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Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing

FOUNDATION INVESTIGATION & DESIGN REPORT
1200 mm STORM SEWER
HIGHWAY 410 EXTENSION – PHASE III
FROM 300 m EAST OF HEART LAKE ROAD TO HIGHWAY 10
AGREEMENT No. 2005-A-000230, W.P. 105-00-00

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FOUNDATION INVESTIGATION REPORT
1200 mm STORM SEWER
HIGHWAY 410 EXTENSION – PHASE III
ONTARIO
AGREEMENT No. 2005-A-000230, W.P. 105-00-00, SITE:

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted along the alignment of the 1200 mm storm sewer on the proposed four-lane of Highway 410 in the Town of Caledon, Ontario.

Previous, investigations were carried out by Terraprobe Limited for the Highway 410 bridge over Etobicoke Creek and the applicable factual data from this investigation was used to supplement the current field investigation.

The purpose of this investigation was to explore the subsurface conditions along the storm sewer alignment and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed using existing data and information obtained from this investigation.

Terraprobe conducted the investigation as a sub-consultant to Giffels Associates Ltd., under the Ministry of Transportation Ontario (MTO) Agreement Number 2005-A-000230.

The following documents are referenced in the preparation of this report:

- Terraprobe Limited, "Draft Foundation Investigation & Design Report, Etobicoke Creek Overpass Structure, Highway 410 Extension – Phase III, From 300 m East of Heart Lake Road to Highway 10", Agreement No. 2005-A-000230, W.P. 105-00-00, dated August 05, 2005.

2 SITE DESCRIPTION

The storm sewer alignment extends from the Valleywood Boulevard interchange easterly and along the north side of the proposed highway to about Sta.24+130 where it crosses under the highway extending to the west bank of Etobicoke Creek.

There is a residential subdivision north of the alignment and at the east project limit Etobicoke creek meanders within its floodplain flowing south to Lake Ontario.

Along the proposed alignment the ground surface is generally flat, rising gently upwards to the east. From the top of the west bank of Etobicoke Creek the ground surface falls to the floodplain by about 8 m over a horizontal distance of 20 m.

The area is generally vegetated with mature stands of deciduous and coniferous trees and light vegetation consisting of grass and small shrubs.

The site is located in the physiographic region of Southern Ontario referred to as the Peel Plain whose topography slopes gradually and gently towards Lake Ontario. Etobicoke Creek and other rivers have cut deep valleys across the Peel Plain.

The Peel Plain is known to consist of generally clayey and silty soils that cover the central portion of the regions of York, Peel and Halton[1]. There are exceptions to be noted in these major soil groups. Trains of sandy alluvium can be found at various places in the stream valleys. These overburden soils are underlain by the Georgian Bay Formation.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between February 20 and March 08, 2006 and consisted of drilling and sampling fifteen boreholes to depths ranging from 8.1 m to 17.3 m. Borehole EC-1 previously drilled for the Etobicoke Bridge structure to a depth of 6.6 m on April 05, 2005 is also included in this report. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations were marked in the field by surveyors from Shiu Geomatics Limited who also provided Terraprobe with their coordinates and geodetic elevations. Utility clearances were obtained by Terraprobe prior to drilling.

The drilling, sampling and in-situ testing operations were conducted with a track mounted CME 75 drill rig owned and operated by Groundworks Drilling Limited of Toronto, Ontario. Solid stem auger drilling techniques were used to advance the boreholes and samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers consisting of 19 mm PVC pipe with a slotted screen enclosed in sand were installed in selected boreholes to permit longer term groundwater level monitoring. The locations and completion details of the piezometers are shown in Table 3.1.

[1] Chapman and Putnam, "The Physiography of South Ontario", 3rd Edition, 1984.

Table 3.1 – Piezometer Installation Details

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation (m)	Completion Details
SS-01	9.1/248.8	Piezometer with 3.0 m slotted screen installed with filter sand to 5.8 m, bentonite seal from 5.8 m to 4.3 m, drill cuttings from 4.3 m to ground surface.
SS-04	10.7/247.4	Piezometer with 3.0 m slotted screen installed with filter sand to 7.3 m, drill cuttings from 7.3 m to 1.8 m and bentonite seal from 1.8 m to ground surface.
SS-07 (P1)	7.6/252.8	Piezometer with 3.0 m slotted screen installed with filter sand to 3.9 m, bentonite seal from 3.9 m to 3.0 m, drill cuttings from 3.0 m to ground surface.
SS-07 (P2)	11.6/248.8	Piezometer with 1.5 m slotted screen installed with filter sand to 9.7 m, bentonite seal from 9.7 m to 7.6 m, filter sand from 7.6 m to 3.9 m, bentonite seal from 3.9 m to 3.0 m, drill cuttings from 3.0 m to ground surface.
SS-08 (P1)	7.6/252.5	Piezometer with 3.0 m slotted screen installed with filter sand to 4.2 m, bentonite seal from 4.2 m to 3.3 m, drill cuttings from 3.3 m to 1.8 m, bentonite seal from 1.8 m to ground surface.
SS-08 (P2)	11.6/248.5	Piezometer with 1.5 m slotted screen installed with filter sand to 9.7 m, bentonite seal from 9.7 m to 7.6 m, filter sand from 7.6 m to 4.2 m, bentonite seal from 4.2 m to 3.3 m, drill cuttings from 3.3 m to 1.8 m, bentonite seal from 1.8 m to ground surface.
SS-12	13.4/247.9	Piezometer with 3.0 m slotted screen installed with filter sand to 10.0 m, drill cuttings from 10.0 m to 0.6 m, bentonite seal from 0.6 m to ground surface.
SS-14	9.3/245.6	Piezometer with 3.0 m slotted screen installed with filter sand to 6.0 m, drill cuttings from 6.0 m to 0.9 m, bentonite seal from 0.9 m to ground surface.
SS-15	3.0/242.8	Piezometer with 1.5 m slotted screen installed with filter sand to 1.2 m, bentonite seal from 1.2 m to ground surface.

The drilling and sampling operations were supervised on a full time basis by a member of Terraprobe's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Terraprobe's Brampton laboratory for further examination and testing.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis and Atterberg Limits tests. The results of this testing program are shown on the Record of Borehole sheets in Appendix A. The grain size distribution curves and plasticity charts are illustrated in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A and Appendix C. Details of the encountered soil stratigraphy are presented in these appendices and on the "Borehole Locations and Soil Strata" drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, the site is underlain by topsoil and overburden soils consisting of sands and silts, clayey silt, clayey silt till, silty sand till and clayey silt fill.

5.1 Topsoil

Topsoil ranging from 100 mm to 300 mm thick was encountered along the alignment. Topsoil thickness may vary between and beyond the boreholes.

5.2 Clayey Silt Fill

Fill consisting of a mixture of clayey silt, trace sand to sand with trace gravel and trace organics was encountered at boreholes SS-09, SS-10 and SS-15. At borehole SS-09 and SS-10 the fill extends to a depth of 5.6 m or to elevations ranging from Elev. 255 m to Elev. 255.1 m. At borehole SS-15 the fill extends to a depth of 0.7 m (Elev. 245.1 m) below ground surface.

A sample of the clayey silt fill was subjected to a grain size distribution test and the results are illustrated in Figure B1. These results show a grain size distribution consisting of 2 % gravel, 24 % sand, 53 % silt and 21 % clay size particles.

SPT 'N' values in the fill material ranged from 2 to 22 blows for 0.3 m penetration indicating a soft to very stiff consistency. The moisture content of samples of the fill soils varies from 15% to 23% by weight.

5.3 Clayey Silt

Layers of clayey silt were encountered in some boreholes extending to depths of 0.7 m and 1.0 m below ground surface or to elevations ranging from Elev. 252.3 to Elev. 257.1 m.

Two samples from the clayey silt deposit were subjected to grain size distribution tests and the results are illustrated in Figure B2. These results show a grain size distribution consisting of 0-13 % gravel, 16-35 % sand, 40-53 % silt and 12-31 % clay size particles.

Standard Penetration tests in this deposit gave 'N' values ranging from 2 to 5 blows per 0.3 m penetration. Based on these results the deposit is considered to have a soft to firm consistency. The moisture content of samples from this stratum ranged from 17% to 24% by weight.

5.4 Sand

Near the west bank of Etobicoke Creek a sand/silty sand deposit was encountered in boreholes EC-1 and SS-15. This layer extends to depths of 2.1 m below ground surface at the borehole locations or to elevations ranging from 243.7 m to 250.9 m.

A sample from this deposit was subjected to a grain size distribution test and the results are illustrated in Figure B3. These results show a grain size distribution consisting of 1 % gravel, 68 % sand, 27 % silt and 4 % clay size particles.

The deposit is considered to have a loose to compact relative density based on SPT 'N' values that ranged from 5 to 14 blows for 0.3 m penetration. The moisture content of samples retrieved from this deposit generally ranges from 16% to 18% by weight and a natural moisture content of 47% was recorded for one sample that contained trace to some organics.

5.5 Silt and Sand

A layer of silt and sand was encountered in borehole SS-15 extending to a depth of 4.4 m (Elev. 241.4 m) below ground surface.

A sample from this stratum was subjected to a grain size distribution test and the results are illustrated in Figure B4. These results show a grain size distribution consisting of 0 % gravel, 37 % sand, 61 % silt and 2 % clay size particles.

Standard Penetration tests in this deposit gave 'N' values that ranged from 18 to 23 blows per 0.3 m penetration. Based on these results the deposit is considered to have a compact relative density. The moisture content of samples from this stratum ranged from 18% to 24% by weight.

5.6 Sand and Silt Till

The site is underlain by deposits of sand and silt till and possible till. The till deposit was fully penetrated in some of the boreholes (Boreholes SS-01, SS-05, SS-06, SS-07 and SS-14) where it extends to depths of 8.2 m to 10.1 m below ground surface or to elevations ranging from 248.0 m to 252.2 m. In some of the boreholes the sand and silt till extends to borehole termination depths ranging from 6.6 m to 17.3 m below ground surface or to elevations ranging from 237.7 m to 246.4 m and possibly beyond.

The results of grain size distribution tests conducted on samples obtained from this deposit are illustrated in Figures B5 and B6 respectively. These results show grain size

distributions consisting of 0-12% gravel, 37-53% sand, 33-53% silt and 4-8% clay size particles.

Standard Penetration tests in these deposits gave 'N' values that ranged from 5 to more than 100 blows per 0.3 m penetration but generally 'N' values ranged from 18 to more than 100 blows per 0.3 m penetration. Based on these results the deposit is considered to have a generally compact to very dense relative density with occasional loose zones. The moisture content of samples from this stratum ranged from 7% to 20% by weight.

5.7 Clayey Silt Till

Discontinuous layers of clayey silt till were encountered across the site in some boreholes. The till deposit extends to borehole termination depths ranging from 9.6 m to 17.2 m below ground surface or to elevations of 240.7 m to 248.7 m.

In boreholes SS-09, SS-10, SS-11 and SS-13 the deposit was fully penetrated and extends to depths ranging from 7.1 m (Elev. 253.6 m) to 10.1 m (Elev. 250.5 m) below ground surface.

The grain size distribution plots of tested samples from these till deposits are presented in Figure B7, B8 and B9. These results show a grain size distribution consisting of 0-7% gravel, 1-61% sand, 27-88% silt and 10-31% clay size particles.

Samples from this deposit were also subjected to Atterberg Limits tests and the results are presented in Figure B10, B11 and B12. The index values from these tests are summarized below:

Liquid Limit:	19-25%
Plastic Limit:	11-19%
Plasticity Index:	4-12%
Natural Moisture Content:	10-18%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in the till layers yielded 'N' values ranging from 2 to more than 100 blows per 0.3 m penetration. Generally however, blow counts ranging from 12 to more than 100 blows per 0.3 m penetration were obtained. Based on these values the till is considered to have a generally stiff to a hard consistency with occasional soft to firm zones. The moisture content of samples from these deposits ranged from 9% to 27% by weight.

5.8 Silt

Silt layers were encountered in some of the boreholes. This silt deposit extends to depths ranging from 7.5 m (Elev. 252.6 m) to 17.3 m (Elev. 244.1 m) below ground surface.

Samples from this deposit were subjected to grain size distribution tests and the results are illustrated in Figure B13. These results show a grain size distribution consisting of 0-3 %

gravel, 1-33 % sand, 59-94 % silt and 5-11 % clay size particles. Two samples were also subjected to Atterberg Limits tests and the results presented in Figure B14 indicate a non-plastic silt.

Standard Penetration tests in this deposit gave 'N' values ranging from 29 to more than 100 blows per 0.3 m penetration. Based on these results the deposit is considered to have a compact to very dense relative density. The moisture content of samples from this stratum ranged from 3% to 25% by weight.

5.9 Water Levels

Standpipe piezometers were installed in selected boreholes and water level readings were taken on separate visits made after the completion of drilling are presented in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
SS-01	March 27, 2006	3.4	254.5
	May 19, 2006	3.4	254.5
SS-04	March 27, 2006	7.1	251.0
	May 19, 2006	7.0	251.1
SS-07	March 27, 2006 (P1)	5.9	254.5
	March 27, 2006 (P2)	8.8	251.6
	May 19, 2006 (P1)	5.2	255.2
	May 19, 2006 (P2)	8.4	252.0
SS-08	March 29, 2006 (P1)	Dry	-
	March 29, 2006 (P2)	9.8	250.3
	May 19, 2006 (P1)	7.8	252.3
	May 19, 2006 (P2)	9.8	250.3
SS-12	March 29, 2006	13.1	248.2
	May 19, 2006	13.0	248.3
SS-14	March 27, 2006	4.5	250.4
	May 19, 2006	4.7	250.2
SS-15	March 27, 2006	0.5	245.3
	May 19, 2006	0.5	245.3

Based on these observations, the local groundwater level generally follows the contours of the land and is about 254.5 m at the west limit of the alignment falling gradually to just below ground surface (Elev. 245.3 m) near the west bank of Etobicoke Creek.

All groundwater observations are short term and the levels are expected to fluctuate seasonally and after severe weather events. The groundwater level at the east project limit will also be controlled by the water level in the creek.

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FOUNDATION DESIGN REPORT

1200 mm STORM SEWER

HIGHWAY 410 EXTENSION – PHASE III

ONTARIO

AGREEMENT No. 2005-A-000230, W.P. 105-00-00, SITE:

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical design recommendations for the proposed sewer installation.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of the investigations.

A 1200 mm diameter sewer will be installed on the north side of the proposed four lanes of Highway 410 between Sta. 24+130 and Sta. 24+735 approximately. The sewer alignment will then cross below the proposed highway extending about 89 m south easterly to its outfall located on the west bank of Etobicoke Creek at about Sta. 24+125.

At the east limit of the alignment (Sta. 24+735) the proposed invert level of the pipe is Elev. 251.9 ±m falling gradually to Elev. 246.7± m at Sta. 24+130. From Sta. 24+130 the invert elevation of the sewer continues to fall along its south easterly alignment to Elev. 245.8 ±m at the outfall.

An existing north to south oriented 300 mm diameter watermain and a 450 mm diameter sanitary sewer cross the proposed alignment at about Sta. 24+445. These existing utilities cross below the proposed four lanes of the highway and above the 1200 mm diameter sewer at invert elevations ranging from Elev. 254 ±m (watermain) to Elev. 252.4 ±m (sanitary sewer). At this location it is proposed to install the sewer in a 25± m long and 1800 mm diameter steel casing.

7 SEWER (OPEN EXCAVATIONS)

7.1 General

Discussions and recommendations related to general sewer design and installation are presented in this section of the report. Recommendations related to tunnelling below the existing 300 mm diameter watermain and the 450 mm diameter sanitary sewer are presented in Section 8.

It is assumed that the preferred method of sewer installation will be by open-cut excavation techniques.

7.1.1 Vertical Alignment

Based on the proposed invert elevations along the alignment and the data from the Record of Borehole Logs the trench bottom will lie in very stiff to hard clayey silt till, dense to very dense silty sand/sand & silt till and very dense silt. At the proposed invert level these soils will provide excellent support to the pipe.

Based on the borehole data, the groundwater table ranges from Elev. 254.5 m at the west limit falling gradually to Elev. 245.3 m at the outfall. Therefore, the groundwater table will generally be above the depth of excavation along most of the alignment. This aspect must be taken into consideration when undertaking excavations at this site.

