



**FINAL REPORT  
PRELIMINARY FOUNDATION INVESTIGATION  
AND DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION (WEST PART)  
ASHBURN ROAD TO SIMCOE STREET NORTH  
REGION OF DURHAM  
W.O. 07 – 20016**

**Geocres Number: 30M15-103**

**Prepared for:**

**Ministry of Transportation Ontario**

## EXECUTIVE SUMMARY

The proposed Highway 407 East Extension extends from the current terminus of Highway 407 at Brock Road in the City of Pickering to Highway 35/115 in the Municipality of Clarington. For the purposes of preliminary design, the project route has been divided into three sections:

- the Western Section that extends from Brock Road in the City of Pickering to Ashburn Road in the Town of Whitby. This section includes a north-south link to Highway 401, designated the West Durham Link.
- the Central Section that extends from Ashburn Road to Courtice Road in the Municipality of Clarington (subsequently divided into west and east parts for the implementation stage).
- the Eastern Section that extends from Courtice Road to Highway 35/115 in the Municipality of Clarington. This section includes a north-south link to Highway 401, designated the East Durham Link.

A Foundation Desktop Study was previously carried out in 2008 for each section of the proposed highway extension to assess the potential geotechnical conditions affecting foundation design at the sites of individual structures in advance of site-specific field investigation. The Desktop Study was based on assessment of site geology using air-photo interpretation and hydrogeologic information, as well as borehole data obtained from previous investigations including the preliminary investigations conducted by MTO in 1994 for planning purposes. The results of the 2008 desktop study were presented in three separate reports (*“Foundation Desktop Study, Highway 407 East Extension-Western Section; Central Section; Eastern Section”*, Thurber Engineering Ltd., October 2008).

This report is one of four Preliminary Foundation Investigation and Design Reports (FIDR) subsequently prepared for the Highway 407 East Extension. The preliminary investigation and design reports provide “as near as possible” preliminary design level foundation information for environmental assessment purposes and to assist planning, selection and preliminary design of foundations for bridge, culvert and grade separation structures, as well as for deep cuts and high fill embankments. The preliminary FIDR supercedes all previous reports including the Desktop Study for the purpose of preliminary foundation design and EA submission.

This particular report addresses the west part of the Central Section (implementation Phase One), from Ashburn Road to Simcoe Street North. The Western, east part of the Central, and Eastern sections are dealt with in separate reports prepared by Golder Associates Ltd. and Thurber Engineering Ltd. The technically preferred alignment of the Central Section is shown on Figure 1 following the text of this report.

The report is presented in two parts:

Part A - Preliminary Foundation Investigation Report (FIR): presents an overall description of the project, description of the regional geology/geomorphology and general groundwater conditions within the project limits, as well as site-specific subsurface and groundwater conditions at each of

the proposed structures, based on the results of limited borehole investigation and laboratory testing or on the desktop study information.

Part B - Preliminary Foundation Design Report (FDR): provides project-wide engineering recommendations for preliminary design, as well as site-specific preliminary foundation recommendations for each proposed structure, culvert, deep cut and high fill site.

As per the requirements of the Request for Proposal, each highway crossing (grade separation, bridge or culvert) was characterized as requiring a low, medium or high level of investigative effort. The target levels are defined in the RFP and summarized in Section 3.0 of this report. The desired investigative effort was attempted at each site; however, the target level could not be achieved at 1 out of 12 structure sites due to restricted access to private properties (no permission to enter).

For each medium and high level site where borehole information was obtained at or near the site, an individual Preliminary Foundation Investigation and Design Report (FIDR) was prepared. Each FIDR consisted of a Preliminary Foundation Investigation Report (FIR) sheet summarizing the results of the field investigation and geotechnical laboratory testing for the site, and a Preliminary Foundation Design Report (FDR) sheet presenting site-specific preliminary foundation design recommendations. The FIR and FDR sheets are presented following the text of the report.

Where permission to enter was not granted for a site, the information presented in the desktop study was utilized and the corresponding Anticipated Foundation Conditions (AFC) sheets are included in this report. AFC sheets for sites ranking a low level of investigative effort are also included.

For deep cut and high fill sections (depth/height greater than 4.5 m), summary tables have been included that summarize the deep cut and high fill locations, depths/heights, the anticipated subsurface conditions, and preliminary geotechnical recommendations. Foundation investigations were completed at 2 out of the 7 deep cut and high fill sections. The remaining 5 sections were not investigated due to lack of permission to enter.

While the information presented in this report may be used for planning and preliminary design purposes, it is not sufficient nor intended for detail design purposes. The preliminary subsurface investigation was limited to borehole drilling within accessible parts of sites where permission to enter was granted, or to desktop study level information. Where drilling was carried out, the boreholes were not necessarily drilled at or within the footprint of the foundation elements. As well, investigation was not possible at 1 of the structure sites due to lack of permission to enter. Accordingly, further investigation at the final locations of the foundation elements, approaches, deep cut and high fill sections will be required during detail design to establish detail design level subsurface information and confirm/reassess the preliminary recommendations.

TABLE OF CONTENTS	
<u>SECTION</u>	<u>PAGE</u>
EXECUTIVE SUMMARY .....	i
TABLE OF CONTENTS .....	ii
 <b>PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT</b>	
1.0 INTRODUCTION .....	1
2.0 PROJECT DESCRIPTION .....	1
3.0 INVESTIGATION PROCEDURES .....	1
4.0 SITE GEOLOGY AND STRATIGRAPHY .....	2
4.1 Regional Geology .....	2
4.2 Site-Specific Descriptions and Subsurface Conditions .....	3
4.3 General Groundwater Conditions .....	4
5.0 CLOSURE.....	5
 <b>PART B - PRELIMINARY FOUNDATION DESIGN REPORT</b>	
6.0 ENGINEERING RECOMMENDATIONS FOR PRELIMINARY DESIGN.....	6
6.1 General .....	6
6.2 Structure Foundation Recommendations.....	6
6.2.1 Spread Footings .....	6
6.2.2 Steel H-Piles .....	7
6.2.3 Caissons.....	7
6.3 Abutment and Retaining Walls.....	8
6.4 Lateral Earth Pressures for Design .....	8
6.5 Structure Approaches .....	9
6.5.1 Subgrade Preparation and Embankment Construction .....	9
6.5.2 Approach Embankment Stability.....	9
6.5.3 Approach Embankment Settlement .....	10
6.6 Seismic Considerations.....	10
6.7 Construction Considerations.....	10
6.7.1 Obstructions During Pile Driving / Caisson Installation .....	10
6.7.2 Excavation and Backfill .....	10
6.7.3 Groundwater and Surface Water Control .....	10
6.7.4 Protection Systems .....	11
6.7.5 Construction Access .....	11
7.0 CULVERTS .....	11

8.0 DEEP CUTS AND HIGH FILLS .....	11
8.1 General.....	11
8.2 Deep Cuts.....	12
8.2.1 Stability and Drainage .....	12
8.2.2 Construction Considerations.....	12
8.3 High Fills .....	12
8.3.1 Embankment Slope Stability.....	12
8.3.2 Settlement .....	13
8.3.3 Construction Considerations.....	13
9.0 CLOSURE.....	14
References.....	15

Figure 1 Key Location Plan  
Drawings 19-2805-10-1 to 19-2805-10-3  
Preliminary Foundation Investigation and Design Report (FIDR) Sheets and  
Anticipated Foundation Conditions (AFC) Sheets  
Preliminary Foundation Investigation Report for Deep Cuts  
Preliminary Foundation Investigation Report for High Fills  
Figure 2 Abutment on Compacted Fill Showing Granular A Core  
Appendices A to C

LIST OF DRAWINGS	
19-2805-10-1	Borehole Location – Central Mainline (West of Ashburn Road to Thickson Road)
19-2805-10-2	Borehole Location – Central Mainline (Thickson Road to West of Simcoe Street)
19-2805-10-3	Borehole Location – Central Mainline (Simcoe Street to Wilson Road)

LIST OF APPENDICES	
Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Record of Borehole Sheets from GEOCRES Reports

## **PART A**

**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HIGHWAY 407 EAST EXTENSION – CENTRAL SECTION (WEST PART)  
ASHBURN ROAD TO SIMCOE STREET NORTH  
REGION OF DURHAM  
MINISTRY OF TRANSPORTATION, ONTARIO  
W.O. 07-20016**



## 1.0 INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the preliminary design of the proposed Highway 407 East Extension - Central Section (West Part) from Ashburn Road in Whitby to Simcoe Street North in Oshawa, Ontario.

The purpose of the preliminary investigation was to explore the subsurface conditions in the vicinity of the proposed grade separation structures, bridges, culverts, deep cuts, and high fills along the alignment of the proposed highway extension and, based on the data obtained, to provide borehole location and soil strata drawings, records of boreholes, laboratory test results and written descriptions of the subsurface conditions for the investigated structures.

Thurber carried out the investigation as a sub-consultant to AECOM Canada Ltd. (Totten Sims Hubicki acting as AECOM), under the Ministry of Transportation, Ontario (MTO) Purchase Order No. 2007-E-0041. The terms of reference and scope of work for the preliminary investigation and design are outlined in MTO's Request for Proposal (RFP) for Work Order No. 07-20016.

## 2.0 PROJECT DESCRIPTION

The technically recommended route for the Central Section of the proposed Highway 407 East Extension consists of an approximately 16 km long highway from Ashburn Road in Whitby to Courtice Road in Clarington. Phase One of the implementation stage is to include the west part of the Central Section, which is an approximately 6 km long section from Ashburn Road in Whitby to Simcoe Street North in Oshawa.

The proposed Highway 407 Mainline route runs primarily through farmland, crossing a number of creek valleys, tributaries, and municipal and regional roads. The mainline section crosses the Lynde, West Oshawa and Oshawa Creek valleys. The overall surface topography is gently sloping downward to the east and south towards Lake Ontario.

Along the west part of the Central Section route there are a total of 12 structure sites, where the highway crosses roads or watercourses. These consist of 9 grade separation/bridge sites and 4 culvert sites. Each site includes one or more structure depending on the configuration of the crossing (e.g. twin bridge structures, interchange ramp grade separation, etc.). The location of each structure site is shown on Figure 1 – Key Location Plan.

Each structure is designated with a prefix of 'CM' for Central Mainline and a sequential number. For multiple structures at a site, a letter is added for additional structures in the group (eg. CM-3 and

CM-3b are twin overpasses at the same site). The initial structure numbering system was retained for the preliminary foundation report, however a new structure numbering system was subsequently provided by AECOM for the Environmental Assessment submission. A cross-reference of site numbers is provided in Table 1, Section 4.2.

In addition to the grade separation, bridge and culvert structures, this report also addresses deep cuts or high fills along the proposed alignment. These are defined as sections where the depth of cut or height of fill exceeds 4.5 m. The deep cut and high fill sections are summarized on Table 2 in Section 4.2.

## 3.0 INVESTIGATION PROCEDURES

During the Desktop Study previously carried out by Thurber, each site was categorized as requiring either a low, medium or high level of investigative effort for the preliminary foundation investigation. The level of investigative effort was assigned by using existing geological information, available boreholes from previous investigations, and site photographs taken by Thurber, and was based on the anticipated soil conditions at the site as well as the type and span length of the structure.

Based on the level of investigative effort assigned to each structure site, the proposed number of boreholes for the preliminary foundation investigation was determined as specified in the RFP and summarized below:

- Low Level Investigative Effort: no borehole investigation required;
- Medium Level Investigative Effort: two representative boreholes at the site; and
- High Level Investigative Effort: four boreholes at strategic locations at the site.

During the course of the project, several structures were added, deleted or modified, which changed the structure category, configuration and target level of investigation. The structure designation, category, location and investigative effort applied during the preliminary investigation are summarized on Table 1 in Section 4.2.

The proposed number of boreholes for the deep cut and high fill sections was based on the length of the deep cut or high fill and the availability of existing information from boreholes drilled at adjacent structures.

It was not possible to drill all of the proposed boreholes due to lack of permission to enter (PTE) private properties to access the borehole locations.

The subsurface investigations were carried out during the period of December 2007 to April 2009, during which time a total of 31 boreholes were drilled for the structure sites and 3 boreholes were drilled for the deep cut and high fill sections. The borehole locations are shown on Drawings 19-2805-10-1 to 19-2805-10-3 relative to the proposed highway alignment and structure locations provided by AECOM.

Thurber measured the borehole locations and elevations in the field using a Trimble Pathfinder ProXRT GPS unit with an accuracy of +/- 0.5 m. The northing and easting coordinates were based on MTM NAD83, with the ground surface elevations referenced to the Geodetic datum. All borehole locations were checked for the presence of underground utilities prior to drilling.

The field investigation was carried out using truck-mounted and track-mounted drill rigs supplied and operated by DBW Drilling Ltd. of Ajax, Ontario. The boreholes were advanced using solid stem augers, hollow stem augers or mud rotary drilling techniques. Soil samples were obtained at selected intervals using a split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure.

The boreholes drilled for the structure sites were advanced to competent strata and generally penetrated 3 m into 'refusal' material, defined as material with a minimum SPT value of 100 blows per 0.3 m penetration. The boreholes drilled for the deep cut sections were advanced to depths of 1.5 times the depth of the cut, and the boreholes for high fill sections were advanced to depths equal to the height of the fill or to competent material. The total depth of the boreholes ranged from 7.7 m to 34.1 m below the existing ground surface.

The groundwater conditions in the open boreholes were observed throughout the drilling operations. At each structure site and deep cut section where boreholes were drilled, at least one piezometer was installed in a selected borehole to permit longer term groundwater level monitoring. The piezometers consisted of 19 to 25 mm diameter PVC pipe with a 1.5 m long slotted screen installed and enclosed in filter sand. The annular space between the piezometer pipe and borehole wall above the filter sand was backfilled with bentonite.

A total of 18 piezometers were installed as part of the subsurface investigation for this section. The locations of the piezometers are listed on Table 3 in Section 4.3. All other boreholes were backfilled with bentonite to the ground surface on completion of drilling in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372/07). After the final water level readings, all piezometers were decommissioned in accordance with Ontario Regulation 903.

Where artesian groundwater conditions were encountered in the boreholes, the artesian condition was sealed at the source; details of the artesian condition and the sealing operations are included on the Record of Borehole sheets, where applicable.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and 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 testing. The results of the drilling and laboratory testing are shown on the Record of Borehole sheets in Appendix A and on the figures in Appendix B.

## **4.0 SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Regional Geology**

The alignment of the proposed Highway 407 East Extension – Central Section is situated within the Regional Municipality of Durham which encompasses three major physiographic regions – the Oak Ridges Moraine, the South Slope and the Iroquois Plain, as delineated in *The Physiography of Southern Ontario* and described below:

The South Slope region: the majority of the central mainline section lies within the South Slope region and is comprised of calcareous clay till with lacustrine clay and silt reworked by glaciers, with numerous scattered drumlins and deep valley cuts caused by streams flowing towards Lake Ontario.

The Oak Ridges Moraine region: located north of the central section alignment, and is comprised predominantly of sand and gravel deposits. The Oak Ridges Moraine is a major regional aquifer and groundwater recharge area.

The Iroquois Plain region: located south of the central section alignment and extending southward to Lake Ontario. The area across the Regional Municipality of Durham is a complex mix of till plains, drumlins and areas of glaciolacustrine sediments deposited in Lake Iroquois – primarily sands, silts and gravels.

The bedrock within the project area underlies thick overburden sediments throughout the analysis area and consists of blue-grey shale of the Blue Mountain Formation and limestone from the Lindsay Formation. The bedrock is described as providing a deep aquifer unit, where groundwater flow occurs through the bedding plane fractures.

## 4.2 Site-Specific Descriptions and Subsurface Conditions

Table 1 summarizes the structure sites, category (i.e. underpass, overpass or culvert), location, site ranking (level of investigative effort), and boreholes advanced at or adjacent to each site as part of the current and/or past investigations. Creek and floodplain crossings are also indicated, many of which are environmentally sensitive locations that will require special consideration in this regard during preliminary design (for example, Lynde Creek crossing Site CM-3/3b). The table includes the new structure numbers (as of October 2009), cross-referenced with the structure numbers used for this foundation report, and the Watercourse IDs provided by AECOM.

For all medium or high ranking sites where boreholes were drilled during the current investigation, a Preliminary Foundation Investigation Report (FIR) sheet was produced, which summarizes the results of the field investigation and geotechnical laboratory testing for each structure and includes a borehole location plan and soil strata drawing. The FIR sheets are presented following the text of the report. Following each FIR sheet is a Preliminary Foundation Design Report (FDR) sheet that includes site specific preliminary foundation recommendations for each site, referenced in Part B of this report. In the case of any structure sites that were deleted after boreholes had been drilled (for example, CM-9), the FIR and FDR sheets have been included for information purposes.

For sites where PTE could not be obtained, no boreholes were drilled. For these sites, a copy of the corresponding Anticipated Foundations Conditions (AFC) sheet from the desktop study has been included in this report for reference. Further foundation investigation is recommended at these sites when PTE is obtained.

A summary of the soil and groundwater conditions encountered at each site, together with site-specific drawings showing the borehole locations and stratigraphic profile, are presented on the individual Preliminary FIR sheets following the text of this report.

**Table 1 – Structure Summary**

New Structure No.	Structure No. used for Foundation Report	Watercourse ID	Category	Location	Site Ranking	Borehole Nos.	Remarks
M-42	CM-2	-	Underpass	Baldwin Street	Medium	CM2-1, P13 <sup>1</sup>	Refer to FIDR sheet <sup>3</sup>
M-43	CM-3 / 3b	CM-LC-24	Overpass	Lynde Creek	Medium	CM3-1, CM3-2, CM3b-1, CM3b-2	Refer to FIDR sheet
M-44	CM-4	CM-TBLC-25	Culvert	Lynde Creek Tributary	Medium	CM4-1, CM4-2	Refer to FIDR sheet <sup>3</sup>
M-45	CM-5	-	Underpass	Anderson Street	Medium	CM5-1, CM5-2	Refer to FIDR sheet <sup>3</sup>
M-46	CM-6 / 6b	-	Underpass	Thickson Road	Medium	CM6-1, CM6-2, CM6b-1, CM6b-2	Refer to FIDR sheet
M-47	CM-7	CM-TBPC-27	Culvert	Pringle Creek Tributary	Medium	CM7-1, CM7-2	Refer to FIDR sheet <sup>3</sup>
Deleted	CM-9	-	Underpass	Garrard Road	Medium	CM9-1/1a, CM9-2/2a, P15 <sup>1</sup>	Refer to FIDR sheet – Structure deleted
M-48	CM-10 / 10b	CM-OCE-28	Overpass	Oshawa Creek West Branch	High	CM10-1, CM10-2, CM10b-1, CM10b-2	Refer to FIDR sheet
M-49	CM-11	-	Overpass	Thornton Road	Medium	CM11-1, CM11-2, P21 <sup>2</sup>	Refer to FIDR sheet <sup>3</sup>
M-50	CM-12 / 12b	-	Overpass	Winchester Road West	Medium	CM12-1, CM12-2, CM12b-1, CM12b-2	Refer to FIDR sheet <sup>3</sup>
M-51	CM-13	CM-TAOCW-32	Culvert	Oshawa Creek West Branch East Tributary (Mainline)	Medium	-	No PTE – Refer to copy of AFC sheet from Desktop Study <sup>3</sup>
M-52	CM-15E	CM-TAOCW-33	Culvert	Oshawa Creek West Branch East Tributary at Simcoe Street	Medium	CM15E-1, CM15E-2	Refer to FIDR sheet
M-53	CM-14	-	Underpass	Simcoe Street	Medium	CM14-1, CM14-2, P22 <sup>2</sup>	Refer to FIDR sheet <sup>3</sup>

<sup>1</sup> MTO Geocres No. 30M14-227

<sup>2</sup> MTO Geocres No. 30M15-85

<sup>3</sup> Structure category, configuration or level of investigative effort changed since Desktop Study

Table 2 summarizes the sections where the proposed highway is to be constructed in a deep cut or as a high fill. The table shows the cut (DC) or fill (HF) number, locations (station to station), maximum cut depth or fill height, and the boreholes advanced as part of the current investigation. At 5 deep cut and high fill sections, it was not possible to drill any boreholes due to lack of permission to enter (PTE) private properties. Wherever possible, borehole information from the adjacent structures has been used to provide recommendations.

The subsurface conditions at the deep cut and high fill sections are summarized in the Preliminary Foundation Investigation Report “Deep Cuts” and “High Fills” tables following the FIDR sheets for the structures. Where relevant borehole information was not available within reasonable distance

from the cut/fill section, the Terrain/Drainage Maps (prepared by AECOM based on air-photo interpretation) provided in the Foundation Desktop Study and the Geologic Cross-Sections provided in the *Foundation Investigation Report For Environmental Assessment (Hydrogeology Specialty)* prepared by AECOM were used to interpret anticipated subsurface conditions.

Table 2 – Deep Cut and High Fill Summary

Deep Cut (DC) or High Fill (HF) Number	Station (From – To)	Maximum Cut Depth or Fill Height	Borehole Nos.
DC-C8	11+200 to 11+980	8.5	-
HF-C1	12+680 to 12+750	7	-
DC-C1	13+250 to 13+430	8	CCM-1
DC-C2	14+490 to 14+660	5.5	-
HF-C2	15+180 to 15+300	15.5	-
HF-C3	15+500 to 16+000	7	FCM-1, FCM-2
HF-C4	16+750 to 17+000	5.5	-

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, and the results of geotechnical laboratory tests carried out on selected soil samples, are given on the Record of Borehole sheets included in Appendix A and on the laboratory test result figures included in Appendix B. A copy of the referenced borehole logs from the 1994 MTO investigations located along the Highway 407 alignment in this section are provided in Appendix C and approximate locations (converted to MTM NAD 83 coordinates) are shown on Drawings 19-2805-10-1 to 19-2805-10-3.

It should be noted that 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. Subsurface conditions will vary between and beyond the borehole locations.

4.3 General Groundwater Conditions

The water level was observed in open boreholes at the time of drilling, and standpipe piezometers were installed at 18 borehole locations as part of the current investigation for the project. Details of the piezometer installation and history of water levels measured in the boreholes are shown on the Record of Borehole sheets in Appendix A. Details of the site-specific groundwater conditions at each site are provided on the Preliminary FIR sheets, following the text of this report.

The groundwater levels measured in the piezometers generally range from 0.7 m to 10 m below ground surface, typically about 0.7 to 5.0 m below the ground surface. The most recent water levels measured in the piezometers are summarized in Table 3.

Groundwater levels are expected to fluctuate as a result of seasonal variations in precipitation and runoff.

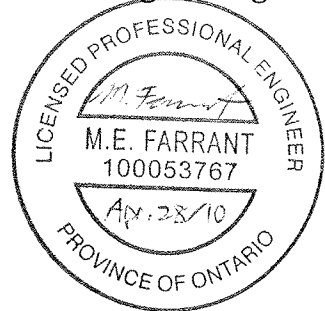
Table 3 – Water Level Measurements

Borehole Number	Ground Surface Elevation (m)	Depth to Water Level below Ground Surface (m)	Water Level Elevation (m)	Date
CM2-1	158.9	Piezometer Damaged	-	July 21, 2009
CM3-2	152.1	4.0	148.1	February 12, 2009
CM3b-1	152.5	4.7	147.8	February 12, 2009
CM4-1	156.0	1.3	154.7	June 6, 2009
CM5-1	161.1	6.0	155.1	July 21, 2009
CM6-2	167.0	5.8	161.2	February 12, 2009
CM6b-1	166.3	3.3	163.0	February 12, 2009
CM7-2	166.9	5.4	161.5	May 9, 2009
CM9-1	171.7	9.6	162.1	March 12, 2008
CM10-1	161.9	4.8	157.1	March 12, 2009
CM10b-2	156.0	2.2	153.8	July 28, 2008
CM11-2	171.1	9.9	161.2	January 16, 2008
CM12b-1	172.2	2.2	170.0	June 6, 2009
CM12-2	173.3	1.2	172.1	May 4, 2009
CM14-1	186.8	2.5	184.3	May 4, 2009
CM15E-2	189.4	0.7	188.7	May 4, 2009
CCM1	166.4	1.6	164.8	February 12, 2009
FCM2	173.5	2.7	170.8	February 10, 2009

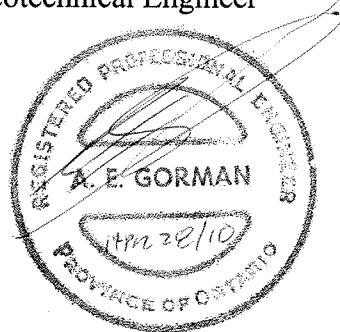
## 5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Mr. Mark Farrant, P.Eng. Mr. Farrant and Mr. Alastair Gorman, P.Eng. directed the field operations. The report was reviewed by Mr. Gorman and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

### Thurber Engineering Ltd.



Mark Farrant, P.Eng.  
Geotechnical Engineer



Alastair Gorman, P.Eng.  
Associate, Senior Foundations Engineer



P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact

## **PART B**

**PRELIMINARY FOUNDATION DESIGN REPORT  
HIGHWAY 407 EAST EXTENSION – CENTRAL SECTION (WEST PART)  
ASHBURN ROAD TO SIMCOE STREET NORTH  
REGION OF DURHAM  
MINISTRY OF TRANSPORTATION, ONTARIO  
W.O. 07-20016**

## 6.0 ENGINEERING RECOMMENDATIONS FOR PRELIMINARY DESIGN

### 6.1 General

This section of the report provides preliminary geotechnical recommendations to assist selection and preliminary design of foundation systems for the proposed bridge and grade separation structures along the Highway 407 East Extension-Central Section (West Part) mainline route. Preliminary geotechnical recommendations for the design of culverts are discussed in Section 7.0. Recommendations for deep cut and high fill sections are discussed in Section 8.0.

The preliminary foundation design recommendations provided herein are based on interpretation of the factual data obtained during limited borehole investigations conducted for the current study as well as boreholes available from previous MTO investigations.

The current subsurface investigation was generally limited to borehole drilling within accessible areas of the structure sites, but not necessarily within the footprint of the foundation elements. Further investigation at the final locations of the foundation elements and approaches will be required during detail design to establish detail design level subsurface information and confirm/reassess the preliminary design recommendations.

The interpretation and recommendations are intended to provide the designers with preliminary information to assess feasible foundation alternatives for the preliminary design of the proposed structure foundations. Where provided, comments regarding construction are presented to highlight aspects which could affect the preliminary design, and for which special provisions or operational constraints could potentially be required.

### 6.2 Structure Foundation Recommendations

As discussed in Section 2.0, 12 bridge and grade separation structures are currently proposed for the Highway 407 central section mainline (west part). Preliminary foundation recommendations for each individual site are provided following the text of this report, in the following forms:

- Where boreholes were advanced, individual Preliminary Foundation Investigation and Design Report (FIDR) sheets were prepared, including a description of the proposed structure configuration at the time of preparation of this report. Part B of the FIDR sheets, referred to as the Preliminary Foundation Design Report (FDR), presents the preliminary foundation recommendations.

- Where borehole information to meet the desired level of investigative effort could not be obtained due to lack of permission to enter, copies of the Anticipated Foundation Conditions (AFC) sheets from the Desktop Study are presented.

The FDR sheets provide a comparison of the advantages and disadvantages of the various foundation alternatives for each site, recommendations for preliminary design of the feasible foundation types, and a recommendation regarding the preferred foundation alternative from a geotechnical viewpoint. Site-specific comments concerning the abutment type, approaches, construction considerations, and recommendations for additional work are also presented.

The following subsections of the report provide project-wide recommendations generally applicable to all structure sites, including design assumptions and limitations associated with the recommendations provided in the Preliminary Foundation Design Report sheets.

The foundation design for all highway structures must be carried out in accordance with the latest Canadian Highway Bridge Design Code (CHBDC) requirements. Design of railway grade separations must also be carried out in conformance with the local railway authority requirements and American Railway Engineering and Maintenance-of-Way Association (AREMA) code.

#### 6.2.1 Spread Footings

Preliminary foundation recommendations for spread footings on native undisturbed soil or on a compacted Granular 'A' pad 'perched' within the structure approaches are provided where subsoil conditions are considered to be suitable for shallow foundations, as indicated on the individual Preliminary FDR sheets for each site.

For spread footings placed (or perched) within the approach embankments on a compacted Granular 'A' core, the geotechnical resistance values provided in the FDR sheets assume a minimum 2 m thickness of Granular 'A' is placed below the base of the footing. The Granular 'A' core should extend at least 1 m beyond the plan limits of the footing and be sloped no steeper than 1 Horizontal to 1 Vertical (1H:1V) in general accordance with MTO guidelines (See Figure 2). The Granular 'A' core should be compacted to 100% of its standard Proctor maximum dry density at  $\pm 2\%$  of optimum moisture content.

Preliminary geotechnical resistance values for spread footings are provided for factored Ultimate Limit States (ULS) and at Serviceability Limit States (SLS) for 25 mm of settlement assuming a 3 m wide footing. The preliminary values are for vertical, concentric loads. In accordance with Sections 6.7.3 and 6.7.4 of the *Canadian Highway Bridge Design Code* (CHBDC 2006), the design must also account for the effects of any eccentric or inclined loads. The resistance values should be re-evaluated and modified

if necessary during detail design based on additional subsurface investigation at the locations of the foundation elements.

Resistance to lateral forces / sliding resistance between the concrete footings and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC (2006)*.

All footings should be provided with a minimum of 1.2 m of soil cover or equivalent thickness of insulation for frost protection (OPSD 3090.101).

### 6.2.2 Steel H-Piles

Preliminary recommendations for steel H-piles, assuming an HP 310 x 110 pile section, are provided on the individual Preliminary FDR sheets for sites where pile foundations are considered practical. The factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical axial reaction at Serviceability Limit States (SLS) for 25 mm of displacement are provided, along with the anticipated pile depth/pile tip elevation based on the subsurface conditions encountered.

The factored ULS resistance, SLS reaction values and pile tip elevations should be re-evaluated during the detail design stage in consideration of additional subsurface data obtained during investigation at the locations of each foundation element.

The pile tip elevations are provided for preliminary estimating purposes only. The actual pile tip elevations will be controlled in the field by use of the Hiley formula. Pile installation should be in accordance with MTO's Special Provision SP903S01 and Standard Structural Drawing SS103-11 using an ultimate geotechnical resistance of two times the factored ULS design load. The pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile size and length of pile.

Where downdrag loads are indicated on the FDR sheets, the structural design of the piles should include a check to confirm that the factored permanent loads plus downdrag loads do not exceed the factored below-ground structural resistance of the pile at the neutral plane (CHBDC Section 6.8.4 and Commentary).

Resistance to lateral loading can be derived using vertical piles, with enhanced support offered by battered piles, if required. For vertical piles, the resistance to lateral loading will be derived solely from the soil in front of the piles, whereas battered piles derive lateral resistance from the soil in front of the piles as well as the horizontal component of the axial load present in the inclined pile. The resistance to lateral loading in front of the pile and pile group action for lateral loading if the pile spacing in the direction of loading is less than six to eight pile diameters, should be accounted for and assessed during

the detail design phase of the project. For preliminary design, lateral resistance values at factored ULS and reaction values at SLS for a lateral displacement of 10 mm at the pile head for a single vertical steel H-pile embedded in typical soil profiles are provided in Table C6.4 of the *CHBDC Commentary (2006)*.

All pile caps should be provided with a minimum of 1.2 m of soil cover or equivalent thickness of insulation for frost protection (OPSD 3090.101).

Where very dense or hard soils are present (SPT N-values exceeding 100 blows), pre-augering may be required to provide an adequate length of pile.

Till deposits often contain cobbles and boulders, and the potential exists that these will be encountered during pile installation. Where applicable, the piles should be reinforced with driving shoes as per OPSD 3000.100 for protection during driving. Pile installation and driving shoes should be in accordance with Special Provision SP903S01.

Where artesian groundwater conditions are present, specialized construction techniques will be required to mitigate the upward flow of water along the pile shaft. Such measures may include driving the piles within a large diameter liner filled with water to counteract artesian head, and provision of an impermeable plug and granular drainage layer. Specialized measures may also be required to minimize disturbance in sensitive wetland areas. Sites with artesian conditions should be extensively investigated and foundation installation procedures re-assessed during detail design.

### 6.2.3 Caissons

Preliminary foundation recommendations for caissons founded within "100-blow" deposits are provided on the individual Preliminary FDR sheets where caissons are considered to be a practical foundation alternative.

The factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical axial reaction at Serviceability Limit States (SLS) for 25 mm of displacement are provided for caisson diameters equal to 1.2 and 1.5 m. The geotechnical resistance values are associated with a recommended caisson base elevation and/or embedment depth into the "100-blow" material, as the caisson will typically derive the majority of its capacity from base resistance. Shaft resistance has also been taken into account assuming permanent steel liners are required.

The factored ULS resistance and SLS reaction values should be re-evaluated during the detail design stage in consideration of additional subsurface data obtained during detailed investigation at the locations of each foundation element.



The resistance to lateral loading developed by the soils in front of the caissons (assuming vertical caissons) and the reductions due to group effects should be accounted for and assessed during the detail design phase of the project.

In general, the use of caisson foundations has not been recommended at locations where water-bearing cohesionless strata are anticipated, due to the potential for caving of the caisson sidewalls or instability or boiling at the caisson base. Where caisson foundations are considered, temporary or permanent caisson liners may be required to support cohesionless soils below the groundwater level and permit cleaning and inspection of the caisson base. Installation procedures, such as maintaining a constant head of water/drilling mud inside the caisson followed by tremied concrete placement, may also be required. Caissons should not be founded in cohesionless soils with artesian water conditions.

Where the caissons are relatively long, temporary liners may be difficult to withdraw due to the length of the liners and the typically hard/very dense nature of the “100-blow” material in which the caissons are installed. In such cases, permanent liners would be preferred for the construction of the caissons, and the reduced shaft resistance (i.e. due to the smooth liner/soil interface) has been considered in the preliminary geotechnical resistance values provided in the FDR sheets. The use of permanent liners should be re-assessed and geotechnical resistance values revised, if necessary, when the caisson installation method has been determined during detail design.

Cobbles and/or boulders may be encountered within the till deposits as indicated in the FDR sheets. Caisson drilling equipment must be capable of penetrating such obstacles, where applicable.

Pile caps for caissons, as applicable, should be provided with a minimum of 1.2 m of soil cover or equivalent thickness of insulation for frost protection (OPSD 3090.101).

### 6.3 Abutment and Retaining Walls

Comments regarding the suitability of conventional, semi-integral or integral abutment types at each site are presented on the Preliminary FDR sheets. Abutment walls and associated retaining/wing walls may consist of either of the following:

- Concrete retaining walls supported on spread footings or on deep foundations depending on the site-specific subsoil conditions as discussed on the FDR sheets. The preliminary foundation recommendations for this type of retaining wall can be considered similar to those provided for the structure foundation elements.

- Retained Soil System (RSS) walls founded on soils that will limit settlements to tolerable levels and provide an adequate factor of safety against global instability. In general, RSS walls should be specified to be “High Performance” and “High Appearance”.

The performance of a RSS is dependent on, among other factors, the characteristics of its foundation. To provide an acceptable foundation performance, the RSS mass must be founded on competent native soils or on engineered fill consisting of OPSS Granular “A” material. Topsoil, alluvium, loose fill, and any soft/wet native material should be stripped from the footprint of the RSS. The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning, and the global stability must be analyzed after the location of the wall is known.

For sites where settlement of the approach fill has been identified as a potential issue (i.e. where soft cohesive deposits were encountered), the selected wall type and impact of approach fill settlement on the retaining wall must be assessed. The preferred settlement mitigation option is site specific and should be confirmed when additional soil information and project scheduling is known during detail design.

### 6.4 Lateral Earth Pressures for Design

The lateral earth pressures acting on abutment walls and any associated retaining walls/wing walls 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, as well as the drainage conditions behind the walls.

The following general recommendations are made concerning the design of the walls. It should be noted that these recommendations and parameters assume a 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 in accordance with Section C6.9.1 of the CHBDC (2006).

- Select free-draining granular fill meeting the specifications of Ontario Provincial Standard Specifications (OPSS 1010) Granular ‘A’ or Granular ‘B’ Type II but with less than 5 per cent passing the 200 sieve should be used as backfill behind the walls. This fill should be compacted in accordance with Special Provision SP 105S10. Backfill, subdrain and frost taper requirements must be in accordance with OPSD 3101.150 and 3121.150.

- For the case where the pressures are based on granular fill behind the wall, the following parameters may be assumed:

	GRANULAR ‘A’	GRANULAR ‘B’ TYPE II
Soil Unit Weight:	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>
Coefficients of Static Lateral Earth Pressure:		
Active, K <sub>a</sub>	0.27	0.27
At Rest, K <sub>o</sub>	0.43	0.43

- For the case where the pressures are based on existing materials behind the wall, the required parameters for design should be assessed on a site-by-site basis during detail design.
- If the wall support and superstructure allow lateral yielding of the abutment stem and retaining walls, active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as:
  - Rotation of approximately 0.002 about the base of a vertical wall;
  - Horizontal translation of 0.001 times the height of the wall; or
  - A combination of both.
- 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 Section 6.9.3 and Figure 6.6 of the CHBDC (2006). Compaction equipment should be used in accordance with SP 105S10. Other surcharge loadings should be accounted for in the design, as required.

**6.5 Structure Approaches**

Based on the available information provided at each site, recommendations associated with the approach stability and settlement are provided on the individual Preliminary Foundation Design Report sheets following the text of this report. The following subsections provide additional generic recommendations associated with the preliminary design and construction of the approaches.

**6.5.1 Subgrade Preparation and Embankment Construction**

It is recommended that all topsoil and organic material be stripped from the proposed embankment footprint. The depth and extent of stripped material should be determined during detail design when

additional subsurface information is available. Particular attention will be required in low floodplain areas where thicker layers of organic/alluvial soils may be present.

After stripping of organics, the exposed subgrade should be proofrolled to identify any loose/softened areas requiring subexcavation or additional compaction prior to fill placement.

Embankment fill should be placed and compacted in accordance with MTO’s SP 206S03 and SP 105S10. New embankment fill placed against existing embankment slopes or on a sloping ground surface should be benched into the existing slope in accordance with OPSD 208.010.

Where approach cuts extend below the groundwater table, the design must include measures to stabilize the cut slope face if instability is experienced. Further comments in this regard are presented in Section 8.0.

To reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection must be in accordance with OPSS 572.

**6.5.2 Approach Embankment Stability**

Preliminary assessment of the stability of the approach embankments at selected sites was carried out based on limit equilibrium analysis using the commercially available slope stability program GSLOPE developed by Mitre Software Inc. Bishop’s modified method of slices was employed.

The analyses were based on soil profiles deduced from the current limited borehole data and existing information, and the maximum embankment heights indicated by profile and general arrangement drawings available at the time of the analysis. Approach embankment side slopes no steeper than 2H:1V, with a minimum 2 m wide mid-slope bench for embankment heights greater than 8 m, were assumed. Where designated as safe against deep-seated slope instability, a target factor of safety of 1.3 under static conditions is implied, assuming appropriate subgrade preparation and proper placement and compaction of embankment fill materials. Assessment of the overall stability of the embankment side slopes under seismic conditions is discussed in Section 6.6.

For embankment slopes higher than 8 m, the minimum requirement is to provide a 2 m wide mid-height bench in order to control surficial erosion and improve stability.

The preliminary assessment of stability of the approach slopes should be reviewed and confirmed based on the actual subsoil conditions encountered within the proposed embankment footprint during the detail

design investigation. Mitigation measures to improve slope stability if required may include slope flattening, utilizing light weight fill materials, staged construction, or a combination of these options.

### **6.5.3 Approach Embankment Settlement**

Settlement of the approach embankments will occur due to compression and consolidation of the foundation soils under the weight of the overlying fill material as well as from compression of the embankment fill itself. The total settlement within the founding soils has been estimated using elastic analysis and Terzaghi one-dimensional consolidation theory, based on the site-specific subsoil conditions deduced from the borehole data and the maximum embankment heights indicated by profile and general arrangement drawings available at the time of the analysis.

Where the estimated embankment settlement exceeds 25 mm, the computed value is indicated on the Preliminary Foundation Design Report sheet for the particular site. For preliminary design, acceptable settlement values are assumed to be less than 25 mm at or near structure locations; however, the highway design criteria will be site specific and based on maintenance considerations at the detail design stage.

The preliminary estimates do not include compression of the embankment fill itself, which would occur during and after the construction of embankment depending on the type of materials used. The magnitude of fill compression usually ranges from 1% to 2% of the height of embankment. Where granular fill is used for embankment construction, settlement of the fill itself is expected to occur during or shortly after completion of embankment construction. Non-granular earth fill or rock fill materials may exhibit additional consolidation settlement over time.

Embankment and platform width design should allow for the anticipated settlements.

Further analyses should be carried out during detail design to confirm the anticipated magnitude of settlement, assess the time rate of post-construction settlement, and develop mitigation measures such as preloading, surcharging or use of light weight fill to reduce anticipated settlements to acceptable levels where necessary.

### **6.6 Seismic Considerations**

The peak zonal acceleration ratio for the project site is 0.05 g as per The Town of Oshawa, Ontario (CHBDC Table A3.1.1). The Site Coefficient,  $S$ , will be based on the type of soils encountered at the founding level at each site (to be determined during detailed design) in accordance with Section 4.4.6 and Table 4.4 of the CHBDC (2006).

Seismic (earthquake) loading on the abutment stem and retaining/wing wall must be considered in the design of the foundations in accordance with Sections 4 and 6 of CHBDC (2006). The walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions plus the applicable earthquake-induced dynamic earth pressure conditions (see Section 24.9 of CFEM). The static and seismic earth pressure coefficients can be determined in accordance with Sections 6.9 and 4.6.4 of the CHBDC (2006) and its Commentary.

The susceptibility to liquefaction of the soil deposits underlying the proposed embankments (and foundations) and the consequent stability of the embankments under seismic loading conditions should be assessed during the detail design stage in accordance with Sections C.4.6.2 and C.4.6.3, respectively, of the CHBDC Commentary (2006).

### **6.7 Construction Considerations**

#### **6.7.1 Obstructions During Pile Driving / Caisson Installation**

Glacial till often contains cobbles and/or boulders that may be encountered during installation of steel piles or drilled caissons. Accordingly, pile driving shoes as per OPSD 3000.100 have been recommended for tip protection during driving in till. In addition, caisson drilling rigs must be capable of dislodging and removing cobbles and boulders. An NSSP will be required in the Contract Documents during detail design to inform the contractor of the possible presence of cobbles and boulders.

#### **6.7.2 Excavation and Backfill**

Preliminary comments regarding open-cut excavations for foundation construction are provided on a site-specific basis on the Preliminary Foundation Design Report sheets. The soil type classification as per the Occupational Health and Safety Act (OHSA), as well as the recommended maximum side slope inclination for temporary excavations, are provided for the conditions anticipated within the foundation excavations. All backfill is to be placed and compacted in accordance with SP 105S10.

#### **6.7.3 Groundwater and Surface Water Control**

The anticipated groundwater conditions and requirements for groundwater and surface water control measures at each site are presented on the Preliminary Foundation Design Report sheets. The comments regarding groundwater control are based on the groundwater levels observed in the boreholes and the anticipated excavation depth required to construct the recommended foundation type.

At locations where near surface cohesionless soils and a high water table are present, prior dewatering will be required to accommodate foundation construction in a dry condition. For footing or pile cap construction in floodplains with a high groundwater table, no excavation should be undertaken without

prior dewatering. Alternatively, the excavation should be carried out within the confines of a properly designed sheet pile cofferdam. For these sites, a Non-Standard Special Provision (NSSP) will be required for inclusion in the Contract Documents.

Caissons constructed with temporary or permanent liners and founded in cohesionless subsoils subjected to unbalanced hydrostatic head will require special measures to prevent ‘boiling’ or basal heave of the base materials. If caisson foundations are adopted for such a site, it is recommended that a constant head of water be maintained inside the caisson liners to counterbalance the natural groundwater pressures. Concrete placement by tremie may be considered. Caissons should not be founded in cohesionless soils with artesian water conditions.

For other deep foundations installed where artesian conditions are expected, it is recommended that a sand filter, possibly in combination with a geotextile, be placed beneath the pile caps to prevent the migration of fines that may be transported along the piles or caisson liner during and after construction. Preliminary recommendations for such conditions (where considered practical) are given on the site-specific Preliminary Foundation Design report sheets. Sites with artesian conditions should be extensively investigated and foundation installation procedures re-assessed during detail design.

General site drainage should be by gravity towards an outlet at a lower elevation and/or pumping.

The need for a Permit to Take Water (PTTW) should be assessed at each specific site during detail design.

#### **6.7.4 Protection Systems**

Excavation support systems may be required for temporary roadway protection during foundation construction. The temporary excavation support system should be designed and constructed in accordance with Special Provision 105S19. In general, the lateral movement of the temporary shoring system should meet Performance Level 2 as specified in SP 105S19. Performance Level 1 may be required adjacent to railways.

#### **6.7.5 Construction Access**

Environmentally sensitive creek valley crossings have been identified during the environmental assessment of the project. Potential environmental impacts will need to be minimized during construction access in the sensitive floodplains. Specific access preparation procedures such as the use of temporary work bridges, winter construction and/or gravel roadways underlain by geosynthetics should be considered to accommodate foundation construction at these locations.

### **7.0 CULVERTS**

All culvert sites with spans exceeding 6 m were classified as medium level effort sites. Where PTE was obtained, field investigations were conducted and FIDR sheets have been prepared.

Where PTE was not obtained, no site specific borehole investigations have been carried out, and therefore, copies of the Anticipated Foundation Conditions (AFC) sheets prepared during the Desktop Study are provided.

The AFC and FIDR sheets for the culverts are included with the FIDR sheets for the other structures at the end of this report. The preliminary project-wide recommendations presented in Section 6.0 are generally applicable to the culvert sites.

### **8.0 DEEP CUTS AND HIGH FILLS**

#### **8.1 General**

This section of the report provides geotechnical recommendations for preliminary design of deep cuts and high fill sections where the depth/height exceeds 4.5 m. Based on the roadway profiles available at the time of analysis (February 2009), deep cuts have been identified at three locations and high fills were identified at four locations. The locations and maximum depth/height are summarized in Table 2, Section 4.2. The maximum depth of cut is in the order of 8.5 m and the maximum fill height is about 15.5 m.

The preliminary design recommendations provided herein are based on interpretation of the factual data obtained during limited borehole investigations conducted at or near the cut/fill sections as well as existing information. Where relevant borehole information was not available within reasonable distance from the cut/fill section, the Terrain/Drainage Maps (prepared by AECOM based on air photo interpretation) provided in the Foundation Desktop Study and the Geologic Cross-Sections provided in the *Foundation Investigation Report For Environmental Assessment (Hydrogeology Specialty)* prepared by AECOM were used to interpret anticipated subsurface conditions.

The anticipated subsurface conditions at the deep cut/fill locations and preliminary recommendations for design are summarized on the “Preliminary Foundation Investigation Report - Deep Cuts” sheets and “Preliminary Foundation Investigation Report – High Fills” sheets presented following the FIDR sheets for the structures at the end of the text of this report.

The interpretation and recommendations are intended to provide the designers with preliminary information to assess design slope inclination, drainage requirements, and mitigation options for

addressing potential stability or settlement issues. Where provided, comments regarding construction are presented to highlight aspects which could affect the preliminary design, and for which special provisions or operational constraints could potentially be required.

Further investigation will be required during detail design to confirm the subsurface conditions that were assumed throughout the cut/fill sections and confirm/reassess the preliminary design recommendations.

## **8.2 Deep Cuts**

### **8.2.1 Stability and Drainage**

Preliminary assessment of the stability of the cut slopes was carried out based on limit equilibrium analysis using the commercially available slope stability program GSLOPE developed by Mitre Software Inc. Bishop's modified method of slices was employed. Cut slopes no steeper than 2H:1V, with a minimum 2 m wide mid-slope bench for cut depths greater than 8 m, were assumed.

For preliminary design, the target factors of safety were assumed to be 1.3 for short term stability, and 1.3 and 1.5 for long term stability in cohesionless and cohesive soils, respectively.

For cut slopes deeper than 8 m, the minimum requirement is to provide a 2 m wide mid-height bench in order to control surficial erosion and improve stability. Earth cut slopes must be provided with erosion protection in accordance with OPSS 572.

Permanent drainage of the cut slope is required. Roadside ditches are expected to provide an adequate level of permanent drainage in most areas. An interceptor ditch should be provided at the top of the cut as per OPSD 200.020.

Where cut excavation extends below the measured groundwater levels in cohesionless soils, more positive measures to provide permanent slope drainage and mitigate surficial instability may be required. Measures may include provision of subdrains positioned along the toe of slope and/or along the rear of the mid-slope bench, as well as gravel sheeting or rip-rap lined channels down the slope.

Seepage and surficial instability may also be experienced from localized permeable zones/sand layers within the less permeable till soils. Determination of the frequency, extent and locations of the seepage zones from the limited borehole data is not possible. Therefore, consideration should be given to the observational approach involving examination of the cut slopes during and following construction to identify any areas of surficial instability, and providing mitigative measures such as a gravel sheeting or subdrains where required. All subdrains should be sloped on a positive grade to an outlet or pumping chamber.

The preliminary assessment of stability and drainage of the cut slopes should be reviewed and confirmed during the detail design investigation based on the subsoil conditions encountered in additional boreholes drilled within the cut sections.

### **8.2.2 Construction Considerations**

Excavation for cut slope construction should be carried out in accordance with OPSS 206 as amended by the most recent Special Provision (SP 206S03).

Excavation in very dense/hard till deposits may be arduous and will require use of heavy duty excavators or dozers. In addition, tills often contain cobbles and boulders. The contract documents should include a NSSP to emphasize these conditions to the contractor. Selection of the method of excavation must remain the responsibility of the contractor however and be based on his equipment, experience and interpretation of the site conditions.

Temporary drainage of the cuts should be provided to maintain a relatively dry, stable excavation. Measures may include temporary drainage ditches or gravel sheeting to maintain surficial stability before permanent drainage measures are in effect.

## **8.3 High Fills**

### **8.3.1 Embankment Slope Stability**

Preliminary assessment of the stability of the fill embankment slopes was carried out based on limit equilibrium analysis using the commercially available slope stability program GSLOPE developed by Mitre Software Inc. Bishop's modified method of slices was employed. Embankment slopes no steeper than 2H:1V, with a minimum 2 m wide mid-slope bench for embankment heights greater than 8 m, were assumed.

For preliminary design, the target factors of safety were assumed to be 1.3 for short term stability, and 1.3 and 1.5 for long term stability of embankments founded on cohesionless and cohesive soils, respectively.

For embankment slopes higher than 8 m, the minimum requirement is to provide a 2 m wide mid-height bench in order to control surficial erosion and improve stability. Earth fill slopes must be provided with erosion protection in accordance with OPSS 572.

Assessment of the stability of the embankment side slopes under seismic conditions should be carried out during detail design.

The preliminary assessment of stability of the embankment slopes should be reviewed and confirmed based on the actual subsoil conditions encountered within the proposed embankment footprint during the detail design investigation. Mitigation measures to improve slope stability if required may include slope flattening, utilizing light weight fill materials, staged construction, or a combination of these options.

### **8.3.2 Settlement**

Settlement of the fill embankments will occur due to compression and consolidation of the foundation soils under the weight of the overlying fill material as well as from compression of the embankment fill itself. The total settlement within the founding soils has been estimated using elastic analysis and Terzaghi one-dimensional consolidation theory, based on the site-specific subsoil conditions deduced from the borehole data and the maximum embankment heights indicated by profile and general arrangement drawings available at the time of the analysis.

Where the estimated embankment settlement exceeds 25 mm, the computed value is indicated on the Preliminary Foundation Design Report sheet for the particular section. The settlement tolerance for embankments may range from 25 to 100 mm depending on the distance from a structure. The highway design criteria will be site specific and based on maintenance considerations at the detail design stage.

The preliminary estimates do not include compression of the embankment fill itself, which would occur during and after the construction of embankment depending on the type of materials used. The magnitude of fill compression usually ranges from 1% to 2% of the height of embankment. Where granular fill is used for embankment construction, settlement of the fill itself is expected to occur during or shortly after completion of embankment construction. Non-granular earth fill or rock fill materials may exhibit additional consolidation settlement over time.

Embankment and platform width design should allow for the anticipated settlements.

Further analyses should be carried out during detail design to confirm the anticipated magnitude of settlement, assess the time rate of post-construction settlement, and where required develop mitigation measures such as preloading, surcharging, wick drains or light weight fill to reduce anticipated settlements to acceptable levels.

### **8.3.3 Construction Considerations**

It is recommended that all topsoil and organic material be stripped from the proposed embankment footprint. The depth and extent of stripped material should be determined during detail design when additional subsurface information is available. Particular attention will be required in low floodplain areas where thicker layers of organic/alluvial soils may be present.

After stripping of organics, the exposed subgrade should be proofrolled to identify any loose/softened areas requiring subexcavation or additional compaction prior to fill placement.

Embankment fill should be placed and compacted in accordance with SP 206S03 and SP 105S10. New embankment fill placed against existing embankment slopes or on a sloping ground surface should be benched into the existing slope in accordance with OPSD 208.010.

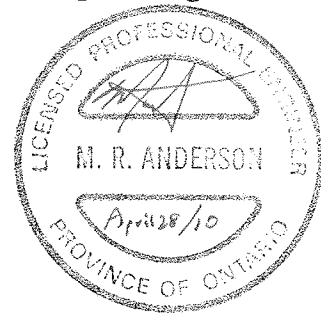
Trafficability of construction equipment may be problematic in low floodplain areas where soft/loose and organic alluvial material may be encountered and where environmental constraints are imposed on site access. Further, drainage in these areas is likely to be poor, with groundwater levels varying subject to seasonal fluctuations. The contractor must be prepared to supply equipment capable of working on this terrain and/or provide alternative measures to improve trafficability such as placement of granular pads underlain by geosynthetics in working areas.

Potential environmental impacts will need to be minimized during construction access into sensitive floodplain or wetland areas. Specific access preparation procedures such as the use of temporary work bridges, winter construction and/or gravel roadways underlain by geosynthetics should be considered.

## 9.0 CLOSURE

The Preliminary Foundation Design Report was prepared by Mr. Murray Anderson, P.Eng. and Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

### Thurber Engineering Ltd.



Murray Anderson, P.Eng.  
Associate, Senior Foundations Engineer



Sydney Pang, P.Eng.  
Associate, Senior Foundations Engineer

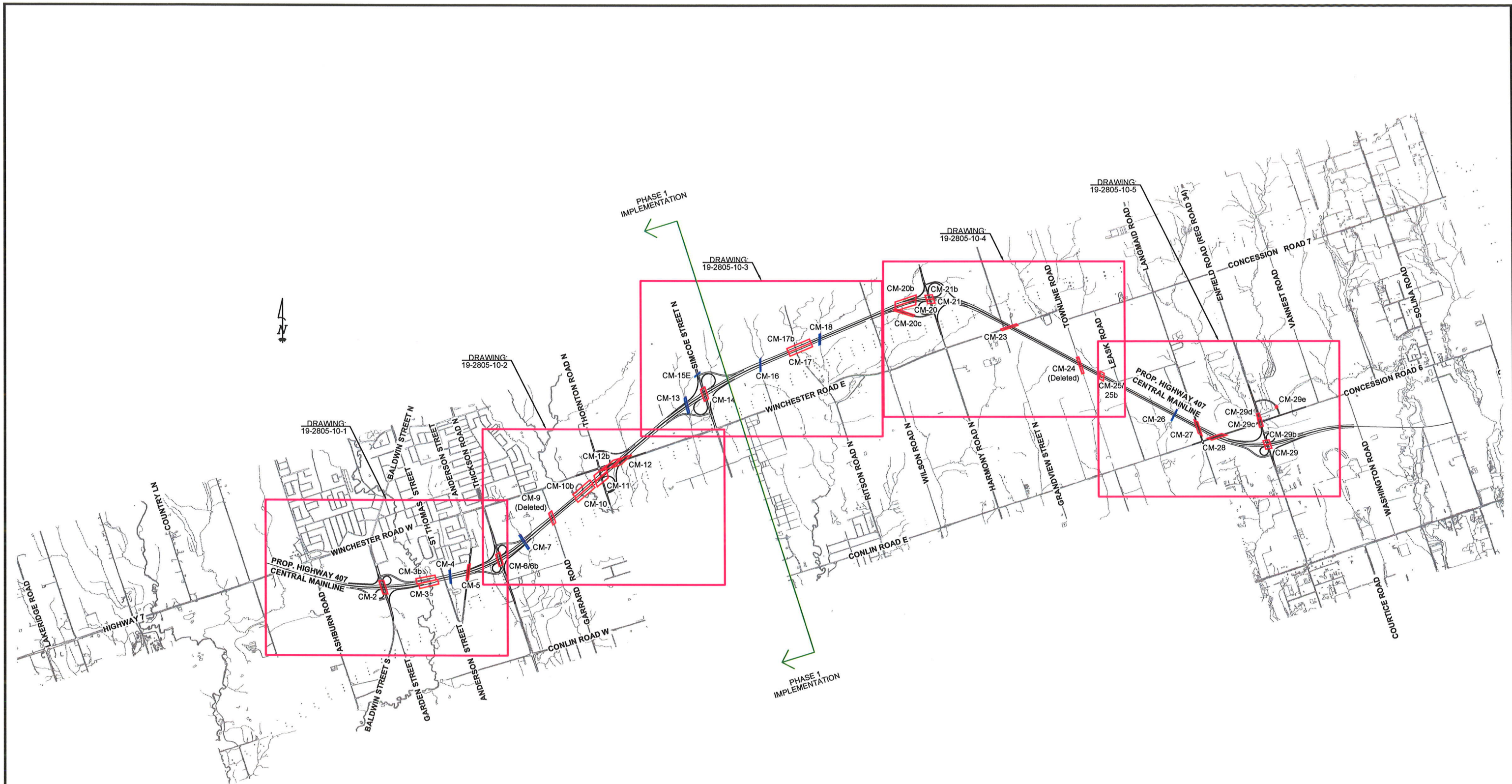


P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact

### **References**

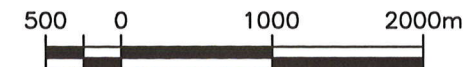
1. Chapman, L.J. and Putnam, D.F. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,00.
2. Gartner Lee Limited operating as AECOM, *Foundation Investigation Report for Environmental Assessment (Hydrogeology Specialty), Highway 407 East Extension – Central Section*, prepared for Ministry of Transportation Ontario, October 2008.
3. Ministry of Transportation Ontario, *Foundation Investigation and Design Report, Preliminary Design Study for Proposed Hwy 407 from Hwy 48 to Whitby/Oshawa Boundary*, Geocres No. 30M14-227, August 1994.
4. Ministry of Transportation Ontario, *Foundation Investigation and Design Report, Feasibility Study for Highway 407 from Whitby/Oshawa Boundary to Hwy 35/115*, Geocres No. 30M15-85, October 1994.
5. Thurber Engineering Ltd., *Foundation Desktop Study, Highway 407 East Extension – Central Section*, W.O. 07-20016, prepared for Ministry of Transportation Ontario, October 2008.





