FOUNDATION INVESTIGATION AND DESIGN REPORT

Highway 65, Station 10+780, Township of Kerns Culvert Replacement Ministry of Transportation, Ontario GWP 5204-14-00

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services related to the replacement of the culvert crossing Highway 65 at Station 10+780, in the Township of Kerns, Ontario, approximately 2.3 km west of the intersection with McCool Road. The Key Plan of the general location of this section of Highway 65 and the location of the investigated area are shown on Drawing 1.

The purpose of this exploration is to establish the subsurface conditions at the culvert replacement site by borehole drilling, with laboratory testing carried out on selected soil samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated February 2018, and the subsequent clarifications/addenda, which forms part of the Consultant's Assignment Number 5017-E-0039 for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project dated November 2018.

2.0 SITE DESCRIPTION

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on the Drawing 1. For the purpose of this report, Highway 65 is oriented in a west-east direction with the culvert positioned on a skew to the highway generally in a north-south orientation. At the culvert location, the creek flows in a south-north direction.

The existing culvert consists of a 1.7 m diameter, 127 m long Corrugated Steel Pipe (CSP). The culvert inlet (south end) and outlet (north end) inverts are approximately Elevations 237.4 m and 235.5 m, respectively. In general, the topography within the vicinity of the culvert consists of relatively flat farmland and forest areas. At the culvert location, the highway grade is at approximately Elevation 246.6 m and the embankment is approximately between 9.2 m and 11.1 m high relative to the culvert invert at the inlet (south end) and outlet (north end), respectively. The ground surface conditions at select locations in the culvert area are shown on Photographs 1 to 4.

3.0 INVESTIGATION PROCEDURES

Field work for this subsurface exploration was carried out on November 18, 2018, and February 20 and 21, 2019, during which time three boreholes (Boreholes C77-1 to C77-3) were advanced at approximately the locations shown on Drawing 1. Borehole C77-1 was advanced through the roadway embankment using a track mounted CME-55LC drilling rig supplied and operated by George Downing Estate Drilling (Downing) of Grenville-Sur-La-Rouge, Quebec. Boreholes C77-2 and C77-3 were advanced near the toes of the highway embankment slopes adjacent to the culvert inlet/outlet using a potable tripod rig supplied and operated by Landcore Drilling (Landcore) of Chelmsford, Ontario. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions.

Borehole C77-1 was advanced through the roadway using 108 mm I.D. Hollow Stem Augers. Boreholes C77-2 and C77-3 were advanced at the toes of the embankment slopes using NW casing with wash boring techniques. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic or cathead hammer in accordance with the Standard Penetration

Test (SPT) procedure (ASTM D1586). The portable tripod rig, supplied by Landcore, used a standard weight (63.6 kg) hammer. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strength (ASTM D2573) using an MTO Standard “N” size vane. The groundwater level inside the augers/casing was observed during and upon completion of drilling operations. The boreholes were backfilled in accordance with Ontario Regulation 903. The roadway surface at the borehole drilled through Highway 65 was capped at ground surface using cold patch asphalt.

Field work was supervised on a full-time basis by a member of Golder’s technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder’s geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determination, grain size distribution, and Atterberg limits was carried out on selected soil samples. The geotechnical laboratory testing was completed according to ASTM and MTO LS standards, as applicable.

The as-drilled borehole locations were measured relative to highway chainages/station marked on the pavement by a member of our technical staff and converted into northing/easting coordinates on the plan drawing. The ground surface elevations at the borehole locations were surveyed relative to the highway and culvert centreline, with the elevation of the centreline provided by AECOM. The MTM NAD 83-CSRS CBN v6-2010.0 (Zone 12) northing and easting coordinates, geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the borehole records in Appendix A and summarized below.

Borehole Number	MTM NAD 83 Northing (m) (Latitude)	MTM NAD 83 Easting (m) (Longitude)	Ground Surface Elevation (m)	Borehole Depth (m)
C77-1	5278348.0 (47.638802)	389087.5 (-79.878217)	246.6	20.4
C77-2	5278381.1 (47.639091)	389160.0 (-79.877246)	235.2	9.8
C77-3	5278313.8 (47.638498)	389055.7 (-79.878647)	238.2	9.6

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS)[1] mapping, the culvert site is located within a glaciolacustrine plain, and the subsoils in the area primarily consist of clay and sand.

Based on geological mapping (MNDM)[2], the site is underlain by mafic and related intrusive rocks and mafic dikes.

[1] Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41PNE

[2] Ontario Ministry of Northern Development and Mines. Bedrock Geology of Ontario, East-Central Sheet. Map 2543

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the summary results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The detailed results of geotechnical laboratory testing are contained in Appendix B. The results of the in-situ field tests (i.e., SPT 'N' values) as presented on the Record of Borehole sheets and discussed in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile shown on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The results of the analytical laboratory testing (by Maxxam) are summarized in Section 4.4 and the detailed laboratory testing report is included in Appendix B.

The subsurface conditions will vary between and beyond the borehole locations, however, the factual data presented on the Record of Borehole sheets governs any interpretation of the site conditions. A summary description of the soil deposits and groundwater conditions encountered in the boreholes is provided below. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions.

4.2.1 Asphalt/Fill

An approximately 100 mm thick layer of asphalt pavement was encountered in Borehole C77-1 at Elevation 246.6 m. A 140 mm thick layer of reclaimed asphalt pavement (RAP) was encountered directly below the asphalt layer in the roadway borehole and a 360 mm thick layer of sand and gravel fill was encountered directly below the RAP. An approximately 2.4 m thick upper layer of sand fill was encountered below the sand and gravel fill at Elevation 246.0 m, underlain by an approximately 4.2 m thick layer of clayey silt fill at Elevation 243.6 m, in turn underlain by a 1.5 m thick lower layer of sand and gravel fill at Elevation 239.4 m.

Boreholes C77-2 and C77-3 encountered a 0.7 m and 1.5, thick layer of clayey silt with sand to clayey silt from ground surface at Elevations 235.2 m and 238.2 m, respectively.

The SPT "N"-values measured within the upper layer of sand fill and the lower layer of sand and gravel fill encountered in Borehole C77-1 at Elevations 246.0 m and 239.4 m, respectively), range between 7 blows and 23 blows per 0.3 m of penetration, indicating a loose to compact compactness condition. The SPT "N"-values measured within the clayey silt fill layer encountered in Borehole C77-1 range from 4 blows to 12 blows per 0.3 m of penetration, indicating a firm to stiff consistency. The STP "N"-value measured within the clayey silt with sand and clayey silt fill layers in Boreholes C77-2 and C77-3 range between 2 blows and 13 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency, with the upper sample likely influenced by frozen ground condition.

A grain size distribution analysis was carried out on one sample of the sand fill and one sample of the lower sand and gravel fill and the results are presented on Figure B-1 in Appendix B. The natural moisture content measured on the sand fill sample is 4 per cent and measured on the sand and gravel sample is 2 per cent.

An Atterberg limits test was carried out on one sample of the cohesive clayey silt fill from Borehole C77-1 and measured a liquid limit of 28 per cent, a plastic limit of 14 per cent, and a plastic index of 14 per cent. The result, which is presented on Figure B-2 in Appendix B, indicates that the cohesive fill is a clayey silt of low plasticity. A grain size distribution analysis was carried out on one sample of the clayey silt fill and the result is presented on

Figure B-3 in Appendix B. The natural moisture content measured on the one sample of the clayey silt fill is 16 per cent.

4.2.2 Clayey Silt to Silty Clay with Silt Laminations

A deposit of clayey silt to silty clay with silt laminations throughout was encountered underlying the fill in each of the boreholes, between Elevations 237.9 m and 234.5 m. All boreholes were terminated within the clayey silt to silty clay deposit after exploring the deposit for a thickness between 8.1 m and 11.7 m.

The SPT “N”-values measured within the clayey silt to silty clay deposit range between 1 blow and 6 blows per 0.3 m of penetration. The in-situ field vane undrained shear strengths measured within the cohesive deposit range between about 48 kPa and 86 kPa, indicating that the deposit has a firm to stiff consistency.

Atterberg limits tests were carried out on seven samples of the deposit and measured with liquid limits between about 29 per cent and 41 percent, plastic limits between about 19 per cent and 20 per cent, and plastic indices between about 9 per cent and 22 per cent. The results of the Atterberg limits tests are presented on Figure B-4 in Appendix B and indicate that the deposit is comprised of clayey silt of low plasticity to silty clay of intermediate plasticity. Grain size distribution analyses were carried out on four samples of the deposit and are presented on Figure B-5 in Appendix B. The natural moisture content measured on seven samples of the deposit range between 32 per cent and 38 per cent.

4.3 Groundwater Conditions

The unstabilized groundwater levels relative to ground surface measured inside the casing or augers upon completion of drilling are summarized below:

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
C77-1	Dry	-
C77-2	0.0	235.2
C77-3	0.0	238.2

The ice level of the creek water level near the culvert inlet, as surveyed by Golder on February 21, 2019, was about Elevation 238.4 m. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a sample of the silt deposit recovered from Borehole C77-1. The soil sample was submitted to Maxxam Analytics of Sudbury, Ontario for corrosivity testing. The analytical laboratory test results are summarized below, and the detailed analytical laboratory test report is included in Appendix B.

Borehole No.	Sample No.	Depth (m)	Parameters					
			Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Soluble Sulphate (SO4) Content (µg/g)	Sulphide (S^-) (µg/g)	Chloride (Cl) Content (µg/g)	pH
C77-1	9	9.1-9.8	3,800	266	<20[1]	0.64	90	7.60

Note:
1. The sulphate concentration is below the reportable detection limit of 20 µg/g.