7.1.2 Excavation

The soils described at this site are considered to be suitable for excavation using trenching and excavating equipment, such as backhoes normally used by contractors for sewer installation. Excavations should be undertaken in accordance with OPSS 514.

Till soils inherently contain cobbles and boulders and the contract documents must identify this fact to bidders. The frequency of boulders is unlikely to be high enough to prevent the use of suitable trenching and excavating equipment. However, the contract documents should include a NSSP alerting bidders to the fact that cobbles and boulders may be encountered in the soil. Suggested wording for this NSSP is included in Appendix F.

7.1.3 OHSA Soil Classification

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils at this site may be classified as Type 2 soils. Excavations above the water table may be sloped at 1.5H:1V. Provided unwatering is carried out as described below, excavations below the water table may be sloped at 2H:1V.

7.1.4 Groundwater Control

The groundwater table at this site is estimated to range from Elev. 254.5 m at the west limit falling gradually to Elev. 245.3 m at the outfall. Groundwater will be encountered in the excavations.

The Contractor must implement such groundwater control and ground support systems as are required to install the sewer in a safe, stable, unwatered excavation. The design of the unwatering system should be the responsibility of the Contractor.

Groundwater seepage into excavations made through the clayey silt till, silty sand/sand & silt till and silt deposits should be moderate and it is believed that this seepage can be controlled by gravity drainage and pumping from strategically located filtered sumps as and where required.

It should be pointed out that the granular silty sand/sand & silt till and silt will be easily disturbed in the presence of water.

Laying the sewer and backfilling on top of heaved; disturbed soil may result in settlement that could result in damage to the pipes. Therefore, it is recommended that excavations below the water table be undertaken expeditiously in as short sections as possible. The trench base must be inspected and approved by the Quality Verification Engineer (QVE).

7.1.5 Bedding

The bedding for the sewer must conform to the requirements of OPSD 802.030 (rigid pipe bedding, earth excavation) or OPSD 802.010 (flexible pipe embedment and backfill, earth excavation) as appropriate.

It is recommended that the bedding material consist of OPSS Granular "A".

Additional bedding requirements that may be imposed by the supplier must also be followed.

All disturbed or softened soils must be removed from the trench base before bedding material is placed.

7.1.6 Backfill

Where the alignment crosses the proposed highway, it is recommended that the trench backfill consist of Granular "B" Type I. The backfill should be compacted to a minimum of 98% of the Standard Proctor Maximum Dry Density (SPMDD) at a moisture content within ±2% of the optimum value.

Elsewhere the backfill may consist of the excavated soil compacted to 95% SPMDD at a moisture content within ±2% of the optimum value.

Trenching, backfilling and compaction operations should be in accordance with OPSS 514.

8 UTILITY CROSSING

The proposed sewer casing has a diameter of 1800 mm and the length of the crossing is about 25± m. These factors limit the range of trenchless installation techniques that would be economically viable at this site. Each method considered has advantages, disadvantages or limitations and these are discussed. The methods that are considered viable are:

1. Open cut trenching
2. Jack and bore
3. Micro Tunnelling
4. Pipe ramming

8.1 Open Cut Trenching

If open cut trenching is selected, the discussion and recommendations presented in Section 7 will apply.

The open cut method is a relatively simple method and would be a continuation of the installation of the remainder of the pipe. However the main disadvantage is that provisions will have to be made for supporting and also protecting the existing watermain and sanitary sewer where exposed.

This method can be considered provided that the Contractor can guarantee that the existing utilities would not be damaged during construction.

8.2 Jack and Bore

Jack and bore installation involves pushing an oversized liner pipe horizontally into the ground by jacking. The soil is removed by augering inside the pipe as it is advanced. Precision is normally ±1% of the driven length. This method is considered to be feasible for this site.

Along this section of the alignment the invert elevation of the steel casing will vary between Elev. 248.9±m and Elev. 248.8±m. The obvert elevation of the casing will range between Elev. 250.7±m and Elev. 250.6±m.

Based on the borehole data the excavation within the zone of tunnelling will encounter hard clayey silt till. The clayey silt till possesses sufficient cohesion and/or cementation and is expected to have a stand-up time of several hours depending on the composition of the soil matrix. Nevertheless, to minimize settlements, the jacking of the liner within the clayey silt till should follow closely behind the advance of the auger head. Ground closure around the liner is expected to be minimal but the application of a bentonite slurry under pressure is recommended to reduce the frictional resistance.

Settlement at the invert levels of the overlying watermain and sewer is estimated to be of the order of 10 mm when tunnelling within the hard clayey silt till. This estimate is based on the assumption that the work will be carried out by experienced tunnellers with great care and good workmanship. It has been our experience that under "normal" jack and bore conditions, ground loss can be limited to acceptable levels. However, excessive ground loss, and settlement can occur when unusual conditions are encountered, such as boulder removal and when water-bearing sand lenses are encountered. A great deal of care is required under these conditions.

Possible problems for tunnelling within the clayey silt till include boulders and water-bearing sand lenses which are common in glacial deposits.

The clayey silt till has a relatively low permeability and groundwater seepage is expected to be in small quantities at a slow rate. This seepage can be handled by gravity drainage into the jacking pit from where it could be removed by pumping from filtered sumps.

8.3 Microtunnelling

This technique is similar to jack and bore where a liner pipe is jacked horizontally into the ground. However, in this case a remote controlled cutting head is used to remove the soil.

Microtunnelling is a very precise method of tunnelling and with the suitable choice of cutting tools a wide soil spectrum can be excavated. Additionally, there is relatively little settlement with this method if handled properly.

This method is feasible for consideration at this site. However, due to the specialized type of machinery required it is likely to be prohibitively expensive for this relatively short run.

8.4 Pipe Ramming

Pipe ramming is a trenchless method for installing steel pipes or casings in which a pneumatic tool is used to hammer the pipe or the casing into the ground. The soils inside the pipe can be removed either during or after the installation by augering, compressed air or water jetting.

Although pipe ramming can be applied in a wide variety of soils, some soils are better suited for this method than others. At this site hard clayey silt till will be encountered and pipe ramming is a little more difficult in this type of material.

Another drawback is the possibility of significant soil disturbance if a blockage is created at the end of the installed pipe especially if this occurs below the existing utilities (watermain and sanitary sewer). Vibrations due to pipe ramming may also have a detrimental effect on these pipes.

Based on the foregoing pipe ramming is not recommended.

9 TUNNEL SUPPORT

In the completed tunnel the maximum residual stress would be expressed in the spring-line of the tunnel diameter where the unbalanced horizontal stress is a maximum. The horizontal and tangential pressure on the permanent tunnel lining is a function of the vertical in situ pressure which is given by:

$P_h = \gamma (h - h_w) + \gamma' h_w + h_w \gamma_w$

γ = bulk unit weight of soil

γ_w = unit weight of water (9.81 kN/m^3)

h = depth below surface (m)

h_w = depth below the groundwater level (m)

For design purposes assume a unit weight of 21 kN/m^3 for the soil overlying the springline of the tunnel.

10 EARTH PRESSURE

The excavation walls will have to be supported by a shoring system. Earth pressures acting on the shoring system may be assumed to be triangular and to be governed by the characteristics of the soil being retained. Earth pressure computations must also take into account the groundwater level. Above the groundwater level, earth pressure is computed using the bulk unit weight of the retained soil. Below the groundwater level, the earth pressures are computed using the submerged unit weight of the soil. A hydrostatic pressure is also applied if the retained soil is not fully drained.

Earth pressures acting on the structure should be computed in accordance with Clause 6.9 of the CHBDC. The appropriate pressures can be computed from the expression:

$P_h = K[\gamma (h - h_w) + (\gamma' h_w) + q] + h_w \gamma_w$

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient (see table 10.1)
γ = bulk unit weight of retained soil (see table 10.1)
γ' = submerged unit weight of soil ($\gamma - \gamma_w$)
γ_w = unit weight of water (9.81 kN/m^3)
h = depth below surface (m)
h_w = depth below the groundwater level (m)
q = value of any surcharge (kPa)

If the shoring is internally braced at more than one level, then it is recommended that the design of the system be undertaken based on an earth pressure distribution consisting of a uniformly distributed pressure defined by the expression:

$P = 0.65\ K[\gamma h + q] + h_w \gamma_w$

K = earth pressure coefficient (see table 10.1)
γ = bulk unit weight of retained soil (see table 10.1)
γ_w = unit weight of water (9.81 kN/m^3)
h = depth below surface (m)
h_w = depth below the groundwater level (m)
q = value of any surcharge (kPa)

The appropriate values of the parameters for use in the design of structures subject to unbalanced earth pressures are given in Table 10.1 below.

Table 10.1 – Earth Pressure Coefficients

Stratum	ϕ	γ	K_a	K_o	K_p
Fill – Clayey Silt	25	18	0.40	0.58	2.50
Clayey Silt	25	18	0.40	0.58	2.50
Sand	25	18	0.40	0.58	2.50
Silt & Sand	28	19	0.36	0.53	2.80
Silty Sand/Sand & Silt Till	30	20	0.33	0.50	3.00
Clayey Silt Glacial Till	30	20	0.33	0.50	3.00
Silt	28	19	0.36	0.53	2.80

The factors in the table above are "ultimate" values and require certain movements for the active and passive conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the CHBDC, 2000.

11 TRENCH CLAY PLUGS & CUT OFF COLLARS

Clay plugs are usually installed in trenches to protect the groundwater and to prevent its lowering due to the "French Drain" effect of the granular bedding and backfill material. If the invert of the trench is below the water table and local drawdown of the groundwater level cannot be tolerated for environmental reasons then clay plugs can be installed within the granular bedding and the granular zones of backfill material.

Clay plugs should be placed in the trenches at 50 m intervals along the full length of the trench, where the invert of the trench is below the water table. The plug should be 1 m thick measured along the pipe, and should completely replace the granular bedding and backfill placed above the springline and the obvert of the sewer. The clay plugs must be compacted to 95% SPMDD.

Material used for the clay plugs should confirm to OPSS 1205. Unshrinkable fill can also be used as a substitute for clay plugs.

Before construction the contractor should submit a representative sample of the proposed clay plug material for permeability and particle size testing to verify compliance with the specifications. During construction, further representative samples should be tested to determine its acceptability.

Alternatively, cut off collars can be installed around the pipe barrel to achieve the same effect. Collars should not be placed closer than 1 m to a pipe joint and precautions should be taken to ensure that 95% compaction is achieved around the collars. Watertight connections are required between the collar and the pipe wall.

12 OUTFALL STRUCTURE

A concrete headwall will be installed at the outfall near the west bank of Etobicoke Creek. Based on the subsurface stratigraphy encountered at this location (Borehole SS-15) the headwall can be supported on spread footings.

Spread footings can be founded on the compact sand at or below Elev. 244.5 m where they can be designed for a factored geotechnical resistance of 225 kPa at ULS and 150 kPa at SLS. Higher geotechnical resistances are available at greater depths but are not believed to be necessary for the light structure proposed.

These values are for vertical, concentric loads only. Effects of load inclination and eccentricity should be taken into account as illustrated in CHBDC, 2000 Clause 6.7.3 and Clause 6.7.4.

The SLS value quoted above corresponds to a settlement of up to 25 mm, a significant portion of which will be complete by the end of construction.

Any weak, organic or otherwise unsuitable soils encountered at the foundation subgrade level should be removed and replaced with lean concrete. Because of the high water table, lean concrete is recommended instead of Granular "A" type material.

Lateral resistance is unlikely to be an issue for this type of structure. However, if required resistance to lateral forces/sliding resistance between the concrete footing and its subgrade should be evaluated in accordance with the CHBD, 2000. Assume an ultimate coefficient of friction of 0.5 for the compact sand and 0.7 for lean concrete.

13 CONSTRUCTION CONCERNS

During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities related to the sewer installation.

Potential construction concerns include, but are not necessarily limited to:

- the possibility of encountering boulders or other obstructions, particularly during trenchless installation below the existing watermain and sanitary sewer.
- the potential for groundwater levels to be higher at the time of construction than those recorded in this report.
- the impact of the groundwater level on the stability of excavations in the absence of effective groundwater control.

Engineering Analysis and Report Preparation by:
R. Abdul, P.Eng.,
Senior Geotechnical Engineer

Report Reviewed by:
Michael Tanos, P.Eng.,
Review Principal

APPENDIX A

Record of Borehole Sheets

Terraprobe Limited

RECORD OF BOREHOLE No SS01 1 OF 1 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844769.6 E:276275.6 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 21.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.9	Ground Surface										
0.0 / 257.6	**280mm TOPSOIL**										
0.3 / 256.9	CLAYEY SILT - trace sand, trace gravel, trace rootlets, soft, brown, damp		1	SS	2		257				
1.0	CLAYEY SILT trace sand to sandy, trace gravel, very stiff to hard, brown, damp (GLACIAL TILL)		2	SS	30		256				
			3	SS	48		255				
	grey		4	SS	35		254				4 27 48 21
250.8			5	SS	33		253				
7.1	SILT AND SAND trace clay, trace gravel, occasional cobbles, very dense, grey, damp (Possible Till)		6	SS	99		252				3 37 53 7
249.3							251				
8.6	CLAYEY SILT some sand, hard, grey, damp (GLACIAL TILL)		7	SS	58		250				0 17 58 25
248.3							249				
9.6	End of Borehole										

Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with a 3.0m slotted screen.

Water Level Readings:

Date	Height(m)	Elevation(m)
Mar.27.06	3.4	254.5
May.19.06	3.4	254.5

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

RECORD OF BOREHOLE No SS02 1 OF 1 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844783.5 E:278331.0 ORIGINATED BY HA

DIST ____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 21.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.3	Ground Surface										
258.1	**200mm TOPSOIL**					*	258				
0.2	weathered, soft ----		1	SS	2				○		
	CLAYEY SILT trace sand to sandy, trace gravel, very stiff to hard, brown, damp (GLACIAL TILL)		2	SS	26		257		○		
							256				
			3	SS	40		255		○		7 29 46 18
	---- occasional cobbles at 4.4m, grey		4	SS	31		254		○		
							253				
			5	SS	34		252		○		
							251				
			6	SS	62		250		○		0 2 80 18
			7	SS	30		249		○		
248.7											
9.6	End of Borehole * Borehole dry (not stabilized) and hole open to full depth upon completion of drilling.										

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

RECORD OF BOREHOLE No SS03 1 OF 1 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844812.1 E:278378.5 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 20.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.0	Ground Surface										
257.8	200mm TOPSOIL										
0.2	weathered, soft		1	SS	3	*			○		
	----						257				
	CLAYEY SILT trace sand to sandy, trace gravel, very stiff to hard, brown, damp to moist		2	SS	25				○		1 31 50 18
	(GLACIAL TILL)						256				
			3	SS	67		255		○		
							254				
	----		4	SS	36				○		
	grey						253		○		
							252				
			5	SS	36				○		
							251				
			6	SS	31				○		
							250				
							249				
			7	SS	22				○		
							248				
246.8			8	SS	29		247		○		0 5 76 19
11.2	End of Borehole * Borehole dry (not stabilized) and hole open to full depth upon completion of drilling.										

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

RECORD OF BOREHOLE No SS04

1 OF 1

METRIC

W.P. 105-00-00 LOCATION Coords: N:4844834.1 E:278390.3 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 20.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.1	Ground Surface										
257.8	250mm TOPSOIL										
0.3	weathered, soft ----		1	SS	3		258				
	CLAYEY SILT trace to some sand, trace gravel, very stiff to hard, brown, damp (GLACIAL TILL)		2	SS	25		257				
			3	SS	40		256				
	--- grey		4	SS	44		255				
			5	SS	38		254				0 9 60 31
			6	SS	29		253				
			7	SS	25		252				
246.9			8	SS	34		251				
11.2	End of Borehole						250				
							249				
							248				
							247				

Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with a 3.0m slotted screen.

