December 2015

FOUNDATION INVESTIGATION AND DESIGN REPORT

Culvert Rehabilitation, Site No. 19-669/C
Station 23+000, Highway 402
Contract 3 Structure Replacements and Rehabilitation
GWP 3045-11-00
Ministry of Transportation, West Region

Submitted to:

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REPORT

Report Number: 12-1132-0163-3000-R02

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Table of Contents

APPENDICES

PART A

FOUNDATION INVESTIGATION REPORT

CULVERT REHABILITATION, SITE NO. 19-669/C
STATION 23+000, HIGHWAY 402
CONTRACT 3 STRUCTURE REPLACEMENTS AND REHABILITATION
GWP 3045-11-00
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 detail design work for GWP 3045-11-00. The project involves the detail design of the replacement and rehabilitation of several structures along multiple highways in southern Ontario. This report addresses the proposed rehabilitation of the Van Hecke Drain culvert at Station 23+000 on Highway 402, Site 19-669/C, in the Geographic Township of Caradoc in Middlesex County.

The purpose of the foundation investigation is to explore the subsurface conditions at the location of the proposed culvert rehabilitation by drilling boreholes and carrying out in situ testing and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal and in Golder Associates' proposal P2-1132-0163 dated February 25, 2013. 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 situated at Station 23+000 on Highway 402, approximately 0.5 kilometres southeast of Glendon Drive in the Township of Caradoc in Middlesex County, Ontario. The town of Mount Brydges is approximately 3.0 kilometres southwest of the site. The location of the culvert is shown on the Key Plan, Figure 1.

This section of Highway 402 is currently a four lane divided highway with paved shoulders. It is generally oriented northwest-southeast in the vicinity of the subject site. The Van Hecke Drain flows in the culvert from west to east beneath Highway 402. The existing culvert is a concrete rigid frame box (RFB) structure constructed in 1980 with the following characteristics:

Dimensions (m)	Obvert Elevation (m)		Construction
	Lt[1]	Rt[1]	
3.05 x 1.83 x 134.05	224.9	228.5	RFB

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 drain immediately upstream and downstream of the culvert are grass covered with concrete wing walls at the inlet and gabion basket slope protection/retaining wall at the outlet. The watercourse flows through fields adjacent to Highway 402. Site photographs are provided in Appendix B.

The culvert is situated in a rural area with low relief. The highway platform elevation in the vicinity of the culvert ranges from about 236 to 237 metres. Off-platform ground surface elevations in the vicinity of the culvert inlet and outlet range from about 227.5 to 225.3 metres.

2.1 Site Geology

The project area is located within the Caradoc Sand Plains and London Annex physiographic region. This region is characterized by water-laid deposits composed of beds of silts and fine sands.[1] The overburden in the area of the site generally consists of Aeolian deposits of fine sand.[2]

The geological mapping indicates that the underlying bedrock consists of alternating grey shale and argillaceous limestone of the Widder Formation of the Hamilton Group of Middle Devonian age.[3] The bedrock surface at the site is at about elevation 180 metres with the overburden thickness being about 43 to 48 metres. [4]

[1] Chapman, L.J., and Putnam, D.F., 1984: Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p. Accompanied by Map. P.2715 (coloured), scale 1:600,000.

[2] Dreimanis, A. and assistants. 1963: Pleistocene Geology of the St. Thomas Area (West Half). Southern Ontario; Ontario Department of Mines Map 238, scale 1:50,000.

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

[4] Dreimanis, A. and assistants . 1968: Bedrock Topography of the St. Thomas Area, Southern Ontario. Ontario Dept. of Mines Preliminary Map No.P.482, Scale 1:50,000.

3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out between July 8 and 10, 2015, during which time two deep boreholes and four shallow boreholes were drilled at the approximate locations shown on the Borehole Location Plan, Drawing 1.

The deep boreholes, labeled 201 and 202, were drilled to depths of 11.1 and 17.2 metres using track-mounted CME 75 drilling equipment supplied and operated by a specialist drilling contractor. Samples of the overburden were typically obtained at depth intervals of 0.75 metres using 50 millimetre outside diameter split spoon sampling equipment in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Borehole 201 was adjacent to the culvert while borehole 202, for access conditions, was drilled on the edge of the eastbound platform some 50 metres south of the culvert. The shallow boreholes, labeled 203 to 206, were advanced by manual drilling methods by members of our engineering staff at the inlet and outlet of the culvert. Auger samples of select soils were obtained from the shallow boreholes.

The recorded SPT N values are noted on the Record of Borehole sheets. The SPT resistance, or N value, is defined as the number of blows required by a 63.5 kilogram hammer dropped from a height of 760 millimetres to drive a split-spoon sampler a distance of 300 millimetres after an initial 150 millimetres of penetration. 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.

Groundwater conditions in the boreholes were observed throughout the drilling operations and a standpipe was installed in borehole 201 as indicated on the corresponding Record of Borehole sheets. 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 experienced members of our staff who located the boreholes in the field, monitored the drilling, sampling and in situ testing operations and logged the boreholes. The samples were identified in the field, placed in labelled containers and transported to our London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations and grain size distribution analyses, were carried out on selected samples. The results of the testing are shown on the Record of Borehole sheets and in Appendix A.

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

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
201	4 753 723	389 805	235.9	17.2
202	4 753 688	389 735	237.1	11.1
203	4 753 705	389 825	223.8	0.5
204	4 753 703	389 826	224.3	1.2
205	4 753 722	389 697	227.5	1.5
206	4 753 727	389 694	227.5	0.6

4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in situ testing and the laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets following the text of this report 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.

Boreholes 201 and 202 generally encountered the existing pavement granulars overlying embankment fill materials or surficial topsoil, over layers of sands and silts.

The locations and elevations of the boreholes, together with the 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

4.2.1 Topsoil

Topsoil was encountered at the ground surface in boreholes 201 and 203 to 206. The topsoil was 150 to 290 millimetres thick. Cobbles were encountered within the topsoil in boreholes 205 and 206.

Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

4.2.2 Fill

Sand and gravel fill materials, 0.5 and 0.3 metres thick, were encountered beneath the topsoil and from the ground surface in boreholes 201 and 202, respectively. In borehole 201, the sand and gravel fill was underlain by 9.9 metres of loose to compact silt and sand fill to elevation 225.2 metres. The sand and gravel fill in borehole 202 was underlain by 1.1 metres of compact sand fill to elevation 235.7 metres.

Standard penetration test N values in the fill materials ranged from 8 to 21 blows per 0.3 metres. Water contents of samples of the fill materials ranged from 4 to 20 per cent. Grain size distribution curves for samples of the fill materials are presented on Figure A-1 in Appendix A.

4.2.3 Sand

Layers of compact to dense sand, 1.2 and 7.2 metres thick, were encountered beneath the fill in boreholes 201 and 202 at elevations 225.2 and 235.7 metres, respectively. A 1.7 metre thick lower layer of dense sand was also encountered in borehole 201 beneath a layer of silt at elevation 221.2 metres. Sand was also encountered beneath the topsoil in boreholes 203 to 206 between elevations 223.6 and 227.4 metres. Boreholes 203 to 206 were terminated in the sand after penetrating the layer for 0.3 to 1.3 metres. Cobbles were encountered in the sand in boreholes 203 and 206, and borehole 203 was terminated due to auger refusal on an inferred cobble.

The sand layers had N values of 10 to 50 blows per 0.3 metres. Samples of the sand had water contents ranging from 3 to 28 per cent with values up to 48 per cent at the inlet/outlet boreholes. Samples with water contents greater than about 20 per cent were obtained from below the encountered water levels in boreholes 201 and 202. Grain size distribution curves for samples of the sand are provided on Figure A-2.

Cobbles and boulders should be expected in the sands since boreholes 203 and 206 were terminated due to refusal on inferred cobbles and cobbles and boulders were visible on the ground near the creek bed.

4.2.4 Silty Sand

A 1.8 metre thick layer of dense silty sand was encountered beneath the sand in borehole 202 at elevation 228.6 metres. The silty sand had an N value of 36 blows per 0.3 metres and a water content of 24 per cent. A grain size distribution curve for a sample of the silty sand is provided on Figure A-3.

4.2.5 Sandy Silt

Compact sandy silt was encountered beneath the silty sand in borehole 202 at elevation 226.7 metres. Borehole 202 was terminated in the sandy silt after penetrating the layer for 0.8 metres. The sandy silt had an N value of 23 blows per 0.3 metres and a water content of 24 per cent.

