



May 2014

## PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

Highway 3 Widening  
Windsor to Leamington (Phase 3A)  
Structural Culverts  
GWP 317-98-00  
Ministry of Transportation, Ontario - West Region

**Submitted to:**

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REPORT



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## Table of Contents

### **PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT**

<b>1.0 INTRODUCTION.....</b>	<b>1</b>
<b>2.0 SITE DESCRIPTION.....</b>	<b>2</b>
2.1 General.....	2
2.2 Site Geology.....	2
<b>3.0 INVESTIGATION PROCEDURES .....</b>	<b>3</b>
<b>4.0 SUBSURFACE CONDITIONS.....</b>	<b>5</b>
4.1 Site Stratigraphy .....	5
4.1.1 Topsoil .....	5
4.1.2 Fill .....	5
4.1.3 Silty Clay Till .....	6
4.1.4 Clayey Silt Till .....	6
4.2 Groundwater Conditions .....	6
<b>5.0 MISCELLANEOUS .....</b>	<b>7</b>

### **PART B - PRELIMINARY FOUNDATION DESIGN REPORT**

<b>6.0 ENGINEERING RECOMMENDATIONS.....</b>	<b>8</b>
6.1 General.....	8
6.2 Foundations.....	9
6.2.1 Geotechnical Resistances.....	9
6.2.2 Resistance to Lateral Forces/Sliding Resistance .....	10
6.3 Retaining Walls/ Wingwalls.....	10
6.3.1 Wingwall Options .....	11
6.3.2 Foundations – Wingwalls .....	11
6.3.3 Sliding Resistance .....	12
6.4 Lateral Earth Pressures .....	13
6.5 Construction Considerations.....	14
6.5.1 General .....	14
6.5.2 Erosion and Scour Protection .....	14
6.6 Excavations and Groundwater Control .....	14



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## PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT STRUCTURAL CULVERTS - HIGHWAY 3 WIDENING

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<b>7.0 FOUNDATION ENGINEERING FOR DETAIL DESIGN .....</b>	<b>16</b>
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<b>8.0 MISCELLANEOUS .....</b>	<b>17</b>
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LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORD OF BOREHOLE SHEETS

FIGURE 1 - Key Plan

DRAWING 1 - Borehole Locations

### **APPENDICES**

#### **APPENDIX A**

Laboratory Test Data

#### **APPENDIX B**

Site Photographs



**PART A**

**PRELIMINARY FOUNDATION INVESTIGATION REPORT**

**HIGHWAY 3 WIDENING  
WINDSOR TO LEAMINGTON (PHASE 3A)  
STRUCTURAL CULVERTS  
GWP 317-98-00  
MINISTRY OF TRANSPORTATION, ONTARIO - WEST REGION**



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the preliminary design work for GWP 317-98-00. The project involves the preliminary design for Phase 3A of the Highway 3 widening, including a new grade separation bridge structure to convey Highway 3 traffic over Victoria Street in the Town of Essex, extension or replacement of six structural culverts and 1 new culvert.

This report addresses the extension of six structural culverts at sites 6-416/C, 6-412/C, 6-588/C, 6-589/C, 6-417/C, and 6-418/C and the construction of a new culvert for the proposed service road adjacent to site 6-416/C.

The purpose of the foundation investigation is to determine the subsurface soil and groundwater conditions at the locations of the culverts 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 11-1132-0143-P01 dated February 27, 2012. The work was carried out in accordance with our Quality Control Plan for Foundations Engineering dated June 2012.



## **2.0 SITE DESCRIPTION**

### **2.1 General**

Culvert sites 6-416/C, 6-412/C, 6-588/C and 6-589/C are located within the Township of Colchester North and culvert sites 6-417/C and 6-418/C are within the Township of Gosfield North, Ontario. The location of the overall project is shown on the Key Plan, Figure 1.

For the purposes of this report, Highway 3 and Service Road are assumed to be oriented in an east-west direction and the culverts are assumed to be oriented in a north-south direction.

This section of Highway 3 is currently a two lane highway. The existing culverts at sites 6-416/C, 6-412/C, 6-589/C and 6-417/C are open footing, non-rigid frame concrete culverts. The culvert at site 6-418/C is an open footing, rigid frame culvert and the culvert at site 6-588/C is a corrugated steel pipe arch (CSPA) culvert. The areas immediately surrounding the sites generally consist of flat-lying agricultural lands, residential properties and various commercial and municipal properties.

It is understood that the existing culverts are to be rehabilitated and extended or replaced to accommodate the Highway 3 widening and a new culvert is to be constructed for the service road at about Station 13+890, Township of Colchester.

Selected site photographs are provided in Appendix B.

### **2.2 Site Geology**

The site is situated on the Essex Clay Plain, a subregion of the physiographic region of southern Ontario known as the St. Clair Clay Plains.<sup>1</sup> This subregion is described as a bevelled till plain with little relief that has been locally smoothed by shallow deposits of lacustrine clay deposited in depressions in the till. The prevailing soil type is reported to be Brookston clay loam.

The dominant surficial soil is clayey silt till which has structures indicative of a waterlain deposit.<sup>2</sup> The underlying bedrock surface is typically found between about 33 and 37 metres below the ground surface.<sup>3</sup> The bedrock is a brown, cherty, crinoidal limestone belonging to the Dundee Formation of the Hamilton group.<sup>4</sup>

<sup>1</sup> L.J. Chapman and D.F. Putnam, 1984. *The Physiography of Southern Ontario*. Third Edition. Ontario Geological Survey, Special Volume 2.

<sup>2</sup> Vagners, U. J., 1972. *Quaternary Geology of the Windsor-Essex Area, (Western Part) Southern Ontario*. Ontario Department of Mines and Northern Affairs, Preliminary Maps P. 749, Geological Series. Scale 1:50,000.

<sup>3</sup> Vagners, U.J., Sado, E.V., and Yundt, S.E. 1973. *Drift Thickness of the Windsor-Essex Area (Western Part), Southern Ontario*, Ontario Division of Mines, Preliminary Maps P.814, Drift Thickness Series. Scale 1:50,000.

<sup>4</sup> Sanford, B.V., 1969. *Geology, Toronto-Windsor Area, Ontario*. Map 1263A. Geological Survey of Canada. 1:250,000.



### 3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out between October 3 and 15, 2012 and on March 1, 2013, during which time seven boreholes were drilled at the approximate locations shown on the Borehole Location Plan, Drawing 1. The table below summarizes the borehole locations, ground surface elevations at the borehole locations and borehole depths.

Borehole	Location				Ground Surface Elevation (m)	Borehole Depth (m)
	Site	Station	Northing (m)	Easting (m)		
1	6-416/C	13+886*	4 670 374	276 487	193.9	9.60
2	Service Road	13+886*	4 670 395	276 509	193.6	9.60
3	6-412/C	14+750*	4 669 751	277 082	194.2	9.60
4	6-588/C	15+950*	4 668 926	277 936	194.7	9.60
5	6-589/C	16+132*	4 668 837	278 095	194.4	9.60
6	6-417/C	10+112**	4 668 393	278 811	194.9	9.60
7	6-418/C	10+320**	4 668 227	279 070	194.8	9.60

\*Township of Colchester

\*\*Township of Gosfield North

The investigation was carried out using an all-terrain vehicle mounted drill rig supplied and operated by a specialist drilling contractor. In the boreholes, samples of the overburden were obtained at generally 0.76 metre intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures (ASTM D1586). The samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 38 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.

In addition, in-situ vane shear strength testing was carried out in accordance with ASTM D2573 in the softer cohesive soils as appropriate.

The boreholes were terminated 9.6 metres below the existing ground surface. Groundwater conditions in the boreholes were observed throughout the drilling operations and these observations are included on the Records of Boreholes. 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 Golder Associates staff members who also 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 Windsor laboratory for further examination and testing. Index and classification tests consisting of water content



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## **PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT STRUCTURAL CULVERTS - HIGHWAY 3 WIDENING**

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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.



## **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.

The boreholes drilled at the site generally encountered topsoil and fill materials overlying an extensive deposit of silty clay to clayey silt till.

#### **4.1.1 Topsoil**

Topsoil layers of between 150 and 240 millimetres thick were encountered at the ground surface in boreholes 1, 2, 3 and 5. A layer of buried topsoil about 150 millimetres thick was also encountered beneath a surficial layer of silty clay fill in borehole 7.

