



# FOUNDATION INVESTIGATION AND DESIGN REPORT

## PROPOSED REHABILITATION OF DUFFERIN STREET OVERPASS HWY 401 EB & WB EXPRESS, TORONTO, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

Site Location: (Long. -79.457898°, Lat. 43.728059°)

GWP 2089-13-00 & 2088-16-00

GEOCRES NO. 30M11-300

WSP PROJECT NO.: 19M-01243-00

SEPTEMBER 18, 2020

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PART A: FOUNDATION INVESTIGATION REPORT  
PROPOSED REHABILITATION OF DUFFERIN STREET OVERPASS  
HWY 401 EB AND WB EXPRESS, TORONTO, ONTARIO

# 1 INTRODUCTION

This work was carried out as part of the Ministry of Transportation, Ontario (MTO) Central Region Highway 401 pavement rehabilitation and structural rehabilitation of various bridges programme under Assignment No: 2018-E-0057. WSP was retained by MTO to carry out detailed foundation investigation and design recommendations to support the Structural rehabilitation design of the Dufferin Street Overpass bridge carrying Highway 401 East bound (EB) and West bound (WB) express traffic. The overall rehabilitation work proposed at Dufferin Street Overpass include superstructure replacement, semi-integral abutment conversion and replacement of approach slabs.

The existing EB and WB structures are each two-span conventional bridges; each span is 15.0 m long. EB structure accommodates four lanes of traffic and WB structure accommodates five lanes of traffic. The bridges were originally constructed in 1966, and the structures were last rehabilitated in 2017.

This report addresses the foundation investigation carried out for the temporary roadway protection works for the proposed rehabilitation as the foundation scope under this assignment. These structures will be referred to as EB and WB structures in this report.

The purpose of the Geotechnical Investigation was to determine the sub-surface conditions and groundwater observations at the site by means of boreholes, field and laboratory tests. Based on the information obtained, the engineering characteristics of the subsurface soils were assessed, and site conditions described to develop geotechnical recommendations to address the foundation scope.

Part A of this report presents factual information concerning the subsurface conditions based on all of the subsurface information at hand and is followed by Part B wherein engineering discussion and foundation recommendations are made for the design and construction of the temporary protection works for the above proposed structure rehabilitation.

This report is based on the General Arrangement (GA) Drawings provided to WSP Structures on March 18, 2020.

## 2 BACKGROUND INFORMATION

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### 2.1 GEOLOGICAL SETTING

Site geology as per Ontario Geological Survey (OGS) Geology Map No: 2556 on the Quaternary Geology of Ontario, Southern Sheet (1:1,000,000 scale) indicates the surficial geology to be Halton till (Ontario-Erie lobe) comprising of predominantly silt to silty clay matrix. As per the Physiography of Southern Ontario map (Chapman and Putnam, 1984), the site is within the physiographic region known as the Peel Plain, and physiographic landforms consist of bevelled till plains.

According to OGS Geology Map No: 2544 on the Bedrock Geology of Ontario, Southern Sheet (1:1,000,000 scale), the bedrock in the general locality consists of shale, limestone, dolostone and siltstone of the Georgian Bay/Blue Mountain/Billings formation, belonging to Upper Ordovician Age.

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### 2.2 PREVIOUS GEOTECHNICAL INFORMATION

The following foundation reports pertain to the general area of the proposed structures rehabilitation.

- WP 233-61-2-1, GEOCRETS NO. 30M11-081: Foundation Investigation, Spadina Bridge #1 – Proposed Retaining Wall adjacent to ramp from Hwy 401 to Dufferin Street, dated July 9, 1963.
- GWP 2131-01-00, GEOCRETS NO. 30M11-247: Foundation Investigation and Design Report, Sign Support Structures, Hwy 401 Eastbound collector rehabilitation from Jane Street to Avenue Road, Toronto, ON, dated May 24, 1962.
- GWP 2131-01-00, GEOCRETS NO. 30M11-262: Foundation Investigation and Design Report, Hwy 401 W – Yorkdale Road Ramp over Dufferin Street (Site No. 37-284), Hwy 401 Eastbound collector rehabilitation from Jane Street to Avenue Road, , dated April 28, 2016.

According to the above reports, the soil stratigraphy generally comprised of fill material of varying thickness (an upper thin layer of granular material and a lower layer of clayey silt), underlain by stiff to hard, silty clay to clayey silt till deposit.

For further information, historic borehole logs from GEOCRETS NO. 30M011-081, namely 1A, 2B, 1C and 2A have been presented along side the current boreholes in **Drawings 1 & 2**. It is to be noted that the historic borehole locations are approximate and that the surface elevation of these boreholes have been assumed to be with respect to the same elevation datum to that of the current boreholes. Further, construction activities over the ensuing years may have masked the nature of surficial deposits identified in the historic borehole logs.

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### 2.3 SITE DESCRIPTION

The site of the proposed bridge rehabilitation is located at the Dufferin Overpass of Highway 401 EB/WB Express, North York, Ontario. The key plan of the site is shown on **Drawings 1 & 2**. Highway 401 EB & WB Express lanes are operationally, a four-lane and a five-lane roadway respectively with paved shoulders. Both Express lanes are bounded by the collector lanes laterally at each end. The highway runs approximately in an east-west direction over Dufferin Street. The posted regulatory speed limit is 100km/hr. There are industrial/commercial density of businesses located within the vicinity of the site. The existing bridges with abutment walls and pier are shown in Photos C1-2 and C1-3. A site reconnaissance visit was carried out on 1st November 2019.

There are minor transverse cracks on the highway (Photo C1-4). Also, there are no visible/observable signs of differential settlement between the approach slab and the approach embankment at each abutment. The embankment side slopes at the east and west approach embankments are well vegetated and green showing no sign of erosional activities.

# 3 FIELD AND LABORATORY INVESTIGATIONS

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## 3.1 FIELD INVESTIGATION

A reconnaissance visit was carried out in November 2019 prior to fieldwork. The reconnaissance observations about the nature of terrain and access constraints for conventional drilling gear were carefully considered in planning the field investigation program. Based on the site reconnaissance, underground utilities were cleared at the borehole locations by representatives of public and MTO. A conventional drilling approach was deployed, i.e. with the use of a truck mounted CME 55 drilling rig. All borehole investigations were carried out in compliance with the operational constraints, during night-time.

Eight (8) boreholes, namely BH 19-1 through BH 19-8 were drilled through the existing pavement, four boreholes each at the EB and WB cores, with two boreholes on each side of the bridge abutment (but diagonally placed either on the inner or the outer, shoulders ) along each core, with the borehole locations as shown on **Drawings 1 and 2**, following the text of the FIR. The boreholes were drilled on November 25 to December 6, 2019. The boreholes were advanced using solid stem augers (150 mm diameter).

The traffic set-up indicated a single lane closure with traffic cones and electronic signboards in accordance with TL-29 Right Lane Closure, MTO Book 7 (Photos C2-1 and C2-2 in **Appendix C**).

Existing express lanes on Dufferin Street overpass at Highway 401 can be seen in Photo C1-1. Night work at boreholes BH 19-3 and BH19-4 with associated traffic control setup is shown in Photos C2-1 and C2-2 in **Appendix C**.

The Fieldwork was carried out under full-time supervision of WSP technical staff who directed the exploration and sampling operation, logged borehole data in accordance with MTO Soils Classification System and took custody of soil samples retrieved for subsequent laboratory testing and identification. Soil samples were visually classified in the field and later re-evaluated by an engineer. The recovered soil samples were placed in labelled moisture-proof bags and returned to WSP's Galaxy laboratory for further assessment.

**Table 3-1** presents the exploratory borehole details of the WSP foundation investigation.



**Table 3 - 1 Summary of Exploratory Borehole Details\***

Structure	Borehole No.	Borehole Eastings, Northings (m) (MTM NAD 83, Zone 10)	Borehole Geospatial Coordinates: Latitude, (Longitude); (°)	Ground Elevation (m)	Explored Depth (m)	Drilling Methodology/Remarks
WB	BH 19 - 1	E308242.4, N4843131.3	43.728121°; (-79.457271)°	195.4	12.8	Solid Stem Auger/SPT Penetration Testing/Field Vane Shear/Shelby Tube Sampling
	BH 19 - 2	E308232.3, N4843128.4	43.728096°; (-79.457396°)	195.6		
	BH 19 - 3	E308161.4, N4843123.7	43.728054°; (-79.458279°)	195.6		
	BH 19 - 4	E308151.5, N4843121.1	43.728028°; (-79.458404°)	195.5		
EB	BH 19 - 5	E308157.2, N4843101.2	43.727856°; (-79.458333°)	195.6		
	BH 19 - 6	E308167.0, N4843104.1	43.727882°; (-79.458209°)	195.6		
	BH 19 - 7	E308226.7, N4843104.6	43.727881°; (-79.457476°)	195.6		
	BH 19 - 8	E308237.3, N4843107.0	43.727906°; (-79.457339°)	195.5		

Notes\*:

- 1) Locates done by CLI with participating companies such as Toronto Hydro One, Toronto Sewer, Toronto Water, Enbridge Gas, and Bell Canada.
- 2) The spacing and quantity of boreholes generally conform to RFP requirements;
- 3) Type of drilling rig used: Truck Mounted - CME 55 rig.
- 4) Co-ordinates: based on MTM NAD 83 Zone 10 coordinates; Terminology of directions, e.g., Reference to North is geographic;
- 5) Traffic control as per MTO Book 7 by Almon Equipment Ltd., Toronto, Ontario;
- 6) Names of Drilling Company: Pontil Drilling Services Inc., Mount Albert, Ontario

- 7) Drilling Supervision: by WSP staff from Toronto office;
- 8) Borehole Survey by WSP representative using Sokkia Archer Global Positioning System (GPS) unit (Model No. GRX2) with a horizontal accuracy of 0.05 m and vertical accuracy of 0.01 m, compliant with MTO requirements.

Samples were retrieved at regular intervals with a 50 mm Outer Diameter (O.D.), split-barrel sampler driven with a hammer weighing 624 N and dropping 760 mm in accordance with the Standard Penetration Test (ASTM D 1586) method. This sampling method recovers samples from the soil strata, and the number of blows required to drive the sampler 300 mm depth into the undisturbed soil (SPT 'N'-values) gives an indication of the compactness condition or consistency of the sampled soil material based on the cohesionless or the cohesive nature of the material, respectively. At select borehole locations, for low blow count fine-grained material, field vane shear tests (MTO Vane 'N') were performed as per ASTM D 2573. The SPT 'N' values are indicated on the Record of Borehole Sheets (Refer to **Appendix A**).

---

## 3.2 LABORATORY INVESTIGATIONS

Visual examination and classification were undertaken on the soil samples returned to WSP laboratory. A routine laboratory testing program consisting of natural water content tests, grain size analysis, hydrometer testing and Atterberg Limit testing was carried out on selected representative soil samples in compliance with the MTO requirements. The results of the laboratory tests are summarized on the appropriate Record of Borehole Sheets in **Appendix A** and compiled test results are given in **Appendix B**.

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## 3.3 GROUNDWATER INVESTIGATION

Groundwater conditions in the boreholes were observed during and on completion of drilling in the open boreholes. Two (2) 50 mm monitoring wells were installed in BH 19-4 (WB) and BH 19-8 (EB) upon completion of drilling to enable long-term groundwater level monitoring and water levels to be read subsequently. The rest of the boreholes were grouted (decommissioned) using a cement/bentonite mixture and surface patched with asphalt as per MTO procedures. As part of the construction, the two installed monitoring wells need to be decommissioned by others, in accordance with Ontario Regulation 903 (amended to Ontario Regulation 372/07).

**Table 3-2** provides information about the monitoring wells installed for this investigation.

**Table 3 - 2 Monitoring Well Installation Details**

BH No./Structure	Ground Surface Elevation (m)	Borehole Bottom		Well Screen Interval Depth, m		Well Screen Interval Elevation, m		Remarks
		Depth (m)	Elevation (m)	From	To	From	To	
BH 19-4 / WB	195.5	12.8	182.7	6.1	9.1	189.4	186.4	WB Structure, Behind West Abutment
BH 19-8 / EB	195.5	12.8	182.7	4.6	7.6	190.9	187.9	EB Structure, Behind East Abutment

# 4 SUBSURFACE CONDITIONS

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## 4.1 GENERAL

The subsurface conditions encountered at the structure locations are described in the following sections.

**Drawings 1 & 2** show key plans with longitudinal profiles for EB and WB structures (projected along the centrelines of the Hwy 401 cores at the proposed structure rehabilitation). The inferred stratigraphic profiles at the structure locations are based on the borehole data. The soil descriptions are based on visual and tactile observations and complemented by the results of field and laboratory soil test results.

For purposes of soil description, the MTO Soil classification manual was generally followed. The strata boundaries shown on the subsurface profiles must not be interpreted as exact planes of geological change but rather as inferred transitions from one soil type to another since they are based on non-continuous sampling information at discrete borehole locations. It should be noted that the subsurface conditions and the pavement fill thicknesses encountered might vary in between and beyond the borehole locations. All pavement fill thicknesses reported should not be relied upon for quantity estimation as they may vary between/beyond the borehole locations. Unless otherwise stated, all SPT 'N' values quoted are for 300 mm of penetration.

An overview of subsurface conditions is described below. All depths quoted are below the existing ground surface.

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## 4.2 OVERVIEW

The intercepted pavement structure was asphalt generally over cohesionless soil as the support layer to asphalt. However, at BH 19-3 a concrete pavement was intercepted, this location likely to be backfill from a previous test pit. The thickness of the pavement structure ranged from 0.4 m to 2.3 m with the road grade elevation varying from 195.4 m to 195.6 m.

Following the pavement structure, the embankment fill encountered comprised of clayey silt material of low plasticity with thickness ranging from 2.5 m to 7.2 m, with a greater fill thickness on the WB. It was found to be typically of a stiff consistency and of low plasticity. This material based on grain size and plasticity information was found to be of low frost susceptibility and medium erodibility.

The native stratigraphy underlying the fill layer predominantly consisted of glacial till comprising predominantly of stiff to hard clayey silt. The intercepted clayey silt and silty clay deposit thickness ranged from 5.2 m to 8.4 m. This material based on grain size and plasticity information was found to be of moderate frost susceptibility and medium erodibility. Drilling was terminated within this native deposit at a depth of 12.8 m.

Stable groundwater depth readings ranging from 6.0 to 7.4 m were observed in the installed monitoring wells.

The intercepted native geology closely resembles the geology reported in the literature (See Section 2.1).

Fuller details of the above overview are given below.

## 4.3 SUBSURFACE CONDITIONS

### 4.3.1 PAVEMENT STRUCTURE

A pavement structure consisting of asphalt/concrete over predominantly cohesionless pavement fill was intercepted in the boreholes. The thickness of asphalt intercepted in the boreholes ranged from 203 mm to 380 mm while the cored concrete was only contacted in BH 19-3 and was 610 mm thick. The pavement fill was typically cohesionless and about 0.5 m thick. While in BH 19-7 the cohesionless layer was 2.0 m thick. The concrete was underlain by a 0.9 m thick sandy clay. Four (4) grain size distribution tests and one (1) Atterberg Limits test was performed on the pavement fill material and the tests indicated the following grain size distribution and index values as shown in **Table 4-1**.

**Table 4 - 1 Grain Size Distribution and Atterberg Limits Summary - Pavement Fill**

Structure	Samples Tested	Size Fraction (%)				Atterberg Limits			Remarks
		Gravel	Sand	Silt	Clay	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	
WB	BH 19-3/SS2	3	40	39	18	22	13	9	Shown in Figure B-1 and B-2, <b>Appendix B</b> Summarized on the relevant Record of Borehole Sheets
EB	BH 19-5/SS1	25	56	17	2	-	-	-	
	BH 19-6/SS2	3	82	11	4	-	-	-	
	BH 19-7/SS3	6	78	12	4	-	-	-	

Based on the above grain size distribution, the material can be classified as primarily cohesionless, with major size fraction to be sand.

### 4.3.2 EMBANKMENT FILL

At WB structure, the approach embankment fill comprising clayey silt was intercepted in all the boreholes (BH 19-1 to BH 19-4), with layer thickness ranging from 5.3 m to 7.2 m.

At EB structure, the approach embankment fill comprising clayey silt was intercepted in the all boreholes (BH 19-5 to BH 19-8), with layer thickness ranging from 2.5 m to 5.1 m. The fill material also consisted of traces of wood in BH 19-6. And intercepted sand seams in BH 19-8.

Fifteen (15) grain size distribution and twelve (12) Atterberg limits tests were performed on the above fill material and the tests indicated the following grain size distribution and index values as shown in **Table 4-2**.