4.2.6 Silt

Borehole 201 encountered layers of compact silt beneath the sand layers at elevations 224.0 and 219.6 metres. The upper layer of silt was 2.8 metres thick. Borehole 201 was terminated in the lower layer of silt after penetrating it for 0.9 metres. The silt had N values of 15 to 22 blows per 0.3 metres and samples of the silt had water contents of 23 to 27 per cent. A grain size distribution curve for a sample of the silt is provided on Figure A-4.

4.3 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling and a groundwater observation standpipe was installed in borehole 201. Installation details are provided on the corresponding Record of Borehole sheets following the text of this report. Groundwater was encountered in boreholes 201 to 206 at depths of 0.2 to 10.4 metres, or elevations 225.5 to 229.5 metres. A summary of the encountered and measured groundwater levels is provided in the table below.

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)	Measured Groundwater Elevation (m)		
			July 10, 2015	July 31, 2015	August 24, 2015
201	235.9	225.5	225.62	225.65	225.62
202	237.1	229.5	-	-	-

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)	Measured Groundwater Elevation (m)		
			July 10, 2015	July 31, 2015	August 24, 2015
203	223.8	223.4	-	-	-
204	224.3	224.1	-	-	-
205	227.5	227.3	-	-	-
206	227.5	227.1	-	-	-

The above-noted encountered water levels are not considered to be representative of the long-term, stabilized groundwater conditions. The corresponding water level in the drain was measured at elevation 226.8 metres at the culvert inlet on July 10, 2015.

Based on the observed groundwater levels, the surrounding topography and the water level in the drain, the groundwater level is inferred to be at about elevations 227.5 and 224.0 metres at the inlet and outlet, respectively at the time of the investigation. The groundwater levels should be 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 Inc., an Ontario Ministry of Environment and Climate Change licensed well contractor. The field operations were supervised by Mr. Brett Thorner, E.I.T. under the direction of the Field Investigation Manager, Mr. David J. Mitchell. The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Chris M. Sewell. 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. Nicole A. Gould, P.Eng. under the direction of the Project Engineer, Ms. Dirka U. Prout, P.Eng. This report was reviewed by Mr. Michael E. Beadle, P.Eng., an Associate and Geotechnical Engineer 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.

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PART B

FOUNDATION DESIGN REPORT

CULVERT REHABILITATION, SITE NO. 19-669/C

STATION 23+000, HIGHWAY 402

CONTRACT 3 STRUCTURE REPLACEMENTS AND REHABILITATION

GWP 3045-11-00

MINISTRY OF TRANSPORTATION - WEST REGION

6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides recommendations on the foundation aspects of the design of proposed retaining walls to be repaired as part of the major rehabilitation of the Van Hecke Drain culvert at Station 23+000 on Highway 402, Site 19-669/C, in the Township of Caradoc in Middlesex County, Ontario.

The recommendations are based on 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 remediation works. 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 is a 134.1 metre long concrete RFB structure with a 3.0 metre span and a 1.8 metre high opening with invert elevations of 226.7 and 223.1 metres at the inlet and outlet, respectively. The culvert has 5.2 and 4.0 metre long concrete wingwalls at the inlet on the west side of the highway and gabion basket slope protection/retaining wall at the outlet. It is indicated in the Request for Proposal that this culvert is scheduled for major rehabilitation in 2016 to 2017. The rehabilitation work will include repair of deteriorated concrete in the top slab and walls and injection of polyurethane grout into cracks and construction joints. The gabion walls at the outlet end will also be repaired. No rehabilitation works are slated for the concrete retaining walls at the inlet.

6.2 Retaining Walls

6.2.1 Inspection of Gabion Wall

The gabion retaining wall at the east (outlet) end of the structure was visually inspected by the Project Engineer on June 11, 2015 at the request of Stantec. The westbound lane embankment slope downstream of the gabion wall was found to be overgrown and steeper than 2 horizontal to 1 vertical (2H:1V) but no signs of instability or erosion were observed; therefore it was deemed to be stable.

A panoramic elevation view of the gabion wall is shown on Photograph 4. The gabion wall consists of 8 courses of baskets which were each approximately 0.5 metres high. The lowermost two courses occupied the area immediately adjacent to the culvert walls. The remaining courses extended across the culvert. Each course was stepped back about 0.5 metres so it has been assumed that the baskets have a typical width of 1 metre. Looking downstream and designating areas as left or right relative to the centreline of the culvert and watercourse, there were five corrugated steel pipe (CSP) culverts at the left side of the wall and one at the right. The largest one was 900 millimetres in diameter and was at the level of the fourth course of gabions from the bottom to the left of the box culvert. No flow was observed from this CSP during the inspection. Four CSPs approximately 500 millimetres in diameter were situated to the right of the culvert along the second course of gabions from the bottom. The third CSP from the box culvert had steady flow and the remainder were dry. The sixth culvert was a 200 millimetre diameter CSP at the level of the watercourse approximately 1 metre downstream of the right wall of the box culvert (see Photograph 5).

The gabions were found to be in relatively good condition. Rusted and broken wires and minor deformations of the wall, typically in the form of bulging and sagging of the baskets above the culvert, were observed. The gabion wall was covered with small shrubs and some woody vegetation has established within the gabions, most notably to the left of the box culvert as shown in Photograph 5. No voids within the baskets were noted; however voids may be present which were either not visible at the exposed surface of the gabion baskets or were obscured by vegetation. No evidence of gabion wall instability was noted; however an erosion channel relatively bare of vegetation was observed along the embankment slope to the left of the gabion wall (see Photographs 4 and 6). This area may also be used as a deer trail since footprints and droppings were observed and a deer was trying to approach the waterway during the site visit. A small sinkhole or possible animal burrow was observed behind the wall at the southwest corner of the wall. Approximately 3 metres vertically above the wall was a larger sinkhole containing a near-vertical CSP (see Photographs 7 and 8). The approximate observed locations of the sink holes are shown in plan on Drawing 1. With the exception of these sinkholes, no subsidence was observed along the top of the gabion wall. Although evidence of scour was observed at the outlet on the left side of the culvert near the toe of the embankment slope (see Photograph 9), the channel is stable downstream of the box culvert (see Photograph 10).

6.2.2 Engineering Assessment of Gabion Wall

The most recent biennial structural inspection report (September 2011) provided by the MTO indicated that the embankments were steep but stable and indicated no performance deficiencies with the gabion retaining wall. The original design drawing from Contract No. 80-77 is provided in Appendix C. It indicates that the side slope of the eastbound embankment was to be inclined at 1.75H:1V but does not indicate the slope inclination of the westbound embankment. Based on our site visit, it appears that the side slope of the westbound embankment is also sloped at about 1.75H:1V. No gabion retaining walls were indicated at the outlet so it is assumed that this structure was added after the culvert was constructed in 1980. However, a former access road was present at the time of construction above the outlet. A culvert was located across the access road in the approximate vicinity of the noted sinkhole containing the sub-vertical CSP.

Golder Associates has assessed the gabion retaining wall as stable based on the visual assessment only. The minor deformations of the wall are attributed to settlement or movement of the gabion fill material due to corrosion of the basket wires. A computational stability check of the gabion wall was not carried out since the exact configuration of the gabion baskets was not known and design or as-built drawings are not available. However, a global stability analysis of the slope and gabion system was carried out using SLOPE/W Version 7.23, a limiting equilibrium slope stability software produced by GEO-SLOPE International, Ltd. The results indicate that the slope is stable with a Factor of Safety greater than 1.3.

6.2.3 Gabion Wall Rehabilitation

Stantec has indicated that rehabilitation of the gabion retaining wall will primarily consist of localized grouting, addition/replacement of wires and/or replacement of baskets. Gabion wall repair works shall be carried out in accordance with Ontario Provincial Standard Specification (OPSS) 512.

During rehabilitation, any baskets which contain significant voids should be repacked or replaced depending on the condition of the wires. When replacing baskets which are in direct contact with the retained fill, the area should be inspected to confirm the presence and condition of a filter fabric/geotextile. If it is absent or damaged, the filter fabric at the rear of the wall should be replaced with non-woven geotextile conforming to OPSS 1860. A minimum overlap of 0.3 metres should be maintained between adjacent pieces of geotextile. Geotextile placed along the top course shall be adequately anchored. Bulging of the face of new or repacked baskets may be minimized through the installation of stiffeners after each lift has been placed.

Localized repair using grouting may be necessary due to limited access if voids are encountered. Difficulties with containing the grout within the coarse gabion stone should be expected. A fabric form may be used to contain the grout. Extensive grouting will result in a reduction of the drainage capacity of the gabion retaining wall. If grouting is required below the inferred groundwater level of elevation 225.5 metres or up to 1 metre above this level, it should be limited in extent and drainage holes should be provided within the grouted area.

