April 2017

FOUNDATION INVESTIGATION AND DESIGN REPORT

Culvert Replacement
Site No. 25-340/C, Highway 23
Contract 4 Structure Replacements and Rehabilitation
GWP 3042-11-00
Ministry of Transportation, West Region

Submitted to:
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REPORT

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MINISTRY OF TRANSPORTATION - WEST REGION

1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detailed design work for GWP 3042-11-00. The project involves the detailed design of the replacement and rehabilitation of several structures along multiple highways in southern Ontario. This report addresses the proposed replacement of the culvert at Site 25-340/C at about Station 19+545 on Highway 23, in Perth County, Geographic Township of Elma, Ontario.

The purpose of the foundation investigation is to explore the subsurface conditions at the location of the proposed culvert replacement by drilling boreholes and carrying out in situ and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal, in Golder Associates' proposal P2-1132-0163 dated February 25, 2013, and in the Change Order 12-1132-0163-4000-C03 dated September 13, 2016. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated March 26, 2013.

2.0 SITE DESCRIPTION

The subject culvert is located at about Station 19+545 and spans Highway 23 approximately 290 metres southwest of the intersection with Fisher Avenue in Atwood, Ontario. The Town of Atwood is approximately 300 metres northeast of the site. The replacement culvert will be constructed in approximately the same location as the existing culvert. The approximate location of the culvert is shown on the Key Plan, Figure 1.

This section of Highway 23 is currently a two lane, undivided highway with gravel shoulders. It is generally oriented northeast-southwest in the vicinity of the subject site. An unnamed watercourse referred to as 'Hanna Drain' on an original drawing flows through the culvert from east to west beneath Highway 23. The existing culvert has an overall length of about 27.6 metres, including extensions. The date of original construction is circa 1938, the date of construction of the extensions is unknown.

Existing Dimensions (m)	Obvert Elevation (m)		Construction
	Lt[1]	Rt[1]	
4.2 x 1.8 x 27.6	360.53	360.55	Concrete NRFO

NOTE: 1. When facing the direction of increasing chainage, Lt and Rt are defined as Left and Right of centreline, respectively.

The banks of the watercourse have been partially lined with riprap and an embankment along Highway 23 at the culvert outlet is supported with sand bags. All other embankments near the culvert are grass covered or supporting elements are not visible due to tall grasses. The unnamed watercourse flows through fields on both sides of Highway 23. Selected site photographs are provided in Appendix B.

2.1 Site Geology

The project area is located within the physiographic region of southern Ontario known as the Dundalk Till Plain, near its southern extent. This area is comprised of a gently undulating till plain with is flutings running southeasterly.

This region is bounded by moraines on the east with some morainic ridges in the northeast portion of the region. Numerous small flat-floored valleys form a network over the plain connecting to the Grand or the Maitland spillways systems; these are frequently swampy. Much of the till plain is characterized by swamps or bogs, and by poorly drained depressions.[1] The overburden in the area of the site generally consists of glaciolacustrine deep water deposits of gravel, sand, and silt.[2]

The geological mapping indicates that the site is on the border of the Lucas Formation, consisting of light tan microcrystalline and microsucrosic dolomite (with anhydrite in the subsurface), and the Amherstburg Formation, which reportedly consists of grey to dark brown crinoidal limestone and dolomite (locally cherty, bituminous, and biostromal).[3] The bedrock surface at the site is at about elevation 342 metres[4], or about 18 metres below the general ground surface[5].

3.0 INVESTIGATION PROCEDURES

The geotechnical field investigation was carried on September 21 and 22, 2016, during which time three boreholes were drilled at the approximate locations shown on Drawing 1, attached.

The boreholes were drilled using a track-mounted Diedrich D50T rig supplied and operated by a specialist drilling contractor. Samples of the overburden were typically obtained at depth intervals of 0.75 metres to about 6 metres depth and at 1.5 metre intervals thereafter using 50 millimetre outside diameter split spoon sampling equipment in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The results of the SPT testing, as presented on the Record of Borehole sheets, Drawing 1 and in Section 4.0 of this report, are unmodified (not standardized for hammer efficiency, borehole diameter, rod length, etc.). The samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 40 millimetres. Therefore, particles or objects that may exist within the soils that are larger than this dimension will not be sampled or represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, are known to be present in the glacial tills as discussed in the text of this report.

Groundwater conditions in the boreholes were observed throughout the drilling operations and a piezometer was installed in borehole BH-503 as indicated on the corresponding Record of Borehole sheet. The boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended).

The field work was monitored on a full-time basis by an experienced member of our staff who located the boreholes in the field, obtained utility locates, monitored the drilling, sampling and in-situ testing operations and logged the boreholes. The samples were identified in the field, placed in uniquely-labelled containers and transported to our London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, grain size distribution analyses and Atterberg limits determination, were carried out on selected samples. The results of the laboratory testing are shown on the Record of Borehole sheets and in Appendix A.

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[1] Chapman, L.J., and Putnam, D.F., 1984: Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p.

[2] Cooper, A.J., Fitzgerald, W.D., and Clue, Jack. 1977: Quaternary Geology of the Seaforth Area, Southern Ontario; Ontario Geological Survey Prelim. Map, P.1233. Geol. Serv., scale 1:50,000. Geology 1975, 1976.

[3] Sanford B.V., 1969: Geology Toronto-Windsor Area, Ontario; Ontario Geological Survey of Canada Map 1263A, Scale 1:250,000.

[4] Cooper, A.J.. 1978. Bedrock Topography of the Goderich-Seaforth Area, Southern Ontario; Ontario Geological Survey Prelim. Map P.1974, Bedrock Topography Ser., Scale 1:50,000. Compilation 1977, 1978.

[5] Cooper, A.J. and Nicks, L.P.. 1981: Drift Thickness of the Goderich and Seaforth Areas, Southern Ontario; Ontario Geological Survey, Map P.2450, Drift Thickness Series, Scale 1:50,000. Compilation 1979, 1980.

The as-drilled borehole locations and ground surface elevations at the borehole locations are shown on the Record of Borehole sheets and on Drawing 1. Table 1, below, summarizes the coordinates, ground surface elevations and depths of the boreholes.

Table 1: Geospatial and borehole exploration summary.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BH-501	4 836 805	423 845	362.02	11.13
BH-502	4 836 820	423 847	361.49	9.60
BH-503	4 836 810	423 861	362.10	9.60

4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in-situ and laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets and in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

The boreholes drilled at the site generally encountered fill materials associated with the adjacent pavements, embankment fill materials, and native clayey silt till, and silty clay till.

The locations and elevations of the boreholes and an interpreted stratigraphic profile are shown on Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized in the following sections.

4.2 Soil Conditions

Fill materials associated with the existing pavements and Highway 23 platform embankment were encountered at the ground surface in all of the boreholes. The fill materials generally consisted of sand and crushed gravel and sand in the upper portion (to about elevation 361.0 to 361.6 metres). Beneath the sand and gravel fill and sand fill, clayey silt and sandy silt embankment fill was encountered. The embankment fill was about 2.1 to 2.4 metres thick at the borehole locations and extended to about elevations 358.6 to 359.2 metres. The fill materials had N values, as determined in the standard penetration testing, of 5 to 20 blows per 0.3 metres. Samples of the fill had water contents of about 10 to 36 per cent. A sample of the fill from BH-501 had plastic and liquid limits of about 22 and 35 per cent, respectively, based on a single Atterberg limits determination. This data is presented on Figure A-4. Grain size distribution curves for samples of the fill materials are provided on Figure A-1.

Below the fill, a 0.3 metre thick layer of sandy silt was encountered in BH-501 at about elevation 359.1 metres. Silty clay till was encountered beneath the sandy silt in BH-501 and the fill in BH-502 at elevation 358.8 and 358.6 metres, respectively. The silty clay till layers were about 2.0 and 2.3 metres thick. The silty clay till had N values of 5 to 26 blows per 0.3 metres with water contents of about 19 to 21 per cent. The silty clay till had average plastic and liquid limits of about 22 and 38 per cent, respectively, based on two Atterberg limits determinations. These data are shown on Figure A-4. Grain Size distribution curves for samples of the silty clay till are provided on Figure A-2. Cobbles and boulders should be expected in the till.

