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REPORT ON

**DETAIL DESIGN
FOUNDATION INVESTIGATION AND DESIGN
CULVERT EXTENSIONS/REPLACEMENTS
HIGHWAY 10 WIDENING FROM 1 KM NORTH OF REGIONAL ROAD 24 NORTHERLY
TO HIGHWAY 9
TOWN OF CALEDON, ONTARIO
W.P. 27-97-00
MINISTRY OF TRANSPORTATION, ONTARIO**

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Ltd. (Morrison Hershfield) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services as part of the widening of Highway 10 from 1 kilometre north of Regional Road 24 northerly to Highway 9 in the Town of Caledon, Ontario.

The terms of reference for the scope of work are outlined in Golder's proposal P31-1093, dated March 2003, and supplemental letter "Revision to Borehole Drilling Program", dated November 20, 2003.

This report addresses the proposed culvert extension and replacements as part of the Highway 10 widening project. The foundation investigation and design recommendations for the proposed bridge widening structures, as well as the high fills and deep cuts are reported separately. The work was carried out in accordance with the Quality Control Plan for this project dated July 2003.

The investigation was supplemented with information contained in the following reports:

- "Drainage and Stormwater Management Report, W.P. 27-97-00", prepared by Winter Burnside, dated December 2003;
- "MTO Preliminary Design Report", prepared by URS Cole, Sherman & Associates, dated July 2002.

2.0 SITE DESCRIPTION

The site is located along Highway 10, from about 1 km north of Regional Road 24 northerly to Highway 9 (see key plan on Drawing 1) in the Town of Caledon, Ontario. The highway is currently either two or three lanes at the existing culvert locations within the study area.

The site generally consist of rolling hills with grassy fields, forest and swamps located on both sides of the existing highway. Several private residences, driveways, and ponds are located near some of the culvert locations, which are typically situated in low-lying valleys. The existing highway grade ranges from about Elevation 406 m to 468 m within the project limits. Drainage ditches are present on both the east and west sides of the existing highway, which direct surface water to culverts and/or natural drainage paths that lead to ponds, streams, or naturally occurring drainage basins.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for this culvert investigation was carried out between October 8, 2003 and January 7, 2004 at which time eight (8) boreholes, numbering C2A, C2B, C4A, C4B, C5A, C5B, C6A and C6B were advanced. The borehole locations are shown in plan on Drawing 1.

The culvert number, approximate location, and boreholes performed at each culvert foundation investigation location are summarized in the following table.

<i>Culvert Number</i>	<i>Approximate Chainage</i>	<i>Borehole Numbers</i>
2	21+416	C2A, C2B
4	23+251	C4A, C4B
5	24+554	C5A, C5B
6	24+808	C6A, C6B

The boreholes were typically advanced within the proposed culvert extension or replacement footprint at the east and west sides of the highway.

The current field investigation was carried out using track-mounted CME 55 drill rigs supplied and operated by Groundwork Drilling Inc. of Etobicoke, Ontario in October, 2003 and Walker Drilling Ltd. of Utopia, Ontario in December, 2003. The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers and 108 mm outside diameter (O.D.) solid stem augers. Soil samples were obtained at intervals ranging from 0.75 m to 1.5 m in depths, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures.

The boreholes were advanced to depths ranging from 3.8 m to 8.1 m below the existing ground surface. The groundwater conditions in the open boreholes were observed during the drilling operations, with piezometers installed in select boreholes at each culvert location to permit more long-term monitoring of the groundwater level at these locations. The piezometers consist of a 25 mm outside diameter solid PVC pipe, with a slotted screen sealed at a select depth within the boreholes. The holes were backfilled with a bentonite slurry. The piezometer installation details and water level readings are described on the Record of Borehole sheets that follow the text of this report.

The field work was supervised by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil

samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further detailed visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards as appropriate. Classification testing (water content, Atterberg Limits and grain size distribution) was carried out on select samples.

The approximate borehole locations were staked in the field by Callon-Dietz personnel prior to drilling operations. Upon completion of the fieldwork, the locations of the completed boreholes were surveyed by Callon-Dietz Inc. using the NAD 83 MTM co-ordinate system and the geodetic datum for elevation.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site is located within the intersection of two physiographic regions known as the Hillsburgh Sandhills and Guelph Drumlin Field (Chapman and Putnam, "The Physiography of Southern Ontario", 3rd Edition, 1984). The Hillsburgh Sandhills are described as having rough topography, sandy materials, and flat-bottomed swampy valleys running through the moraine from Orangeville to Hillburgh. The Guelph Drumlin Field is predominantly composed of stony tills of the drumlins and deep gravel terraces of the old meltwater spillways; usually having a shallow overlying veneer of loam. The regions in the vicinity of the site are described to consist of kame moraines with spillways consisting of gravel terraces, and swamps.

4.2 Subsoil Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets and in Appendix A following the text of this report.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests (SPTs). These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The subsoils at the culvert sites consist of a surficial layer of topsoil and silty sand with organics typically underlain by interlayered sand and silt, silty sand, and sand. At some locations, deposits of clayey silt and sand and gravel were encountered below the sand and silt, silty sand, and sand layers. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil / Silty Sand with Organics (Fill)

Topsoil and silty sand with organics was encountered at the existing ground surface in the boreholes put down during this investigation (Boreholes C2A, C2B, C4A, C4B, C5A, C5B, C6A and C6B). The silty sand with organics could be either fill resulting from local landscaping or sedimentary deposits laid down within the drainage channel. The existing ground surface ranged between Elevation 427.7 m and 452.9 m and the topsoil and silty sand with organics layer ranged from 0.3 m to 1.0 m thick.

Standard Penetration Testing (SPT) 'N' values recorded within the silty sand with organics layer ranged between 2 and 6 blows per 0.3 m of penetration, indicating a very loose to loose relative density. One Standard Penetration Test (SPT) 'N' value recorded within the topsoil was 4 blows per 0.3 m of penetration, indicating a soft to firm consistency.

Natural water contents measured on samples of the silty sand with organics ranged between 24 and 67 percent. The natural water content measured on a sample of the topsoil was 19 percent.