LEGEND:

- APPROXIMATE STRUCTURE LOCATION
- APPROXIMATE CULVERT LOCATION



BASE PLAN PROVIDED BY AECOM

MINISTRY OF TRANSPORTATION ONTARIO

HIGHWAY 407 EAST EXTENSION  
CENTRAL SECTION  
KEY LOCATION PLAN

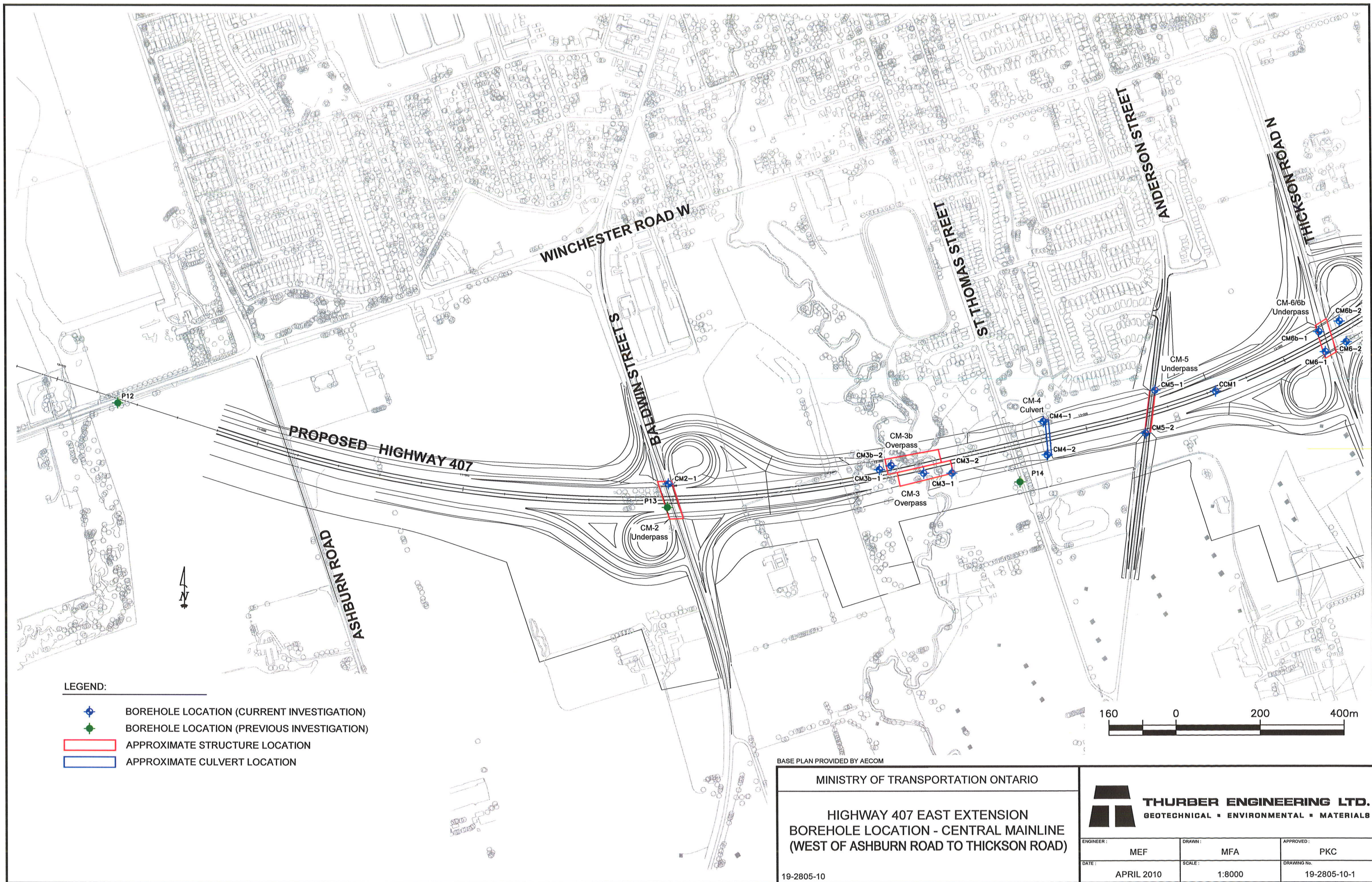
19-2805-10



**THURBER ENGINEERING LTD.**  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER :	DRAWN :	APPROVED :
MEF	MFA	PKC
DATE :	SCALE :	DRAWING No.
APRIL 2010	1:50000	FIGURE 1



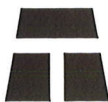


BASE PLAN PROVIDED BY AECOM

MINISTRY OF TRANSPORTATION ONTARIO

HIGHWAY 407 EAST EXTENSION  
BOREHOLE LOCATION - CENTRAL MAINLINE  
(WEST OF ASHBURN ROAD TO THICKSON ROAD)

19-2805-10

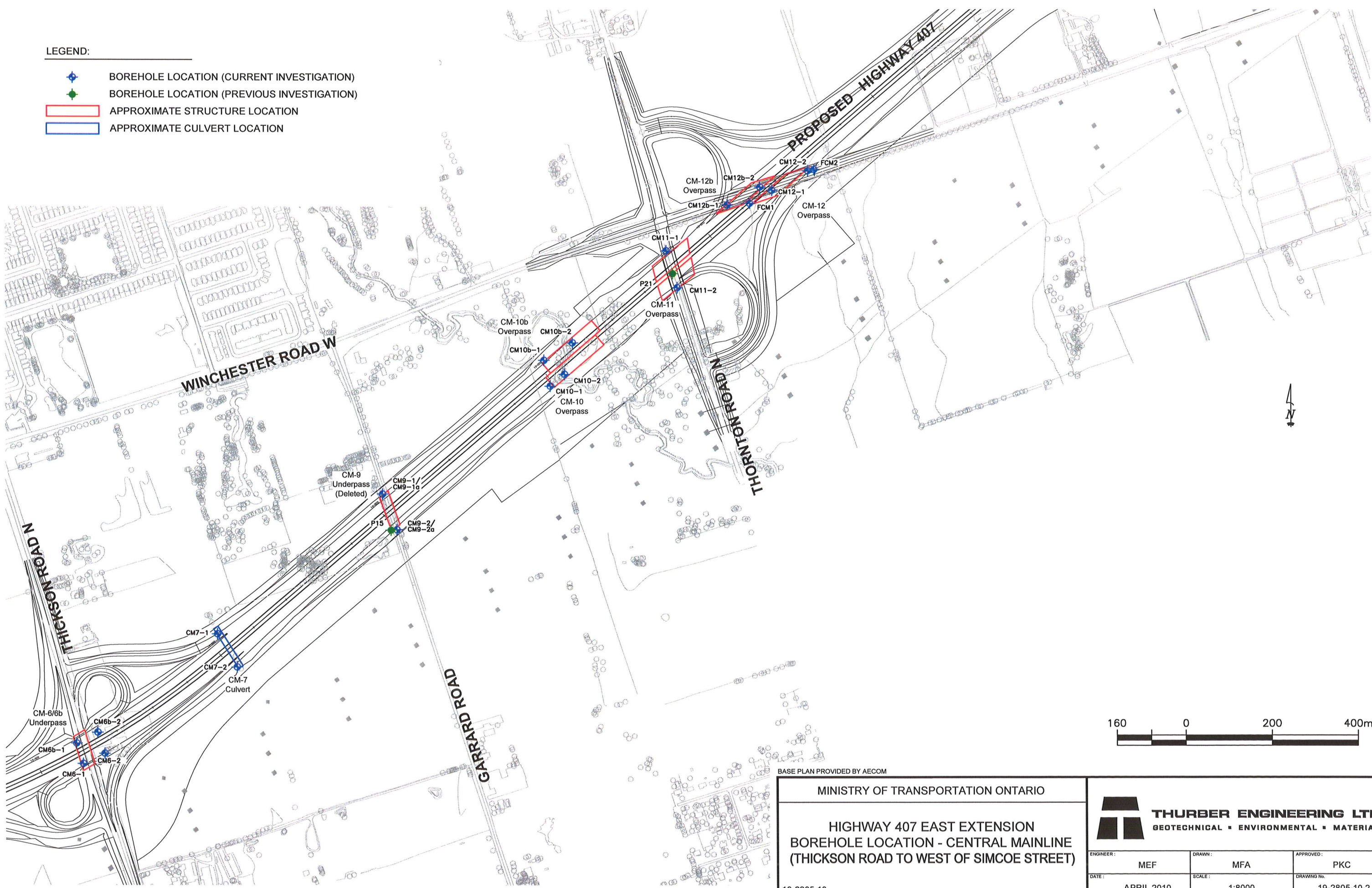
**THURBER ENGINEERING LTD.**  
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS

ENGINEER : MEF	DRAWN : MFA	APPROVED : PKC
DATE : APRIL 2010	SCALE : 1:8000	DRAWING No. 19-2805-10-1



LEGEND:

- BOREHOLE LOCATION (CURRENT INVESTIGATION)
- BOREHOLE LOCATION (PREVIOUS INVESTIGATION)
- APPROXIMATE STRUCTURE LOCATION
- APPROXIMATE CULVERT LOCATION



BASE PLAN PROVIDED BY AECOM

MINISTRY OF TRANSPORTATION ONTARIO

HIGHWAY 407 EAST EXTENSION  
BOREHOLE LOCATION - CENTRAL MAINLINE  
(THICKSON ROAD TO WEST OF SIMCOE STREET)

19-2805-10



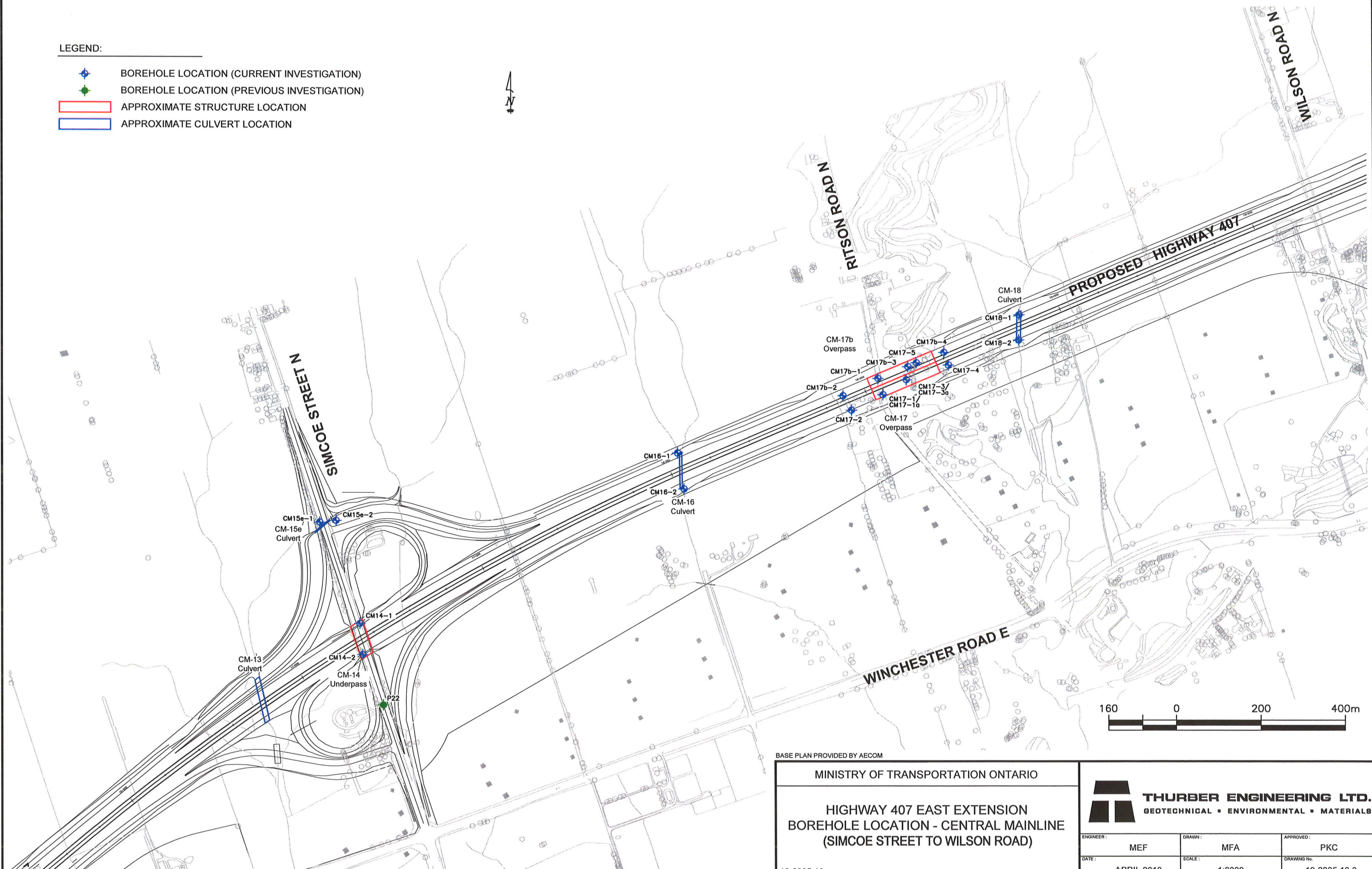
**THURBER ENGINEERING LTD.**  
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS

ENGINEER:	DRAWN:	APPROVED:
MEF	MFA	PKC
DATE:	SCALE:	DRAWING No.
APRIL 2010	1:8000	19-2805-10-2



LEGEND:

- BOREHOLE LOCATION (CURRENT INVESTIGATION)
- BOREHOLE LOCATION (PREVIOUS INVESTIGATION)
- APPROXIMATE STRUCTURE LOCATION
- APPROXIMATE CULVERT LOCATION




BASE PLAN PROVIDED BY AECOM

MINISTRY OF TRANSPORTATION ONTARIO

HIGHWAY 407 EAST EXTENSION  
BOREHOLE LOCATION - CENTRAL MAINLINE  
(SIMCOE STREET TO WILSON ROAD)

19-2805-10

**THURBER ENGINEERING LTD.**  
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS

ENGINEER :	DRAWN :	APPROVED :
MEF	MFA	PKC
DATE :	SCALE :	DRAWING No.
APRIL 2010	1:8000	19-2805-10-3

FILENAME: D:\Drafting\19\2805\10\BoreholePlan(TSH).dwg  
PLOTDATE: Apr 22, 2010 4:48pm

**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT (FIDR) SHEETS**

**AND**

**ANTICIPATED FOUNDATION CONDITIONS (AFC) SHEETS**

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:	CM-2
--------------	------

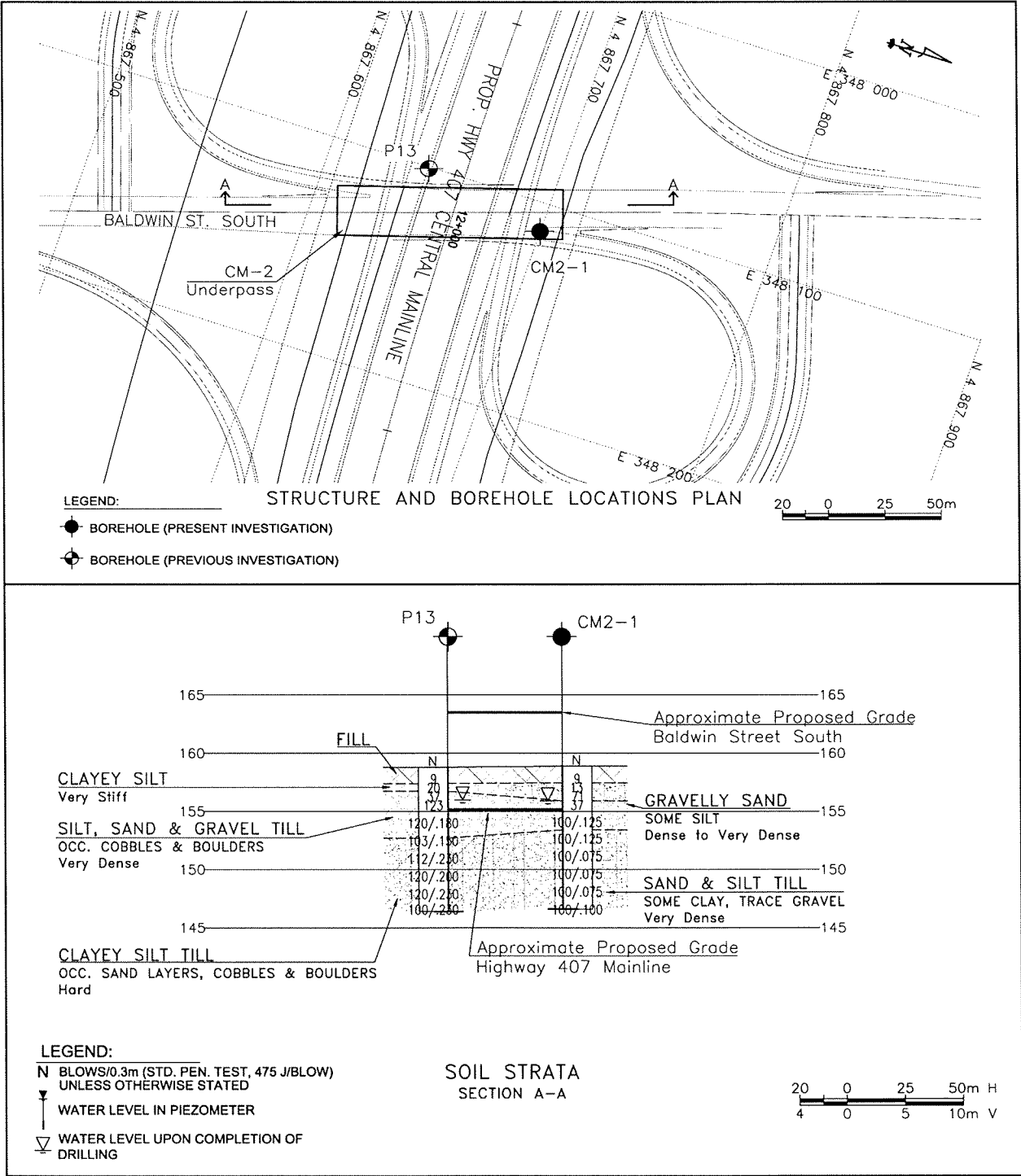
Structure Description: Underpass Highway 407 Mainline / Baldwin Street

Highway 407 Proposed Grade: ~El. 155.0 to 156.0 m

Site Ranking: Medium

Existing Ground Elevation: ~El. 158.0 to 161.0 m

Station: ~11+993



FOUNDATION INVESTIGATION

Site Description:

At this site, Baldwin Street is a two-lane, undivided roadway. Terrain mapping shows that the site is underlain by silt till ground moraine. The relief is low, rolling and imperfectly to poorly drained.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM2-1	North Abutment	4 867 699.9	348 113.2	158.9	12.3
P13	Mainline at Baldwin Street	4 867 644.1	348 110.8	158.8	12.4

Subsurface Conditions:

**Fill:** Granular and clayey silt fill was encountered from the surface to 1.4 m depth in boreholes CM2-1 and P13. The underside of the fill varies between Elev. 157.4 m and 157.5 m. The consistency of the clayey silt fill is stiff with an ‘N’ value of 9 blows/0.3 m penetration. Measured moisture content of the fill was of about 17%.

**Clayey Silt:** A 0.7 m thick layer of brown clayey silt with gravel was encountered below the fill layer in borehole P13, extending to Elev. 156.7 m. The consistency of the clayey silt is very stiff with an ‘N’ value of 20 blows/0.3 m penetration.

**Sand, Silt and Gravel Till:** Brown to grey silt, sand and gravel to brown sand and silt till with trace to some clay was encountered below the fill layer in borehole CM2-1 and below the clayey silt in borehole P13. This layer is 1.6 to 4.0 m in thickness, extending to Elev. 155.9 to 152.7 m. This cohesionless deposit is compact to very dense with ‘N’ values ranging from 13 blows/0.3 m penetration to greater than 100 blows for less than 0.3 m penetration. The moisture contents ranged from 7% to 13%. Grain size distribution curve for a sample of this till is presented in Figure CM2-B1. This layer contains cobbles and boulders.

**Gravelly Sand:** A 2.5 m thick layer of brown gravelly sand, some silt was encountered under the upper sand and silt till in Borehole CM2-1. This cohesionless soil is dense to very dense with ‘N’ values ranging from 37 blows/0.3 m penetration to greater than 100 blows for less than 0.3 m penetration. The underside of this layer is at Elev. 153.4 m. Figure CM2-B2 presents a grain size distribution curve of this deposit. Measured water content of the gravelly sand ranged between 10% and 13%. The layer contains cobbles.

**Sand and Silt Till:** A lower deposit of sand and silt till, some clay, trace gravel was encountered below the gravelly sand layer in borehole CM2-1. This layer is at least 6.8 m in thickness, extending to Elev. 146.6 m where borehole CM2-1 was terminated. This brown to grey till layer is very dense throughout with ‘N’ values greater than 100 blows for less than 0.3 m penetration, with occasional cobbles and boulders. Figure CM02-B1 presents the grain size distributions of this till layer. The measured water contents ranged between 6% and 12%.

**Clayey Silt Till:** A deposit of grey clayey silt till with trace gravel, occasional sand layers and cobbles and boulders was encountered below the silt, sand and gravel till in borehole P13. This layer is at least 6.3 m in thickness, extending to Elev. 146.4 m where borehole P13 was terminated. This till is hard throughout with ‘N’ values greater than 100 blows for less than 0.3 m penetration.

Groundwater Conditions:

- BH CM2-1:** 3.0 m depth (Elev. 155.9 m) in open borehole on April 24, 2009 (unstabilized reading).
- BH P13:** 2.7 m depth (Elev. 156.1 m) in open borehole on December 13, 1993 (unstabilized reading).



**PART B - PRELIMINARY FOUNDATION DESIGN REPORT**  
**HWY 407 EAST EXTENSION – CENTRAL SECTION**  
**W.O. 07 – 20016**

**LOCATION No:** CM-2

**FOUNDATION RECOMMENDATIONS**

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General:** A two span structure with two abutments and a central pier is proposed.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread Footings founded on dense to very dense sand and silt till</i>	- Conventional construction - Low cost alternative	- Does not permit integral abutment design - Potential variability of surficial soils; footings must be extended below these soils - Dewatering may be required during excavation
<i>Spread Footings perched on Granular A pads for abutments</i>	- Lower cost than deep foundations - Minimize excavation requirements	- Higher cost than spread footings on native soils - Sub-excavation of existing fill is required
<i>Steel H-Piles driven to very dense sand and silt till and hard clayey silt till</i>	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - Preaugering may be required to achieve sufficient pile length
<i>Caissons founded in very dense sand and silt till and hard clayey silt till</i>	- Higher bearing resistance - Not so affected by surficial soil variability	- Does not permit integral abutment design - Potential installation problems including basal stability due to water-bearing sands/silts

**A - Spread Footings**

Spread footings founded on dense sand and silt till may be used for the abutments and at the pier. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary geotechnical design resistances and founding levels for spread footings on native soils, and spread footings on compacted Granular A cores, are as follows:

<b>Founding Stratum</b>	<b>Geotechnical Resistance</b>		<b>Foundation Level</b>
	<b>Factored ULS</b>	<b>SLS</b>	
Sand and Silt Till	600 kPa	400 kPa	At or below Elev. 156.5 m
Compacted Granular A	700 kPa	350 kPa	Fill base at or below Elev. 157.4 m (abutments)

**B - Steel H-Piles**

Steel H-piles driven to refusal within the very dense sand and silt till and hard clayey silt till may be used to provide foundation support. The recommended preliminary design geotechnical resistances and tip elevations are as follows:

<b>Pile</b>	<b>Axial Geotechnical Resistance</b>		<b>Downdrag Load</b>	<b>Anticipated Pile Tip Elevation</b>
	<b>Factored ULS</b>	<b>SLS</b>		
HP 310 x 110	1,600 kN	1,400 kN	Not applicable	At or below Elev. 151.0 m

Preaugering may be required to install piles, particularly at the pier.

**C – Caissons**

Based on the presence of water-bearing cohesionless deposits and the potential of base boiling and uncertainties associated with cleaning and inspecting the base, the use of caisson foundation is not recommended at this site and the option has not been developed.

**Recommended Foundation Alternative**

The recommended foundation alternative at this site is steel H-piles driven into the very dense sand and silt till and hard clayey silt till. Spread footings founded on very dense sand and silt till and hard clayey silt till may be used at the pier.

• **ABUTMENT TYPE**

The soil conditions at this site are suitable for conventional, integral or semi-integral abutment design.

• **APPROACHES**

Highway 407 mainline will be in a 3 to 6 m deep cut. In addition approach fills up to the order of 3 to 6 m high are anticipated.

**Stability**

Approach cut and fill up to 12 m in height are anticipated to be stable at side slope inclinations of 2H : 1V using SSM or granular material. A 2 m wide mid-height bench is required for embankment slope higher than 8 m.

**Settlement**

Settlements are expected to be less than 25 mm and to occur essentially during construction.

• **CONSTRUCTION CONSIDERATIONS**

**Pile Installation**

During pile installation through glacially derived soils at this site, there is a medium probability of encountering obstructions such as cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

**Excavation**

Temporary excavation slopes in the fill and the upper compact soils should not be steeper than 1H : 1V. In accordance with OHSA the fill materials are classified as Type 3 material. The sand and silt till is Type 2 material above the water table and Type 3 soil below the water table.

**Groundwater/Surface Water Control**

It is anticipated that excavation for footings or pile cap construction at the pier will extend approximately 5 m below the groundwater level observed during drilling. Prior to excavation for pier construction, groundwater control systems such as well points or pumping from wells may be required. At the abutments, diversion of surface runoff from the excavation and pumping from carefully constructed, filtered sumps should be adequate to control the water during construction.

**Protection Systems**

Protection systems may be required at excavation locations where stable slopes cannot be constructed due to space limitations and where vertically sided excavations are used for footing or pile cap construction. One possible system is the use of soldier piles and lagging. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

• **RECOMMENDATIONS FOR ADDITIONAL WORK**

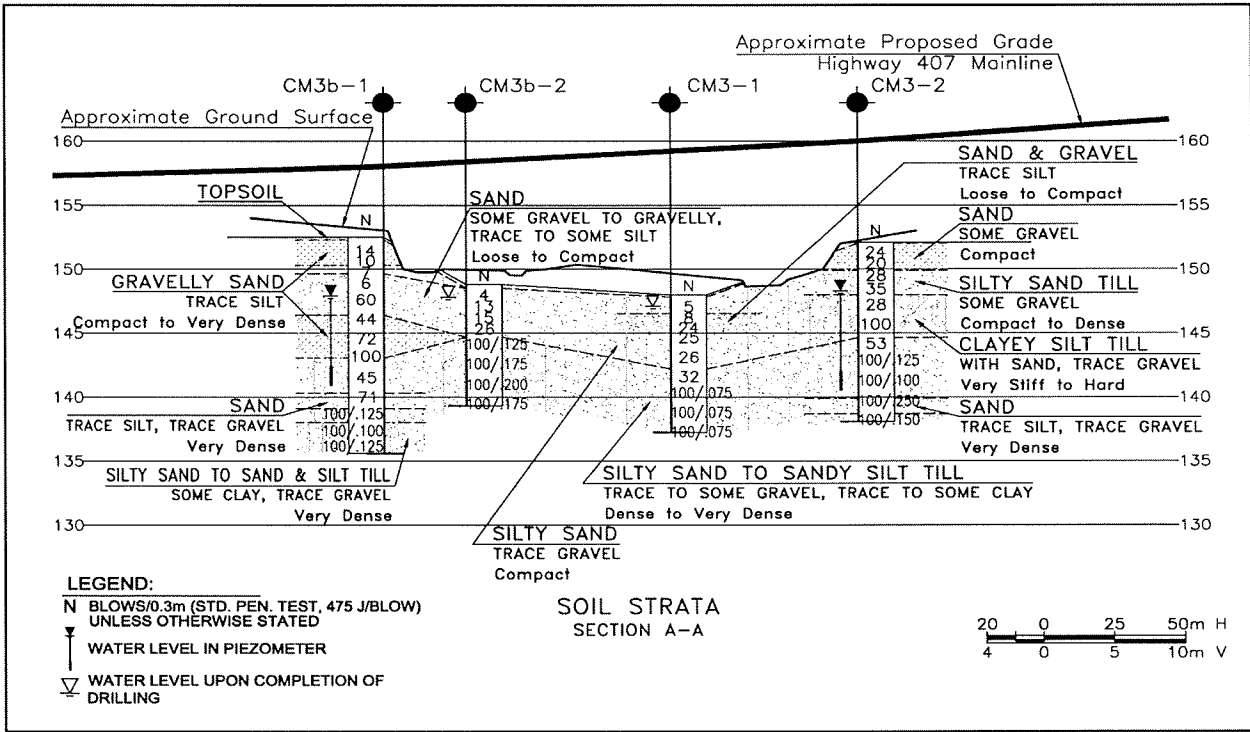
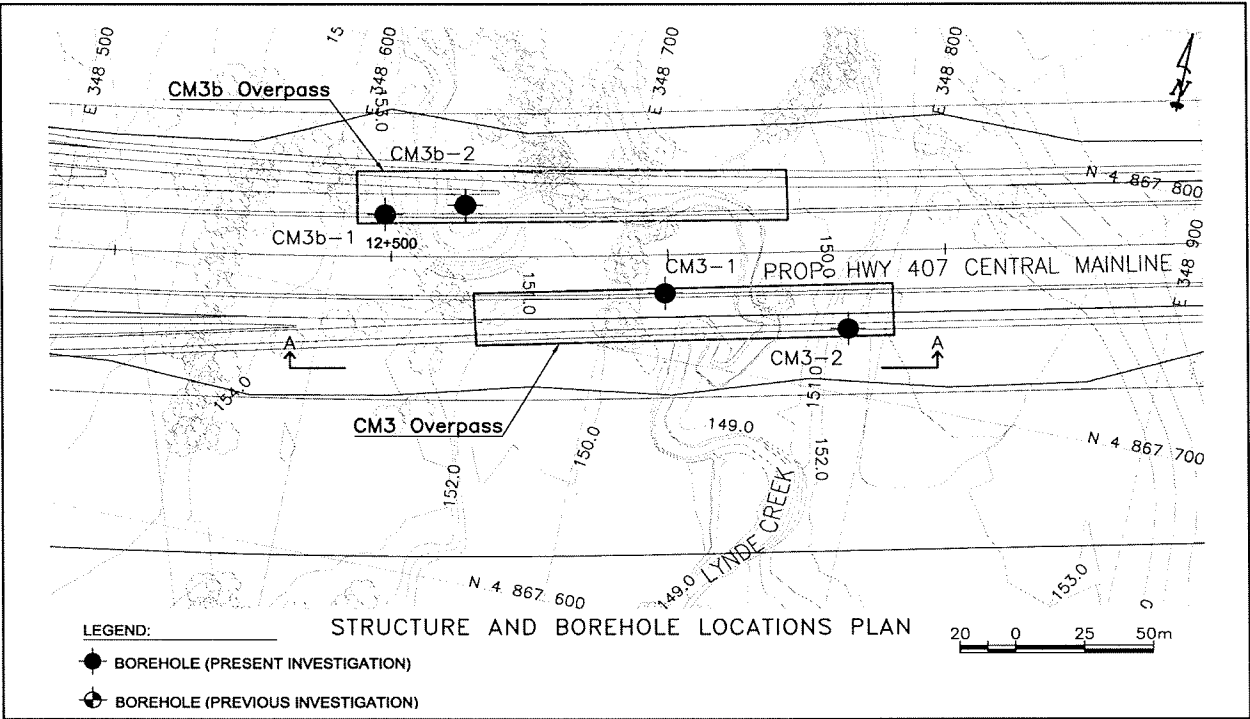
Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the actual abutment and pier locations and at the approaches. The feasibility, cost effectiveness and need for alternate dewatering systems should be investigated.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-3/3b

Structure Description: Overpass Highway 407 mainline / Lynde Creek

Highway 407 Proposed Grade: ~158 m (west)  
~160 m (east)
Site Ranking: Medium
Existing Ground Elevation: ~149 to 150 m (floodplain)
Station: ~12+600



FOUNDATION INVESTIGATION

Site Description:

At this site, Lynde Creek meanders within a 150 m wide floodplain through silty, gravelly sand alluvium with buried organic soils and peat. The terrain is locally flat within the floodplain and the site is poorly to very poorly drained. The site is underlain by silty sand glaciolacustrine plain on the west side, while the surrounding area is silt till ground moraine.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM3b-1	WBL West Approach	4 867 733.5	348 614.6	152.5	16.9
CM3b-2	WBL East Approach	4 867 742.9	348 642.2	148.8	9.5
CM3-1	EBL West Approach	4 867 724.7	348 719.7	148.0	10.7
CM3-2	EBL East Approach	4 867 725.0	348 786.9	152.1	14.0

Subsurface Conditions:

- Topsoil**  
Topsoil was encountered at ground surface in all four boreholes. The topsoil thickness ranges between 75 and 300 mm.
- Silty Sand, Sand / Gravel**  
Interlayered alluvial deposits of silty sand, sand, gravelly sand, sand and gravel were encountered in Boreholes CM3b-1, CM3b-2 and CM3-1. These soils are typically loose to compact ('N' values from 4 to 26 blows) at shallower depths, becoming dense to very dense ('N' values from 44 to 100 blows) at larger depth in Borehole CM3b-1. The underside of these typically brown soils varies between Elev. 142.2 m and 149.9 m. Figures CM3-B1, B2 and B3 show the grain size distributions of the silty sand, sand, sand and gravel to gravelly sand, respectively. Measured water contents of these cohesionless deposits typically ranged between 8% and 20% with occasional values up to 38%.

- Clayey Silt Till**  
A clayey silt till deposit was encountered interlayering with the sand and silt till in Borehole CM3-2. This cohesive till changes from brown to grey with depth and has a very stiff to hard consistency ('N' values of 28 and 100 blows). The underside of this till layer is at Elev. 144.6 m. Figures CM3-B4 and B5 present laboratory test results of this till. Measured water contents of the clayey silt till ranged between 10% and 12%.

- Sand / Silt Till**  
The entire floodplain and its immediate surroundings are underlain by a silty sand, sand and silt to sandy silt till. Occasional sand interbeds were encountered in some boreholes. This brown to grey till is largely very dense ('N' values of greater than 100 blows for less than 0.3 m penetration) with inferred cobbles or boulders, except for occasional dense zones ('N' values of 32 and 45 blows) near the top of the deposit. Figures CM3-B6 and B7 present the grain size distributions of this till with various proportions of sands and silts. Measured water contents of this cohesionless till ranged between 5% and 15%.

Groundwater Conditions:

- BH CM3b-1:** 4.7 m depth (Elev. 147.8 m) in piezometer on February 12, 2009.
- BH CM3b-2:** 1.0 m depth (Elev. 147.8 m) in open borehole on March 13, 2008.
- BH CM3-1:** 0.9 m depth (Elev. 147.1 m) in open borehole on March 3, 2008.
- BH CM3-2:** 4.0 m depth (Elev. 148.1 m) in piezometer on February 12, 2009.



PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-3/3b

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General:**

Twin structures each with two abutments and two piers are proposed.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread Footings founded on dense to very dense gravelly sand to sand, sand/silt or clayey silt till</i>	- Conventional construction	- Deep excavations are required to reach competent founding soils - Unwatering and protection systems are likely required
<i>Spread Footings perched on Granular A pads for abutments</i>	- Lower cost than deep foundations - Minimize excavation requirements	- Lower bearing resistance than deep foundations - Potential for settlements during construction
<i>Steel H-Pile driven to very dense silty sand, sand and silt to sandy silt till</i>	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - Pre-drilling may be required to install the piles to the desired depths
<i>Caissons founded in very dense gravelly sand to sand and gravel</i>	- Higher bearing resistance - Not so affected by surficial soil variability	- Does not permit integral abutment design - Potential installation problems including side sloughing and base boiling due to the extensive water-bearing silts, sands and gravel

**A - Spread Footings**

The preliminary geotechnical design resistances and founding levels for spread footings on native soils, and spread footings on compacted Granular A cores, are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Gravelly Sand to Sand Sand/Silt or Clayey Silt Till	600 kPa	400 kPa	Base of footing at or below Elev. 148 m (WBL west abut)
			Base of footing at or below Elev. 144 m (WBL west pier)
			Base of footing at or below Elev. 146 m (EBL east abut) Base of footing at or below Elev. 141 m (EBL west pier)
Compacted Granular A	700 kPa	350 kPa	Base of Fill Pad at or below Elev. 148 m (WBL west abut)
			Base of Fill Pad at or below Elev. 147 m (WBL west pier)
			Base of Fill Pad at or below Elev.151.5 m (EBL east abut) Base of Fill Pad at or below Elev.145.5m (EBL west pier)

In light of the potential for soil variability and associated settlements, spread footings founded on the surficial alluvial sands and gravel are not recommended at this site. Within the floodplain, spread footings are not recommended due to requirements of deep excavations, unwatering and protection systems.

**B - Steel H-Piles**

Steel H-piles driven to refusal within the very dense silty sand, sand and silt to sandy silt till may be used to provide foundation support. The recommended preliminary design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1,600 kN	1,400 kN	Not applicable	Below Elev. 137 m - WBL west abutment Below Elev. 142 m - WBL west pier Below Elev. 139 m - EBL west pier Below Elev. 141 m - EBL east abutment

**C – Caissons**

Based on the presence of water-bearing cohesionless deposits and the associated potential of base boiling, the use of caisson foundations is not recommended at this site and the option has not been developed.

**Recommended Foundation Alternative**

The recommended foundation alternative at this site is steel H-piles driven into the very dense sand and silt to sandy silt till. Alternatively, spread footings founded on compacted Granular A cores may be used for the abutments.

• **ABUTMENT TYPE**

The soil conditions at this site are suitable for integral abutment design.

• **APPROACHES**

**Stability**

Approaches up to 10 m in height, with side slopes not steeper than 2H : 1V, are expected to be stable at this site. Mid-height benches of 2 m in width are required for slopes exceeding 8 m in height.

**Settlement**

Settlement is not expected to be an issue at this site. Within the floodplain, extensive stripping of topsoil, organics, alluvium and other disturbed or unsuitable soils may be required.

• **CONSTRUCTION CONSIDERATIONS**

**Pile Installation**

During pile installation through glacially derived soils at this site, there is a medium probability of encountering obstructions such as cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

**Excavation**

Shallow excavations will be required at this site for pile cap and shallow footing construction. For cuts through the native soils at this site, temporary unsupported side slopes should not be steeper than 1H : 1V. Within the floodplain, unsupported slopes may have to be flatter, say 1.5H : 1V, due to the presence of loose cohesionless soils and shallow groundwater table. In accordance with the OHSA, the soils within the floodplain and soils below the groundwater level elsewhere are classified as Type 3 soils. Soils above the groundwater level outside the floodplain are classified as Type 2 soils.

**Groundwater/Surface Water Control**

Unwatering will be required for pile cap and footing construction within the floodplain. Sheetpiled enclosures with unwatering will be required for footing and/or pile cap construction in the floodplain. Diversion of surface water and temporary creek diversion may be required. The required groundwater control systems should be further assessed during detail design.

**Protection Systems**

Within the floodplain, protection systems will be required for foundation construction if vertically sided excavations are anticipated. Outside the floodplain, protection systems may be required at some locations for abutment construction. Protection systems used for construction may be left in place as part of the scour protection schemes that will be required for the foundation elements located within the floodplain. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

**Floodplain Access**

Potential environmental impacts will need to be minimized during construction access into the sensitive floodplain. Specific access preparation procedures including the use of gravel roadways underlain by geosynthetics should be considered.

• **RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the exact foundation element locations within the floodplain and at the approaches. The feasibility and cost effectiveness of alternate unwatering systems would need to be investigated.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION

LOCATION No:	CM-04
--------------	-------

Structure Description: Highway 407 Mainline over Culvert Carrying Lynde Creek Tributary

W.O. 07 – 20016

Highway 407 Proposed Grade: ~ El. 160.6 m

Site Ranking: Medium

Existing Ground Elevation: ~ El. 155.0 to 156.0 m

Station: 12+900

FOUNDATION INVESTIGATION

Site Description:

At this site, the creek flows in a north to south direction in a shallow valley underlain by silt till moraine. The relief is low, rolling and imperfectly drained.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM04-1	North side	4 867 847.5	349 004.5	156.0	9.8
CM04-2	South side	4 867 768.1	349 013.4	155.0	9.3

Subsurface Conditions:

• **Topsoil:** Between 0.6 and 0.8m of topsoil was encountered in both boreholes. The thickness and extent of the topsoil are expected to vary between and beyond the borehole locations, and the information in this report should not be used for quantity estimating purposes.

• **Fill:** A 0.8m thick layer of dark brown clayey silt fill was encountered below the topsoil in borehole CM04-1. This clayey silt fill is firm, with an ‘N’ value of 8 blows/0.3m penetration and moisture content of 14%.

• **Silty Sand:** Silty sand with trace of gravel and clay was encountered below the topsoil in borehole CM04-2. The silty sand layer is 1.3 m thick, with an underside at Elev. 152.9. The silty sand is compact to dense with ‘N’ values ranging from 16 to 34 blows /0.3 m penetration and moisture content ranging from 13 to 19%. A grain size distribution curve for a sample of this soil is presented in Figure CM04-B3.

• **Sandy Silt:** A deposit of sandy silt with trace clay and silty sand layer was encountered below the silty sand in borehole CM04-2 and below the clayey silt fill in borehole CM04-1. This sandy silt layer was 5.2 m thick, with an underside at Elev. 147.7 m in borehole CM04-02, and 4.7m thick with an underside at Elev. 149.9 m in borehole CM04-1. This sandy silt layer is compact to very dense with ‘N’ values ranging from 17 to 73 blows/0.3 m penetration. Weathered shale bedrock fragments were noted inside this layer. Moisture contents ranged from 8 to 18%. Grain size distribution curves for samples of this soil are presented in Figure CM04-B1.

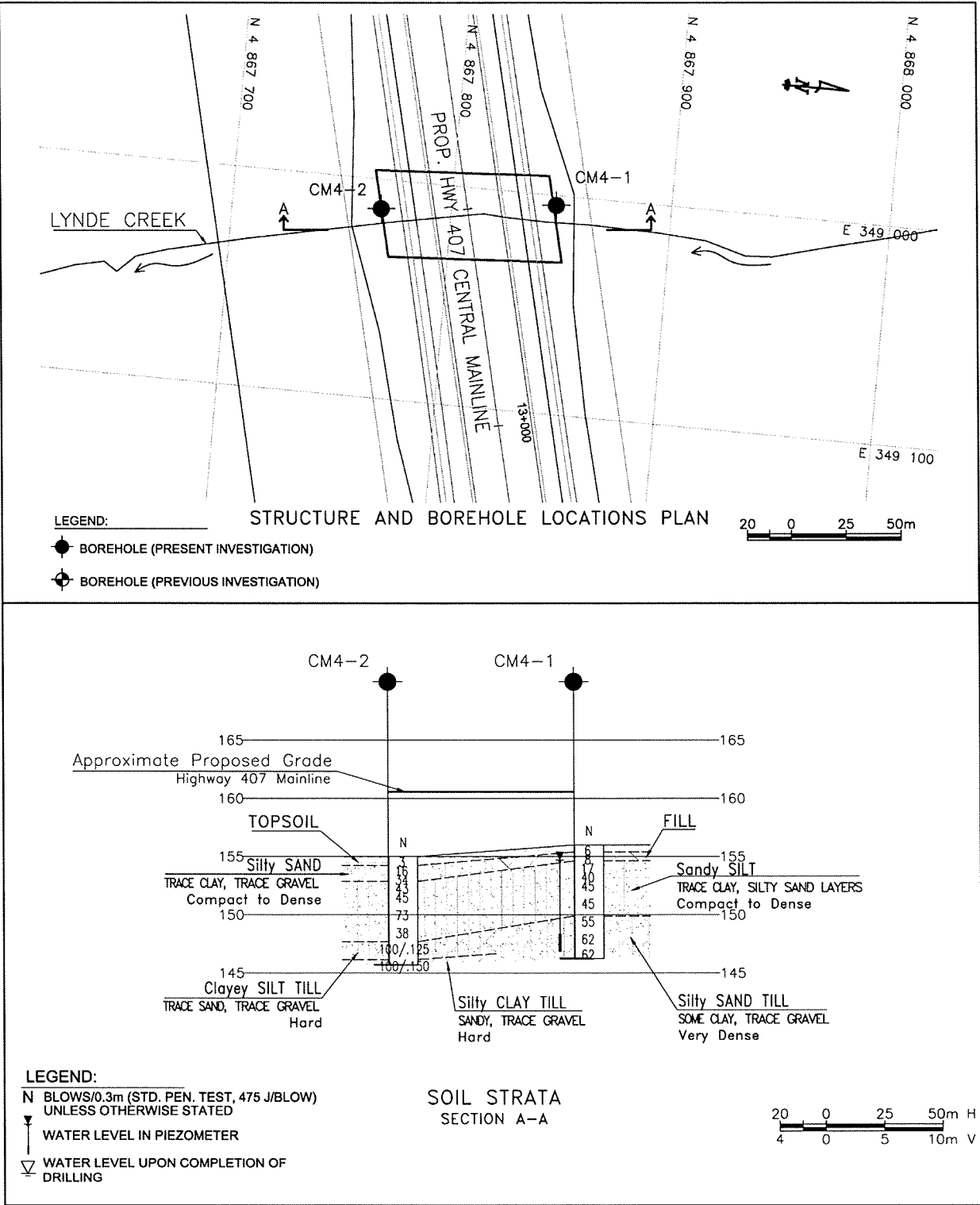
• **Silty Sand Till:** Brown silty sand till with some clay and trace of gravel was encountered below the sandy silt layer in borehole CM04-1. Borehole CM04-1 was terminated in this till at 9.8 m depth (Elev. 146.2 m). This silty sand till layer is very dense with ‘N’ values ranging from 55 to 62 blows/0.3 m penetration and with moisture content ranging from 9% to 12%. A grain size distribution curve for a sample of this soil is presented in Figure CM04-B2. Glacial tills typically contain cobbles and boulders.

• **Clayey Silt Till:** Brown clayey silt till with trace of sand and gravel was found below the sandy silt layer in Borehole CM04-2. This clayey silt till layer is 1.5 m thick with an underside at Elev. 146.2 m. This soil is hard with ‘N’ value greater than 100 blows for less than 0.3m penetration. Measured moisture content was 10%. Glacial tills typically contain cobbles and boulders.

• **Silty Clay Till:** Sandy silty clay till with trace of gravel was encountered below the clayey silt till layer in borehole CM04-2. Borehole CM04-2 was terminated in this silty clay layer at 9.3 m depth (Elev. 145.7 m). This silty clay till layer is hard with ‘N’ value of 100 blows for less than 0.3m penetration and with moisture content of about 10%. A grain size distribution curve for a sample of this soil is presented in Figure CM04-B4.

Groundwater Conditions:

- BH CM04-1: 3.2 m depth (Elev. 152.8 m) in piezometer on February 12, 2009.  
1.6 m depth (Elev. 154.4 m) in piezometer on May 4, 2009.  
1.3 m depth (Elev. 154.7 m) in piezometer on June 6, 2009.



PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-04

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General :** An open footing concrete culvert is proposed.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread footings founded on dense sandy silt or dense silty sand</i>	- Conventional construction - Low cost alternative	- Dewatering will be required - Variability of surficial soils in floodplain - Scour protection is required for footings in floodplain - Sub-excavation of topsoil, fill, compact silty sand and sandy silt to construct footings
<i>Spread Footings perched on Granular A pads</i>	- Lower cost than deep foundations - Founding level can be adjusted	- Dewatering may be required - Scour protection is required for footings in floodplain - Sub-excavation of topsoil and fill to construct pads - More costly than spread footings on native soils
<i>Steel H-Piles driven to hard clayey silt till, hard silty clay till or very dense silty sand till</i>	- Higher bearing resistance - Not affected by surficial soil variability	- Higher cost than spread footings - Sub-excavation required for pile cap construction - Unwatering may be required for pile cap construction
<i>Caissons founded within the hard clayey silt till, hard silty clay till or very dense silty sand till</i>	- Higher bearing resistance - Not so affected by surficial soil variability	- Higher cost than spread footings - Unwatering may be required for pile cap construction - Require liners to address installation problems including side wall sloughing associated with cohesionless soils - Need to dislodge and handle cobbles and boulders - Potential for base boiling

**A – Spread Footings**

Spread footings founded on native undisturbed dense sandy silt or dense silty sand below the topsoil and the fill may be used. A footing founded on compacted Granular A pad may also be used as long as the topsoil and the fill layers are removed. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Sandy silt or silty sand	450 kPa	300 kPa	At or below Elev. 153.5 m
Compacted Granular A	700 kPa	350 kPa	North side: Base of Fill Pad at or below Elev. 154.6 m South side: Base of Fill Pad at or below Elev. 154.2 m

**B – Steel H-Piles**

Steel H-piles driven to refusal within the very dense silty sand till, hard clayey silt till or hard silty clay till, may be used to provide foundation support. The preliminary design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1600 kN	1400 kN	Not applicable	At or below Elev.145.0 m

**C – Caissons**

Caissons are not recommended at this site due to possible installation problems related to water bearing cohesionless deposits, a high groundwater table, the associated potential of base boiling, and the presence of cobbles and boulders in the Silty Sand Till.

**Recommended Foundation Alternative**

From a foundation engineering perspective, the recommended foundation alternative at this site is spread footings founded on dense sandy silt or silty sand at or below Elev. 153.5 m.

**• APPROACHES**

Up to approximately 6.0 m of fill, including removal and replacement of the topsoil and existing fill layers, will be required to construct the highway mainline approaches.

**Stability**

Fill embankments up to approximately 6.0 m in height are anticipated to be stable at side slope inclinations of 2H : 1V using SSM or granular material.

**Settlement**

Foundation settlement will occur as fill is placed and should be completed by the end of construction. It is estimated that foundation settlement will be less than 25 mm.

**• CONSTRUCTION CONSIDERATIONS**

**Pile Installation**

During pile installation through glacially derived soils at this site, there is a medium probability of encountering cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

**Excavation**

Excavations will be required for footing and pile cap construction. No excavation should be carried out in the creek valley below the water table without prior dewatering. Temporarily unsupported side slopes should not be steeper than 1H : 1V where groundwater control measures are implemented as outlined below. In accordance with the OHSA, silts and sands above the water table are classified as Type 3 soils and below the water table are classified as Type 4 soils.

**Groundwater/Surface Water Control**

The groundwater table is near the floodplain grade. Prior to excavations in the floodplain, groundwater control systems such as interlocking sheetpiled cofferdams and/or well points may be required. Diversion of stream flow and surface runoff from the excavation and pumping from carefully constructed, filtered sumps should be used to supplement the above systems. The required groundwater control systems should be further assessed during detail design.

**Protection Systems**

Protection systems are not expected to be required at this site.

**• RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the culvert. As a minimum, this is likely to require additional boreholes along the culvert alignment. The feasibility and cost effectiveness of alternate dewatering systems would need to be assessed during detail design.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:	CM-5
--------------	------

**Structure Description:** Underpass Highway 407 mainline / Anderson Street

**Highway 407 Proposed Grade:** ~ El. 159.0 to 160.0 m

**Site Ranking:** Medium

**Existing Ground Elevation:** ~ El. 159.0 to 163.0 m

**Station:** ~13+155

FOUNDATION INVESTIGATION

**Site Description:**

At this site, Anderson Street is an existing two-lane, undivided roadway. Terrain mapping shows that the site is underlain by silt till ground moraine. The relief is low, rolling and imperfectly to poorly drained.

**Borehole Information:**

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM5-1	North Side	4 867 921.6	349 270.4	161.1	12.6
CM5-2	South Side	4 867 819.3	349 247.8	158.8	14.0

**Subsurface Conditions:**

• **Fill:** Brown compact sand fill was encountered from the surface to 0.9 m and 0.7 m depths in boreholes CM5-1 and CM5-2 respectively. The underside of the fill varies between Elev. 160.2 m and 158.1 m.

• **Silty Clay and Clayey Silt Till:** A 1.8 m thick layer of brown silty clay till and a 1.9 m thick layer of brown clayey silt till, were encountered below the fill in boreholes CM5-1 and CM5-2 respectively. The consistency of the layers varies from stiff to hard with ‘N’ values ranging from 11 blows/0.3 m penetration to 100 blows for less than 0.3 m penetration. Moisture contents of these cohesive soils ranged between 12% and 20%. The underside of these layers varies from Elev. 158.4 m to 156.2 m. Grain size distribution curve for a sample of the silty clay till is presented in Figure CM5-B1. The Atterberg limit test results are presented in Figure CM5-B2.

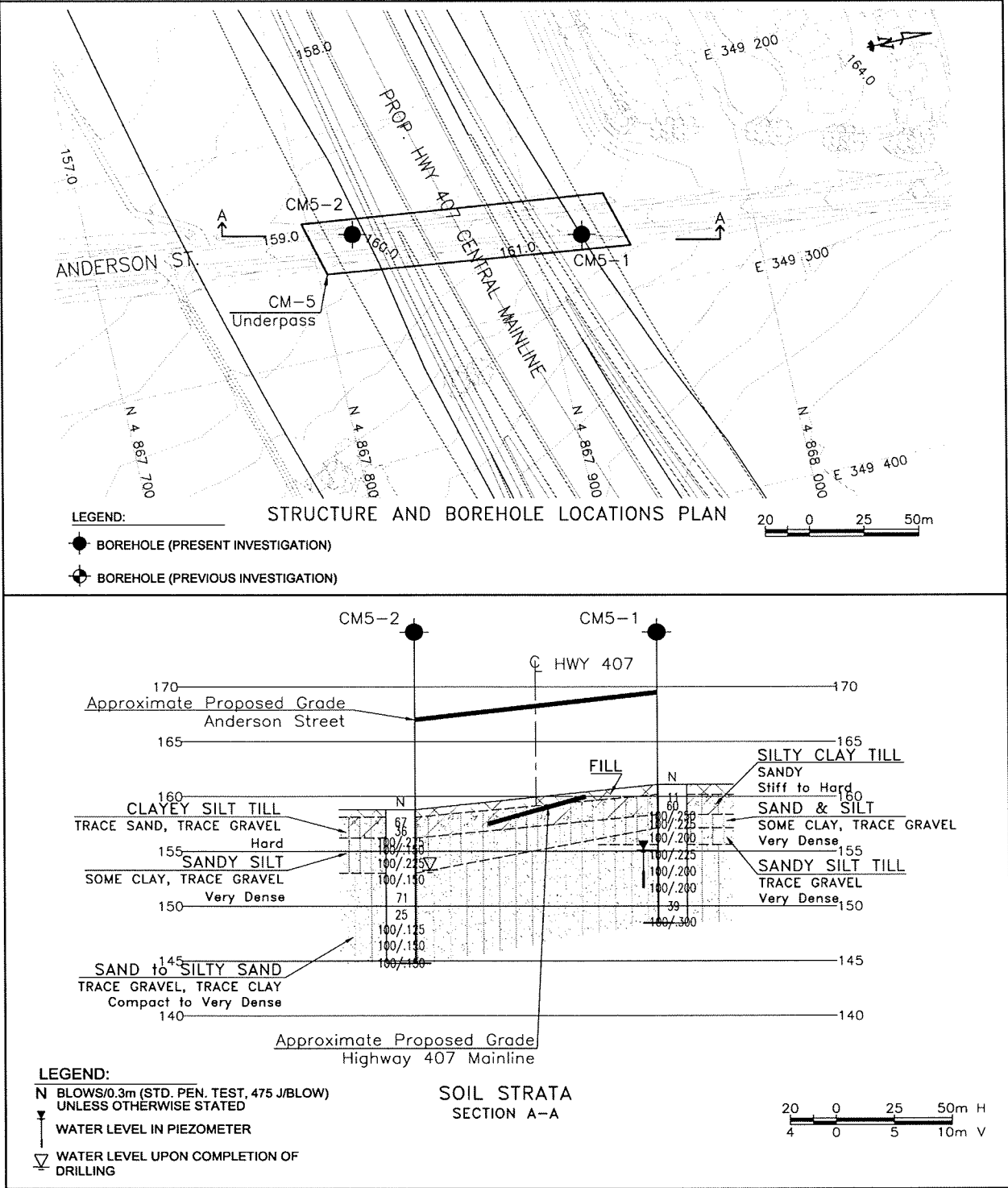
• **Sand and Silt to Sandy Silt:** Brown sand and silt to sandy silt, some clay, trace gravel was encountered below the cohesive layer in both boreholes. This layer is 1.3 m to 3.2 m in thickness, extending to Elev. 157.2 m to 153.0 m. This cohesionless deposit is very dense with ‘N’ values of 100 blows for less than 0.3 m penetration and with moisture contents ranging from 9% to 19%. Grain size distribution curves for samples of this soil are presented in Figure CM5-B3.

• **Sandy Silt Till:** A 1.5 m thick layer of grey sandy silt till, trace gravel underlies the sand and silt deposit in borehole CM5-1. The underside of this layer lies at Elev. 155.6 m. This till is very dense with ‘N’ values of 100 blows for less than 0.3 m penetration, with moisture content of about 8%.

• **Sand to Silty Sand:** Grey sand to silty sand, trace gravel, trace clay was encountered below the sandy silt and sandy silt till deposits in both boreholes. This layer is at least 7.1 m to 8.2 m in thickness, extending to Elev. 148.5 m to 144.8 m where both boreholes were terminated. This cohesionless deposit is compact to very dense with ‘N’ values ranging from 25 blows/0.3 m penetration to 100 blows for less than 0.3 m penetration and with moisture contents ranging from 8% to 21%. Grain size distribution curves for samples of this soil are presented in Figure CM5-B4.

**Groundwater Conditions:**

- BH CM05-1:** 5.8 m depth (Elev. 155.3 m) in open borehole on April 23, 2009 (unstabilized reading).  
6.0 m depth (Elev. 155.1 m) in piezometer on July 21, 2009.
- BH CM05-2:** 5.5 m depth (Elev. 153.3 m) in open borehole on April 22, 2009 (unstabilized reading).



Record of Borehole Sheets – Appendix A

Laboratory Test Results – Appendix B

Key Location Plan – Figure 1

PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:

CM-5

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General:** A two span structure with two abutments and a central pier is proposed.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread Footings founded on hard silty clay and clayey silt till or very dense sand and silt to sandy silt</i>	- Conventional construction - Low cost alternative	- Does not permit integral abutment design - Potential variability of surficial soils; footings must be extended below these soils - Unwatering may be required during excavation
<i>Spread Footings perched on Granular A pads for abutments</i>	- Lower cost than deep foundations - Minimize excavation requirements - Founding elevation may be adjusted	- Higher cost than spread footings on native soils - Sub-excavation of existing fill is required
<i>Steel H-Piles driven to very dense sandy silt, silty sand or sand</i>	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - Preaugering may be required to achieve adequate pile embedment
<i>Caissons founded in very dense sand to silty sand</i>	- Higher bearing resistance - Not so affected by surficial soil variability	- Does not permit integral abutment design - Potential installation problems including basal stability due to water-bearing sands/silts

**A - Spread Footings**

Spread footings founded on stiff to hard silty clay and clayey silt till or very dense silt/sand may be used for the abutments and at the pier. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary geotechnical design resistances and founding levels for spread footings on native soils, and spread footings on compacted Granular A cores, are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Silt Clay and Clayey Silt Till or Silt/Sand	450 kPa	300 kPa	At or below Elev. 159.5 m (north abutment) At or below Elev. 158.0 m (south abutment) At or below 158.0 m (pier)
Compacted Granular A	700 kPa	350 kPa	Fill base at or below Elev. 160.0 m (north abutment) Fill base at or below Elev. 158.0 m (south abutment)

**B - Steel H-Piles**

Steel H-piles driven to refusal within the very dense sandy silt to sand may be used to provide foundation support. The preliminary design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1,600 kN	1,400 kN	Not applicable	Below Elev. 154.0 m

Preaugering may be required in the very dense soils to achieve adequate pile embedment.

**C - Caissons**

Based on the presence of cohesionless deposits and potential for base boiling and uncertainties associated with cleaning and inspecting of the caisson bases, the use of caisson foundations is not recommended at this site and the option has not been developed.

**Recommended Foundation Alternative**

The recommended foundation alternative at this site is spread footings bearing on hard silty clay or clayey silt till or very dense silt/sand. Steel H-piles driven into the very dense sandy silt/sand may also be considered if integral abutment design is desired.

• **ABUTMENT TYPE**

The soil conditions at this site are suitable for conventional, integral or semi-integral abutment design.

• **APPROACHES**

Highway 407 mainline will be in a cut up to 5 m deep. In addition at the abutments approach fills in the order of 7 to 8 m high are proposed.

**Stability**

Approach embankments up to 10 m in height are anticipated to be stable at side slope inclinations of 2H : 1V using SSM or granular material. A 2 m wide mid-height bench is required for embankment slopes higher than 8 m.

**Settlement**

Settlements are expected to be less than 50 mm and to occur essentially during construction.

• **CONSTRUCTION CONSIDERATIONS**

**Pile Installation**

During pile installation through glacially derived soils at this site, there is a high probability of encountering obstructions such as cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

**Excavation**

Temporary excavation slopes for footing or pile cap construction should not be steeper than 1H : 1V. In accordance with OHSA the fill materials are classified as Type 3 material. The silty clay/clayey silt till and silt/sand are Type 2 material above the water table and Type 3 soil below the water table.

**Groundwater/Surface Water Control**

Diversion of surface runoff from the foundation excavation and pumping from carefully constructed, filtered sumps should be adequate to control water within excavations during construction.

**Protection Systems**

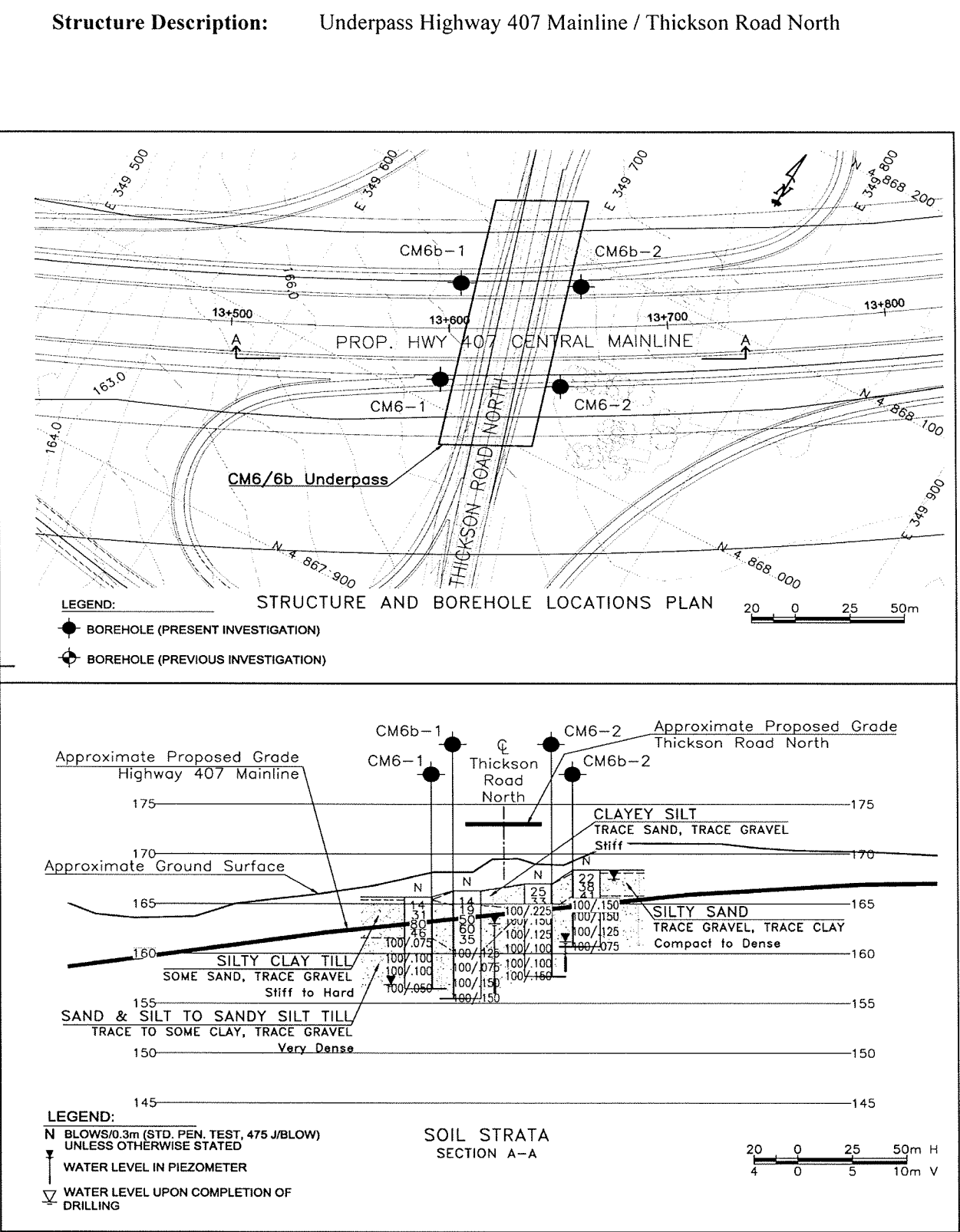
Protection systems would be required at excavation locations where stable slopes cannot be constructed due to space limitations and where vertically sided excavations are used for footing or pile cap construction. One possible system is the use of soldier piles and lagging. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

• **RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the actual abutment and pier locations and at the approaches.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:	CM-6/6b
--------------	---------





PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:	CM-6/6b
--------------	---------

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General:

A two-span structure with two abutments and one pier is proposed.

Foundation Option	Advantages	Disadvantages
Spread Footings founded on very dense sand and silt till or hard silty clay till	- Conventional construction	- Does not permit integral abutment design - Potential variability of surficial soils; footings must be extended below these soils - Unwatering/protection systems may be required
Spread Footings perched on Granular A pads for abutments	- Lower cost than deep foundations - Minimize excavation requirements	- Higher cost than spread footings on native soils - Potential variability of surficial soils
Steel H-Pile driven into very dense sand and silt till	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - Pre-drilling may be required to install the piles to the desired depths
Caissons founded in very dense sand and silt till	- Higher bearing resistance - Not so affected by surficial soil variability	- Higher cost than spread footings - Does not permit integral abutment design - Potential installation problems due to high groundwater level and water-bearing sands/silts

A - Spread Footings

Spread footings founded on very dense native sand and silt till, or hard silty clay till deposits, may be used for closed abutments and the pier. All footings must be founded below the proposed highway grade. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Sand and Silt Till Silty Clay Till	600 kPa	400 kPa	At or below Elev. 164.0 m – North Abutment West (NAW) At or below Elev. 165.5 m – North Abutment East (NAE)
			At or below Elev. 163.5 m – South Abutment West (SAW) At or below Elev. 164.4 m – South Abutment East (SAE)
Compacted Granular A	700 kPa	350 kPa	Base of Fill Pad at/below Elev. 164.5 m – NAW Base of Fill Pad at/below Elev. 167.5 m – NAE
			Base of Fill Pad at/below Elev. 164.3 m – SAW Base of Fill Pad at/below Elev. 166.0 m – SAE

B - Steel H-Piles

Steel H-piles driven to refusal within the very dense sand and silt till may be used to provide foundation support. The recommended design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1,600 kN	1,400 kN	Not applicable	North Abutment At or Below Elev. 159 m (west)/162 m (east)
				South Abutment and Pier At or Below Elev. 159 m (west)/161 (east)

C – Caissons

Based on the presence of water-bearing cohesionless deposits and the relatively high groundwater table, the use of caisson foundations is not recommended and the option has not been developed.

Recommended Foundation Alternative

The recommended foundation alternative at this site is steel H-piles driven into the very dense sand and silt till. Alternatively, spread footings founded on the very dense sand and silt till, or hard silty clay till, deposits may be used for the piers.

• ABUTMENT TYPE

The soil conditions at this site are suitable for integral abutment design.

• APPROACHES

General

Cut – The proposed Hwy. 407 mainline grade at this location is in the order of Elev. 164 to 165 m (west to east), requiring a cut in the order of 3 to 4 m in depth. Retaining walls may be required at locations where property restrictions do not allow formation of stable permanent cut slopes.

Fill – Based on a proposed Thickson Road grade at about Elev. 173 to 175 m, up to the order of 5 to 6 m of fill will be required to construct the approaches.