Water Level Readings:

Date	Height(m)	Elevation(m)
Mar.27.06	7.1	251.0
May.19.06	7.0	251.1

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

RECORD OF BOREHOLE No SS05 1 OF 1 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844867.8 E:278411.1 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 20.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.1	Ground Surface						258				
258.0 / 0.1	100mm TOPSOIL										
	CLAYEY SILT some sand, trace organics, soft, brown, damp		1	SS	2						0 16 53 31
257.1 / 1.0	CLAYEY SILT trace sand to sandy, trace gravel, occasional silty sand seams and partings, very stiff to hard, brown, dry to damp (GLACIAL TILL)		2	SS	29		257				
			3	SS	123		256				
	---- grey		4	SS	53		255				
			5	SS	42		254				
251.0 / 7.1	SAND AND SILT trace clay, trace gravel, dense to very dense, grey, damp to moist (GLACIAL TILL)		6	SS	173/ 28cm		253				
			7	SS	46		252				
248.0 / 10.1	CLAYEY SILT trace sand, trace gravel, hard, grey, damp to moist (GLACIAL TILL)		8	SS	43	▽*	251				5 45 44 6
246.9 / 11.2	End of Borehole * Water level at 10.4m (not stabilized) and hole open to full depth on completion of drilling.						250				
							249				
							248				
							247				

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

RECORD OF BOREHOLE No SS06 1 OF 1 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844898.8 E:278451.7 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 20.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.7	Ground Surface										
258.5	**200mm TOPSOIL**										
0.2	weathered, soft CLAYEY SILT trace sand to sandy, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL)		1	SS	2	*	258				
			2	SS	28		257				
			3	SS	41		256				
	grey		4	SS	45		255				
			5	SS	51		254				
251.7							253				
7.0	SAND AND SILT trace clay, trace gravel, occasional cobbles, very dense, grey, moist (GLACIAL TILL)		6	SS	72		252				3 49 40 8
250.1							251				
8.6	CLAYEY SILT trace sand, hard, grey, damp to moist (GLACIAL TILL)		7	SS	56		250				
			8	SS	91		249				0 1 88 11
246.0			9	SS	62		248				
12.7	End of Borehole * Borehole dry (not stabilized) and hole open to full depth upon completion of drilling.						247				
							246				

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

RECORD OF BOREHOLE No SS07

1 OF 2

METRIC

W.P. 105-00-00 LOCATION Coords: N:4844938.5 E:278482.9 ORIGINATED BY HA

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 21.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS P1 P2	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.4	Ground Surface										
0.0 / 260.1	**280mm TOPSOIL**		1	SS	7		260				
0.3	weathered, firm ---- CLAYEY SILT trace sand to sandy, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL)		2	SS	16		259				
			3	SS	27		258				
			4	SS	39		257				
			5	SS	46		256				2 61 27 10
			6	SS	69		255				
253.7							254				
6.7	SAND AND SILT trace clay, trace gravel, occasional cobbles, very dense, brown, moist (GLACIAL TILL)		7	SS	164		253				4 50 40 6
252.2			8	SS	117		252				
8.2	brown ---- CLAYEY SILT trace sand, trace gravel, hard, grey, damp to moist (GLACIAL TILL)		9	SS	80						
			10	SS	68		251				0 2 87 11
			11	SS	53*		250				* Sampler wet
			12	SS	55		249				
			13	SS	56		248				
	---- some sand		14	SS	54		247				
			15	SS	58						
246.2			16	SS	67						
14.2	End of Borehole										

Continued Next Page

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

RECORD OF BOREHOLE No SS07 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844938.5 E:278482.9 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 21.02.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL

Nested Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with

P1-3.0m slotted screen,
P2-1.5m slotted screen.

Water Level Readings (P1) :

Date	Height(m)	Elevation(m)
Mar.27.06	5.9	254.5
May.19.06	5.2	255.2

Water Level Readings (P2) :

Date	Height(m)	Elevation(m)
Mar.27.06	8.8	251.6
May.19.06	8.4	252.0

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

RECORD OF BOREHOLE No SS08

1 OF 2

METRIC

W.P. 105-00-00 LOCATION Coords: N:4844959.9 E:278503.9 ORIGINATED BY HA

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 22.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS P1 P2	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.1	Ground Surface								
0.0 / 259.8	**300mm TOPSOIL**		1	SS	11		260		
0.3	weathered, stiff ---- CLAYEY SILT sandy, trace gravel, very stiff to hard, brown, damp (GLACIAL TILL)		2	SS	21		259		7 33 41 19
			3	SS	44		258		
254.5			4	SS	44		257		3 40 40 17
5.6	SILT some sand, some clay, trace gravel, occasional cobbles, very dense, brown, damp		5	SS	100/13cm		256		
252.6			6	SS	119		255		1 11 77 11
7.5	brown ---- CLAYEY SILT trace sand, trace gravel, hard, grey, moist (GLACIAL TILL)		7	SS	163		254		
			8	SS	61		253		0 1 86 13
			9	SS	42		252		
			10	SS	59		251		
			11	SS	51		250		
			12	SS	40		249		
			13	SS	41		248		
			14	SS	48		247		
245.9	---- some sand		15	SS	72		246		
14.2	End of Borehole								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

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

Continued Next Page

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

RECORD OF BOREHOLE No SS08 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844959.9 E:278503.9 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 22.02.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Nested Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with P1-3.0m slotted screen, P2-1.5m slotted screen. **Water Level Readings (P1) :** Date Height(m) Elevation(m) Mar.29.06 dry - May.19.06 7.8 252.3 **Water Level Readings (P2) :** Date Height(m) Elevation(m) Mar.29.06 9.8 250.3 May.19.06 9.8 250.3										

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

RECORD OF BOREHOLE No SS09

1 OF 2

METRIC

W.P. 105-00-00 LOCATION Coords: N:4844995.4 E:278538.9 ORIGINATED BY HA

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic. DATE 24.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.6	Ground Surface										
260.4 / 0.2	150mm TOPSOIL										
	soft to firm FILL - Clayey Silt, some sand to sandy, trace gravel, trace rootlets, trace organics, very stiff, dark brown, damp		1	SS	4		260		○		
			2	SS	16		259		○		2 24 53 21
			3	SS	22		258		○		
			4	SS	21		257		○		
255.0 / 5.6	CLAYEY SILT trace to some sand, trace gravel, occasional cobbles, hard, brown, damp to moist (GLACIAL TILL)		5	SS	79		256		○		
			6	SS	91		255		○		
			7	SS	120		254		○		
250.5 / 10.1	SILT trace sand, trace clay, very dense, grey, damp to moist		8	SS	53		253		○		
			9	SS	65		252		○		
			10	SS	55		251		○		
245.6			11	SS	72		250		○		

Continued Next Page

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

RECORD OF BOREHOLE No SS09 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4844995.4 E:278538.9 ORIGINATED BY HA

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 24.02.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
15.0	End of Borehole * Borehole dry (not stabillzed) and hole open to full depth upon completion of drilling.										

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

RECORD OF BOREHOLE No SS10 1 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845021.1 E:278581.1 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 27.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.7	Ground Surface										
260.5	**230mm TOPSOIL**										
0.2	FILL - Clayey Silt, some sand to sandy, trace gravel, trace to some organics, stiff to very stiff, dark brown, damp		1	SS	10		260				
			2	SS	15		259				
			3	SS	20		258				
			4	SS	13		257				
255.1							256				
5.6	CLAYEY SILT sandy, trace gravel, hard, brown, damp (GLACIAL TILL)		5	SS	45		255				
253.6							254				
7.1	SILT trace sand, trace clay, occasional gravel inclusions, dense to very dense, brown, damp to moist		6	SS	100/ 11cm		253				0 3 88 9
			7	SS	148/ 28cm		252				
	grey		8	SS	100		251				
			9	SS	71		250				0 1 90 9
			10	SS	45	▽	249				
245.7	sandy						248				
							247				
							246				

Continued Next Page

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

RECORD OF BOREHOLE No SS10 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845021.1 E:278581.1 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 27.02.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
15.0	SILT sandy, trace clay, trace gravel, compact, grey, wet		11	SS	29	**			○		3	33	59	5
245.0							245							
15.7	End of Borehole													

* Water level at 13.7m (not stabilized) and hole open to 13.9m upon completion of drilling.

** Sampler wet.

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

RECORD OF BOREHOLE No SS11 1 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845064.2 E:278611.6 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 27.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.4	Ground Surface										
261.1 0.0	250mm TOPSOIL										
0.3	weathered --- CLAYEY SILT trace sand to sandy, trace gravel, stiff to hard, brown, damp (GLACIAL TILL)		1	SS	12		261				
			2	SS	14		260				
			3	SS	53		259				
			4	SS	47		258				
	--- grey		5	SS	26		257				
			6	SS	25		256				
252.0			7	SS	111		255				
9.4	SILT trace clay, trace sand, very dense, brown, damp		8	SS	170/ 27cm		254				
	--- grey		9	SS	93		253				0 1 94 5
	--- some sand		10	SS	76		252				
							251				
							250				
							249				
							248				
							247				

Continued Next Page

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

RECORD OF BOREHOLE No SS11 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845064.2 E:278611.6 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 27.02.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	SILT trace clay, trace sand, dense, grey, damp *(continued)*		11	SS	42		246				
							245				
244.1			12	SS	45						
17.3	End of Borehole Wet cave at 14.0m upon completion of drilling.										

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

RECORD OF BOREHOLE No SS12

1 OF 2

METRIC

W.P. 105-00-00 LOCATION Coords: N:4845094.6 E:278652.5 ORIGINATED BY HA

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 28.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.3	Ground Surface										
261.0 / 0.3	**250mm TOPSOIL**		1	SS	7		261		○		
	weathered, firm CLAYEY SILT trace to some sand, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL)		2	SS	41		260		○		
			3	SS	42		259		○		
	grey		4	SS	21*		258		○		*No recovery.
	75mm silty sand seam		5	SS	15		257		○		
			6	SS	84		256		○		
			7	SS	48		255		○		
			8	SS	54		254		○		
249.6 / 11.7	SILT some sand, trace clay, very dense, brown, moist		9	SS	105		253		○		0 20 72 8
	grey, wet		10	SS	74		252		○		
							251		○		
							250		○		
							249		○		
							248		○		
							247		○		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

○ ³% STRAIN AT FAILURE

RECORD OF BOREHOLE No SS12 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845094.6 E:278652.5 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 28.02.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	SILT some sand, trace clay, very dense, grey, moist *(continued)*		11	SS	84		246		○		
245.1 16.2	CLAYEY SILT sandy, hard, grey, damp (GLACIAL TILL)		12	SS	156/ 27cm		245		○		0 24 64 12
244.1 17.2	End of Borehole										

Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with a 3.0m slotted screen.

Water Level Readings:

Date	Height(m)	Elevation(m)
Mar.29.06	13.1	248.2
May.19.06	13.0	248.3

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

RECORD OF BOREHOLE No SS13 1 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845131.7 E:278682.3 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 28.02.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.3	Ground Surface										
260.1 / 0.2	150mm TOPSOIL										
	weathered, trace rootlets, firm to stiff		1	SS	8		260				
	CLAYEY SILT trace sand to sandy, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL)		2	SS	27		259				
			3	SS	43		258				
			4	SS	37		257				
	grey		5	SS	33		256				4 26 46 24
			6	SS	25		255				
			7	SS	88		254				
250.2 / 10.1	SILTY SAND trace to some gravel, trace clay, compact to very dense, brown, moist (GLACIAL TILL)		8	SS	76		253				12 48 33 7
			9	SS	147/ 27cm		252				
	grey		10	SS	18		251				
							250				
							249				
							248				
							247				
							246				

Continued Next Page

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

RECORD OF BOREHOLE No SS13 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845131.7 E:278682.3 ORIGINATED BY HA

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 28.02.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	SILTY SAND trace to some gravel, trace clay, dense, grey, moist (GLACIAL TILL) *(continued)*		11	SS	37		245 244		○		
243.0			12	SS	46				○		
17.3	End of Borehole Wet cave at 12.8m upon completion of drilling.						243				

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

RECORD OF BOREHOLE No SS14 1 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845156.7 E:278730.5 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 08.03.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.9	Ground Surface										
0.0 / 254.6	**250mm TOPSOIL**										
0.3 / 253.9	CLAYEY SILT sandy, some gravel, trace rootlets, firm, brown, damp		1	SS	5		254				13 35 40 12
1.0	SAND AND SILT trace clay, trace gravel, loose, brown, damp to moist (GLACIAL TILL)		2	SS	7		253				
			3	SS	5		252				0 53 42 5
	dense to very dense		4	SS	40		251				
			5	SS	70		250				
			6	SS	78		249				
	grey		7	SS	33		248				8 47 41 4
244.8 / 10.1	CLAYEY SILT trace sand, hard, grey, damp to moist (GLACIAL TILL)		8	SS	62		247				
			9	SS	164		246				0 2 85 13
240.7 / 14.2	End of Borehole		10	SS	71		245				0 2 88 10
							244				
							243				
							242				
							241				

Continued Next Page

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

RECORD OF BOREHOLE No SS14 2 OF 2 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845156.7 E:278730.5 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 08.03.06 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Piezometer Installation consists of 19mm diameter, schedule 40 PVC pipe with a 3.0m slotted screen. Water Level Readings: Date Height(m) Elevation(m) Mar.27.06 4.5 250.4 May.19.06 4.7 250.2										

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

RECORD OF BOREHOLE No SS15 1 OF 1 METRIC

W.P. 105-00-00 LOCATION Coords: N:4845116.6 E:278800.4 ORIGINATED BY HA

DIST HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 08.03.06 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
245.8	Ground Surface										
0.0 / 245.5	250mm TOPSOIL										
0.3 / 245.1	FILL - Clayey Silt, trace sand, trace gravel, soft, brown, damp to moist		1	SS	2						
0.7	SAND silty, trace clay, trace gravel, trace rootlets, trace to some organics, loose to compact, grey, moist to wet		2	SS	7		245				1 68 27 4
243.7			3	SS	14		244				
2.1	SILT AND SAND trace clay, compact, brown, wet		4	SS	23		243				
	grey		5	SS	18						0 37 61 2
241.4			6	SS	19		242				
4.4	SAND AND SILT trace clay, trace gravel, compact, grey, moist to wet (GLACIAL TILL)		7	SS	21		241				5 47 41 7
			8	SS	25		240				3 49 42 6
237.7			9	SS	19		239				
8.1	End of Borehole						238				

Piezometer installation consists of 19mm diameter, schedule 40 PVC pipe with a 1.5m slotted screen.