4.2.2 Sand and Silt / Silty Sand / Sand

Underlying the topsoil and silty sand with organics, deposits of sand and silt, silty sand and sand were encountered in Boreholes C2A, C2B, C4A, C4B, C5A, C5B, and C6A. The sand and silt, silty sand, and sand deposits typically contained trace to some gravel and clay. Clayey silt interlayers were present in Borehole C4A. Occasional sand seams and cobbles were present in Borehole C4B. The top of the sand and silt, silty sand, and sand deposit was encountered at depths ranging between 0.3 and 1.0 m. The top of this layer ranged between Elevation 432.1 and Elevation 452.5 and the thickness varied between 0.5 m and over 5.8 m. Boreholes C4A, C4B, C5A, and C5B were terminated within this deposit at depths of 6.1 m (Elevation 446.8 m), 5.3 m (Elevation 447.5 m), 6.2 m (Elevation 435.2 m), and 6.6 m (Elevation 432.9 m) respectively.

Standard Penetration Testing (SPT) 'N' values recorded within this deposit typically ranged between 4 blows and 85 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The SPT 'N' values were found to generally increase with depth, with the 'N' value of 4 recorded at a depth of about 0.8 m in Borehole C5A, and with the 'N' value of 85 recorded at a depth of 4.6 m in Borehole C4B. For reference, the mean, median, and standard deviation of the 'N' values within this deposit for the boreholes were 25, 17, and 24 respectively. The mean and median values indicate a generally compact relative density for the deposit.

The natural water content measured on samples of the sand and silt, silty sand and sand deposits ranged between 8 and 24 percent. Grain size distribution curves for selected samples of the sand and silt deposit are shown on Figure A1 in Appendix A.

4.2.3 Sand and Gravel / Sandy Gravel

A deposit of sand and gravel to sandy gravel with silt was encountered in Boreholes C2A, C6A and C6B. This sand and gravel to sandy gravel with silt deposit typically contained cobbles and boulders with trace clay. The top of the sand and gravel to sandy gravel with silt deposit was encountered at depths ranging between 0.9 m and 3.8 m. The top of the sand and gravel to sandy gravel with silt deposit ranged between Elevation 426.8 m and Elevation 438.4 m and the

thickness varies between 2.3 m and over 4.7 m. Boreholes C6A and C6B were terminated within the sand and gravel deposit at depths of 6.2 m (El. 426.9 m) and 3.8 m (El. 423.9) respectively.

Standard Penetration Testing (SPT) 'N' values recorded within the sand and gravel to sandy gravel with silt deposit ranged between 11 blows and greater than 100 blows per 0.3 m of penetration, indicating a compact to very dense state of packing. The higher blow counts may be attributed to cobbles and boulders encountered within the deposit.

The natural water content measured on samples of the sand and gravel to sandy gravel with silt deposit ranged between 6 and 19 percent. A grain size distribution curve for a selected sample of the sandy gravel with silt deposit is shown on Figure A2 in Appendix A.

4.2.4 Clayey Silt

A deposit of clayey silt was encountered below the sand and silt, silty sand, and sand layer in Boreholes C2A and C2B. The clayey silt typically contained trace to some sand, trace gravel, and occasional silt and sand seams. The clayey silt deposit in Borehole C2A contained an interlayer of sand and gravel that was 2.3 m thick as described above in Section 4.2.3. The top of the clayey silt deposit was encountered at depths of 2.3 m (Elevation 439.9 m) and 4.6 m (Elevation 437.3 m) for Boreholes C2A and C2B respectively. Boreholes C2A and C2B were terminated within the clayey silt deposit at depths of 6.6 m (Elevation 435.7 m) and 8.1 m (Elevation 433.8 m) respectively.

Standard Penetration Testing (SPT) 'N' values recorded within the clayey silt typically ranged between 12 blows and 40 blows per 0.3 m of penetration, indicating a stiff to hard consistency.

The results of Atterberg Limits testing carried out on a sample of the clayey silt deposit are illustrated on the plasticity chart on Figure A3 in Appendix A. The test results are summarized in the following table.

<i>Borehole</i>	<i>Sample</i>	<i>Elevation (m)</i>	<i>Liquid Limit (%)</i>	<i>Plastic Limit (%)</i>	<i>Plasticity Index (%)</i>
C2B	8	435.4-435.8	30	16	14

The test results on this sample within the clayey silt deposit indicate it is low plasticity. The natural water content measured on samples of the clayey silt deposit ranged between 10 and 24 percent.

4.2.5 Groundwater Conditions

The water levels within the open boreholes were noted after the drilling operations. Piezometers were also installed in Boreholes C2B, C4B, C5B and C6A. The piezometer installed in Borehole C2B was sealed in the silty sand deposit. The piezometers installed in Boreholes C4B and C5B were sealed within the silt and sand, silty sand, and sand deposit. The piezometer installed in Borehole C6A was sealed within the sand and gravel to sandy gravel with silt deposit. Details of the piezometer installations are shown in the Record of Borehole Sheets following the text of this report. The water levels measured in the open boreholes upon completion of drilling and in the piezometers are summarized in the table below:

<i>Borehole</i>	<i>Installation</i>	<i>Ground Surface Elevation (m)</i>	<i>Water Level Depth (m)</i>	<i>Water Level Elevation (m)</i>	<i>Date</i>
C2A	Open Borehole	442.2	Ground surface	442.2	Dec. 15, 2003
C2B	Open Borehole	441.9	2.1	439.8	Oct. 8, 2003
C4A	Open Borehole	452.9	1.5	451.4	Dec. 15, 2003
C4B	Piezometer	452.8	0.3	452.5	Jan. 7, 2004
C5A	Open Borehole	441.4	5.8	435.6	Dec. 19, 2003
C5B	Piezometer	439.4	2.7	436.7	Jan. 7, 2004
C6A	Piezometer	433.1	Dry	-	Jan. 7, 2004
C6B	Open Borehole	427.7	Dry	-	Dec. 18, 2003

It should be noted that the groundwater level in the areas of the culverts depends on the recent rainfall and snowmelt conditions. A perched water table condition may exist above the clayey silt deposit at Culvert No. 2. It should also be emphasized that groundwater levels in the area are subject to seasonal fluctuations.