Beneath the silty clay till in BH-501 and BH-502 and the fill in BH-503, clayey silt till was encountered between about elevation 356.3 and 359.2 metres. All of the boreholes were terminated in the clayey silt till after exploring it for about 4.4 to 6.7 metres. The clayey silt till had N values of 4 to greater than 100 blows per 0.3 metres and water contents of about 17 to 33 per cent. The clayey silt till had average plastic and liquid limits of about 16 and 31 per cent, respectively, based on four Atterberg limits determinations. These data are shown on Figure A-4. Grain size distribution curves for samples of the clayey silt till are shown on Figure A-3. Cobbles and boulders should be expected in the clayey silt till.

4.3 Groundwater Conditions

Groundwater conditions were observed during drilling and a groundwater observation piezometer was installed in BH-503. The installation details are provided on the corresponding Record of Borehole sheet. Groundwater was encountered during drilling in BH-503. BH-501 and BH-502 remained dry during drilling on September 21 and 22, 2016, respectively. A summary of the encountered and measured groundwater levels is provided in the table below.

Table 2: Encountered and measured groundwater levels.

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)	Measured Groundwater Elevation (m)	
			September 22, 2016	October 25, 2016
BH-501	362.02	Dry	-	-
BH-502	361.49	Dry	-	-
BH-503	362.10	354.5	Piezometer dry to 354.2	358.82

The above-noted encountered water levels are not considered to be representative of the long-term, stabilized groundwater conditions. Based on the change in soil colour from brown to grey and the surrounding topography, the long-term groundwater level is inferred to typically be at about elevation 358.4 metres. Groundwater levels are expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring snow melt conditions.

5.0 MISCELLANEOUS

The investigation was carried out using equipment supplied and operated by London Soil Test Limited, an Ontario Ministry of Environment and Climate Change licensed well contractor. The field operations were supervised by Mr. Daniel Hyland, E.I.T. under the direction of the Field Investigation Manager, Mr. Brett Thorner, P.Eng. The laboratory testing was carried out at Golder's London laboratory under the direction of Mr. Michael Arthur. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Ms. Cara Kennedy, E.I.T. under the direction of the Project Engineer Ms. Dirka U. Prout, P.Eng.. The report was reviewed by Mr. Michael E. Beadle, P.Eng., an Associate with Golder Associates. Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment, conducted an independent quality review of the report.

GOLDER ASSOCIATES LTD.

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PART B

FOUNDATION DESIGN REPORT

CULVERT REPLACEMENT
SITE NO. 25-340/C, HIGHWAY 23
CONTRACT 4 STRUCTURE REPLACEMENTS AND REHABILITATION
GWP 3042-11-00
MINISTRY OF TRANSPORTATION - WEST REGION

6.0 ENGINEERING RECOMMENDATIONS

This section of the report provides recommendations on the foundation aspects of the design of the proposed culvert replacement at Site 25-340/C at Station 19+545 on Highway 23 in Perth County, Ontario. The replacement culvert will be constructed in approximately the same location as the existing culvert. The approximate location of the culvert is shown on the Key Plan, Figure 1.

The recommendations provided in the following sections are based on our interpretation of the factual data obtained from the boreholes advanced during the investigation at this site. The interpretation and recommendations are intended to provide the designers with sufficient information to design the proposed foundations. As such, where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, and scheduling.

The existing culvert has an overall length of about 27.6 metres, including extensions. The date of original construction is circa 1938, but the date of construction for the extensions is unknown. The streambed elevation at the inlet of the existing footing culvert is approximately 358.5 metres. Based on the information provided by Stantec, the replacement culvert will be a 24.4 metre long precast concrete box culvert with a 4.2 metre span and a 2.4 metre high opening with an invert at approximately elevation 358.07 metres. Recommendations have been included for both a new open footing culvert and a new box culvert. The replacement culvert will be installed at about the same location as the existing culvert.

6.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the Canadian Highway Bridge Design Code (CHBDC version S6-14) and its Commentary, a classification of ‘typical’ consequence has been assumed for the proposed replacement culvert and foundation system. This consequence classification should be confirmed by Stantec and the MTO.

The degree of understanding based on the scope of the foundation investigation and proximity of the boreholes to the culvert is considered ‘typical’ as described in Clause 6.5.3.2 of the 2014 CHBDC. The appropriate Ultimate Limit States (ULS) and Serviceability Limit States (SLS) consequence factor, Ψ, geotechnical resistance factors at ULS (ϕ_{gu}) and SLS (ϕ_{gs}), respectively from Tables 6.1 and 6.2 of the CHBDC should be used for design.

6.2 Foundations

Based on the existing investigation, the new box culvert can be founded at or below elevation 358 metres in the silty clay till and clayey silt till. The culvert foundations may be designed using a factored geotechnical resistance at Ultimate Limit States (ULS) of 300 kilopascals (kPa) and a geotechnical reaction at Serviceability Limit States (SLS) of 200 kPa. The SLS value corresponds to 25 millimetres of settlement. Bedding for a precast culvert and a levelling pad should be provided as discussed in Section 6.2.3. In the event that an open footing culvert is constructed, the footings should be founded at or below elevation 356.7 metres and the geotechnical resistances provided for a box culvert may be used for design. The recommended founding elevation considers the required frost depth below the proposed invert elevation.

6.2.1 Frost and Scour Protection

Frost treatment in the form of a frost taper symmetrical about the culvert centreline should be provided in accordance with Ontario Provincial Standard Drawing (OPSD) 803.010. The design frost penetration depth for this area is 1.4 metres. Footings for cast-in-place open footing culverts are to be provided with adequate soil cover or thermal equivalent for frost protection. The culvert should also be adequately protected against scour as noted in Section 1.9.5 of the CHBDC.

6.2.2 Resistance to Lateral Forces/Sliding Resistance

The resistance to lateral forces/sliding resistance between the base of the culvert and the bedding or native silty clay till or clayey silt till should be calculated in accordance with Section 6.10.5 of the CHBDC. Cut-off walls should be provided in accordance with Clause 1.9.5.6 of the CHBDC.

The factored horizontal geotechnical resistance, H_{ri} and H_{rs}, is calculated as follows:

$$H_{ri} = \psi\phi_{gu} (A'c'_i + V_f\tan\delta'_i) > H_f \text{ (for pre-cast elements)}$$

$$H_{rs} = \psi\phi_{gu} (A'c' + V_f\tan\phi') > H_f \text{ (for open footing culverts)}$$

Where:

Ψ = consequence factor, given in Section 6.5.2, Table 6.1 of the CHBDC

ϕ_{gu} = ultimate geotechnical resistance factor, given in Section 6.9.1, Table 6.2 of the CHBDC

A' = effective contact area, square metres

c'_i = effective cohesion along the interface between box culvert base and bedding/levelling, nil

c' = effective cohesion, nil

$\tan\delta'_i$ = coefficient of friction for interface between box culvert base and bedding/levelling pad

$\tan\phi'$ = coefficient of friction between footings and native founding soils

V_f = factored vertical force, kilonewtons

H_f = factored horizontal load, kilonewtons

The factored horizontal resistance may be calculated using the parameters in the following table:

Structure	Interaction	Angle of Friction, δ/ϕ (degrees)	Coefficient of Friction, tan δ/ϕ
Precast Box Culvert	Precast concrete on Granular A bedding/levelling pad	30	0.58
Open Footing Culvert	Cast-in-Place concrete on native silty clay till or clayey silt till	32	0.62

6.2.3 Bedding, Backfill and Cover

Backfill for the culvert should consist of free-draining, non-frost susceptible granular materials such as Ontario Provincial Standard Specifications (OPSS) Granular B, Type III, or Granular A placed in 0.3 metre thick loose lifts and uniformly compacted. Heavy compaction equipment should not be used immediately adjacent to the walls and roof of the culvert. The height of backfill adjacent to the culvert walls should be maintained as equal as possible on both sides of the culvert during all stages of backfill placement. The height of the backfill at each side of the culvert should differ no more than 500 millimetres at any time.