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.

#### **4.1.2 Fill**

Brown silty clay fill material was encountered at the ground surface in boreholes 4, 6 and 7 and beneath the topsoil in borehole 1. The fill layers were between 0.6 to 1.4 metres thick at the borehole locations. The fill had N values, as determined in the standard penetration testing, of 8 to 12 blows per 0.3 metres.



### **4.1.3 Silty Clay Till**

Silty clay till was encountered in all of the boreholes beneath the topsoil and/or fill materials between elevations 192.5 and 194.2 metres. Boreholes 2, 5, 6 and 7 were terminated in the silty clay till after exploring it for about 8.3 to 9.4 metres. Where penetrated in the other boreholes, the silty clay till was 2.4 to 5.7 metres thick.

The silty clay till had N values of 7 to 32 blows per 0.3 metres. In-situ vane testing yielded undrained shear strengths of 85 to greater than 144 kilopascals (kPa) indicating a stiff to very stiff consistency. The water contents of samples of the silty clay till ranged from 16 to 23 per cent. The silty clay till had corresponding average plastic and liquid limits of 18 and 37 per cent, respectively, based on fifteen Atterberg limits determinations, the results of which are shown on Figure A-3. The silty clay till is of low to intermediate plasticity.

Grain size distribution curves for samples of the silty clay till are provided on Figure A-1.

### **4.1.4 Clayey Silt Till**

Clayey silt till was encountered beneath the silty clay till in boreholes 1, 3 and 4 between about elevations 187.6 and 190.1 metres. Boreholes 1, 3 and 4 were terminated in the clayey silt till after exploring it for about 2.5 to 5.8 metres. In situ vane testing yielded undrained shear strengths of 105 to greater than 144 kPa indicating a very stiff consistency. The clayey silt till had N values of 7 to 15 blows per 0.3 metres with water contents of 18 to 22 per cent.

Grain size distribution curves for samples of the clayey silt till are provided on Figure A-2. The clayey silt till had corresponding average plastic and liquid limits of 16 and 33 per cent, respectively, based on four Atterberg limits determinations, the results of which are shown on Figure A-3. The clayey silt till is of low plasticity.

## **4.2 Groundwater Conditions**

All of the boreholes remained dry during drilling.

The water levels in the adjacent water courses at each site were between elevations 192.0 and 193.0 metres at the times of drilling. Based on the soil colour change from brown to grey, the inferred groundwater level is at elevation 191 metres. Groundwater levels are expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring melt conditions.



## **5.0 MISCELLANEOUS**

This investigation was carried out using equipment supplied and operated by Aardvark Drilling Inc., an Ontario Ministry of Environment licensed well contractor. The field operations were supervised by Mr. Steven Mayer under the direction of Mr. David J. Mitchell.

The laboratory testing was carried out at Golder Associates' Windsor 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 Mr. Michael E. Beadle, P.Eng. and the Team Leader, Dr. Storer Boone, P.Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

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**PART B**  
**PRELIMINARY FOUNDATION DESIGN REPORT**  
**HIGHWAY 3 WIDENING**  
**WINDSOR TO LEAMINGTON (PHASE 3A)**  
**STRUCTURAL CULVERTS**  
**GWP 317-98-00**  
**MINISTRY OF TRANSPORTATION, ONTARIO - WEST REGION**



## 6.0 ENGINEERING RECOMMENDATIONS

### 6.1 General

This section of the report provides our recommendations on the foundation aspects of the preliminary design of the extension of six culverts and the construction of a new culvert associated with the widening of Highway 3. The recommendations are based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. 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 culverts addressed in this report have been summarized in the following table.

Structure Name	Site No.	Station	Existing Culvert Type	Existing Culvert Dimensions			Proposed Extension Length (m)	Borehole
				Width (m)	Height (m)	Length (m)		
Culvert	6-416/C	13+890*	Open footing, non-rigid frame, reinforced cast-in-place concrete	3.1	1.5	26.8	22	1
New Service Road Culvert	Service Road	13+890*	N/A	-	-	-	-	2
Replace Culvert	6-412/C	14+750*	Open footing, non-rigid frame, reinforced cast-in-place concrete (with 1.5m CSP overflow cell)	3.7	1.9	36.5	20	3
Culvert # 588	6-588/C	15+950*	Corrugated steel pipe arch (CSPA)	3.6	2.0	26.1	23	4
Culvert # 589	6-589/C	16+130*	Open footing, non-rigid frame, reinforced cast-in-place concrete	3.1	1.2	22.6	22	5
West Town Line Drain Culvert	6-417/C	10+020**	Open footing, non-rigid frame, reinforced cast-in-place concrete	3.7	1.5	41.2	25	6
Russel Drain Culvert	6-418/C	10+335**	Open footing, rigid frame, reinforced cast-in-place concrete	3.1	1.5	25.6	20	7

\*Township of Colchester

\*\*Township of Gosfield North

Based on the preliminary design information provided by Dillon, it is understood that six culverts are to be extended by 20 to 25 metres to the south to accommodate additional lanes of traffic. It is anticipated that the extension to the structures will be similar to the existing structures. Further, the proposed culvert at the service road location is to accommodate a two lane service road. It is anticipated that this new culvert will be of similar construction to the adjacent structure at site 6-416/C.



## 6.2 Foundations

The subsurface conditions encountered during the investigation generally consisted of topsoil and fill materials overlying native silty clay till encountered between elevations 192.5 and 194.2 metres, followed by clayey silt till. The water levels in the adjacent water courses were between elevations 192.0 and 193.0 metres at the time of drilling. Based on the soil colour change from brown to grey, the inferred groundwater level is at elevation 191 metres.

The culvert extensions and new culvert should be designed to withstand the appropriate weight of fill and traffic loading. Based on the soil conditions encountered at the borehole locations, and assuming the invert elevations of the extensions will be near those of the existing culverts (between approximately 191.3 and 193.3 metres), the culverts may be founded on the silty clay till at or below the elevations noted in the table below. Open footing culverts will require 1.2 metres of frost cover or thermal equivalent below the bed level. Corrugated steel pipe arches require a minimum frost cover of 300 millimetres.

Site	Approximate Founding Elevation (m)		Culvert Type
	Open Footing CIP Culvert	Concrete Box Culvert or CSPA	
6-416/C	190.6	-	Open Footing
Service Road	190.6	-	Open Footing
6-412/C	190.3	-	Open Footing
6-588/C	-	191.0	CSPA
6-589/C	192.0	-	Open Footing
6-417/C	191.3	-	Open Footing
6-418/C	191.2	-	Open Footing

### 6.2.1 Geotechnical Resistances

The firm to very stiff silty clay till is suitable for support of the proposed culvert extensions, replacements and new culvert. For preliminary design purposes, a factored geotechnical resistance at Ultimate Limit States (ULS) of 225 kilopascals and a geotechnical resistance at Serviceability Limit States (SLS) of 150 kilopascals may be used. The SLS values correspond to a maximum of 25 millimetres of total settlement.



## 6.2.2 Resistance to Lateral Forces/Sliding Resistance

The resistance to lateral forces/sliding resistance between the culvert base and founding soil should be calculated in accordance with Section 6.7.5 of the CHBDC. The angle of friction,  $\delta$ , and the coefficient of friction,  $\tan \delta$ , for the various structure types has been summarized in the following table.

Wall Type	Interaction	Angle of Friction, $\delta$ (degrees)	Coefficient of Friction, $\tan \delta$
Open Footing Concrete Culvert	Cast-in-place concrete footing on silty clay till	34	0.67
Corrugated Steel Pipe Arch	Corrugated steel pipe on Granular A levelling pad	27	0.51

In accordance with the CHBDC Section 6.7.5, a factor of 0.8 is applied in the equation to calculate the factored horizontal geotechnical resistance,  $H_{ri}$ , as follows:

$$H_{ri} = 0.8A'c' + 0.8V\tan\delta > H_f$$

Where:

- $A'$  - effective contact area, square metres
- $c'$  = nil
- $\tan \delta$  = as given above
- $V$  - unfactored vertical force, kilonewtons
- $H_f$  - factored horizontal load, kilonewtons

## 6.3 Retaining Walls/Wingwalls

The existing culverts at sites 6-588/C, 6-589/C and 6-417/C have cast-in-place concrete wing walls on the south side of Highway 3 where the culvert extensions are to be constructed.