Water Level Readings:

Date	Height(m)	Elevation(m)
Mar.27.06	0.5	245.3
May.19.06	0.5	245.3

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

ONTARIO MOT 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ ONTARIO MOT.GDT 14/06/06

APPENDIX B

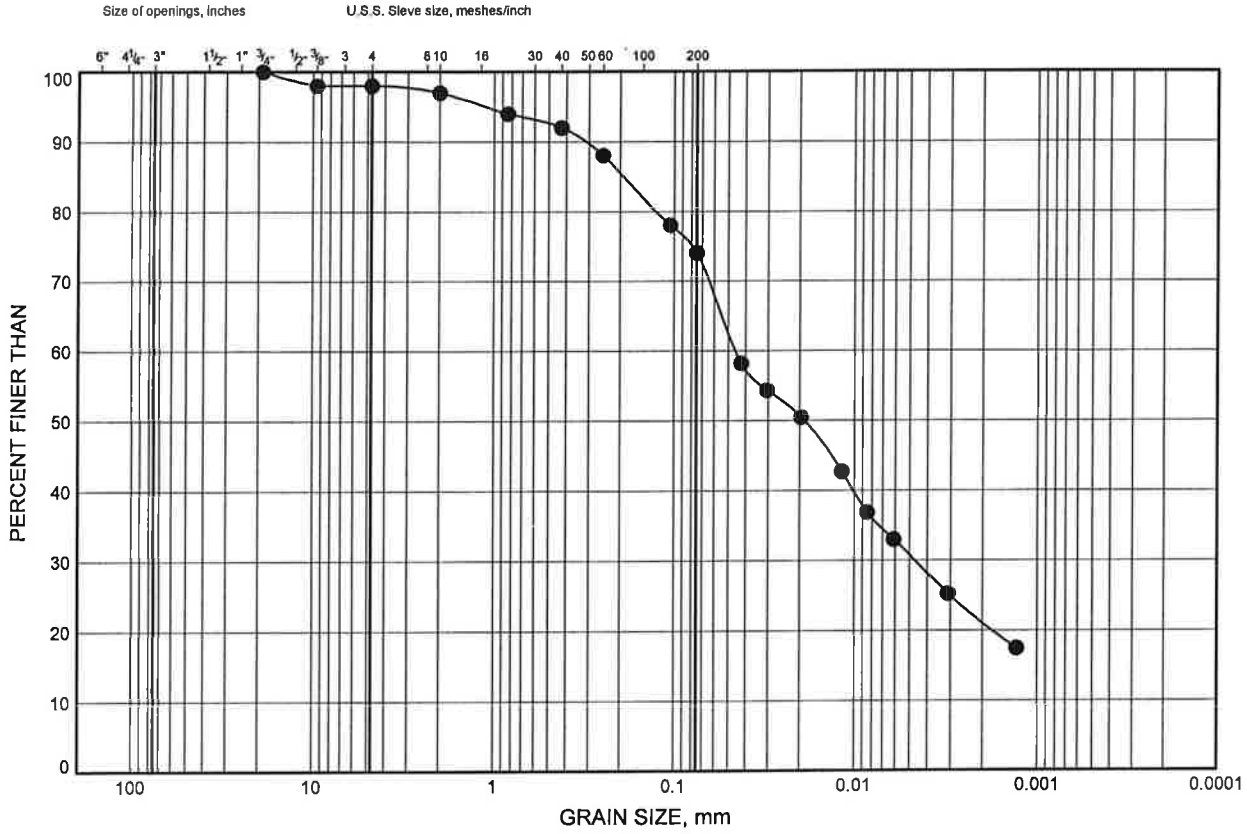
Laboratory Test Results

Terraprobe Limited

GRAIN SIZE DISTRIBUTION

FIGURE B1

Fill - Clayey Silt



COBBLE SIZE	GRAVEL		SAND			SILT and CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS09	1.7	258.9

Date January 2007

Project 105-00-00

Prep'd DB

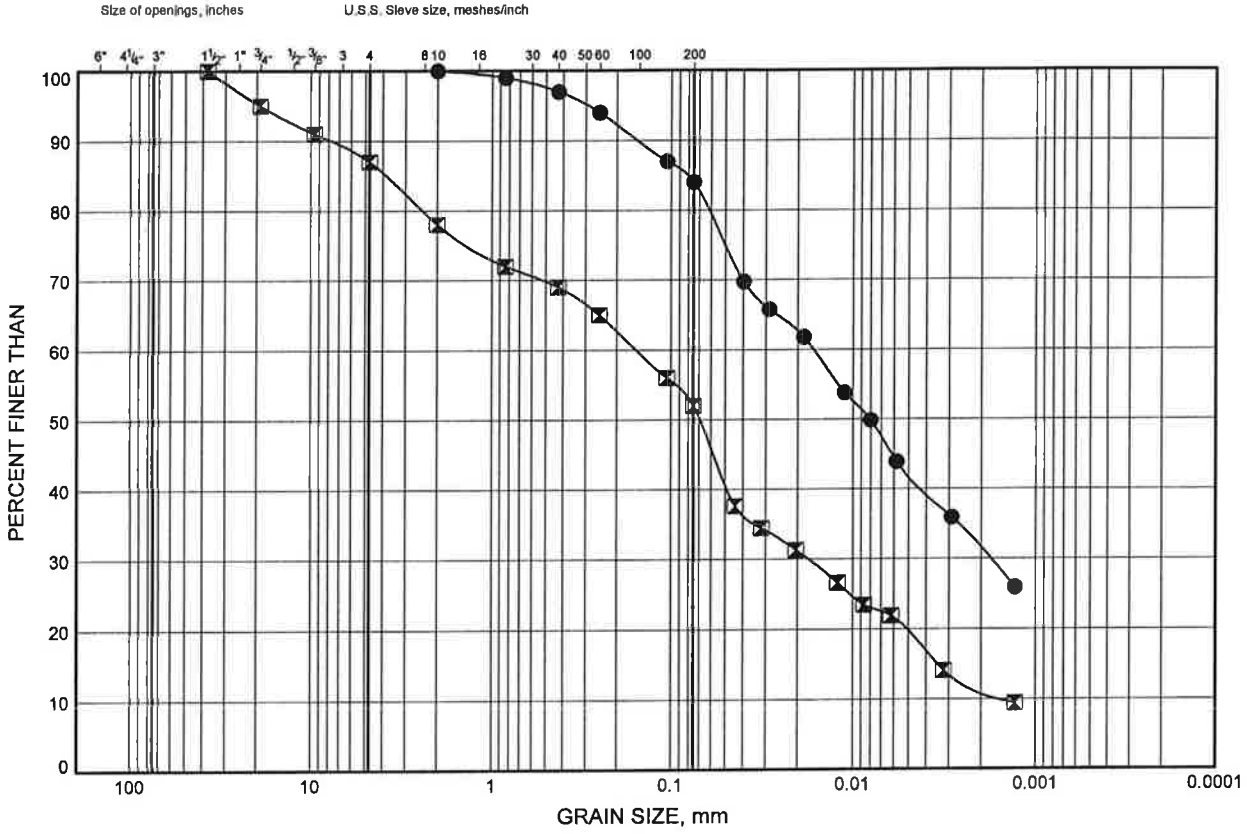
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B2

Clayey Silt



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS05	0.3	257.8
⊠	SS14	0.3	254.6

Date January 2007

Project 105-00-00

Prep'd DB

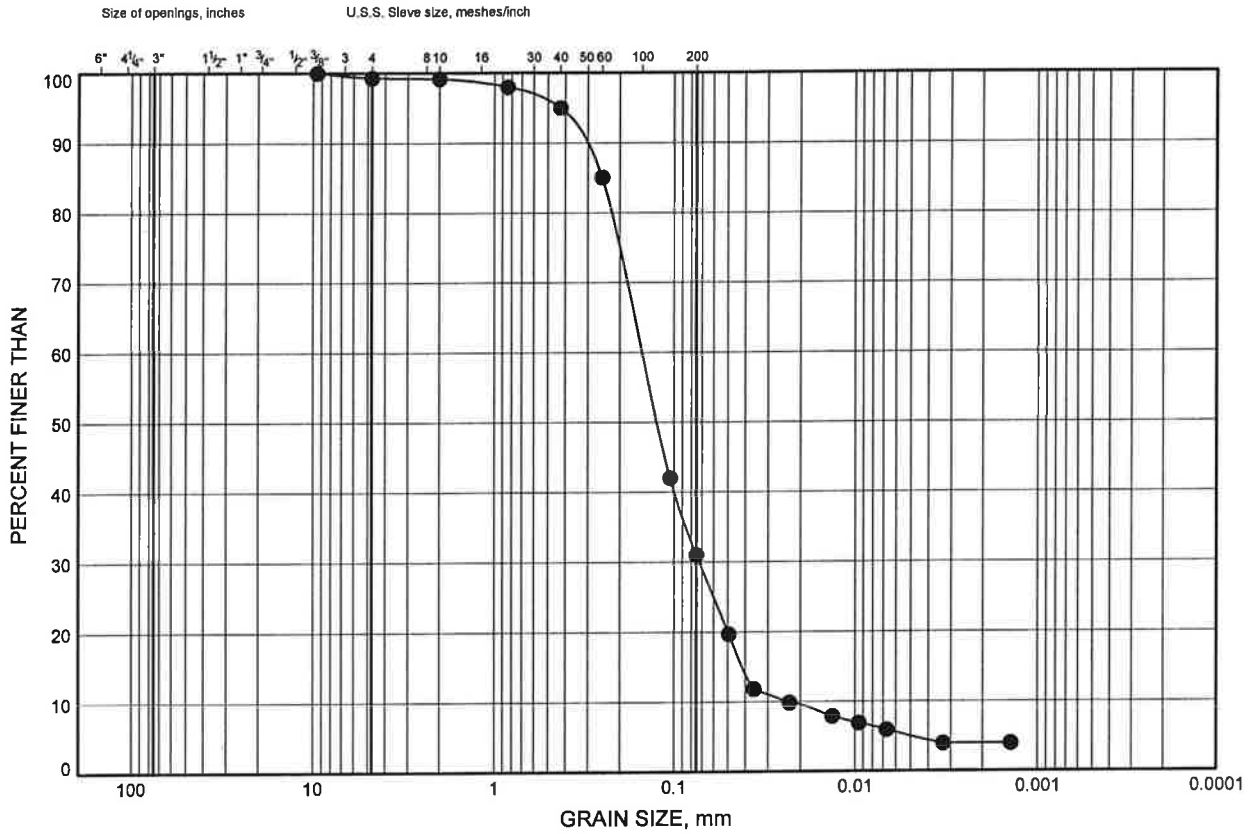
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B3

Sand



COBBLE SIZE	GRAVEL		SAND			SILT and CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS15	1.0	244.8

Date January 2007

Project 105-00-00

Prep'd DB

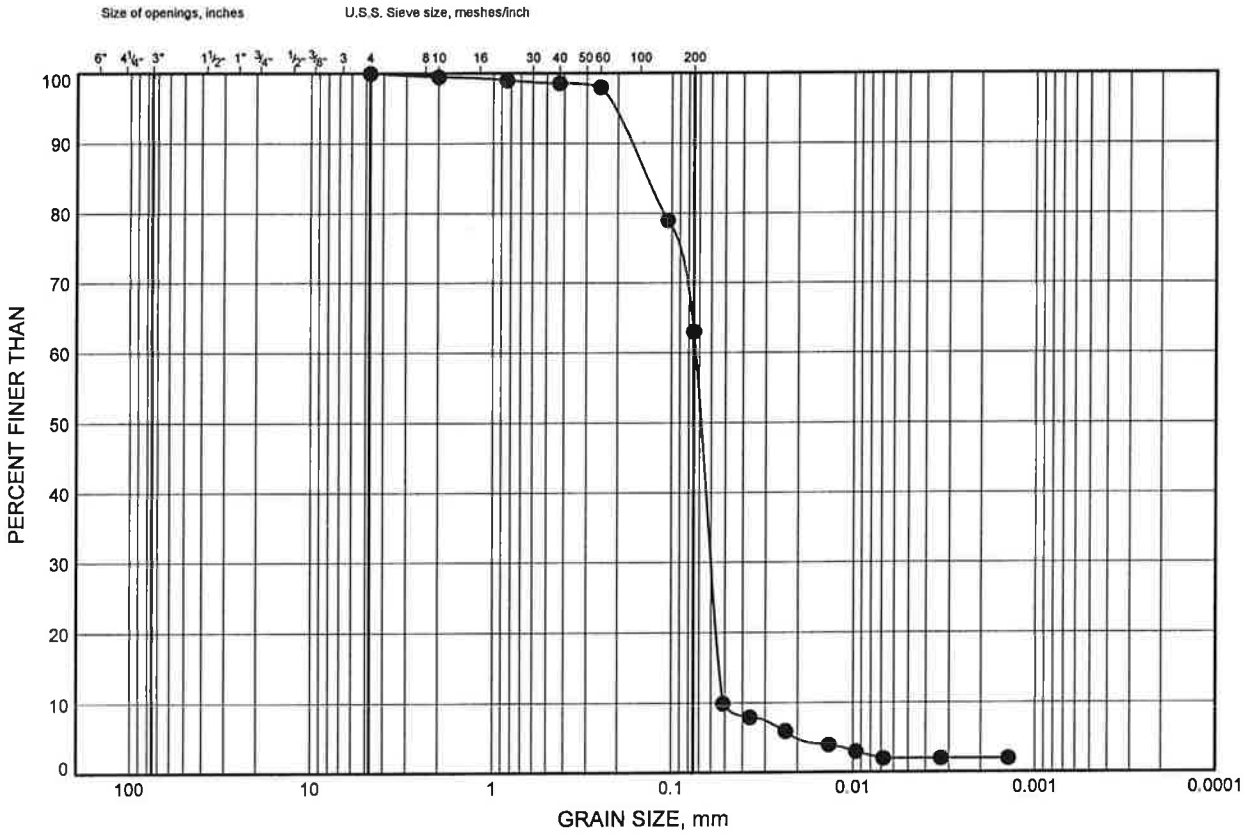
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B4

Silt and Sand



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS15	3.2	242.6

Date January 2007

Project 105-00-00

Prep'd DB

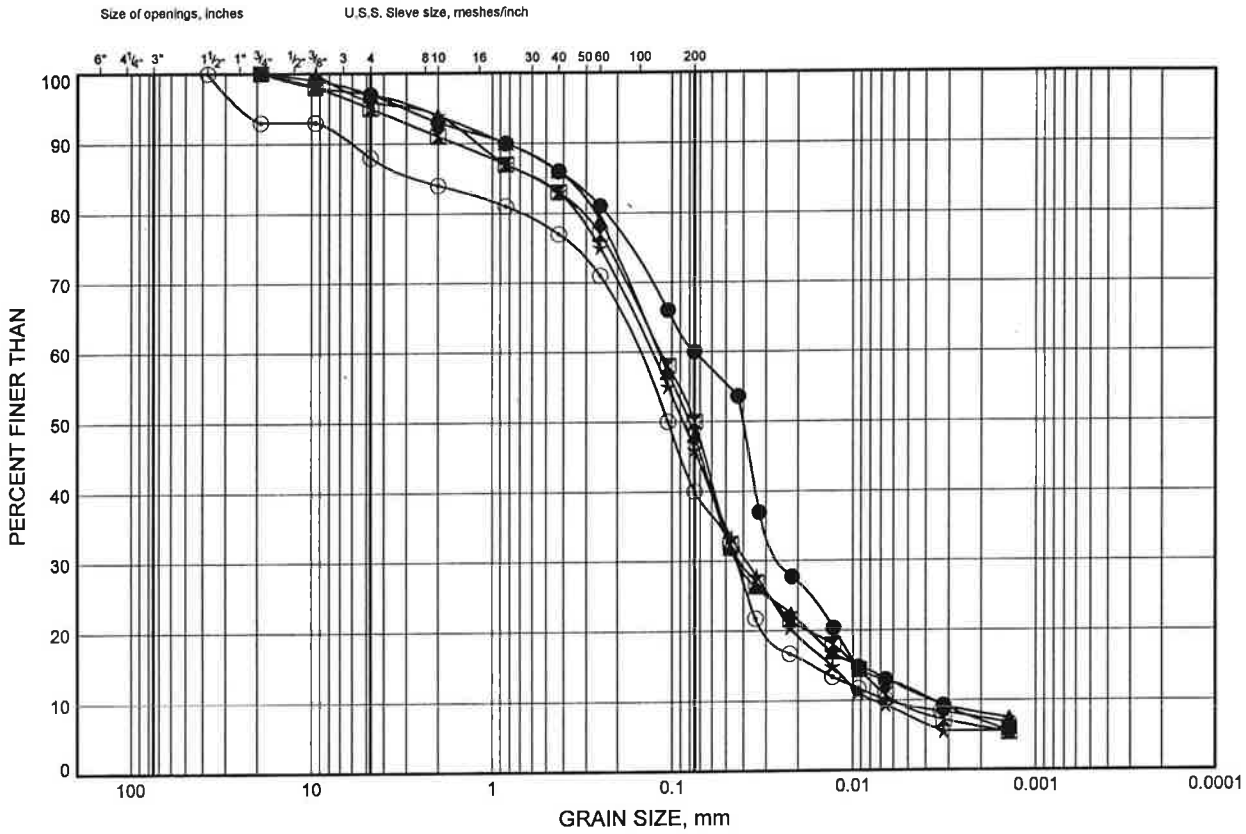
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B5

Sand and Silt Till



COBBLE SIZE	GRAVEL		SAND			FINE GRAINED
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS01	7.8	250.1
⊠	SS05	9.3	248.8
▲	SS06	7.8	250.9
★	SS07	7.0	253.4
⊙	SS13	10.9	249.4

Date January 2007

Project 105-00-00

Prep'd DB

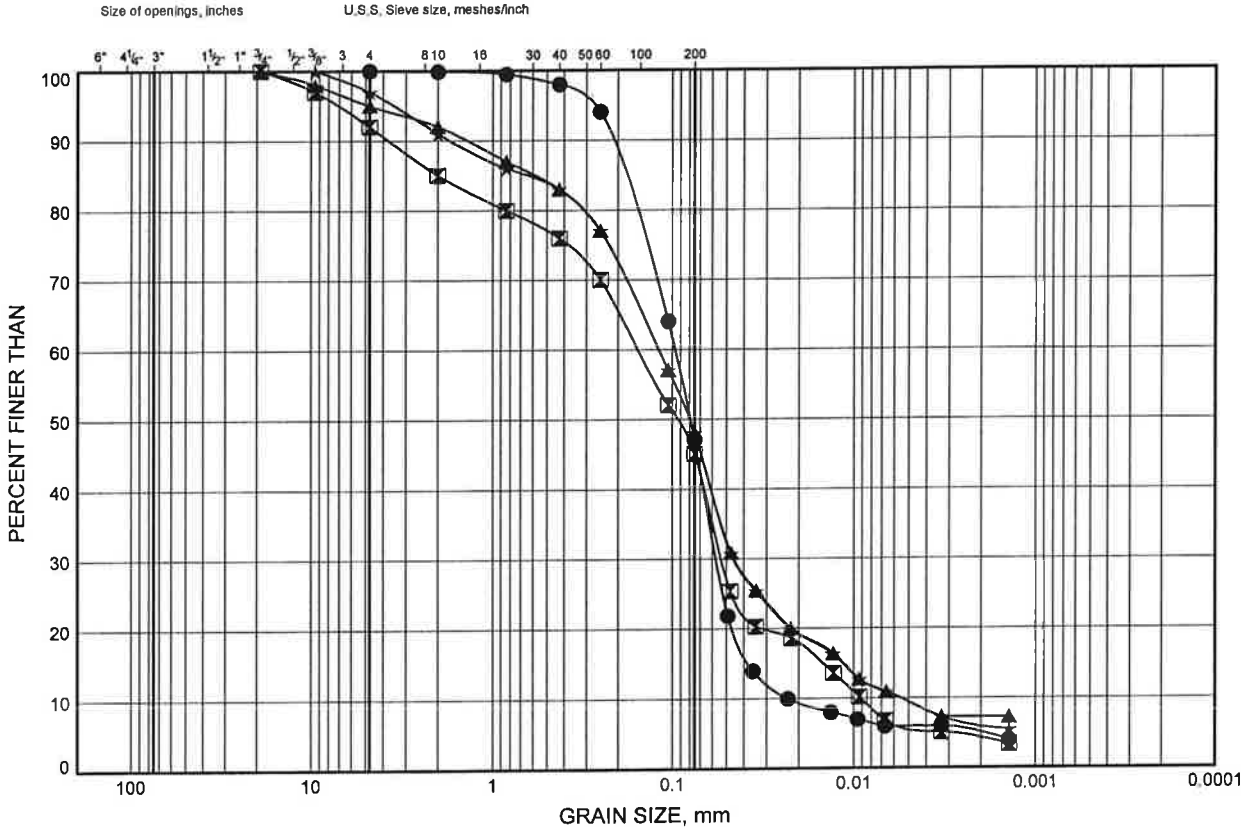
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 19/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B6

Sand and Silt Till



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS14	3.2	251.7
⊠	SS14	7.8	247.1
▲	SS15	4.7	241.1
★	SS15	6.3	239.5

Date January 2007

Project 105-00-00

Prep'd DB

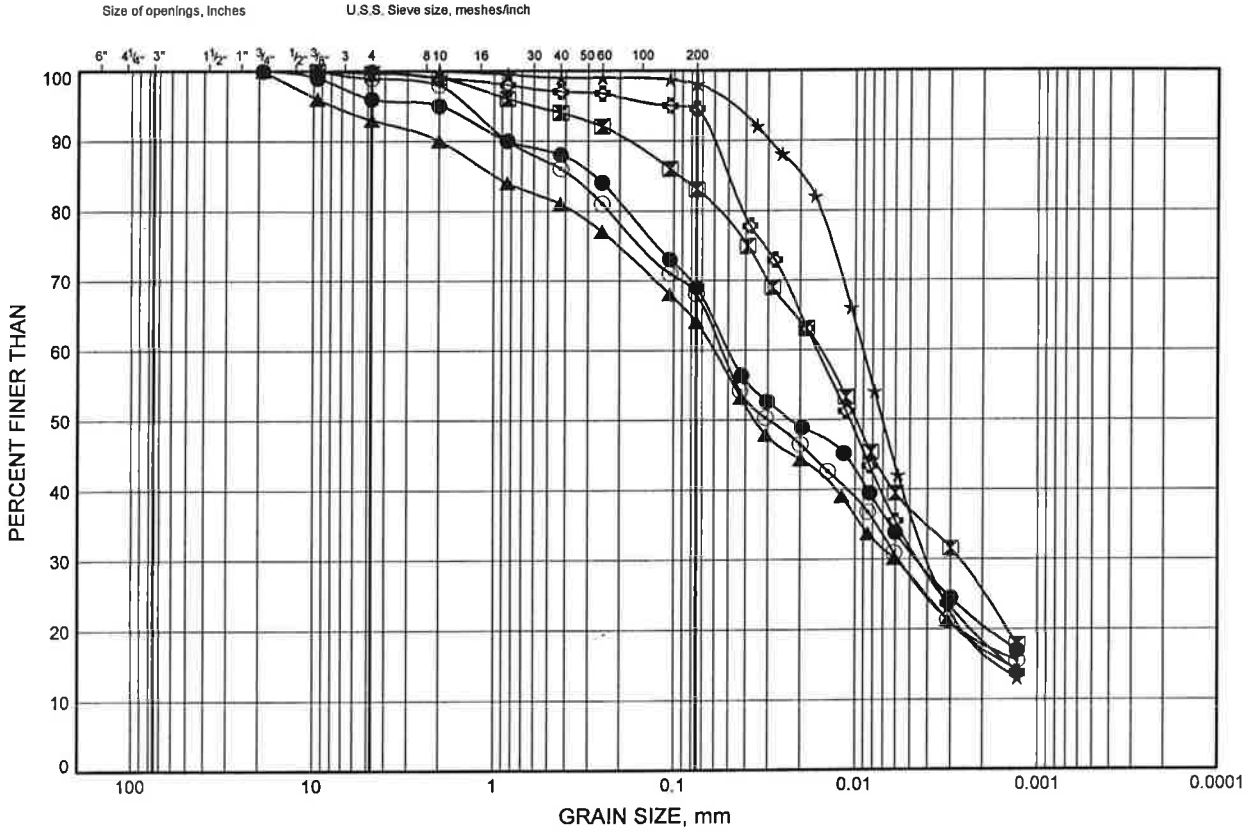
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B7

Clayey Silt Till



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS01	4.7	253.2
⊠	SS01	9.3	248.6
▲	SS02	3.2	255.1
★	SS02	7.8	250.5
⊙	SS03	1.7	256.3
✿	SS03	10.9	247.1

Date January 2007

Project 105-00-00

Prep'd DB

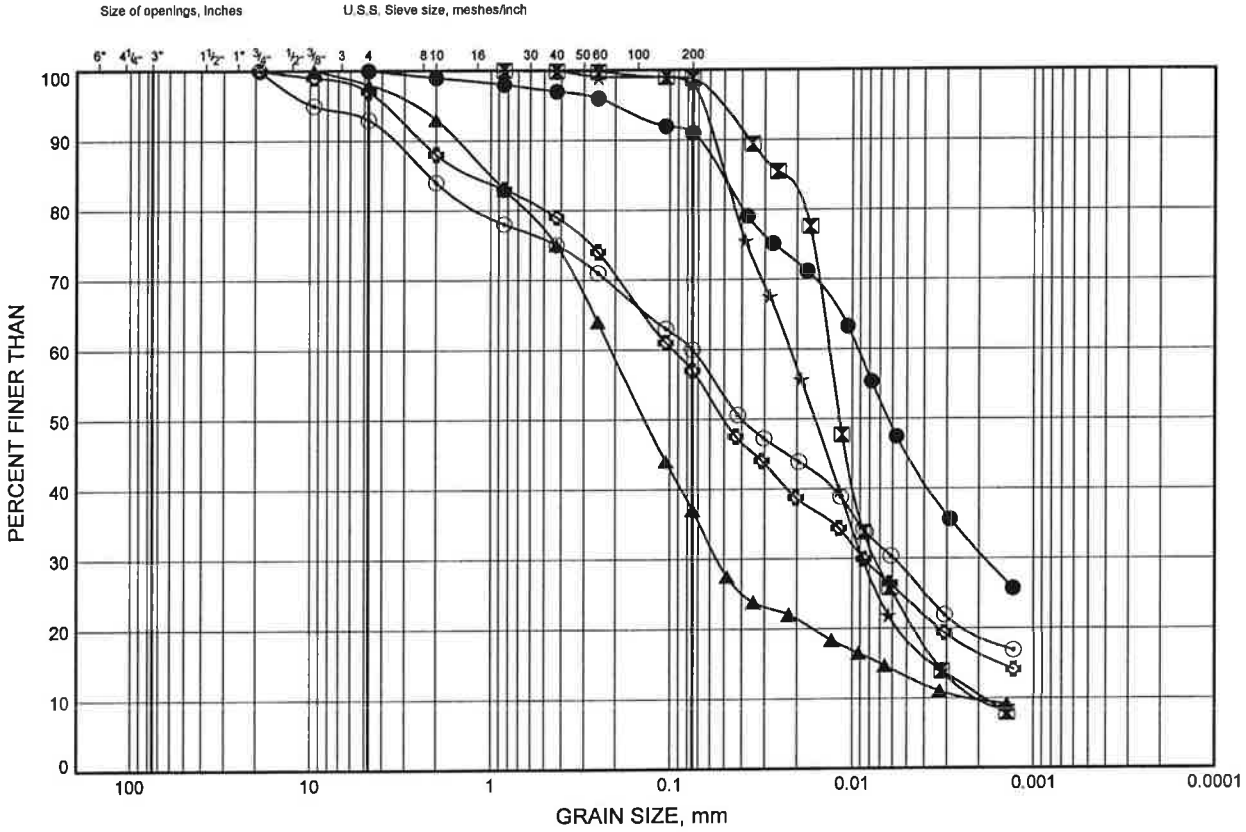
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B8

Clayey Silt Till



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS04	6.3	251.8
⊠	SS06	10.9	247.8
▲	SS07	4.7	255.7
★	SS07	9.3	251.1
⊙	SS08	1.7	258.4
✿	SS08	4.7	255.4

Date January 2007

Project 105-00-00

Prep'd DB

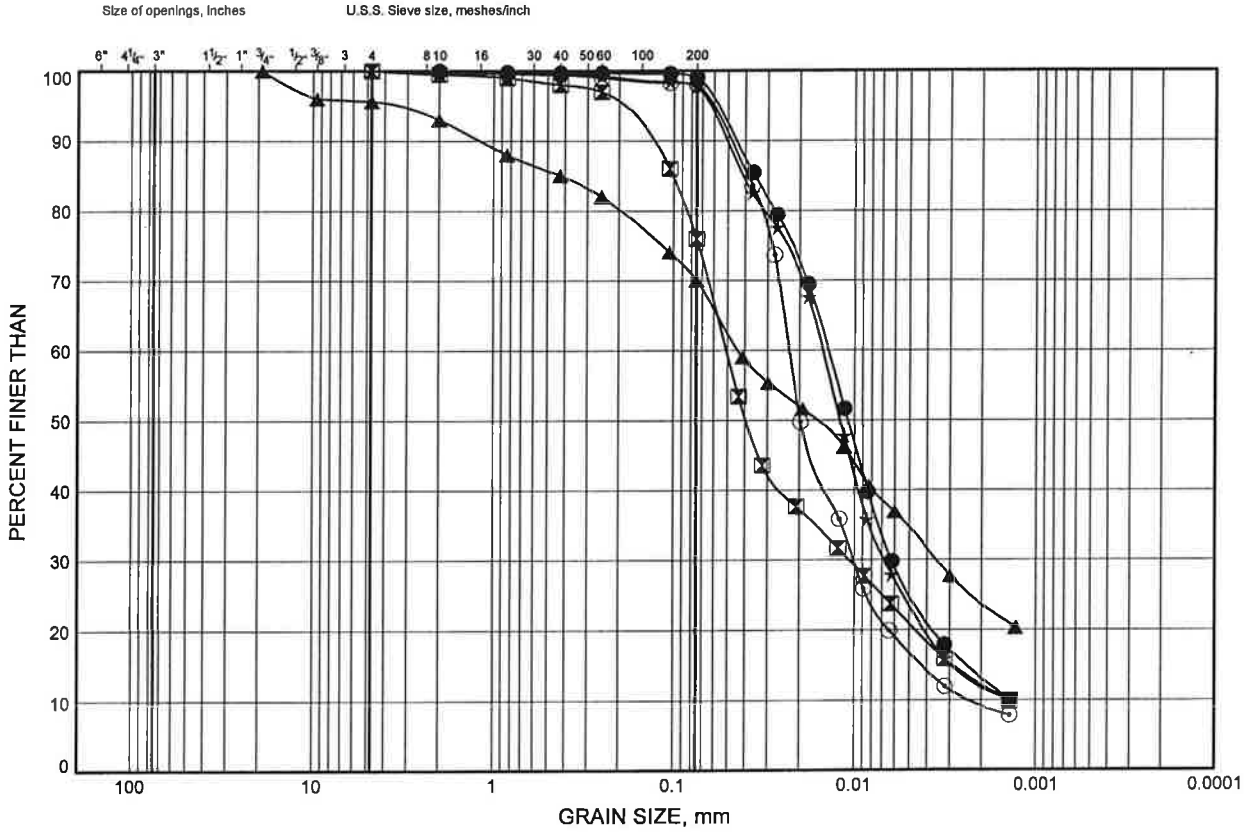
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B9

Clayey Silt Till



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS08	8.6	251.5
⊠	SS12	17.0	244.3
▲	SS13	6.3	254.0
★	SS14	10.9	244.0
⊙	SS14	12.3	242.6

Date January 2007

Project 105-00-00

Prep'd DB

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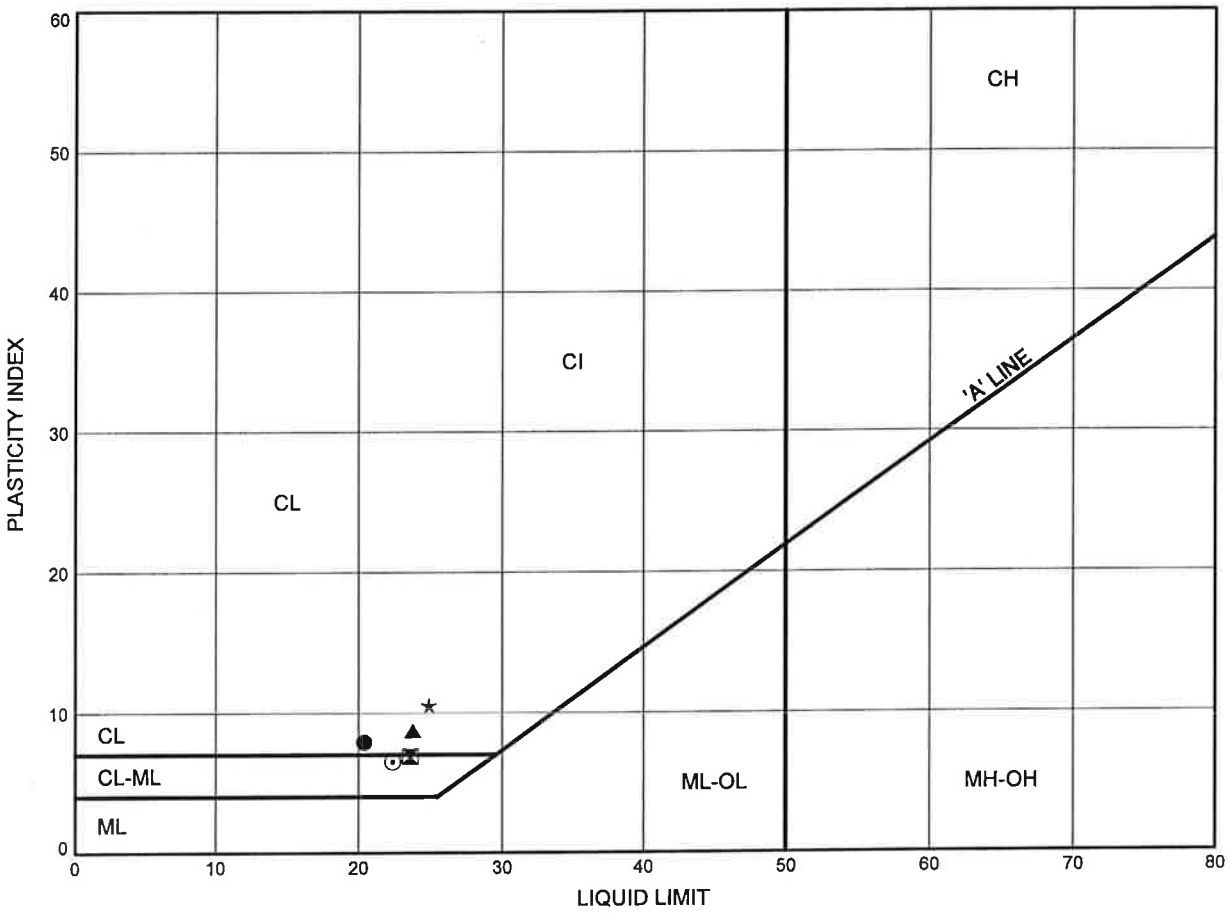
GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