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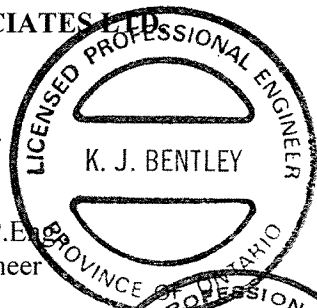
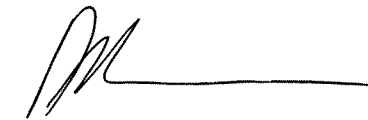
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5.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the four (4) proposed culvert extension/replacements that will be required as part of the Highway 10 widening project. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation at this site. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess the feasible foundation alternatives, and to design the proposed culvert extension/replacements. As such, 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, scheduling and the like.

The limits of the project extend along Highway 10 from about 1 km north of Regional Road 24 northerly to Highway 9. It is understood that the existing highway is to be widened to at least four lanes, with a median lane and turning lanes at some locations. As a result, the existing culverts located beneath Highway 10 must be extended or replaced in order to facilitate drainage across the highway.

The culvert number, type, proposed extension or replacement options and corresponding length are summarized in the table below. This table is based on information presented in the "Drainage and Stormwater Management Report", dated December 2003.

<i>Culvert Number</i>	<i>Approximate Chainage</i>	<i>Existing Culvert Size (Type) and Length</i>	<i>Proposed Extension/Replacement Type</i>	<i>Proposed Total/Replacement Length</i>
2	21+416	1220mm x 910 mm x 26.2 m (Concrete culvert – open footing)	Replace with 1830mm x 910mm or twin with 1220mm x 910mm (Concrete box)	35.0 m
4	23+251	1220mm x 1220mm x 23.8 m (Concrete box – closed footing with CSP extension)	Replace with 1830mm x 1220 mm (Concrete box)	38.5 m
5	24+554	910mm x 910 mm x 29.5 m (Concrete box – closed footing with CSP extension)	Replace with 2130mm x 910 mm (Concrete box)	40.0 m
6	24+808	1520mm x 1220mm x 57.2 m (Concrete box – closed footing)	Extend with 1520mm x 1220 mm (Concrete box)	60.0 m

Note: CSP = Corrugated Steel Pipe

It should be noted that additional culverts are to be extended or replaced within the project area, however, these culverts were not identified in the Terms of Reference or otherwise targeted for investigation by Morrison Hershfield.

5.1 General

As indicated in the above table, Culvert Nos. 2, 4, and 5 are to be replaced with larger and longer box culverts than the existing although there is also an option to twin Culvert No. 2 with another box the same size. Culvert No. 6 is to be extended on both sides of the highway. The proposed road grade for the widened highway will match the existing grade at the culvert locations. The embankment fill in the area of the culvert replacements (i.e. Culvert Nos. 2, 4, and 5) is less than 2.5 m high, and the embankment fill in the area of the Culvert 6 extension will be up to 4.5 m in height. The culverts should be designed to withstand the maximum anticipated overburden pressure, live loads, and frost pressures expected at each location.

5.2 Culvert Foundations

Apart from the existing roadway embankment fill, the subsoils at Culvert Nos. 2, 4, and 5 consist of a surficial deposit of topsoil and silty sand with organics, underlain by deposits of sand and silt, silty sand, and sand. At the location of Culvert 6, the topsoil and silty sand with organics is underlain by sand and gravel to sandy gravel with silt. The water level readings indicate that the groundwater table is within about 2 m of existing ground at Culverts 2 and 4, and more than 2.5 m below ground surface at Culverts 5 and 6 during the time of the investigations. A perched water table condition may exist above the clayey silt deposit at Culvert No. 2.

Based on the subsurface information obtained, the native soils located below the surficial topsoil and silty sand with organics deposits are considered suitable for the support of the box culverts.

5.2.1 Axial Geotechnical Resistance

The invert elevations, recommended subexcavation and consequent founding soil type for each culvert are shown in the following table (assuming that the replacement and/or extension structures are box culverts).

Culvert Number	Culvert Station	Relevant Boreholes	Invert Elevation (m) (U/S, D/S)	Recommended Subexcavation Level for Proposed Culvert (m)	Founding Soil Type
2	21+416	C2A, C2B	441.3, 441.2 (Replacement)	440.5	Compact sand to sand and silt
4	23+251	C4A, C4B	452.0, 451.8 (Replacement)	N/A	Loose to compact sand and silt
5	24+554	C5A, C5B	439.8, 439.2 (Replacement)	438.0 D/S	Loose to compact sand and silt
6	24+808	C6A, C6B	432.5, 427.7 (Extension)	431.1 U/S; 426.5 D/S	Compact to dense sand and gravel/sandy gravel

Notes: RFB refers to rigid frame box (i.e. reinforced concrete)

N/A indicates the invert level is within appropriate founding soils at the borehole locations

The recommended subexcavation level given above is only for the depth required to reach the appropriate founding soils. The actual founding level will depend on the base slab thickness and the depth of the granular bedding required under the culvert (see Section 5.3.2). The factored geotechnical resistance at Ultimate Limit States (ULS), and geotechnical resistance at Serviceability Limit States (SLS) to be used for design of each culvert are given in the table below.

Culvert Number	Proposed Box Culvert Width (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Resistance at SLS (kPa) for 25 mm settlement
2	1.83	150	100
4	1.22	200	150
5	1.52	300	200
6	1.52	300	200

These geotechnical resistance values assume the culverts are founded on approved undisturbed native soil beneath the topsoil and silty sand with organics which for design may be assumed to extend to the subexcavation levels indicated above. It should be noted that there is expected to be some variation in the depth of these surficial deposits at the culvert sites and there must be provision in the contract for dealing with greater or lesser amounts of subexcavation and replacement with compacted granular fill.