The excavations for this culvert should have a clearance width that exceeds the width of the culvert by at least 1.0 metre on each side to allow for good workmanship and effective compaction of the fill. Bedding for precast box culvert is to be placed on properly prepared native competent materials or approved compacted granular materials and should be at least 300 millimetres thick. At no time should the culvert be constructed on frozen materials. Granular A would be considered suitable for use as bedding material where a precast box culvert is to be installed. The levelling course can consist of a 75 millimetre thick layer of Granular A or materials meeting the gradation requirements for fine concrete aggregates.

6.2.4 Other Design Considerations

The fill height above the culvert roof will be less than 4.5 metres and no grade raise or widening is planned. The foundation materials consist of low compressibility glacial till deposits. Therefore, differential settlement along the length of this culvert is expected to be negligible and cambering is not required.

If the results of hydraulic analysis indicate that there will be significant difference in hydraulic head between the inlet and outlet, then the culvert inlet must be provided with a headwall, clay seal or other seepage control measure. The design of the replacement culvert should include a cut-off wall at the inlet in accordance with Section 1.9.5.6 of the CHDBC.

Erosion protection for the culvert backfill should be provided to protect the roadway, approach embankments, and culvert, as appropriate. Consideration could be given to using suitable non-woven geotextile and rip rap, as required, to provide erosion protection based on hydraulic requirements. Temporary erosion protection and sedimentation control measures should be implemented in accordance with OPSS 805. Rip-rap treatment at the culvert outlet should be provided in accordance with OPSD 810.010. In addition, sediment control such as silt fences and erosion control blankets may be required during construction together with diversion of any flows to mitigate migration of fine soil particles.

6.3 Excavations and Groundwater Control

The excavations will extend through the existing fill and sandy silt into the silty clay till and clayey silt till. Cobbles and boulders should be expected in the till and may be present in the fill. It is anticipated that seepage into the open excavations can be controlled using properly constructed and filtered sumps in the base of the excavation. Surface water runoff should be directed away from the excavations at all times. The existing culvert flows are anticipated to be diverted/piped during construction.

Temporary open cut slopes should be maintained no steeper than 1 horizontal to 1 vertical and may need to be flattened in the fill or blanketed with clear stone to enhance stability. All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The fill materials and native sandy silt would be classified as Type 3 soils and the native silty clay till and clayey silt till would be classified as Type 2 soils.

6.4 Liquefaction Potential and Seismic Analysis

6.4.1 Seismic Parameters

For the purposes of this project, Site Class D is appropriate based on the results of the investigation. Seismic performance should be calculated in accordance with Section 4.4.3 of the CHBDC (version S6-14).

The importance category of the replacement culvert is “other” based on the CHBDC. The corresponding Seismic Category for the structure is 1 based on Table 4.10 of the CHBDC. Structures in Seismic Category 1 need not be analysed for seismic loads. However, minimum requirements as outlined in CHBDC Clause 4.4.5.1 must be followed. It should be noted that the MTO views culverts with spans of 3 metres or greater as being similar to bridges. The designer should ensure that the selected culvert design meets the seismic requirements for buried structures as outlined in Clause 7.5.5 of the CHBDC.

6.4.2 Seismic Hazard Assessment

A preliminary screening of the soil stratigraphy was conducted using the procedure outlined in the Federal Highway Administration recommended procedures[6] and Canadian Foundation Engineering Manual (CFEM). The potential for liquefaction occurring at this site is very low due to historically low seismicity in this area, founding soils with a shear strength greater than 100 kPa or a normalized SPT $(N_1)_{60}$ generally greater than 25 blows per 0.3 metres, and the relatively shallow depth to bedrock. Therefore, a detailed evaluation of the liquefaction potential of the foundation soils is not considered warranted.

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[6]Federal Highway Administration (FHWA). (1997). “Design Guidance: Geotechnical Earthquake Engineering For Highways. Volume I – Design Principles.” *Geotechnical Engineering Circular No. 3:FHWA-SA-97-076*, Washington, D.C.p

6.5 Lateral Earth Pressures for Design

The lateral pressures acting on the proposed culvert will depend on the type and method of placement of the backfill materials, the soil behind the backfill, surcharge loadings including construction loadings, the freedom of lateral movement of the structure and on the drainage conditions behind the walls.

The following recommendations are made concerning the design of the walls in accordance with the CHBDC (version S6-14). It should be noted that these design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Backfill should be placed in accordance with Section 6.2.3 above.
- A compaction surcharge equal to 12 kPa should be included in the lateral earth pressures for the structural design in accordance with CHBDC Figure 6.6.
- If the wall support does not allow lateral yielding (such is typically the case for a rigid concrete box culvert), at-rest earth pressures should be assumed for geotechnical design. The granular fill should be placed in a zone with a width equal to at least 1.4 metres behind the culvert walls (Case (a) from commentary on CHBDC Figure C6.20).
- For Case (a), the restrained case, the pressures are based on the existing embankment fill materials; however, since frost tapers will be provided, the pressures will be based on the materials used to construct the tapers. The following parameters (unfactored) may be used:

	GRANULAR A	GRANULAR B TYPE II	GRANULAR B TYPE III
Soil unit weight:	22 kN/m³	21 kN/m³	21 kN/m³
Coefficients of lateral earth pressure: 'At rest' or restrained, K_o	0.43	0.43	0.47

- If the wall support allows lateral yielding (unrestrained structure, such as for an open footing culvert), active earth pressures are used in the geotechnical design of the structure. The granular fill should be placed in a wedged shaped zone with a width equal to at least 1.4 metres at the base of foundation level against a cut slope which begins at the footing level and extends upwards at a maximum inclination of 1 horizontal to 1 vertical (case (b) from commentary on CHBDC Figure C6.20).

- For walls backfilled using granular materials in accordance with Case (b), the following parameters (unfactored) may be assumed:

	GRANULAR A	GRANULAR B TYPE II	GRANULAR B TYPE III
Fill unit weight:	22 kN/m^3	21 kN/m^3	21 kN/m^3
Coefficients of lateral earth pressure:			
'active' or unrestrained, K_a	0.27	0.27	0.31
'passive', K_p	3.7	3.7	3.2

6.6 Temporary Roadway Protection

It is understood that temporary roadway protection is required should a single lane of traffic need to be maintained on Highway 23 at the culvert location during construction. Temporary support systems could consist of cantilevered soldier piles and lagging, or steel sheet piles. Installation of steel sheets into the firm to hard till materials will be difficult and could be complicated by cobbles or boulders in the till.

Excavation support systems should be designed and constructed in accordance with OPSS 539 and the design should limit the lateral movement of the temporary shoring system to meet Performance Level 2. The contractor is responsible for the complete detailed design of the protection system.

Where the support to the wall is provided by anchors or rakers, the wall design should be based on a triangular earth pressure distribution using the design parameters given below. The raker/anchor support must be designed to accommodate the loads applied from pressures and surcharge pressures from area, line, or point loads as well as the impact of sloping ground behind the system. Passive toe restraint to the soldier piles may be determined using a triangular pressure distribution acting over an equivalent width equal to three times the pile socket diameter.

The unfactored triangular earth pressure distribution (p' in kN/m^2; increasing with depth) can be calculated as follows:

$$p' = K_a (H - h_w)\gamma + K_a(\gamma - \gamma_w)h_w + \gamma_w h_w + K_a q$$

where,
- H = the height of the excavation at any point in metres
- K_a = active coefficient of earth pressure
- γ = soil unit weight
- γ_w = unit weight of water or 9.8 kN/m^3
- q = surcharge for traffic and other loading
- h_w = height of groundwater level above excavation base

The support systems may be designed using the parameters provided in the table below. These parameters are provided to assist with design for the unfactored ultimate resistance and loading conditions and may not result in a temporary support design that adequately controls ground and structure displacements. Achieving adequate displacement control in accordance with the MTO performance criteria may require designs that result in a system that is stiffer than might otherwise be required based on the soil parameters provided in the table below.