Apart from repairs/replacement of corroded baskets or replacement of baskets where required, rehabilitation works should include remediation of the two sinkhole areas, removal of all woody vegetation growing within the baskets and implementation of erosion protection measures along the left side of the gabion wall, including the outlet area. The sinkhole immediately behind the rear of the wall should be filled with lean concrete. However, the larger sinkhole may likely have developed due to collapse of soil surrounding the CSP due to corrosion. If this CSP is no longer needed, it should be filled with lean concrete. Otherwise, it should be replaced, slip-lined or repaired. Large woody vegetation growing through the gabions should be removed and the wires repaired and stone replaced, as required. The slope along the right (southern) side of the retaining wall should be regraded and erosion protection installed.

6.3 Construction Considerations

Sediment control such as silt fences and erosion control blankets may be required during construction. All retaining wall foundations must be protected against scour as noted in the CHBDC Section 1.9.5.

6.4 Excavations and Groundwater Control

Excavations are expected to extend through the existing fill and the underlying native sands and silts. Excavations for the gabion repairs are not expected to extend below the inferred groundwater levels of elevations 227.5 and 224.0 metres at the inlet and outlet, respectively. Some groundwater seepage from the native sands and granular fill should be anticipated, particularly after major precipitation events. Surficial water seepage into the excavations should be expected and will be more significant during periods of sustained precipitation. It is considered that surface water in the excavations can be controlled by pumping from properly constructed and filtered sumps located at the base of the excavations. Depending on the timing of construction, seasonal variation potentially resulting in groundwater levels higher than those encountered during the investigation should be expected.

Surface water runoff should be directed away from the excavations at all times. The existing culvert flows may need to be diverted/piped during construction. The appropriate NSSP should be included in the contract documents to alert the contractor about the need for adequate control of surface and groundwater flows.

Temporary open cut slopes within the fill materials should be maintained no steeper than 1H:1V and localized sloughing and ground movements should be expected. 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 native sands and silts below the groundwater level and the fill materials would be classified as Type 3 soils. Native sands and silts above the groundwater level would be classified as Type 2 soils.

6.5 Shoring and Temporary Roadway Protection

Based on the correspondence with Stantec, shoring will not be required for the proposed culvert repairs. The following recommendations have been provided for completeness.

Should excavations be ultimately required, for the culvert repairs temporary support systems could consist of soldier piles and lagging or steel sheet piles. Cobbles and boulders were encountered within the sands at the culvert inlet and outlet. The contractor should be prepared for the presence of cobbles and boulders within the sands and in the fill materials which may impede installation of the steel sheet piles.

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; water level to be taken as elevations 227.5 and 224.0 metres at the inlet and outlet, respectively, as measured at the time of the investigation in the summer of 2015, and assumed to vary linearly along the length of the culvert

If braced excavations with struts and walers are required for temporary shoring excavations for repair of the culvert walls and top slabs, the following recommendations are provided.

For braced excavations in granular fill and native materials, the unfactored rectangular earth pressure distribution (p in kN/m²; constant with depth), can be calculated as follows:

$$p = 0.65\,K_a\,(\gamma H + q)$$

where H = the height of the excavation at any point in metres

K_a = active coefficient of earth pressure

γ = soil unit weight

q = surcharge for traffic and other loading

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 □(kN/m^3)	Effective Unit Weight □(kN/m^3)
	Active, K_a	At Rest, K_o	Passive, K_p			
Fill	0.36	0.53	2.8	28	19	9.0
Sand	0.33	0.50	3.0	30	19	9.0
Silty Sand	0.35	0.52	2.9	29	19	9.0
Sandy Silt	0.36	0.53	2.8	28	19	9.0
Silt	0.38	0.55	2.7	27	18.5	8.5

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 increased accordingly.

7.0 MISCELLANEOUS

This section of the report was prepared by Ms. Nicole A. Gould, P.Eng. 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 and Geotechnical Engineer 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.

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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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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.) split spoon 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) 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	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.

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
F	factor of safety
V	volume
W	weight

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
v	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

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
l_p	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_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
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 ($\phi = 0$ 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
* density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

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RECORD OF BOREHOLE No 201

METRIC

PROJECT 12-1132-0163

W.P. 3045-11-00 LOCATION N 4753722.8 , E 389805.2 ORIGINATED BY BT

DIST HWY 402 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY WDF

DATUM GEODETIC DATE July 8, 2015 CHECKED BY

ELEV / DEPTH	SOIL PROFILE DESCRIPTION
235.86	GROUND SURFACE
0.00	TOPSOIL, silty Brown
0.27	FILL, sand and gravel, some silt Brown
235.13 0.73	FILL, silt and sand, trace to some clay Loose to Compact Brown
225.19 10.67	SAND, fine, some silt, trace gravel Compact Grey
223.98 11.88	SILT, trace to some sand, trace to some clay Compact Grey
221.23 14.63	

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	9				
2	SS	11	0	53	33	14
3	SS	13				
4	SS	8				
5	SS	8				
6	SS	10	0	48	37	15
7	SS	13				
8	SS	12				
9	SS	12				
10	SS	11				
11	SS	9	1	39	48	12
12	SS	8				
13	SS	10	3	61	31	5
14	SS	10				
15	SS	10				
16	SS	21				
17	SS	22	0	5	89	6

GROUND WATER CONDITIONS: Granular Bentonite; Backfill; Granular Bentonite; Filer Sand & Caved Material; Piezometer

ELEVATION SCALE: 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221

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

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No 201

METRIC

PROJECT 12-1132-0163
W.P. 3045-11-00
LOCATION N 4753722.8 , E 389805.2
ORIGINATED BY BT
DIST
HWY 402
BOREHOLE TYPE POWER AUGER, HOLLOW STEM
COMPILED BY WDF
DATUM GEODETIC
DATE July 8, 2015
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, fine, trace to some silt Dense Grey		18	SS	41		220		~20		
219.55 16.31	SILT, some sand, some clay Compact Grey		19	SS	15		219		~23		
218.64 17.22	END OF BOREHOLE Groundwater encountered at about 225.5m during drilling on July 8, 2015. Water level measured at 225.62m on July 10, 2015. Water level measured at 225.65m on July 31, 2015. Water level measured at 225.62m on Aug. 24, 2015.										

$+^3, \times^3$: Numbers refer to Sensitivity   O $^{3\%}$ STRAIN AT FAILURE

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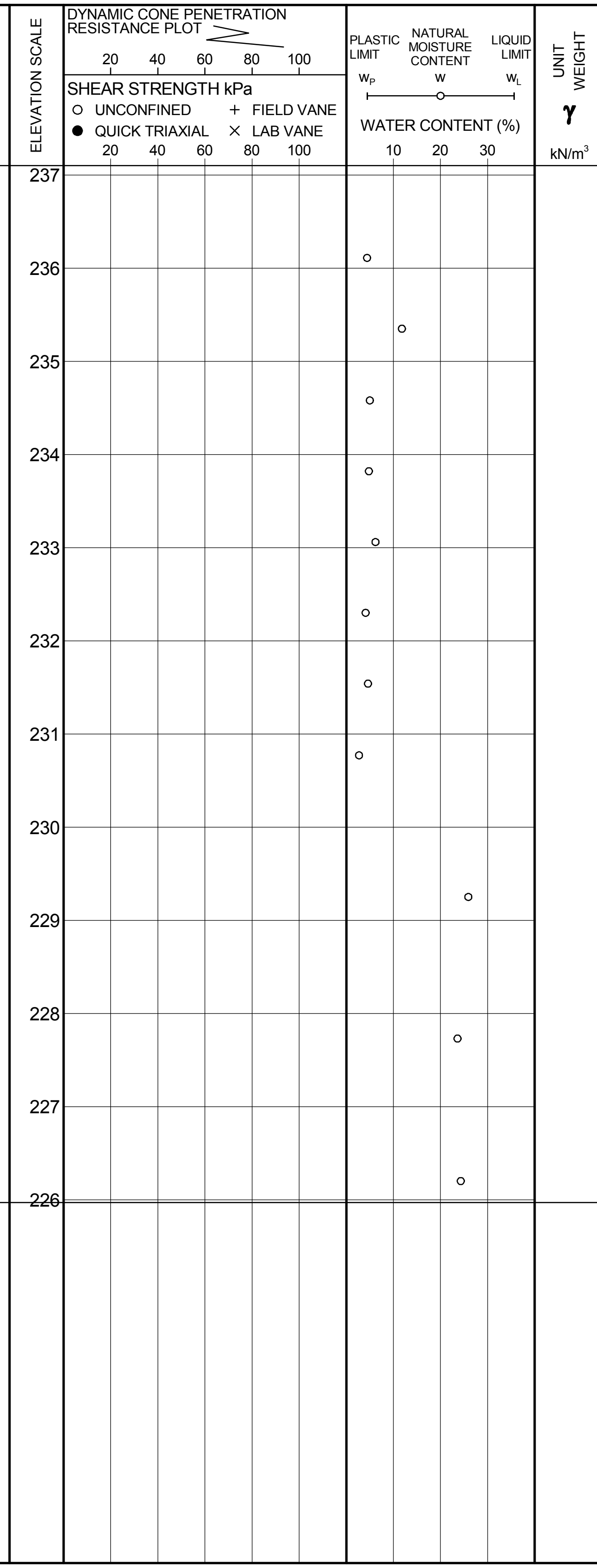
RECORD OF BOREHOLE No 202