5.2.2 Resistance to Lateral Loads

Resistance to lateral forces (i.e. sliding resistance) between the base of the concrete footings and the undisturbed native materials should be calculated in accordance with Section 6.7.5 of the *CHBDC*. Assuming the culverts are precast concrete and are placed on compacted granular

bedding, a coefficient of friction value ($\tan \delta$) of 0.4 can be used for design. In accordance with the *CHBDC*, a factor of 0.8 is to be applied to the coefficient of friction value when calculating the horizontal resistance.

5.2.3 Settlement

Provided that the topsoil, sandy silt with organics, and any loosened or deleterious material is removed from the culvert footprint and that the underlying bedding material is placed and compacted according to Section 5.3.1, the settlement of the culvert extensions and replacements is expected to be less than 25 mm. Settlement of the underlying native silts and sands is expected to occur rapidly (i.e. during or shortly after construction).

5.3 Culvert Construction

5.3.1 Subgrade Preparation and Excavation

Based on the borehole results, the near surface ground conditions beyond the limits of the existing culverts and within the footprint of the proposed extensions consist of topsoil and sandy silt with organics that ranged in thickness from 0.3 m to 1.0 m.

All topsoil and underlying soils containing organics, and softened or loosened soils should be stripped from below the proposed culvert footprint. At the Culvert Nos. 2, 4, and 5 locations, excavations up to about 4 m will be required through the existing embankment fill, topsoil and into the underlying sand and silt/silty sand/sand deposits. At the Culvert No. 6 extension location, it is anticipated that excavations up to 1.0 m deep will be required to remove the topsoil and organic soils, and expose the native sand and gravel to sandy gravel with silt soil.

Excavations works should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities, and follow the guidelines outlined in OPSS 902 and special provision 422S01.

In accordance with the OHSA guidelines, the native sands and silts, embankment fill, and existing surficial soils above the water table are classified as a Type III soil, and therefore temporary open-cut slopes can be carried out at 1 horizontal to 1 vertical (1H:1V). Open cuts within the native soils below the water table should be carried out with slopes no steeper than 3 horizontal to 1 vertical (3H:1V).

It is noted that the soils in which the excavations will be formed are susceptible to disturbance from groundwater drainage, ponded water, and construction traffic. Groundwater and surface

water control will be required according to Section 5.3.5. For this reason, it may be more feasible to twin Culverts No. 2 and 4, instead of removing and re-installing larger sized culverts.

For protection of the founding soils, a working mat of lean concrete may be placed as soon as practical after reaching the base of the excavation and following inspection of the subgrade by qualified geotechnical personnel. Where sloping or levelling is required, additional granular bedding should be provided.

5.3.2 Bedding and Backfill

All subgrade soils should be proof-rolled prior to placement of the bedding fill, and any poorly performing areas should be subexcavated and replaced with approved engineered fill. The bedding, leveling pad, and backfill requirements for the culvert extensions should be in accordance with OPSS 422 for precast concrete rigid frame culverts.

For closed box culvert extension and replacements, the box culvert should be provided with at least 500 mm of OPSS Granular 'A' material for bedding purposes and partial frost protection. The bedding should be placed in lifts not exceeding 200 mm in loose thickness, and compacted to at least 95 per cent of the Standard Proctor maximum dry density. For closed box culverts, a minimum 75 mm thick leveling pad should be provided.

Backfill to the culvert walls should consist of granular fill meeting the specifications for OPSS Granular 'A' or Granular 'B' Type II (but with less than 5 per cent passing the 200 sieve). The backfill should be placed in lifts not exceeding 200 mm in loose thickness and compacted to 95 per cent Standard Proctor dry density. At no time during placement and compaction should the level of placed fill on one side of the culvert walls exceed the other by 400 mm as per Section 5.3.3 of this report. Reference should also be made in the contract documents to special provision 422S01 and OPSS 902. For design, an embankment fill unit weight of 21 kN/m³ can be used.

The final lift prior to placement of the granular subbase and base courses should be compacted to 100 per cent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

Groundwater and surface water control will be required in accordance with Section 5.3.5.

5.3.3 Lateral Earth Pressures

The lateral earth pressures acting on the walls of the culvert extension or replacement will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. For this site location, the geotechnical seismic considerations do not impact on the design since it is within the lowest seismic zone given in CHDBC.

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

- Select, free-draining granular fill meeting the specifications of Ontario Provincial Standard Specifications (OPSS) Granular 'A' or Granular 'B' Type II but with less than 5 percent passing the 200 sieve should be used as backfill behind the walls. This fill should be placed in loose lifts not greater than 200 mm in thickness, and compacted to 95 per cent of the material's Standard Proctor maximum dry density in accordance with OPSS 501. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3501.00 and 3504.00.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem, in accordance with *CHBDC* Section 6.9.3 and Figure 6.9.3. Compaction equipment should be used in accordance with OPSS 501.06. Other surcharge loadings should be accounted for in the design as required.
- The granular fill may be placed either in a zone with the width equal to at least 1.2 m behind the back of the walls (see Case I in Figure C6.9.1(l) of the *Commentary to the CHBDC*), or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (see Case II in Figure C6.9.1(l) of the *Commentary to the CHBDC*).
- For Case I, the pressures are based on the proposed embankment fill materials and the following parameters (unfactored) may be used:

Soil unit weight:	Earth Fill 21 kN/m ³
Coefficients of static lateral earth pressure:	
Active, K_a	0.33
At rest, K_o	0.50

- For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	GRANULAR 'A'	GRANULAR 'B' TYPE II
Soil unit weight:	22 kN/m ³	21 kN/m ³
Coefficients of static lateral earth pressure:		
Active, K_a	0.27	0.31
At rest, K_o	0.43	0.47

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

5.3.4 Erosion Protection

Typically, the subsoils at the invert level of the culverts consists of sand and silt, silty sand, and sand deposits. If the anticipated drainage flow velocities are sufficiently high, provision should be made for scour and erosion protection.

In order to prevent water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine particles), a clay seal or cut-off headwall should be provided at the upstream end of the box culverts. If a clay seal is used, it should have a minimum thickness of 0.3 m, be keyed into the native subsoil, and extend a minimum horizontal distance of 2 m on either side of the culvert inlet openings, with a minimum vertical height equal to the high water level. The material for the clay seal should be in accordance with the requirement of OPSS 1205.

