

Prepared By: Keli Shi, P.Eng.

Date: Wednesday, May 13, 2020

Reviewed By: Jason Lee, P.Eng.
P.K. Chatterji, P.Eng.

No. H427-7-FND-REP-002-G

Prepared For: Peter Bamforth, P.Eng.
Tatiana Ojala, P.Eng.

Subject: **Foundation Investigation and Design Report**
Highway 427 Expansion – Package 7 (100% Submission)
Hwy 427 NBL/SBL Overpass Structures at Street ‘A’ (Bridges 14A/14B)

TABLE OF CONTENTS

1.	INTRODUCTION.....	3
2.	SITE DESCRIPTION AND GEOLOGY BACKGROUND.....	3
3.	GEOTECHNICAL INVESTIGATION	3
4.	SUBSURFACE CONDITIONS	4
4.1	Topsoil.....	4
4.2	Surficial Silty Clay.....	4
4.3	Upper Cohesive Till	4
4.4	Silty Sand Till.....	4
4.5	Lower Clayey Silt Till	4
4.6	Shale Bedrock	5
4.7	Groundwater Levels	5
4.8	Corrosion and Sulphate Test Results	6
5.	PROJECT DESCRIPTION	6
6.	GEOTECHNICAL RECOMMENDATIONS.....	7
6.1	Foundation Design	7
6.1.1	Axial Pile Resistance.....	7
6.1.2	Lateral Pile Resistance.....	7
6.1.3	Downdrag.....	9
6.1.4	H-Pile Installation	9
6.1.5	Pile Tips.....	9
6.2	Frost Protection	10
6.3	Backfill to Abutments	10
6.4	Lateral Earth Pressure.....	10
6.5	Seismic Considerations	10
6.6	Approach Embankments and Reinforced Soil System (RSS)	11
6.6.1	General	11
6.6.2	Subgrade Preparation	12

6.6.3	Geotechnical Resistances.....	13
6.6.4	Predicted Settlement.....	13
6.6.5	Approach Embankment/Cut Stability.....	13
6.6.6	Approach Embankment Construction.....	13
6.7	Excavation and Dewatering.....	13
6.8	Corrosion and Sulphate Attack Potential.....	14
6.9	Construction Concerns.....	14

Statement of Limitations and Conditions

APPENDICES

Appendix A	Record of Borehole Sheets – Current Investigation
Appendix B	Laboratory Test Results – Current Investigation
Appendix C	Borehole Locations and Soil Strata Drawings
Appendix D	Previous Investigation (Geocres Report No.: 30M13-216)
Appendix E	Stability Analysis Plots
Appendix F	Sketch – Street A - Future Widening Bridge Clearances (For Information Only)



1. INTRODUCTION

This report provides foundation recommendations for the design and construction of the proposed overpass structures to carry northbound lanes (NBL) and southbound lanes (SBL) of Highway 427 over the future Street "A". This project is part of the assignment that involves 6.6 km long extension of Highway 427 from Highway 7 to Major Mackenzie Drive in the City of Vaughan, Ontario.

Recommendations on the foundation aspects of the bridge design presented in this report were based on the interpretation of the subsurface information obtained during the current geotechnical investigation by Thurber Engineering.

Reference has been made to available subsurface information from a previous investigation documented in the report titled "Preliminary Foundation Investigation and Design Report, Highway 427 Expansion – Extension Section, Highway 427 NBL and SBL Overpass at Street 'A', City of Vaughan, Ontario, Assignment No. 2014-E-0056, WO 2016-11005 – 18A", dated September 2016, prepared by Peto MacCallum Ltd. (Geocres 30M13-216).

The discussion and recommendations for design of the overpass structures presented in this report were based on the latest General Arrangement (GA) drawings H427-D-H-7-STR-B14A-DWG-500 and H427-D-H-7-STR-B14B-DWG-600.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION AND GEOLOGY BACKGROUND

The site is located approximately 0.9 km north of Langstaff Road and 1.2 km south of Rutherford Road, in the City of Vaughan, Ontario. Lands surrounding the site have been developed for agricultural uses. The site topography is relatively flat.

The site is situated within the physiographic region known as the Peel Plain (*The Physiography of Southern Ontario* by L. J. Chapman and D. F. Putnam, 1984). The subsurface conditions in the region generally comprise clayey silt to silty clay till (Halton Till) with interlayers of sand and silt till. Localized recent deposits of sands, silts and soft clays formed in small glacial meltwater ponds throughout the region may be encountered near the river and creek valleys. The site is underlain at depth by shale bedrock of the Georgian Bay Formation with siltstone and limestone interlayers.

3. GEOTECHNICAL INVESTIGATION

The current field investigation program for this project was conducted between May 26 and July 29, 2017 and consisted of drilling and sampling eight (8) boreholes, designated as Boreholes SA17-01 to SA17-08. The boreholes were advanced to depths ranging from 9.8 m to 29.4 m.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were surveyed by CJV and provided to Thurber. The Record of Borehole sheets are included in Appendix A and approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix C.

Track-mounted CME55 drill rigs supplied by Landshark Drilling Ltd. of Ontario, were used to advance the boreholes. Soil samples were obtained at selected intervals using a 50 mm nominal diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT) procedures as per ASTM D1586. Four boreholes were advanced to bedrock and the bedrock was confirmed by approximately 3 m coring using HQ-sized coring equipment. All rock cores were logged, and Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and Fracture Indices (FI) were determined.

Groundwater conditions were observed in open boreholes throughout the drilling operations and upon completion of drilling. Standpipe piezometers were installed in Boreholes SA17-03 to SA17-05. Boreholes without piezometers were decommissioned as per O. Reg. 903. The piezometers will be decommissioned in general accordance with Ontario Reg. 903 following the final water level readings.

4. SUBSURFACE CONDITIONS

Details of the encountered soil strata are presented on the Record of Borehole sheets included in Appendix A.

The subsurface information obtained from the previous investigation (Geocres Report 30M13-216) has been reviewed and used for the preparation of this report. The Record of Borehole sheets for Boreholes 427N-1, 427N-2, 427S-1 and 427S-2 and Borehole Location and Soil Strata Drawing from the Geocres report are included in Appendix D for reference.

In general, the soil stratigraphy at this site consists of a thin layer of surficial silty clay overlying stiff to hard silty clay to clayey silt till. Below a depth of 16 to 19 m, the cohesive till was interbedded with very dense sand and sandy silt to silty sand till. Occasional cobbles were noted in the till deposits. The shale bedrock was encountered in four boreholes between depths of 24.4 and 26.4 m (Elev. 164.8 to 163.2).

Detailed descriptions of individual strata encountered in the current investigation are presented below.

4.1 Topsoil

Topsoil was encountered in all boreholes. Topsoil thickness at borehole locations ranged from 100 to 275 mm. The thickness of the topsoil may vary across the site. An SPT-N value recorded in the topsoil in Borehole SA17-07 was 50 blows for 0.05 m of penetration likely indicating presence of cobbles.

4.2 Surficial Silty Clay

A surficial deposit of brown silty clay with trace to some sand and trace gravel was encountered beneath the topsoil in all boreholes. Trace organics (rootlets) were noted in the deposit. The base of the silty clay ranged from a depth of 0.5 m to 1.6 m (Elev. 189.0 to 187.4). The recorded SPT-N values varied from 2 to 14 blows per 0.3 m of penetration indicating a soft to stiff consistency.

4.3 Upper Cohesive Till

Brown to grey clayey silt to silty clay till was encountered in all boreholes underlying the surficial silty clay. The deposit contained trace to some sand, trace gravel and occasional cobbles. Boreholes SA17-01, SA17-02, SA17-07 and SA-08 were all terminated at a depth of 9.8 m in the cohesive till. Where penetrated, the base of silty clay to clayey silt varied from a depth of 16.3 m (Elev. 172.6) to 19.4 m (Elev. 170.2). SPT-N values recorded in the cohesive till ranged from 13 to greater than 100 blows per 0.3 m of penetration indicating a stiff to hard consistency.

4.4 Silty Sand Till

A silty sand till deposit with trace to some clay and trace to some gravel was encountered below the upper cohesive till. In Boreholes SA17-03 and SA17-04, the till was 1.5 to 2.8 m thick and extended to a depth of 20.9 m (Elev. 168.4 to 168.7). In Boreholes SA17-05 and SA17-06, the till was 0.8 to 1.5 m thick and extended to a depth of 17.8 m (Elev. 171.1 to 171.4).

SPT-N values recorded in the silty sand till were greater than 100 blows per 0.3 m of penetration indicating a very dense relative density of the deposit

4.5 Lower Clayey Silt Till

A lower clayey silt till deposit with trace to some sand and gravel was encountered below 17.8 m to 20.9 m depth.

A 1.5 m thick silty sand till interlayer was encountered in Boreholes SA17-03 and SA17-06 at 22.4 m and 19.4 m depth, respectively. The lower till extended to bedrock surface at depths of 24.4 to 26.4 m (Elev. 164.8 to 163.2). Occasional cobbles were noted in the till deposit and shale fragments were observed in the lower zone of the till.

The SPT-N values obtained in the deposit were typically greater than 100 blows for 0.3 m penetration, indicating a hard consistency or a very dense relative density.

Glacial tills inherently contain cobbles and boulders, which should be expected to be present within the deposit.

4.6 Shale Bedrock

Grey shale bedrock of the Georgian Bay Formation was encountered in Boreholes SA17-03 to SA17-06 at depths varying from 24.4 to 26.4 m (Elev. 164.8 to 163.2). Typically, the upper zone of the shale bedrock was highly weathered and fractured, beneath which it becomes moderately weathered to fresh, thinly bedded with occasional fresh limestone interbeds. Occasional fractured zones were noted at various depths in the shale bedrock.

Total Core Recovery (TCR) of the bedrock ranged from 89 to 100%. Solid Core Recovery (SCR) ranged from 85% to 100%. The Rock Quality Designation (RQD) values of 54 to 83% were obtained for the rock cores, indicating fair to good rock quality. Fracture Index (FI) of the rock cores indicating frequency of natural fractures per 0.3 m of core run, ranged from 0 to greater than 10, typically from 2 to 5.

The average unconfined compressive strength (UCS) of the rock correlated from point load tests conducted on core samples ranged from 7.2 to 21.7 MPa for shale indicating a weak rock strength, and 67.2 to 139 MPa for limestone interbeds indicating a strong to very strong rock strength. The rock core test results are presented on the Record of Borehole sheets in Appendix A.

The depths to bedrock and bedrock elevations encountered in the boreholes are summarized in Table 1.

Table 1 – Depths and Elevations of Bedrock Surface

Borehole No.	Depth to Bedrock below Ground Surface (m)	Bedrock Elevation (m)	Comment
SA17-03	26.4	163.2	Proved by coring
SA17-04	25.9	163.4	Proved by coring
SA17-05	24.4	164.8	Proved by coring
SA17-06	24.4	164.5	Inferred by auger refusal

4.7 Groundwater Levels

Water levels measured in the piezometers installed during the current investigation and from the previous investigations (by others) are summarized in Table 2.

Table 2 – Piezometer Details and Groundwater Level Measurements

Borehole	Measurement Date	Water Level (m)		Screen Depth (m)	Native Material at Screen
		Depth	Elevation		
SA17-03	July 11, 2017	6.3	183.3	6.1 - 7.6	Silty Clay/ Clayey Silt Till
	Oct. 20, 2017	1.1	188.5		
SA17-04	July 11, 2017	2.9	186.4	15.2 - 18.3	Silty Clay/ Clayey Silt Till
	Oct. 20, 2017	2.6	186.7		
SA17-05	July 11, 2017	2.6	186.6	12.2 - 15.2	Silty Clay/ Clayey Silt Till
	Oct. 20, 2017	2.5	186.7		
427S-1	July 21, 2016	4.4	184.9	18.3 - 21.3	Sand/Silty Sand Till
	August 2, 2016	3.1	186.2		

The above groundwater levels represent relatively short-term readings and seasonal fluctuations of the groundwater level are to be expected. The groundwater level may be at higher elevations after the spring snowmelt or after periods of heavy rainfall. Perched water may be present at higher levels in more permeable lenses or zones within the till.

4.8 Corrosion and Sulphate Test Results

Soil samples of the native soil collected from selected boreholes were submitted for analytical testing of corrosivity parameters and sulphate. The laboratory certificates of analyses are presented in Appendix B. The results of the analytical tests are summarized in Table 3.

Table 3 – Analytical Test Results

Parameter Tested	Unit	SA17-03	SA17-04	SA17-06
		SS4	SS2	SS3
Moisture	%	13.0	13.2	13.3
Corrosivity Index	-	4	1	1
pH	-	8.66	8.48	8.49
Soil Redox Potential	mV	222	220	239
Sulphide	%	< 0.02	< 0.02	< 0.02
Chloride	µg/g	1.3	1.5	1.4
Sulphate	µg/g	49	37	16
Electrical Conductivity	µS/cm	142	119	108
Resistivity	ohms.cm	7020	8400	9240

5. PROJECT DESCRIPTION

Based on the General Arrangement (GA) drawings, a single span overpass structure is proposed at each NBL and SBL of Highway 427. The NBL Structure has a span length of 27.6 m and an average deck width of 27.4 m. The SBL Structure has a span length of 27.8 m and an average deck width of 28.4 m. The design grade of the bridges is indicated to be approximate Elev. 190.6 to 190.9 m at the NBL and Elev. 190.5 to 190.9 at the SBL.

The superstructure of the bridges is proposed to be supported on integral abutments. Street 'A' will be constructed in an approximately 6.5 m deep cut by others in the future. The height of the approach embankments will be in the order of 6.5 to 7.0 m above the roadway surface of the proposed Street 'A'. Reinforced Soil Systems (RSS) walls are proposed to retain the permanent cut at the abutments of both NBL and SBL structures. A sketch prepared by WSP showing the Street A future widening bridge clearances is included in Appendix F for information only.

The initial phase of this project will consist of construction of the overpass structures including RSS wall construction. The temporary excavation for RSS wall construction will be backfilled to approximately 1 m below the underside of the overpass structures. It is understood that a sheet of heavy-duty plastic and temporary plywood protection will cover the front face of the RSS wall to protect the outside surface of the wall panels when the wall is backfilled. Temporary surface drainage will be provided following the backfilling operation until Street 'A' is designed and constructed by others in the subsequent phase. The subsequent phase of this project should consist of design and construction of Street 'A' including the cut sections between and beyond Highway 427 NBL and SBL.

The discussion and recommendations presented in this report are based on factual data obtained during this investigation, in combination with the subsurface information presented in the Geocres Report No. 30M13-216.