Soil Type	Coefficient of Earth Pressure			Internal Angle of Friction (degrees)	Bulk Unit Weight γ (kN/m^3)	Effective Unit Weight γ' (kN/m^3)
	Active, K_a	At Rest, K_o	Passive, K_p			
Fill	0.39	0.56	Nil	26	19.0	9.0
Sandy Silt	0.33	0.50	3.0	30	19.0	9.0
Silty Clay Till	0.31	0.47	3.3	32	20.0	10.0
Clayey Silt Till	0.31	0.47	3.3	32	20.0	10.0

The earth pressure coefficients identified above may be applied assuming a horizontal ground surface behind the retaining structure. Where the ground surface behind the retaining structure is sloped, the earth pressure coefficients provided in the table above must be adjusted accordingly.

6.7 Construction Considerations

Care should be taken during construction to avoid disturbance of the subgrades prior to constructing foundations or placing bedding. All existing fill and any topsoil, organics, frozen and soft or loose soils should be stripped from the proposed founding areas prior to placement of the bedding materials or working mat. Subgrade preparation should be performed and monitored in accordance with OPSS 902 and as modified by these recommendations.

It is recommended that the footing excavations be carried out such that the final 0.5 metres of excavation is completed with a Quality Verification Engineer (QVE) experienced in geotechnical engineering on site. The prepared excavation base should be inspected by the QVE. If footings cannot be poured within a 24-hour period, the subgrade must be protected with a mud slab particularly if a precipitation event is anticipated.

A Non-standard Special Provision (NSSP) or Notice to the Contractor should be added to the Contract Documents to advise the Contractor of the potential for cobbles and boulders in the fill and cohesive till strata. Example text for the NSSP is included in Appendix C.

7.0 MISCELLANEOUS

This section of the report was prepared by Ms. Cara Kennedy, E.I.T., under the direction of the Project Engineer Ms. Dirka U. Prout, P.Eng. The report was reviewed by Mr. Michael E. Beadle, P.Eng., and Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment, who conducted an independent quality review of the report.

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LICENSED PROFESSIONAL ENGINEER
D. U. PROUT
Apr 13/17
PROVINCE OF ONTARIO

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Apr 13/17
PROVINCE OF ONTARIO

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MTO Designated Contact

CK/DUP/MEB/FJH/cr

n:\active\2012\1132 - geo\1132-0100\12-1132-0163 stantec-fdns-mega culverts-3011-e-0041\ph 4000-gwp 3042-11-00\rpts\r05 25-340-c hanna drain\1211320163-4000-r05 apr 12 17 (draft) partsa&b replaceclvrt-25-340-c.docx

LIST OF SYMBOLS

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
$\sigma_1, \sigma_2, \sigma_3$	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 $= (w_l - w_p)$
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 $= \sigma'_p / \sigma'_{vo}$

(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 $= \tan \delta$
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ 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

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º 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

Piezo-Cone Penetration Test (CPT)

A 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 (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index / Relative Density	**N / Blows/300 mm or Blows/ft**
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils
Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
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, G_s)
DS	direct shear test
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	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or	Sand and Gravel
	With (cohesive)	Silty Clay with sand / Clayey Silt with sand

Golder Associates
London, Ontario

RECORD OF BOREHOLE No BH-501

METRIC

PROJECT 12-1132-0163
W.P. 3042-11-00
LOCATION N 4836804.6 , E 423845.1
ORIGINATED BY DH
DIST HWY 23
BOREHOLE TYPE POWER AUGER, HOLLOW STEM
COMPILED BY ZJB/LMK
DATUM GEODETIC
DATE September 21, 2016
CHECKED BY

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
362.02	GROUND SURFACE					
0.00	FILL, sand and crushed gravel, Brown					
361.62 / 0.40	FILL, sand, some silt, some gravel, with cobbles, Brown					
361.26 / 0.76	FILL, clayey silt, some sand, trace gravel with topsoil layers, Very stiff, Brown	1	SS	20		
360.50 / 1.52	FILL, clayey silt, some sand to sandy, trace gravel, with topsoil layers, Firm to stiff, Brown and grey	2	SS	15		
		3	SS	5		0 22 60 18
359.12 / 2.90	SANDY SILT, trace gravel, trace clay, Loose, Brown					
3.20	SILTY CLAY TILL, some sand, trace gravel, Firm to very stiff, Brown to grey at about elev. 358.4m	4	SS	5		
		5	SS	19		1 10 42 47
		6	SS	23		
356.84 / 5.18	CLAYEY SILT TILL, some sand, trace gravel, Very stiff, Grey	7	SS	20		
		8	SS	18		
		9	SS	19		0 16 42 42
		10	SS	22		
		11	SS	21		
350.89 / 11.13	END OF BOREHOLE. Borehole dry during drilling on September 21, 2016					

ELEVATION SCALE: 362 – 351

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

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

LDN_MTO_06 1211320163-4000.GPJ LDN_MTO.GDT 09/02/17

Golder Associates
London, Ontario

RECORD OF BOREHOLE No BH-502

METRIC

PROJECT 12-1132-0163
W.P. 3042-11-00 LOCATION N 4836820.3 , E 423846.6 ORIGINATED BY DH
DIST HWY 23 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY ZJB/LMK
DATUM GEODETIC DATE September 21, 2016 CHECKED BY

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
361.49	GROUND SURFACE							
0.00	FILL, sand and crushed gravel Brown							
361.12 / 0.37	FILL, sand, some silt, some gravel Brown							
0.52	FILL, sandy silt, some clay, trace gravel, with topsoil layers Loose Brown	1	SS	9	3	29	51	17
360.12 / 1.37	FILL, sandy silt, some clay, trace gravel, with topsoil layers Loose Brown and grey	2	SS	8				
		3	SS	5				
358.59 / 2.90	SILTY CLAY TILL, trace to some sand, trace gravel Very stiff Grey	4	SS	15	0	9	40	51
		5	SS	22				
		6	SS	26				
356.31 / 5.18	CLAYEY SILT TILL, some sand, trace gravel, with cobbles Very stiff to hard Grey	7	SS	26				
		8	SS	19	0	13	41	46
		9	SS	50/ 76mm				
		10	SS	23				
351.89 / 9.60	END OF BOREHOLE Borehole dry during drilling on September 21, 2016							

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (361–352); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

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RECORD OF BOREHOLE No BH-503

METRIC

PROJECT	12-1132-0163		
W.P.	3042-11-00	LOCATION	N 4836810.1 , E 423860.8
DIST	HWY 23	BOREHOLE TYPE	POWER AUGER, HOLLOW STEM
DATUM	GEODETIC	DATE	September 22, 2016

ORIGINATED BY DH
COMPILED BY ZJB/LMK
CHECKED BY

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
362.10	GROUND SURFACE					362	
0.08	FILL, sand and crushed gravel Brown						
361.59	APSHALT						
0.51	FILL, sand and crushed gravel Brown						
	FILL, sandy silt, some clay, trace gravel, with topsoil layers Loose to compact	1	SS	20	Cuttings	361	
		2	SS	11		360	
		3	SS	8			5 38 42 15
359.20 / 2.90	CLAYEY SILT TILL, some sand, trace gravel Firm to hard Brown to grey at about elev. 358.4m	4	SS	4		359	0 14 65 21
		5	SS	14	Granular Bentonite	358	
		6	SS	18		357	
		7	SS	21			0 12 44 42
		8	SS	28	Filter Sand	356 / 355	
		9	SS	60/ 254mm	Piezometer	354	
		10	SS	26	Caved Material	353	
352.50 / 9.60	END OF BOREHOLE						