**Table 4 - 2 Grain Size Distribution and Atterberg Limits Summary - Embankment Fill**

Structure	Samples Tested	Size Fraction (%)				Atterberg Limits			Remarks
		Gravel	Sand	Silt	Clay	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	
WB	BH 19-1/SS2	1	28	48	23	27	15	12	Shown in Figure B-3 and B-4, <b>Appendix B</b> Summarized on the relevant Record of Borehole Sheets
	BH 19-1/SS7	1	27	50	22	26	15	11	
	BH 19-2/SS4	1	27	48	24	27	15	12	
	BH 19-2/SS6	2	26	48	24	29	16	13	
	BH 19-3/SS6	2	25	48	25	32	16	16	
	BH 19-4/SS3	3	28	47	22	26	14	12	
EB	BH 19-5/SS5	1	25	48	26	30	16	14	For primarily cohesive fill, sand fraction ranged from 24-40%. LL values ranged from 22-32 and PI values ranged from 9-16, resulting in low plasticity.
	BH 19-6/SS4	1	24	50	25	30	16	14	
	BH 19-7/SS7	2	24	46	28	31	16	15	
	BH 19-8/SS2	3	32	46	19	24	13	11	
	BH 19-8/SS4	2	32	44	22	27	13	14	

Based on the visual, tactile, grain size and Atterberg limits testing information, the fill material can be described as primarily clayey silt of low plasticity. Based on the shape of the grain size distribution curves it can be describes as a fill of glacial till origin. Accordingly, based on the MTO Frost Susceptibility Chart and the MTO Erosion and Sediment Control guidelines (MTO Environmental Guide for Erosion and Sediment Control During Construction of Highway Projects), the fill material can be ranked as “Moderate” frost susceptibility and “Medium Erodibility” on the erodibility classification, respectively.

For the WB structure, measured moisture contents of the spoon samples ranged from 12% to 31% indicative of a moist to wet condition.

SPT ‘N’ values recorded in the range 4 to 20. Field Shear Vane results recorded an average undrained shear strength of about 72 kPa (based on three measurements). Collectively, these indicate the fill to be of firm to very stiff consistency.

For the EB structure, measured moisture contents of the spoon samples ranged from 11% to 24%, with the moisture content within upper 1.5 m around the 11% and below that the moisture was around 20%. This is indicative of a moist to wet condition. SPT ‘N’ values recorded in the range 6 to 19 indicate the fill to be firm to very stiff, but typically firm to stiff.

No cobbles, boulders or other obstructions were intercepted in this fill layer. However, their presence cannot be discounted.

### 4.3.3 COHESIVE TILL (CLAYEY SILT)

The dominant native soil deposit underlying the fill material intercepted in all the boreholes at both WB and EB structures, was a cohesive till comprising predominantly of clayey silt with a silty clay deposit overlying clayey silt in BH 19-3. All boreholes terminated within this deposit. The intercepted thickness of the deposit ranged from 5.2 m (BH 19-1) to 8.4 m (BH 19-6) with an average of 7.0 m. The intercepted top elevation of the deposit varied from 191.2 m (BH 19-6) to 187.8 m (BH 19-1).

Sixteen (16) grain size distribution and sixteen (16) Atterberg limits tests were performed on the above till deposit and the tests indicated the following grain size distribution and index values as shown in **Table 4-3**.

**Table 4 - 3 Grain Size Distribution and Atterberg Limits Summary - Clayey Silt (Till)**

Structure	Sample Tested	Size Fraction (%)				Atterberg Limits			Remarks
		Gravel	Sand	Silt	Clay	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	
WB	BH 19-1/SS11	2	20	51	27	29	15	14	Shown in Figure B-5 and B-6, <b>Appendix B</b> , Summarized on the relevant Record of Borehole Sheets
	BH 19-1/SS13	2	30	49	19	21	12	9	
	BH 19-2/SS10	1	23	54	22	29	15	14	
	BH 19-2/SS12	2	24	51	23	25	13	12	
	BH 19-3/SS11	1	9	43	47	39	19	20	
	BH 19-3/SS13	1	28	51	20	23	12	11	
	BH 19-4/SS10	1	24	52	23	29	16	13	
	BH 19-4/SS13	1	27	52	20	23	12	11	
EB	BH 19-5/SS10	2	26	49	23	24	13	10	For cohesive till, LL values ranged from 21-39 and PI values ranged from 9-20, resulting in low to intermediate plasticity
	BH19-5/SS12	3	28	45	24	28	15	13	
	BH 19-6/SS9	1	21	53	25	30	17	13	
	BH 19-6/SS11	3	23	51	23	27	14	13	
	BH 19-7/SS11	2	21	50	27	30	15	15	
	BH 19-7/SS13	3	24	50	23	24	12	12	
	BH 19-8/SS10	3	22	52	23	28	15	13	
	BH 19-8/SS12	2	23	51	24	25	13	12	

Based on the visual, tactile, grain size and Atterberg limits testing information, the deposit can be described as predominantly a glacial clayey silt deposit of low plasticity with a localized silty clay deposit of intermediate plasticity deposit intercepted overlying the clayey silt at borehole BH19-3.

Measured moisture contents ranged from 10% to 27% with an average of 15%, indicative of a moist condition.

SPT 'N' blow counts ranged from 7 to 44 (based on 43 measurements), indicating firm to hard consistency. Two Field Shear Vane Tests measured and average undrained shear strength of about 86 kPa. Collectively, the native till deposit can be described typically as stiff to hard.

No cobbles or boulders were intercepted in this glacial deposit. However, their presence cannot be discounted.

## 4.4 GROUNDWATER LEVEL OBSERVATIONS

Monitoring wells were installed in Boreholes BH 19-4 & BH 19-8 for long-term groundwater monitoring. The screen for the well was installed spanning the clayey silt/silty clay fill/till. It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations in response to major weather events. Findings are summarized in **Table 4-4**.

**Table 4 - 4 Summary of Groundwater Level Observations**

Structure	BH No.	Existing Ground Elevation (m)	Date of Measurement	Groundwater Level- Depth (m)	Groundwater Level - Elevation (m)	Notes
WB	BH 19-1	195.4	November 28, 2019 (upon completion)	Not Encountered	Not Encountered	No Cave-in and dry borehole upon completion
	BH 19-2	195.6	November 27, 2019 (upon completion)	Not Encountered	Not Encountered	No Cave-in and dry borehole upon completion
	BH 19-3	195.6	November 25, 2019 (upon completion)	7.0	188.6	Wet spoon below 7.6 m, No Cave-in and wet borehole upon completion
	BH 19-4 (MW)	195.5	November 26, 2019 (upon completion)	7.9	187.6	Borehole cave-in at 11.6 m below GL and wet borehole upon completion
			December 5, 2019	12.5	183.0	
			March 19, 2020	6.0	189.5	
	BH 19-5	195.6	December 6, 2019 (upon completion)	Not Encountered	Not Encountered	No Cave-in and dry borehole upon completion
EB	BH 19-6	195.6	December 5, 2019 (upon completion)	12.5	183.1	No Cave-in and wet borehole upon completion
	BH 19-7	195.6	December 3, 2019 (upon completion)	Not Encountered	Not Encountered	No Cave-in and dry borehole upon completion
	BH 19-8 (MW)	195.5	December 2, 2019 (upon completion)	Not Encountered	Not Encountered	No Cave-in and dry borehole upon completion
			March 25, 2020	7.4	188.1	

All groundwater levels observed in the exploratory holes are subject to seasonal fluctuations and variations due to precipitation events.

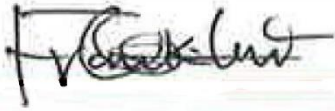


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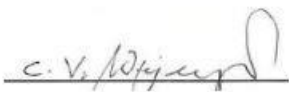
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Anuj Choudhari, M.S.C.E., P.E.  
Geotechnical EIT



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Franklin Oliha, MSc., P.Eng., PMP  
Geotechnical Engineer



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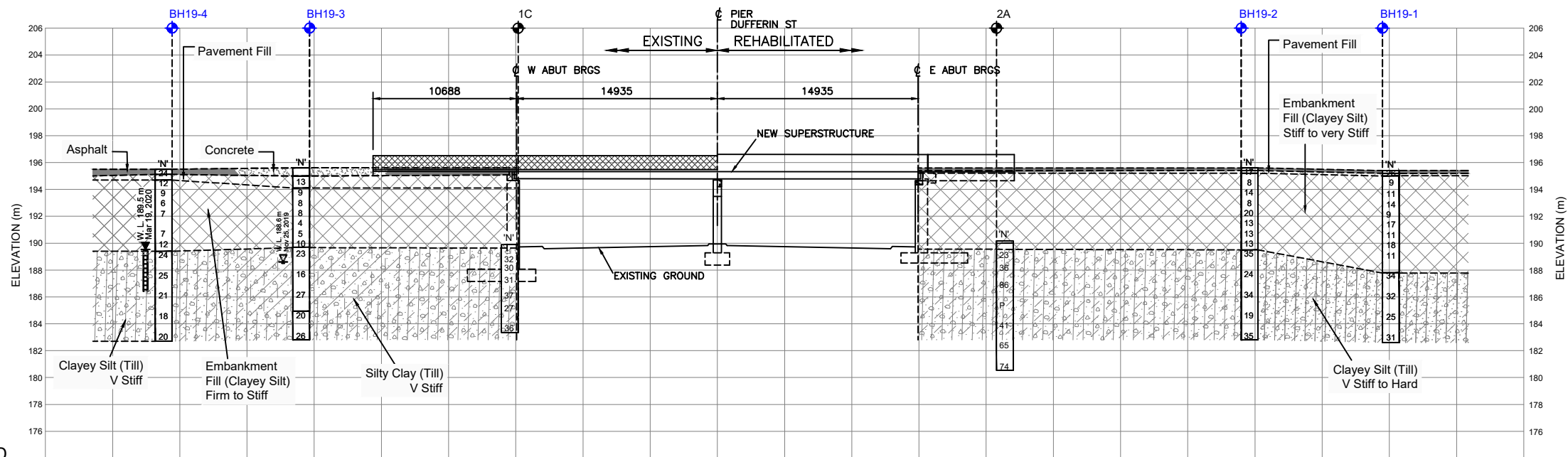
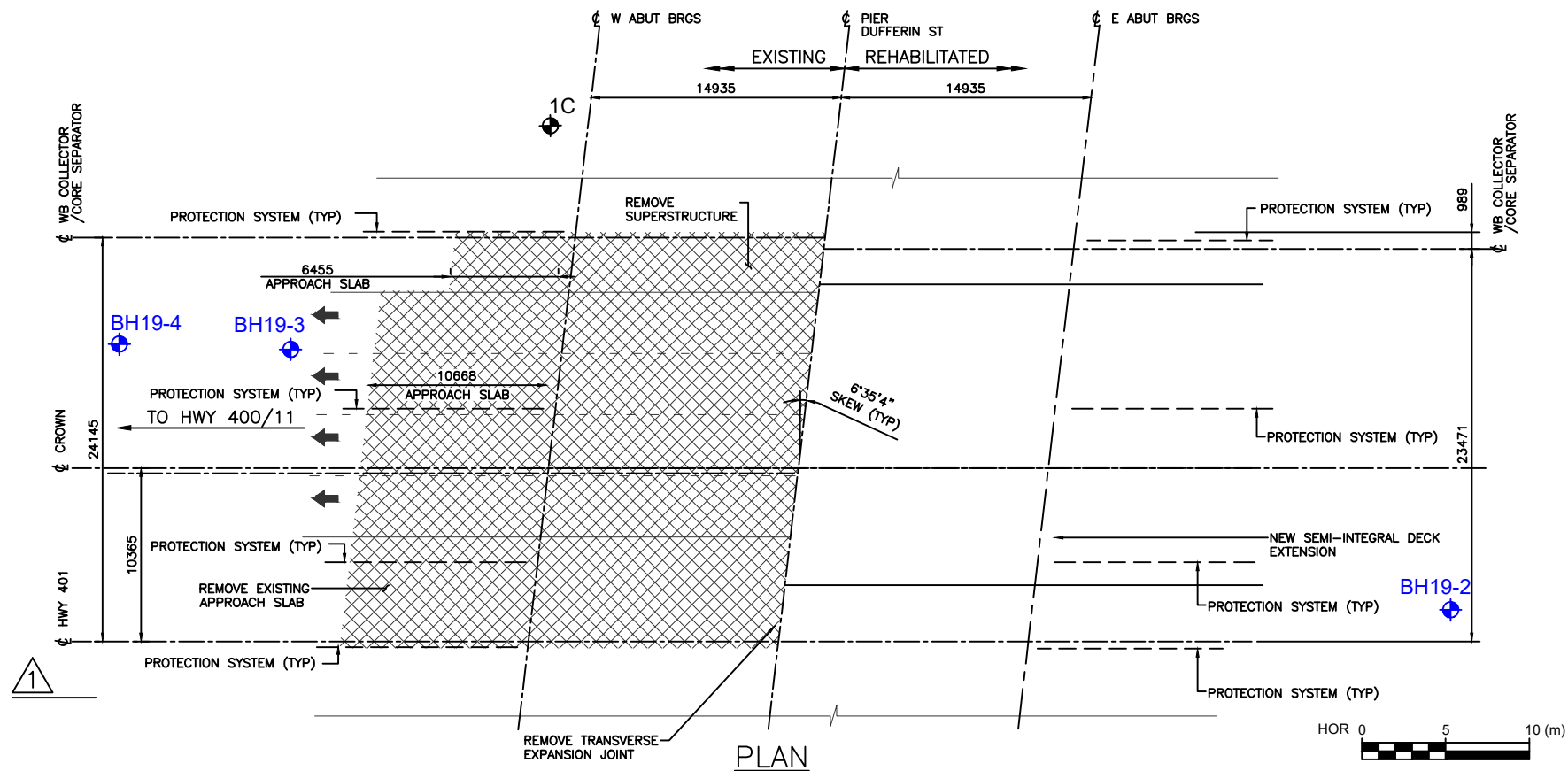
Vasantha Wijeyakulasuriya, M.Eng., P.Eng.  
MTO Designate (Foundations).



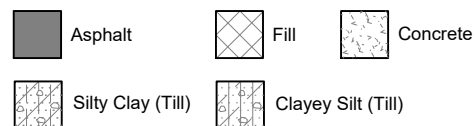
# DRAWINGS

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CONSTRUCTION  
NORTH



### LEGEND



PROFILE 1-1  
PROFILE OF HWY 401 WB CORE

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



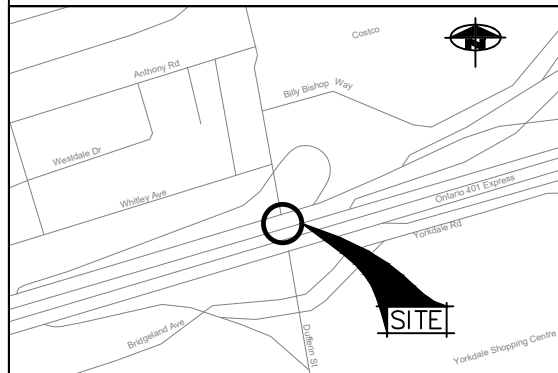
GWP No. 2089-13-00

CONT No. 2018-E-0057

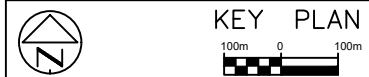
HIGHWAY 401 WB CORE  
DUFFERIN STREET OVERPASS WB  
BRIDGE REHABILITATION  
BOREHOLE LOCATIONS & SOIL STRATA

SHEET  
1 OF 1






**WSP** 2 International Blvd, Suite 201  
Toronto, Ontario  
M9W 1A2



KEY PLAN



## SOIL STRATA SYMBOLS

- |    | Borehole                              |  | Borehole by Others |
|---|---------------------------------------|---|--------------------|
| N   | Blows/0.3m (Std Pen Test, 475 J/blow) |   |                    |
|    | WL upon completion of drilling        |   |                    |
|   | WL in Piezometer                      |   |                    |
|  | Piezometer                            |   |                    |