Stability

Approaches up to 10 m in height above the proposed highway grade are anticipated to be stable at slope inclinations of 2H : 1V using SSM or better material. Permanent cut slopes along the highway alignment, formed through compact to dense silty sand, stiff clayey silt and silty clay till, are anticipated to be stable at inclinations of 2H : 1V or flatter provided that adequate drainage is in place to maintain the groundwater level below the base of the cut. A 2 m wide mid-height berm would be required for slopes higher than 8 m.

Settlement

Settlement is not expected to be an issue at this site. Elastic settlements are expected to occur as fill is placed.

• CONSTRUCTION CONSIDERATIONS

Pile Installation

During pile installation through glacially derived soils at this site, there is a medium probability of encountering obstructions such as cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

Excavation

Excavations of up to 3 to 4 m depth will be required to form the cut for the highway mainline. Shallower excavations below the highway grade are required should there be a need for footing construction. For cuts through the surficial silty sand, clayey silt and the upper portion of the silty clay till, temporary unsupported side slopes should not be steeper than 1H : 1V. In accordance with the OHSA, native soils above the groundwater level are classified as Type 2 soils, while native soils below the groundwater level and fills are classified as Type 3 soils.

Groundwater/Surface Water Control

It is anticipated that much of the water accumulation within the cut will be from surface runoff and precipitation, with some contribution from perched water in the surficial silty sand and seepage from water-bearing interlayers within the cohesive soils. Diversion of surface runoff from the excavations and pumping from carefully constructed, filtered sumps should be adequate to control the water during construction.

Protection Systems

Protection systems may be required at some locations for abutment and pier construction, and along the highway cut where vertically sided temporary cuts are required. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. Depending on the final design layout, this may include additional boreholes for the approaches and shallow footing foundations, or for different foundation element locations.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION

LOCATION No:	CM-07
--------------	-------

Structure Description: Culvert at Pringle Creek Tributary, Highway 407 E Central Mainline

W.O. 07 – 20016

Highway 407 Proposed Grade: ~ El. 170.5 m
Site Ranking: Medium

Existing Ground Elevation: ~ El. 166.9 to 167.3 m
Station: 14+000

FOUNDATION INVESTIGATION

Site Description:

At this site, the creek flows in a north-south direction in a shallow valley underlain by silt till ground moraine. Alluvial deposits are mapped along the creek. The relief is low, rolling and imperfectly to poorly drained.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM07-1	North side	4 868 315.0	349 989.1	167.3	9.3
CM07-2	South side	4 868 237.7	350 034.4	166.9	9.2

Subsurface Conditions:

• **Topsoil:** Between 0.5 and 0.8m of topsoil was encountered in both boreholes. The thickness and extent of the topsoil are expected to vary between and beyond the borehole locations, and the information in this report should not be used for quantity estimating purposes.

• **Clayey Silt:** A 0.9m thick layer of brown clayey silt with some sand and trace gravel was encountered below the topsoil in borehole CM07-2. This clayey silt is stiff, with an ‘N’ value of 13 blows/0.3m and it has a moisture content of 9%.

• **Silty Sand Till:** Silty sand till with some clay and trace gravel was encountered below the clayey silt layer in borehole CM07-2. This layer is 3 m thick, with an underside at Elev. 162.5m. The till layer is very dense with ‘N’ values ranging from 60 to more than 100 for less than 0.3m penetration and it has a moisture content ranging from 5 to 8%. A grain size distribution curve for a sample of this soil is presented in Figure CM07-B4. Glacial tills typically contain cobbles and boulders.

• **Silty Clay:** A deposit of dark brown silty clay with some sand was encountered below the topsoil in borehole CM07-1. This layer is 3.2 m thick, with an underside at Elev. 163.3 m. This layer is stiff to hard with ‘N’ values ranging from 9 to more than 100 blows for less than 0.3m penetration. Moisture contents ranged from 11 to 19%. A grain size distribution curve for a sample of this soil is presented in Figure CM07-B1.

• **Sand and Silt:** Brown sand and silt with trace of clay and trace gravel was encountered below the silty sand till layer in borehole CM07-2 and below the silty clay in borehole CM07-1. This layer is 1.7m in thickness with an underside at Elev. 160.8m in borehole CM07-2 and is 3.3m thick in borehole CM07-1 with an underside at Elev. 160m. This layer is dense to very dense with ‘N’ values ranging from 43 to more than 100 blows for less than 0.3m penetration. Measured moisture contents ranged from 8% to 19%. Grain size distribution curves for samples of this soil are presented in Figure CM07-B2.

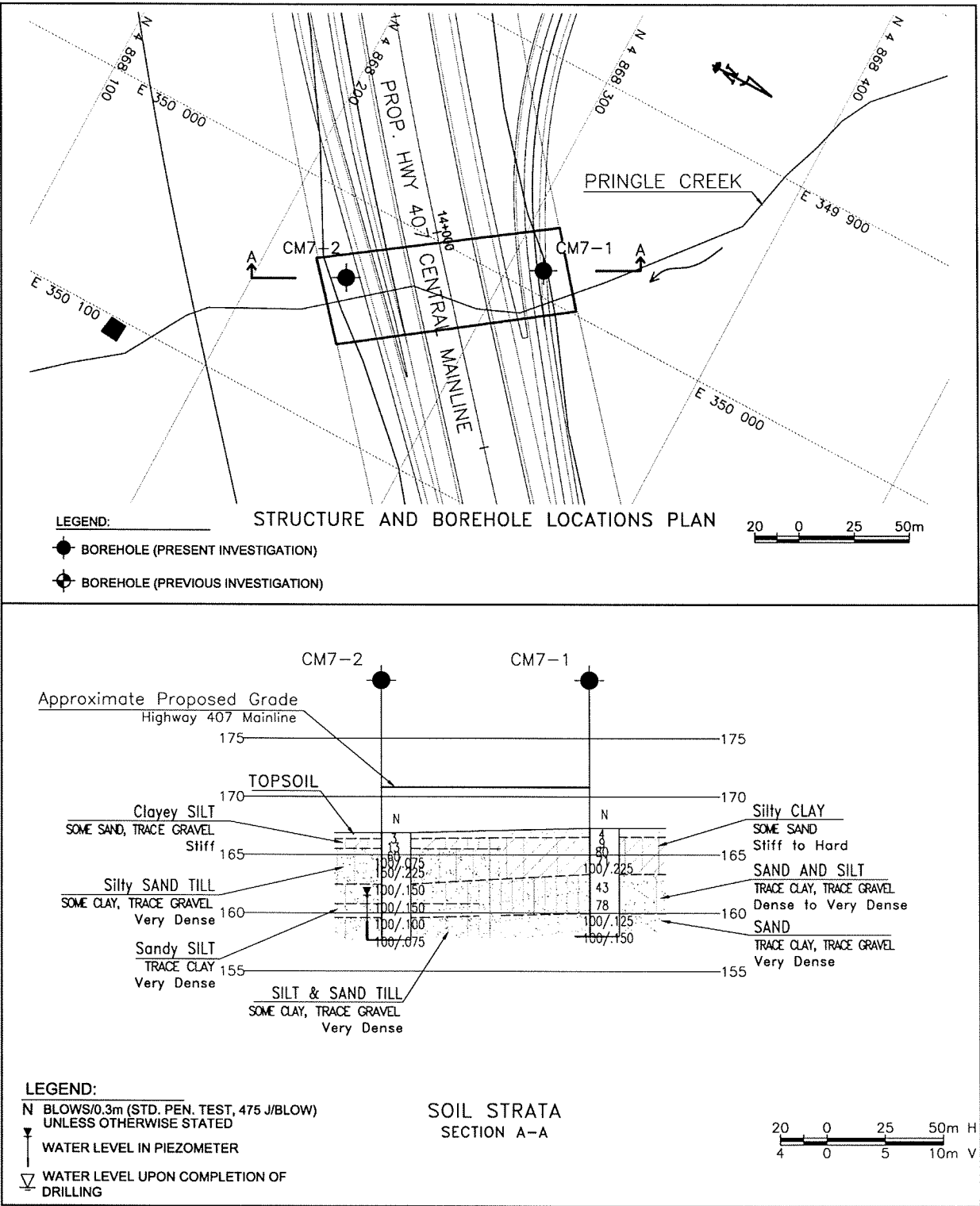
• **Sand:** Brown sand with trace of clay and trace gravel was encountered below the sand and silt layer in Borehole CM07-1. Borehole CM07-1 was terminated in this sand at 9.3 m depth (Elev. 158 m). This layer is very dense with ‘N’ values greater than 100 blows for less than 0.3m penetration. Measured moisture content ranged from 14 to 15%. A grain size distribution curve for a sample of this soil is presented in Figure CM07-B3.

• **Sandy Silt:** Brown sandy silt with trace of clay was encountered below the sand and silt layer in borehole CM07-2. This layer is 1.2 m in thickness, with an underside at Elev. 159.6 m. This layer is very dense with ‘N’ value of 100 blows for less than 0.3m penetration and with moisture content of about 19%. A grain size distribution curve for a sample of this soil is presented in Figure CM07-B5.

• **Silt and Sand Till:** Brown silt and sand till with some clay and trace of gravel was encountered below the sandy silt layer in borehole CM07-2. Borehole CM07-2 was terminated in this till at 9.2 m depth (Elev. 157.7 m). This soil is hard with ‘N’ values of 100 blows for less than 0.3m penetration and with moisture content ranging from 6 to 9%. A grain size distribution curve for a sample of this soil is presented in Figure CM07-B6.

Groundwater Conditions:

• **BH CM07-2:** 2.6 m depth (Elev. 164.3 m) in piezometer on February 12, 2009.  
5.4 m depth (Elev. 161.5 m) in piezometer on May 9, 2009.





PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:	CM-07
--------------	-------

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General** : An open footing concrete culvert is proposed.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread footings founded on hard silty clay or very dense silty sand till</i>	- Conventional construction - Low cost alternative	- Unwatering will be required - Variability of surficial soils in floodplain - Scour protection is required for footings in floodplain - Sub-excavation of topsoil and native clayey silt or silty clay to construct footings
<i>Spread Footings perched on Granular A pads on stiff to hard silty clay or stiff clayey silt</i>	- Lower cost than deep foundations - Founding level can be adjusted	- Unwatering will be required - Variability of surficial soils in floodplain - Scour protection is required for footings in floodplain - Sub-excavation of topsoil to construct pads - Higher cost than spread footings on native soil
<i>Steel H-Pile driven into very dense sand or very dense silt and sand till</i>	- Higher bearing resistance - Not affected by surficial soil variability	- Higher cost than spread footings - Unwatering will be required for pile cap construction
<i>Caissons socketted in very dense sand or very dense silt and sand till</i>	- Higher bearing resistance - Not affected by surficial soil variability	- Higher cost than spread footings - Unwatering will be required for pile cap construction - Require liners to address installation problems including side sloughing associated with cohesionless soils - Need to dislodge and handle cobbles and boulders - Potential for base boiling

**A – Spread Footings**

Spread footings founded on hard silty clay or very dense silty sand till may be used. Footings founded on a compacted Granular A pad may also be used as long as the topsoil and soft soils are removed. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Silty clay or silty sand till	525 kPa	350 kPa	At or below Elev. 165.5 m
Compacted Granular A	700 kPa	350 kPa	Base of Fill Pad at/below Elev. 166 m

**B – Steel H-Piles**

Steel H-piles are not recommended for a culvert at this site since hard to dense native soils are present at shallow depth below the stream bed.

**C – Caissons**

Caissons are not recommended at this site due to possible installation problems related to water bearing cohesionless deposits, a high groundwater table, the associated potential of base boiling, and the presence of cobbles and boulders in till deposits. Furthermore, hard to dense native soil are present at shallow depth below the stream bed.

**Recommended Foundation Alternative**

From a foundation engineering perspective, the recommended foundation alternative at this site is spread footings founded on hard silty clay or very dense silty sand till at or below Elev. 165.5m.

• **APPROACHES**

Up to 4.0 m of fill will be required to construct the highway mainline approaches.

**Stability**

Fill embankments up to 4.0 m in height are anticipated to be stable at side slope inclinations of 2H : 1V using SSM or better material.

**Settlement**

Settlement is not expected to be an issue at this site.

• **CONSTRUCTION CONSIDERATIONS**

**Excavation**

Excavations will be required for footing construction. No excavation should be carried out in the floodplain without prior dewatering. Temporarily unsupported side slopes should not be steeper than 1H : 1V where groundwater control measures are implemented as outlined below. In accordance with the OHSA, all fills and stiff clayey silt/silty clay are classified as Type 3 soils. The hard clay and very dense silty sand till is Type 2 soil above water table and Type 3 below water table.

**Groundwater/Surface Water Control**

The groundwater table is expected to be near the creek water level. Diversion of stream flow and surface runoff from the excavation and pumping from carefully constructed, filtered sumps are expected to be adequate to control groundwater within foundation excavations. The required groundwater control systems should be further assessed during detail design.

**Protection Systems**

Protection systems are not expected to be required at this site.

• **RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the culvert. As a minimum, this is likely to require additional boreholes along the culvert alignment. The feasibility and cost effectiveness of alternate dewatering systems would need to be investigated.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:	CM-9
--------------	------

Structure Description: Underpass Highway 407 mainline / Garrard Road

Highway 407 Proposed Grade: ~ 166.6 m at centreline

Site Ranking: Medium

Existing Ground Elevation: ~ El. 172 m

Station: 14+518

FOUNDATION INVESTIGATION

Site Description:

At this site, Garrard Road is an existing two-lane, rural undivided roadway surrounded by farmlands. The terrain is locally flat, and is mapped as a glacial silt till plain.

Borehole Information:

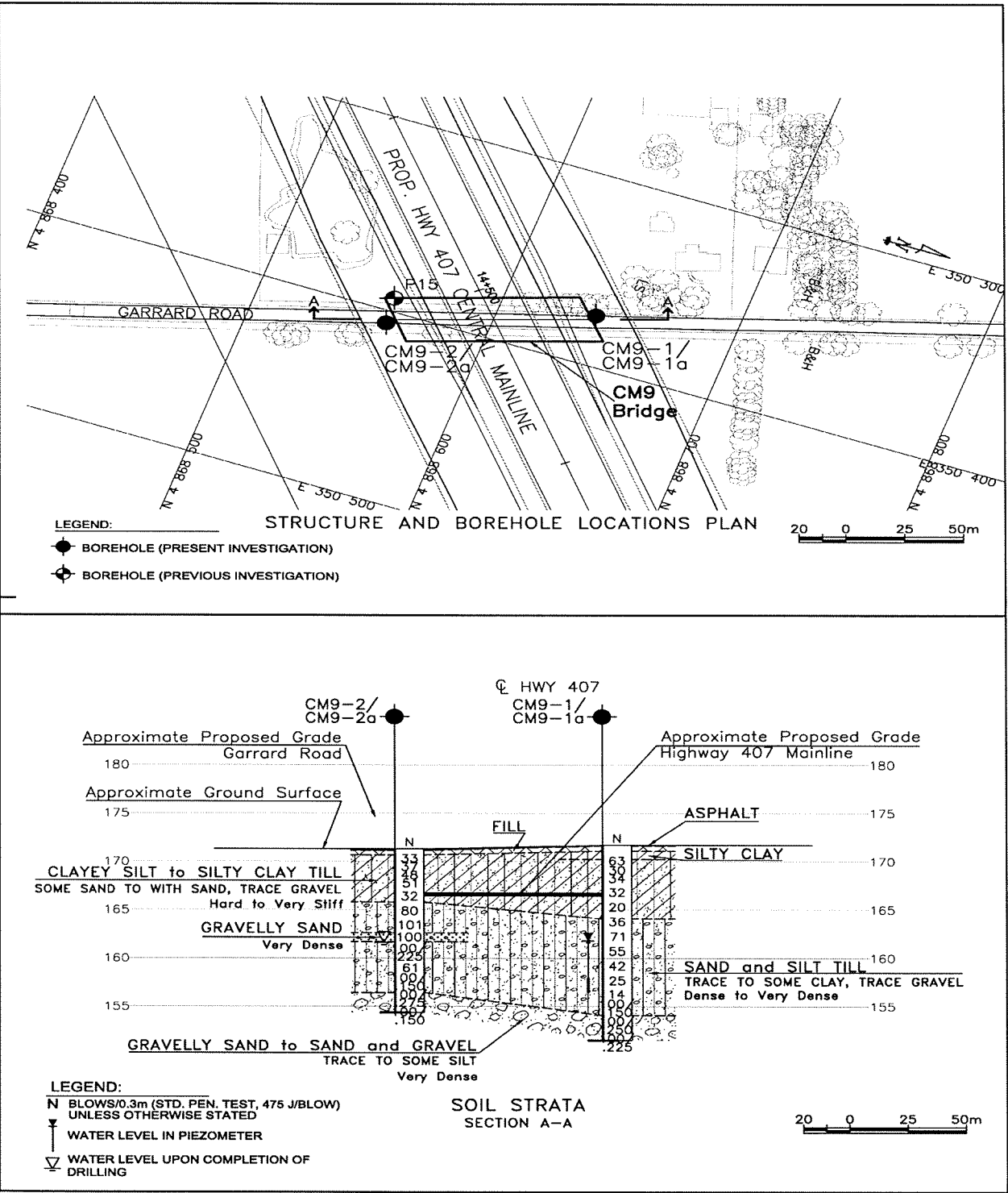
Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM9-1/1A	North Abutment	4 868 640.5	350 373.3	171.7	20.2
CM9-2/2A	South Abutment	4 868 557.6	350 406.6	171.3	16.9
P15	South Abutment	4 868 556.6	350 392.8	172.2	17.0

Subsurface Conditions:

- Fill Materials :** A 0.6 m thick pavement structure (75 to 150 mm of asphalt over brown and moist sand fill) is present at ground surface which varies between Elev. 171.7 and 171.3 m in Boreholes CM9-1/1A and CM9- 2/2A. The underside of the fill varies from Elev. 171.1m on the north side to 170.7 m on the south side. Measured water contents of the fill were less than 5%.
- Clayey Silt and Silty Clay Till :** The fill is underlain by a deposit of clayey silt till, which grades into a silty clay till at the north side, containing some sand, trace gravel and occasional cobbles. The thickness of these cohesive tills ranged from 4.9 to 6.2 m. The underside of these brown to grey cohesive tills varies from Elev. 164.1 m on the north side to 165.8 m on the south side. The clayey silt till is hard throughout (SPT ‘N’ values range from 30 to 89 blows/0.3m penetration), and the silty clay till changes from hard to very stiff with depth (‘N’ values of 32 and 20 blows/0.3m penetration). Figures CM9-B1 to B4 present the laboratory test results for these tills. The Atterberg limits tests indicate that both the clayey silt till and silty clay till are of low plasticity (LL = 15 to 16, PI = 6 to 7 for clayey silt matrix; LL=33, PI=19 for silty clay matrix). A 0.8 m thick layer of silty clay is present above the clayey silt till on the north side. Measured water contents of the cohesive tills typically ranged between 8% and 23%.
- Sand and Silt Till :** A sand and silt till containing trace to some clay, trace gravel underlies the clayey silt and silty clay till across the site. This till layer is about 10 m thick on the north side and about 9.4 m thick on the south side. The underside of this till lies at Elev. 154.1 m in Borehole CM9-1/1A (north side) and at Elev. 156.5 m in Boreholes CM9-2/2A (south side). Borehole P15 was terminated within this till at Elev. 155.2 m. This cohesionless till is typically grey and moist, and is in a compact to very dense state (‘N’ values ranging from 14 blows/0.3m penetration to >100 blows for <0.3m penetration). Figure CM9-B5 presents the laboratory test results for this till. Measured water contents of this cohesionless till typically varied from 5% to 15%.
- Gravelly Sand :** A deposit of gravelly sand (occasionally sand and gravel) with trace to some silt underlies the sand and silt till in Boreholes CM9-1/1A and CM9-2/2A. The thickness of this deposit ranges from 0.6 m to greater than 2.6 m. Boreholes CM9-1/1A and CM9-2/2A were terminated within this deposit at Elev. 151.5 and 154.4 m, respectively. This soil is grey and wet, contains inferred cobbles and boulders, and is in a very dense state (‘N’ values of 100 blows/0.3m and >100 blows for <0.3m). Figure CM9-B6 presents the laboratory test results for samples of these deposits. Measured water contents of these deposits ranged from 2% to 5%.

Groundwater Conditions:

- BH CM9-1:** 9.5 m depth (Elev. 162.2 m) in piezometer on March 12, 2008.
  - BH CM9-2A:** 9.9 m depth (Elev. 161.4 m) in open borehole on December 10, 2007.
  - BH P15:** 3.7 m depth (Elev. 168.5 m) in open borehole on December 7, 1993.
- Note: The water level in the open hole at BH P15 was an unstabilized reading taken 5 hours after completion of drilling. The piezometer readings monitored over a 3-month period in BH CM9-1 indicate a relatively stabilized water level.



Record of Borehole Sheets – Appendix A

Laboratory Test Results – Appendix B

Key Location Plan – Figure 1

PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION

LOCATION No:

CM-9

W.O. 07 – 20016

C - Caissons

Based on the presence of water-bearing cohesionless deposits containing cobbles and boulders, and the associated potential of base boiling, the use of caisson foundations is not recommended and the option has not been developed.

Recommended Foundation Alternative

The recommended foundation alternative at this site is spread footings founded on the dense to very dense sand and silt till. Alternatively, steel H-piles driven into the very dense sand/silt till or gravelly sand may be considered for the abutments.

• ABUTMENT TYPE

The soil conditions at this site are suitable for semi-integral abutment design, but an integral abutment design is also possible.

• APPROACHES

General

Cut - The proposed Hwy. 407 mainline grade at this location is at approximate Elev. 166.6 m, requiring a cut of about 5.5 m below existing grade. Retaining walls may be required at locations where property restrictions do not allow formation of stable permanent cut slopes.

Fill - Based on a proposed Garrard Road grade at Elev. 174.5, up to 2.5 m of fill will be required to construct the approaches.

Stability

Approaches up to 8 m in height above the proposed highway grade are expected to be stable at side slopes of 2H : 1V at this site. Permanent cut slopes formed through the clayey silt to silty clay till are anticipated to be stable at inclinations of 2H : 1V.

Settlement

Settlement is not expected to be an issue at this site.

• CONSTRUCTION CONSIDERATIONS

Pile Installation

During pile installation through glacially derived soils, there is a medium probability of encountering cobbles or boulders. Pile driving shoes should be fitted to the pile tips for reinforcement and enhancing penetration.

Excavation

Excavations of up to 5.5 m will be required to form the cut for the highway mainline. For cuts through the existing fill and the hard clayey silt to silty clay till, temporary unsupported side slopes should not be steeper than 1H : 1V. In accordance with the OHSA, the existing fill, glacial tills, sands and gravel below the groundwater level are classified as Type 3 soils; glacial tills above the groundwater level are classified as Type 2 soils.

Groundwater/Surface Water Control

It is anticipated that much of the water accumulation within the cut will be from surface runoff, with some contribution from perched water in the existing fill and seepage from water-bearing interlayers within the cohesive tills. Diversion of surface runoff from the cut and pumping from carefully constructed, filtered sumps should be adequate to control this water.

Protection Systems

Protection systems may be required at excavation locations where stable slopes cannot be constructed due to space limitations. One possible system is soldier piles and lagging although installation of the soldier piles in dense till may be difficult. The feasibility of installing the protection system should be assessed once further subsurface investigation is carried out during detail design.

• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the pier location, the approaches and possibly at the abutments if shallow footings are used. Pile installation methods would need to be investigated for integral abutment design.

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General** : A two span structure with two abutments and a central pier is anticipated..

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread Footings founded on very dense sand and silt till</i>	- Conventional construction	- Requires sub-excavation of up to 2.5m below the proposed base of cut - Protection systems (temporary shoring) may be required
<i>Spread Footings perched on Granular A pads for abutments</i>	- Lower cost than deep foundations - Minimize excavation requirements	- Higher cost than spread footings on native soils - Sub-excavation of existing fill and native cohesive soils is required
<i>Steel H-Pile driven to dense sand/silt till or the underlying gravelly sand</i>	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - May encounter difficulties when driving piles through dense till
<i>Caissons founded in very dense gravelly sand to sand and gravel</i>	- Higher bearing resistance - Not so affected by surficial soil variability	- Higher cost than spread footings - Does not permit integral abutment design - Potential problems due to augering through cobbles/boulders; and the need to use liners and/or drilling mud to stabilize the hole in cohesionless soils below the water table

A - Spread Footings

Spread footings founded on very dense sand and silt till may be used for the pier and for closed abutments. Footings on native soils must be founded below the proposed highway grade at approximate Elev. 166.6 m. This will require excavations of up to 2.5 m below the proposed highway grade. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Sand and Silt Till	600 kPa	400 kPa	At or below Elev. 164.1 m – north side At or below Elev. 165.8 m – south side
Compacted Granular A	700 kPa	350 kPa	Base of Fill Pad at or below Elev. 170.2 m – north side Base of Fill Pad at or below Elev. 170.7 m – south side

B - Steel H-Piles

Steel H-piles driven to refusal within the very dense sand/silt till or the underlying gravelly sand may be used to provide foundation support. The preliminary design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1,600 kN	1,400 kN	Not applicable	Below Elev. 154 m – north side Below Elev. 157 m – south side

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – EASTERN SECTION

LOCATION No:	CM-10/10b
--------------	-----------

Structure Description: Overpass Highway 407 Central Mainline / Oshawa Creek West Branch

W.O. 07 – 20016

Highway 407 Proposed Grade: ~ El. 165 to 168 m

Site Ranking: Medium

Existing Ground Elevation: ~ El. 155 m (floodplain level)  
~ El. 162 to 165 m (west plateau)

Station: ~ 15+080

FOUNDATION INVESTIGATION

Site Description:

At this site, the creek flows within a 250 m wide valley consisting of a silty, gravelly sand alluvial plain. The relief is low plain and poorly to very poorly drained. Peat is mapped at the east side of the alluvial plain.

Borehole Information:

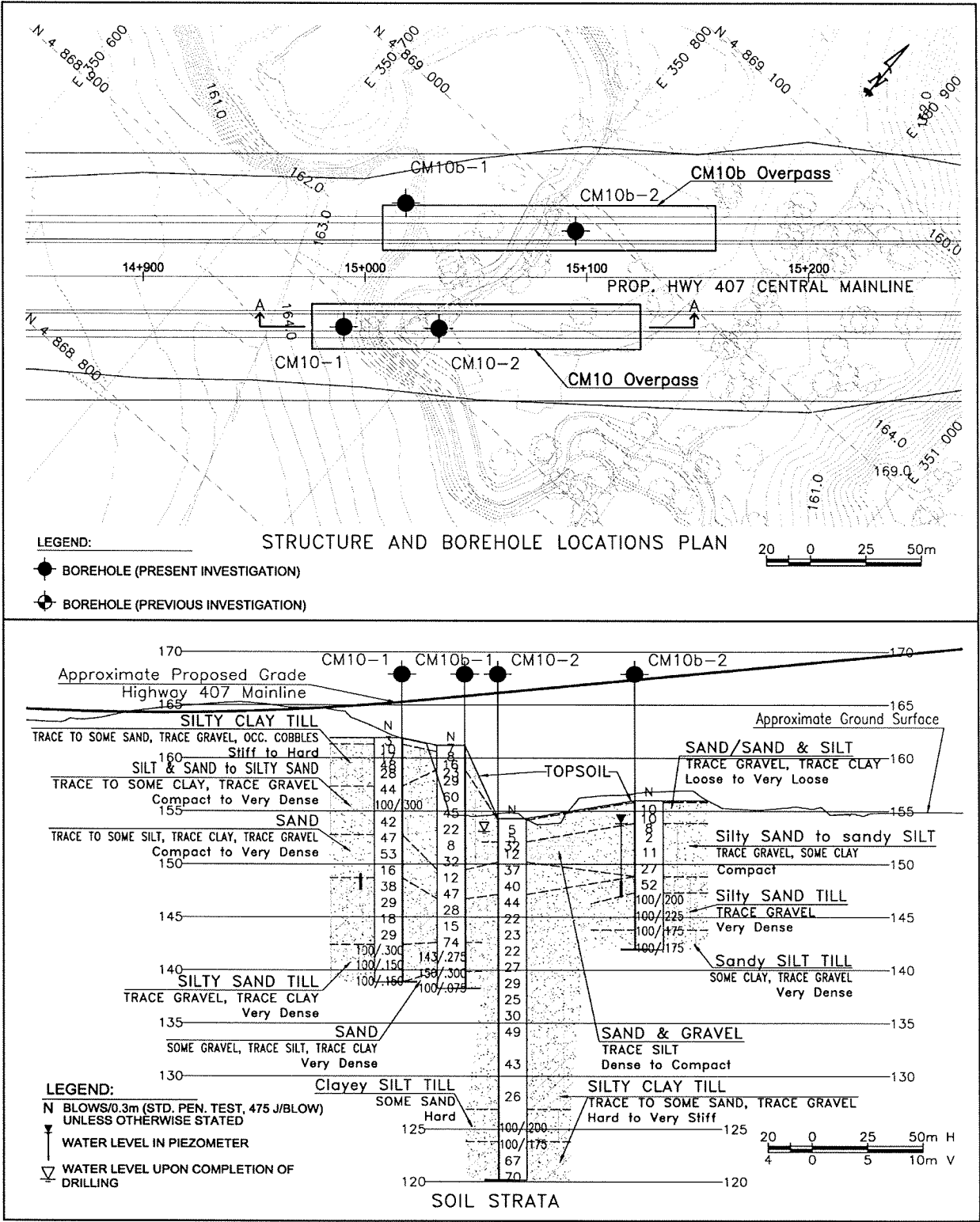
Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM10-2	Floodplain (CM10 Overpass)	4 868 918.7	350 796.7	154.3	34.1
CM10-1	West Abut. (CM10 Overpass)	4 868 891.2	350 763.6	161.9	23.0
CM10b-2	Floodplain (CM10b Overpass)	4 868 991.9	350 815.3	156.0	14.0
CM10b-1	West Abut. (CM10b Overpass)	4 868 951.4	350 749.1	161.2	22.9

Subsurface Conditions:

- Topsoil:** Between 150 and 600 mm of topsoil containing roots was encountered in all four boreholes. The thickness and extent of topsoil are expected to vary between and beyond the borehole locations, and the information in this report should not be used for quantity estimating purposes.
- Sands and Silts:** Layers of brown to grey deposits of sands and silts were encountered below the topsoil or the silty clay till in all four boreholes. The combined thickness of these deposits range between 7.0 and 12.2 m, with underside elevations ranging from 145.7 to 148.8 m. These cohesionless soils are typically loose becoming compact to dense with depth ('N' values ranging between 2 and 45 blows/0.3m penetration). Figures CM10/10b-B1 to -B3 present grain size distribution curves for samples of these soils. Measured moisture contents of these soils varied between 10% and 32%.
- Sand and Gravel:** A layer of sand and gravel was found interlayered within the sands and silts in Borehole CM10-2. This layer is 1.9 m thick and its underside is at Elev. 150.2 m. This cohesionless soil is dense to compact ('N' values of 32 and 12 blows/0.3m penetration). Figure CM10/10b-B4 presents the grain size distribution curve for a sample of this soil. Measured moisture contents of this soil were at 8% to 10%.
- Silty Clay Till:** A deposit of grey silty clay till, trace to some sand and trace gravel was encountered below the topsoil or surficial sands and silts in all four boreholes. This till ranges between 1.5 and 23.8 m in thickness, with undersides ranging between Elev. 147.3 m in Borehole CM10b-2 to Elev. 120.2 m where Borehole CM10-2 was terminated. This till has a stiff to hard consistency ('N' values ranging from 8 to 70 blows/0.3m penetration with occasional 'N' value of >100 for <0.3m penetration). Glacial tills typically contain cobbles and boulders. Figures CM10/10b-B5 to -B8 present laboratory test results for samples of this till. The Atterberg limits results indicate that it has a low to medium plasticity (LL = 24 to 37 and PI = 11 to 20). Measured moisture contents of this soil ranged between 10% and 30%.
- Clayey Silt Till:** A deposit of clayey silt till, some sand was found interlayered with the silty clay till in Borehole CM10-2. This layer is 3.1 m thick with an underside at Elev. 123.8 m. This till has a hard consistency ('N' value >100 for <0.3m penetration). Glacial tills typically contain cobbles and boulders. Figure CM10/10b-B9 presents the grain size distribution of a sample of the clayey silt till. A moisture content of about 12% was measured.
- Silty Sand/Sandy Silt Till:** Silty sand and sandy silt till containing some clay and trace gravel was encountered below the silty clay till in Boreholes CM10-1, CM10b-1 and CM10b-2. The combined thickness of these till deposits is at least 2.7 m to greater than 5.3 m. The three boreholes were terminated within the till. The till is very dense throughout ('N' values >100 blows for <0.3m penetration). Glacial tills typically contain cobbles and boulders. Figure CM10/10b-B10 presents the grain size distribution curves of samples of silty sand till. Measured moisture contents of these soils ranged between 8% and 15%.

Groundwater Conditions:

- BH CM10-2:** 1.2 m depth (Elev. 153.1 m) in open borehole on March 12, 2008.
- BH CM10-1:** 4.8 m depth (Elev. 157.1 m) in open borehole on March 12, 2009.
- BH CM10b-2:** 2.2 m depth (Elev. 153.8 m) in piezometer on July 28, 2008.



PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – EASTERN SECTION

LOCATION No: CM-10/10b

W.O. 07 – 20016

caissons extending 4 m into the hard (‘N’ >100 blows) silty clay till, or 4 m into the very dense sand and silt till, and developing resistance through shaft friction and a portion of end-bearing within the till are as follows:

Caisson Diameter	Axial Geotechnical Resistance		Downdrag Load (Factored ULS)	Highest Founding Level
	Factored ULS	SLS		
1.2 m	6,400 kN	5,000 kN	Not Applicable	Elev. 122 m (CM10 Overpass pier) Elev. 138 m (CM10 Overpass west abutment)
1.5 m	9,000 kN	6,000 kN	Not Applicable	Elev. 143 m (CM10b Overpass pier) Elev. 139 m (CM10 Overpass west abutment)

Given the uncertainties associated with cleaning and inspection of the base, the extent and apparent lack of continuity of the cohesive silty clay till across the site, the above recommended values and founding levels must be reassessed during detail design (Recommendations for Additional Work).

Recommended Foundation Alternative

From a foundation engineering perspective, the recommended foundation alternative at this site is steel H-piles driven to the very stiff to hard clayey silt to silty clay till, or the very dense sand and silt till.

ABUTMENT TYPE

The soil conditions at this site are suitable for conventional or integral abutment design.

APPROACHES

Up to 15 m of fill (approximately 150 m in length) will be required to construct the highway mainline east approach, while up to 4 m of fill will be required for the west approach.

Stability

For the west approach, fill embankments up to 4 m in height are anticipated to be stable at side slope inclinations of 2H : 1V using SSM or better material. For the east abutment, approach embankments up to 15 m in height, in conjunction with two 2 m wide mid-height berm, are anticipated to be stable at side slope inclinations of 2H : 1V using SSM or better material.

Settlement

Foundation settlement will occur as fill is placed and should be completed by the end of construction. It is estimated that post construction foundation settlement and fill compression will not exceed 25 and 75 mm at the west and east approaches, respectively.

CONSTRUCTION CONSIDERATIONS

Pile Installation

During pile installation through glacially derived soils at this site, there is a medium probability of encountering cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

Excavation

Excavations will be required for footing and pile cap construction. No excavation should be carried out in the floodplain without prior unwatering. Temporarily unsupported side slopes should not be steeper than 1H : 1V where groundwater control measures are implemented as outlined below. In accordance with the OHSA, sands and silts below the groundwater level are classified as Type 3 and Type 4 soils, respectively.

Groundwater/Surface Water Control

The groundwater table is near the floodplain grade. Prior to excavations in the floodplain, groundwater control systems such as well points and/or interlocking sheetpiled cofferdams would be required. Diversion of surface runoff from the excavation and pumping from carefully constructed, filtered sumps should be used to supplement the above systems. The required groundwater control systems should be further assessed during detail design.

Protection Systems

Protection systems would be required at excavation locations where stable slopes cannot be constructed due to space limitations and where vertically sided excavations are used for footing or pile cap construction. One possible system at the floodplain level is an interlocking sheetpiled cofferdam which can also be used for groundwater cutoff as outlined above. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

Floodplain Access

Potential environmental impacts will need to be minimized during construction access into the sensitive floodplain. Specific access preparation procedures including the use of gravel roadways underlain by geosynthetics should be considered.

RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the actual abutment and pier locations and at the approaches. The feasibility and cost effectiveness of alternate unwatering systems would need to be investigated. Should caissons be adopted for foundation support in the creek valley, additional deeper boreholes will need to be drilled to obtain additional subsurface information to reassess the caisson design and installation techniques.

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General : Twin four-span structures each with two abutments and three piers are proposed.

Foundation Option	Advantages	Disadvantages
Spread Footings founded on very loose to compact sands and silts with high groundwater table within floodplain	- Conventional construction	- Variable density and very low bearing resistance for soils in floodplain; requires sub-excavation up to 5 to 6m depth to reach competent founding soils in floodplain - Extensive unwatering and protection (temporary shoring) systems will be required for footing construction - Scour protection is required for footings in floodplain
Spread Footings perched on Granular A pads at both abutments	- Lower cost than deep foundations - Minimize excavation requirements	- Variability of surficial soils in floodplain; sub-excavation of approximately 2 to 4 m depth may be required - Protection systems (temporary shoring) may be required for footing construction
Steel H-Piles driven to very stiff to hard silty clay till or very dense sand and silt till	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - Sub-excavation of topsoil, organics and native sands and silts at shallow depths to construct pile caps - Unwatering and protection (temporary shoring) systems may be required for pile cap construction
Caissons founded within very stiff to hard silty clay till or very dense sand and silt till	- Higher bearing resistance - Not so affected by surficial soil variability	- Higher cost than spread footings - Does not permit integral abutment design - Potential installation problems including side sloughing and base boiling associated with sands and silts and cohesionless till (CM10b Overpass) - Need to dislodge and handle cobbles and boulders

A – Spread Footings

Spread footings founded on native very loose to compact sands and silts below high groundwater table are not recommended. As such, footings are not a preferred foundation option at this site. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Compacted Granular A	700 kPa	350 kPa	Fill base at or below Elev. 159.5 m (west abutments) ( CM10 Overpass and CM10b Overpass)

B – Steel H-Piles

Steel H-piles driven to refusal within the very dense sand and silt till, or very stiff to hard silty clay till, may be used to provide foundation support. The preliminary design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1,600 kN	1,400 kN	Not applicable	At or below Elev.125 m (CM10 piers) At or below Elev.140 m (CM10 west abut.) At or below Elev.145 m (CM10b piers) At or below Elev.140 m (CM10b west abut.)

C - Caissons

In the creek valley, consideration may be given to using augered caissons socketted within the very stiff to hard silty clay till or very dense sand and silt till. The preliminary design geotechnical resistances and base elevations for



PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-11

Structure Description: Overpass Highway 407 Mainline over Thornton Road

Highway 407 Proposed Grade: ~ 172 m at Thornton Rd. centreline

Site Ranking: Medium

Existing Ground Elevation: ~ El. 172 m

Station: 15+383

FOUNDATION INVESTIGATION

Site Description:

At this site, Thornton Road North is a two-lane, rural undivided roadway surrounded by farmlands. The terrain is locally flat to gently rolling, and the site is underlain by clayey silt to silty clay till ground moraine.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
CM11-1	North road approach cut	4 869 206.2	351 033.7	171.3	20.0
CM11-2	South road approach cut	4 869 120.2	351 059.4	171.1	23.3
P21	Near mainline centreline	4 869 153.2	351 048.6	172.0	9.4

Note: Borehole layout selected for underpass; structure now changed to overpass.

Subsurface Conditions:

Fill Materials

A 0.6 m thick pavement structure, consisting of 50 to 60 mm thick asphalt layers overlying brown and moist sand fill, is present at ground surface. A 50 mm thick buried layer of asphalt was encountered in BH CM11-2. The underside of the fill varies between Elev. 170.7 m and 170.5 m. Figure CM11-B1 shows the grain size distribution of a sand fill. Measured water contents of the fill were in the order of 8% to 12%.

Silty Clay Till and Silty Clay

The pavement structure is underlain by layers of silty clay till and silty clay. These cohesive soils change from brown to grey with depth and have a typically very stiff to hard consistency. The underside of the upper silty clay till layer ranges between Elev. 169.1 and 168.9 m. The underside of the lower layers varies from Elev. 158.2 m on the north side to Elev. 154.8 m on the south side. Figures CM11-B3 to B6 present laboratory test results of these cohesive deposits. Measured water contents of these cohesive soils ranged between 8% and 24%.

Silt, Sand, Sand and Silt Till

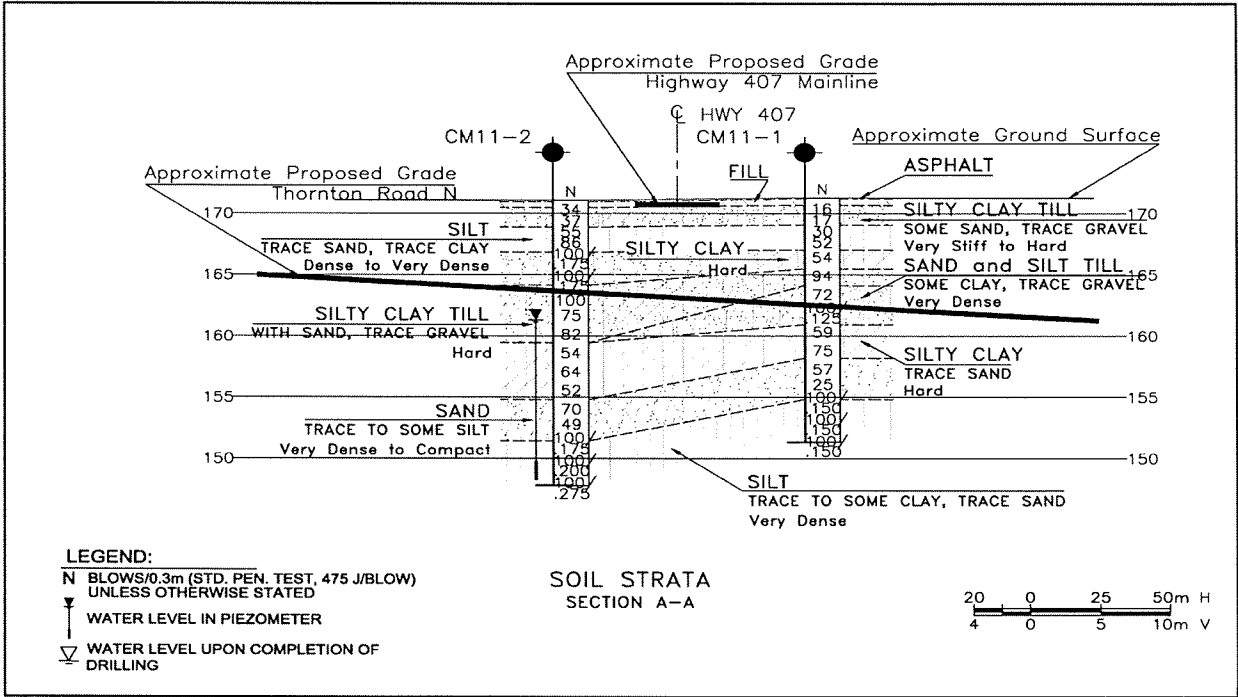
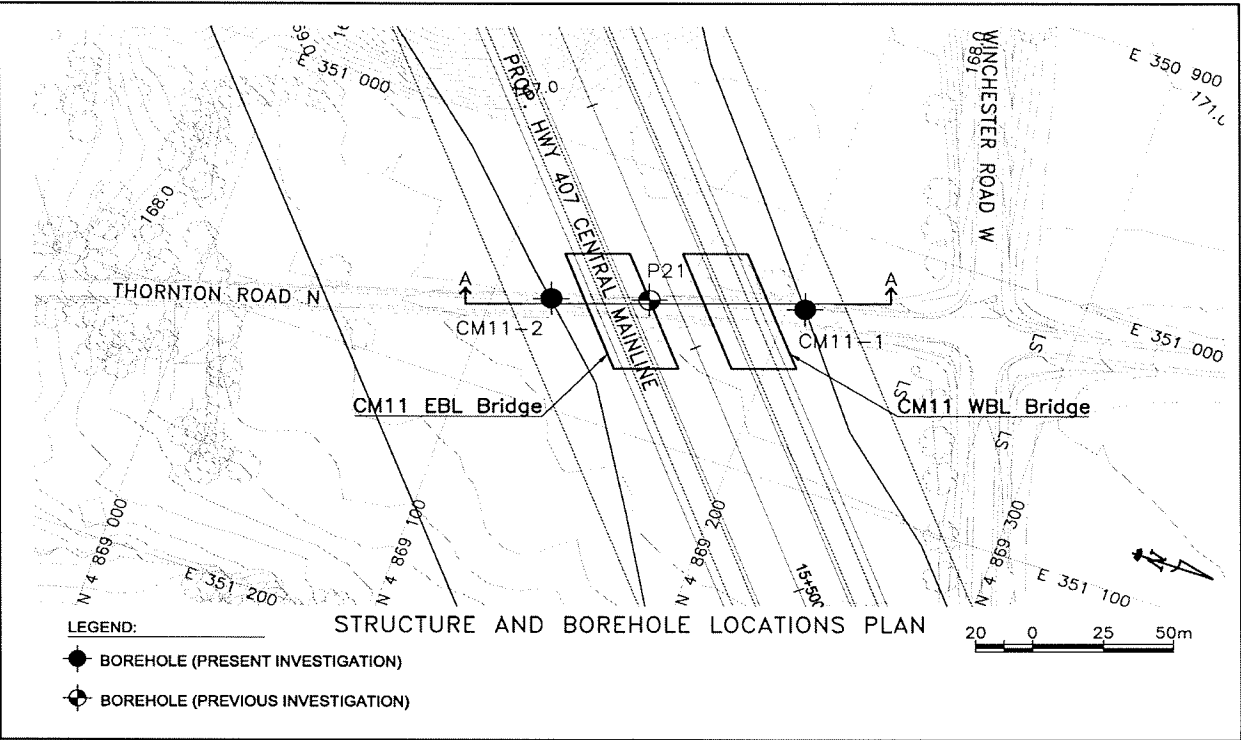
The cohesive deposits are interlayered with cohesionless deposits of silts and sands. These soils are dense to very dense throughout, with inferred cobbles or boulders within the sand and silt till. The underside of these brown to grey deposits varies from Elev. 154.9 m on the north side to Elev. 151.5 m on the south side. Figures CM11-B2, B7 and B8 show the grain size distributions of the upper silt, sand and silt till, and sand, respectively. Measured water contents of these cohesionless deposits ranged between 8% and 18%.

Lower Silt

A lower silt underlies the sand layer across the site. This cohesionless soil is grey and wet, contains cobbles or boulders, and is very dense throughout. This deposit extends to below Elev. 151.4 m on the north side and below Elev. 147.8 m on the south side. Figure CM11-B9 presents the grain size distribution of a sample of this lower silt. Measured water contents of this deposit varied between 10% and 18%.

Groundwater Conditions:

- BH CM11-1: 8.7 m depth (Elev. 162.6 m) in open borehole on December 6, 2007.
- BH CM11-2: 9.9 m depth (Elev. 161.2 m) in piezometer on January 16, 2008.
- BH P21: 2.8 m depth (Elev. 169.2 m) in open borehole on May 30, 1994.



Record of Borehole Sheets – Appendix A

Laboratory Test Results – Appendix B

Key Location Plan – Figure 1

PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-11

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General:

Twin single span structures each with two abutments are proposed.

Foundation Option	Advantages	Disadvantages
Spread Footings founded on very dense sand and silt till or hard silty clay till	- Conventional construction	- Potential variability of surficial soils exposed after the cut is formed
Spread Footings perched on Granuar A pads	- Lower cost than deep foundations - Minimize excavation requirements	- Lower bearing resistance than deep foundations - Higher cost than spread footings on native soils - Potential variability of surficial soils
Steel H-Pile driven to very dense lower silt	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - Pre-drilling may be required to install the piles to the desired depths
Caissons founded in very dense lower silt	- Higher bearing resistance - Not so affected by surficial soil variability	- Higher cost than spread footings - Does not permit integral abutment design - Potential installation problems including basal stability due to the water-bearing sand and silt layers

A - Spread Footings

Spread footings founded on very dense sand and silt till, or hard silty clay till, may be used for closed abutments. All footings must be founded below the proposed Thornton Road grade. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Sand and Silt Till / Silty Clay Till	600 kPa	400 kPa	At or below Elev. 163 m, or 1.2 m below cut elevation
Compacted Granular A	700 kPa	350 kPa	Base of Fill Pad at or below Elev. 170.5 m

B - Steel H-Piles

Steel H-piles driven to refusal within the very dense lower silt deposit may be used to provide foundation support. The recommended design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1,600 kN	1,400 kN	Not applicable	Below Elev. 153 m – CM11 WBL Below Elev. 150 m – CM11 EBL

C - Caissons

Based on the presence of water-bearing cohesionless deposits and the associated potential of base boiling, the use of caisson foundations is not recommended and the option has not been developed.

Recommended Foundation Alternative

The recommended foundation alternative at this site is steel H-piles driven into the very dense lower silt deposit. Alternatively, spread footings founded on the very dense or hard glacial till deposits may be considered.

ABUTMENT TYPE

The soil conditions at this site are suitable for integral abutment design.

APPROACHES

General

The proposed Thornton Road North at this location is to be formed in a cut up to 8 m in height with a centreline elevation of 164 m. Retaining walls may be required at some locations. Minor cutting of up to 3 m in height is anticipated at the west approach. Only minor filling is anticipated.

Stability

Road cuts up to 9 m in height with side slopes not steeper than 2H : 1V are expected to be stable at this site, provided that groundwater control is implemented as required. Alternatively, combinations of various heights of retaining walls and 2H : 1V backslopes may also be feasible.

The road cuts may require temporary dewatering during construction. The permanent cut along Thornton Road North will require permanent drainage. Rock/gravel sheeting may be required.

Settlement

Settlement is not expected to be a major issue at this site.

CONSTRUCTION CONSIDERATIONS

Pile Installation

During pile installation through glacially derived soils at this site, there is a medium probability of encountering obstructions such as cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

Excavation

Excavations up to 8 m will be required to form the cut for the vertically realigned Thornton Road North. For cuts through the native sands, silts and clays, temporary unsupported side slopes should not be steeper than 1H : 1V. In accordance with the OHSA, the silt, silty clay and silty clay till above the groundwater level are classified as Type 2 soils, and all soils below the groundwater level are classified as Type 3 soils.

Groundwater/Surface Water Control

It is anticipated that much of the water accumulation within the cut will be from surface runoff as well as seepage from water-bearing sand and silt layers. Diversion of surface runoff from the cut and pumping from carefully constructed, filtered sumps should be adequate to temporarily control the water. A permanent drainage system may be required for the road cut.

Protection Systems

Protection systems may be required during construction of the abutment and the road cut. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the abutment locations, along the proposed road cut and retaining wall alignments.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No:	CM-12/12b
--------------	-----------

Structure Description: Overpass Highway 407 mainline / Winchester Road West

Highway 407 Proposed Grade: ~ El. 178.0 to 179.5 m

Site Ranking: Medium

Existing Ground Elevation: ~ El. 172.0 to 173.5 m

Station: ~15+675

FOUNDATION INVESTIGATION

Site Description:

At this site, Winchester Road West is an existing two-lane, undivided roadway. Terrain mapping shows that the site is underlain by silt till ground moraine with a minor occurrence of alluvium. The relief is low, rolling and imperfectly to poorly drained.

Borehole Information:

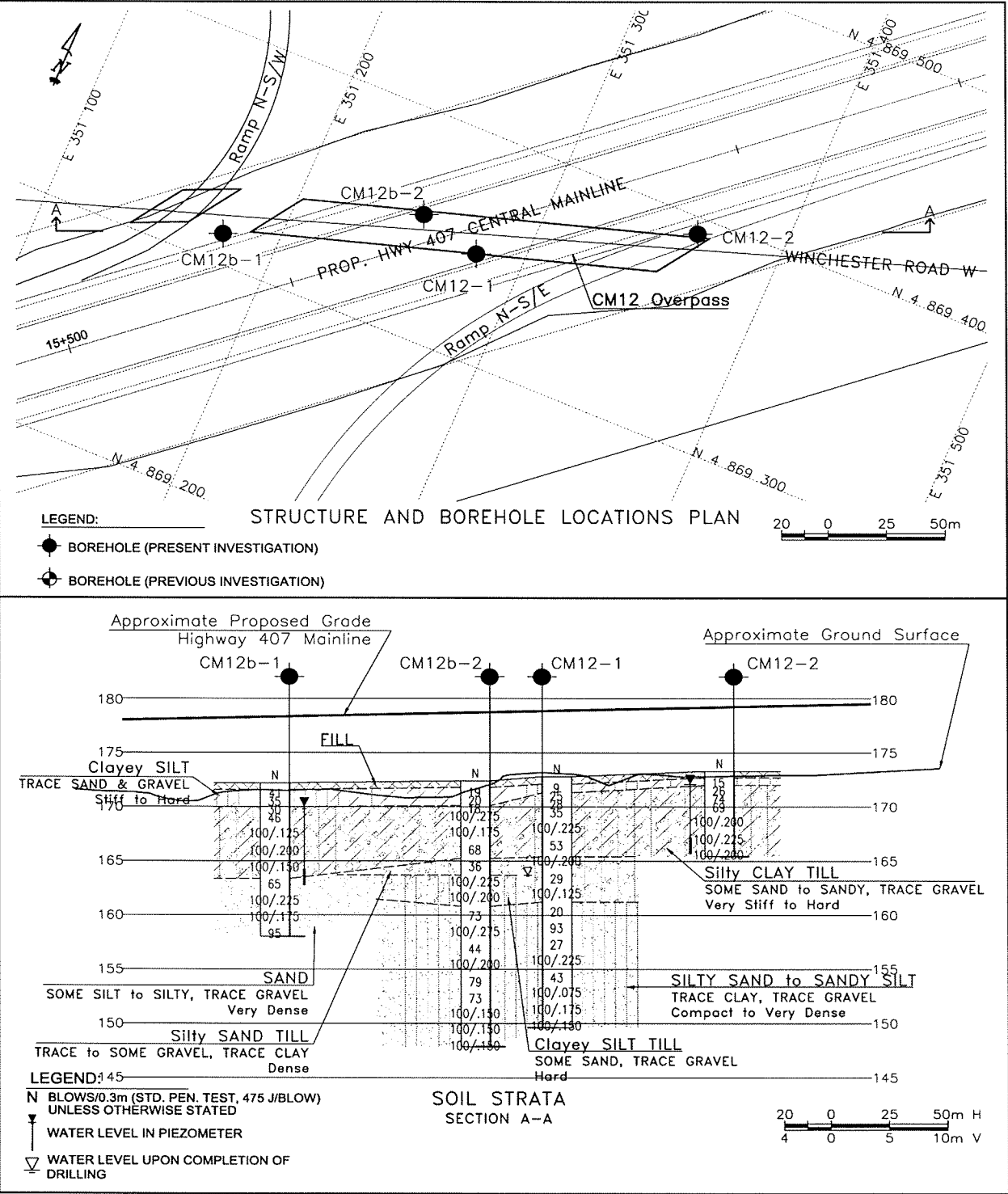
Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM12b-1	WBL West Approach	4 869 313.3	351 176.6	172.2	14.2
CM12b-2	WBL East Approach	4 869 354.8	351 252.3	172.4	24.5
CM12-1	EBL West Approach	4 869 347.3	351 279.9	172.8	23.2
CM12-2	EBL East Approach	4 869 392.7	351 363.5	173.3	7.8

Subsurface Conditions:

- Fill:** Brown compact sand to sand and gravel fill was encountered from the surface to 0.6 m and 0.7 m depths in all four boreholes. The underside of the fill varies between Elev. 171.6 m to 172.7 m.
- Clayey Silt:** A layer of brown clayey silt with trace sand and gravel was encountered below the fill in all four boreholes. The thickness of this deposit ranges between 0.7 m and 1.7 m, with underside elevations ranging from 170.0 m to 172.0 m. The consistency varies from stiff to hard with ‘N’ values ranging from 9 to 41 blows/0.3 m penetration. Moisture contents of these cohesive soils ranged between 13% and 18%.
- Silty Clay Till:** Brown to grey silty clay till with some sand and trace gravel was encountered below the clayey silt layer in all four boreholes. This layer is 4.9 m to at least 6.6 m in thickness, extending to Elev. 163.4 m to 165.4 m, where borehole CM12-2 was terminated. This cohesive deposit is very stiff to hard with ‘N’ values of 18 blows/0.3 m penetration to 100 blows for less than 0.3 m penetration. The measured moisture contents ranged from 7% to 16%. Grain size distribution curves for samples of this soil are presented in Figure CM12-B1. The Atterberg limit test results are presented in Figure CM12-B2. Occasional cobbles and boulders were noted in borehole CM12-1. Till typically contains cobbles and boulders.
- Silty Sand Till:** A 1.5 m to 4.2 m thick layer of brown to grey silty sand till, trace to some gravel, trace to some clay underlies the silty clay till in boreholes CM12b-2 and CM12-1. The underside of this layer lies between Elev. 163.7 m to 161.2 m. This till is compact to very dense with ‘N’ values ranging from 29 blows/0.3 m penetration to 100 blows for less than 0.3 m penetration. Moisture contents ranged between 7% and 9%. Grain size distribution curves for samples of this soil are presented in Figure CM12-B3.
- Clayey Silt Till:** Grey clayey silt till, some sand, trace gravel, was encountered below the silty sand till in borehole CM12b-2. This layer is 2.9 m in thickness, extending to Elev. 160.8 m. This till is hard with ‘N’ values over 100 blows for less than 0.3 m penetration. Moisture contents ranged from 6% to 13%.
- Sands and Silts:** Layers of grey sands and silts were encountered below the till deposit in boreholes CM12b-1, CM12-b2 and CM12-1. This layer is at least 5.4 m to 13.0 m in thickness, extending to Elev. 158.1 m to 147.8 m where all three boreholes were terminated. This cohesionless deposit is compact to very dense with ‘N’ values ranging from 20 blows/0.3 m penetration to 100 blows for less than 0.3 m penetration. The measured moisture contents ranged from 11% to 22%. Grain size distribution curves for samples of these soils are presented in Figure CM12-B4 to CM12-B8.

Groundwater Conditions:

- BH CM12-b1:** 2.2 m depth (Elev. 170.0 m) in piezometer on June 06, 2009.
- BH CM12-1:** 9.1 m depth (Elev. 163.7 m) in open borehole on April 15, 2009 (unstabilized reading).
- BH CM12-2:** 1.2 m depth (Elev. 172.1 m) in piezometer on May 04, 2009.



Record of Borehole Sheets – Appendix A

Laboratory Test Results – Appendix B

Key Location Plan – Figure 1



PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-12/12b

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General:** Two single span structures, one for the N-S/W Ramp and one for the Hwy 407 Mainline and N-S/E Ramp are proposed. The abutments on either side of Winchester Road will consist of continuous RSS walls encompassing both structures.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread Footings founded on very stiff to hard silty clay till</i>	- Conventional construction - Low cost alternative	- Does not permit integral abutment design - Potential variability of surficial soils; footings must be extended below these soils - Unwatering may be required during excavation
<i>Spread Footings perched on Granular A pads for abutments</i>	- Lower cost than deep foundations - Minimize excavation requirements	- Higher cost than spread footings on native soils - Sub-excavation of existing fill is required
<i>Steel H-Piles driven to very dense sand and silt</i>	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings - Preaugering may be required to achieve adequate pile embedment - Potential for variable pile lengths
<i>Caissons founded in very dense sand and silt</i>	- Higher bearing resistance - Not so affected by surficial soil variability	- Does not permit integral abutment design - Potential installation problems including basal instability due to water-bearing sands/silts

A - Spread Footings

Spread footings founded on very stiff to hard silty clay till may be used for the abutments. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary geotechnical design resistances and founding levels for spread footings on native soils, and spread footings on compacted Granular A cores, are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Silty Clay Till	600 kPa	400 kPa	At or below Elev. 169.0 m (WBL structures) At or below Elev. 170.0 m (EBL structures)
Compacted Granular A	700 kPa	350 kPa	Fill base at or below Elev. 171.6 m (WBL structures) Fill base at or below Elev. 172.0 m (EBL structures)

RSS walls should be founded on the upper native very stiff to hard clayey silt or silty clay till.

B - Steel H-Piles

Steel H-piles driven to refusal within the hard silty clay/clayey silt till or very dense sand and silt may be used to provide foundation support. The preliminary design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1,400 kN	1,200 kN	Not applicable	At or below Elev. 162.0 m to 164.0 m

C – Caissons

Based on the presence of water-bearing cohesionless deposits and the potential of base boiling and uncertainties associated with cleaning and inspecting the base, the use of caisson foundations is not recommended at this site and the option has not been developed.

Recommended Foundation Alternative

The recommended foundation alternative at this site is spread footings bearing on very stiff to hard silty clay till. Steel H-piles driven into the hard silty clay and clayey silt till or very dense sand and silt may also be considered if integral abutment design is desired.

ABUTMENT TYPE

The soil conditions at this site are suitable for conventional, integral or semi-integral abutment design.

APPROACHES

Approach embankments in the order of 3 to 6 m high in combination with cuts of 1 to 5 m are anticipated within the RSS retaining wall sections, for an overall height up to 8 m.

Stability

Global stability of the RSS and embankment slopes along Hwy 407 is not expected to be a problem at this site.

Settlement

Settlements are expected to be less than 50 mm and to occur essentially during construction.

CONSTRUCTION CONSIDERATIONS

Pile Installation

During pile installation through glacially derived soils at this site, there is a medium probability of encountering obstructions such as cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

Excavation

Temporary excavation slopes for footing construction should not be steeper than 1H : 1V. In accordance with OHSA the fill materials are classified as Type 3 material. The silty clay and clayey silt till are Type 2 material above the water table and Type 3 soil below the water table.

Groundwater/Surface Water Control

Diversion of surface runoff from the excavation and pumping from carefully constructed, filtered sumps should be adequate to control ground water during foundation construction.

Protection Systems

Protection systems will be required at excavation locations where stable slopes cannot be constructed due to space limitations and where vertically sided excavations are used for footing or pile cap construction. One possible system is the use of soldier piles and lagging. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the actual abutment and pier locations and at the approaches. If pile foundations are selected, the additional work should include boreholes to confirm the predicted pile tip elevations and geotechnical resistances.