5.0 CLOSURE

The field exploration program was carried out under the supervision of Mr. Mathew Riopelle, under the overall direction of Mr. André Bom, P.Eng. This Foundation Investigation Report was prepared by Mr. Gavin Mundry, and Mr. André Bom, P.Eng. provided a technical review of the report. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review of this report.

Signature Page

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https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2. reporting/r07 - ker177/3. final/189634 r-r07-reva aecom culvert 77 (ker 177) hwy 65 fidr 28nov_19.docx

PART B

FOUNDATION DESIGN REPORT

HIGHWAY 65, STA 10+780, TOWNSHIP OF KERNS

CULVERT REPLACEMENT

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5204-14-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design and recommendations for the replacement of the culvert crossing Highway 65 at about Station 10+780, Township of Kerns, Ontario, approximately 2.3 km west of the intersection with McCool Road. These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess feasible foundation alternatives and culvert types and to design the proposed replacement culvert. The foundation investigation report, discussion and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 Proposed Culvert Alignment and Installation Options

The existing culvert consists of a 1.7 m diameter, 127 m long Corrugated Steel Pipe (CSP). Based on the drawings provided by AECOM via email on May 7, 2019, and our site observations during the foundation exploration work, the existing culvert crosses the existing Highway 65 embankment on a skew alignment; and we understand from AECOM that the proposed replacement culvert will cross the highway on or near the existing culvert alignment and will be of similar circular size as the existing culvert. As noted in Section 2.0, the existing embankment is between about 9.2 m and 11.1 m high relative to the culvert invert at the inlet (south end) and outlet (north end). The invert at the inlet and outlet of the existing culvert is about Elevations 237.4 m and 235.5 m, respectively.

Based on our site observations at the time of the foundation exploration field program, the existing culvert ends are in good condition with minor surface rusting. There were no indications of embankment side slope instability or sloughing, distress in the immediate vicinity of the existing culvert nor readily observed cracking or settlement of the roadway. The existing embankment crosses a relatively deep and narrow ravine at a skew of about 35° in relation to the highway alignment. The existing culvert is also skewed, with a similar alignment as the ravine. We understand from AECOM that a combination of roadway protection and temporary grade lowering of the highway is being considered to allow for culvert replacement, and that a permanent grade raise or widening of the roadway embankment is not required.

We understand from AECOM that lining the culvert is the preferred/proposed rehabilitation work to be completed at this site instead of full culvert replacement; as such, a temporary protection system(s) will be required for installation of the liner near one end of the culvert.

6.2 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code* (CHBDC, 2014) and its *Commentary*, as the proposed culvert crosses Highway 65 and the highway and culvert and foundation system are expected to carry medium traffic volumes and its performance will have potential impacts on other transportation corridors; hence, the structure is classified as having a "typical consequence level" associated with exceeding limits states design. In addition, given the typical project-specific foundation investigation carried out at this site (as presented in Part A of the report), in comparison to the degree of site understanding in Section 6.5 of *CHBDC* (2014), the level of confidence for design is considered to be a "typical degree of site and prediction model understanding." Accordingly, the appropriate corresponding ultimate limit state (ULS) and serviceability limit state (SLS) consequence factor, Ψ, and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs}, from Tables 6.1 and 6.2 of the *CHBDC* have been used for design.

6.3 Circular Culvert Installation by Open Cut Excavation

In the event that ultimately a decision is made to full replacement of the existing culvert by the open-cut method of construction, recommendations are presented below for replacement using a pipe culvert (such as a concrete pipe, CSP or other flexible pipe).

6.3.1 Settlement and Stability

Provided the proposed reconstructed embankment is not widened or raised following culvert replacement, immediate or long-term settlement of the foundation soils beneath the culvert is not anticipated. If a permanent grade raise or widening is required, then a settlement analysis of the culvert/embankment foundation (subgrade) should be carried out.

Due to the presence of the cohesive deposit at this site, if temporary widening is considered for traffic staging and culvert replacement, the extent and duration of temporary widening should be minimized as much as possible to minimize settlement of the foundation soil. It is understood from discussion with AECOM that a temporary widening will not be considered for this site.

The reconstructed embankment regraded after culvert replacement to match the adjacent side slopes will be stable from a global slope stability perspective for the long-term, drained conditions (i.e. permanent conditions), based on a typical consequence factor when referring to CHBDC (2014) for this site, as the culvert site is well away from a bridge structure, provided the embankment in the immediate are of the culvert is reconstructed of granular material and with side slopes at an inclination of 2 horizontal to 1 vertical (2H:1V) or flatter and graded to match the adjacent existing side slopes. For the proposed/planned culvert rehabilitation by lining, regrading/reconstruction of the existing approximately 2H:1V embankment side slope that may be required as a cut at the culvert outlet is also stable, as shown in Figure 1.

6.3.2 Bedding and Cover

It is not necessary to found a pipe culvert below the depth of frost penetration, as pipe culverts are tolerant of small magnitudes of movement related to freeze-thaw cycles. A circular pipe concrete culvert installed by open cut method should be completed in accordance with Ontario Provincial Standard Drawing (OPSD) 802.031 (*Rigid Pipe Bedding, Cover and Backfill)*, and should be designed in accordance with the MTO Gravity Pipe Design Guidelines (2014). If the replacement culvert is to consist of a CSP or plastic pipe installed by open cut method, it should be constructed in accordance with OPSD 802.010 (Flexible Pipe Embedment and backfill). All unsuitable, deleterious, organic materials, and fill materials are to be removed from the base/below the culvert footprint along its entire alignment. The bedding should be compatible with the class of pipe, the surrounding subsoil and anticipated loading conditions and should consist of OPSS.PROV 1010 (Aggregates) Granular ‘A’ material. Depending on the success of the contractor’s groundwater control methods, and the quality of the bearing stratum exposed at the base of the excavation, a thicker bedding layer may be required at some locations where wet and softened soil conditions, unsuitable fill, or organic material are present at the base of the excavation. Therefore, the Contract Documents should include a provision for additional thickness of compacted Granular ‘A’ bedding, if required.

From the top of the bedding to 300 mm above the obvert of the culvert, Granular ‘A’ should be used around the culvert. All bedding and cover materials should be placed, and culvert construction carried out in accordance with OPSS.PROV 421 (*Pipe Culvert Installation in Open Cut*) and OPSS 401 (*Trenching, Backfilling and Compacting*), and the bedding/cover soil should be compacted in accordance with OPSS.PROV 501 (*Compacting*), as amended by Special Provision (SP) 105S22. If the bottom of the excavation is wet and dewatering is not satisfactorily maintaining the water level sufficiently below the base of the excavation to allow compaction, it is recommended that OPSS.PROV 1010 (*Aggregates*) Granular ‘B’ Type II material be used for bedding and as additional sub-excavation backfill below the bedding, as maybe required.

6.3.2.1 Trench Backfill

The excavated embankment fill materials from the culvert site will vary in quality and composition, comprised of sand to clayey silt with sand to clayey silt. The existing fill materials and native clayey soil should not be reused as backfill for reconstruction of the highway embankment in the immediate vicinity or over the new culvert in the case of replacement of the culvert by open-cut construction.

Granular material which meets the requirements of OPSS.PROV 1010 (*Aggregates*) Select Subgrade Material (SSM) or Granular ‘B’ Type I may be used as trench backfill. These materials should also be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*) as amended by SP 105S22.

6.4 Analytical Testing for Construction Materials

The results of analytical tests on one sample of native silt recovered in Borehole C77-1 is summarized in Section 4.4. The potential for sulphate attack and corrosion are discussed in the following paragraphs; however, it is ultimately up to the designer to determine the appropriate construction materials, including the exposure class, and ensuring that all aspects of CSA A23.1-14 (2014) Section 4.1.1 “Durability Requirements” are followed when designing concrete elements.

6.4.1 Potential for Sulphate Attack

The analytical test results were compared to CSA A23.1-14 Table 3 ("Additional requirements for concrete subjected to sulphate attack”) for the potential sulphate attack on concrete. The water soluble-sulphate concentration measured in the soil sample is less than the reportable detection limit of 0.002 per cent, which is below the exposure class of S-3 (Moderate), and is considered Negligible according to Table 7.2 in the MTO Gravity Pipe Design Guidelines (2014). Therefore, based on the test result for the sample, when the designer is selecting the exposure class for the structure, the effects of sulphates from within the near surface/culvert invert native soil(s) may not need to be considered.

6.4.2 Potential for Corrosion

The soil has a pH of 7.6 and according to the MTO Gravity Pipe Design Guidelines (2014), the pH is not considered detrimental to culvert durability. The resistivity is 3,800 ohm-cm, which indicates that the soil corrosiveness is Moderate (2,000>R>4,500 ohm-cm), as per Table 3.2 of the MTO Gravity Pipe Design Guidelines (2014). It is also noted that sulphide at a concentration of about 0.64 µg/g was detected in the analyzed test sample; and sulphide is considered very corrosive to cast iron/steel materials (Cashman and Preene, 2001). As the culvert would extend under the roadway shoulders and be exposed to de-icing salt, concrete should be designed for a “C” type exposure class as defined by CSA A23.1-14 Table 1. The culvert should be designed with consideration given to Table 7.1 of the MTO Gravity Pipe Design Guidelines (2014).

