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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
SHORT SPAN CULVERTS  
HIGHWAY 40 RECONSTRUCTION  
GWP 760-91-00, AGREEMENT NO. 3005-E-0043  
MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION**

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LIST OF SYMBOLS

RECORD OF BOREHOLE SHEETS

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**PART A**  
**FOUNDATION INVESTIGATION REPORT**

**SHORT SPAN CULVERTS**  
**HIGHWAY 40 RECONSTRUCTION**  
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**MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION**

## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder Associates) has been retained by Delcan Corporation (Delcan) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detail design work for GWP 760-91-00. The project includes the reconstruction of 5.8 kilometres of Highway 40 from 0.1 kilometres south of Courtright Line (Lambton Road 80) northerly to 0.1 kilometres north of Rokeby Line in Lambton County, Ontario.

The scope of work for this project involves replacement of the existing composite pavement with a new flexible pavement and includes updating or replacement of features which do not meet current design standards and/or have reached the end of their life span. The roadway profile and alignment remain essentially unchanged. Elements which are scheduled to be replaced or updated include:

- Drainage elements including culvert rehabilitation/replacement and ditch clean out
- Guide rail
- Signals and illumination
- Intersection geometrics including turning lanes where warranted

This report addresses the foundation investigation for the replacement of 3 short span (less than 3 metre span) culverts.

The purpose of the foundation investigation is to determine the subsurface conditions at the locations of the proposed works 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 P61-3076 dated May 16, 2006. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated July 11, 2006.

The centreline and stations of the alignment were surveyed by others prior to commencing the foundation investigation program. Delcan provided Golder Associates with preliminary drawings for this project in digital format.

## 2.0 SITE DESCRIPTION

GWP 760-91-00 extends along Highway 40 from 0.1 kilometres south of Courtright Line (Lambton Road 80), northerly to 0.1 kilometres north of Rokeby Line in the Township of Moore, Lambton County, Ontario. Moore Line (Moore Township Road No. 5) runs east-west roughly half way between the project limits. The location of the project is shown on the Key Plan, Figure 1.

Land use in the vicinity of the site is typically agricultural with few commercial properties to the west of Highway 40.

The adjacent topography is generally flat to slightly rolling with a ground surface elevation between 190 and 197 metres increasing to the north.

### 2.1 Site Geology

The project is located in the Lambton Clay Plain, a subregion of the physiographic region of southern Ontario known as the St. Clair Clay Plain.<sup>1</sup> This subregion is described as a till plain that has been locally smoothed by shallow deposits which settled in depressions in the till. The prevailing soil type is reported to be the Brookston clay or Caistor clay. The available surficial geology mapping for the project area indicates that the predominant surficial soils are clayey silt till.<sup>2</sup>

The bedrock surface lies between elevation 140 to 143 metres beneath 40 to 43 metres of overburden.<sup>3</sup> The subcropping bedrock is reported to be Shale of the Dundee foundation.<sup>4</sup>

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<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> Ontario Geological Survey (OGS), 1979. *Quaternary Geology, Sarnia-Brights Grove Area*. OGS, Preliminary Map P.2222.

<sup>3</sup> J.F. Caley and B.V. Sanford, 1991. *Preliminary Maps, Lambton County showing Drift-Thickness and Bedrock Contours*. Geological Survey of Canada, Paper 52-2.

<sup>4</sup> OGS, 1991. *Bedrock Geology of Ontario, Southern Sheet*. OGS, Map 2544.

### **3.0 INVESTIGATION PROCEDURES**

The field work for this portion of the investigation was carried out on August 28 and 29, 2006, during which time nine boreholes were drilled. Three boreholes were drilled for each of the culvert replacements.

The drilling for boreholes 1, 4, and 7 was carried out using a truck-mounted power auger supplied and operated by a specialist drilling contractor. Samples of the overburden were obtained at 0.75 metres intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures.

The remaining six boreholes were drilled manually by Golder Associates' staff and non-standard penetration testing and sampling was carried out. The penetration testing was carried out with a 31.5 kilogram hammer and the driving resistances were interpreted to approximate N values.

Groundwater conditions in the boreholes were observed throughout the drilling operations and these observations are provided on the Record of Borehole sheets. All of the boreholes were backfilled in accordance with current regulations, MTO recommended procedures and Ontario Regulation 128/03.

The field work was supervised on a full-time basis by experienced members of our engineering staff who arranged for utility locates, directed the drilling, sampling and in-situ testing operations, logged the boreholes, and cared for the samples obtained. The soil samples were identified in the field, placed in labeled containers and transported to Golder Associates' London laboratory for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses and Atterberg limits determinations were carried out on selected samples. The results of the field and laboratory testing are given on the Record of Borehole sheets and in Appendix A.

Temporary traffic control was carried out in accordance with the Ontario Traffic Manual, Temporary Conditions, Book 7, dated March 2001.

The as-drilled borehole locations and ground surface elevations and the locations of the boreholes are shown on the Record of Borehole sheets and on Drawing 1.

The table below summarizes the culvert locations, ground surface elevations and depths of the associated boreholes.

<u>STATION/LOCATION</u>	<u>BOREHOLE</u>	<u>LOCATION (m)</u>		<u>GROUND SURFACE ELEVATION (m)</u>	<u>BOREHOLE DEPTH (m)</u>
		<u>Northing</u>	<u>Easting</u>		
16+735	4	4 742 649.9	311 560.4	191.52	4.27
Highway 40	5	4 742 650.5	311 554.3	190.41	1.98
	6	4 742 644.0	311 578.1	190.39	1.98
20+856	1	4 746 757.0	311 721.8	196.41	4.27
Highway 40	2	4 746 760.2	311 717.4	195.14	1.98
	3	4 746 759.6	311 739.2	195.29	1.98
Moore Line	7	4 744 357.0	311 596.5	192.30	4.27
50 m Lt Highway 40 C/L	8	4 744 364.7	311 597.1	191.47	1.98
	9	4 744 339.6	311 596.9	191.80	1.98

The existing culverts have the following characteristics:

<u>CULVERT</u>	<u>DIMENSIONS (m)</u>	<u>INVERT ELEVATION (m)</u>		<u>CONSTRUCTION</u>
		(Lt)	(Rt)	
16+735	1.22 x 16.98	189.95	189.83	CSP
Highway 40				
20+856	0.60 x 21.83	194.69	194.75	CSP
Highway 40				
Moore Line	0.80 x 24.59	190.97	buried	CSP
50 m Lt Highway 40 C/L				

## **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 and 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 sampling or observations of drilling resistance and represent transitions between soil types rather than exact planes of geological change. Subsurface conditions will vary between and beyond the borehole locations.