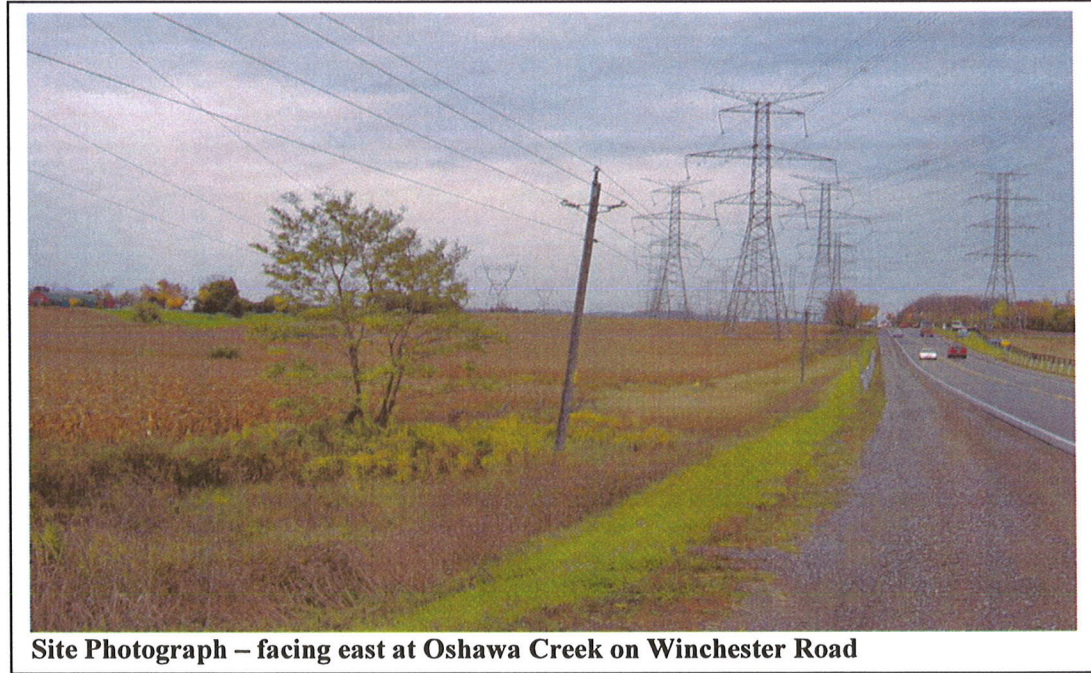
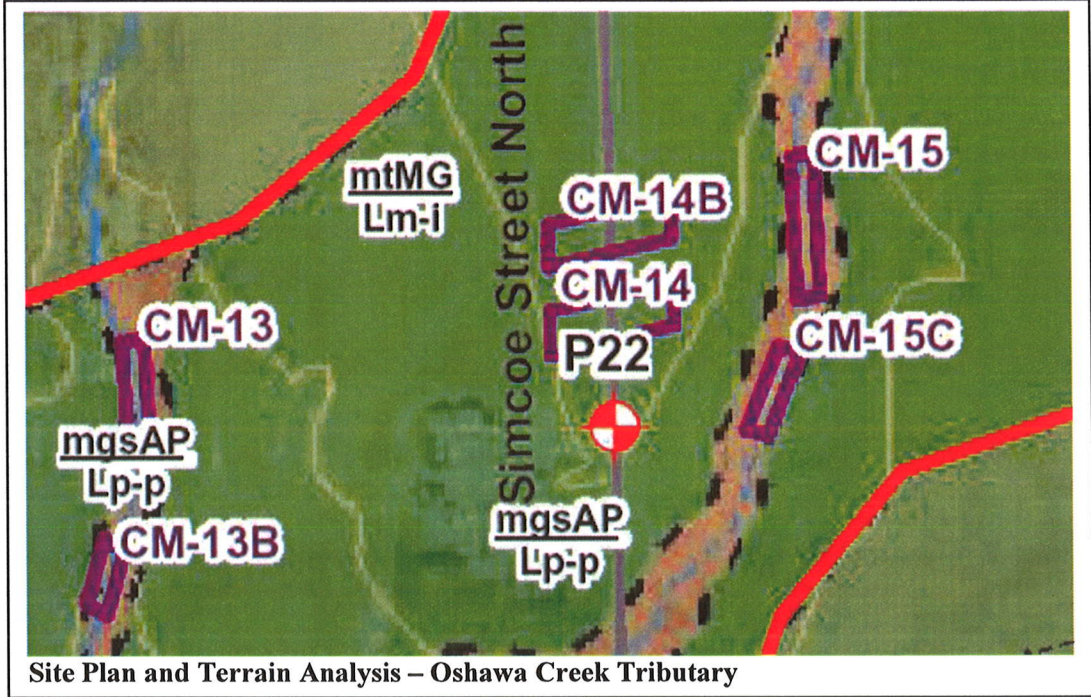


**HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS**  
(Based on interpolated or very limited data. The recommendations are for planning and preliminary design only and are not suitable for detail design)

Site No:	CM-13 CM-13B
----------	-----------------

W.O: 07-20016    Section: Central    Location: Mainline at Oshawa Creek Tributary    Sta. 16+872

Original Grade: ~175    Proposed Grade:    Description: Twin culverts to carry Mainline over Oshawa Creek Trib.



Summarized Subsurface Conditions	Recommendations		Remarks
	Structure	Approaches	
<b>Boreholes: No BH at the site. BH P22, M15-85 lies 250m southwest.</b>	<b>1. Abutments</b>	Approach fills up to 10 m high may be constructed at side slopes up to 2H:1V using SSM or better.	Some dewatering and surface water control may be required during construction.
Mapping (Central 2) shows that the site is underlain by a narrow band of alluvium within an area of silt till ground moraine. The relief in the general area is low, rolling, imperfectly drained.  BH P22 encountered:  0.0 – 5.5 Clayey silt, some sand, trace gravel, glacial till. Hard  5.5 – 12.6 EOH Silty sand to sandy silt, trace clay,, trace gravel, till, dense to very dense  <b>Groundwater</b>  GWL encountered approximately 3mbgs in the BH, probably close to the surface at the creek..  <b>Estimated overburden thickness – 50 m.</b>	a. Footings may be founded on compacted Granular A cores as per current MTO standard practices approx 2mbgs.  b. For closed abutments, footings may be founded on native at estimated 3mbgs a. Factored resistance at ULS – 750 kPa b. Resistance at SLS – 500 kPa  c. Abutments may also be supported on HP 310X110 piles driven to refusal below El.148.0. a. ULS resistance – 1,600 kN b. SLS resistance – 1,400 kN  d. Integral abutments are feasible. Assume 15m piles. Predrilling may be required to install the piles.	No global stability or settlement issues are anticipated based on available information.  Stripping of topsoil or other unsuitable soils will be required prior to construction.	Narrow, shallow valley with no geomorphic evidence of significant valleside instability
	<b>2. Piers</b>	Piers may be supported using the same foundation options as for abutments.	
<b>Site Ranking</b>			
<b>Foundations:</b>		<b>Low</b>	
<b>Hydrogeology:</b>		<b>Medium</b>	



PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-15E

Structure Description: Culvert at Rerouted Oshawa Creek Tributary, Simcoe Street N at Highway 407 WBL Ramp

Simcoe Street Proposed Grade: ~ El. 193.3 m  
Existing Ground Elevation: ~ El. 189.4 to 190.5 m

Site Ranking: Medium  
Station: ~ 9+710

FOUNDATION INVESTIGATION

Site Description: At this site, the rerouted Oshawa Creek Tributary stream will flow from east to west underneath Simcoe street north. Terrain mapping indicates that the site is underlain by silt till glacial moraine. The relief is low, rolling and imperfectly drained.

Borehole Information:

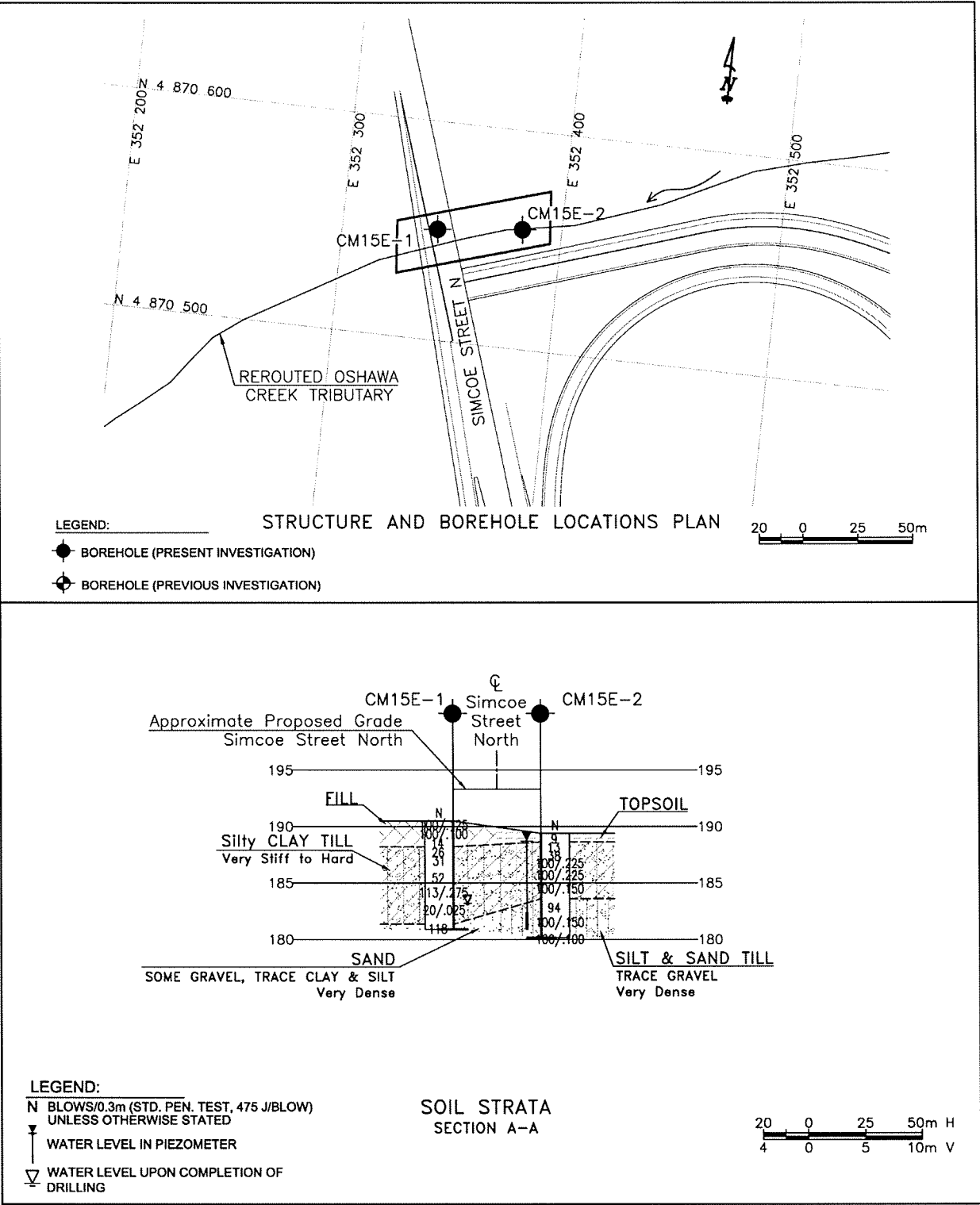
Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM15E-1	West side	4 870 550.7	352 343.5	190.5	9.6
CM15E-2	East side	4 870 554.8	352 382.1	189.4	9.2

Subsurface Conditions:

- Topsoil:** 0.8m of topsoil was encountered in borehole CM15E-2. The thickness and extent of topsoil is expected to vary between and beyond the borehole locations, and the information in this report should not be used for quantity estimating purposes.
- Sand Fill:** A 1.8m thick layer of dark brown sand with either some or trace of gravel was encountered in borehole CM15E-1. This cohesionless fill was frozen at the time of the field work with ‘N’ values of more than 100 blows for less than 0.3m penetration. The moisture content is around 5%.
- Clayey Silt Fill:** Clayey silt fill was encountered below the sand fill in borehole CM15E-1. The layer is 0.5 m thick with an underside at Elev. 188.2m. This clayey silt fill is stiff with an ‘N’ value of 14 blows /0.3m penetration and moisture content around 21%.
- Silty Clay Till:** A deposit of silty clay till was encountered below the fill in borehole CM15E-1 and below the topsoil in borehole CM15E-2. This layer was 6.8 m thick, with an underside at Elev. 181.4 m in Borehole CM15E-01, and 5m thick with an underside at Elev. 183.6 m in borehole CM15E-2. This silty clay till is stiff to hard with ‘N’ values ranging from 13 to more than 100 blows for less than 0.3m penetration. Moisture contents ranged from 10 to 16%. Grain size distribution curves for samples of this soil are presented in Figure CM15E-B1. Glacial tills typically contain cobbles and boulders.
- Sand:** A deposit of grey sand with some gravel and trace of silt and clay was found below the silty clay till layer in Borehole CM15E-1. Borehole CM15E-1 was terminated in this sand at 9.6 m depth (Elev. 180.9 m). This sand is very dense with an ‘N’ value of 118 blows /0.3m penetration and moisture content of 15%. A grain size distribution curve for a sample of this soil is presented in Figure CM15E-B2.
- Silt and Sand Till:** Brown silt and sand till with some clay was encountered below the silty clay till layer in borehole CM15E-2. Borehole CM15E-2 was terminated in this silt and sand till at 9.2 m depth (Elev. 180.2 m). This silt and sand till layer is very dense with ‘N’ values 94 to 100 blows for less than 0.3m penetration and with moisture content ranging from 8 to 14%. A grain size distribution curve for a sample of this soil is presented in Figure CM15E-B3. Glacial tills typically contain cobbles and boulders.

Groundwater Conditions:

- BH CM15E-1:** 7.3 m depth (Elev. 183.2 m) in open borehole on February 05, 2009 (unstabilized reading).
- BH CM15E-2:** 1.7 m depth (Elev. 187.7m) in piezometer on February12, 2009.  
0.7 m depth (Elev. 188.7 m) in piezometer on May 4, 2009.



PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-15E

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General:** An open footing concrete culvert is proposed.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread footings founded on hard silty clay till or very dense silt and sand till</i>	- Conventional construction - Low cost alternative	- Unwatering will be required - Scour protection is required for culvert footings - Sub-excavation required to construct footings
<i>Spread Footings perched on Granular A pads</i>	- Lower cost than deep foundations - Founding level can be adjusted	- Unwatering will be required - Scour protection is required for culvert footings - Sub-excavation required to construct pads - More costly than spread footings on native soil
<i>Steel H-Pile driven into hard silty clay till or very dense silt and sand till</i>	- Higher bearing resistance - Not affected by surficial soil variability	- Higher cost than spread footings - Unwatering will be required for pile cap construction
<i>Caissons socketted in hard silty clay till or very dense silt and sand till</i>	- Higher bearing resistance - Not affected by surficial soil variability	- Higher cost than spread footings - Unwatering will be required for pile cap construction - Require liners to address installation problems including side sloughing associated with cohesionless soils - Need to dislodge and handle cobbles and boulders - Potential for base boiling

**A – Spread Footings**

Spread footings founded on hard silty clay till or very dense silt and sand till may be used. A footing founded on compacted Granular A pad is not appropriate at this site since hard native soils exist below proposed stream bed level. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Silty clay till or silt and sand till	525 kPa	350 kPa	At or below Elev. 185 m

**B – Steel H-Piles**

Driven steel H-piles are not recommended at this site since hard/very dense native soils exist just below the proposed stream bed.

**C – Caissons**

Caissons are not recommended at this site due to probable installation problems related to a high groundwater table, the associated potential of base boiling where caisson bases will be founded in silt and sand till below the clay till layer, and the presence of cobbles and boulders in till deposits.

**Recommended Foundation Alternative**

From a foundation engineering perspective, the recommended foundation for the culvert at this site is spread footings founded on hard silty clay till or very dense silt and sand till at or below Elev. 183.5m.

• **APPROACHES**

An approximate 3 to 4 m high fill will be required to achieve proposed grade for Simcoe Street over the culvert. The stream bed will be excavated approximately 5 to 6 m below existing grade.

**Stability**

Slopes up to 8 m in height are anticipated to be stable at side slope inclinations of 2H : 1V.

**Settlement**

Settlement is not expected to be a concern at this site.

• **CONSTRUCTION CONSIDERATIONS**

**Excavation**

Excavations of up to about 7 m depth will be required for culvert and footing construction. Temporarily unsupported side slopes should not be steeper than 1H : 1V where groundwater control measures are implemented as outlined below. In accordance with the OHSA, all fills are classified as Type 3 soils. The clay fill is classified as Type 2 soil above ground water level.

**Groundwater/Surface Water Control**

The groundwater table is near the ground surface. However temporary excavations will extend through silty clay till which has low permeability. Diversion of surface runoff from the excavation and pumping from carefully constructed, filtered sumps are required to control the water during construction. The required groundwater control systems should be further assessed during detail design.

**Protection Systems**

Protection systems may be required where space restrictions prohibit formation of safe side slopes. One possible system is soldier pile & lagging. The feasibility of installing such protection system should be assessed once further subsurface investigation is carried out during detail design.

• **RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the culvert. As a minimum, this is likely to require additional boreholes along the culvert alignment. The feasibility and cost effectiveness of alternate unwatering systems would need to be investigated.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION

LOCATION No: CM-14

Structure Description: Underpass Highway 407 Mainline / Simcoe Street North

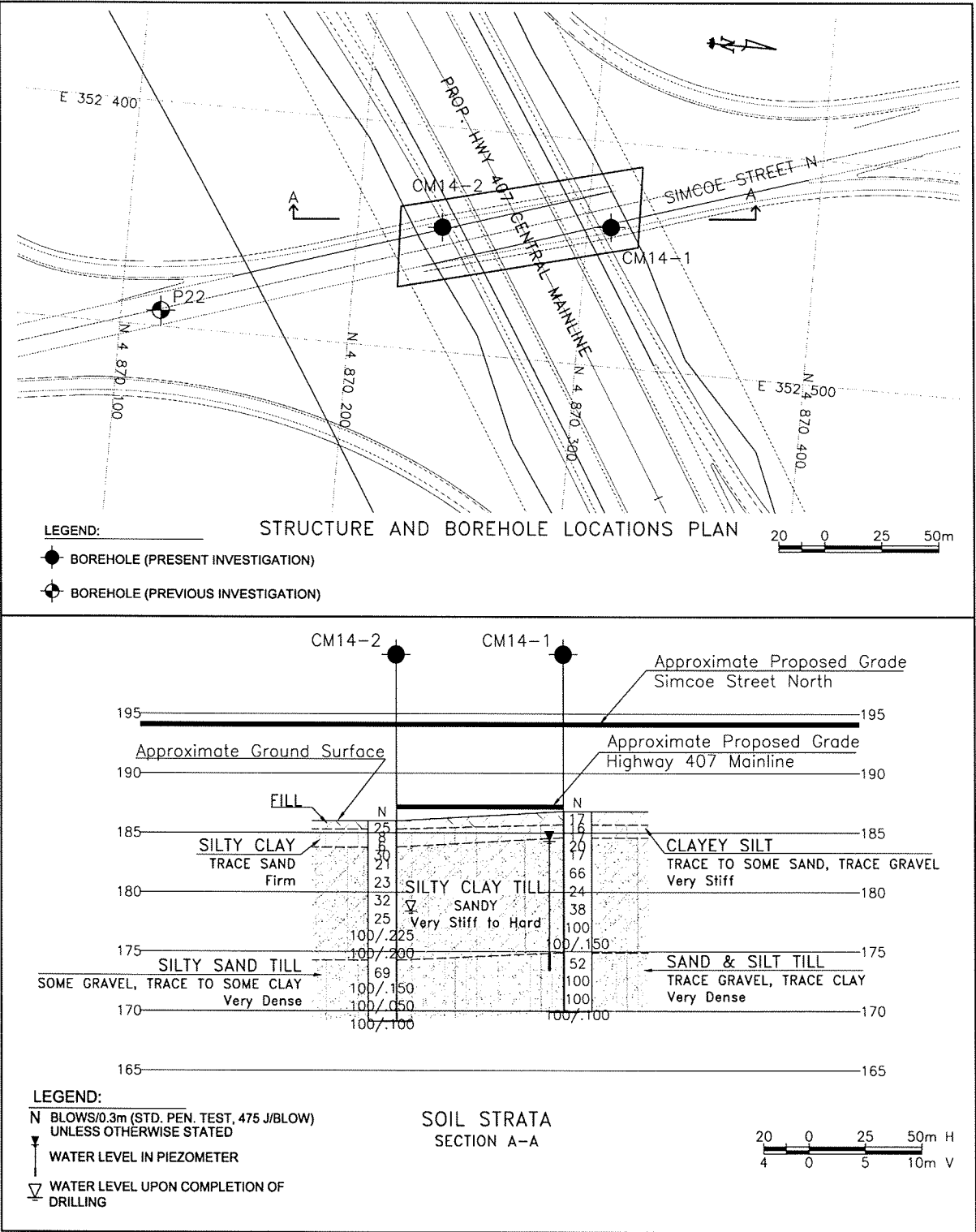
W.O. 07 – 20016

Highway 407 Proposed Grade: ~ El. 187.0 to 188.0 m

Existing Ground Elevation: ~ El. 186.0 to 187.0 m

Site Ranking: Medium

Station: ~ 17+165



FOUNDATION INVESTIGATION

Site Description:

At this site, Simcoe Street North is a two-lane, rural undivided roadway. The relief is low, rolling, imperfectly drained. Terrain mapping shows that the site is underlain by silt till glacial moraine.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 - Easting	Borehole Elevation (m)	Borehole Depth (m)
CM14-1	North Abutment	4 870 310.4	352 438.0	186.8	16.9
CM14-2	South Abutment	4 870 236.8	352 444.7	186.0	16.9
P22	Mainline at Simcoe Street North	4 870 117.4	352 492.9	184.9	12.6

Subsurface Conditions:

- Fill:** Dark brown clayey silt fill was encountered from the surface to 1.1 m and 0.7 m depths in boreholes CM14-1 and CM14-2 respectively. The underside of the fill varies between Elev. 185.7 m and 185.3 m. The consistency is very stiff with ‘N’ values ranging from 17 to 25 blows/0.3 m penetration. Measured moisture contents of the fill were in the order of 6% to 17%.
- Clayey Silt and Silty Clay:** A 1.1 m layer of brown clayey silt and a 1.5 m layer of brown silty clay were encountered below the fill in boreholes CM14-1 and CM14-2 respectively. The consistency varies from firm to very stiff with ‘N’ values of 6 to 17 blows/0.3 m penetration. Measured moisture contents of these cohesive soils ranged between 10% and 17%. The underside of these layers varies from Elev. 184.6 m and 183.8 m.
- Silty Clay Till:** A deposit of brown to grey silty clay till, sandy, was encountered below the clayey silt and silty clay layers in boreholes CM14-1 and CM14-2. This layer is 9.5 to 9.7 m thick with an underside at Elev. 175.0 m and 174.3 m. The consistency of this silty clay till is very stiff to hard with ‘N’ values ranging from 17 blows/0.3 m penetration to 100 blows for less than 0.3 m penetration. Moisture contents ranged from 7% to 16%. Grain size distribution curves for samples of this till are presented in Figure CM14-B1. Atterberg Limits test results are presented in Figure CM14-B2. Glacial tills typically contain cobbles and boulders.
- Sand and Silt to Silty Sand Till:** Greyish brown sand and silt to silty sand till, trace to some gravel, trace to some clay was encountered below the silty clay till layer in both boreholes. This layer is at least 5.0 to 5.2 m in thickness, extending to Elev. 170.0 to 169.2 m where both boreholes were terminated. This cohesionless deposit is very dense with ‘N’ values ranging from 52 blows/0.3 m penetration to 100 blows for less than 0.3 m penetration and with moisture content ranging from 6% to 16%. Grain size distribution curves for samples of this soil are presented in Figures CM14-B3 and CM14-B4. Glacial tills typically contain cobbles and boulders.

Groundwater Conditions:

- BH CM14-1:** 2.5 m depth (Elev. 184.3 m) in piezometer on May 04, 2009.  
7.6 m depth (Elev. 179.2 m) in open borehole on March 17, 2009 (unstabilized reading).
- BH CM14-2:** 7.6 m depth (Elev. 178.4 m) in open borehole on March 18, 2009 (unstabilized reading).

PART B - PRELIMINARY FOUNDATION DESIGN REPORT  
HWY 407 EAST EXTENSION – CENTRAL SECTION  
W.O. 07 – 20016

LOCATION No: CM-14

FOUNDATION RECOMMENDATIONS

Note: The site specific foundation recommendations are for planning purposes only. Refer to Section 6 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

**General** : A two-span structure with two abutments and a central pier is proposed.

<i>Foundation Option</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spread footings founded on very stiff to hard silty clay till</i>	- Conventional construction - Low cost alternative	- Does not permit integral abutment design - Potential variability of surficial soils; footings must be extended below these soils - Unwatering may be required during excavation - Relatively low bearing resistance
<i>Spread footings perched on Granular A pads</i>	- Lower cost than deep foundations - Minimize excavation requirements	- Higher cost than spread footings on native soils - Sub-excavation of surficial fills and firm soils is required - Higher bearing resistance than footings on native soils
<i>Steel H-Piles driven to very dense sand and silt till or silty sand till</i>	- Higher bearing resistance - Permits use of integral abutments - Not affected by surficial soil variability	- Higher cost than spread footings
<i>Caissons founded within the very dense sand and silt till or silty sand till</i>	- Higher bearing resistance - Not so affected by surficial soil variability	- Does not permit integral abutment design - Potential installation problems including basal stability due to water-bearing sands/silts

**A – Spread Footings**

Spread footings founded on very stiff to hard silty clay till may be used for the abutments and at the pier. Footings for perched abutments may be founded on compacted Granular A cores in accordance with current MTO practices. The preliminary design geotechnical resistances and founding levels are as follows:

Founding Stratum	Geotechnical Resistance		Foundation Level
	Factored ULS	SLS	
Silty Clay Till	375 kPa	250 kPa	At or below Elev. 183.5 m (south end) to 184.5 m (north end)
Compacted Granular A	700 kPa	350 kPa	Fill base at or below 183.8 m (south end) to 185.5 m (north end)

**B – Steel H-Piles**

Steel H-piles driven to refusal within the very dense sand and silt till or very dense silty sand till, may be used to provide foundation support. The preliminary design geotechnical resistances and tip elevations are as follows:

Pile	Axial Geotechnical Resistance		Downdrag Load	Anticipated Pile Tip Elevation
	Factored ULS	SLS		
HP 310 x 110	1600 kN	1400 kN	Not applicable	At or below Elev. 171.0 m

**C - Caissons**

Consideration may be given to using augered caissons socketted within the very dense sand and silt to silty sand till. The preliminary design geotechnical resistances and base elevations for caissons extending 4 m into the

very dense (‘N’ >100 blows) sand and silt to silty sand till, and developing resistance through shaft friction and a portion of end-bearing within the till are as follows:

Caisson Diameter	Axial Geotechnical Resistance		Downdrag Load (Factored ULS)	Highest Founding Level
	Factored ULS	SLS		
1.2 m	6,400 kN	5,000 kN	Not Applicable	Elev. 170.0 m
1.5 m	9,000 kN	6,000 kN	Not Applicable	

Given the potential for base boiling under hydrostatic pressure and uncertainties associated with cleaning and inspecting the base, the above recommended values must be reassessed during detail design.

**Recommended Foundation Alternative**

The recommended foundation alternative at this site is steel H-piles driven into the very dense sand and silt till or silty sand till. Spread footings founded on very stiff to hard silty clay till may be considered for the pier.

• **ABUTMENT TYPE**

The soil conditions at this site are suitable for conventional, integral or semi-integral abutment design.

• **APPROACHES**

Approach embankments up to the order of 8 m high are anticipated.

**Stability**

Approach embankments up to 8 m in height are anticipated to be stable at side slope inclinations of 2H : 1V using SSM or granular material. A 2 m wide mid-height bench is required for embankment slopes higher than 8 m.

**Settlement**

Settlements are expected to be less than 50 mm and to occur essentially during construction.

• **CONSTRUCTION CONSIDERATIONS**

**Pile Installation**

During pile installation through glacially derived soils at this site, there is a medium probability of encountering cobbles or boulders. Driving shoes should be fitted to the pile tips for reinforcement and enhancing seating of the piles.

**Excavation**

Temporary excavation slopes in the fill and the upper firm soils should not be steeper than 1H : 1V. In accordance with the OHSA the fill materials are classified as Type 3 material. The silty clay till is Type 2 material above the water table and Type 3 soil below the water table.

**Groundwater/Surface Water Control**

Measures such as diversion of surface runoff from the excavation and pumping from carefully constructed, filtered sumps should be adequate to control groundwater within foundation excavations during construction.

**Protection Systems**

Protection systems would be required at excavation locations where stable slopes cannot be constructed due to space limitations and where vertically sided excavations are used for footing or pile cap construction. One possible system is the use of soldier piles and lagging. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detail design.

• **RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation, analysis and design should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements. As a minimum, this is likely to require additional boreholes at the actual abutment and pier locations and at the approaches.

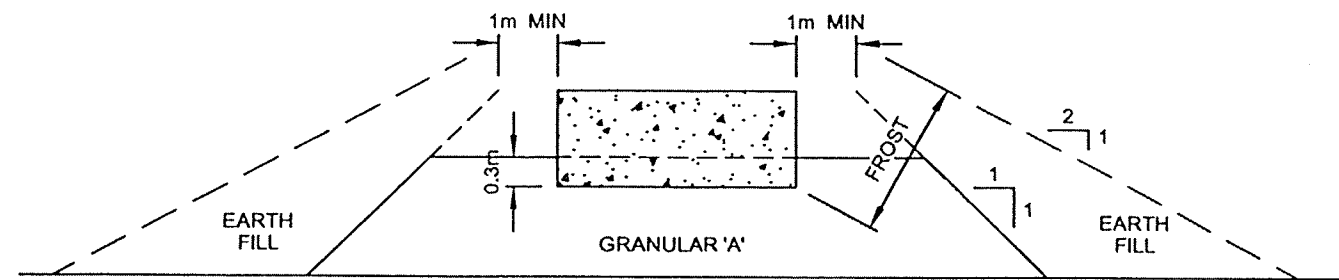
**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
DEEP CUTS  
HWY 407 EAST EXTENSION – CENTRAL SECTION (WEST PART)  
W.O. 07 - 20016**

Deep Cut No.	Station (From – To)	Proposed Highway Grade (m)	Maximum Cut Depth (m)	Reference Data	Subsurface Conditions	Preliminary Recommendations
Hwy 407 Central Mainline						
DC-C8	11+200 to 11+980	155.1 to 158.6	8.5	P13, Desktop Study, Hydrogeology Report	<b>Stratigraphy:</b> Primarily dense to very dense/hard sand and silt till ground moraine. <b>Groundwater:</b> Estimated near 2 to 3 m depth (Elev. 156.0 to 162.0 m).	<b>Design Slope Inclination:</b> Cut slopes up to 8.5 m high may be constructed at 2H : 1V with a 2 m wide mid-height bench on slopes exceeding 8 m in height. <b>Drainage:</b> No major groundwater issues are anticipated. Side ditches should be adequate for surface drainage. <b>Recommendations for Further Investigation:</b> Boreholes should be advanced to confirm the stratigraphy within the cut section.
DC-C1	13+250 to 13+430	158.9 to 160.6	8	CCM-1	<b>Stratigraphy:</b> Very stiff to hard, clayey silt till to 2.4 m depth (Elev. 163.9 m), overlying 3.1 m of very dense sand and silt till, underlain by hard silty clay till at 5.5 m depth (Elev. 160.9 m). <b>Groundwater:</b> 1.5 m depth (Elev. 164.9 m) in piezometer on October 10, 2008. 1.6 m depth (Elev. 164.8 m) in piezometer on February 12, 2009.	<b>Design Slope Inclination:</b> Cut slopes up to 8 m high may be constructed at 2H : 1V. <b>Drainage:</b> No major groundwater issues are anticipated. Side ditches should be adequate for surface drainage. <b>Recommendations for Further Investigation:</b> Additional boreholes should be advanced to confirm the stratigraphy within the cut section.
DC-C2	14+490 to 14+660	165.9 to 167.2	5.5	Site CM-9	<b>Stratigraphy:</b> A 4.9 to 6.2 m thick layer of very stiff to hard silty clay to clayey silt till, underlain at 5.5 to 7.6 m depth (Elev. 164.1 to 165.8 m) by 9.4 to 10 m of dense to very dense sand and silt till, overlying a sand and gravel deposit at 14.9 to 17.6 m depth (Elev. 154.1 to 156.5 m). <b>Groundwater:</b> 9.5 m depth (Elev. 162.2 m) in piezometer on March 12, 2008.	<b>Design Slope Inclination:</b> Cut slopes up to 5.5 m high may be constructed at 2H : 1V. <b>Drainage:</b> No major groundwater issues are anticipated. Side ditches should be adequate for surface drainage. <b>Recommendations for Further Investigation:</b> Boreholes should be advanced to confirm the stratigraphy within the cut section.

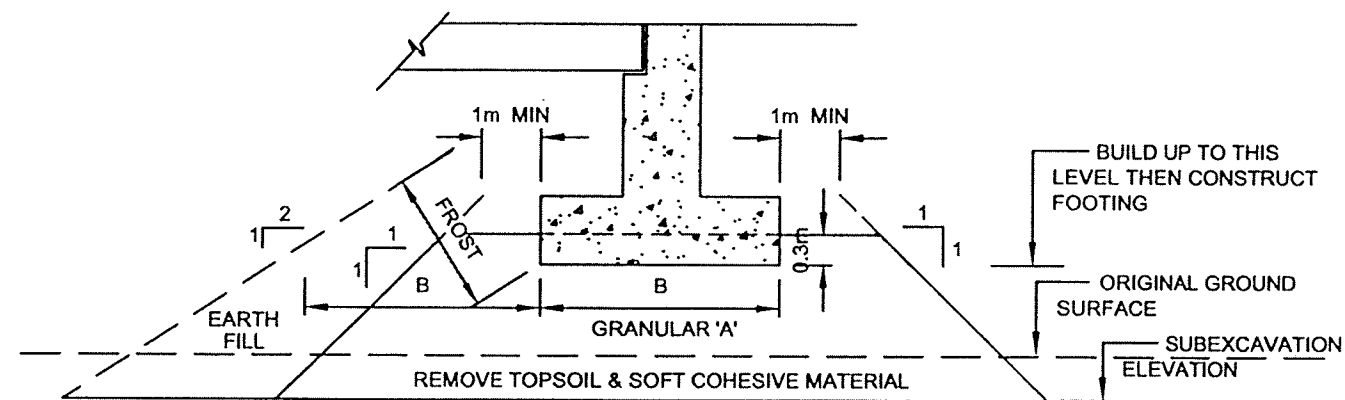
**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HIGH FILLS  
HWY 407 EAST EXTENSION – CENTRAL SECTION (WEST PART)  
W.O. 07 - 20016**

High Fill No.	Station (From – To)	Proposed Highway Grade (m)	Maximum Fill Height (m)	Reference Data	Subsurface Conditions	Preliminary Recommendations
<b>Hwy 407 Central Mainline</b>						
HF-C1	12+680 to 12+750	159.8 to 160.2	7	Site CM-3/3b (BH CM3-2)	<p><b>Stratigraphy:</b> Compact sand, some gravel, to 2.2 m depth (Elev. 149.9 m), overlying compact to dense silty sand till to 4.1 m depth (Elev. 148.0 m), underlain by very stiff to hard clayey silt till. The clayey silt till layer is 3.4 m thick and is underlain by very dense silty sand till.</p> <p><b>Groundwater:</b> 4.0 m depth (Elev. 148.1 m) in piezometer on February 12, 2009.</p>	<p><b>Design Slope Inclination:</b> Fill slopes up to 7 m high may be constructed at 2H : 1V with a 2 m wide mid-height bench on slopes exceeding 8 m in height.</p> <p><b>Stability:</b> No stability issues are anticipated. Embankment construction will require removal of peat, organic and other unsuitable materials</p> <p><b>Settlement:</b> No settlement issues are anticipated.</p> <p><b>Recommendations for Further Investigation:</b> Additional boreholes should be advanced to confirm the stratigraphy in the high fill section.</p>
HF-C2	15+180 to 15+300	169.1 to 171.5	15.5	Site CM-10/10b	<p><b>Stratigraphy:</b> Layers of sands and silts having a combined thickness of 5.1 to 7.0 m and a lower boundary at Elev. 147.2 to 148.8 m, underlain by very stiff to hard silty clay till or very dense sand/silt till. The sands and silts are loose becoming compact to dense with depth.</p> <p><b>Groundwater:</b> 2.2 m depth (Elev. 153.8 m) in piezometer on July 28, 2008.</p>	<p><b>Design Slope Inclination:</b> Fill slopes up to 15.5 m high may be constructed at 2H : 1V with a 2 m wide mid-height bench on slopes exceeding 8 m in height.</p> <p><b>Stability:</b> No stability issues are anticipated. Embankment construction will require removal of peat, organic and other unsuitable materials.</p> <p><b>Settlement:</b> Post-construction settlement in the order of 75 mm is anticipated under a maximum 15.5 m high embankment.</p> <p><b>Mitigation Options:</b> Measures to minimize post-construction settlement, such as advance embankment construction (preloading) should be evaluated.</p> <p><b>Recommendations for Further Investigation:</b> Additional boreholes should be advanced and laboratory testing conducted to confirm the stratigraphy, further evaluate the magnitude of anticipated settlement, and assess measures such as preloading.</p>
HF-C3	15+500 to 16+000	175.5 to 181.1	7	FCM-1 FCM-2	<p><b>Stratigraphy:</b> A 1.8 to 2.7 m thick layer of firm to hard silty clay till, underlain by dense to very dense sandy silt till at 2.3 to 4.1 m depth (Elev. 168.2 to 169.4 m), overlying dense to very dense silty sand till or very stiff to hard silty clay till.</p> <p><b>Groundwater:</b> 2.7 m depth (Elev. 170.8 m) in piezometer on February 10, 2009.</p>	<p><b>Design Slope Inclination:</b> Fill slopes up to 7 m high may be constructed at 2H : 1V.</p> <p><b>Stability:</b> No stability issues are anticipated. Existing fill, topsoil and upper 1.0 m of softened clay till will require stripping where present.</p> <p><b>Settlement:</b> No settlement issues are anticipated.</p> <p><b>Recommendations for Further Investigation:</b> Additional boreholes should be advanced to confirm the stratigraphy within the fill section.</p>
HF-C4	16+750 to 17+000	185.0 to 186.3	5.5	Desktop Study, Hydrogeology Report	<p><b>Stratigraphy:</b> Clayey silt till ground moraine overlaying sand and silt till.</p> <p><b>Groundwater:</b> Estimated near 2 to 3 m depth (Elev. 177 m).</p>	<p><b>Design Slope Inclination:</b> Fill slopes up to 5.5 m high may be constructed at 2H : 1V.</p> <p><b>Stability:</b> No stability issues are anticipated.</p> <p><b>Settlement:</b> No settlement issues are anticipated.</p> <p><b>Recommendations for Further Investigation:</b> Boreholes should be advanced to confirm the stratigraphy within the fill section.</p>





CROSS-SECTION




LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND SOFT SILTY CLAY SUBSOIL UNDER FOOTPRINT OF COMPACTED GRANULAR 'A'.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ENGINEER	AEG	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	 THURBER
DRAWN	SS		
DATE	MARCH 2009		
APPROVED	PKC		
SCALE	NTS		
		DWG. NO. FIGURE 2	

**APPENDIX A**

**RECORD OF BOREHOLE SHEETS**

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing

2) Field Insitu Vane Testing

3) Laboratory Vane Testing

4) SPT value

5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS	Split Spoon Sample	WS	Wash Sample	AS	Auger (Grab) Sample
	TW	Thin Wall Shelby Tube Sample	TP	Thin Wall Piston Sample		
	PH	Sampler Advanced by Hydraulic Pressure	PM	Sampler Advanced by Manual Pressure		
	WH	Sampler Advanced by Self Static Weight	RC	Rock Core	SC	Soil Core

Sensitivity =

Undisturbed Shear Strength

-----

Remoulded Shear Strength

Water Level

Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT                Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. $(W_L < 30\%)$ .
		CI	Inorganic clays of medium plasticity, silty clays. $(30\% < W_L < 50\%)$ .
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

ONTMT4S 0510.GPJ 7/8/09

ONTMT4S 0510.GPJ 7/8/09

RECORD OF BOREHOLE No CM03-1										1 OF 2		METRIC						
G.W.P. W.O. 07-20016		LOCATION N 4 867 724.7 E 348 719.7				ORIGINATED BY SLL												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES												
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03				CHECKED BY MEF												
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20	40							60	80	100
148.0																		
0.0	TOPSOIL, trace roots and rootlets: (175mm) Dark Brown Wet																	
0.2	SAND and SILT, trace roots, trace gravel Loose Dark Brown Wet		1	SS	5													
146.5																		
1.4	SAND and GRAVEL, trace silt Loose to Compact Dark Brown Wet		2	SS	8													
			3	SS	24													
145.0																		
3.0	Silty SAND, trace gravel Compact Brown Wet		4	SS	25													
			5	SS	26													
142.2																		
5.8	SAND and SILT, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)		6	SS	32													
	cobble at 7.39 to 7.52m																	
			7	SS	1007													
	cobble at 8.53 to 8.63m																	
			8	SS	1007													
	cobble at 9.75 to 9.85m																	

Continued Next Page

+ 3 × 3 Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CM03-1										2 OF 2		METRIC						
G.W.P. W.O. 07-20016		LOCATION N 4 867 724.7 E 348 719.7				ORIGINATED BY SLL												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES												
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03				CHECKED BY MEF												
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20	40							60	80	100
	Continued From Previous Page																	
137.2	SAND and SILT, some clay, trace gravel Dense Brown Moist (TILL) cobble at 10.21 to 10.31m		9	SS	1007													
10.7	END OF BOREHOLE AT 10.7m. BOREHOLE OPEN AND WATER LEVEL AT 0.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m AND AUGER CUTTINGS TO SURFACE.				.075													

+ 3 × 3 Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CM03-2										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 867 725.0 E 348 786.9				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.02.29 - 2008.02.29				CHECKED BY MEF							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 20 40 60 80 100			PLASTIC LIMIT W <sub>P</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%) 20 40 60		
152.1 0.0 0.1	TOPSOIL, with roots and rootlets: (75mm)  SAND, some gravel Compact Brown Moist						152						
	becoming silty, trace gravel		1	SS	24		151						
149.9			2	SS	20		150						
2.2	Silty SAND, some gravel Compact to Dense Brown Moist (TILL)		3	SS	28		149						
			4	SS	35		148						
148.0	Clayey SILT, with sand, trace gravel Very Stiff to Hard Brown to Grey Moist (TILL)(CL-ML)		5	SS	28		147						
			6	SS	100		146						
144.6	Silty SAND, some gravel Very Dense Grey Moist (TILL)		7	SS	53		145						
			8	SS	100/ .125		144						
							143						

Continued Next Page

+ 3 . X 3 . Numbers refer to  
Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CM03-2										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 867 725.0 E 348 786.9				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.02.29 - 2008.02.29				CHECKED BY MEF							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 20 40 60 80 100			PLASTIC LIMIT W <sub>P</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%) 20 40 60		
	Continued From Previous Page												
	Silty SAND, some gravel Very Dense Grey Moist (TILL) cobble or boulder at 10.26 to 10.46m		9	SS	100/ .100		142						
							141						
139.9							140						
12.2	SAND, trace silt, trace gravel Very Dense Grey Wet		10	SS	100/ 250		139						
138.7													
13.4	Silty SAND, trace clay Very Dense Grey Wet (TILL)		11	SS	100/ .150								
138.1													
14.0	END OF BOREHOLE AT 14.0m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.03.12 3.8 148.3 2009.02.12 4.0 148.1												

+ 3 . X 3 . Numbers refer to  
Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM03b-1												1 OF 2		METRIC			
G.W.P. W.O. 07-20016		LOCATION N 4 867 733.5 E 348 614.6				ORIGINATED BY SLL											
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03				CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa									WATER CONTENT (%)
								20	40	60	80						
152.5																	
0.0	TOPSOIL, trace roots and rootlets: (200mm)																
0.2	Dark Brown Moist																
	Gravelly SAND, trace silt																
	Compact																
	Brown																
	Moist																
150.3																	
2.2	Silty CLAY, trace gravel																
	Firm																
	Brown																
149.6																	
2.8	SAND, some silt																
	Loose																
	Brown																
	Moist																
	becoming Very Dense																
	trace to some gravel																
146.4																	
6.1	Gravelly SAND, trace silt																
	Dense to Very Dense																
	Brown																
	Wet																
143.0																	
9.4	silt seams																
	Silty SAND, some gravel																
	Dense																
	Grey																

Continued Next Page

+ 3 . X 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM03b-1												2 OF 2		METRIC			
G.W.P. W.O. 07-20016		LOCATION N 4 867 733.5 E 348 614.6				ORIGINATED BY SLL											
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03				CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa									WATER CONTENT (%)
								20	40	60	80						
	Continued From Previous Page																
	Moist to Wet (TILL)																
			9	SS	45											12 59 29 (SI+CL)	
140.3																	
12.2	SAND, trace silt, trace gravel																
	Very Dense		10	SS	71												
	Grey																
	Moist																
139.1																	
13.4	Silty SAND, trace gravel																
	Very Dense		11	SS	100/												
	Grey				.125												
	Moist (TILL)																
138.0																	
14.5	SAND and SILT, some clay, trace gravel																
	Very Dense		12	SS	100/												
	Grey				.100											3 45 34 18	
	Moist (TILL)																
135.6																	
16.9	END OF BOREHOLE AT 16.9m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2007.04.28 4.6 147.9 2009.02.12 4.7 147.8																

+ 3 . X 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM03b-2													1 OF 2		METRIC			
G.W.P. W.O. 07-20016		LOCATION N 4 867 742.9 E 348 642.2					ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.13 - 2008.03.13					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20	40	60	80	100						
148.8																		
0.0	TOPSOIL, with roots: (300mm)																	
148.5	Brown Moist																	
0.3	SAND, some gravel to gravelly, trace silt																	
	Loose to Compact																	
	Brown Moist		1	SS	4													
			2	SS	13													
			3	SS	15													
			4	SS	26													
144.7																		
4.1	Silty SAND, trace gravel																	
	Very Dense																	
	Grey Moist (TILL)		5	SS	100/													
					.125													
142.7																		
6.1	Sandy SILT, some clay, trace gravel		6	SS	100/													
	Very Dense				.175													
	Grey Moist (TILL)																	
			7	SS	100/													
					.200													
140.4																		
8.4	Silty SAND, trace gravel																	
	Very Dense																	
	Grey Moist (TILL)																	
			8	SS	100/													
					.175													
139.3																		
9.5	END OF BOREHOLE AT 9.5m.																	
	BOREHOLE OPEN TO 1.1m AND WATER LEVEL AT 1.0m UPON																	

Continued Next Page

+ 3 . x 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CM03b-2													2 OF 2		METRIC			
G.W.P. W.O. 07-20016		LOCATION N 4 867 742.9 E 348 642.2					ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.13 - 2008.03.13					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20	40	60	80	100						
	Continued From Previous Page																	
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																	

+ 3 . x 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM04-1												1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 867 847.5 E 349 004.5				ORIGINATED BY LH									
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES									
DATUM Geodetic		DATE 2009.01.23 - 2009.01.23				CHECKED BY LT									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W			LIQUID LIMIT W <sub>L</sub>		
156.0	TOPSOIL (600mm)		1	SS	6										
155.4	Clayey SILT, trace organics, trace rootlets Firm Dark brown (FILL)		2	SS	8										
154.6	Sandy SILT, trace clay, silty sand layers, trace oxide staining Compact to Dense Yellowish brown Wet		3	SS	17										
	Shale fragments Brown		4	SS	40										
			5	SS	45							0 21 72 7			
			6	SS	45							0 37 57 6			
149.9	Silty SAND, some clay, trace gravel Very Dense Brown Wet (TILL)		7	SS	55										
	Trace silt		8	SS	62							4 51 30 15			
			9	SS	62										
146.2	END OF BOREHOLE AT 9.8m.														
9.8															

Continued Next Page

+ <sup>3</sup> . × <sup>3</sup> : Numbers refer to Sensitivity  
20  
15 10 5  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM04-1												2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 867 847.5 E 349 004.5				ORIGINATED BY LH									
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES									
DATUM Geodetic		DATE 2009.01.23 - 2009.01.23				CHECKED BY LT									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W			LIQUID LIMIT W <sub>L</sub>		
	Continued From Previous Page														
	Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2009.02.12 3.2 152.8 2009.04.05 1.6 154.4 2009.06.06 1.3 154.7														

+ <sup>3</sup> . × <sup>3</sup> : Numbers refer to Sensitivity  
20  
15 10 5  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM04-2

1 OF 1

METRIC

G.W.P. W.O. 07-20016 LOCATION N 4 887 768.1 E 349 013.4 ORIGINATED BY LH  
HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
DATUM Geodetic DATE 2009.01.23 - 2009.01.23 CHECKED BY LT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT		
155.0								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE	W P	W	W L		
0.0	TOPSOIL (800mm)		1	SS	3		155						
154.2													
0.8	Silty SAND, trace gravel, trace clay, trace oxide staining Compact to dense Yellowish brown Wet		2	SS	16		154						
			3	SS	34		153						3 54 35 8
152.9													
2.1	Sandy SILT, trace clay, clayey silt layers, silty sand layers Dense to very dense Brown Wet		4	SS	43		152						
			5	SS	45		151						
			6	SS	73		150						0 17 76 7
			7	SS	38		149						
147.7							148						
7.3	Clayey SILT, trace sand, trace gravel Hard Brown Wet to moist (TILL)		8	SS	100/ .125		147						
146.2							146						
8.8	Silty CLAY, sandy, trace gravel Hard Brown		9	SS	100/ .150								3 33 40 24
145.7	Moist (TILL)(CL)												
9.3	END OF BOREHOLE AT 9.30m.												

+ 3 . X 3 : Numbers refer to  
Sensitivity

20  
15 5  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM05-1										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 867 921.6 E 349 270.4 Anderson Street				ORIGINATED BY LH							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SLL							
DATUM Geodetic		DATE 2009.04.23 - 2009.04.23				CHECKED BY LT							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
							20 40 60 80 100	40 80 120 160 200	20 40 60				
							○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL X LAB VANE					
161.1	SAND, some gravel, trace silt Compact Brown Moist (FILL)												
160.2													
0.9	Silty CLAY, sandy Stiff to Hard Brown (TILL)(CL)		1	SS	11								
			2	SS	60								
158.4			3	SS	100/ 250								
2.7	SAND and SILT, some clay, trace gravel Very Dense Brown Moist		4	SS	100/ 225								
157.2													
4.0	Sandy SILT, trace gravel Very Dense Grey Moist (TILL)		5	SS	100/ 200								
155.6													
5.5	SAND, trace to some silt Very Dense Grey Wet		6	SS	100/ 225								
			7	SS	100/ 200								
152.6													
8.5	Silty SAND, trace gravel Very Dense Grey Wet		8	SS	100/ 200								

Continued Next Page

+<sup>3</sup> × 3<sup>3</sup>: Numbers refer to Sensitivity  
20  
15 10 5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM05-1										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 867 921.6 E 349 270.4 Anderson Street				ORIGINATED BY LH							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SLL							
DATUM Geodetic		DATE 2009.04.23 - 2009.04.23				CHECKED BY LT							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
							20 40 60 80 100	40 80 120 160 200	20 40 60				
							○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL X LAB VANE					
	Continued From Previous Page												
	Silty SAND, trace gravel Very Dense Grey Wet		9	SS	39								
			10	SS	100/ 300								
148.5													
12.6	END OF BOREHOLE AT 12.6m. WATER LEVEL AT 5.8m UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen.												
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2009.07.21 6.0 155.1												

+<sup>3</sup> × 3<sup>3</sup>: Numbers refer to Sensitivity  
20  
15 10 5 (%) STRAIN AT FAILURE



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

+ 3, X 3: Numbers refer to Sensitivity

ONTMT4S 0510.GPJ 6/2/08

ONTMT4S 0510.GPJ 6/2/08



RECORD OF BOREHOLE No CM06-2										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 036.5 E 349 726.8 Thickson Road				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04				CHECKED BY MEF							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	PLASTIC LIMIT			NATURAL MOISTURE CONTENT	LIQUID LIMIT
167.0	TOPSOIL, with roots: (50mm) Brown Moist  Silty SAND, trace gravel Compact to Dense Brown Moist												
166.4			1	SS	25								
			2	SS	33								
			3	SS	100/ .225						1 73 26 (SI+CL)		
164.4	SAND and SILT, some clay, trace gravel, occasional oxide staining Very Dense Brown to Grey Moist (TILL)		4	SS	100/ .150						0 20 70 10		
			5	SS	100/ .125								
			6	SS	100/ .100								
			7	SS	100/ .100						0 42 39 19		
157.7	END OF BOREHOLE AT 9.3m. BOREHOLE OPEN TO 9.1m AND WATER LEVEL AT 1.2m UPON COMPLETION. Piezometer installation consists of		8	SS	100/ .150								
9.3													

ONTMT4S 0510.GPJ 3/17/09

+ <sup>3</sup> . X <sup>3</sup> : Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM06-2										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 036.5 E 349 726.8 Thickson Road				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04				CHECKED BY MEF							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	PLASTIC LIMIT			NATURAL MOISTURE CONTENT	LIQUID LIMIT
	Continued From Previous Page												
	19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.03.07 4.8 162.2 2008.03.12 5.5 161.5 2009.02.12 5.8 161.2												

ONTMT4S 0510.GPJ 3/17/09

+ <sup>3</sup> . X <sup>3</sup> : Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM06b-1				1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 060.4 E 349 661.6 Thickson Road		ORIGINATED BY SLL			
HWY 407		BOREHOLE TYPE Solid Stem Augers		COMPILED BY ES			
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04		CHECKED BY MEF			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE											
WATER CONTENT (%)								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT											
20 40 60								w <sub>p</sub> w w <sub>L</sub>											
166.3																			
0.0 0.1	TOPSOIL, with roots: (50mm) Brown Moist																		
	Clayey SILT, trace sand, trace gravel Stiff Brown		1	SS	14						○								
164.8																			
1.4	Silty CLAY, some sand, trace gravel Very Stiff to Hard Brown (TILL)(CL)		2	SS	19						○								
			3	SS	50						○								
			4	SS	60						○								
			5	SS	35						○								
160.2			6	SS	100/ .125						○								
6.1	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)																		
			7	SS	100/ .075						○								
			8	SS	100/ .150						○								
	inferred cobble at 8.97 to 9.12m																		

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity  
20  
15 5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM06b-1				2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 060.4 E 349 661.6 Thickson Road		ORIGINATED BY SLL			
HWY 407		BOREHOLE TYPE Solid Stem Augers		COMPILED BY ES			
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04		CHECKED BY MEF			

SOIL PROFILE					SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					SHEAR STRENGTH kPa					
										20 40 60 80 100					
										○ UNCONFINED + FIELD VANE					
										● QUICK TRIAXIAL x LAB VANE					
										WATER CONTENT (%)					
20 40 60 80 100				w <sub>p</sub> w w <sub>L</sub>											
	Continued From Previous Page								156						
155.5	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		9	SS	100/ .150								o		
10.8	END OF BOREHOLE AT 10.8m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.03.07 8.6 157.7 2008.03.12 2.3 164.0 2009.02.12 3.3 163.0														

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity  
20  
15 5  
10 (%) STRAIN AT FAILURE

+ 3, x 3, Numbers refer to Sensitivity





RECORD OF BOREHOLE No CM07-1										1 OF 1		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 315.0 E 349 989.1				ORIGINATED BY LH							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2009.01.26 - 2009.01.26				CHECKED BY LT							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
							20 40 60 80 100	○ UNCONFINED + FIELD VANE				kN/m <sup>3</sup>	GR SA SI CL
							40 80 120 160 200	● QUICK TRIAXIAL × LAB VANE					
167.3													
0.0	TOPSOIL (800mm)		1	SS	4								
166.5													
0.8	Silty CLAY, some sand Stiff to Hard Dark brown (CL)		2	SS	9								
			3	SS	80								
			4	SS	71								
			5	SS	100/ .225								
163.3													
4.0	SAND and SILT, trace gravel, trace clay Dense to very dense Brown Wet		6	SS	43								
			7	SS	78								
160.0													
7.3	SAND, trace clay, trace gravel Very dense Brown Wet		8	SS	100/ .125								
158.0			9	SS	100/ .150								
9.3	END OF BOREHOLE AT 9.30m.												

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (% STRAIN AT FAILURE



RECORD OF BOREHOLE No CM07-2										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 237.7 E 350 034.4				ORIGINATED BY LH							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2009.01.26 - 2009.01.26				CHECKED BY LT							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
							20 40 60 80 100	○ UNCONFINED + FIELD VANE				kN/m <sup>3</sup>	GR SA SI CL
							40 80 120 160 200	● QUICK TRIAXIAL × LAB VANE					
166.9													
0.0	TOPSOIL (500mm)		1	SS	3								
166.4													
0.5	Clayey SILT, some sand, trace gravel, trace oxide staining Stiff Brown		2	SS	13								
165.5													
1.4	Silty SAND, trace gravel, some clay, trace oxide staining Very Dense Brown Wet (TILL)		3	SS	60								
			4	SS	100/ .075								
			5	SS	150/ .225								
162.5													
4.4	SAND and SILT, trace clay Very Dense Brown Wet		6	SS	100/ .150								
160.8													
6.1	Sandy SILT, trace clay Very Dense Brown Wet		7	SS	100/ .150								
159.6													
7.3	SILT and SAND, some clay, trace gravel Very Dense Brown Moist to Wet (TILL)		8	SS	100/ .100								
157.7			9	SS	100/ .075								
9.2	END OF BOREHOLE AT 9.2m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS:												

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (% STRAIN AT FAILURE



RECORD OF BOREHOLE No CM07-2															2 OF 2		METRIC	
G.W.P. W.O. 07-20016			LOCATION N 4 868 237.7 E 350 034.4					ORIGINATED BY LH										
HWY 407			BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES										
DATUM Geodetic			DATE 2009.01.26 - 2009.01.26					CHECKED BY LT										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE		W P W L WATER CONTENT (%)								
	Continued From Previous Page							20 40 60 80 100										
	DATE DEPTH (m) ELEV. (m) 2009.02.12 2.6 164.3 2009.04.09 5.4 161.5																	



RECORD OF BOREHOLE No CM9-1										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 640.5 E 350 373.3				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM							
DATUM Geodetic		DATE 2007.12.05 - 2007.12.05				CHECKED BY MEF							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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	SHEAR STRENGTH kPa					
							20 40 60 80 100	20 40 60					
171.7	ASPHALT: (75 mm)		1	AS									
0.0													
171.1	SAND, some gravel, trace silt Brown Moist (FILL)												
0.6													
170.2	Silty CLAY, some topsoil staining Brown												
1.4	Clayey SILT, with sand, trace gravel, occasional cobbles Hard Brown to Grey (TILL)(CL-ML)		1	SS	63								
			2	SS	30							2 38 42 18	
			3	SS	34								
167.4	Silty CLAY, some sand, trace gravel Hard to Very Stiff Grey (TILL)(CL)		4	SS	32							2 14 35 49	
4.3													
			5	SS	20								
164.1	SAND and SILT, trace to some clay, trace gravel, occasional cobbles Dense to Very Dense Grey Moist (TILL)		6	SS	36							7 46 35 11	
7.6													
			7	SS	71								

Continued Next Page

+ 3 . X 3 : Numbers refer to  
Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM9-1										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 640.5 E 350 373.3				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM							
DATUM Geodetic		DATE 2007.12.05 - 2007.12.05				CHECKED BY MEF							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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	SHEAR STRENGTH kPa					
							20 40 60 80 100	20 40 60					
	Continued From Previous Page												
	SAND and SILT, trace to some clay, trace gravel, occasional cobbles Dense to Very Dense Grey Moist (TILL)		8	SS	55								
			9	SS	42								
	becoming Compact		10	SS	25								9 47 35 8
			11	SS	14								
	becoming Very Dense												
154.6	BOREHOLE CONTINUED ON CM9-1a.		2	SS	100/								
17.1	END OF BOREHOLE AT 17.1m. BOREHOLE OPEN TO 15.4m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted Screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV (m) 2007.12.10 11.2 160.5 2007.12.21 10.2 161.5 2008.01.16 9.90 161.8 2008.03.12 9.50 162.2												

+ 3 . X 3 : Numbers refer to  
Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

ONTMT4S 0510.GPJ 9/30/08

ONTMT4S 0510.GPJ 9/30/08



RECORD OF BOREHOLE No CM9-2										1 OF 2		METRIC				
G.W.P. W.O. 07-20016		LOCATION N 4 868 557.6 E 350 406.6				ORIGINATED BY SLL										
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM										
DATUM Geodetic		DATE 2007.12.06 - 2007.12.10				CHECKED BY MEF										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			20	40	60						80
171.3																
0.0	ASPHALT: (150mm)															
0.2	SAND, some gravel, trace silt Brown Moist (FILL)		1	AS												
170.7																
0.6	Clayey SILT, some sand to with sand, trace gravel Hard Brown (TILL)(CL)		1	SS	33											
			2	SS	37											
			3	SS	48											
			4	SS	51											
			5	SS	32											
165.8																
5.5	SAND and SILT, trace to some clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	80											
			7	SS	101											
162.6																
8.7	Gravelly SAND, some silt Very Dense Grey Moist BOREHOLE CONTINUED ON CM9-2A.		8	SS	100											
161.7																
9.6	END OF BOREHOLE AT 9.6m. BOREHOLE OPEN TO 9.5m AND															

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity  
20  
15 10 5  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM9-2										2 OF 2		METRIC				
G.W.P. W.O. 07-20016		LOCATION N 4 868 557.6 E 350 406.6				ORIGINATED BY SLL										
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM										
DATUM Geodetic		DATE 2007.12.06 - 2007.12.10				CHECKED BY MEF										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			20	40	60						80
	Continued From Previous Page															
	DRY ON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m AND ASPHALT TO SURFACE.															