6.5 Construction Considerations

6.5.1 Open Cut Excavation

An open cut excavation through the embankment and into the subgrade to the base of the culvert bedding level associated with the removal of the existing culvert and reconstruction of the embankment would generally advance through sand fill and clayey silt with sand to clayey silt fill and into the silt and clayey silt to silty clay native soils. The excavation is anticipated to extend to or to below the groundwater level. Where space permits for an open cut excavation into these materials, the excavation must be carried out in accordance with the guidelines outlined in the Occupation Health and Safety Act (OHSA) for Construction Activities. Above the water table, the existing fill materials and underlying native granular and cohesive soils are classified as Type 3 soil (assuming that the native granular and cohesive soils are dewatered), according to OHSA and temporary excavations (i.e., those which are open for a relatively short time period) should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V). Below the water table, the existing fill materials and underlying native soils are classified as Type 4 soil, according to OHSA and temporary excavations (i.e., those which are open for a relatively short time period) into this soil type should be made with side slopes no steeper than 3 horizontal to 1 vertical (3H:1V).

Depending upon the construction procedures adopted by the contractor, groundwater seepage conditions, and weather conditions at the time of construction, some local flattening of the slopes of open cut excavations may be required, especially in looser/softer zones or where localized seepage is encountered. Further, layering of soils and the effectiveness of the contractor’s dewatering systems could affect the OHSA classification and, therefore, the classification of soils for OHSA purposes must be made at the time the excavation is open and can be directly observed during construction.

6.5.2 Groundwater Control

The groundwater level is expected to be at or slightly below the proposed culvert along most of its alignment and is potentially about 2.5 m above the invert at/near the outlet; the excavation for the culvert replacement should be expected to extend below the groundwater level. The groundwater should be lowered to at least 1 m below the base of the excavation to maintain basal stability. Groundwater may be controlled by providing an active dewatering system installed and operated in advance of the excavation, or in combination with a sheet piling wall.

The contractor is responsible for the assessment of dewatering requirements, which depends on their chosen method of open cut excavation, as well as on the method and procedure for construction/operation/maintenance and decommissioning. The contractor is also responsible for confirming that the radius of groundwater drawdown does not impact the existing embankment. Groundwater and/or surface water control will be required for excavation and construction of the culvert. Dewatering should be carried out in accordance with OPSS.PROV 517 (*Dewatering*) and in accordance with OPSS.PROV 421 (*Pipe Culvert Installation in Open Cut*).

Surface water should be directed away from open excavation areas to prevent ponding of water that could result in disturbance and weakening of the subgrade.

6.5.3 Temporary Protection Systems

The temporary excavation protection and support systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*) as amended by SP 105S09. The lateral movement of the protection systems should meet Performance Level 2 as specified in OPSS.PROV 539, provided that any utilities, if present, can tolerate this magnitude of deformation.

It is anticipated that a driven interlocking steel sheet pile system would be suitable and constructible at this site, as the Standard Penetration Test (SPT) “N”-values measured within the clayey silt to silty clay stratum are generally less than about 20 blows per 0.3 m of penetration. The contractor may elect to use a soldier pile and lagging system; however, the site would need to be adequately dewatered prior to installation of the lagging boards as the silt deposit will not have adequate stand-up time to permit installation of the lagging boards.

The sheet piles or soldier piles will need to extend to a sufficient depth to provide the necessary passive resistance for the retained soil height, plus any surcharge loads behind the protection system. Lateral support to the sheet pile wall or soldier pile wall could be provided in the form of rakers or temporary anchors, if and as required.

Vibratory equipment for the installation of temporary protection systems may be used at this site provided that it does not impact the embankment or nearby buried infrastructure if present. The installation of temporary protection systems by vibratory equipment should be monitored to ensure the vibration levels produced by such construction activity are within tolerable limits and in consultation with the infrastructure / utility and property owners within the zone of influence of the site.

While the selection and design of the temporary protection system will be the responsibility of the contractor, the following information is provided to MTO and its designers to aid in the assessment of the approximate construction costs during detail design.

Stratigraphic Unit	Bulk Unit Weight, γ (kN/m^3)	Angle of Internal Friction, φ (degrees)	Undrained Shear Strength, s_u (kPa)	Lateral Earth Pressure Coefficients[1/2]		
				Passive, K_p[3]	Active, K_a	At-rest, K_o
Embankment Fill – Loose to compact sand	20	32	-	3.25	0.31	0.47
Embankment Fill – Firm to stiff clayey silt with sand to clayey silt	20	-	50	-	-	-
Loose silt with silty clay lenses	18	28	-	2.77	0.36	0.53
Firm to stiff clayey silt to silty clay with silt laminations	17	-	50	-	-	-

Notes:
1. The design groundwater level may be assumed to be Elevation 237.0 m, based on the water levels in the boreholes.
2. The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are expected, the coefficients should be corrected accordingly.
3. The total passive resistance below the base of the excavation (i.e., adjacent to the temporary protection system) may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.16 of the CHBDC (2014) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

It is recommended that the ground surface extending back/upwards from the top of the protection system to the existing Highway 65 surface be graded to an inclination no steeper than 2 horizontal to 1 vertical (2H:1V). This should be shown on the Contract staging drawings.

The loading from construction equipment as well as any material stockpiles within a distance defined by a 1 horizontal to 1 vertical line drawn from the bottom of the excavation to the existing ground surface should be included as a surcharge in the design of the temporary protection system.

Consideration could be given to either partial or full removal of the temporary protection system upon completion of construction or each stage of construction (as required). At this site, full removal of the protection system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work. If partial removal is considered required rather than full removal, an NSSP amending OPSS.PROV 539 should be included in the Contract; an example NSSP is included in Appendix C. Vibration and noise controls during extraction of any temporary systems should meet the same tolerable limits used for installation.

6.5.4 Obstructions

Evidence of boulders and cobbles were not directly encountered during the drilling exploration, but they may be inferred to be present from observations during drilling progress in the fill (augers grinding). Based on experience on similar projects, cobbles and boulders can be present within highway embankment fill which could affect the installation of temporary protection systems. There is also the potential for the presence of organic material (as encountered in the fill material in Boreholes C77-2 and C77-3), roots and tree stumps, at the interface of fill and native soils under the existing embankment, due to possible poor stripping practices during the embankment construction. A Notice to Contractor to identify to the contractor the possible presence of cobbles, boulders and deleterious material within the fill soils and organics at the fill and native soil interface, should be included in the Contract Documents; a copy of which is included in Appendix C.

6.5.5 Subgrade Protection

For open cut culvert installation, the subgrade soils will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that the granular bedding layer be placed immediately after preparation and approval of the subgrade.

6.5.6 Embankment Reconstruction

Fill for reconstruction of the embankment for the open-cut culvert replacement option should consist of OPSS.PROV 1010 (Aggregates) Granular ‘A’ or Granular ‘B’ Type I or Type II material. The embankment fill should be placed and compacted in accordance with OPSS.PROV 501 (Compacting), as emended by SP 105S22 and OPSS.PROV 206 (Grading). Embankment side slopes should be constructed no steeper than 2 Horizontal to 1 Vertical (2H:1V) in granular fill.

Fill for reconstruction of the embankment side slope adjacent to the culvert end(s) and excavation backfill in cuts made for the culvert lining works may consist of the material excavated from the embankment (clayey silt and/or sand to sand and gravel fill).

6.5.7 Embankment Stability and Settlement

Limit equilibrium slope stability analyses were preformed for the reconstructed north-facing embankment side slope at the cut to allow for culvert lining works using GeoStudio 2019 software, employing the Morgenstern-Price method of analysis. For all analyses, the Factor of Safety (FoS) of numerous potential failure surfaces was computed in order to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum factored FoS of 1.33 in the short-term/temporary undrained conditions as per the CHBDC (2014). Figure 1 presents the results of the stability analysis for the reconstructed slope with a FoS of 1.4 and this FoS is considered appropriate for the embankment at this site considering the design requirements, site conditions and field data available.

6.5.8 Surficial Embankment Stability and Erosion Protection

If the culvert is replaced, depending on the selected embankment fill material type, slope geometry, surface treatment and weather conditions (i.e., precipitation, cycles of wetting-drying and/or freezing-thawing), surficial instability of the embankment side slopes may occur, which could include localized sloughing and erosion. As such, in order to maintain the integrity of the new embankments, erosion protection measures may be required depending on the fill type selected for construction.

Based on the specified material types and hence the gradation envelope, granular fill such as OPSS.PROV 1010 (Aggregates) Granular ‘A’, or Granular ‘B’ Type I or Type II, have a low potential for erosion. For embankments constructed of granular fill, erosion control may be limited to hydro-seeding and vegetation following the construction specifications of OPSS.PROV 802 (Topsoil) and OPSS.PROV 804 (Seed and Cover). On-going maintenance for embankments constructed of this material is not expected to be required.

The specification for OPSS.PROV 1010 (Aggregates) SSM allows for much more variation in the gradation of the material compared to Granular ‘A’, or Granular ‘B’ Type I or Type II, and therefore has the potential to be low - erodible to moderate - erodible. Erosion protection for slopes constructed of SSM should consist of erosion control blankets and hydro-seeding. Slopes constructed of SSM and properly protected from erosion should require limited on-going maintenance.

7.0 CLOSURE

This foundation design report was prepared by Mr. Gavin Mundry, a member of the geotechnical group with Golder, and the technical aspects were reviewed by Mr. André Bom, P.Eng., a senior geotechnical engineer and Associate of Golder. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant with Golder conducted an independent and quality control review of the report.

Signature Page

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https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2. reporting/r07 - ker177/3. final/189634 r-r07-reva aecom culvert 77 (ker 177) hwy 65 fidr 28nov_19.docx

REFERENCES

Canadian Standards Associations (CSA) Group 2014. Canadian Highway Bridge Design Code and Commentary S6-14

Canadian Standards Association (CSA), 2014. CSA A23.1-14 Concrete Materials and Methods of Construction (R2014)

Cashman, P.M. and Preene M. (2001) Groundwater Lowering in Construction, A Practical Guide. Spoon Press Publisher.