6. GEOTECHNICAL RECOMMENDATIONS

6.1 Foundation Design

The GA drawings indicate that the bridges will be supported on integral abutments founded on steel H-pile foundations. The ground conditions at the site are suitable for the use of H-piles driven into hard/very dense till deposit. Alternatively, H-piles may be installed to bedrock if higher pile resistance is required.

Spread footings founded on very stiff to hard till are deemed a feasible foundation option if conventional abutment type is considered other than integral abutment. However, the bridge spans will likely be longer as spread footings will need to set back a certain distance behind the edges of the cut. Accordingly, this option has not been developed further.

6.1.1 Axial Pile Resistance

The recommended geotechnical resistances and reactions for steel HP 310x110 piles driven into hard/very dense till or shale bedrock are presented in Table 4.

Table 4 - Recommended Axial Resistance for HP310x110 Steel Piles

Foundation Element	Design Pile Head Elev. (m)	Reference Borehole	Founding Stratum	Estimated Tip Elevation (m)	Factored ULS (kN)	Factored SLS (kN)
NBL North Abutment	185.8	SA17-05, 427N-1	Very dense/hard Till	168.0	1400	1200
			Shale Bedrock	164.8	2000	2000
NBL South Abutment	185.4	SA17-06, 427N-2	Very dense/hard Till	168.0	1400	1200
			Shale Bedrock	164.5	2000	2000
SBL North Abutment	187.4	SA17-04, 427S-1	Very dense/hard Till	168.0	1400	1200
			Shale Bedrock	163.4	2000	2000
SBL South Abutment	187.2	SA17-03, 427S-2	Very dense/hard Till	168.0	1400	1200
			Shale Bedrock	163.2	2000	2000

The values of factored geotechnical resistance at SLS refer to up to 25 mm of pile head settlement. The value of factored geotechnical resistance at ULS was assessed assuming a consequence factor equal to 1 (Typical), and a resistance factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC (2014). The factored geotechnical resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

Cobbles and boulders generally exist within the till deposits.

6.1.2 Lateral Pile Resistance

The lateral resistance in the cohesionless soils may be calculated using coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (\text{kPa})$$

Where: z = depth of embedment of pile (m)

D = pile width (0.310 m for HP310x110)

n_h = coefficient related to soil relative density (kN/m^3)

γ' = effective unit weight (kN/m^3)

K_p = passive earth pressure coefficient

The lateral resistance in the cohesive soils may be calculated using coefficient of horizontal subgrade reaction

(k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = 67 s_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 s_u \quad (\text{kPa})$$

Where:

s_u = undrained shear strength (kPa)

D = pile width (0.310 m for HP310x110)

The above equations and parameters provided in Table 5 below may be used to analyze the interaction between a pile and the surrounding soil. Lateral pressures obtained from analysis must not exceed the ultimate lateral resistance.

The spring constant, K_s , for analysis may be obtained by the expression, $K_s = k_s L D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m³), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance, P_{ult} , can be obtained from the expression, $P_{ult} = p_{ult} L D$. This represents the ultimate load at which the soil fails and will not support any additional load at greater pile displacement.

Table 5 – Geotechnical Design Parameters for Lateral Pile Resistance

Soil Unit	Elevation (m)		γ' (kN/m ³)	n_h (kN/m ³)	K_p	S_u (kPa)
	Top	Bottom				
NBL Overpass						
North Abutment (SA17-05 and 427N-1)						
Clayey Silt – stiff	189.0	187.5	19.0	-	-	60
Clayey Silt/Silty Clay Till – v. stiff/hard	187.5	185.5	20.0	-	-	150
Clayey Silt/Silty Clay Till – v. stiff/hard	185.5	179.0	10.0 (*)	-	-	125
Clayey Silt/Silty Clay Till – hard	179.0	173.0	11.0 (*)	-	-	200
Silty Sand Till – very dense	173.0	171.0	11.0 (*)	10,000	4.0	-
Clayey Silt/Silty Clay Till – hard	171.0	164.8	12.0 (*)	-	-	350
South Abutment (SA17-06 and 427N-2)						
Clayey Silt – stiff	189.0	187.5	19.0	-	-	60
Clayey Silt/Silty Clay Till – v. stiff/hard	187.5	185.5	20.0	-	-	150
Clayey Silt/Silty Clay Till – v. stiff/hard	185.5	179.0	10.0 (*)	-	-	125
Clayey Silt/Silty Clay Till – hard	179.0	172.5	11.0 (*)	-	-	200
Silty Sand Till – very dense	172.5	168.0	11.0 (*)	10,000	4.0	-
Clayey Silt/Silty Clay Till – hard	168.0	164.5	12.0 (*)	-	-	350
SBL Overpass						
North Abutment (SA17-04 and 427S-1)						
Clayey Silt – stiff	189.0	188.0	19.0	-	-	40
Clayey Silt/Silty Clay Till – v. stiff/hard	188.0	186.0	20.0	-	-	150
Clayey Silt/Silty Clay Till – stiff/v. stiff	186.0	176.0	10.0 (*)	-	-	100
Clayey Silt/Silty Clay Till – hard	176.0	173.0	11.0 (*)	-	-	200
Silty Sand Till – very dense	173.0	168.5	11.0 (*)	10,000	4.0	-
Clayey Silt/Silty Clay Till –hard	168.5	163.4	12.0 (*)	-	-	350
South Abutment (SA17-03 and 427S-1)						
Clayey Silt – stiff	189.5	188.0	19.0	-	-	60
Clayey Silt/Silty Clay Till – v. stiff/hard	188.0	186.0	20.0	-	-	150
Clayey Silt/Silty Clay Till – hard	186.0	172.0	11.0 (*)	-	-	200

Soil Unit	Elevation (m)		γ' (kN/m ³)	n_h (kN/m ³)	K_p	S_u (kPa)
	Top	Bottom				
Clayey Silt/Silty Clay Till – hard	172.0	170.0	11.0 (*)	-	-	250
Silty Sand Till – very dense	172.0	166.0	11.0 (*)	10,000	4.0	-
Clayey Silt/Silty Clay Till – hard	166.0	163.2	12.0 (*)	-	-	350

Note: (*) Submerged Unit Weight

The modulus of subgrade reaction and ultimate lateral resistance should be reduced based on the pile spacing to account for group effect. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 6. Intermediate values may be obtained by linear interpolation.

Table 6 – Subgrade Reaction Reduction Factors for Pile Spacing

Loading Condition	Pile Spacing (Centre to Centre)	Reduction Factor
Pile group oriented perpendicular to direction of loading	4D	1.0
	1D	0.5
Pile group oriented parallel to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

6.1.3 Downdrag

The GA drawing indicates the proposed highway design grade will require generally less than 1 m of grade raise above the existing ground. Based on the subsurface conditions encountered at the proposed abutment locations, downdrag is considered not an issue.

6.1.4 H-Pile Installation

Piles should be installed in accordance with OPSS.PROV 903.

Pile driving should be controlled in accordance with Standard Drawing SS103-11 (Hiley Formula). The Hiley formula need not be used until the piles are within 2 m of the design tip elevation. The appropriate pile driving note is “Piles to be driven in accordance with Standard SS103-11 using an ultimate resistance of ‘R’ kN per pile”. ‘R’ should have a minimum value of twice the design load at ULS but should not exceed twice the factored ULS resistance at each foundation element.

High-strain dynamic testing or PDA testing may be used in place of the Hiley Formula to prove the ultimate pile resistance in accordance with ASTM D4945. PDA testing should be carried out on a minimum of 10% of the piles, but no fewer than 2 piles, for each bridge abutment as per OPSS.PROV 903.

The piles may encounter refusal on the cobbles and/or boulders that may be present in the till deposit above the design tip elevations. The pile installation equipment should be capable of penetrating through the cobbles and boulders. Oversize materials (e.g. greater than 75 mm nominal diameter) should not be used for any new fill which the piles will be driven through including pile driving pad if required.

6.1.5 Pile Tips

To prevent structural damages to the piles when setting them in the very dense/hard till/shale bedrock or if cobbles or boulders are encountered, piles should be equipped with tip protection. All driven H-piles should be fitted with pile tip protection as per OPSS.PROV 903 and OPSD 3000.100 (Type I H-Pile Driving Shoe).

Care must be taken when driving piles to very dense/hard till with cobbles and boulders or to bedrock to avoid overdriving and damage to the piles. If pile damage or misalignment occurs, PDA testing may be required to

assess the pile capacity and integrity. Consideration should be given to using Titus Steel (Standard H-point) or approved equivalent for the remaining piles at this site.

6.2 Frost Protection

The design depth of frost penetration at this site is 1.2 m. All pile caps and footing bases should be provided with 1.2 m of earth cover or an equivalent thickness of synthetic insulation.

6.3 Backfill to Abutments

Backfill to the abutment walls should be Granular A or Granular B Type II material meeting the requirements of OPSS.PROV 1010. The backfill should be in accordance with OPSS 902 and placed to the extent shown in OPSD 3101.150.

Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501. The design of the abutment should incorporate a subdrain as shown in OPSD 3101.150.

6.4 Lateral Earth Pressure

Lateral earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K * (\gamma h + q)$$

where:

P_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	lateral earth pressure coefficient
γ	=	unit weight of retained soil (kN/m ³)
H	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

In accordance with Clause 6.12.3 of the CHBDC, a compaction surcharge should be added.

Earth pressure coefficients for backfill to the abutment wall are dependent on properties of the granular fill used as the backfill. Typical values are shown in Table 7 below.

Table 7 – Coefficients of Lateral Earth Pressure

Loading Condition	OPSS Granular A or B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At-rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

* For wing walls

6.5 Seismic Considerations

Based on the encountered subsurface conditions from the previous investigation, Site Class C should be assumed to evaluate the seismic site response, as per Table 4.1, Clause 4.4.3.2 of the CHBDC 2014.

The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.110 g as per

the National Building Code of Canada 2015 (NBCC 2015).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 8 may be used:

Table 8 – Earth Pressure Coefficients for Earthquake Loading

Loading Condition	OPSS Granular A or B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.31	0.35
Passive (K_{PE})	3.5	3.1
At-rest (K_{OE})**	0.57	0.62

* After Mononobe and Okabe

** After Woods

Given the low seismic ground motion and the presence of stiff to hard clayey silt to silty clay till and very dense silty sand till, potential for liquefaction is considered low at this site.

6.6 Approach Embankments and Reinforced Soil System (RSS)

6.6.1 General

The GA drawing indicates that reinforced soil system (RSS) for false abutments of Street 'A' structures and wingwalls between and beyond the bridge structures will be installed. The RSS walls are designed to retain the cut and embankment fill behind the abutments and will also serve as temporary roadway protection and shoring system when Street 'A' is constructed in the future by the City of Vaughan. Excavation for Street 'A' construction in the future shall not undermine the completed RSS walls and their engineered fill pad. Protection of the RSS mass and wall panels consisting of a sheet of heavy-duty plastic and temporary plywood protection will be provided under this contract. The designer and constructor of Street 'A' for City of Vaughan will be responsible for ensuring that their work does not impact the stability/integrity of the overpass structures and RSS walls during and after construction of Street 'A'. Consideration could be given to using hand excavation methods within ~150 mm of the face of the wall. After removal of the protective materials on the front face of the wall, City of Vaughan should clean and inspect the wall faces to ensure there is no material build up in the gaps between the RSS panels. City of Vaughan may consider monitoring groundwater levels before construction, but that is not a requirement while the front face of the RSS walls is backfilled against.

It should be noted that no structural loading is applied to the RSS system in the case of false abutment. The proposed RSS walls will be up to about 8 m high at the abutments, and taper in height at wingwall locations.

The RSS walls will be designed to "High Performance" and "High Appearance" at this site. To provide an acceptable performance, the RSS mass should be founded on competent soils or on engineered fill. Uniform and competent subgrade conditions within the entire footprint of the RSS mass will be critical for performance of the RSS walls.

The construction of the Street 'A' Overpass structures will require 0.5 to 1 m of fill placement at the approaches. The construction of the proposed Street 'A' will require excavation to approximately 6.5 m below the existing ground surface. The total height of the approach embankments will be up to approximately 7 m above the Street 'A' design grade. The side slopes of the approach embankments will be at an inclination of 2H:1V.

The proposed RSS walls will become partially submerged until Street 'A' is constructed in the future by others. The proprietary designer of these RSS walls must address the following aspects which include but are not limited to:

- Potential erosion of the RSS walls after backfilling
- Type of backfill material and control of migration of fines
- Reinforcement strength, facing connection strength and pullout resistance of reinforcement under submerged conditions
- Durability of the reinforcing strips against potential corrosion under submerged conditions

Through discussions with the proprietary RSS designer/supplier (i.e. Reinforced Earth), their RSS wall design for Street 'A' addressing the above aspects is presented below:

- 1) When backfilling against the front facing of RSS wall (i.e. the side for temporary backfilling and removal for Street A), the type of backfill material and compaction requirement should follow the specifications for embankment backfill behind the RSS wall and the rate of backfill placement will be limited to 250 mm per lift and compacted to 95% of SPMDD.
- 2) The friction along the strip length is mobilized during backfilling and compaction of the RSS mass. Therefore, the tension in the strips is developed based on active backfill pressure. The active pressure against the panels when the RSS wall is backfilled will not exceed the passive pressure behind the panel, therefore no compression in the strips is expected. The factor of safety for internal stability of the RSS mass will actually increase in that loading stage.
- 3) Filter fabric will be placed behind the joints around the panels and is adequate against potential loss of backfill materials assuming an unfavourable surface/groundwater condition with high hydraulic gradient during and after construction, i.e. the high Groundwater level was measured at Elev. 188.5 vs. the base of RSS base near Elev. 183 (~5 m head). In addition, RSS backfill is a well-draining material with less than 8% fine content and the groundwater is collected in the subdrain inside the RSS wall before going through the joints around the panel.
- 4) After the RSS wall is backfilled, the RSS wall is expected to be under saturated conditions due to groundwater recharge and surface water infiltration. The RSS wall design has considered potential corrosion of the reinforcing strips. The corrosion rate in calculating steel strip capacity is based on the code (AASHTO, CHBDC) that considers wet condition.
- 5) The wall is not designed for rapid drawdown and hydrostatic pressure. If the excavation is below the groundwater table, the differential head should stay below 0.5 m. The rate of excavation needs to be assessed based on actual conditions, e.g. groundwater table at the time of excavation and RSS mass permeability. The reinforced backfill is well-drained and should drain ground water quickly. The groundwater levels within and outside the RSS mass should be monitored prior to and during the excavation to control the rate of excavation.
- 6) The RSS designer/supplier does not expect any negative impact on internal stability of the wall due to temporary burial of the RSS wall. However, soil may stain precast panels and excavation in later stage may cause damage to wall facing. A protection layer is recommended.