In general, the boreholes drilled at the proposed culvert replacements typically encountered topsoil and fill materials underlain by a deposit of silty clay till.

The locations of the boreholes are shown on the attached 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.

#### **4.1.1 Station 16+735, Highway 40**

Boreholes 4, 5 and 6 were drilled in the area of the proposed replacement of the culvert at Station 16+735.

##### Topsoil and Fill

Topsoil layers with an average thickness of 270 millimetres, were encountered at ground surface in boreholes 5 and 6.

A 0.1 metre thick layer of sand and gravel fill was encountered at ground surface in borehole 4. Below the sand and gravel fill, a layer of sand fill was encountered at elevation 191.4 metres. The sand fill had a standard penetration test N value of 16 blows per 0.3 metres and a water content of about 16 per cent.

##### Silty Clay Till

Beneath the topsoil in boreholes 5 and 6, and the fill materials in borehole 4, a layer of very stiff silty clay till was encountered at approximately elevation 190.2 metres. The silty clay till had N values of 15 to 29 blows per 0.3 metres with natural water contents of 19 to 22 per cent. The results of a grain size analysis of a sample of the silty clay till recovered from the standard



penetration testing are presented on Figure A-1 of Appendix A. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The silty clay till is of intermediate plasticity based on plastic and liquid limits of 17 and 39 per cent, respectively, and a plasticity index of 22 per cent. The Atterberg limits data are shown on the Plasticity Chart, Figure A-3.

#### **4.1.2 Station 20+856, Highway 40**

Boreholes 1, 2, and 3 were drilled in the area of the proposed replacement of the culvert at Station 20+856.

##### Topsoil and Fill

Topsoil layers, 80 to 270 millimetres thick were encountered at ground surface in all three boreholes.

Fill materials, consisting of clayey silt and sand, were encountered below the topsoil in borehole 1 from elevation 196.3 metres. The total thickness of the fill layers was 1.3 metres. Two layers of clayey silt fill were encountered in borehole 1 at elevations 196.3 and 195.5 metres. The clayey silt fill had a standard penetration test N value of 8 blows per 0.3 metres and a water content of about 25 per cent. A 0.5 metre sand fill layer was encountered between the layers of clayey silt fill at elevation 196.2 metres and had a water content of about 10 per cent.

##### Clayey Silt Till

Beneath the fill materials in borehole 1, a 2.2 metre thick layer of stiff to hard clayey silt till was encountered at elevation 195.0 metres. The clayey silt till had N values of 12 to 41 blows per 0.3 metres and averaged 31 blows per 0.3 metres. Natural water contents varied between 15 to 23 per cent and averaged about 18 per cent. The results of grain size testing on the clayey silt till recovered from the standard penetration testing are presented on Figure A-2. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The clayey silt till is of low plasticity based on plastic and liquid limits of 15 and 33 per cent, respectively, and a plasticity index of 18 per cent. The Atterberg limits data are shown on the Plasticity Chart on Figure A-3.

### Silty Clay Till

Beneath the topsoil in boreholes 2 and 3 from about elevation 195.0 metres and the clayey silt till in borehole 1 from elevation 192.8 metres, a layer of firm to very stiff silty clay till was encountered. All of the boreholes were terminated in the silty clay till which had N values of 7 to 21 blows per 0.3 metres and averaged 15 blows per 0.3 metres. Natural water contents varied between 15 to 20 per cent and averaged about 17 per cent. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

#### **4.1.3 Moore Line, 50 metres Lt Highway 40 C/L**

Boreholes 7, 8 and 9 were drilled in the area of the proposed replacement of the culvert on Moore Line, 50 metres west of Highway 40.

### Topsoil and Fill

Clayey topsoil layers 200 and 310 millimetres thick were encountered at ground surface in boreholes 8 and 9, respectively.

Fill materials were encountered at ground surface in borehole 7 and below the clayey topsoil in borehole 9 at elevation 190.8 metres. The fill consisted of clayey silt, sand and gravel, and silty clay with wood. The soft silty clay fill in borehole 9 had an N value of 4 blows per 0.3 metres and a water content of about 80 per cent. A 0.5 metre thick layer of sand and gravel fill was encountered at ground surface in borehole 7. Below the sand and gravel fill in borehole 7, a layer of stiff clayey silt fill was encountered at elevation 191.8 metres. The clayey silt fill had an N value of 12 blows per 0.3 metres and a measured water content of about 25 per cent.

A 310 millimetre thick layer of buried clayey topsoil was encountered below the fill material in borehole 7 at elevation 190.8 metres. The topsoil had an N value of 6 blows per 0.3 meters and a water content of about 39 per cent.

### Silty Clay Till

Beneath the buried and surficial topsoil in boreholes 7 and 8, respectively, and the fill materials in borehole 9, firm to stiff silty clay till was encountered between elevations 190.5 and 191.3 metres. The results of grain size testing on samples of the silty clay till recovered from the standard penetration testing are presented on Figure A-3 in Appendix A. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The silty clay till had N values of 4 to 15 blows per 0.3 metres and water contents which varied between 19 and 20 per cent. The silty clay till is of intermediate plasticity based on plastic and liquid limits of 18 and 39 per cent, respectively, and a plasticity index of 21 per cent. The Atterberg limits data are shown on the Plasticity Chart on Figure A-3.