ATTERBERG LIMITS TEST RESULTS

FIGURE B10

Clayey Silt Till



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS01	4.7	253.2
⊠	SS01	9.3	248.6
▲	SS02	3.2	255.1
★	SS03	1.7	256.3
⊙	SS03	10.9	247.1

Date January 2007

Project 105-00-00

Prep'd DB

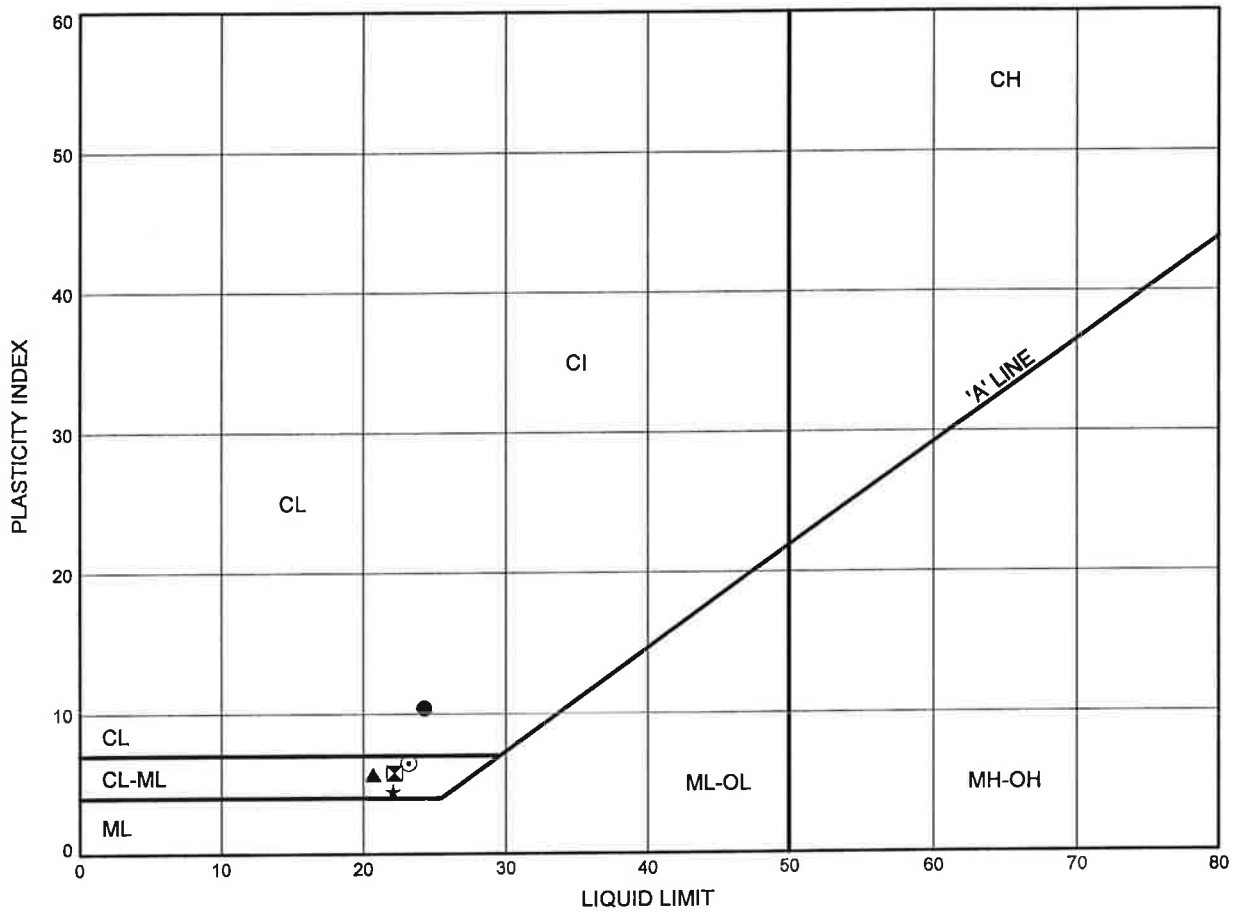
Chkd. RA

ALTR 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

ATTERBERG LIMITS TEST RESULTS

FIGURE B11

Clayey Silt Till



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS04	6.3	251.8
⊠	SS06	10.9	247.8
▲	SS07	4.7	255.7
★	SS07	9.3	251.1
⊙	SS08	1.7	258.4

Date January 2007

Project 105-00-00

Prep'd DB

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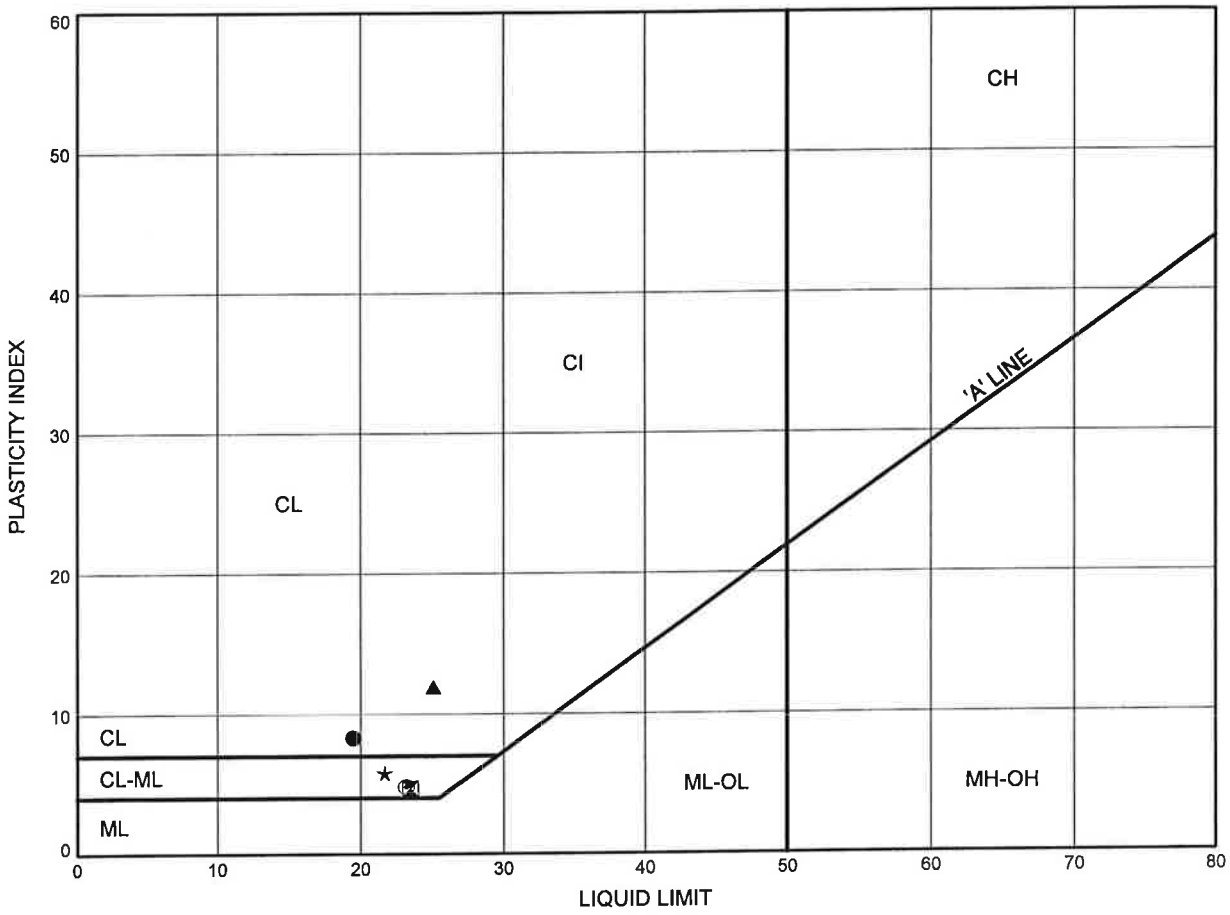
ALTR 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

ATTERBERG LIMITS TEST RESULTS

FIGURE B12

Clayey Silt Till



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS08	4.7	255.4
⊠	SS08	8.6	251.5
▲	SS13	6.3	254.0
★	SS14	10.9	244.0
⊙	SS14	12.4	242.5

Date January 2007

Project 105-00-00

Prep'd DB

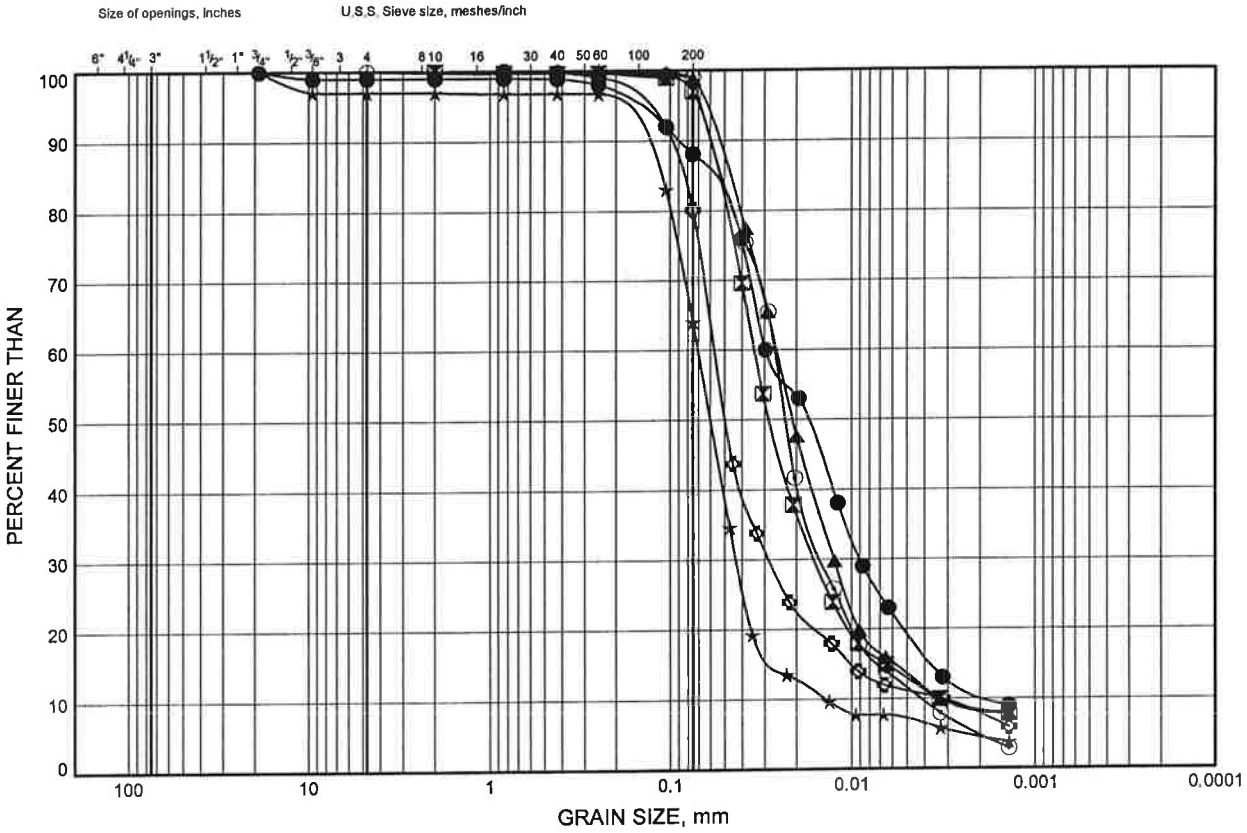
Chkd. RA

ALTR 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

GRAIN SIZE DISTRIBUTION

FIGURE B13

Silt



COBBLE SIZE	GRAVEL		SAND			SILT and CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS08	7.0	253.1
⊠	SS10	7.8	252.9
▲	SS10	12.3	248.4
★	SS10	15.4	245.3
⊙	SS11	12.3	249.1
✿	SS12	12.3	249.0

Date January 2007

Project 105-00-00

Prep'd DB

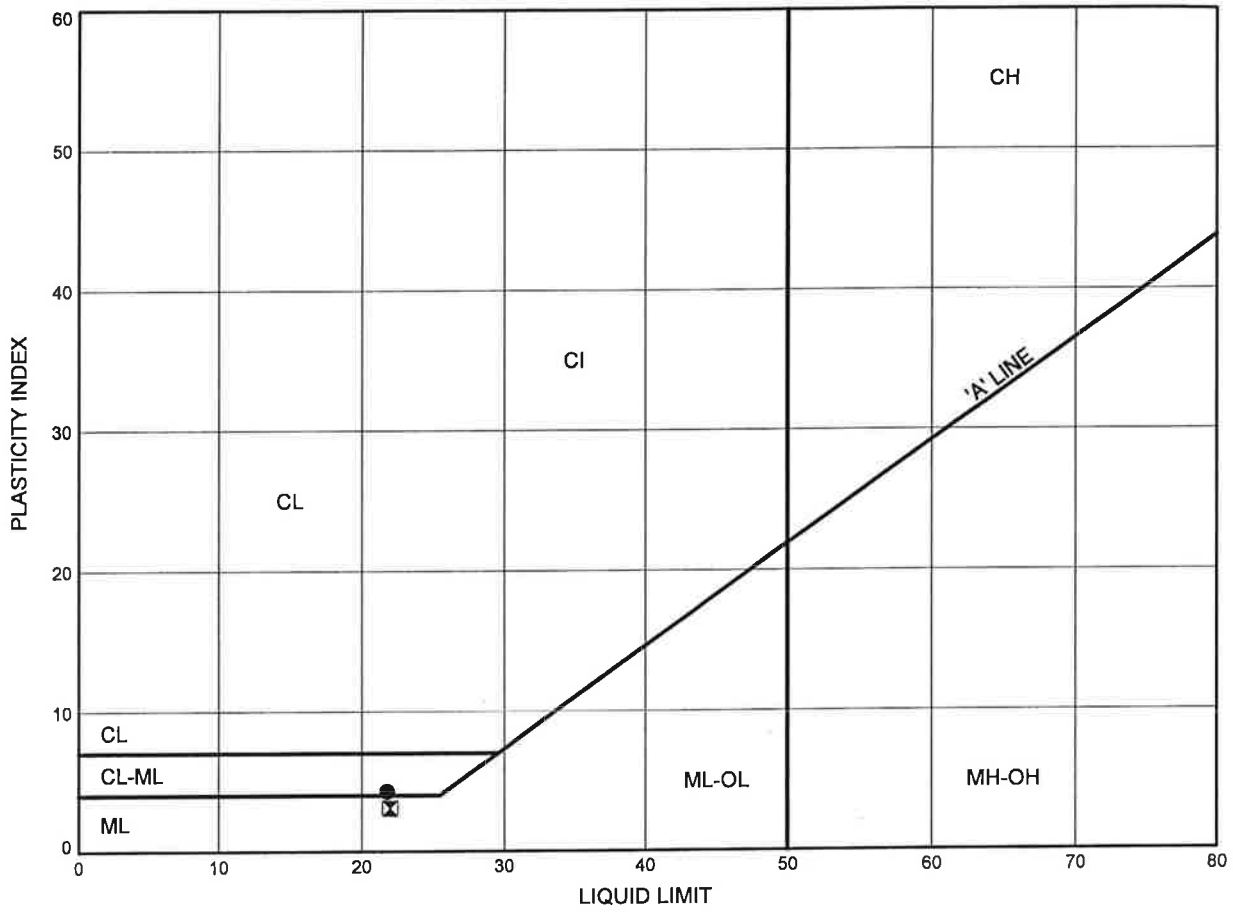
Chkd. RA

GSD 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

ATTERBERG LIMITS TEST RESULTS

FIGURE B14

Silt



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SS10	12.4	248.3
⊠	SS11	12.4	249.0

Date January 2007

Project 105-00-00

Prep'd DB

Chkd. RA

ALTR 1-00-0350 HWY 410 CULVERT & STORM SEWER.GPJ 16/01/07

APPENDIX C

Record of Boreholes
(Previous Investigations)

Terraprobe Limited

RECORD OF BOREHOLE No EC-1

1 OF 1

METRIC

W.P. 105-00-00 LOCATION Coords: N:4845155.1 E:278749.2 (Etobicoke Creek) ORIGINATED BY MS

DIST _____ HWY 410 Phase III BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 05.04.05 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
253.0	Ground Surface										
0.0	**200mm TOPSOIL**										
0.2 / 252.3	**CLAYEY SILT** - some sand, trace gravel, trace rootlets and wood pieces, damp, firm, brown		1	SS	4						
0.7	**SILTY SAND** trace gravel, damp, loose, brown		2	SS	5		252				
			3	SS	7						
250.9							251				
2.1	**SAND AND SILT** trace gravel, trace clay, moist to wet, dense to very dense, brown (GLACIAL TILL)		4	SS	51						
			5	SS	50/15cm		250				
			6	SS	57		249				9 41 44 6
	grey		7	SS	42	▽*	248				
	compact		8	SS	29						
			9	SS	36		247				
246.4											
6.6	End of Borehole										

*Water level at 5.0m (unstabilized) and hole open to 5.3m on completion of drilling.

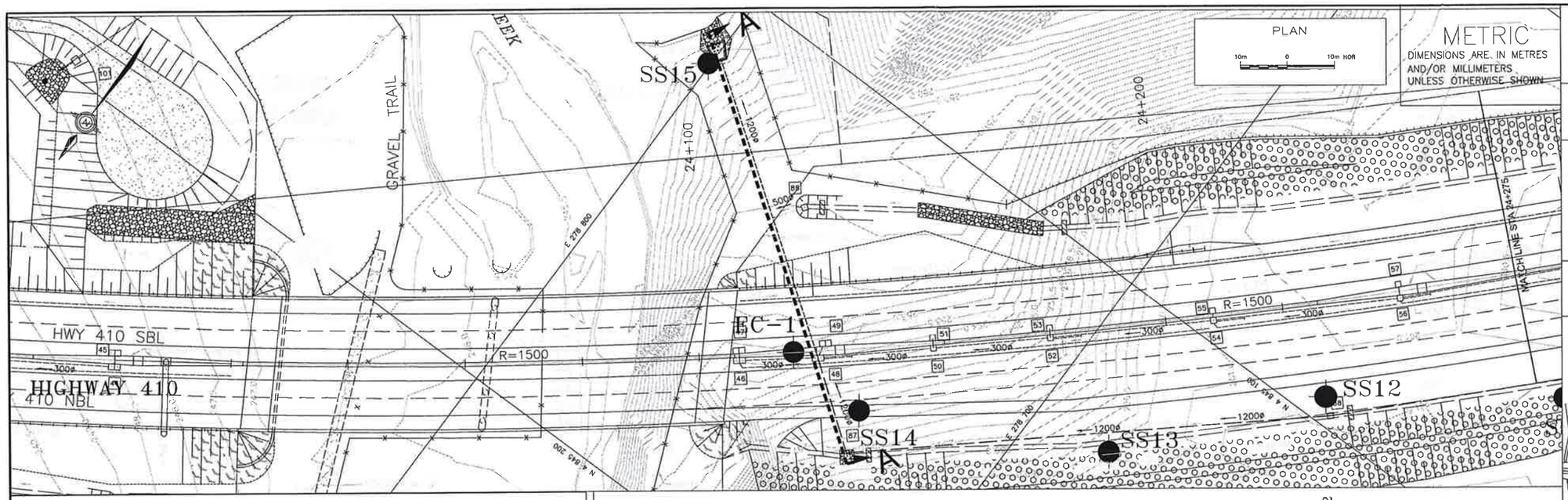
+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

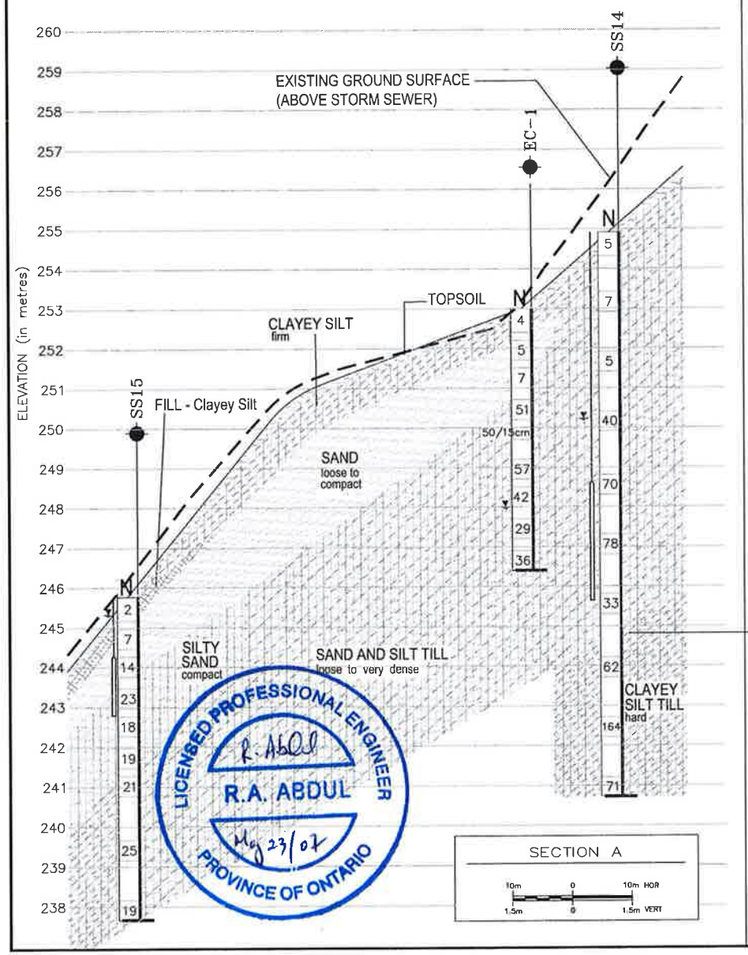
APPENDIX D

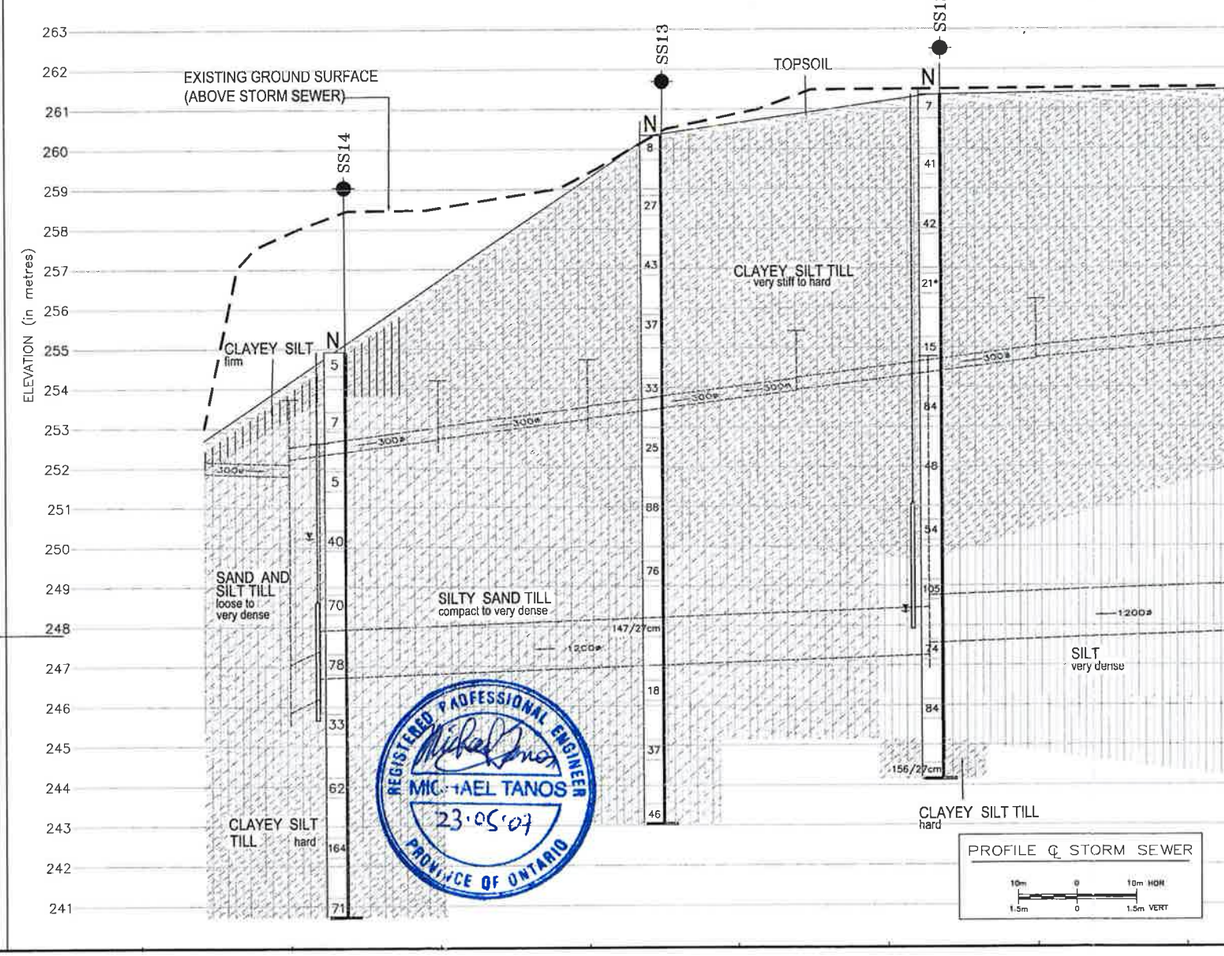
Drawing titled

"Borehole Locations and Soil Strata"

Terraprobe Limited







CONT No

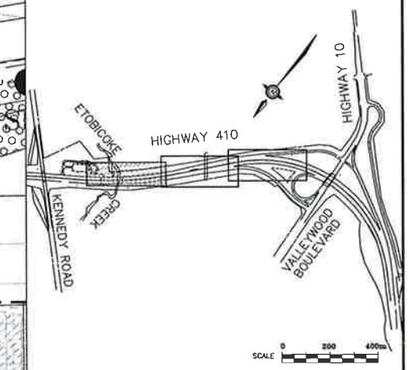
WP No 105-00-00

HIGHWAY 410 PHASE III
1200mm STORM SEWER
BOREHOLE LOCATIONS & SOIL STRATA

SHEET 1 OF 3

Giffels
An Ingenium Group Company

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing



KEY PLAN

LEGEND

●	Bore Hole
⊕	Dynamic Cone Penetration Test
⊕	Bore Hole And Cone
'N'	Blows/0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
▼	WL at Time of Investigation
▼	WL in Piezometer 2006 05
	Piezometer
90%	Rock Quality Designation
A/R	Auger Refusal

No	ELEVATION	COORDINATES NORTHING	COORDINATES EASTING
SS12	261.3	4845094.6	278652.5
SS13	260.3	4845131.7	278682.3
SS14	254.9	4845156.7	278730.5
SS15	245.8	4845116.6	278800.4
EC-1	253.0	4845155.1	278749.2

NOTE

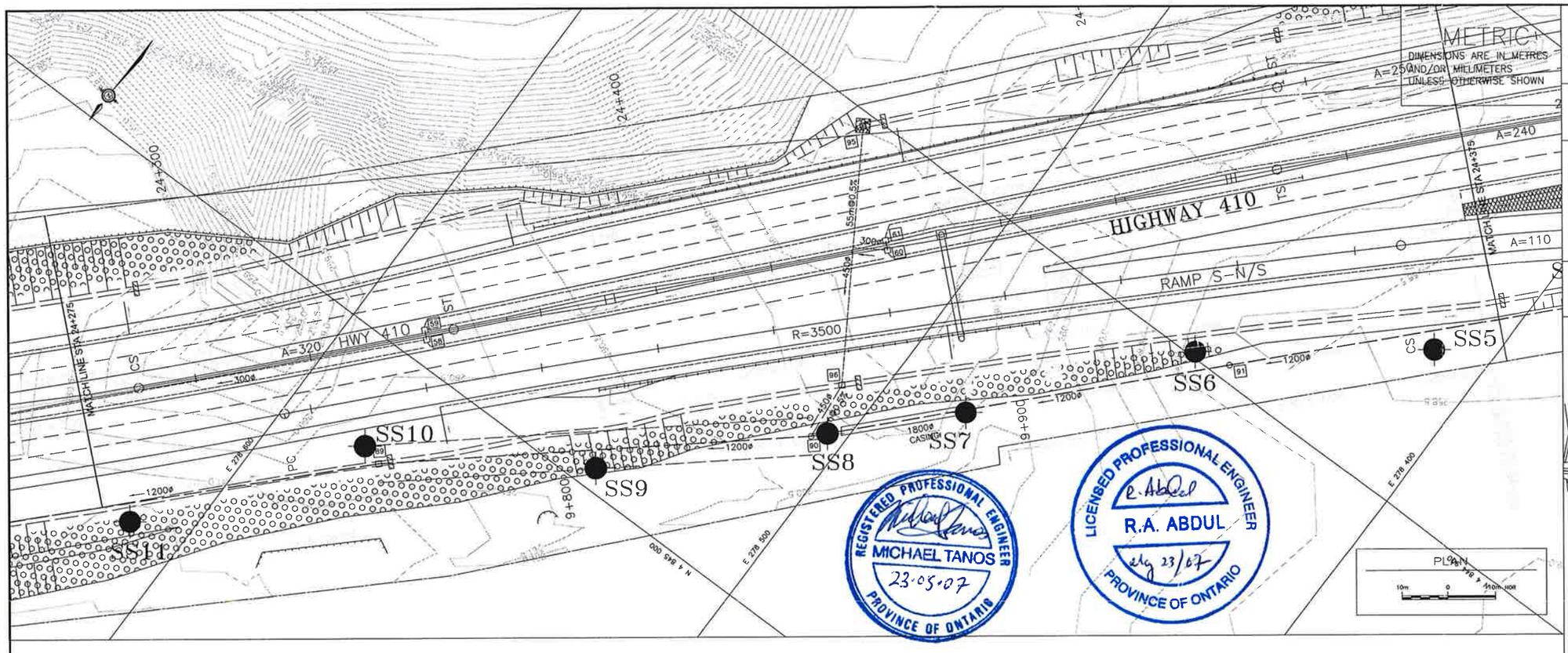
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

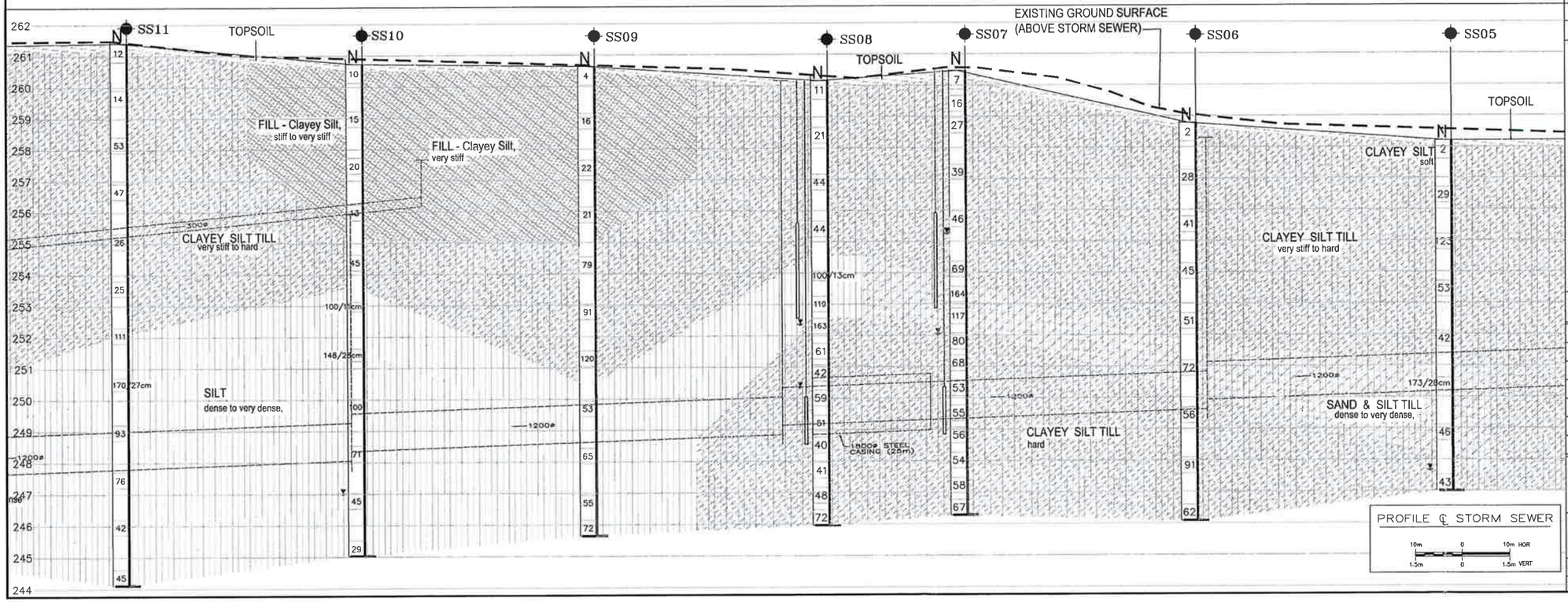
REVISIONS	DATE	BY	DESCRIPTION

DESIGN R.A	CODE		LOAD	DATE	JAN. 2007	
DRAWN JD	CHK R.A	SITE	STRUCT	SCHEME	DWG 2	

LICENSED PROFESSIONAL ENGINEER R.A. ABDUL PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER MICHAEL TANOS 23.05.07 PROVINCE OF ONTARIO





CONT No

WP No

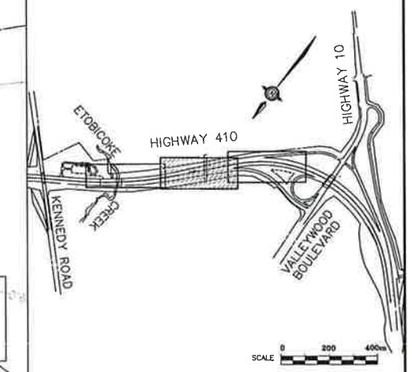
100-00

HIGHWAY 410 PHASE III
1200mm STORM SEWER
BOREHOLE LOCATIONS & SOIL STRATA

SHEET 2 OF 3

Giffels
An Ingenium Group Company

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing



KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- 'N' — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer 2006 05
- Piezometer
- 90% — Rock Quality Designation
- A/R — Auger Refusal

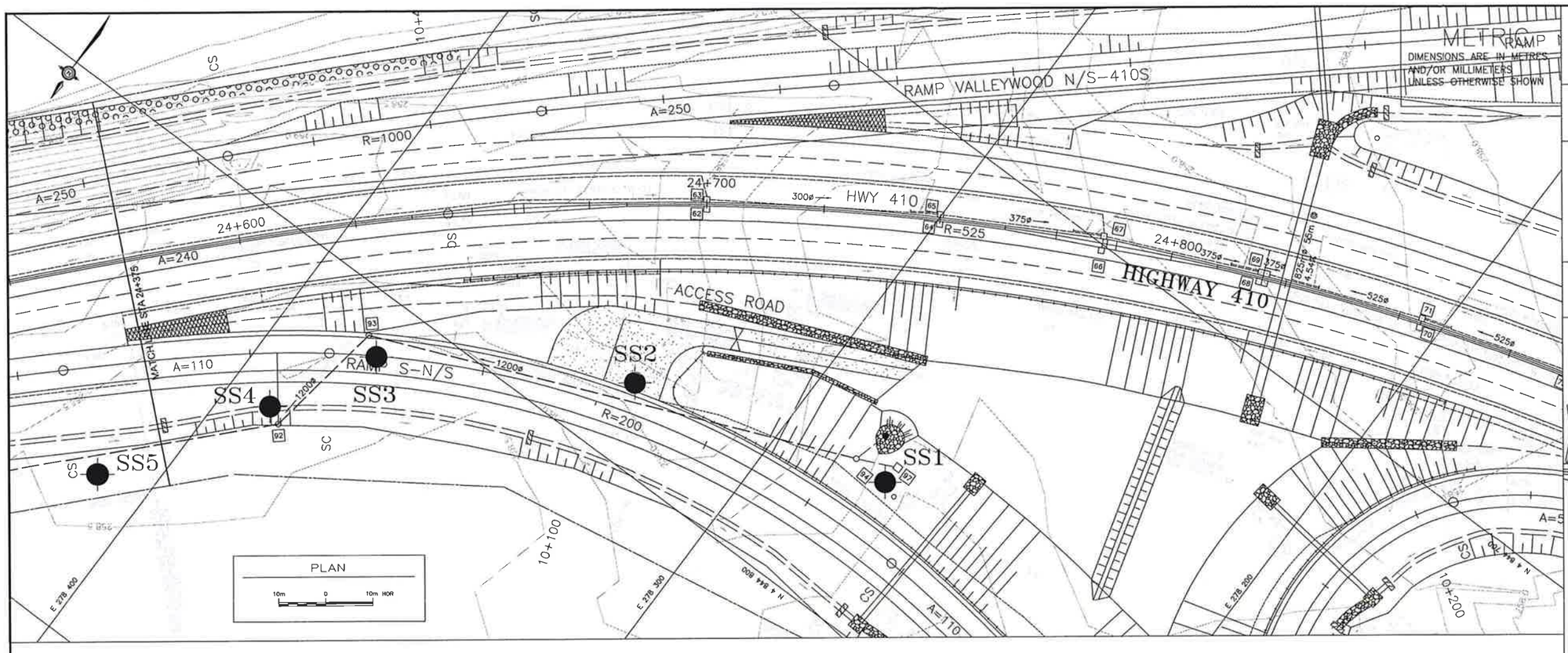
No	ELEVATION	COORDINATES	
		NORTHING	EASTING
SS5	258.1	4844867.8	278411.1
SS6	258.7	4844898.8	278451.7
SS7	260.4	4844938.5	278482.9
SS8	260.1	4844959.8	278503.9
SS9	260.6	4844995.4	278538.9
SS10	260.7	4845021.1	278581.1
SS11	261.4	4845064.2	278611.6

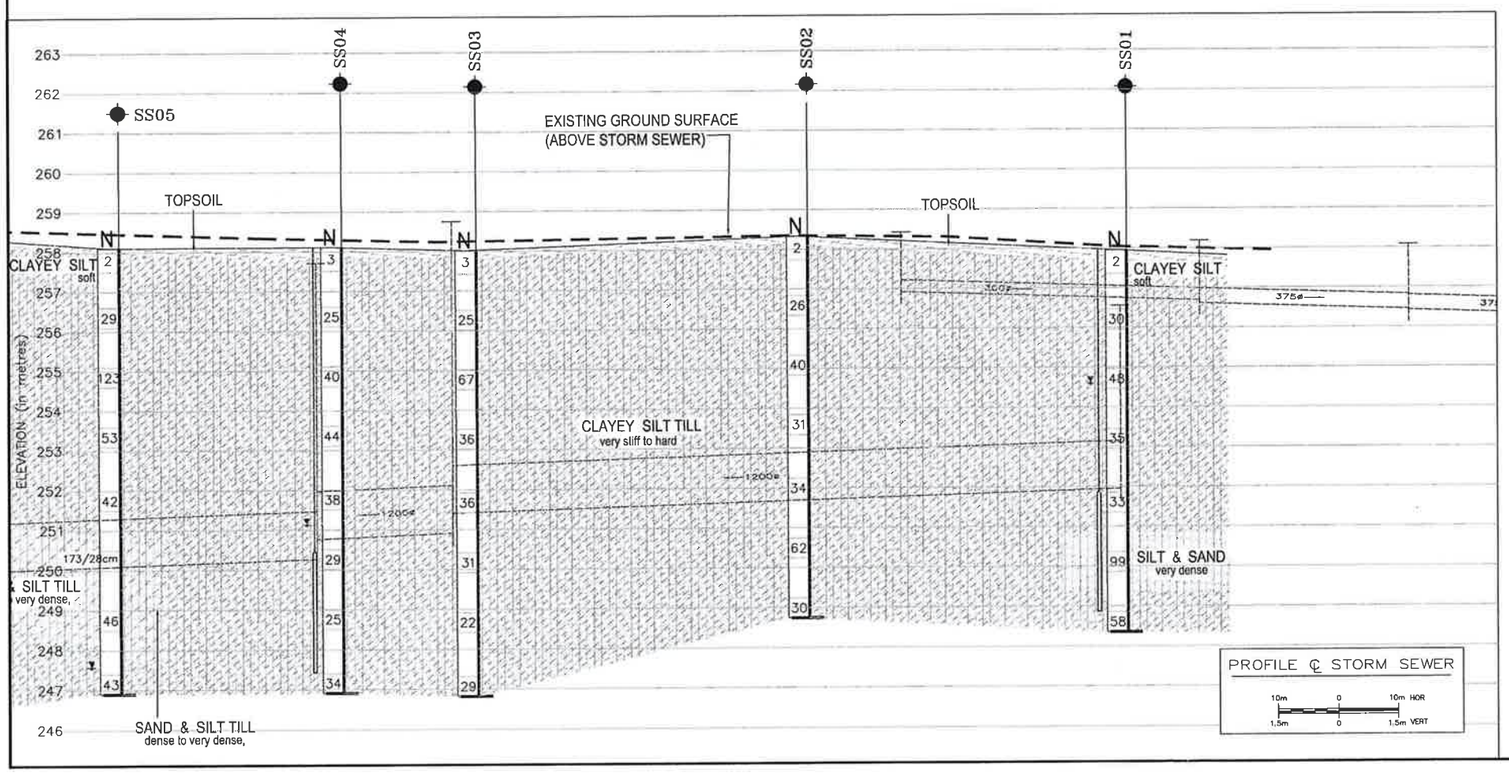
NOTE

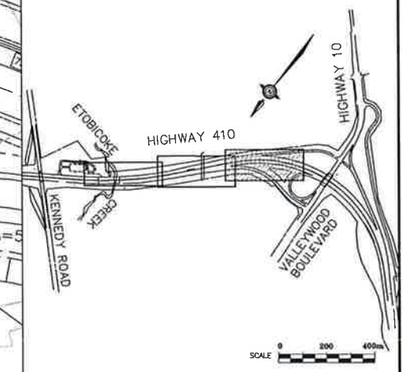
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN R.A	CODE		LOAD		DATE JAN. 2007		
DRAWN JD	CHK R.A	SITE	STRUCT	SCHEME	DWG 2		







KEY PLAN

CONT No
WP No

100-00

HIGHWAY 410 PHASE III
1200 mm STORM SEWER
BOREHOLE LOCATIONS & SOIL STRATA

SHEET 3 OF 3

Giffels
An Ingenium Group Company

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing

DIMENSIONS ARE IN METRES AND/OR MILLIMETERS UNLESS OTHERWISE SHOWN

REGISTERED PROFESSIONAL ENGINEER
MICHAEL TANOS
23.05.07
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
R.A. ABDUL
dtg 23/07
PROVINCE OF ONTARIO

LEGEND

●	Bore Hole
⊕	Dynamic Cone Penetration Test
⊕	Bore Hole And Cone
'N'	Blows/0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
▼	WL at Time of Investigation
▼	WL in Piezometer 2006 05
	Piezometer
90%	Rock Quality Designation
A/R	Auger Refusal

No	ELEVATION	COORDINATES	
		NORTHING	EASTING
SS1	257.9	4844768.6	278275.6
SS2	258.3	4844783.5	278331.0
SS3	258.0	4844812.1	278378.5
SS4	258.1	4844834.1	278390.3
SS5	258.1	4844867.8	278411.1

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	R.A	CODE		LOAD		DATE	JAN. 2007
DRAWN	JD	CHK	R.A	SITE	STRUCT	SCHEME	DWG 2

APPENDIX E

Comparison of Installation Methods

Terraprobe Limited

COMPARISON OF SEWER INSTALLATION METHODS

Open Cut Excavation	Jack & Bore	Microtunnelling	Pipe Ramming
Advantages: i. Readily available equipment/technology. ii. Construction method is relatively simple and well known by many contractors in Ontario. iii. Economical. ***Disadvantages:*** i. Requires protection and support of the existing watermain and sanitary sewer utilities where they cross the excavation.	***Advantages:*** i. Avoids open cut excavation over the existing watermain and sanitary sewer. ii. Readily available equipment/technology. iii. More economical than Microtunnelling. iv. Accuracy/Tolerance ±25 mm. v. Relatively good control of potential settlement. ***Disadvantages:*** i. More expensive than open cut excavation. ii. Requires constructing special jacking and receiving pits. iii. Requires good care and workmanship by experienced tunnellers in order to reduce ground settlement above the existing utility pipes. iv. Potential problems such as boulders and water bearing sand lenses can cause ground loss during tunnelling which can result in excessive ground settlement and damage to the existing overhead watermain and sanitary sewer.	***Advantages:*** i. Avoids open cut excavation over the existing watermain and sanitary sewer utilities. ii. Well tested technology. iii. Smaller jacking and receiving pits compared to jack and bore. iv. Accuracy/Tolerance ±25 mm. v. Relatively good control of potential settlement. ***Disadvantages:*** i. Equipment not readily available. ii. More expensive than Jack & Bore.	***Advantages:*** i. Avoids open cut excavation over the existing watermain and sanitary sewer. ii. More economical than microtunnelling. iii. Perhaps best control over potential settlement. ***Disadvantages*** i. Technology not readily available in local area. ii. Potential for significant soil disturbance if a blockage is created at the end of the pipe during installation. iii. Vibrations due to pipe ramming may have a detrimental effect on the existing utilities above. iv. Accuracy/Tolerance >25 mm v. Relatively large area required to accommodate bore pit and to lay out pipe.

APPENDIX F

Suggested NSSP Wording

Terraprobe Limited

In this report reference is made to the following Provincial Standard

- OPSS 514, November 2005.

The contract documents should contain a NSSP containing the following wording:

Cobbles and Boulders

"The Contractor is informed that the soils at this site may contain cobbles and boulders that may impede the progress of trenching and trenchless installation. The soil conditions are described in the Foundation Investigation Report prepared for this site. Reference should be made to this report for a description of the soil conditions"

QUALITY CONTROL RECORD

Project *Highway 410 Extension – Phase III From 300 m East of Heart Lake Road to Highway 10*

Agreement No. *2005-A-000230* **W.P. No.** *105-00-00*

Site. *Storm Sewer* **Terraprobe File No.** *1-00-0350*

Task No./Description

- Final Foundation Investigation and Design Report & Response to MTO's comments on draft report.

Item/s Submitted for Review

- MTO's Memorandum of August 28, 2006
- Final Foundation Investigation & Design Report
- Terraprobe's letter of response to MTO's comments.

Submitted for review by: Rehman Abdul on (M/D/Y) 05/22/2007

Item Reviewed by: Mike Jarvis on (M/D/Y) 05/22/2007

- [x] Accepted As Is
- [ ] Accepted with Minor Revisions
- [ ] Revisions Required Item to be Resubmitted

Comments: _____