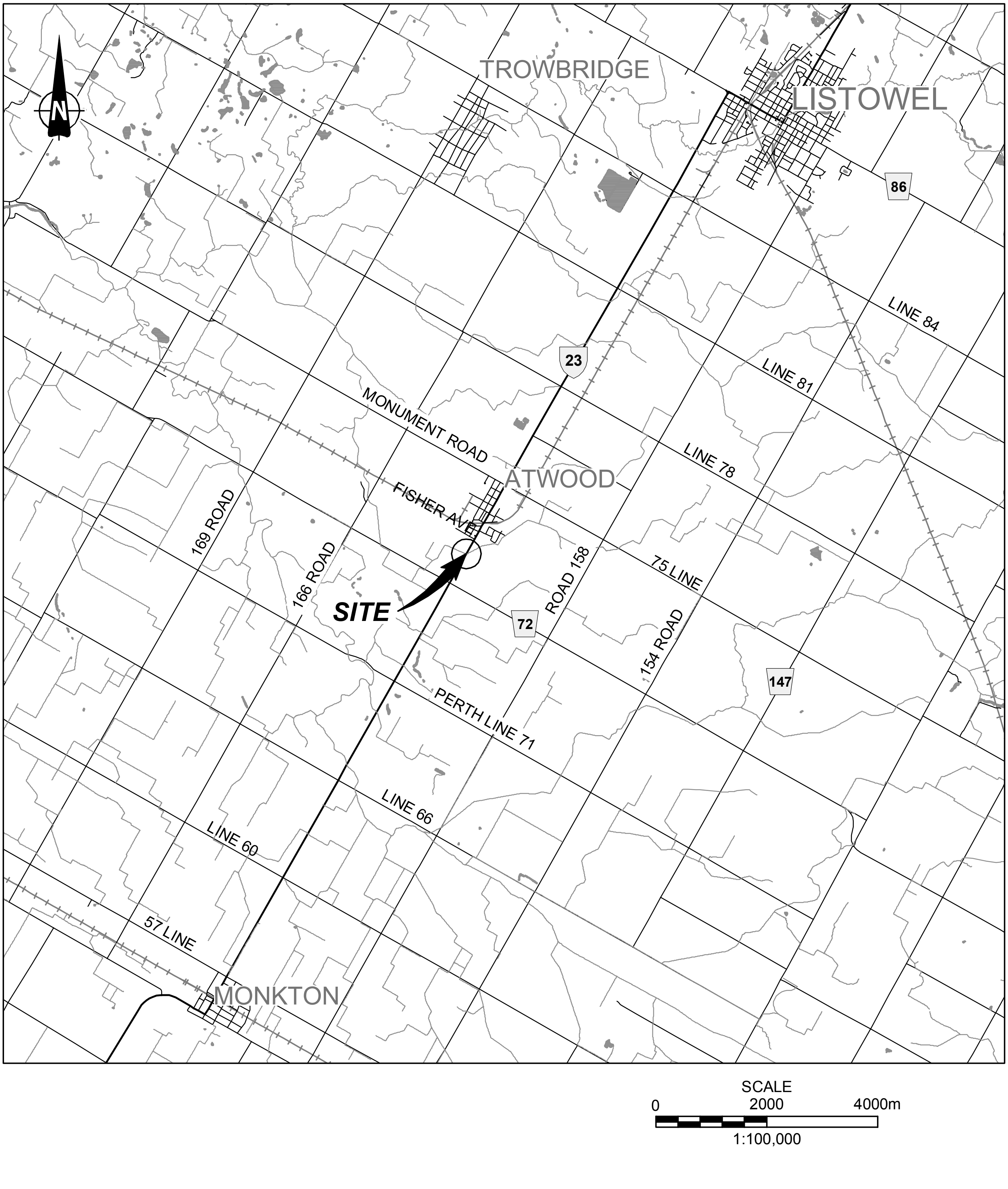
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³

Groundwater encountered at about elev. 354.5m during drilling on September 22, 2016.

Piezometer dry after installation on September 22, 2016.

Water level measured in piezometer at elev. 358.82m on October 25, 2016.

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



REFERENCE

PLAN BASED ON CANMAP STREETFILES V.2008.5.

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT
HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C
HIGHWAY 23
GWP 3042-11-00