METRIC

PROJECT 12-1132-0163			
W.P. 3045-11-00	LOCATION N 4753688.3 , E 389734.6		ORIGINATED BY BT
DIST	HWY 402	BOREHOLE TYPE POWER AUGER, HOLLOW STEM	COMPILED BY WDF
DATUM GEODETIC	DATE July 8, 2015		CHECKED BY

SOIL PROFILE / SAMPLES

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.10	GROUND SURFACE					
0.00	FILL, sand and gravel, some silt Brown					
0.30	FILL, sand, some gravel, some silt, with asphalt Compact Brown	1	SS	21		
235.73 1.37	SAND, fine to medium, trace silt, trace clay Compact Brown	2	SS	14		
		3	SS	11		0 93 6 1
		4	SS	15		
		5	SS	23		
		6	SS	16		
		7	SS	21		
		8	SS	50		0 91 7 2
					▽	
		9	SS	24		
228.57 8.53	SILTY SAND Dense Brown	10	SS	36		0 69 27 4
226.74 10.36	SANDY SILT, trace clay Compact Grey	11	SS	23		
225.97 11.13	END OF BOREHOLE Groundwater encountered at about 229.5m during drilling on July 8, 2015.					



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

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RECORD OF BOREHOLE No 203

METRIC

PROJECT	12-1132-0163				
W.P.	3045-11-00	LOCATION	N 4753704.8 , E 389825.3	ORIGINATED BY	BT
DIST	HWY 402	BOREHOLE TYPE	MANUAL AUGER, SOLID STEM	COMPILED BY	WDF
DATUM	GEODETIC	DATE	July 10, 2015	CHECKED BY	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 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
223.83	GROUND SURFACE										
0.00	TOPSOIL, silty, some gravel										
0.20	Brown SAND, trace silt, with cobbles					▽					
0.50	Grey END OF AUGERHOLE Auger refusal on inferred cobble. Groundwater encountered at about 223.4m during drilling on July 10, 2015.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No 204

METRIC

PROJECT 12-1132-0163

W.P. 3045-11-00 | LOCATION N 4753703.0 , E 389825.7 | ORIGINATED BY BT

DIST ___ HWY 402 | BOREHOLE TYPE MANUAL AUGER, SOLID STEM | COMPILED BY WDF

DATUM GEODETIC | DATE July 10, 2015 | CHECKED BY ___

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT 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
224.29	GROUND SURFACE										
0.00	TOPSOIL, sandy					∇					
0.15	Brown SAND, fine, some silt, trace clay Brown to Grey		1	AS			224		○ (approx. 28)		0 84 13 3
223.09 / 1.20	END OF AUGERHOLE Groundwater encountered at about 224.1m during drilling on July 10, 2015.										

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

LDN_MTO_06 1211320163-3000.GPJ LDN_MTO.GDT 09/09/15

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RECORD OF BOREHOLE No 205

METRIC

PROJECT 12-1132-0163			
W.P. 3045-11-00	LOCATION N 4753722.0 , E 389697.1		ORIGINATED BY BT
DIST	HWY 402	BOREHOLE TYPE MANUAL AUGER, SOLID STEM	COMPILED BY WDF
DATUM GEODETIC	DATE July 10, 2015		CHECKED BY

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 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
227.54	GROUND SURFACE										
0.00	TOPSOIL, sandy, with roots and cobbles Brown					▽					
0.18	SAND, fine, trace silt Brown to Grey						227				
			1	AS					48		
226.04 / 1.50	END OF AUGERHOLE Groundwater encountered at about 227.3m during drilling on July 10, 2015.										

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

LDN_MTO_06 1211320163-3000.GPJ LDN_MTO.GDT 09/09/15

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RECORD OF BOREHOLE No 206

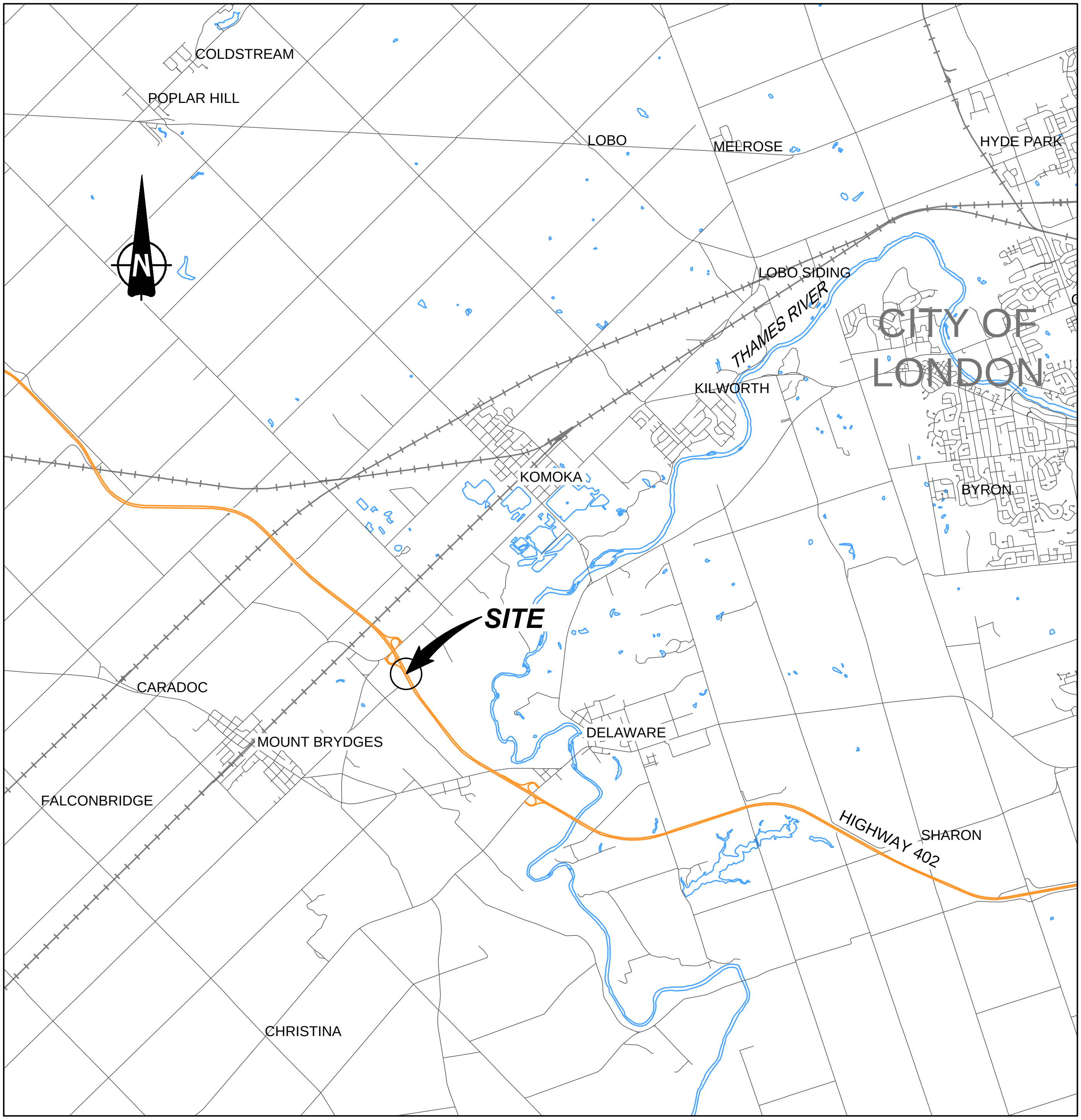
METRIC

PROJECT 12-1132-0163
W.P. 3045-11-00
LOCATION N 4753727.2 , E 389694.1
ORIGINATED BY BT
DIST ____ HWY 402
BOREHOLE TYPE MANUAL AUGER, SOLID STEM
COMPILED BY WDF
DATUM GEODETIC
DATE July 10, 2015
CHECKED BY ____

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 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
227.51	GROUND SURFACE										
0.00	TOPSOIL, sandy, with roots and cobbles Brown					∇	227				
226.91 0.60	SAND, fine, trace silt, trace gravel, with cobbles Grey										
	END OF AUGERHOLE Auger refusal on inferred cobble. Groundwater encountered at about 227.1m during drilling on July 10, 2015.										