## 4.2 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling. All boreholes remained dry during drilling.

The water levels in the watercourses at the culvert locations were measured on August 29, 2006. The water levels are summarized below:

<u>STATION/LOCATION</u>	<u>WATER LEVEL IN WATERCOURSES</u> (elevation - m)
16+735, Highway 40	190.1
20+856, Highway 40	195.0
Moore Line, 50 m Lt of Highway 40 C/L	191.2

Since the groundwater table was not encountered during the investigation, and only borehole 1 intercepted grey soils, it has been inferred that the long term groundwater table may generally be below the depths of investigation. However, the groundwater levels are expected to fluctuate seasonally and are likely to be higher during periods of sustained precipitation or spring melt.

## **5.0 MISCELLANEOUS**

The investigation was carried out using equipment supplied and operated by Aardvark Drilling Inc., which is an Ontario Ministry of Environment licensed well contractor. The field operations were supervised by Mr. Mike Arthur, and Mr. Dan Babcock under the direction of 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. Dirka U. Prout, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, 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**  
**FOUNDATION DESIGN REPORT**

**SHORT SPAN CULVERTS**  
**HIGHWAY 40 RECONSTRUCTION**  
**GWP 760-91-00, AGREEMENT NO. 3005-E-0043**  
**MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION**

## **6.0 ENGINEERING RECOMMENDATIONS**

### **6.1 General**

This section of the report provides our recommendations on the foundation aspects of the design of culverts proposed to replace three existing short span culverts situated in the project area. Two of the culverts are on Highway 40 at Stations 16+735 and 20+856 and the third is on Moore Line (Moore Township Road No. 5), 50 metres left of the centerline of Highway 40.

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 in order 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.

### **6.2 Foundations**

Highway 40, within the project limits, will be reconstructed to current standards with a minor grade raise of approximately 250 millimetres. Moore Line will also be reconstructed in order to tie into the proposed Highway 40 modifications.

The subsoils encountered in the boreholes advanced during the investigation typically consist of topsoil, surficial fills and buried topsoil over firm to very stiff silty clay till or occasionally stiff to hard clayey silt till. The groundwater table was not encountered in these clayey soils during the investigation.

All culverts should be designed to withstand the appropriate weight of fill and traffic loading. Site specific recommendations are provided in the following sections.

Footing excavations should penetrate all existing fill and buried topsoil so that foundations bear directly on the native silty clay or clayey silt till soils. The footing base should be clean and free of loose debris, ponded water and frost. The cleaned excavation base should be inspected by qualified geotechnical personnel prior to installation of the culvert and the final 0.5 metres of excavation completed when the geotechnical personnel are present on site.

Free draining, well-graded granular material such as Granular A, should be used for the bedding. The bedding and cover materials and placement of bedding and cover materials should adhere to MTO Special Provision No. 421S01.

Backfill transition (frost taper) will be required above the frost line which is expected to be about 1.2 metres below the ground surface. In areas where the frost penetration line is below the

bottom of the bedding grade, the frost taper should start at the bedding grade in accordance with Ontario Provincial Standard Drawing (OPSD) 803.030. In areas where the frost penetration line is between the bottom of the bedding grade and the springline of the pipe, a frost taper as specified in OPSD 803.031 should be provided. Frost tapers are not required if the frost penetration line is above the pipe invert.

Site specific recommendations are presented in the following discussions and recommendations are included for concrete culverts, should they be considered. The recommended bearing resistances of Ultimate Limit States (ULS) and at Serviceability Limit States (SLS) assume a maximum allowable settlement of 25 millimetres. Detailed design information such as the proposed invert elevations and size of the replacement culverts has not been provided. Therefore, the new inverts have been assumed to correspond to those of the existing culverts.

#### **6.2.1 Station 16+735, Highway 40**

The existing corrugated steel pipe (CSP) culvert at this location is 1220 millimetres in diameter and 16.98 metres long with an invert at about elevation 189.9 metres and it is to be replaced. Based on the information from boreholes 4, 5 and 6, the culvert can be founded on the very stiff silty clay till at or below elevation 189.7 metres. Free groundwater was not encountered during the investigation and the long term groundwater table is likely below elevation 187 metres. Minimal groundwater seepage is expected at the founding depths. Should the replacement culvert at this location be a concrete culvert, it may be designed using a factored geotechnical resistance at ULS of 300 kilopascals (kPa) and a geotechnical resistance at SLS of 200 kPa with an unfactored coefficient of sliding of 0.50.

#### **6.2.2 Station 20+856, Highway 40**

The existing CSP culvert at this location is 600 millimetres in diameter, 21.83 metres long with an invert at about elevation 194.7 metres and it is to be replaced. Based on the information from boreholes 1, 2 and 3, the culvert can be founded on the hard clayey silt till and stiff to very stiff silty clay till at or below elevation 194.0 metres. Minimal groundwater seepage is expected at the founding depths since free groundwater was not encountered during the investigation and the long term groundwater table is likely below elevation 193 metres. If the replacement culvert at this location is designed as a concrete culvert, it may be designed using a factored geotechnical resistance at ULS of 225 kPa and a geotechnical resistance at SLS of 150 kPa with an unfactored coefficient of sliding of 0.50.

#### **6.2.3 Moore Line, 50 m Lt Highway 40 C/L**

The existing CSP culvert at this location is 800 millimetres in diameter, 24.59 metres long with an invert at about elevation 191.0 metres and it is to be replaced. Based on the information from

boreholes 7, 8 and 9, the culvert can be founded on stiff silty clay till at or below elevation 190.5 metres. Minimal groundwater seepage is expected at the founding depths. The groundwater table was not encountered during the investigation and the groundwater table is likely below elevation 187 metres. Should a concrete culvert be selected to replace the existing culvert at this location it may be designed using a factored geotechnical resistance at ULS of 150 kPa and a geotechnical resistance at SLS of 100 kPa with an unfactored coefficient of sliding resistance of 0.50.