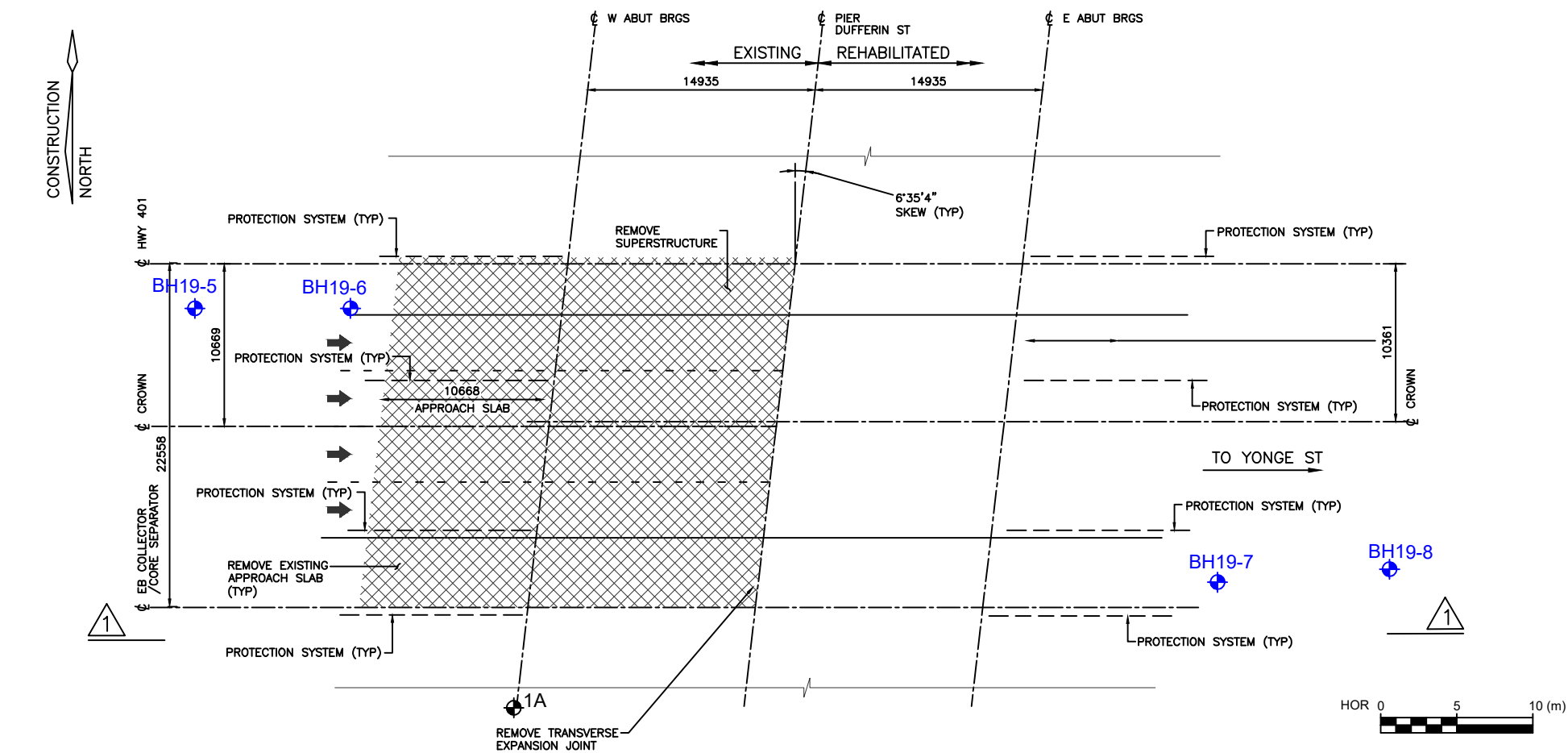
BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTHING (m)	EASTING (m)
BH19-1	195.4	4843131.3	308242.4
BH19-2	195.6	4843128.4	308232.3
BH19-3	195.6	4843123.7	308161.4
BH19-4	195.5	4843121.1	308151.5

HWY 401 WB CORE COORDINATES:  
LAT: 43.728095° LONG: -79.457909°

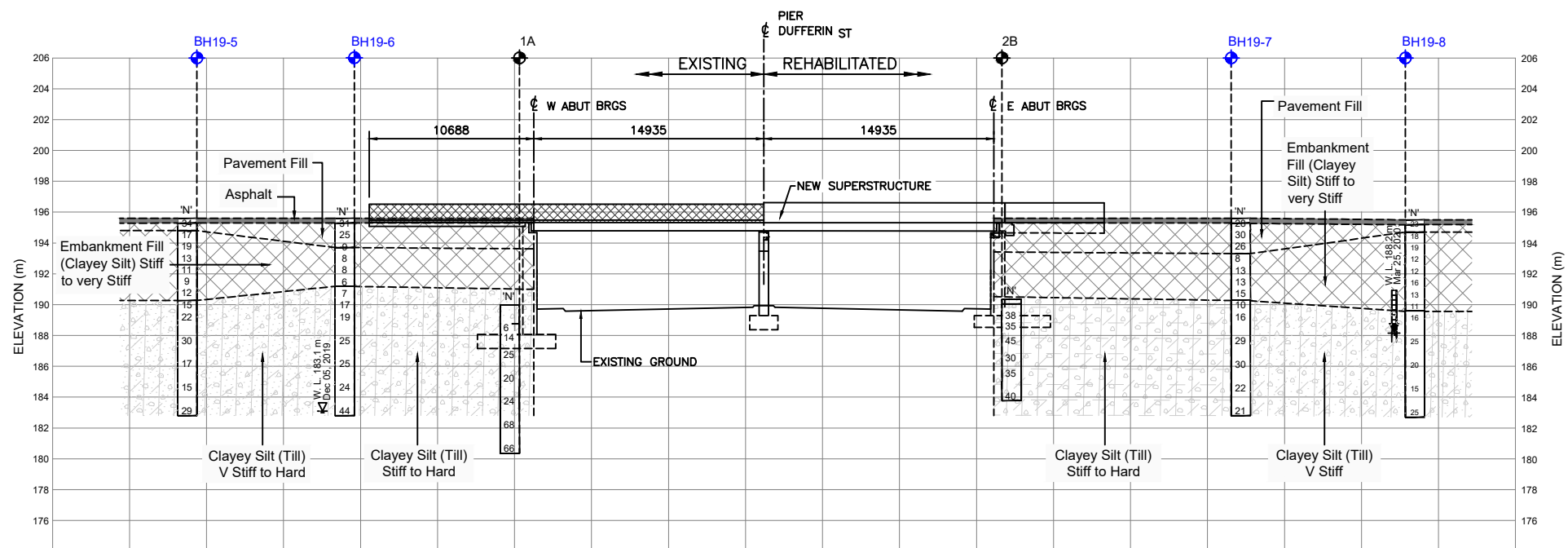
— NOTES —

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

REVISIONS	Sept 17, 2020	WSL	Final Submission to MTO		
	April 29, 2020	WSL	Submission for MTO review		
	April 13, 2020	ZMO	Submission for MTO review		
	DATE	BY	DESCRIPTION		
WSP No : 19M-01243--00			GEOCREs No : 30M11-300		
HWY No 401				DIST	
SUBM'D		CHECKED FO	DATE Sept 17/ 2020	SITE	
DRAWN	ZMO	CHECKED FO	APPROVED VW	DWG	1



## PLAN



PROFILE 1-1

# PROFILE OF HWY 401 EB CORE

### LEGEND



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



GWP No. 2088-16-00

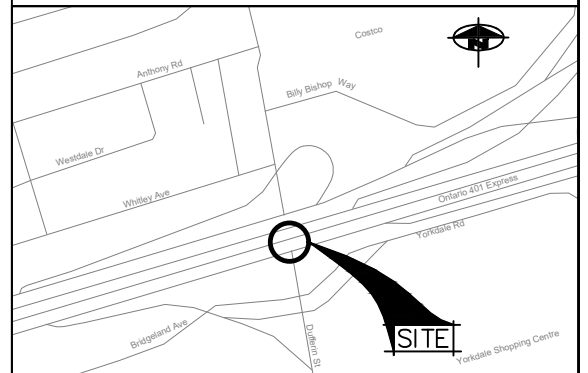
CONT No. 2018-E-0057


HIGHWAY 401 EB CORE  
DUFFERIN STREET OVERPASS EB  
BRIDGE REHABILITATION  
BOREHOLE LOCATIONS & SOIL STRATA

SHEET  
1 OF 1






2 International Blvd, Suite 201  
Toronto, Ontario  
M9W 1A2



 KEY PLAN



## SOIL STRATA SYMBOLS

- |   | Borehole                              | Borehole by Others |
|---|---------------------------------------|--------------------|
| N   | Blows/0.3m (Std Pen Test, 475 J/blow) |                    |
|  | WL upon completion of drilling        |                    |
|  | WL in Piezometer                      |                    |
|  | Piezometer                            |                    |

BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTHING (m)	EASTING (m)
BH19-5	195.6	4843101.2	308157.2
BH19-6	195.6	4843104.1	308167.0
BH19-7	195.6	4843104.6	308226.7
BH19-8	195.5	4843107.0	308237.3

HWY 401 EB CORE COORDINATES:  
LAT: 43.727897° LONG: -79.457858°

— NOTES —

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

REVISIONS	Sept 17, 2020	WSL	Final Submission to MTO
	April 29, 2020	WSL	Submission for MTO review
	April 13, 2020	ZMO	Submission for MTO review
	DATE	BY	DESCRIPTION

WSP No : 19M-01243-00

GEOCRES No : 30M11-300

HWY No 401			DIST
SUBM'D	CHECKED FO	DATE Sept 17/ 2020	SITE
DRAWN ZMO	CHECKED FO	APPROVED VW	DWG 2

# APPENDIX

**A**

RECORD OF BOREHOLE SHEETS





## Explanation of Terms Used in the Record of Borehole

### Sample Type

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Dimension type sample
FS	Foil sample
NR	No recovery
RC	Rock core
SC	Soil core
SS	Spoon sample
SH	Shelby tube sample
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### Penetration Resistance

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) required to drive a 50 mm (2 in) drive open sampler for a distance of 300 mm (12 in).

WH – Samples sinks under “weight of hammer”

#### Dynamic Cone Penetration Resistance, $N_d$ :

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) to drive uncased a 50 mm (2 in) diameter, 60° cone attached to “A” size drill rods for a distance of 300 mm (12 in).

### Textural Classification of Soils (ASTM D2487-10)

Classification	Particle Size
Boulders	> 300 mm
Cobbles	75 mm - 300 mm
Gravel	4.75 mm - 75 mm
Sand	0.075 mm - 4.75 mm
Silt	0.002 mm - 0.075 mm
Clay	<0.002 mm (*)

(\*) Canadian Foundation Engineering Manual (4<sup>th</sup> Edition)

### Coarse Grain Soil Description (50% greater than 0.075 mm)

Terminology	Proportion (*)
Trace	0-10%
Some	10-20%
Adjective (e.g. silty or sandy)	20-35%
And (e.g. sand and gravel)	> 35%

(\*) Canadian Foundation Engineering Manual (4<sup>th</sup> Edition)

### Soil Description

#### a) Cohesive Soils (\*)

Consistency	Undrained Shear Strength (kPa)	SPT “N” Value
Very soft	<12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very stiff	100-200	15-30
Hard	>200	>30

(\*) Hierarchy of Shear Strength prediction

1. Lab triaxial test
2. Field vane shear test
3. Lab. vane shear test
4. SPT “N” value
5. Pocket penetrometer

#### b) Cohesionless Soils

Density Index (Relative Density)	SPT “N” Value
Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

### Soil Tests


w	Water content
w <sub>p</sub>	Plastic limit
w <sub>l</sub>	Liquid limit
C	Consolidation (oedometer) test
CID	Consolidated isotropically drained triaxial test
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement
D <sub>R</sub>	Relative density (specific gravity, G <sub>s</sub> )
DS	Direct shear test
ENV	Environmental/ chemical analysis
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified proctor compaction test
SPC	Standard proctor compaction test
OC	Organic content test
U	Unconsolidated Undrained Triaxial Test
V	Field vane (LV-laboratory vane test)
γ	Unit weight



METRIC 1 OF 2

[illegible]

19M-01243-00

Measurement    

JSP-SOIL-ROCK-MAY-29-2017 AC.GLB

RECORD OF BOREHOLE No 19-1

METRIC 2 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308242.4, N 4843131.3 ORIGINATED BY BS  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
DATUM Geodetic DATE Nov-28-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (G <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)							
						20 40 60 80 100					10 20 30							
Continued	CLAYEY SILT (TILL): trace gravel, sandy, grey, moist, very stiff to hard (continued)																	
11			12	SS	25													
12																		
182.6			13	SS	31													
12.8	END OF BOREHOLE																	
	Notes: 1) No Cave-in upon borehole completion 2) No water at the bottom of borehole upon completion																	

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ ●=3% Strain at Failure

19M-01243-00



RECORD OF BOREHOLE No 19-2

METRIC 1 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308232.3, N 4843128.4 ORIGINATED BY BS  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
DATUM Geodetic DATE Nov-27-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						
195.6	Ground Surface																	
0.0 195.4	ASPHALT 203 mm																	
0.2 195.2	PAVEMENT FILL:		1	SS1A	17													
0.4	sand and gravel, brown, moist, compact			SS1B														
	EMBANKMENT FILL:																	
	clayey silt, trace gravel, sandy, brown to greyish brown, moist to wet, stiff to very stiff																	
1			2	SS	8													
2			3	SS	14													
3			4	SS	8													
4			5	SS	20													
5			6	SS	13													
6			7	SS	13													
6.1 189.5	CLAYEY SILT (TILL):		9	SS	35													
	trace gravel, sandy, grey, moist, very stiff to hard																	
7			10	SS	24													
8			11	SS	34													
9																		
10																		

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

19M-01243-00

RECORD OF BOREHOLE No 19-2

METRIC 2 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308232.3, N 4843128.4 ORIGINATED BY BS  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
DATUM Geodetic DATE Nov-27-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (G <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)										
						20	40	60	80	100	20	40	60	80	100	10	20	30			
Continued	<b>CLAYEY SILT (TILL):</b> trace gravel, sandy, grey, moist, very stiff to hard (continued)																				
11			12	SS	19																
12																					
182.8			13	SS	35																
12.8	<b>END OF BOREHOLE</b> Notes: 1) No Cave-in upon borehole completion 2) No water at the bottom of borehole upon completion																				

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

19M-01243-00

RECORD OF BOREHOLE No 19-3

METRIC 1 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308161.4, N 4843123.7 ORIGINATED BY BS  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO  
DATUM Geodetic DATE Nov-25-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (C <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100						
195.6 0.0	Ground Surface														
	CONCRETE 610 mm		1	AS											
195.0 0.6	PAVEMENT FILL: sandy silty clay, trace gravel, trace organics, brown, moist, stiff		2	SS	13		195								3 40 39 18
194.1 1.5	EMBANKMENT FILL: clayey silt, trace gravel, sandy, brown, moist, firm to stiff		3	SS	9		194								
			4	SS	8		193								
			5	SS	8		192								
			6	SS	4		191								2 25 48 25
			7	SS	5		190								
			8	SS	10		189								
189.7 5.9	SILTY CLAY (TILL): trace gravel, trace sand, trace oxidization, brownish grey, moist, very stiff		9	SS	23		188								Wet Spoon
			10	SS	16		187								
			11	SS	27		186								1 9 43 47

W. L. 188.6 m  
Nov 25, 2019

Wet Spoon

19M-01243-00

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to  
Sensitivity

○ = 3% Strain at Failure

RECORD OF BOREHOLE No 19-3

METRIC 2 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308161.4, N 4843123.7 ORIGINATED BY BS  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
DATUM Geodetic DATE Nov-25-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						
	Continued																	
184.9	<b>SILTY CLAY (TILL):</b> trace gravel, trace sand, trace oxidization, brownish grey, moist, very stiff ( <i>continued</i> )																	
10.7	<b>CLAYEY SILT (TILL):</b> trace gravel, sandy, trace oxidization, brownish grey to grey, moist, very stiff		12	SS	20													
182.8			13	SS	26													
12.8	<b>END OF BOREHOLE</b> Notes: 1) No Cave-in upon borehole completion 2) Water level was at 7.0 m upon completion																	

GROUNDWATER ELEVATIONS





Measurement 1st 2nd 3rd 4th

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

19M-01243-00

**METRIC** 1 OF 2

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN. (C <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE		"N" VALUES	SHEAR STRENGTH kPa	W <sub>P</sub>	W	W <sub>L</sub>				WATER CONTENT (%)
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
195.5	Ground Surface													
0.0	<b>ASPHALT</b> 380 mm													
195.1	<b>PAVEMENT FILL:</b>		1	SS1A	24									
0.4	sand and gravel, brown, moist, compact			SS1B										
194.7	<b>EMBANKMENT FILL:</b>													
0.8	clayey silt, trace gravel, sandy, trace organics, trace oxidization, brown to greyish brown, moist to wet, firm to very stiff		2	SS	12									
1														
2			3	SS	9									
3			4	SS	6									
4			5	SS	7									
5			6	SH										
6			7	SS	7									
6.1	<b>CLAYEY SILT (TILL):</b>		8	SS	12									
6.1	trace gravel, sandy, trace oxidization, brown to greyish brown, moist, very stiff		9	SS	24									
7														
8			10	SS	25									
9			11	SS	21									

	1st	2nd	3rd	4th
Measurement				

+3, ×3: Numbers refer to Sensitivity      ○ **8**=3% Strain at Failure

19M-01243-00

# RECORD OF BOREHOLE No 19-4

METRIC 2 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308151.5, N 4843121.1 ORIGINATED BY BS  
 DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
 DATUM Geodetic DATE Nov-26-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (G <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						
	Continued														
	<b>CLAYEY SILT (TILL):</b> trace gravel, sandy, trace oxidization, brown to greyish brown, moist, very stiff (continued)														
11			12	SS	18										
12															
182.7			13	SS	20										
12.8	<b>END OF BOREHOLE</b>  Notes: 1) Cave-in at 11.6 m upon borehole completion 2) Water level at 7.9 m depth upon completion 3) Water level in monitoring wells measured as follows:  <b>Water Level:</b> Date W.L. Depth (m) Elevation (m) December 5, 2019 12.5 183.0 March 19, 2020 6.0 189.5														