Thurber is in general agreement with the above assessment by the proprietary RSS designer/supplier.

6.6.2 Subgrade Preparation

Topsoil and any soft surficial clayey silt/silty clay, loose fill, disturbed soils and deleterious materials within the footprint of the approach embankments should be removed and replaced with suitable granular material compacted as per OPSS.PROV 501. The exposed subgrade surface should be proof-rolled and inspected to confirm that the subgrade is suitable and uniformly competent.

The groundwater table is anticipated to be drawn down upon completion of excavation prior to constructing the RSS walls. The work should be carried out in accordance with OPSS 902 and wall construction must be carried out in the dry. Once the subgrade is prepared, the construction traffic and equipment should not travel on the subgrade.

The RSS walls should be founded on a minimum 500 mm thick layer of engineered fill conforming to OPSS Granular A requirements to form a uniform subgrade. Engineered fill placed under the RSS mass to achieve the design founding level should be compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill layer should extend at least 500 mm beyond the limits of the RSS mass.

6.6.3 Geotechnical Resistances

As per MTO RSS Design Guidelines, the minimum soil cover to the underside of the levelling pad shall be at least 800 mm or 40% of the frost depth in the area, whichever is greater. The minimum soil cover to the top of the levelling pad shall be at least 500 mm.

The RSS walls founded on the stiff to very stiff silty clay to clayey silt till at Elevation 183 m or lower should be designed for a Factored Geotechnical Resistance at ULS of 350 kPa and a Factored Geotechnical Reaction at SLS of 250 kPa. The resistance values assume that the length of RSS wall reinforcement will extend for a distance equal at least 70% height of embankment (i.e. from the base of RSS mass to the design Highway 427 road grade) behind the wall face. For RSS walls underneath the abutment stem, the length of reinforcing strips should be sized based on the elevation difference from the highway design grade to the base of RSS wall.

The recommended geotechnical resistances are for vertical concentric loading. The effects of load inclination and eccentricity need to be considered in accordance with the CHBDC.

The RSS mass must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base on native silty clay to clayey silt till and engineered fill may be estimated using ultimate friction coefficients of 0.4 and 0.55, respectively.

The internal stability or structural integrity of the RSS walls should be analyzed by the supplier/designer of the proprietary product selected for this site.

6.6.4 Predicted Settlement

Given the 0.5 to 1.0 m grade raise, the total settlements of the approach embankments, including foundation compression and self-compression of the fill, are estimated to be less than 25 mm and will be essentially complete at the end of fill placement.

6.6.5 Approach Embankment/Cut Stability

The embankment fill will be placed on stiff silty clay to clayey silt subgrade near surface and very stiff to hard cohesive till at depth. Global stability of the side slopes of the approach embankments is considered not a concern.

Global stability of the temporary cut for RSS wall construction and the permanent RSS walls after completion of Street 'A' construction has been assessed. The output plots of the stability analysis are included in Appendix E. Global stability of the abutment RSS walls is assessed to be acceptable under both short-term and long-term conditions. The temporary cut slope for RSS wall construction will be up to approximately 8 m in height and should be constructed to 1.5H:1V or flatter to maintain a stable excavation during construction.

6.6.6 Approach Embankment Construction

Embankment fill should be placed in accordance with OPSS.PROV 206.

Embankments constructed with granular or earth fill compacted as per OPSS.PROV 501 will have stable side slopes at inclinations not steeper than 2H:1V. Careful selection and/or treatment of the earth fill prior to reuse are required.

Side slope face treatment/surficial erosion protection should be in general accordance with OPSS.PROV 804.

6.7 Excavation and Dewatering

All excavations should be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the surficial soft silty clay within the depth of excavation and any cohesionless soils below the groundwater table may be classed as Type 4 soil. The firm to very stiff clayey silt to silty clay within the depth of excavation may be classed as Type 3 soil.

The excavation and backfilling for foundations should be carried out in accordance with OPSS 902. Reference should be made to Section 6.6.5 for temporary cut slope inclination for RSS construction.

The water levels measured in the standpipe piezometers ranged between approximately Elev. 186 to 188.5 m. The base of excavation will extend below the groundwater table. In addition, perched groundwater may be present at shallower levels. Given the consistency and relatively low permeability of the clayey silt to silty clay till, groundwater control measures such as perimeter ditches and pumping from filtered sumps may be effective to remove any accumulation of water from the excavation base and lower the groundwater table to a minimum of 0.5 m below the base of excavation. The possibility exists that additional pumps may be required if localized zones of high volume of perched groundwater are encountered.

Temporary drainage of the cut should be provided to maintain a relatively dry, stable excavation. Positive drainage of the permanent cut must be provided. Roadside ditches are expected to provide an adequate level of surface drainage in most areas. An interceptor ditch should be provided at the top of the cut.

All foundation pile caps should be constructed in the dry. Clayey subgrade should be covered as soon as practical upon exposure and be protected from any disturbances that could weaken the material.

6.8 Corrosion and Sulphate Attack Potential

The results of the analytical tests for soil corrosivity and sulphate content conducted on the samples collected at this site indicate the following:

- The potential for sulphate attack on structural concrete from the surrounding soil is negligible based on the generally low concentration of sulphate in the samples tested.
- The potential for corrosion on metal elements of the structure is considered to be mild.
- Appropriate protection measures are recommended if metal structural elements are used.

6.9 Construction Concerns

Potential construction concerns include, but not necessarily limited to:

- Pile installation may encounter cobbles and boulders inherently present in the till deposits;
- The driven steel H-pile installation in the glacial till may result in pile misalignment and/or damages at the pile tip due to the presence of cobbles and/or boulders. The piling contractors should be warned of the associated risks. Pre-augering may be required;
- The sequence of pile installation and cut construction should be carefully considered to not induce excessive lateral pile movement.
- All pile caps and RSS walls should be constructed in the dry. The clayey silt to silty clay subgrade should be covered/protected as soon as practical upon exposure and be protected from any disturbances that will likely weaken the material.

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

Appendix A

Record of Borehole Sheets – Current Investigation

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


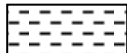



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

<u>TERMS</u>	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No SA 17-01

1 OF 2

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 734.3 E 293 599.0 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.26 - 2017.05.26 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
189.7	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.0	TOPSOIL: (175mm)							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.2	Silty CLAY , trace sand, trace gravel Stiff Brown		1	SS	9		189							
189.0	Moist													
0.7	Silty CLAY , trace to some sand, trace gravel, occasional cobbles Stiff to Very Stiff Brown to Grey Moist (TILL)		2	SS	13		188							
			3	SS	14									
			4	SS	25		187							
			5	SS	19		186							
			6	SS	27		185							
			7	SS	14		184							
			8	SS	17		182							
			9	SS	17		181							
179.9							180							
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SA 17-01

2 OF 2

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 734.3 E 293 599.0 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.26 - 2017.05.26 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
	BOREHOLE OPEN TO 7.6m AND DRY. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

ONTMT4S MTO-19484.GPJ 2017TEMPLATE(MTO).GDT 3/28/18

RECORD OF BOREHOLE No SA 17-02

1 OF 2

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 803.2 E 293 586.8 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.29 - 2017.05.29 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W _P W W _L WATER CONTENT (%)							
189.2	GROUND SURFACE							20	40	60	80	100							
0.0	TOPSOIL: (175mm)							20	40	60	80	100							
0.2	Silty CLAY , trace sand, trace gravel Soft Brown Moist		1	SS	2		189								○				
			2	SS	4		188								○				
187.4															○				
1.8	Silty CLAY , trace to some sand, trace gravel, occasional cobbles Very Stiff Brown to Grey Moist (TILL)		3	SS	10		187								○				
			4	SS	28		186								○				
			5	SS	24										○				
							185												
			6	SS	23		184								○				
			7	SS	26		183								○				
							182								○				
			8	SS	14		181												
			9	SS	20		180								○				
179.4															○				
9.8	END OF BOREHOLE AT 9.8m.																		

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No SA 17-03

1 OF 4

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 751.5 E 293 582.6 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.06.27 - 2017.07.07 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
189.6	GROUND SURFACE													
0.0	TOPSOIL: (100mm)													
0.1	Silty CLAY , trace sand, trace gravel Stiff Brown Moist		1	SS	14									
188.8														
0.8	Silty CLAY to Clayey SILT , trace to some sand, trace gravel Very Stiff to Hard Brown Moist (TILL)		2	SS	34									
			3	SS	33									
			4	SS	50									
			5	SS	42									
	Becoming Grey Switch to Tricone													
			6	SS	38									
			7	SS	40									
			8	SS	45									
			9	SS	36									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity



20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SA 17-03

2 OF 4

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 751.5 E 293 582.6 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.06.27 - 2017.07.07 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)				
	Continued From Previous Page							20	40	60	80	100							
	Silty CLAY to Clayey SILT , trace to some sand, trace gravel Very Stiff to Hard Grey Moist (TILL)						179												
			10	SS	33														0 18 53 29
			11	SS	32														
			12	SS	29														
			13	SS	45		174												
							173												
			14	SS	33														
							172												
			15	SS	71		171												
170.2							170												
19.4	Silty SAND , trace to some clay Very Dense Grey Wet		16	SS	100/													10 52 22 16	

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SA 17-03

3 OF 4

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 751.5 E 293 582.6 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.06.27 - 2017.07.07 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
						WATER CONTENT (%)							
						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT							
						20 40 60 80 100							
						20 40 60 80 100							
						20 40 60 80 100							
	Continued From Previous Page				0.225								
168.7	Silty SAND , trace to some clay Very Dense Grey Wet (TILL)												
20.9	Clayey SILT , some to trace sand, trace gravel, occasional cobbles Hard Grey Moist (TILL)		17	SS	100/ 0.200						○		
167.2													
22.4	Silty SAND , some gravel, trace clay, occasional cobbles Very Dense Grey Moist (TILL)		18	SS	100/ 0.125						○		
165.7													
23.9	Clayey SILT , sandy, trace to some gravel, occasional shale fragments Hard Grey Moist (TILL)		19	SS	100/ 0.250						○		
163.2													
26.4	SHALE moderately weathered, thinly bedded, weak with medium strong to very strong limestone interbeds, grey: (Georgian Bay Formation) Highly fractured zone (75mm) at 26.4m and (25mm) at 27.4m Limestone interbeds (50mm) at 26.4m, (150mm) at 26.5m, (25mm) at 26.9m, 27.0m, (175mm) at 27.4m and (25mm) at 27.8m Vertical fracture (50mm) at 26.5m and (175mm) at 27.3m Limestone interbeds (275mm) at 27.9m, (100mm) at 28.3m and (50mm) at 28.6m Vertical fracture (50mm) at 27.9m and (25mm) at 28.9m		20	SS	100/ 0.150						○		

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No SA 17-04

1 OF 3

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 784.5 E 293 599.5 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.28 - 2017.07.29 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	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 (%) W _P W W _L				GR	SA	SI	CL
189.3	GROUND SURFACE							20	40	60	80	100							
0.0	TOPSOIL: (125mm)							20	40	60	80	100							
0.1	Silty CLAY , trace to some sand, trace gravel, trace organics (rootlets)		1	SS	8		189							○					
188.5	Firm Brown Moist																		
0.8	Moist																		
	Silty CLAY to Clayey SILT , trace to some sand, trace gravel		2	SS	25		188							○					
	Very Stiff to Hard																		
	Brown to Grey Moist (TILL)		3	SS	28									○					
			4	SS	42		187							○					
			5	SS	23		186							○					
							185												
			6	SS	27		184							○					
							183												
			7	SS	41									○					
							182												
			8	SS	34									○					
							181												
			9	SS	20		180							○					

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SA 17-04

2 OF 3

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 784.5 E 293 599.5 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.28 - 2017.07.29 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
	Continued From Previous Page													
	Silty CLAY to Clayey SILT , trace to some sand, trace gravel Very Stiff to Hard Grey Moist (TILL)		10	SS	27		179							
							178							
			11	SS	27		177							
							176							
			12	SS	48		175							
							174							
			13	SS	37		173							
							172							
	Cobbles		14	SS	100/ 0.175		171							
							170							
171.2														
18.1	Silty SAND , trace to some clay, trace gravel Very Dense Grey Moist (TILL)		15	SS	100/ 0.200		171							
							170							
			16	SS	100/									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No SA 17-05

1 OF 3

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 808.7 E 293 678.8 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.07 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
189.2	GROUND SURFACE																
0.0	TOPSOIL: (150mm)																
0.2	Silty CLAY , trace sand, trace gravel, trace organics Stiff Brown		1	SS	14												
188.4	Brown																
0.8	Moist Silty CLAY to Clayey SILT , trace to some sand, trace gravel Very Stiff to Hard Brown to Grey Moist (TILL)		2	SS	18												
			3	SS	24												
			4	SS	33												
			5	SS	30												
			6	SS	17												
			7	SS	17												
			8	SS	38												
			9	SS	24												

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SA 17-05

2 OF 3

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 808.7 E 293 678.8 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.07 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
	Silty CLAY to Clayey SILT , trace to some sand, trace gravel Hard Grey Moist (TILL)		10	SS	35		179							
							178							
			11	SS	51		177							
							176							
			12	SS	56		175							
							174							
			13	SS	65		173							
							172							
172.2			14	SS	100/0.250		171							
17.0	Silty SAND , trace clay Very Dense Grey Wet (TILL)						170							
171.4														
17.8	Silty CLAY to Clayey SILT , trace sand, trace gravel, occasional cobbles Hard Grey Moist (TILL)		15	SS	94									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SA 17-05

3 OF 3

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 808.7 E 293 678.8 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone/HQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.07 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W _P W W _L WATER CONTENT (%)				
	Continued From Previous Page		16	SS	100/ 0.200		169									
			17	SS	100/ 0.250		168									
			18	SS	100/ 0.175		167									
164.8			19	SS	100/ 0.050		166									
24.4	SHALE moderately weathered, thinly bedded, weak with strong limestone interbeds, grey: (Georgian Bay Formation) Vertical fracture (50mm) at 24.6m Vertical fracture (100mm) at 25.0m and (75mm) at 26.4m Limestone interbed (75mm) at 25.8m and (75mm) at 26.5m		1	RUN			165									
			2	RUN			164									
162.6							163									
26.6	END OF BOREHOLE AT 26.6m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.07.11 2.6 186.6 2017.10.20 2.5 186.7															

ONTMT4S MTO-19484.GPJ 2017TEMPLATE(MTO).GDT 3/28/18

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S MTO-19484.GPJ 2017TEMPLATE(MTO).GDT 3/28/18