Ministry of Transportation, Ontario, MTO Gravity Pipe Design Guidelines, April 2014

Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41PNE

Ontario Ministry of Northern Development and Mines. Bedrock Geology of Ontario, East-Central Sheet. Map 2543

Ontario Regulation 903 (Wells)

Occupational Health and Safety Act and Regulation for Construction Projects (as amended)

ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

ASTM D2573 Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils

Ontario Provincial Standard Drawings (OPSD)

OPSD 802.010	Flexible Pipe Embedment in Embankment and Backfill, Earth Excavation
OPSD 802.031	Rigid Pipe Bedding, Cover, And Backfill, Type 3 Soil - Earth Excavation

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 401	Construction Specification for Trenching, Backfilling and Compacting
OPSS.PROV 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS. PROV 802	Construction Specification for Topsoil
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Special Provisions

SP 105S22	Amendment to OPSS 501
SP 105S09	Amendment to OPSS 539

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

CONT No.
GWP No. 5204-14-00

SHEET

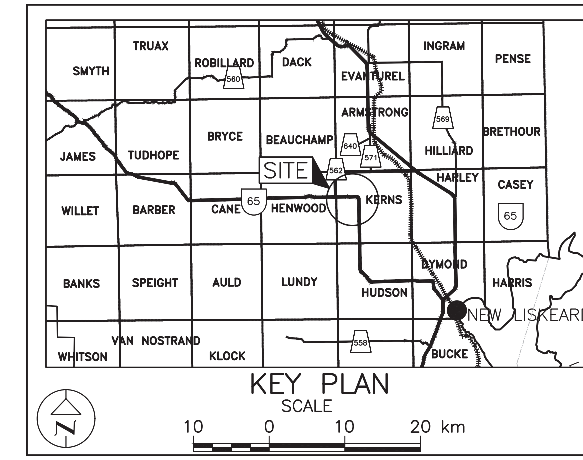
HIGHWAY 65

STATION 10+780 TOWNSHIP OF KERNS CULVERT

BOREHOLE LOCATIONS AND SOIL STRATA

GOLDER

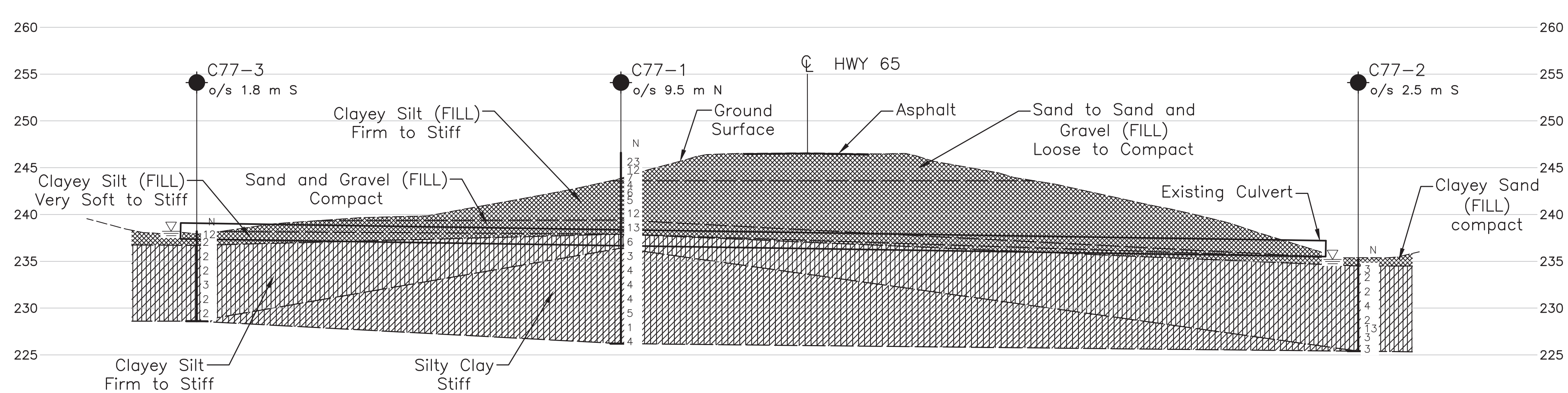
PLAN
SCALE
6 0 6 12 m



KEY PLAN
SCALE
10 0 10 20 km

LEGEND

●	Borehole – Current Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▽	WL upon completion of drilling



PROFILE
SCALE
6 0 6 12 m

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)			
No.	ELEVATION	NORTHING	EASTING
C77-1	246.6	5278348.0	389087.5
C77-2	235.2	5278381.1	389160.0
C77-3	238.2	5278313.8	389055.7

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

REFERENCE

Base plans provided in digital format by AECOM LTD. drawing file no. B065KER SITE 177.dwg, received JUNE 13, 2019.

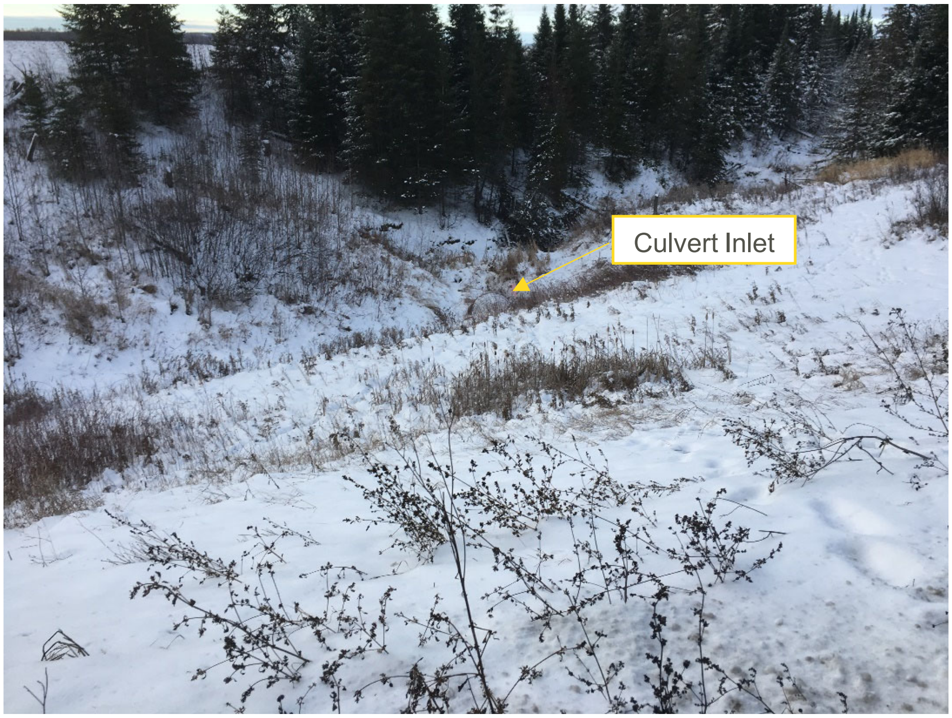
NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31M-127

HWY. 65		PROJECT NO. 1896349	DIST.
SUBM'D.	CHKD. TB	DATE: 11/22/2019	SITE:
DRAWN: TR	CHKD. AB	APPD.	DWG. 1

Photograph 1: Road Surface at Sta. 10+780 Culvert, Facing West (November, 2018)

Photograph 2: Road Surface at Sta. 10+780 Culvert, Facing East (November, 2018)

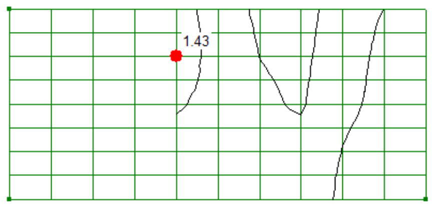


Photograph 3: Embankment South Slope and Culvert Inlet looking south from Roadway Surface (November 2018)

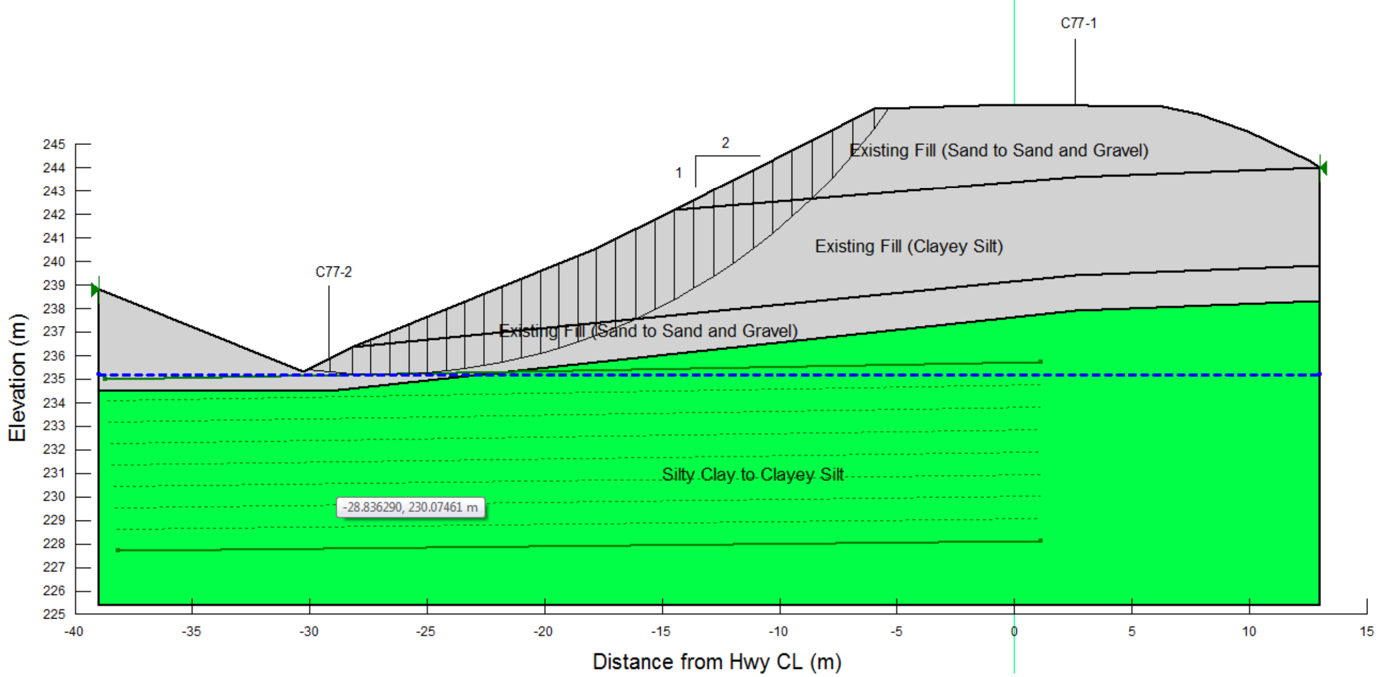
Photograph 4: Embankment North Slope and Culvert Outlet looking north from Roadway Surface (November 2018)