Erosion protection should be provided upstream and downstream of the culvert as appropriate. Consideration could be given to the use of suitable non-woven geotextiles and rip-rap to provide erosion protection based on hydraulic requirements.

In addition, sediment control such as silt fences and / or erosion control blankets may be required during construction to mitigate migration of fine soil particles into the nearby water courses.

5.3.5 Groundwater and Surface Water Control


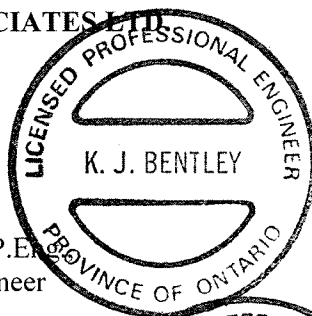
The founding soils for the culverts are susceptible to disturbance due to seepage, water ponding, and / or construction traffic. Groundwater or seepage into the excavations is expected within the areas of Culverts 2 and 4, and to a lesser extent near the areas of Culverts 5 and 6. The severity of the ground water conditions is dependent upon many factors including the season during which construction occurs. In general, pumping using properly filtered sumps, or a filtered drain placed at the base of the excavation should provide sufficient groundwater control during foundation works. A ditch collecting surface water flows will have to be diverted around the construction areas to help permit construction in the dry.

Based on our understanding of the subsurface soil and groundwater conditions, at Culvert Nos. 2 and 4, conventional sump pumping is not likely to be adequate to lower the water table at this site, and a more extensive dewatering system (i.e. well-point system) may be required. Such a system may also be required at these and the other sites if open footings are considered. Any groundwater control system proposed should be designed, installed and operated by an experienced specialist firm.

GOLDER ASSOCIATES LTD.



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KJB/RS/ASP/FJH/sd

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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.) drive open sampler for a distance of 300 mm (12 in.)

Consistency

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

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 cm² 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 ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

LIST OF SYMBOLS

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

I. General

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
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
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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




- Notes:**
- 1 $\tau = c' + \sigma' \tan \phi'$
 - 2 shear strength $= (\text{compressive strength})/2$
 - * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

PROJECT 03-1111-023			RECORD OF BOREHOLE No C2A			1 OF 1 METRIC		
W.P. 27-97-00			LOCATION N 4859290.3 ; E 263418.5			ORIGINATED BY GD		
DIST HWY 10			BOREHOLE TYPE POWER AUGERING USING 108 mm I.D. HOLLOW STEM AUGERS			COMPILED BY KG		
DATUM Geodetic			DATE December 15, 2003			CHECKED BY KB		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
							PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	
							UNIT WEIGHT γ kN/m ³	
							REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
442.2	GROUND SURFACE							
0.0	Silty Sand with organics, some clay, contains rootlets Very loose Brown Moist		1	SS	3		442	
441.5								
0.8	Silty Sand, trace gravel, clay and rootlets Loose Brown Moist		2	SS	9		441	
440.7								
1.5	Sand and Silt, some gravel, trace to some clay Compact Brown Wet		3	SS	21		440	
439.9								
2.3	Clayey Silt, some sand, trace gravel, occasional sand seams Stiff to very stiff Brown Wet		4	SS	12		439	
438.4								
3.8	Sand and Gravel, trace silt Compact Brown Wet		6	SS	12		438	
436.1								
6.1	Clayey Silt, trace sand Hard Brown Moist		8	SS	40		436	
435.7								
6.6	End of Borehole							
Notes:								
1. Water level at ground surface upon completion of drilling.								
2. Borehole caved to 3.7 m upon completion of drilling.								

PROJECT		03-1111-023		RECORD OF BOREHOLE No C2B		1 OF 1 METRIC														
W.P.		27-97-00		LOCATION		N 4859260.9 ; E 263389.6														
DIST		HWY 10		BOREHOLE TYPE		POWER AUGERING USING 108 mm I.D. HOLLOW STEM AUGERS														
DATUM		Geodetic		DATE		October 8, 2003														
ORIGINATED BY		GD		COMPILED BY		KG														
CHECKED BY		KJB																		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ					
441.9	0.0	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30	52.3								
441.3	0.6	Silty sand with organics, occasional rootlets, (FILL) Very loose Dark brown Moist		1	SS	2		441	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED											
440.4	1.5	Silty Sand Loose Brownish-grey Moist		2	SS	7		440												
438.9	3.1	Sand, trace silt Compact Brownish-grey Wet		3	SS	11		439												
437.3	4.6	Silty Sand, trace gravel, increasing clay content with depth Loose to compact Brown Moist		4	SS	13		438												
433.8	8.1	Clayey Silt, trace to some sand, occasional silt seams and sand seams Very stiff to hard Brown Moist		5	SS	8		437												
				6	SS	13		436												
				7	SS	27		435												
				8	SS	17		434												
				9	SS	34														
End of Borehole																				
Notes:																				
1. Water level in open borehole at 2.1 m depth upon completion of drilling.																				

PROJECT <u>03-1111-023</u>		RECORD OF BOREHOLE No C4A		1 OF 1 METRIC													
W.P. <u>27-97-00</u>		LOCATION <u>N 4860605.2 ; E 262134.6</u>		ORIGINATED BY <u>GD</u>													
DIST <u> </u> HWY <u>10</u>		BOREHOLE TYPE <u>POWER AUGERING USING 108 mm I.D. HOLLOW STEM AUGERS</u>		COMPILED BY <u>KG</u>													
DATUM <u>Geodetic</u>		DATE <u>December 15, 2003</u>		CHECKED BY <u>KB</u>													
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
452.9	GROUND SURFACE																
0.0	Silty sand with organics, trace gravel, occasional rootlets (FILL) Loose Dark brown to brown Wet		1	SS	5											62.4	
452.1																	
0.8	Sand and Silt, trace to some gravel and clay, contains clayey silt interlayers Compact Brown Moist		2	SS	10												
			3	SS	13												
			4	SS	11												
			5	SS	29												
			6	SS	23												
	Occasional cobbles encountered below 4.6 m depth		7	SS	29												
446.8	Cobble/boulder encountered at 6.1m depth End of Borehole Auger Refusal																
6.1																	
	Notes: 1. Water level at 1.5 m depth upon completion of drilling. 2. Borehole caved to a depth of 1.8 m below ground surface.																