RECORD OF BOREHOLE No SA 17-06

2 OF 3

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 781.8 E 293 685.3 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2017.07.04 - 2017.07.05 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
	Continued From Previous Page							20 40 60 80 100					
	Silty CLAY to Clayey SILT , trace to some sand to sandy, trace gravel Hard Grey Moist (TILL)		10	SS	44		178						
							177						
			11	SS	36		176						
							175						
			12	SS	66		174						
							173						
			13	SS	100/ 0.175		172						
172.6							171						
16.3	Silty SAND , trace to some clay, trace gravel Very Dense Grey Moist (TILL)		14	SS	100/ 0.125		170						
171.1							169						
17.8	Silty CLAY to Clayey SILT , trace to some sand, trace gravel Hard Grey Moist (TILL)		15	SS	93								
169.5													
19.4	Silty SAND , some clay, trace gravel Very Dense Grey (TILL)		16	SS	100/ 0.125								

8 30 40 22

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa		WATER CONTENT (%)			
						20 40 60 80 100	○ UNCONFINED + FIELD VANE	20 40 60					
	Continued From Previous Page						● QUICK TRIAXIAL × LAB VANE						
168.0	Silty SAND , some clay, some gravel Very Dense Grey Moist (TILL)				0.275								9 54 25 12
20.9	Clayey SILT , some sand, some gravel, occasional shale fragments Hard Grey Wet (TILL)		17	SS	100/ 0.200	168							
						167							
						166							
164.5			18	SS	100/ 0.200	165							
24.4	END OF BOREHOLE AT 24.4m UPON REFUSAL ON BEDROCK.		19	SS	100/ 0.050								

RECORD OF BOREHOLE No SA 17-07

1 OF 2

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 758.8 E 293 680.0 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.26 - 2017.05.26 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
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				
189.3	GROUND SURFACE																
0.0	TOPSOIL: (200mm)		1	SS	50/												
0.2	Silty CLAY, trace sand, trace gravel, trace organics Stiff Brown Moist				0.050												
188.2			2	SS	12												
1.1	Silty CLAY, trace to some sand, trace gravel, occasional cobbles Stiff to Very Stiff Brown to Grey Moist (TILL)																
			3	SS	17												
			4	SS	27												
			5	SS	22												
			6	SS	13												
			7	SS	13												
			8	SS	18												
			9	SS	21												
179.5	END OF BOREHOLE AT 9.8m.																

ONTMT4S MTO-19484.GPJ 2017TEMPLATE(MTO).GDT 3/28/18

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SA 17-07

2 OF 2

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 758.8 E 293 680.0 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.26 - 2017.05.26 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
	BOREHOLE OPEN TO 7.6m AND DRY. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

ONTMT4S MTO-19484.GPJ 2017TEMPLATE(MTO).GDT 3/28/18

RECORD OF BOREHOLE No SA 17-08

1 OF 2

METRIC

W.P. _____ LOCATION Street 'A' N 4 850 826.8 E 293 665.4 ORIGINATED BY CAR
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.29 - 2017.05.29 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
189.4	GROUND SURFACE							<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>20 40 60 80 100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>WATER CONTENT (%)</div> <div>20 40 60</div>						
0.0	TOPSOIL: (275mm)													
189.1														
0.3	Silty CLAY , trace sand, trace gravel, trace organics Stiff Brown Moist		1	SS	9		189							
			2	SS	11									
188.0							188							
1.4	Silty CLAY , trace to some sand, trace gravel, occasional cobbles Stiff to Very Stiff Brown to Grey Moist (TILL)		3	SS	16									
			4	SS	26		187							
			5	SS	22		186							
			6	SS	16		185							
							184							
			7	SS	27		183							
							182							
			8	SS	16		181							
			9	SS	30		180							
179.6														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

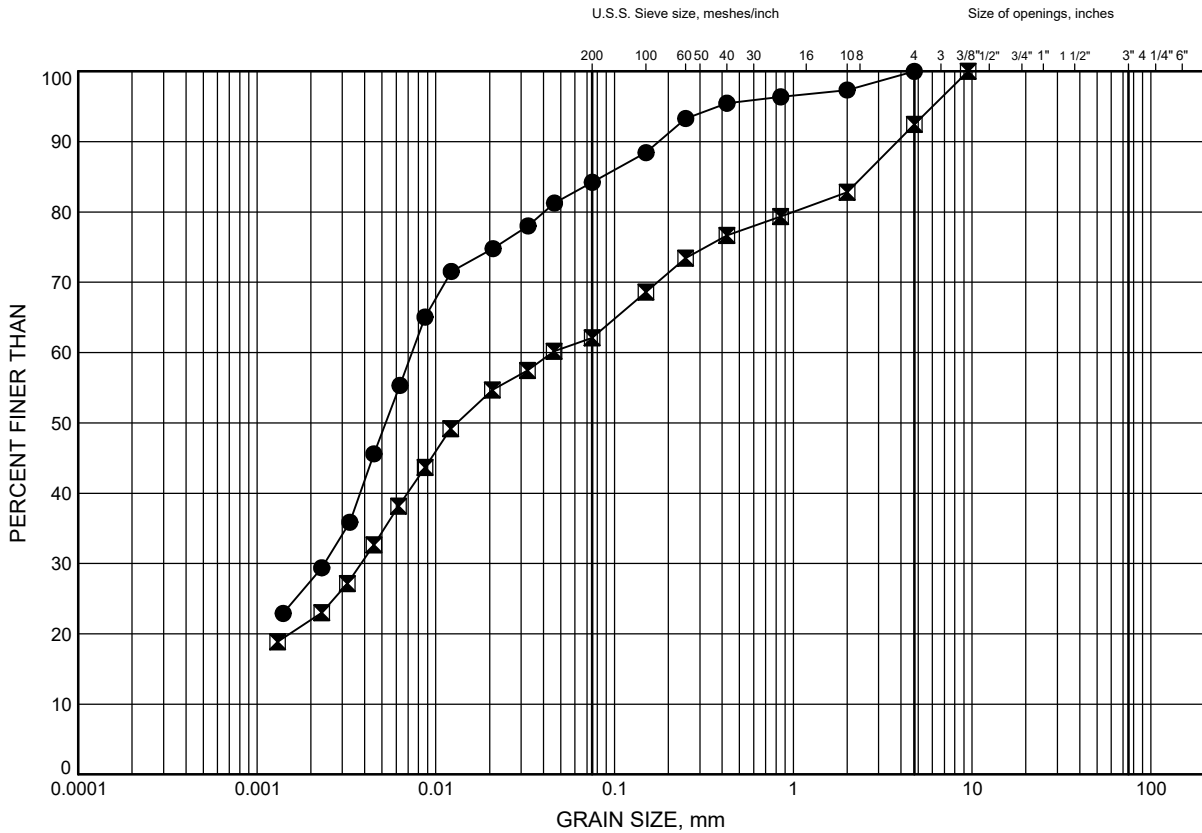
Appendix B
Laboratory Test Results – Current Investigation

Street 'A'

GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty CALY to Clayey SILT TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SA 17-05	15.5	173.7
⊠	SA 17-06	12.5	176.4

Date September 2017
W.P.



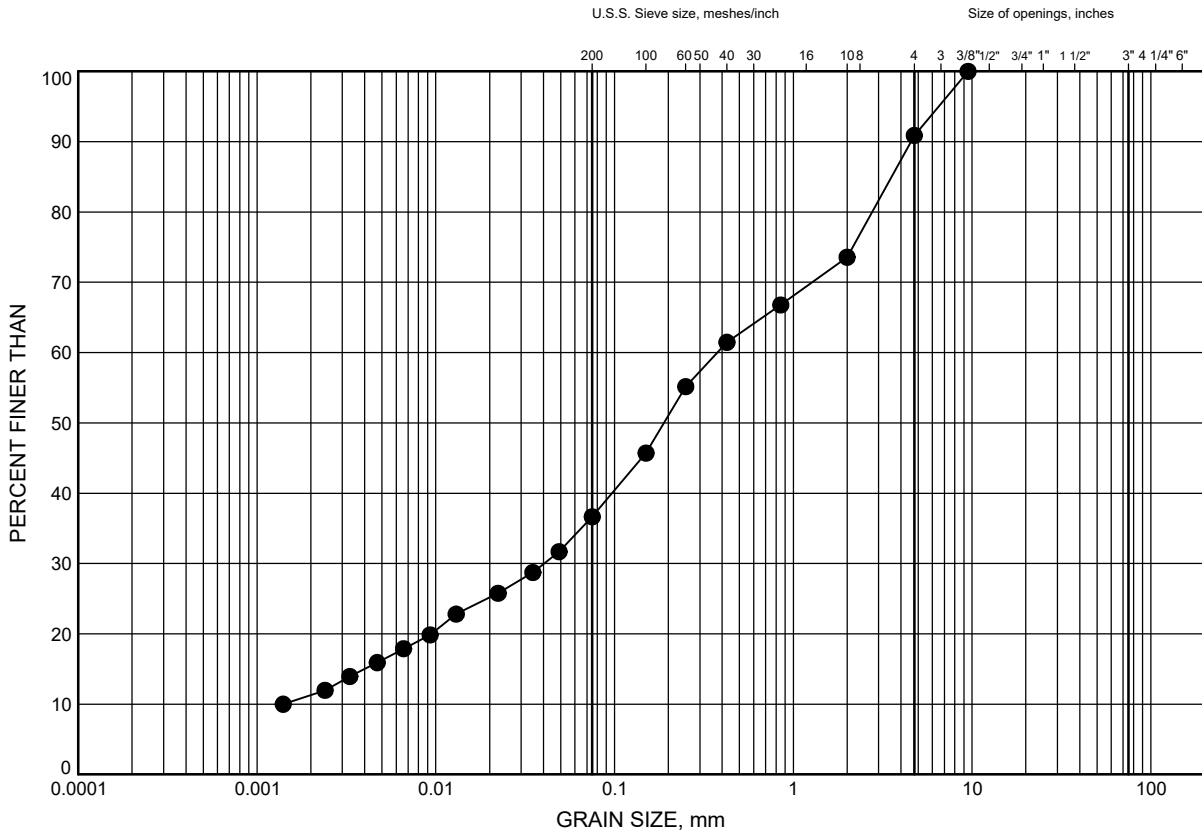
Prep'd AN
Chkd. AMP

Street 'A'

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SA 17-06	20.1	168.8

Date September 2017
W.P.



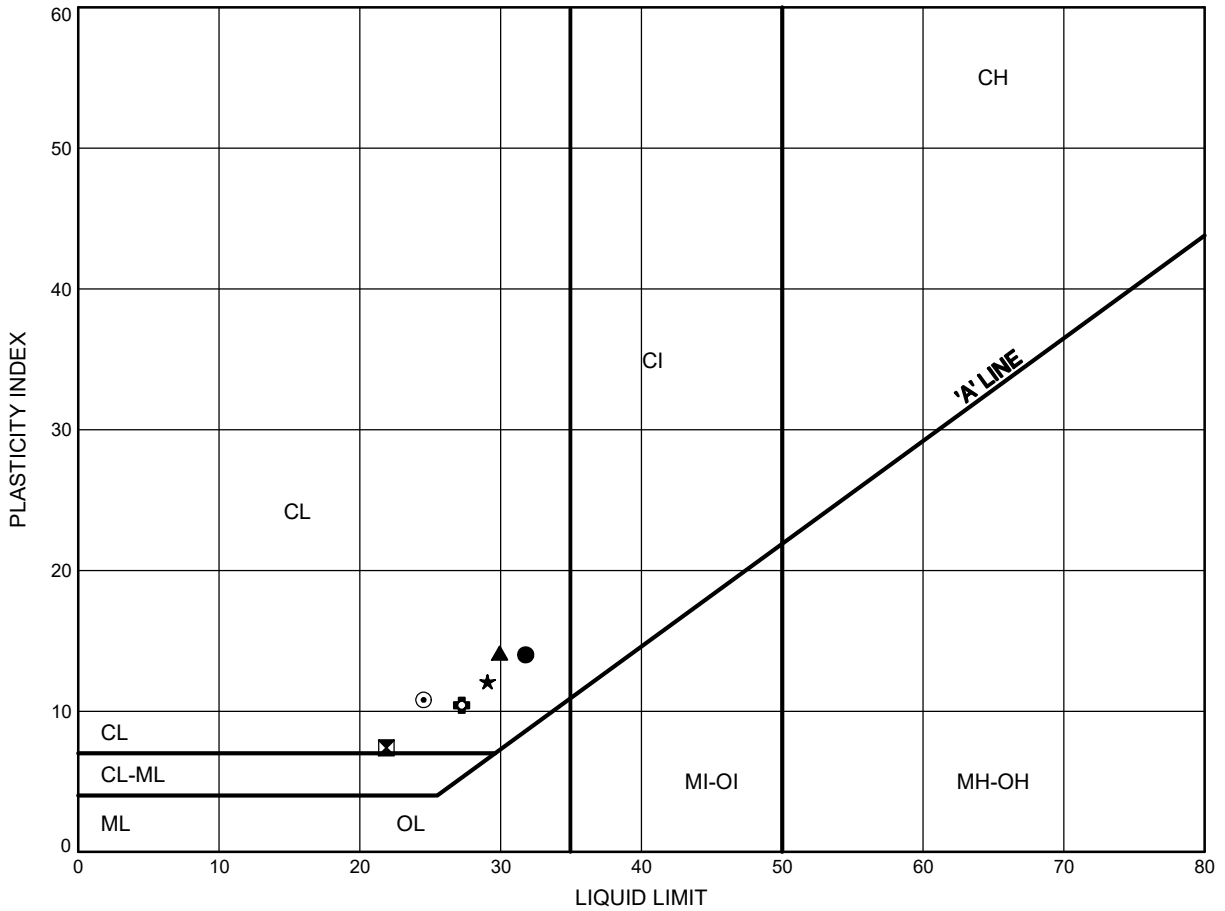
Prep'd AN
Chkd. AMP

Street 'A'

ATTERBERG LIMITS TEST RESULTS

FIGURE B3

Silty CLAY to Clayey SILT TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SA 17-01	2.6	187.1
⊠	SA 17-01	7.9	181.8
▲	SA 17-02	3.4	185.8
★	SA 17-03	2.6	187.0
⊙	SA 17-03	14.0	175.6
⊕	SA 17-04	1.8	187.5

Date September 2017
W.P.