TITLE
KEY PLAN

Golder Associates

PROJECT No.		12-1132-0163	FILE No.	1211320163-4000-F05001		
			SCALE	AS SHOWN	REV.	0
CADD	LMK	Jan. 12/17				
CHECK						

FIGURE 1

Drawing file: 1211320163-4000-F05001.dwg   Jan 12, 2017 - 9:12am

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

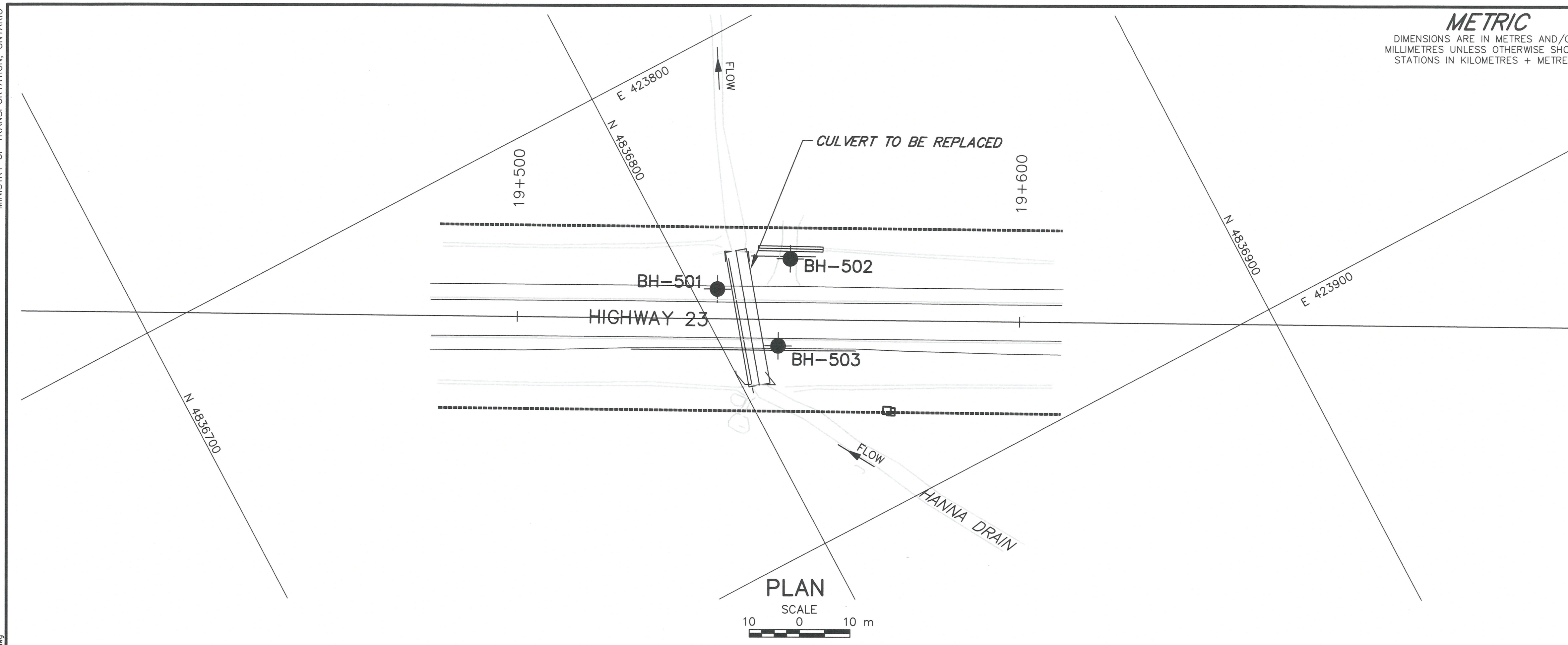
CONT No.
WP No. 3042-11-00

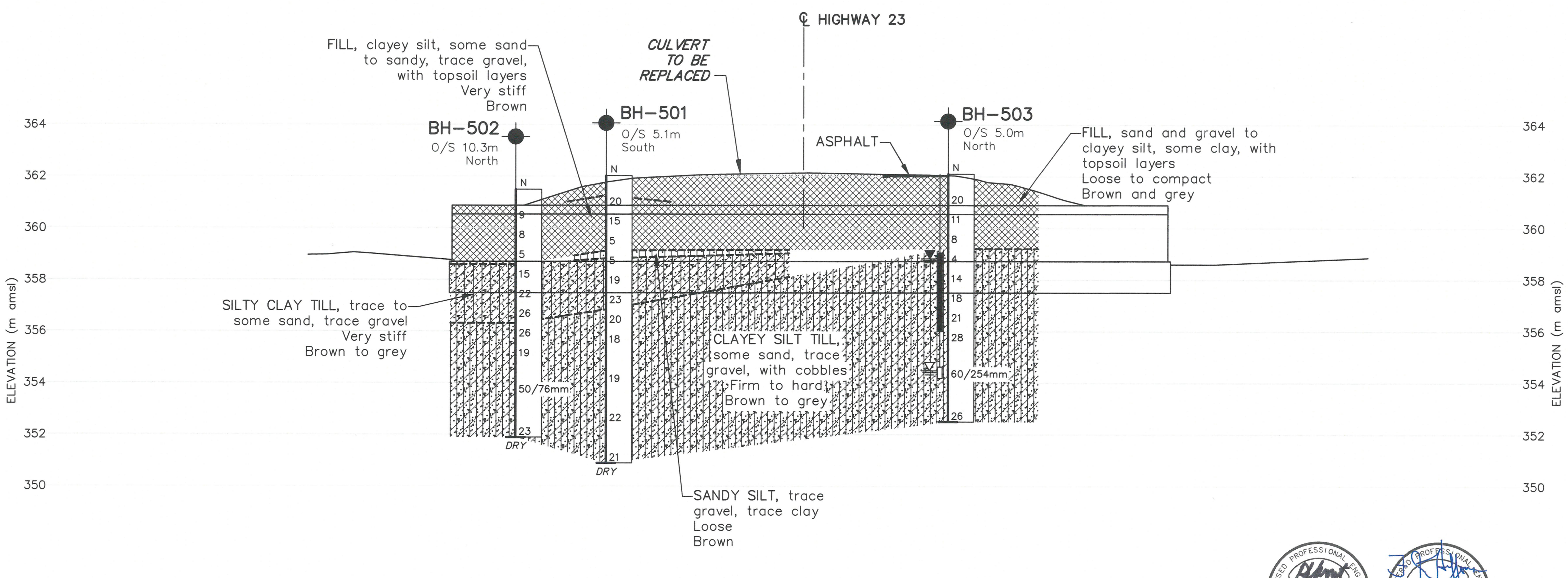
SHEET

CULVERT REPLACEMENT

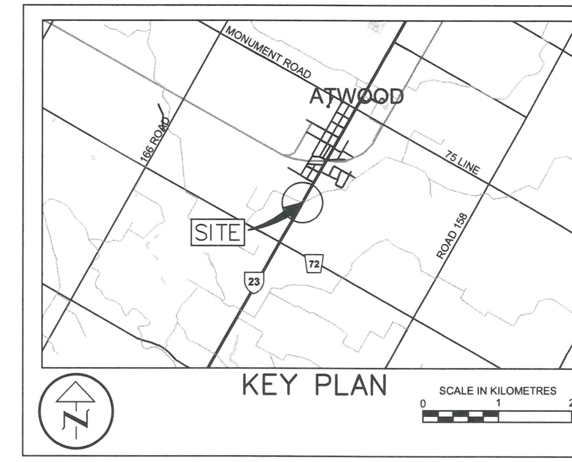
HIGHWAY 23 SITE No. 25-340/C
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
LONDON, ONTARIO, CANADA





PROFILE ALONG ℄ OF HANNA DRAIN
HORIZONTAL SCALE 2 0 2 m
VERTICAL SCALE 2 0 2 m



LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL encountered during drilling
- WL measured on October 25, 2016
- DRY Borehole dry during drilling

No.	ELEVATION	CO-ORDINATES (MTM ZONE 11) NORTHING	EASTING
BH-501	362.02	4 836 804.6	423 845.1
BH-502	361.49	4 836 820.3	423 846.6
BH-503	362.10	4 836 810.1	423 860.8

NOTES

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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 Stantec.

NO.	DATE	BY	REVISION

Geocres No. 40P11-22

HWY. 23		PROJECT NO. 12-1132-0163	DIST.
SUBM'D. BT	CHKD. DH	DATE: Mar 16/17	SITE: 25-340/C
DRAWN: LMK	CHKD. DUP	APPD. FJH	DWG. 1

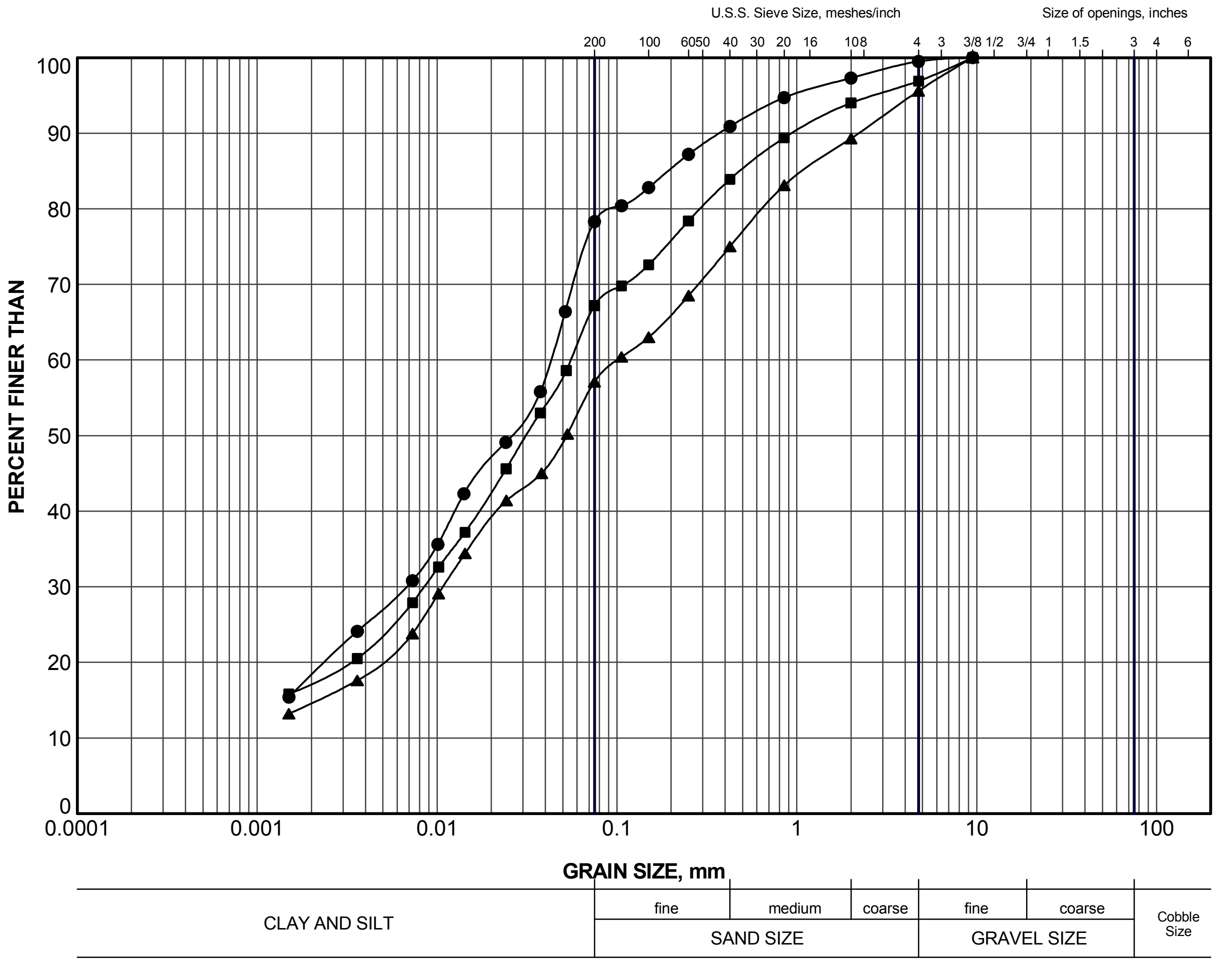
D. U. PROUT — LICENSED PROFESSIONAL ENGINEER, PROVINCE OF ONTARIO
F. J. HEFFERNAN — REGISTERED PROFESSIONAL ENGINEER, PROVINCE OF ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