+ 3, x 3: Numbers refer to Sensitivity  
20  
15 10 5  
(%) STRAIN AT FAILURE





RECORD OF BOREHOLE No CM9-2a															1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 557.6 E 350 406.6					ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2007.12.10 - 2007.12.10					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa									WATER CONTENT (%)	
171.3																		
0.0	BOREHOLE CONTINUED FROM CM9-2. No Sampling until 6.1m.																	
171																		
170																		
169																		
168																		
167																		
166																		
165																		
164																		
163																		
162																		
165.2																		
6.1	SAND and SILT, trace to some clay, trace gravel Very Dense Grey Moist (TILL)		1	SS	100/275													
162.3																		
9.0	Gravelly SAND, some silt Very Dense Grey Moist		3	SS	100/.150													
161.7																		
9.6	SAND and SILT, trace clay, trace gravel																	

Continued Next Page

+ 3 . X 3 : Numbers refer to Sensitivity  
15 5 10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM9-2a															2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 557.6 E 350 406.6					ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2007.12.10 - 2007.12.10					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa									WATER CONTENT (%)	
	Continued From Previous Page																	
161																		
160																		
159																		
158																		
157																		
156																		
155																		
156.5																		
14.9	SAND and GRAVEL, some silt Very Dense Grey Wet		7	SS	100/275													
154.4																		
16.9	END OF BOREHOLE AT 16.9m. BOREHOLE OPEN TO 15.1m. WATER LEVEL AT 10.0m ON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.5m. THEN AUGER CUTTING TO 0.2m AND ASPHALT TO SURFACE.		8	SS	100/.150													

+ 3 . X 3 : Numbers refer to Sensitivity  
15 5 10 (%) STRAIN AT FAILURE



ONTMT4S 0510.GPJ 3/12/09

ONTMT4S 0510.GPJ 3/12/09

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity

+ 3, x 3: Numbers refer to Sensitivity

ONTMT4S 0510.GPJ 12/8/08

ONTMT4S 0510.GPJ 12/8/08



RECORD OF BOREHOLE No CM10-2										4 OF 4		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 868 918.7 E 350 796.7 Oshawa Creek West				ORIGINATED BY JM								
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES								
DATUM Geodetic		DATE 2008.03.06 - 2008.03.12				CHECKED BY MEF								
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
	Continued From Previous Page													
123.8	Clayey SILT, some sand Hard Grey (TILL)		19	SS	100/.175									
30.5	Silty CLAY, some sand, trace gravel Hard Grey (TILL)(CI)		20	SS	67									0 20 38 43
			21	SS	70									
120.2	END OF BOREHOLE AT 34.1m. BOREHOLE OPEN TO 12.2m AND WATER LEVEL AT 1.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													
34.1														

+ 3 . X 3 : Numbers refer to Sensitivity  
20  
15 5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM10b-1										1 OF 3		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 868 951.4 E 350 749.1 Oshawa Creek West				ORIGINATED BY LH								
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES								
DATUM Geodetic		DATE 2009.01.29 - 2009.02.11				CHECKED BY MEF								
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
	TOPSOIL: (600mm) Firm Brown Moist		1	SS	7									
0.0														
160.6	Silty CLAY, trace sand, oxidized staining Stiff to Very Stiff Brown (TILL)(CL)		2	SS	8									
0.6			3	SS	16									0 8 57 35
158.9			4	SS	23									
2.3	SILT and SAND, trace clay, trace gravel, oxidized staining Compact to Very Dense Brown Moist to Wet		5	SS	29									2 36 55 7
			6	SS	60									
155.4			7	SS	45									0 79 21 (SI+CL)
5.8	Silty SAND Dense to Compact Brown Moist to Wet		8	SS	22									
			9	SS	8									

Continued Next Page

+ 3 . X 3 : Numbers refer to Sensitivity  
20  
15 5  
10 (%) STRAIN AT FAILURE





RECORD OF BOREHOLE No CM10b-1															2 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 951.4 E 350 749.1 Oshawa Creek West										ORIGINATED BY LH						
HWY 407		BOREHOLE TYPE Solid Stem Augers										COMPILED BY ES						
DATUM Geodetic		DATE 2009.01.29 - 2009.02.11										CHECKED BY MEF						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
Continued From Previous Page																		
149.5	Silty SAND Dense Brown Moist to Wet		10	SS	32									2 65 28 5				
11.7	SAND, trace silt, trace gravel Compact to Dense Brown Wet		11	SS	12													
146.7			12	SS	47													
14.5	Silty CLAY, trace sand Very Stiff Grey (TILL)(CL)		13	SS	28													
			14	SS	15									0 1 64 35				
142.6			15	SS	74									1 62 28 9				
18.6	Silty SAND, trace gravel, trace clay Very Dense Grey Moist (TILL)		16	SS	143/													

Continued Next Page

+ 3, X 3 : Numbers refer to Sensitivity  
20  
15 5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM10b-1															3 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 951.4 E 350 749.1 Oshawa Creek West										ORIGINATED BY LH						
HWY 407		BOREHOLE TYPE Solid Stem Augers										COMPILED BY ES						
DATUM Geodetic		DATE 2009.01.29 - 2009.02.11										CHECKED BY MEF						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
	Continued From Previous Page				0.275													
139.9	Silty SAND, trace gravel, trace clay Very Dense Grey Moist (TILL)																	
21.3	SAND, some gravel, trace silt, trace clay Very Dense Brown Wet		17	SS	150/									15 66 19 (SI+CL)				
					0.300													
138.3			18	SS	100/													
22.9	END OF BOREHOLE AT 22.9m. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO SURFACE.				0.075													

+ 3, X 3 : Numbers refer to Sensitivity  
20  
15 5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM10b-2

1 OF 2

METRIC

G.W.P. W.O. 07-20016

LOCATION N 4 868 991.9 E 350 815.3 Oshawa Creek West

ORIGINATED BY JM

HWY 407

BOREHOLE TYPE Solid Stem Augers

COMPILED BY ES

DATUM Geodetic

DATE 2008.03.06 - 2008.03.07

CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100				
								SHEAR STRENGTH kPa				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE			
								WATER CONTENT (%)				
								20 40 60				
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
								w <sub>p</sub> w w <sub>L</sub>				
						GR SA SI CL						
156.0												
0.0												
0.2	TOPSOIL: (150mm), with roots Brown Moist											
	SAND, some silt, trace gravel, trace clay, trace to some rootlets Loose Brown Moist		1	SS	10							
			2	SS	10							
153.8												
2.1	SAND and SILT, trace clay Loose to Very Loose Brown to Grey Wet		3	SS	8							0 46 46 8
			4	SS	2							
151.9												
4.1	Silty SAND, trace gravel Compact Grey Wet		5	SS	11							1 70 29 (SI+CL)
149.9												
6.1	Sandy SILT, some clay Compact Grey Moist		6	SS	27							
148.8												
7.2	Silty CLAY, trace sand, trace gravel Hard Grey (TILL)(CL)		7	SS	52							
147.3												
8.7	Silty SAND, trace gravel Very Dense Grey Moist (TILL)		8	SS	100/ 200							

Continued Next Page

+ 3 . X 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM10b-2

2 OF 2

METRIC

G.W.P. W.O. 07-20016

LOCATION N 4 868 991.9 E 350 815.3 Oshawa Creek West

ORIGINATED BY JM

HWY 407

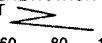
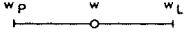


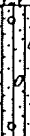


BOREHOLE TYPE Solid Stem Augers

COMPILED BY ES

DATUM Geodetic

DATE 2008.03.06 - 2008.03.07

CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES										
								SHEAR STRENGTH kPa							
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL X LAB VANE							
								WATER CONTENT (%)							
															
								20 40 60 80 100							
								20 40 60							
GR SA SI CL															
Continued From Previous Page							146								
	Silty SAND, trace gravel Very Dense Grey Moist (TILL)		9	SS	100/ .326										4 73 23 (SI+CL)
							145								
							144								
143.8							143								
12.2	Sandy SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		10	SS	100/ .175										
							142								
141.9			11	SS	100/ .175										
14.0	END OF BOREHOLE AT 14.1m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.04.28 2.3 153.7 2008.07.28 2.2 153.8														

+ 3 . X 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM11-1										1 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 869 206.2 E 351 033.7				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM							
DATUM Geodetic		DATE 2007-12-06 - 2007-12-06				CHECKED BY MEF							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
171.3	ASPHALT: (60 mm)						20	40	60	80	100		
170.7	SAND, some gravel, some silt Brown Moist (FILL)		1	AS									15 71 14 (SI+CL)
169.1	Silty CLAY, some sand, trace gravel Very stiff Brown (TILL)		1	SS	16								
			2	SS	17								
167.1	SILT, trace clay, trace sand Dense to Very Dense Brown Moist		3	SS	30								0 3 90 7
			4	SS	52								
165.5	Silty CLAY, trace thin sand seams Hard Brown to Grey Moist (CI)		5	SS	54								0 7 28 65
164.2	Silty CLAY, some sand, trace gravel Hard Grey Moist (TILL)		6	SS	94								
			7	SS	72								4 44 35 17
			8	SS	100/125								

Continued Next Page

+ 3 x 3 Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM11-1										2 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 869 206.2 E 351 033.7				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM							
DATUM Geodetic		DATE 2007-12-06 - 2007-12-06				CHECKED BY MEF							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
161.0	Continued From Previous Page						20	40	60	80	100		
161.0	Silty CLAY, trace sand seams Hard Grey Moist (CI)		9	SS	59								
158.2	SAND, trace to some silt Very Dense to Compact Grey Wet		10	SS	75								0 0 34 66
			11	SS	57								
154.9	SILT, some sand, trace clay Very Dense Grey Moist to Wet		13	SS	100/150								0 91 9 (SI+CL)
			14	SS	100/150								
			15	SS	100/150								

Continued Next Page

+ 3 x 3 Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE



Ministry of  
Transportation  
Ontario



SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>	
171.1	ASPHALT: (50 mm)													
0.1	SAND, some gravel (FILL)		1	AS							o			
170.5	ASPHALT: (50 mm)													
0.6	SAND, some gravel, trace silt Brown Moist (FILL)		1	SS	34						o			
	Silty CLAY, some sand, trace gravel Hard Brown Moist (TILL)		2	SS	37						o			
168.9														
2.2	SILT, trace sand, trace clay Very Dense Brown Wet		3	SS	55						o			
			4	SS	86						o			0 8 85 7
166.9														
4.3	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		5	SS	100/ .175						o			
			6	SS	100/ .175						o			
164.2														
6.9	Silty CLAY, with sand, trace gravel Hard Grey Moist (TILL)(CL)		7	SS	100						o			1 41 30 28
			8	SS	75						o			

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity





Ministry of  
Transportation  
Ontario

ONTMT4S 0510.GPJ 7/20/09

+ 3, X 3: Numbers refer to Sensitivity

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

ONTMT4S 0510.GPJ 7/20/09ONTMT4S 0510.GPJ 7/16/09



RECORD OF BOREHOLE No CM12b-2												1 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 869 354.8 E 351 252.3 Winchester Road East				ORIGINATED BY LH									
HWY 407		BOREHOLE TYPE Solid Stem Augers/HW Casing				COMPILED BY SLL									
DATUM Geodetic		DATE 2009.03.13 - 2009.03.17				CHECKED BY LT									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
172.4	SAND, trace gravel Brown Moist (FILL)					20 40 60 80 100			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	WATER CONTENT (%)	GR SA SI CL		
0.0						SHEAR STRENGTH kPa									
171.8	Clayey SILT, trace gravel Very Stiff Brown		1	SS	19	40 80 120 160 200			W P	W	W L	0 22 53 25			
0.6						UNCONFINED + FIELD VANE									
			2	SS	20	40 80 120 160 200			QUICK TRIAXIAL X LAB VANE						
						WATER CONTENT (%)									
170.1	Silty CLAY, sandy, trace gravel Very Stiff to Hard Brown to Grey (TILL)(CL)		3	SS	18	20 40 60			W P	W	W L	18 51 22 9			
2.3						SHEAR STRENGTH kPa									
			4	SS	100/275	40 80 120 160 200			QUICK TRIAXIAL X LAB VANE						
						WATER CONTENT (%)									
165.2	Silty SAND, some gravel, trace clay Dense Grey Moist (TILL)		5	SS	100/175	20 40 60			W P	W	W L				
7.2						SHEAR STRENGTH kPa									
			6	SS	68	40 80 120 160 200			QUICK TRIAXIAL X LAB VANE						
						WATER CONTENT (%)									
163.7	Clayey SILT, some sand, trace gravel Hard Grey (TILL)		7	SS	36	20 40 60			W P	W	W L				
8.7						SHEAR STRENGTH kPa									
			8	SS	100/225	40 80 120 160 200			QUICK TRIAXIAL X LAB VANE						
						WATER CONTENT (%)									



RECORD OF BOREHOLE No CM12b-2												2 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 869 354.8 E 351 252.3 Winchester Road East				ORIGINATED BY LH									
HWY 407		BOREHOLE TYPE Solid Stem Augers/HW Casing				COMPILED BY SLL									
DATUM Geodetic		DATE 2009.03.13 - 2009.03.17				CHECKED BY LT									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
162	Clayey SILT, some sand, trace gravel Hard Grey (TILL)		9	SS	100/200	20 40 60 80 100			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	0 5 86 9			
						SHEAR STRENGTH kPa									
160.8	SILT, trace to sandy, trace clay Very Dense Grey Moist		10	SS	73	40 80 120 160 200			W P	W	W L				
11.6						UNCONFINED + FIELD VANE									
			11	SS	100/275	40 80 120 160 200			QUICK TRIAXIAL X LAB VANE						
						WATER CONTENT (%)									
			12	SS	44	20 40 60			W P	W	W L				
						SHEAR STRENGTH kPa									
			13	SS	100/200	40 80 120 160 200			QUICK TRIAXIAL X LAB VANE						
						WATER CONTENT (%)									
154.6	SAND and SILT, trace gravel, trace clay Very Dense Grey Moist to Wet with thin clayey silt layers		14	SS	79	20 40 60			W P	W	W L	1 44 50 5			
17.8						UNCONFINED + FIELD VANE									
						40 80 120 160 200			QUICK TRIAXIAL X LAB VANE						
						WATER CONTENT (%)									

ONTMT4S 0510.GPJ 7/16/09

Continued Next Page

+ 3 . X 3 : Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM12b-2															3 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 869 354.8 E 351 252.3 Winchester Road East										ORIGINATED BY LH						
HWY 407		BOREHOLE TYPE Solid Stem Augers/HW Casing										COMPILED BY SLL						
DATUM Geodetic		DATE 2009.03.13 - 2009.03.17										CHECKED BY LT						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa										WATER CONTENT (%)
Continued From Previous Page																		
151.0	SAND and SILT, trace gravel, trace clay Very Dense Grey Moist to Wet		15	SS	73		152											
21.3	Sandy SILT, some clay Very Dense Grey Wet		16	SS	100/ .150		151										0 24 65 11	
							150											
			17	SS	100/ .150		149											
147.8			18	SS	100/ .150		148											
24.5	END OF BOREHOLE AT 24.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																	





RECORD OF BOREHOLE No CM15E-1												1 OF 2		METRIC				
G.W.P. W.O. 07-20016		LOCATION N 4 870 550.7 E 352 343.5				ORIGINATED BY ES												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY AN												
DATUM Geodetic		DATE 2009.02.05 - 2009.02.05				CHECKED BY LT												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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 (%)			Y	GR	SA	SI	CL
190.5								20 40 60 80 100	40 80 120 160 200	20 40 60								
0.0	SAND, some to trace gravel, hydrocarbon odour, frozen Very Dense to Compact Dark Brown Moist (FILL)		1	SS	100/0.125		190											
			2	SS	100/0.100													
188.7			3	SS	14		189											
1.8	Clayey SILT, trace sand, trace gravel Stiff Dark Brown (FILL)																	
188.2			4	SS	26		188											
2.3	Silty CLAY, some sand Very Stiff to Hard Grey Brown (TILL)(CL) Occasional oxide staining		5	SS	31		187											
	Trace gravel, occasional sand pockets Brown		6	SS	52		186											
			7	SS	113/0.275		185											
			8	SS	20/0.025		184											
							183											
							182											
181.4																		
9.1	SAND, fine grained, some gravel, trace silt and clay Very Dense		9	SS	118		181											
180.9																		
9.6	Grey Wet																	

Continued Next Page

+ 3 . X 3 : Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM15E-1												2 OF 2		METRIC				
G.W.P. W.O. 07-20016		LOCATION N 4 870 550.7 E 352 343.5				ORIGINATED BY ES												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY AN												
DATUM Geodetic		DATE 2009.02.05 - 2009.02.05				CHECKED BY LT												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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 (%)			Y	GR	SA	SI	CL
	Continued From Previous Page							20 40 60 80 100	40 80 120 160 200	20 40 60								
	END OF BOREHOLE AT 9.6m. BOREHOLE OPEN AND WATER LEVEL AT 7.3m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m. THEN CUTTINGS TO SURFACE.																	

+ 3 . X 3 : Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CM15E-2										1 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 870 554.8 E 352 382.1				ORIGINATED BY LH								
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY AN								
DATUM Geodetic		DATE 2009.02.06 - 2009.02.06				CHECKED BY LT								
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	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	SHEAR STRENGTH kPa						WATER CONTENT (%)
189.4	0.0	TOPSOIL (800mm)	1	SS	9									
188.6	0.8	Silty CLAY, sandy, trace gravel, trace iron oxide Yellowish Brown Stiff to Hard Wet to Moist (TILL)(CL)  Fine sand pockets	2	SS	13									
			3	SS	38									0 24 49 27
			4	SS	100/ 0.225									
			5	SS	100/ 0.225									
		Trace Sand Brown	6	SS	100/ 0.150									0 3 62 35
183.6	5.8	SILT and SAND, some clay, trace gravel, occasional cobble or boulder Very Dense Brown Wet (TILL)	7	SS	94									3 36 45 16
			8	SS	100/ 0.150									
		Silty sand layers	9	SS	100/ 0.100									
180.2	9.2	END OF BOREHOLE AT 9.2m. WATER LEVEL AT 7.0m UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe												

Continued Next Page

+ 3 . X 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CM15E-2										2 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 870 554.8 E 352 382.1				ORIGINATED BY LH								
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY AN								
DATUM Geodetic		DATE 2009.02.06 - 2009.02.06				CHECKED BY LT								
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	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	SHEAR STRENGTH kPa						WATER CONTENT (%)
	Continued From Previous Page													
	with a 1.52m slotted screen.													
	WATER LEVEL READINGS:													
	DATE DEPTH (m) ELEV. (m)													
	2009.02.12 1.7 187.7													
	2009.05.04 0.7 188.7													

+ 3 . X 3 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

+<sup>3</sup>, ×<sup>3</sup>. Numbers refer to Sensitivity

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

+3, X3; Numbers refer to Sensitivity



RECORD OF BOREHOLE No FCM-01										1 OF 1	METRIC				
G.W.P. W.O. 07-20016		LOCATION N 4 869 316.7 E 351 228.5		ORIGINATED BY MEF											
HWY 407		BOREHOLE TYPE Solid Stem Augers		COMPILED BY AN											
DATUM Geodetic		DATE 2008.10.01 - 2008.10.01		CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL			x LAB VANE	W <sub>P</sub>	W
170.5							20	40	60	80	100				
0.0	TOPSOIL (300mm), some rootlets Very Loose Brown Wet		1	SS	2										
170.0															
0.5	Silty CLAY, trace sand Firm Brown (TILL) (CL-CI)  becoming Hard		2	SS	4										
			3	SS	39									0 9 47 44	
168.2															
2.3	Sandy SILT, some clay, trace gravel Dense to Very Dense Brown Wet (TILL)		4	SS	39										
			5	SS	112									0 24 63 13	
166.2															
4.3	Silty SAND, some clay to clayey, trace gravel, occasional cobbles Very Dense to Dense Grey Dry (TILL)		6	SS	100/ .225										
			7	SS	78									6 42 33 19	
			8	SS	41										
162.2															
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN TO 7.6m AND WET AT 0.3m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.														

+ 3, x 3 : Numbers refer to Sensitivity  
20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No FCM-02										1 OF 1	METRIC				
G.W.P. W.O. 07-20016		LOCATION N 4 869 395.6 E 351 378.1		ORIGINATED BY MEF											
HWY 407		BOREHOLE TYPE Solid Stem Augers		COMPILED BY AN											
DATUM Geodetic		DATE 2008.09.29 - 2008.09.29		CHECKED BY MEF											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						W P W W L	
173.5															
0.0	SAND and GRAVEL, trace silt Compact Brown Dry (FILL)		1	SS	21										
172.4															
1.1	TOPSOIL		2	SS	11										
172.1	Compact Brown Moist														
1.4	Silty CLAY, some sand, trace gravel Very Stiff to Hard Brown (TILL)(CL)		3	SS	21										
			4	SS	46										
			5	SS	50/ 125										
169.4															
4.1	Sandy SILT, some clay, trace gravel Dense Grey Wet (TILL)		6	SS	42										
167.4															
6.1	Silty CLAY, some sand, trace gravel Very Stiff to Hard Grey (TILL)(CI)		7	SS	28										
			8	SS	73										
165.3															
8.2	END OF BOREHOLE AT 8.2m. WATER LEVEL AT 6.4m UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2009.02.10 2.7 170.8														

+ 3, x 3 : Numbers refer to Sensitivity  
20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

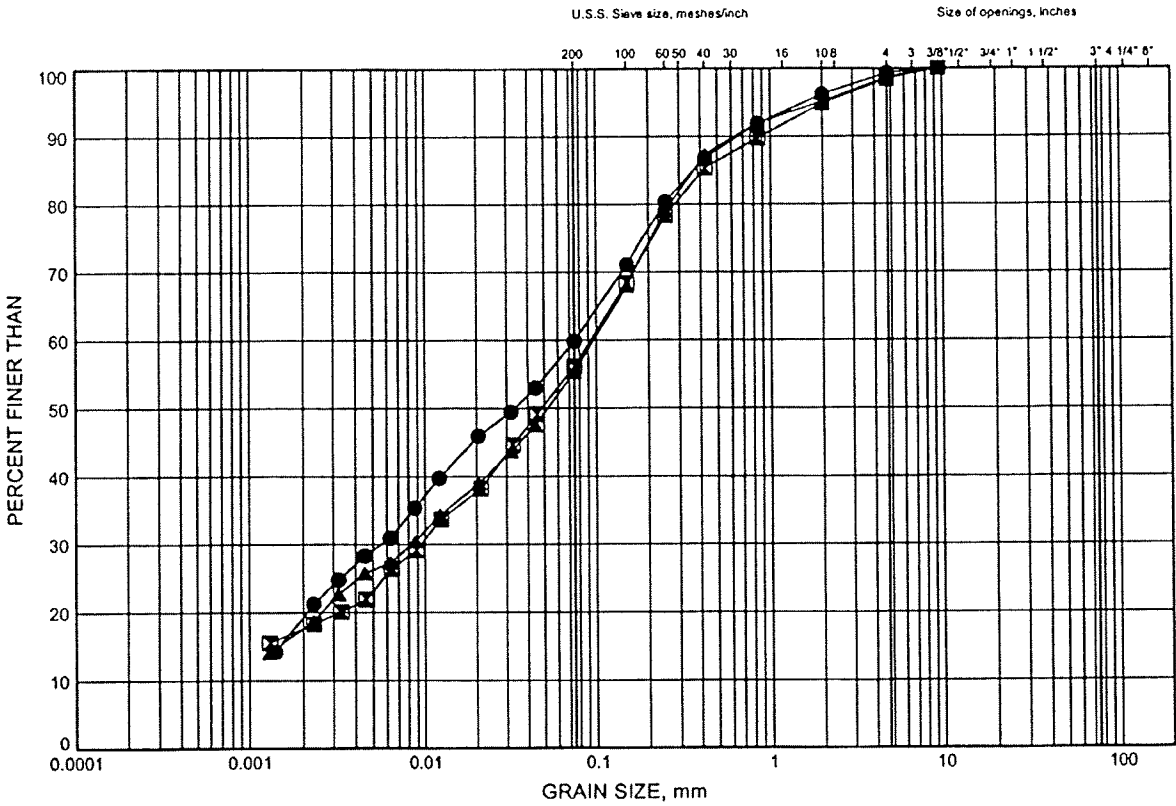
## **APPENDIX B**

### **LABORATORY TEST RESULTS**

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM2-B1

SAND & SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM2-1	1.83	157.02
■	CM2-1	6.16	152.69
▲	CM2-1	10.71	148.14

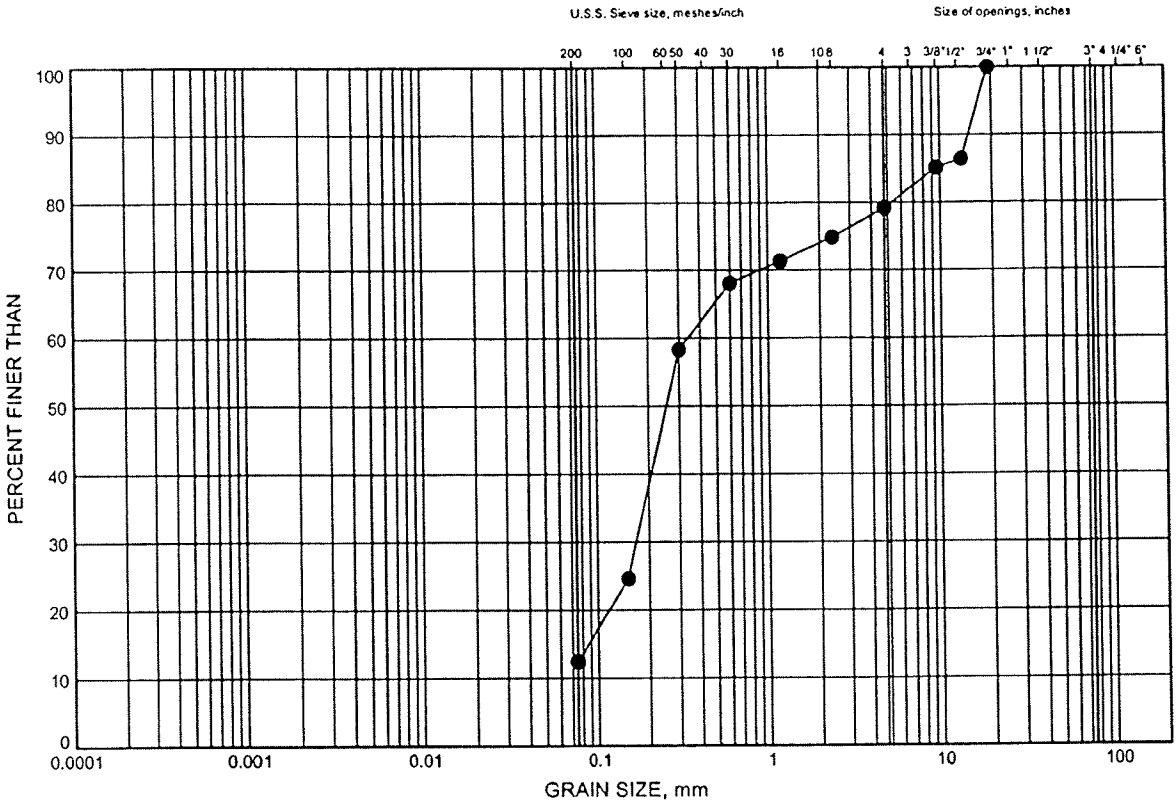


W.P.# W.O. 07-20016...  
Prepared By AN  
Checked By LT

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM2-B2

GRAVELLY SAND



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

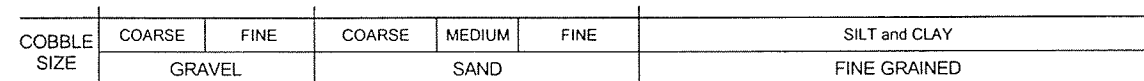
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM2-1	4.71	154.14



W.P.# W.O. 07-20016...  
Prepared By AN  
Checked By LT

## FIGURE CM3-B1

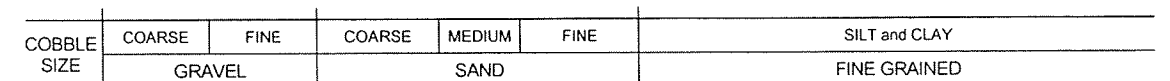


Date May 2008  
Project W.O. 07-20016



Prep'd MFA  
Chkd. SKP

## FIGURE CM3-B2



Date May 2008  
Project W.O. 07-20016



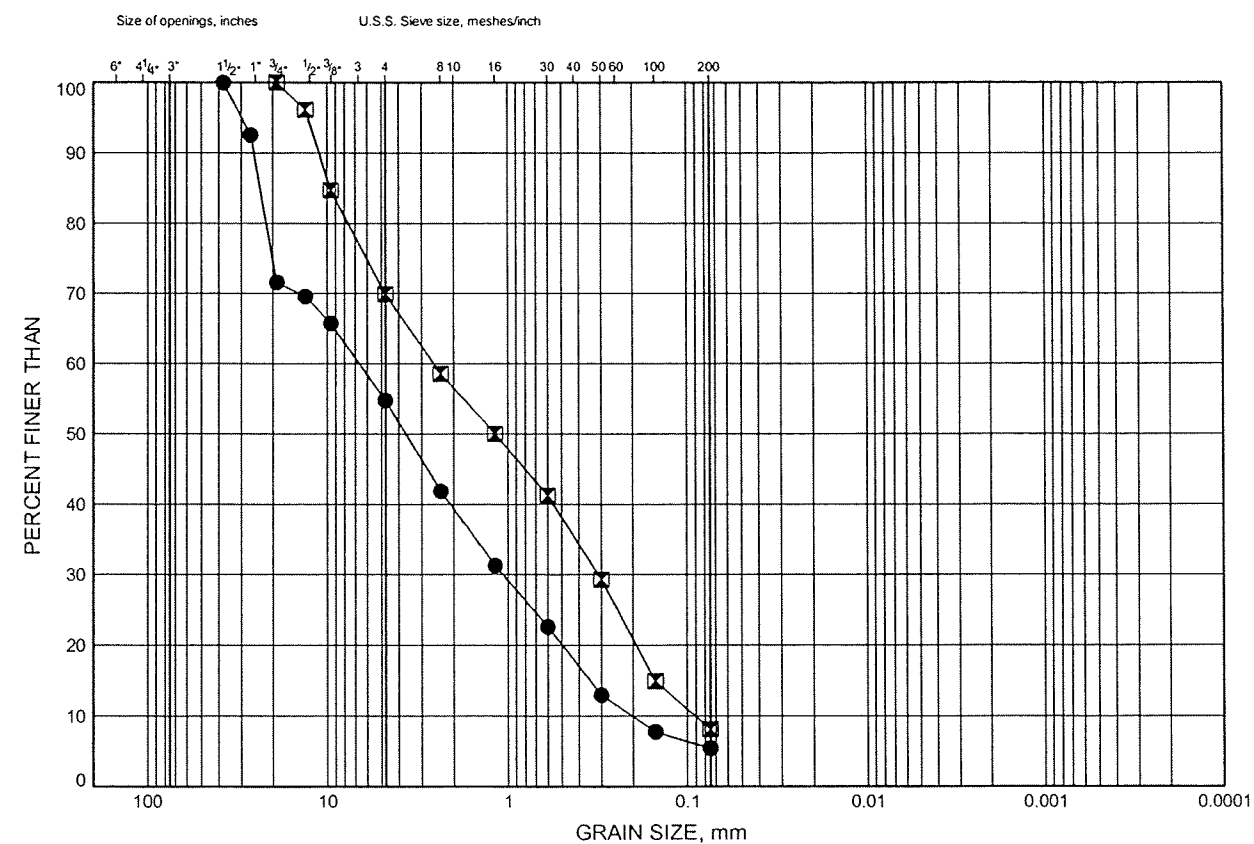
Prep'd ..... MFA .....  
Chkd. .... SKP .....

# Hwy 407 East Extension - Central Section

## GRAIN SIZE DISTRIBUTION

FIGURE CM3-B3

### SAND AND GRAVEL TO GRAVELLY SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM03-1	2.59	145.38
□	CM03b-1	9.27	143.20

Date May 2008  
Project W.O. 07-20016



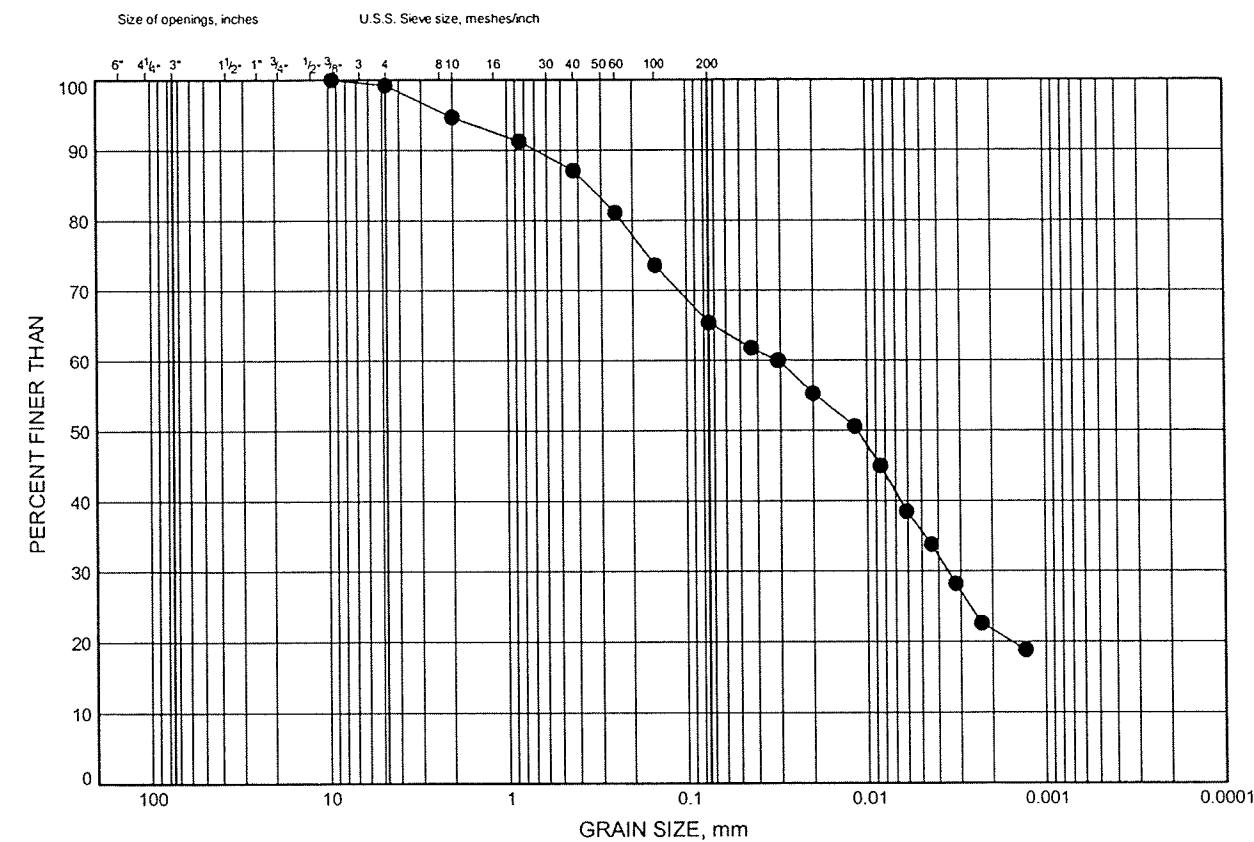
Prep'd MFA  
Chkd. SKP

# Hwy 407 East Extension - Central Section

## GRAIN SIZE DISTRIBUTION

FIGURE CM3-B4

### CLAYEY SILT TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM03-2	4.88	147.23

Date May 2008  
Project W.O. 07-20016



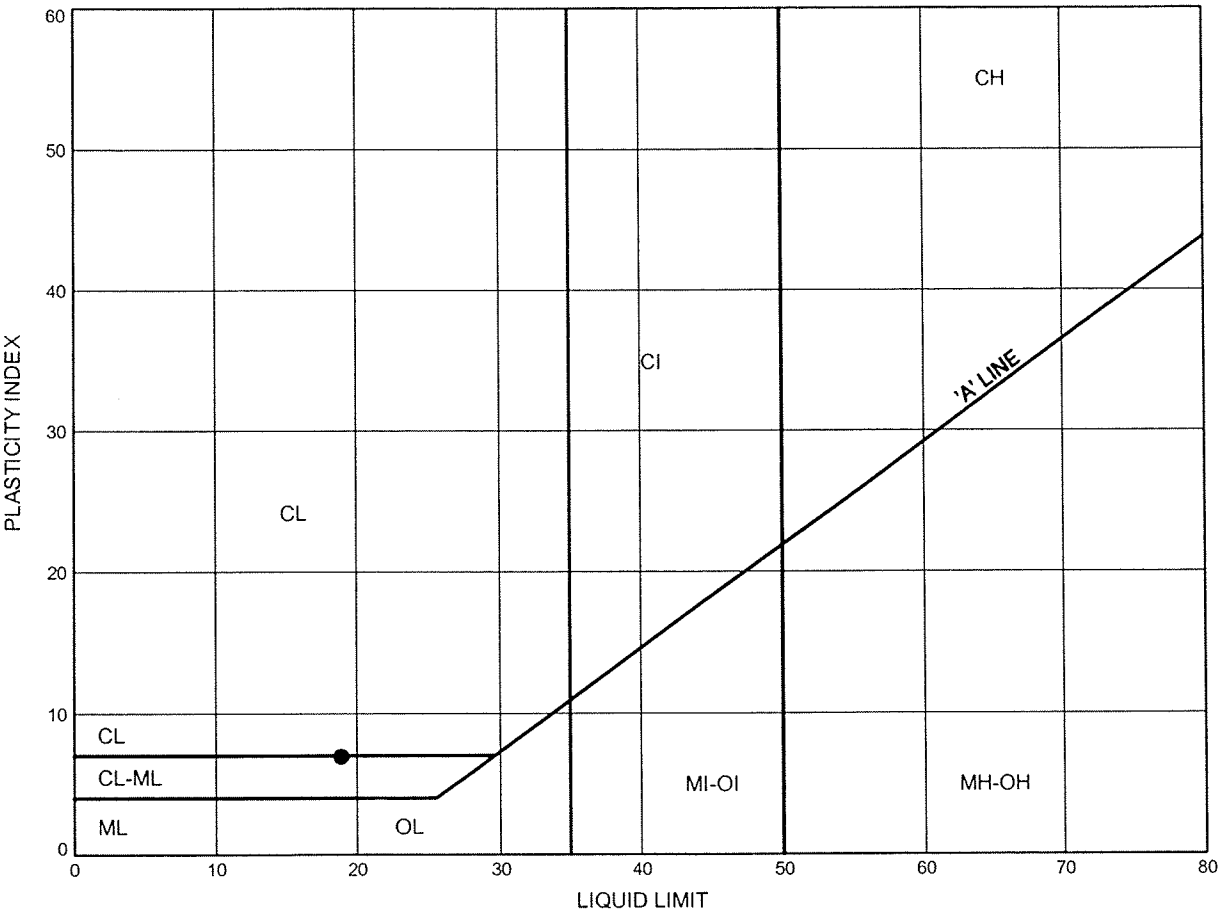
Prep'd MFA  
Chkd. SKP



Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM3-B5

CLAYEY SILT TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM03-2	4.88	147.23



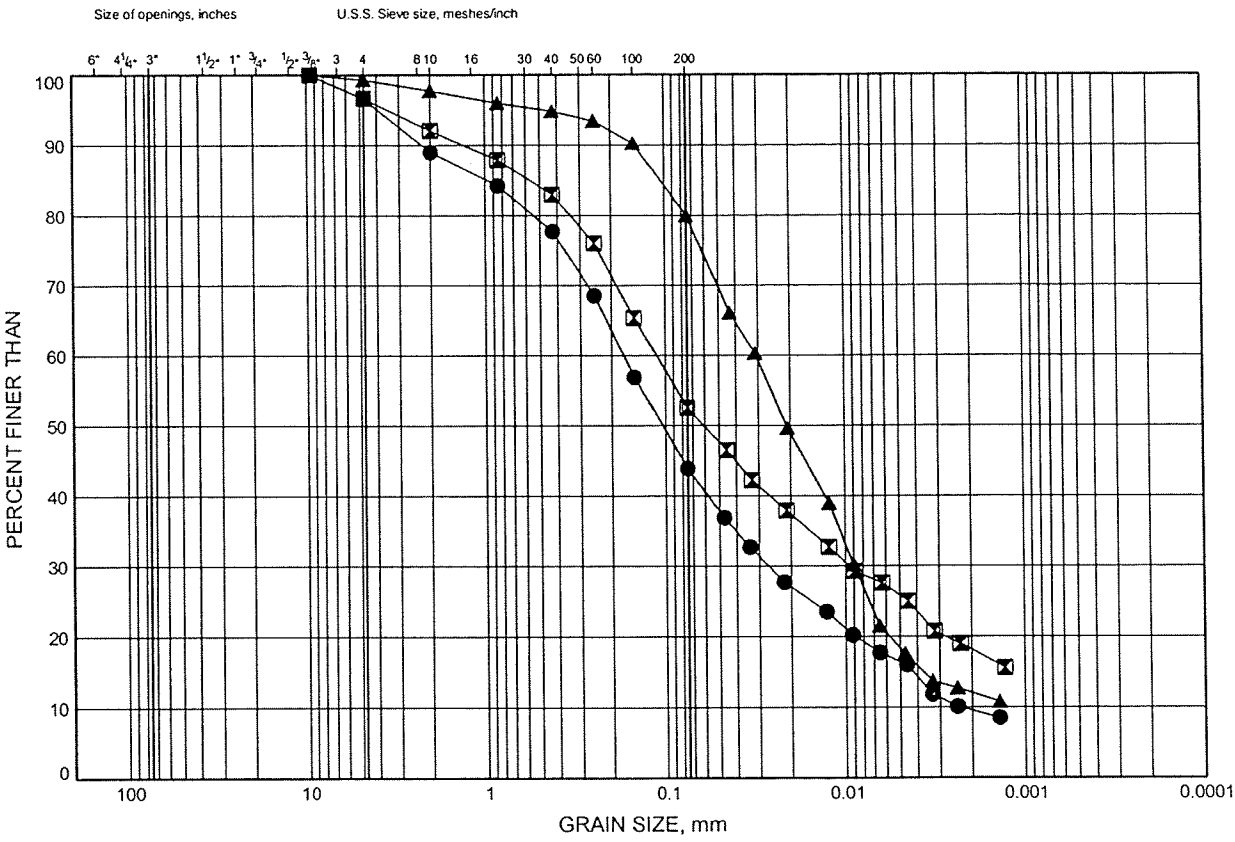
Date May 2008  
Project W.O. 07-20016

Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM3-B6

SAND AND SILT TO SANDY SILT TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM03-1	7.66	140.31
×	CM03b-1	15.29	137.18
▲	CM03b-2	7.80	140.99



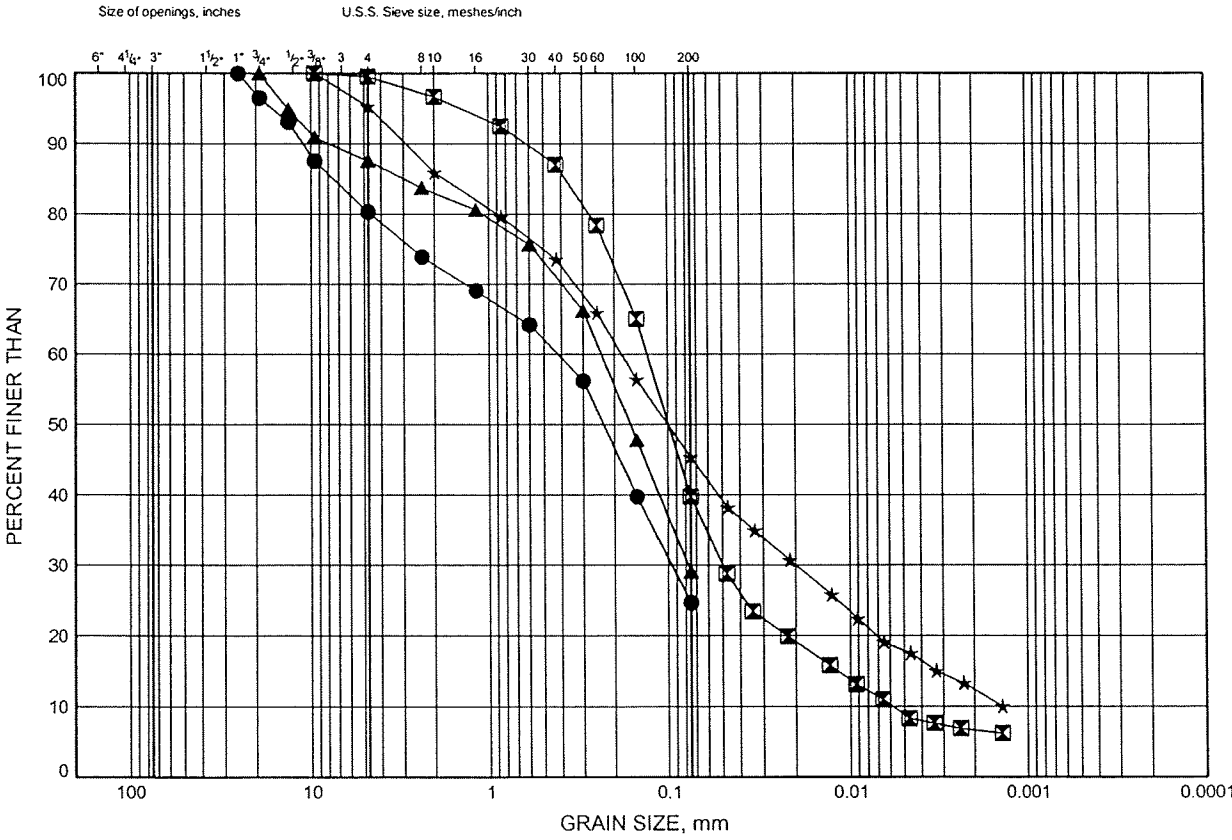
Date May 2008  
Project W.O. 07-20016

Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM3-B7

SILTY SAND TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM03-2	7.92	144.19
⊠	CM03-2	13.87	138.24
▲	CM03b-1	10.97	141.50
★	CM03b-2	4.64	144.15

Date May 2008  
Project W.O. 07-20016

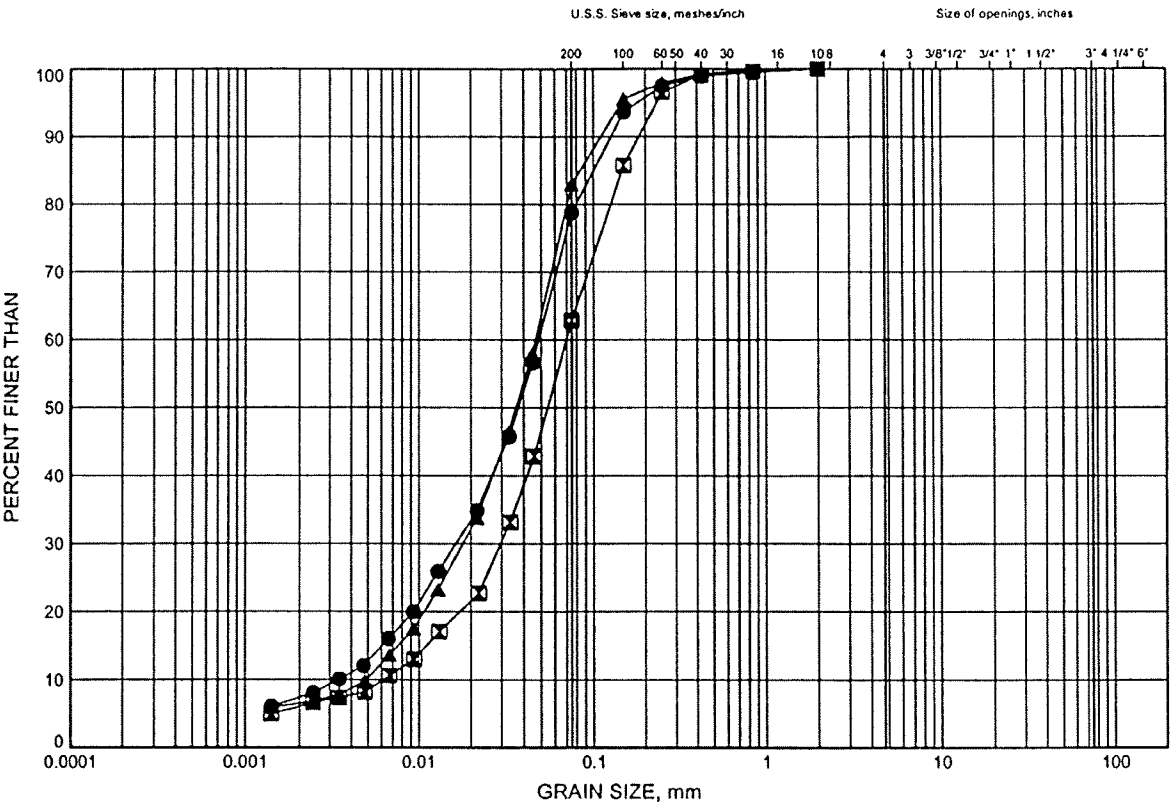


Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM04-B1

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM04-1	3.35	152.65
⊠	CM04-1	4.88	151.12
▲	CM04-2	4.88	150.12

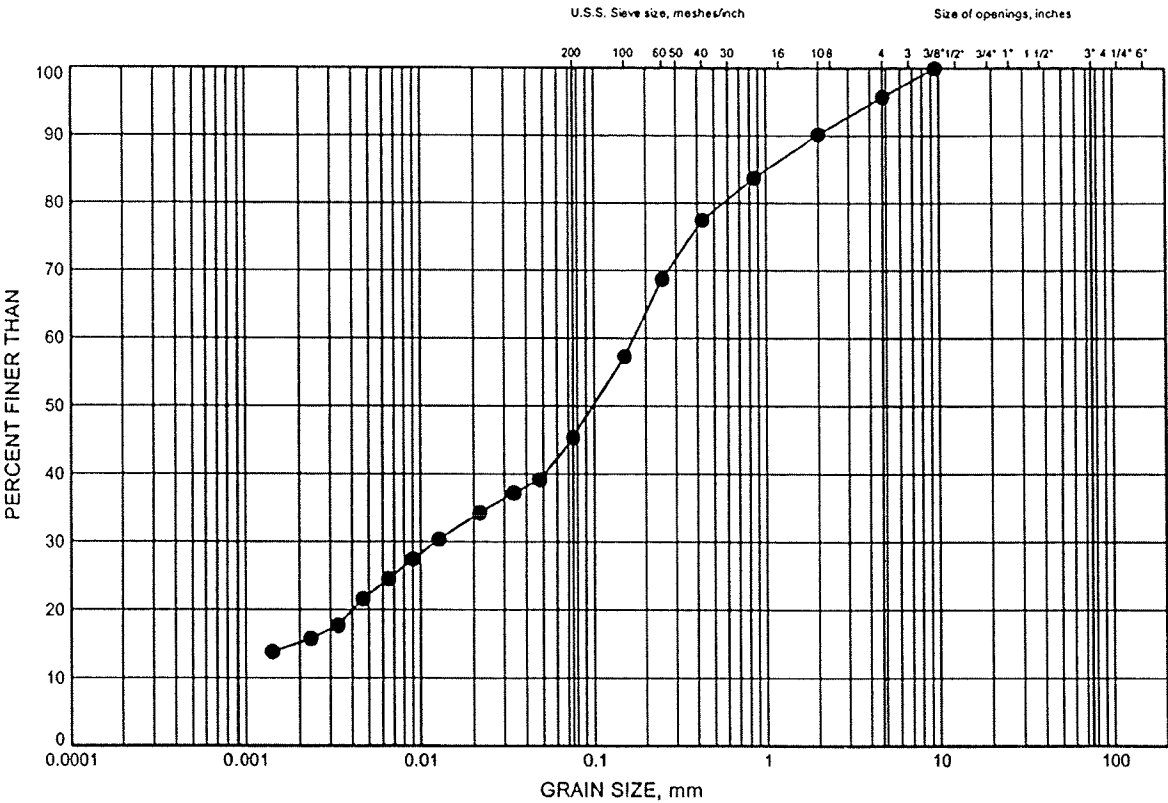


W.P.# .W.O..07-20016...  
Prepared By .AN.....  
Checked By .GFA.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM04-B2

SILTY SAND TILL



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

LEGEND

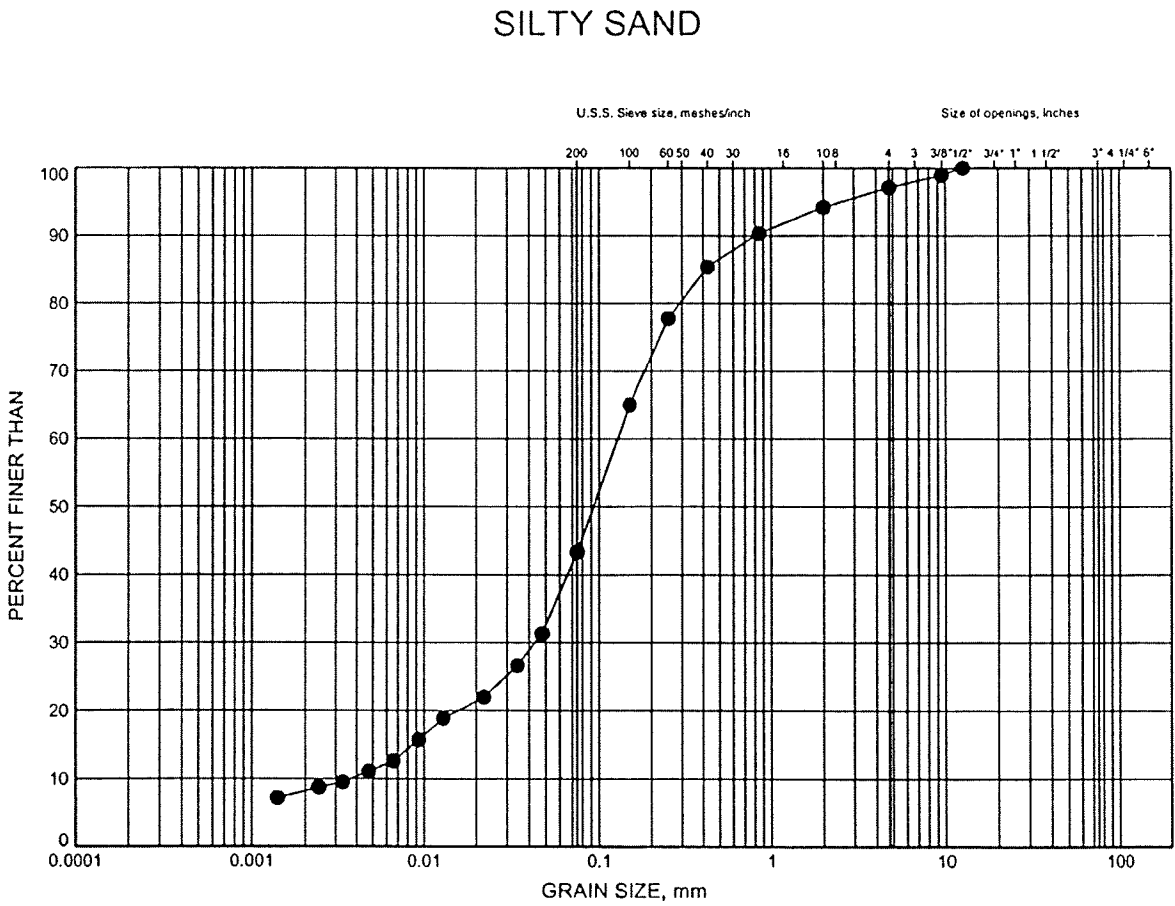
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM04-1	7.92	148.08



W.P.# .W.O..07-20016...  
Prepared By .AN.....  
Checked By .GFA.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM04-B3



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

LEGEND

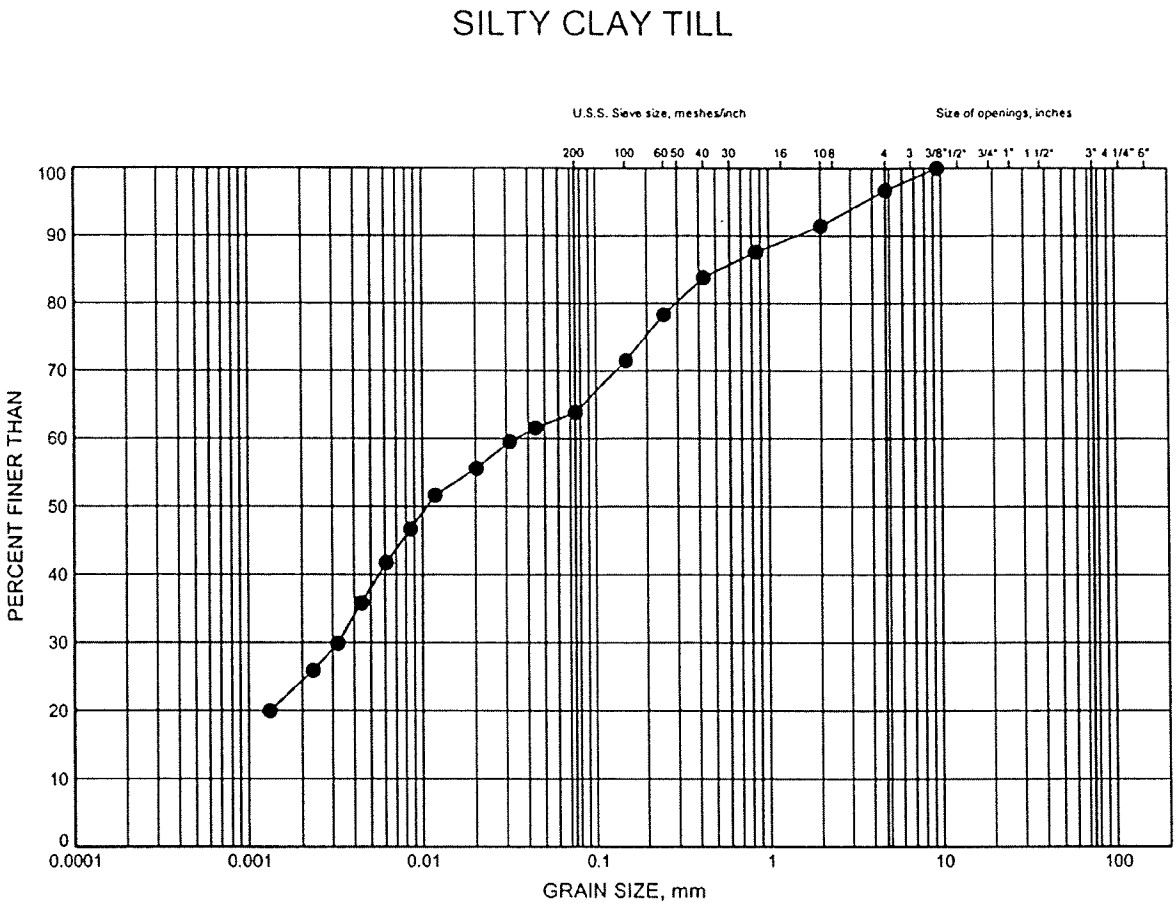
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM04-2	1.83	153.17



W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By GFA.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM04-B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM04-2	9.18	145.82

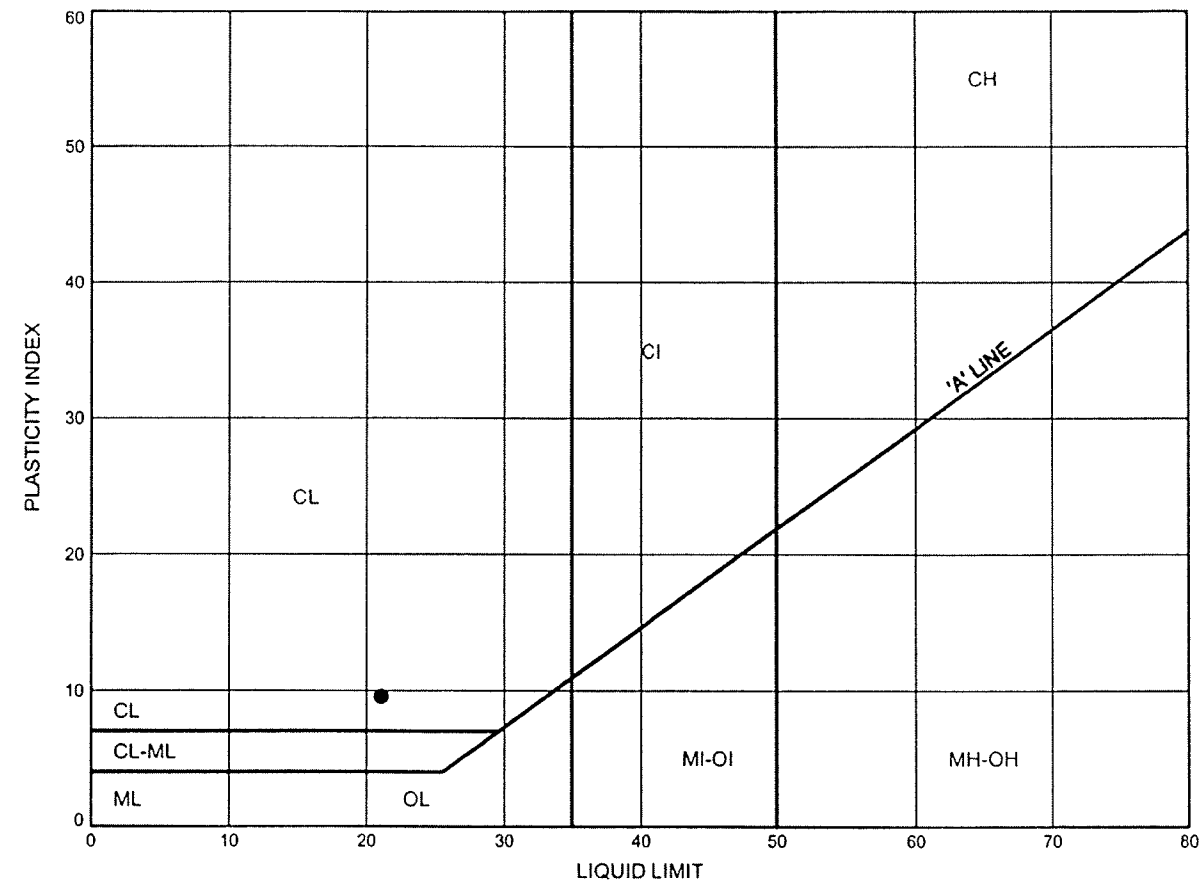


W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By GFA.....

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM04-B5

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM04-2	9.22	145.78

Date May 2009  
Project W.O. 07-20016



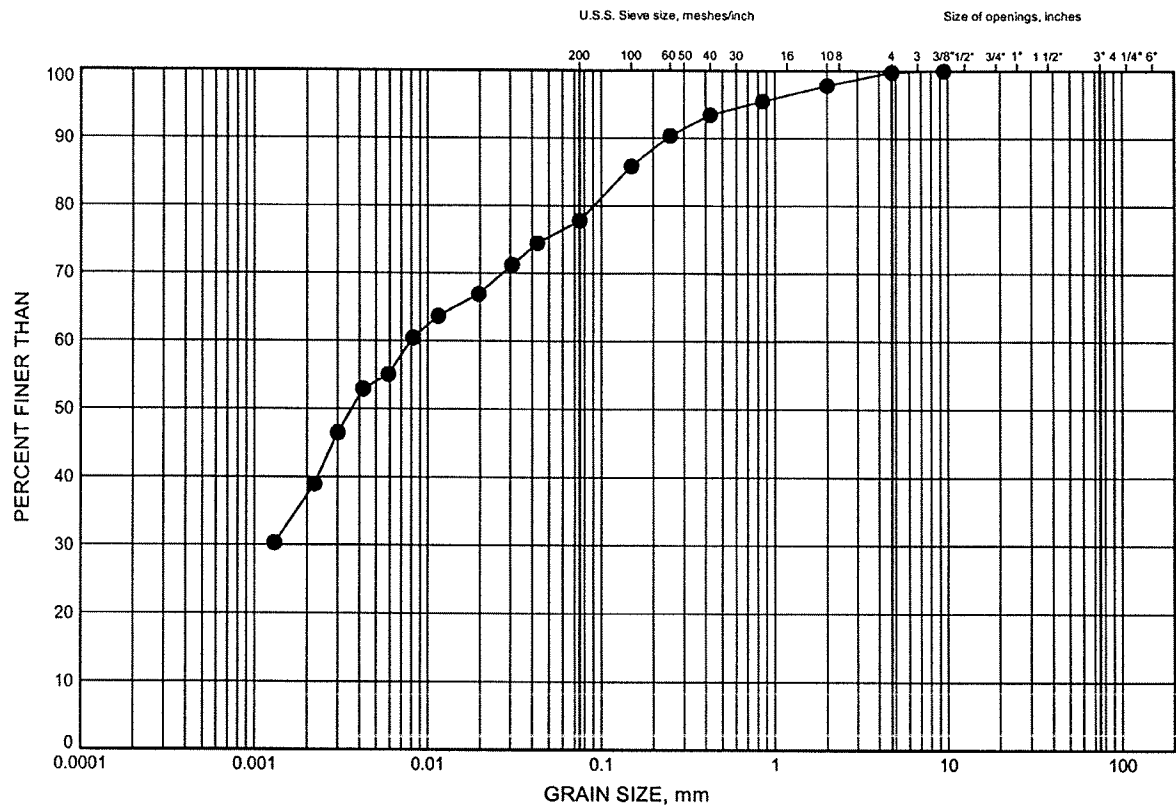
Prep'd AN  
Chkd. GFA



Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM5-B1

SILTY CLAY TILL



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

LEGEND			
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM5-1	1.83	159.31

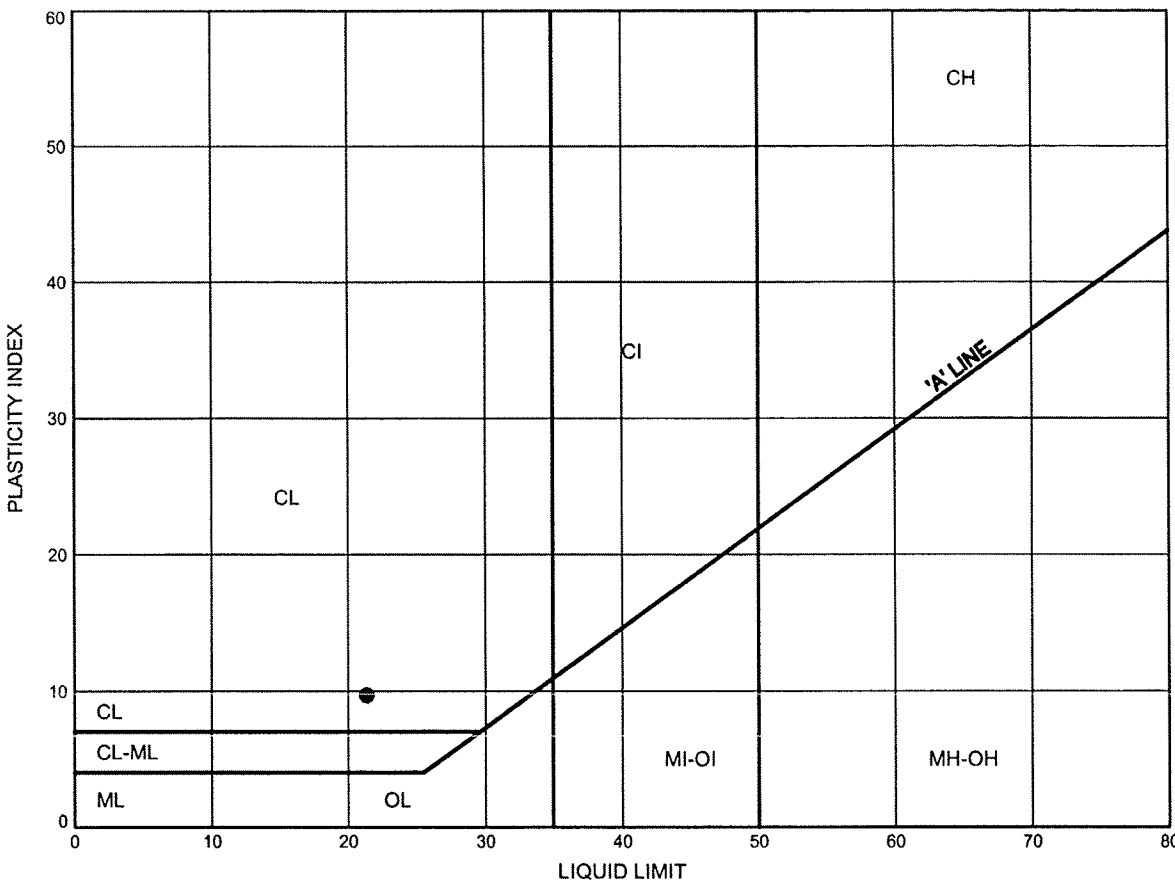


W.P.# W.O. 07-20016..  
Prepared By AN..  
Checked By LT..