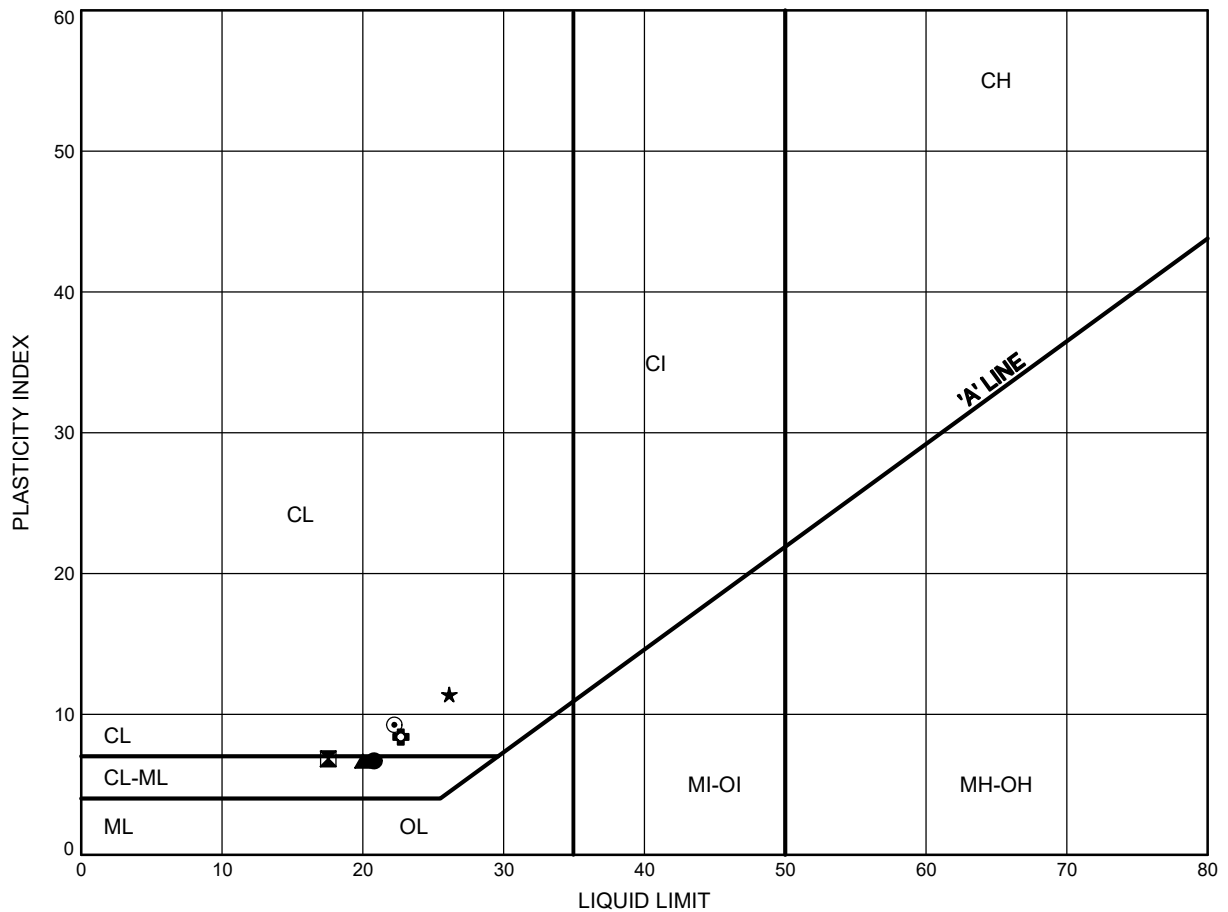
Prep'd AN
Chkd. AMP

Street 'A'

ATTERBERG LIMITS TEST RESULTS

FIGURE B4

Silty CLAY to Clayey SILT TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SA 17-04	7.9	181.4
⊠	SA 17-04	14.0	175.3
▲	SA 17-05	6.4	182.8
★	SA 17-05	21.6	167.6
⊙	SA 17-06	3.1	185.8
⊕	SA 17-06	4.9	184.0

Date September 2017
W.P.



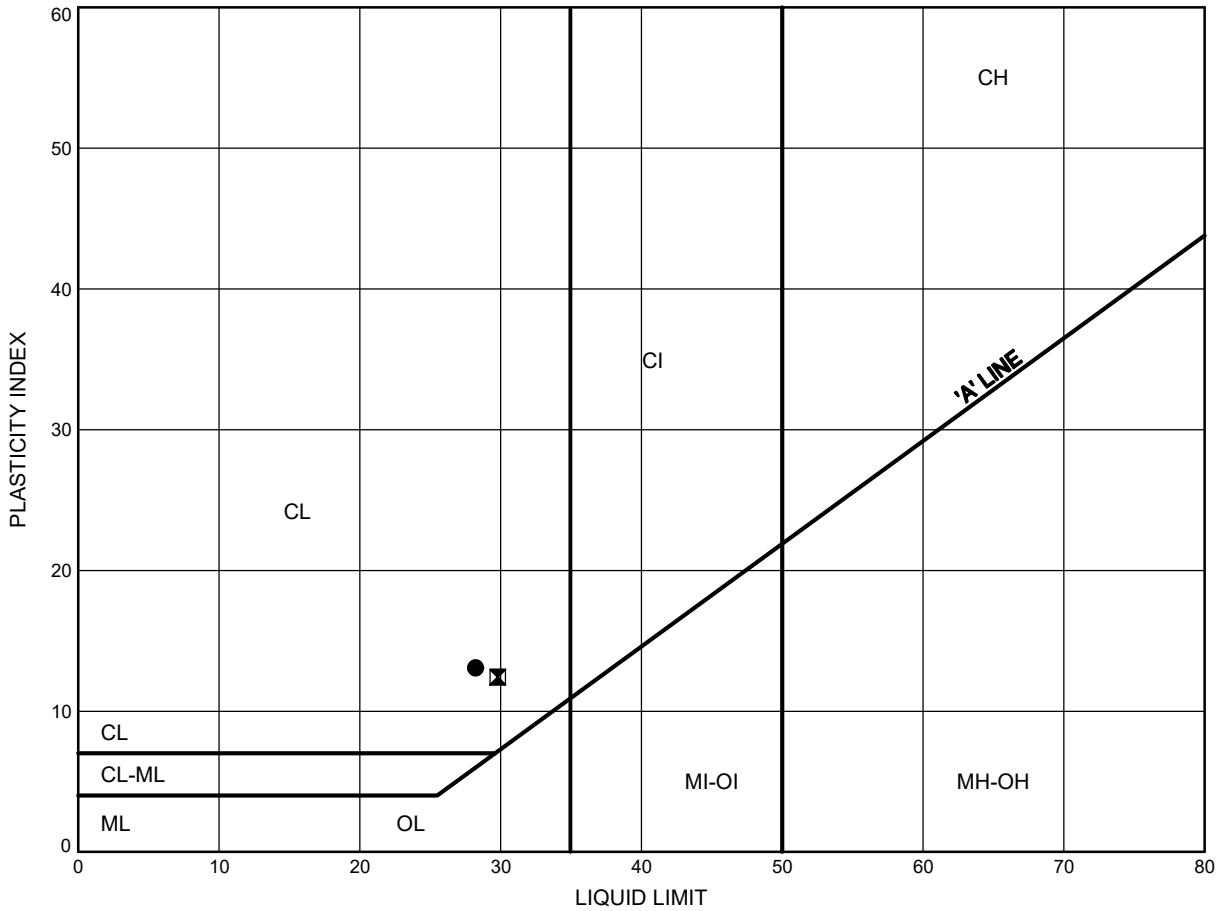
Prep'd AN
Chkd. AMP

Street 'A'

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY to Clayey SILT TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SA 17-07	3.4	185.9
⊠	SA 17-08	1.8	187.6

Date September 2017
W.P.



Prep'd AN
Chkd. AMP

Certificate of Analysis

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont., Canada, K0L 2H0



Client
SGS LIMS Number
Analysis Package:

Attention: Mohammad Eghtesadi
Project#: 12307-427
Thurber Engineering Ltd.
CA14660-AUG17
Corrosivity (Soil)

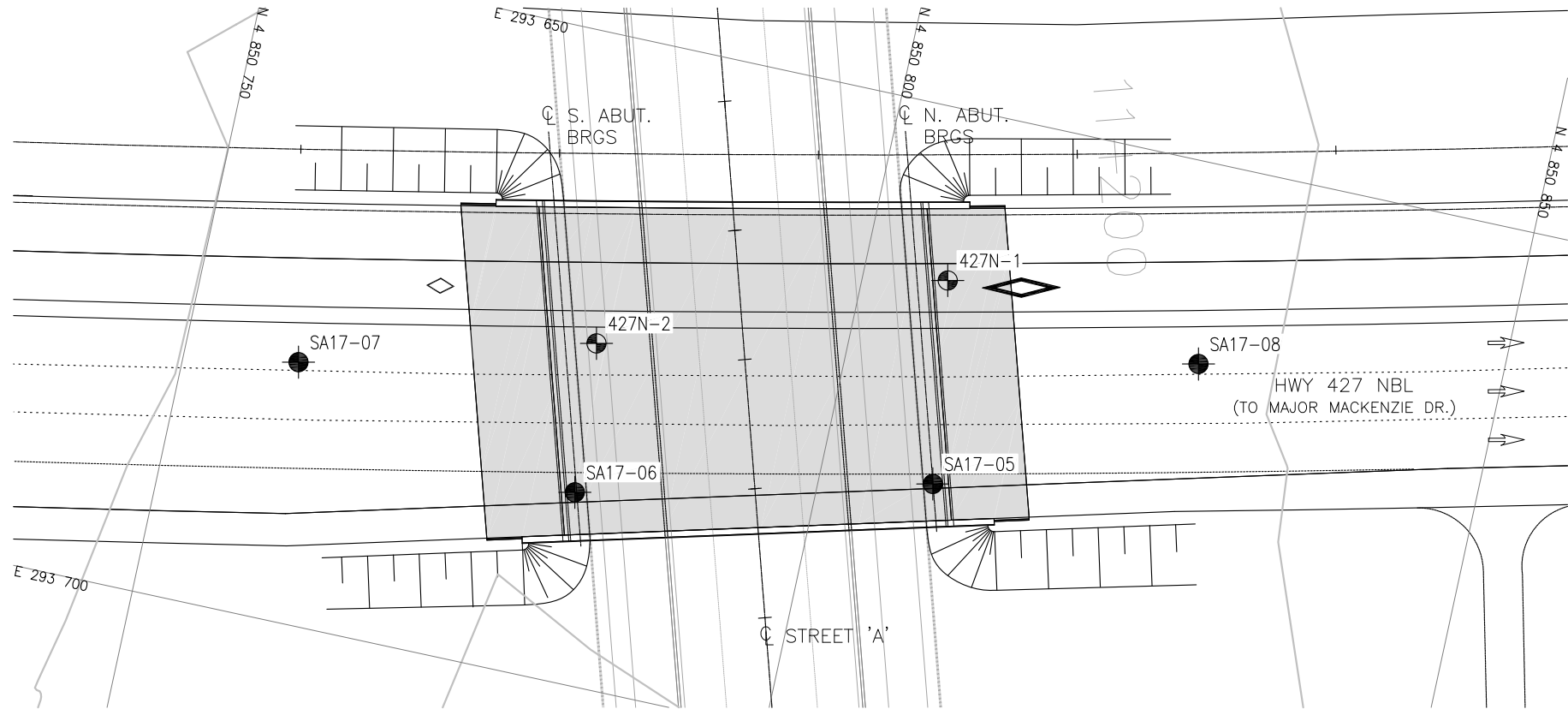
Sample ID	Unit	SA 17-03, SS4 (7.5-9.5)	SA17-04, SS2 (2.5-4.5)	SA17-06, SS3 (5-7)
-----------	------	-------------------------	------------------------	--------------------

Sample Date/Time		27-Jun-17	28-Jun-17	04-Jul-17
Moisture	%	13.0	13.2	13.3
pH	no unit	8.66	8.48	8.49
Corrosivity Index	none	4.0	1.0	1.0
Soil Redox Potential	mV	222	220	239
Sulphide	mg/L	<0.02	<0.02	<0.02
Chloride	mg/L	1.3	1.5	1.4
Sulphate	mg/L	49	37	16
Conductivity	uS/cm	142	119	108
Resistivity (calculated)	ohms.cm	7020	8400	9240

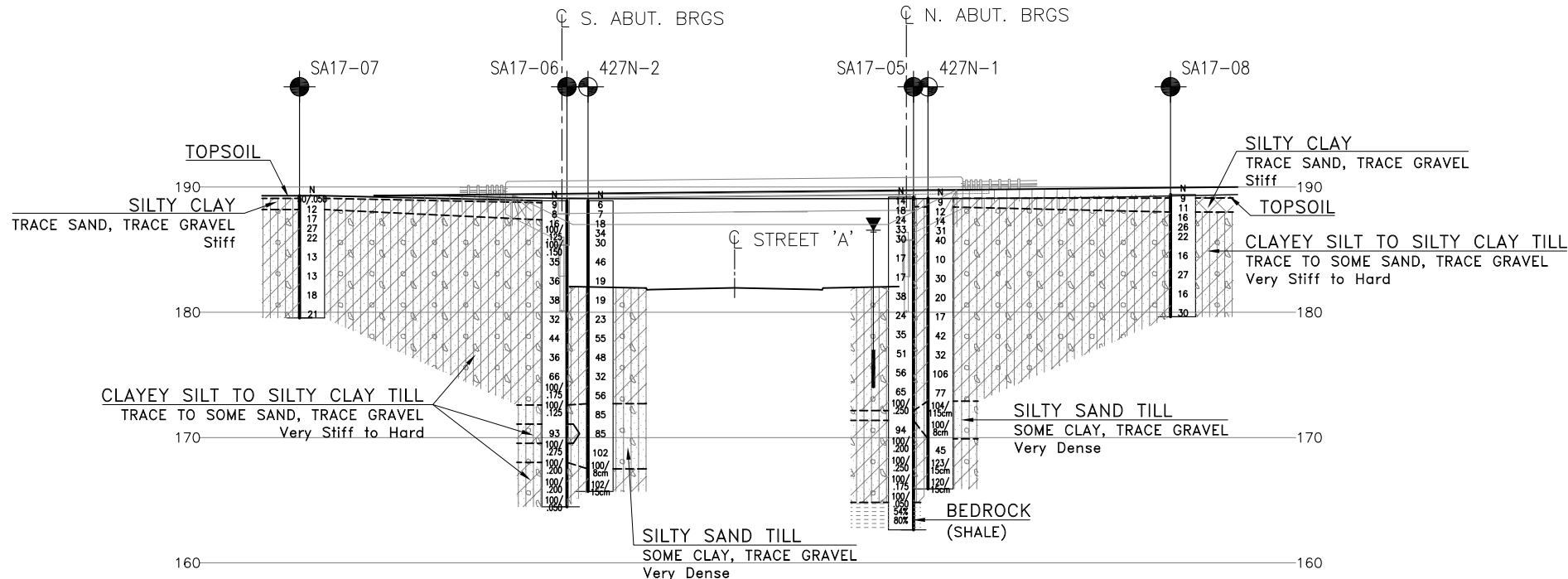
Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

Appendix C
Borehole Locations and Soil Strata Drawings



PLAN



PROFILE

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



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
427N-1	189.1	4 850 806.5	293 663.2
427N-2	188.9	4 850 781.0	293 673.7
427S-1	189.3	4 850 780.8	293 588.5
427S-2	189.4	4 850 755.5	293 594.6
SA17-01	189.7	4 850 734.3	293 599.0
SA17-02	189.2	4 850 803.2	293 586.8
SA17-03	189.6	4 850 751.5	293 582.6
SA17-04	189.3	4 850 784.5	293 599.5
SA17-05	189.2	4 850 808.7	293 678.8
SA17-06	188.9	4 850 781.8	293 685.3
SA17-07	189.3	4 850 758.8	293 680.0
SA17-08	189.4	4 850 826.8	293 665.4

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No.

