		23	500	0
Clayey silt till		21	100	0
Silty Clay		20	35	0

Project	407 Commuter Car Pool Lot Bridge
Analysis Description	Rapid Drawdown-East side slope of Northern approach embankment
Drawn By	MP
Scale	1:141
Company	WSP Canada
Date	
File Name	407 ccl - east side slope at sta.1+095 - rapid.slim

WSP

SLIDEINTERPRET 6.020

Figure No. 2



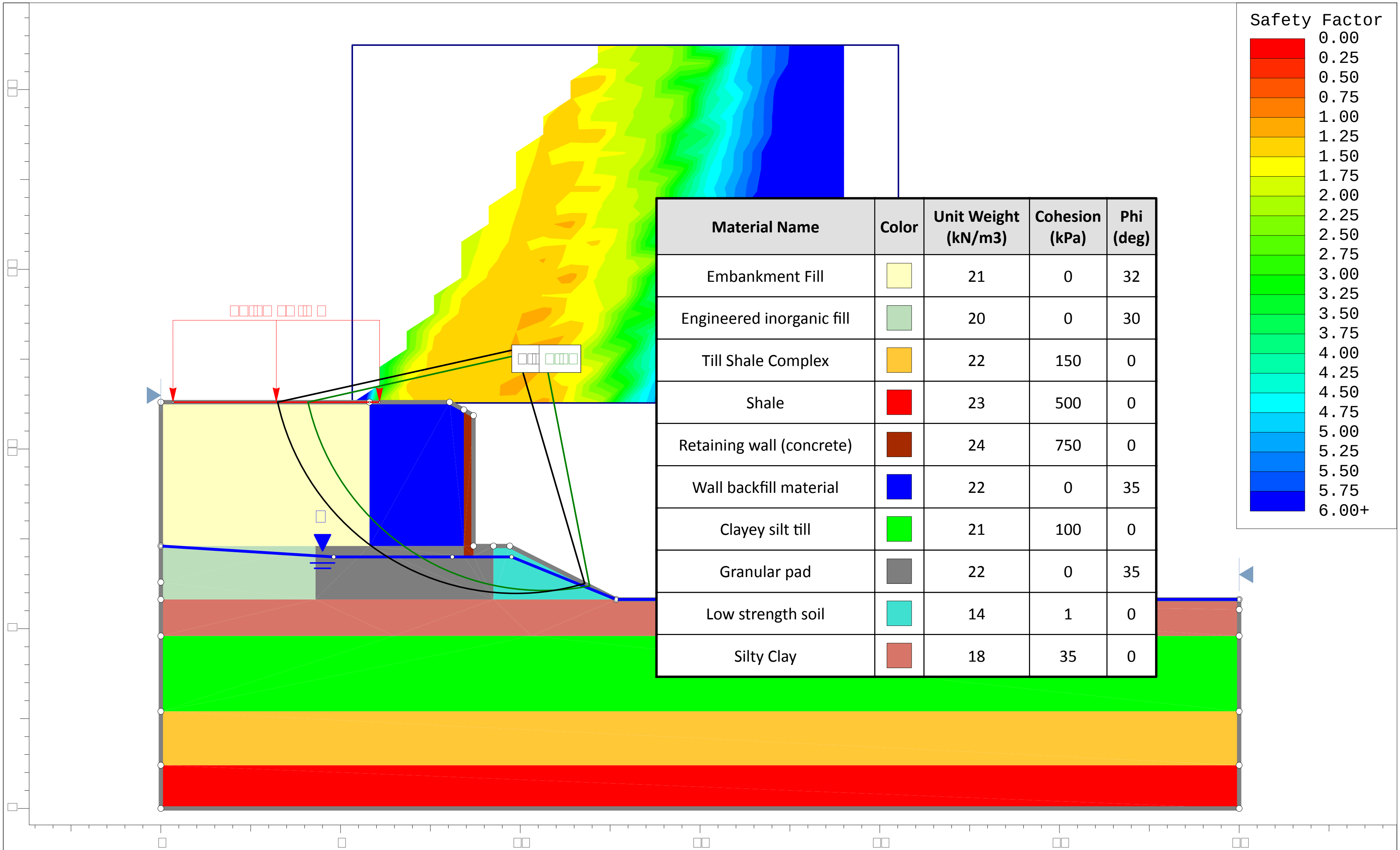
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Embankment Fill		21	0	32
Engineered inorganic fill		20	0	30
Till Shale Complex		21	150	0
Shale		23	500	0
Clayey silt till		21	100	0
Silty Clay		20	35	0