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM5-B2

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM5-1	1.83	159.31



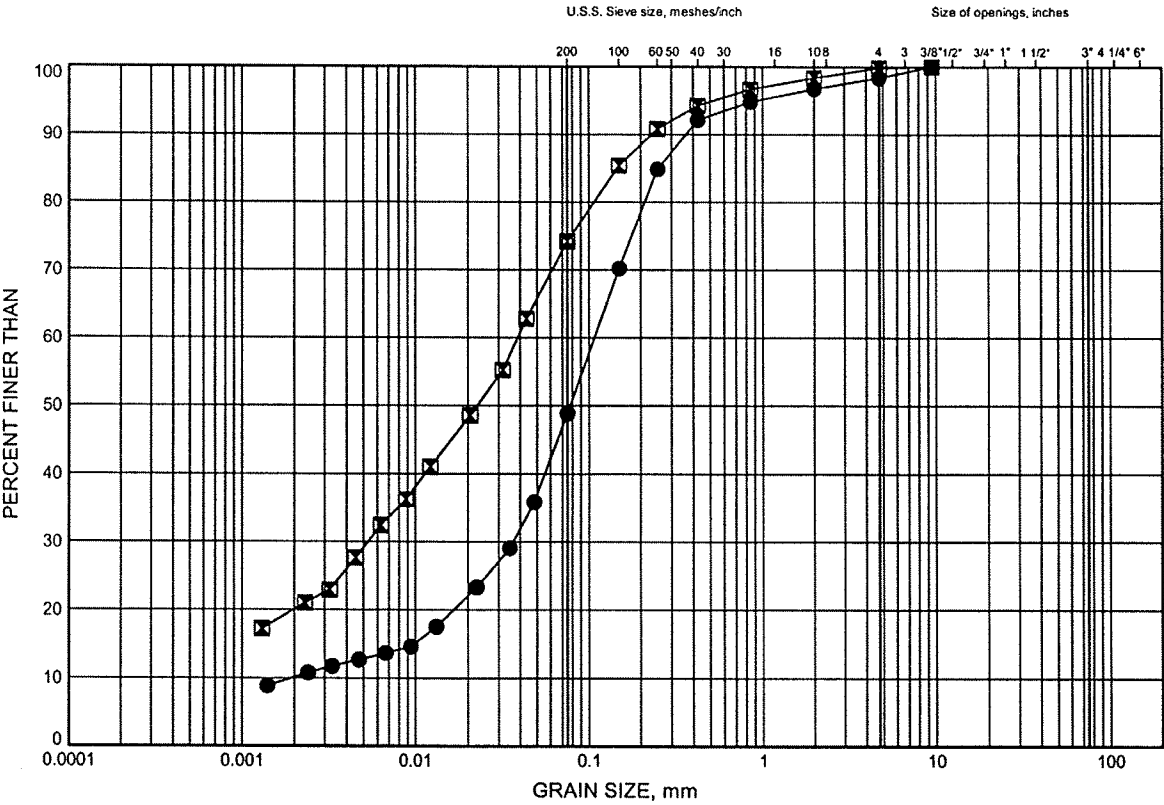
Date July 2009..  
Project W.O. 07-20016..

Prep'd AN..  
Chkd. LT..

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM5-B3

SAND and SILT & SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM05-1	3.24	157.90
■	CM05-2	3.20	155.60

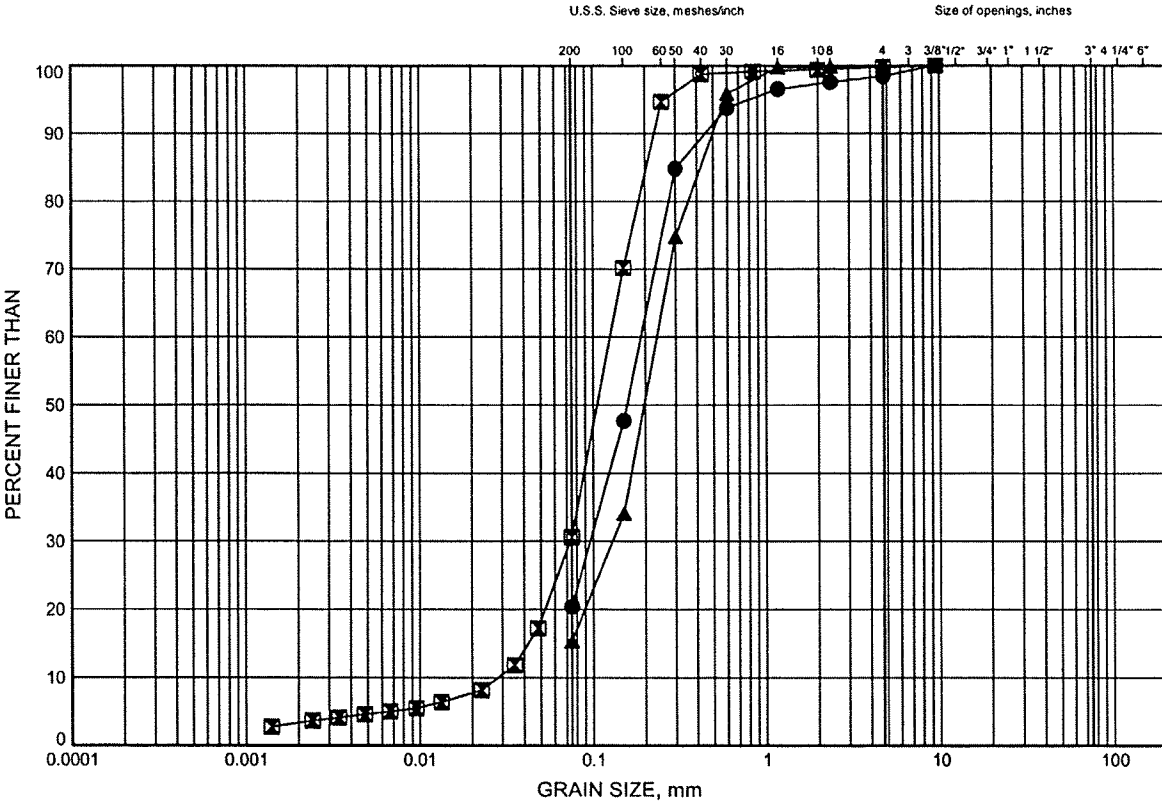


W.P.# .W.O. 07-20016...  
Prepared By .MFA.....  
Checked By .LT.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM5-B4

SAND & SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM05-1	10.97	150.16
■	CM05-2	7.92	150.87
▲	CM05-2	10.81	147.99

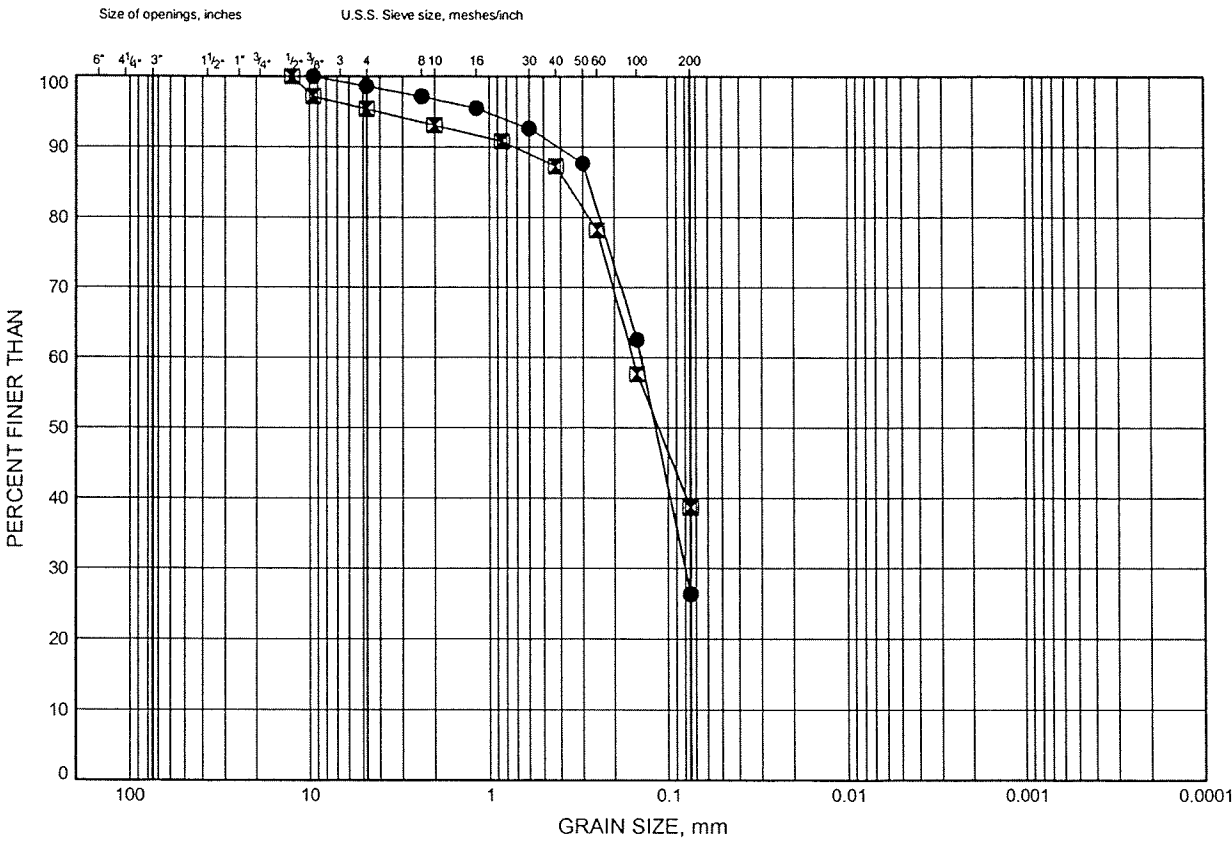


W.P.# .W.O. 07-20016...  
Prepared By .MFA.....  
Checked By .LT.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM6-B1

SILTY SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM6-2	1.83	165.14
⊠	CM6b-2	1.83	166.58



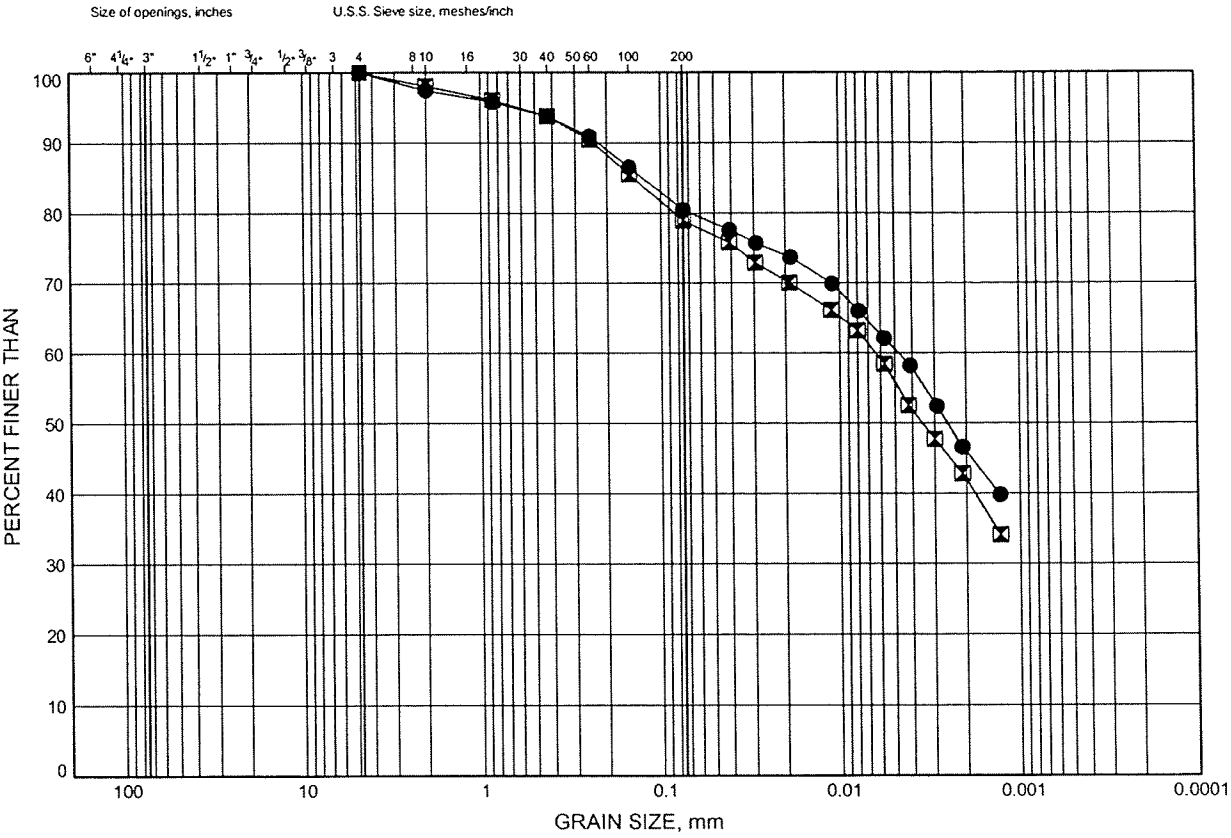
Date June 2008  
Project W.O. 07-20016

Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM6-B2

SILTY CLAY TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM6-1	2.59	163.14
⊠	CM6b-1	2.59	163.69



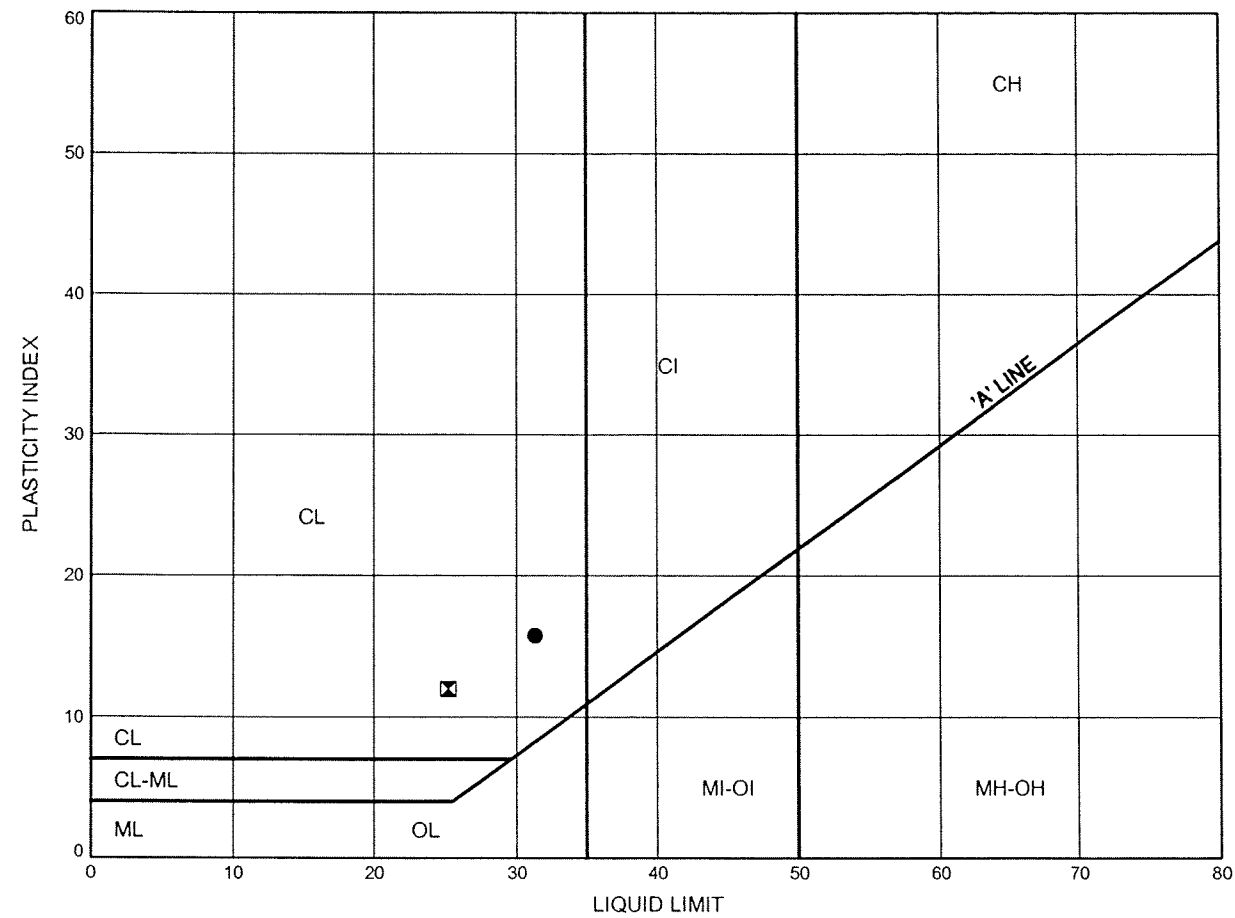
Date June 2008  
Project W.O. 07-20016

Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE CM6-B3

**SILTY CLAY TILL**



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM6-1	2.59	163.14
⊠	CM6b-1	2.59	163.69

Date June 2008  
 Project W.O. 07-20016



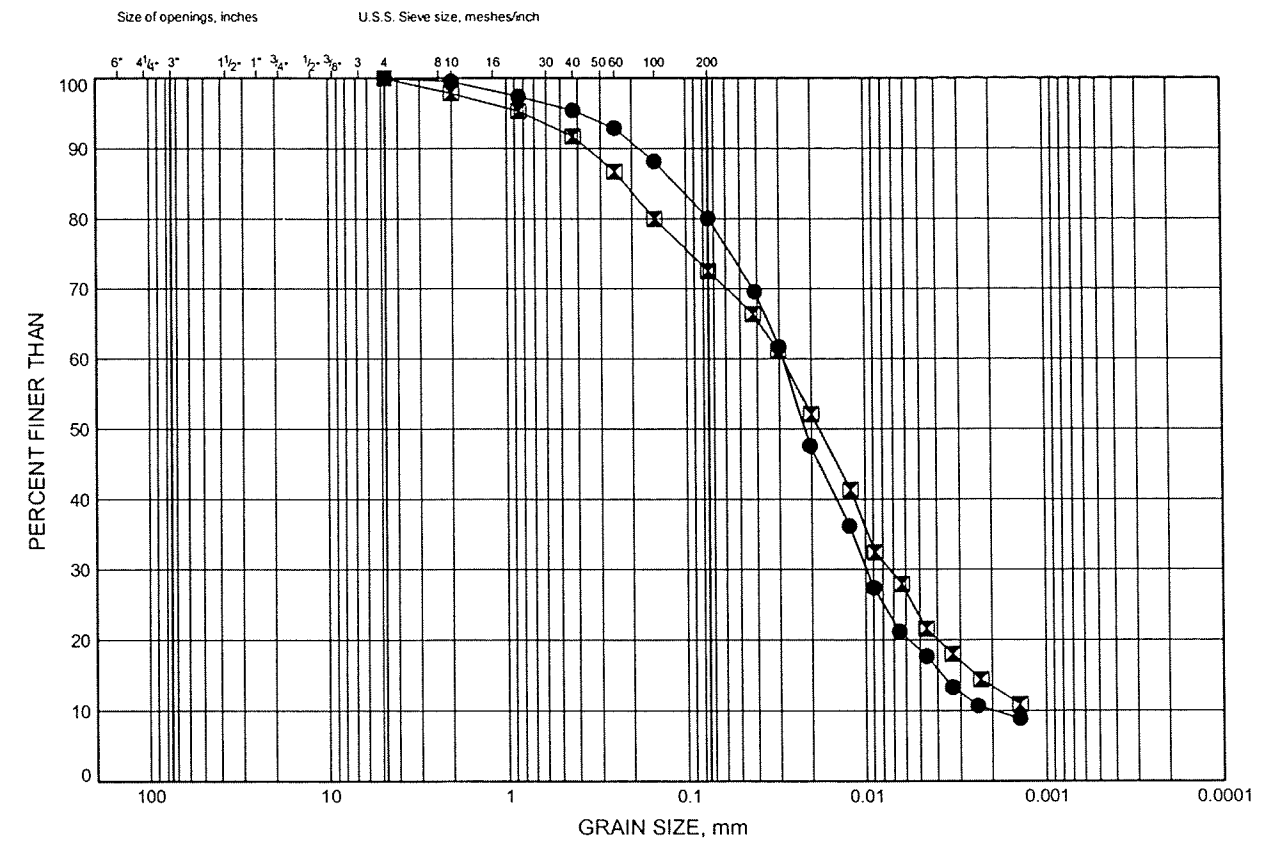
Prep'd MFA  
 Chkd. SKP

THURBALT 0510.GPJ 6/2/08

Hwy 407 East Extension - Central Section  
**GRAIN SIZE DISTRIBUTION**

FIGURE CM6-B4

**SANDY SILT TILL**



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM6-2	2.59	164.38
⊠	CM6b-2	6.16	162.25

Date June 2008  
 Project W.O. 07-20016



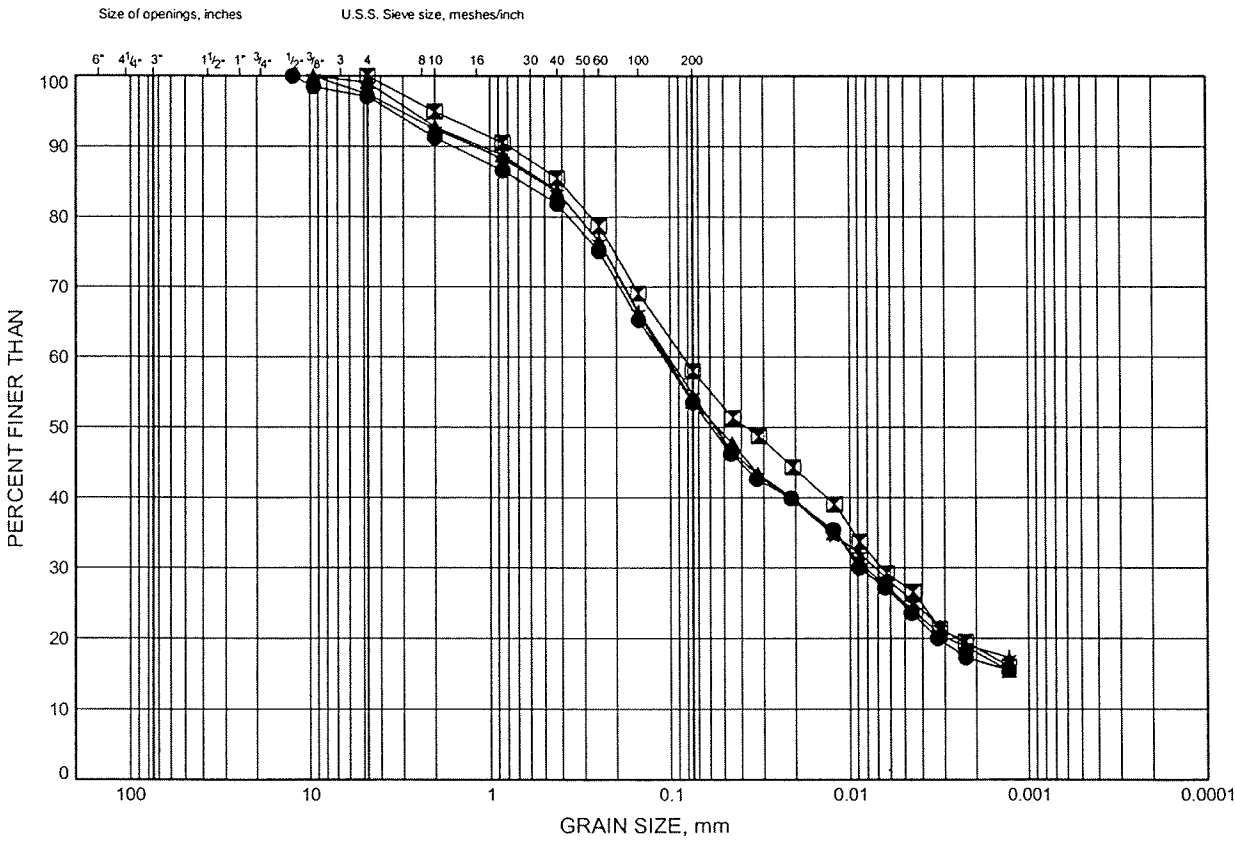
Prep'd MFA  
 Chkd. SKP

THURBGSD 0510.GPJ 6/2/08

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM6-B5

SAND AND SILT TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM6-1	7.67	158.07
⊠	CM6-2	7.67	159.30
▲	CM6b-1	6.32	159.96
★	CM6b-1	9.22	157.06

Date June 2008  
Project W.O. 07-20016

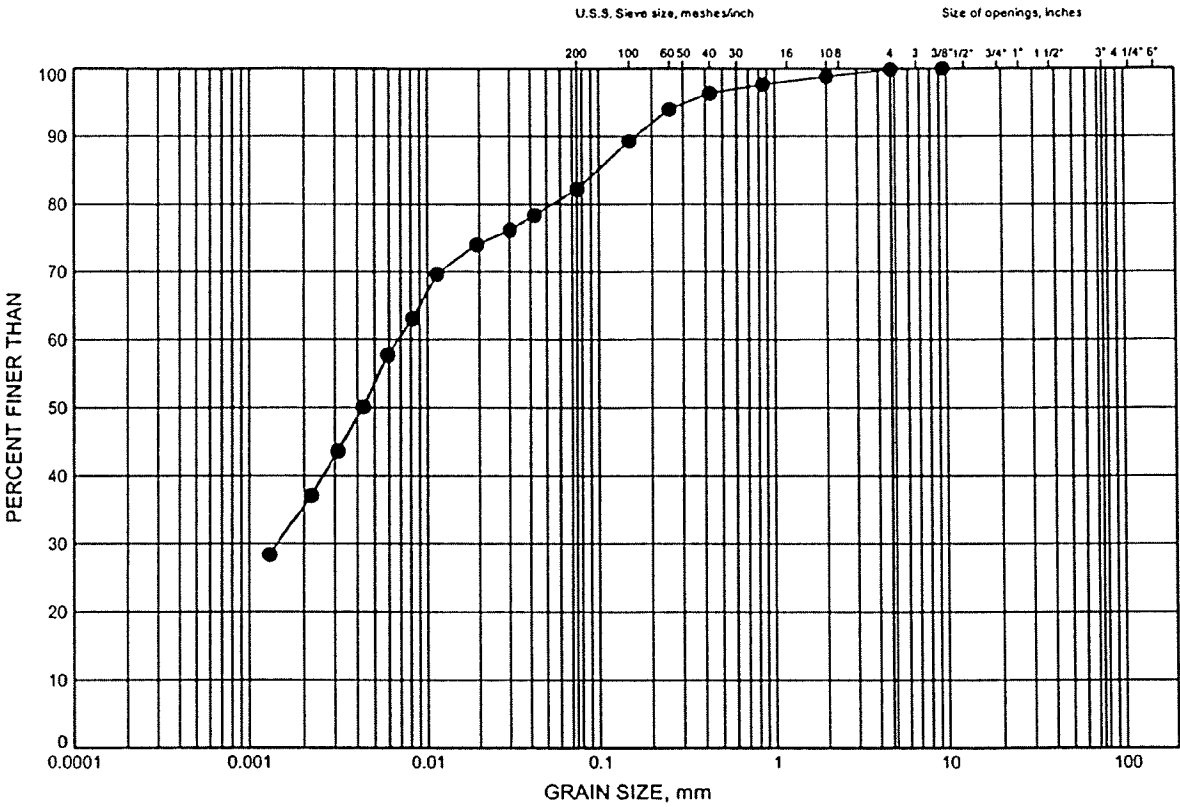


Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM07-B1

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM07-1	2.59	164.71

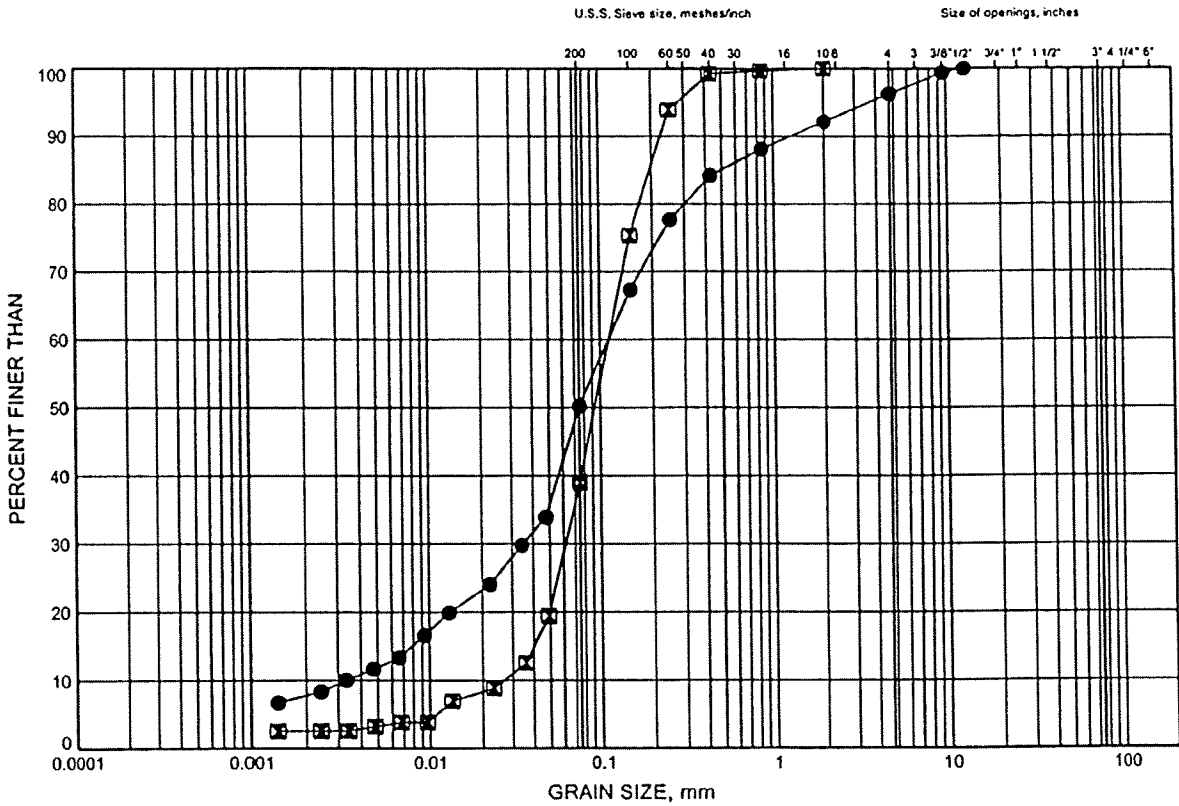


W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By GFA.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM07-B2

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM07-1	6.40	160.90
⊠	CM07-2	4.72	162.18

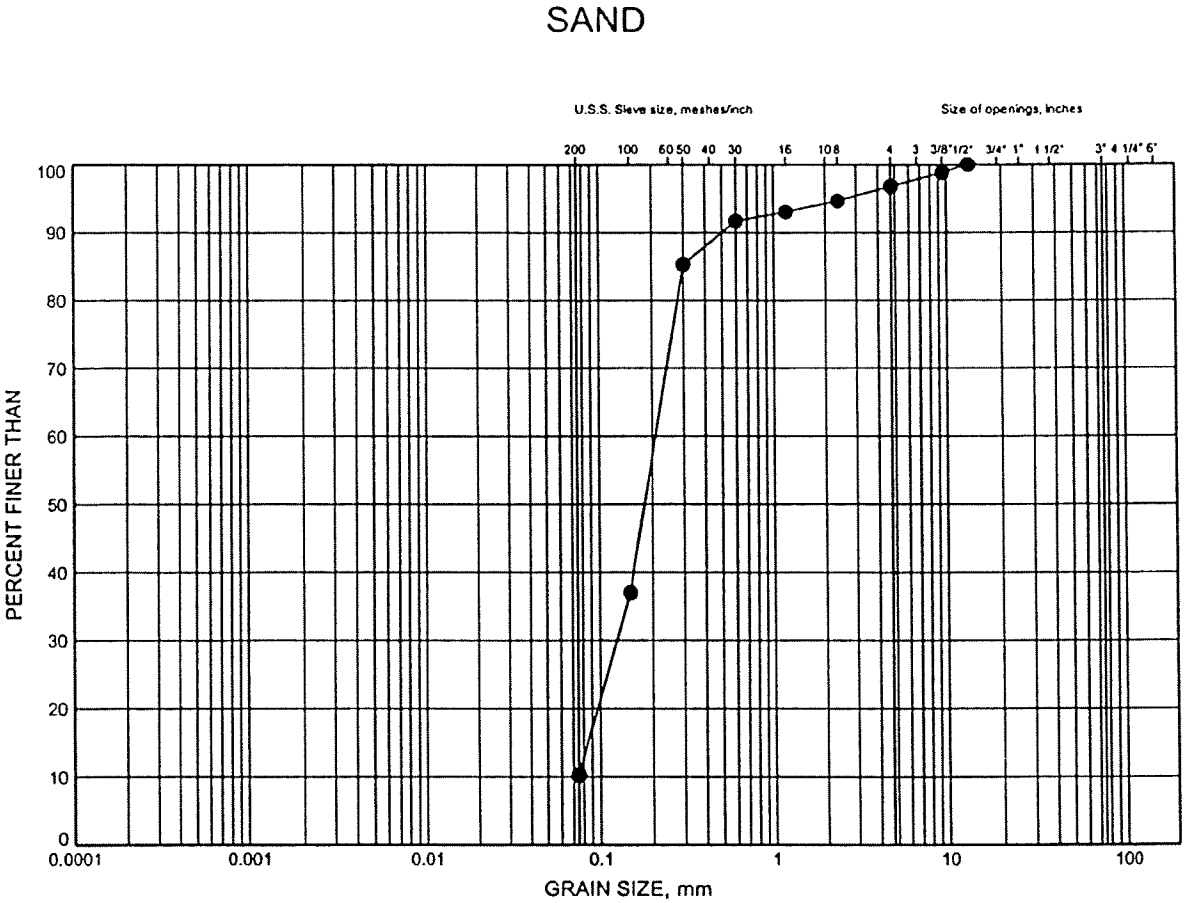


W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By GFA.....



Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM07-B3



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

LEGEND

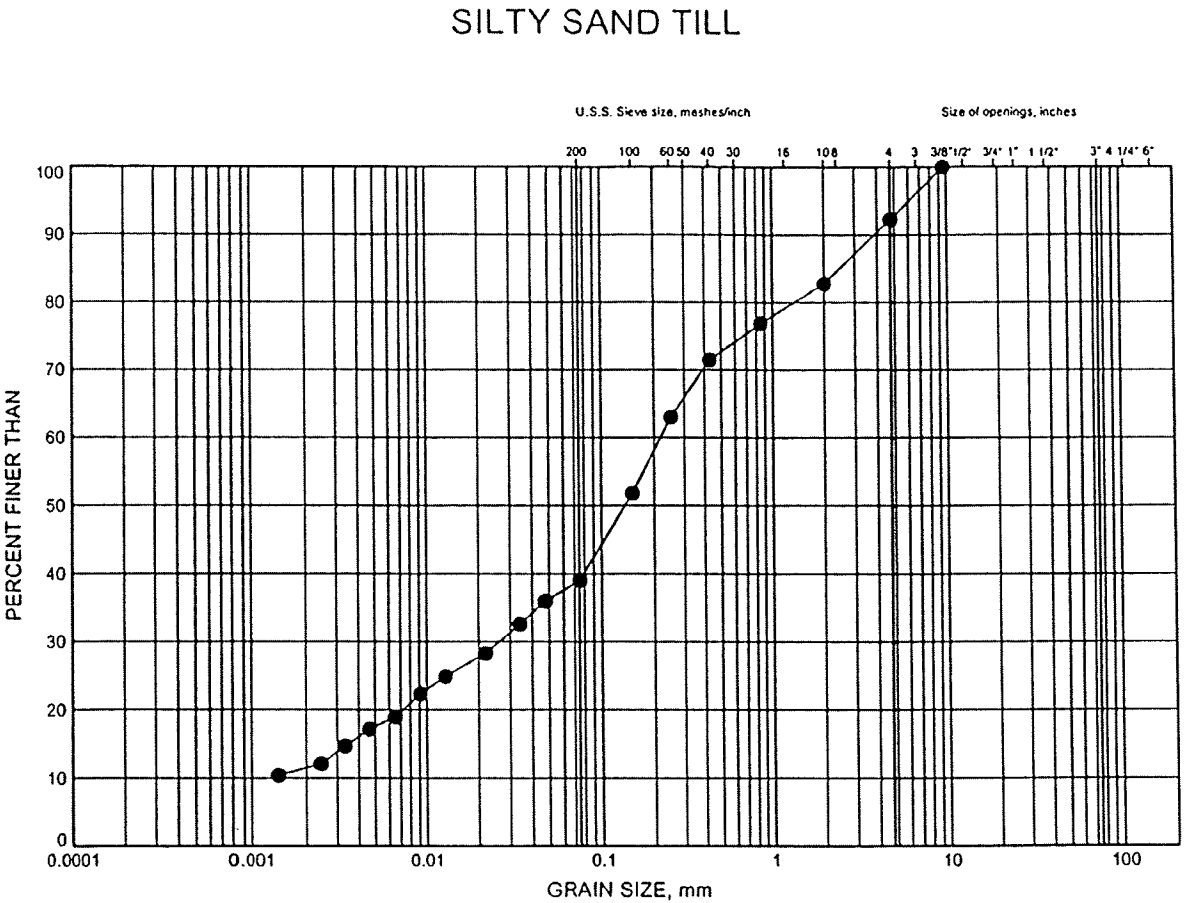
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM07-1	7.76	159.54



W.P.# W.O. 07-20016...  
Prepared By AN...  
Checked By GFA...

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM07-B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM07-2	2.39	164.51

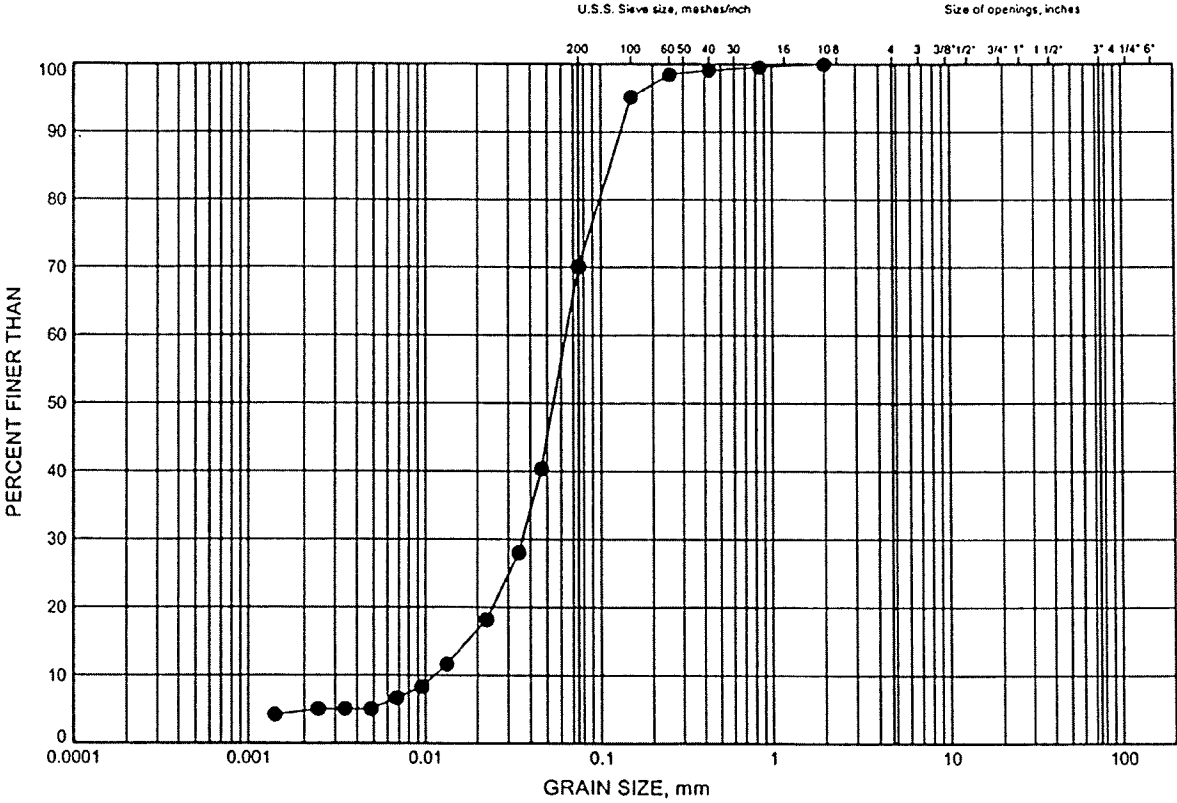


W.P.# W.O. 07-20016...  
Prepared By AN...  
Checked By GFA...

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM07-B5

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM07-2	6.25	160.65

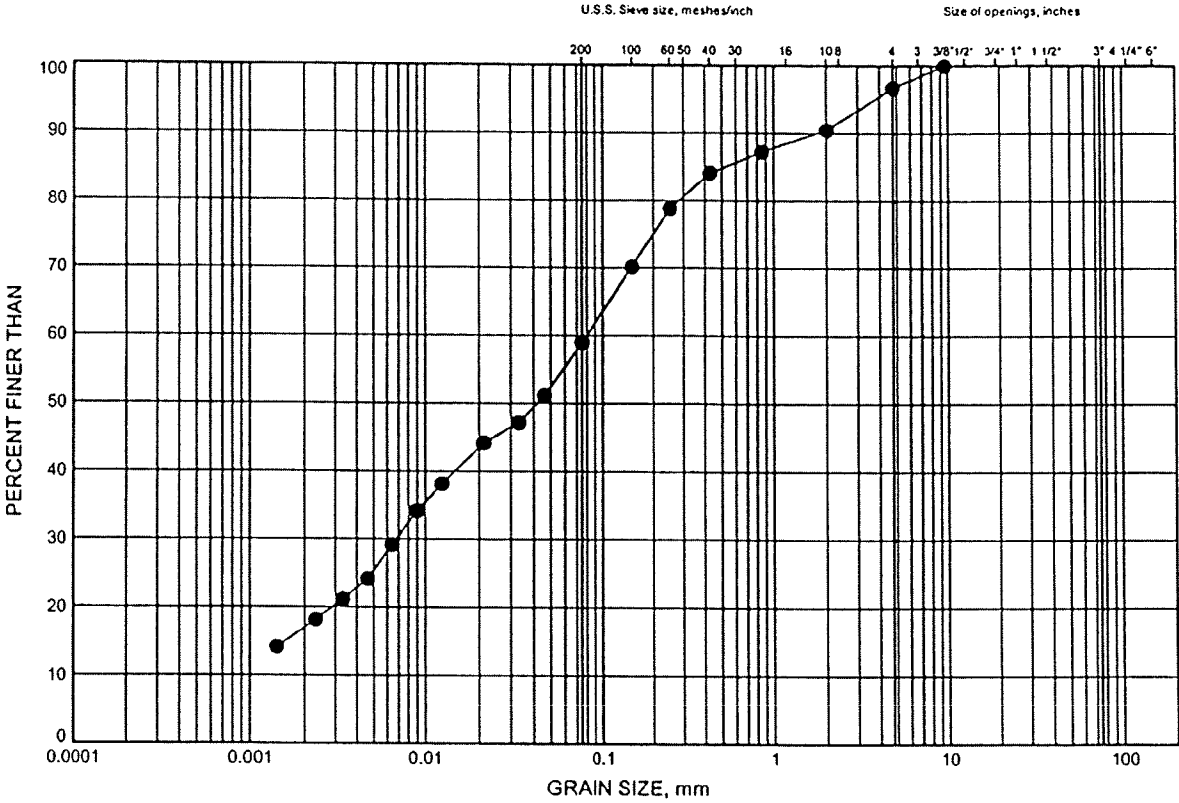


W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By GFA.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM07-B6

SILT & SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM07-2	7.67	159.23



W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By GFA.....

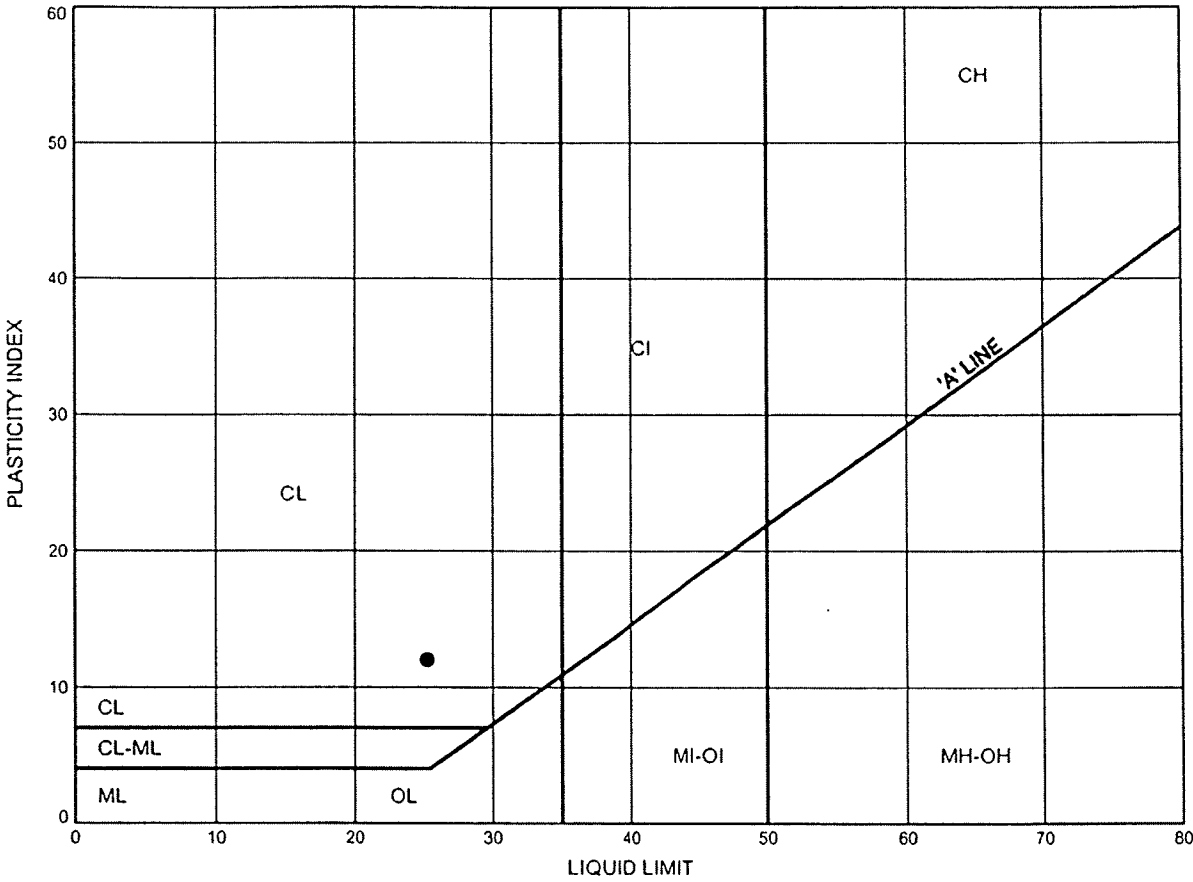
GRAIN SIZE DISTRIBUTION - THURBER 0510.GPJ 5/15/09

GRAIN SIZE DISTRIBUTION - THURBER 0510.GPJ 5/15/09

Hwy 407 East Extension - Central Section  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE CM07-B7

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM07-1	2.59	164.71

Date May 2009  
Project W.O. 07-20016

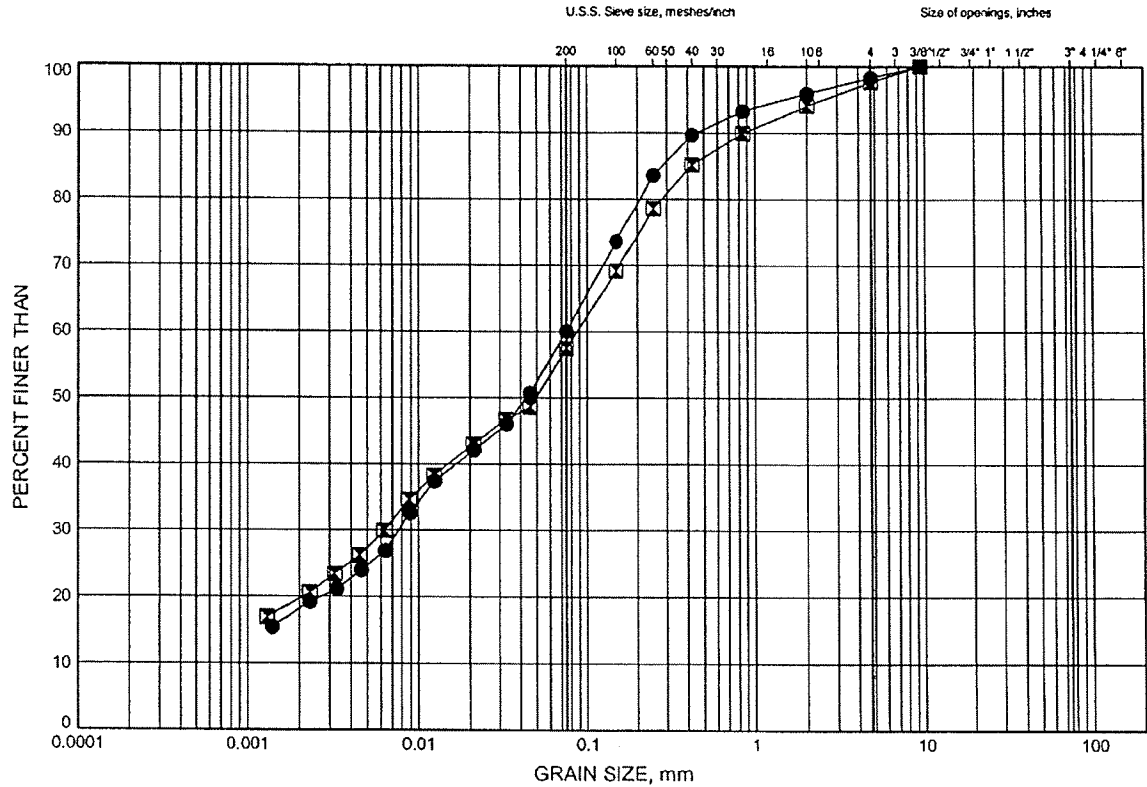


Prep'd AN  
Chkd. GFA

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM9-B1

CLAYEY SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM9-1	2.59	169.10
□	CM9-2	3.35	167.98

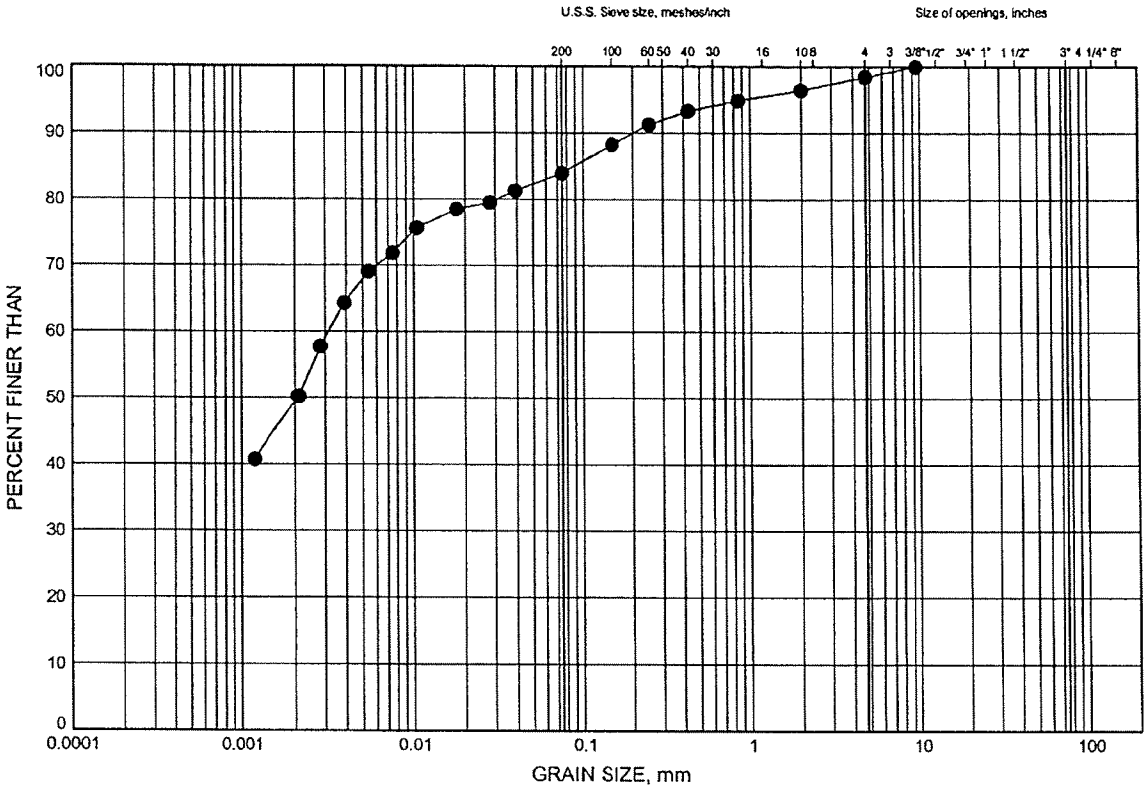


W.P.# W.O. 07-20016...  
Prepared By AW  
Checked By SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM9-B2

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM9-1	4.88	166.81

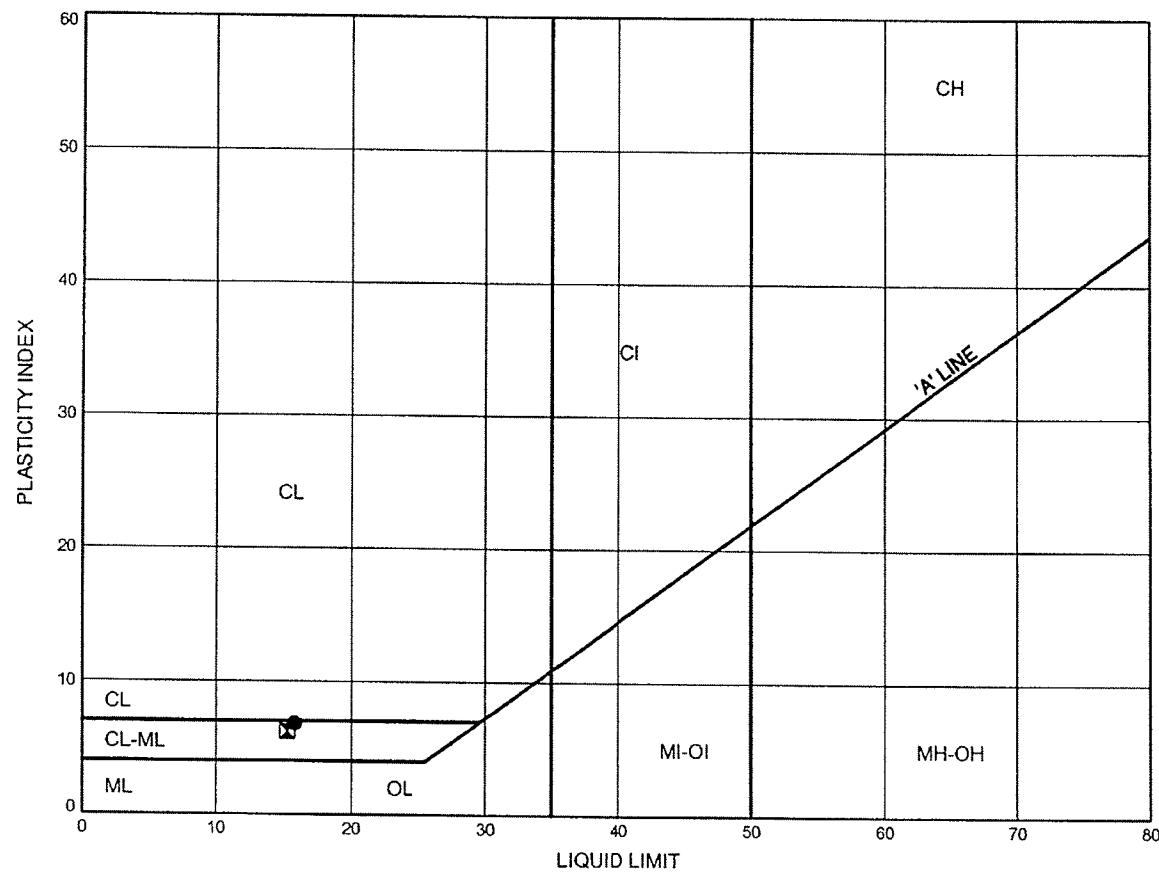


W.P.# W.O. 07-20016...  
Prepared By AW  
Checked By SKP

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM9-B3

CLAYEY SILT TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM9-1	2.59	169.10
⊠	CM9-2	3.35	167.98

Date September 2008  
Project W.O. 07-20016

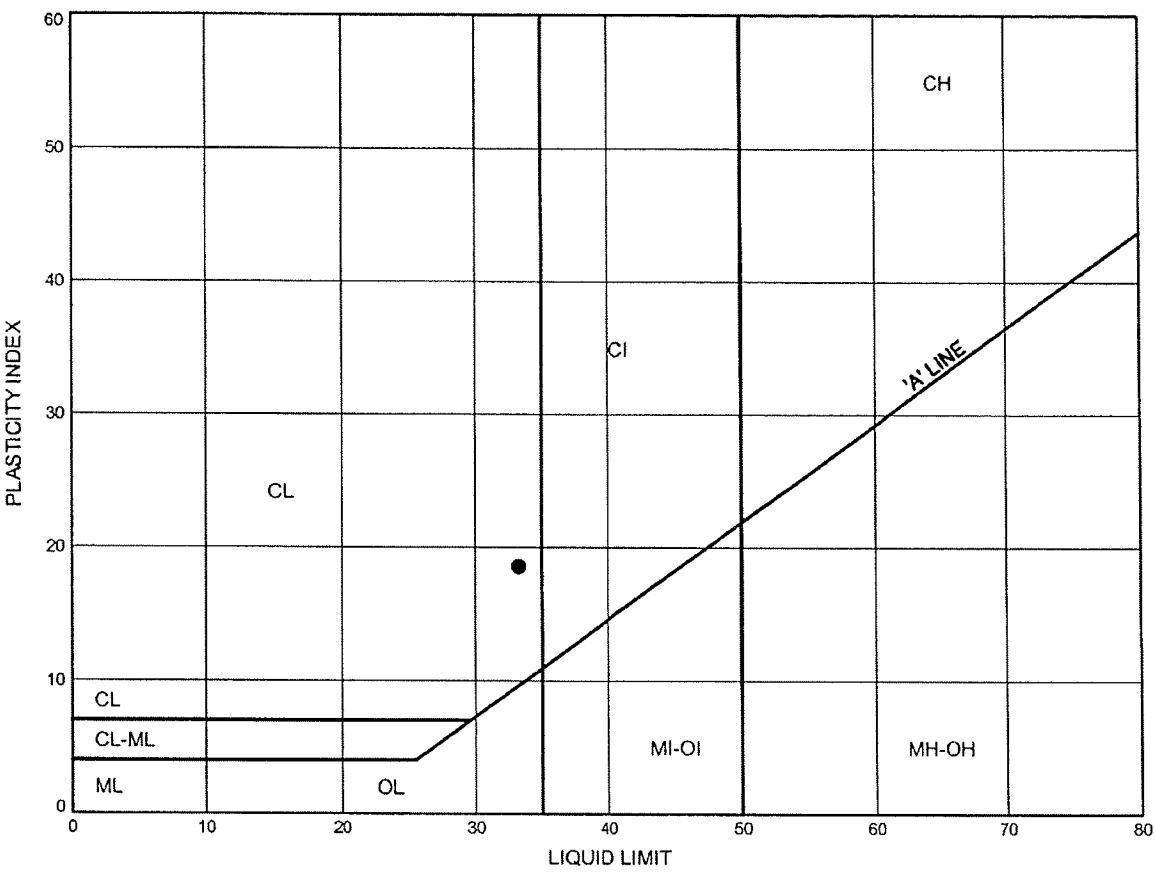


Prep'd AW  
Chkd. SKP

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM9-B4

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM9-1	4.88	166.81

Date September 2008  
Project W.O. 07-20016

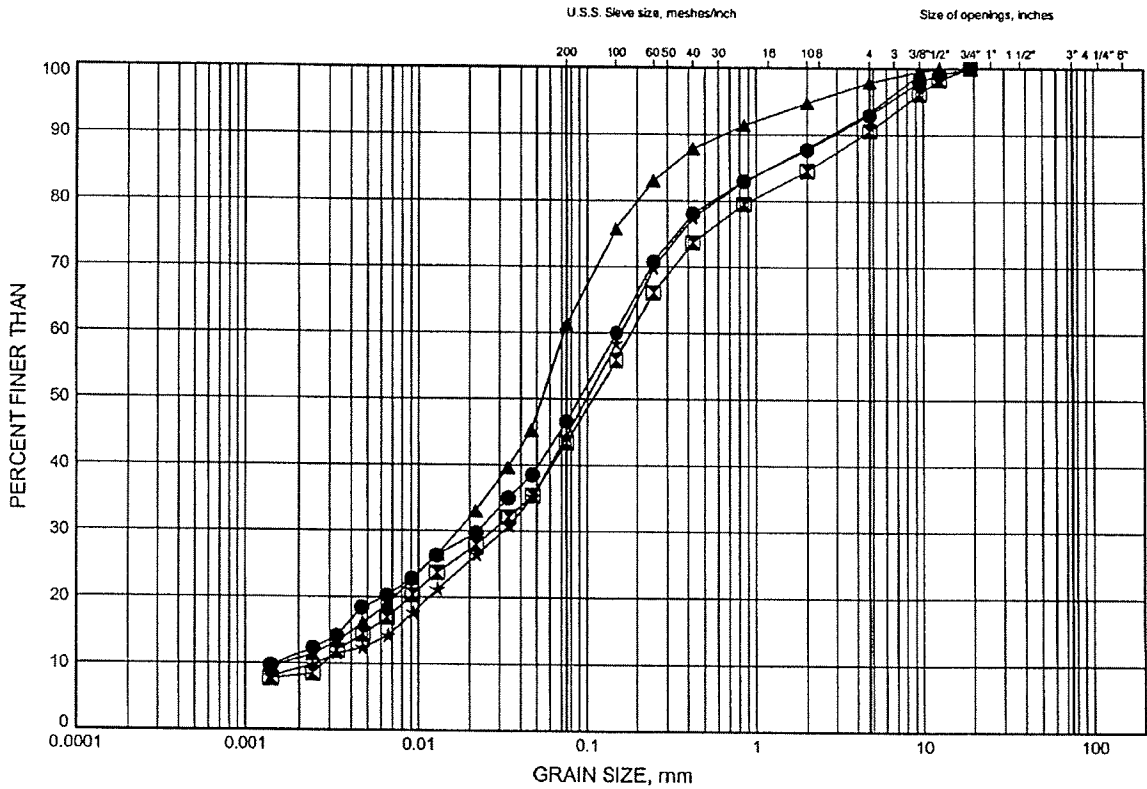


Prep'd AW  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM9-B5

SAND AND SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM9-1	7.92	163.76
⊠	CM9-1	14.02	157.67
▲	CM9-2	7.85	163.49
★	CM9-2a	12.50	158.84