If wingwalls for the culvert extensions or new culvert are planned, consideration may be given to the use of reinforced concrete gravity or cantilever walls, retained soil system (RSS) walls or gabion walls. Concrete gravity walls could consist of pre-cast elements or be cast-in-place. Pre-cast wingwalls are preferred for compatibility with pre-cast culverts. Further, wingwalls should be structurally separate from box culverts to accommodate some differential settlement.



### **6.3.1 Wingwall Options**

#### ***Reinforced Concrete Gravity and Cantilever Walls***

Construction of reinforced concrete gravity or cantilever walls is geotechnically feasible. Compared to RSS walls, footings for gravity and cantilever walls must be constructed with 1.2 metres of frost cover. This may result in a longer foundation construction time compared to a pre-cast concrete toe wall or RSS wall, particularly if cast-in-place walls are used.

#### ***RSS Walls***

It is anticipated that the wingwall heights will be relatively low. Therefore, an RSS wall utilizing an interlocking block system and geogrid reinforcement is a geotechnically feasible alternative. Retained soil system walls are proprietary systems which are to be designed by the supplier and constructed in accordance with their specifications. The internal stability of the mechanically-reinforced soil walls should be verified by the RSS supplier/designer. If an RSS block system wall is selected, the geotechnical aspects of the global stability of the detailed retaining wall design should be reviewed prior to construction. Depending on the design approach selected, an embedment depth equivalent to the frost depth may not be required for foundations for an RSS block system wall. This wall type can be constructed relatively quickly and inexpensively using small equipment.

#### ***Gabion Walls***

Construction of gabion walls is geotechnically feasible at the sites. Gabion walls require the least amount of space behind the wall. Gabion walls do not require an embedment depth equivalent to the frost depth provided it is founded on a granular pad 300 millimetres in compacted thickness and the foundations have adequate embedment to provide a stable structure. Advantages of gabion walls compared to more rigid structures include the ability to accommodate differential settlements, dissipation of the energy of flowing water and they are free-draining provided an adequate filter is placed behind the wall. Gabion walls can be constructed relatively quickly with minimal equipment and materials. The life expectancy of a gabion wall can be extended by utilizing PVC-coated galvanized steel baskets. Gabion walls are to be constructed in accordance with OPSS 512, and SP512S03 for structures less than 2 metres in height.

### **6.3.2 Foundations – Wingwalls**

Cast-in-place reinforced concrete gravity and cantilever walls must be provided with 1.2 metres of frost cover or thermal equivalent. Assuming the culvert extensions will be founded at approximately the same elevations as the existing culverts, foundations for these walls should be founded in the firm to very stiff silty clay till at the elevations indicated in Section 6.2. A factored geotechnical resistance at ULS of 225 kilopascals and a geotechnical reaction at SLS of 150 kilopascals may be used for design. The SLS value corresponds to 25 millimetres of settlement.



RSS walls may be designed such that the facing blocks are constructed on a levelling pad. The levelling pad should be constructed with Granular A fill and be at least 300 millimetres thick. As noted previously, depending on the design selected by the RSS supplier, it may not be necessary to provide 1.2 metres of earth cover or thermal equivalent for frost protection. However, the foundations must have adequate embedment to provide a stable structure. Typically, the embedment depth, defined as the distance between the top of the levelling pad to the top of the adjoining finished grade, is a minimum of 500 millimetres. A factored geotechnical resistance at ULS of 225 kilopascals and a geotechnical reaction at SLS of 150 kilopascals may be used for design of RSS walls founded on a granular levelling pad. The SLS value corresponds to 25 millimetres of settlement.

Gabion walls may be founded directly on a 300 millimetre thick compacted Granular A pad placed on the firm to stiff silty clay till. The geotechnical resistances recommended above for design of RSS walls may be used for design of gabion walls. Alternatively, gabion baskets can be placed at the frost depth on the silty clay till; the geotechnical resistances recommended above for design of gravity walls may be used for design. If required, a granular levelling course approximately 75 millimetres thick may be provided. Non-woven geotextile is to be placed between the gabions and the backfill placed in accordance with OPSS 512, OPSS 1860 and the manufacturer's specifications.

All wingwall foundations must be protected against scour as noted in the CHBDC Section 1.9.5.

### **6.3.3 Sliding Resistance**

The resistance to lateral forces/sliding resistance between the compacted granular backfill (assumed to be Granular B Type II) for RSS block system walls and gabion walls or concrete footings for gravity and cantilever walls and the subgrade soils should be calculated in accordance with Section 6.7.5 of the CHBDC. Each retaining wall shall be checked for overturning. Assuming that the founding soils are not loosened/disturbed during excavation and footing construction, the following angles of friction and corresponding unfactored coefficient of friction,  $\tan \delta$ , may be used for the interaction between the base of the walls and the founding soils.

Wall Type	Interaction	Angle of Friction, $\delta$ (degrees)	Coefficient of Friction, $\tan \delta$
Reinforced Concrete Gravity or Cantilever Wall	Cast-in-place concrete footing on silty clay till	34	0.67
RSS Block System	Pre-cast concrete block facing units on Granular A levelling pad	33	0.65
Gabion Wall	Gabion cage on Granular A pad	33	0.65
	Gabion cage on silty clay till	34	0.67



## 6.4 Lateral Earth Pressures

The lateral pressures acting on the culverts and wingwalls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the freedom of lateral movement of the structure and the drainage conditions behind the walls. The following recommendations are made concerning the design of the walls in accordance with the CHBDC:

- Select, free-draining granular fill meeting the specifications of Ontario Provincial Standard Specification (OPSS) Granular A or Granular B Type II but with less than 5 per cent passing the No. 200 sieve should be used as backfill behind the walls. The fill should be compacted in loose lifts not greater than 200 millimetres in thickness. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.
- 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.
- The granular fill may be placed either in a zone with a width equal to at least 1.2 metres behind the back of the stem (Case a from Commentary on CHBDC Figure C6.20) or within the wedge-shaped zone defined by a line drawn at a maximum 1 horizontal to 1 vertical extending up and back from the rear face of the footing (Case b from Commentary on CHBDC Figure C6.20).
- For Case a, the restrained case, the pressures are based on the fill materials. For Case b, the unrestrained case, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	<u>GRANULAR A</u>	<u>GRANULAR B</u> <u>Type II</u>
Soil unit weight:	22 kN/m <sup>3</sup>	22 kN/m <sup>3</sup>
Coefficients of lateral earth pressure:		
Active, $K_a$	0.27	0.27
At rest, $K_o$	0.43	0.43
Passive, $K_p$	3.69	3.69

- If the wall support and superstructure allow lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the wall support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design.

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. The lateral earth pressure coefficients should be adjusted if there is sloping ground at the back of the wall.



## **6.5 Construction Considerations**

### **6.5.1 General**

Care should be taken during construction to avoid disturbance of the subgrades prior to constructing foundations for the culverts and wingwalls. All existing fill and any topsoil, organics, and soft or loose soils should be stripped from the proposed founding areas prior to placement of concrete or base materials.

It is recommended that the footing excavations be carried out such that the final 0.5 metres of excavation is completed with a geotechnical quality verification engineer (QVE) on site. The cleaned excavation bases should be inspected by the QVE and granular base materials or working slabs should be placed immediately after inspection to protect the founding materials.

### **6.5.2 Erosion and Scour Protection**

Erosion and scour protection for the culvert backfills and stream banks should be provided as appropriate, based on hydraulic considerations. Consideration could be given to using suitable non-woven geotextile and rip rap, as required, to provide erosion protection based on hydraulic requirements. In addition, sediment control such as silt fences and erosion control blankets may be required during construction as well as during diversion/piping of the watercourses to mitigate against migration of fine particles.

## **6.6 Excavations and Groundwater Control**

Excavations for the culvert extensions and new culvert will encounter surficial topsoil and fill materials and firm to very stiff silty clay till. Temporary open cut slopes should be maintained no steeper than 1 horizontal to 1 vertical. 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 silty clay till at the site would be classified as Type 2 soils and the existing fill would be classified as a Type 3 soil.

It is anticipated that excavations will not extend significantly below the groundwater level; however some minor seepage should be anticipated. Groundwater at the site may be controlled by using properly filtered and constructed sumps in the base of the excavations. Sumps should be maintained outside of the actual footing limits. Surficial water seepage into the excavations should be expected and will be heavier during periods of sustained precipitation. Surface water should be directed away from the excavations at all times. The existing culvert flows will need to be diverted/piped during construction.