PROJECT 03-1111-023			RECORD OF BOREHOLE No C4B			1 OF 1 METRIC		
W.P. 27-97-00			LOCATION N 4860575.8 ; E 262110.5			ORIGINATED BY GD		
DIST HWY 10			BOREHOLE TYPE POWER AUGERING USING 108 mm I.D. HOLLOW STEM AUGERS			COMPILED BY KG		
DATUM Geodetic			DATE October 8, 2003			CHECKED BY KJB		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
452.8	GROUND SURFACE							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%)
0.0	Silty sand with organics, trace gravel, occasional rootlets (FILL)		1	SS	8		452	
0.3	Loose Dark brown Moist		2	SS	16		451	
	Silt and Sand, some gravel Loose to compact Brown Wet		3	SS	9		450	
			4	SS	9		449	
449.8			5	SS	13		448	
3.1	Silty Sand, trace to some gravel, occasional sand seams and cobbles Compact to very dense Brown Wet to moist		6	SS	20			
			7	SS	85			
447.5	Probable boulder encountered at 5.3 m End of Borehole Auger Refusal							
5.3	Notes: 1. Water level in open borehole at 2.4 m depth upon completion of drilling operations. 2. Water level in piezometer measured at 0.3 m depth (Elev. 452.5 m) on January 7, 2004.							

PROJECT <u>03-1111-023</u>		RECORD OF BOREHOLE No C5A				1 OF 1 METRIC										
W.P. <u>27-97-00</u>		LOCATION <u>N 4861516.9; E 261241.6</u>				ORIGINATED BY <u>GD</u>										
DIST <u> </u> HWY <u>10</u>		BOREHOLE TYPE <u>POWER AUGERING USING 108 mm O.D. SOLID STEM AUGERS</u>				COMPILED BY <u>KG</u>										
DATUM <u>Geodetic</u>		DATE <u>December 19, 2003</u>				CHECKED BY <u>KB</u>										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
441.4	GROUND SURFACE															
0.0	Silty sand with organics, trace rootlets and wood fragments (FILL) Loose Dark brown Moist		1	SS	6											
440.6																
0.8	Sand and Silt, some gravel, trace to some clay Loose to very dense Brown Moist		2	SS	4											
			3	SS	18											
			4	SS	20											
			5	SS	47											
			6	SS	35											
			7	SS	81											
435.3																
6.2	Sand, trace silt and gravel Compact Brown Moist End of Borehole		8	SS	100/0.05											
	Notes: 1. Water level in open boehole at 5.8 m depth upon completion of drilling.															

PROJECT 03-1111-023			RECORD OF BOREHOLE No C5B			1 OF 1 METRIC											
W.P. 27-97-00			LOCATION N 4861509.1 ; E 261204.2			ORIGINATED BY GD											
DIST _____ HWY 10			BOREHOLE TYPE POWER AUGERING USING 108 mm O.D. SOLID STEM AUGERS			COMPILED BY KG											
DATUM Geodetic			DATE December 19, 2003			CHECKED BY KB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
								20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	10 20 30	10 20 30	10 20 30				
439.4	GROUND SURFACE																
0.0	Silty Sand with organics, some clay, contains rootlets Soft Dark brown Wet		1	SS	3		439										
438.6																	
0.8	Sand and Silt, trace to some clay, trace gravel Loose Brown Wet		2	SS	8		438										
			3	SS	5												
437.1							437										
2.3	Sand, some silt, trace to some gravel Compact to very dense Brown Moist		4	SS	17												
			5	SS	27		436										
			6	SS	29												
							435										
			7	SS	30												
							434										
432.9			8	SS	73		433										
6.6	End of Borehole																
	Notes: 1. Water level at depth of 1.5 m upon completion of drilling. 2. Borehole caved to 4.6 m upon completion of drilling. 3. Water level in piezometer at 2.7 m depth (Elev. 436.7 m) on January 7, 2004.																

PROJECT 03-1111-023			RECORD OF BOREHOLE No C6A			1 OF 1 METRIC											
W.P. 27-97-00			LOCATION N 4861717.4 ; E 261062.1			ORIGINATED BY GD											
DIST _____ HWY 10			BOREHOLE TYPE POWER AUGERING USING 108 mm I.D. HOLLOW STEM AUGERS			COMPILED BY KG											
DATUM Geodetic			DATE October 9, 2003			CHECKED BY KJB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W _p W W _L			γ	GR SA SI CL
433.1	GROUND SURFACE							20 40 60 80 100									
0.0	Silty Sand with organics, some clay, contains rootlets Loose Dark brown Moist		1	SS	5		433										
432.1			2	SS	7		432										
1.0	Sand, trace gravel Loose Brown Moist																
431.6																	
1.5	Sand and Gravel, trace silt, contains cobbles Compact to dense Brown Moist		3	SS	20		431										
			4	SS	36		430										
			5	SS	38		429										
			6	SS	50		428										
			7	SS	42		427										
426.9	End of Borehole		8	SS	50/0.08												
6.2	Auger and spoon refusal Notes: 1. Borehole open and dry upon completion of drilling operations. 2. Effective auger and split spoon refusal on probable cobble/boulder at 6.2 m depth. 3. Piezometer dry on January 7, 2004.																



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

MIS-MTO 001 031111023AAGDR.GPJ GAL-MISS.GDT 4/12/06



METRIC

<p style="text-align: center;">HIGHWAY 10 CULVERT EXTENSION/REPLACEMENTS BOREHOLE LOCATIONS</p>

 Borehole – Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
C2A	442.2	4859290.3	263418.5
C2B	441.9	4859260.9	263389.6
C4A	452.9	4860605.2	262134.6
C4B	452.8	4860575.8	262110.5
C5A	441.4	4861516.9	261241.6
C5B	439.4	4861509.1	261204.2
C6A	433.1	4861717.4	261062.1
C6B	427.7	4861690.5	260999.4

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

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

For subsurface information only

Drawing based on plans provided in digital format by Morrison Hershfield Ltd., received on December 15, 2003.