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

19M-01243-00

RECORD OF BOREHOLE No 19-5

METRIC 1 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308157.2, N 4843101.2 ORIGINATED BY FO  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO  
DATUM Geodetic DATE Dec-06-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			
195.6 0.0	Ground Surface														
195.3 0.3	ASPHALT 310 mm		1	SS	34		195								25 56 17 2
194.8 0.8	PAVEMENT FILL: gravelly sand, some silt, trace clay, brown, moist, dense														
	EMBANKMENT FILL: clayey silt, trace gravel, sandy, trace sand seams, brown to grey, moist, stiff to very stiff		2	SS	17										
			3	SS	19		194								
			4	SS	13		193								
			5	SS	11		192								1 25 48 26
			6	SS	9		191								
			7	SS	12		190								
190.3 5.3	CLAYEY SILT (TILL): trace gravel, sandy, grey, moist, very stiff to hard		8	SS	15		189								
			9	SS	22		188								
			10	SS	30		187								2 26 49 23
			11	SS	17		186								

Continued Next Page

GROUNDWATER ELEVATIONS


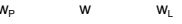

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to  
Sensitivity

○ = 3% Strain at Failure

19M-01243-00

**METRIC** 2 OF 2

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	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT  WATER CONTENT (%)	POCKET PEN (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES							
	Continued											
	<b>CLAYEY SILT (TILL):</b> trace gravel, sandy, grey, moist, very stiff to hard <i>(continued)</i>											
11			12	SS	15		185			100		3 28 45 24
12							184					
182.8			13	SS	29		183			>225		

**END OF BOREHOLE**

Notes:

- 1) No Cave-in upon borehole completion
- 2) No water at the bottom of borehole upon completion

+3, ×3: Numbers refer to Sensitivity      ○ **8**=3% Strain at Failure

19M-01243-00



# RECORD OF BOREHOLE No 19-6

METRIC 1 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308167, N 4843104.1 ORIGINATED BY FO  
 DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO  
 DATUM Geodetic DATE Dec-05-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100						
195.6 0.0	Ground Surface														
195.3 0.3	ASPHALT 310 mm		1	SS	31		195								
194.8 0.8	PAVEMENT FILL: sand and gravel, brown, moist, dense		2	SS	25		194								3 82 11 4
193.7 1.9	sand, some silt, trace gravel, trace clay, brown, moist, loose to compact		3	SS3A SS3B	9		193								
191.2 4.4	EMBANKMENT FILL: clayey silt, trace gravel, sandy, traces of wood, trace oxidization, brownish grey to grey, moist, firm to very stiff		4	SS	8		192								
			5	SS	8		191								
			6	SS	6		190								
			7	SS	7		189								
			8	SS	17		188								
			9	SS	19		187								
			10	SS	25		186								
			11	SS	25										

Continued Next Page

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

19M-01243-00

# RECORD OF BOREHOLE No 19-6

METRIC 2 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308167, N 4843104.1 ORIGINATED BY FO  
 DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
 DATUM Geodetic DATE Dec-05-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (C <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)							
						20 40 60 80 100					10 20 30							
Continued	CLAYEY SILT (TILL): trace gravel, sandy, trace oxidization, grey, moist, firm to hard (continued)																	
11			12	SS	24													
12																		
182.8			13	SS	44													
12.8	END OF BOREHOLE																	
	Notes: 1) No Cave-in upon borehole completion 2) Water level at 12.5 m depth upon completion																	

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

19M-01243-00

RECORD OF BOREHOLE No 19-7

METRIC 1 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308226.7, N 4843104.6 ORIGINATED BY FO  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO  
DATUM Geodetic DATE Dec-03-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100						
195.6 0.0	Ground Surface														
195.3 0.3	ASPHALT 310 mm		1	SS	28		195								
194.8 0.8	PAVEMENT FILL: sand and gravel, trace silt, trace clay, brown, moist, dense		2	SS	30		194								
	sand, some silt, trace gravel, brown, moist, compact to dense		3	SS	26		193								6 78 12 4
193.3 2.3	EMBANKMENT FILL: clayey silt, trace gravel, sandy, brown to greyish brown, moist, stiff to hard		4	SS	8		192								
			5	SS	13		191								
			6	SS	13		190								
			7	SS	15		189								
190.3 5.3	CLAYEY SILT (TILL): trace gravel, sandy, trace oxidization, grey, moist, stiff to hard		8	SS	10		188								
			9	SS	16		187								
			10	SS	29		186								
			11	SS	30										2 21 50 27

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to  
Sensitivity

○ = 3% Strain at Failure

19M-01243-00

RECORD OF BOREHOLE No 19-7

METRIC 2 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308226.7, N 4843104.6 ORIGINATED BY FO  
DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
DATUM Geodetic DATE Dec-03-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
	Continued																	
11	CLAYEY SILT (TILL): trace gravel, sandy, trace oxidization, grey, moist, stiff to hard (continued)		12	SS	22													
12																		
182.8			13	SS	21													
12.8	END OF BOREHOLE																	
	Notes: 1) No Cave-in upon borehole completion 2) No water at the bottom of borehole upon completion																	

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

19M-01243-00

METRIC 1 OF 2

[illegible]

19M-01243-00

Measurement    

# RECORD OF BOREHOLE No 19-8

METRIC 2 OF 2

W.P. 2089-13-00 & 2088-16-00 LOCATION MTM NAD 1983 (Zone 10), E 308237.3, N 4843107 ORIGINATED BY FO  
 DIST HWY 401 BOREHOLE TYPE CME55 Truck Mount/Solid Stem Auger (150 mm O.D) COMPILED BY FO  
 DATUM Geodetic DATE Dec-02-2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (G <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
	Continued													
	<b>CLAYEY SILT (TILL):</b> trace gravel, sandy, grey, moist, very stiff (continued)													
11			12	SS	15		185					175		2 23 51 24
12							184							
182.7			13	SS	25		183					>225		
12.8	<b>END OF BOREHOLE</b>  Notes: 1) No Cave-in upon borehole completion 2) No water at the bottom of borehole upon completion 3) Water level in monitoring wells measured as follows:  <b>Water Level:</b> Date W.L. Depth (m) Elevation March 25, 2020 7.4 188.1													