It is anticipated that the foundations for the culvert extensions will be at about the same elevations of the existing foundations, therefore, the existing culvert foundations should be protected during construction.



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## **PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT STRUCTURAL CULVERTS - HIGHWAY 3 WIDENING**

---

The exposed silty clay till will be sensitive to disturbance from construction activities once exposed to moisture. Therefore, it will be essential to redirect surface water flow away from the excavations and construct all granular levelling pads or cast-in-place concrete footings the same day the excavation is completed.



## **7.0 FOUNDATION ENGINEERING FOR DETAIL DESIGN**

For detail design, the foundation engineering scope should include:

- Advancement of additional boreholes should the location of the proposed culvert locations and culvert extensions be modified from the preliminary design locations.
- Recommendations for foundations and associated axial, lateral and sliding resistances, including founding elevations.
- Recommendations for bedding, backfill, backfill transition and cover.
- Recommendations for inlet seals, outlet filters, cut-offs, erosion control and camber.
- Seismic analysis and liquefaction potential (per Sections 4.4.6 and 4.6 in the CHBDC).
- Frost protection recommendations.
- Construction considerations including groundwater control and channel diversion, excavations and temporary cut slopes and temporary roadway protection, if necessary.



## **8.0 MISCELLANEOUS**

This report was prepared by Ms. Nicole A. Gould, P.Eng. under the direction of Mr. Michael E. Beadle, P.Eng. and the Team Leader, Dr. Storer Boone, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

### **GOLDER ASSOCIATES LTD.**

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MTO Designated Contact

NG/MEB/FJH/cr

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n:\active\2011\1132-geo\1132-0100\11-1132-0143 dillon-gwp 317-98-00-hwy 3\ph 1000-fdns\rpts\r01 culverts\1111320143-1000-r01 may 14 14 (final) hwy 3 part a&b prelim fdn culverts.docx

## 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

### 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

### 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.)

#### Consistency

	<u>kPa</u>	<u>psf</u>
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

#### (b) Cohesive Soils

#### 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, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> 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.

### 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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)
$\gamma$	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

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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
$I_p$	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
$\sigma'_p$	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	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  $= (\text{compressive strength})/2$
  - \* density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density x acceleration due to gravity)

**RECORD OF BOREHOLE No 1**

1 OF 1

**METRIC**

PROJECT 11-1132-0143  
W.P. 317-98-00 LOCATION N 4670374.4 , E 276486.9 ORIGINATED BY SM  
DIST HWY 3 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY AGIWFILK  
DATUM GEODETIC DATE October 3, 2012 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		
193.87	GROUND SURFACE						20	40	60	80	100									
0.00	TOPSOIL, clayey Brown																			
0.15	FILL, silty clay, some sand, trace gravel Stiff Brown		1	SS	12															
192.50																				
1.37	SILTY CLAY TILL, some sand, trace gravel Stiff to very stiff Mottled brown and grey, becoming brown at about elev. 191.7m.		2	SS	15											1 16 41 42				
			3	SS	25															
			4	SS	21															
190.06																				
3.81	CLAYEY SILT TILL, some sand, trace to some gravel Stiff Grey		5	SS	15											13 14 39 34				
			6	SS	12															
			7	SS	14															
			8	SS	14											2 15 45 38				
			9	SS	9															
						</														

**RECORD OF BOREHOLE No 2**

1 OF 1

**METRIC**

PROJECT 11-1132-0143  
W.P. 317-98-00 LOCATION N 4670394.5 , E 276509.2 ORIGINATED BY SM  
DIST HWY 3 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY AGIWFILK  
DATUM GEODETIC DATE October 3, 2012 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>P</sub>	W	W <sub>L</sub>			WATER CONTENT (%)
193.58	GROUND SURFACE							20	40	60	80	100			
0.00	TOPSOIL, clayey Brown							20	40	60	80	100			
0.20	SILTY CLAY TILL, some sand, trace gravel Firm to very stiff Mottled brown and grey, becoming brown at about elev. 192.2m and becoming grey at about elev. 190.6m														
			1	SS	11		193								
			2	SS	17		192								
			3	SS	29		191								
			4	SS	15		190								2   14   46   38
			5	SS	11		189								
			6	SS	10		188								
							188								
			7	SS	9		187								3   15   44   39
							187								
			8	SS	10		186								
							186								
							185								
			9	SS	7		184								
183.98	END OF BOREHOLE						184								
9.60	Borehole dry during drilling.														

# RECORD OF BOREHOLE No 3

1 OF 1

**METRIC**

PROJECT 11-1132-0143  
W.P. 317-98-00 LOCATION N 4669751.2, E 277082.2 ORIGINATED BY SM  
DIST HWY 3 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY WDF  
DATUM GEODETIC DATE March 1, 2013 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED	+	FIELD VANE								
194.20	GROUND SURFACE						● QUICK TRIAXIAL	×	LAB VANE	WATER CONTENT (%)								
0.00	TOPSOIL, clayey Brown						20 40 60 80 100											
0.24	SILTY CLAY TILL, some sand, trace gravel Stiff to very stiff Brown																	
			1	SS	10													
			2	SS	8													
			3	SS	23													
			4	SS	25													
			5	SS	18													
189.78	CLAYEY SILT TILL, some sand, trace gravel Very stiff Grey		6	SS	9													
4.42			7	SS	9													
			8	SS	7													
184.60	END OF BOREHOLE		9	SS	7													
9.60	Borehole dry during drilling March 1, 2013.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 4**

1 OF 1

**METRIC**

PROJECT 11-1132-0143  
W.P. 317-98-00 LOCATION N 4668925.8 , E 277936.4 ORIGINATED BY SM  
DIST HWY 3 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY AGIWFILK  
DATUM GEODETIC DATE October 11, 2012 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× LAB VANE		
194.73	GROUND SURFACE														GR SA SI CL			
0.00	FILL, silty clay, some sand, trace gravel Stiff Brown		1	SS	11													
193.36	SILTY CLAY TILL, some sand, trace gravel Stiff to hard Mottled brown and grey, becoming brown at about elev. 192.6m and becoming grey at about elev. 191.1m		2	SS	14													
1.37			3	SS	23													
			4	SS	32													
			5	SS	20													
			6	SS	11													
			7	SS	10													
			8	SS	9													
187.64	CLAYEY SILT TILL, some sand, trace gravel Firm to stiff Grey		9	SS	9													
7.09																		
185.13	END OF BOREHOLE		10	SS	7													
9.60	Borehole dry during drilling.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 5**

1 OF 1

**METRIC**

PROJECT 11-1132-0143  
W.P. 317-98-00 LOCATION N 4668836.5 , E 278095.2 ORIGINATED BY SM  
DIST HWY 3 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY AGIWFILK  
DATUM GEODETIC DATE October 11, 2012 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20   40   60   80   100	W <sub>P</sub> W                      W <sub>L</sub>	WATER CONTENT (%)				
								SHEAR STRENGTH kPa						
							○ UNCONFINED                      + FIELD VANE							
							● QUICK TRIAXIAL                      × LAB VANE							
194.37	GROUND SURFACE						20   40   60   80   100				10   20   30	kN/m <sup>3</sup>	GR   SA   SI   CL	
0.00	TOPSOIL, clayey Brown													
0.20	SILTY CLAY TILL, some sand, trace gravel Firm to very stiff Mottled brown and grey, becoming brown at about elev. 192.1m and becoming grey at about elev. 191.5m													
			1	SS	16								0   13   44   43	
			2	SS	13									
			3	SS	29									
			4	SS	27									
			5	SS	14									
			6	SS	12									
			7	SS	11								1   14   44   42	
			8	SS	11								1   12   44   43	
			9	SS	10									
</														

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 6**

1 OF 1

**METRIC**

PROJECT 11-1132-0143  
W.P. 317-98-00 LOCATION N 4668393.2, E 278811.1 ORIGINATED BY SM  
DIST HWY 3 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY AGIWFILK  
DATUM GEODETIC DATE October 12, 2012 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE							● QUICK TRIAXIAL	× LAB VANE	
194.93	GROUND SURFACE							20	40	60	80	100						
0.00	FILL, silty clay, some sand, trace to some gravel Firm Brown		1	SS	8		194											
193.56																		
1.37	SILTY CLAY TILL, some sand, trace gravel Firm to stiff Mottled brown and grey, becoming brown at about elev. 192.8m and becoming grey at about elev. 191.3m		2	SS	7		193											
			3	SS	16		192										1	13 43 43
			4	SS	29													
			5	SS	14		191											
			6	SS	11		190										3	14 46 37
			7	SS	9													
			8	SS	8		189											
							188											
			9	SS	7		187										1	13 46 40
							186											
185.33			10	SS	8													
9.60	END OF BOREHOLE  Borehole dry during drilling.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 7**