### **6.3 Excavations and Temporary Cut Slopes**

Following diversion of flows in the existing channels, all topsoil, fill, organic material and other deleterious materials should be stripped from the proposed founding area prior to construction of the replacement culverts. Any disturbed or deleterious materials encountered should also be removed and low areas brought to grade using compacted Granular A. In areas where groundwater flow may preclude the use of Granular A, 19 millimetre crushed stone placed on a separation geotextile should be used. In order to provide for good workmanship and effective compaction of the fill, a minimum of 300 millimetres for culverts 900 millimetres or less in diameter or 500 millimetres for larger culverts should be present at each side of the pipe.

Excavations will encounter surficial fills, topsoil and underlain by clayey silt till or silty clay till. The presence of cobbles and/or boulders within the till soils should be anticipated. It is anticipated that, in general, groundwater flows into foundation excavations will be minimal and can be handled by properly located, sized and filtered sumps placed in the base of the excavation. Flatter side slopes may be required in excavations in loose and wet fill materials for stability. The excavation side slopes should be maintained at an inclination of 1 horizontal to 1 vertical or flatter in accordance with the current Occupation Health and Safety Act (OSHA). Based on the current OSHA, all fill materials may be classified as Type 3 soils. The clayey silt till and silty clay till may be classified as a Type 2 soil.

### **6.4 Backfill**

Backfill around the culverts should be carried out in accordance with (OPSD) 802.010. Culvert backfill should consist of free-draining, non-frost susceptible granular materials such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B, Type III. Fill and/or backfill above the bedding may consist of the excavated materials provided all topsoil, organics and other deleterious materials as well as excessively wet materials, are wasted. Alternatively, approved earth borrow may be used.

Heavy compaction equipment should not be used immediately over or adjacent to the culverts or within 900 millimetres of the culvert crown. The height of backfill adjacent to the culverts should be maintained equal on both sides of the structure during all stages of backfill placement. Temporary diversion of surface water flow may be required during culvert installation. Adequate



erosion protection, such as suitable non-woven geotextile and rip rap, as determined by a hydraulic assessment, should be provided at the outlet and inlet. Rip-rap treatment at the outlets should be placed in accordance with OPSD 810.010.

## 6.5 Lateral Earth Pressures for Design

If the culverts are replaced with concrete culverts, the granular fill should be placed with a width equal to at least 1.2 metres behind the culvert. Where backfill soils are placed and compacted behind the walls, a compaction surcharge equal to 12 kPa should be included in the lateral earth pressures for structural design in accordance with the Canadian Highway Bridge Design Code (CHBDC). Compaction equipment should be used in accordance with OPSS 501.06. For walls backfilled as noted above, the following parameters (unfactored) may be assumed:

Total unit weight:	22 kN/m <sup>3</sup>
Coefficients of lateral earth pressures:	
‘active’, $K_a$ (unrestrained case)	0.31
‘at-rest’, $K_o$ (restrained case)	0.47

If the wall support allows lateral yielding (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the culvert wall support does not allow lateral yielding (restrained structure), at-rest pressures should be assumed for geotechnical design.

Resistance to sliding may be based on an unfactored shearing resistance of 27 degrees. The unfactored coefficient of passive pressure for the portion of the culvert wall and footing below the invert may be taken as 2.70.

## 6.6 Surface and Groundwater Control

Appropriate grading should be carried out prior to construction to direct surface flows away from the open excavations.

Depending on the time of year and the prevailing weather conditions during construction, control of creek flows may be required. Construction should be scheduled to preclude excavation during spring conditions. Control of creek flows, depending on their magnitude, may be handled by pumping from sumps in conjunction with temporary earthen cofferdams constructed on the native silty clay till. If excessive creek flows are present, temporary diversion of the channel may be required.

Based on the results of the investigation, it is considered that, typically, groundwater control can be accomplished using properly constructed and filtered sumps in the base of the excavations.

## **6.7 Additional Comments**

Culvert end treatment is not considered necessary as the potential for uplift, piping or undermining is considered to be low.

The reconstructed profile results in a minimal grade raise compared to the existing road profile. Therefore post construction settlements are expected to be minimal and camber of the replacement culverts is not considered necessary.

Erosion protection for the culvert backfill should be provided, as appropriate and consisted with OPSD 810.010. 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 and diversion of the watercourses to mitigate migration of fine soil particles.

## **7.0 MISCELLANEOUS**

This report was prepared by Ms. Dirka U. Prout, P.Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, 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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## 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 = (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 06-1130-132  
G.W.P. 760-91-00 LOCATION N 4746757.0 ; E 311721.8 ORIGINATED BY M.A.  
DIST HWY 40 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 28, 2006 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 (%)		
								20	40	60							80	100
196.41	GROUND SURFACE																	
0.08	TOPSOIL, sandy Brown																	
0.37	FILL, clayey silt, some sand, some gravel Brown																	
195.50																		
0.91	FILL, sand, some gravel, trace silt, trace clay Compact Brown		1	SS	8													
195.04																		
1.37	FILL, clayey silt, trace organics Firm Grey		2	SS	12													
	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown and Grey		3	SS	39													
			4	SS	41													
192.75																		
3.66	SILTY CLAY, trace sand, trace gravel (TILL) Very Stiff Grey		5	SS	17													
192.14																		
4.27	END OF BOREHOLE																	
	Borehole dry during drilling August 29, 2006																	

# RECORD OF BOREHOLE No 2

1 OF 1

**METRIC**

PROJECT 06-1130-132  
G.W.P. 760-91-00 LOCATION N 4746760.2 ; E 311717.4 ORIGINATED BY D.B.  
DIST HWY 40 BOREHOLE TYPE MANUAL AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 29, 2006 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 ● QUICK TRIAXIAL × LAB VANE										
195.14	GROUND SURFACE						20	40	60	80	100							
0.00	TOPSOIL, clayey Brown																	
0.27	SILTY CLAY, trace sand, trace gravel (TILL) Firm to Very Stiff Brown																	
			1	SS	7													
193.16			2	SS	21													
1.98	END OF BOREHOLE																	
	Borehole dry during drilling August 29, 2006																	