Note: 0.29 depth also marked at topsoil boundary.

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE



SCALE
0 2000 4000m
1:100,000

REFERENCE

PLAN BASED ON CANMAP STREETFILES V.2008.5.

NOTE

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

PROJECT
CULVERT REHABILITATION, SITE 19-669/C
HIGHWAY 402
GWP 3045-11-00

TITLE

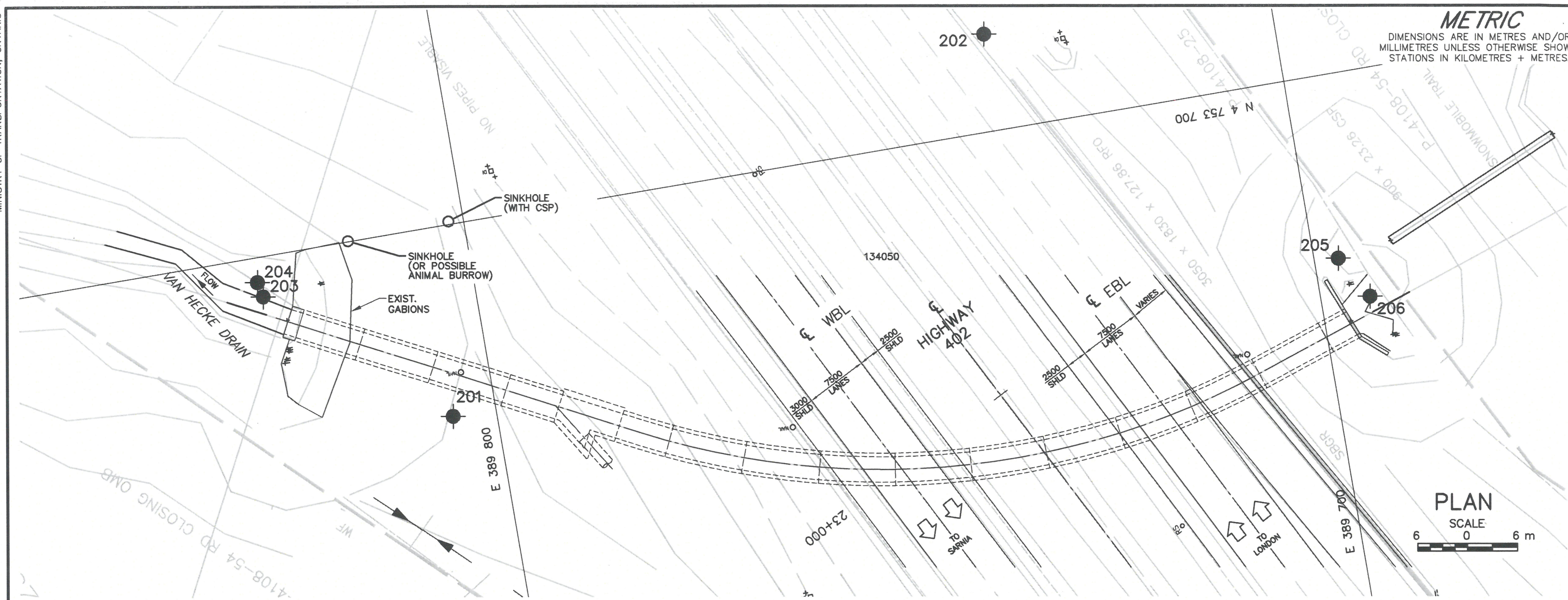
KEY PLAN

Golder Associates
LONDON, ONTARIO

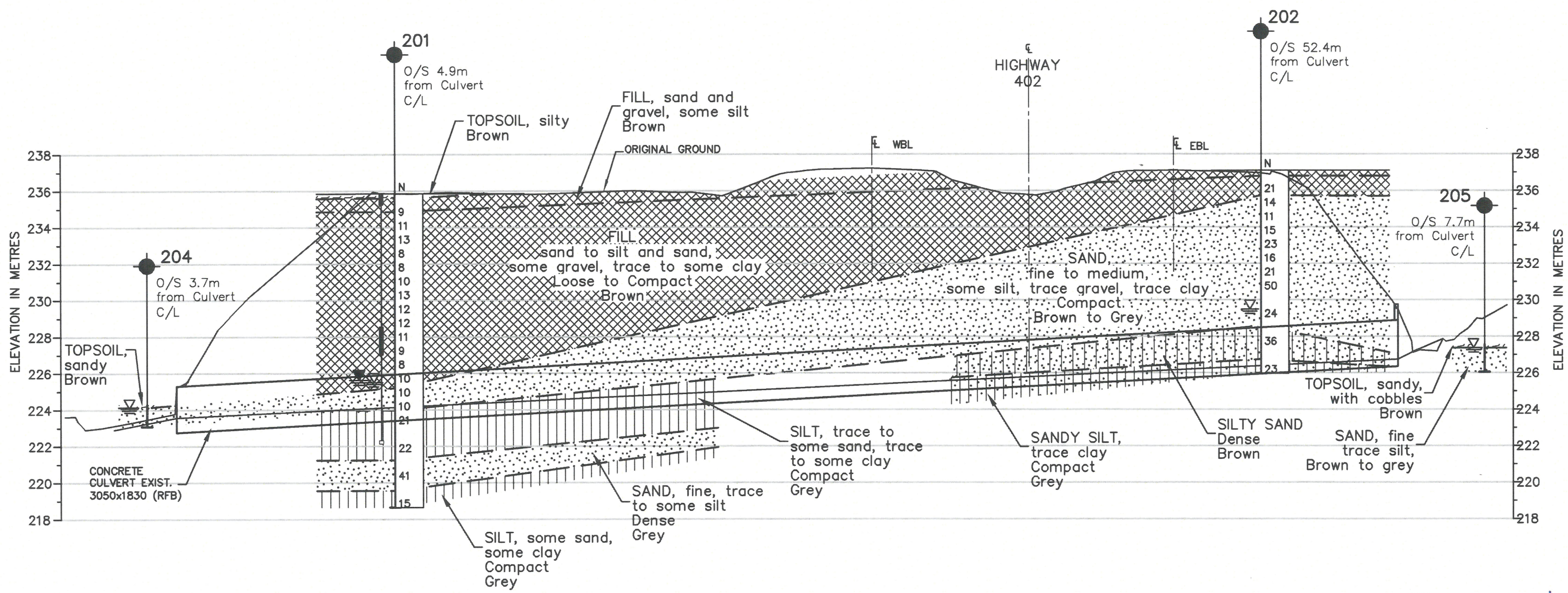
PROJECT No.	12-1132-0163		FILE No.	1211320163-3000-F02001
			SCALE AS SHOWN	REV. 0
CADD	WF	Aug. 11/15	**FIGURE 1**	
CHECK				

Drawing file: 1211320163-3000-F02001.dwg Aug 23, 2015 - 8:56pm

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



PLAN
SCALE
6 0 6 m



PROFILE ALONG ℄ CULVERT
HORIZONTAL SCALE 6 0 6 m
VERTICAL SCALE 3 0 3 m

CONT No.
WP No. 3045–11–25

SHEET

VAN HECKE DRAIN CULVERT
HIGHWAY 402
STRUCTURE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

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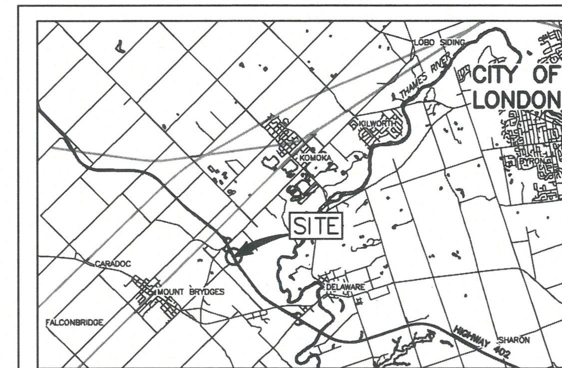
LONDON, ONTARIO, CANADA



KEY PLAN
SCALE IN KILOMETRES
0 2.5 5.0

LEGEND

- Borehole – Current Investigation
- Seal
- Standpipe
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL measured on August 24, 2015.
- WL encountered during drilling
- *DRY* — Water level not established

No.	ELEVATION	CO-ORDINATES (MTM NAD83 ZONE 11) NORTHING	EASTING
201	235.86	4 753 722.8	389 805.2
202	237.10	4 753 688.3	389 734.6
203	223.83	4 753 704.8	389 825.3
204	224.29	4 753 703.0	389 825.6
205	227.54	4 753 722.0	389 697.1
206	227.51	4 753 727.2	389 694.1

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 by Stantec.