Figure 1

Global Stability Analysis
Highway 65, Sta. 10+780, Township of Kerns Culvert
Existing Embankment
North Side Slope – Culvert Lining Option



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Existing Fill (Clayey Silt)	18	0	28
	Existing Fill (Sand to Sand and Gravel)	20	0	30
	Silty Clay to Clayey Silt	18	50	0



Date: November 2019
Project No: 1896349-R07

Analysis By: GM/TB **Reviewed By:** AB

GOLDER

APPENDIX A

Record of Boreholes

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS
MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (*i.e.,* SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (*i.e.,* some sand)
≤ 10	trace (*i.e.,* trace fines)

1. Only applicable to components not described by Primary Group Name.
2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve friction (f_s) are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

COARSE-GRAINED SOILS

Compactness[1]

Term	SPT 'N' (blows/0.3m)[2]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	➢ 50

3. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
4. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	< 12	0 to 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	> 200	> 30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

LIST OF SYMBOLS
MINISTRY OF TRANSPORTATION, ONTARIO

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma$ - u)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
U	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
E	void ratio
N	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength (ϕ = 0 analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1. $\tau = c' + \sigma' \tan \phi'$
2. shear strength = (compressive strength)/2

RECORD OF BOREHOLE No C77-1

 METRIC

PROJECT 1896349

G.W.P. 5204-14-00

LOCATION N 5278348.0; E 389087.5 NAD83 MTM ZONE 12 (LAT. 47.638802; LONG. -79.878217)

ORIGINATED BY MR

DIST

HWY 65

BOREHOLE TYPE 108 mm I.D. Hollow Strem Augers

COMPILED BY GM

DATUM GEODETIC

DATE November 18, 2018

CHECKED BY AB

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT / SHEAR STRENGTH	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.6	GROUND SURFACE						
0.0	ASPHALT (100 mm)						
0.2	Reclaimed asphalt pavement (RAP)						
	Sand and gravel (360 mm) (FILL)						
246.0 0.6	Sand, trace gravel, trace silt (FILL) Loose to compact Brown Moist				246		
		1	SS	23			
					245		
		2	SS	12		w plotted	6 86 (8)
		3	SS	7	244		
243.6 3.0	Clayey silt, some sand, trace gravel (FILL) Firm to stiff Grey w>PL	4	SS	4			
					243		
		5	SS	6		w_P–w–w_L plotted	16 38 22 24
					242		
		6	SS	5			
					241		
		7	SS	12	240		
239.4 7.2	Sand and gravel, trace silt, trace clay (FILL) Compact Brown Moist				239		
		8	SS	13		w plotted	31 62 5 2
237.9 8.7	CLAYEY SILT, with silt laminations Loose Grey Wet				238		
		9	SS	6	237	w_P–w–w_L plotted	0 0 45 55
236.4 10.2	SILTY CLAY, with silt laminations Stiff Grey w>PL				236		
		10	SS	3		w_P–w–w_L plotted	
					235	+ (field vane) sensitivity 2	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

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

GOLDER

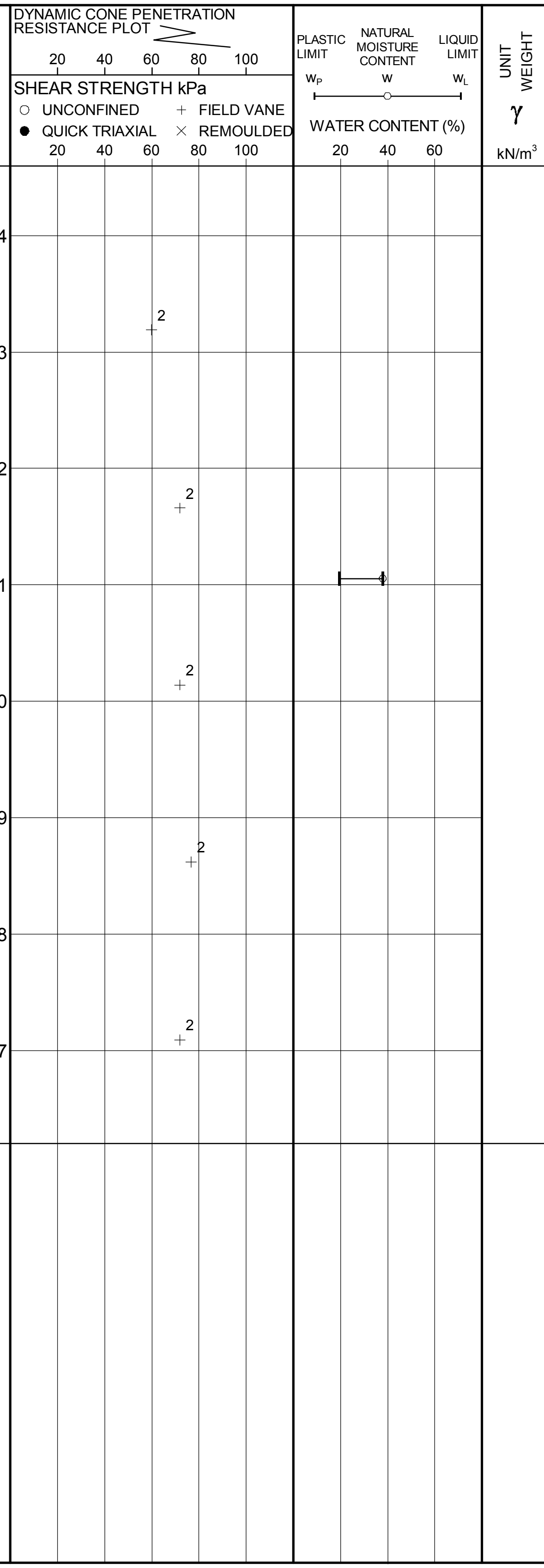
RECORD OF BOREHOLE No C77-1

 METRIC

PROJECT 1896349
G.W.P. 5204-14-00
LOCATION N 5278348.0; E 389087.5 NAD83 MTM ZONE 12 (LAT. 47.638802; LONG. -79.878217)
ORIGINATED BY MR
DIST HWY 65
BOREHOLE TYPE 108 mm I.D. Hollow Strem Augers
COMPILED BY GM
DATUM GEODETIC
DATE November 18, 2018
CHECKED BY AB

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY, with silt laminations Stiff Grey w>PL	11	SS	4	234	
		12	SS	4	233, 232	
		13	SS	4	231	0 0 54 46
		14	SS	5	230, 229	
		15	SS	1	228	
226.2		16	SS	4	227	
20.4	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.					



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

RECORD OF BOREHOLE No C77-2

 METRIC

PROJECT 1896349

G.W.P. 5204-14-00

DIST ______ HWY 65

DATUM GEODETIC

LOCATION N 5278381.1; E 389160.0 NAD83 MTM ZONE 12 (LAT. 47.639091; LONG. -79.877246)

BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring

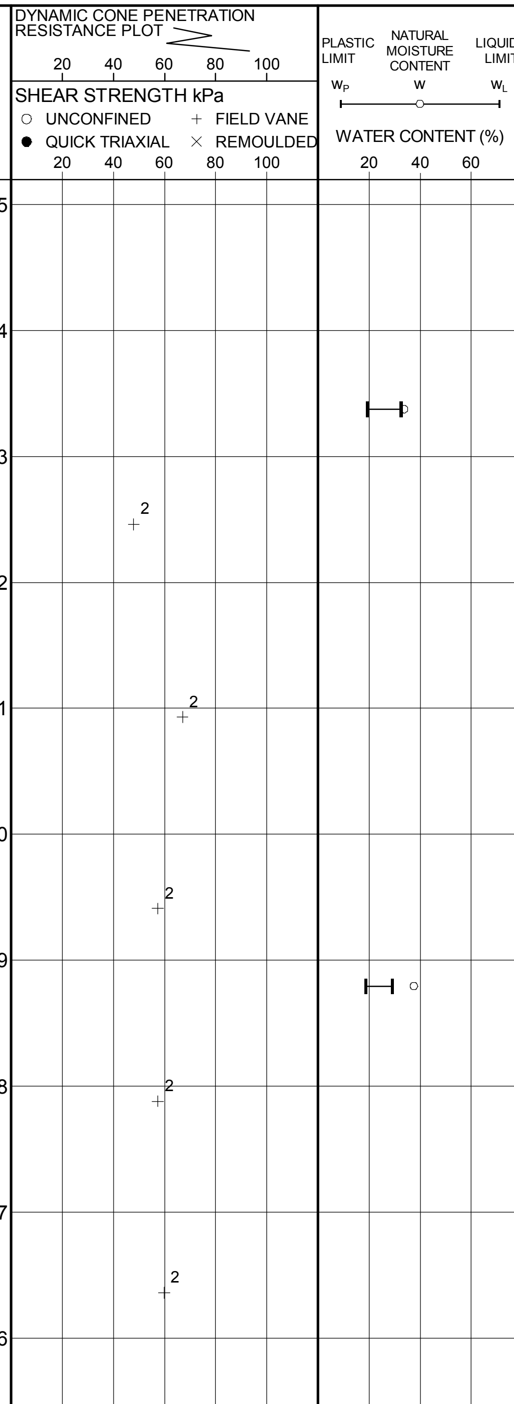
DATE February 20 and 21, 2019

ORIGINATED BY MR

COMPILED BY GM

CHECKED BY AB

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
235.2	GROUND SURFACE				▽							
0.0	Clayey sand, trace to some organics, trace gravel (FILL) Compact Grey Frozen					235						
234.5 0.7	CLAYEY SILT, with silt laminations Firm to stiff Grey w>PL	2	SS	3		234						
		3	SS	2			plotted		0	0	51	49
						233						
		4	SS	2		232						
						231						
		5	SS	4		230						
						229						
		6	SS	2			plotted		0	0	72	28
		1	SS	13		228						
		7	SS	3		227						
						226						
		8	SS	3								
225.4 9.8	END OF BOREHOLE											