**RECORD OF BOREHOLE No 3**

1 OF 1

**METRIC**

PROJECT 06-1130-132 G.W.P. 760-91-00 LOCATION N 4746759.6 ; E 311739.2 ORIGINATED BY D.B.  
DIST            HWY 40 BOREHOLE TYPE MANUAL AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 29, 2006 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>
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE												
195.29	GROUND SURFACE							20	40	60	80	100								
0.00	TOPSOIL, clayey Brown						195													
0.27	SILTY CLAY, trace sand, trace gravel (TILL) Very Stiff to Stiff Brown		1	SS	17		194							○						
193.31			2	SS	13									○						
1.98	END OF BOREHOLE																			
	Borehole dry during drilling August 29, 2006																			



**RECORD OF BOREHOLE No 4**

1 OF 1

**METRIC**

PROJECT 06-1130-132  
G.W.P. 760-91-00 LOCATION N 4742649.9 ; E 311560.4 ORIGINATED BY M.A.  
DIST HWY 40 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 28, 2006 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT   NATURAL   LIQUID LIMIT   MOISTURE   LIMIT CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20   40   60   80   100	○ UNCONFINED   + FIELD VANE	● QUICK TRIAXIAL   × LAB VANE	W <sub>p</sub> W   W <sub>L</sub>					
191.52	GROUND SURFACE															
0.00 0.12	FILL, sand and gravel, some silt Brown						191									
	FILL, sand, fine to medium, trace silt Compact Brown		1	SS	16											
190.15							190									
1.37	SILTY CLAY, trace sand, trace gravel (TILL) Very Stiff Brown		2	SS	22											
			3	SS	29		189								0   4   51   45	
			4	SS	25		188									
187.25			5	SS	20											
4.27	END OF BOREHOLE															
	Borehole dry during drilling August 29, 2006															

**RECORD OF BOREHOLE No 5**

1 OF 1

**METRIC**

PROJECT 06-1130-132 G.W.P. 760-91-00 LOCATION N 4742650.5 ; E 311554.3 ORIGINATED BY D.B.  
DIST            HWY 40 BOREHOLE TYPE MANUAL AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 29, 2006 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										WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×						LAB VANE		
190.41	GROUND SURFACE						20	40	60	80	100		10	20	30					
0.00	TOPSOIL, clayey Brown																			
0.27	SILTY CLAY, trace sand, trace gravel (TILL) Very Stiff Brown																			
		1	SS	29																
188.43			2	SS	25															
1.98	END OF BOREHOLE  Borehole dry during drilling August 29, 2006																			

**RECORD OF BOREHOLE No 6**

1 OF 1

**METRIC**

PROJECT 06-1130-132 G.W.P. 760-91-00 LOCATION N 4742644.0 ; E 311578.1 ORIGINATED BY D.B.  
DIST            HWY 40 BOREHOLE TYPE MANUAL AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 29, 2006 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									
								20 40 60 80 100									
190.39	GROUND SURFACE																
0.00	TOPSOIL, clayey Brown																
0.27	SILTY CLAY, trace sand, trace gravel (TILL) Very Stiff Brown																
			1	SS	15												
188.41			2	SS	25												
1.98	END OF BOREHOLE																
	Borehole dry during drilling August 29, 2006																

**RECORD OF BOREHOLE No 7**

1 OF 1

**METRIC**

PROJECT 06-1130-132  
G.W.P. 760-91-00 LOCATION N 4744357.0 ; E 311596.5 ORIGINATED BY M.A.  
DIST HWY 40 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 29, 2006 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	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
192.30	GROUND SURFACE						20	40	60	80	100						
0.00	FILL, sand and gravel, some silt Brown																
191.84																	
0.46	FILL, clayey silt, trace sand, trace gravel, trace to some topsoil Stiff Brown and Grey		1	SS	12												
190.78																	
1.52	TOPSOIL, clayey		2	SS	6												
190.47	Firm Black																
1.83	SILTY CLAY, trace sand, trace gravel (TILL) Stiff Brown		3	SS	10												
			4	SS	15												
			5	SS	14												
188.03																	
4.27	END OF BOREHOLE  Borehole dry during drilling August 29, 2006																

**RECORD OF BOREHOLE No 8**

1 OF 1

**METRIC**

PROJECT 06-1130-132 G.W.P. 760-91-00 LOCATION N 4744364.7 ; E 311597.1 ORIGINATED BY D.B.  
DIST            HWY 40 BOREHOLE TYPE MANUAL AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 29, 2006 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										WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE												
191.47	GROUND SURFACE							20	40	60	80	100								
0.00	TOPSOIL, clayey Brown																			
0.20	SILTY CLAY, trace sand, trace gravel (TILL) Stiff Brown and Grey						191													
			1	SS	10															
189.49			2	SS	12		190													
1.98	END OF BOREHOLE																			
	Borehole dry during drilling August 29, 2006																			

**RECORD OF BOREHOLE No 9**

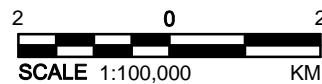
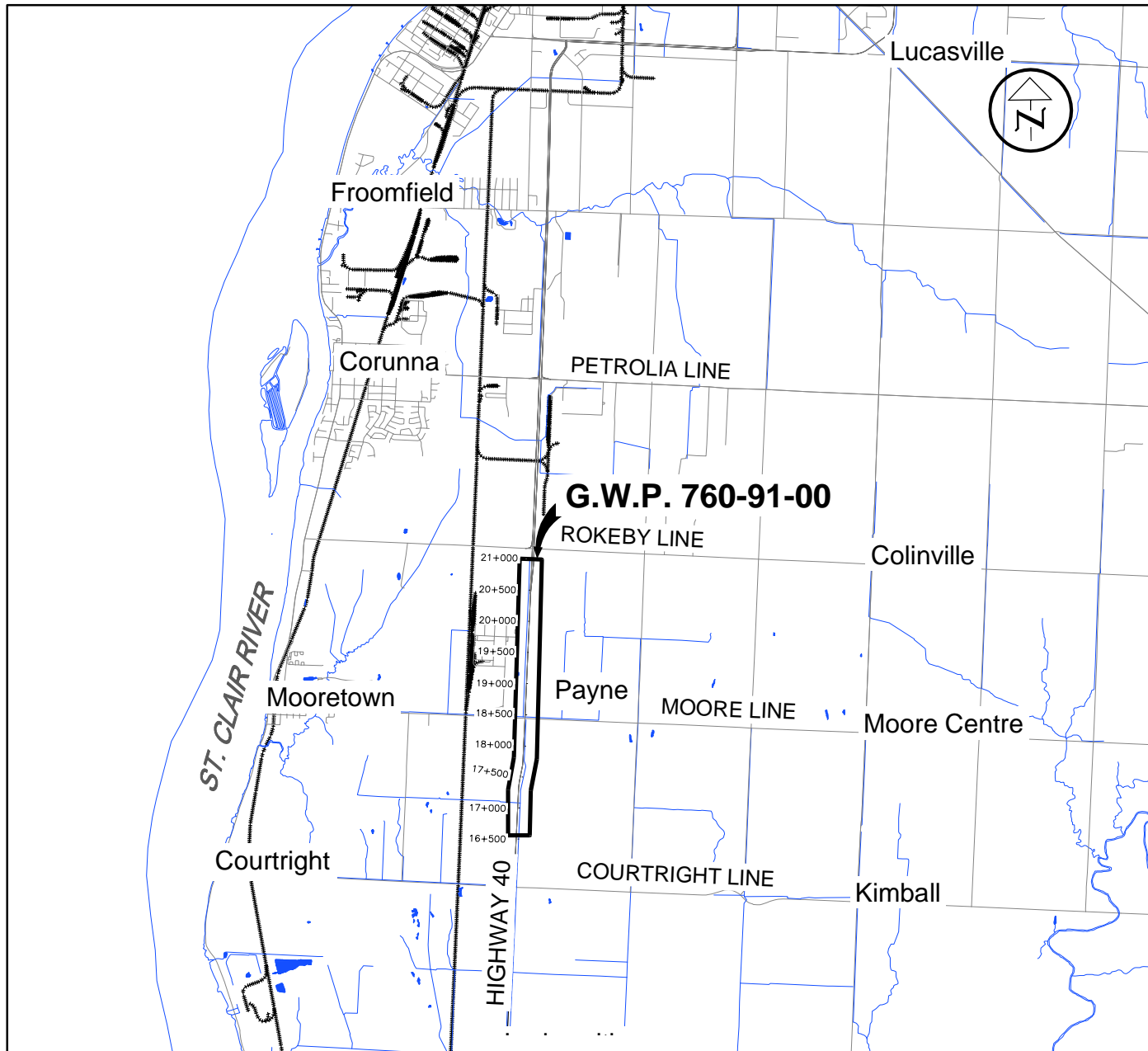
1 OF 1

**METRIC**

PROJECT 06-1130-132  
G.W.P. 760-91-00 LOCATION N 4744339.6 ; E 311596.9 ORIGINATED BY D.B.  
DIST HWY 40 BOREHOLE TYPE MANUAL AUGER COMPILED BY T.M.  
DATUM GEODETIC DATE August 29, 2006 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													
191.80	GROUND SURFACE							20	40	60	80	100		10	20	30		GR SA SI CL			
0.00	TOPSOIL, clayey Brown																				
191.49																					
0.31	FILL, silty clay, trace sand, trace gravel, with wood																				
190.82	Soft Brown		1	SS	4		191										80.4				
0.98	SILTY CLAY, trace sand, trace gravel (TILL) Firm to Stiff Grey and Brown																				
189.82			2	SS	13		190														
1.98	END OF BOREHOLE																				
	Borehole dry during drilling August 29, 2006																				

DRAWING FILE: 061130132BB-001.DWG Plot Date: Jan 10, 2007 - 3:13pm



**NOTE**

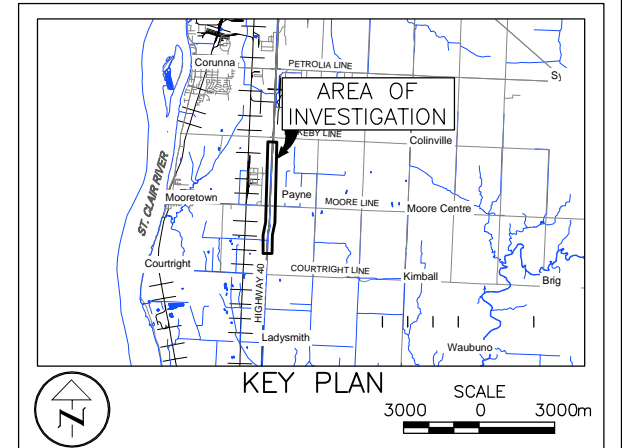
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT		SHORT SPAN CULVERTS HIGHWAY 40 RECONSTRUCTION G.W.P. 760-91-00			
TITLE		KEY PLAN			
 Golder Associates LONDON, ONTARIO		PROJECT No. 06-1130-132-1		FILE No. 061130132BB-001	
		CADD	DCH	OCT. 26/06	SCALE AS SHOWN
		CHECK			REV. 0
					FIGURE 1



SHEET

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



● Borehole – Current Investigation

No.	ELEVATION	CO—ORDINATES (MTM Zone 11)	
		NORTHING	EASTING
1	196.41	4 746 757.0	311 721.8
2	195.14	4 746 760.2	311 717.4
3	195.29	4 746 759.6	311 739.2
4	191.52	4 742 649.9	311 560.4
5	190.41	4 742 650.5	311 554.3
6	190.39	4 742 644.0	311 578.1
7	192.30	4 744 357.0	311 596.5
8	191.47	4 744 364.7	311 597.1
9	191.80	4 744 339.6	311 596.9

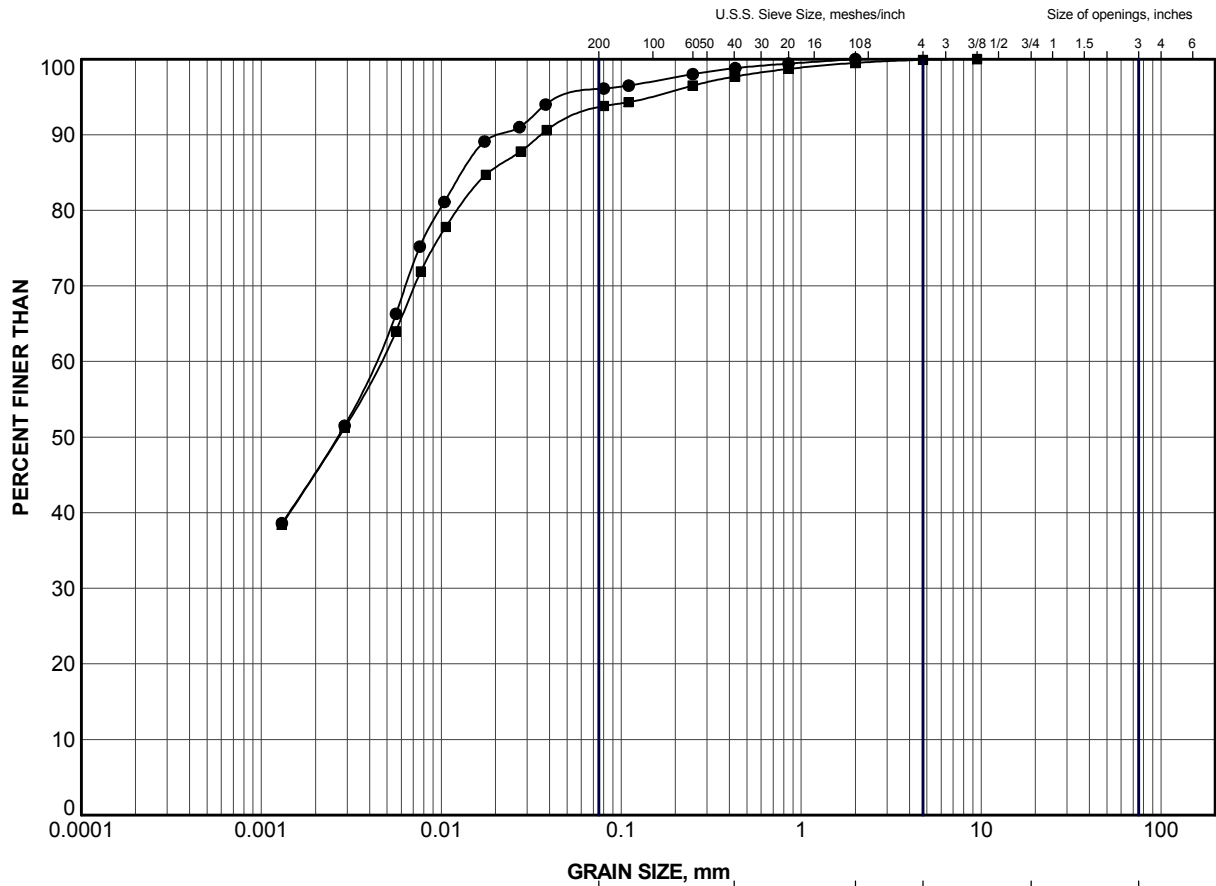
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

Base plans provided in digital format by DILLON CONSULTING

NO.	DATE	BY	REVISION	
Geocres No.		40J16-76		
HWY. 40		PROJECT NO.06-1130-132-1		DIST.
SUBM'D. DUP		CHKD. DUP	DATE: Jan 08/07	SITE:
DRAWN: DCH		CHKD.	APPD.	DWG. 1