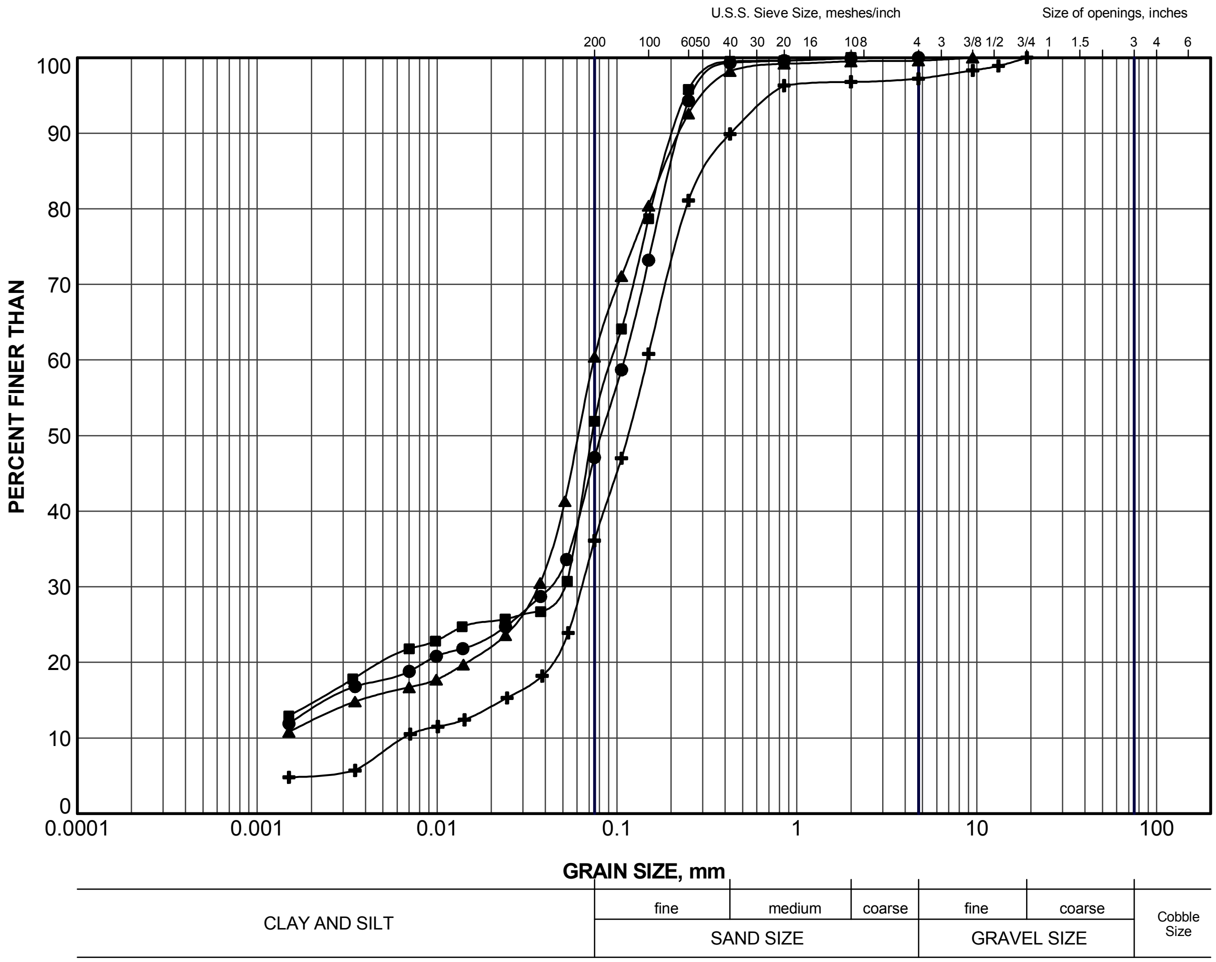
NO.	DATE	BY	REVISION

Geocres No. 40I14–163			
HWY. 402	PROJECT NO. 12–1132–0163		DIST.
SUBM'D. BT	CHKD. NAG	DATE: Nov. 13/15	SITE: 19–669/C
DRAWN: WDF/DCH	CHKD. MEB	APPD. FJH	DWG. 1

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

APPENDIX A

Laboratory Test Data

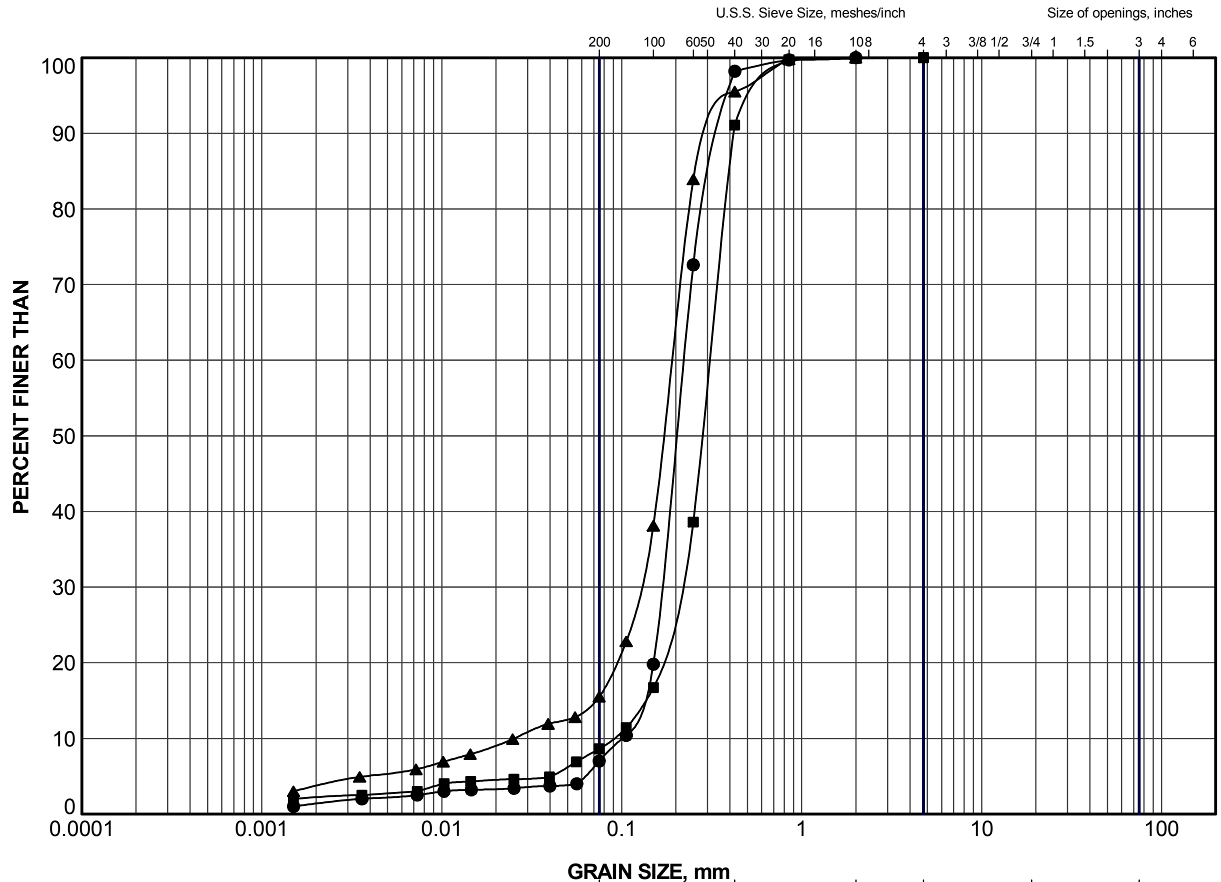


LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	201	2	234.1
■	201	6	231.1
▲	201	11	227.2
✚	201	13	225.7