PLOT DATE: March 31, 2017

APPENDIX A

Laboratory Test Data



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-501	3	359.5
■	BH-502	1	360.5
▲	BH-503	3	359.6

PROJECT
HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C
HIGHWAY 23
GWP 3042-11-00

TITLE
GRAIN SIZE DISTRIBUTION
FILL

PROJECT No.	12-1132-0163	FILE No. 1211320163-4000-F050A1	
		SCALE N/A	REV.
DRAWN ZJB/LMK	Dec 23/16	**FIGURE A-1**	
CHECK			

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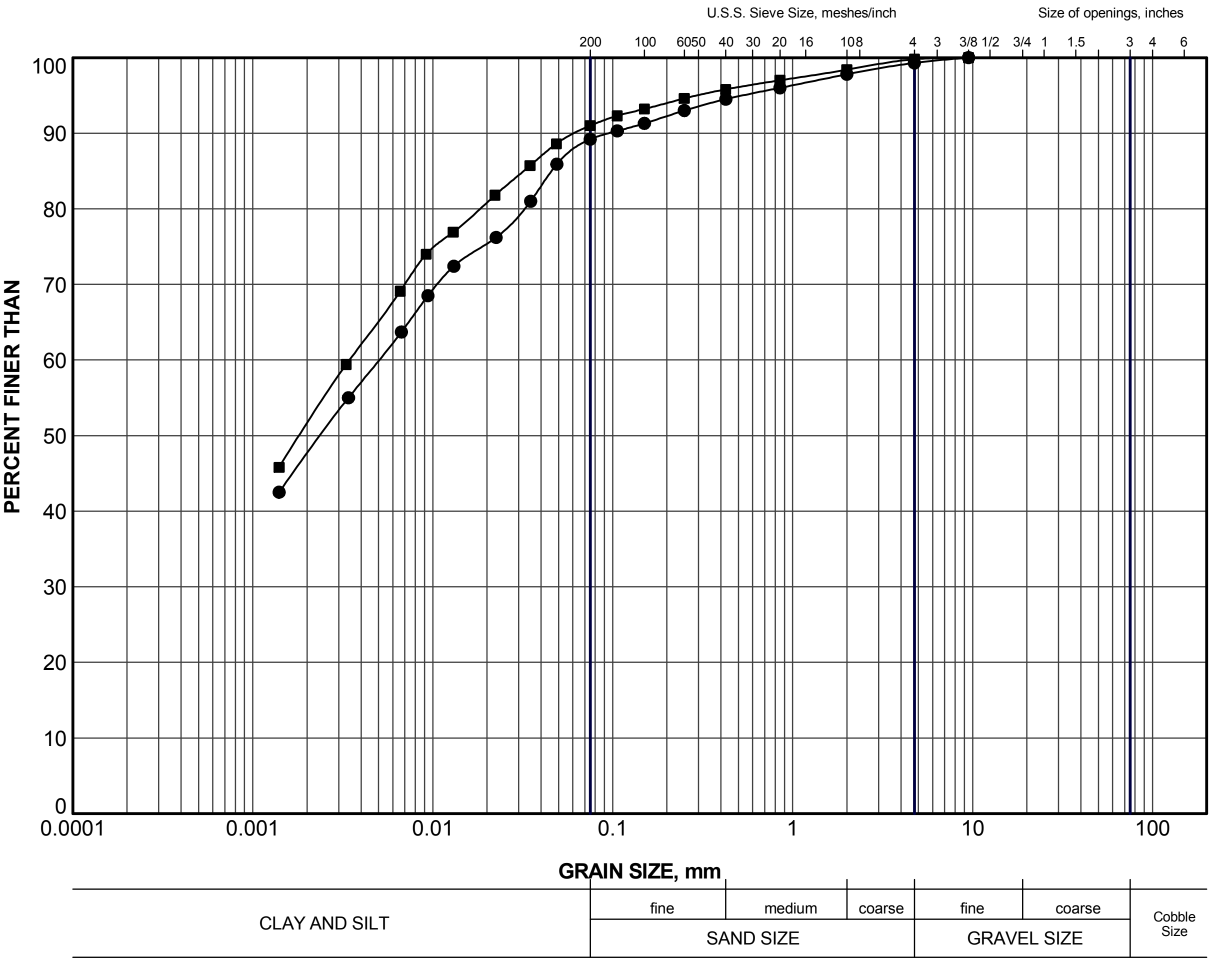
LDN_MTO_GSD GLDR_LDN.GDT 17/10/16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-501	5	358.0
■	BH-502	4	358.2

PROJECT
HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C
HIGHWAY 23
GWP 3042-11-00

TITLE

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL

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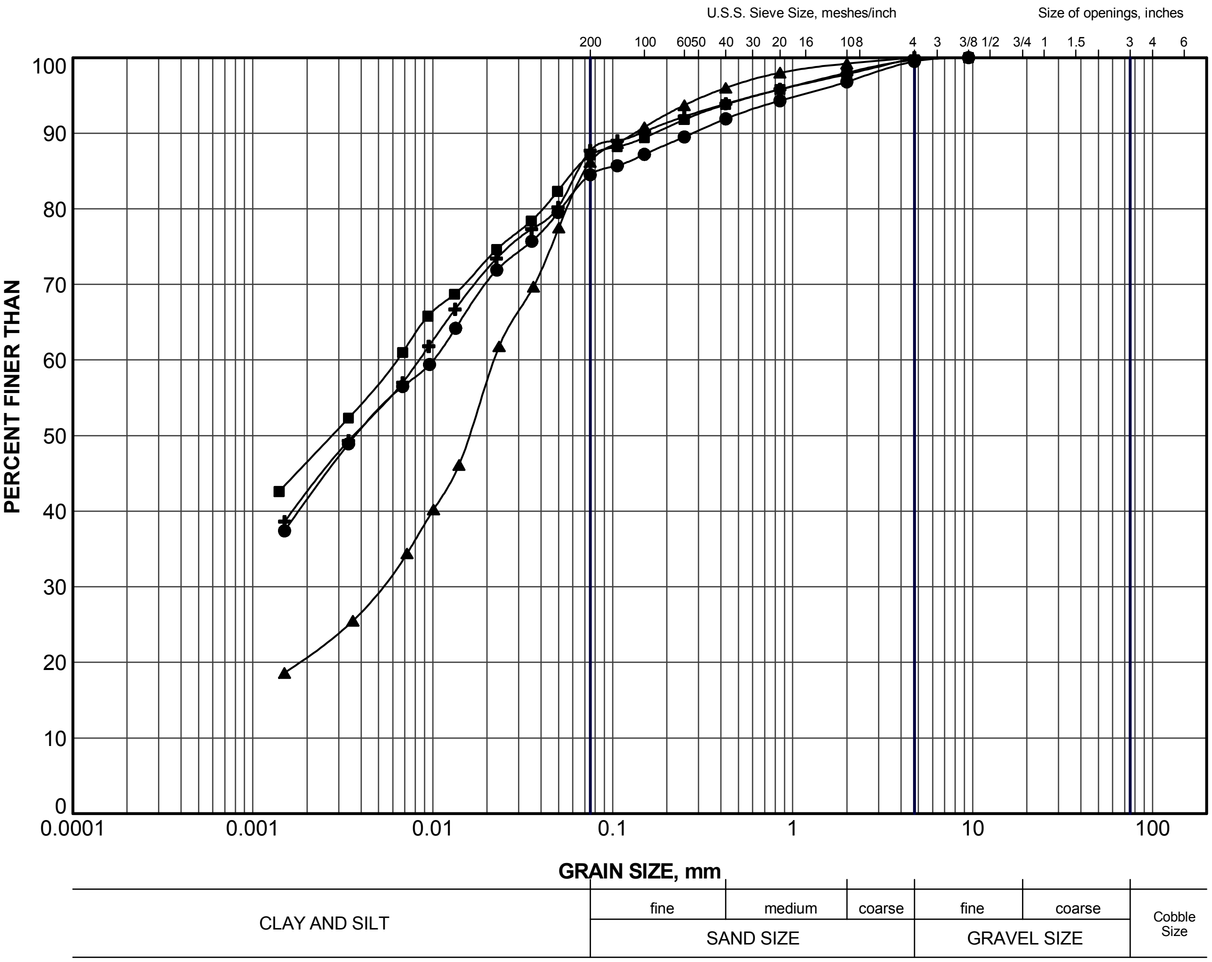
PROJECT No.	12-1132-0163	FILE No. 1211320163-4000-F050A2	
		SCALE N/A	REV.
DRAWN ZJB/LMK	Dec 23/16	**FIGURE A-2**	
CHECK			