**APPENDIX A**  
**LABORATORY TEST DATA**

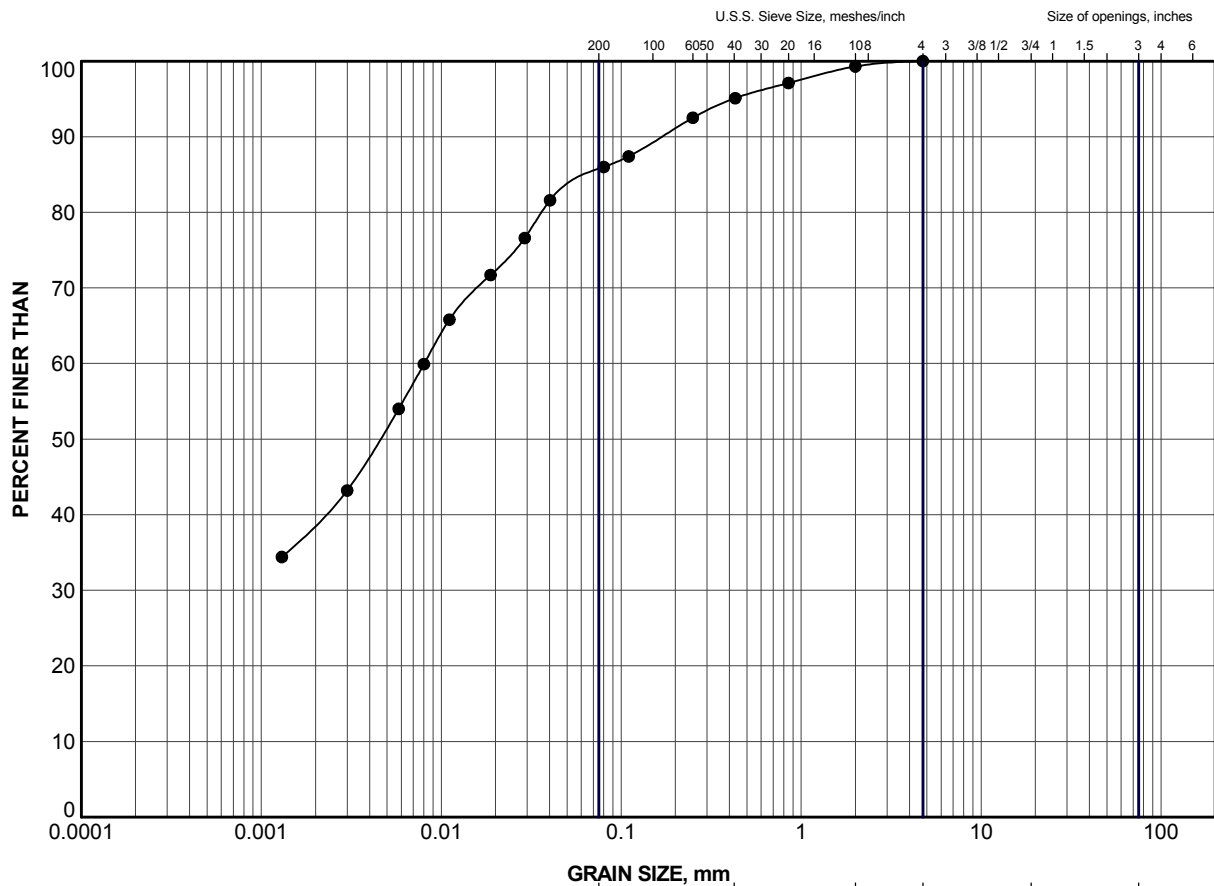


CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	4	3	189.0
■	7	3	189.7

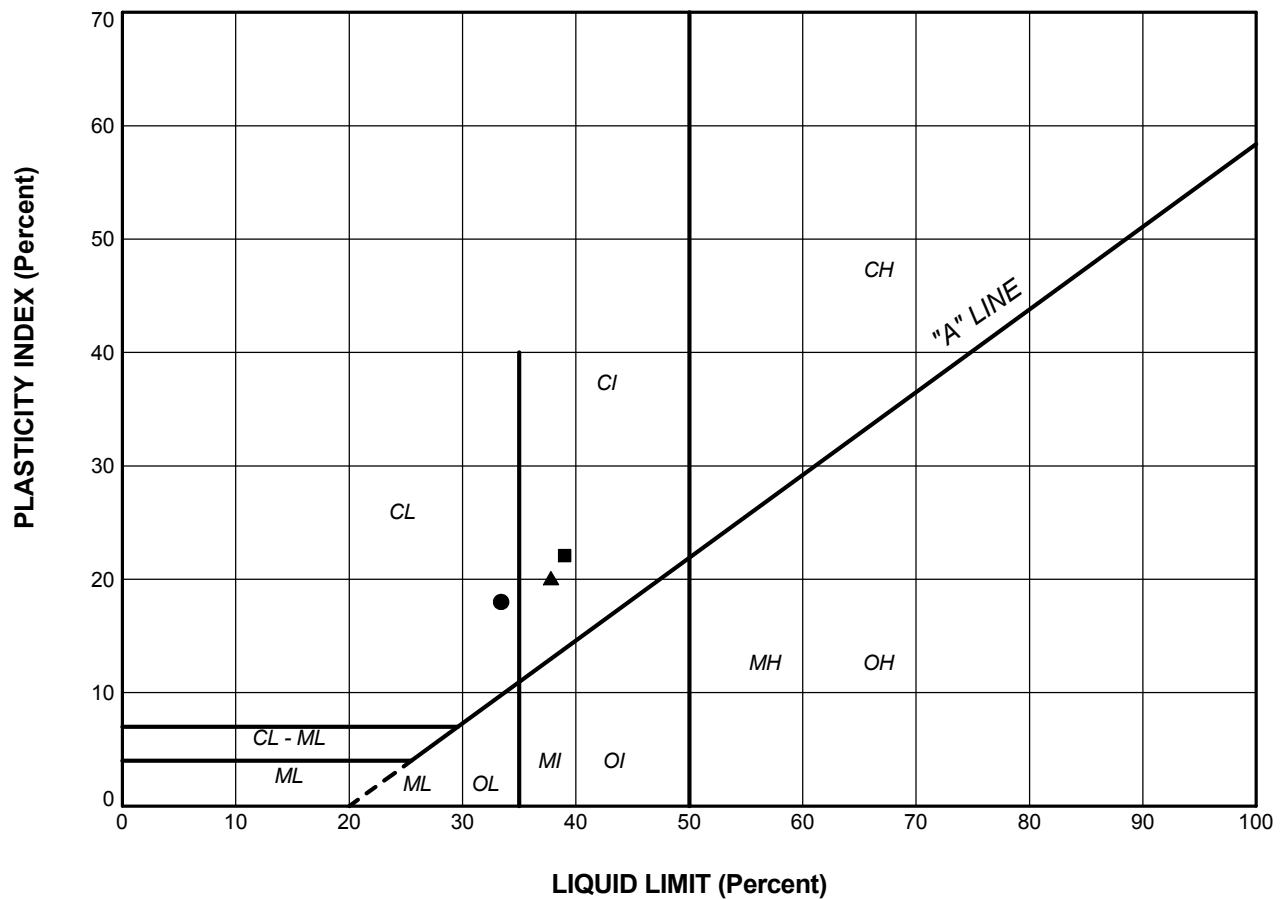
PROJECT				SHORT SPAN CULVERTS HWY 40 RECONSTRUCTION GWP 760-91-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY CLAY TILL			
PROJECT No.		06-1130-132-1		FILE No.		06-1130-132-BB-GPJ	
DRAWN		WDF		SCALE		N/A	
CHECK				REV.			
		Oct 26/06					
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-1</b>			



### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	4	193.8

PROJECT				SHORT SPAN CULVERTS HWY 40 RECONSTRUCTION GWP 760-91-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL			
PROJECT No.		06-1130-132-1		FILE No.		06-1130-132-BB-GPJ	
DRAWN		WDF		SCALE		N/A	
CHECK				REV.			
		Oct 25/06					
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-2</b>			



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	1	4	33.4	15.4	18.0
■	4	3	39.0	16.9	22.1
▲	7	3	37.8	17.7	20.1

PROJECT		SHORT SPAN CULVERTS HWY 40 RECONSTRUCTION GWP 760-91-00	
TITLE		PLASTICITY CHART	
PROJECT No. 06-1130-132-1		FILE No. 06-1130-132-BB-GPJ	
DRAWN	WDF	Oct 25/06	SCALE N/A
CHECK			REV.
 <b>Golder Associates</b> LONDON, ONTARIO			<b>FIGURE A-3</b>