WSP

SLIDEINTERPRET 6.020

Project	407 Commuter Car Pool Lot Bridge		
Analysis Description	Pseudo-static stability-East side slope of Northern approach embankment		
Drawn By MP	*Scale* 1:141	*Company*	WSP Canada
Date		*File Name*	407 ccl - east side slope at sta.1+095 - seismic.slim

Figure No. 3



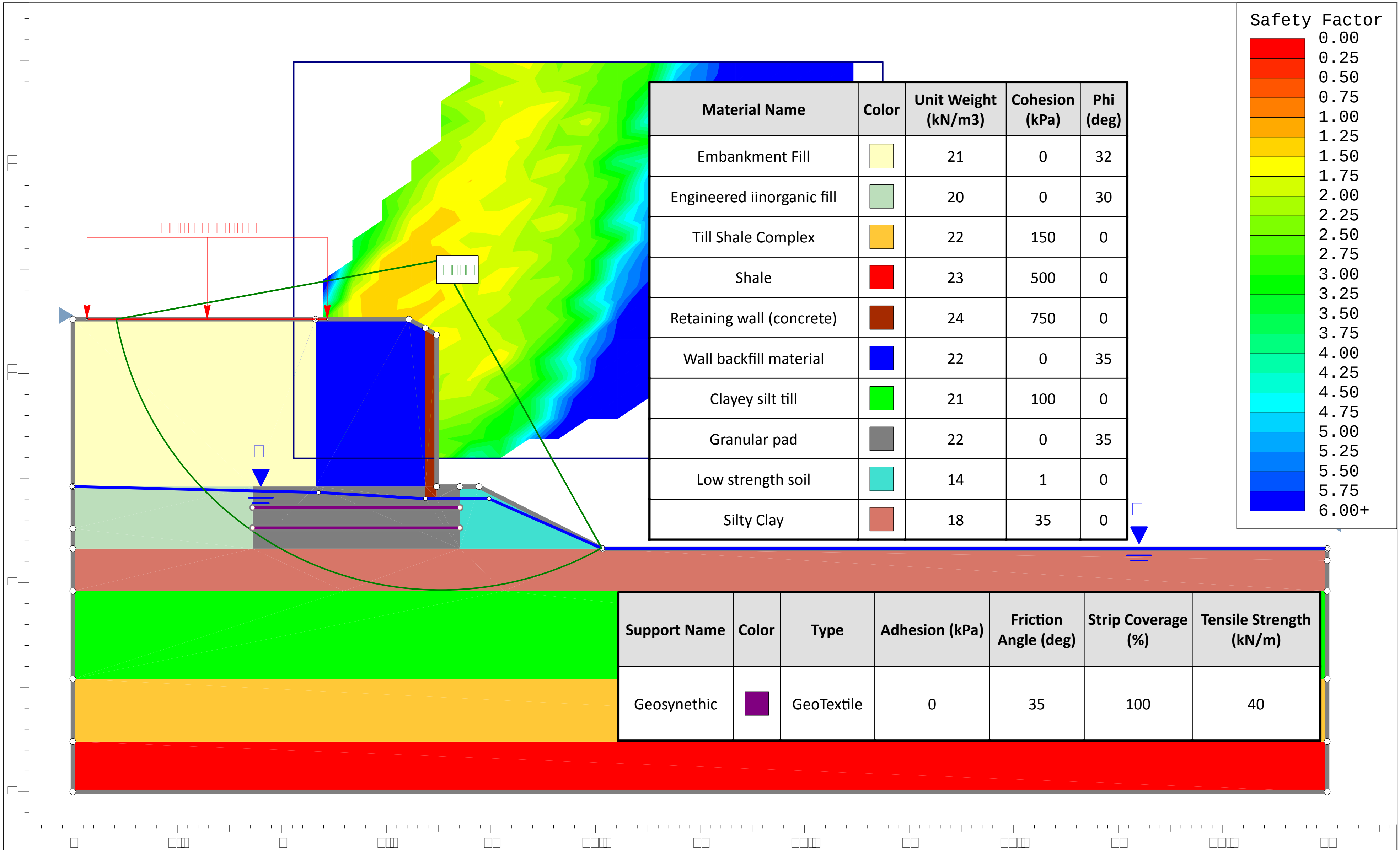
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Embankment Fill		21	0	32
Engineered inorganic fill		20	0	30
Till Shale Complex		22	150	0
Shale		23	500	0
Retaining wall (concrete)		24	750	0
Wall backfill material		22	0	35
Clayey silt till		21	100	0
Granular pad		22	0	35
Low strength soil		14	1	0
Silty Clay		18	35	0