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

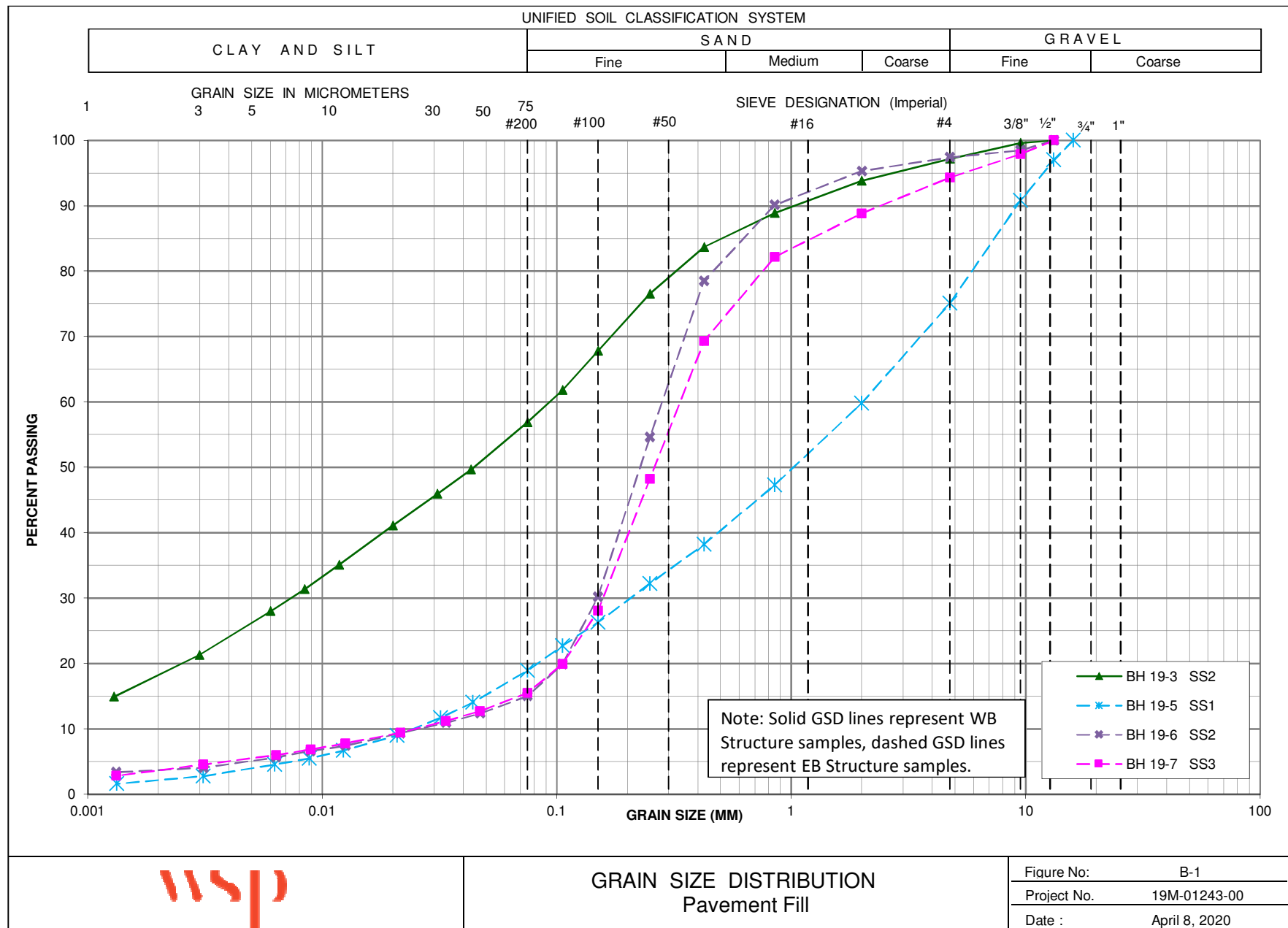
19M-01243-00

# APPENDIX

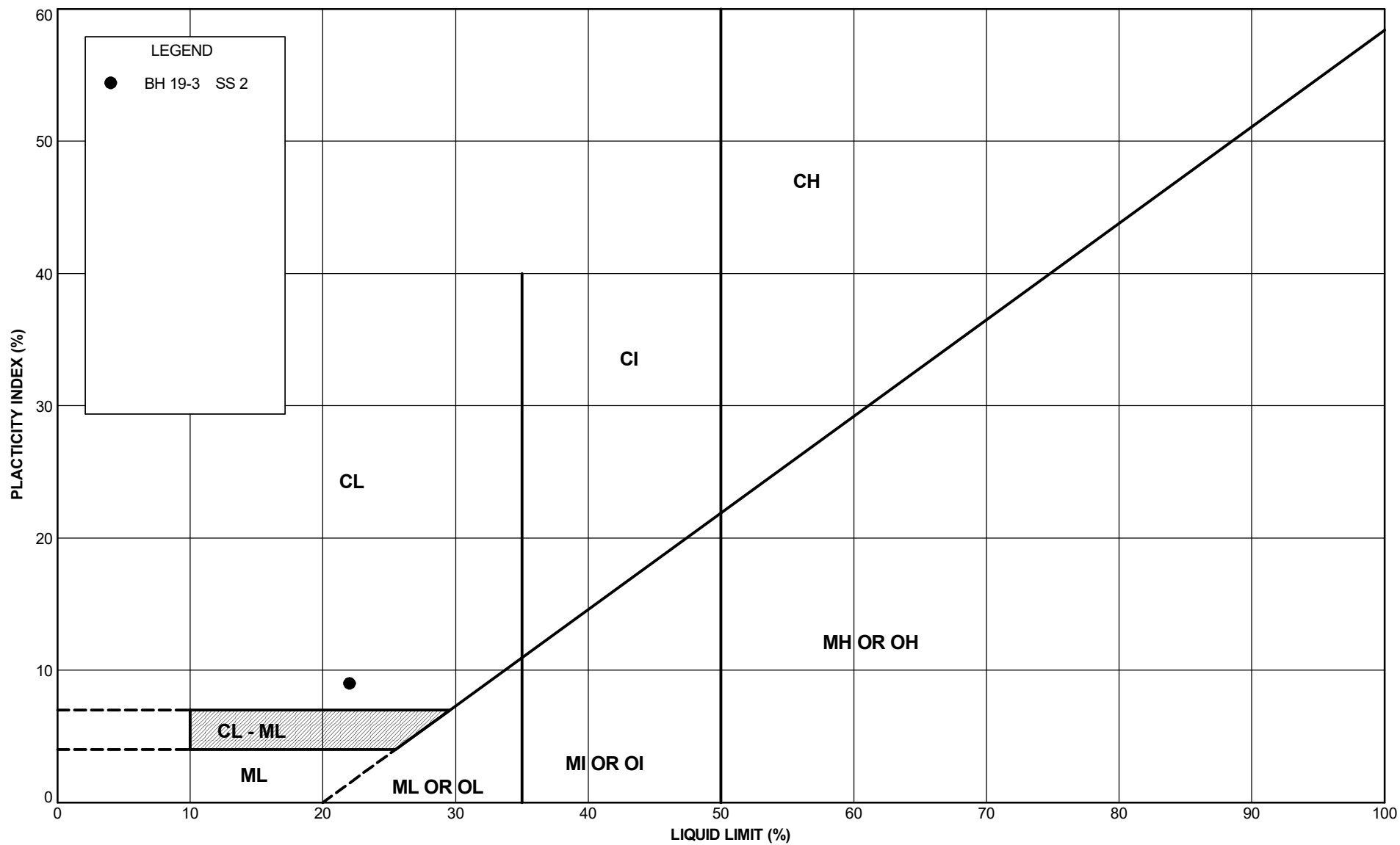
## B

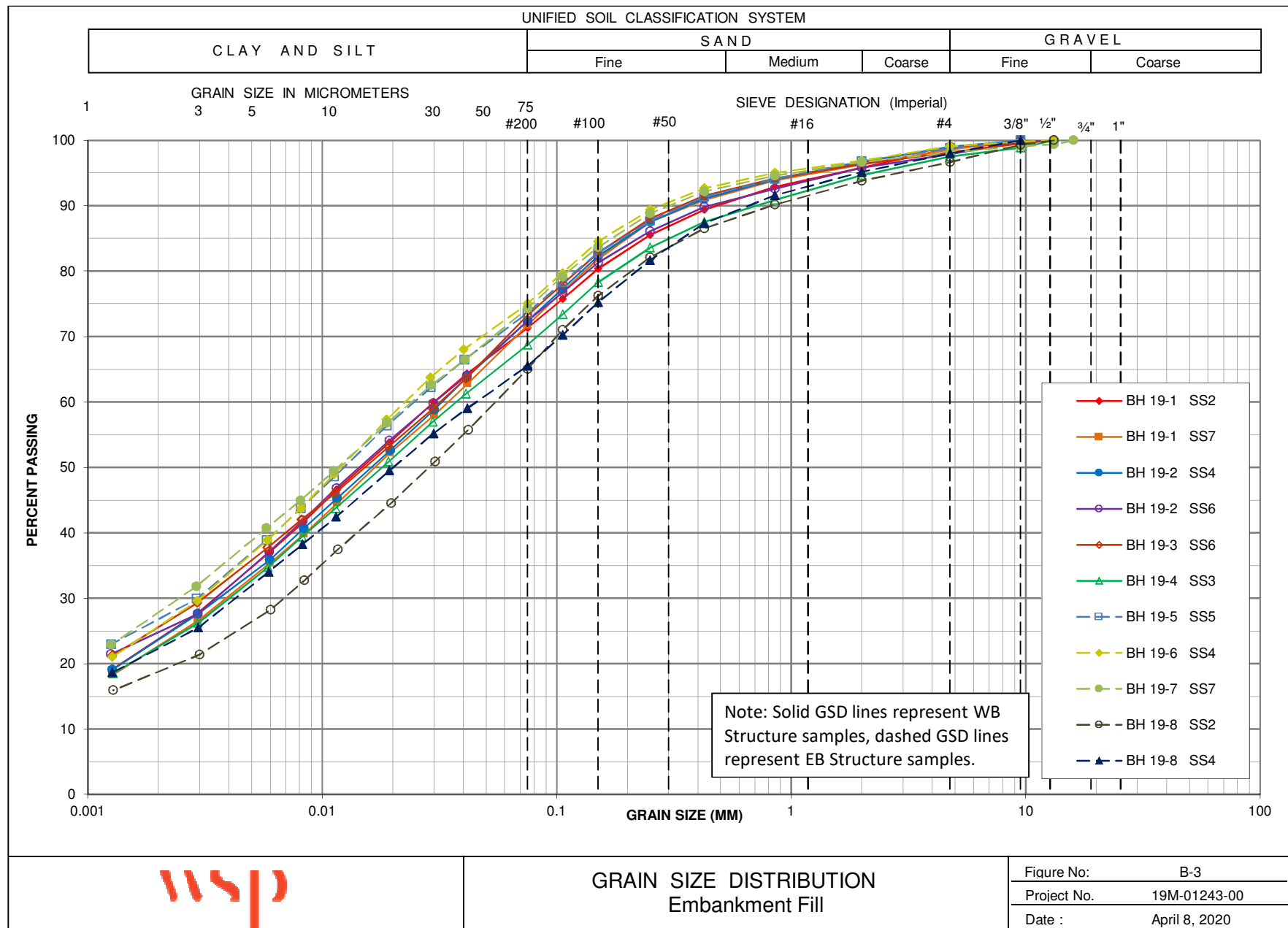
### LABORATORY TEST RESULTS

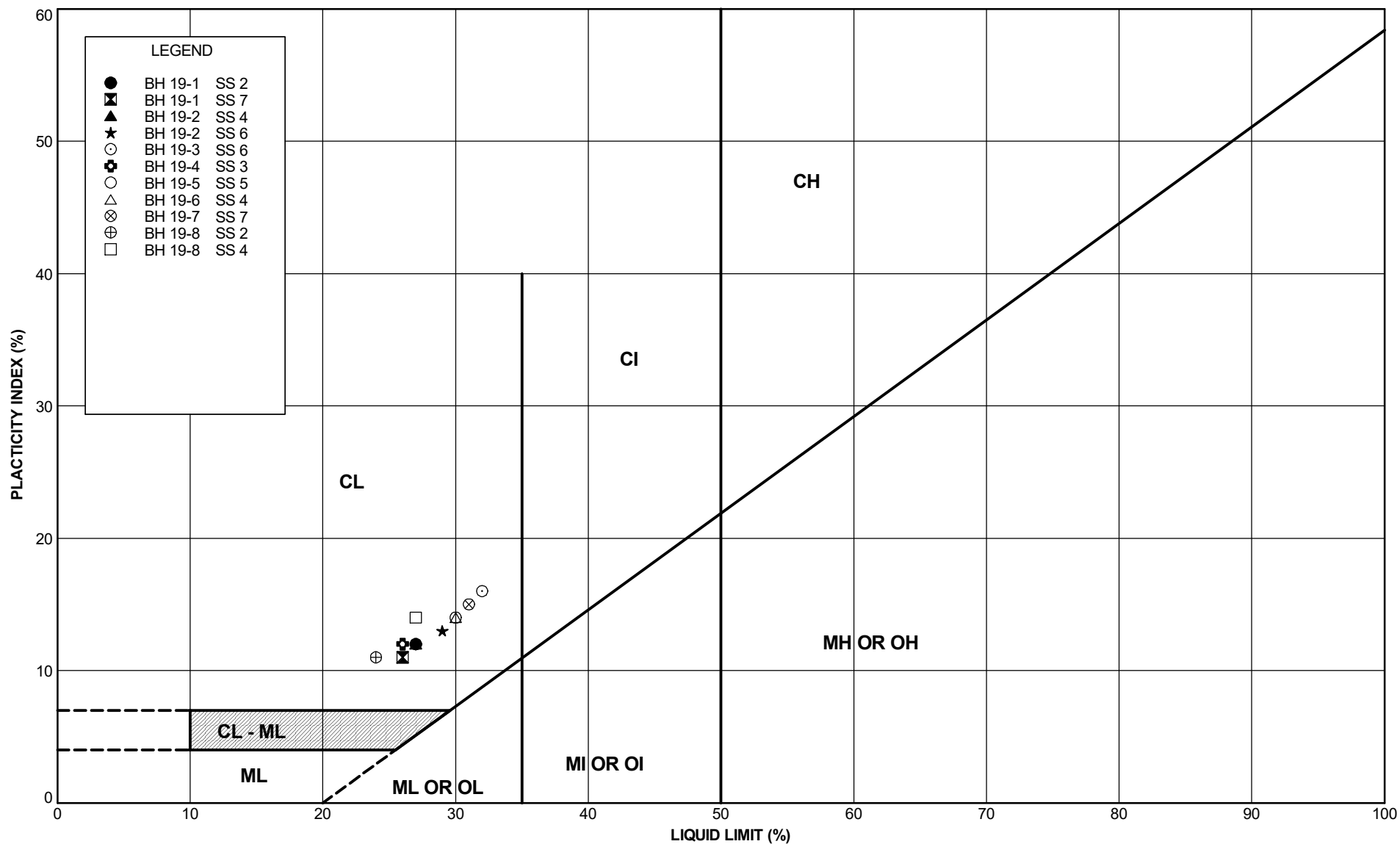


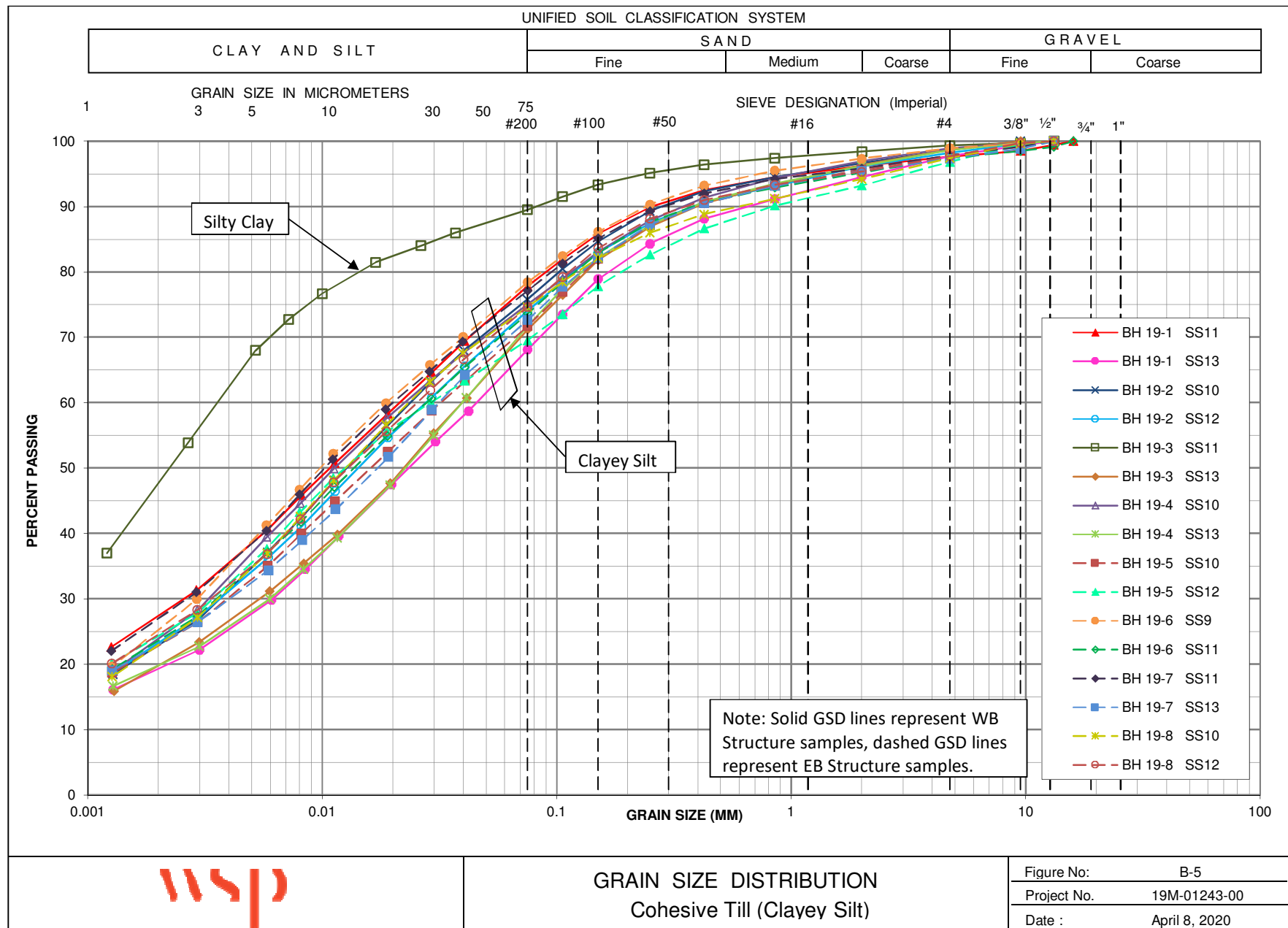


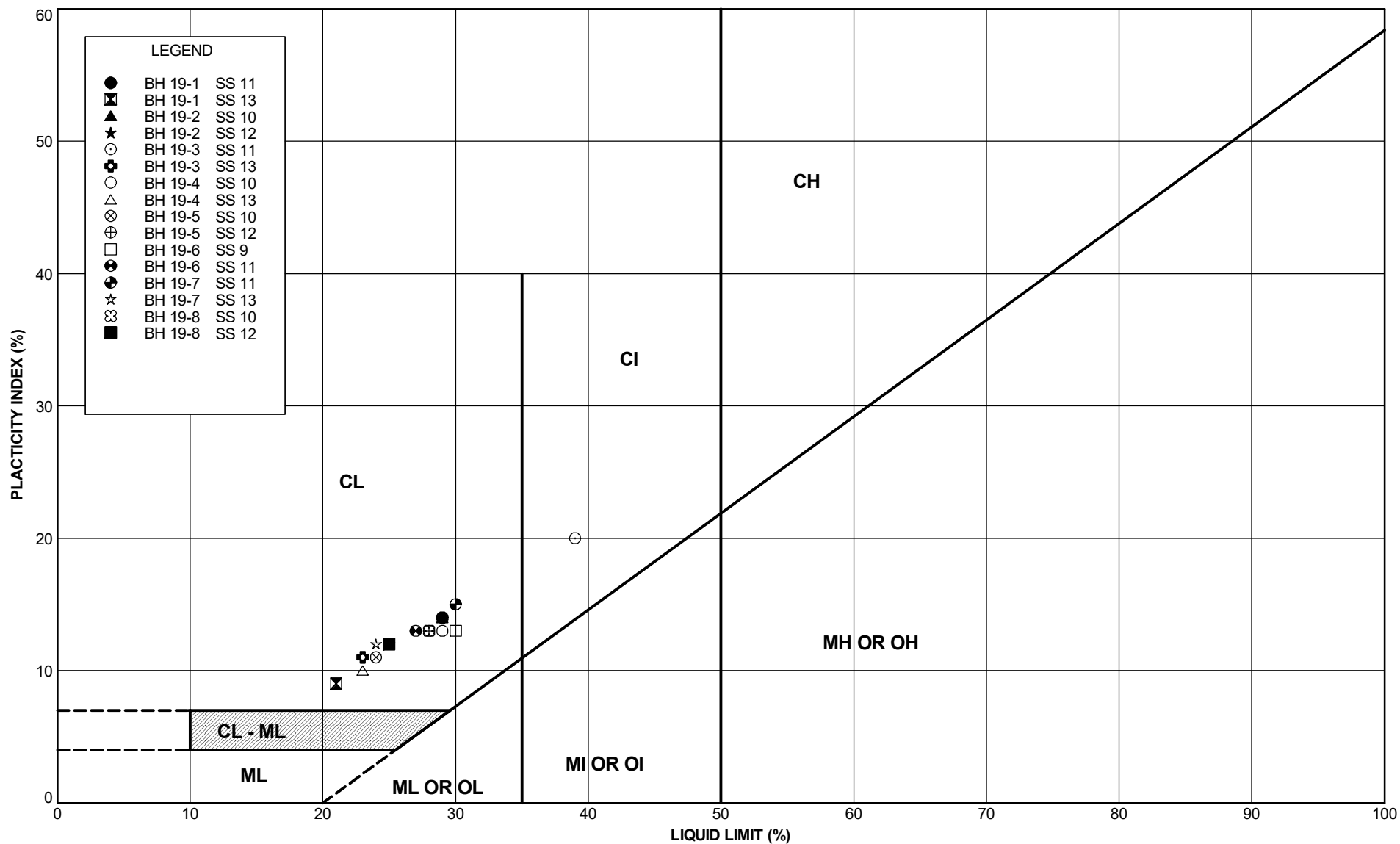












# APPENDIX

C

SITE PHOTOGRAPHS



# **Project: Proposed Rehabilitation of Dufferin Street Overpass Hwy 401EB/WB Express**

**GWP: 2089-13-00 & 2088-16-00**

**Assignment No. 2018 – E – 0057**

## **SITE VISIT PHOTOGRAPHS**

**C1: Site Reconnaissance Photographs**

**C2: Field Investigation Photographs**



Photo C1-1 Looking towards West at Dufferin Street Overpass Highway 401 Express (November 2019)

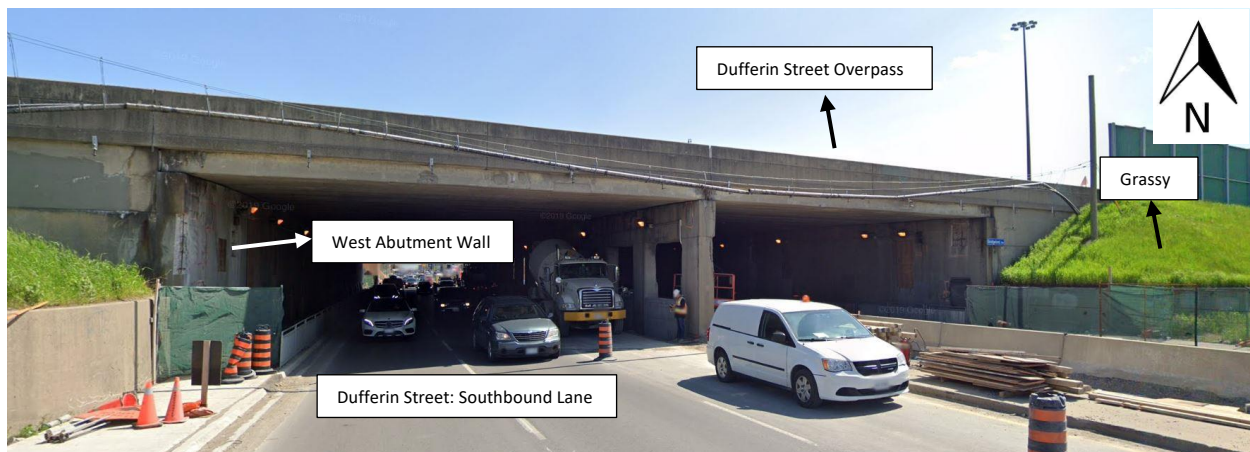


Photo C1-2 Looking towards North: Dufferin Street Overpass (November 2019)



Photo C1-3 Looking towards South: Dufferin Street Overpass (November 2019)



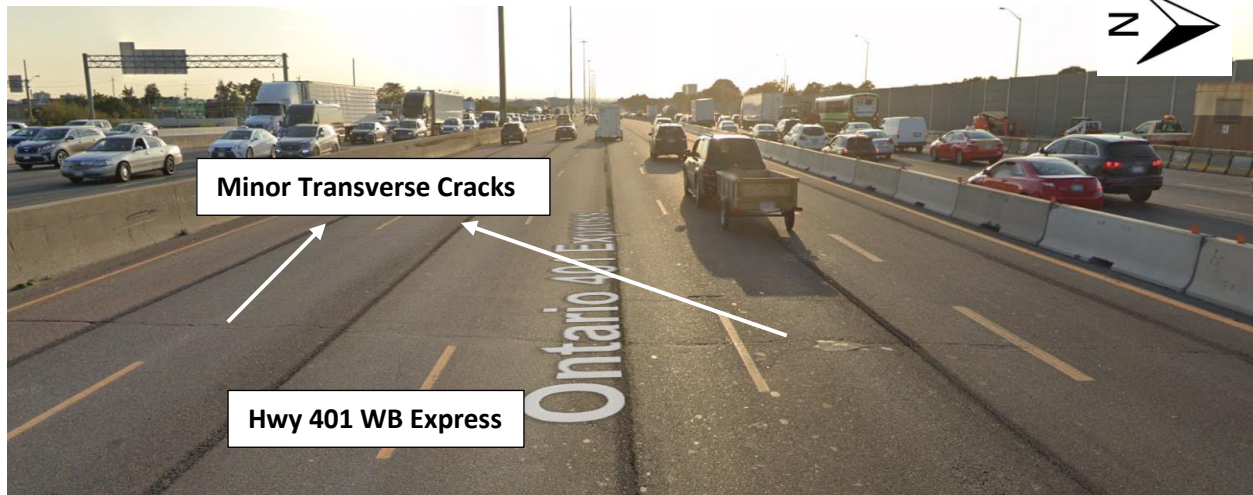


Photo C1-4 Looking towards West : Dufferin Street Overpass (November 2019)