LDN_MTO_GSD GLDR_LDN.GDT 17/10/16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-501	9	354.2
■	BH-502	8	355.2
▲	BH-503	4	358.9
✚	BH-503	7	356.5

PROJECT
HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C
HIGHWAY 23
GWP 3042-11-00

TITLE

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL

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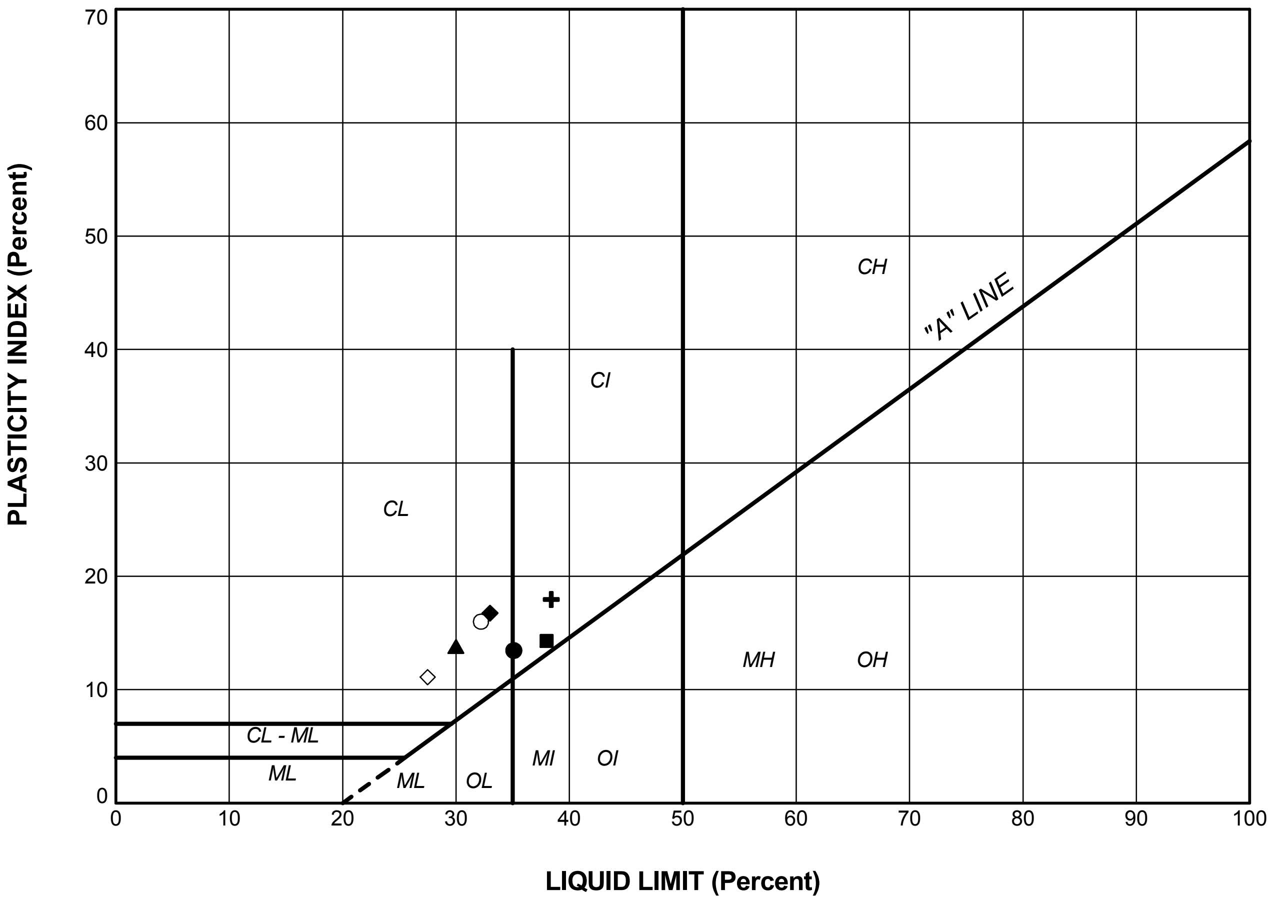
PROJECT No.	12-1132-0163	FILE No. 1211320163-4000-F050A3	
		SCALE N/A	REV.
DRAWN ZJB/LMK	Apr 13/17	**FIGURE A-3**	
CHECK			

LDN_MTO_GSD GLDR_LDN.GDT 17/10/16



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL					
●	BH-501	3	35.1	21.7	13.5
SILTY CLAY TILL					
■	BH-501	5	38.0	23.7	14.3
✚	BH-502	4	38.4	20.5	18.0
CLAYEY SILT TILL					
▲	BH-501	9	30.0	16.2	13.8
◆	BH-502	8	33.0	16.3	16.8
◇	BH-503	4a	27.5	16.4	11.1
○	BH-503	7	32.2	16.2	16.0

PROJECT
HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C
HIGHWAY 23
GWP 3042-11-00

TITLE

PLASTICITY CHART

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PROJECT No.	12-1132-0163	FILE No. 1211320163-4000-F050A4	
		SCALE N/A	REV.
DRAWN	ZJB/LMK	Dec 23/16	**FIGURE A-4**
CHECK			

LDN_MTO_PI GLDR_LDN.GDT 17/10/16

APPENDIX B

Site Photographs

Photograph 1: East elevation (inlet) of Culvert Site 25-340/C.

Photograph 2: West elevation (outlet) of Culvert Site 25-340/C.

Photograph 3: Looking southwest along Highway 23, east ditch toward inlet of Culvert Site 25-340/C.

Photograph 4: Looking northeast along Highway 23, west ditch toward outlet of Culvert Site 25-340/C.

APPENDIX C

NSSP for Cobbles and Boulders

NOTICE TO CONTRACTOR – Soil Conditions - Item No.

Non-Standard Special Provision

The Contractor is alerted to the presence of cobbles and boulders within the fill and native cohesive till soils. All associated work relating to this shall be included in the applicable tender items.

BASIS OF PAYMENT

Payment at the contract price for this Tender Item shall include full compensation for all labour, equipment and material required to do the work.

n:\active\2012\1132 - geo\1132-0100\12-1132-0163 stantec-fdns-mega culverts-3011-e-0041\ph 4000-gwp 3042-11-00\rpts\r05 25-340-c hanna drain\1211320163-4000-r05 apr 3 17 (final) app c nssp cobbles and boulders.docx

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