WSP

SLIDEINTERPRET 6.020

Project	407 Commuter Car Pool Lot Bridge
Analysis Description	End of Construction-West side slope with conventional granular pad
Drawn By	MP
Scale	1:149
Company	WSP Canada
Date	
File Name	407 ccl - West side slope with wall at sta.1+105 - eoc - without geo.slim

Figure No. 4



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Embankment Fill		21	0	32
Engineered iinorganic fill		20	0	30
Till Shale Complex		22	150	0
Shale		23	500	0
Retaining wall (concrete)		24	750	0
Wall backfill material		22	0	35
Clayey silt till		21	100	0
Granular pad		22	0	35
Low strength soil		14	1	0
Silty Clay		18	35	0

Support Name	Color	Type	Adhesion (kPa)	Friction Angle (deg)	Strip Coverage (%)	Tensile Strength (kN/m)
Geosynthetic		GeoTextile	0	35	100	40

WSP SLIDEINTERPRET 6.020	*Project* 407 Commuter Car Pool Lot Bridge		
	Analysis Description End of Construction-West side slope with geosynthetic reinforcement		
	Drawn By MP	*Scale* 1:129	*Company* WSP Canada
	Date		*File Name* 407 ccl - West side slope with wall at sta.1+105 - eoc - geosynthetic.slim

Figure No. 5

Appendix E: Foundation and Retaining Wall Alternatives

APPENDIX E

Summary of Foundation Alternatives

Foundations Type	Advantage/ Disadvantage	Risks/ Consequences	Relative Costs	Recommendations
Spread Footings	Low cost Will require some shoring and dewatering effort	Dewatering may be required depending on the groundwater conditions of the time of construction	Low to medium cost	Not recommended
Drilled Caissons	Less vibrations than driven piles Sub-artesian groundwater conditions; Will require dewatering; Difficulties of base inspections	Due to shallow bedrock conditions and sub-artesian groundwater conditions, piles will be end bearing. However, base inspections may be compromised due to safety considerations.	Moderate to high	Not recommended
Auger Press Concrete Piles (CFA Piles)	Less vibrations than driven piles Hole stability is addressed by the installation process itself. Not particularly suited for lateral loads. Demands a higher degree of construction control to monitor auger extraction and concrete intrusion.	Quality control issues and resulting uncertainties; If independent quick capacity assessment is required, reliability issues with PDA with such piles could be a risk.	Moderate	Not recommended.
Driven Steel Tube Piles	Plugging issues with open driving and hence may require intermittent cleaning. Driving close ended needs significant reinforcement and potential for damage. Pile lengths can be changed easily	Hard driving conditions are anticipated. Cobles and boulders in till can pose obstruction	Moderate to High	Not recommended
Driven Steel H-Piles	Common in Ontario and widely used for integral abutments. Many contractors and resulting competitiveness and economies. Can withstand hard driving with suitable rock points. Pile soil interface under sub-artesian ground conditions can erode shaft resistance and loosen end bearing in cohesionless soils. Pile lengths can be changed easily	Cobles and boulders in till can pose obstruction. In the present ground conditions, shaft resistance can be compromised. However, the piles will act predominantly in end bearing onto the weathered shale under the project conditions	Moderate to high	Recommended.

Summary of Retaining Wall Alternatives

Retaining Wall Type	Advantage/ Disadvantage	Risks/ Consequences	Relative Costs	Recommendations
Concrete Cantilever Retaining Wall	Common wall system Less sympathetic to movements, hence more effort for site preparation May require some shoring and dewatering effort More time involved in construction issues, e.g. steel erection and in-situ concreting Limited in providing aesthetic finishes	Susceptible to movement damage High in-situ construction elements could mean susceptibility to durability issues	Low to medium cost for low height walls of limited length	Recommended
RSS Wall	Widely used in Southern Ontario More sympathetic to ground movements Less demand for in-situ erection procedures More capacity for providing aesthetic finishes May not be competitive for low height and limited length of walls	Granular backfill with embedded reinforcing ties play a geo-structural; hence greater control in backfill compaction is required. Also the integrity of the connections between the reinforcing elements and the wall panels are critical. Environmental and chemical/electro-chemical considerations are relevant and may vary between inextensible steel reinforcement systems and geosynthetic reinforcement systems.	Low to moderate Attractive for higher height walls	Recommended
Armour Stone Wall	Not appropriate for as part of bridge substructure, i.e. wing wall	Quality control issues and resulting uncertainties;	Moderate	Not recommended.

Appendix F: List of SPs, OPSSs, OPSDs and NSSPs

List of SPs, OPSSs, OPSDs and NSSPs referenced in the Report

SSD	S103-11	STANDARD STRUCTURAL DRAWING SS-103-11
OPSD	3000.100	FOUNDATION PILES STEEL H-PILE DRIVING SHOE
OPSD	3101.150	WALLS ABUTMENT, BACKFILL - MINIMUM GRANULAR REQUIREMENT
OPSD	3121.150	WALLS RETAINING, BACKFILL - MINIMUM GRANULAR REQUIREMENT
OPSS	501	CONSTRUCTION SPECIFICATION FOR COMPACTING
OPSS	803	CONSTRUCTION SPECIFICATION FOR SODDING
OPSS.PROV	212	CONSTRUCTION SPECIFICATION FOR EARTH BORROW
OPSS	206	CONSTRUCTION SPECIFICATION FOR GRADING
OPSS	804	CONSTRUCTION SPECIFICATION FOR SEED AND COVER
OPSS	902	CONSTRUCTION SPECIFICATION FOR EXCAVATING AND BACKFILLING - STRUCTURES
OPSD	3102.100	WALLS ABUTMENTS BACKFILL DRAIN
NSSP		ROCK POINTS
OPSS.PROV	1010	MATERIAL SPECIFICATION FOR PAVING AND BACKFILL
OPSS	1860	MATERIAL SPECIFICATION FOR GEOTEXTILES
NSSP		MUD MAT
OPSS	517	CONSTRUCTION SPECIFICATION FOR DEWATERING OF PIPELINE, UTILITY, AND ASSOCIATED STRUCTURE EXCAVATION
OPSS	903	CONSTRUCTION SPECIFICATION FOR DEEP FOUNDATIONS
OPSS	539	CONSTRUCTION SPECIFICATION FOR TEMPORARY PROTECTION SYSTEMS
NSSP		SPECIFICATION OF GEOSYNTHETIC REINFORCEMENT
OPSS	180	GENERAL SPECIFICATIONS FOR THE MANAGEMENT OF EXCESS MATERIALS
NSSP		NON-FROST SUSCEPTIBLE ENGINEERED FILL
NSSP		H-PILES - HP 310X110

H-PILES - HP 310X110

Special Provision

The requirements of OPSS 903, November, 2009 shall govern this- specification with the following amendments:

903.07.02 DRIVEN PILES

The Contractor shall note that there is a possibility of the presence of cobbles, boulders and shale rock slabs in the area where piles are to be installed, and heavy pile driving requirements through the very dense strata. If such obstructions are encountered, the Contractor shall employ the necessary measures to comply with the requirements of OPSS 903. The Contractor shall avoid overdriving and damaging the pile tip, i.e. the structural capacity of the piles shall not be exceeded.

903.10 BASIS FOR PAYMENT

903.10.02 H-PILES - ITEM

Subsection 903.10.02 is amended by the addition of the following paragraphs:

If obstacles such as cobbles, boulders, rock slabs, and heavy pile driving conditions are encountered there will be no additional cost to the Contract.

DRIVING SHOES

Non-Standard Special Provision

Scope

As part of the work under the above tender item, the Contractor shall supply Titus Standard "H" Bearing Pipe Point design driving shoes on HP 310 x 110 Piles. Road.

References
OPSS 906 – Structural Steel
SP903S01

Materials

The driving shoes shall be of the following:

Product	***Manufacturer***
HPP-S-12	Titus Steel Company Ltd. 6767 Invader Cr. Mississauga, ON Tel (905) 564-2446

(Or approved equivalent)

Basis of Payment

Payment at the Contract Price for the above tender items shall be full compensation for all labour, equipment and material to do the work.

Non-Frost Susceptible Engineered Fill

Non-Standard Special Provision

Scope of Work:

The scope of work for the above noted tender item includes supply and replacement of weak organic surficial material generally up to 1.0 m thickness under the embankment footprint excluding the footprint delineated for the retaining wall.

The requirements of OPSS 212 PROV, November 2013 shall govern this specification for the replacement material with the following amendment:

212.05.01 Earth Borrow

Earth borrow shall consist of earth as defined in OPSS 206 and shall be free from organic and foreign material and containing not more than 40% of its particles by mass passing the 75 μm in size, as determined using LS-702, shall be considered as earth borrow.

Basis of Payment

Payment at the Contract Price for the above tender item shall be full compensation for material supplied conforming to this Special Provision.

Geosynthetic Reinforcement (Granular Pad)

Non-Standard Special Provision

Material Specification:

The first paragraph of Subsection 1860.05 **MATERIALS** is amended as follows:

The uniaxial geogrid shall be of polyester, or high density polyethylene polymer. It shall have a long-term design strength of 40 kN/m at the end of the design life of the structure which is specified in the contract documents.

LEAN CONCRETE (MUD MAT)

Non-Standard Special Provision

Scope of Work:

The scope of work for the above noted tender item includes supply and installation of the lean concrete (i.e. mud mat) to prevent erosion and/or disturbance to the foundation soils, if required. If the granular pad for the retaining wall footings on the native or engineered fill soil cannot be poured immediately after the excavation and inspection, a working mat of lean concrete should be placed in the excavation to protect the integrity of the bearing stratum.

Construction

Lean concrete shall have a compressive strength of at least 5 MPa, shall be placed in general accordance with OPSS 904, and the working mat shall have a minimum thickness of 75 mm. The working mat should extend to at least one metre beyond the granular pad footprint.

Basis of Payment

Payment at the contract price for the above noted tender item includes full compensation for all labour, equipment and materials to do the required work.

Appendix G: Limitations

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to WSP Canada Inc. at the time of preparation. Unless otherwise agreed in writing by WSP Canada Inc., it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.