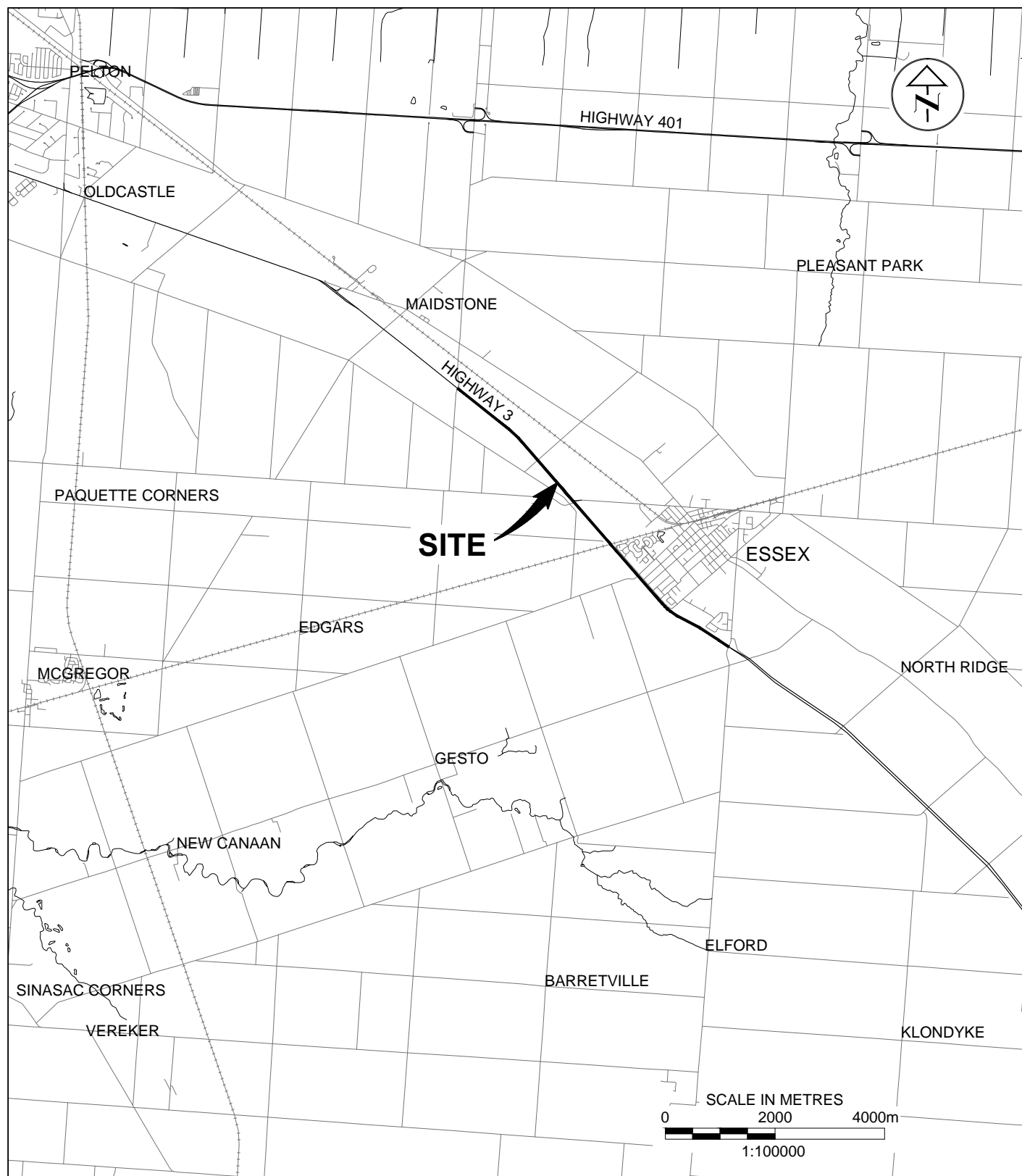
1 OF 1

**METRIC**

PROJECT 11-1132-0143  
W.P. 317-98-00 LOCATION N 4668226.7 , E 279070.3 ORIGINATED BY SM  
DIST HWY 3 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY AGIWFILK  
DATUM GEODETIC DATE October 15, 2012 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20   40   60   80   100	W <sub>P</sub> W   W <sub>L</sub>	WATER CONTENT (%)	10   20   30	kN/m <sup>3</sup>		
194.84	GROUND SURFACE													
0.00	FILL, silty clay, some sand, trace gravel Brown													
194.23														
0.61	TOPSOIL, clayey Brown and black													
0.76	SILTY CLAY TILL, some sand, trace gravel Mottled brown and grey, becoming brown at about elev. 192.7m and becoming grey at about elev. 191.2m		1	SS	12		194							
			2	SS	11		193							
			3	SS	25		192						1   13   43   44	
			4	SS	25		191							
			5	SS	13		190						2   13   46   40	
			6	SS	10		189							
			7	SS	11		188							
			8	SS	12		187						1   13   45   41	
							186							
			9	SS	11									

Drawing file: 1111320143-1000-F01001.dwg May 29, 2013 - 3:32pm



## REFERENCE

PLAN BASED ON CANMAP STREETFILES V.2008.4.

## NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.
2. ALL LOCATIONS ARE APPROXIMATE ONLY.

PROJECT

**HIGHWAY 3 WIDENING  
WINDSOR TO LEAMINGTON (PHASE 3A)  
GWP 317-98-00**

TITLE

## KEY PLAN



PROJECT No.		11-1132-0143	FILE No.		1111320143-1000-F01001
CADD	WDF	Mar. 27/13	SCALE	AS SHOWN	REV. 0
CHECK			<b>FIGURE 1</b>		

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

CONT No.  
WP No. 317-98-00

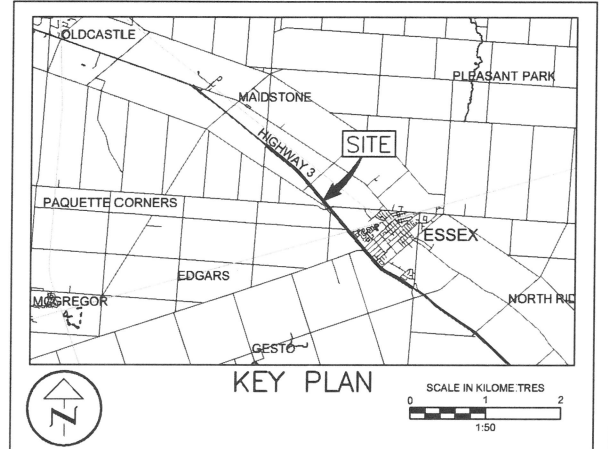


CULVERTS  
HIGHWAY 3 WIDENING  
BOREHOLE LOCATIONS

SHEET



**Golder Associates Ltd.**  
LONDON, ONTARIO, CANADA



KEY PLAN

SCALE IN KILOMETRES  
0 1 2  
1:50

LEGEND

● Borehole - Current Investigation

No.	ELEVATION	CO-ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
1	193.87	4 670 374.4	276 486.9
2	193.58	4 670 394.5	276 509.2
3	194.20	4 669 751.2	277 082.2
4	194.73	4 668 925.8	277 936.4
5	194.37	4 668 836.5	278 095.2
6	194.93	4 668 393.2	278 811.1
7	194.84	4 668 226.7	279 070.3