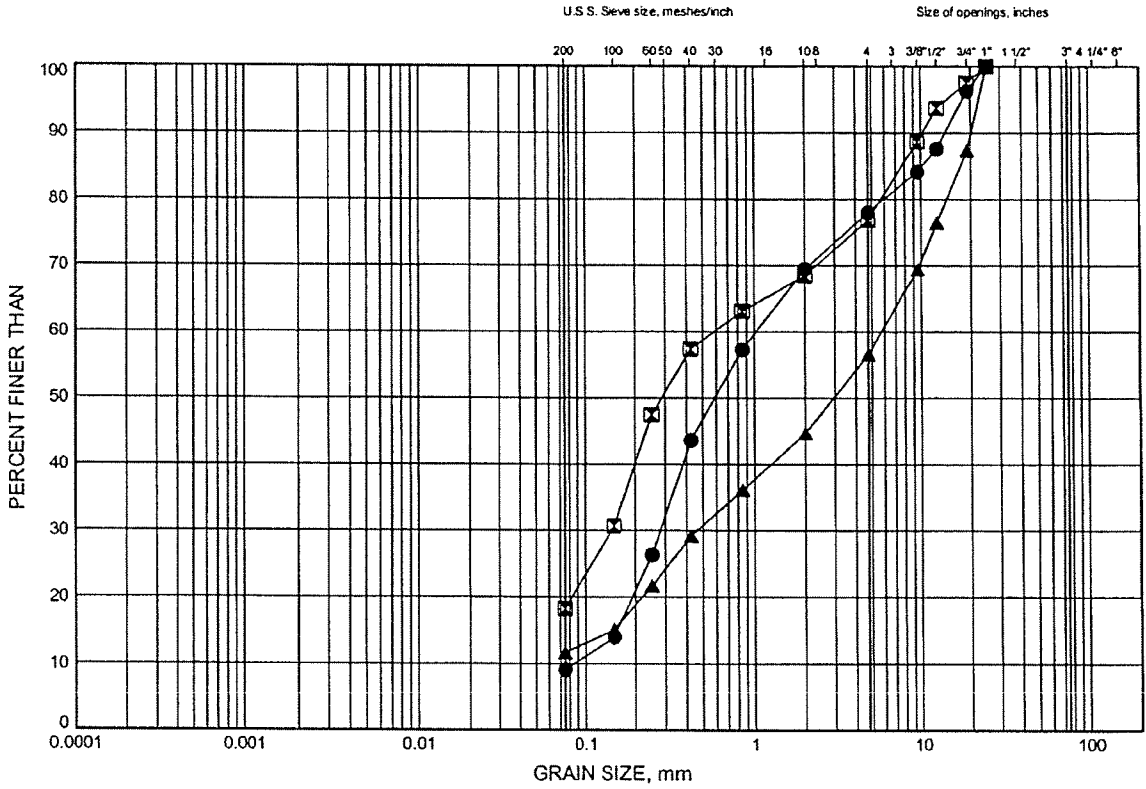


W.P.# W.O. 07-20016...  
Prepared By AW  
Checked By SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM9-B6

GRAVELLY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM9-1a	18.49	153.20
⊠	CM9-2	9.22	162.11
▲	CM9-2a	15.43	155.90



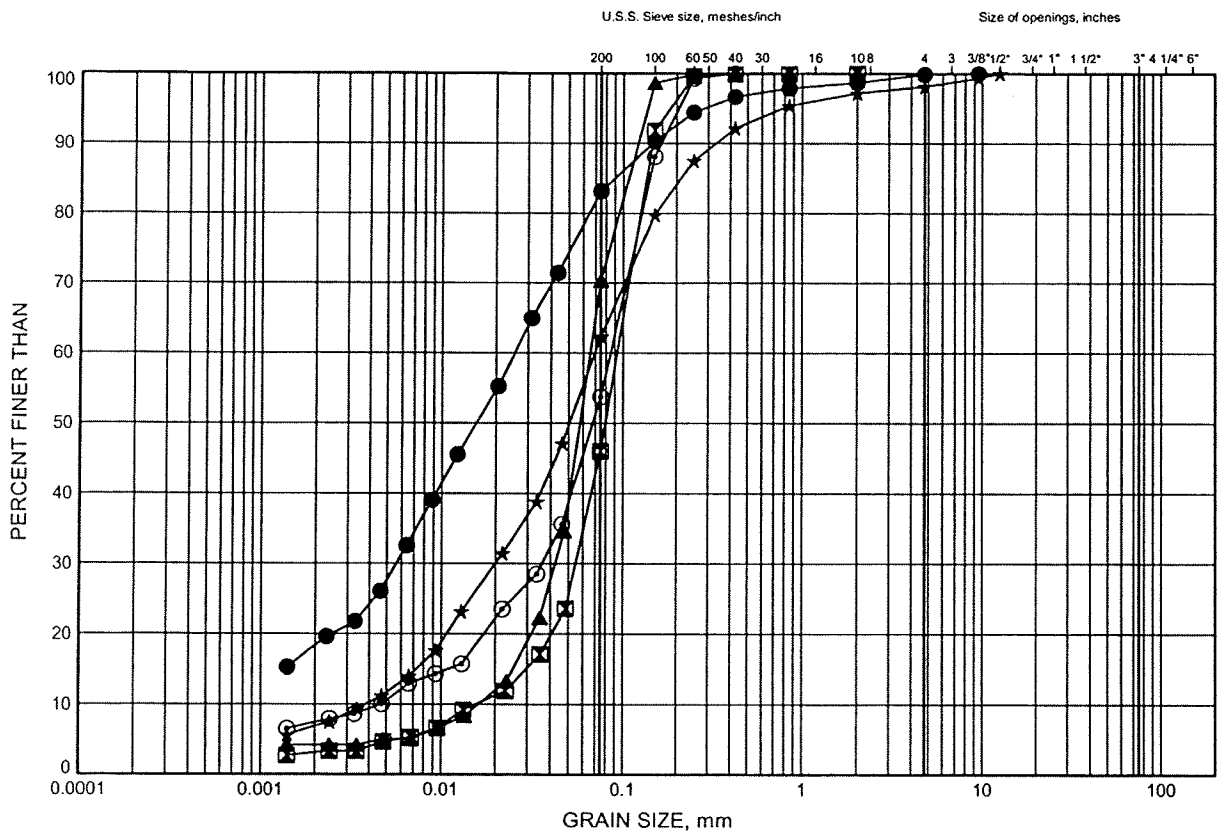
W.P.# W.O. 07-20016...  
Prepared By AW  
Checked By



Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B1

SILT / SILT AND SAND / SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10-1	4.88	157.02
⊠	CM10-1	6.40	155.50
▲	CM10-1	7.92	153.98
★	CM10b-1	3.35	157.85
⊙	CM10b-2	2.59	153.38

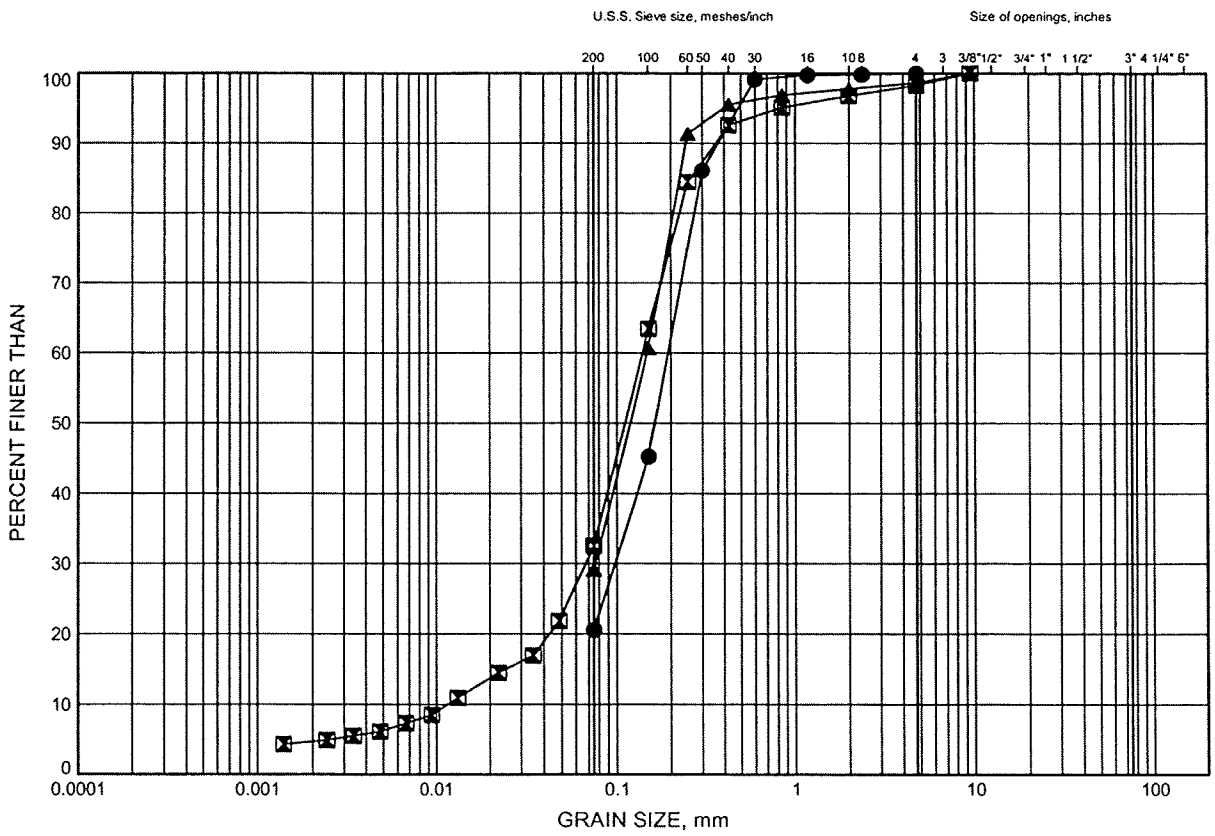


W.P.# W.O. 07-20016...  
Prepared By MFA  
Checked By SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B2

SILTY SAND



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

LEGEND

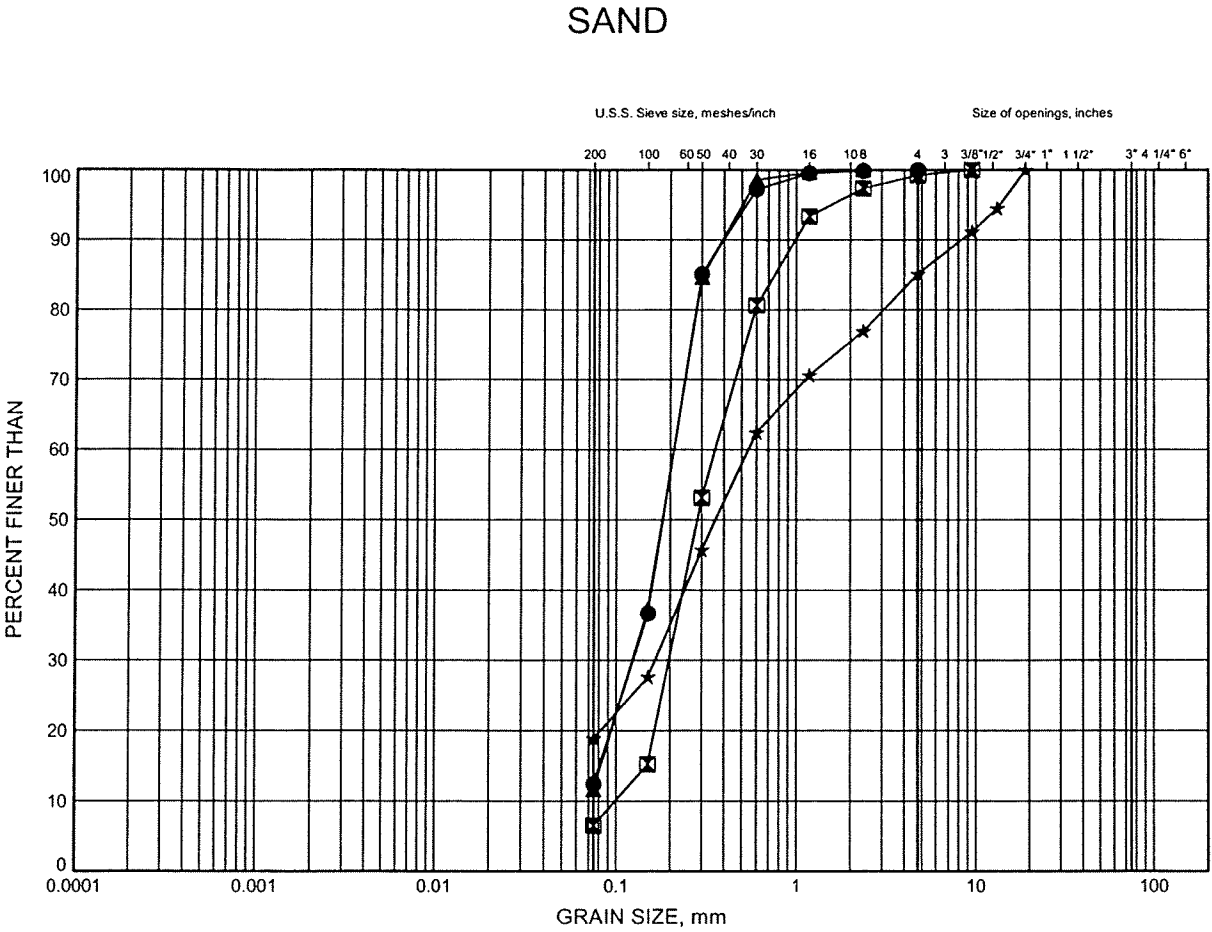
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10b-1	6.40	154.80
⊠	CM10b-1	10.97	150.23
▲	CM10b-2	4.88	151.09



W.P.# W.O. 07-20016...  
Prepared By MFA  
Checked By SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B3



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

LEGEND

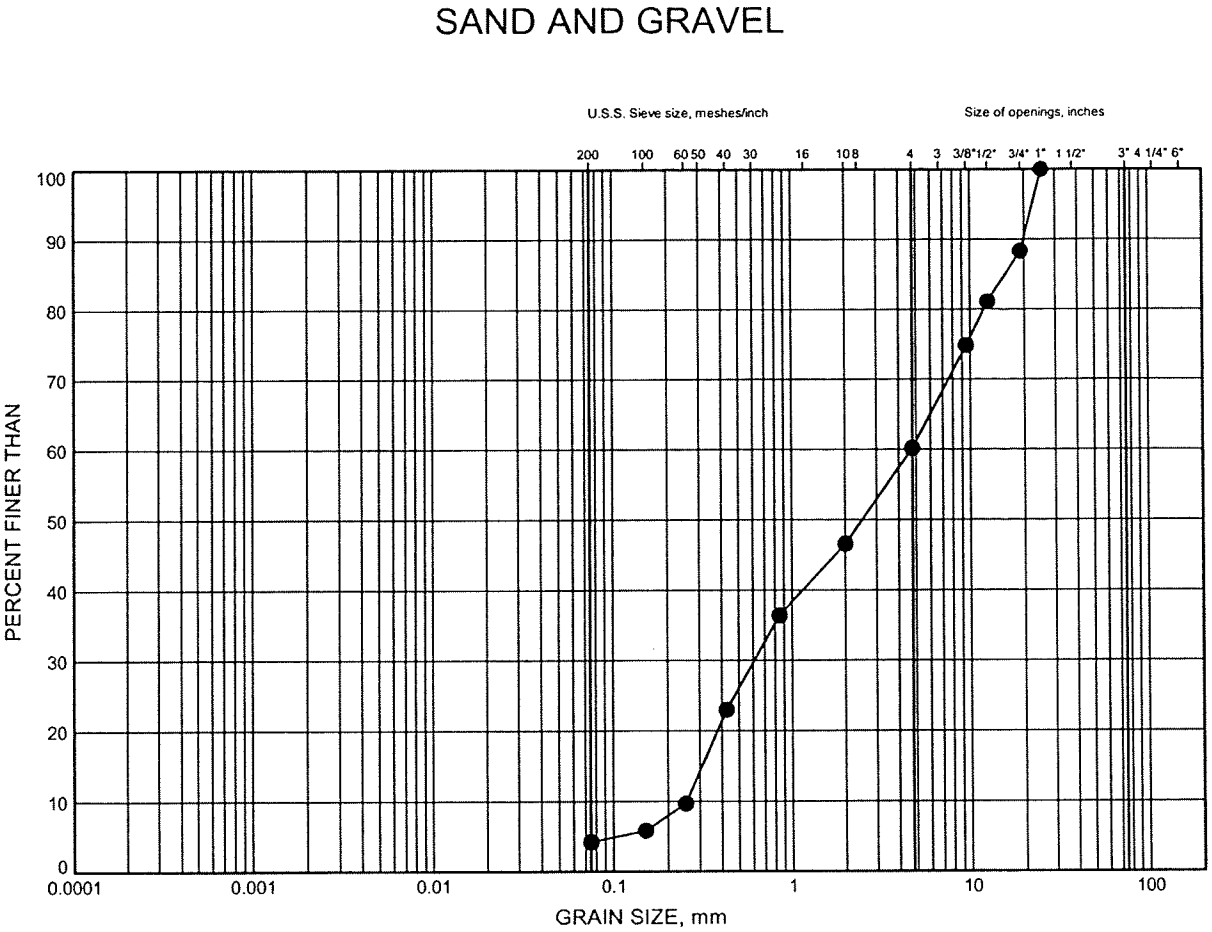
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10-1	9.45	152.45
⊠	CM10-1	15.54	146.36
▲	CM10-2	6.40	147.92
★	CM10b-1	21.49	139.71



W.P.# W.O. 07-20016...  
Prepared By MFA.....  
Checked By SKP.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B4



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

LEGEND

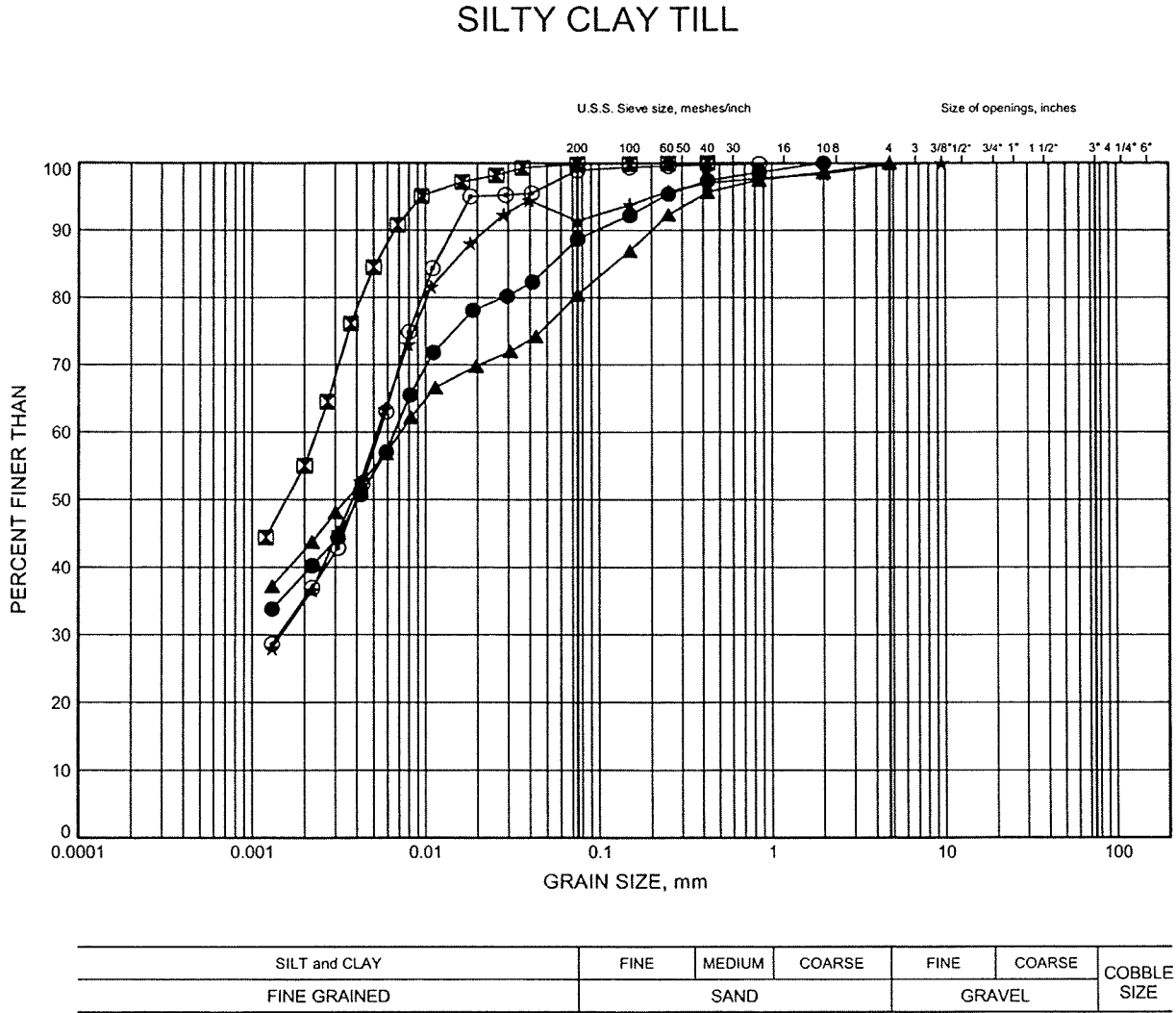
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10-2	3.35	150.97



W.P.# W.O. 07-20016...  
Prepared By MFA.....  
Checked By SKP.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B5



LEGEND

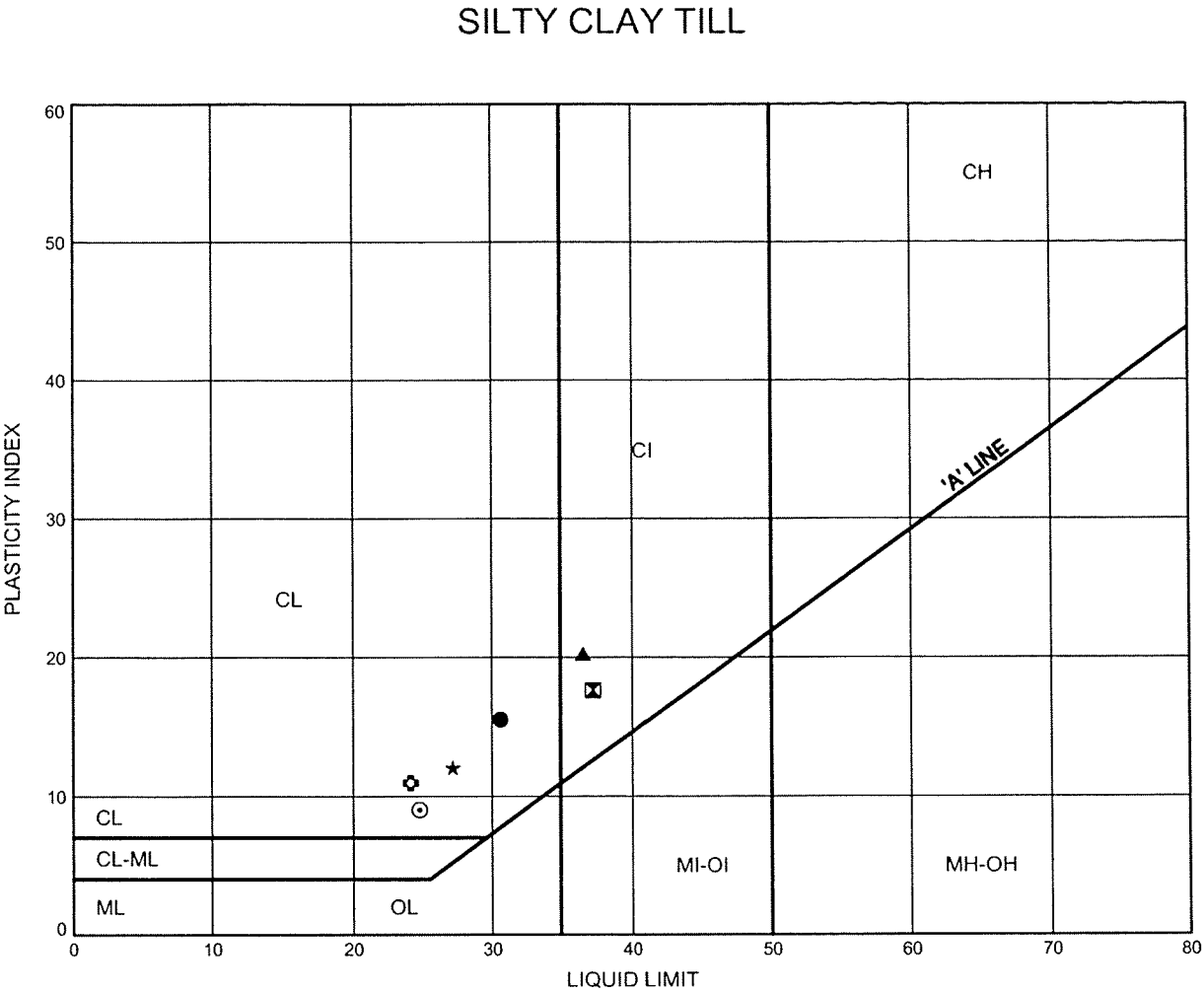
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10-2	7.92	146.39
⊠	CM10-2	18.59	135.73
▲	CM10-2	32.31	122.01
★	CM10b-1	1.83	159.37
⊙	CM10b-1	17.07	144.13



W.P.# W.O. 07-20016  
Prepared By MFA  
Checked By SKP

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM10/10b-B6



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM10-2	7.92	146.39
⊠	CM10-2	18.59	135.73
▲	CM10-2	32.31	122.01
★	CM10b-1	1.83	159.37
⊙	CM10b-1	17.07	144.13
⊕	CM10b-2	7.92	148.04

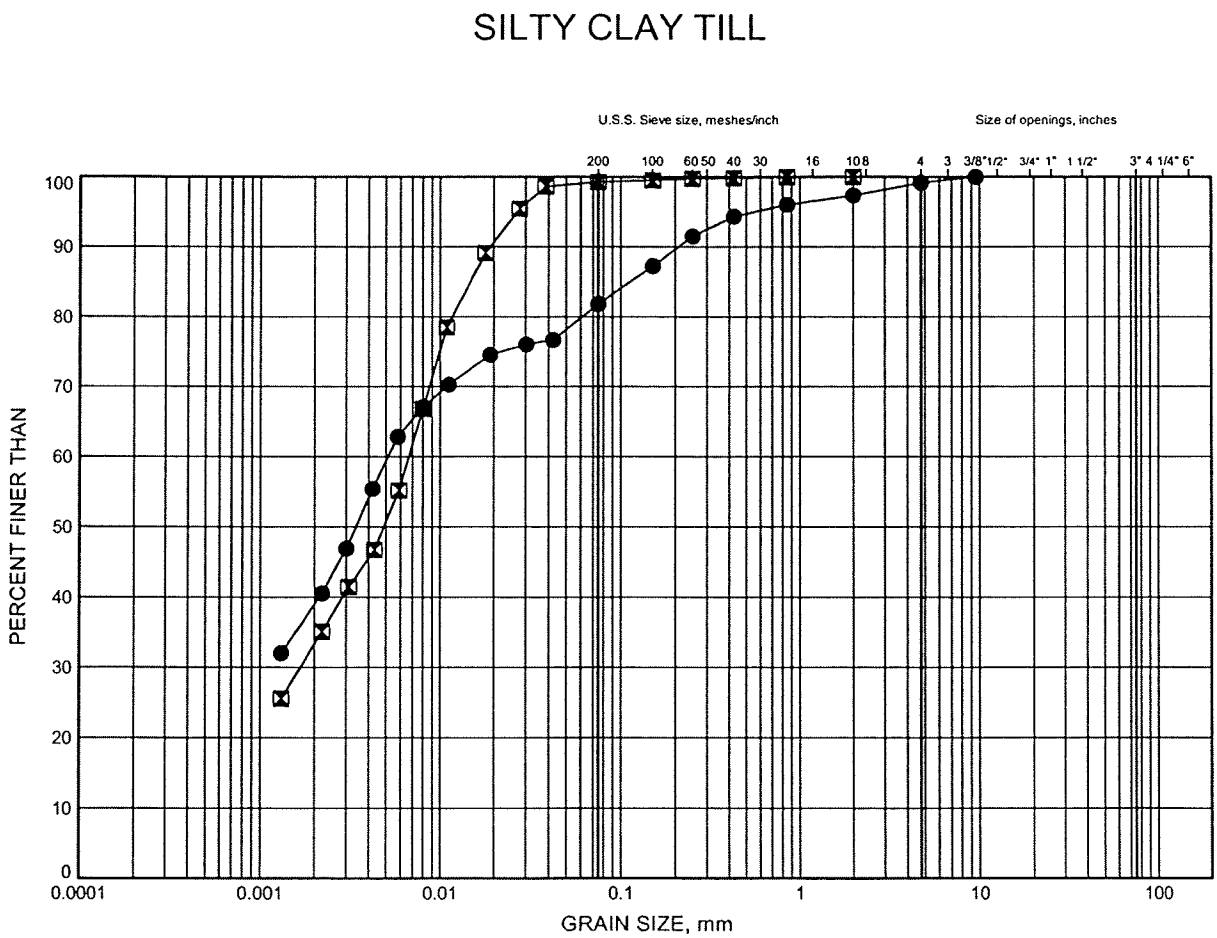


Date March 2009  
Project W.O. 07-20016

Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B7



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

LEGEND

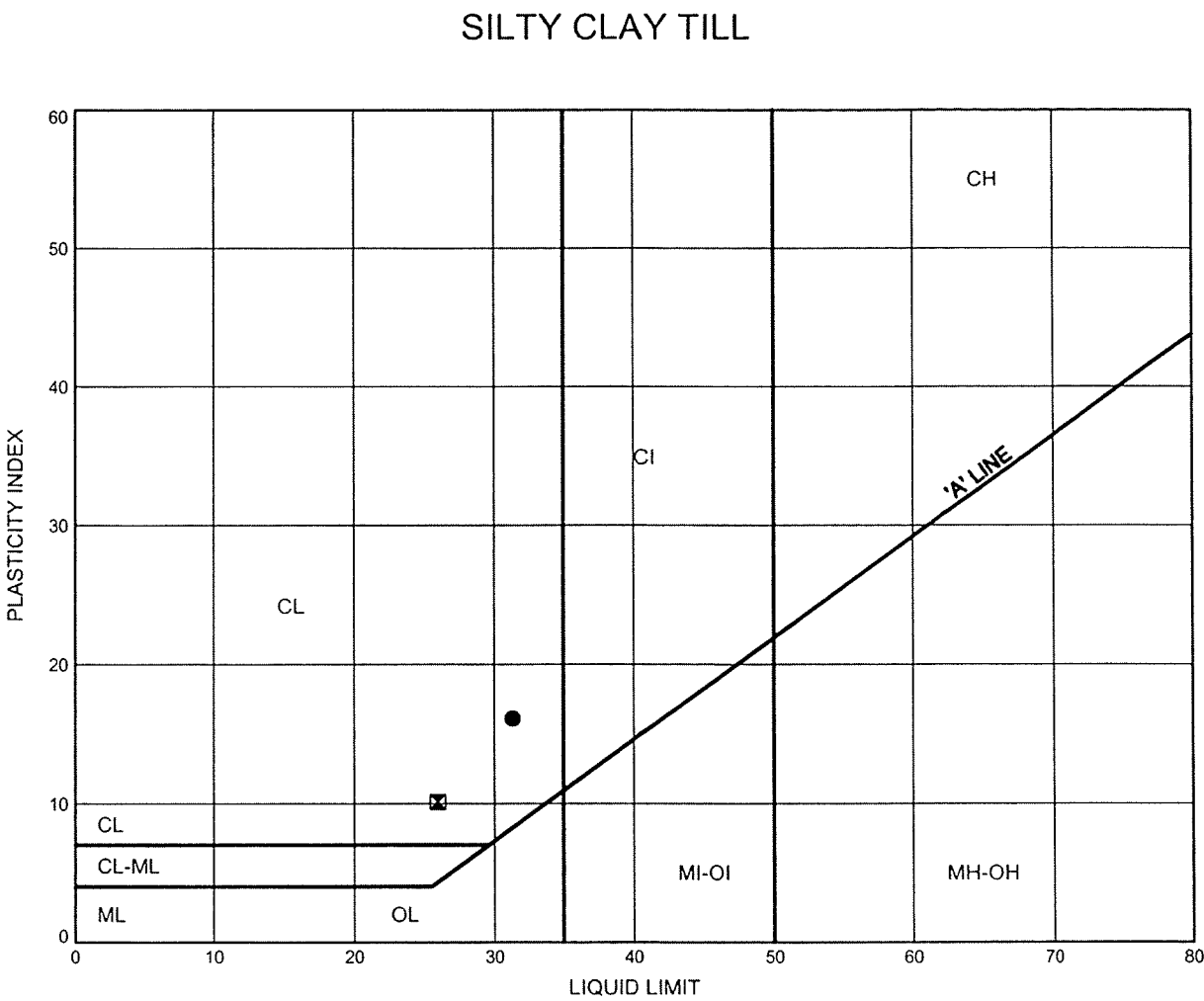
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10-1	3.35	158.55
⊠	CM10-1	18.59	143.31



W.P.# W.O. 07-20016...  
Prepared By MFA...  
Checked By SKP...

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM10/10b-B8



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM10-1	3.35	158.55
⊠	CM10-1	18.59	143.31



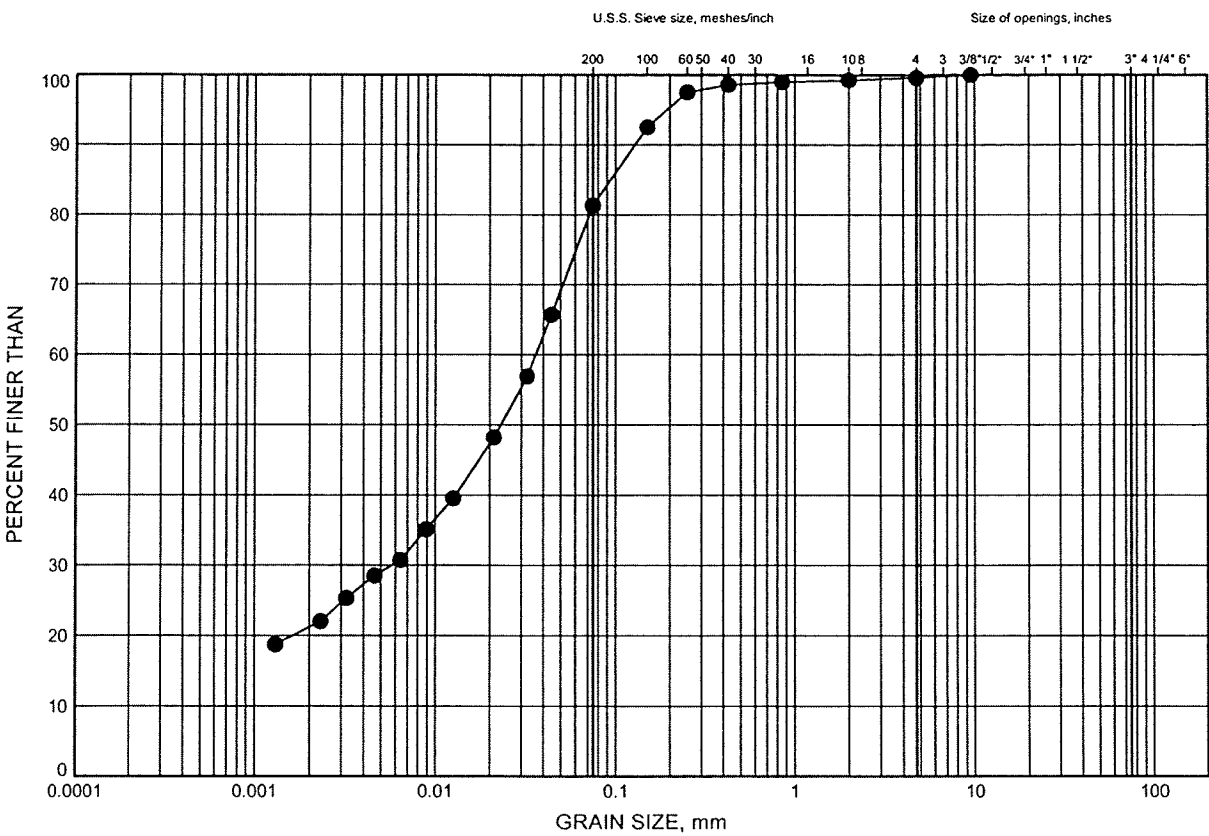
Date March 2009  
Project W.O. 07-20016

Prep'd MFA  
Chkd SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B9

CLAYEY SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10-2	29.13	125.19

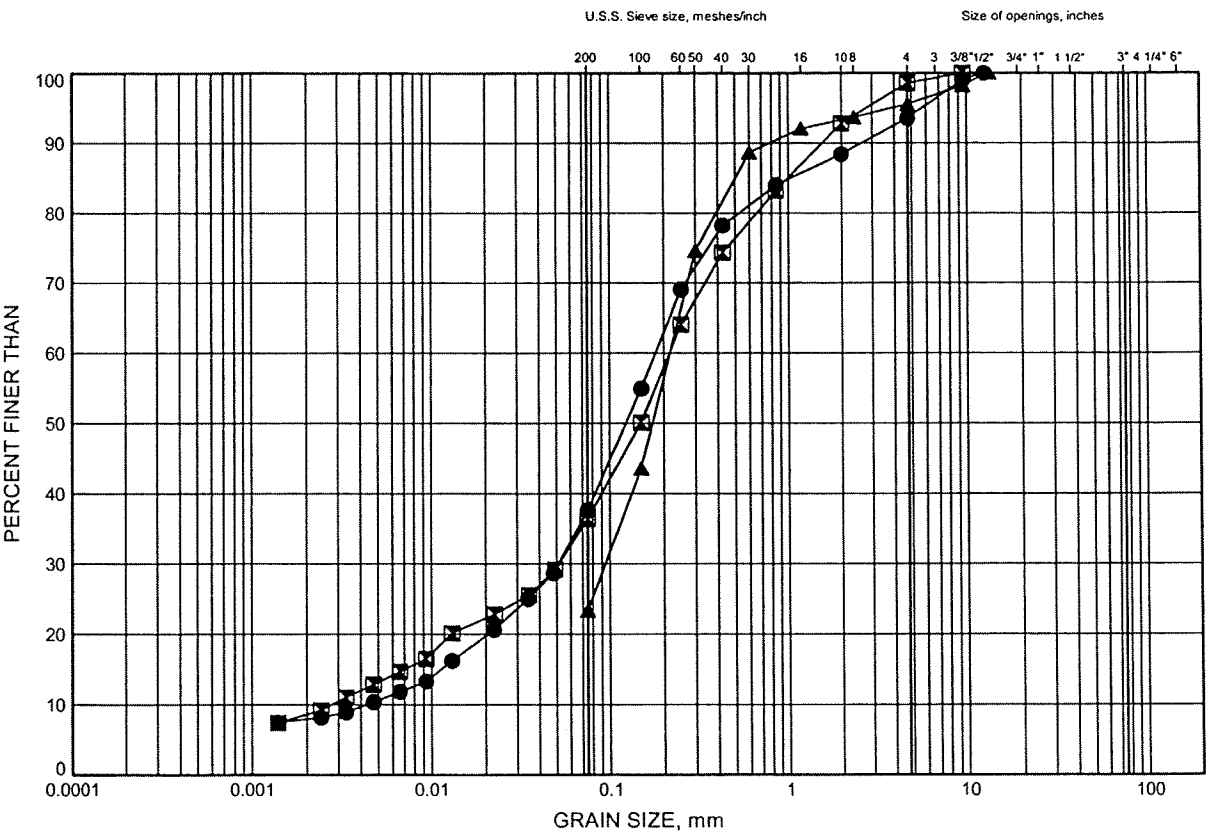


W.P.# W.O. 07-20016...  
Prepared By MFA  
Checked By SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM10/10b-B10

SILTY SAND TILL



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

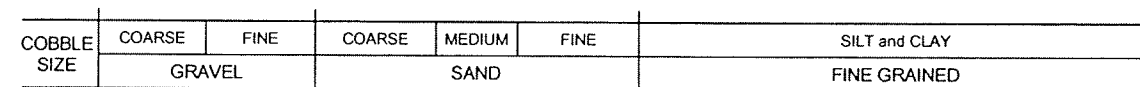
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM10-1	21.41	140.49
☒	CM10b-1	18.75	142.45
▲	CM10b-2	10.85	145.12



W.P.# W.O. 07-20016...  
Prepared By MFA  
Checked By SKP

## FIGURE CM11-B1

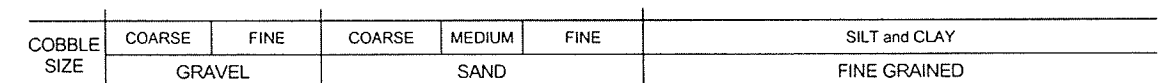


Date March 2008  
Project W.O. 07-20016



Prep'd ..... MFA .....  
Chkd. .... SKP .....

## FIGURE CM11-B2



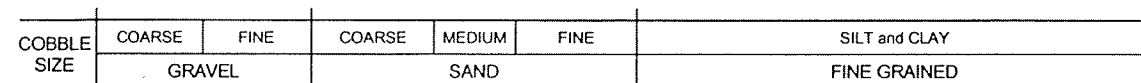
Date April 2008  
Project W.O. 07-20016



Prep'd ..... MFA .....  
Chkd. .... SKP .....



## FIGURE CM11-B3

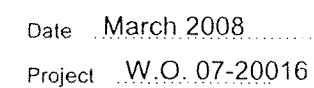


Date March 2008  
Project W.O. 07-20016



Prep'd ..... MFA .....  
Chkd. .... SKP .....

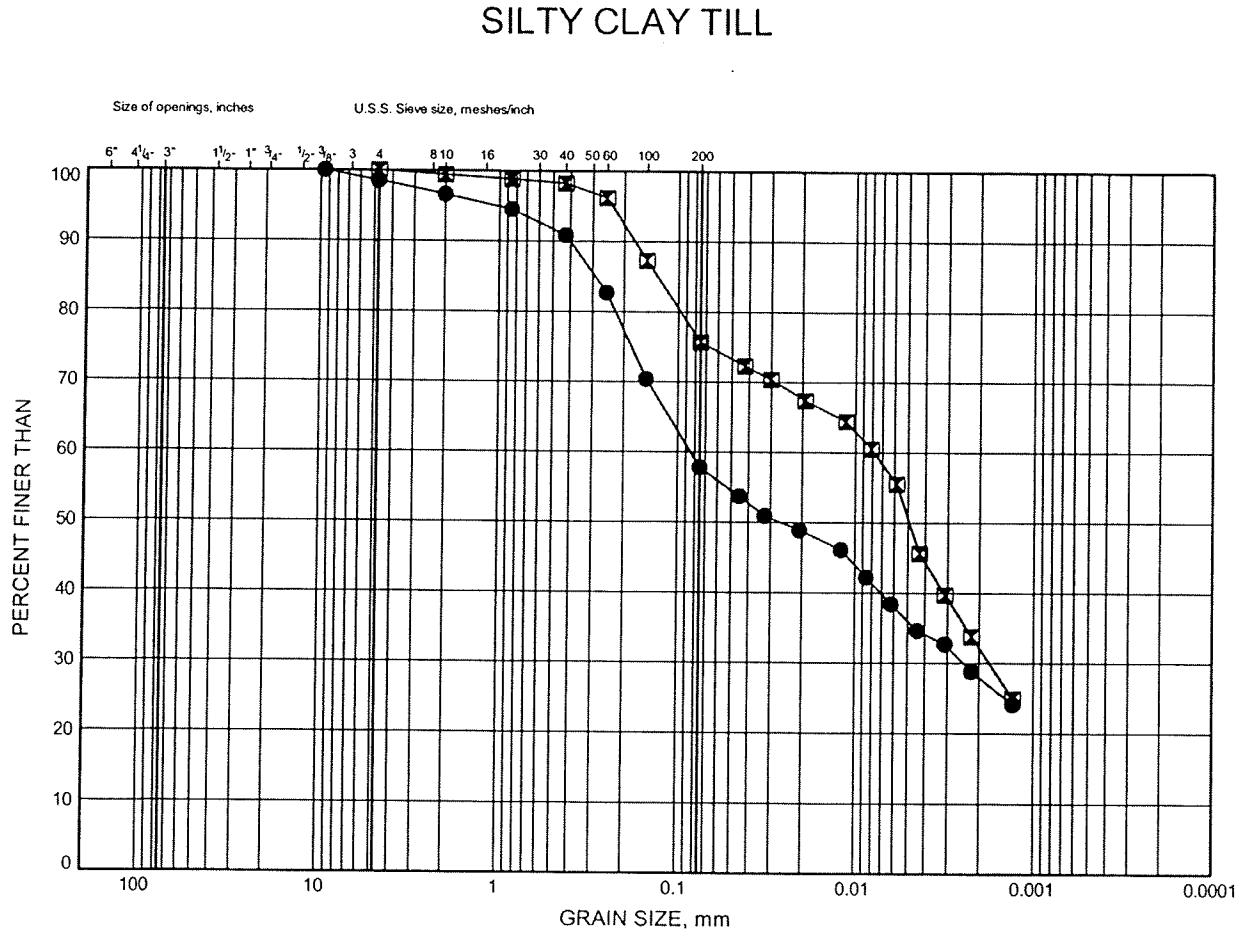
## FIGURE CM11-B4



Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM11-B5



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM11-2	7.85	163.29
⊠	CM11-2	10.96	160.18

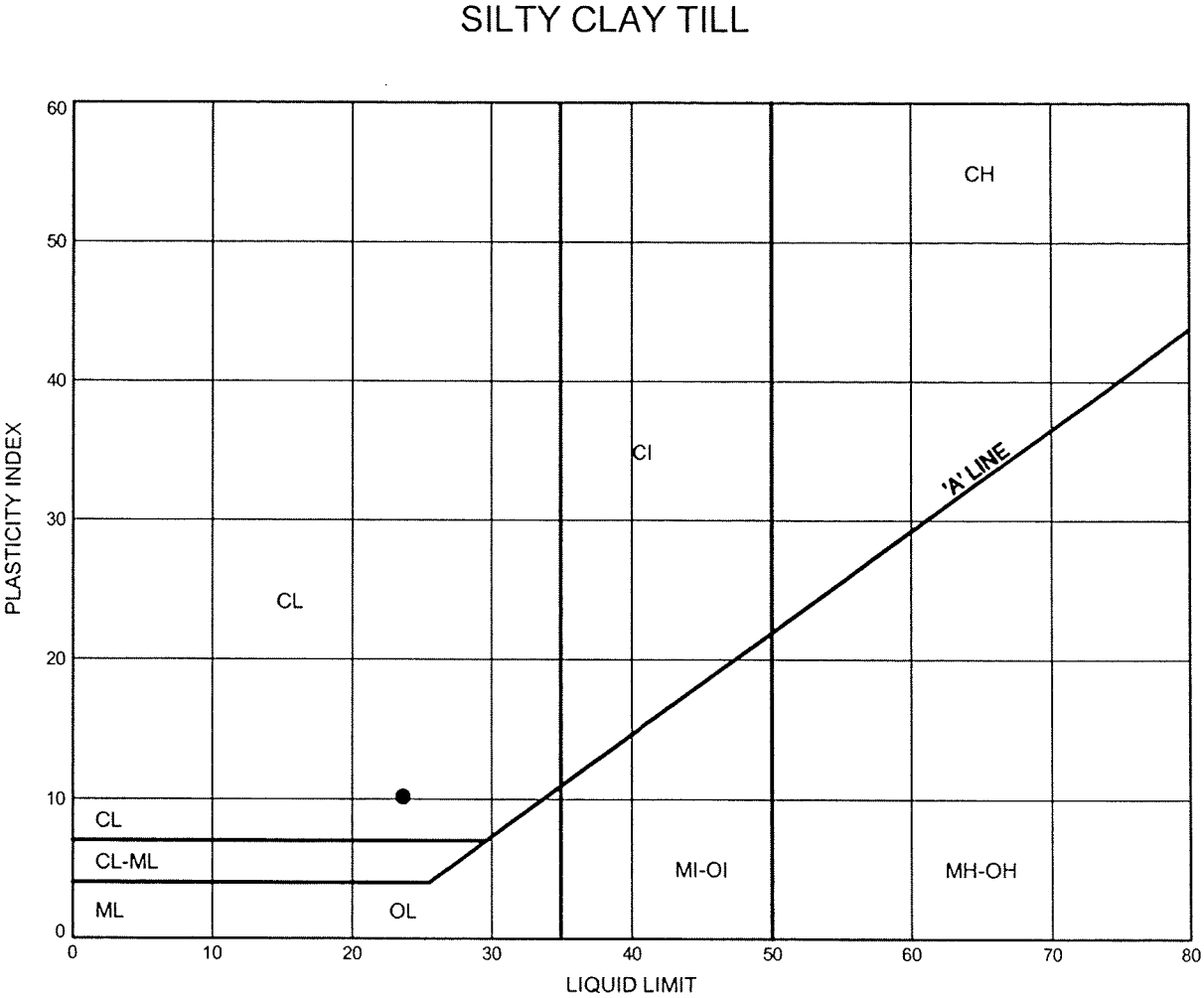


Date March 2008  
Project W.O. 07-20016

Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM11-B6



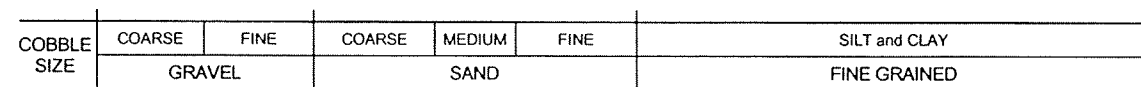
SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM11-2	10.96	160.18



Date March 2008  
Project W.O. 07-20016

Prep'd MFA  
Chkd. SKP

## FIGURE CM11-B7

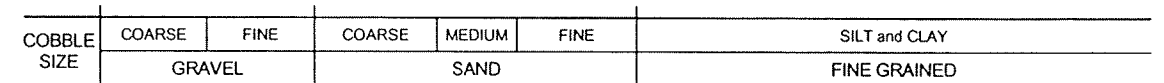


Date March 2008  
Project W.O. 07-20016



Prep'd ..... MFA .....  
Chkd. .... SKP .....

## FIGURE CM11-B8



Date March 2008  
Project W.O. 07-20016

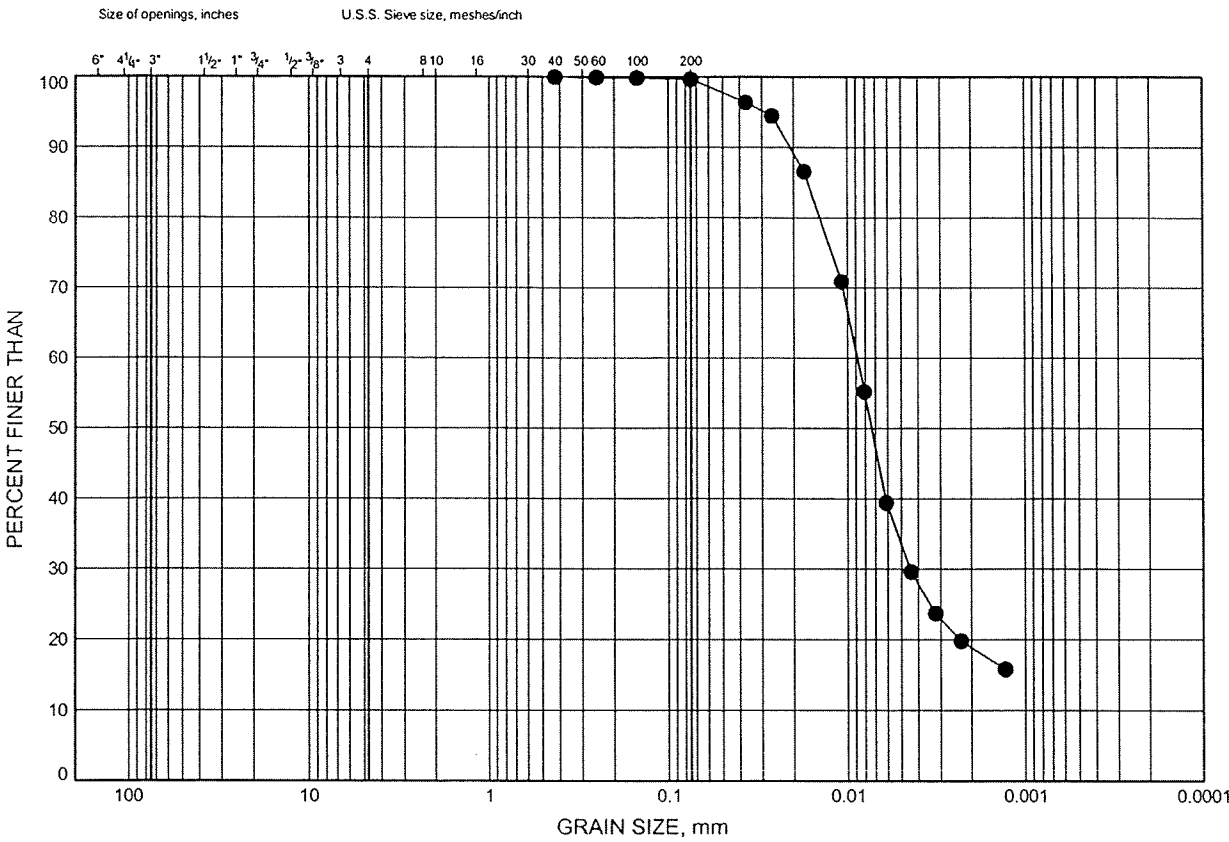


Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM11-B9

LOWER SILT



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM11-2	23.08	148.06

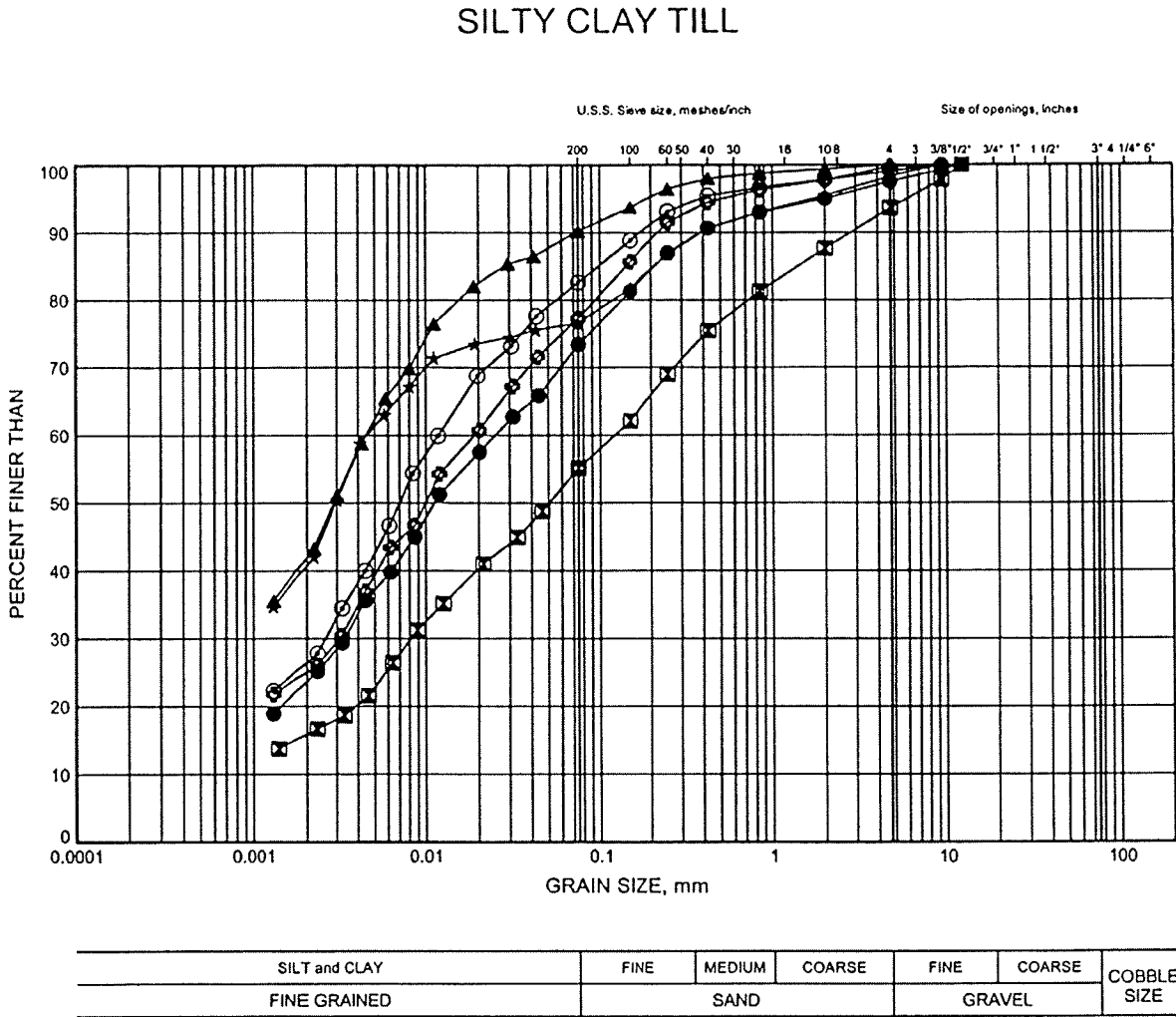
Date April 2008  
Project W.O. 07-20016



Prep'd MFA  
Chkd. SKP

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM12-B1



LEGEND

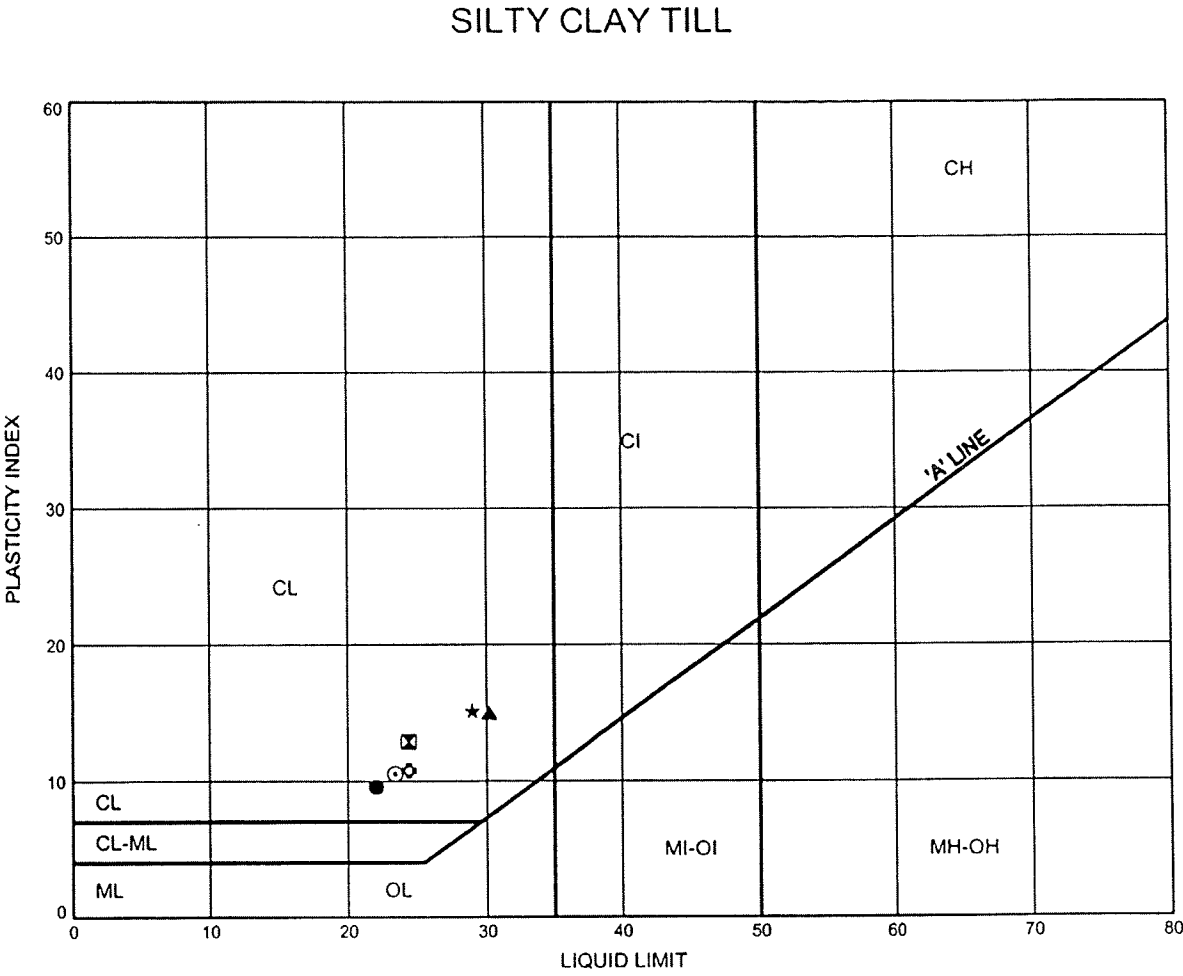
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM12-1	2.51	170.29
⊠	CM12-1	6.40	166.40
▲	CM12-2	3.35	169.92
★	CM12-2	6.28	166.99
⊙	CM12b-1	3.28	168.95
⊕	CM12b-2	2.59	169.79