HWY 427 EXPANSION
HWY 427 NORTH BOUND LANE
OVER STREET 'A'

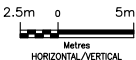
BOREHOLE LOCATIONS AND SOIL STRATA

PROJECT ID.	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION
H427-D	H	7	STR	B14A	DWG	501	A

FILENAME: H:\Drafting\19000\19484\1ED19484-PLPR-HWY 427 Street 'A'.dwg
PLOT DATE: 2/28/2020 10:22 AM

NO.	DATE	REVISIONS	BY	CHK	LEAD	PRJL
A	20/02/28	100% SUBMISSION TO CA	AN	KS	JL	PB

SCALE :

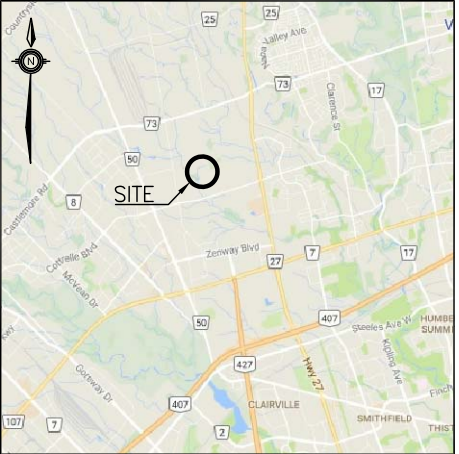


DESIGNED	A. PIASIK	AP	20/02/28
DRAWN	A. NOOR	AN	20/02/28
CHECKED	K. SHI	KS	20/02/28
APPROVED LEAD ENGINEER	J. LEE	JL	20/02/28
APPROVED PROJ. MANAGER	P. BAMFORTH	PB	20/02/28
NAME (PRINT)	INIT.	DATE	



TITLE

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



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
427N-1	189.1	4 850 806.5	293 663.2
427N-2	188.9	4 850 781.0	293 673.7
427S-1	189.3	4 850 780.8	293 588.5
427S-2	189.4	4 850 755.5	293 594.6
SA17-01	189.7	4 850 734.3	293 599.0
SA17-02	189.2	4 850 803.2	293 586.8
SA17-03	189.6	4 850 751.5	293 582.6
SA17-04	189.3	4 850 784.5	293 599.5
SA17-05	189.2	4 850 808.7	293 678.8
SA17-06	188.9	4 850 781.8	293 685.3
SA17-07	189.3	4 850 758.8	293 680.0
SA17-08	189.4	4 850 826.8	293 665.4

-NOTES-

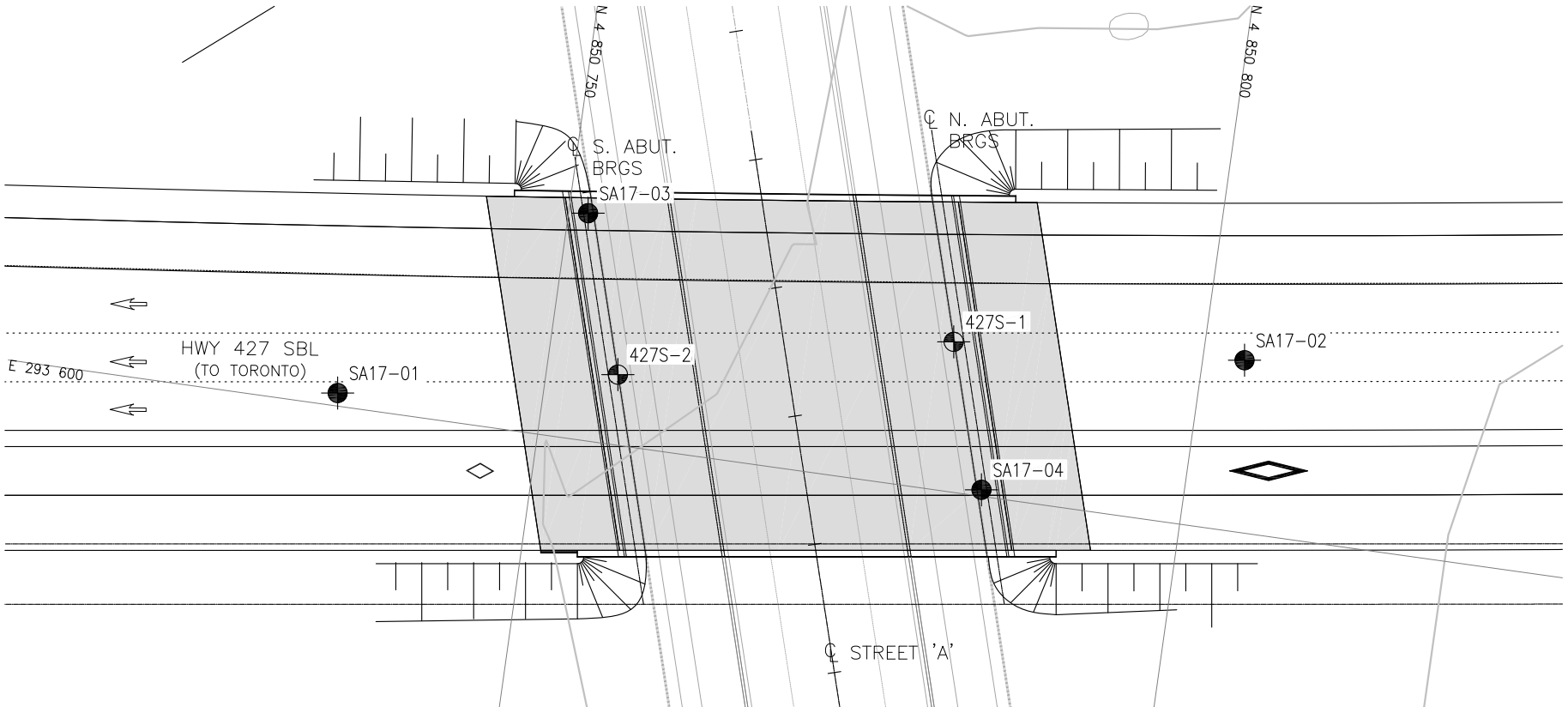
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No.

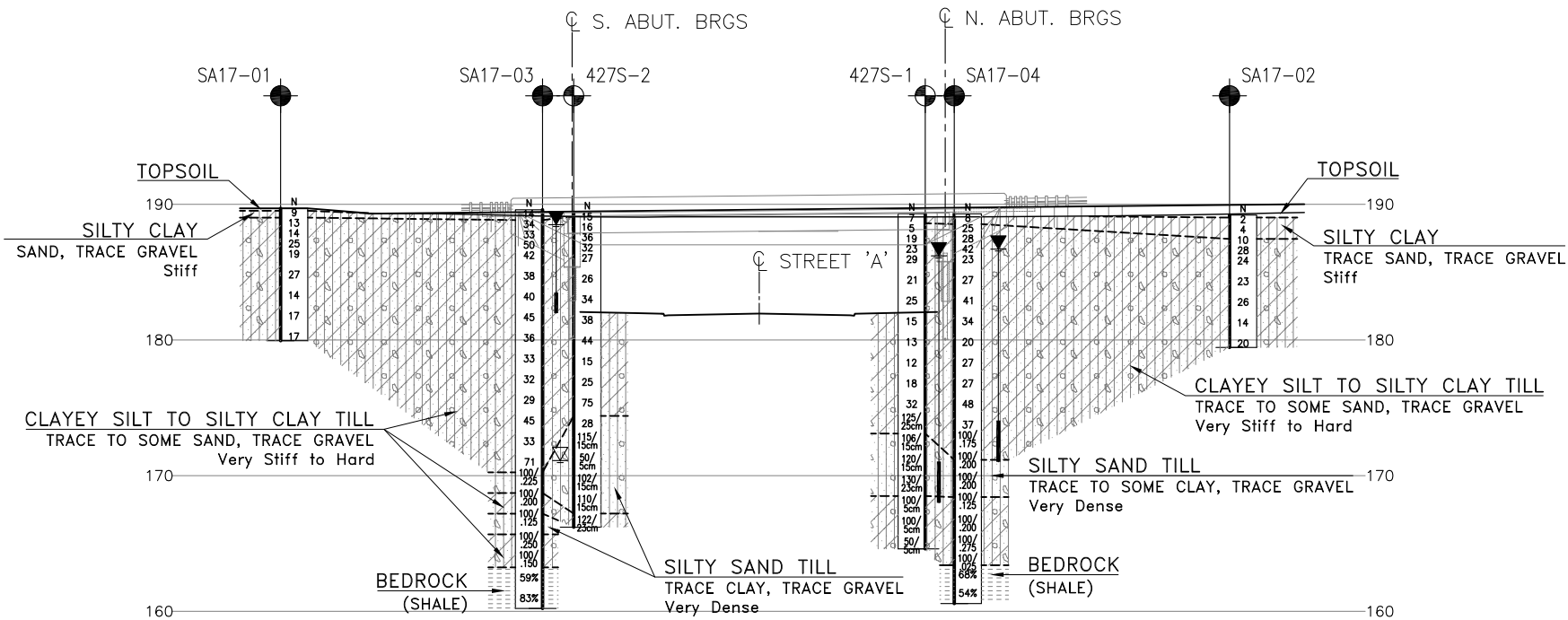
HWY 427 EXPANSION
HWY 427 SOUTH BOUND LANE
OVER STREET 'A'

BOREHOLE LOCATIONS AND SOIL STRATA

PROJECT ID.	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D	H	7	STR	B14B	DWG	601	A



PLAN

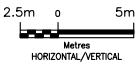


PROFILE

FILENAME: H:\Drafting\19000\19484\1ED19484-PLR-HWY 427 Street 'A'.dwg
PLOT DATE: 2/28/2020 10:22 AM

NO.	DATE	REVISIONS	BY	CHK	LEAD	PRJL
A	20/02/28	100% SUBMISSION TO CA	AN	KS	JL	PB

SCALE :



DESIGNED	A. PIASIK	AP	20/02/28
DRAWN	A. NOOR	AN	20/02/28
CHECKED	K. SHI	KS	20/02/28
APPROVED LEAD ENGINEER	J. LEE	JL	20/02/28
APPROVED PROJ. MANAGER	P. BAMFORTH	PB	20/02/28
NAME (PRINT)	INIT.	DATE	



PROJECT ID.	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D	H	7	STR	B14B	DWG	601	A