Including the following files;
4006ALIGN.dwg, 4006raiseprofile.dwg, b-146-10-base.dwg, Design.dwg,
new-ROW&bars.dwg and util.dwg.

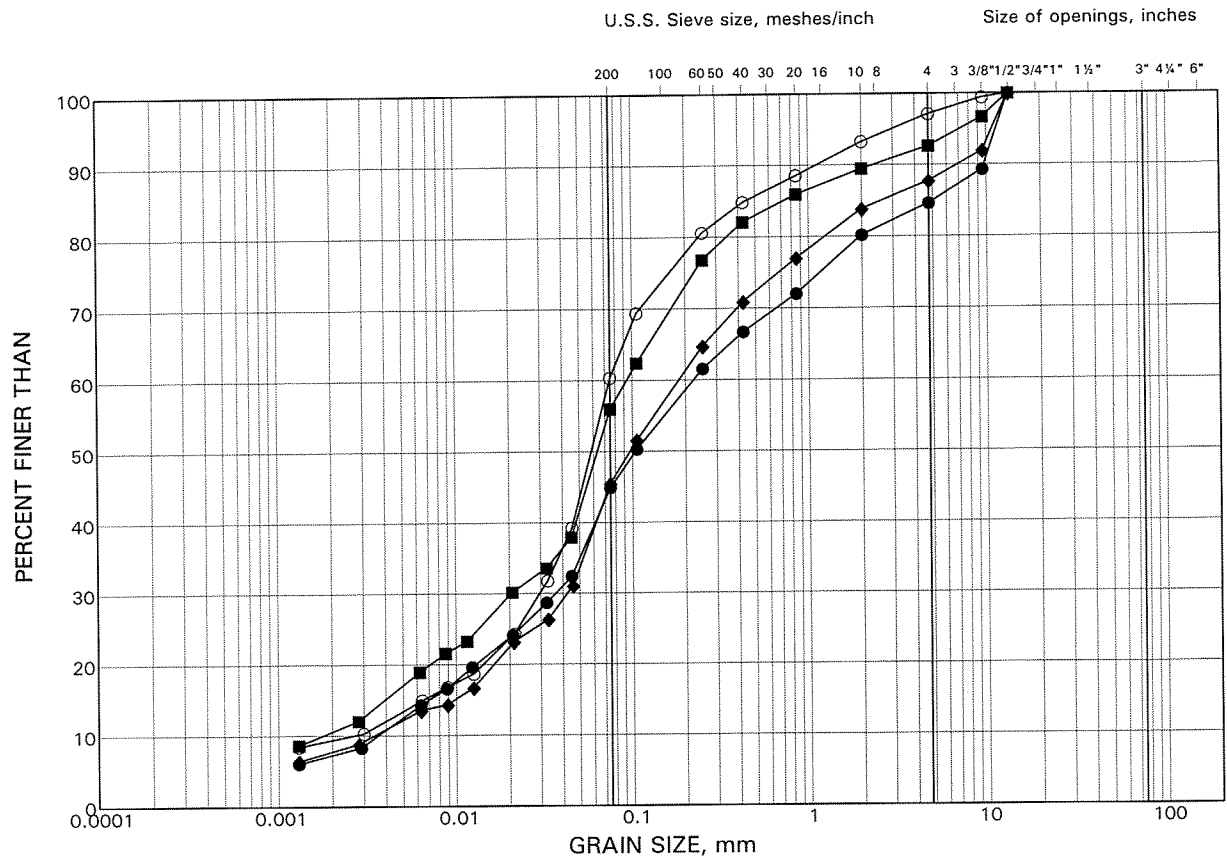
NO.	DATE	BY	REVISION		
Geocres No. 40P16-21					
HWY. 10		PROJECT NO. 03-1111-023		DIST.	
SUBM'D.		CHKD.	DATE: MAR., 2004		SITE:
DRAWN: JDR		CHKD.	APPD.		DWG. 1