NOTES:

1. Water level at ground surface (Elev. 235.2 m) inside casing upon completion of drilling.

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

Foundation Design

GOLDER

RECORD OF BOREHOLE No C77-3

 METRIC

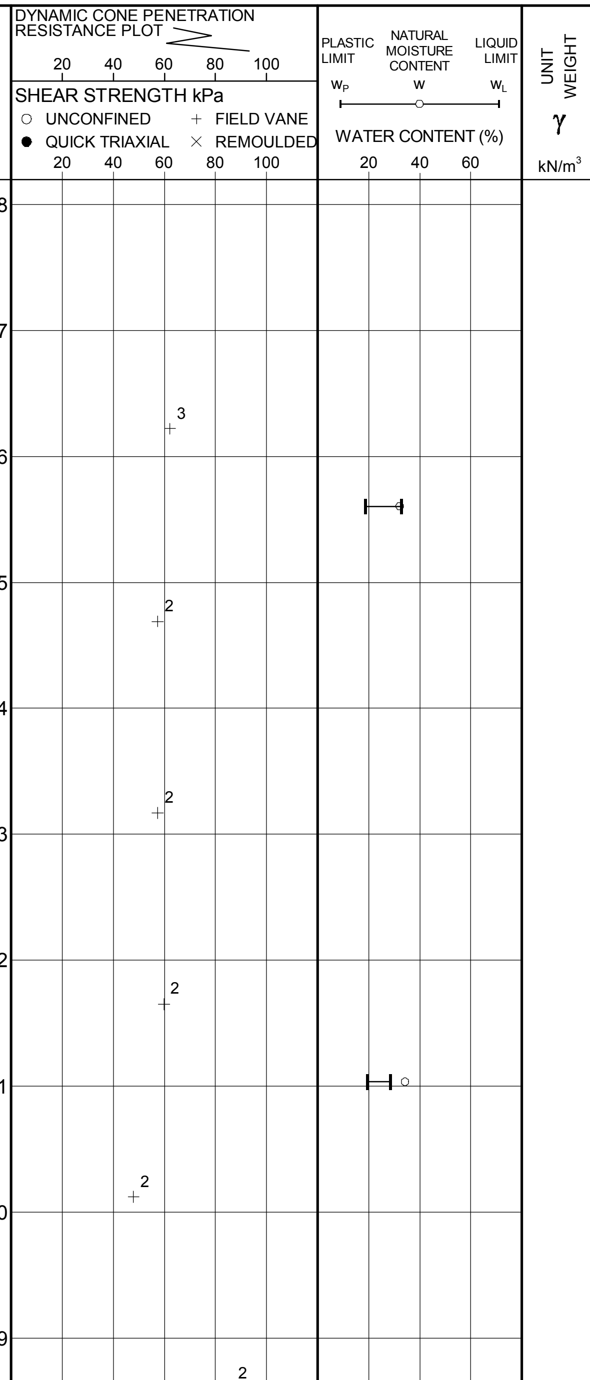
PROJECT 1896349

G.W.P. 5204-14-00 LOCATION N 5278313.8; E 389055.7 NAD83 MTM ZONE 12 (LAT. 47.638498; LONG. -79.878647) ORIGINATED BY MR

DIST ___ HWY 65 BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring COMPILED BY GM

DATUM GEODETIC DATE February 20, 2019 CHECKED BY AB

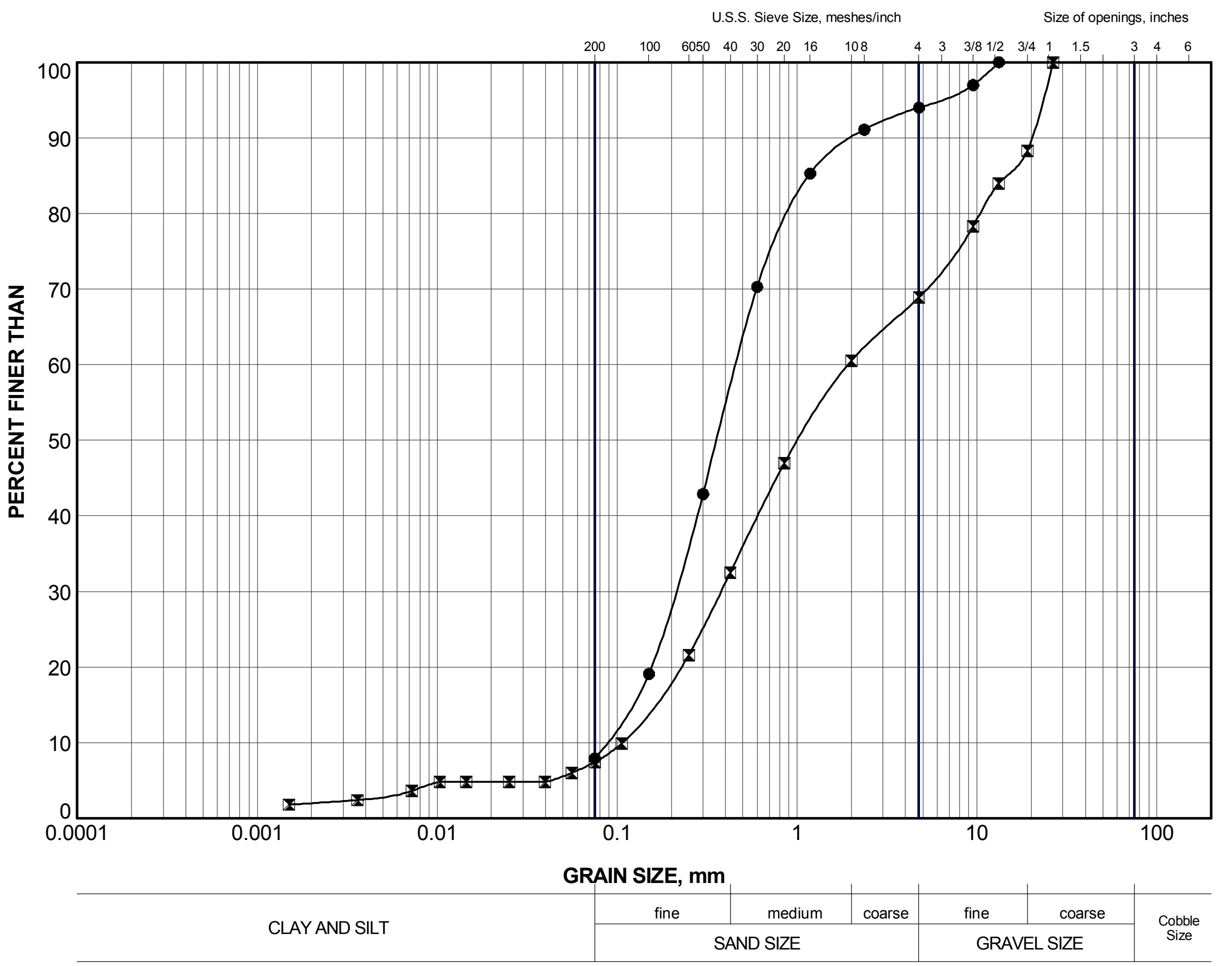
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
238.2	GROUND SURFACE					▽		
0.0	Clayey silt, trace organics, trace gravel (FILL) Very soft to stiff Grey Frozen		1	SS	12		238	
			2	SS	2		237	
236.7 1.5	CLAYEY SILT, with silt laminations Firm to stiff Grey w>PL						236	
			3	SS	2		235	
			4	SS	2		234	
							233	
			5	SS	3		232	
			6	SS	2		231	
							230	
			7	SS	2		229	
228.6 9.6	END OF BOREHOLE NOTES: 1. Water level at ground surface (Elev. 238.2 m) inside casing upon completion of drilling.							



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

APPENDIX B

Laboratory Test Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C77-1	2	244.8
⧗	C77-1	8	238.7

PROJECT

HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE

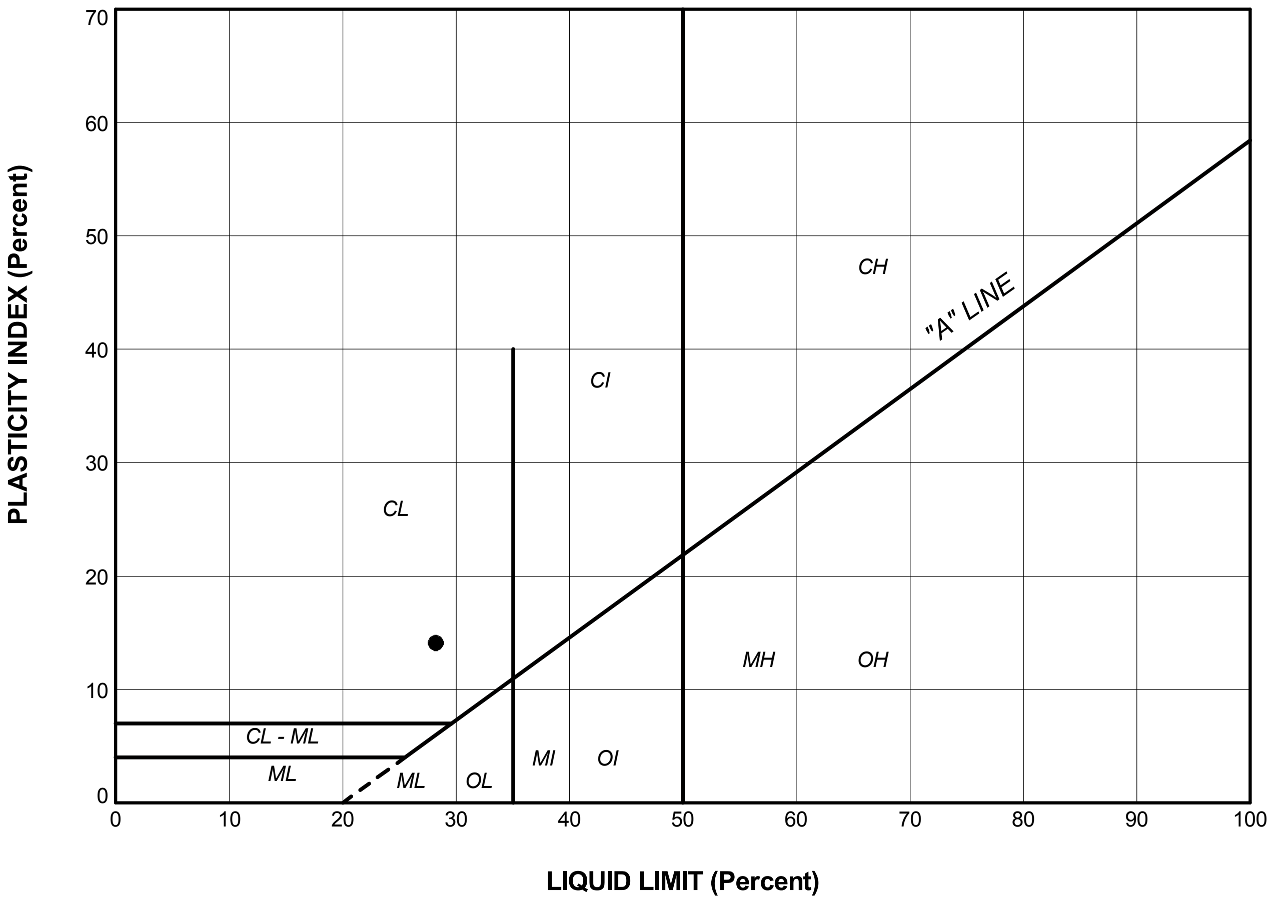
GRAIN SIZE DISTRIBUTION

Sand to Sand and Gravel (FILL)

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.	1896349.GPJ
DRAWN	TR	Jul 2019	SCALE N/A	REV.
CHECK	AB	Jul 2019	**FIGURE B-1**	
APPR	JMAC	Jul 2019		

SUD-MTO GSD GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C77-1	5	28.2	14.1	14.1

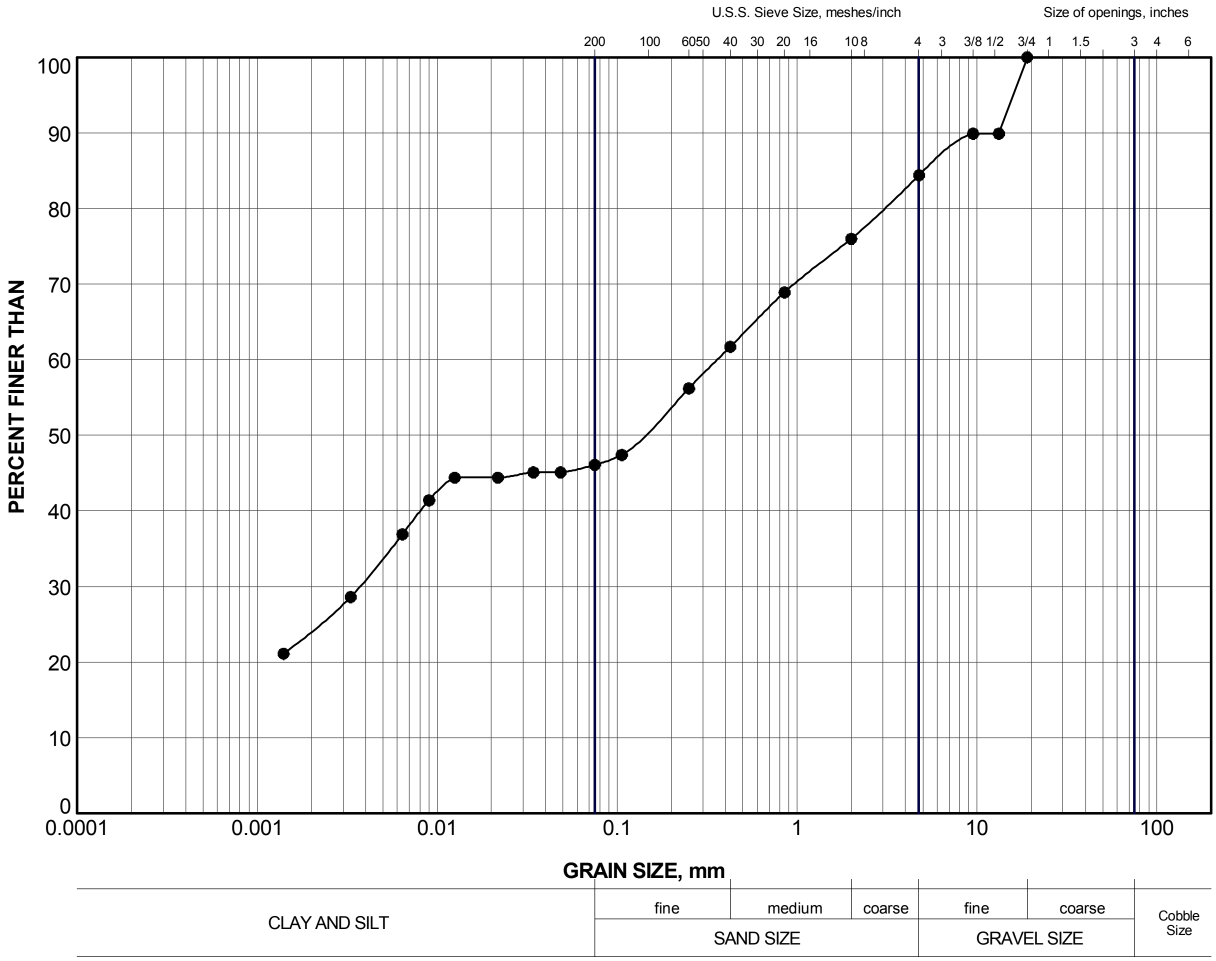
PROJECT
HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE
PLASTICITY CHART
Clayey Silt (FILL)

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.	1896349.GPJ
DRAWN	TR	Jul 2019	SCALE N/A	REV.
CHECK	AB	Jul 2019	FIGURE B-2	
APPR	JMAC	Jul 2019		

SUD-MTO PL GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C77-1	5	242.5

PROJECT

HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

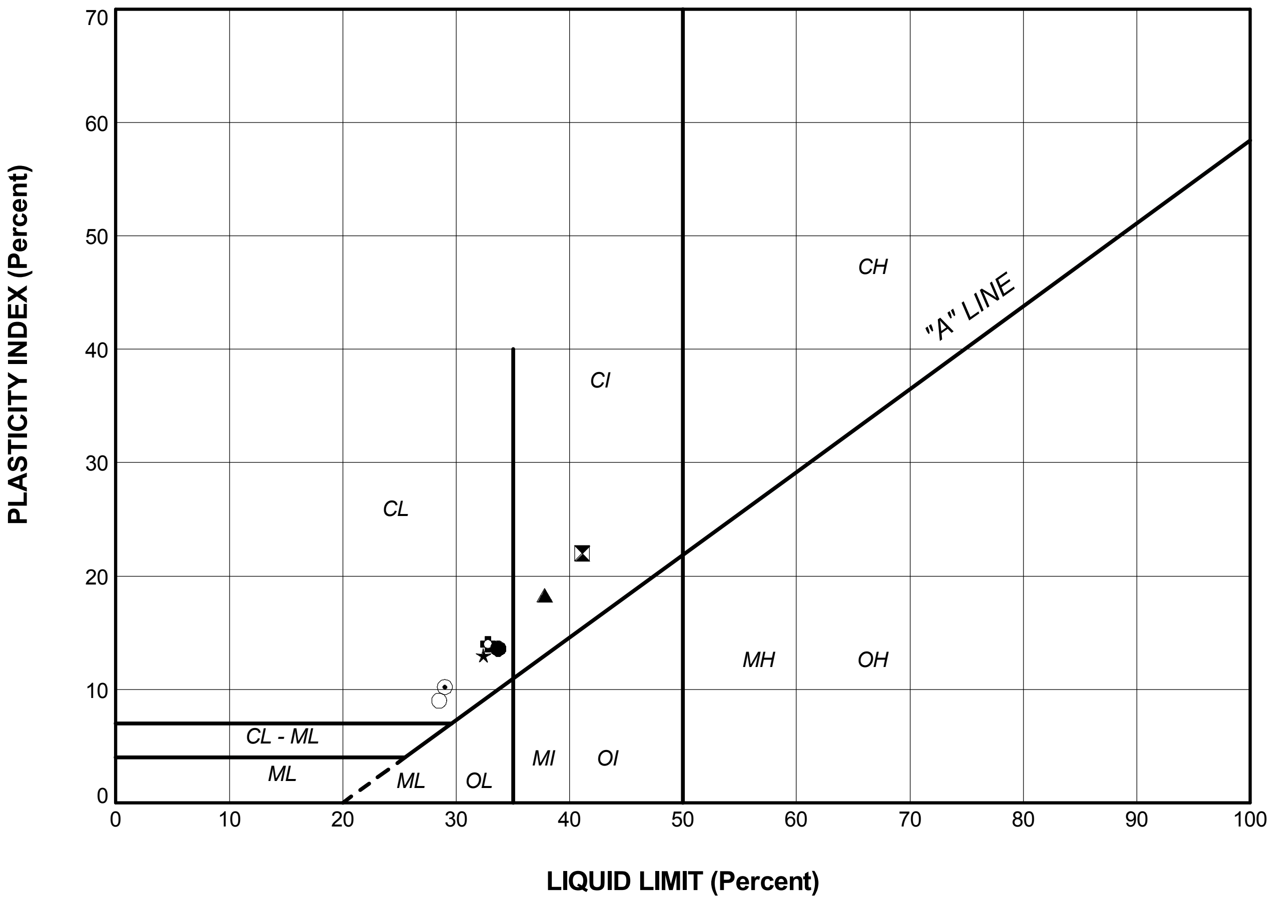
Clayey Silt (FILL)

GOLDER

SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.	1896349.GPJ
DRAWN	TR	Jul 2019	SCALE N/A	REV.
CHECK	AB	Jul 2019		
APPR	JMAC	Jul 2019	FIGURE B-3	

SUD-MTO GSD GLDR_LDN.GDT



SOIL TYPE	PLASTICITY
C = Clay	L = Low
M = Silt	I = Intermediate
O = Organic	H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C77-1	9	33.7	20.1	13.6
⧗	C77-1	10	41.1	19.1	22.0
▲	C77-1	13	37.8	19.5	18.3
★	C77-2	3	32.4	19.4	13.0
⊙	C77-2	6	29.0	18.8	10.2
✿	C77-3	3	32.8	18.8	14.0
○	C77-3	6	28.5	19.5	9.0

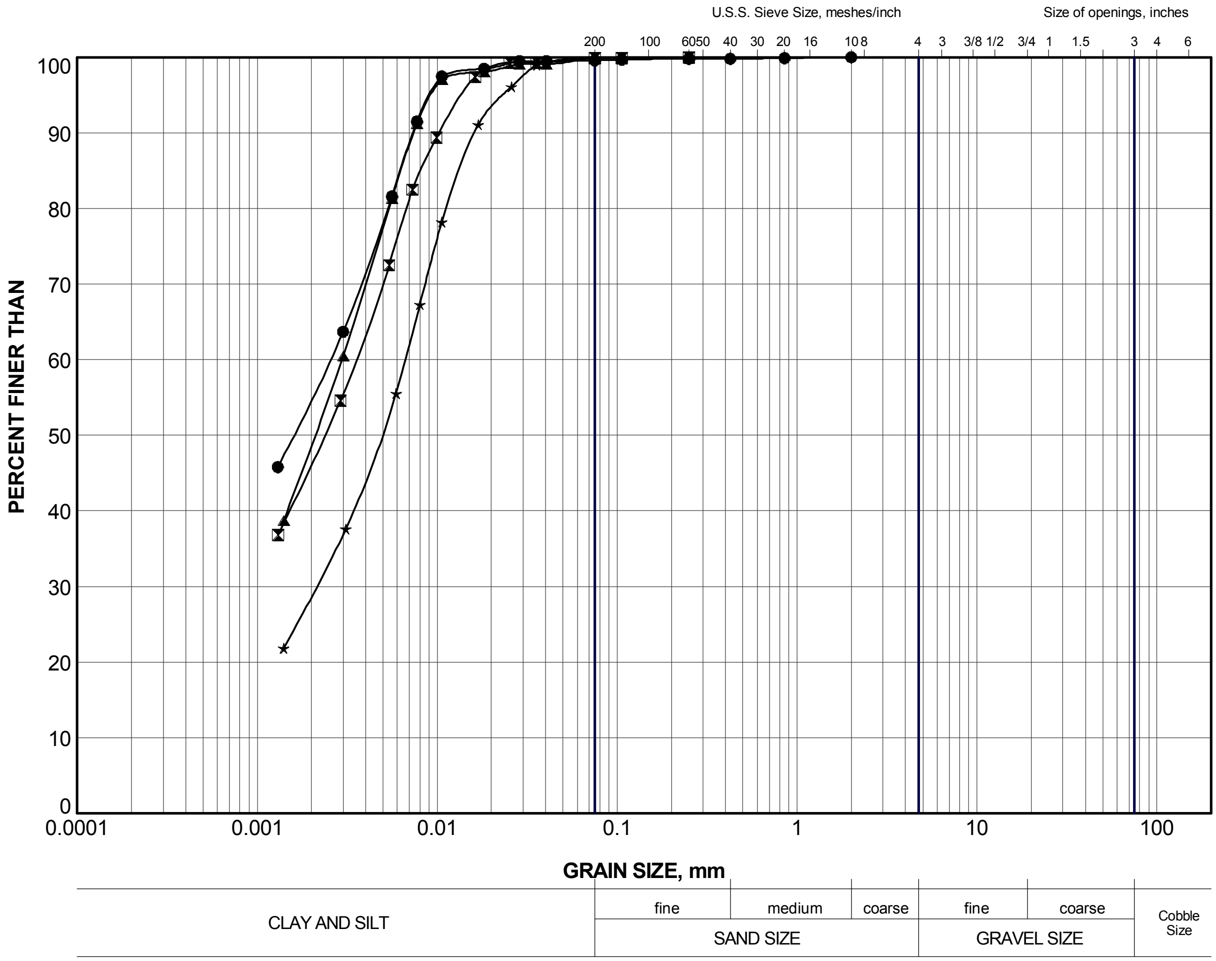
PROJECT
HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE
PLASTICITY CHART
Clayey Silt to Silty Clay with Silt Laminations

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.	1896349.GPJ
DRAWN	TR	Jul 2019	SCALE N/A	REV.
CHECK	AB	Jul 2019	FIGURE B-4	
APPR	JMAC	Jul 2019		

SUD-MTO PL GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C77-1	9	237.2
⧗	C77-1	13	231.1
▲	C77-2	3	233.4
★	C77-2	6	228.0

PROJECT

HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay with Silt Laminations

GOLDER

SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.	1896349.GPJ
DRAWN	TR	Jul 2019	SCALE N/A	REV.
CHECK	AB	Jul 2019	FIGURE B-5	
APPR	JMAC	Jul 2019		

SUD-MTO GSD GLDR_LDN.GDT

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8V6548
Report Date: 2018/12/05

Golder Associates Ltd
Client Project #: 1896349 PHASE 2100
Site Location: HWY 65
Sampler Initials: MR

RESULTS OF ANALYSES OF SOIL

Maxxam ID		IKA226			IKA226			IKA227	IKA228		
Sampling Date		2018/11/13 10:41			2018/11/13 10:41			2018/11/17 11:30	2018/11/18 12:13		
COC Number		62170			62170			62170	62170		
	UNITS	**C14-3 SA 1**	**RDL**	**QC Batch**	**C14-3 SA 1 Lab-Dup**	**RDL**	**QC Batch**	**C27-1 SA 1**	**C77-1 SA 1**	**RDL**	**QC Batch**
CONVENTIONALS											
Sulphide	ug/g	7.35	0.50	5872398				<0.55	0.64	0.55	5872398
Calculated Parameters											
Resistivity	ohm-cm	1200		5859836				2000	3800		5859836
CONVENTIONALS											
Redox Potential	mV	140	N/A	5865933				140	130	N/A	5865933
Inorganics											
Soluble (20:1) Chloride (Cl-)	ug/g	430	20	5862969				250	90	20	5862969
Conductivity	umho/cm	868	2	5863312	909	2	5863312	508	266	2	5863312
Available (CaCl2) pH	pH	7.23		5864763				7.54	7.60		5864763
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	5862489				<20	<20	20	5862489
Physical Testing											
Moisture-Subcontracted	%	24	0.30	5872397				17	25	0.30	5872397

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

APPENDIX C

Non-Standard Special Provisions and Notice to Contractor

OBSTRUCTIONS – Item No.

Notice to Contractor

The contactor shall be alerted to the potential presence of cobbles, boulders, and asphalt fragments within the fill deposits along the alignment of the Highway 65, Station 10+780, Township of Kerns culvert. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for open cut excavations, installation of temporary protection systems.

TEMPORARY PROTECTION SYSTEM – Item No.

Non-Standard Special Provision

Amendment to OPSS 539, November 2014

539.07.02 Removal of Protection Systems

Subsection 539.07.02 od OPSS 539 is deleted in its entirety and replaced with the following:

Protection systems shall be removed from the right-of-way unless it is specified in the Contract Documents that the protection system may be left in place.

Where piles are left in place, the top shall be removed to at least 1.2 m below the finishing grade or ground surface.

The method and sequence of removal shall be such that there shall be no damage to the new work, existing work or facility being protected.

All distributed areas shall be restored to an equivalent to better condition than existing prior to the commencement of construction.

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