NOTES

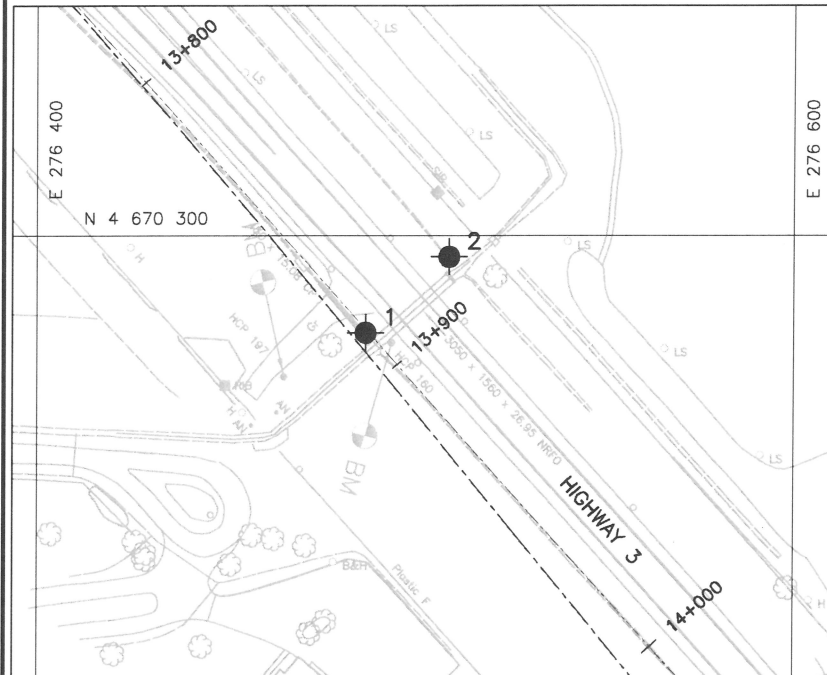
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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

REFERENCE

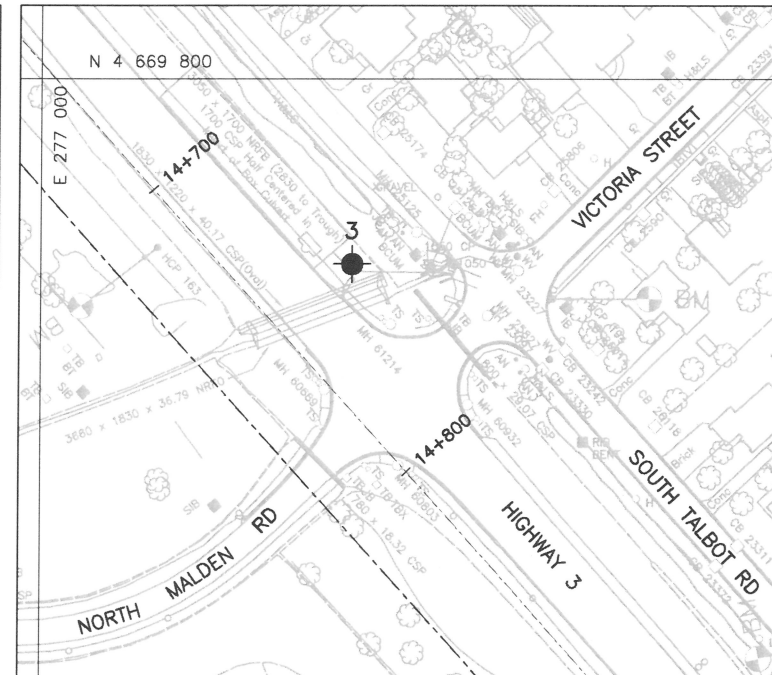
Base plans provided in digital format by DILLON

NO.	DATE	BY	REVISION
Geocres No. 40J2-128			
HWY.	3	PROJECT NO.	11-1132-0143
SUBM'D.	NAG	CHKD.	NAG
DRAWN:	WDF/AMG	CHKD.	MEB
DATE:	JUNE 4/13	APPD.	FJH
SITE:		DWG.	1



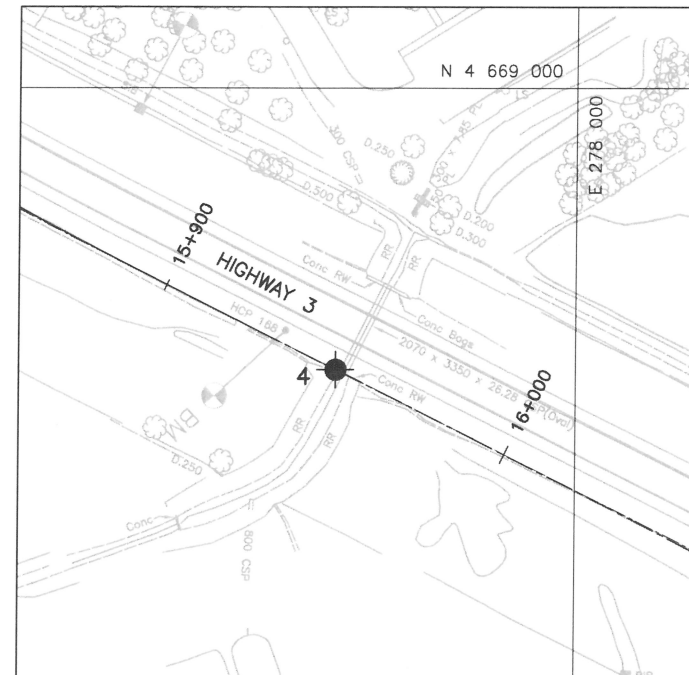
PLAN 6-416/C and  
SERVICE ROAD

SCALE  
20 0 20 m  
1:1000



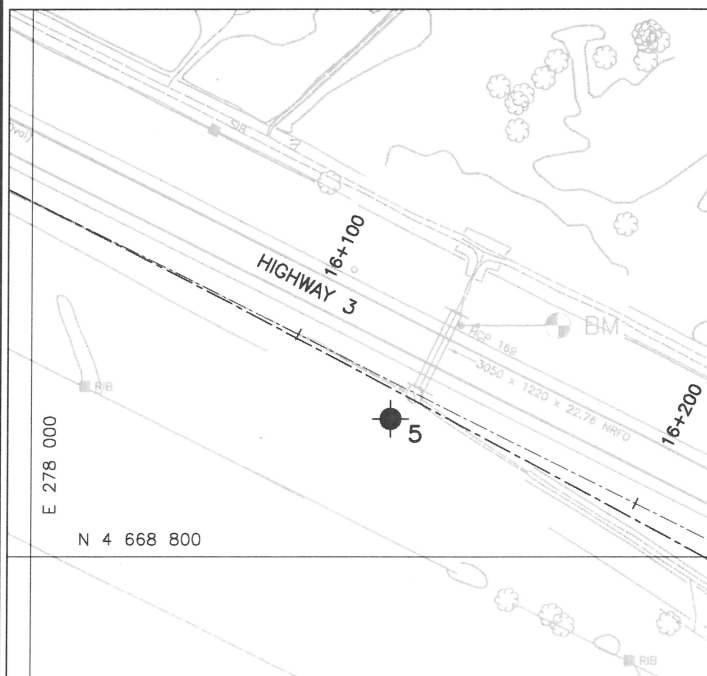
PLAN 6-412/C

SCALE  
20 0 20 m  
1:1000



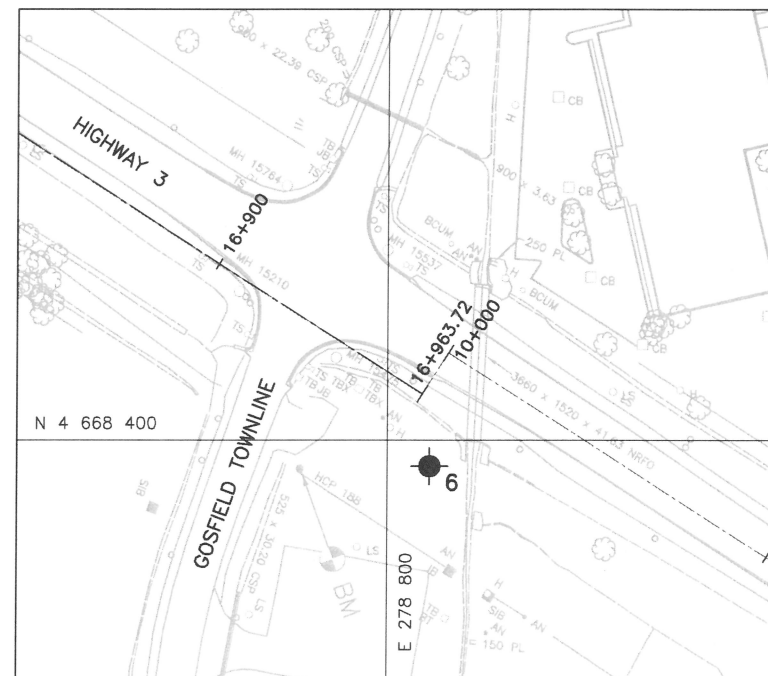
PLAN 6-588/C

SCALE  
20 0 20 m  
1:1000



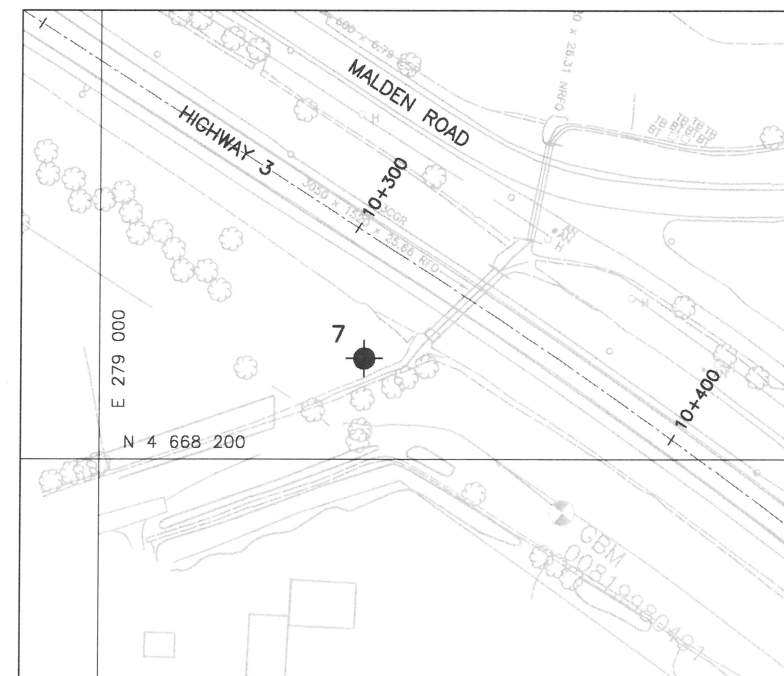
PLAN 6-589/C

SCALE  
20 0 20 m  
1:1000



PLAN 6-417/C

SCALE  
20 0 20 m  
1:1000



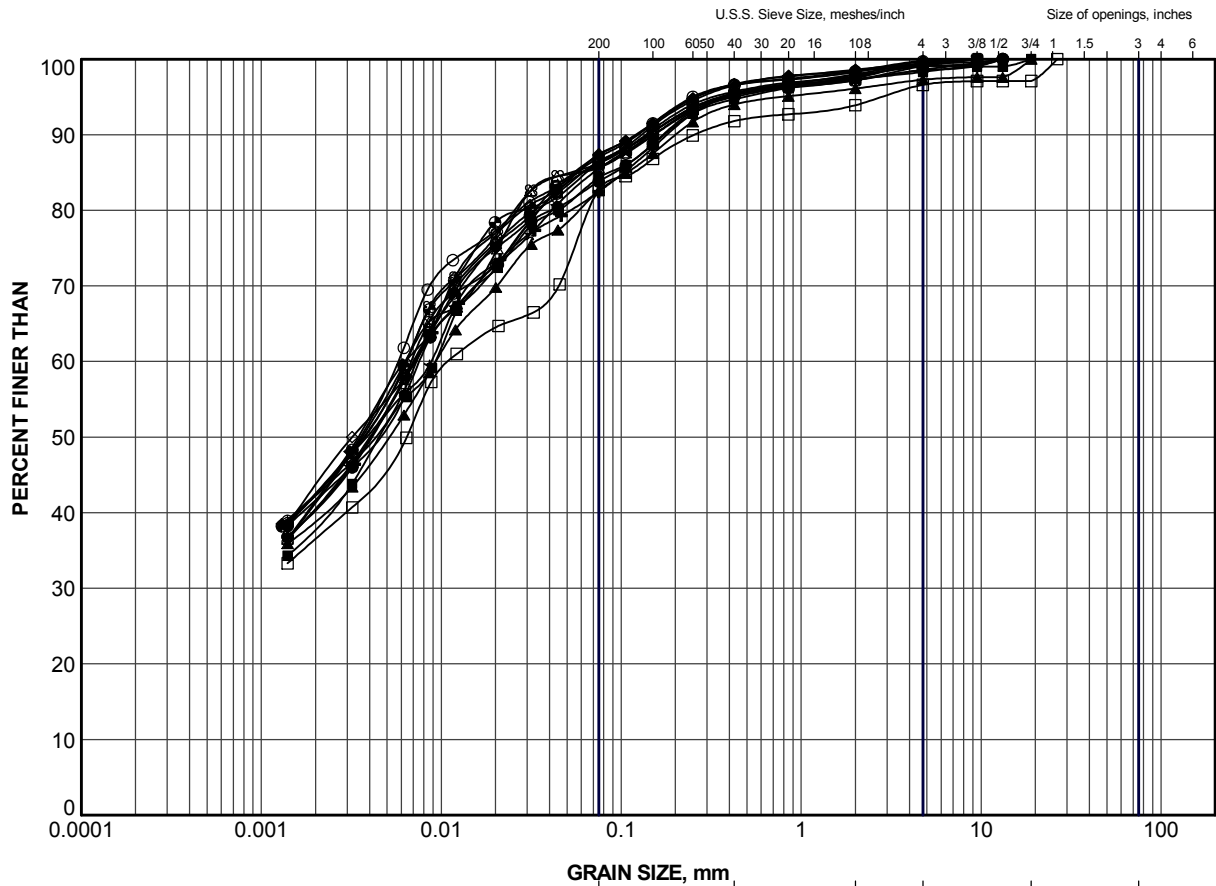
PLAN 6-418/C

SCALE  
20 0 20 m  
1:1000



# **APPENDIX A**


## **Laboratory Test Data**

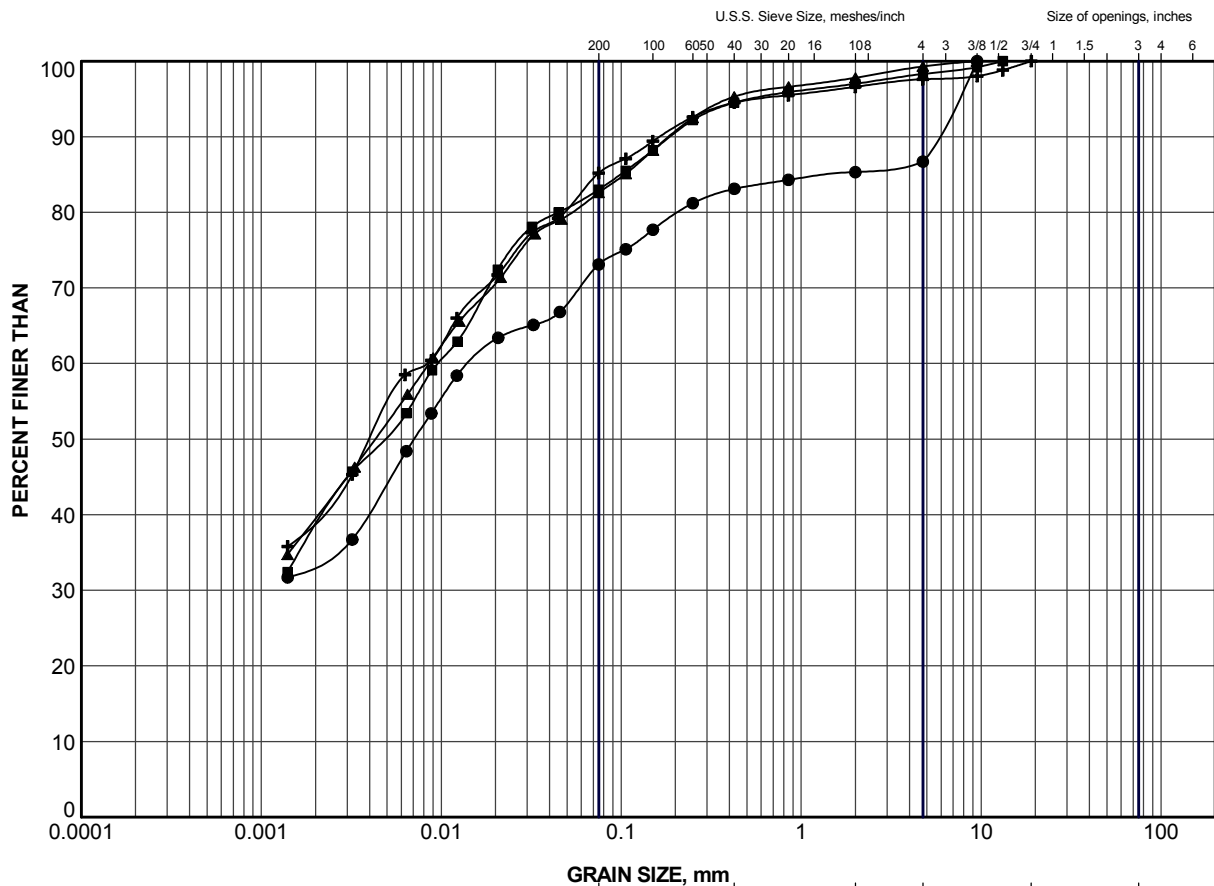


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	2	192.1
■	2	4	190.3
▲	2	7	187.3
+	3	3	191.7
◆	4	3	192.2
◇	4	7	189.2
○	5	2	192.6
△	5	7	188.8
⊗	5	8	188.0
⊕	6	3	192.4
□	6	6	190.1
⊙	6	9	187.1
⊗	7	3	192.3
★	7	6	190.0
⊗	7	8	188.5