Photo C2-1: Looking towards West at Dufferin street Overpass on Highway 401 WB Express. – Traffic Control Set-up (November 2019)

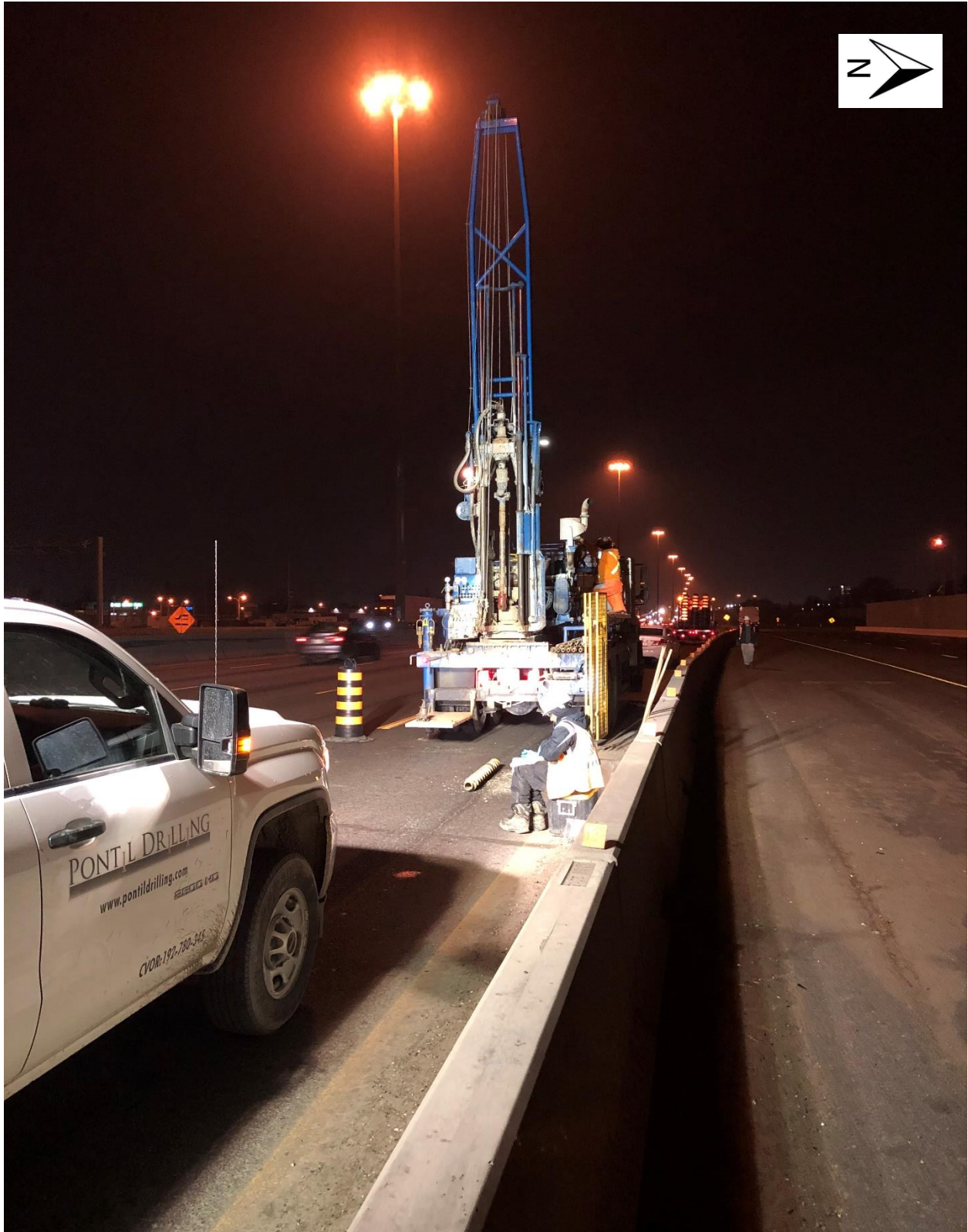


Photo C2-2: Looking towards West at Dufferin street Overpass on Highway 401 WB Express. – Traffic Control Set-up (November 2019)

Foundation Investigation Report  
Proposed Rehabilitation of Dufferin Street Overpass Hwy 401EB/WB Express, Toronto, Ontario.  
WSP Project No. 19M-01243-00



# FOUNDATION DESIGN REPORT

## PROPOSED REHABILITATION OF DUFFERIN STREET OVERPASS HWY 401 EB & WB EXPRESS, TORONTO, ONTARIO

MINISTRY OF TRANSPORTATION ONTARIO

Site Location: (Long. -79.457898°, Lat. 43.728059°)

GWP 2089-13-00 & 2088-16-060

GEOCRES NO. 30M11-300

WSP PROJECT NO.: 19M-01243-00

SEPTEMBER 18, 2020

WSP CANADA INC.  
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FIGURE 1	VARIATION OF SPT BLOW COUNT 'N' & MOISTURE CONTENT WITH DEPTH
FIGURE 2	VARIATION OF UNDRAINED SHEAR STRENGTH & MOISTURE CONTENT WITH DEPTH

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## *APPENDICES*

APPENDIX D	SEISMIC HAZARD CALCULATIONS
APPENDIX E	GLOBAL SLOPE STABILITY
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APPENDIX G	LIMITATIONS OF REPORT

## 5 DISCUSSION AND RECOMMENDATIONS

---

### 5.1 GENERAL

Under Assignment No: 2018-E-0057, foundation services are required for the rehabilitation of the Highway 401 EB and WB express bridge structures over Dufferin Street in the MTO Central Region. These bridge structures will be referred to as EB and WB structures. As part of this assignment it is proposed to carry out superstructure replacement in stages and for semi-integral abutment conversion. It is understood that any additional load increase, if any, on the structure foundations would have been assessed by others so as not to require any assessment of the existing foundations and therefore has not been required under the foundation scope.

This section of the report provides foundation recommendations for temporary roadway protection systems along the locations shown on Drawings 1 and 2 of both EB and WB core lanes. The discussions and recommendations presented in this report are intended to assist the structural designers with sufficient information that would serve as input to design the above bridge rehabilitation.

Construction comments made herein are based on geotechnical considerations only and should not be relied upon without further independent assessment and qualification to formulate means and methods for construction.

According to the scope mentioned in the RFP, it is to be noted that under this assignment, no foundation boreholes were undertaken at any existing structures.

The existing EB and WB structures are each two-span conventional bridges; each span is 15.0 m long. EB structure accommodates four lanes of traffic, WB structure accommodates five lanes of traffic. The bridges were originally constructed in 1966, and the structures were last rehabilitated in 2017.

In what follows, the Canadian Highway Bridge Design Code (CHBDC, 2014: CSA S6-14) will be referred to as S6-14, the Commentary on CSA S6-14, Canadian Highway Bridge Design Code will be referred to as the “Commentary”.

---

### 5.2 GEOTECHNICAL CHARACTERIZATION

#### 5.2.1 OVERVIEW OF SUBSURFACE CONDITIONS

In general terms, the stratigraphic sequence encountered can be described as pavement structure overlying embankment fill material and underlain by a glacial till deposit.

The pavement structure comprised of 203 mm to 380 mm thick asphalt and 610 mm thick concrete over 0.5 m to 2.0 m thick predominantly cohesionless pavement fill.

Below the pavement structure, the embankment fill comprised predominantly clayey silt material and ranges in thickness from 2.5 m to 7.2 m, with a shallower thickness on the EB cores. The embankment fill is indicative of a firm to very stiff consistency (WB: SPT ‘N’ ranging from 4 to 20 (28 ‘N’ values; avg. ‘N’ of 13); EB: SPT ‘N’ ranging from 6 to 19 (20 ‘N’ values; avg. ‘N’ of 13); moist to wet as per moisture content values ranging from 11% to 32%.

The underlying glacial till deposit was predominantly clayey silt, the explored thicknesses ranging in thickness from 5.2 to 8.4 m. This deposit can be typically described as stiff to very stiff in consistency (WB: SPT ‘N’ ranging from 16 to 35 (19 ‘N’ values; avg. ‘N’ of 26); EB: SPT ‘N’ ranging from 7 to 44 (24 ‘N’ values; avg. ‘N’ of 22); and moist as per moisture content values ranging from 10% to 27%.

The findings of the current WSP investigation are generally in line with the four borehole details from a previous investigation also shown on 1 and 2. However, it is to be noted that these previous borehole locations as shown on the plan views of Drawings 1 and 2 are farther from the subject bridge abutments.

Figure 1 (see at the end of the text) shows the SPT 'N' profiles of the embankment fill material and the native glacial till at the project site. Based on the figure and the discussion above, there is no significant difference between the WB subsoils and the EB subsoils. Hence, a common geotechnical model is used to address the temporary roadway protection issues. Sand seams as intercepted within the embankment fill in BH 19-8, could compromise matric suctions that hold the undrained shear strength in cohesive subsoils. Figure 2 shows increasing natural moisture with depth (weakening effect) within the embankment fill. This is reflected in the same figure by the generally decreasing strength values measured by the pocket penetrometer, however crude such measurement could be, but the general trend should not be ignored. This weakening effect would have been caused by capillary rise of groundwater into the embankment fill from the underlying glacial till over the years, being in contact with a very shallow groundwater table. The implications of these observations are discussed in Section 5.4.2.2.

Discussions with the WSP structural group has indicated for the purposes of semi-integral abutment conversion, based on the existing abutment bridge drawings, excavation depths not exceeding 2.0 m would be adequate to address the bearing conversions.

Stable groundwater readings ranging from 6.0 to 7.4 m below road grade were observed in the installed monitoring wells, and therefore would be much below the excavation depths. The possibility of localized perched water within the pavement fills cannot be ruled out and will be addressed in Section 5.4.1.

## 5.2.2 GROUND MOTION PARAMETERS

Based on the borehole information and our review of the general subsurface conditions in the area (see Fig.1), the subject site for the proposed structures can be classified as 'Class D' for seismic site response, based on recorded SPT 'N' values within the deposits, according to Table 4.1 of CSA S6-14.

The Peak Ground Acceleration (PGA) for North York, Toronto Metropolitan Region, Ontario for 2% / 50-year return probability based on the National Building Code of Canada (NBCC2015) is 0.133g and  $S_a(0.2)$  is 0.208g, as provided in the calculation shown in Appendix D. The site adjusted amplification factor  $F(PGA)$  based on S6-14, Table 4.8 for seismic site class D is 1.29. These in turn yield, PGA (Site Adjusted) as equal to 0.172g.

## 5.2.3 FROST CONSIDERATIONS

The frost depth for the project site is about 1.2 m based on the MTO Foundation Frost Penetration Depths for Southern Ontario, **OPSD 3090.101**.

The surficial deposit generally within the frost depth comprises cohesionless pavement fill and embankment fill consisting of predominantly clayey silt of low plasticity. These deposits can be assigned a frost susceptibility of Low to Moderate based on the grain size information as per the MTO Frost Classification Table.

## 5.2.4 CONSEQUENCE AND SITE UNDERSTANDING CLASSIFICATION

Based on the level of foundation investigations completed at the existing subject bridge structure locations in comparison to the degree of site understanding outlined in Section 6.5 of S6-14, a "Typical Degree of Site and Prediction Model Understanding" is considered appropriate for the foundation design issues associated with the proposed bridge super-structure rehabilitation.

For the above-mentioned degree of site understanding, the value for the corresponding consequence factor,  $\Psi$  is equal to 1.0, from Table 6.1 of S6-14. Since our analysis is limited to the global stability corresponding to temporary roadway protection system, the geotechnical resistance factor,  $\phi_{gu}$  is equal to 0.75 (Embankments (Fill) – Global Stability – Temporary Condition) from Table 6.2 of the S6-14.

---

# 5.3 ABUTMENTS – LATERAL EARTH PRESSURES

## 5.3.1 GENERAL

Backfill is regarded as an integral and important part of the semi-integral bridge concept. Superstructure and backfill at abutments

of semi-integral bridges form a partially composite interactive action. While rigid abutments provide vertical support for the superstructure and lateral support for the backfill, the backfill at the superstructure level of these bridges provide longitudinal support for the superstructure and vertical support for approach slabs. It is acknowledged that in a semi-integral conversion of an existing bridge, the depth of excavation to install the bearings may be well short of the full abutment height and thus may not be practically feasible to ensure all preferred backfill construction requirements full depth. This is especially the case when the bridge girder depths are not very deep as in the case of a short span bridge, as in the present situation.

### 5.3.2 LATERAL EARTH PRESSURE

Backfill behind structures and retaining walls should consist of non-frost susceptible, free-draining granular materials in accordance with **OPSD 3101.150**. Free-draining backfill (Granular 'A' or Granular 'B' Type I or Type II, with less than 5% fines, i.e. 200 sieve). The provision of drain pipes and weep holes should prevent hydrostatic pressure build-up. Computation of earth pressures should be in accordance with S6-14. For design purposes, the following unfactored static earth pressure parameters can be used (assuming wall friction is neglected, the back wall is vertical, and the ground surface is horizontal in front of the toe):

**Table 5 - 1 Unfactored Static Earth Pressure Coefficients**

Wall Movement Condition	Compacted Granular 'A' and Granular 'B' Type II Angle of Internal Friction, $\phi = 35^\circ$ Unit Weight = 22 kN/m <sup>3</sup> (Wall friction neglected)		Compacted Granular 'B' Type I Angle of Internal Friction, $\phi = 32^\circ$ Unit Weight = 21 kN/m <sup>3</sup> (Wall friction neglected)	
	Top Ground Surface Angle		Top Ground Surface Angle	
	Horizontal	2H:1V	Horizontal	2H:1V
<b>Active Earth Pressure (<math>K_A</math>)</b>	0.27	0.38	0.31	0.46
<b>At-Rest Earth Pressure (<math>K_0</math>)</b>	0.43	0.62	0.47	0.68
<b>Passive Earth Pressure (<math>K_P</math>)</b>	3.69	-	3.25	-

S6-14 Commentary Fig. C6.16 and Table C6.6 should be consulted to assess the minimum movements required before the adoption of active lateral pressures and if movements are found to be inadequate due to the restraints imposed by the superstructure and sub-structure elements, then at-rest earth pressures should be considered for design. Passive earth pressures within the frost depth in front of the walls should be disregarded. In accordance with S6-14 Section 6.12.5, a minimum live surcharge of 16 kPa should be considered in the design and other surcharge loadings, if relevant, should also be accounted for in the design.

### 5.3.3 BACKFILL AND DRAINAGE BEHIND ABUTMENTS

Positive drainage of the granular backfill should be provided with transverse drains and weep holes whilst **OPSD 3101.150** and **OPSD 3121.150** requirements should be met with respect to backfill, sub-drains and frost taper. Selection of compaction equipment should be compliant with **OPSS 501**. Minimum backfill placement requirements should conform to S5-14 Commentary, Figure C6.20.

Backfill and frost taper to the abutments should consist of Granular A or Granular B and placement should be in accordance with **OPSS 902**. Drainage should be provided as per **OPSD 3102.100**.

As superstructures of semi-integral bridges are restrained in place longitudinally by backfill at both abutments, and to some extent by the shearing resistance of elastomeric bearings, placement of the backfill should be controlled to avoid unbalanced backfill



pressures. Failures of such practices could lead to unbalanced pressures on the fixed pier as in this project, i.e. a two-span bridge situation. Therefore, compaction at opposite abutments should follow OPSS 902.07.06.01 regarding maximum level difference for compaction.

---

## 5.4 CONSTRUCTION CONSIDERATIONS

The ground conditions observed at this site are considered to be fairly uniform as seen in Fig. 1. The following sections discuss the construction considerations for the temporary protection systems for the proposed structure rehabilitation.

### 5.4.1 CONSTRUCTION DEWATERING

No groundwater issues are anticipated as the excavation will be within the embankment fill well above the measured groundwater level. However, perched water and resulting seepage/inflows can be expected at isolated locations at the project site. In such situations, properly located and filtered sump pumps within the excavation could be used to control the inflows. Any such ingress should be discharged as per OPSS.PROV 517 – Construction Specifications for Dewatering.

### 5.4.2 TEMPORARY EXCAVATION SUPPORT

#### 5.4.2.1 General

As per the RFP, to enable the proposed bridge rehabilitation, the locations of the required temporary roadway protection have been identified by WSP Structures and are shown on Drawings 1 and 2. It is assumed that any temporary roadway protection system should be designed to not require any additional lane closures on the retained side of the excavations. Temporary excavation support in the form of either steel sheet pile wall systems or soldier piles with timber lagging are considered appropriate given the shallow temporary excavations about 2.0 m depth that are required from a geotechnical perspective.

There could be possible obstructions within the embankment material (usually cobbles, boulders or other debris) and cobbles and boulders within the glacial till which need to be considered when planning the means and methods of the shoring installations and open-cut excavations. An **NSSP** should be included in the contract to ‘red flag’ the precautions to be undertaken to mitigate obstructions to excavatability and installation of shoring. The suggested wordings are included for reference in **Appendix F**.

#### 5.4.2.2 Global stability

Short-term global stability analysis was performed using Rocscience SLIDE software. First, undrained stability within the embankment fill was assumed due to the cohesive nature of the embankment fill. Property parameters in Table 5-3 (See Section 5.4.2.3) were adopted except undrained shear strengths of 50 kPa and 100 kPa were assigned to the cohesive fill and the native till respectively. This analysis gave a factor of safety in excess of 1.5 (See Figures E.1 and E.3 in **Appendix E**). To ensure that global stability will not be impacted significantly due to possible sand seams (as discussed in Section 5.2.1), a drained global stability was undertaken with the parameters given in Table 5-3. This drained analysis too gave a factor of safety greater than 1.5 with a design water table at a depth of 6.0 m below road grade. Both analyses simulated a surcharge traffic loading of 16 kPa as per the S6-14 requirements. Hence short-term global stability meets the requirements of Table 6.2 of S6-14.

Given the wide width of the Hwy 401 cores (several lanes wide) at the Dufferin Underpass, as shown on Drawings 1 and 2, shored excavations in the middle of the expressway in each direction will take place between two adjacent temporary shoring support lines. In such situations, excavation bottom heave (basal heave) stability is appropriate to be checked. This is especially relevant given the increasing natural moisture with depth (a weakening effect) and associated decreasing shear strength trend with depth as shown in Fig. 2 and discussed in Section 5.2.1. Given the relative width of the excavations compared to the depth of the excavations, bottom heave stability was checked with the Terzaghi model for bottom heave. It was found to have adequate resistance against bottom heave with a factor of safety in excess of 1.5 for a basal undrained shear strength of 50 kPa.

#### 5.4.2.3 Open-Cut Excavation Stability

All excavations should be carried out in accordance with the Province’s Occupational Health and Safety Act (OHSA), O. Reg. 213/91, as well as **OPSS.PROV 539** Construction Specification for Temporary Protection Systems.

In accordance with the Province's Safety Regulations, the following soil classifications would be applicable for open-cut. However, based on site specific ground conditions and engineering judgement, OHSA classifications have been qualified and adopted to err on the side of safety.

**Table 5 - 2 Interpreted OHSA Requirements for Open-Cut Excavations**

Material/Deposit	Groundwater	OHSA Classification/Recommendation	Remarks
Pavement Fill – gravelly sand / sand and gravel / sand	Non-perched groundwater	Type 3	
	Perched wet soil	Not steeper than 1V:2H	
Embankment Fill – clayey silt Glacial Till – clayey silt/silty clay	No visible seepage cut face	Type 3	
	Seepage on cut face	Not steeper than 1V:1.5H	
Glacial Till – clayey silt/silty clay		Type 3	

These temporary excavation slopes for the above soil types as per OHSA are to be used only as guidelines for temporary excavation slopes for a short duration. We also recommend that these slopes be visually monitored for any movement especially if workers are present at the toe of the slopes.

Excavations should be possible in the above soil types using equipment such as a hydraulic excavator.

#### 5.4.2.4 Temporary Shoring Recommendations

The shoring system should be designed so that the lateral movement of the portion of the 'roadway protection system' will not exceed the established criterion for the structure performance level. In this case, the required Performance Level is considered to be 2 (OPSS.PROV 539). The shoring design should be carried out by a Professional Engineer, experienced in this type of work and the design will be the sole responsibility of the shoring designer.

Geotechnical parameters (unfactored) for temporary shoring support are as follows:

**Table 5 - 3 Geotechnical Design Parameters (Unfactored) – Temporary Shoring**

Material	$D_r^{**}$ (typical)	Unit weight $\gamma$ , (kN/m <sup>3</sup> )	Effective Shear Strength Parameters		Earth Pressure Parameters		
			$c'$ (kPa)	$\Phi'$ (deg)	$K_a$	$K_p$	$K_o$
Pavement Fill – gravelly sand / sand and gravel / sand	Compact	21	0	31	0.32	3.12	0.48
Embankment Fill – clayey silt	Stiff	20	0	30	0.33	3.00	0.50
Glacial Till – clayey silt/silty clay	Very Stiff	21	0	32	0.31	3.25	0.47

\*  $c'$  – Effective cohesion;  $\Phi'$  – Effective friction angle;

$K_a$  – Active Earth Pressure Coefficient;  $K_p$  – Passive Earth Pressure Coefficient;  $K_o$  – At-Rest Earth Pressure Coefficient;  $D_r^{**}$  – Relative Density / Consistency

Notes:

1- A factor of safety of 2 shall be applied for computing passive resistance to lateral loads. During freezing ground conditions, passive resistance within the frost depth should be ignored

2- Adequate allowance should be made for surcharge loads; In accordance with S6-14 Section 6.12.5, a minimum live surcharge of 16 kPa should be considered in the design and other surcharge loadings, if relevant, should also be accounted for in the design.

3- Earth pressure coefficients given in the table are for horizontal backfill and level surface in front (toe area). Any departures from this should be taken into account. Passive earth pressures within the frost depth in soil should be disregarded except in the summer season but the weight of the overburden taken into account.

4- Elevation 189.0 m can be assumed as the design groundwater level.

5- Within the anticipated excavation depths, no groundwater issues are relevant.

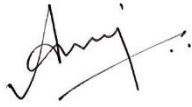
Due to possible perched water effects as discussed and resulting potential erosion of cohesionless pavement fines, mitigation measures should be adopted by the shoring contractor to prevent the loss of fines from the retained sides so as not to impact operational traffic on the Highway.

### 5.4.3 BACKFILLING OF EXCAVATIONS

Specific requirements for backfilling behind abutments are discussed in Section 5.3.3. All temporary roadway protection excavation needs to be backfilled and returned to pre-construction grades with sound construction materials, similar or better than the excavated material and engineered to meet pavement requirements. Any material shortfall should be met with approved materials and backfilling must conform to OPSS 902, **OPSS 501** and site restoration to **OPSS 492**.

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# SIGNATURES



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Geotechnical EIT



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Franklin Oliha, M.Sc., P.Eng.  
Geotechnical Engineer



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Vasantha Wijeyakulasuriya, M.Eng., P.Eng  
MTO Foundations Designated Contact



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## REFERENCES

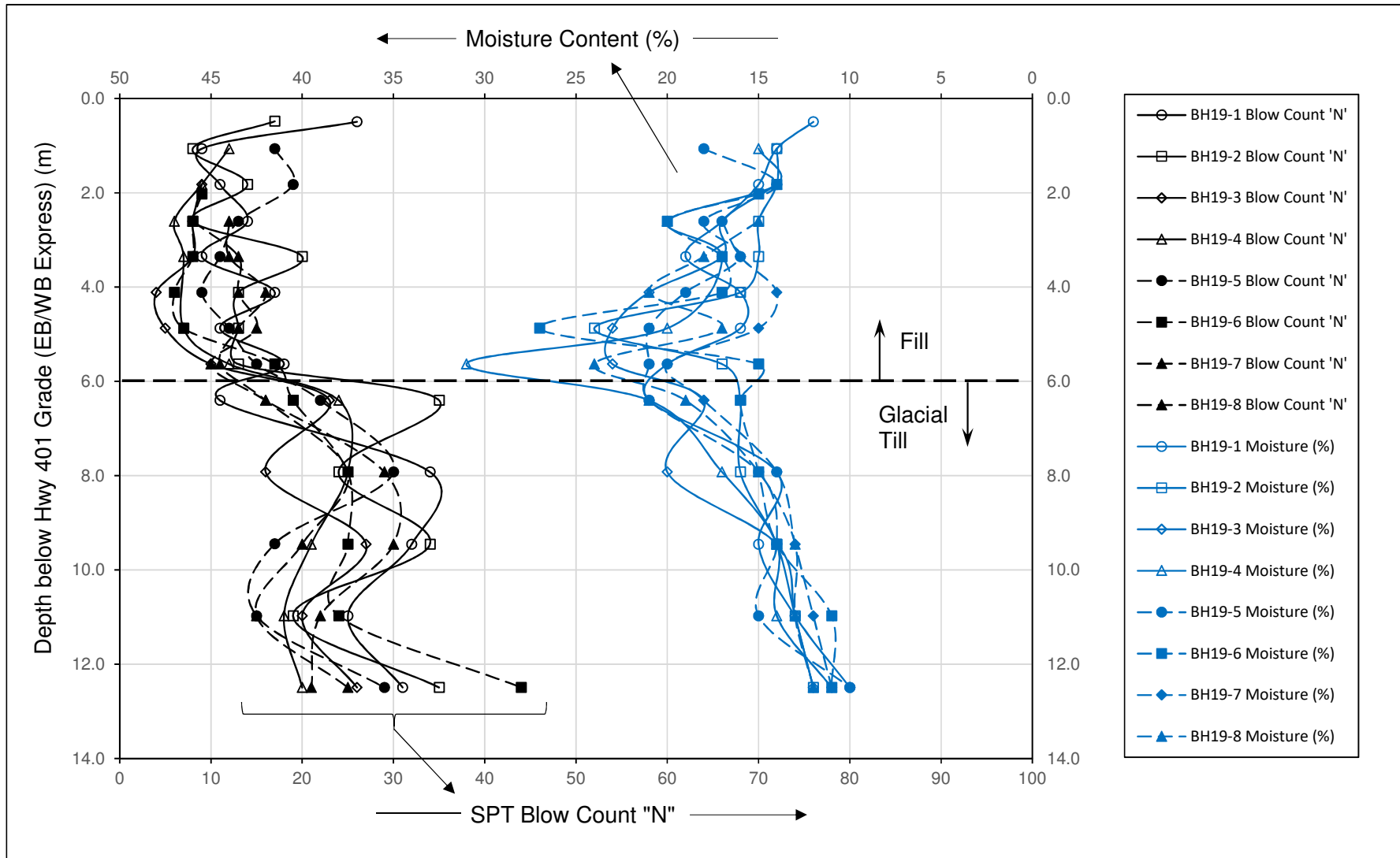
Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-14. 2014. CSA Special Publication, S6.1 14. Canadian Standard Association.

Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

M.T.O Soil Classification Manual, Ministry of Transportation, Ontario.

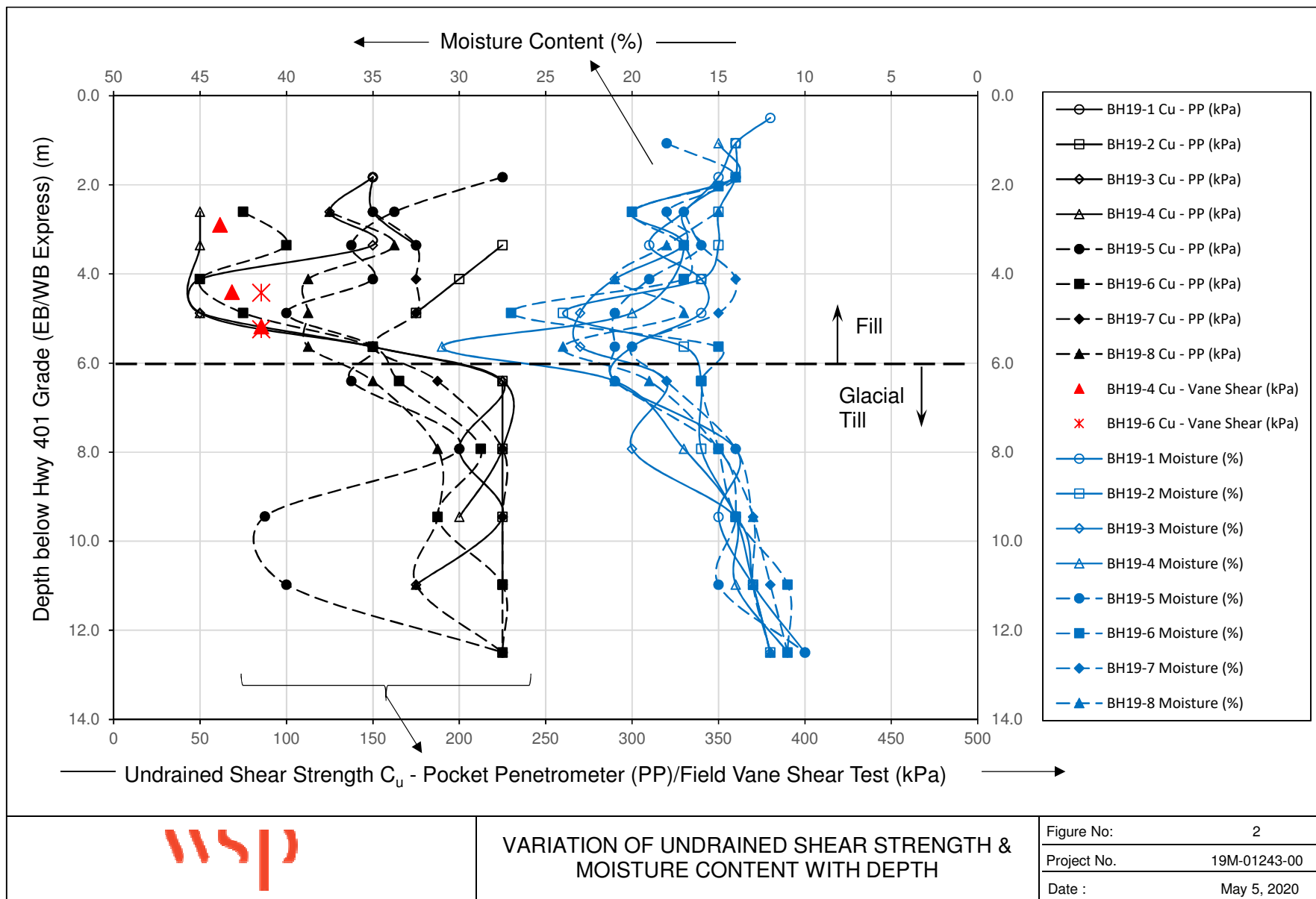
# FIGURES

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# VARIATION OF SPT BLOW COUNT 'N' & MOISTURE CONTENT WITH DEPTH

Figure No:	1
Project No.	19M-01243-00
Date :	May 5, 2020



# VARIATION OF UNDRAINED SHEAR STRENGTH & MOISTURE CONTENT WITH DEPTH

Figure No:	2
Project No.	19M-01243-00
Date :	May 5, 2020



# APPENDIX

## D

### SEISMIC HAZARD CALCULATIONS



# 2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836  
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 43.728N 79.458W

User File Reference: Toronto, ON

2020-09-17 19:31 UT

Requested by: Proposed Rehabilitation of Dufferin Street Overpass, Hwy 401 EB & WB Express, WSP Canada Inc.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.203	0.103	0.055	0.012
Sa (0.1)	0.248	0.132	0.074	0.018
Sa (0.2)	0.208	0.114	0.068	0.020
Sa (0.3)	0.158	0.089	0.055	0.018
Sa (0.5)	0.111	0.066	0.042	0.014
Sa (1.0)	0.058	0.036	0.023	0.007
Sa (2.0)	0.028	0.017	0.011	0.003
Sa (5.0)	0.007	0.004	0.002	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.133	0.071	0.040	0.010
PGV (m/s)	0.089	0.051	0.031	0.008

**Notes:** Spectral ( $S_a(T)$ , where  $T$  is the period in seconds) and peak ground acceleration (PGA) values are given in units of  $g$  ( $9.81 \text{ m/s}^2$ ). Peak ground velocity is given in  $\text{m/s}$ . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity  $450 \text{ m/s}$ ). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

## References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)  
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites [www.EarthquakesCanada.ca](http://www.EarthquakesCanada.ca) and [www.nationalcodes.ca](http://www.nationalcodes.ca) for more information



Natural Resources  
Canada

Ressources naturelles  
Canada

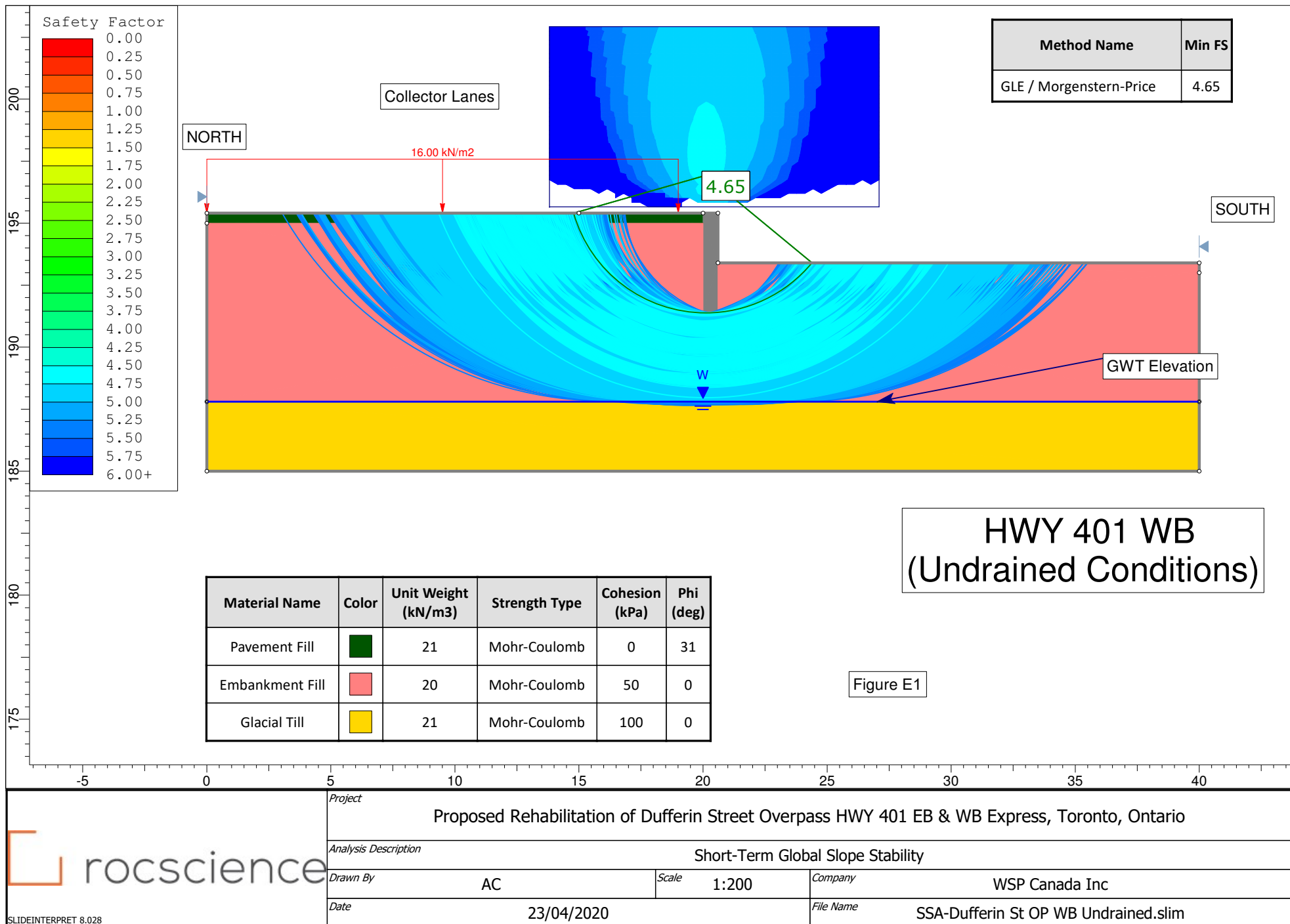
Canada

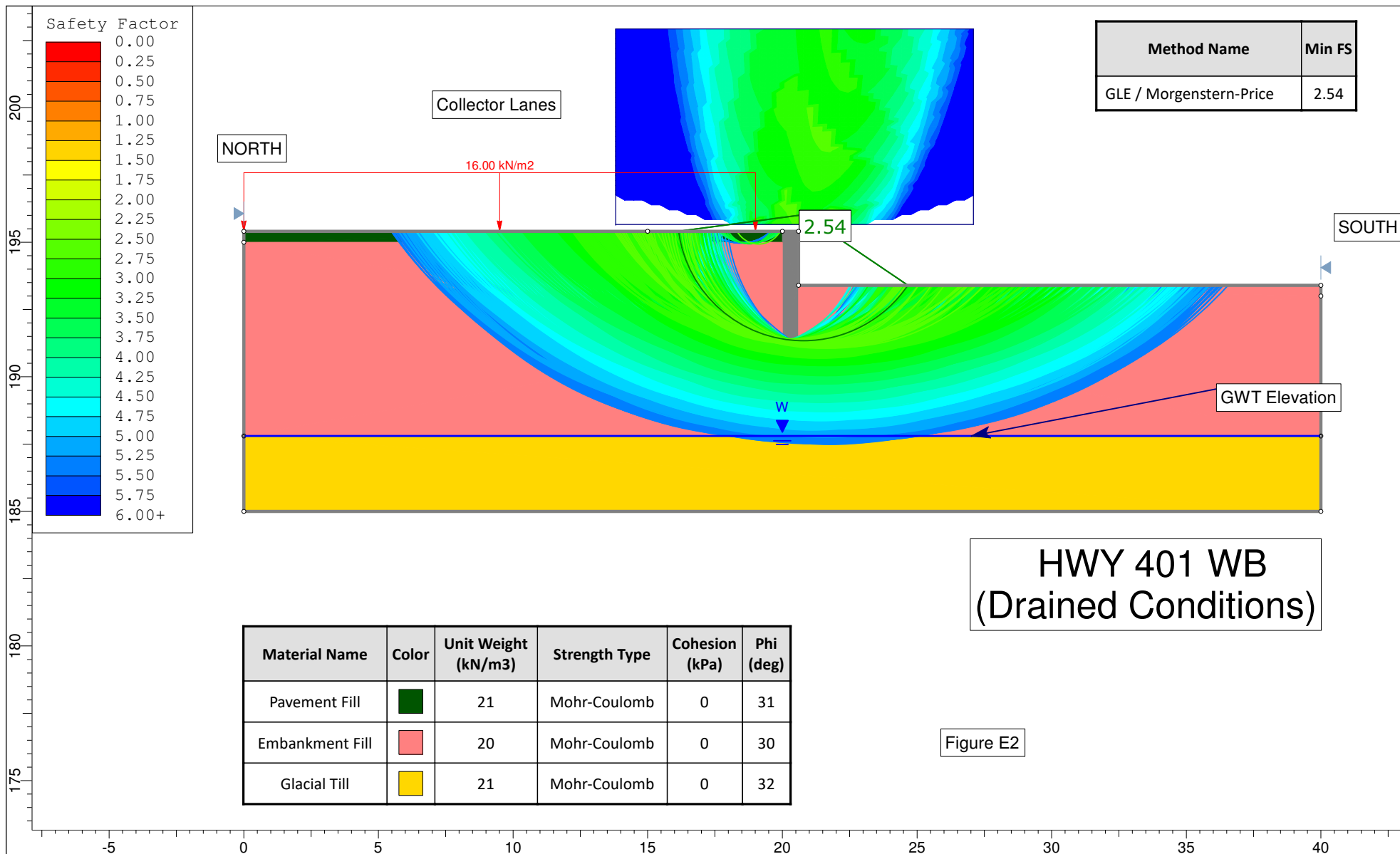
# APPENDIX


# E

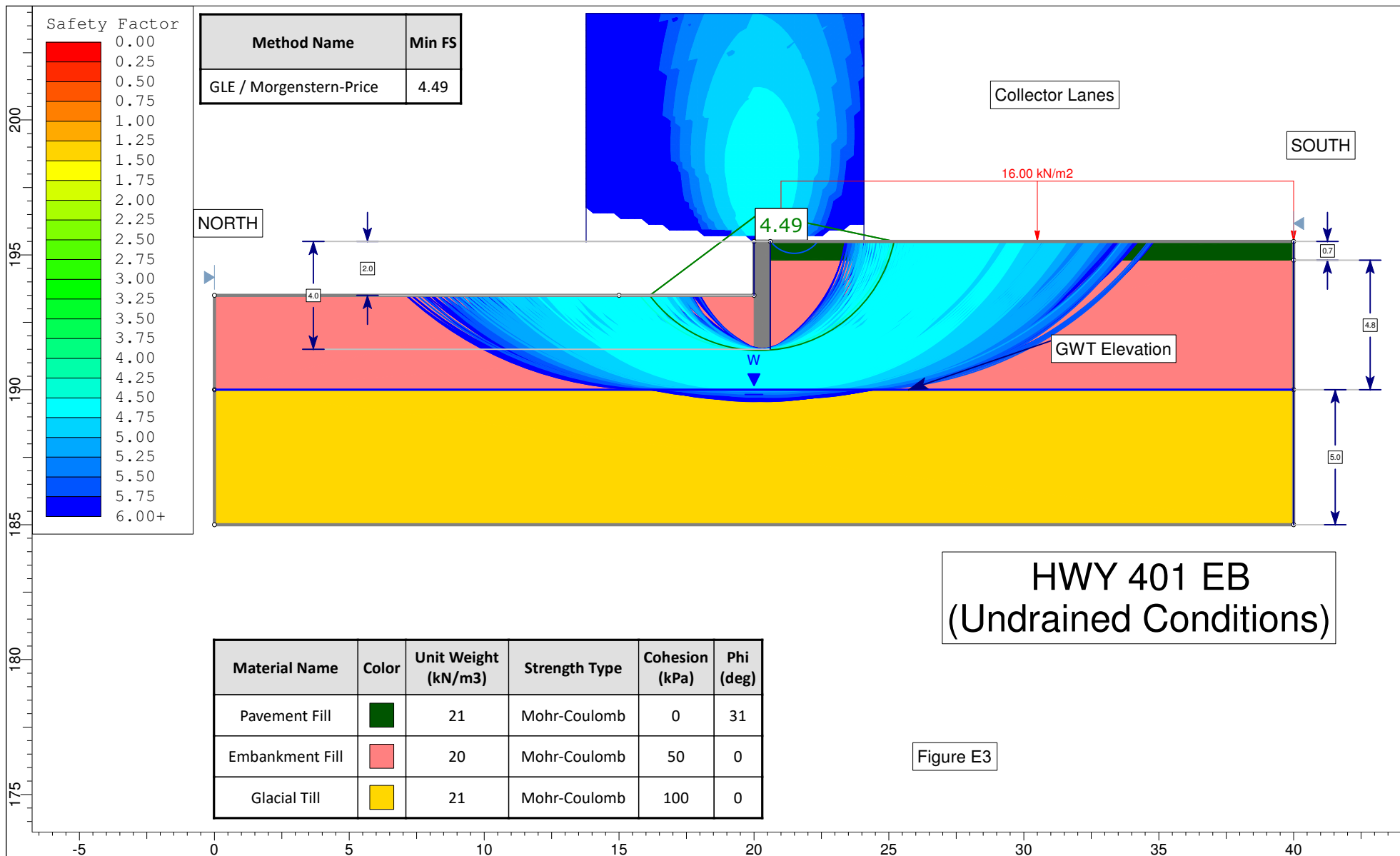
GLOBAL SLOPE STABILITY







 SLIDEINTERPRET 8.028	Project					
	Proposed Rehabilitation of Dufferin Street Overpass HWY 401 EB & WB Express, Toronto, Ontario					
	Analysis Description					
	Short-Term Global Slope Stability					
	Drawn By		AC	Scale	1:200	Company
Date		23/04/2020			File Name	SSA-Dufferin St OP WB Drained.slim



<div> <div></div> <div>rocscience</div> </div>	Project				
	Proposed Rehabilitation of Dufferin Street Overpass HWY 401 EB & WB Express, Toronto, Ontario				
	Analysis Description				
	Short-Term Global Slope Stability				
	Drawn By	AC	Scale	1:200	Company
					WSP Canada Inc
	Date	23/04/2020	File Name	SSA-Dufferin St OP EB Undrained.slim	

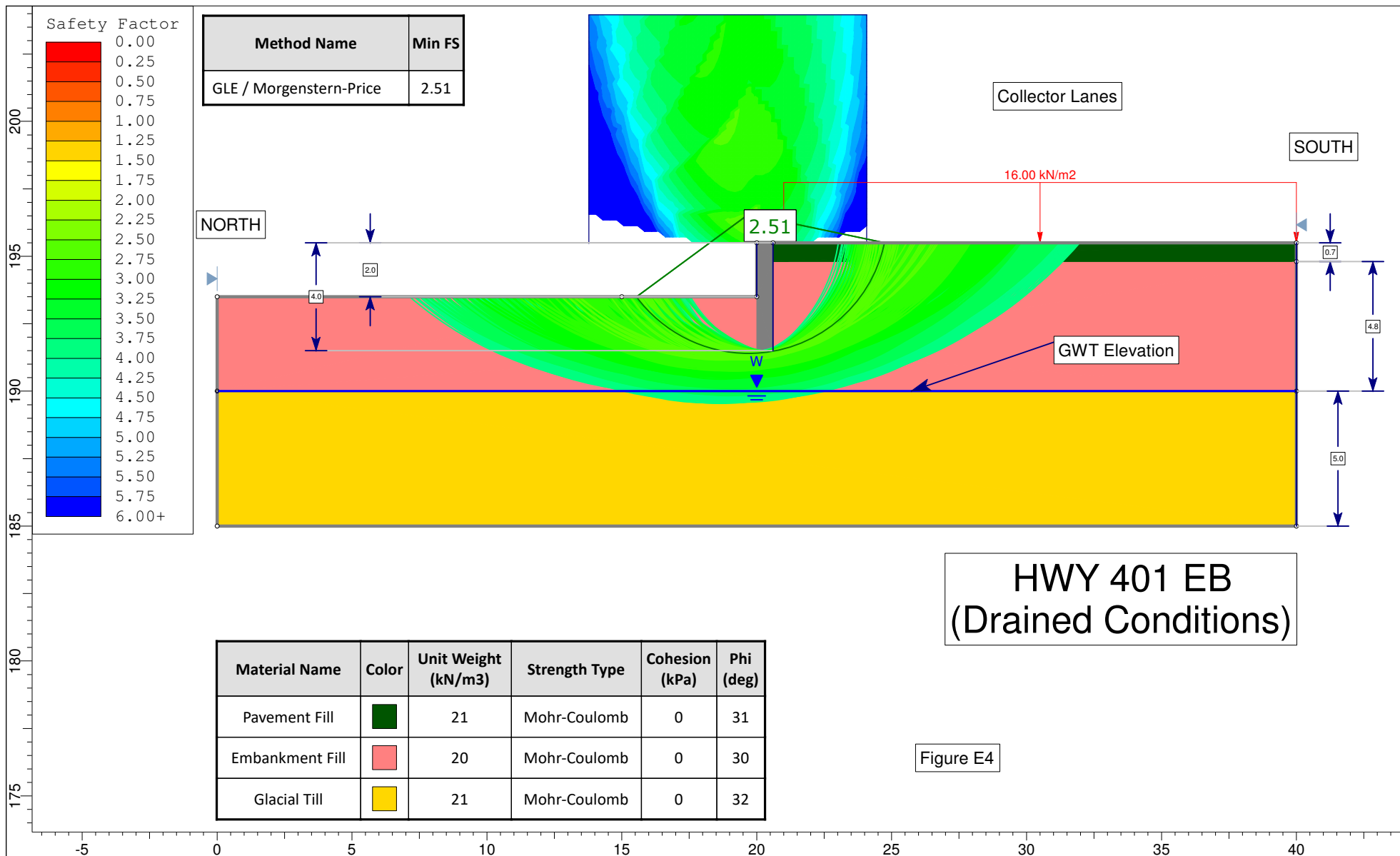



Figure E4

 SLIDEINTERPRET 8.028	Project					
	Proposed Rehabilitation of Dufferin Street Overpass HWY 401 EB & WB Express, Toronto, Ontario					
	Analysis Description					
	Short-Term Global Slope Stability					
	Drawn By		AC	Scale	1:200	Company
Date		23/04/2020			File Name	SSA-Dufferin St OP EB Drained.slim

# APPENDIX

## F

LIST OF OPSSs, OPSDs AND NSSPs REFERENCED  
IN THE REPORT





## List of OPSSs/OPSDs referenced in the Report

Document	No.	TITLE
OPSS	492	CONSTRUCTION SPECIFICATION FOR SITE RESTORATION FOLLOWING INSTALLATION OF PIPELINES, UTILITIES, AND ASSOCIATED STRUCTURES
OPSS	501	CONSTRUCTION SPECIFICATION FOR COMPACTING
OPSS.PROV	517	CONSTRUCTION SPECIFICATION FOR DEWATERING FOR EXCAVATION
OPSS.PROV	539	CONSTRUCTION SPECIFICATION FOR TEMPORARY PROTECTION SYSTEMS
OPSS	902	CONSTRUCTION SPECIFICATION FOR EXCAVATING AND BACKFILLING - STRUCTURES
OPSD	3090.101	FOUNDATION FROST DEPTHS FOR SOUTHERN ONTARIO
OPSD	3101.150	WALLS ABUTMENT, BACKFILL MINIMUM GRANULAR REQUIREMENT
OPSD	3102.100	WALLS ABUTMENT, BACKFILL DRAIN
OPSD	3121.150	WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
NSSP		OBSTRUCTIONS TO EXCAVATABILITY

## **OBSTRUCTIONS TO EXCAVATABILITY**

### **Non-Standard Special Provision**

The interception of debris, cobbles, boulders and hard layers is possible within embankment fill material and glacial till deposits. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for construction of temporary roadway protection system.

#### ***Basis of Payment:***

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

# APPENDIX

G

LIMITATIONS OF REPORT



## **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.