W.P.# W.O. 07-20016  
Prepared By AN  
Checked By LT

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM12-B2



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM12-1	2.51	170.29
⊠	CM12-1	6.40	166.40
▲	CM12-2	3.35	169.92
★	CM12-2	6.28	166.99
⊙	CM12b-1	3.28	168.95
⊕	CM12b-2	2.59	169.79



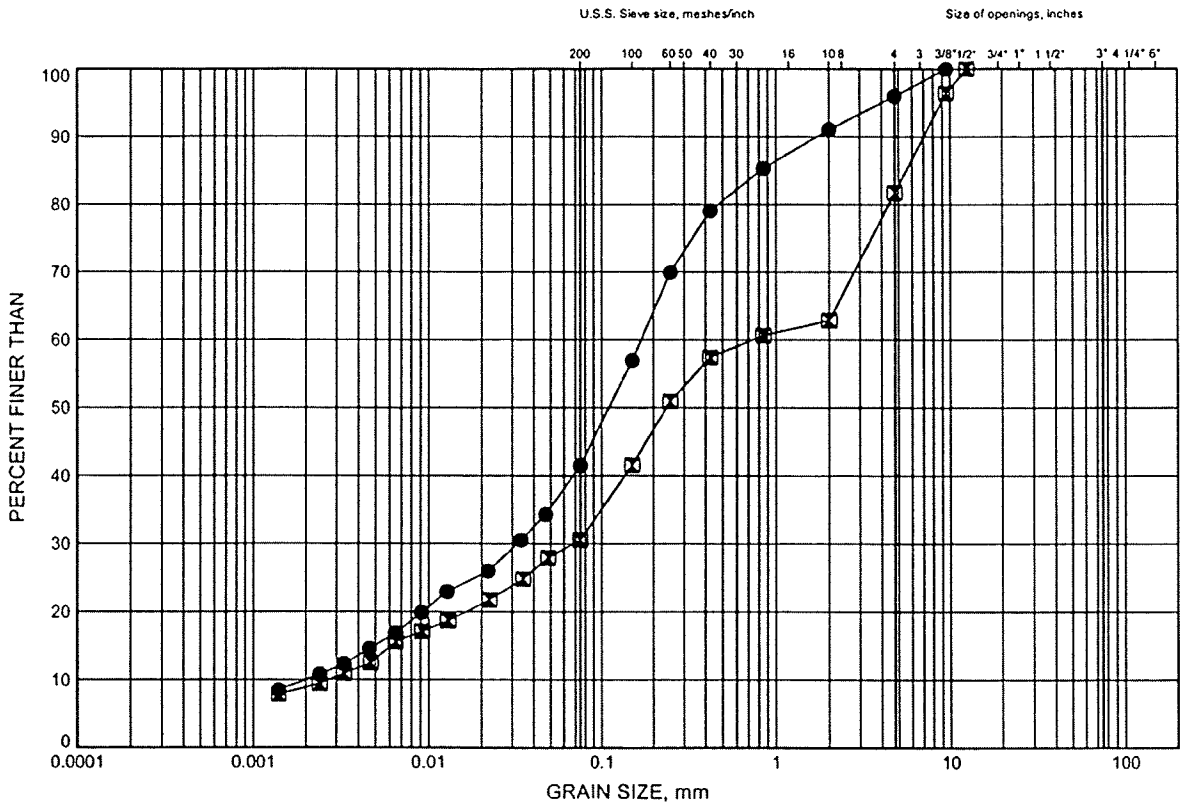
Date July 2009  
Project W.O. 07-20016

Prep'd AN  
Chkd. LT

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM12-B3

SILTY SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM12-1	9.45	163.35
□	CM12b-2	7.92	164.46

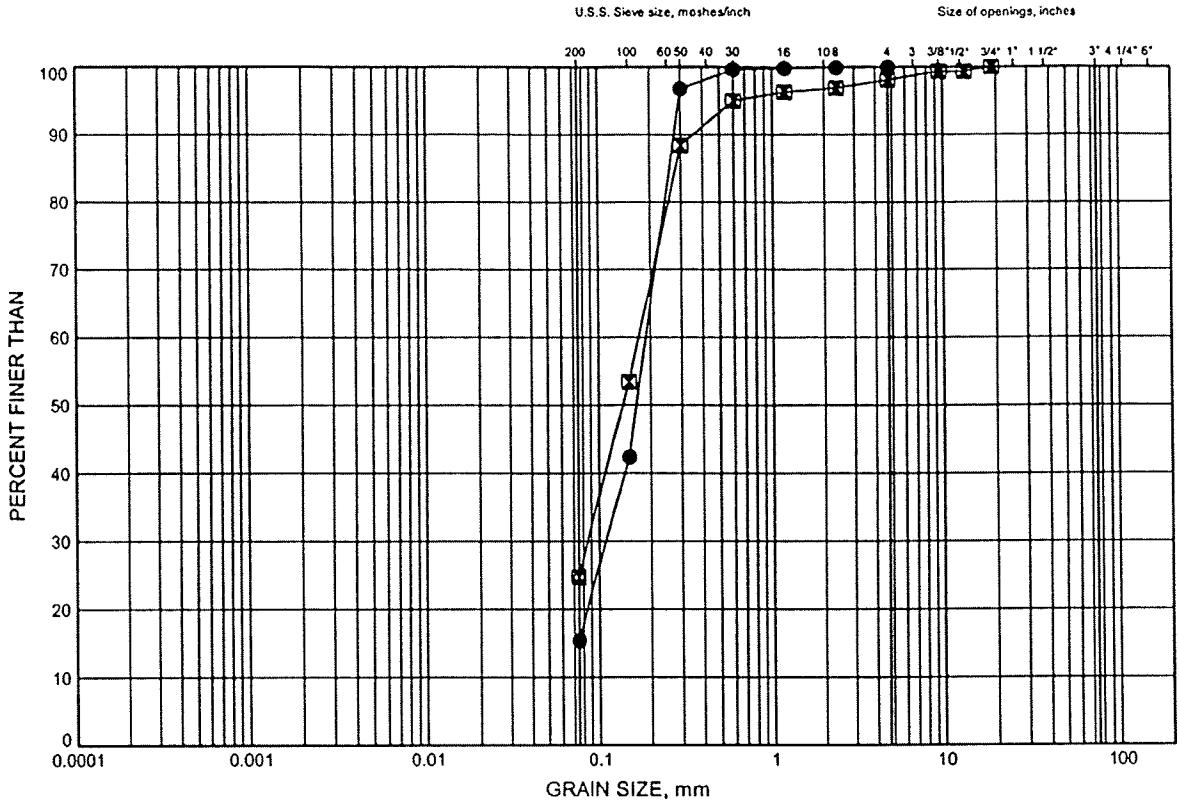


W.P.# W.O. 07-20016...  
Prepared By AN  
Checked By LT

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM12-B4

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM12b-1	9.37	162.86
□	CM12b-1	13.94	158.29

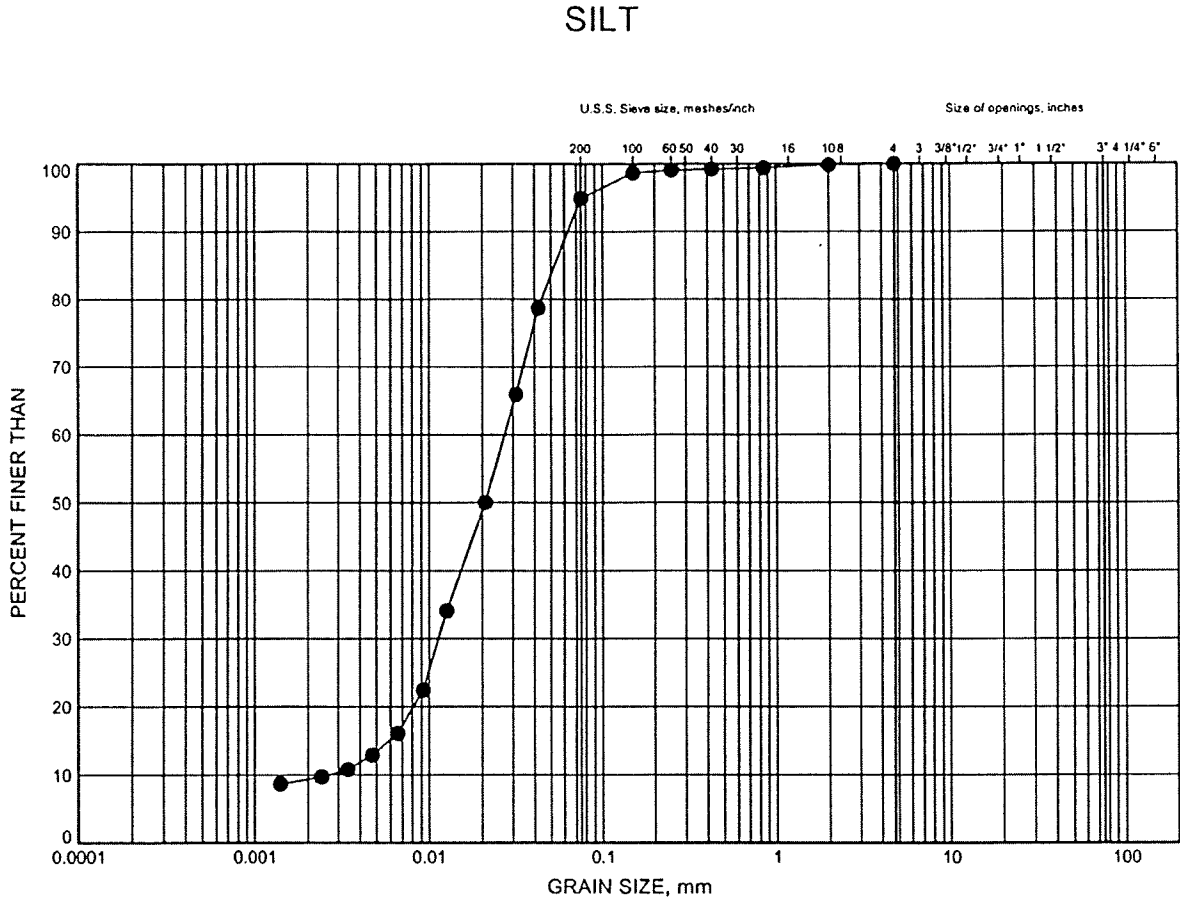


W.P.# W.O. 07-20016...  
Prepared By AN  
Checked By LT



Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM12-B5



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

LEGEND

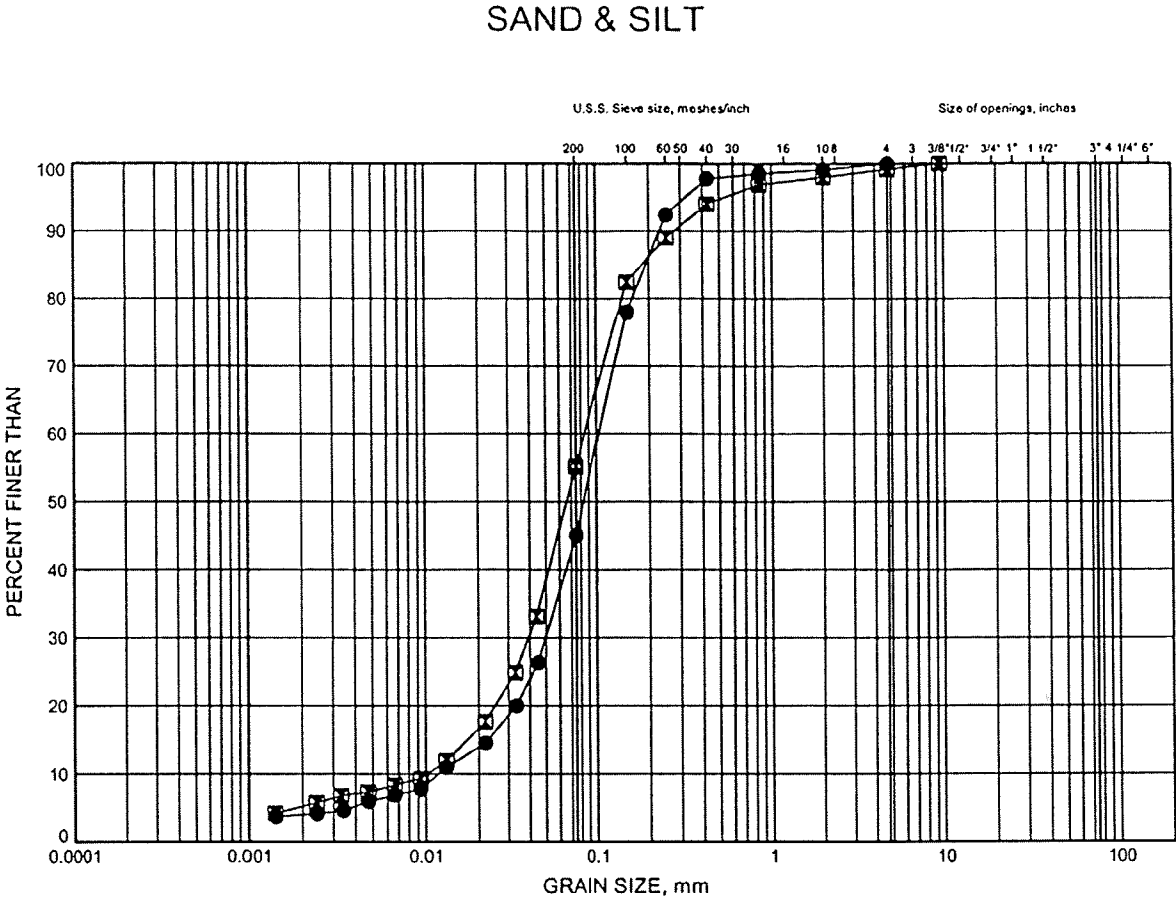
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM12b-2	12.50	159.89



W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By LT.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM12-B6



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

LEGEND

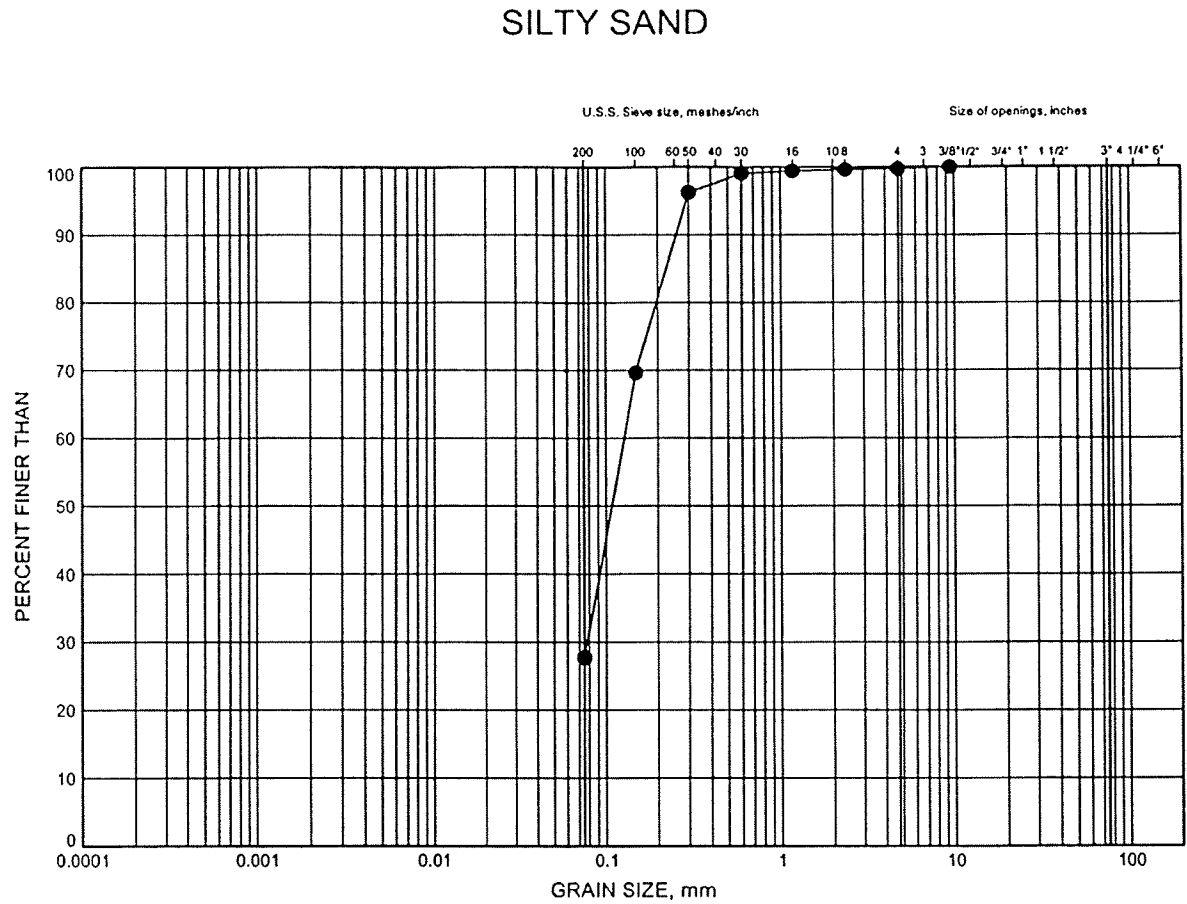
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM12-1	12.50	160.30
□	CM12b-2	18.59	153.79



W.P.# W.O. 07-20016...  
Prepared By AN.....  
Checked By LT.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM12-B7



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

LEGEND

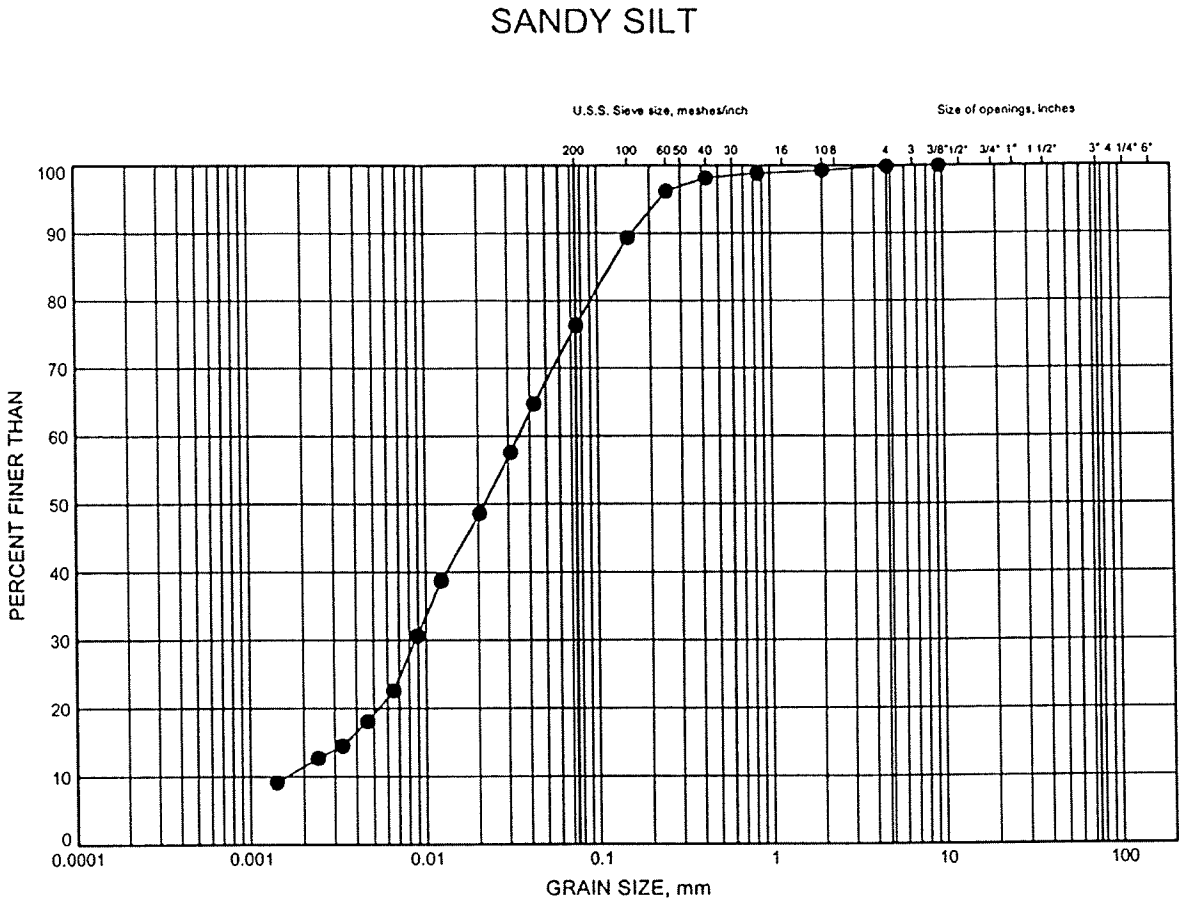
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM12-1	18.59	154.21



W.P.# W.O. 07-20016...  
Prepared By .AN.....  
Checked By .LT.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM12-B8



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM12b-2	21.49	150.90

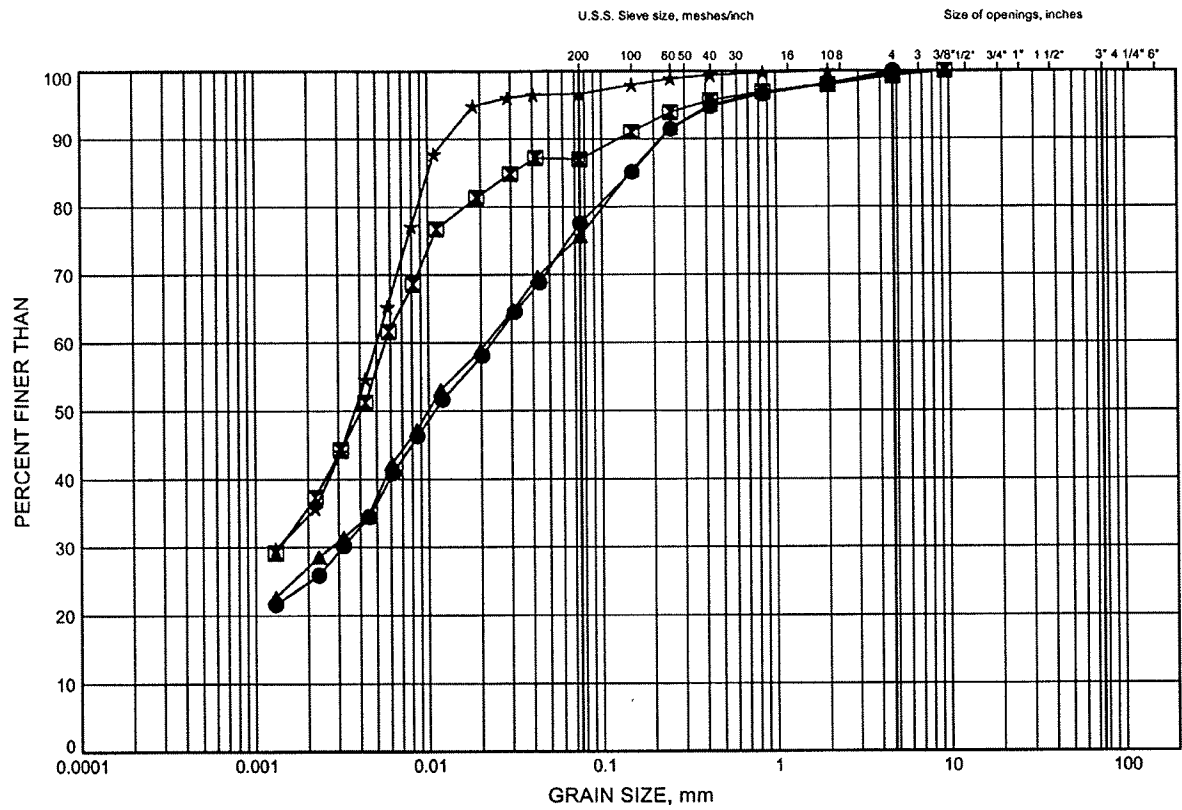


W.P.# W.O. 07-20016...  
Prepared By .AN.....  
Checked By .LT.....

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM15E-B1

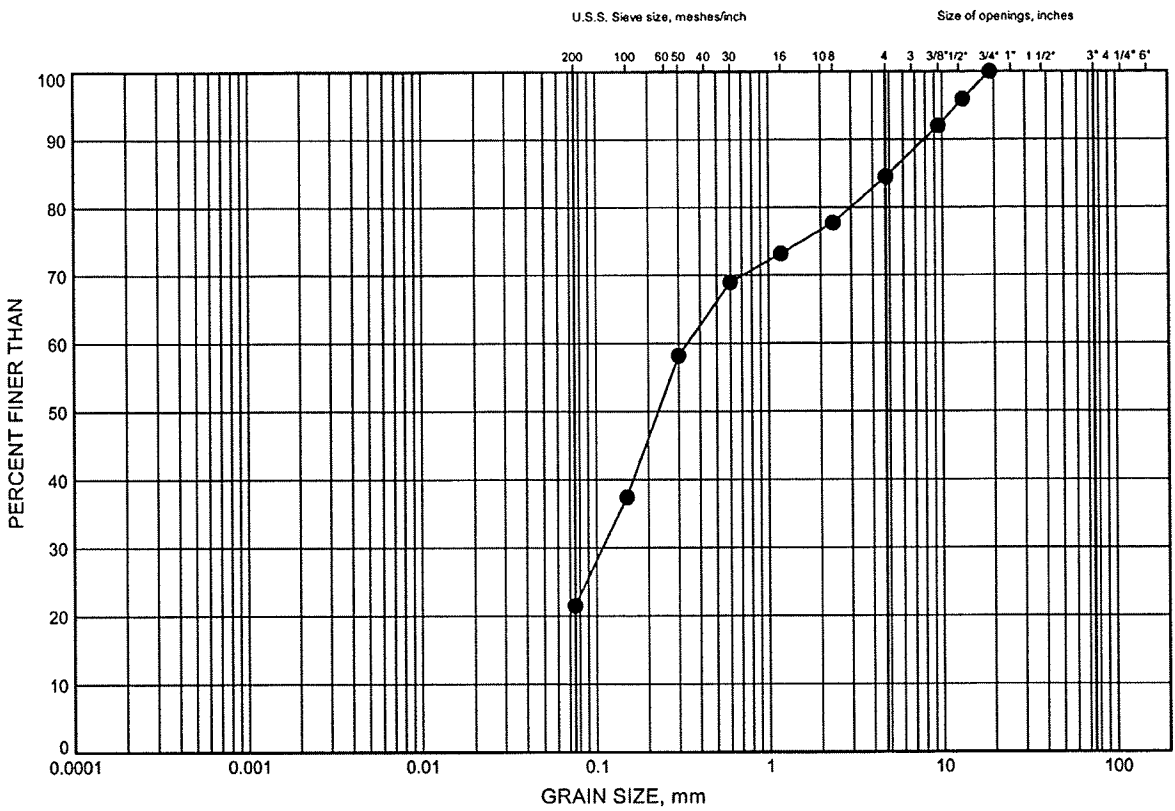
SILTY CLAY TILL



Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM15E-B2

SAND



GRAIN SIZE DISTRIBUTION - THURBER 0510.GPJ 7/20/09

W.P.# .W.O..07-20016..  
Prepared By .AN..  
Checked By .GFA..



GRAIN SIZE DISTRIBUTION - THURBER 0510.GPJ 8/7/09

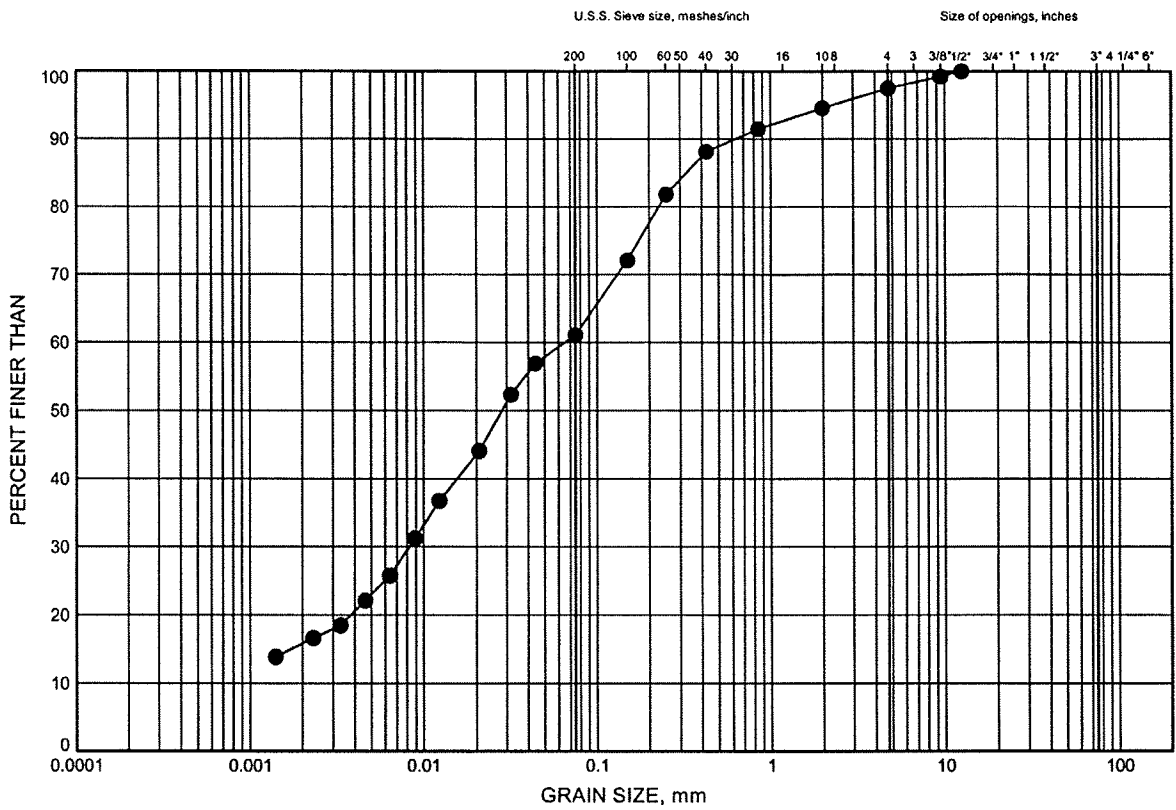
W.P.# .W.O..07-20016..  
Prepared By .AN..  
Checked By .GFA..



Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM15E-B3

SILT & SAND TILL



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

LEGEND			
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM15E-2	6.40	183.00

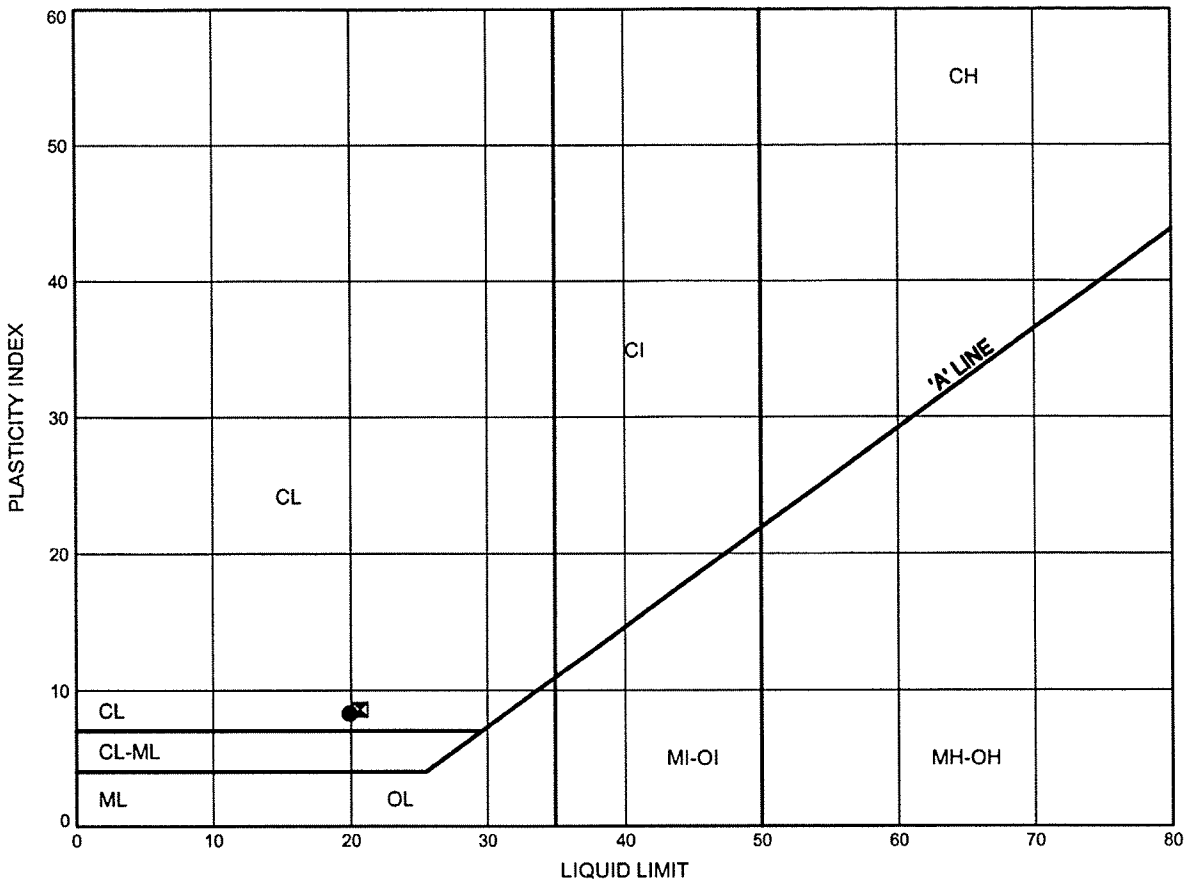


W.P.# W.O. 07-20016  
Prepared By AN  
Checked By GFA

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM15E-B4

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM15E-1	3.35	187.15
⊠	CM15E-2	1.83	187.57

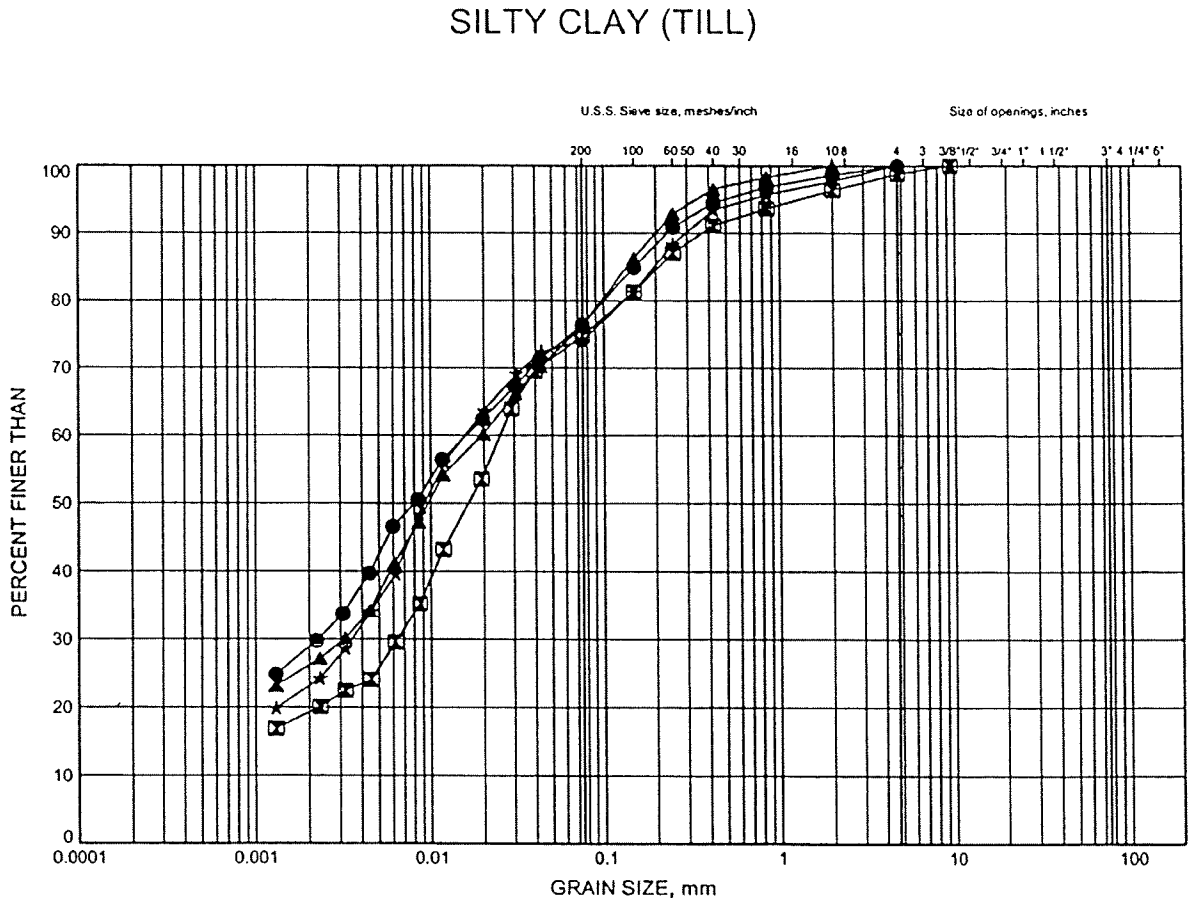


Date July 2009  
Project W.O. 07-20016

Prep'd AN  
Chkd GFA

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM14-B1



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

LEGEND

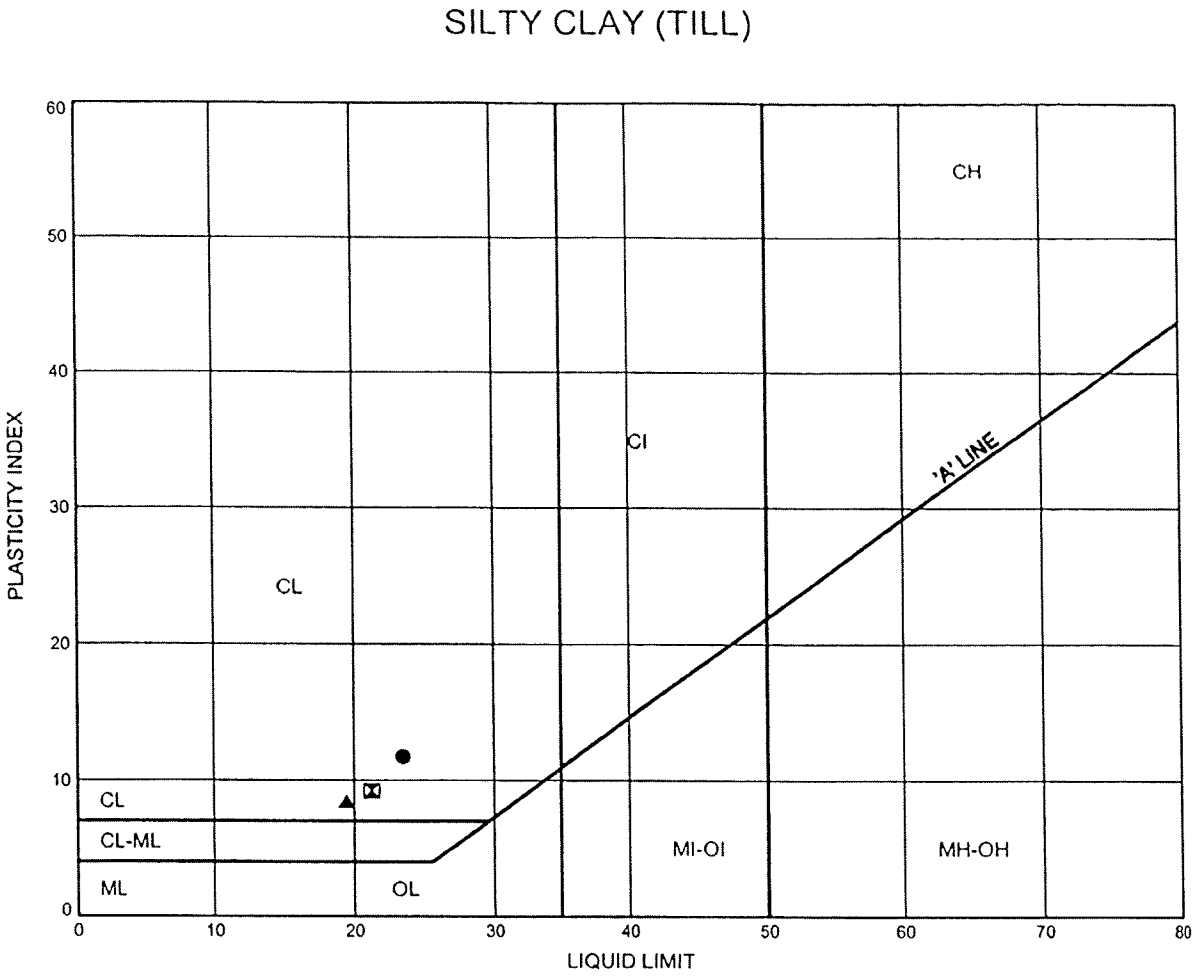
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM14-1	3.35	183.49
⊠	CM14-1	7.92	178.91
▲	CM14-2	2.59	183.43
★	CM14-2	6.40	179.62



W.P.# W.O. 07-20016  
Prepared By AN  
Checked By LT

Hwy 407 East Extension - Central Section  
ATTERBERG LIMITS TEST RESULTS

FIGURE CM14-B2



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CM14-1	3.35	183.49
⊠	CM14-2	2.59	183.43
▲	CM14-2	6.40	179.62



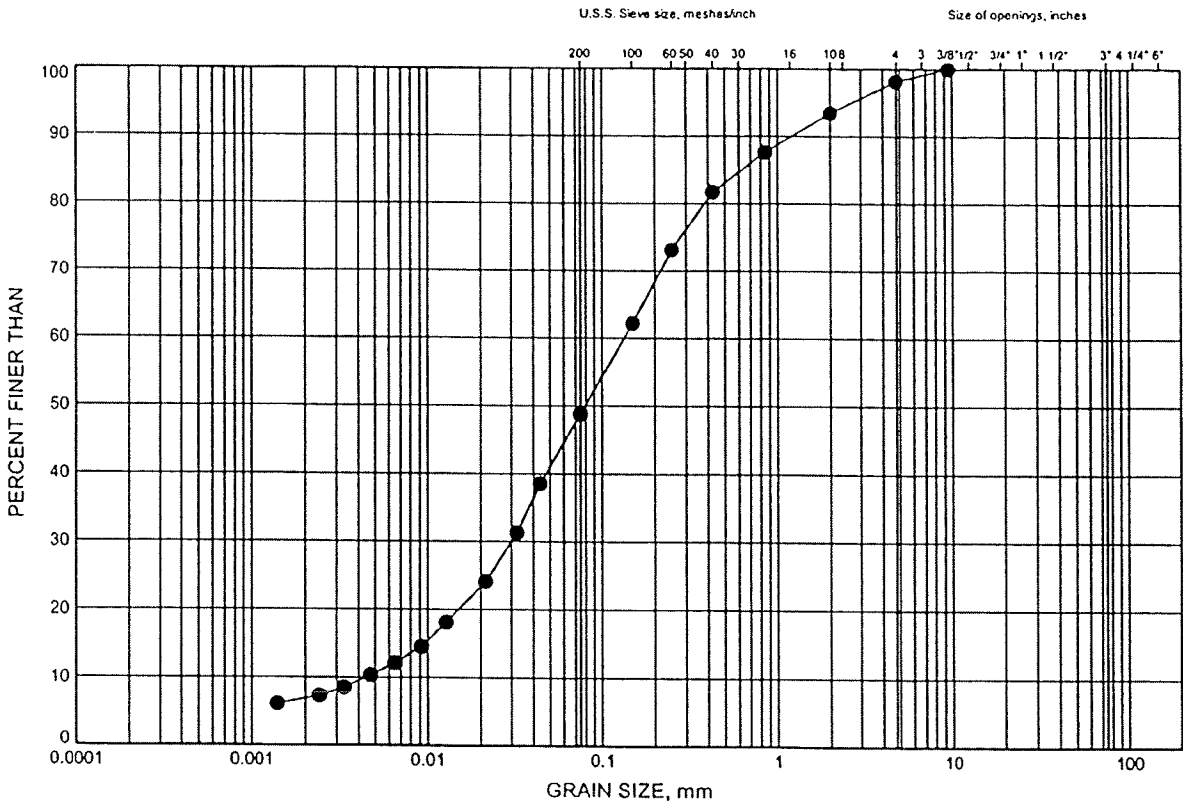
Date June 2009  
Project W.O. 07-20016

Prep'd AN  
Chkd. LT

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM14-B3

SAND & SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM14-1	13.94	172.89

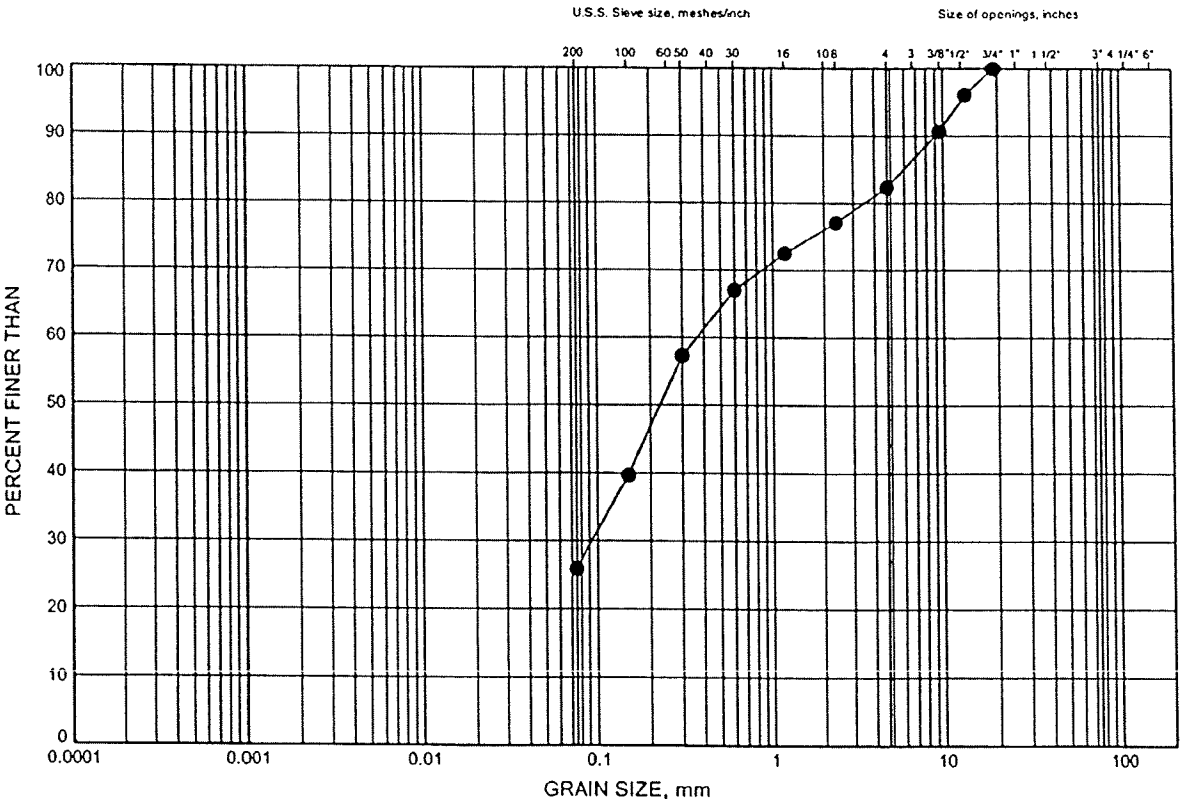


W.P.# W.O. 07-20016...  
Prepared By AN  
Checked By LT

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CM14-B4

SILTY SAND (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CM14-2	12.50	173.53



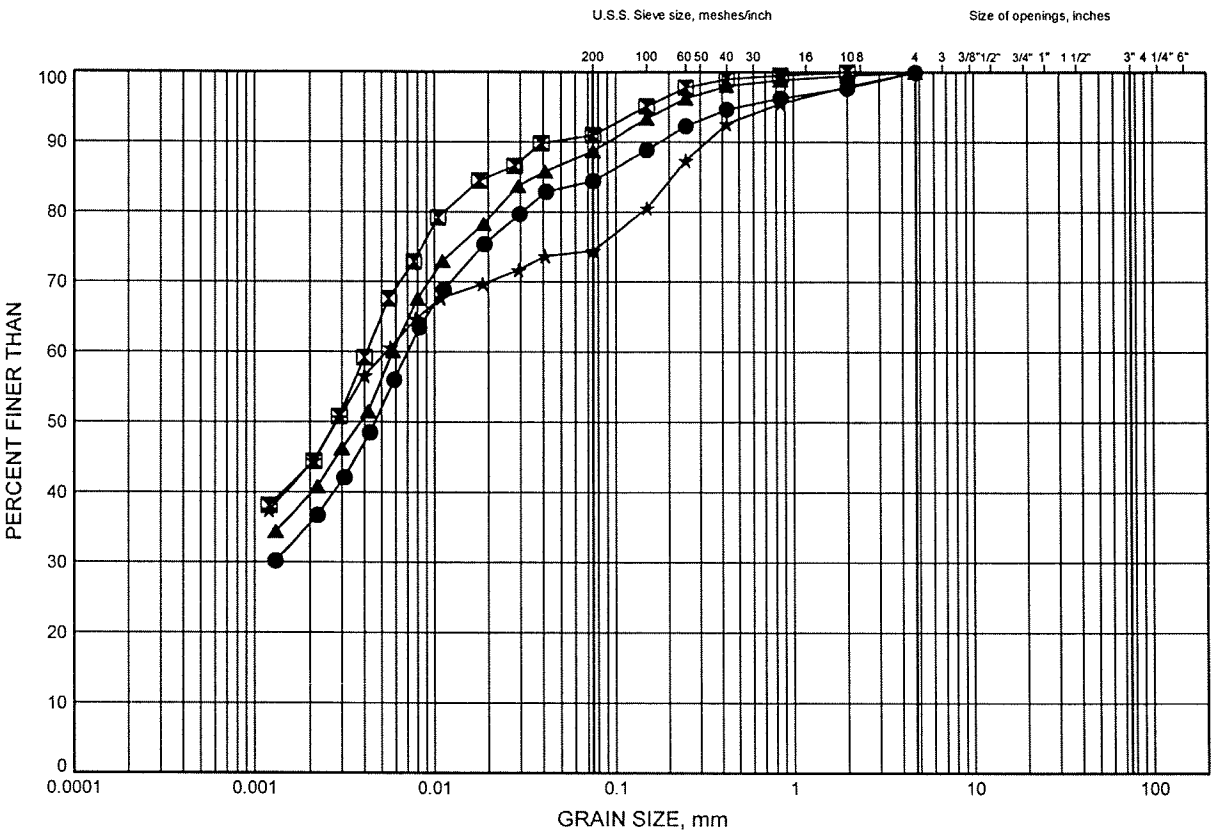
W.P.# W.O. 07-20016...  
Prepared By AN  
Checked By LT



Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CF-B1

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CCM-01	7.76	158.62
⊠	FCM-01	1.83	168.62
▲	FCM-02	2.59	170.92
★	FCM-02	6.40	167.11

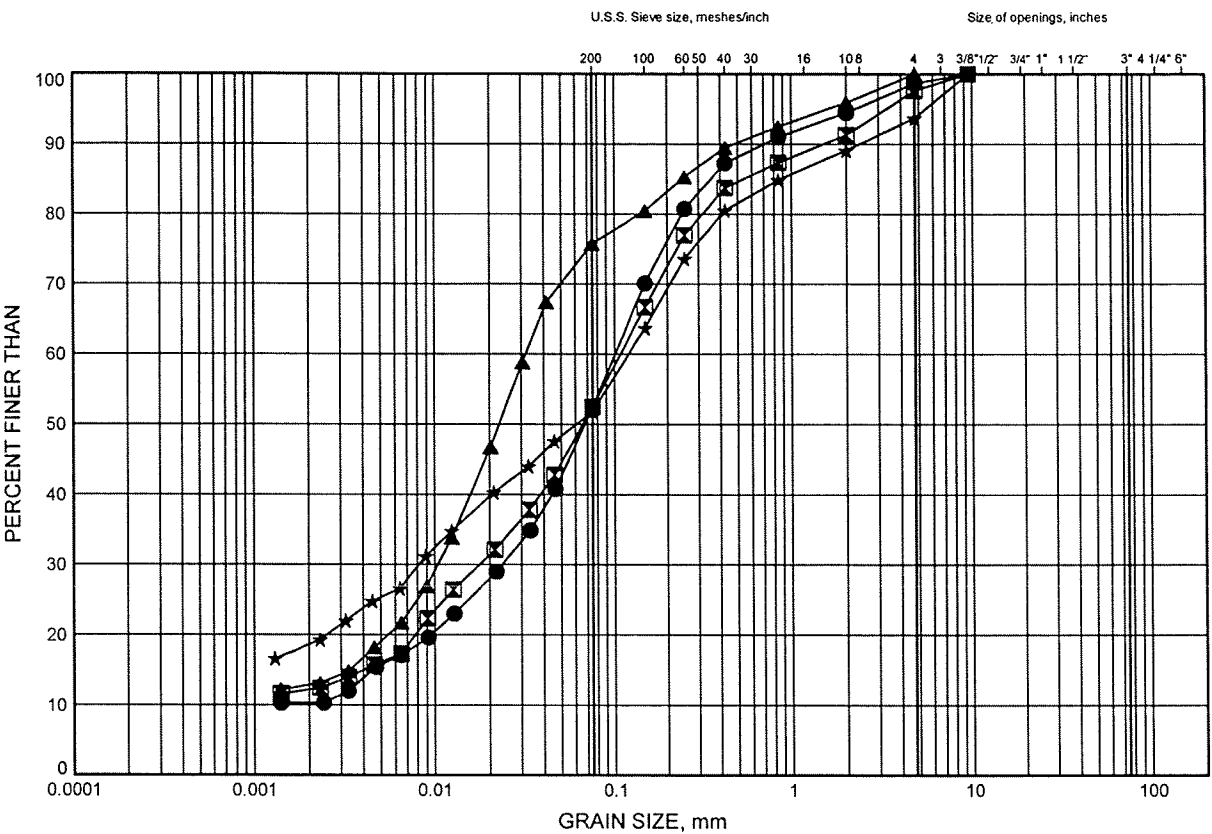


W.P.# W.O. 07-20016  
Prepared By MFA  
Checked By MEF

Hwy 407 East Extension - Central Section  
GRAIN SIZE DISTRIBUTION

FIGURE CF-B2

SILTY SAND TO SANDY SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CCM-01	2.50	163.88
⊠	CCM-01	4.86	161.52
▲	FCM-01	3.20	167.25
★	FCM-01	6.40	164.05

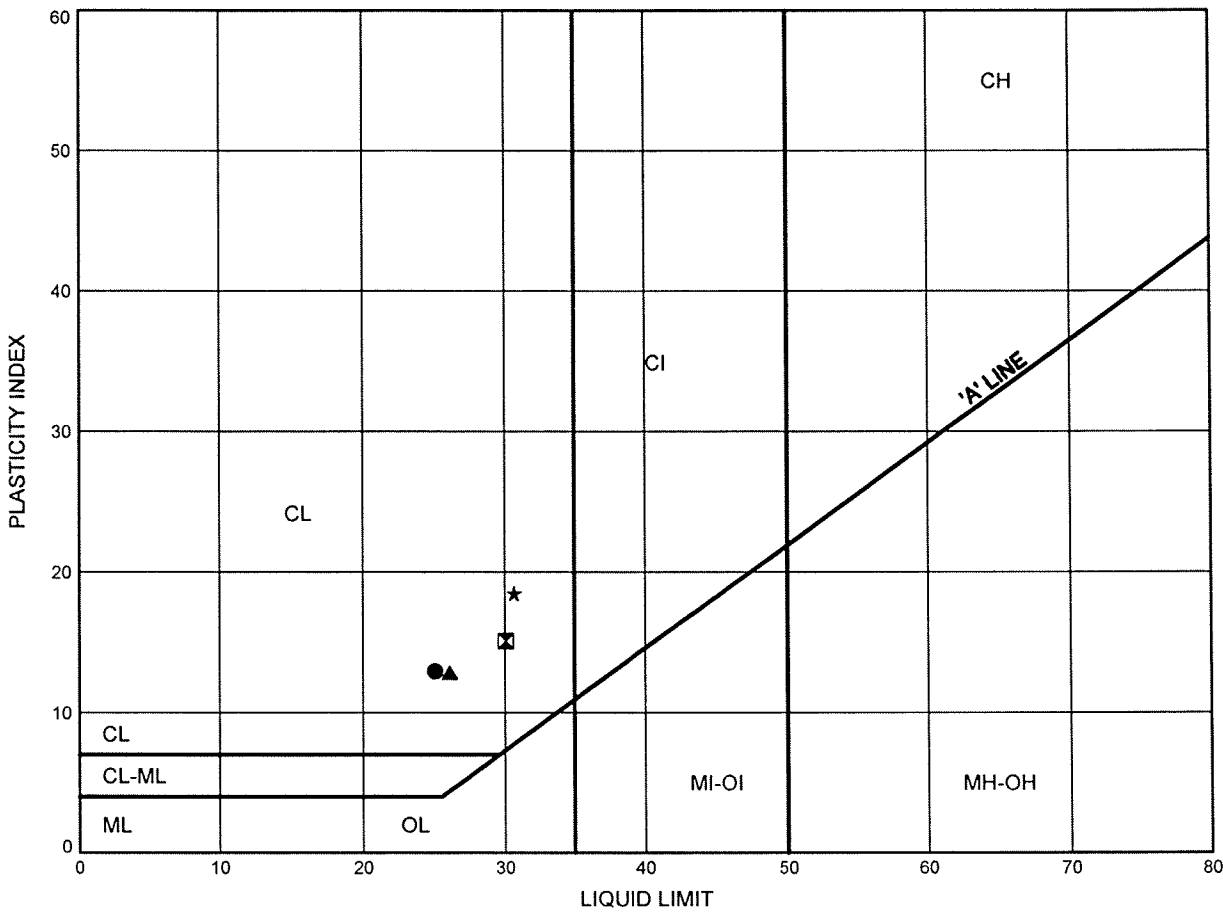


W.P.# W.O. 07-20016  
Prepared By MFA  
Checked By MEF

Hwy 407 East Extension - Central Section  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE CF-B3

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CCM-01	7.76	158.62
⊠	FCM-01	1.83	168.62
▲	FCM-02	2.59	170.92
★	FCM-02	6.40	167.11

Date April 2010  
Project W.O. 07-20016



Prep'd MFA  
Chkd. MEF

**APPENDIX C**

**RECORD OF BOREHOLE SHEETS FROM GEOCRES REPORTS**

RECORD OF BOREHOLE No P12															1 OF 1		METRIC						
W.P. 282-86-01			LOCATION N 4 867670.7 E 346795.7			ORIGINATED BY OK																	
DIST 6 HWY 407			BOREHOLE TYPE H.S. Auger, Cone Test			COMPILED BY DT																	
DATUM Geodetic			DATE 93 12 14 - 93 12 15			CHECKED BY BI																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			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																		
161.5	Ground Surface																						
160.7	Granular Fill																						
0.8	Heterogeneous Mixture of Clayey Silt, Trace Sand and Gravel	Brown	1	SS	26																		
	Very Stiff to Hard ( Glacial Till )	Grey	2	SS	33																		
			3	SS	21																		
157.7			4	SS	25																		
3.8			5	SS	36																		
	Silty Sand		6	SS	5**																		
	Grey Loose		7	SS	6**																		
	Heterogeneous Mixture of Silt, Sand and Gravel		8	SS	24																		
	Occasional Cobbles and Boulders		9	SS	120																		
	Grey, Compact to Very Dense ( Glacial Till )		10	SS	52																		
	Trace Clay		11	SS	80																		
			12	SS	40																		
	Trace Clay		13	SS	54																		
			14	SS	113																		
	Some Sand Layers		15	SS	42																		
141.1			16	SS	115																		
20.4	Heterogeneous Mixture of Clayey Silt, Trace Gravel		17	SS	120																		
	Occasional Cobbles and Boulders																						
	Grey, Hard ( Glacial Till )																						
136.9																							
24.8	End of Borehole																						
* Unstabilized water level measured upon completion of drilling on 93 12 15 ** Unrepresentative blowcounts due to possible disturbance caused by unbalanced hydrostatic heads																							

+3, x5: Numbers refer to Sensitivity 20 15 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P13															1 OF 1		METRIC						
W.P. 282-86-01			LOCATION N 4 867422.8 E 348100.7			ORIGINATED BY OK																	
DIST 6 HWY 407			BOREHOLE TYPE H.S. Auger, Cone Test			COMPILED BY DT																	
DATUM Geodetic			DATE 93 12 13			CHECKED BY BI																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			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																		
158.8	Ground Surface																						
0.0	Granular Fill																						
0.5	Clayey Silt, Trace Sand, with Organic Inclusions ( Fill )		1	SS	9																		
157.4			2	SS	20																		
1.4	Heterogeneous Mixture of Clayey Silt, Gravel, Brown, Very Stiff		3	SS	37																		
2.1	Brown, Dense Grey, Very Dense		4	SS	123																		
	Heterogeneous Mixture of Silt, Sand and Gravel, Occasional Cobbles and Boulders		5	SS	120																		
	( Glacial Till )		6	SS	103																		
152.7			7	SS	117																		
6.1	Heterogeneous Mixture of Clayey Silt, Trace Gravel		8	SS	120																		
	Occasional Sand layers, Cobbles and Boulders, Grey, Hard		9	SS	120																		
	( Glacial Till )		10	SS	104																		
146.4			11	SS	104																		
12.4	End of Borehole																						
* Unstabilized water level measured upon completion of drilling on 93 12 13																							

+3, x5: Numbers refer to Sensitivity 20 15 10 (%) STRAIN AT FAILURE

1 OF 1

METRIC

ORIGINATED BY DK

COMPILED BY DT

— CHECKED BY BA

+3, x<sup>5</sup>: Numbers refer to Sensitivity

1 OF 1

METRIC

ORIGINATED BY DK

COMPILED BY DT

CHECKED BY BT

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No P21															1 OF 1		METRIC					
W.P. 326-88-01		LOCATION Coords.: N 4 868 931.8 E 351 038.5				ORIGINATED BY LO																
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem / Hollow Stem				COMPILED BY LO																
DATUM Geodetic		DATE 1994 05 30				CHECKED BY KA																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)				
								20	40	60	80	100	UNCONFINED + FIELD VANE QUICK TRIAXIAL * LAB VANE 20 40 60 80 100					10	20	30		
172.0	Ground Surface																					
0.0	Clayey Silt Some Sand, Trace Gravel Hard (Glacial Till)		1	SS	31																	
	Sandy Silt		2	SS	31																	
			3	SS	41																	
			4	SS	57																	
			5	SS	104																	
162.5			6	SS	120																	
9.4	End of Borehole																					

+3, x<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15-5 (X) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No P22															1 OF 1		METRIC					
W.P. 326-88-01		LOCATION Coords.: N 4 869 896.0 E 352 482.8				ORIGINATED BY LO																
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem / Hollow Stem				COMPILED BY LO																
DATUM Geodetic		DATE 1994 05 26				CHECKED BY KA																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)				
								20	40	60	80	100	UNCONFINED + FIELD VANE QUICK TRIAXIAL * LAB VANE 20 40 60 80 100					10	20	30		
184.9	Ground Surface																					
0.0	Clayey Silt Some Sand, Trace Gravel Hard (Glacial Till)		1	SS	74																	
			2	SS	100																	
179.4			3	SS	39																	
5.5	Silty Sand to Sandy Silt Trace of Clay, Trace of Gravel Dense to V. Dense (Glacial Till)		4	SS	41																	
			5	SS	108																	
			6	SS	100																	
172.3			7	SS	101																	
12.6	End of Borehole																					

+3, x<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15-5 (X) STRAIN AT FAILURE  
10