PROJECT				HIGHWAY 3 WIDENING WINDSOR TO LEAMINGTON (PHASE 3A) GWP 317-98-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY CLAY TILL			
PROJECT No.		11-1132-0143		FILE No.		1111320143-1000-F010A1	
DRAWN		LMK/WDF		SCALE		N/A	
CHECK				REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-1</b>			



#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	5	189.8
■	1	8	187.5
▲	3	6	189.4
+	4	9	186.9

PROJECT

HIGHWAY 3 WIDENING  
WINDSOR TO LEAMINGTON (PHASE 3A)  
GWP 317-98-00

TITLE

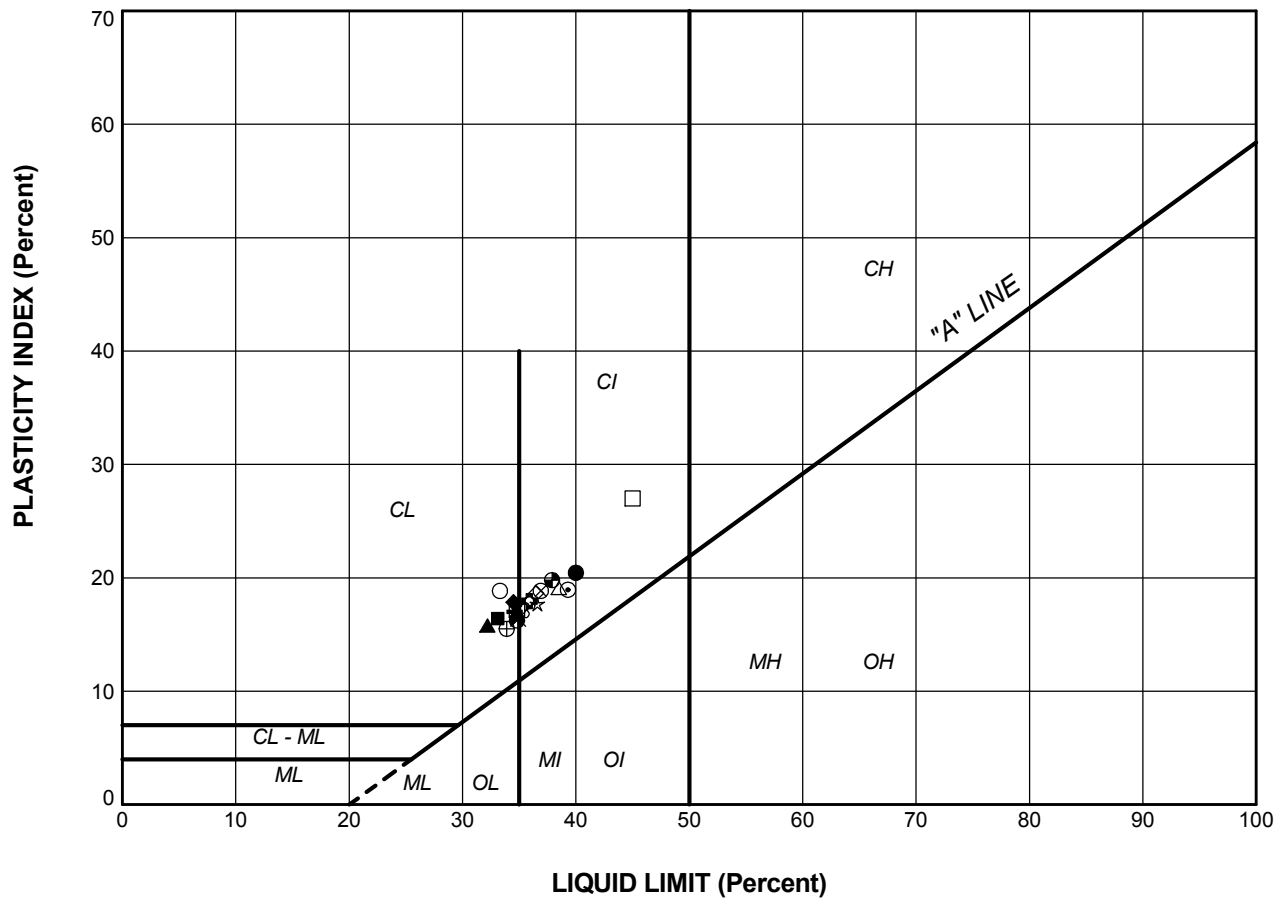
### GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL



**Golder  
Associates**  
LONDON, ONTARIO


PROJECT No.	11-1132-0143	FILE No.	1111320143-1000-F010A2
DRAWN	LMK/WDF	Mar. 28/13	SCALE N/A REV.
CHECK			

**FIGURE A-2**



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
<b>SILTY CLAY TILL</b>					
●	1	2	40.0	19.6	20.5
+	2	4	34.6	17.6	17.0
◆	2	7	34.5	16.7	17.9
◇	3	3	36.5	17.9	18.7
△	4	3	38.5	19.4	19.1
⊗	4	7	36.9	18.1	18.9
□	5	2	45.0	18.0	27.0
⊕	5	7	34.8	18.6	16.3
⊙	5	8	37.9	18.1	19.8
*	6	3	36.6	18.9	17.7
⊗	6	6	35.2	18.1	17.2
⊠	6	9	34.8	17.6	17.2
⊙	7	3	39.3	20.4	19.0
⊕	7	6	35.9	18.0	18.0
×	7	8	34.9	18.5	16.4
<b>CLAYEY SILT TILL</b>					
■	1	5	33.1	16.7	16.4
▲	1	8	32.2	16.4	15.8
○	3	6	33.3	14.5	18.9
⊕	4	9	33.9	18.4	15.5

PROJECT				HIGHWAY 3 WIDENING WINDSOR TO LEAMINGTON (PHASE 3A) GWP 317-98-00			
TITLE				PLASTICITY CHART			
PROJECT No.		11-1132-0143		FILE No.		1111320143-1000-F010A3	
DRAWN		LMK/WDF		SCALE		N/A	
CHECK				REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				Mar. 28/13		<b>FIGURE A-3</b>	



# **APPENDIX B**

## **Site Photographs**



## APPENDIX B SITE PHOTOGRAPHS



Photograph 1: Site 6-416/C, looking southeast.



Photograph 2: Site 6-412/C, looking northwest.



## APPENDIX B SITE PHOTOGRAPHS



Photograph 3: Site 6-588/C, looking northeast.



Photograph 4: Site 6-589/C, looking northeast.



## APPENDIX B SITE PHOTOGRAPHS



Photograph 5: Site 6-417/C, looking north.



Photograph 6: Site 6-418/C, looking east.



## APPENDIX B SITE PHOTOGRAPHS



Photograph 1: Site 6-416/C, looking southeast.



Photograph 2: Site 6-412/C, looking northwest.



## APPENDIX B SITE PHOTOGRAPHS



Photograph 3: Site 6-588/C, looking northeast.



Photograph 4: Site 6-589/C, looking northeast.



## APPENDIX B SITE PHOTOGRAPHS



Photograph 5: Site 6-417/C, looking north.



Photograph 6: Site 6-418/C, looking east.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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