PROJECT	CULVERT REHABILITATION, SITE 19-669/C HIGHWAY 402 GWP 3045-11-00			
TITLE	**GRAIN SIZE DISTRIBUTION** **FILL**			
Golder Associates	PROJECT No.	12-1132-0163	FILE No. 1211320163-3000-F020A1	
			SCALE N/A	REV.
	DRAWN	WDF	Aug 23/15	**FIGURE A-1**
	CHECK			

LDN_MTO_GSD GLDR_LDN.GDT 23/08/15



CLAY AND SILT	SAND SIZE: fine	SAND SIZE: medium	SAND SIZE: coarse	GRAVEL SIZE: fine	GRAVEL SIZE: coarse	Cobble Size

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	202	3	234.6
■	202	8	230.8
▲	204	1	223.6

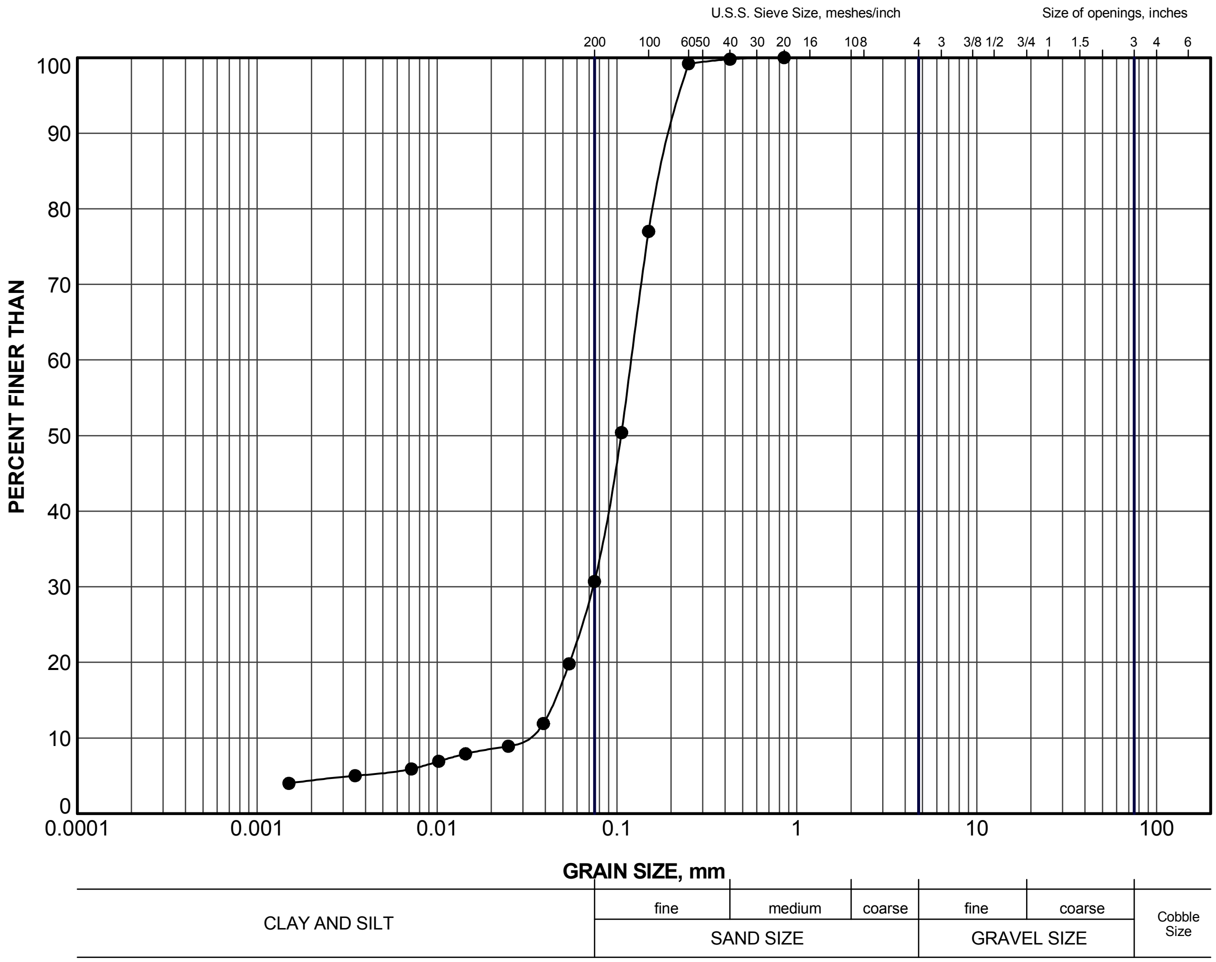
PROJECT
CULVERT REHABILITATION, SITE 19-669/C
HIGHWAY 402
GWP 3045-11-00

TITLE
GRAIN SIZE DISTRIBUTION
SAND

Golder Associates

PROJECT No.	12-1132-0163	FILE No. 1211320163-3000-F020A2
		SCALE N/A REV.
DRAWN WDF	Aug 23/15	FIGURE A-2
CHECK		

LDN_MTO_GSD GLDR_LDN.GDT 23/08/15



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	202	10	227.7

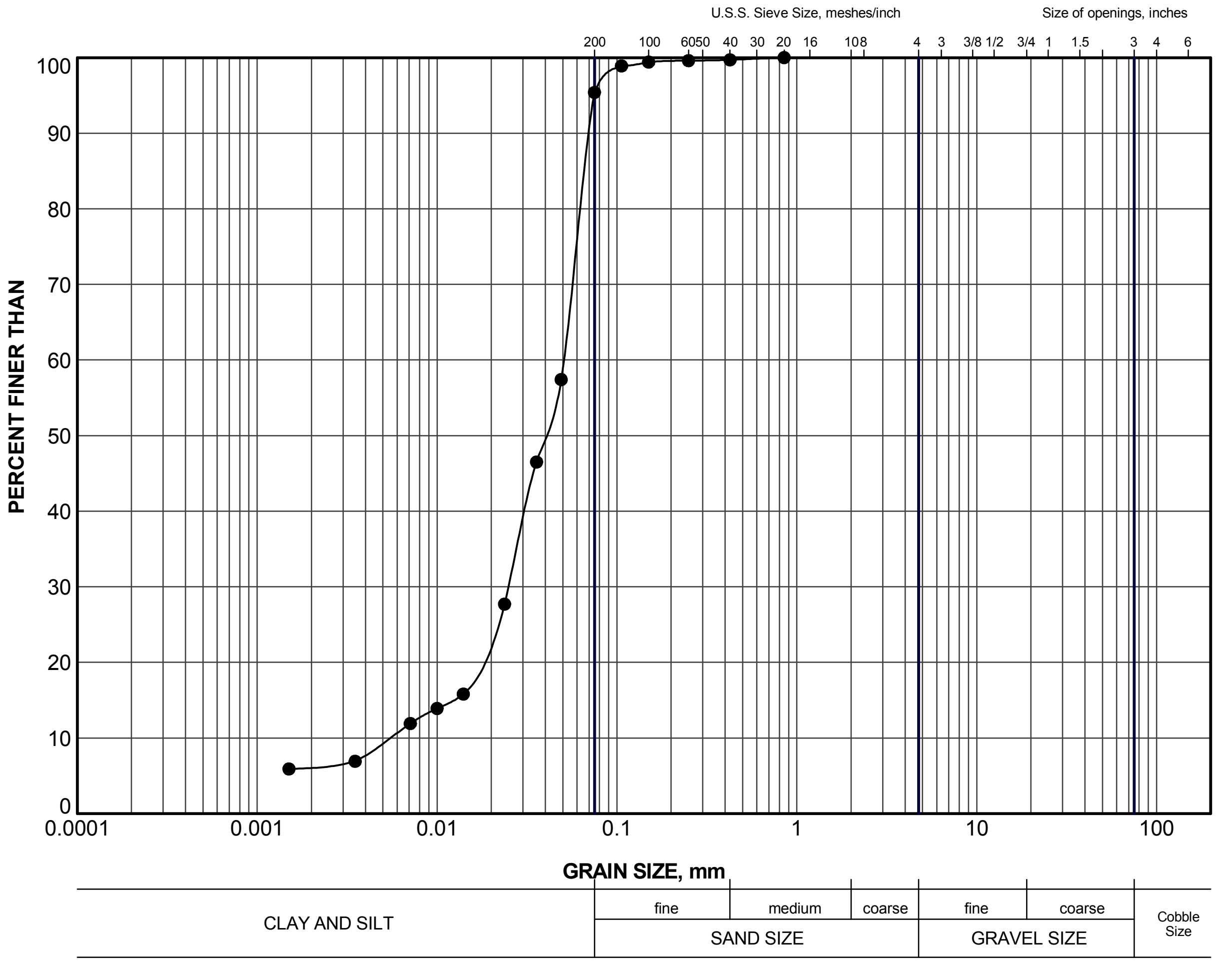
PROJECT: CULVERT REHABILITATION, SITE 19-669/C
HIGHWAY 402
GWP 3045-11-00