Appendix D

**Borehole Location Drawing and Record of Borehole Sheets – Previous Investigation
Geocres Report No.: 30M13-216**

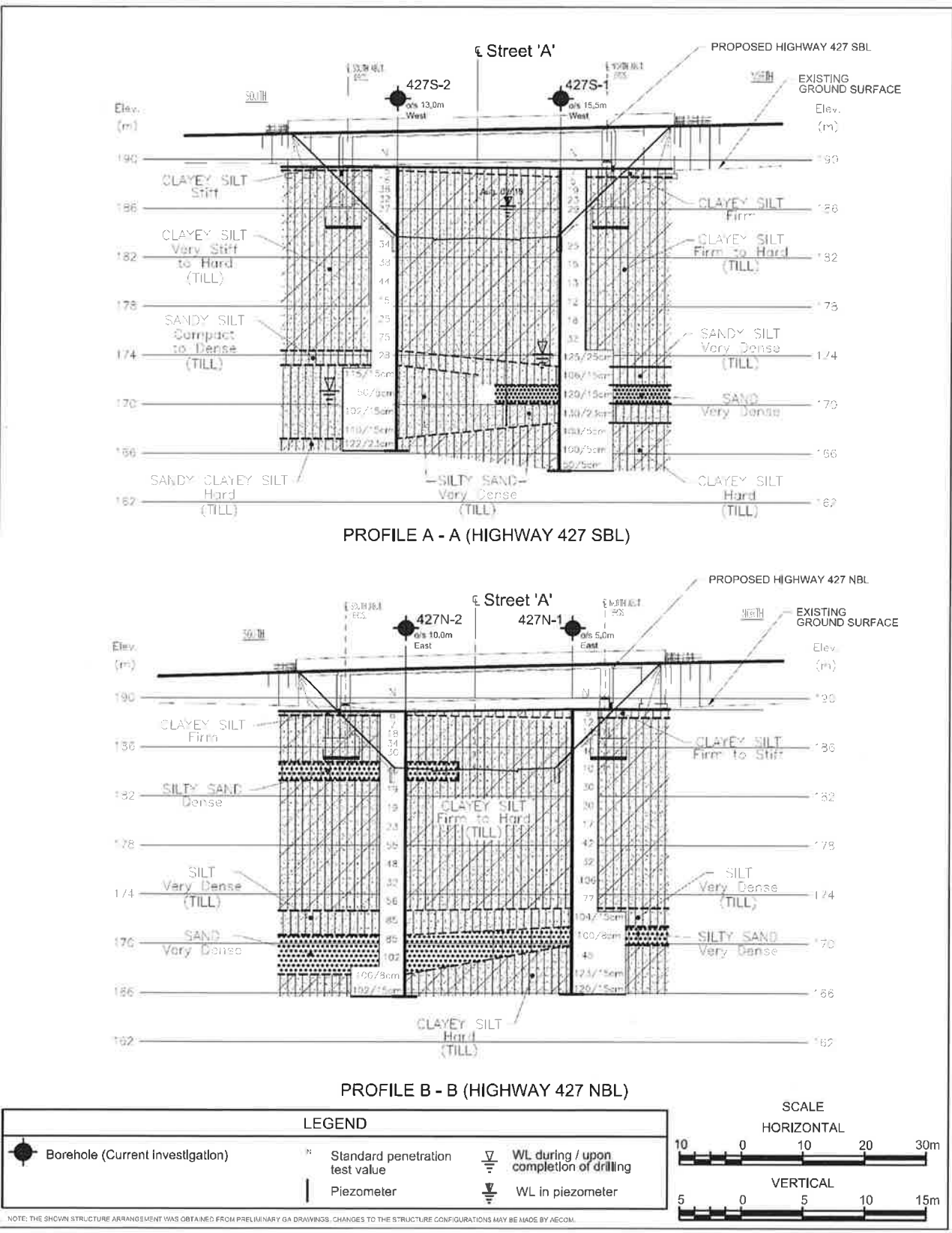
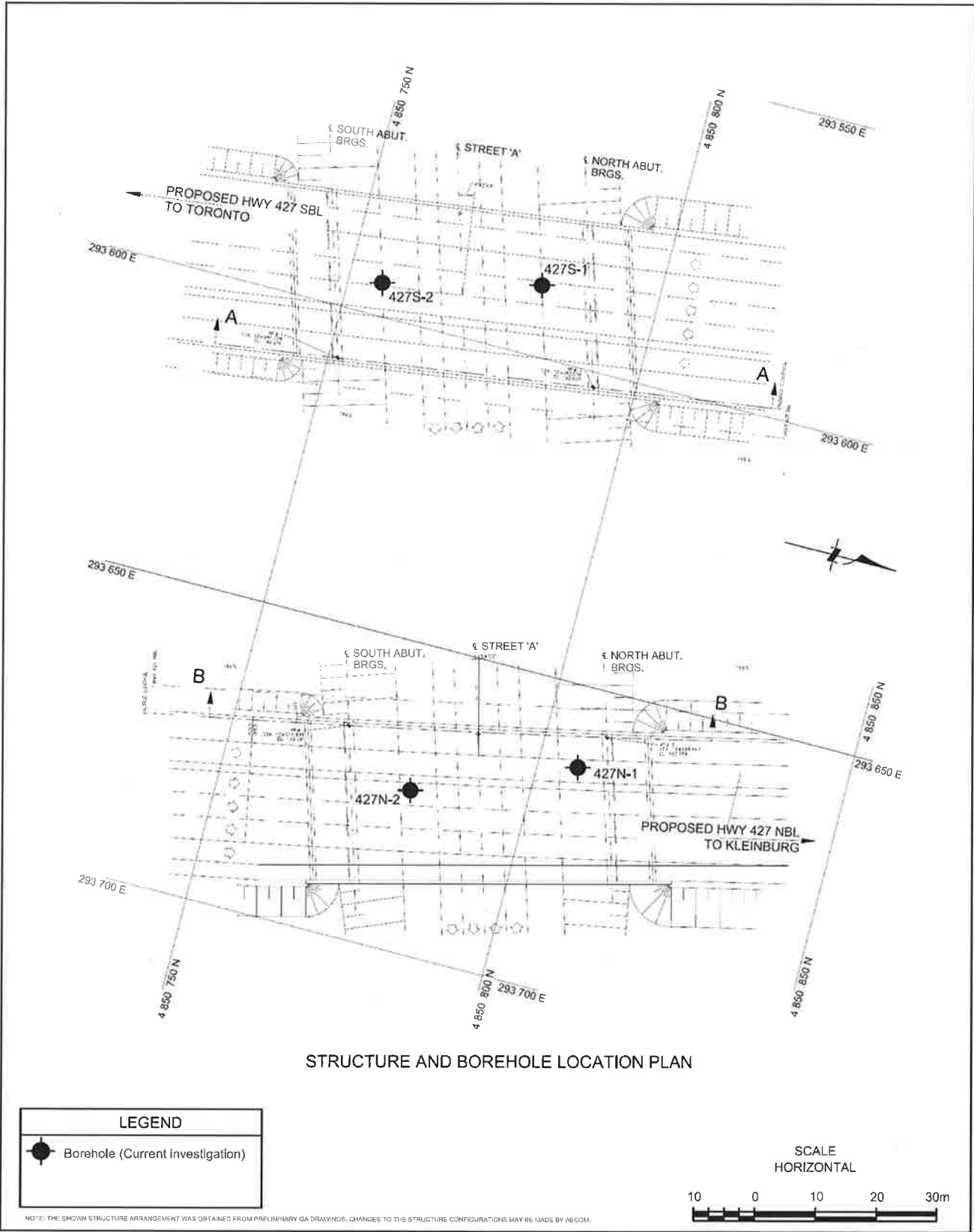
Structure Description: Highway 427 NBL and SBL Overpass at Street ‘A’

Highway 427 Proposed Grade: 192.2 – 192.8 m

Existing Ground Elevation: 188.9 – 189.4 m

Complexity Rating: Middle

Station: 12+968



RECORD OF BOREHOLE No 427N-1

1 of 2

METRIC

G.W.P. _____ LOCATION Highway 427 Co-ords: 4 850 806.5 N; 293 663.2 E ORIGINATED BY A.H.
DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary COMPILED BY G.D.
DATUM Geodetic DATE July 15, 2016 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
189.1	Ground Surface													
0.0	Clayey silt, organics		1	SS	9		189							
188.4	Firm to Dark Moist stiff brown													
0.7	Clayey silt trace to some sand trace gravel		2	SS	12		188							
	Stiff Light Moist to hard brown		3	SS	14									
	(TILL)		4	SS	31		187							
	Grey		5	SS	40		186							
			6	SS	10		185							
			7	SS	30		184							
			8	SS	20		183							
			9	SS	17		182							
			10	SS	42		181							
			11	SS	32		180							
			12	SS	106		179							
	a thin layer of sand						178							
							177							
							176							
							175							
174.1														

ON MTO_NEW LOGO HWY 427 15TF013A.GPJ ON_MOT.GDT 24/08/2016 3:53:42 PM

Numbers refer to
Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 427N-1

2 of 2

METRIC

G.W.P. _____ LOCATION highway 427
Co-ords: 4 850 806.5 N; 293 663.2 E ORIGINATED BY A.H.
DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary COMPILED BY G.D.
DATUM Geodetic DATE July 15, 2016 CHECKED BY B.R.

[illegible]

RECORD OF BOREHOLE No 427N-2

1 of 2

METRIC

G.W.P. _____ LOCATION Highway 427 Co-ords: 4 850 781.0 N; 293 673.7 E ORIGINATED BY A.H.
DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary COMPILED BY G.D.
DATUM Geodetic DATE July 14, 2016 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
188.9	Ground Surface													
0.0 188.9 0.3	Clayey silt, organics Firm Dark Moist brown		1	SS	6									
	Clayey silt some sand, trace gravel Firm to Light Moist hard brown		2	SS	7		188							
	(TILL)		3	SS	18		187							1 12 60 27
			4	SS	34		186							
	Grey		5	SS	30		185							
184.8 4.1	Silty sand, trace clay Dense Grey Moist		6	SS	46		184							0 59 34 7
183.3 5.6	Clayey silt some sand, trace gravel Very stiff Grey Moist to hard		7	SS	19		183							
	(TILL)		8	SS	19		182							
			9	SS	23		181							
			10	SS	55		180							
			11	SS	48		179							
			12	SS	32		178							2 15 61 22
							177							
							176							
							175							
173.9							174							

ON MTO_NEW LOGO HWY 427 15TF013A.GPJ ON MOT.GDT 24/08/2016 3:53:43 PM

+ , X 5 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 427N-2

2 of 2

METRIC

G.W.P. _____ LOCATION Highway 427
 Co-ords: 4 850 781.0 N; 293 673.7 E
 DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary
 DATUM Geodetic DATE July 14, 2016
 ORIGINATED BY A.H.
 COMPILED BY G.D.
 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W _p			W	W _L
							20 40 60 80 100				10 20 30						
173.9																	
15.0	Clayey silt some sand, trace gravel Hard Grey Moist (TILL) (Cont'd.)		13	SS	56								○				
172.7																	
16.2	Silt, some sand trace clay, trace gravel Very dense Grey Moist (TILL)		14	SS	85								○				
170.7																	
18.2	Sand with silt, trace gravel Very dense Grey Moist with gravel, trace silt Wet trace gravel		15	SS	85								○				
													○				
167.5																	
21.4	Clayey silt trace sand, trace gravel shale fragments Hard Grey Moist (TILL)		17	SS	100/8cm								○				
165.7			18	SS	102/15cm								○				
23.2	End of borehole																

RECORD OF BOREHOLE No 427S-1

1 of 2

METRIC

G.W.P. _____ LOCATION Highway 427 Co-ords: 4 850 780.8 N; 293 588.5 E ORIGINATED BY A.H.
 DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary COMPILED BY G.D.
 DATUM Geodetic DATE July 12 and 13, 2016 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N-VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
189.3	Ground Surface							20 40 60 80 100							
0.0	Clayey silt, trace sand		1	SS	7		189								
188.6	Firm Light Moist brown														
0.7	Clayey silt trace to some sand trace gravel		2	SS	5		188								
	Firm to Light Moist hard brown		3	SS	19		187								
	(TILL)		4	SS	23		186								
			5	SS	29		185								
			6	SS	21		184								
			7	SS	25		183								
			8	SS	15		182								
			9	SS	13		181								
			10	SS	12		180								
			11	SS	18		179								
			12	SS	32		178								
							177								
							176								
							175								

RECORD OF BOREHOLE No 427S-1

2 of 2

METRIC

G.W.P. _____ LOCATION Highway 427
 Co-ords: 4 850 780.8 N; 293 588.5 E
 DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary
 DATUM Geodetic DATE July 12 and 13, 2016
 ORIGINATED BY A.H.
 COMPILED BY G.D.
 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N° VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
174.3							20	40	60	80	100					
15.0	Clayey silt some sand, trace gravel Hard Grey Moist (TILL) (Cont'd.)		13	SS	125/25cm											
173.1																
16.2	Sandy silt trace clay, trace gravel shale fragments Very dense Grey Moist to wet (TILL)		14	SS	106/15cm											
171.6																
17.7	Sand, trace silt Very dense Grey Wet		15	SS	120/15cm											
170.1																
19.2	Silty sand some clay, trace gravel shale fragments Very dense Grey Moist (TILL)		16	SS	130/23cm											
168.5																
20.8	Clayey silt some sand, trace gravel shale fragments Hard Grey Moist (TILL)		17	SS	100/5cm											
			18	SS	100/5cm											
															</	

RECORD OF BOREHOLE No 427S-2

1 of 2

METRIC

G.W.P. _____ LOCATION Highway 427 Co-ords: 4 850 755.5 N; 293 594.6 E ORIGINATED BY A.H.
DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE July 11, 2016 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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			GR	SA	SI	CL
189.4	Ground Surface																		
0.0 189.1	Clayey silt, trace sand		1	SS	15														
0.3	Stiff Dark Moist brown																		
	Clayey silt trace to some sand trace gravel		2	SS	16														
	Very stiff Light Moist to hard brown		3	SS	36														
	(TILL)		4	SS	32														
			5	SS	27														
	Grey		6	SS	26														
			7	SS	34														
			8	SS	38														
			9	SS	44														
			10	SS	15														
			11	SS	25														
			12	SS	75														
174.4																			

ON MTO_NEW LOGO HWY 427 15TF013A.GPJ ON MOT.GDT 24/08/2016 3:53:44 PM

+ , x 5

Numbers refer to Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 427S-2

2 of 2

METRIC

G.W.P.	LOCATION	Highway 427 Co-ords: 4 850 755.5 N: 293 594.6 E
--------	----------	--

ORIGINATED BY A.H.

DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers

COMPILED BY G.D.

DATUM Geodetic DATE July 11, 2016

CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20 40 60 80 100		20 40 60 80 100							10 20 30	
174.4	Sandy silt some clay, trace gravel Compact Grey Moist to dense (TILL)		13	SS	28		174								7 31 47 15			
173.2																		
16.2																		
Silty sand trace to some gravel trace clay shale fragments Very dense Grey Moist to wet (TILL)	14	SS	115/15cm		173													
			15	SS	50/5cm			172										
			16	SS	102/15cm			171										
			17	SS	110/15cm			170										
			</															

