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Highway 427 Expansion
Major Mackenzie Drive Over West Robinson Creek (Structure B19)

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1. INTRODUCTION

This report presents the results of a foundation investigation and provides foundation recommendations for the design and construction of the proposed bridge to carry the realigned Major Mackenzie Drive (MMD) over West Robinson Creek (WRC). The project is part of the proposed 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 foundation investigation by Thurber Engineering (Thurber) as well as previous investigations at the site the results of which were presented in the reports listed below:

- GEOCRE 30M13-175: Preliminary Foundation Investigation and Design Report, West Robinson Creek bridge on Major Mackenzie drive, Highway 427 Extension from Highway 7 to Major Mackenzie Drive, Ministry of Transportation, Ontario, W.O. 05-20012, dated August 2009, prepared by Golder Associates.
- GEOCRE 30M13-216: Preliminary Foundation Investigation and Design Report, Highway 427 Expansion Project, Extension from Highway 7 to Major Mackenzie Drive, City of Vaughan, Ontario, W.O. 18, dated March 2016, prepared by Peto MacCallum Ltd.

Foundation recommendations presented in this report were prepared based on Preliminary General Arrangement (GA) drawing H427-D-F-5A-STR-B19-DWG-800-A.

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, GEOLOGY BACKGROUND AND PROJECT DESCRIPTION

The site is located along the existing Major Mackenzie Drive approximately 600 m west of Huntington Road and 100 m north of Canadian Pacific Railway (CPR) in Vaughan, Ontario.

The proposed structure will be located within the floodplain of the West Robinson Creek. The Creek at the site is up to 6 m wide and flows generally north to south. The streambed is at approximately Elev. 198 to 198.5 m. The floodplain to the west of the creek is broad and flat and at approximately Elev. 199 m. To the east of the creek, the ground surface increases at a 3H:1V slope to about Elev. 202.5 m.

The site is situated within the Peel Plain physiographic region the subsurface condition in which generally comprises clayey silt to silty clay of Halton till with interlayers of sand and silt. 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 by shale bedrock of the Georgian Bay Formation with siltstone and limestone interlayers.

Based on the GA drawing, the proposed structure is a single span bridge with integral abutment configuration. The bridge abutments are proposed to be supported on driven H-piles. The side slopes and foreslopes of the approach embankments will have a slope inclination of 2H:1V.

3. GEOTECHNICAL INVESTIGATION

The current field investigation at the proposed bridge site was conducted between July 4 and July 28, 2017, and consisted of advancing five (5) boreholes, designated as Boreholes MMW 17-01 to MMW 17-05 to depths ranging between 9.3 m and 35.3 m.

Borehole coordinates and ground surface elevations were provided by CJV. The Record of Borehole sheets (which includes the approximate locations in MTM NAD 83, Zone 10 coordinates) and the Borehole Locations and Soil Strata Drawing are included in Appendix A and Appendix D, respectively.

Track and truck mounted drill rigs supplied by Landshark Drilling Inc. of Brantford, Ontario, and Walker Drilling Ltd., of Utopia, Ontario, were used to advance the boreholes. Soil and highly weathered rock samples were obtained at selected intervals using a 50 mm nominal inner diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT) procedures as per ASTM D1586. The bedrock was cored a minimum of 3 m using NQ-sized coring equipment in one borehole. All rock cores were logged, and Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and Fracture Index (FI) were determined.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and measured upon completion of drilling. However, since water was used during the drilling operations these measurements were considered not reliable. Standpipe piezometers were installed in two Boreholes (MMW 17-03 and MMW 17-04). The other boreholes were backfilled as per O. Reg. 903. All piezometers will be decommissioned by Project Co. following final round of groundwater level measurements as per O. Reg. 903.

Three borehole logs are available from the previous investigations. Boreholes S31 and S32 from the 2009 report and Borehole MMRC-1 from the 2016 report are enclosed in Appendix C.

4. SUBSURFACE CONDITIONS

A general description of the stratigraphy is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description which was prepared for interpretation of the site conditions. Subsurface soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions at the site generally consist of a surficial layer of clayey silt to silty clay underlain clayey silt to silty clay till overlying silt and sand till. The sand and silt till was underlain by a sand to gravelly sand deposit over shale bedrock at the west side of the creek and extended to shale bedrock at the east side of the creek. Occasional auger grinding, hard augering, and/or split spoon bouncing were noted during advancing the boreholes in till deposits and sand to gravelly sand, likely indicating presence of cobbles and/or boulders.

More descriptions of the subsurface conditions at the site are presented below.

4.1 Asphalt

Asphalt was encountered at the ground surface in the boreholes advanced through the existing Major Mackenzie Drive (Boreholes MMW 17-01 and MMW 17-05). The thickness of the asphalt ranged from 25 to 125 mm.

4.2 Topsoil

Topsoil was encountered at the ground surface in the boreholes advanced north of the existing Major Mackenzie Drive (MMW 17-02 to MMW 17-04). The thickness of the topsoil ranged from 100 to 225 mm.

4.3 Fill

A 1.5 to 2.1 m thick layer of sand fill was encountered beneath the asphalt pavement in Boreholes MMW 17-01 and MMW 17-05. The fill extended to depths of 1.5 m and 2.2 m (Elev. 199.3 and 198.8m). The SPT-N values recorded within the fill ranged from 13 to 28 blows per 0.3 m of penetration indicating a compact relative density.

4.4 Surficial Clayey Silt to Silty Clay

A surficial layer of clayey silt to silty clay was encountered in all boreholes. The layer was 0.7 to 2.5 m thick. The silty clay extended to depths ranging from 0.8 to 4.1 m (Elev. 201.9 to 196.8 m). The SPT-N values within the silty clay ranged typically from 4 to 10 blows per 0.3 m of penetration indicating a firm to stiff consistency.

4.5 Clayey Silt to Silty Clay Till

A 4.7 to 4.8 m thick layer of clayey silt to silty clay till was encountered underlying the surficial clayey silt to silty

clay in the current boreholes advanced east of West Robinson Creek (MMW 17-02 and MMW 17-04). The cohesive till extended to 5.6 m depth (Elev. 197.2 m and 197.1 m).

SPT-N values recorded within the cohesive till ranged from 17 to 51 blows per 0.3 m penetration indicating a very stiff to hard consistency.

Glacial tills inherently contain cobbles and boulders.

4.6 Silt and Sand Till

A layer of silt and sand till was encountered below the surficial clayey silt to silty clay in Boreholes MMW 17-01, MMW 17-03 and MMW 17-05, and below the clayey silt to silty clay till in Boreholes MMW 17-02 and MMW 17-04. Boreholes MMW 17-01 and MMW 17-02 were terminated within the sand and silt till. The till ranged from 7.9 to 24.9 m in thickness and extended to 10.2 to 30.5 m depth (Elev. 189.2 to 172.2 m).

SPT-N values recorded within the sand and silt till ranged typically from 34 blows to greater than 100 blows per 0.3 m of penetration indicating a dense to very dense consistency.

Glacial tills inherently contain cobbles and boulders.

4.7 Sand to Gravelly Sand

A layer of sand to gravelly sand was encountered underlying the sand and silt till in Boreholes MMW 17-03 and MMW 17-05. Borehole MMW 17-03 was terminated within the layer at 15.8 m depth. The sand layer was 15.2 m thick and extended to a depth of 28.5 m (172.5 m).

SPT-N values within the sand to gravelly sand layer ranged typically from 51 blows per 0.3 m penetration to 100 blows per 0.075 m of penetration indicating a very dense relative density. Two SPT-N values of 12 and 16 blows recorded in Borehole MMW 17-03 were likely associated with hydraulic disturbance.

4.8 Silt

A 2.9 m thick silt layer was encountered within the sand to gravelly sand layer in Borehole MMW 17-05 at a depth of 20.9 m. The silt extended to a depth of 23.8 m (Elev. 177.2 m).

An SPT-N value of 44 blows per 0.3 m penetration was recorded in the silt indicating a dense relative density.

4.9 Shale Bedrock

Grey shale bedrock of the Georgian Bay Formation was encountered in Boreholes MMW 17-04 and MMW 17-05. The bedrock was confirmed by coring in Borehole MMW 17-04. The bedrock surface was encountered at depths ranging between 28.5 and 30.5 m (Elev. 172.5 and 172.2 m). The shale bedrock was highly weathered generally within 1 m of bedrock surface. The TCR, SCR and RQD values obtained below the highly weather zone ranged from 90 to 100%, 90 to 100%, and 67 to 87%, respectively.

4.10 Groundwater Levels

Water levels measured in the piezometers installed during the current investigation are summarized in Table 4.1.

Table 4.1 – Piezometer Details and Groundwater Level Measurements

Borehole	Measurement Date	Water Level (m)		Native Material at Screen
		Depth	Elevation	
MMW 17-03	-	-	-	Silt and Sand Till
MMW 17-04 (S)	Aug 9, 2017 Oct 24, 2017	Dry 3.5	Dry 199.2	Clayey Silt Till

Borehole	Measurement Date	Water Level (m)		Native Material at Screen
		Depth	Elevation	
MMW 17-04 (D)	Aug 9, 2017	1.9	200.8	Silt and Sand Till
	Oct 24, 2017	2.0	200.7	

(S) denotes Shallow piezometer, (D) denotes Deep piezometer

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 lenses or zones of more permeable sands and silts within the till.

The preliminary GA drawing indicates a 100-year flood level at Elev. 199.8 m and a regional storm level at Elev. 202.0 m.

4.11 Corrosion and Sulphate Test Results

Soil samples collected from selected boreholes were submitted for analytical testing of corrosivity parameters and sulphate content. The laboratory certificates of analyses are presented in Appendix B. The results of the analytical tests are summarized in Table 4.2.

Table 4.2 – Corrosion and Sulphate Test Results

Parameter Tested	Unit	MMW 17-03	MMW 17-04	MMW 17-05
		SS5	SS6	SS2
Moisture	%	6.9	14.8	4.8
Corrosivity Index	-	7.5	4.5	13
pH	-	8.7	8.45	9.6
Soil Redox Potential	mV	191	162	227
Sulphide	%	0.08	0.14	< 0.02
Chloride	µg/g	24	5.3	1300
Sulphate	µg/g	80	150	42
Electrical Conductivity	µS/cm	166	249	1650
Resistivity	Ohms.cm	6040	4020	607

5. GEOTECHNICAL RECOMMENDATIONS

5.1 Foundation Design

5.1.1 Spread Footings

Spread footings are not considered a suitable foundation option at this site due to the relatively low bearing resistances available in the surficial clayey silt to silty clay layer, the depth to competent founding stratum and associated dewatering requirement, and the potential for scour at the footing base in close proximity of the water course. Therefore, this foundation option has not been developed further.

5.1.2 Driven H-Piles

Based on the available subsurface information, supporting the proposed bridge on steel H-piles driven into the very dense sand and gravel or silt and sand till is feasible. The recommendations and discussion on design and construction of driven H-piles are presented below. Cobbles and boulders generally exist within the till deposits in the project area.

5.1.2.1 Axial Pile Resistance

The axial resistances of a steel HP310x110 pile driven into the very dense sand and gravel or silt and sand till were assessed based on the subsurface conditions encountered at the proposed abutment locations. The estimated axial geotechnical resistances are summarized in Table 5.1 below.

Table 5.1 – Geotechnical Resistances for HP310x110

Location (Reference Borehole)	Estimated Pile Tip Elevation (m)	Founding Stratum	Factored ULS (kN)	Factored SLS (kN)
West Abutment (MMW17-03, MMW17-05)	186	Very Dense Sand and Gravel	1400	1100
East Abutment (MMW17-04, MMRC-2)	186	Very Dense Sand and Silt Till	1400	1100

The 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.

The factored geotechnical resistance at SLS provided above corresponds to up to 25 mm of settlement.

5.2 Lateral Pile Resistance

The geotechnical lateral resistance acting on a steel HP310x110 pile in 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)

$$D = \text{pile width in metres (0.31 m for HP310x110)}$$

The lateral resistance acting on a HP310x110 pile in cohesionless soils may be calculated using a value for the 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)

$$D = \text{pile width in metres (0.31 m for HP310x110)}$$

$$n_h = \text{coefficient related to soil relative density (kN/m}^3\text{)}$$

$$\gamma' = \text{effective unit weight (kN/m}^3\text{)}$$

$$K_p = \text{passive earth pressure coefficient}$$

The above equations and parameters provided in Table 5.2 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 pile fails and will not support any additional load at greater displacements.

Table 5.2 – Geotechnical Design Parameters for Lateral Pile Resistance

Location	Soil Unit	Elevation (m)		γ' (kN/m ³)	n_h (kN/m ³)	K_p	S_u (kPa)
		Top	Bottom				
West Abutment (MMW17-03, MMW17-05)	Clayey Silt – Firm	199	198	18	-	-	30
	Clayey Silt – Stiff	198	197	9 (*)	-	-	60
	Silt and Sand Till – Dense	197	196	11 (*)	6,000	3.5	-
	Silt and Sand Till – Very Dense	196	189	12 (*)	10,000	3.8	-
	Sand and Gravel – Very Dense	189	186	12 (*)	12,000	4.0	-
East Abutment (MMW17-04, MMRC-2)	Clayey Silt - Firm	202.5	202	19	-	-	30
	Clayey Silt Till – Very Stiff	202	200	20	-	-	100
	Clayey Silt Till – Hard	200	197	11 (*)	-	-	200
	Silt and Sand Till – Dense	197	195	11 (*)	6,000	3.5	-
	Silt and Sand Till – Very Dense	195	191	12 (*)	10,000	3.8	-
	Silt and Sand Till – Dense to Very Dense	191	186	11.5 (*)	9,000	3.7	-

Note (*): Submerged Unit Weight

The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 5.3. Intermediate values may be obtained by linear interpolation.

Table 5.3 – Subgrade Reaction Reduction Factors for Pile Spacing

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

5.2.1 H-Pile Installation

Pile driving must be controlled in accordance with Standard Drawing SS103-11 (Hiley Formula) and an ultimate pile resistance (2 times the design load at ULS) should be specified by the structural designer.

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.

5.2.2 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.

5.3 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.

5.4 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.

5.5 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	=	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 6.9.3 of the CHBDC, a compaction surcharge should be applied in the design.

Earth pressure coefficients for backfill to the abutment walls are dependent on properties of the granular fill used as the backfill. Typical values are shown in Table 5.4.

Table 5.4 – 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 Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	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

5.6 Seismic Considerations

Based on the encountered subsurface conditions, Site Class C may 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 0.11 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 5.5 may be used:

Table 5.5 – Earth Pressure Coefficients for Earthquake Loading

Loading Condition	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or Type 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, passive case assumes a horizontal surface in front of the wall.

** After Woods

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

5.7 Approach Embankments

5.7.1 General

The existing soils at the abutments and approach embankments generally consist of 0.7 to 2.5 m of firm to stiff clayey silt to silty clay beneath topsoil overlying 4.7 to 4.8 m of very stiff to hard clayey silt to silty clay till. The construction of the structure will require placement of up to 5.7 m of fill at the west approach and up to 2 m at the east approach. The side slopes of the approach embankments will be at an inclination of 2H:1V.

5.7.2 Subgrade Preparation

Stripping of soft and compressible soil and existing topsoil should be subject to construction inspection and completed in accordance with OPSS.PROV 206 and OPSS 802. Should topsoil deposits be encountered with thickness in excess of 250 mm, they should be excavated as per OPSD 203.010. All topsoil and organic deposits encountered in areas where the existing ground slope is steeper than 3H:1V or within 75 m of each structure abutment must be stripped from under the proposed footprint of the embankment as per OPSS.PROV 206.

Following stripping/organic removal, the exposed subgrade should be backfilled with suitable earth/granular materials compacted as per OPSS.PROV 501. The work should be carried out in accordance with OPSS 902 and construction should be carried out in the dry. Once the subgrade is prepared the construction traffic and equipment should not travel on the subgrade.

5.7.3 Approach Embankment Stability

Slope stability analyses were carried out to assess the global stability of the approach embankments. The results of the analysis indicate a factor of safety of greater than 1.3 for short-term conditions and greater than 1.5 for the long-term condition (Figures E1 and E2). The computed FOS for the seismic conditions was greater than 1.1 (Figure E3).

5.7.4 Predicted Settlement

The settlements of the foundation soils were estimated to be in the range of 25 to 35 mm at the west approach and expected to be negligible at the east approach. Significant percentage of the estimated settlements will occur during embankment construction and within first two months following the completion of the embankment construction.

Embankment settlement due to fill compression is estimated to 0.5% of the fill height for granular fill or earth fill compacted to 100% of their SPMDD at a moisture content within 2% of optimum. Approximately 50% of the total fill compression (or 0.25% of the fill height) will occur during construction and the remaining 50% or approximately 15 mm at the west approach and less than 10 mm at the east approach will occur after construction. After backfilling the structure, a waiting period of minimum 2 months should be allowed for embankment settlement to take place prior to final paving.

5.8 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 cohesive till within the likely depth of excavation may be classed as Type 3 soil and cohesionless soils as Type 4 soil.

The excavation and backfilling for foundations should be carried out in accordance with OPSS 902.

The water level measured in piezometers installed into the till varied between Elev. 200.8 and 199.2 m. Excavation for pile cap construction will extend to or below the normal groundwater level at the east abutment. Given the consistency and relatively low permeability of the clayey silt 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 to lower the groundwater table to below the base of excavation and maintain a dry condition within the excavation. The possibility exists that additional pumps may be required if localized zones of high volume of perched groundwater are encountered. A minimum 100 mm thick concrete mud slab is recommended to be placed on the exposed subgrade as soon as practical.

The abutment pile caps should be constructed in the dry.

5.9 Erosion Protection

Slope face treatment/surficial erosion protection should be in general accordance with OPSS.PROV 804. Erosion protection should be provided along any soil surfaces that may be in contact with the creek flow. Detailed design of the erosion protection measures should be carried out by a qualified hydraulic designer.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS.PROV 804.

The bridge GA drawing has been reviewed from a geotechnical perspective. The geotechnical components of the GA drawing are generally consistent with the recommendations provided above.

5.10 Corrosion and Sulphate Attack Potential

The results of the analytical testing for corrosivity and sulphate content of the soil samples 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 to very severe.
- Appropriate protection measures are recommended if metal structural elements are used.

5.11 Construction Concerns

Potential construction concerns include, but not necessarily limited to:

- The driven steel H-pile installation in the till materials may result in pile misalignment and/or tip damages due to the presence of cobbles and boulders. The piling contractors should be alerted to the associated risks.
- All pile caps 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

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


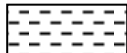



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
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.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
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 MMW 17-01 1 OF 2 METRIC

W.P. _____ LOCATION N 4 853 547.5 E 291 323.8 ORIGINATED BY ES
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.06 - 2017.07.06 CHECKED BY ME

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				
200.8	GROUND SURFACE							20	40	60	80	100				
0.8	ASPHALT: (25mm)															
	SAND, some to trace gravel Compact Brown Moist (FILL)		1	GS			200									
			1	SS	16											
199.3																
1.5	Clayey SILT, some sand, trace gravel Soft to Stiff Dark Brown Moist		2	SS	5		199									
			3	SS	4		198									
			4	SS	9											
	75mm sand seam at 3.5m						197									
196.8																
4.0	SILT and SAND, trace clay, trace gravel Very Dense Grey Moist (TILL)		5	SS	50/ 0.100		196									
							195									
			6	SS	91		194									
			7	SS	88		193									
							192									
191.5	Cobbles		8	SS	86/											
9.3	END OF BOREHOLE AT 9.3m. BOREHOLE OPEN AND WATER LEVEL AT 8.2m. BOREHOLE BACKFILLED WITH				0.175											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

2 OF 2

W.P.	LOCATION	N 4 853 547.5 E 291 323.8	ORIGINATED BY	ES
HWY 427	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM Geodetic	DATE	2017.07.06 - 2017.07.06	CHECKED BY	ME

[illegible]

RECORD OF BOREHOLE No MMW 17-02 1 OF 2 METRIC

W.P. _____ LOCATION N 4 853 577.0 E 291 399.6 ORIGINATED BY ES
 HWY 427 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.28 - 2017.07.28 CHECKED BY ME

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					W _P W W _L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)							
202.8	GROUND SURFACE							20	40	60	80	100								
0.0	TOPSOIL: (100mm)																			
0.1	Clayey SILT , some sand, trace gravel Firm Brown Moist		1	SS	6									○						
201.9							202							○						
0.9	Clayey SILT , some sand, trace gravel Very Stiff to Hard Brown to Grey Moist (TILL)		2	SS	22									○						
	Occasional oxide stains		3	SS	32		201							○						
			4	SS	37		200							○						
			5	SS	26									○						
							199													
			6	SS	19		198							○						
	Occasional sand seam																			
197.2																				
5.6	SILT and SAND , some clay, some gravel Compact to Very Dense Grey Moist (TILL)		7	SS	24		197							○						
														○						
							196													
			8	SS	88		195							○						
							194													
			9	SS	40									○						
193.0																				
9.8	END OF BOREHOLE AT 9.8m.																			

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Sensitivity

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(%) STRAIN AT FAILURE




2 OF 2

W.P.	LOCATION	N 4 853 577.0 E 291 399.6	ORIGINATED BY	ES
HWY 427	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM Geodetic	DATE	2017.07.28 - 2017.07.28	CHECKED BY	ME

[illegible]

RECORD OF BOREHOLE No MMW 17-03 1 OF 2 METRIC

W.P. _____ LOCATION N 4 853 568.0 E 291 337.7 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2017.07.10 - 2017.07.10 CHECKED BY ME

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									
199.4	GROUND SURFACE							20 40 60 80 100									
0.0	TOPSOIL: (225mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
0.2	Clayey SILT , trace sand, trace gravel Soft to Stiff Brown Moist		1	SS	2		199										
			2	SS	4		198										
			3	SS	10												
197.1																	
2.3	SILT and SAND , some clay Dense to Very Dense Grey Moist (TILL)		4	SS	34		197										
			5	SS	59		196										
							195										
			6	SS	100/ 0.250		194										
			7	SS	70		193										
							192										
			8	SS	81		191										
			9	SS	102/ 0.275		190										

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

RECORD OF BOREHOLE No MMW 17-03 2 OF 2 METRIC

W.P. _____ LOCATION N 4 853 568.0 E 291 337.7 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2017.07.10 - 2017.07.10 CHECKED BY ME

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			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
Continued From Previous Page																				
189.2																				
10.2	SAND and GRAVEL , trace silt, trace clay Very Dense Grey Moist Containing cobbles		10	SS	87		189													
							188													
			11	SS	51		187													
							186													
			12	SS	12															
							185													
			13	SS	16		184													
183.6																				
15.8	END OF BOREHOLE AT 15.8m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																			

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RECORD OF BOREHOLE No MMW 17-04 1 OF 4 METRIC

W.P. _____ LOCATION N 4 853 582.0 E 291 376.7 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.06 CHECKED BY ME

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						
202.7	GROUND SURFACE							20	40	60	80	100		
0.0	TOPSOIL: (100mm)							20	40	60	80	100		
0.1	Clayey SILT , trace gravel, organics Firm Brown Moist		1	SS	5		202							
201.9														
0.8	Clayey SILT , trace sand, trace gravel Very Stiff to Hard Brown to Grey Moist (TILL)		2	SS	17		201							
			3	SS	17									
			4	SS	51		200							
			5	SS	30									
							199							
			6	SS	32		198							
197.1							197							
5.6	SILT and SAND , some gravel, some clay Dense to Very Dense Grey Moist (TILL)		7	SS	40		196							
			8	SS	88		195							
							194							
			9	SS	101/ 0.250		193							

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+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MMW 17-04 2 OF 4 METRIC

W.P. _____ LOCATION N 4 853 582.0 E 291 376.7 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.06 CHECKED BY ME

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													
	SILT and SAND, some gravel, some clay Dense to Very Dense Grey Moist (TILL)		10	SS	100/ 0.275		192							
							191							
			11	SS	68		190							
							189							
			12	SS	53		188							
							187							
			13	SS	38		186							
							185							
			14	SS	100/ 0.275		184							
							183							
			15	SS	100/ 0.275									

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

3 OF 4

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+³, ×³: Numbers refer to Sensitivity

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RECORD OF BOREHOLE No MMW 17-04 4 OF 4 METRIC

W.P. LOCATION N 4 853 582.0 E 291 376.7 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.06 CHECKED BY ME

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							20	40	60	80	100					
172.2																	
30.5	SHALE moderately weathered to fresh, thinly bedded, horizontal laminated, weak to medium strong with strong to very strong limestone interbeds, grey: (Georgian Bay Formation)		20	SS	100/0.075		172										
171.2																	
171.2			21	SS	100/0.075												
31.5	Highly fractured (100mm) at 31.5m						171										
	Sub-vertical fracture (175mm) at 31.7m and (50mm) at 32.0m		1	RUN													
	Vertical fracture (75mm) at 32.2m																
	Limestone interbed (175mm) at 32.2m and (150mm) at 32.7m		2	RUN			170										
	Limestone interbed (350mm) at 33.9m and (225mm) at 34.3m						169										
	Vertical fracture (150mm) at 33.8m		3	RUN			168										
167.4																	
35.3	END OF BOREHOLE AT 32.3m. Piezometer installation consists of two 25mm and 50mm diameter Schedule 40 PVC pipe with a 3.05m and 1.52m slotted screen. DEEP WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2017.08.09 1.9 200.8 2017.10.24 2.0 200.7 SHALLOW WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2017.08.08 Dry - 2017.08.09 Dry - 2017.10.24 3.5 199.2																

RECORD OF BOREHOLE No MMW 17-05 1 OF 4 METRIC

W.P. _____ LOCATION N 4 853 547.5 E 291 344.6 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.04 - 2017.07.11 CHECKED BY ME

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIMIT LIQUID CONTENT 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
201.0	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (125mm)							20	40	60	80	100								
0.1	SAND, some gravel, trace silt Compact Brown Moist (FILL)		1	SS	28		200							○						
			2	SS	13								○							
			3	SS	14								○							
198.8							199													
2.2	Silty CLAY, some sand, trace gravel Stiff Brown Moist		4	SS	9		198							○						
			5	SS	9								○							
196.9							197													
4.1	SILT and SAND, some clay Very Dense Grey Moist (TILL)		6	SS	62		196							○						
			7	SS	70		195								○					
			8	SS	75		193								○					
							192													
													○							

Continued Next Page

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

RECORD OF BOREHOLE No MMW 17-05 2 OF 4 METRIC

W.P. _____ LOCATION N 4 853 547.5 E 291 344.6 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.04 - 2017.07.11 CHECKED BY ME

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					
	Continued From Previous Page							20 40 60 80 100					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
								20 40 60 80 100					
									PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT		
									w _p	w	w _L		
									WATER CONTENT (%)				
									20 40 60				

Continued Next Page

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

RECORD OF BOREHOLE No MMW 17-05 3 OF 4 METRIC

W.P. _____ LOCATION N 4 853 547.5 E 291 344.6 ORIGINATED BY KK
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.04 - 2017.07.11 CHECKED BY ME

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 NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L WATER CONTENT (%)				
	Continued From Previous Page				0.275			20	40	60	80	100						
180.1	SAND to SAND and GRAVEL , trace silt Very Dense Grey Moist																	
20.9	SILT , some clay, trace sand Dense Grey Moist		17	SS	44		180											0 3 85 12
							179											
							178											
177.2							177											
23.8	SAND and GRAVEL , trace silt Very Dense Grey Wet		18	SS	100/ 0.225		176											
							175											
							174											
			19	SS	100/ 0.075		173											
172.5							172											
28.5	SHALE highly weathered, thinly bedded, horizontal laminated, weak, grey		20	SS	100/ 0.050													
171.4																		
29.6	END OF BOREHOLE AT 29.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND																	

Continued Next Page

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

4 OF 4

W.P.	LOCATION	N 4 853 547.5 E 291 344.6	ORIGINATED BY	KK
HWY	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	DATE	2017.07.04 - 2017.07.11	CHECKED BY	ME

[illegible]

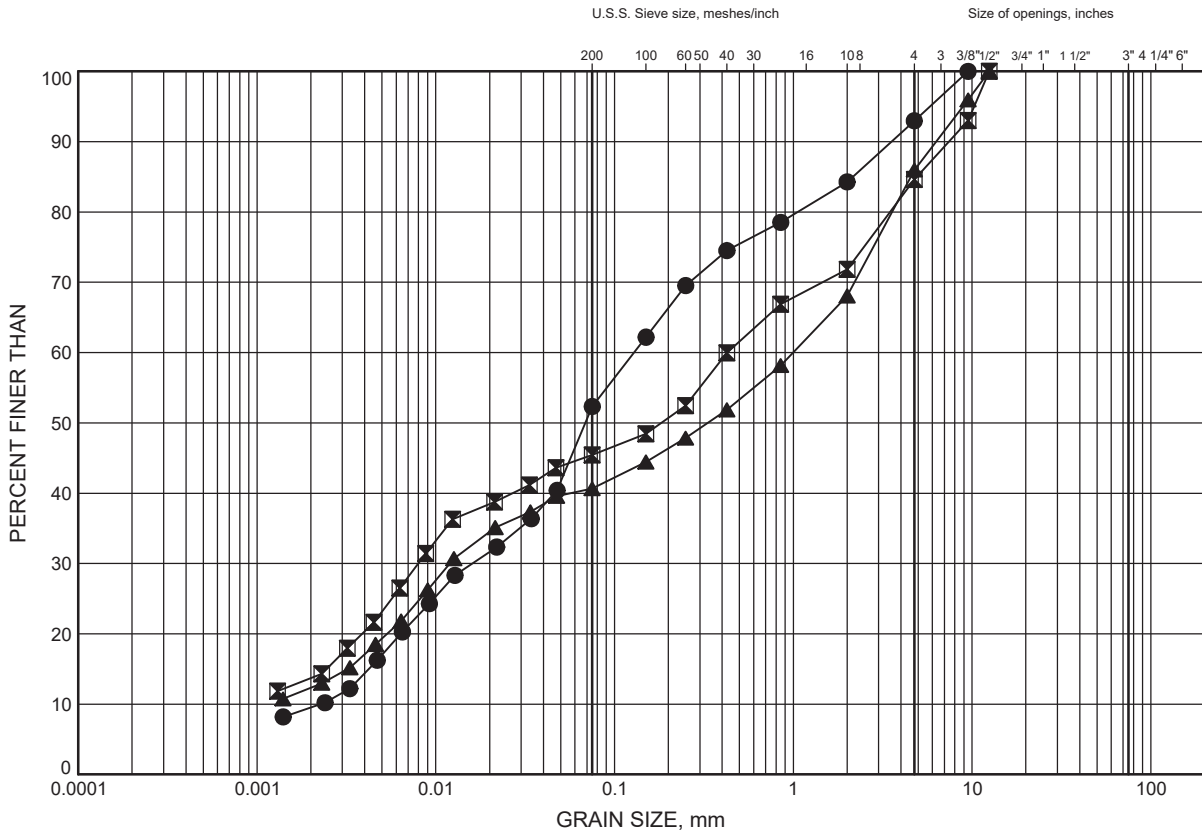
Appendix B

Geotechnical and Analytical Laboratory Test Results – Current Investigation

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILT and SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MMW 17-01	6.3	194.5
⊠	MMW 17-04	15.5	187.2
▲	MMW 17-04	27.6	175.1

Date December 2017
W.P.

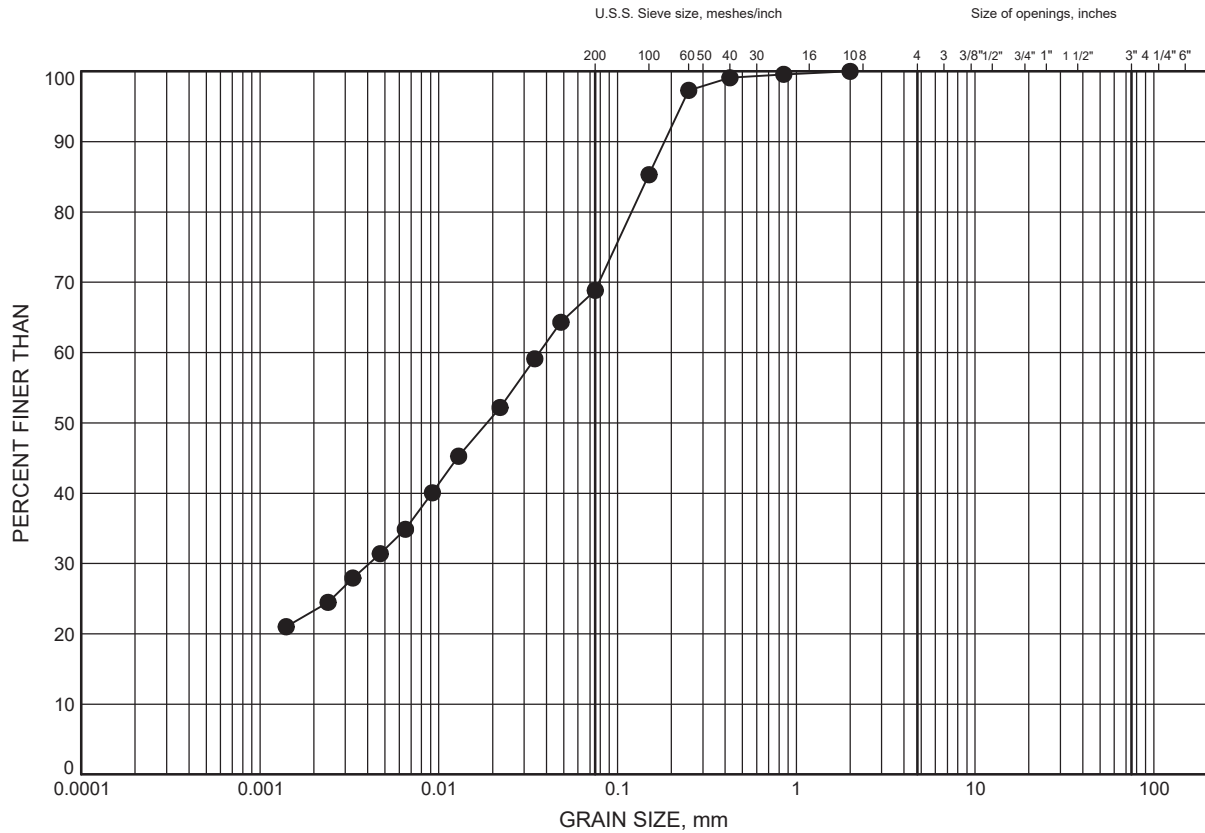


Prep'd AN
Chkd. GRL

GRAIN SIZE DISTRIBUTION

FIGURE B2

Clayey SILT to Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MMW 17-05	12.4	188.6

Date December 2017
W.P.

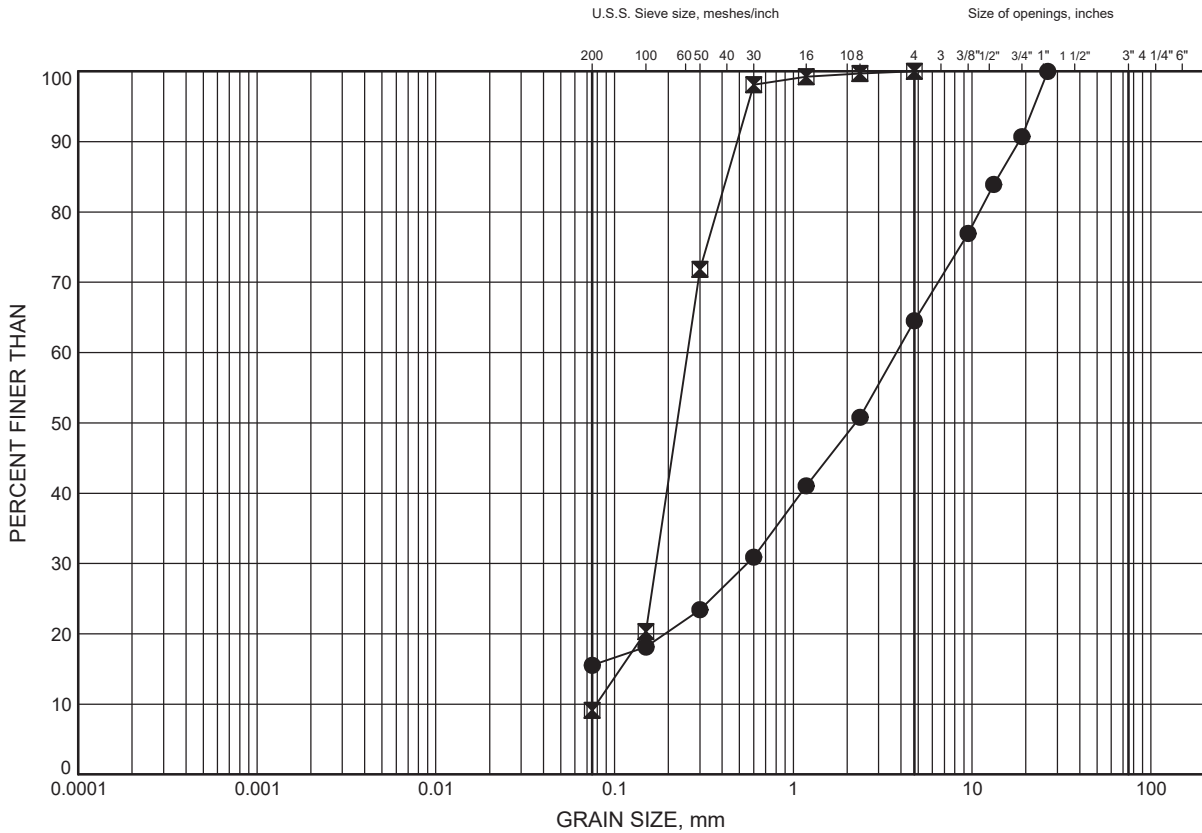


Prep'd AN
Chkd. GRL

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND to SAND and GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MMW 17-03	11.0	188.4
⊠	MMW 17-05	15.5	185.5

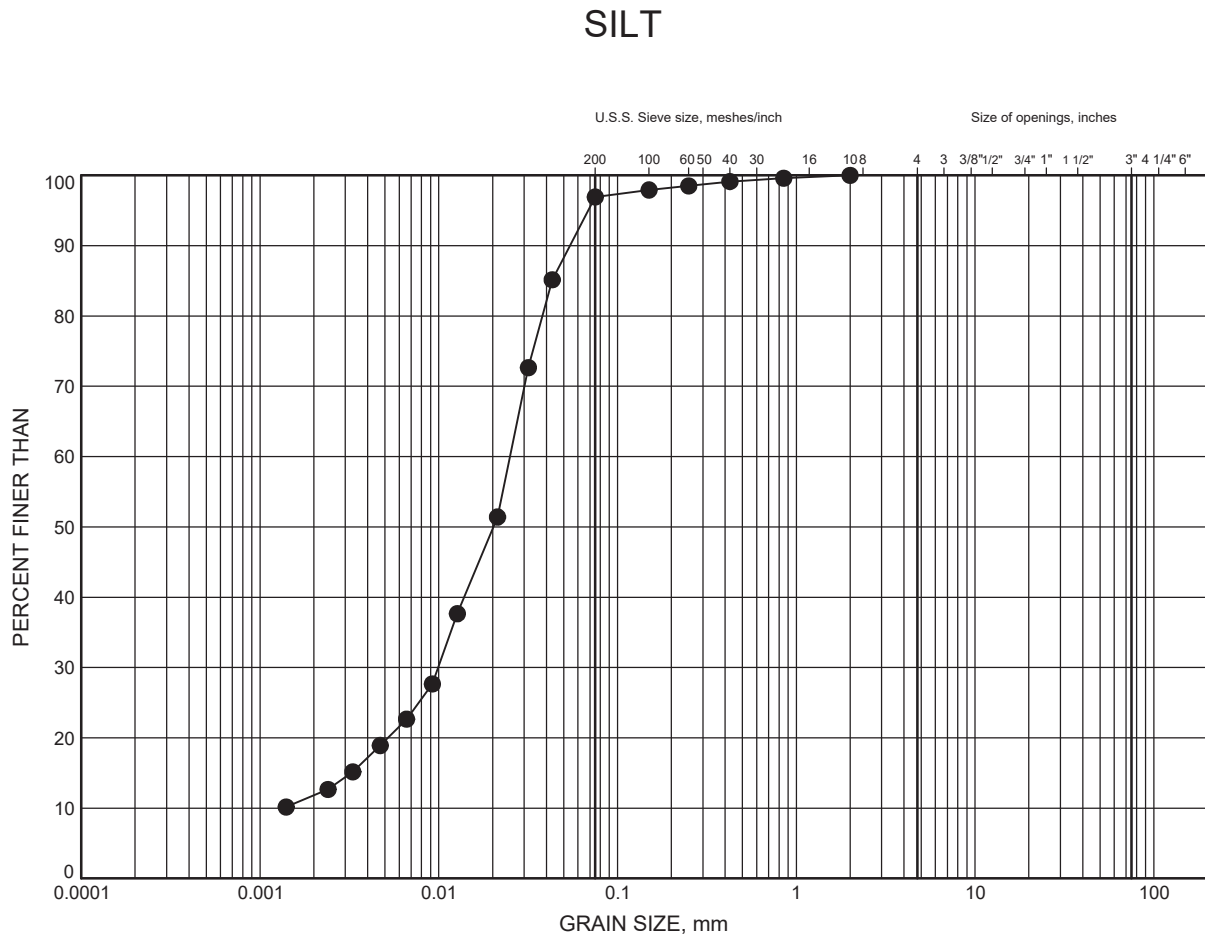
Date December 2017
W.P.



Prep'd AN
Chkd. GRL

GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MMW 17-05	21.6	179.4

Date December 2017
W.P.

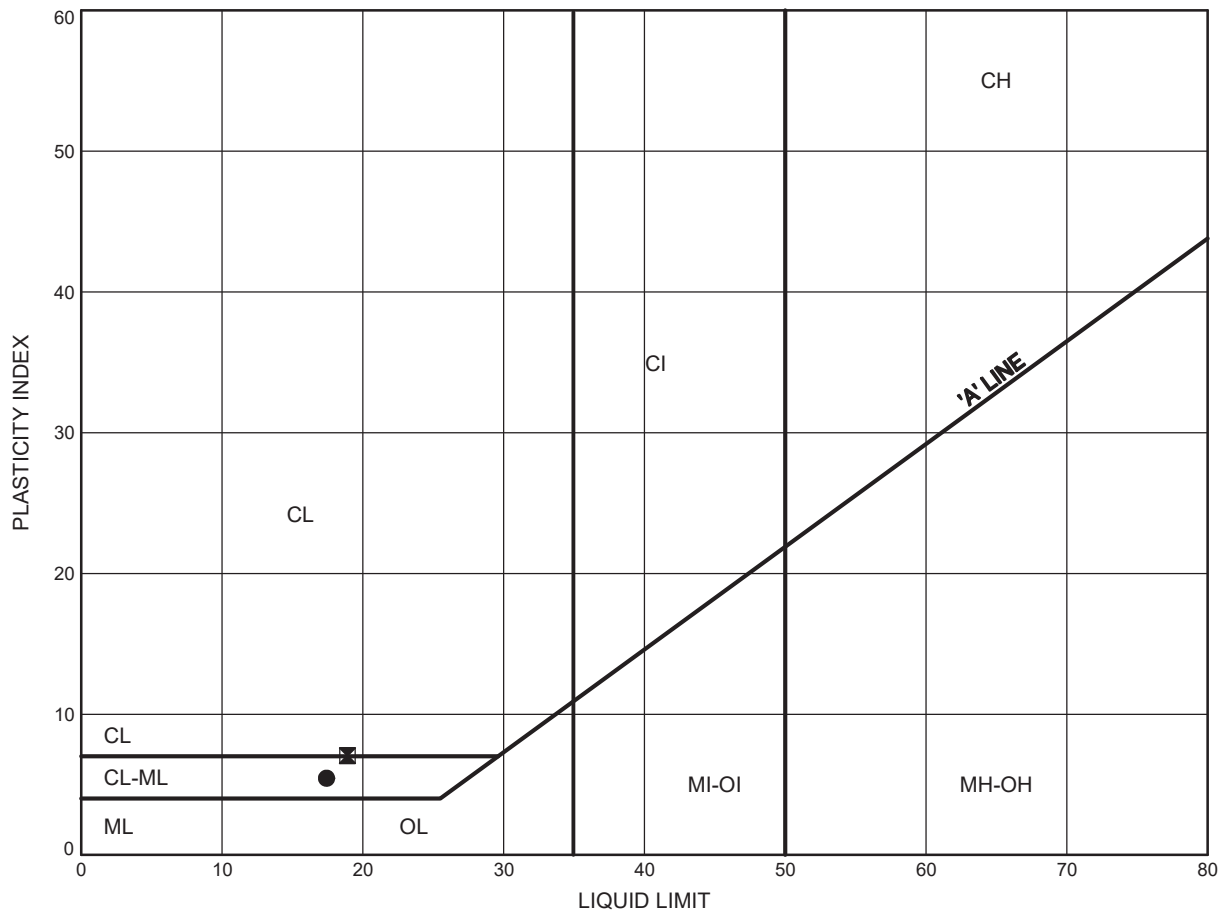


Prep'd AN
Chkd. GRL

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

SILT and SAND TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MMW 17-03	4.8	194.6
⊠	MMW 17-04	10.8	191.9

Date December 2017
W.P.

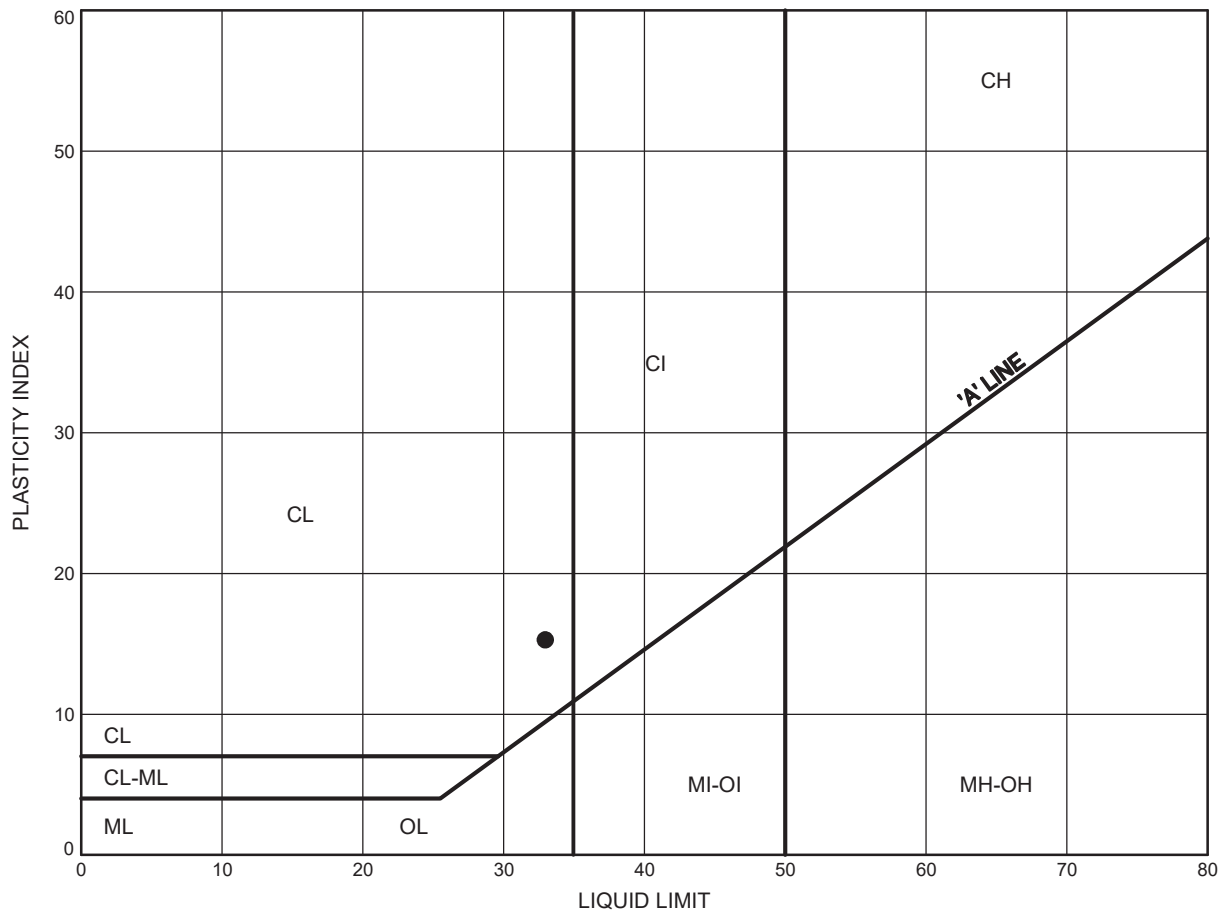


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ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Clayey SILT to Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MMW 17-05	3.4	197.6

Date December 2017
W.P.



Prep'd AN
Chkd. GRL

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.
CA14662-AUG17
Corrosivity (Soil)

Sample ID	Unit	MMW17-03, SS5 (10-12)	MMW17-04, SS6 (15- 17)	MMW17-05, SS2 (2.5- 4.5)
-----------	------	--------------------------	---------------------------	-----------------------------

Sample Date/Time		07-Jul-17	05-Jul-17	04-Jul-17
------------------	--	-----------	-----------	-----------

Moisture	%	6.9	14.8	4.8
pH	no unit	8.70	8.45	9.60
Corrosivity Index	none	7.5	4.5	13.0
Soil Redox Potential	mV	191	162	227
Sulphide	mg/L	0.08	0.14	<0.02
Chloride	mg/L	24	5.3	1300.0
Sulphate	mg/L	80	150	42
Conductivity	uS/cm	166	249	1650
Resistivity (calculated)	ohms.cm	6040	4020	607

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

Record of Borehole Sheets – Previous Investigations

RECORD OF BOREHOLE No MMRC-1															1 of 2		METRIC	
G.W.P.		LOCATION				Coords: 4 853 539.6 N; 291 318.9 E				ORIGINATED BY					F.P.			
DIST		Central		HWY		427		BOREHOLE TYPE		Continuous Flight Hollow Stem Augers				COMPILED BY		N.L.		
DATUM		Geodetic		DATE		October 13, 2015				CHECKED BY					A.V.			
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
200.7	Ground Surface							20	40	60	80	100						
200.5	ASPHALT (150mm)																	
0.2	SAND and GRAVEL		1	SS	35													
	Compact to dense Brown and grey Moist		2	SS	16													
199.2	(FILL)																	
1.5	SILTY CLAY, trace sand, trace gravel		3	SS	6													
	Firm Dark brown to brown Moist to wet		4	SS	4													
197.8	CLAYEY SILT, with sand to sandy, trace to some gravel		5	SS	13													
2.9	Stiff to hard Grey Moist		6	SS	66													
	(TILL)		7	SS	92													
			8	SS	56													
			9	SS	83													
			10	SS	100/13cm													
190.8	SANDY SILT, trace to some gravel, trace clay		11	SS	101													
9.9	Very dense Grey Moist to wet		12	SS	107													
	(TILL)		13	SS	103/15cm													
186.7	End of borehole																	
14.0																		

RECORD OF BOREHOLE No MMRC-1															2 of 2		METRIC	
G.W.P.		LOCATION				Coords: 4 853 539.6 N; 291 318.9 E				ORIGINATED BY					F.P.			
DIST		Central		HWY		427		BOREHOLE TYPE		Continuous Flight Hollow Stem Augers				COMPILED BY		N.L.		
DATUM		Geodetic		DATE		October 13, 2015				CHECKED BY					A.V.			
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
185.7								20	40	60	80	100						
	Monitoring Well Legend:																	
	Flush mount + Concrete																	
	Bentonite seal																	
	Filter sand																	
	50mm dia. screen																	
	Filter bed																	
	Bentonite																	
	Water level noted during drilling																	
	Water level measured in piezometer																	
	Note:																	
	1. Groundwater level measurments in piezometer measured at a depth of 3.7m and 29m below groundwater surface (Elev. 197.0m and 197.8m, respectively).																	
	Monitoring Well Readings:																	
	Date																	
	Depth (m)																	
	Elev. (m)																	
	13/10/15																	
	3.7																	
	197.0																	
	23/12/15																	
	2.9																	
	197.8																	

RECORD OF BOREHOLE No MMRC-2 1 of 2 METRIC																	
G.W.P. _____		LOCATION Coords: 4 849 744.6 N; 293 321.0 E				ORIGINATED BY M.Kh											
DIST Central HWY 427		BOREHOLE TYPE Solid Stem Augers to 4.6m, then Mud Rotary and Tricone				COMPILED BY N.L.											
DATUM Geodetic		DATE October 09, 2015				CHECKED BY A.V.											
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
202.1	Ground Surface							20	40	60	80	100					
201.9	ASPHALT (150mm)																
0.2	SAND and GRAVEL		1	SS	46												
	Compact to dense Brown and grey Moist																
200.7	(FILL)		2	SS	15												
1.4	CLAYEY SILT, trace to some sand, trace gravel		3	SS	18												
199.9	Very stiff Brown Moist																
2.2	CLAYEY SILT, with sand, trace gravel		4	SS	34												
	Very stiff to hard Brown to grey Moist to wet (TILL)		5	SS	25												
198.4	SILT and SAND to SILT, with sand, trace clay, trace gravel		6	SS	68												
	Very dense Grey Wet (TILL)		7	SS	64												
	_____ containing sand and gravel		9	SS	95/23cm												
			10	SS	50/10cm												
			11	SS	93/28cm												
190.6	CLAYEY SILT, some sand, trace gravel																
11.5	Hard Grey Moist (TILL)		12	SS	50/10cm												
			13	SS	55												
	Cont'd																

RECORD OF BOREHOLE No MMRC-2 2 of 2 METRIC																	
G.W.P. _____		LOCATION Coords: 4 849 744.6 N; 293 321.0 E				ORIGINATED BY M.Kh											
DIST Central HWY 427		BOREHOLE TYPE Solid Stem Augers to 4.6m, then Mud Rotary and Tricone				COMPILED BY N.L.											
DATUM Geodetic		DATE October 09, 2015				CHECKED BY A.V.											
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
187.1								20	40	60	80	100					
187.0	SAND, with silt, some gravel, trace clay		14	SS	81/28cm												
15.1	Very dense Grey Moist (TILL)																
185.0			15	SS	98/20cm												
17.1	End of borehole																
	Water level measured upon completion																
	Notes:																
	1. Groundwater level measured at a depth of 3.7m below groundwater surface (Elev. 198.4) upon completion of drilling.																
	2. Upon completion of drilling, the borehole did not cave-in																

Continued Next Page

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

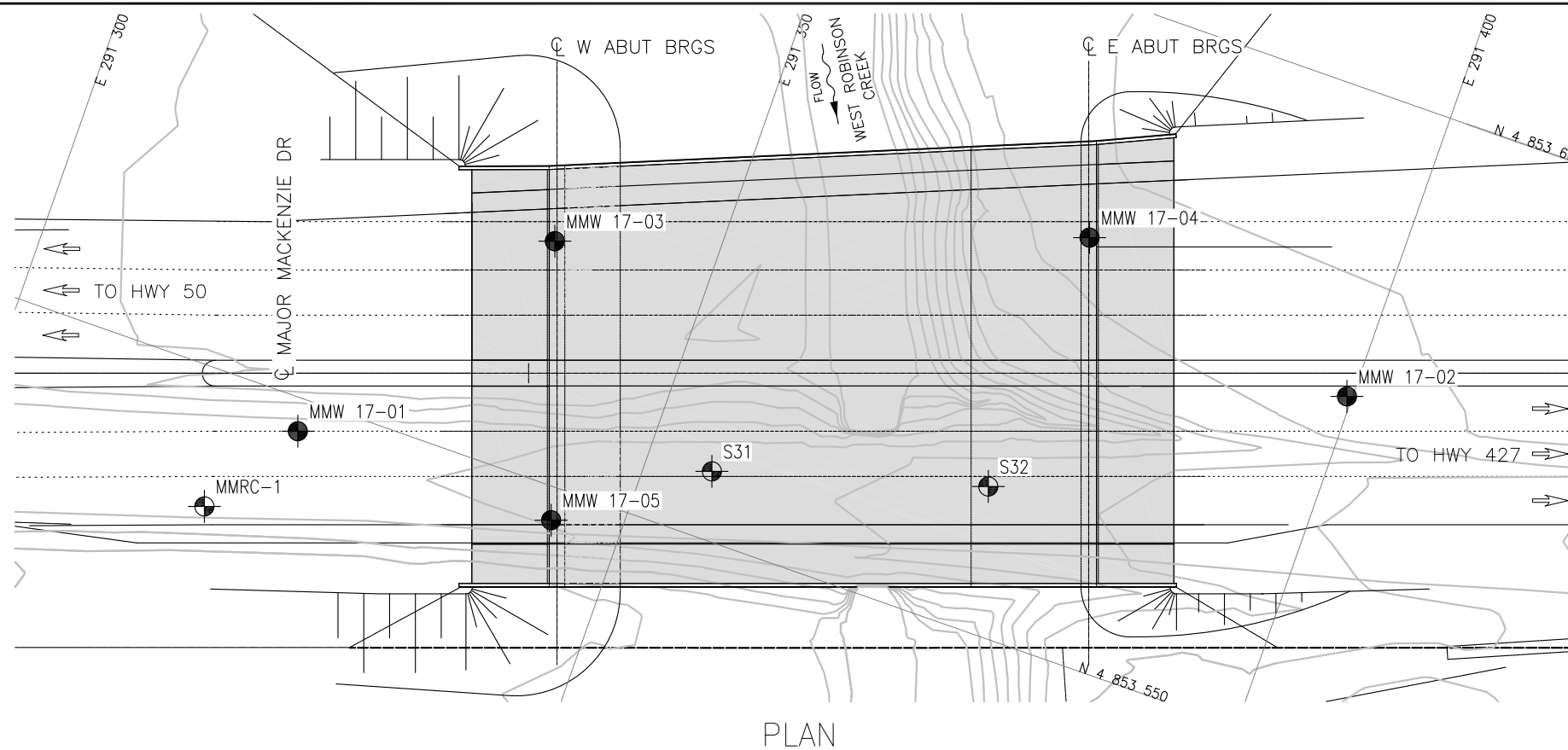
PROJECT 06-1111-012		RECORD OF BOREHOLE No S32		1 OF 1 METRIC																						
W.O. 05-20012		LOCATION N 4853561.2 ; E 291375.7		ORIGINATED BY SB																						
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY VA																						
DATUM Geodetic		DATE March 18, 2009		CHECKED BY SMM <i>SM</i>																						
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT <div style="display: flex; justify-content: space-around; font-size: small;"> <div> <p>SHEAR STRENGTH kPa</p> <p>○ UNCONFINED + FIELD VANE</p> <p>● QUICK TRIAXIAL × REMOULDED</p> </div> <div> <p>WATER CONTENT (%)</p> <p>W_p W W_L</p> </div> </div>	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)															
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER									TYPE	"N" VALUES													
201.8	GROUND SURFACE																									
200.4	Asphalt Sand, trace to some gravel, trace clay (FILL) Compact Brown Moist		1	SS	16																					
198.1	SILTY CLAY, trace to some sand Stiff to very stiff Brown to grey Moist		2	SS	9																					
			3	SS	21																					
			4	SS	20																					
197.3	SILT, trace sand, containing clay seams Dense Grey Moist Containing oxidation zones to a depth of 3.8 m		5	SS	42						0 2 91 7															
196.0	SAND, trace to some silt Loose Grey Wet		6	SS	WR																					
194.6	CLAYEY SILT, some sand, trace gravel (TILL) Hard Grey Moist		7	SS	46																					
193.1	Sandy SILT, trace gravel, trace clay (TILL) Very dense Grey Moist		8	SS	111						2 19 75 4															
190.7	CLAYEY SILT, some sand, trace gravel (TILL) Hard Grey Moist		9	SS	119																					
11.1	END OF BOREHOLE		10	SS	141																					
NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 10.4 m (Elev. 191.4 m). Water level measurements <table style="width:100%; font-size: x-small;"> <thead> <tr> <th>Date</th> <th>Depth</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>On Completion</td> <td>4.9 m</td> <td>196.9 m</td> </tr> <tr> <td>April 24, 2009</td> <td>3.1 m</td> <td>198.7 m</td> </tr> <tr> <td>May 13, 2009</td> <td>3.4 m</td> <td>198.4 m</td> </tr> <tr> <td>May 25, 2009</td> <td>3.4 m</td> <td>198.4 m</td> </tr> </tbody> </table>												Date	Depth	Elev.	On Completion	4.9 m	196.9 m	April 24, 2009	3.1 m	198.7 m	May 13, 2009	3.4 m	198.4 m	May 25, 2009	3.4 m	198.4 m
Date	Depth	Elev.																								
On Completion	4.9 m	196.9 m																								
April 24, 2009	3.1 m	198.7 m																								
May 13, 2009	3.4 m	198.4 m																								
May 25, 2009	3.4 m	198.4 m																								

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

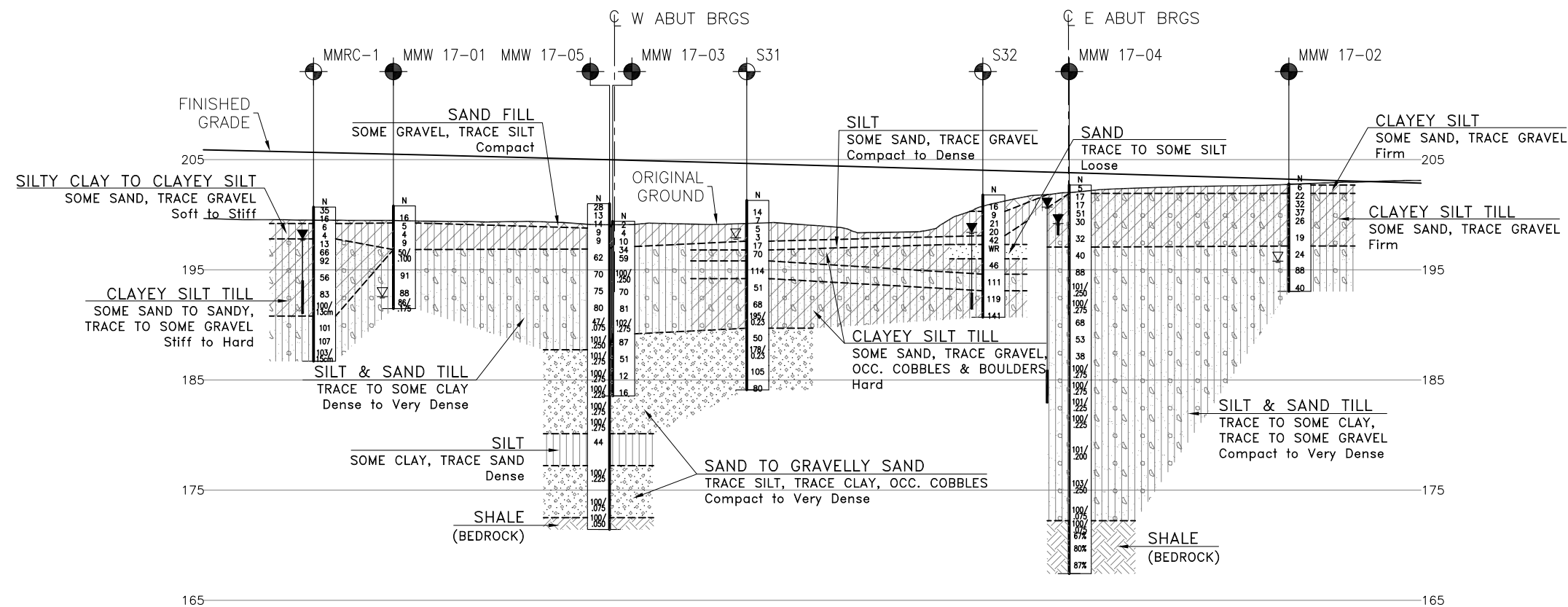
MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

Appendix D

Borehole Locations and Soil Strata Drawing



PLAN



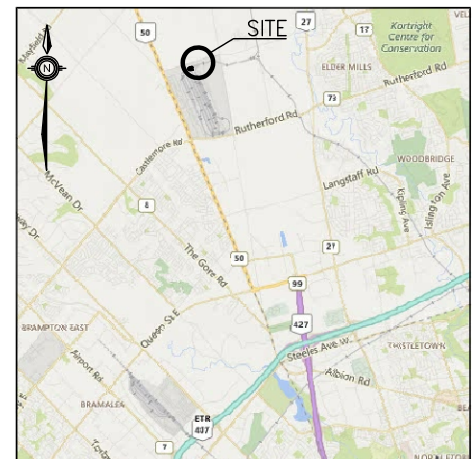
PROFILE ALONG C MAJOR MACKENZIE DR.

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN








THURBER ENGINEERING LTD.



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

[illegible]

-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.

FILENAME: H:\Drafting\19000\19484\TED19484-PLPR-MajorMacKenzieDr Over WestRobinsonCreek.dwg
 PLOTTED: 5/20/2010 1:07 PM

ELEMENT: HA Duffing\19005\1946 DDATE: 5/29/2019 1:01 PM							
A	19/05/29		100% SUBMISSION TO CA			KS	JL
NO.	DATE		REVISIONS			BY	CHK
						LEAD	PRO
						DISC	MAN

SCALE :

2.5m 0 5m H 1:500
1.25m 0 2.5m V 1:250
Metres



CONSULTANT	DESIGNED	K. SHI	KS	19/05/05
	DRAWN	A. NOOR	AN	19/05/05
	CHECKED	J. LEE	JL	19/05/05
	APPROVED LEAD ENGINEER	J. LEE	JL	19/05/05
	APPROVED PROJ. MANAGER	P. BAMFORTH	PB	19/05/05
		NAME (PRINT)	INIT.	DATE



<p>TITLE</p> <p>HWY 427 EXPANSION MAJOR MACKENZIE DRIVE OVER WEST ROBINSON CREEK</p> <p>BOREHOLE LOCATIONS AND SOIL STRATA</p>							
PROJECT ID.	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D	H	5A	STR	B19	DWG	801	A

Appendix E

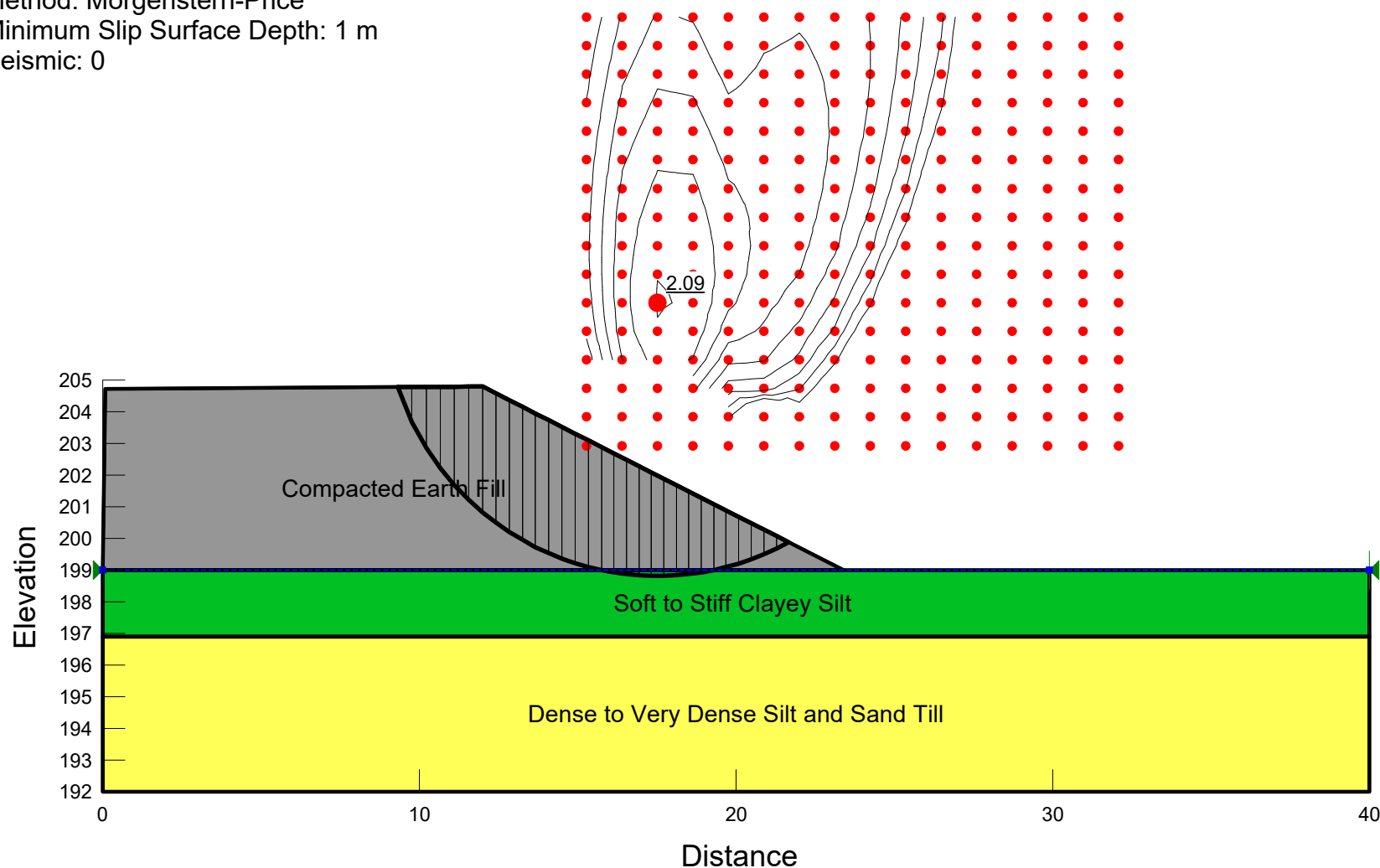
Stability Analysis Output for Approach Embankments

FIGURE E1

CRITICAL EMBANKMENT SECTION (STA. 9+390) SHORT-TERM CONDITION

File Name: MM over WRC West Embankment TSA Stability.gsz
 Last Edited By: Geoff Lay
 Date: 11/30/2017
 Method: Morgenstern-Price
 Minimum Slip Surface Depth: 1 m
 Seismic: 0

Soft to Stiff Clayey Silt	18 kN/m ³	50 kPa	0 °
Dense to Very Dense Silt and Sand Till	20 kN/m ³	0 kPa	36 °
Compacted Earth Fill	20 kN/m ³	0 kPa	30 °



CRITICAL EMBANKMENT SECTION (STA. 9+390) **LONG-TERM CONDITION**

File Name: MM over WRC West Embankment ESA Stability.gsz
 Last Edited By: Geoff Lay
 Date: 11/16/2017
 Method: Morgenstern-Price
 Minimum Slip Surface Depth: 1 m
 Seismic: 0

Soft to Stiff Clayey Silt	18 kN/m ³	5 kPa	29 °
Dense to Very Dense Silt and Sand Till	20 kN/m ³	0 kPa	36 °
Compacted Earth Fill	20 kN/m ³	0 kPa	30 °

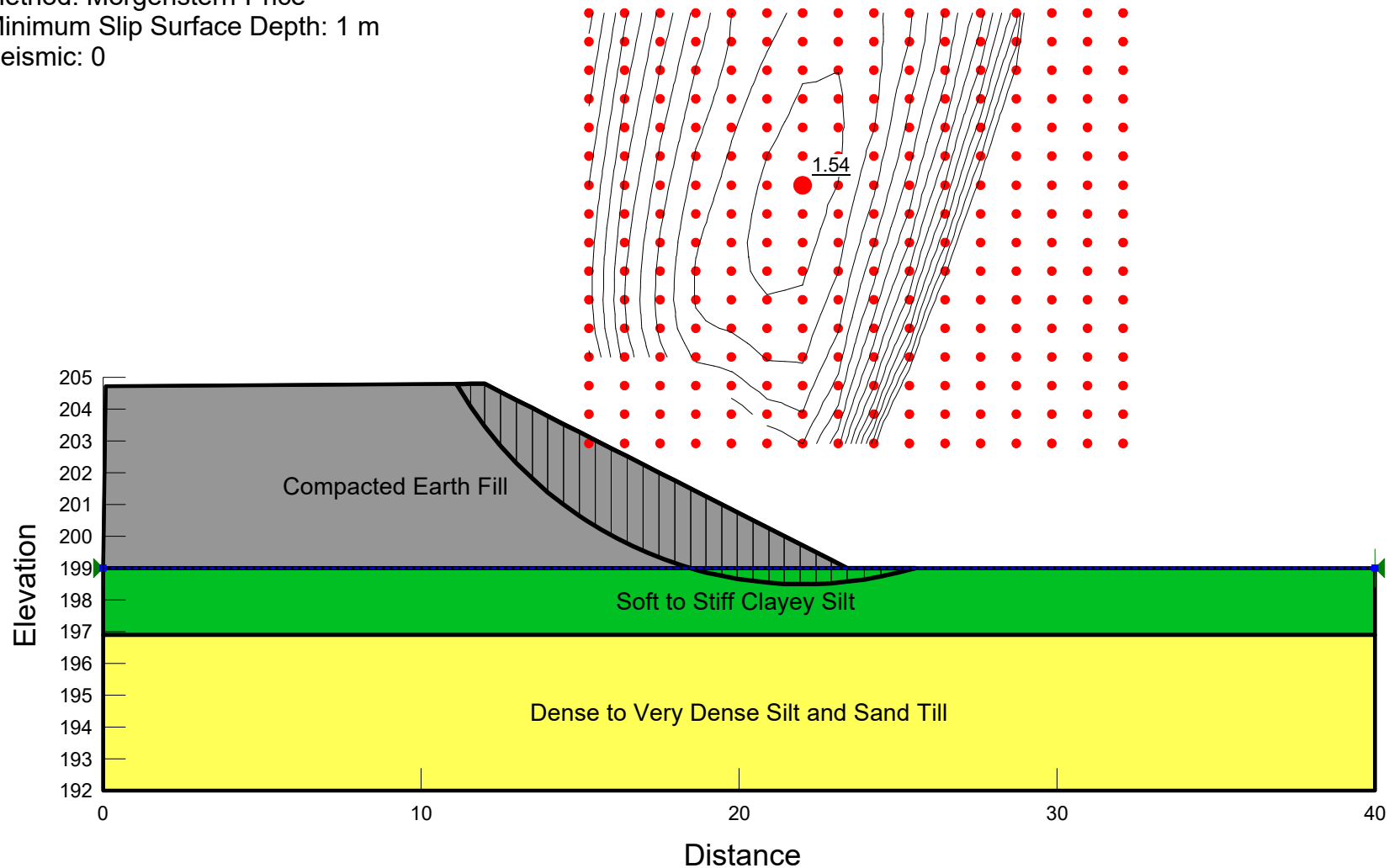


FIGURE E3

CRITICAL EMBANKMENT SECTION (STA. 9+390) SEISMIC CONDITION

File Name: MM over WRC West Embankment Seismic Stability.gsz

Last Edited By: Geoff Lay

Date: 11/30/2017

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0.055g

Soft to Stiff Clayey Silt	18 kN/m ³	50 kPa	0 °
Dense to Very Dense Silt and Sand Till	20 kN/m ³	0 kPa	36 °
Compacted Earth Fill	20 kN/m ³	0 kPa	30 °