TITLE:
GRAIN SIZE DISTRIBUTION
SILTY SAND

Golder Associates

PROJECT No.	12-1132-0163		FILE No. 1211320163-3000-F020A3	
			SCALE N/A	REV.
DRAWN	WDF	Aug 23/15	**FIGURE A-3**	
CHECK				

LDN_MTO_GSD GLDR_LDN.GDT 23/08/15



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	201	17	221.9

PROJECT
CULVERT REHABILITATION, SITE 19-669/C
HIGHWAY 402
GWP 3045-11-00

TITLE

GRAIN SIZE DISTRIBUTION

SILT

PROJECT No.	12-1132-0163	FILE No. 1211320163-3000-F020A4	
		SCALE N/A	REV.
DRAWN	WDF	Aug 23/15	
CHECK			

Golder Associates

FIGURE A-4

LDN_MTO_GSD GLDR_LDN.GDT 23/08/15

APPENDIX B

Site Photographs

Photograph 1: East elevation (inlet) of Culvert Site 19-669/C. (Courtesy MTO)

Photograph 2: West elevation (outlet). (Courtesy MTO)

Photograph 3: Westbound Lanes of Highway 402 looking south from Culvert Site 19-669/C.

Photograph 4: Panorama view of gabion wall looking upstream towards outlet (June 11, 2015).

Photograph 5: Looking north at outlet of box culvert. Small drainage culvert in bottom right (June 11, 2015).

Photograph 6: Looking south at erosion channel adjacent to south edge of gabion wall (June 11, 2015).

Photograph 7: Sinkhole with CSP (June 11, 2015).

Photograph 8: Looking south at embankment slope approximately 3 metres above gabion retaining wall. The sinkhole with the CSP is visible in the lower part of the photo (June 11, 2015).

Photograph 9: Scour area near inlet, looking south towards right bank (June 11, 2015).

Photograph 10: Looking southeast and downstream of outlet (June 11, 2015).

APPENDIX C

Contract No. 80-77 Drawing, Sheet 37

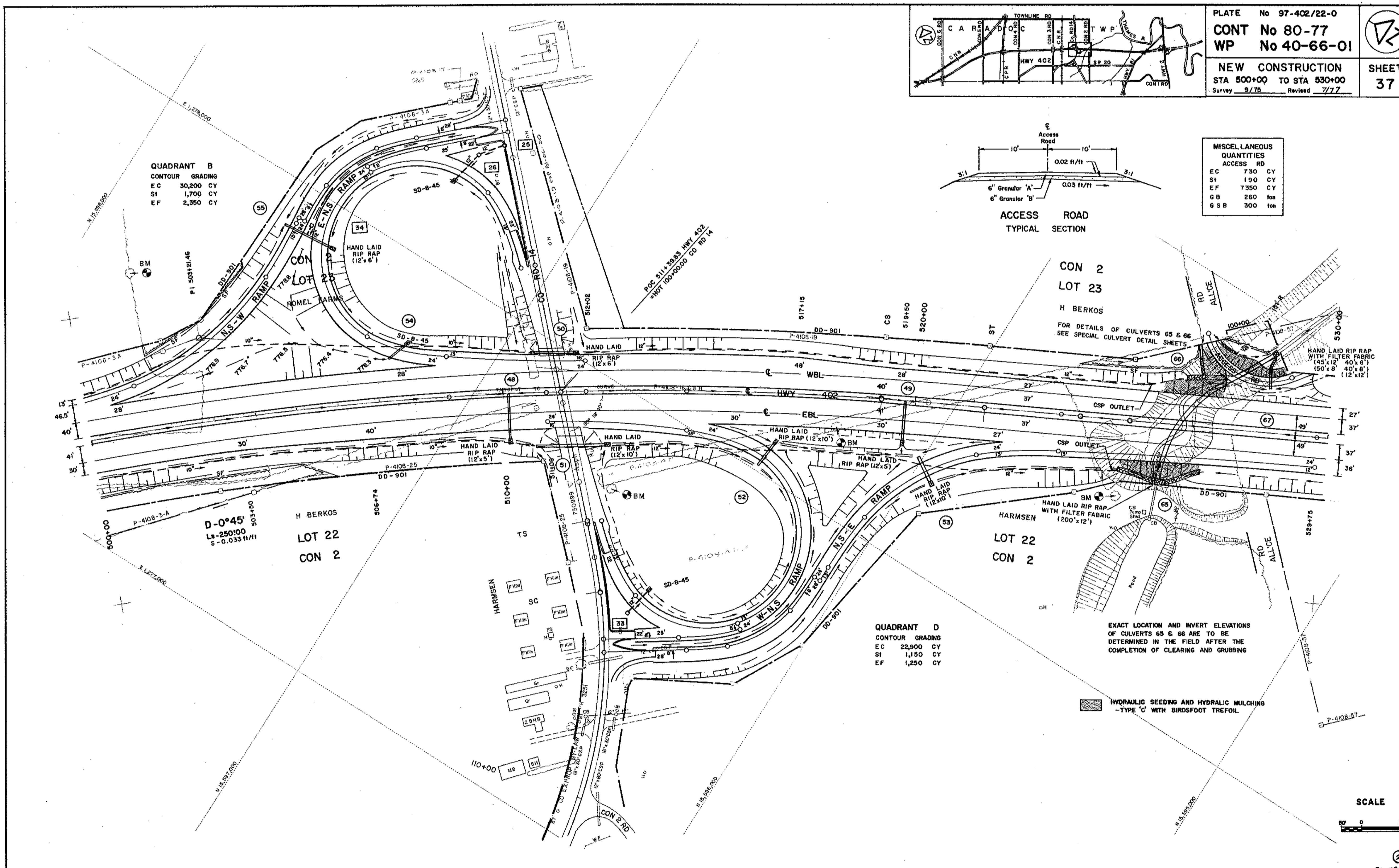


PLATE No 97-402/22-0
CONT No 80-77
WP No 40-66-01
NEW CONSTRUCTION
STA 500+00 TO STA 530+00
Survey 9/75 Revised 7/77
SHEET 37
TOWNLINE RD
CARADOC TWP
CON 6 RD
CON 5 RD
CON 4 RD
CON 3 RD
CON 2 RD
CON 1 RD
Co. RD 14
CNR
CPR
HWY 402
SR 20
HWY 81
HWY 2
THAMES R
Access Road
10'
0.02 ft/ft
0.03 ft/ft
3:1
6" Granular 'A'
6" Granular 'B'
ACCESS ROAD
TYPICAL SECTION
MISCELLANEOUS QUANTITIES
ACCESS RD
EC 730 CY
St 190 CY
EF 7350 CY
GB 260 ton
GSB 300 ton
QUADRANT B
CONTOUR GRADING
EC 30,200 CY
St 1,700 CY
EF 2,350 CY
QUADRANT D
CONTOUR GRADING
EC 22,900 CY
St 1,150 CY
EF 1,250 CY
CON 2
LOT 23
H BERKOS
FOR DETAILS OF CULVERTS 65 & 66 SEE SPECIAL CULVERT DETAIL SHEETS
ROMEL FARMS
N-S-W RAMP
E-N-S RAMP
N-S-E RAMP
W-N-S RAMP
CO RD 14
HWY 402
WBL
EBL
HAND LAID RIP RAP (12'x6')
HAND LAID RIP RAP (12'x5')
HAND LAID RIP RAP (12'x10')
HAND LAID RIP RAP WITH FILTER FABRIC (45'x12' 40'x8') (50'x8' 40'x8') (12'x12')
HAND LAID RIP RAP WITH FILTER FABRIC (200'x12')
CSP OUTLET
POC 511+39.83 HWY 402 =HOT 100+00.00 CO RD 14
D-0°45'
Ls-250.00
S-0.033 ft/ft
H BERKOS
LOT 22
CON 2
HARMSEN
LOT 22
CON 2
RD ALL'CE
CON 2 RD
EXACT LOCATION AND INVERT ELEVATIONS OF CULVERTS 65 & 66 ARE TO BE DETERMINED IN THE FIELD AFTER THE COMPLETION OF CLEARING AND GRUBBING
HYDRAULIC SEEDING AND HYDRALIC MULCHING -TYPE 'C' WITH BIRDSFOOT TREFOIL
SCALE
79.02 LP

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