Appendix E
Stability Analysis Plots

STREET 'A' OVERPASS TEMPORARY CUT UNDRAINED CONDITION

File Name: Street 'A' Temporary Cut - Undrained.gsz

Date: 1/23/2020

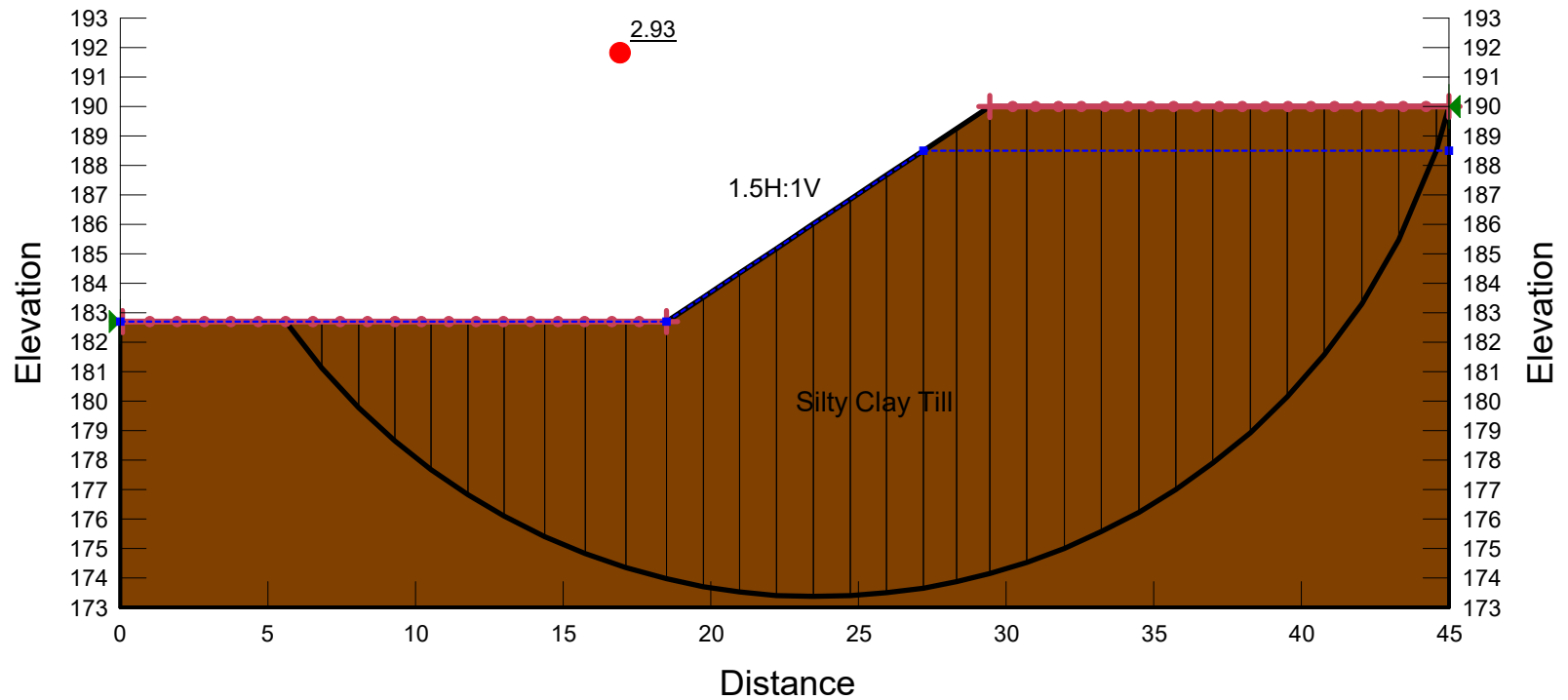
Last Edited By: Geoff Lay

Silty Clay Till 20 kN/m³ 75 kPa 0 °

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0



STREET 'A' OVERPASS TEMPORARY CUT DRAINED CONDITION

File Name: Street 'A' Temporary Cut - Drained.gsz

Date: 1/23/2020

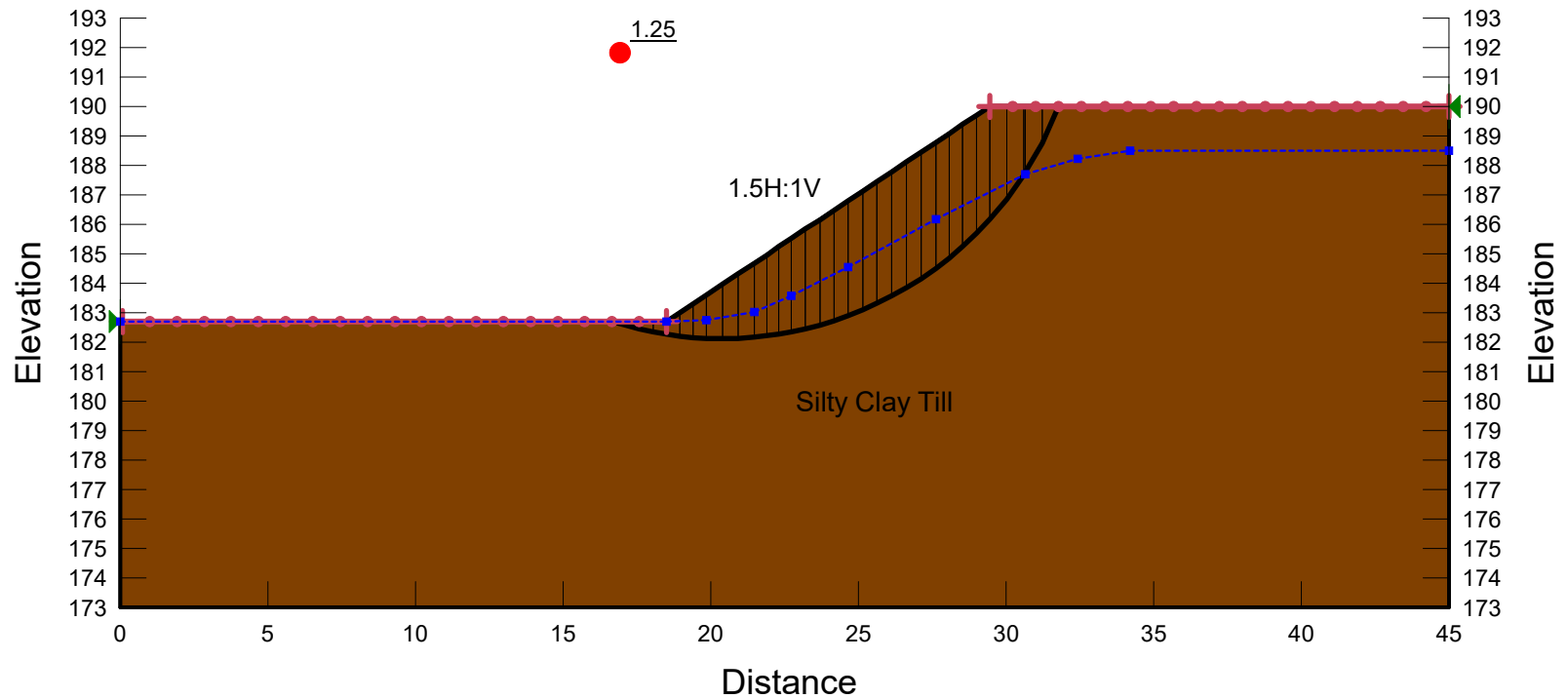
Last Edited By: Geoff Lay

Silty Clay Till 20 kN/m³ 5 kPa 29 °

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0



STREET 'A' OVERPASS PERMANENT CUT UNDRAINED CONDITION

File Name: Street 'A' Permanent Cut - Undrained.gsz

Date: 1/23/2020

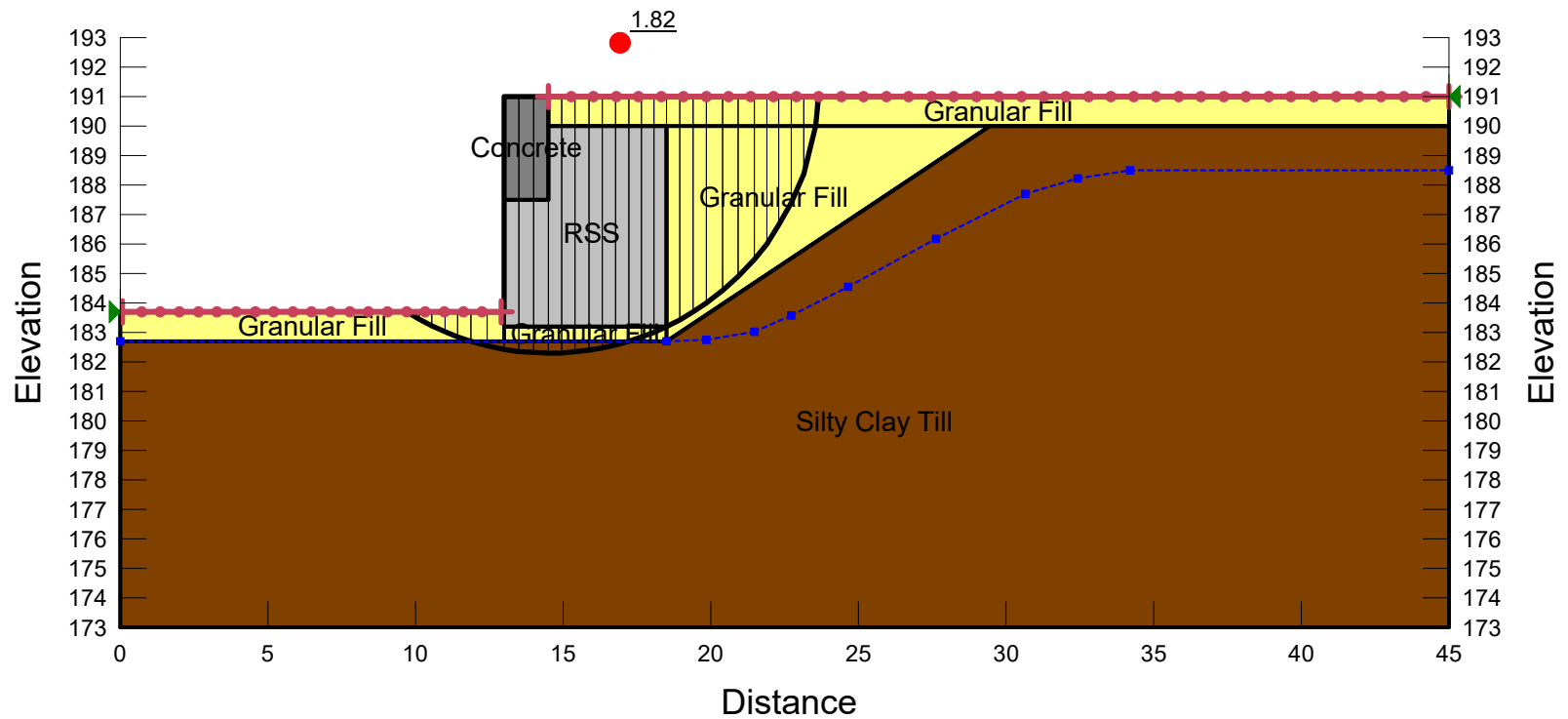
Last Edited By: Geoff Lay

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0

Concrete	1 kN/m ³	1,000 kPa	0 °
RSS	22 kN/m ³	200 kPa	34 °
Granular Fill	21 kN/m ³	0 kPa	35 °
Silty Clay Till	20 kN/m ³	75 kPa	0 °



STREET 'A' OVERPASS PERMANENT CUT DRAINED CONDITION

File Name: Street 'A' Permanent Cut - Drained.gsz

Date: 1/23/2020

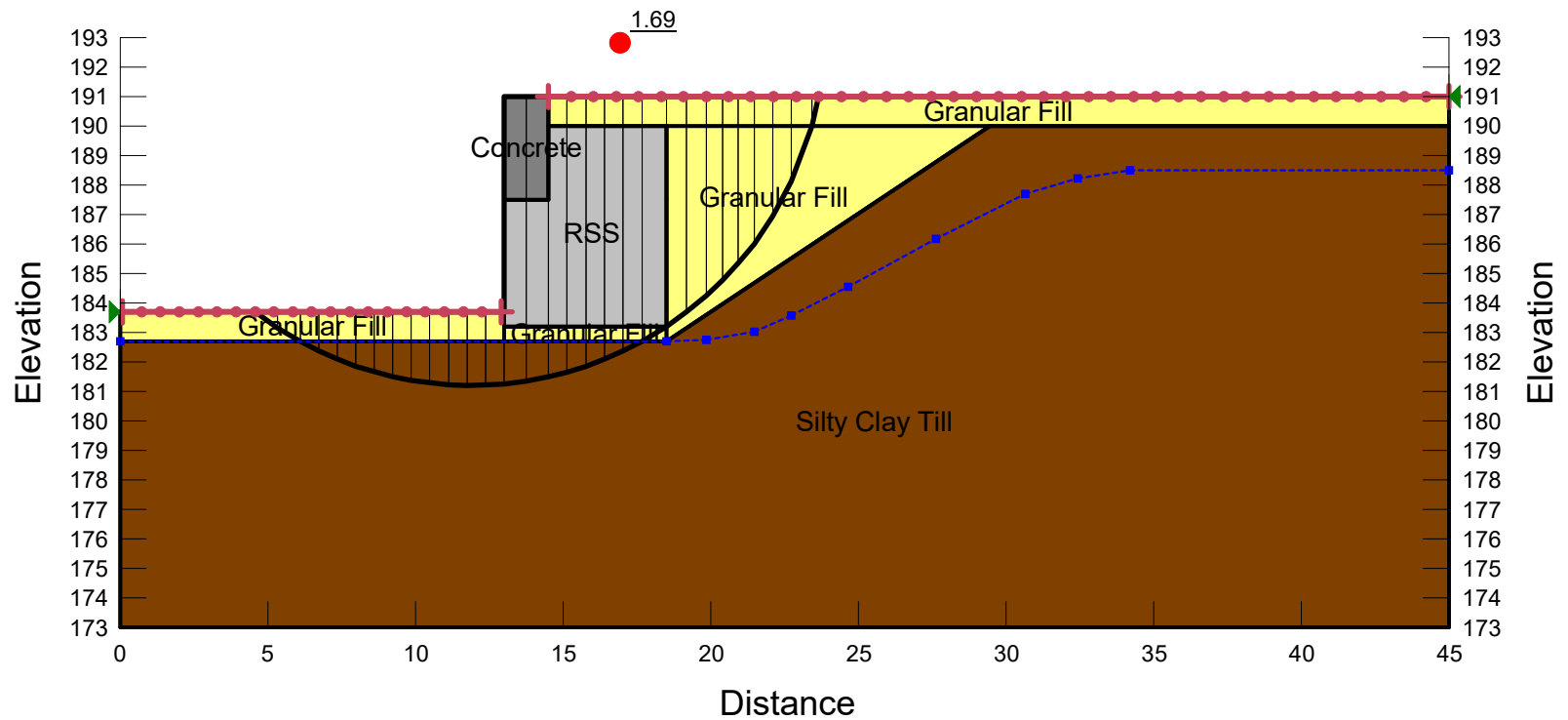
Last Edited By: Geoff Lay

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

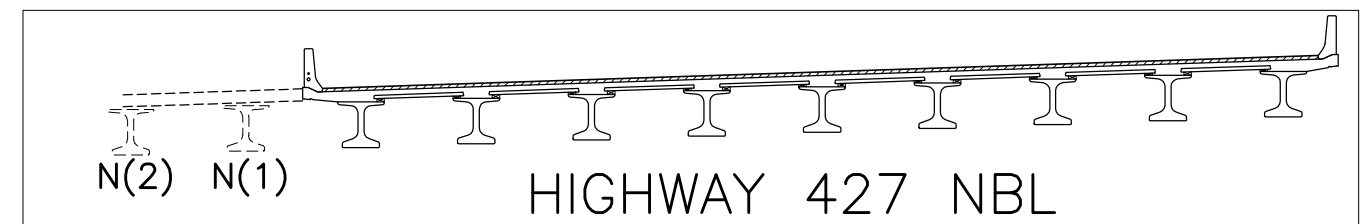
Seismic: 0

Concrete	1 kN/m ³	1,000 kPa	0 °
RSS	22 kN/m ³	200 kPa	34 °
Granular Fill	21 kN/m ³	0 kPa	35 °
Silty Clay Till	20 kN/m ³	5 kPa	29 °



Appendix F

Sketch – Street A Future Widening Bridge Clearances (For Information Only)



NOTES:

1. FUTURE GIRDER SPACING ASSUMED CURRENT DESIGN SPACING.
2. FUTURE GIRDERS ASSUMED CURRENT GIRDER DESIGN HEIGHTS.
3. NEW PROFILE IS FROM JANUARY 2020. PROVIDED BY COLE ENGINEERING
4. OLD PROFILE IS FROM 2016/2017. PROVIDED FROM PA BACKGROUND DOCUMENTS.

<div style="text-align: center;"> HWY 427 EXPANSION STREET A FUTURE WIDENING BRIDGE CLEARANCES </div>							
PROJECT ID:	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D		7	HWY	B14	SKF	216	B