APPENDIX A
LABORATORY TEST DATA

GRAIN SIZE DISTRIBUTION

Sand and Silt

FIGURE A1



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

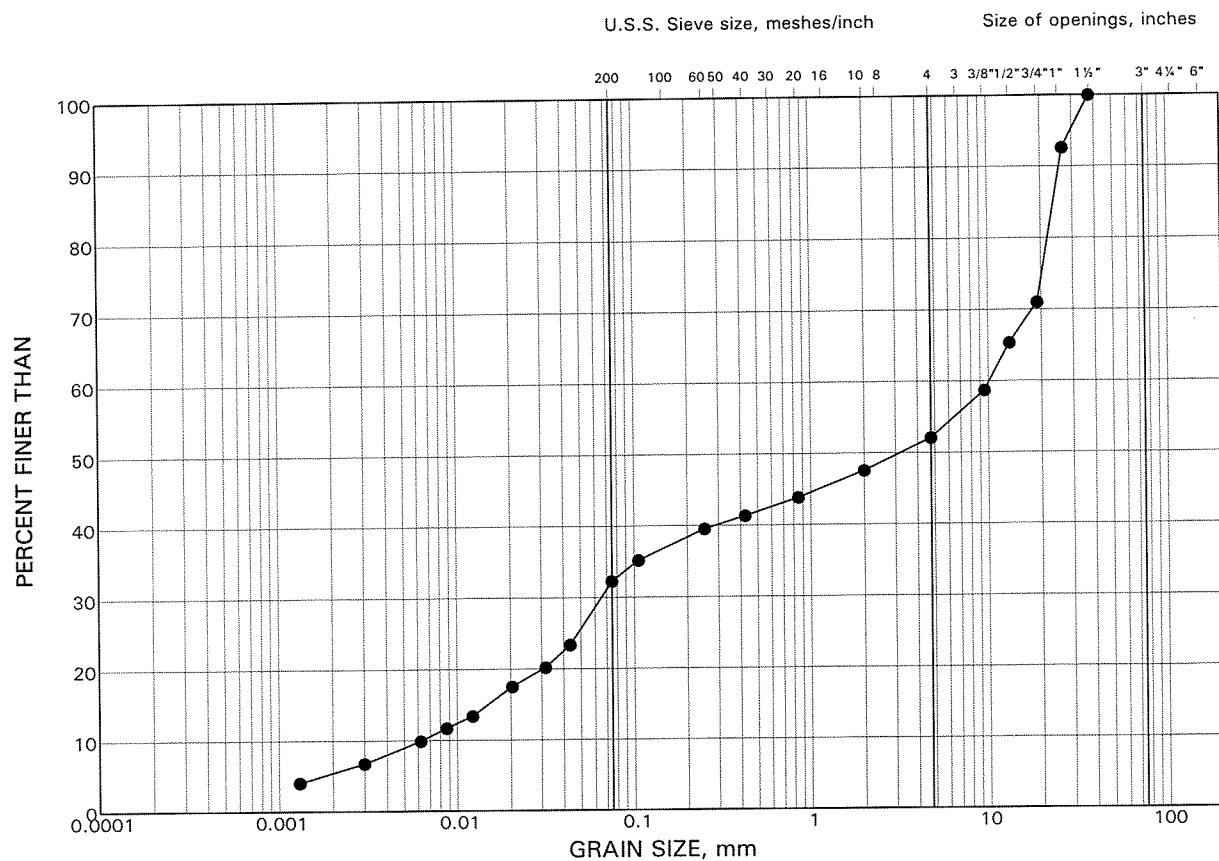
LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	C2A	3	1.5-2.0
■	C4A	5	3.0-3.5
◆	C5A	3	1.5-2.0
○	C5B	3	1.5-2.0

GRAIN SIZE DISTRIBUTION

Sandy Gravel with Silt

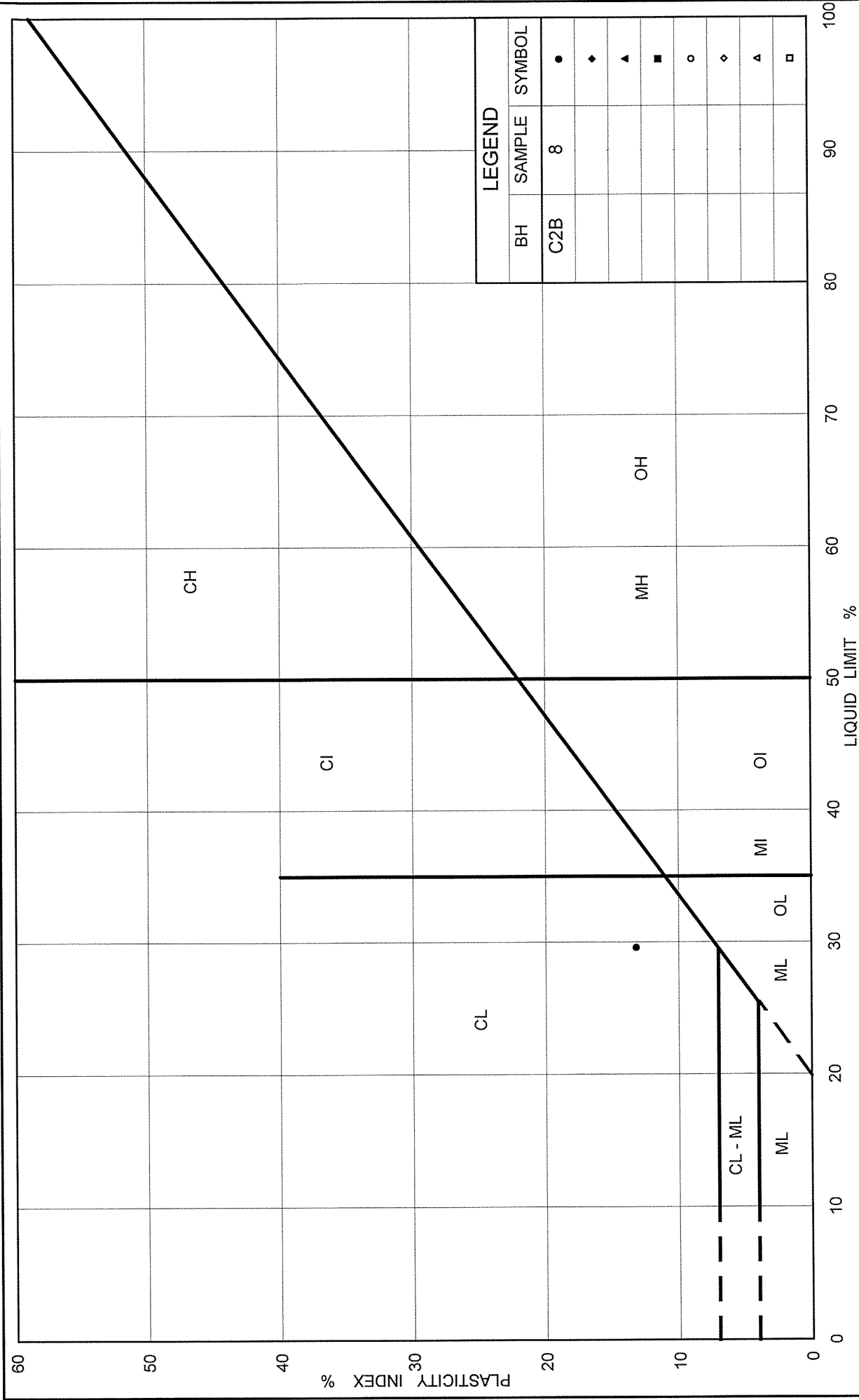
FIGURE A2



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	C6B	3	1.5-2.0



LEGEND		
BH	SAMPLE	SYMBOL
C2B	8	•
		◆
		▲
		■
		○
		◇
		△
		□

Ministry of Transportation

PLASTICITY CHART

Clayey Silt

FIG No. A3

Project No. 03-1111-023D

Checked By: