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PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT HIGHWAY 407 EAST EXTENSION – WESTERN SECTION REGION OF DURHAM MINISTRY OF TRANSPORTATION, ONTARIO W.O. 07-20015

Submitted to:

URS Canada Inc.
75 Commerce Valley Drive East
Thornhill, Ontario
L3T 7N9

GEOCRES NO: 30M14-316

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HIGHWAY 407 EAST EXTENSION – WESTERN SECTION
REGION OF DURHAM
MINISTRY OF TRANSPORTATION, ONTARIO
W.O. 07-20015

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, the Central Section and the Eastern Section) as shown on Drawing 1.

The planning component and preliminary design of foundations component for the proposed Highway 407 East Extension project were carried out in two separate phases. A Phase I desktop study for this project was completed in 2008 for each section of the proposed highway extension for planning and feasibility study purposes by Thurber Engineering Ltd. and is presented in three separate reports for each section titled "Foundation Desktop Study, Highway 407 East Extension-Western Section; Central Section; Eastern Section, W.O. 07-20015", dated November 2008. The Phase I 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 investigation conducted by MTO in 1994 for planning purposes.

This Preliminary Foundation Investigation and Design Report (FIDR) presents the results of the Phase II foundation investigation and provides recommendations for the planning (including environmental assessment) and preliminary design of the proposed Highway 407 East Extension - Western Section, which extends from Brock Road in the City of Pickering to Ashburn Road in the Town of Whitby, including the proposed West Durham Link to Highway 401 (as shown on Drawing 1). The purpose of this Phase II study is to provide "as near as possible" preliminary design level foundation investigation and design information for environmental assessment purposes given the constraints at the time of the investigation. The preliminary FIDR supercedes all previous reports for the purpose of preliminary foundation design and EA submission.

As stipulated in the Request for Proposal, this Phase II investigation includes characterizing each highway crossing site (i.e. bridge, culvert, etc.) as requiring low, medium, or high level investigative effort. The definitions of the target effort levels are defined in the RFP and summarized in Section 3.0 of this report. After each site was characterized, an attempt was made to achieve the desired investigative effort; however, due to restricted access to private properties (Permission to Enter (PTE) not granted) and other project constraints, many sites were not able to be investigated to the desired target level. As a result, the highest achievable level of planning and/or preliminary field investigation and design was performed at each site and the results are included in this FIDR.

Preliminary Foundation Investigation and Design Reports for the Central and Eastern sections of the proposed Highway 407 East Extension from Ashburn Road to Highway 35/115, including the East Durham Link, are addressed by others in separate reports. This report is presented in two parts:

1 - 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 highway bridge crossings and interchanges, based on the results of limited borehole investigation and laboratory testing carried out at bridge sites for which PTE was granted, or on the desktop study information where no PTE was granted. Individual Preliminary Foundation Investigation Report sheets summarizing the results of the field investigation and geotechnical laboratory testing for each structure site are presented following the text of the report.

2 - Part B: Preliminary Foundation Design Report (FDR), provides project-wide engineering recommendations for preliminary design for each proposed structure, culvert, deep cut and high fill site. Individual site-specific recommendations are provided on the Preliminary Foundation Design Report Sheets presented following the text of this report and are appended to their respective Preliminary Foundation Investigation Report sheets (refer to Part A above).

For structure sites to which PTE was not granted, the Phase I Anticipated Foundation Conditions sheets prepared by Thurber Engineering Ltd. as part of the Phase I desktop study have been included in this Phase II report for planning and preliminary design of those structures. This report also includes copies of the Phase I Anticipated Foundation Conditions sheets for the proposed culvert structure sites, prepared by Thurber Engineering Ltd. as part of the Phase I desktop study for this project. All culvert structure sites were classified as low-complexity sites during the Phase I study, thus requiring no borehole investigation for the purposes of planning and preliminary design. Some culvert sites were recently re-classified from requiring low level investigative effort to requiring medium level investigative effort due to increased span lengths and open footing design based on hydrological / geomorphology requirements as determined by the Project Team. However, due to lacks of permission to enter, project constraints and schedule restrictions, the re-classified medium level culvert structure sites were not assessed to the same level of investigative effort as bridge structures (refer to Section 7.0 for more details). 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 based on any nearby structure boreholes and available terrain / drainage maps.

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. Investigation was not possible at a number of 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 or confirm/reassess the preliminary recommendations provided herein.

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with the project planning including environmental assessment and preliminary design of the proposed Highway 407 East Extension - Western Section. The project limits extend from the present terminus of the existing Highway 407 at Brock Road in the City of Pickering to Ashburn Road in the Town of Whitby (approximately 15 km), including the West Durham Link (WDL) extending southerly from the proposed Highway 407, just east of Halls Road North, to Highway 401 in the Region of Durham, Ontario (approximately 10 km) as shown on Drawing 1.

This report provides sufficient information for planning and preliminary foundation investigation and design (at sites where sufficient subsurface investigation was performed) for a total of sixty six (66) structure sites of which fifty (50) sites are bridges and sixteen (16) sites are culverts. There are a total of ten interchanges along the proposed Highway 407 Western Section mainline and WDL alignments. Each bridge site typically includes up to two structures depending on the proposed configuration for the highway crossing, and up to four structures at the interchanges. As the investigation and design progressed, structures were deleted, added and locations revised according to the revised Hwy 407 and WDL alignments and profiles. In addition, eleven (11) deep cut areas and fifteen (15) high fill areas were included in the study for the West Section.

The original terms of reference and scope of work for the foundation investigation and design are outlined in MTO's Request for Proposal for Assignment No. 2007-E-0042, Work Order No. 07-20015, issued in October, 2007 and in Section 5.8 of URS's *Technical Proposal* for this project.

2.0 PROJECT DESCRIPTION

The Technically Recommended Route for the proposed Highway 407 East Extension starts at the current terminus at Brock Road in the City of Pickering and ends at Highway 35/115 in Clarington. The route includes two north-south links connecting the proposed Highway 407 extension to Highway 401; the West Durham Link (WDL) in Whitby and the East Durham Link (EDL) in Clarington. The proposed highway extension is divided into three main sections: a Western Section which extends from Brock Road to Ashburn Road and includes the WDL, a Central Section which extends from Ashburn Road to Courtice Road, and an Eastern Section which extends from Courtice Road to Highway 35/115 in Clarington and includes the EDL. Drawing 1 shows the proposed alignment for the above described overall route.

The Western Section, which is addressed in this report, consists of two roadway sections referred to as the Highway 407 West Mainline and the West Durham Link.

The West Mainline is an approximately 15 km long highway section, running from Brock Road to Ashburn Road through the City of Pickering and Town of Whitby with a total of thirty-three (33) structure sites consisting of twenty-six (26) bridge sites and seven (7) culvert sites. There are five (5) interchanges located along the West Mainline at the realigned Brock Road, Westney Road, Salem Road, Lakeridge Road and the WDL.

The West Durham Link is an approximately 11 km long highway section, extending from Highway 407 southerly to Highway 401 with a total of thirty-three (33) structure sites consisting of twenty-four (24) bridge sites and nine (9) culvert sites. There are five (5) interchanges on the WDL, located at Winchester Road West (Highway 7), Taunton Road, Rossland Road West, Dundas Street West and Highway 401.

Structures were originally designated as 'WM' (West Mainline) structures or 'WL' (West Durham Link) structures with a sequential number. However, for structures that were added to the project or modified after the destkop study was prepared, an alternate designation (such as WM-EDC-9 for West Mainline East Duffins Creek) was used. The original and revised structure designation, category, location and site ranking complexity is summarized in Section 4.2. The final "official" numbering system will be provided by others as part of the Environmental Assessment submission.

The configuration for the proposed WDL - Highway 401 interchange includes the re-alignment to the north of an approximately 5 km long section of the existing Highway 401, and the re-construction of the Lakeridge Road bridge over Highway 401 and CN Rail. It is understood that future plans involve the extension of the WDL north of the proposed Highway 407.

The proposed Highway 407 West Mainline and WDL routes run mainly through farmland, crossing a number of creek valleys, tributaries, as well as municipal and regional roads. Several wide low-lying valleys are present where the mainline crosses Duffins Creek (east of Paddock Road) and where the mainline crosses several tributaries to Lynde Creek (between Coronation Road and Winchester Road). The WDL also crosses the CP rail line north of Rossland Road. The overall surface topography along the proposed routes is gently sloping downward to the east and to the south towards Lake Ontario, and is incised by various creeks and associated tributaries, such as Urfe Creek, Brougham Creek, Spring Creek, East Duffins Creeks, Carruthers Creek and Lynde Creek. There are no identified wetland areas crossed by the West Mainline nor by the WDL, but wetlands are present at various distances from the proposed highway, such as the South of Claremont Wetland Complex and Brock Road Wetland Complex to the north of the West Mainline and the Heber Down Wetland Complex and Lynde Creek Coastal Wetland Complex to the east and south of the WDL, respectively.

3.0 INVESTIGATION PROCEDURES

Where permission to enter (PTE) was granted, subsurface investigations were carried out at or adjacent to the locations of the proposed bridge sites. The fieldwork was performed between December 2007 and September 2008, during which time a total of sixty-nine (69) boreholes were advanced as part of the Phase II preliminary foundation investigation for the proposed highway crossings. The borehole locations are shown on Drawings 2 to 8 relative to the proposed preliminary bridge structure locations provided by URS Canada Inc. The complexity of each site (i.e. target investigative effort level) was defined by Golder based on existing geological information, available borehole information from previous investigations and seventy-five (75) site photographs provided by URS. The corresponding number of boreholes required to be advanced at each bridge/interchange site were determined by the site complexity designation as specified in the RFP and as summarized below.

- Low complexity sites: no borehole investigation required;
- Medium complexity sites: two boreholes required; one at or as close as possible to each of the proposed abutment locations; and
- High complexity sites: four boreholes required; two boreholes at or near the proposed bridge abutment locations and two boreholes at the locations of the approaches.

As previously mentioned, some of the proposed bridge sites located on private property for which PTE could not be obtained were not investigated to the target effort level (i.e. complexity rating). Where considered practical, alternative borehole locations were drilled as close as possible to these proposed bridge sites, taking into consideration local access constraints such as railway lines, underground services, property lines and right-of-way, fences, difficult terrain, and environmental considerations.

The field investigations were carried out using truck-mounted and track-mounted drill rigs, or portable drilling equipment, supplied and operated by Eastern Soil Drilling of Oshawa, Ontario. The boreholes were advanced using solid stem and hollow stem augers (108 mm and 210 mm outer diameter, respectively) or wash boring methods with casing (92 mm outer diameter), to competent strata and generally penetrated 3 m into ‘100-blow’ materials or terminated upon practical refusal (i.e. typically on shale bedrock). Two boreholes drilled with portable equipment were terminated on competent material and a Dynamic Cone Penetration Test (DCPT) was advanced below the base of the borehole to refusal. In three boreholes, refusal on bedrock was verified by coring a minimum of 3 m into the rock using an HQ-size (96 mm outside diameter) core barrel. The depths of the boreholes ranged from 5.5 m to 41.5 m below the existing ground surface.

Soil samples were obtained at 0.75 m to 1.5 m intervals of depth, using 50 mm outside diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedure. In-situ vane tests using an MTO “N”-sized vane were carried out at selected depths where soft to stiff cohesive soils were encountered, and relatively undisturbed, thin-walled Shelby tube samples of these materials were obtained at selected locations.

The groundwater conditions in the open boreholes were observed throughout the drilling operations, and whenever possible, one piezometer was installed in a selected borehole at each bridge site. A total of thirty (30) piezometers were installed as part of the subsurface investigation for this project. The piezometers consist of 50 mm outside diameter rigid PVC pipe with a 1.5 m long screen that is surrounded by a sand pack and sealed at a selected depth within the boreholes. The annulus between the borehole wall and the piezometer pipe above the filter pack was backfilled to ground surface using bentonite pellets. All other boreholes were backfilled to ground surface using bentonite pellets on completion of drilling in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

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 field work was supervised on a full-time basis by members of Golder’s engineering or technical staff who located the boreholes in the field, arranged for the clearance of underground service locations, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder’s laboratory in Mississauga for further examination and testing. Various combinations of index and classification tests consisting of water content determinations, Atterberg limits, grain size distribution, laboratory organic content, as well as oedometer (consolidation) testing, were carried out on selected soil samples. Laboratory Point Load tests were carried out on selected samples of the rock core.

The borehole locations in plan were measured on-site by Golder personnel using a Trimble Pathfinder ProXH GPS unit with an accuracy of +/- 1 m. Because the GPS unit does not provide a suitable accuracy for ground surface elevation, the elevation of the ground surface at the borehole locations was subsequently determined based on the Digital Terrain Model and topographical mapping provided by URS. The borehole locations (MTM NAD83 northing and easting coordinates) and the ground surface elevations (referenced to Geodetic datum) at the borehole locations are presented on the Record of Borehole sheets, provided in Appendix A.

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geology

The alignment of the proposed Highway 407 East Extension – Western Section, including the West Durham Link, 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*[1] and described below.

The Oak Ridges Moraine region: forms the northern boundary of the western 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 South Slope region: the majority of the Highway 407 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 flowing streams towards Lake Ontario.

The Iroquois Plain region: encompasses the area of the proposed West Durham Link and extends south 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 is described as being comprised of blue-grey shales of the Blue Mountain Formation and limestones of the Lindsay Formation. The bedrock in the area 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

The structure designation, structure category (i.e. overpass, underpass, culvert), location, designated site complexity/ranking (desired level of investigative effort), boreholes advanced at or adjacent to the site as part of the current and/or previous investigations, and current status of investigation for each structure are summarized below.

All structure locations and designations were provided by URS on February 20, 2009 and are shown on Drawings 2 to 8. The bridge structures located along the proposed Highway 407 West Mainline and WDL are designated as 'WM' structures and 'WL' structures, respectively. The water crossing structures are designated with a revised structure number (i.e. Watershed Number).

It should be noted that some bridge / culvert structure locations were added and others deleted as the project progressed, due to changes in alignment and profile and re-classification of through roads to cul-de-sacs. The new and deleted bridge / culvert sites are also identified below. FIDR sheets or AFC sheets were not developed for the new sites. At some locations, the bridge / culvert structures were deleted after the boreholes had been drilled and as a result, FIR (Part A) only sheets were developed for information purposes and are included in this report.

It should also be noted that all culvert sites were originally designated as low-complexity sites in the Phase I study report. Thus, no borehole investigation was carried out at the culvert sites as part of the current Phase II foundation investigation. Subsequent to completion of the field investigation at sites for which PTE had been granted the structural designer indicated that the designation of some culverts in the Phase I study had been changed to medium complexity bridge structures (span length greater than 6 m with open footing foundations as agreed upon by the Foundations Team for the project). In addition, new culvert and bridge structures have been identified for the project that were not included in the Phase I study. As a result, the target investigative effort initially identified for all new structures and culverts that have been re-classified as medium complexity was not achieved and additional investigations will be required at a later stage as new permission to enter are granted or during detailed design.

[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

Original Structure No. (Original Site Ranking)	Revised Structure No.	Revised Category (Original Category)	Revised Location (Original Location)	Revised Site Ranking	Borehole Nos.	Remarks[5]
WEST MAINLINE STRUCTURES						
WM-A (Medium)	WM-UC-2	Bridge	EBL-Urfe Creek South Widening	Medium	WMA-1, WMA-2	Refer to Phase II FIDR sheets
WM-1/2 (Medium)	WM-BC-3	Bridge	WBL&EBL Widening over Brougham Creek	Medium	WM1-1, WM2-1	Refer to Phase II FIDR sheets
n/a	WM-BC-3A	Bridge	Sideline 16 over Brougham Creek at Site#3A	Medium	-	New Structure – Phase I or II sheets to be developed
WM-2A/2B (Low)	WM-TABC-4	Culverts	407 WBL/EBL over Brougham Creek at Site #4	Medium	-	Revised Ranking – new structure and Phase I or II sheets to be developed
n/a	WM-TABC-5	Culvert	Realigned Brock Road over Brougham Creek tributary at Site #5	Low	-	New Structure – Phase I AFC sheet to be developed
n/a	WM-TABC-101	Culvert	Realigned Hwy 7 over Brougham Creek tributary at Site #101	Medium	-	New Structure - Phase I or II sheets to be developed
n/a	WM-TABC-102	Culvert	Realigned Brock Road over Brougham Creek tributary at Site #102	Medium	-	New Structure – Phase I or II sheets to be developed
WM-3 (Medium)	WM-3	Underpass	Realigned Brock Road over Hwy 407	Medium	WM3-1, WM3-2	Refer to Phase II FIDR sheets
~~WM-4 (Medium)~~	n/a	(Overpass)	(Realigned Highway 7)	n/a	-	Structure Deleted
WM-5/6 (Medium)	WM-SC-7	Bridge	WBL&EBL over Spring Creek	Medium	-	No PTE - Refer to copy of Phase I AFC sheet
WM-7 (Medium)	WM-7	Overpass	Realigned Hwy 7	Medium	WM7-2, WM7-1A	Refer to Phase II FIDR sheets
WM-8 (Medium)	WM-8	Underpass	Realigned Sideline 14 (Sideline 14)	Medium	WM8-1, P6[1]	Refer to Phase II FIDR sheets
WM-9/10 (Medium)	WM-SC-8	Bridge	EBL&WBL over Spring Creek	Medium	-	No PTE – Refer to copy of Phase I AFC sheet
~~WM-11 / 11A (High)~~	n/a	(Underpass)	(Realigned Paddock Road over 407)	n/a	WM11-1, WM11-2, WM11A-1, P7[1]	Structure Deleted – (FIDR sheet included for information purposes only)
WM-12 / 13 (Medium)	WM-EDC-9	Bridge	EBL&WBL over East Duffins Creek	Medium	WM12-1, WM13-1	Refer to Phase II FIDR sheets
WM-14/15/16 (Low)	WM-TBEDC-10	Culverts	WBL&EBL over realigned East Duffins Creek tributary at Site#10	Low	-	Refer to copy of Phase I AFC sheets for each structure
n/a	WM-TBEDC-10A	Culvert	Westney Road over East Duffins Creek tributary at Site #10	Low	-	New Structure – Phase I sheet to be developed
WM-17 (Medium)	WM-17	Underpass	Westney Rd. over 407	Medium	WM17-1, WM17-2	Refer to Phase II FIDR sheets
WM-18/19 (Medium)	WM-TACC-11	Bridge	EBL&WBL over Carruthers Creek West tributary	Medium	-	No PTE - Refer to copy of Phase I AFC sheet
WM-20/21 (Medium)	WM-TBCC-12	Bridge	EBL&WBL over Carruthers Creek West tributary	Medium	-	No PTE – Refer to copy of Phase I AFC sheet
WM-22 (Medium)	WM-22	Underpass	Salem Road over 407	Medium	WM22-1, P8[1]	Refer to Phase II FIDR sheets
~~WM-23A (Low)~~	n/a	(Culvert)	(EBL&WBL over watercourse at Site #13)	n/a	-	Structure Deleted
WM-23 (Low)	WM-TDCC-14	Bridge (Culvert)	EBL&WBL over tributary to Carruthers Creek at Site#14	Medium	-	Revised Ranking – Refer to Phase I AFC sheet (Phase II sheets to be developed)
WM-24 (Low)	WM-TECC-15	Bridge (Culvert)	EBL&WBL over Carruthers Creek at Site#15	Medium	WM25-1, P9[1]	Refer to Phase II FIDR sheets
~~WM-25 (Medium)~~	n/a	(Overpass)	(Sideline 4)	n/a	WM25-1, P9[1]	Structure Deleted – (FIDR sheet included for information purposes only)
WM-26 (Low)	WM-TALC-16	Bridge (Culvert)	EBL&WBL over Lynde Creek tributary at Site#16	Medium	-	Revised Ranking – Refer to Phase I AFC sheet (Phase II sheets to be developed)
WM-27 (Medium)	WM-27	Overpass	EBL&WBL over Kinsale Rd.	Medium	WM27-1, WM27-2	Refer to Phase II FIDR sheets
WM-28 (Medium)	WM-28	Underpass	Lakeridge Road over 407	Medium	WM28-1, P10[1]	Refer to Phase II FIDR sheets
~~WM-29 (Medium)~~	n/a	(Underpass)	(Halls Rd. N. over 407)	n/a	(WM29-1, WM29-2)	Structure Deleted – (FIDR sheet included for information purposes only)
n/a	WM-TDLC-17A/17B/17C	Culvert(s)	Lakeridge Rd/407 IC – E-NS Ramp / S-W Ramp / N/S-E Ramp over realigned watercourse at Site#17	Low	WM29-1, WM29-2, WL31-1	New Structure(s) – Phase I level sheet to be developed
~~WM-30/31 (Medium)~~	n/a	(Overpass)	(EBL&WBL over West Lynde Creek)	n/a	-	Structure Deleted
WM-32 (Medium)	WM-32A/32B/32C	Underpass	Coronation Rd. over 407/over 407-WDL IC – E-S Ramp/ over 407-WDL IC-S-E Ramp (Realigned Coronation Rd.)	Medium	P11[1]	Revised Structure Location – Refer to Phase I AFC sheet for general site conditions but actual location of structure has shifted 250 m West (Phase II sheets to be developed)

Original Structure No. (Original Site Ranking)	Revised Structure No.	Revised Category (Original Category)	Revised Location (Original Location)	Revised Site Ranking	Borehole Nos.	Remarks[5]
WM-33 / 34 (Medium)	WM-TGLC-19	Bridge	EBL&WBL over West Lynde Creek	Medium	-	No PTE – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)
~~WM-35 (Medium)~~	n/a	(Underpass)	(Country Lane over Hwy 407)	n/a	(WM35-1, WM35-2)[4]	Structure Deleted - (FIDR sheet at original location included for information purposes only)[4]
n/a	WM-35[4]	Underpass	Lakeridge Rd/407 IC – N/S- E Ramp over 407-WDL IC – W-S Ramp	Medium	WL27-1, WM29-2, 8[2]	New Structure - FIR sheet for original WL-27 structure at this location included for information purposes; Phase I or II sheets to be developed
WM-36/37 (Medium)	WM-THLC-20	Bridge	EBL&WBL over Lynde Creek tributary	Medium	WM36-1, WM37-1	Refer to Phase II FIDR sheets
WM-38 (Medium)	WM-38	Underpass	Cochrane St. over 407	Medium	WM38-1, WM38-2	Refer to Phase II FIDR sheets
WM-39/40 (Medium)	WM-TILC-21	Bridge	EBL&WBL over East Lynde Creek tributary	Medium	WM39-1, WM40-1, WM41-1, WM41-2	Refer to Phase II FIDR sheets
~~WM-41 (Medium)~~	n/a	(Overpass)	(Cochrane St./407 IC – E-NS Ramp over watercourse at Site#21)	n/a	(WM41-1, WM41-2)	Structure Deleted
WM-42 (Medium)	WM-TILC-21A	Underpass	Winchester Rd. West (Hwy 7) over 407 and Lynde Creek tributary at Site#21	Medium	WM39-1, WM42-1, WM40-1, P12[1]	Refer to Phase II FIDR sheets
WM-43 (Medium)	WM-43	Underpass	Ashburn Rd. over 407	Medium	WM43-1, WM43-2	Refer to Phase II FIDR sheets
WEST DURHAM LINK STRUCTURES						
WL-1 (Low)	WL-TTLC-99	Culvert	EBL&WBL over Site#99	Medium	9-1[3], 9-2[3]	Revised Ranking – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)
n/a	WL-TTLC-99A	Culvert	Realigned Lake Ridge Rd. over Site #99A	Low	-	New Structure – Phase I sheet to be developed
WL-2 / 3 (High)	WL-2	Overpass	Realigned Lakeridge Road over Realigned Hwy 401 N-W Ramp/CNR and GO Transit Tracks	High	WL2-1, WL2-2, WL3-1, WL3-2, WL3-3, 9-2[3]	Refer to Phase II FIDR sheets
~~WL-4 (Medium)~~	n/a	(Overpass)	(WDL/Hwy 401 IC- EB On-Ramp over W-N Ramp)	n/a	WL4-1, 9-3[3]	Structure Deleted - (FIDR sheet included for information purposes only)

Original Structure No. (Original Site Ranking)	Revised Structure No.	Revised Category (Original Category)	Revised Location (Original Location)	Revised Site Ranking	Borehole Nos.	Remarks[5]
WL-5 (Medium)	WL-TALC-51A	Overpass	WDL/Hwy 401 IC- N-W ramp over Lakeridge Road/401 IC-E-NS Ramp and over West Lynde Creek at Site #51	Medium	WL5-2	Refer to Phase II FIDR sheets
n/a	WL-TALC-51B	Bridge	Hwy 401/Lakeridge Road E-NS Ramp over West Lynde Creek at Site #51	Medium	WL5-2	New Structure – Phase I or II sheets to be developed
WL-6 (Low)	WL-TALC-51	Bridge (Culvert)	Realigned Hwy 401 over West Lynde Creek at Site#51	Medium	WL5-2	Revised Ranking – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)
WL-7 (High)	WL-TALC-51C/WL7	Underpass & Overpass	WDL/Hwy 401 IC- W-N Ramp over Realigned Hwy 401 and West Lynde Creek and under N-E Ramp	High	WL7-1, WL7-2, WL4-1, WL8-1, WL8-3, 9-3[3]	Refer to Phase II FIDR sheets
n/a	WL-TALC-51D	Bridge	Lakeridge Road/401 IC – NS-E Ramp over West Lynde Creek at Site#51	Medium	-	New Structure – Phase I or II sheets to be developed
WL-8 / 9 (High)	WL-9	Overpass	WDL/Hwy 401 IC- N-E Ramp over realigned Hwy 401 and W-N Ramp	High	WL8-2, WL8-3, WL9-1, 9[2]	Refer to Phase II FIDR sheets
WL-10 (Medium)	WL-LC-100A	Bridge	Hwy 401-WDL IC – N-E Ramp over Lynde Creek	Medium	WL10-1, WL11-1	Refer to Phase II FIDR sheets
WL-11 (Medium)	WL-LC-100	Bridge	Realigned Hwy 401 over Lynde Creek	Medium	WL10-1, WL11-1	Refer to Phase II FIDR sheets
WL-12 (Medium)	WL-12	Underpass	WDL under Dundas Street West	Medium	WL12-1, 1[2]	Refer to Phase II FIDR sheets
n/a	WL-TALC-49	Culvert	Dundas St. over West Lynde Creek at Site#49	Medium	-	New Structure – Phase I or II sheets to be developed
~~WL-13/14 (Low)~~	n/a	(Culverts)	(WDL over creek at Stn 11+100 and realigned Halls Rd. over site #48)	n/a	-	Structures Deleted
~~WL-15 (Medium)~~	n/a	(Underpass)	(Realigned Halls Rd. North over WDL)	n/a	-	Structure Deleted
n/a	WL-TBLC-47	Bridge	WDL over West Lynde Creek tributary at Site #47	Medium	-	New Structure – Phase I or II sheets to be developed
WL-16 (Medium)	WL-16	Underpass	Rossland Road West over WDL	Medium	WL16-1	Refer to Phase II FIDR sheets
WL-17 (Low)	WL-TBLC-47A	Culvert	Rossland Rd & E-N Ramp over realigned watercourse at Site #47A	Medium	3[2]	Revised Ranking – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)

Original Structure No. (Original Site Ranking)	Revised Structure No.	Revised Category (Original Category)	Revised Location (Original Location)	Revised Site Ranking	Borehole Nos.	Remarks[5]
n/a	WL-TALC-97	Culvert	Rossland Rd. over West Lynde Creek tributary at Site #97	Medium	-	New Structure – Phase I or II sheets to be developed
~~WL-17A (Low)~~	n/a	(Culvert)	(Realigned Halls Rd. over watercourse at Site #46)	n/a	-	Structure Deleted
~~WL-18 (High)~~	n/a	(Overpass)	(Realigned Halls Rd. over CPR)	n/a	-	Structure Deleted
WL-19/19A (High)	WL-19	Underpass	CPR over WDL	High	WL19-2A, WL19-3A, WL19A-1A, WL19A-2A	Refer to Phase II FIDR sheets
n/a	CPR Culvert	Culvert	CPR over existing watercourse east of WDL	Medium	-	New Structure – Phase I or II sheets to be developed
~~WL-19B (Low)~~	n/a	(Culvert)	Taunton Rd. over existing watercourse	n/a	-	Structure Deleted
WL-20 (Medium)	WL-20	Underpass	Taunton Rd. over WDL	Medium	WL20-1, WL20-2	Refer to Phase II FIDR sheets
n/a	WL-TBLC-45	Culvert	Taunton Rd & E-N Ramp over realigned watercourse at Site#45	Medium	-	New Structure – Phase I or II sheets to be developed
WL-21 (Low)	WL-TBLC-44	Bridge (Culvert)	WDL over existing watercourse at Site #44	Medium	-	Revised Ranking – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)
~~WL-22 (Medium)~~	n/a	(Underpass)	(Realigned Halls Rd. N. over WDL)	n/a	-	Structure Deleted
n/a	WL-AC-2	Culvert	Wildlife crossing over Stn. 15+850	Low	-	New Structure – Phase I level sheet to be developed
n/a	WL-AC-1	Culvert	Wildlife crossing over Stn. 16+790	Medium	-	New Structure – Phase I or II sheets to be developed
n/a	WL-TMLC-43	Bridge	WDL over watercourse at Site #43	Medium	-	New Structure – Phase I or II sheets to be developed
WL-23 (Medium)	WL-23	Overpass	WDL SB over Winchester Rd. W. (Hwy 7)	Medium	WL23-1, 7[2]	Refer to Phase II FIDR sheets
WL-23 (Medium)	WL-23A	Overpass	WDL NB over Winchester Rd. W. (Hwy 7)	Medium	WL23-1, 7[2]	Refer to Phase II FIDR sheets
~~WL-24 (Medium)~~	n/a	(Bridge)	(Realigned Coronation Rd. over Lynde Creek)	n/a	(WL24-1, WL24-2)	Structure Deleted (refer to FIR sheet for information purposes only)
~~WL-24A (Low)~~	n/a	(Culvert)	(realigned Coronation Road over tributary of Lynde Creek)	n/a	-	Structure Deleted

Original Structure No. (Original Site Ranking)	Revised Structure No.	Revised Category (Original Category)	Revised Location (Original Location)	Revised Site Ranking	Borehole Nos.	Remarks[5]
WL-25 (Medium)	WL-TDLC-41B	Bridge	407-WDL IC – S-W & S-E Ramps over Lynde Creek tributary at Site#41B	Medium	-	No PTE – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)
WL-26 (Medium)	WL-TDLC-41A	Bridge	407-WDL IC – E-S and W-S Ramps over Lynde Creek tributary at Site #41A	Medium	WL26-1, WL26-2	Refer to Phase II FIDR sheets
~~WL-27 (Medium)~~	n/a	(Overpass)	(407-WDL IC – W-S Ramp over Lynde Creek tributary at Site #17)	n/a	(WL27-1, WL27-2)	Structure Deleted (refer to FIR sheet for information purposes only)
WL-28 (High)	WL-28	Overpass-Tunnel (Underpass)	407-WDL IC – 407 over E-S Ramp	High	WL28-1, WL28-2	Refer to Phase II FIDR sheets
WL-29 (High)	WL-29	Underpass	407-WDL IC – S-W Ramp over 407 and over E-S Ramp	High	-	No PTE – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)
~~WL-30 (Medium)~~	n/a	(Overpass)	(407-WDL IC – S-W Ramp over watercourse at Site #17)	n/a	-	Structure Deleted
WL-31 (Medium)	WL-31	Overpass	407-WDL IC – S-W Ramp over Halls Rd.	Medium	WL31-1, WM29-1	Refer to Phase II FIDR sheets
WL-32 (Medium)	WM-TGLC-19A	Bridge	407-WDL IC – E-S Ramp over Lynde Creek at Site #19	Medium	-	No PTE – Refer to copy of Phase I AFC sheet (Phase II sheets to be developed)
~~WL-33 (Medium)~~	n/a	(Underpass)	(Realigned Coronation Rd. over 407/WDL IC – E-S Ramp)	n/a	-	Structure Deleted
~~WL-33A/B (Low)~~	n/a	(Culverts)	(407 over Lynde Creek tributary)	n/a	-	Structures Deleted

1 MTO Geocres No. 30M14-227
2 MTO Geocres No. 30M15-84
3 MTO Geocres No. 30M15-80
4 Structure location WM-35 has changed significantly since borehole investigation.
5 When referring to Phase I AFC sheets, it is noted that the Hwy 407 Stationing provided in the Phase I AFC sheets is different from the current Hwy 407 Phase II Stationing.

The 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 and rock 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 previous MTO investigations located along the Highway 407 and WDL alignments in this section are provided in Appendix C and approximate locations (converted to MTM NAD 83 co-ordinates) are shown on Drawings 2 to 8.

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. It should also be noted that the water levels which were observed in the open boreholes or measured in the piezometers are expected to fluctuate seasonally and should be expected to rise during the spring and other wet periods of the year.

A summary of the subsoil and groundwater conditions encountered at each proposed bridge site, together with site-specific drawings showing the proposed structure, the borehole location and a stratigraphic profile, are presented in the individual Preliminary Foundation Investigation Report sheets, following the text of this report.

The sections where the proposed highway is to be constructed in a deep cut or as a high fill are summarized below. The summary shows the deep cut area (designated 'DC-') or high fill area (designated 'HF-') number, location (station to station), maximum depth and height of the proposed cut or fill, and existing boreholes in the area. At the deep cut and high fill areas, specific boreholes have not yet been drilled as "Authorization to Proceed" with the work has not been granted. Therefore, wherever possible, borehole information from adjacent structures has been used to develop the recommendations provided. Where relevant borehole information was not available within reasonable distance (about 150 m) 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 subsurface conditions at the deep cut and high fill sections are summarized in the Preliminary Foundation Investigation and Design "Deep Cuts" and "High Fills" tables following the FIDR and AFC sheets for the structures.

Deep Cut or High Fill Section	Approximate Station Limits		Length (m)	Approximate Maximum Depth of Cut (m)	Approximate Maximum Height of Fill (m)	Existing Borehole(s) in Area
West Mainline						
HF-W1	11+725	11+800	75	-	5.5	WM1-1, WM2-1
HF-W2	11+925	11+975	50	-	5.0	-
HF-W3	12+475	12+930	455	-	17	WM7-1A, WM7-2
DC-W1	13+225	13+500	355	18.0	-	WM8-1, P6
HF-W4	13+625	13+900	275	-	10.0	-
HF-W5	14+400	14+975	575	-	14.5	WM12-1,WM13-1, P7, WM11A-1, WM11-2
DC-W2	15+500	15+885	385	6.5	-	-
HF-W6	16+150	16+275	125	-	6.5	-
HF-W7	16+525	16+735	210	-	6.5	-
HF-W8	17+240	17+625	385	-	6.5	-
DC-W3	18+060	18+300	240	12.0	-	-
HF-W9	18+450	18+550	100	-	5.5	WM27-1, WM27-2
DC-W4	18+700	19+200	500	7.0	-	WM27-1, WM27-2
DC-W5	19+560	19+700	140	8.0	-	WM28-1, P10
DC-W6	20+275	20+450	175	8.0	-	WL28-2
DC-W7	20+615	20+700	85	5.5	-	WL28-1,WL28-2, P11
HF-W10	20+885	21+225	340	-	11.5	-
DC-W8	21+450	21+590	140	11.5	-	WM35-1, WM35-2
HF-W11	21+675	22+075	400	-	7.0	WM36-1, WM37-1
DC-W9	22+325	22+625	300	7.5	-	WM38-1, WM38-2
HF-W12	22+930	23+000	70	-	6.5	WM40-1
DC-W10	23+275	23+725	450	7.0	-	WM43-1, WM43-2
West Durham Link						
HF-W13	18+050	18+490	440	-	10.0	WL23-1, 7
HF-W14	17+325	17+700	375	-	7.5	-
HF-W15	14+350	15+075	725	-	8.0	-
DC-W11	12+400	12+890	490	6.5	-	WL-19A-1A, WL-19A-2A, WL19-2A, WL-19-3A

Notes:

1. Deep cuts/high fills are defined as areas which are deeper/higher than 4.5 m;
2. The extent and depth/height of deep cuts and high fills were estimated from base plans and profiles provided in digital format by URS drawing file titled “407E Western Section Plan & Profile (Ver 4.2).dwg”, received Nov.6, 2008.

It should be noted that the subsurface conditions presented in the Preliminary Foundation Investigation and Design tables for High Fills and Deep Cuts are inferred from limited borehole information and interpreted from terrain/digital maps, as noted above. The subsurface conditions described are therefore approximate and may differ from the actual subsurface conditions that exist along the proposed deep cut and high fill sections.

4.3 General Groundwater Conditions

The water level was observed in open boreholes at the time of drilling, and standpipe piezometers were installed at thirty (30) borehole locations as part of the current investigation for the project. The remaining boreholes were backfilled immediately after the completion of drilling and before the local water level had stabilized.

Details of the piezometer installations and history of water levels measured in the boreholes are shown on the Record of Borehole sheets in Appendix A.

The most recent water levels measured in the piezometers are summarized below and represent the stabilized groundwater levels (except where noted). The water level(s) in open boreholes at completion of drilling are presented on the Record of Borehole sheets but are not considered stabilized and are in fact affected by water introduced during drilling operations, or depressed due to advancement of the boreholes.

Borehole Number	Ground Surface Elevation (m)	Depth to Water Level below Ground Surface (m)	Water Level Elevation (m)	Date
WMA-2	196.0	5.4	190.6	April 4, 2008
WM2-1	187.6	4.5	183.1	April 4, 2008
WM3-2	181.0	3.9	177.1	April 4, 2008
WM7-2	166.4	2.1	164.3	April 4, 2008
WM8-1	168.1	0.7	167.4	April 4, 2008
WM11-2[1,2]	152.4	-(2.4)	154.8	March 24, 2008
WM17-1	155.0	2.5	152.5	April 4, 2008
WM22-1	169.0	4.8	164.2	April 4, 2008
WM25-1	180.1	2.2	177.9	April 4, 2008
WM27-2	191.8	0.3	191.5	April 5, 2008
WM28-1	194.0	3.4	190.6	April 4, 2008
WM29-2	190.0	7.8	182.2	April 4, 2008
WM35-1	165.0	2.5	162.5	April 4, 2008
WM37-1	153.2	1.6	151.6	April 4, 2008
WM38-1	170.1	3.9	166.2	April 4, 2008
WM39-1	159.0	1.6	157.4	April 4, 2008
WM41-2	161.2	1.7	159.5	April 4, 2008
WM43-1	164.0	1.2	162.8	April 4, 2008
WL3-3	88.0	3.1	84.9	April 5, 2008
WL5-2	80.0	0.7	79.3	April 5, 2008
WL8-3	82.0	0.7	81.3	April 5, 2008
WL11-1	79.0	0.0	79.0	April 5, 2008
WL12-1	87.0	0.6	86.4	August 15, 2008
WL19-2A	105.8	2.5	103.3	March 23, 2009
WL20-2	115.0	7.4	107.6	April 5, 2008
WL23-1	166.3	1.3	165.0	April 4, 2008
WL24-2	150.0	0.3	149.7	April 14, 2008
WL27-2	174.0	0.3	173.7	April 4, 2008
WL28-2	176.3	0.3	176.0	April 4, 2008
WL31-1	188.4	0.2	188.2	April 5, 2008

[1] Artesian Conditions encountered.
[2] Piezometer decommissioned on March 24, 2008 in accordance with Ontario Regulation 903.

The measured groundwater levels in the piezometers range from ground surface to 8 m below ground surface but typically were measured within about 5 m below ground surface. It should be noted that artesian water conditions were measured at one piezometer location (WM11-2) and observed during drilling at three other deep borehole locations (WM12-1, WM13-1, and WM41-1). The boreholes which encountered artesian conditions are located within low-lying creek or valley areas, specifically near Duffins Creek and Lynde Creek tributaries. The artesian water pressures were measured to be up to about 2.4 m above existing ground surface and were encountered within granular layers (typically greater than 10 m thick) present about 8 m to 20 m below ground surface which are overlain by cohesive deposits. Details of the site-specific groundwater conditions at each bridge site are provided on the Preliminary Foundation Investigation (FIR) sheets, following the text of this report.

It should be noted that the groundwater levels at the site are anticipated to fluctuate as a result of seasonal variations in precipitation and runoff at the site.

5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Ms. Beng Lay Teh and Mr.Tomasz Zalucki, E.I.T., and reviewed by Mr. Kevin Bentley, P.Eng., a Senior Geotechnical Engineer with Golder, with technical input from Mr. Murty Devata, P.Eng., a Specialist Foundations Consultant to Golder. Mr. Jorge M.A. Costa, P.Eng., a Principal of Golder and a Designated MTO Contact provided quality control review of this report for conformance with the project Terms of Reference.

GOLDER ASSOCIATES LTD.

Beng Lay Teh
Geotechnical Group

Tomasz Zalucki, E.I.T.
Geotechnical Group

Kevin J. Bentley, P.Eng.
Senior Geotechnical Engineer

Jorge M.A. Costa, P.Eng.
Principal, Designated MTO Contact

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PART B

PRELIMINARY FOUNDATION DESIGN REPORT
HIGHWAY 407 EAST EXTENSION – WESTERN SECTION
REGION OF DURHAM
MINISTRY OF TRANSPORTATION, ONTARIO
W.O. 07-20015

6.0 ENGINEERING RECOMMENDATIONS FOR PRELIMINARY DESIGN

6.1 General

This section of the report provides foundation design recommendations for the preliminary design of the proposed bridge structures along the Highway 407 East Extension-Western Section Mainline and West Durham Link (WDL) routes. The preliminary foundation design recommendations provided herein are based on interpretation of the factual data obtained from limited current borehole investigations and previous borehole data obtained by MTO, at or near the site of the proposed structures, but not necessarily at or within the footprint of the foundation elements. The interpretation and recommendations are intended to provide the designers with adequate information to assess the feasible foundation alternatives for the preliminary design of the proposed structure foundations. Where comments are made on construction they are provided in order to highlight those aspects which could affect the current preliminary design of the project, and for which special provisions or operational constraints could potentially be required.

6.2 Structure Foundation Recommendations

As discussed in Section 2.0, sixty-six (66) structures consisting of fifty (50) bridge structures and sixteen (16) culvert structures are currently proposed for the crossing of the Highway 407 West Mainline and WDL at the locations of creeks, municipal or regional roads, railways and associated new ramps/bridges. Preliminary foundation recommendations for each bridge site where boreholes were advanced, including a description of the proposed bridge structure(s) configuration assumed at the time of preparation of this report, are provided in the individual Preliminary Foundation Investigation and Design Report (FIDR) sheets, following the text of this report. At structure sites where no borehole information was obtained to meet the Phase II level of investigative effort, copies of the Phase I Anticipated Foundation Conditions Sheets (prepared by Thurber) have been included in lieu of the Preliminary FIDR sheets. Any new structure sites that were identified late in the Phase II investigation and design process are identified in Section 4.2 and on Drawings 2 to 8, but no Phase I or II foundation sheets were currently prepared and will be added as more information is obtained.

It is noted that the current subsurface investigation is generally limited to drilling boreholes near the locations of the bridge abutments to obtain subsurface information representative of the general site. No boreholes were advanced specifically within the foundation footprint of the bridge abutments, potential pier locations, nor at the approach embankment locations for any medium or high complexity sites. The boreholes were advanced to obtain subsurface information representative of the general site. Therefore, further investigations at the final locations of the bridge abutments and piers are required during detail design to obtain subsurface information specific to the foundation locations and to confirm that the subsurface conditions and the geotechnical parameters and resistance values provided in this preliminary design phase are appropriate for the detail design of the foundations.

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.

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

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 bridge approaches are provided where subsoil conditions are considered to be suitable for shallow foundations, as indicated on the individual Preliminary FIDR sheets for each bridge 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 thick Granular ‘A’ pad placed below the base of the footing. The Granular ‘A’ pad should extend at least 1 m beyond the plan limits of the footing and be sloped no steeper than 1 Horizontal : 1 Vertical (1H:1V) in general accordance with MTO guidelines (see Figure 1). The Granular ‘A’ pad should be constructed in accordance with MTO Special Provision 105S10.

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. These preliminary values are given under the assumption that the loads are applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC, 2006)*and its *Commentary*. The geotechnical resistance values will have to be re-evaluated and modified if necessary during detail design based on future 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 x110 pile section, are provided where considered practical for foundation design of abutments and piers as indicated on the individual Preliminary FIDR sheets for each bridge site. 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 for the steel H-pile foundations founded at the anticipated pile depth/pile tip elevation are provided, based on the subsurface conditions encountered in the boreholes, respective to each bridge site.

The factored ULS resistance and SLS reaction values provided will have to be re-evaluated and modified, if necessary, during detail design in consideration of the additional subsurface investigations at the locations of each bridge foundation element. The factored geotechnical axial resistance at ULS should then be verified in the field by the use of the Hiley formula (MTO Standard Structural Drawing SS-103-11) during the final stages of driving. The ultimate geotechnical axial resistance predicted from the Hiley formula should then be multiplied by a geotechnical resistance factor equal to 0.4 in accordance with Table 6.6.2.1 in the CHBDC (2006) to verify the factored ULS design value. Based on MTO experience with the Hiley formula in the Southern Ontario region, a resistance factor equal to 0.5 may be used for this project. For complex bridge sites, if warranted during the detail design stage, the ultimate load capacity and/or load-settlement behaviour (serviceability) should be verified by full-scale pile load tests.

Pile installation should be in accordance with MTO's Special Provision SP903S01. The pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile size and length of pile.

The structural design of the piles should be based on full downdrag load where applicable and as indicated on the FDR sheets, unless measures to significantly reduce anticipated post-construction settlements are undertaken. In this case the downdrag loads can be eliminated. For preliminary design, downdrag is not considered to be a concern if the differential movement between the settlement of the soil and the compression of the pile at the pile-soil interface is less than 10 mm (NCHRP, 1997).

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 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).

The soils at many structure locations are very dense or hard glacial tills (SPT 'N'-values exceeding 100 blows) at depths of less than 5 m from the ground surface. To provide an adequate length of pile at these locations, pre-augering may be required to penetrate the very dense or hard glacial till soils.

For the installation of steel H-piles, consideration will have to be given to the possible presence of cobbles and/or boulders within the till deposits and bedrock encountered at the locations of a number of bridge sites as indicated on the FIDR sheets. Where applicable, the piles should be reinforced with driving shoes such as Titus Standard "H" Bearing Pile Point design or flange plates as per OPSD 3000.100 for protection during driving. For piles to be driven into bedrock, the following note should also be included in the Contract Drawings: "Piles to be driven to bedrock". 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 possible 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 for an impermeable plug and granular drainage layer.

In the case of bridge widening (e.g. Structure WM-A, west of Brock Road), vibration monitoring should be carried out during pile installation to ensure that the vibration levels at the existing bridge structure are maintained within tolerable levels. The tolerable limit will depend on the type and condition of the existing structure and foundation system, proximity to pile driving, etc. and will need to be determined during detail design. For preliminary assessment, a maximum peak particle velocity (PPM) of 50 mm/s at the existing bridge structure can be assumed. However, this value will need to be re-evaluated and adjusted as necessary as more information is made available during detail design.

6.2.3 Caissons

Preliminary foundation recommendations for caissons founded within "100-blow" deposits or within shale bedrock as applicable, were provided where caissons were considered to be practical for foundation design as indicated on the individual Preliminary FDR sheets for each bridge site. The factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical axial resistance at Serviceability Limit States (SLS) for 25 mm of displacement are provided for caisson diameters equal to 1.2 m and 1.5 m. The geotechnical resistance values are associated with a recommended caisson base elevation and/or embedment depth into the "100-blow" materials or into shale bedrock as the caisson will typically derive the majority of its capacity from base resistance, although shaft resistance has also been taken into account assuming permanent steel liners are required.

The factored ULS and SLS resistance values provided will have to be re-evaluated and modified, if necessary, during detail design in consideration of the additional subsurface investigations at the locations of each bridge foundation element. For complex bridge sites, if warranted during the detail design stage, the ultimate load capacity and/or load-settlement behaviour (serviceability) should be verified by full-scale caisson load tests.

The structural design of the caissons should be based on full downdrag load where applicable and as indicated on the FDR sheets, unless measures to significantly reduce anticipated post-construction settlements are undertaken in which case the downdrag loads can be eliminated. For preliminary design, downdrag is not a concern if the differential movement between the settlement of the soil and the compression of the caisson at the caisson-soil interface is less than 10 mm (NCHRP, 1997).

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.

It should be noted that “running” or “flowing” of water-bearing cohesionless strata, where encountered, could occur during or after drilling of caisson foundations. Therefore, where caisson foundations are considered, temporary or permanent caisson liners may be required to support these type of soils during construction and permit cleaning and inspection of the caisson base (possibly with a downhole camera). At some locations (as indicated on the FDR sheets), it is recommended caissons be drilled while maintaining a constant head of water inside the caisson liners to counterbalance high groundwater or artesian conditions followed by tremied concrete placement (see Section 6.7.3). 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 can result in “necking” of the caissons. 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 for the full length of the caissons. 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.

Consideration will have to be given to the possible presence of cobbles and/or boulders within the till deposits encountered at the locations of a number of bridge sites as indicated in the FDR sheets. Caisson drilling equipment must be capable of penetrating such obstacles, where applicable (refer to Section 6.7.4).

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), unless the caissons are extended above ground surface to the underside of the deck with a pile cap.

6.3 Bridge Retaining/Wing Walls

Most of the proposed bridge structures may require the construction of retaining walls and/or wing walls depending on the proposed bridge crossing configuration, available space and surrounding ground elevations. Feasible bridge retaining wall/wing wall options may include:

- Concrete retaining walls supported on spread footings or on deep foundations (often cantilevered beyond the abutment foundation) depending on the site-specific subsoil conditions as discussed on the respective Foundation Design Report sheets following the text of this report. The preliminary foundation recommendations for this type of retaining wall can be considered to be similar to the recommendations provided for the preliminary design of the bridge foundations elements.

- Retained Soil System (RSS) walls: RSS walls are considered to be the most feasible wall option for most of the bridge abutment / approach locations provided differential settlements are within tolerable limits and an adequate factor of safety against global instability is achieved. The performance of an RSS wall during foundation settlement depends primarily on the characteristics of its front facing system. Total settlements up to about 75 mm can be tolerated and a typical precast concrete panel facing can tolerate up to about 1% differential settlement (RECo, 2000). Specialized slip joints can be incorporated into the design if differential settlements exceed 1%. Subexcavation of surficial soft/loose materials, where encountered, and replacing with compacted granular material, will be required to construct the reinforced soil mass. The front facing is typically supported on a strip footing placed at shallow depth below the ground surface. The footing must be founded on competent native soils or approved engineered fill, after subexcavation and backfilling the areas where topsoil, loose/soft fill or unsuitable native soils exist. The factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical axial resistance at Serviceability Limit States (SLS) for up to 75 mm of displacement should be provided for the footings of the wall facing and reinforced earth mass during detail design. It should be noted that the limiting displacement value for SLS design should be re-assessed and confirmed during detail design and will be dependent on the actual facing type or possibly the serviceability limit of the supporting roadway or foundation (typically less than 25 mm), if applicable. The internal stability of a reinforced earth wall should be assessed by the proprietary product supplier / designer. The external stability of the RSS wall has been provided in the FDR sheets, where indicated, and should be confirmed by the geotechnical consultant at the detail design stage taking into account the final geometry and configuration.

For settlement sensitive sites (i.e. where soft cohesive deposits were encountered), retaining walls will be affected by the post-construction settlement of the wall backfill materials, depending on the height/thickness of the backfill. The selection of the wall option for such sites will thus be dependent on the predicted settlement and should be assessed during detail design. Measures to reduce settlement could be achieved by incorporating site improvement techniques such as using light weight fill materials (i.e. slag or expanded polystyrene (EPS)), installing wick drains, preloading or surcharging, and staged construction as discussed in the individual FDR sheets, where applicable. 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 the bridge abutment stems and any associated retaining walls/wing walls will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the magnitude of surcharge including construction loadings, on the freedom of lateral movement of the structure, as well as on the drainage conditions behind the walls.

The following general recommendations are made concerning the design of the stems/walls. It should be noted that these recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope in accordance with Section C6.9.2.2 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 MTO's Special Provision SP 105S10. Transverse drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3101.150 and 3121.150.

- 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.

- The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the wall stem (Case I on Figure C6.20(a) of the *Commentary to the CHBDC*) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case II on Figure C6.20(b) of the *Commentary to the CHBDC).*

- 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^3	21 kN/m^3
Coefficients of Static Lateral Earth Pressure:		
Active, K_a	0.27	0.27
At Rest, K_o	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.

6.5 Structure Approaches

The configuration of the structure approaches varies from site to site and includes approach embankment construction with fills and/or cuts depending on the design grades and ground elevations for each bridge crossing. Based on the available information provided at each bridge site, recommendations associated with the approaches stability and settlement are provided on the individual Preliminary FDR sheets following the text of this report. The following subsections provide additional project-wide recommendations associated with the preliminary design and construction of the bridge approaches.

6.5.1 Subgrade Preparation and Embankment Construction

For all proposed bridge sites, 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 valley 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. In the case of approach cuts with a shallow water table condition, it is expected that measures will need to be undertaken to stabilize the embankment slope face due to possible groundwater seepage (refer to Section 8.0 on Deep Cuts and High Fills).

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.

In the case of bridge / embankment widening (e.g. Structure WM-A), in order to minimize differential settlement between the widened portions of the approach embankments due to settlement of the fill itself, the use of granular fill is preferred over the use of cohesive fill, since the majority of settlement of granular fills will occur during construction whereas some settlement of cohesive fills, if used, would occur post−construction. The new embankment fill should be benched into the existing embankment in accordance with OPSD 208.010.

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.

6.5.2 Approach Embankment Stability

The preliminary assessment for the stability of the approaches at each bridge site was calculated based on limit equilibrium analyses using the commercially available program Slide, 2005 (Version 5.018) produced by Rocscience Inc. employing the Morgenstern-Price method of analyses and is provided on the respective Preliminary Foundation Design Report sheets for each proposed bridge/interchange site. The analyses assume approach cut/embankment side slopes no steeper than 2H:1V associated with a maximum approach height as indicated on the GA drawings provided (including a minimum 2 m wide bench at mid-height for embankment heights greater than 8 m). Where designated as safe or adequate 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.

Approaches higher than 8 m, where deemed feasible, should be constructed with a 2 m wide mid-height bench in order to control surficial erosion and to 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 approach/embankment footprint during detail design. Mitigation measures to improve slope stability for greater embankment heights can be achieved by utilizing light weight fill materials, wick drains, and staged construction, or a combination of these options, which will also help to reduce settlements.

6.5.3 Approach Embankment Settlement

Settlement of the approach embankments will occur at bridge sites due to compression of the embankment fill itself, as well as compression and consolidation of the foundation soils. The total settlement within the founding soils has been estimated based on the existing site-specific subsoil conditions for preliminary design using the commercially available program Settle 3D, 2008 (Version 1.010) produced by Rocscience Inc. and the results are reported on the individual Preliminary Foundation Design Report sheets for each bridge/interchange site. These preliminary estimates do not include compression of the 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. In the case 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 whereas non-granular earth fill or rock fill materials will exhibit additional consolidation settlement over time.

Embankment and platform width design should allow for the anticipated settlements and future padding of the pavement structure.

Where estimated post-construction (i.e. consolidation) settlement within the foundation soils exceeds acceptable limits, measures to reduce such settlement to acceptable values have been proposed. 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 for each site and will likely be based on maintenance considerations at the detail design stage. Comprehensive analyses should be carried out during detail design to further estimate the anticipated amount and time rate of post-construction settlements and to develop the final design and construction requirements of the approach embankments in such site conditions, as well as develop mitigation measures to reduce anticipated settlements to acceptable levels.

6.6 Seismic Considerations

The peak zonal acceleration ratio for the project site is 0.05 g for The Town of Whitby/Ajax, 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).

Abutment Stem and Retaining Wall/Wing Wall design: seismic (earthquake) loading must be considered in the design of the foundations in accordance with Sections 4 and 6 of CHBDC (2006) as significant seismic loading will result, for example, in increased lateral earth pressures acting on the abutment stem and retaining walls. 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 active earth pressure coefficients can be determined in accordance with Sections 6.9 and 4.6.4 of the CHBDC (2006) and its Commentary.

Approach Embankment design: liquefaction susceptibility 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 Section C.4.6.2 and C.4.6.3, respectively, of the *CHBDC Commentary* (2006).

6.7 Construction Considerations

6.7.1 Excavation and Backfill

Preliminary recommendations for open-cut excavations are provided on a site-specific basis on the Preliminary Foundation Design sheets for each bridge site and include the type of soils anticipated to be within the foundation excavations according to the Occupational Health and Safety Act (OHSA), as well as the recommended maximum side slope inclination for temporary excavations. All backfill is to be placed and compacted in accordance with MTO's SP 105S10.

6.7.2 Protection Systems

Excavation support systems may be required at the proposed bridge sites for temporary roadway protection. Where required, the temporary excavation support system should be designed and constructed in accordance with MTO's SP 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.

6.7.3 Groundwater and Surface Water Control

Anticipated groundwater levels within the foundation excavations at each proposed bridge site and anticipated groundwater and surface water control measures are reported on the individual Preliminary Foundation Design Report sheets. Groundwater levels were typically measured at ground surface down to a depth of about 5 m below ground surface. However, artesian conditions were recorded at some sites.

At locations where near surface granular (cohesionless) soils are present with a high water table, groundwater infiltration should be anticipated during excavation in such deposits, particularly during wet periods of the year. Dewatering at these sites will be required to allow for construction of foundation elements 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 during detail design.

Caissons constructed with temporary or permanent liners in granular 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 a site, it is recommended that a constant head of water be maintained inside the caisson liners to counterbalance the natural groundwater or artesian conditions. Concrete placement by tremie methods may be considered. For deep foundations at locations where artesian conditions are expected within the lower granular deposits, 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 and these aspects should be 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 Obstructions During Pile Driving / Caisson Installation

Till deposits have been encountered at a number of bridge sites along the proposed Highway 407 East Extension-Western Section route. It is anticipated that cobbles and/or boulders will be encountered within the till deposits, as noted in several boreholes, and may affect the installation of steel H-piles or drilled caissons. As such, an NSSP will need to be included in the Contract Documents during the detail design to identify to the contractor the possible presence of cobbles and/or boulders within the overburden soils on a site-by-site basis. Preliminary recommendations regarding potential obstructions during pile driving and caisson installation have been provided on the site-specific Preliminary Foundation Design Report sheets. An estimate of the range in size and quantity of cobbles / boulders for applicable sites should be incorporated into the detail design when additional borehole information is obtained.

6.7.5 Construction Access

Several creek valley crossings (i.e. environmentally sensitive areas) have been identified during the environmental assessment of the project. Potential environmental impacts will need to be minimized during construction access in the sensitive valleys such as near Lynde Creek and East Duffins Creek. Specific access preparation procedures such as the use of temporary work bridges, winter construction and/or gravel roadways underlain by geosythetics should be considered to accommodate foundation construction at these locations.

7.0 CULVERTS

As noted in the previous sections of this report, culvert sites along the proposed route for the Highway 407 East Extension - Western Section Mainline and WDL were ranked as "low complexity" sites during the Phase I desktop study for this project. As such, no site specific borehole investigations have been carried out at the proposed culvert sites during the current Phase II foundation investigation for the planning and preliminary design. Anticipated Foundation Conditions (AFC) sheets were prepared by Thurber Engineering for each culvert site and were included in the Phase I desktop study. Copies of the Anticipated Foundation Conditions sheets for culvert sites are provided following the text of this report.

During the Phase II study, the project team has identified new water crossing locations and many of the water crossings (i.e. culverts) identified during the Phase I study now require larger span lengths to satisfy hydrology / geomorphology requirements. Based on the recent General Arrangement drawings provided by the structural designer, many of the culverts now require single span structures (longer than 6 m) with open footings and have been re-classified as 'medium complexity' investigative effort sites.

A list of all culvert structures are provided in Section 4.2 and the locations are shown on Drawings 2 to 8. Copies of the Phase I AFC sheets for culverts identified in the Phase I study are provided following the text of this report. Preliminary Foundation Investigation and Design Report sheets will need to be incorporated as an addendum to this Phase II report as subsequent borehole investigations are carried out at these sites, or alternatively, appropriate site investigations to establish and/or confirm site conditions and design assumptions will be required during detail design for all culvert sites.

8.0 DEEP CUTS AND HIGH FILLS

Deep cut and high fill areas have been identified along the Highway 407 East Extension – Western Section Mainline alignment. Due to project scheduling constraints, no confirmation of authorization to proceed and lack of permissions to enter at private properties, boreholes have not been advanced (but are intended to eventually be advanced) for the purpose of assessing the preliminary foundation design requirements along deep cut/high fill sections. It is our understanding that boreholes may be completed at a later date and the findings and design recommendations included in the final report that would supercede this Phase II interim report.

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 the assessment (December 2008), deep cuts have been identified at 11 locations and high fills have been identified at 15 locations. The location, extent and depth/height of the identified deep cut/high fill areas are summarized in Section 4.2. The maximum depth of cut is in the order of 18 m and the maximum fill height is about 15 m.

Boreholes specific to the identified deep cut/high fill sections have not been drilled at this time. The preliminary design recommendations provided herein are based on interpretation of the factual data obtained during limited borehole investigations conducted at structure locations near the cut/fill sections as well as existing information obtained from previous investigations near the sites. Where relevant borehole information was not available within a reasonable distance (i.e. 150 m) 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/high fill locations and preliminary recommendations for design are summarized on the "Preliminary Foundation Investigation Report - Deep Cuts" table and "Preliminary Foundation Investigation Report – High Fills" table presented following the FIDR and AFC 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.

Geotechnical investigations will be required during detail design to confirm the subsurface conditions that were assumed throughout the cut/fill sections and confirm/re-assess 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 at a typical cut section based on limit equilibrium analysis using the commercially available program Slide, 2005 (Version 5.018) produced by Rocscience Inc. employing the Morgenstern-Price method of analyses. 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 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 provide 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).

The soil deposits in many of the cut sections, and notably till deposits, will typically be very dense/hard and often contain cobbles and boulders. Excavation in these deposits may be arduous and will require use of heavy duty excavators or dozers. 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 for a typical high fill embankment based on limit equilibrium analysis using the commercially available program Slide, 2005 (Version 5.018) produced by Rocscience Inc. employing the Morgenstern-Price method of analyses. 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 Investigation Report table for the particular section. The settlement tolerance for embankments may range from 25 mm 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 and future padding of the pavement structure.

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 shall be determined during detail design when additional subsurface information is available. Particular attention will be required in low valley 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 may be 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 in working areas.

Potential environmental impacts will need to be minimized during construction access into sensitive floodplain or valley 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. Further, sediment control measures such as silt fences, straw bales and/or granular check-dams will need to be installed downgradient of the works to reduce sediments impacts to surface water bodies.

9.0 CLOSURE

This Preliminary Foundation Design Report was prepared by Ms. Beng Lay Teh and Ms. Houda Jadi, P.Eng., and reviewed by Mr. Kevin Bentley, P.Eng., a Senior Geotechnical Engineer with Golder, with technical input and review by Mr. Murty Devata, P.Eng., a Specialist Foundations Consultant to Golder. Mr. Jorge M.A. Costa, P.Eng., a Principal of Golder and a Designated MTO Contact provided quality control review of this report for conformance with the project Terms of Reference.

GOLDER ASSOCIATES LTD.

Kevin J. Bentley, P.Eng.
Senior Geotechnical Engineer

Murty Devata, P. Eng.
Specialist Consultant

Jorge M.A. Costa, P.Eng.
Principal, Designated MTO Contact

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LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

LIST OF SYMBOLS

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

I. General

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p)/I_p$
I_C	consistency index $= (w_l - w)/I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p/\sigma'_{vo}$

(d) Shear Strength

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

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: * Grains >60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
‖ - Parallel To	
⊥ - Perpendicular To	

Form...G.A.-R-3

PHASE II PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT (FIDR)

AND

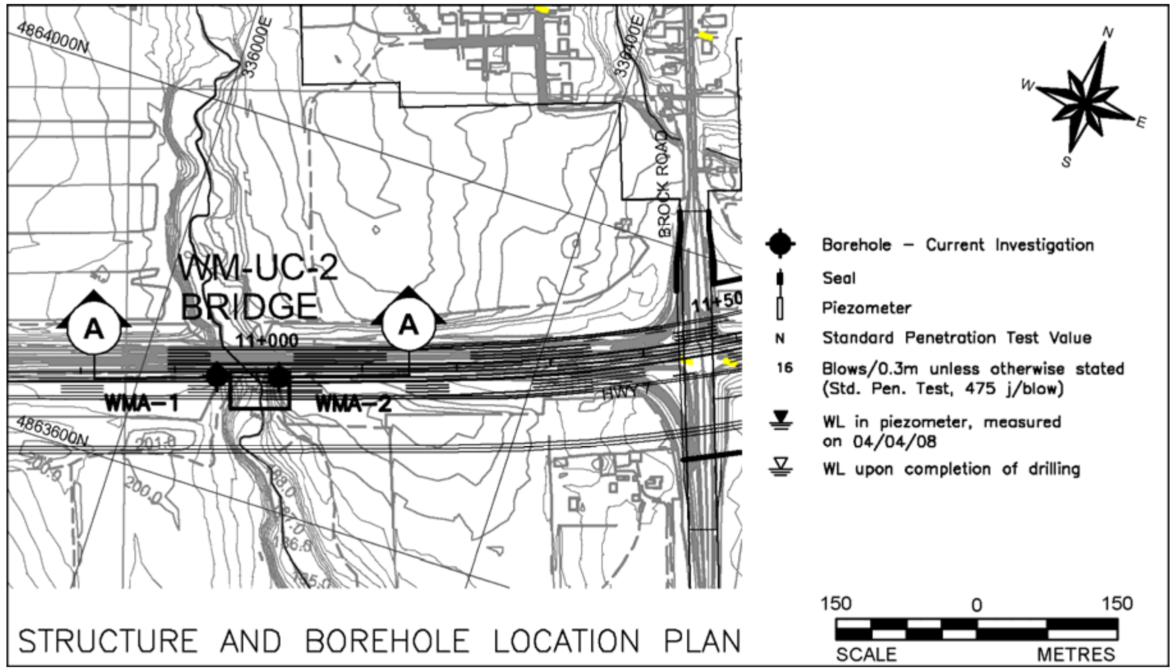
PHASE I ANTICIPATED FOUNDATION CONDITIONS (AFC)

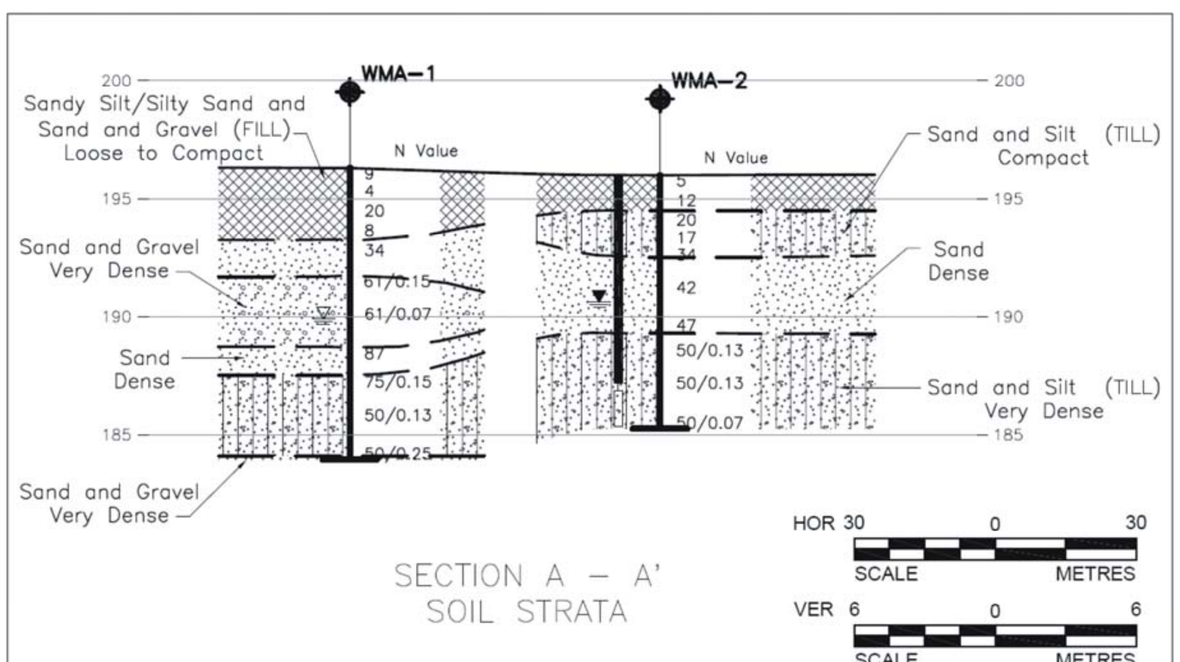
FOR STRUCTURES

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass Highway 407 EBL / Urfe Creek- South Widening **Hwy 407 Proposed Grade:** 196.7 m **Site Ranking:** Medium

Location No: WM-A (WM-UC-2) **Existing Ground Elevation:** 190 m – 196.7 m **Station:** 11+000





FOUNDATION INVESTIGATIONS

Site Description:

The proposed Urfe Creek bridge structure is located immediately south of the existing Highway 407, approximately 560 m west of Brock Road in the City of Pickering, Ontario. The bridge structure will carry the proposed highway south widening over Urfe Creek. The existing single-span bridge structure currently carrying Highway 407 over Urfe Creek of two lanes in each of the east and west bound directions. Vegetation in the vicinity of the current and proposed bridge structure consists of shrubs and trees to the north and south of Highway 407.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WMA-1	West Abutment	4 863 719.6	336 079.0	196.3	12.3
WMA-2	East Abutment	4 863 738.8	336 142.1	196.0	10.7

Subsurface Conditions:

- **Fill:** loose to compact sandy silt to silty sand containing trace clay, gravel and organic matter and sand and gravel containing trace silt. The fill extends to depths of approximately 1.5 m to 3.1 m in Boreholes WMA-2 and WMA-1, respectively. SPT 'N' values within the fill materials vary from 4 to 20 blows per 0.3 m of penetration. The result of one grain size distribution test on a sample of the fill materials is shown on Figure WMA-A (Appendix B). Measured water contents on samples of the fill vary between about 11 and 16 percent.
- **Till:** sand and silt till containing trace to some clay, trace gravel, and occasional cobbles and boulders. At Borehole WMA-2, the till deposit was encountered at Elevation 194.5 m and is interlayered with a sand deposit between Elevation 192.5 m and Elevation 189.3 m. At Borehole WMA-1, the till was encountered at Elevation 187.5 m underlying the sand and sand and gravel deposit. Measured SPT 'N' values range from 17 blows per 0.3 m of penetration to 50 blows per 0.07 m of penetration, indicating a compact to very dense relative density. The results of grain size distribution and Atterberg limits testing are presented on Figures WMA-B and WMA-C, respectively (Appendix B). Measured water contents range between 4.8 and 9.0 percent.
- **Sand and Sand and Gravel:** sand and sand and gravel deposits containing trace to some silt, trace clay and occasional cobbles were encountered immediately below the fill materials in Borehole WMA-1 and below the upper layer of sand and silt till in Borehole WMA-2. Measured SPT 'N' values within these deposits vary from 34 blows per 0.30 m of penetration to 61 blows per 0.07 m of penetration, indicating a dense to very dense relative density. The results of grain size distribution tests on sand and sand and gravel samples of these deposits are presented on Figures WMA-D and WMA-E, respectively (Appendix B). Measured water contents on samples of these layers range between about 2 and 16 percent.

Groundwater Conditions:

- **BH WMA-1:** Depth of 6.4 m below ground surface (Elev. 189.9 m) in the open borehole upon completion of drilling.
- **BH WMA-2:** Depth of 5.4 m below ground surface (Elev. 190.6 m) in piezometer on April 4, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 2**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-A (WM-UC-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 General Arrangement drawing for Structure WM-UC-2 is not yet available. For the purpose of preliminary foundation design, the bridge is assumed to be a single span structure as indicated in the preliminary structure and alignment layout drawings provided by URS. The new bridge will carry the proposed Highway 407 south widening over Urfe creek; up to 7 m of additional fill materials will be required to construct the embankment widening south of the existing Highway 407 at this location. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very dense sand or sand and silt till or on compacted Granular ‘A’ pad for abutment footings “perched” within the approach fills	• Most practical • Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of up to 3 m of surficial fill materials
Caissons bored to found within “100-blow” sand and silt till or sand and gravel	• Higher bearing resistances than spread footings	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the surface elevation of the creek bed at about Elevation 190 m, footings can be founded within the very dense sand or sand and silt till at or below Elevation 188.8 m and at a minimum depth of 1.2 m below the lowest surrounding grade. Alternatively, spread footings for the abutments could be founded on a Granular ‘A’ pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Sand and Silt Till/ Sand and Gravel	600 kPa	400 kPa
Compacted Granular ‘A’ (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel H- Piles are considered to be not practical at this site due to the presence of very dense (i.e. “100-blow”) materials at shallow depths below the existing ground surface, resulting in very short piles. However, if pile foundations are desired, consideration may be given to pre-augering and driving to provide sufficient embedment of piles. Further assessment of this alternative may be carried out during detail design.

C – Caissons: Abutments on caissons, founded within the “100-blow” sand and silt till or very dense sand and gravel at or below Elevation 185.5 m. Caissons lengths should be at least 6 m and extend 4 m to 5 m into the “100-blow” materials below the cap.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,500 kN	2,800 kN
1.5 m	5,500 kN	4,400 kN

Recommended Foundation Alternative: Shallow Foundations.

• ABUTMENT TYPE

The site soils are not suitable for construction of integral abutments, unless pile foundations are constructed using pre-augering and driving methods.

• APPROACHES

Embankment Height: up to 7 m of additional fill materials will be required to construct the embankment widening.

Stability: Approach embankments up to 8 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability:

Settlement: Assuming the use of conventional earth or granular embankment fill, it is expected that less than 50 mm of settlement will occur under the footprint of the embankment widening. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and upper sand and silt till or sand and sand and gravel deposits are classified as Type 3 and Type 2 soils, respectively according to the OHSA. Temporary excavations (i.e. open for a relatively short period of time) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within excavations for shallow foundations at about Elevation 188.8 m can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles, if selected, should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles/boulders encountered within the sand and silt till and sand and gravel layers.

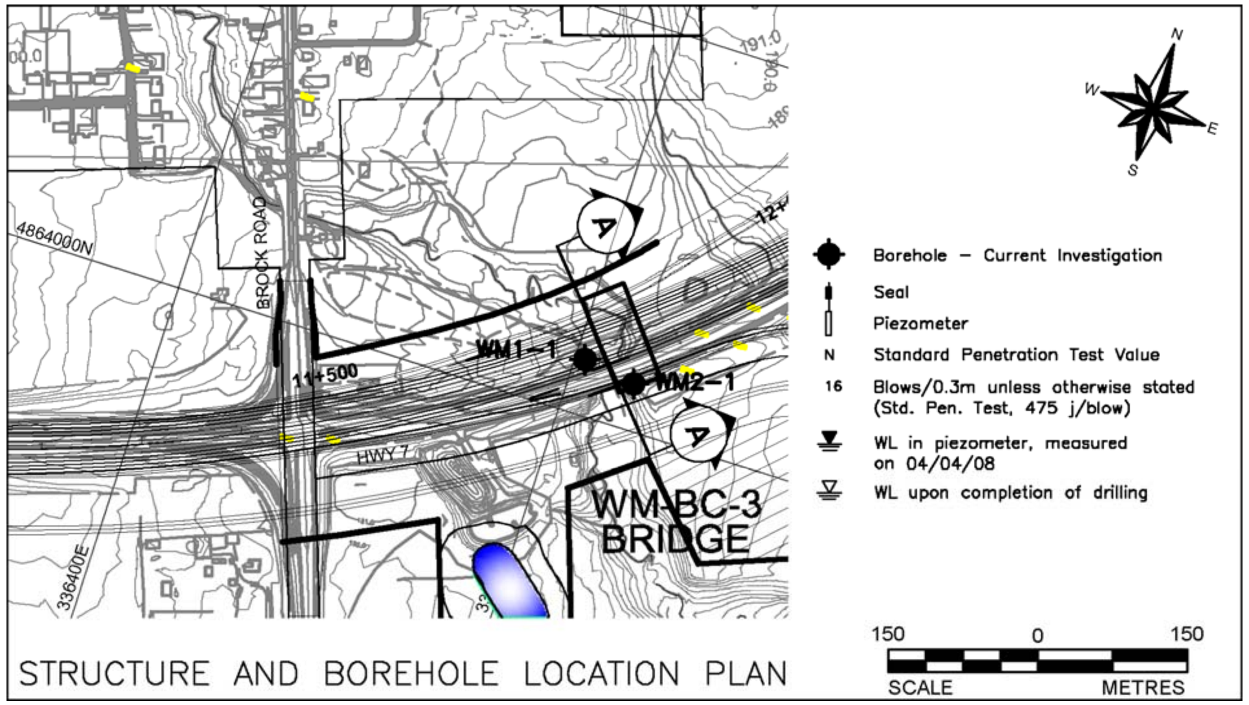
• RECOMMENDATIONS FOR ADDITIONAL WORK

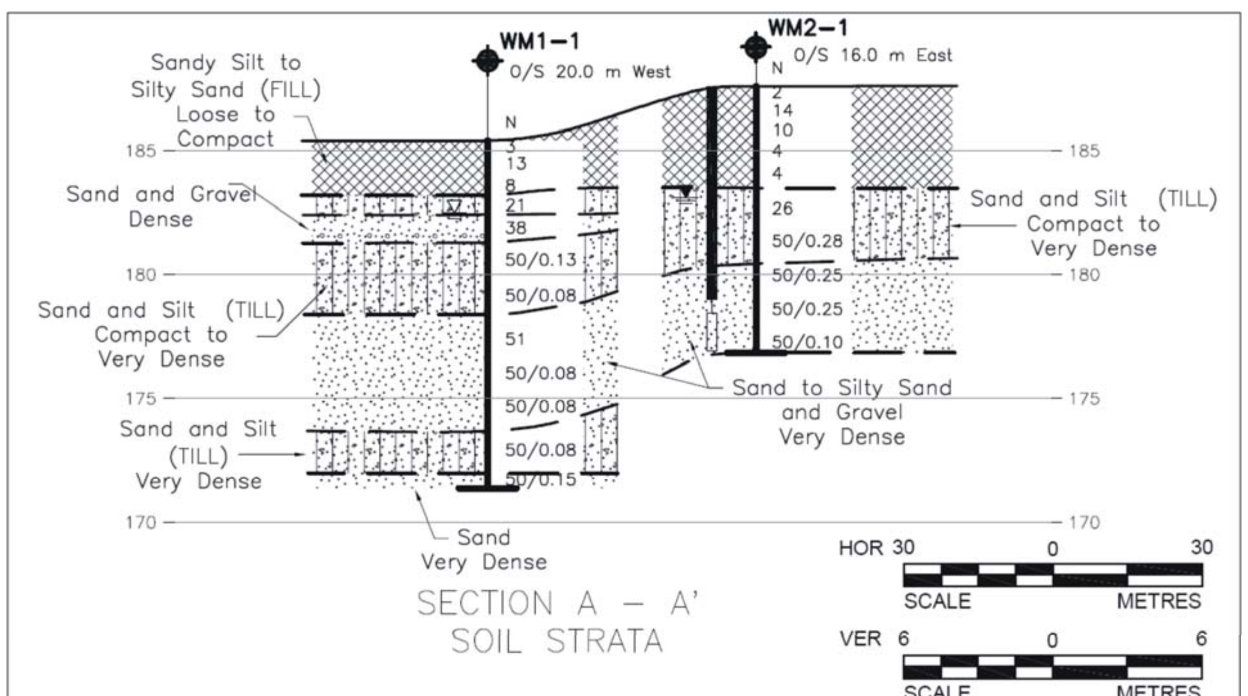
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.
In addition, footings will be founded at or below prevailing groundwater level (on granular subsoils), and groundwater conditions will have to be assessed.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass Highway 407 / Brougham Creek - WBL & EBL Widening
Hwy 407 Proposed Grade: 188.5 m - 191.5 m
Site Ranking: Medium

Location No: WM-1, WM-2 (WM-BC-3)
Existing Ground Elevation: 184 m - 187.5 m
Station: 11+875





FOUNDATION INVESTIGATIONS

Site Description:

The proposed Brougham Creek twinned bridge structures WM-1 and WM-2 are located immediately north of Highway 7, approximately 300 m east of Brock Road in Pickering, Ontario. Highway 7 in this area consists of two lanes each in both west-bound and east-bound directions. The 1.2 m wide Brougham Creek channel flows within a 50 m valley from north to south across the existing Highway 7 overpass structure. Vegetation in the vicinity of the site consists of grasses, shrubs and trees to the north and south of Highway 7.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM1-1	West Abutment	4 864 055.5	336 810.0	185.4	14.0
WM2-1	East Abutment	4 864 046.9	336 863.8	187.6	10.8

Subsurface Conditions:

- **Topsoil / Fill:** 200 mm to 300 mm of topsoil overlying very loose to compact sandy silt to silty sand fill, containing some gravel and clayey silt interlayers. The fill extends to depths of 2.2 m (Elev. 183.2 m) and 4.1 m (Elev. 183.5 m) in Boreholes WM1-1 and WM2-1, respectively. SPT 'N' values varied from 2 to 14 blows per 0.3 m of penetration. The results of grain size distribution and Atterberg limits tests are presented on Figures WM2-A and WM2-B (Appendix B), respectively. Measured water contents on samples of the fill range between about 9 and 16 percent.

- **Till:** sand and silt till containing trace to some clay, gravel, cobbles and boulders, encountered at Elevation 183.2 m and Elevation 183.5 m in Boreholes WM1-1 and WM2-1, respectively. The till extends to a depth of 7.2 m (Elev.180.4 m) in Borehole WM 2-1 and to a depth of 13.4 m (Elev. 172 m) in Borehole WM1-1, including 1 m to 4.5 m thick interlayers of sand and gravel. SPT 'N' values range from 21 blows per 0.3 m of penetration to 50 blows per 0.08 m of penetration, indicating a compact to very dense relative density. Grain size distribution test results are presented on Figures WM1-A and WM2-C and the results of one Atterberg limits test are presented on Figure WM1-B (Appendix B). Measured water contents range between about 7 and 8 percent.

- **Sand and Gravel:** sand and gravel, trace to some silt to silty sand and gravel, containing cobbles and boulders, encountered below the till in Borehole WM2-1 extending to the bottom of the borehole at a depth of 10.8 m (Elev. 176.8 m) and in Borehole WM1-1 extending to a depth of 11.7 m (Elev. 173.7 m) and is interlayered with the till deposit. Measured SPT 'N' values vary from 38 blows per 0.30 m of penetration to 50 blows per 0.08 m of penetration, indicating a dense to very dense relative density. The results of Atterberg limits and grain size distribution tests are presented on Figures WM1-B, WM1-C and WM2-D (Appendix B). Measured water contents on samples of the sand and gravel layers range between 4 and 13 percent.

- **Sand:** fine sand, containing trace to some silt encountered only in Borehole WM1-1 at a depth of 13.4 m (Elev. 172.0 m) and extending to the termination depth of the borehole at a depth of 14 m (Elev. 171.4 m). The water content of a sample of this layer was about 20 percent.

Groundwater Conditions:

- **BH WM1-1:** Depth of 2.9 m below ground surface (Elev. 182.5 m) in open borehole.
- **BH WM2-1:** Depth of 9.7 m below ground surface (Elev. 177.9 m) in open borehole; 5.0 m below ground surface (Elev. 182.6 m) in piezometer on February 28, 2008 and 4.5 m below ground surface (Elev. 183.1 m) on April 4, 2008.

Record of Borehole Sheets – Appendix A | Laboratory Test Results – Appendix B | Key Location Plan – Drawing 2

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-1 & WM-2 (WM-BC-3)

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 General Arrangement drawing for Structure WM-BC-3 is not yet available. For the purpose of preliminary foundation design, the bridge is assumed to be a single span structure as indicated in the preliminary structure and alignment layout drawings provided by URS. The new bridge will carry the proposed Highway 407 over Brougham Creek. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on compact to very dense sand and silt till or on compacted Granular 'A' pad for abutment footings "perched" within the bridge approaches	• Lower costs than deep foundations • Conventional construction	• Requires subexcavation of up to 4 m of surficial fill and into the sand and silt till
Caissons bored to found within "100-blow" silty sand to sand deposit	• Caissons will have higher bearing resistances than spread footings	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Founded within the compact to very dense sand and silt till at or below Elevation 183 m and at a minimum depth of 1.2 m below the lowest surrounding grade. Alternatively, spread footings for the abutments could be founded on a Granular 'A' pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Sand and Silt Till	500 kPa	350 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel H- Piles are considered to be not practical at this site due to the presence of very dense (i.e. "100-blow") materials at relatively shallow depths (4.5 m to 6 m below the ground surface), resulting in short piles. However, if pile foundations are desired, consideration may be given to pre-augering and driving to provide sufficient embedment of piles. Further assessment of this alternative may be carried out during detail design.

C – Caissons: Abutments on caissons founded within the "100-blow" sand to silty sand and gravel deposits at or below Elevation 177 m. Caissons lengths will be at least 6 m and will extend 3 m to 4 m within the "100-blow" materials.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,500 kN	2,800 kN
1.5 m	5,500 kN	4,400 kN

Recommended Foundation Alternative: Shallow Foundations.

• ABUTMENT TYPE

The site soils are not suitable for construction of integral abutments, unless pile foundations are constructed using pre-augering and driving methods.

• APPROACHES

Embankment Height: up to 8 m.

Stability: Approach embankments up to 8 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H:1V) will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fill, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankment. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and sand and silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for shallow foundations at Elevation 183 m can be adequately controlled by pumping from properly filtered sumps. However, dewatering ahead of the excavation operations may be required for excavations below about Elev. 183 m to prevent possible "boiling" of the base of the excavation in silty materials as a result of unbalanced hydrostatic heads.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H Piles, if selected, should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles/boulders encountered within the sand and gravel layers.

Other: It is noted that basal heave could occur in the more pervious sand to silty sand and gravel soils near the caisson base during installation. Refer to Section 6.7.3 of the Report for preliminary recommendations regarding use of caisson liners, drilling fluid, and tremie concrete methods.

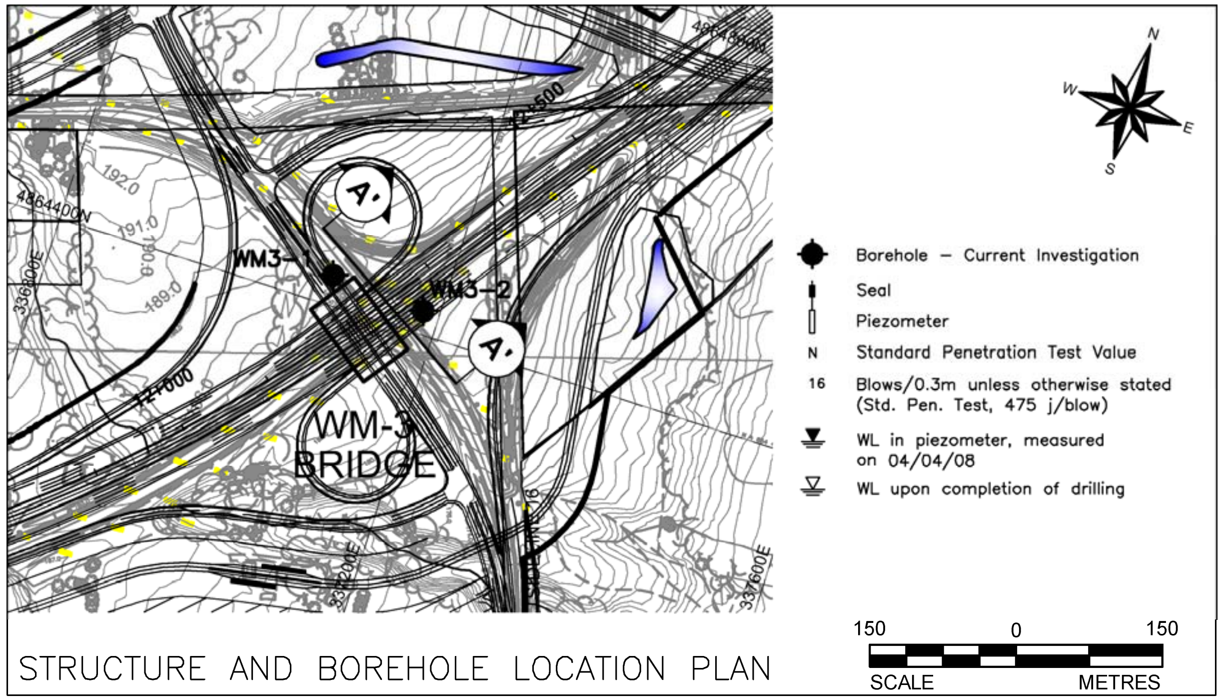
• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

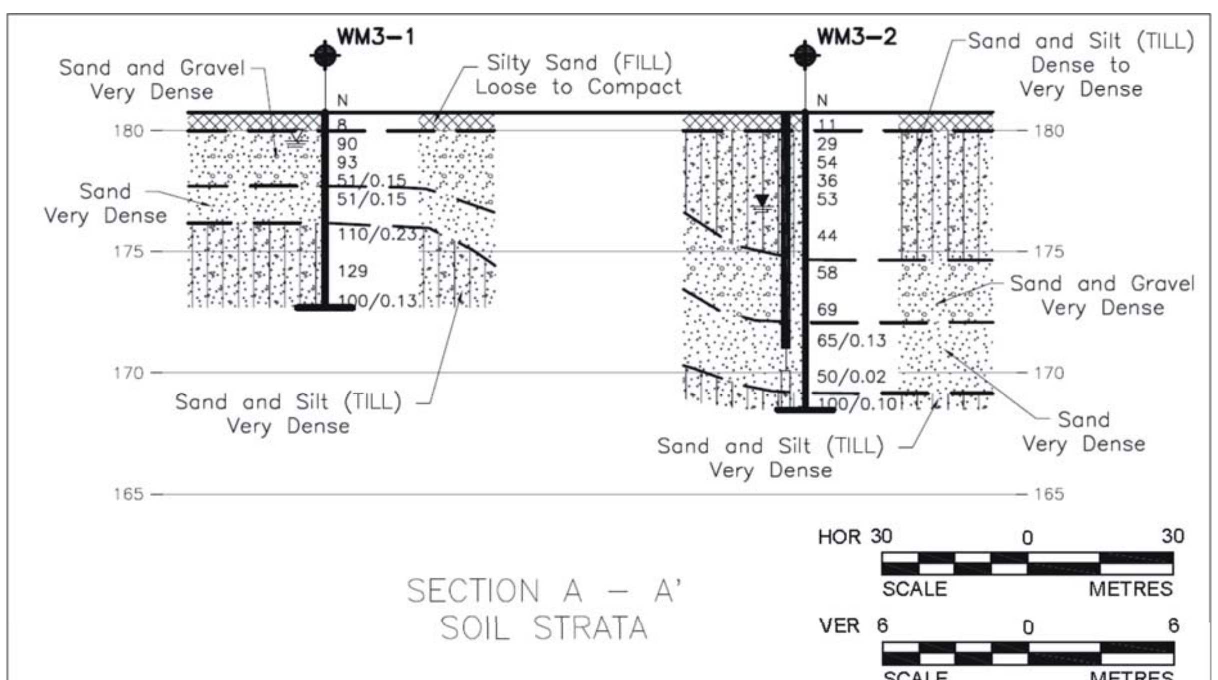
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Brock Road **Hwy 407 Proposed Grade:** 182.6 m **Site Ranking:** Medium

Location No: WM-3 **Existing Ground Elevation:** 181.0 m – 182.0 m **Station:** 12+230



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-3 underpass structure is located at the crossing of the realigned Brock Road and proposed Highway 407, at approximately 300 m south of the proposed location of the realigned Highway 7 and 800 m east of the existing Brock Road. Brock Road is constructed on embankment fill (sand and gravel) approximately 1.0 m high. The site is surrounded by gently rolling farm land and includes vegetation consisting of grasses, shrubs and trees.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM3-1	North Abutment	4 864 430.5	337 084.4	181.0	8.1
WM3-2	South Abutment	4 864 424.0	337 183.0	181.0	12.3

Subsurface Conditions:

- **Fill:** silty sand, trace gravel and containing rootlets encountered to a depth of 0.8 m in both boreholes. SPT 'N' values measured within the fill were 8 and 11 blows per 0.3 m of penetration, indicating a loose to compact relative density. Measured water contents on samples of the fill materials were 13 and 20 percent.
- **Sand and Gravel:** sand and gravel**,** some silt, trace clay, containing cobbles and occasional boulders, encountered immediately underlying the fill in Borehole WM3-1 and extends to a depth of 3.1 m (Elevation 178 m); in Borehole WM3-2 sand and gravel encountered underlying an upper sand and silt till layer between a depth of 6.1 m and 8.7 m (Elevation 174.9 m and 172.3 m). SPT 'N' values measured in the sand and gravel range from 58 to 93 blows per 0.3 m of penetration, indicating a very dense relative density. Grain size distribution test results are presented on Figure WM3-A (Appendix B). Measured water contents within this deposit range between about 4 and 8 percent.
- **Sand:** sand, trace to some silt, trace gravel encountered below the sand and gravel to depths of 4.6 m (Elev. 176.4 m) at Borehole WM3-1 and 11.6 m (Elev. 169.4 m) at Borehole WM3-2. SPT 'N' values measured in the sand range from 65 blows per 0.13 m of penetration to 50 blows per 0.02 m of penetration, indicating a very dense relative density. Measured water contents within this deposit were 10 and 13 percent.
- **Till:** sand and silt till, some clay and gravel, containing cobbles and occasional boulders, encountered in Borehole WM3-2 immediately beneath the fill materials extending to a depth of 6.1 m (Elevation 174.9 m) and the till was also encountered underlying the sand layer at a depth of 11.6 m (Elev. 169.4 m) and extending to the base of the borehole at 12.3 m depth (Elevation 168.7 m). In Borehole WM3-1 the till layer was encountered beneath the sand layer (Elev. 176.4 m); the till deposit extends to the borehole termination depth of 8.1 m (Elev. 172.9 m). SPT 'N' values measured in the upper till in Borehole WM3-2 range from 29 to 54 blows per 0.3 m of penetration, indicating a compact to very dense relative density. SPT 'N' values in the till in Borehole WM3-1 and in the lower till in Borehole WM3-2 range from 129 blows per 0.3 m penetration to 100 blows per 0.10 m of penetration, indicating a very dense relative density. Grain size distribution and Atterberg limits test results are presented on Figures WM3-B and WM3-C, respectively (Appendix B). Measured water contents within this deposit range between about 6 and 10 percent.

Groundwater Conditions:

- **BH WM3-1:** Depth of 1.2 m below ground surface (Elev. 179.8 m) in open borehole on completion of drilling.
- **BH WM3-2:** Depth of 4.9 m below ground surface (Elev. 176.1 m) in open borehole on completion of drilling; 4.1 m below ground surface (Elev. 176.9 m) in piezometer on February 28, 2008 and at 3.9 m below ground surface (Elev. 177.1 m) in piezometer on April 4, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 2**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-3

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS and dated December 2008, the proposed bridge structure will carry Brock Rd. over Hwy 407. The proposed underpass is a two span structure with a total structure length of approximately 81.5 m. Highway 407 is proposed to be constructed on shallow fill between about Elevation 183 m and 186 m. The proposed realigned Brock Road grade is at about Elevation 194 m with approach embankments up to 13 m high. Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very dense sand and gravel, dense to very dense sand and silt till or on a compacted Granular 'A' pad for abutment footings "perched" within the bridge approach	• Lower costs than deep foundations • Conventional construction	• May require subexcavation of about 1 m of surficial fill materials and loose sand and silt till
Steel H-Piles driven into "100-blow" sand/sand and silt till for abutments with "perched" pile caps	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, containing cobbles
Caissons bored to found within "100-blow" sand or sand and silt till	• Higher bearing resistances than steel H piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the proposed Highway 407 grade at Elevation 182.6 m, spread footings placed at or below Elevation 179 m, and at a minimum depth of 1.2 m below the lowest surrounding grade will be founded on very dense sand and gravel or dense to very dense sand and silt till. Alternatively, spread footings for the abutments can be founded on a compacted Granular 'A' pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Dense to very dense Sand and Silt Till or Very dense Sand and Gravel	600 kPa	400 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt till deposit at or below Elevation 176 m on the west abutment, and within the "100-blow" sand deposit at or below Elevation 170 m on the east abutment, are feasible for support of abutments with perched pile caps. Piles would be approximately 17 m long.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	1,400 kN

C – Caissons: Abutments and piers on caissons founded within the "100-blow" sand and silt till deposit at or below Elevation 176 m on the west abutment and within the "100-blow" sand deposit at or below Elevation 170 m on the east abutment. Caissons lengths would be at least 11 m, extending a minimum of 2 m into the "100-blow" materials.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,500 kN	2,800 kN
1.5 m	5,500 kN	4,400 kN

Recommended Foundation Alternative: Shallow foundations; steel H-Piles with "perched" pile caps are also appropriate for support of the abutments.

- ### ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- ### APPROACHES

Height: up to about 13 m.

Stability: Immediate approach embankments and adjacent approach fills up to 13 m high, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fills, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- ### CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and sand and silt till and sand and gravel are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: Based on the groundwater conditions encountered in the boreholes, excavation for shallow foundations will be above the groundwater table. However, dewatering measures may be required for excavation below the groundwater level (measured at about Elev. 177 m on April 4, 2008) to prevent possible "boiling" of the base of the excavation in sand and gravel materials as a result of unbalanced hydrostatic heads. Where fill heights are up to 13 m , interceptor ditches or subdrains may be considered along the mid-height bench to control surficial erosion.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles/boulders within the sand and silt till and sand and gravel layers.

- ### 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.

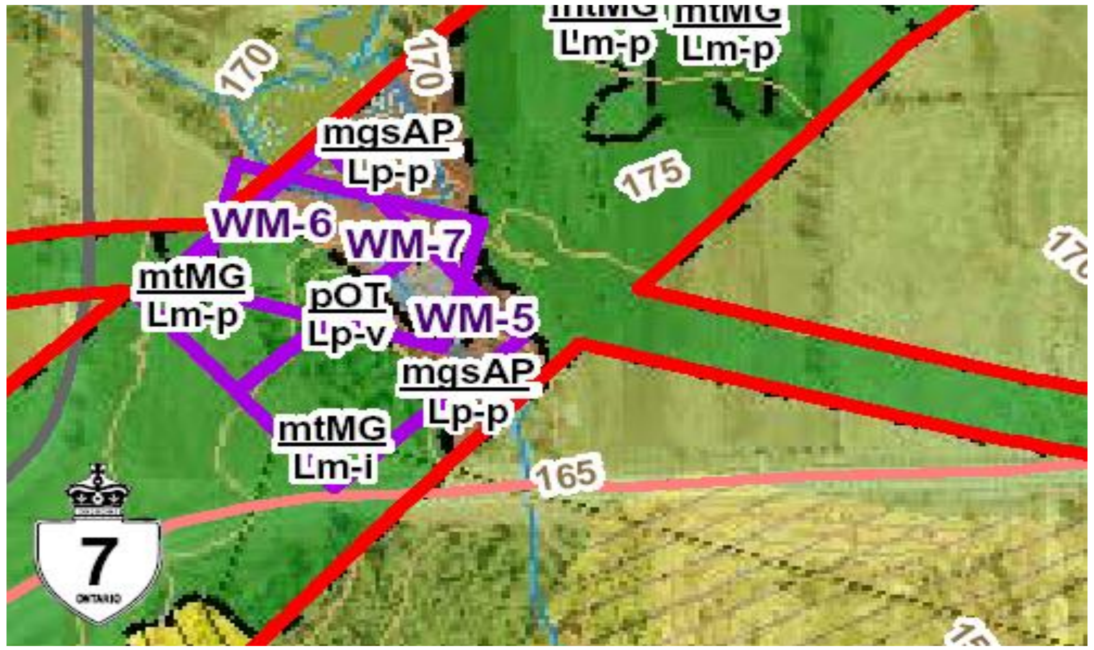
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-5 WM-6

W.O: 07-20015 **Section:** West **Location:** Mainline over West Spring Creek Tributary **Sta.**

Original Grade: **Proposed Grade:** **Description:** Twin structures carrying mainline over creek.



Site Plan and Terrain Analysis

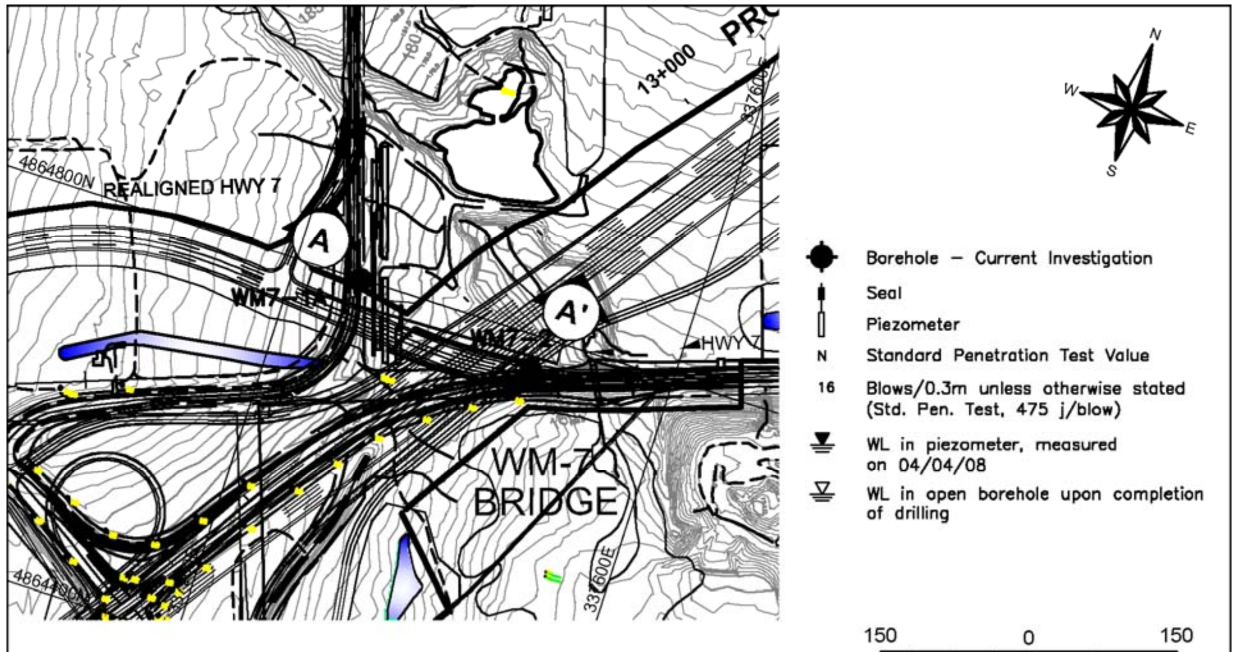
Site Photograph – Looking east from Sideline 16 towards pond near site

Summarized Subsurface Conditions	Recommendations: Structure	Recommendations: Approaches	Remarks
Boreholes: No boreholes at the site Mapping (West 2) shows that the creek valley is occupied by peaty, organic soil and that the surrounding tableland is silt till ground moraine. An impounded pond intrudes into the north side of the ROW. **<u>Groundwater</u>** Based on the presence of the pond, high GWL must be assumed. **Estimated overburden thickness – 55m.**	There is insufficient information on which to base site-specific recommendations. Due to the mapped organic terrain and assumed high GWL, piled foundations should be assumed for planning purposes. The following resistances may be assumed: a. ULS resistance – 1,600 kN b. SLS resistance – 1,400 kN Integral abutments are feasible. Assume 20 m to 25 m long piles.	Approaches on the tableland may be constructed at side slopes no steeper than 2H: 1V using SSM or granular materials However, in the creek valley there may be extensive organic and/or soft soil deposits, which will require to be investigated to assess embankment stability and settlement; complete removal of these soils may be required.	The existing pond would require to be drained, soft and deleterious materials at the base of the pond to be removed and the pond area backfilled with properly compacted cohesion-less materials Narrow, moderately deep valley with approx. 20o steep valleysides; potential for localized valleyside instability due to saturated conditions
		Site Ranking **Foundations:** **High** **Hydrogeology:** **Medium**	

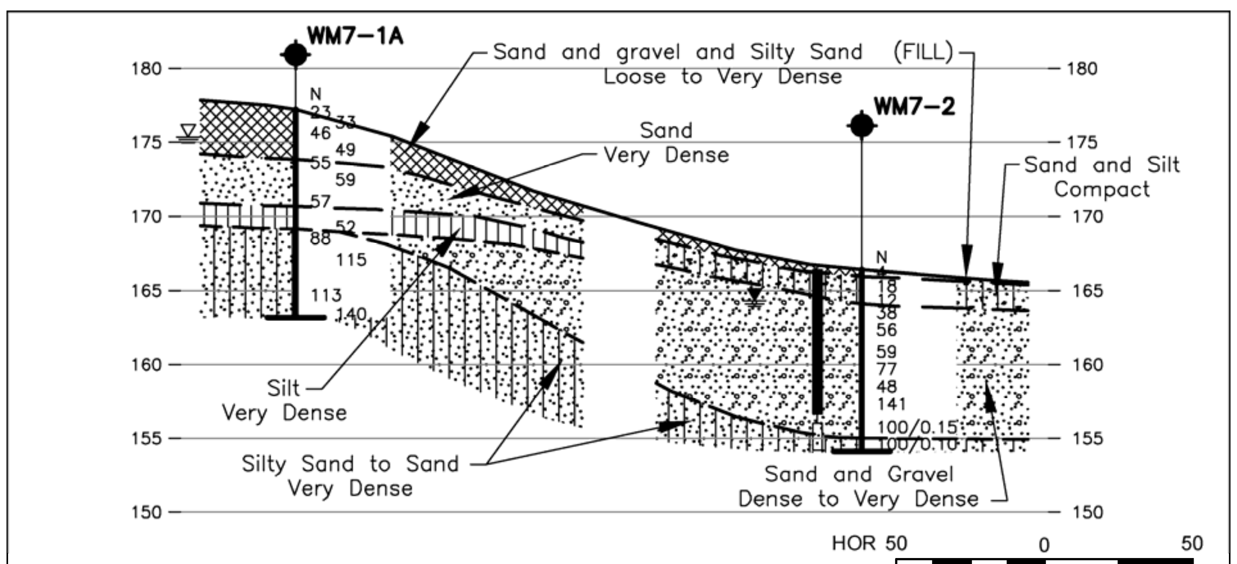
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass Highway 407, Realigned Highway 7 **Hwy 407 Proposed Grade:** 182.0 m – 183.0 m **Site Ranking:** Medium

Location No: WM-7 **Existing Ground Elevation:** 172.0 m – 174.5 m **Station:** 12+600



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of Structure WM-7 s is located along the proposed realigned Highway 7, just north of the existing Highway 7 and east of Sideline 16 in the City of Pickering, Ontario. The site is surrounded mainly by farmland and densely treed areas to the east and south-east. A small pond is also located about 180 m north-east of the proposed bridge structure. The overall topography of the terrain is sloping down towards the south-east.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM7-1A	East Abutment	4 864 799.5	337 267.5	177.2	14.0
WM7-2	West Abutment	4 864 765.1	337 459.7	166.4	12.3

Subsurface Conditions:

- **Fill:** compact sand and gravel fill, 0.6 m in thickness, was encountered in Borehole WM7-1A at the ground surface. One measured SPT 'N' was 23 blows per 0.3 m of penetration. Silty sand fill was encountered in Borehole WM7-1A, underlying the sand and gravel layer and extended to a depth of 3.4 m. Measured SPT 'N' values varied from 33 to 49 blows per 0.3 m of penetration, indicating a dense relative density. In Borehole WM7-2, the silty sand fill, containing organics, was encountered at the ground surface and extended to a depth of 0.5 m. One SPT 'N' value was 4 blows per 0.3 m of penetration, indicating a loose relative density. Measured water contents were approximately 7 to 17 percent.

- **Till:** a surficial till deposit, 1.8 m thick and consisting of sand and silt, containing some clay, and trace to some gravel, was encountered in Borehole WM7-2 at Elevation 165.9 m. SPT 'N' values measured within the till deposit were 12 and 18 blows per 0.3 m of penetration, indicating a compact relative density. Grain size distribution and Atterberg limits test results are presented on Figures WM7-A and WM7-B (Appendix B), respectively. One measured water content of the till deposit was about 12 percent.

- **Sand to Silty Sand to Silt:** a 3.2 m thick layer of very dense sand, containing trace to some silt and trace gravel, was encountered underlying the fill in Borehole WM7-1A. The layer of sand extended to a depth of 6.6 m (Elev. 170.7 m) and is underlain by a 1.5 m thick layer of silt, trace to some sand and trace clay. Silty sand to sand was encountered underlying the silt layer and extended to the termination depth of the borehole at 14 m below ground surface corresponding to Elevation 163.2 m. In Borehole WM7-2, a sand layer was encountered below till and sand and gravel deposits at a depth of 11.9 m below ground surface corresponding to Elevation 154.5 m; the borehole was terminated at Elevation 154.1 m within the sand deposit. Measured SPT 'N' values varied from 52 blows per 0.3 m of penetration to 100 blows per 0.1 m of penetration, indicating a very dense relative density. The results of grain size distribution tests of the silt and sand layers are presented on Figures WM7-C and WM7-D (Appendix B), respectively. Measured water contents within the silty sand to sand deposits vary from about 5 to 17 percent, one water content measured on a sample of the silt layer was 20 percent.

- **Sand and Gravel:** a 9.6 m thick deposit of sand and gravel, containing trace to some silt was encountered between the till deposit and the layer of sand in Borehole WM7-2. SPT 'N' values measured within the sand and gravel deposit varied from 38 blows per 0.3 m of penetration to 100 blows per 0.15 m of penetration, indicating a dense to very dense relative density. Results of two grain size distribution tests are presented on Figure WM7-E (Appendix B). Measured water contents vary from approximately 6 to 8 percent.

Groundwater Conditions:

- **BH WM7-1A:** Depth of 1.8 m below the ground surface (Elev. 175.4) in open borehole upon completion of drilling.
- **BH WM7-2:** Depth of 2.1 m below ground surface (Elev. 164.3 m) in piezometer on April 4, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 2**

Golder Associates Ltd.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-7

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a General Arrangement drawing of Structure WM-7, received from URS on October 28, 2008, Structure WM-7 will carry the proposed Highway 407, along with two ramps connecting the proposed realigned Brock Road with Highway 407, over the realigned Highway 7. The proposed overpass is a single 35 m long span bridge structure with closed end type abutments and approach embankments approximately 11 m high. Based on the existing subsurface information, the feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option. It should be noted that the subsequent information from Borehole WM7-2 has not been considered in the design and foundation recommendations as it is located approximately 100 m away from the east abutment and about 8 m lower in ground surface elevation than the nearest abutment; it should also be noted that the Spring Creek tributary flows southerly across Highway 7, about 150 m east of the proposed WM-7 structure.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into “100-blow” silty sand to sand deposits.	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through the very dense layers of sand and gravel
Caissons bored to found within “100-blow” silty sand to sand or s deposits.	• Higher bearing resistances than steel H-Piles	• Drilling must be advanced through very dense layers of sand and gravel • May require temporary or permanent liner to prevent seepage inflow and softening of the caisson base

A – Steel H-Piles: Steel HP 310 x 110 piles driven to found within the “100-blow” silty sand to sand at or below Elevation 164.5 are feasible for support of west and east abutments. Pile lengths would be approximately 12.5 m (for a pile cap base at about Elevation 177 m).

Location	*Pile*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
Abutments	HP 310 x 110	1,600 kN	1,400 kN

B – Caissons: West and east abutments on caissons founded a minimum of 1.5 m within the “100-blow” silty sand to sand deposit below Elevation 165 m; caisson would be approximately 12 m long.

Location	*Caisson Diameter*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
Abutments	1.2 m	4,500 kN	3,500 kN
	1.5 m	6,500 kN	5,500 kN

Recommended Foundation Alternative: Steel H-Piles or caissons.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- **APPROACHES**

Height: Up to 11 m. Embankments constructed of earth fill to heights greater than 8 m will require a mid height berm in accordance with MTO design requirements.

Stability: Approach embankments consisting of select subgrade material or granular fill up to about 11 m high with side slopes and back slope above the RSS wall no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability. A wall embedment of 4.5 m or greater will provide adequate global stability against deep seated failure of the wall for a factor of safety greater than 1.3. The internal stability of the approximately 11 m high RSS wall (including 4.5 m embedment) will be provided with adequate soil reinforcement and is the responsibility of the proprietary wall supply/design firm; it is also assumed that sliding and overturning of the RSS wall be satisfied. Measures to stabilize the embankment slope face due to potential surface water flow/seepage at the slope face will have to be implemented.

Settlement: Assuming the use of conventional earth or granular embankment fills, where applicable, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the existing fill materials and cohesionless soils (i.e. silt, silty sand to sand and sand and gravel) are classified as a Type 3 and Type 2 soils, respectively, according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving into or through the very dense sand and gravel layers. No major obstructions (e.g. cobbles or boulders) are anticipated at the site based on the borehole data at this site.

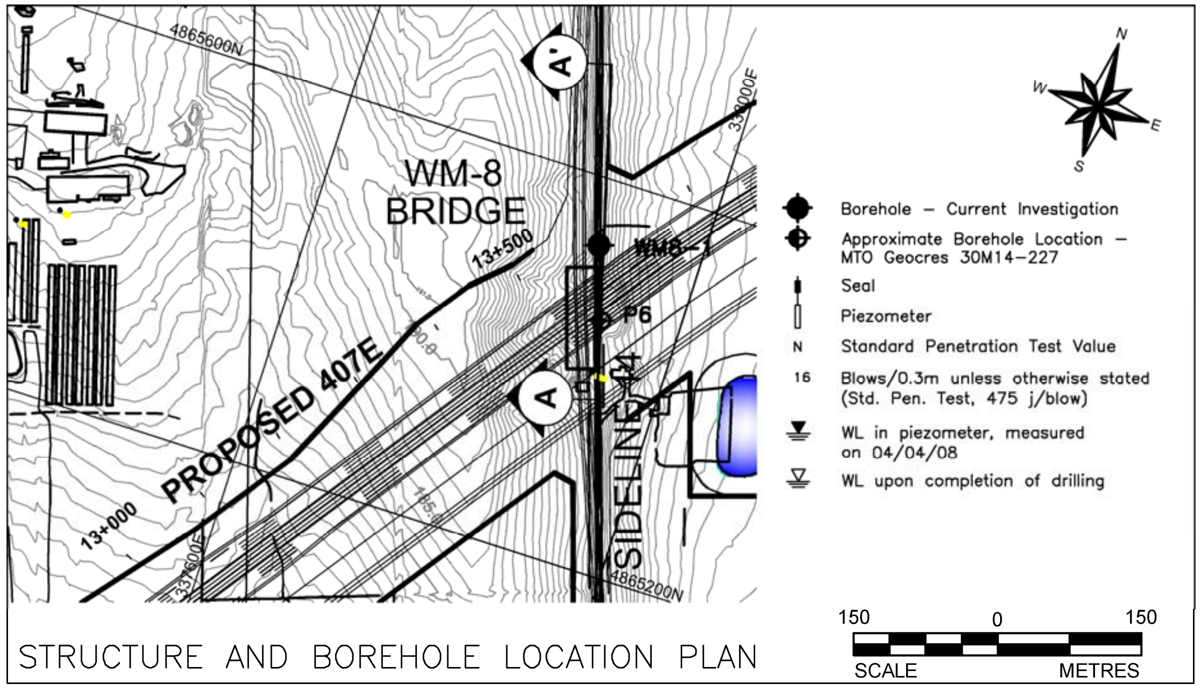
- **RECOMMENDATIONS FOR ADDITIONAL WORK**

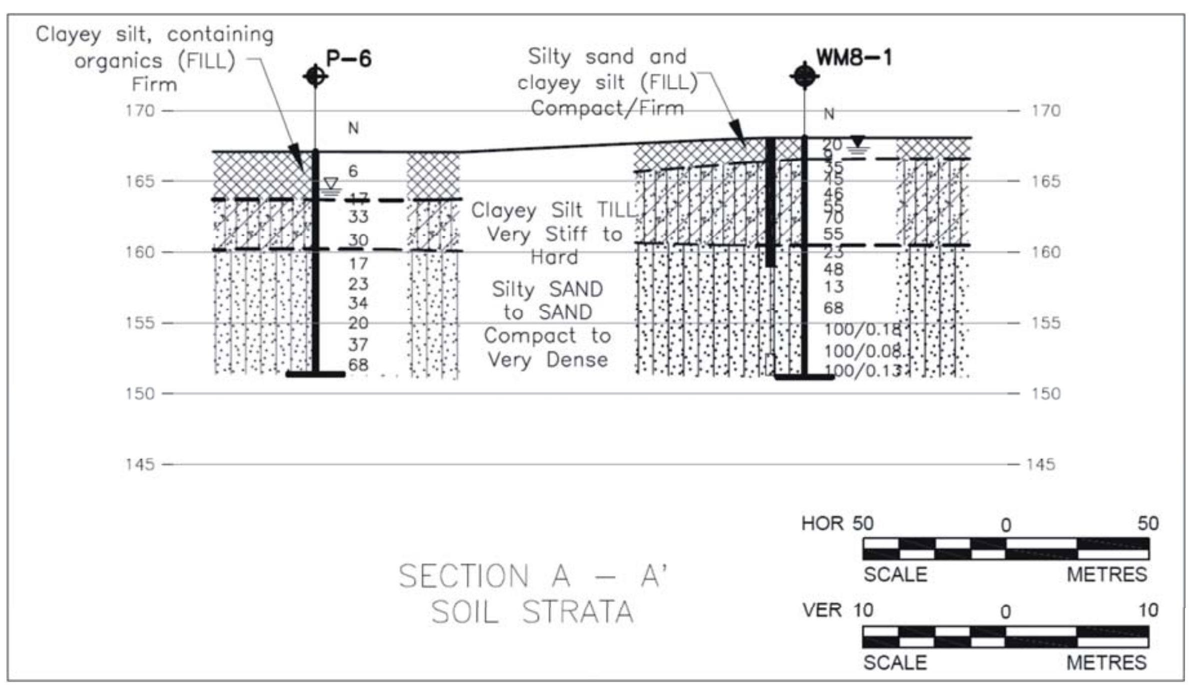
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Sideline 14
Hwy 407 Proposed Grade: 169 m
Site Ranking: Medium

Location No: WM-8
Existing Ground Elevation: 171 m – 175 m
Station: 13+540





FOUNDATION INVESTIGATIONS

Site Description:

The site of proposed bridge structure WM-8 is located on Sideline 14, approximately 600 m north of Highway 7 in Pickering, Ontario. Sideline 14 in this area is approximately 6 m wide, consisting of a gravel surfaced road. The area immediately to the west of Sideline 14 is heavily treed and the area to the east is mainly grass and shrub covered. The topography of the terrain is gently sloping downward to the east toward Spring Creek.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM8-1	North & South Abutments	4 865 531.0	337 893.6	168.1	16.9
P6*	South Approach	4 865 457.1	337 920.0	167.1	15.7

*MTO GEOCRES 30M14-227. Coordinates on original Borehole log referenced to MTM-NAD27.

Subsurface Conditions:

- **Fill:** compact silty sand and firm clayey silt, containing trace gravel and organic matter to depths of approximately 1.5 m to 3.4 m. One SPT ‘N’ value within the silty sand fill was 20 blows per 0.3 m of penetration and SPT ‘N’ values within the clayey silt fill ranged from 6 to 9 blows per 0.3 m of penetration. Water contents on samples of the fill materials range between about 8 and 14 percent.
- **Till:** clayey silt with sand, trace gravel and occasional sand seams and cobbles, encountered immediately beneath the fill materials and extends to a depth of 7.6 m (Elev. 160.5 m) in Borehole WM8-1 and to a depth of 6.9 m (Elev. 160.2 m) in Borehole P6. SPT ‘N’ values within the clayey silt till at both boreholes typically ranged from 30 to 70 blows per 0.3 m of penetration, indicating a generally hard consistency. Grain size distribution and Atterberg limits test results are presented on Figures WM8-A and WM8-B, respectively (Appendix B). Measured water contents on samples of this deposit range between about 8 and 9 percent.
- **Silty Sand To Sand:** silty sand to sand, some silt and trace clay encountered below the clayey silt till to depths of 16.9 m (Elev. 151.2 m) at Borehole WM8-1 and 15.7 m (Elev. 151.4 m) at Borehole P6; the silty sand to sand deposit extends to the bottom of both boreholes. SPT ‘N’ values varied from 13 blows per 0.3 m of penetration to 100 blows per 0.08 m of penetration, indicating a compact to very dense relative density. Grain size distribution test results are presented on Figure WM8-C (Appendix B). The measured water contents on samples of this deposit varied from about 9 to 22 percent.

Groundwater Conditions:

- **BH WM8-1:** Depth of 2.4 m below ground surface (Elev. 165.7 m) in open borehole upon completion of drilling; 0.7 m below ground surface (Elev. 167.4 m) in piezometer on January 7, 2008 and April 4, 2008.
- **BH P6:** Depth of 2.8 m below ground surface (Elev. 164.3) in open borehole upon completion of drilling.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-8

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing of Structure WM-8 provided by URS on January 2009, the proposed bridge structure will carry Sideline 14 over hwy 407. The proposed underpass is planned to be a two span structure with a total structure length of about 113 m and approach embankments up to 5.5 m high. Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option. Borehole P-6 has not been considered in the design and foundation recommendations as it is located much further south than Borehole WM8-1.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on compact to very dense silty sand to sand or on a compacted Granular 'A' pad for abutment footings 'perched' within the bridge approaches	• Lower costs than deep foundations • Conventional construction • Eliminates dewatering requirements for foundations	• Requires subexcavation of up to 8 m of surficial fill and into the clayey silt till
Steel H-Piles driven into "100-blow" silty sand to sand deposit for abutments with "perched" pile caps.	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through cobbles
Caissons bored to found within "100-blow" silty sand to sand deposit.	• Larger caissons have higher bearing resistances than steel H piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Spread footings for the north abutment/centre pier and south abutment placed within the hard clayey silt till at or below Elevation 166 m and Elevation 163 m, respectively, and placed at a minimum depth of 1.2 m below the lowest surrounding grade. Alternatively, abutment footings may be founded on a compacted Granular 'A' pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Hard Clayey Silt Till	500 kPa	350 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" silty sand to sand deposit, below Elevation 152 m are feasible for support of abutments with perched pile caps; piles' length would be approximately 15 m.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,200 kN	1,000 kN

C – Caissons: Abutments and central pier on caissons founded a minimum of 2 m within the "100-blow" silty sand to sand deposit, at or below Elevation 152 m. Effective caissons lengths would be about 8 m at the piers locations and abutments.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	2,500 kN	2,000 kN
1.5 m	4,000 kN	3,000 kN

Recommended Foundation Alternative: Shallow Foundations; pile foundations with "perched" pile caps are also appropriate for supporting the bridge abutments.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- **APPROACHES**

Approach Height: up to 9.5 m consisting of about 4.5 m to 6 m cut and 3.5 m to 5 m fill.

Stability: Approach cut slopes up to 6 m high and fill sections up to 5 m high, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability will be safe against deep-seated slope instability. Measures to stabilize the embankment slope face due to potential groundwater seepage at the slope surface subsequent to the embankment slope cut will have to be implemented.

Settlement: Considering that about half of the approaches' height for this bridge structure will be constructed in cut, and assuming the use of conventional earth or granular embankments fills for the fill section, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the existing fill materials and clayey silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V and slope to within 1.2 m of the bottom of the excavation with a slope of 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for shallow foundations at Elevation 163 m to 166.5 m can be adequately controlled by pumping from properly filtered sumps. Potential groundwater seepage at the surface of the approach cut slopes should be controlled to prevent slope erosion.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles within the clayey silt till layer.

- **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.
In addition, footings will be founded at or below prevailing groundwater level (within granular subsoils), and groundwater conditions will have to be assessed.

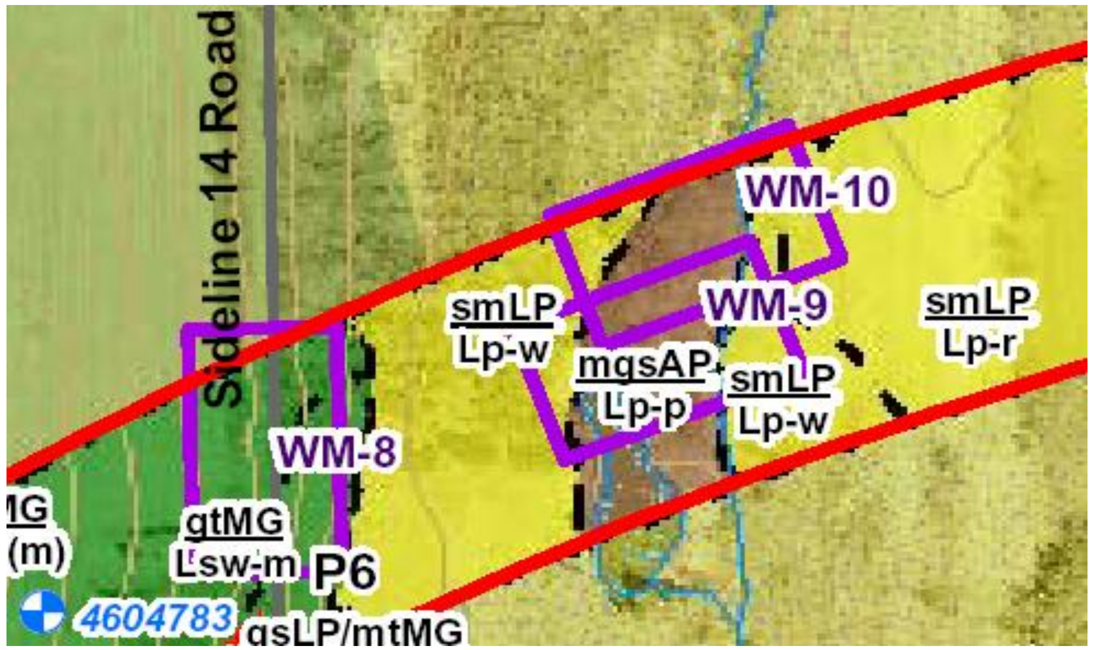
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-9 WM-10

W.O: 07-20015 **Section:** Western **Location:** Mainline at Spring Creek **Sta.** 13+850

Original Grade: **Proposed Grade:** **Description:** Twin structures to carry mainline over Spring Creek



Site Plan and Terrain Analysis

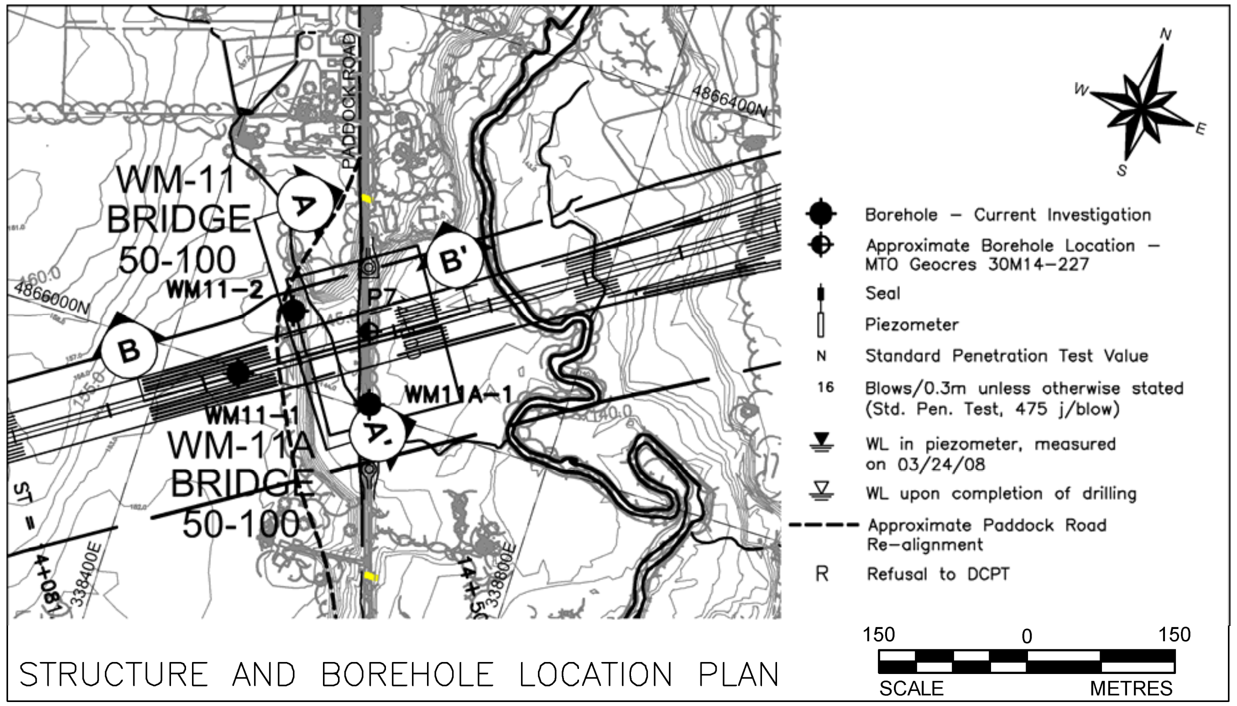
Site Photograph – Looking east towards site from Sideline 14

Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks
Boreholes: BH P6, Book 15 lies approx. 250m west Mapping (West 2) shows the site to be underlain by a 75m wide, poorly drained, silty sand alluvial plain within a wider sandy silt glaciolacustrine plain. The creek runs down the east edge of the alluvial plain and a small pond is present in the southwest of the site. Both the mapping and nearby BH P6 indicate that the glaciolacustrine plain is underlain by the silt till ground moraine that predominates in the area. **Groundwater** Based on the poor drainage and proximity to the creek and pond, the GWL should be assumed to be at or close to the ground surface. **Estimated overburden thickness – 45m.**	There is insufficient information on which to base site-specific recommendations. Due to the mapped wet, alluvial terrain and assumed high GWL, piled foundations should be assumed for planning purposes. The following resistances may be assumed: a. ULS resistance – 1,600 kN b. SLS resistance – 1,400 kN Integral abutments are feasible. Assume 20 m to 25 m long piles.	Approaches on the silty sand plain may be constructed at side slopes no steeper than 2H: 1V using SSM or granular materials However, in the creek valley there may be extensive organic and/or soft soils , which will require to be investigated to assess embankment stability and settlement; complete removal of these soils may be required.	The existing small pond water would require to be pumped out and soft/loose materials excavated and the pond area backfilled with properly compacted cohesionless materials Moderately high priority in terms of Permission To Enter. Moderately wide, shallow valley with no geomorphic evidence of significant valleyside instability
		Site Ranking **Foundations:** **Medium** **Hydrogeology:** **High**	

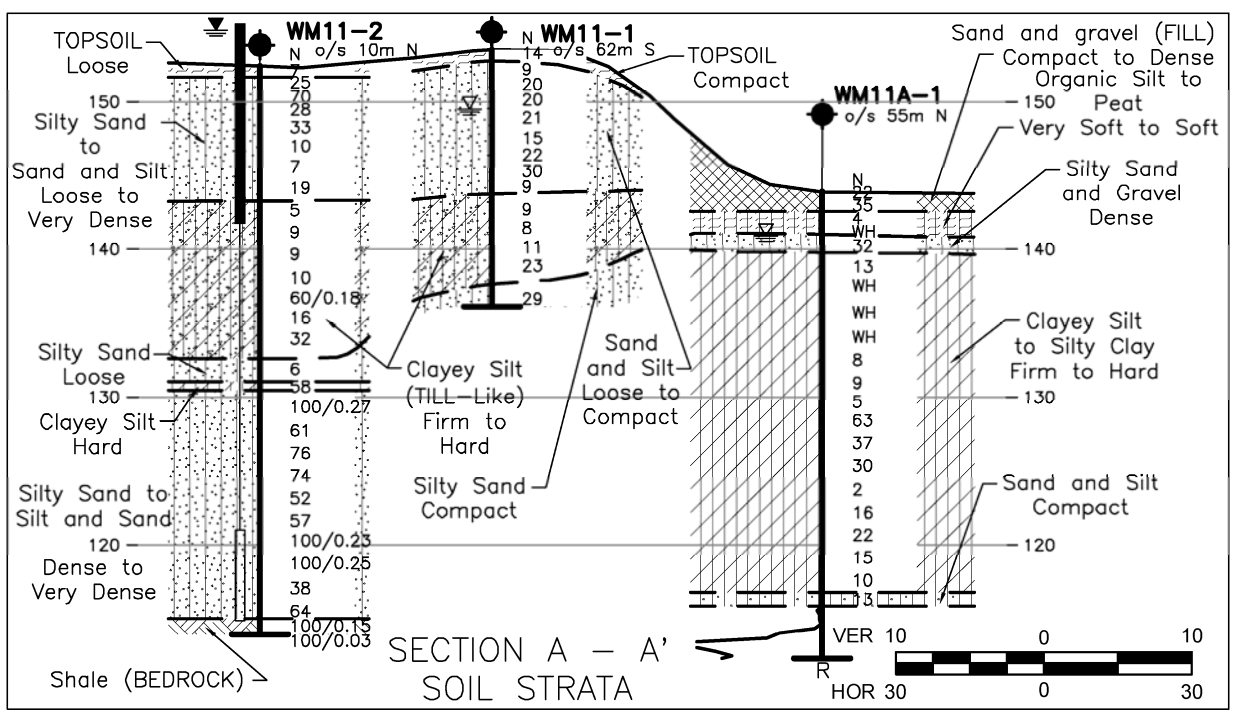
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass 407 at Re-aligned Paddock Road **Hwy 407 Proposed Grade:** 148.2 m **Site Ranking:** High

Location No: WM-11 (Deleted), WM-11A (Deleted) **Existing Ground Elevation:** 153 m to 154.2 m **Station:** 14+450



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A' SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The proposed bridge underpass structure, originally proposed as two overpass structures WM-11 and WM-11A, will carry the re-aligned Paddock Road over the highway. The underpass is located approximately 750 m north of Highway 7, west of the existing Paddock Road in Pickering, Ontario. Existing Paddock Road in the area is 8.0 m wide, surrounded by farmland and some dense vegetation. The general terrain is gently sloping down towards the east, with the exception of a steep valley slope located east of the re-aligned Paddock Road.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM11-1	South Abutment	4 865 995.6	338 473.7	153.5	17.4
WM11A-1[1]	South Abutment	4 866 005.9	338 609.9	143.9	31.6
WM11-2	North Abutment	4 866 073.0	338507.6	152.4	38.4
P7 [1, 2]	-	4 866 076.3	338 586.8	145.4	18.7

[1] Since the re-aligned Paddock Road will be located west of the original proposed location, Boreholes WM11A-1 and P7 are no longer in near vicinity of the re-aligned Paddock Road. However, Borehole WM11A-1 is still used in evaluating foundation recommendations along the south abutment.

[2] GEOCRES 30M14-227. Coordinates on original Borehole log referenced to MTM-NAD27.

Subsurface Conditions:

- **Fill/Topsoil:** sand and gravel and silty sand fill materials were encountered in Boreholes WM11A-1 and P7 at the ground surface and extended to depths of 1.4 m and 2.3 m, respectively. Measured SPT ‘N’ values within the fill layers are 22 and 35 blows per 0.3 m of penetration, indicating a compact to dense relative density. Water content on a sample of the sand and gravel fill is about 4 percent.
  Topsoil, 0.8 m in thickness, was encountered in Boreholes WM11-1 and WM11-2. SPT ‘N’ values are 7 and 14 blows per 0.3 m of penetration in Boreholes WM11-2 and WM11-1, respectively, indicating a loose to compact relative density.

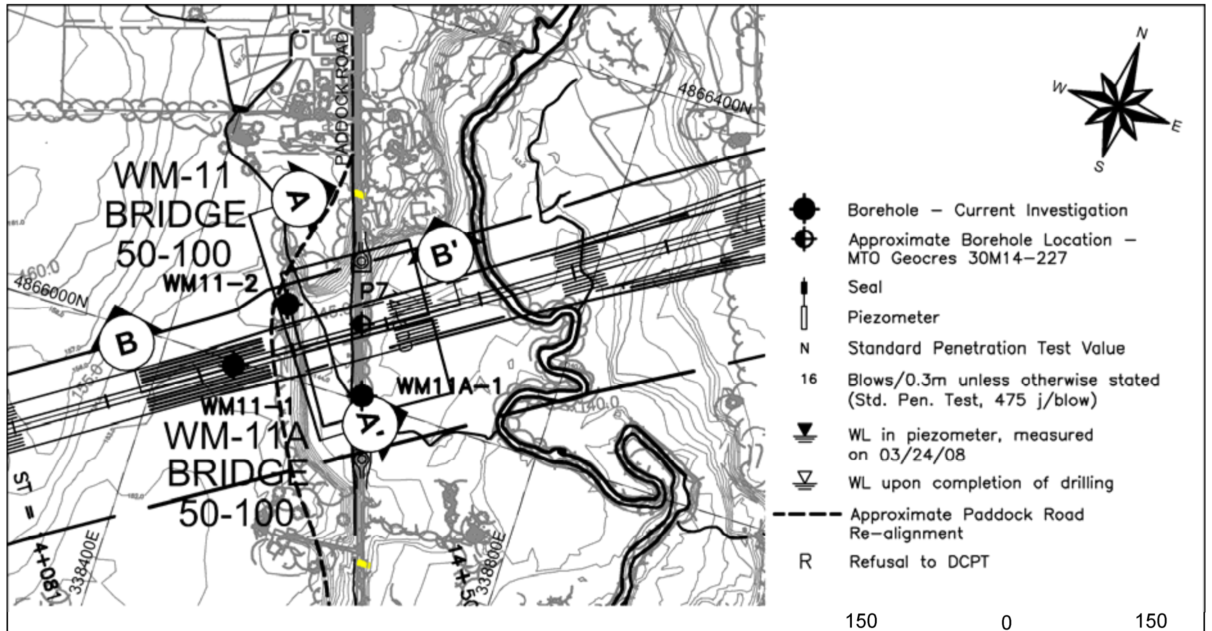
- **Organic Silt to Peat:** organic silt to peat, containing occasional sand seams, encountered in Boreholes WM11A-1 and P7, underlying the fill material. The organic layer extended to depths of 2.9 m (Elev. 141.0 m) in Borehole WM11A-1 and 3.5 m in Borehole P7. Measured SPT ‘N’ values measured within the organic layer range from the weight of the hammer to 8 blows per 0.3 m of penetration, indicating a very loose to loose relative density. Measured water contents on selected samples are 31 and 55 percent; the organic content of one sample of peat is approximately 31 percent.

- **Upper Silty Sand/Sand and Silt to Sand with Gravel:** sand with gravel, 1.8 m in thickness, encountered in Borehole P7 immediately below the peat layer. One SPT ‘N’ value is 32 blows per 0.3 m of penetration, indicating a dense relative density. Silty sand to sand and silt was encountered in all boreholes, except in Borehole P7. These deposits were encountered below the topsoil and peat layers and varied in thickness from 1.2 m to 9.0 m and extended to Elevation 143.4 m. SPT ‘N’ values vary from 7 to 70 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The results of grain size distribution and Aterberg limits tests are presented on Figures WM11-A and WM11-B (Appendix B), respectively. Water contents within the silty sand layers vary from 4 to 10 percent; water contents in the sand and silt to silt deposits range between 11 and 26 percent.

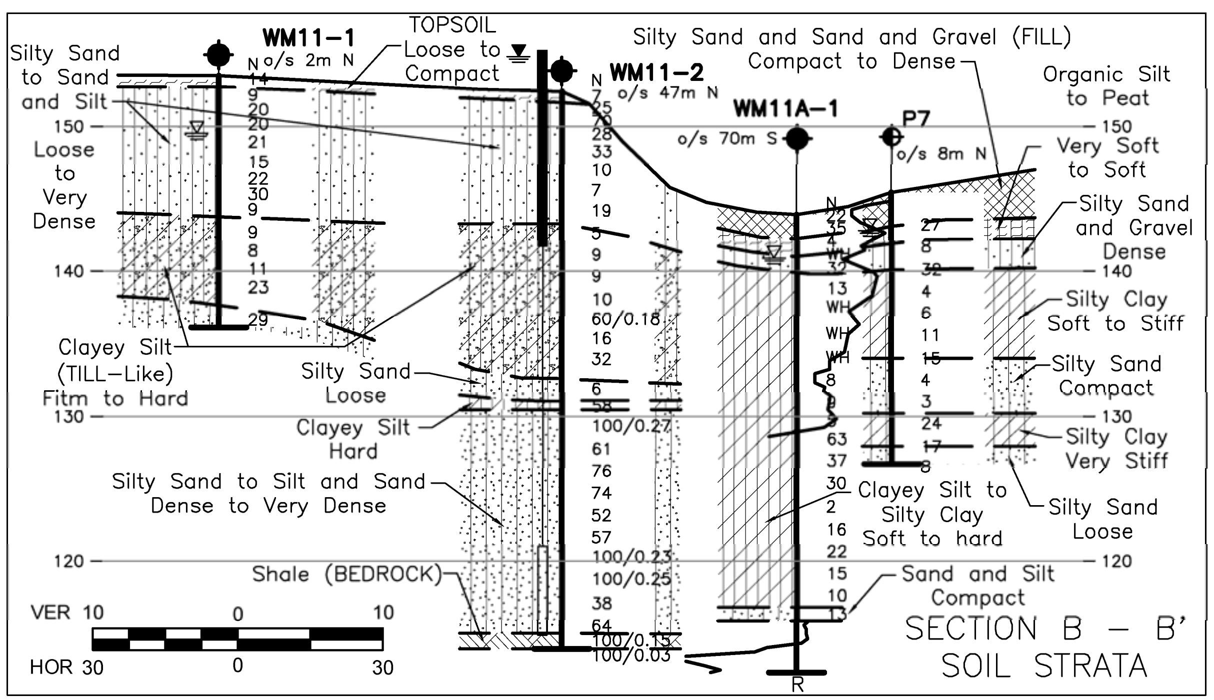
- **Till-Like Deposits:** consisting of clayey silt to clayey silt with sand; these deposits were encountered in Boreholes WM11-1 and WM11-2 underlying the sand and silt to silt deposits at depths of 9.8 m (Elev. 143.8 m) and 9.1 m (Elev. 143.3 m), respectively. The till-like deposits extended to depths of 15.9 m and 19.8 m corresponding to Elevations 137.7 m and 132.6 m in Boreholes WM11-1 and WM11-2, respectively. SPT ‘N’ values generally vary from 7 to 33 blows per 0.3 m of penetration and field measured undrained shear strength values typically range from 56 kPa to more than 96 kPa, indicating a firm to hard consistency. Grain size distribution and Atterberg limits test results are presented on Figures WM11-C and WM11-D (Appendix B), respectively. Measured water contents generally range between 23 and 26 percent; however, water contents on samples near the lower portion of the till like deposits vary from 12 to 18 percent.

PART B- PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-11 (Deleted), WM-11A (Deleted)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION B – B'
SOIL STRATA

- **Clayey Silt with Sand/Clayey Silt/Silty Clay:** clayey silt with sand to clayey silt to silty clay deposits encountered in all boreholes, except in Borehole WM11-1. In Borehole WM11-2 a 0.7 m thick layer of clayey silt was encountered at a depth of 21.3 m (Elev. 131.1). One SPT ‘N’ value is 58 blows per 0.3 m of penetration, indicating a hard consistency; one water content was about 11 percent. In Borehole P7 a silty clay deposit was encountered at a depth of 5.3 m (Elev. 140.1 m), extending to a depth of 17.5 m (Elev. 127.9 m). Interlayered within the silty clay in Borehole P7 was a layer of silty sand, 3.8 m thick, at a depth of 11.4 m. SPT ‘N’ values within the upper portion of silty clay range from 4 to 15 blows per 0.3 m of penetration, indicating a soft to stiff consistency; SPT ‘N’ values measured within the lower portion of the silty clay are 17 and 24 blows per 0.3 m of penetration, indicating a very stiff consistency. In Borehole WM11A-1 a layer of clayey silt with sand, 3.5 m thick, was encountered at Elevation 139.8 m underlying a 4.6 m thick silty clay deposit, which in turn was underlain by a clayey silt deposit which extended to a depth of 27.4 m (Elev. 116.5 m). Overall, SPT ‘N’ values within the clayey silt to silty clay deposits range from weight of hammer to 13 blows per 0.3 m of penetration. Field measured undrained shear strength within the clayey silt with sand deposit vary from 31 kPa to 38 kPa, indicating a firm consistency; within the silty clay deposit the values are 16 kPa and 19 kPa, indicating a soft consistency. Measured SPT ‘N’ values within the clayey silt generally vary from 5 to 63 blows per 0.3 m of penetration, indicating a soft to hard consistency; one SPT ‘N’ value within the clayey silt at a depth of about 20 m is 2 blows per 0.3 m of penetration. The results of grain size distribution and Atterberg limits test results are presented on Figures WM11A-A and WM11A-B (Appendix B), respectively. Measured water contents vary from 13 to 30 percent.

- **Lower Silty Sand/ to Sand/Sand and Silt:** sand and silt, containing trace clay and gravel, encountered in Borehole WM11A-1 below the clayey silt at a depth of 27.4 m; the borehole was terminated within this layer at a depth of 28 m corresponding to Elevation 115.9 m. A dynamic cone penetration test (DCPT) was carried out from the bottom of this borehole to refusal at a depth of 31.6 m (Elev. 112.4 m). One measured SPT ‘N’ value is 13 blows per 0.3 m of penetration, indicating a compact relative density. One grain size distribution test carried out on a sample of the sand and silt layer from this borehole is presented on Figure WM11A-C. Measured water content was approximately 15 percent. Silty sand to sand, 1.3 m to 15.4 m in thickness, was encountered in Boreholes WM11-1, WM11A-1 and P7 at Elevations varying from 132.6 m to 137.7 m; all of the boreholes were terminated within this deposit. SPT ‘N’ values in Boreholes WM11-1 and WM11A-1 generally range between 29 blows per 0.3 m of penetration and 100 blows per 0.23 m of penetration, indicating a compact to very dense relative density; and SPT ‘N’ values within the silty sand in Borehole P7 and one SPT ‘N’ value within the upper portion of silty sand in Borehole WM11-2 vary from 3 to 8 blows per 0.3 m of penetration, indicating a very loose to loose relative consistency. The results of grain size distribution and Atterberg limits tests are presented on Figures WM11-E and WM11-F (Appendix B), respectively. Measured water contents range between 11 and 19 percent.

- **Bedrock:** Shale bedrock was encountered in Borehole WM11-2 at approximately Elevation 115 m. The borehole was terminated within the shale at a depth of 38.4 m (Elev. 114.0 m) upon auger refusal. In Borehole WM11A-1 refusal to DCPT advance was recorded at a depth of 31.6 m (Elev. 112.4 m).

Groundwater Conditions:

- Artesian conditions were encountered during drilling in Borehole WM11-2 within the lower silty sand and upper portion of the shale bedrock.

- **WM11-1:** Depth of 4.0 m below ground surface (Elev. 149.5 m) in open borehole upon completion of drilling.
- **WM11-2:** Depth of 1.5 m below ground surface (Elev. 150.9 m) in open borehole upon completion of drilling; 2.4 m above ground surface (Elev. 154.8 m) in piezometer on March 24, 2008 - piezometer was decommissioned on March 24, 2008 by overcoring to a depth of 18.3 m below ground surface (Elevation 134.1 m) and backfilled with hydrated bentonite slurry.
- **WM11A-1:** Depth of 3.0 m below ground surface (Elev. 140.9 m) in open borehole upon completion of drilling.
- **BH P7:** Depth of 2.5 m below ground surface (Approximately Elev.142.9 m) in open borehole upon completion of drilling.

PART B- PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-11 (Deleted), WM-11A (Deleted)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the profile of Paddock Road at Highway 407 East (Alternative 1), dated April 10, 2008 and received from URS on July 10, 2008, the proposed Highway 407 underpass will be a single span structure with a total length of approximately 55 m. The proposed Highway 407 at this location will be constructed in a 5 m cut along the south abutment and 6 m cut along the north abutment to about Elevation 148.2 m. The proposed realigned Paddock Road grade will be at about Elevation 155.4 m with a south approach height of 7 m and north approach height of 7.5 m. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option. It is noted that the existing subsoil conditions and artesian hydrostatic head are not considered suitable for shallow foundations and caissons, respectively. The bridge has been deleted.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into shale bedrock at the north abutment and sand and silt or possibly bedrock at the south abutment.	• Allows for integral abutment design • Minimize differential settlement between foundation elements	• Requires flange plate reinforcement to facilitate driving into shale bedrock. • Dewatering may be required during construction (e.g. pile caps), special techniques may be required if artesian condition are encountered.
Caissons bored to found within shale bedrock at the north abutment and sand and silt or possibly bedrock at the south abutment.	• Higher bearing resistances than steel H-Piles	• May require temporary or permanent liner to prevent seepage inflow and softening of the caisson base • Dewatering may be required during construction (e.g. pile caps), special techniques may be required if artesian condition are encountered.

A – Steel H-Piles: Steel HP 310 x 110 piles driven to refusal into the shale bedrock at or below Elevation 115 m, are feasible for support of the north abutment. Steel HP 310 x 110 piles driven to refusal into the inferred dense to very dense sand and silt deposit* and possibly on bedrock at or below Elevation 113 m, are feasible for support of the south abutment. Pile lengths would range from approximately 37 m and 39 m long. It should be noted that if the configuration of the bridge structure and approaches is changed to include embankment fills instead of cuts, then downdrag loads will act on the piles and should be considered for the structural design of the piles.

Location	*Pile*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
North Abutment (Shale Bedrock)	HP 310 x 110	1,600 kN	Does not govern
South Abutment (Sand and Silt)	HP 310 x 110	1,400 kN	1,200 kN

Recommended Foundation Alternative: Steel H-Piles

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional or integral abutments.

- **APPROACHES**

Height: up to 7.5 m consisting of about 5 m to 6 m cut and 1.5 m to 2 m fill.

Stability: Approach heights of up to 7.5 m with cuts of 5 m to 6 m and side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V), will be safe against deep-seated slope instability. Measures to stabilize the embankment slope face due to potential surface water flow/seepage at the slope surface will have to be implemented.

Settlement: The approaches for this bridge structure will be mainly constructed in cut and thus settlement issues are not anticipated.

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the upper cohesionless deposits (silt to silt and sand to silty sand with gravel) are classified as Type 3 soils according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V.

Groundwater/Surface Water Control: it is anticipated that any groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps. However, the proposed Highway 407 road grade at Elevation 148.2 m would extend up to 6 m below the present ground surface and about 2 m below the groundwater level encountered during drilling. Shallow groundwater may be controlled by purging from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving into shale bedrock.

Other: It is noted that basal heave could occur in the more pervious sand and silt soils near the caisson base during installation and caissons are not considered as a practical option. If caisson foundations are being considered for this site, axial geotechnical resistance values can be provided and it is recommended that a constant head of water or drilling fluid be maintained inside the caisson liners to balance the excess head as encountered in Borehole WM11-2. In addition, temporary or permanent caisson liners and tremie concrete methods would be required to prevent loosening of foundation soils during construction. Due to the artesian water conditions within the lower cohesionless deposit, 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 steel H-Pile or along the caisson liners.

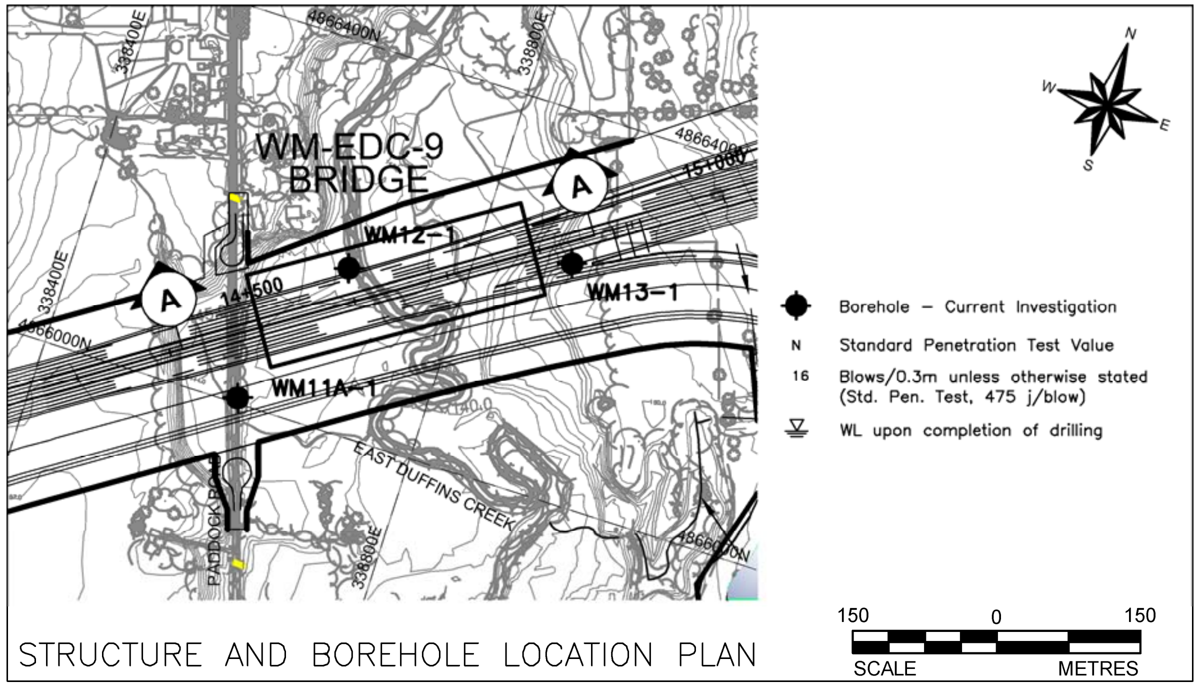
- **RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation and detailed analyses should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements and to assess embankment fills construction requirements and final geometry.

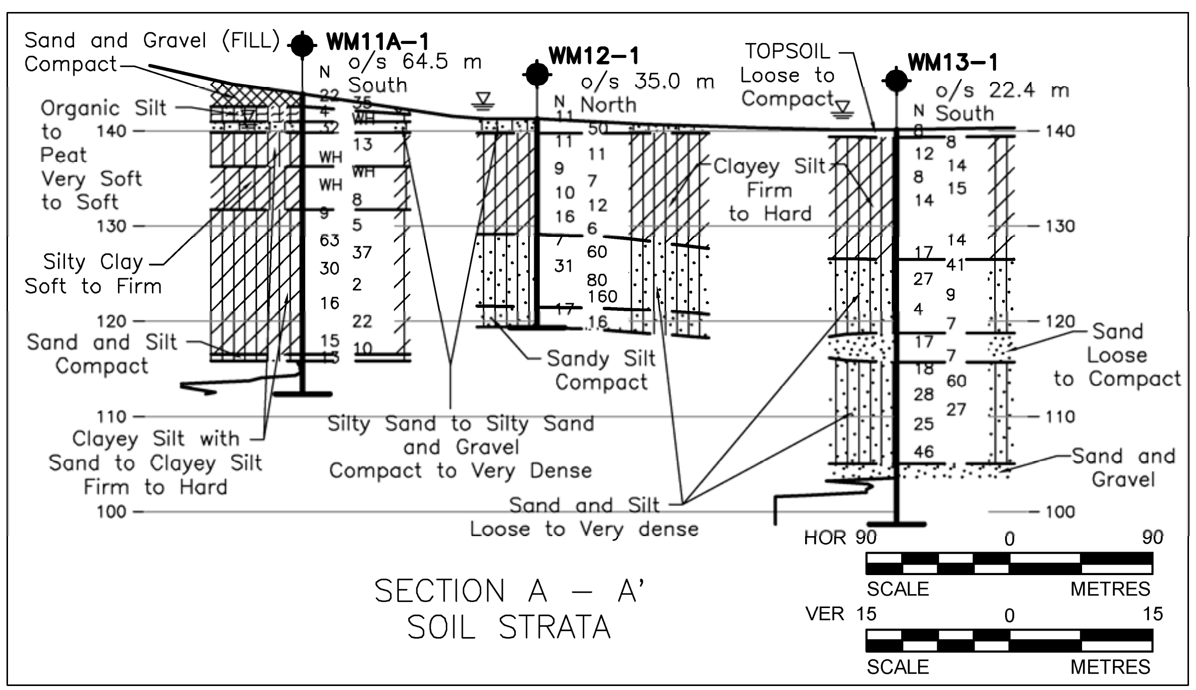
* Borehole WM11A-1 has been used to estimate the elevation and type of end bearing foundation stratum for the south abutment.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass Highway 407 EBL/WBL over East Duffins Creek
Location No: WM-12, WM-13 (WM-EDC-9)
Hwy 407 Proposed Grade: 154 m – 155.3 m
Existing Ground Elevation: 141 m – 145 m
Site Ranking: Medium
Station: 14+632



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed bridge structures WM-12 and WM-13 (WM-EDC-9) is located east of Paddock Road, approximately 800 m north of Highway 7 in the City of Pickering, Ontario. The site lies within a treed area with the East Duffins Creek flowing southerly across the proposed bridge structures. Beyond the creek and treed area, the site is surrounded by farmland. Topographically, the site is within an approximately 400 m wide plain.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM11A-1	West Abutment	4 866 005.9	338 609.9	143.9	31.6
WM12-1	East Abutment	4 866 170.2	338 678.7	141.3	22.0*
WM13-1	East Abutment	4 866 246.2	338 899.0	148.9	41.5

* Borehole terminated at depth of 22.0 m due to portable equipment drilling limitations and artesian conditions.

Subsurface Conditions:

- **Topsoil/Organic Silt to Silty Peat/Fill:** loose to compact topsoil, 0.1 m to 0.8 m in thickness, encountered in Boreholes WM12-1 and WM13-1, respectively. Two SPT 'N' values measured within the topsoil were 8 and 11 blows per 0.3 m of penetration. Sand and gravel fill extending from the ground surface to a depth of 1.4 m (Elev. 142.5 m) encountered in Borehole WM11A-1. Two SPT 'N' values within the fill layer were 22 and 35 per 0.3 m of penetration, indicating a compact to dense relative density. One water content at the bottom of the fill was about 4 percent. Very soft to soft organic silt to silty peat was encountered immediately below the fill in Borehole WM11A-1. The layer extended to a depth of 2.9 m (Elev. 141.0 m). Two SPT 'N' values were 4 blows per 0.3 m of penetration and the weight of hammer. Organic content on a sample of the layer was approximately 31 percent. Two water contents were about 31 and 55 percent.

- **Silty Sand/Silty Sand and Gravel/Sand and Gravel:** silty sand, containing some gravel, to silty sand and gravel encountered in the upper portions of Boreholes WM12-1 and WM11A-1, respectively. SPT 'N' values varied from 11 to 50 blows per 0.3 m of penetration, indicating a compact to very dense relative density. Measured water contents were approximately 6 and 12 percent in Boreholes WM11A-1 and WM12-1, respectively. A sand and gravel layer was encountered in Borehole WM13-1 at a depth of 35.1 m (Elev. 113.8 m). A dynamic cone penetration test was carried out within this deposit from 35.6 m (Elevation 113.3 m) to 41.5 m (Elevation 107.4 m) where the borehole was terminated.

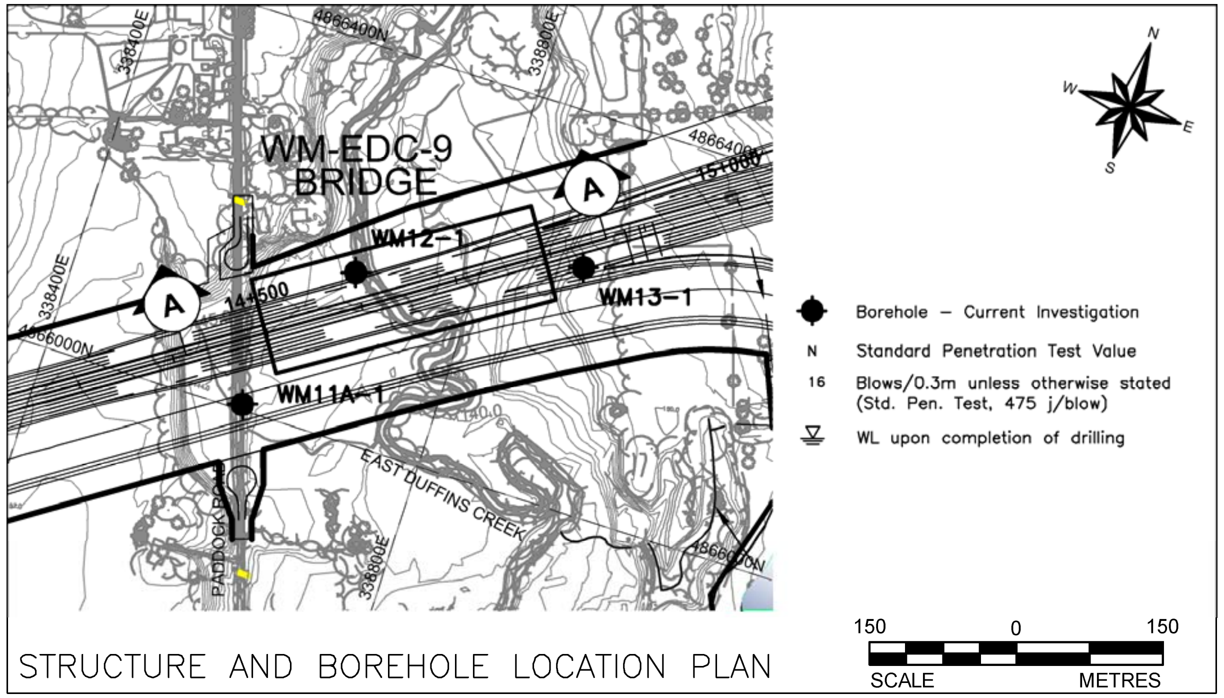
- **Sandy Silt:** sandy silt, containing trace to some gravel and clay, was encountered in Boreholes WM12-1. The sandy silt was encountered at a depth of 19.8 m (Elev. 121.5 m) and extended to the termination depth of the borehole. Two SPT 'N' values were 17 to 16 blows per 0.3 m of penetration, indicating a compact relative density. Measured water contents were approximately 13.5 to 16 percent.

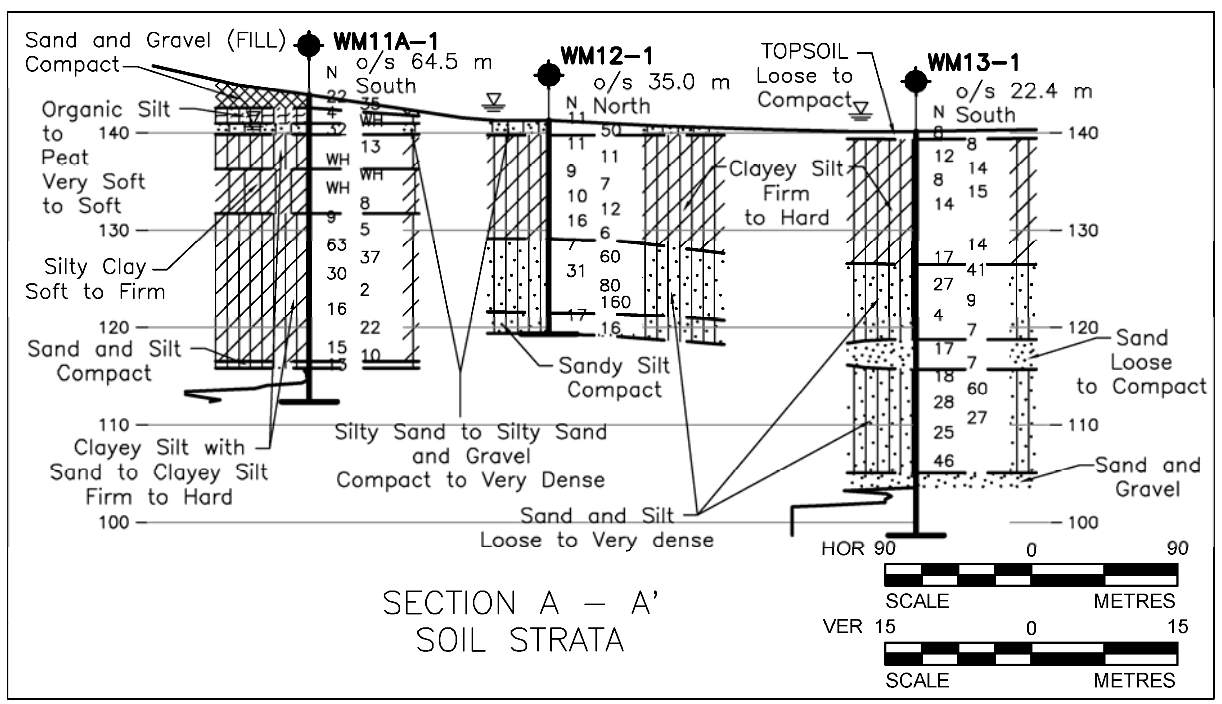
- **Sand and Silt:** sand and silt, containing trace gravel and clay, encountered in all three boreholes. In Borehole WM11A-1, the sand and silt layer was encountered immediately below the silt layer and extended to a depth of 28 m (Elev. 115.9 m); a dynamic cone penetration test was carried out to refusal at a depth of 31.6 m (Elevation 112.4 m). In Borehole WM12-1, sand and silt deposit extended between Elevation 129.1 m and 121.5 m. In Borehole WM13-1, sand and silt deposit extended from a depth of 13.7 m (Elev. 135.2 m) to 35.1 m (Elev. 113.8 m). A distinct layer of sand, 2.5 m thick, was encountered interlayered within the sand and silt deposit in Borehole WM13-1 at Elevation 127.6 m.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 3**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-12, WM-13 (WM-EDC-9)





Two SPT 'N' values within the sand layer were 7 and 17 blows per 0.3 m of penetration, indicating a loose to compact relative density. The results of one grain size distribution test within the sand layer are presented on Figure WM13-E (Appendix B). One water content was about 13percent. Overall, the SPT 'N' values within the sand and silt deposits varied from 4 to 160 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The results of grain size distribution tests are presented on Figures WM11A-C, WM12-C and WM13-D (Appendix B). Measured water contents ranged from about 11 to 22 percent.

- **Clayey Silt/Silty Clay:** clayey silt to silty clay encountered in all three boreholes. In Borehole WM11A-1, the deposit consists of clayey silt with sand, extended from a depth of 4.1 m (Elev. 139.8 m) to 27.4 m (Elev. 116.5 m). A layer of silty clay was interlayered within the clayey silt deposit at Elevation 136.3 m and extended to a depth of 12.2 m (Elev. 131.7 m). SPT 'N' values within the silty clay varied from weight of hammer to 8 blows per 0.3 m of penetration and field measured undrained shear strengths were 19 kPa and 27 kPa, indicating a soft to firm consistency. The results of one Atterberg limits test are presented on Figure WM11A-B. Measured water contents varied from 23 to 30 percent. In Borehole WM12-1, the clayey silt, containing trace to some sand and trace gravel, extended from Elevation 139.8 m to Elevation 129.1 m. In Borehole WM13-1, the clayey silt, containing trace to some gravel and sandy silt to silty sand seams, was encountered below the topsoil and extended to a depth of 13.7 m (Elev. 135.2 m). Overall, SPT 'N' values within the clayey silt deposits varied from the weight of hammer to 63 blows per 0.3 m of penetration and field measured undrained shear strengths typically ranged from 27 kPa to 54 kPa, indicating a firm to hard consistency. The results of grain size distribution tests are presented on Figures WM11A-A, WM12-A and WM13-A (Appendix B); Atterberg limits test results are shown on Figures WM11A-B, WM12-B and WM13-C. Measured water contents ranged between 13 and 27 percent.

<u>Groundwater Conditions:</u>

- **BH WM11A-1:** Depth of 3.0 m below ground surface (Elev. 131.7 m) in open borehole upon completion of drilling.

- **BH WM12-1:** Depth of 1.2 m below ground surface (Elev. 140.1 m) on April 15, 2008; artesian conditions first encountered at depth of 16.8 m below ground surface (Elev. 124.5 m) on April 17, 2008; 1.5 m above the ground surface (Elev. 142.8 m) in open borehole upon completion of drilling.

- **BH WM13-1:** Depth of 7.9 m below the ground surface (Elev. 132.2 m) on April 30, 2008; artesian conditions first encountered at depth of 15.2 m below ground surface (Elev. 124.9 m) on April 30, 2008; 1.8 m above ground surface (Elev. 141.9 m) upon completion of drilling, 1.8 m above ground surface (Elev. 141.9 m) on May 7, 2008.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-12, WM-13 (WM-EDC-9)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in March 2009, the proposed bridge structure will carry the Hwy 407 over East Duffins Creek. The proposed bridge structure is a five span bridge with a total length of about 270 m and approximately 12 m high approach embankments. Based on the existing subsurface information, the feasible foundation options for the proposed bridge abutments and piers is listed below with advantages and disadvantages associated with the recommended option. However, the embankments are limited by the subsurface conditions encountered at the site between 8 m and 12 m as discussed below. It is noted that spread footings and caissons are not considered to be practical options given the subsoil conditions and artesian conditions present at the site.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into “100-blow” sand and gravel deposits for abutments with “perched” pile caps.	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through the inferred very dense sand and gravel deposit

A - Steel H-Piles: Steel HP 310 x 110 piles driven to refusal into the inferred dense sand and gravel deposit at or below Elevation 100 m are feasible for support of piers and west and east abutments with “perched” pile caps. Pile lengths at the west abutment would be approximately 47 m long, based on an 8 m high earth fill embankment or 52 m in length, based on a 12 m high lightweight fill embankment. At the east abutment, pile lengths would be approximately 45 m and 50 m corresponding to an 8 m high earth fill embankment and a 12 m high lightweight fill embankment, respectively. Pile lengths at the pier locations would be approximately 39.5 m long. Friction piles were considered as an alternative but are not expected to achieve signficant capacity within the cohesive deposits. The structural design of the abutment piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to significantly reduce post-construction settlements under the new embankment loading; in this case downdrag loads can be eliminated.

Location	*Pile*	*Axial Geotechnical Resistance*		*DowndragLoad (Unfactored)*
		Factored ULS	**SLS**	
West Abutment	HP 310 x 110	1,600 kN	1,400 kN	500 kN
Piers	HP 310 x 110	1,600 kN	1,400 kN	500 kN
East Abutment	HP 310 x 110	1,600 kN	1,400 kN	400

Recommended Foundation Alternative: Steel H-Piles.

During detail design, when site-specific subsoil information is obtained, other options such as the use of wick-drains in combination with ground improvement methods may be considered.

• ABUTMENT TYPE

The site soils are suitable for construction of semi-integral or integral abutments.

• APPROACHES

Height: Based on the GA drawing, the east and west approach embankments will be up to 12 m high. Based on the subsoil conditions encountered at the site, approach embankments consisting of 8 m high earth fill or 12 m high lightweight fill can be constructed. However, subexcavation of approximately 3 m of existing fill and organic silt to silty peat at the west abutment would be required.

Stability: Approach embankments up to 8 m high, constructed of select subgrade materials or granular fill and with side slopes no steeper than 2 horizontal to 1 vertical (2H:1V) will be safe against deep-seated slope instability. Approach embankments up to 12 m high, constructed of lightweight fill with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will also be safe against slope instability. In addition, construction of a mid-height berm will be required for embankments exceeding 8 m in height in to control surficial erosion and improve stability. Measures to stabilize the embankment slope face due to potential surface water flow/seepage at the slope surface will have to be implemented. From a stability perspective, embankments higher than 8 m earth fill and up to 12 m lightweight fill are not recommended.

Settlement: Based on consolidation parameters and elastic deformation moduli of the approach embankment foundation soils near the east and west abutment (estimated based on results of consolidation testing on samples from adjacent boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT ‘N’ values), total settlements have been estimated. Assuming 8 m high conventional earth or granular embankment fill or 12 m high lightweight embankment fill, the predicted total settlement at the west and east embankment locations is expected to be in the order of 500 mm and 300 mm, respectively. About 10 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement); the majority (about 95%) of the remaining consolidation settlement is anticipated to occur over a period of nine to twelve months. Therefore, measures to reduce post-construction settlement to acceptable values should be undertaken; these may include preloading with a surcharge and construction staging. Additionally, depending on the results of detailed geotechnical analyses, the use of wick drains may be warranted to promote dissipation of pore pressures and promote settlement at a faster rate. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and use of lightweight fill materials. Higher embankments are not recommended, although such embankments could be considered in combination with lightweight fill, stabilizing toe berms and much longer preload/surcharge periods.

• CONSTRUCTION CONSIDERATIONS

Excavation: surficial fill/silty sand/clayey silt and organic silt to silty peat are classified as Type 3 soils and Type 4 soils, respectively, according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and at 3H: 1V in the Type 4 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from filtered sumps. Artesian groundwater conditions may be encountered when advancing deep foundations such as piles through the granular deposits from approximately Elevations 133.7 m to 124.5 m.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving into or through the inferred dense sand and gravel layer.

Other: Due to the artesian water conditions within the lower cohesionless deposit, 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 steel H-Pile. Refer to Section 6.7.3 of the Report. In addition, specific access preparation procedures such as the use of temporary work bridges, winter construction and/or gravel roadways underlain by geosythetics should be considered to accommodate foundation construction at this location.

• RECOMMENDATIONS FOR ADDITIONAL WORK

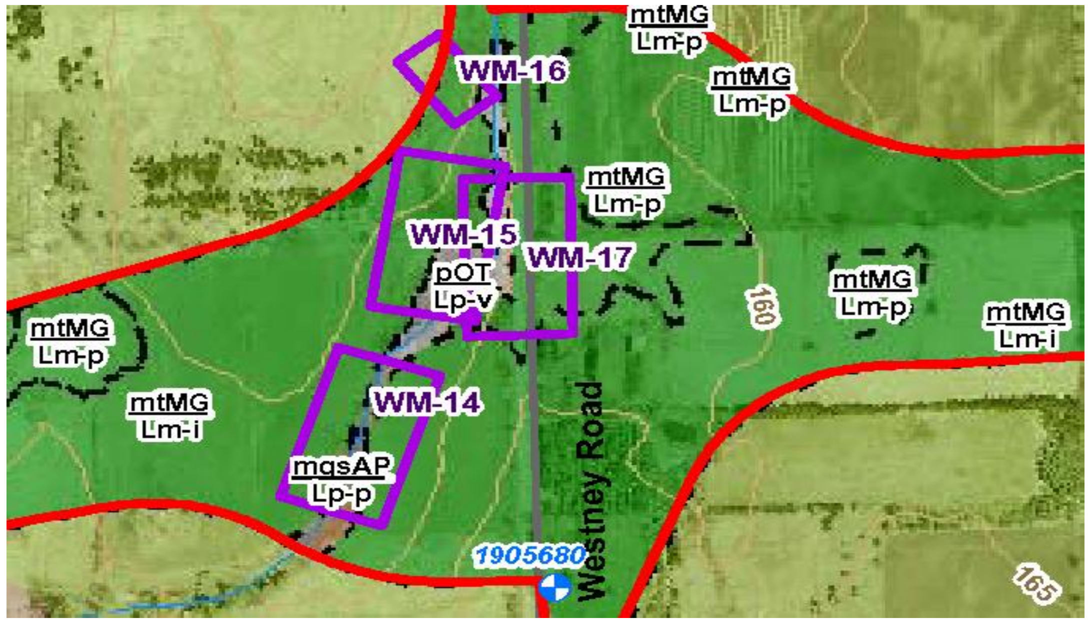
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

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:	WM-14

W.O: 07-20015 **Section:** Western **Location:** Tributary of East Duffin's Creek west of Westney Road **Sta.** ~15+300

Original Grade: **Proposed Grade:** **Description:** W – N/S Ramp crosses creek on culvert.



Site Plan and Terrain Analysis

Site Photograph – looking west from Westney Road towards site.

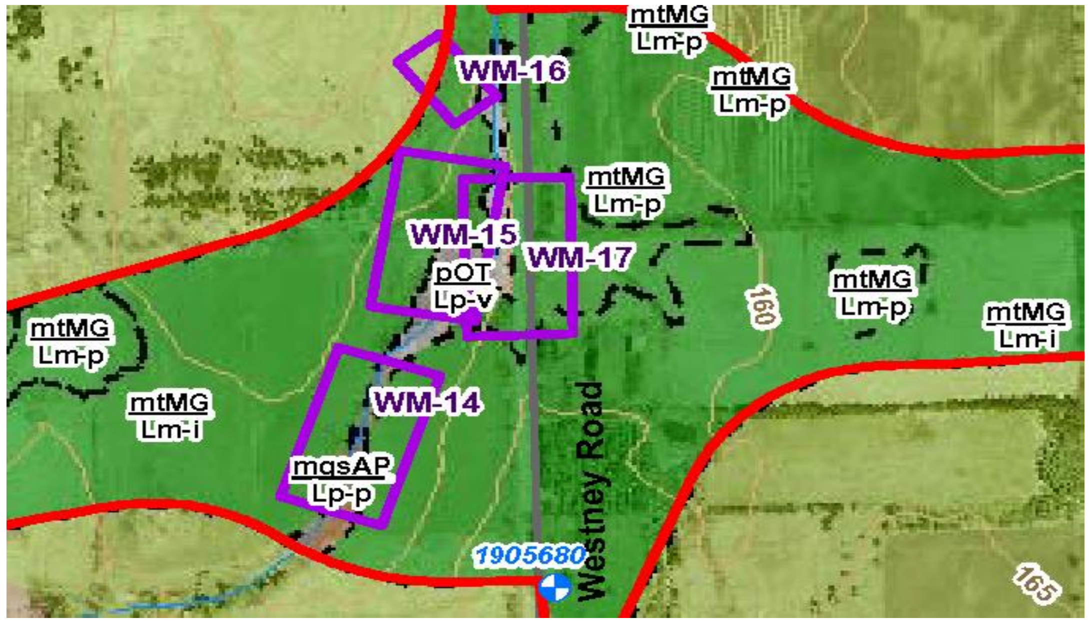
Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks
Boreholes: No existing boreholes for this site. Mapping shows that the site is underlain by silt till ground moraine with a minor alluvial deposit to the west of Westney Road. **Groundwater** Due to the presence of the small creek to the west, GWL is assumed to be close to the ground surface. **Estimated overburden thickness – 40m.**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Comparatively low approaches across a shallow valley in silt and silt till. No stability or settlement issues are anticipated provided organic and soft or loose soils are subexcavated and replaced with compacted granular fill. **Site Ranking** **Foundations:** **Low** **Hydrogeology:** **Low**	Poorly defined, shallow valley with no geomorphic evidence of significant valleyside instability. Valley bottom mostly organic material (<1 m) overlying till, with discontinuous sandy alluvial deposits Dewatering may be required.

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:	WM-15

W.O: 07-20015 **Section:** Western **Location:** Tributary of East Duffin's Creek west of Westney Road **Sta.** 15+300

Original Grade: **Proposed Grade:** **Description:** Mainline and ramp crosses creek on culvert.



Site Plan and Terrain Analysis


Site Photograph – looking west from Westney Road towards site.

Summarized Subsurface Conditions	**Recommendations – Structure**	**Recommendations – Approaches**	**Remarks**
Boreholes: No existing boreholes for this site. Mapping shows that the site is underlain by silt till ground moraine with a minor alluvial deposit to the west of Westney Road. **Groundwater** Due to the presence of the small creek to the west, GWL is assumed to be close to the groundsurface. **Estimated overburden thickness – 45m.**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Comparatively low approaches across a shallow valley in silt and silt till. No stability or settlement issues are anticipated provided organic and soft or loose soils are subexcavated and replaced with compacted granular fill.	Poorly defined, shallow valley with no geomorphic evidence of significant valleyside instability. Valley bottom mostly organic material (<1 m) overlying till, with discontinuous sandy alluvial deposits Dewatering may be required.

Site Ranking

Foundations: **Low**

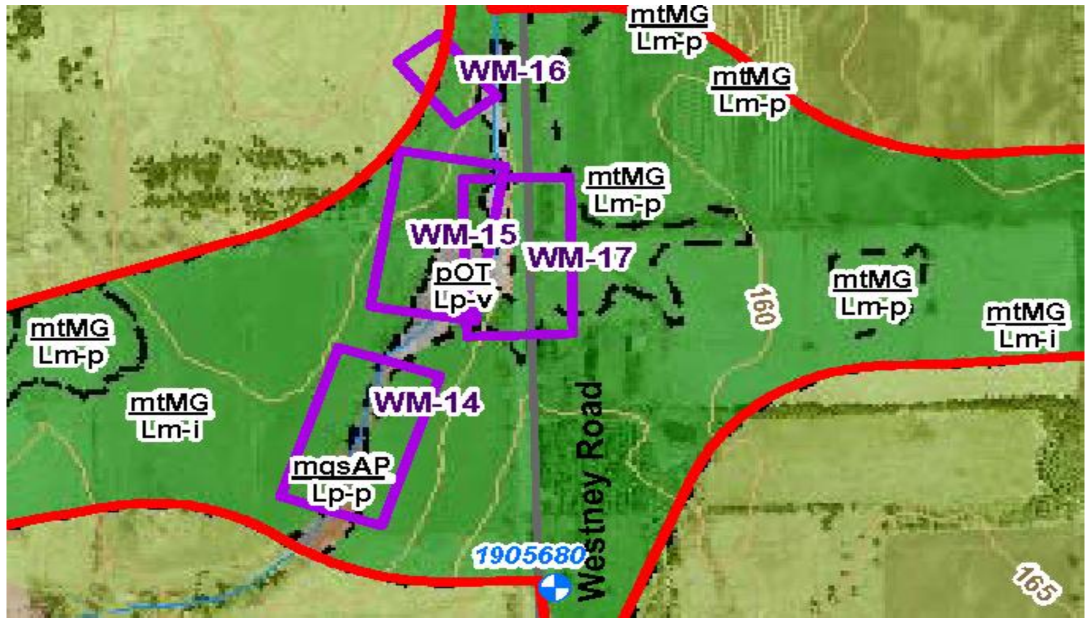
Hydrogeology: **Low**

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:	WM-16

W.O: 07-20015 **Section:** Western **Location:** Tributary of East Duffin's Creek west of Westney Road **Sta.** 15+350

Original Grade: **Proposed Grade:** **Description:** Ramp crosses creek on culvert.



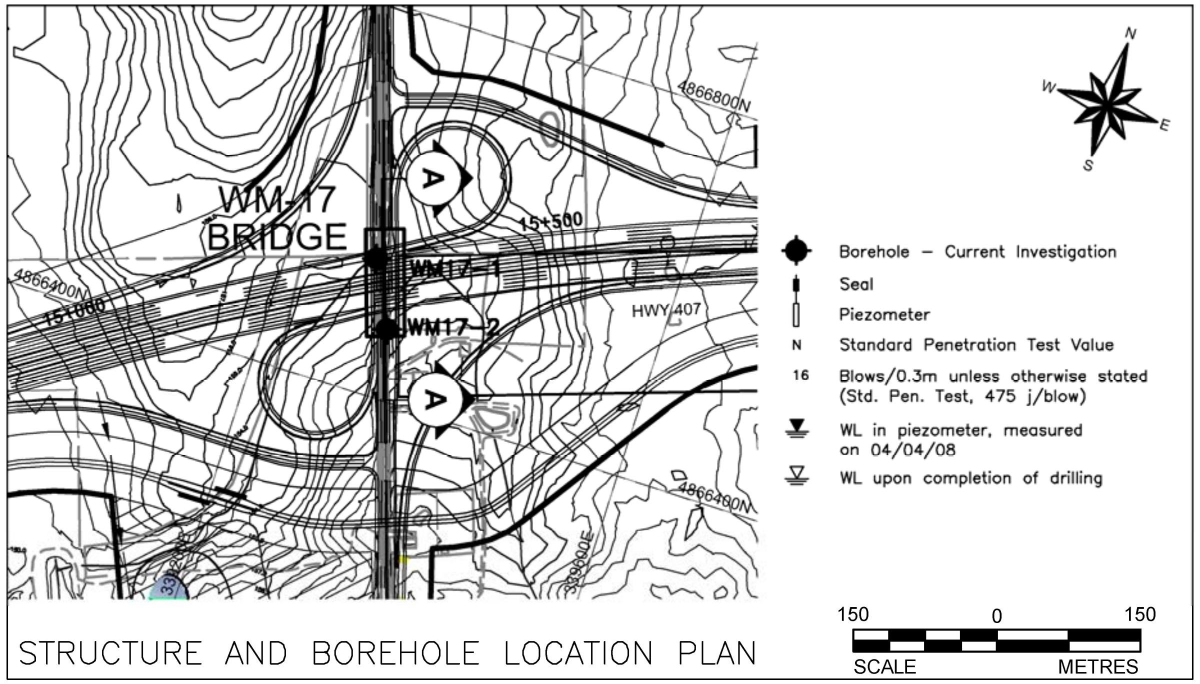
Site Plan and Terrain Analysis

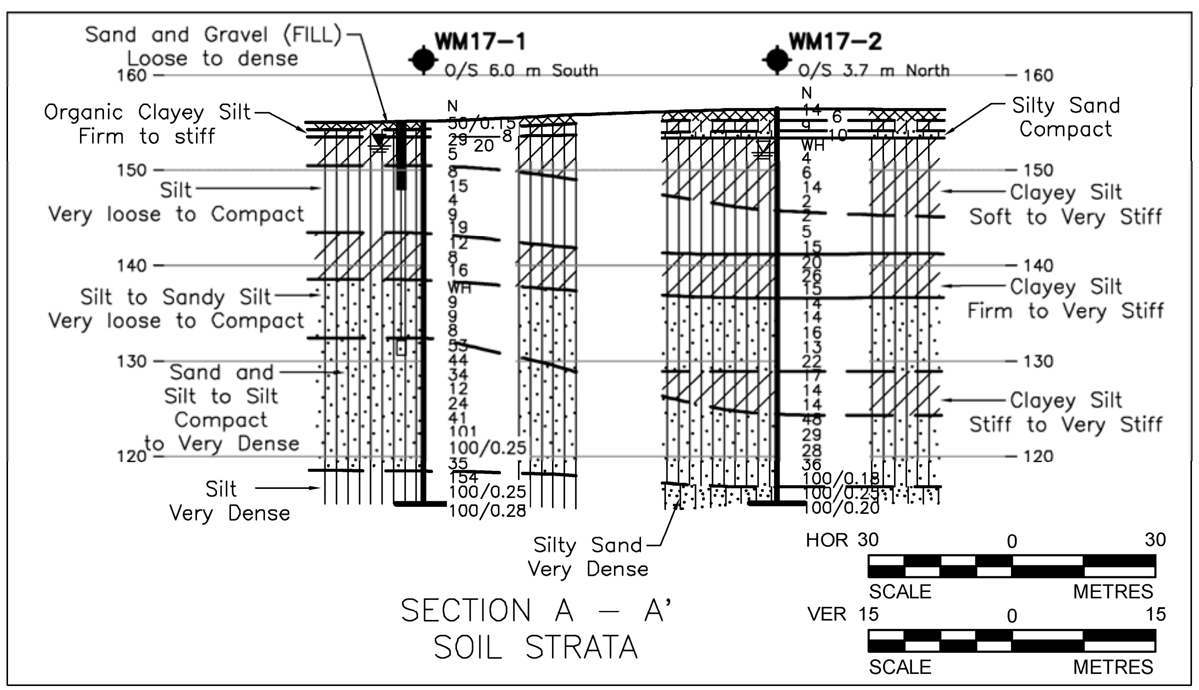
Site Photograph – looking west from Westney Road towards site.

Summarized Subsurface Conditions	**Recommendations – Structure**	**Recommendations – Approaches**	**Remarks**
Boreholes: No existing boreholes for this site. Mapping shows that the site is underlain by silt till ground moraine with a minor alluvial deposit to the west of Westney Road. **Groundwater** Due to the presence of the small creek to the west, GWL is assumed to be close to the surface. **Estimated overburden thickness – 45m.**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Comparatively low approaches across a shallow valley in silt and silt till. No stability or settlement issues are anticipated provided organic, loose and soft soils are subexcavated and replaced by compacted granular fill..	Poorly defined, shallow valley with no geomorphic evidence of significant valleyside instability. Valley bottom mostly organic material (<1 m) overlying till, with discontinuous sandy alluvial deposits Dewatering may be required.
		Site Ranking **Foundations:** **Low** **Hydrogeology:** **Low**	

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	Underpass Highway 407 / Westney Road	**Hwy 407 Proposed Grade:**	155.4 m – 156.7 m	**Site Ranking:**	Medium
Location No:	WM-17	**Existing Ground Elevation:**	156 m to 158 m	**Station:**	15+320





FOUNDATION INVESTIGATIONS

Site Description:

The site of Structure WM-17 is located on Westney Road, approximately 450 m north of Highway 7 in the City of Pickering, Ontario. Westney Road in this area is approximately 7.5 wide consisting of two lanes. The site is surrounded by farmland with vegetation consisting primarily of grasses, shrubs and trees on both sides of the road. The overall terrain is relatively flat to gently sloping.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM17-1	North Abutment	4 866 540.5	339 291.5	155.0	40.1
WM17-2	South Abutment	4 866 473.4	339 324.1	156.4	41.4

Subsurface Conditions:

- **Fill / Organic Soil:** loose to dense sand and gravel fill materials, extending to depths of 0.8 m and 1.2 m in Boreholes WM17-1 and WM17-2, respectively. SPT 'N' values within the fill materials ranged from 6 blows per 0.3 m of penetration to 50 blows per 0.15 m of penetration. Measured water contents on samples of the fill ranged from 3 to 14 percent. A 700 mm to about 1.1 m-thick layer of stiff organic clayey silt was encountered below the surficial fill, with measured water contents of about 20 percent.
- **Clayey Silt:** soft to very stiff clayey silt, containing trace to some sand, underlying the surficial fill/organic clayey silt and silty sand interlayer at a depth of 1.5 m (Elev. 153.5 m) and 3.1 m (Elev. 153.3 m) in Boreholes WM17-1 and WM17-2, respectively. The clayey silt deposit is interlayered with a silt to sandy silt or silty sand to sand and silt deposit to the termination depths of the boreholes at 40.1 m (Elev. 114.9 m) and 41.4 m (Elev. 115 m). SPT 'N' values within this deposit ranged from 'weight of the hammer' to 29 blows per 0.3 m of penetration and field vane shear strength typically varied from 16 kPa to 80 kPa, indicating a soft to stiff consistency. Measured water contents varied from about 15 to 28 percent. Grain size distribution and Atterberg limits test results are presented on Figures WM17-A and WM17-B (Appendix B). The results of one Oedometer test carried out on a sample of the upper soft to firm clayey silt are shown on Figures WM17-C1 to WM17-C4 and indicate that the sample tested is over consolidated; the consolidation parameters as interpreted from the Oedometer test results are summarized below as:

BH/Sample No.	*Sample Depth /Elev.*	*γ (kN/m^3)*	*σ_{vo}'(kPa)*	*σ_p'(kPa)*	*C_c*	*C_r*	*e_o*	*OCR*
WM17-2 / 6A	4.8 m / 151.5 m	20.9	65	150	0.12	0.024	0.55	2.3

Notes: σ_P': Apparent pre-consolidation pressure; σ_{VO}': Computed existing vertical effective stress; Cc: Compression index; Cr: Recompression Index; e_o: Initial void ratio; OCR: overconsolidation ratio.

- **Silt/Sandy Silt to Silty Sand/Sand and Silt:** silt to sandy silt and silty sand/sand and silt, containing trace to some clay and occasionally trace gravel, encountered at a depth of 4.6 m (Elev.150.4 m) and 2.3 m (Elev. 154.1 m) in Boreholes WM17-1 ad WM17-2, respectively. The silt/sandy silt to silty sand/sand and silt was found interlayered with the clayey silt deposit to the termination depths of the boreholes. SPT 'N' values in the upper silt to sandy silt to silty sand strata ranged from 'weight of hammer' to 22 blows per 0.3 m of penetration and varied from 12 blows per 0.3 m of penetration to 100 blows per 0.18 m of penetration in the lower silt to silty sand to sand strata. Grain size distribution and Atterberg limits test results are presented on Figures WM17-D, WM17-E, WM17-F and WM-G (Appendix B). Measured water contents typically varied from about 10 to 25 percent. A layer of very dense silty sand was encountered in Borehole WM17-2 at a depth of 39.6 m (Elev. 116.8 m) and extended to the termination depth of the borehole at 41.4 m (Elev. 115 m). The results of one grain size distribution test on a sample of the silty sand are shown on Figure WM17-H.

Groundwater Conditions:

- **BH WM17-1:** Depth of 2.5 m below ground surface (Elev.152.5 m) in piezometer on April 4, 2008
- **BH WM17-2:** Depth of 2.6 m below ground surface (Elev. 153.8 m) upon completion of drilling on January 17, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 3**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-17

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing of Structure WM-17, received in February 2009, the proposed underpass is a two span structure with a total structure length of about 92 m and approach embankments about 9 m high. The proposed Westney Road grade at Highway 407 is at about Elevation 168 m. Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread footings "perched" on a well compacted Granular 'A' pad for the bridge abutments	• Minimizes excavation requirements • Lower foundation costs	• Potential differential settlement between abutments and pier. • Schedule to accommodate preloading time before construction of the abutments to minimize potential for differential settlement
Steel H-Piles driven into "100-blow" silt to sandy silt or silty sand deposits	• Allows for integral abutment design • Minimize differential settlement between foundation elements	• More expensive than shallow foundations
Caissons bored to found within "100-blow" silt to sandy silt or silty sand deposits.	• Larger caissons have higher bearing resistances than steel H-Piles, though partially offset by higher downdrag loads than for steel H-piles	• More expensive than shallow foundations • May require temporary or permanent liner

.**A - Spread Footings:** The upper subsoil conditions are not suitable for support of shallow foundations; however, spread footings "perched" on a well compacted Granular 'A' pad may be considered for the bridge abutments, provided that preloading or other measures are taken during the construction of the approach embankments to reduce anticipated post-construction settlements within the underlying soft to firm clayey silt soils.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Compacted Granular A (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" silt to sandy silt to silty sand deposits, below Elevation 117 m (minimum of 1.5 m embedment into the "100-blow" materials) are feasible for support of the abutments and central pier. Pile lengths would be on the order of 46 m for abutments with "perched" pile caps and on the order of 40 m for the central pier. The structural design of the piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to minimize post-construction settlements under the new embankment loading; in this case downdrag loads can be eliminated.

Pile	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored) abutments only*
	Factored ULS	**SLS**	
HP 310 x 110	1,600 kN	1,400 kN	550 kN

C – Caissons: Abutments and central pier on caissons founded a minimum of 2 m within the "100-blow" silt to sandy silt or silty sand deposits below Elevation 117.5 m. Effective caissons lengths would be about 39 m. Full downdrag loads as provided below should be accounted for unless long-term settlement mitigation measures as discussed above for pile foundations are undertaken.

Caisson Diameter	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored)*
	Factored ULS	**SLS**	
1.2 m	4,500 kN	3,500 kN	1,400 kN
1.5 m	6,500 kN	5,500 kN	2,000 kN

Recommended Foundation Alternative: Steel H-Piles.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- **APPROACHES**

Embankment Height: approximately 9 m.

Stability: Approach embankments up to 7.5 m high, constructed with select subgrade materials or granular fill, with side slopes no steeper than 2 horizontal to 1 vertical (2H:1V) will be safe against deep-seated slope instability. Approach embankments up to 9 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1 V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fill materials and based on consolidation parameters and elastic deformation moduli of the approach embankments foundation soils (estimated based on the results of oedometer testing and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlement within the embankment foundation soils is on the order of 400 mm. About 50 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement); the remainder settlement (i.e. consolidation settlement) is anticipated to occur over a period of six to nine months. Therefore, measures to reduce post-construction settlement to acceptable values should be undertaken; these may include preloading with a surcharge and construction staging, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Detailed geotechnical analyses need to be carried out during the bridge detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation and to assess the use of lightweight fill materials.

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the existing fill materials and upper soft/firm clayey silt soils are classified as Type 3 soil according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1 H: 1V.

Groundwater/Surface Water Control: it is anticipated that any groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: No major obstructions (e.g. cobbles or boulders) are anticipated at the site based on the borehole data at this site.

Other: It is noted that basal heave could occur in the more pervious sand and silt to silty sand soils at/near the caisson base. If caisson foundations are adopted for this site, temporary or permanent caisson liners would be required to support the soils during construction and permit inspection and cleaning of the caisson base. Temporary liners can however, be difficult to withdraw, owing to the length of the liners and the very dense nature of the lower strata; such difficulties can result in "necking" of the caisson. As such, permanent liners would be preferred over temporary liners for the construction of the caissons.

- **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.

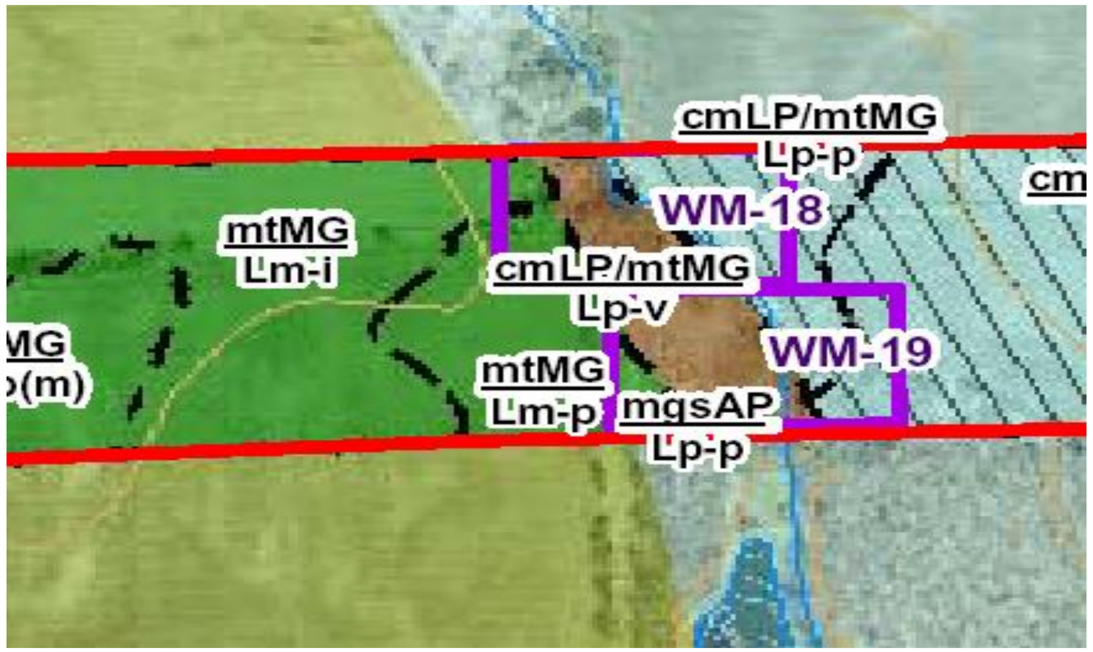
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-18 WM-19

W.O: 07-20015 **Section:** Western **Location:** Mainline at Carruther's Creek West Tributary **Sta.** 16+200

Original Grade: **Proposed Grade:** **Description:** Twin structures to carry the Mainline over the creek.



Site Plan and Terrain Analysis

Site Photograph – Looking north towards site from Hwy 7

Summarized Subsurface Conditions	Recommendations: Structure	Recommendations: Approaches	Remarks
Boreholes: No existing boreholes at this site. Mapping (West 3) shows that the creek lies along the east edge of a 50m wide alluvial plain within a wider glaciolacustrine plain. A small pond straddles the south edge of the ROW at the west side of the alluvial plain. **Groundwater** GWL may be assumed to be at about the creek level. **Estimated overburden thickness – 40m.**	**1. Abutments** In the absence of specific borehole data at the site and based on the presence of glaciolacustrine soils, a piled foundation may be assumed for preliminary design purposes. HP 310X110 piles may be designed for: – ULS resistance – 1,600 kN – SLS resistance – 1,400 kN Integral abutments are feasible. Assume 25m long piles The feasibility of shallow foundations should be assessed based on additional field investigation **2. Piers** If piers are required, assume piles, as described for abutments.	Some removal of organic soil (peat) and other unsuitable soil from below the approach fills will be required. Assume 2m of subexcavation Based on the mapped glaciolacustrine soils, it may be necessary to pre-build the approaches to allow for consolidation settlement. Approach embankments up to 10m are expected to be stable, or, at most, to require some slope flattening. **Site Ranking** **Foundations:** **Medium** **Hydrogeology:** **Medium**	It is anticipated that routine dewatering of excavations will be required and may be carried out using sumps and pumps Narrow, shallow valley with no geomorphic evidence of significant valleyside instability

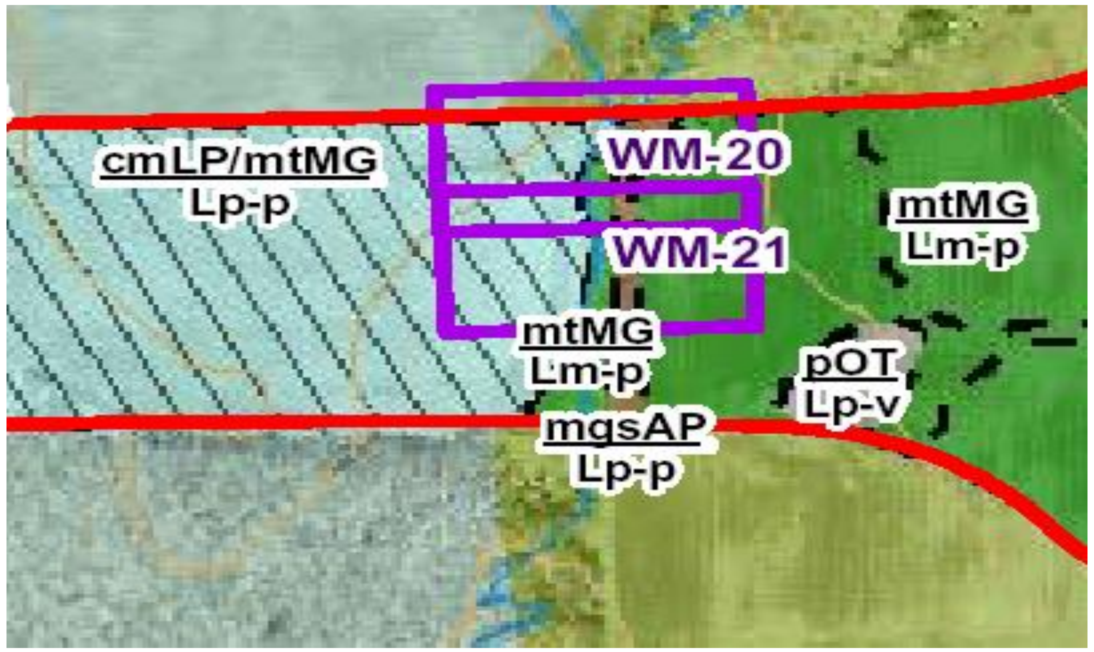
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-20 WM-21

W.O: 07-20015 **Section:** Western **Location:** Mainline at Carruther's Creek West Tributary (2) **Sta.** 16+575

Original Grade: **Proposed Grade:** **Description:** Twin structures to carry the Mainline over the creek.



Site Plan and Terrain Analysis

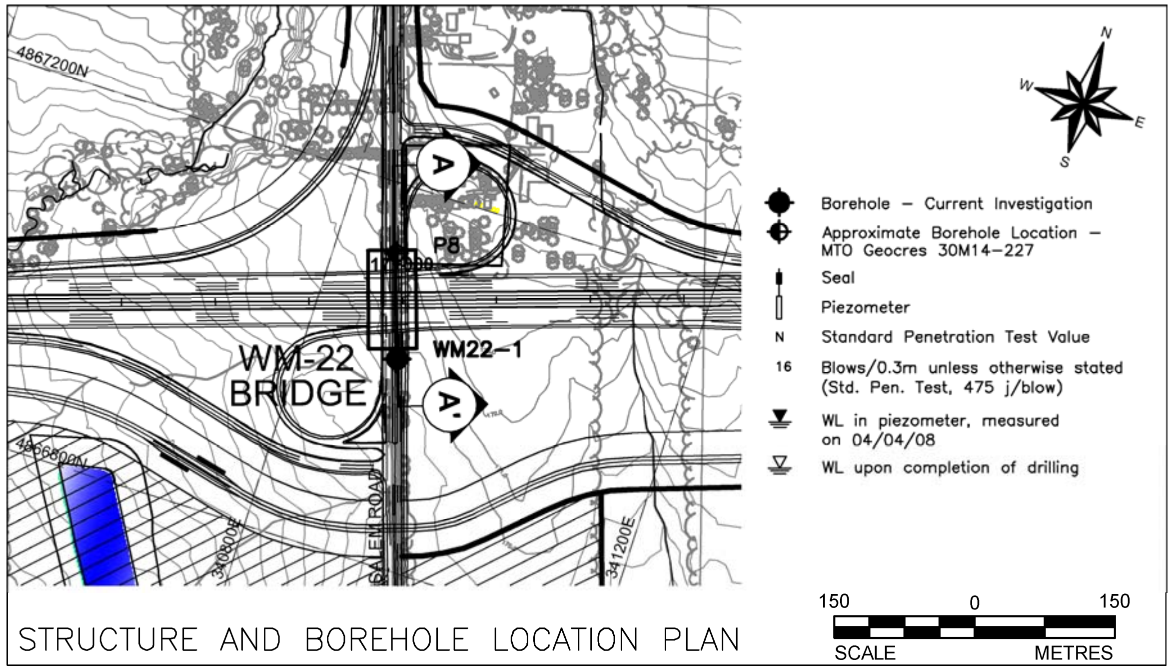

Site Photograph – Looking west towards site from Salem Road

Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks
Boreholes: No existing boreholes at this site. BH P8, Book 15 lies 350m east. Mapping (West 3) shows that the creek lies across a narrow creek valley with alluvial deposits within an area of silt till ground moraine and with a glaciolacustrine plain lying to the west. Borehole P8 located about 350 m east of the site encountered a very stiff to hard clayey silt glacial till deposit followed by dense to very dense sand and silt and a deeper hard silty clay deposit. **Groundwater** Based on the presence of the creek, GWL may be assumed to be near the ground surface. The water level noted upon completion of drilling Borehole P-8 was at about 0.4 m depth (about El. 169.5 m) **Estimated overburden thickness – 40m.**	**1. Abutments** In the absence of specific borehole data but based on the presence of silt till ground moraine and subsurface information from Borehole P-8, the following may be assumed for preliminary design purposes. a. Footings may be founded on compacted Granular A cores as per current MTO standard practices , at least 1.2 m below existing ground b. For closed abutments, footings may be founded on native soil at least 1m below existing surface. – Factored resistance at ULS – 450 kPa – Resistance at SLS – 300 kPa c. Abutments may also be supported on HP 310X110 piles driven to refusal – ULS resistance – 1,600 kN – SLS resistance – 1,400 kN d. Integral abutments are feasible. Assume 30m piles. **2. Piers** If piers are required, assume same recommendations as described for abutments.	Some removal of organic soil (peat) and other unsuitable soil from below the approach fills will be required. Approach embankments up to 10 m may be constructed with side slopes no steeper than 2H:1V using SSM or granular materials.	Groundwater control will likely be required for foundation excavations at the abutments and piers locations. Narrow, shallow valley with no geomorphic evidence of significant valleyside instability
		Site Ranking **Foundations:** **Medium** **Hydrogeology:** **Medium**	

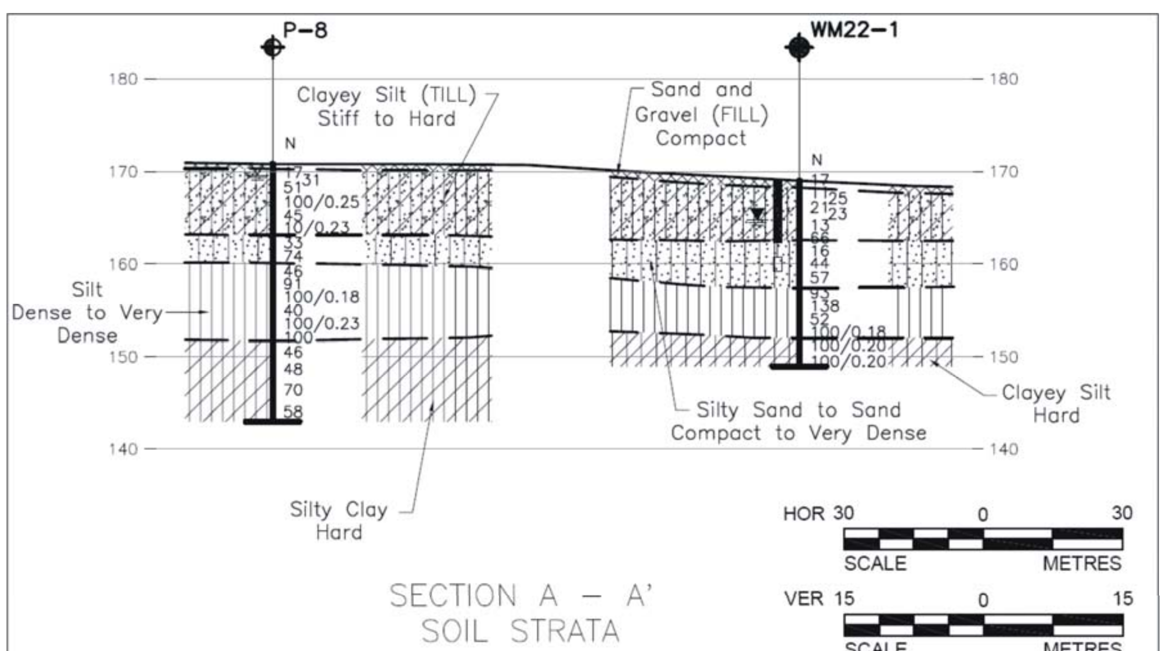
PRELIMINARY FOUNDATION INVESTIGATION AND RECOMMENDATIONS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Salem Road **Hwy 407 Proposed Grade:** 171.6 m **Site Ranking:** Medium

Location No: WM-22 **Existing Ground Elevation:** 169 m to 171 m **Station:** 17+988



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of structure WM-22 is located on Salem road, approximately 1 km north of Highway 7 in the City of Pickering, Ontario. Salem Road in this area is a gravel surfaced road with an approximate width of 6 m. The terrain at the site is relatively flat to gently sloping and the vegetation surrounding the site consists of grasses, shrubs and trees.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM22-1	South Abutment	4 867 019.3	340 901.0	169.0	20.0
P8*	North Abutment	4 867 127.0	340 865.8	170.7	27.9

*GEOCRES 30M14-227. Coordinates on original Borehole log referenced to MTM-NAD27.

Subsurface Conditions:

- **Fill:** sand and gravel fill encountered in both boreholes and ranging to depths of 0.5 m to 0.8 m below the existing ground surface. One SPT ‘N’ value measured within the fill was 17 blows per 0.3 m of penetration indicating compact relative density. One water content measured on a sample of the fill was about 4 percent.
- **Till:** clayey silt till with sand, trace gravel, occasional cobbles and boulders, encountered in both boreholes immediately below the fill materials and extends to a depth of 6.4 m (Elev. 162.6 m) in Borehole WM22-1 and to a depth of 7.6 m (Elev. 163.1 m) in Borehole P8. SPT ‘N’ values measured within the clayey silt till at both boreholes ranged from 11 blows per 0.3 m of penetration to 100 blows per 0.23 m of penetration, indicating a stiff to hard consistency. Grain size distribution and Atterberg limits test results are presented on Figures WM22-A and WM22-B, respectively (Appendix B). Measured water contents on samples of this deposit range between about 11 and 24 percent.
- **Silty Sand to Sand:** silty sand to sand, some silt containing trace to some gravel, trace clay and occasional cobbles, encountered in both boreholes underlying the till deposit to a depth of 11.6 m (Elev. 157.4 m) in Borehole WM22-1 and to a depth of 10.7 m (Elev. 160.0 m) in Borehole P8. SPT ‘N’ values vary from 16 to 74 blows per 0.3 m of penetration indicating a compact to very dense relative density. The results of grain size distribution tests are presented on Figure WM22-C (Appendix B). Measured water contents on samples of this deposit range between 7 and 18 percent.
- **Silt:** silt, containing trace to some sand and clay and trace gravel, encountered in both boreholes below the silty sand to sand layer extending to a depth of 18.0 m (Elev. 151.0 m) in Borehole WM22-1 and to a depth of 19.1 m (Elev. 151.6 m) in Borehole P-8. SPT ‘N’ values on samples of the silt deposit range between 40 blows per 0.3 m of penetration and 100 blows per 0.18 m of penetration, indicating dense to very dense relative density. Grain size distribution test results are presented on Figure WM22-D (Appendix B). Water contents on samples of the silt deposit vary from about 8 to 20 percent.
- **Clayey Silt to Silty Clay:** clayey silt to silty clay, containing sand seams, encountered below the silt deposit to depths of 20.0 m (Elev. 149.0 m) and 27.9 m (Elev. 142.8 m) in Boreholes WM22-1 and P8, respectively. Both Boreholes were terminated in the clayey silt to silty clay deposit. SPT ‘N’ values varied from 48 blows per 0.3 m of penetration to 100 blows per 0.2 m of penetration, indicating a hard consistency. The results of grain size distribution and Atterberg limits tests are presented on Figures WM22-E and WM22-F, respectively (Appendix B). Water contents on samples of this deposit vary from about 12 to 24 percent.

Groundwater Conditions:

- **BH WM22-1:** 4.0 m below ground surface (Elev. 165.0 m) in open borehole upon completion of drilling; 5.6 m below ground surface (Elev. 163.4 m) in piezometer on January 7, 2008 and 4.8 m below ground surface (Elev. 164.2 m) on April 4, 2008.
- **BH P8:** 1.2 m below ground surface (Elev. 169.5 m) in open borehole upon completion of drilling.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 4**

PRELIMINARY FOUNDATION INVESTIGATION AND RECOMMENDATIONS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-22

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing of Structure WM-22 provided by URS on January 2009, the proposed bridge structure will carry Salem Rd. over Hwy 407. The proposed underpass will be a two span structure with a total structure length of about 104 m and approach embankments between 8 m high and 10 m high. Highway 407 grade is proposed at Elevation 171.6 m. The proposed Salem Road grade is at about Elevation 179 m at the crossing of Highway 407. Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread footings on very stiff clayey silt till or on a compacted Granular 'A' pad for abutment footings "perched" within the bridge approaches	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of up to 2 m of surficial materials and into the clayey silt till
Steel H-Piles driven into "100-blow" clayey silt deposit	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through cobbles
Caissons bored to found within "100-blow" clayey silt deposit	• Higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through materials containing occasional cobbles and possibly boulders. • May require temporary or permanent liner

A - Spread Footings: Founded within the very stiff to hard clayey silt till at or below Elevation 167.5 m at the south abutment (based on Borehole WM22-1) and at or below Elevation 169 m at the north abutment (based on Borehole P8); all footings should be placed at a minimum depth of 1.2 m below the lowest surrounding grade.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Clayey Silt Till	450 kPa	300 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Abutments and central pier on steel HP 310 x 110 piles driven to found within the "100-blow" clayey silt or silt deposits to found between about Elevation 153 m and Elevation 150 m. Pile lengths would vary from about 20.5 m to 23.5 m at the abutments and from 15.5 m to 18.5 m at the central pier location.

Pile	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,400 kN	1,200 kN

C – Caissons: Abutments and central pier on caissons founded at least 1.5 m within the "100-blow" clayey silt or silt deposits between Elevation 150 m and Elevation 153 m.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	4,500 kN	3,500 kN
1.5 m	6,500 kN	5,500 kN

Recommended Foundation Alternative: Steel H-Pile foundations.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Embankment Height: approximately 8 m to 10 m high.

Stability: Approach embankment up to 10 m high with side slopes no steeper that 2 horizontal to 1 vertical (2H : 1V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fills, where applicable, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill and clayey silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1 H : 1V in Type 3 soils, and 1H : 1V to within 1.2 m of the bottom of the excavation in Type 3 soils.

Groundwater/Surface Water Control: it is anticipated that foundation excavations will be above the existing groundwater table which is at a depth of about 4 m below ground surface (Elev. 165 m). Any surface water and/or groundwater seepage into the foundation excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. Caisson drilling equipment must be capable of penetration obstructions such as cobbles/boulders in the silty sand to sand and upper clayey silt till layers.

• 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.

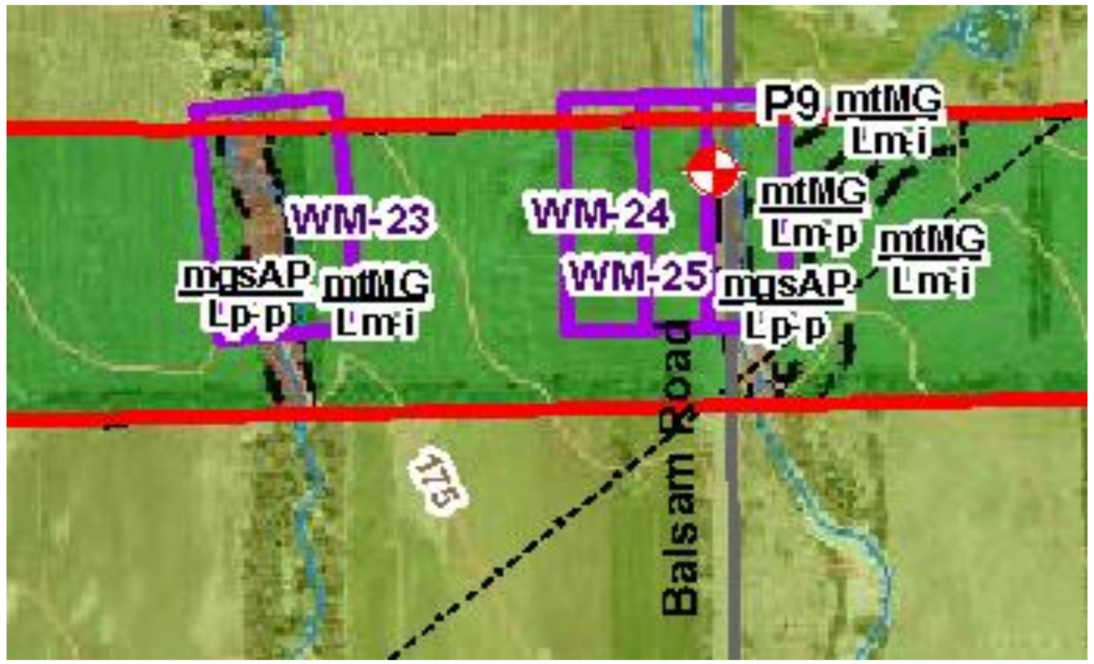
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-23

W.O: 07-20015 **Section:** Western **Location:** Culvert 250m west of Balsam Road **Sta.** 17+580

Original Grade: **Proposed Grade:** **Description:** Mainline crosses un-named creek on culvert



Site Plan and Terrain Analysis

Site Photograph – looking west towards culvert site.

Summarized Subsurface Conditions	Recommendations		Remarks
	Structure	Approaches	
Boreholes: No borehole at the site. Mapping (West 3) shows that the site lies in the silt till ground moraine. The relief is low plain, poorly drained. The stream flows in a narrow band of recent alluvium. **Groundwater** The GWL is anticipated to be close to the ground surface at the culvert. **Estimated overburden thickness – 55m.**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Comparatively low approaches across a shallow valley in a till sheet. No stability or settlement issues are anticipated.	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys Depending on the final design and time of year construction is carried out, unwatering and temporary stream diversion may be required.

Site Ranking

Foundations: **Low**

Hydrogeology: **Low**

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Highway 407 over Carruthers Creek Tributary

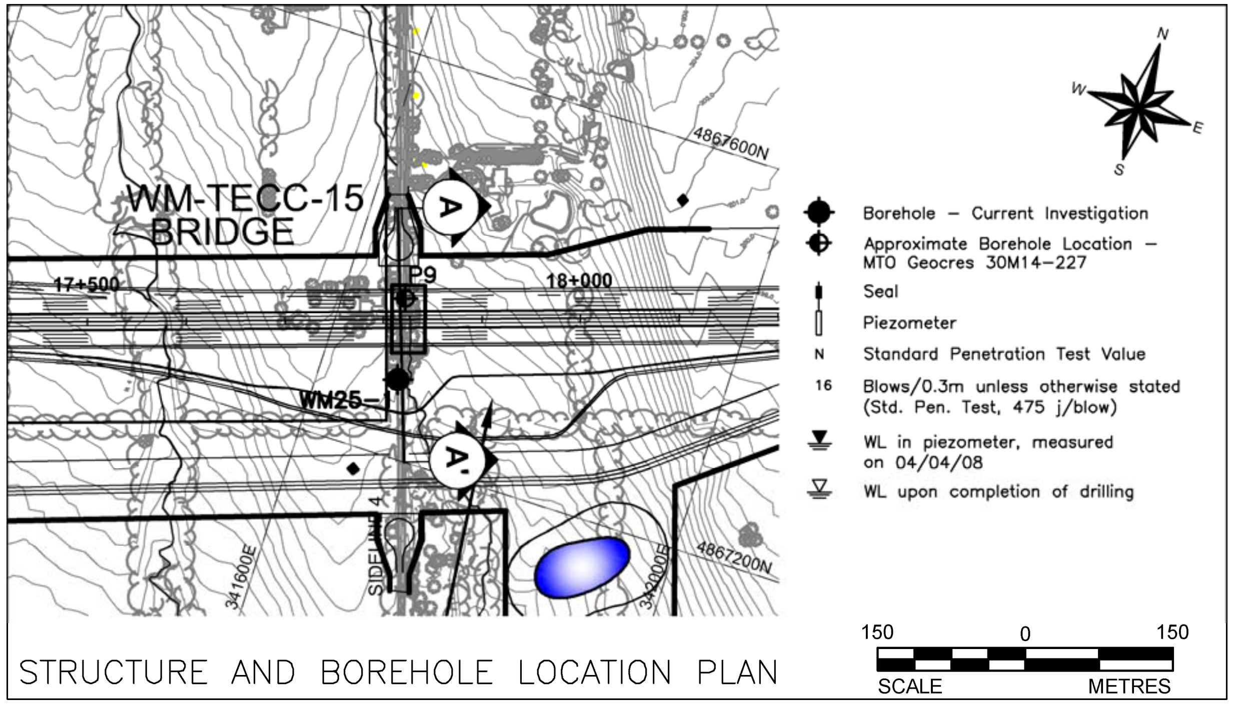
Hwy 407 Proposed Grade: 184.5 m

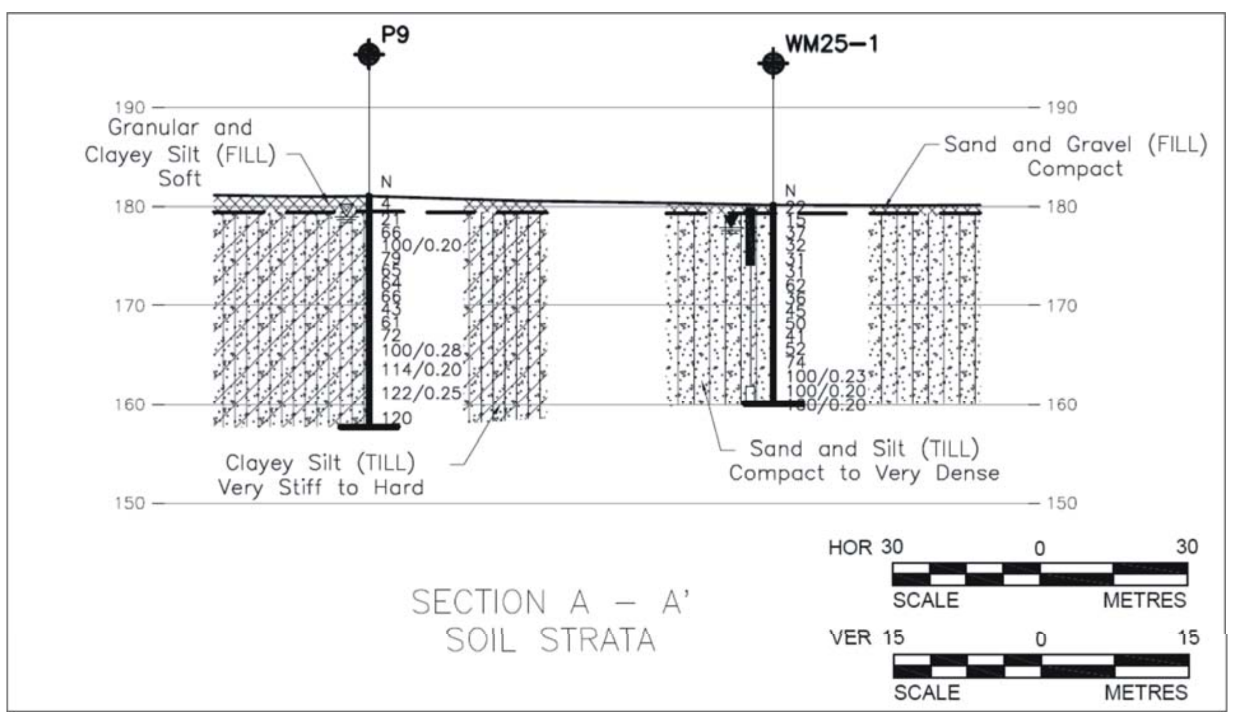
Site Ranking: Medium

Location No: WM-24 (WM-TECC-15)

Existing Ground Elevation: 179.5 m – 182 m

Station: 17+827





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-TECC-15 bridge structure is located east of Sideline 4, approximately 1,000 m north of Highway 7 in the City of Pickering, Ontario. Sideline 4 in the vicinity of the site consists of an approximately 6 m wide, gravel surfaced road with relatively flat to gently sloping surface topography and Carruthers Creek Tributary flows from north to south, immediately east of the road. The site in the vicinity of the proposed bridge structure is mainly surrounded by farmland, with vegetation near the creek and road consisting of grasses, shrubs and trees.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM25-1	South Abutment	4 867 278.2	341 679.9	180.1	20.0
P9*	North Abutment	4 867 359.2	341 661.9	181.1	23.3

*GEOCRES 30M14-227. Coordinates on Borehole log originally referenced to MTM-NAD27.

Subsurface Conditions:

- **Fill:** sand and gravel fill encountered in Borehole WM25-1 to a depth of 0.8 m (elev. 179.3 m); 500 mm of granular fill overlying a 1 m think layer of soft clayey silt fill containing trace gravel and organics encountered in Borehole P9 to a depth of 1.5 m (Elev. 179.6 m). SPT 'N' values measured within the sand and gravel fill and the clayey silt fill were 22 and 4 blows per 0.3 m of penetration respectively, indicating compact relative density or soft consistency. Measured water content on one sample of the sand and gravel fill was about 8 percent.

- **Till:** clayey silt to sand and silt, some clay, containing trace to some gravel, occasional cobbles and boulders encountered immediately below the fill materials and extending to the termination depths of the boreholes. SPT 'N' values measured within the till deposit varied from 15 blows per 0.3 m to 114 blows per 0.2 m, indicating a very stiff to hard consistency /compact to very dense relative density. The results of grain size distribution and Atterberg limits tests are presented on Figures WM25-A and WM25-B (Appendix B), respectively. Measured water contents on samples of the sand and silt till range between about 5 and 9 percent.

Groundwater Conditions:

- **BH WM25-1:** Depth of 6.1 m (Elev. 174.0 m) in open borehole; depth of 2.2 m (Elev. 177.9 m) in piezometer on April 4, 2008.

- **BH P9:** Depth of 2.3 m (Elev. 178.8 m) in open borehole upon completion of drilling.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-24 (WM-TECC-15)

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: Based on the General Arrangement drawing provided by URS on January 2009, the proposed bridge structure will carry the Hwy 407 EB and WB lanes over Carruthers Creek Tributary. Bridge WM-TECC-15 is a single span structure with closed-end type abutments and a total length of 34 m. The approach embankments are 3.5 m and 4 m high at the west and east abutments, respectively. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on dense sand and silt till or hard clayey silt till	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of about up to 2 m of surficial fill materials
Steel H-Piles driven into "100-blow" sand and silt till or clayey silt till	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, containing cobbles.
Caissons bored to found within "100-blow" sand and silt till or clayey silt till	• Higher bearing resistances than steel H piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Spread footings for the west and east abutments founded within the hard clayey silt till and dense sand and silt till, respectively, at or below Elevation 178.5 m and at a minimum depth of 1.2 m below the lowest surrounding grade.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Hard Clayey Silt Till (West Abutments)	500 kPa	350 kPa
Dense Sand and Silt Till (East Abutments)	500 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt till or clayey silt till between Elevation 164.5 m (west abutments) and Elevation 162 m (east abutments), are feasible for support of the bridge abutments. Piles lengths would vary between about 13.5 m and 16 m.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	1,400 kN

C – Caissons: Abutments on caissons, extending a minimum of 2 m into the "100-blow" till between Elevation 164 m (west abutments) and Elevation 161.5 m (east abutments) can be considered.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	4,500 kN	3,500 kN
1.5 m	6,500 kN	5,500 kN

Recommended Foundation Alternative: Shallow Foundations; caissons and pile foundations are also appropriate.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional, semi-integral abutments or integral abutments.

- **APPROACHES**

Approach Height: up to 4 m.

Stability: Approach embankments consisting of select subgrade material or granular fill up to 4 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) should have adequate factor of safety against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fills, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the existing fill materials and native till deposits are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H: 1V in Type 3 soils, and sloped to within 1.2 m of the bottom of the excavation at a slope 1H: 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for shallow foundations at Elevation 178.5 m can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles, if selected, should be used; caisson drilling equipment must be capable of penetrating obstructions such as cobbles/boulders within the sand and silt till and clayey silt till deposits.

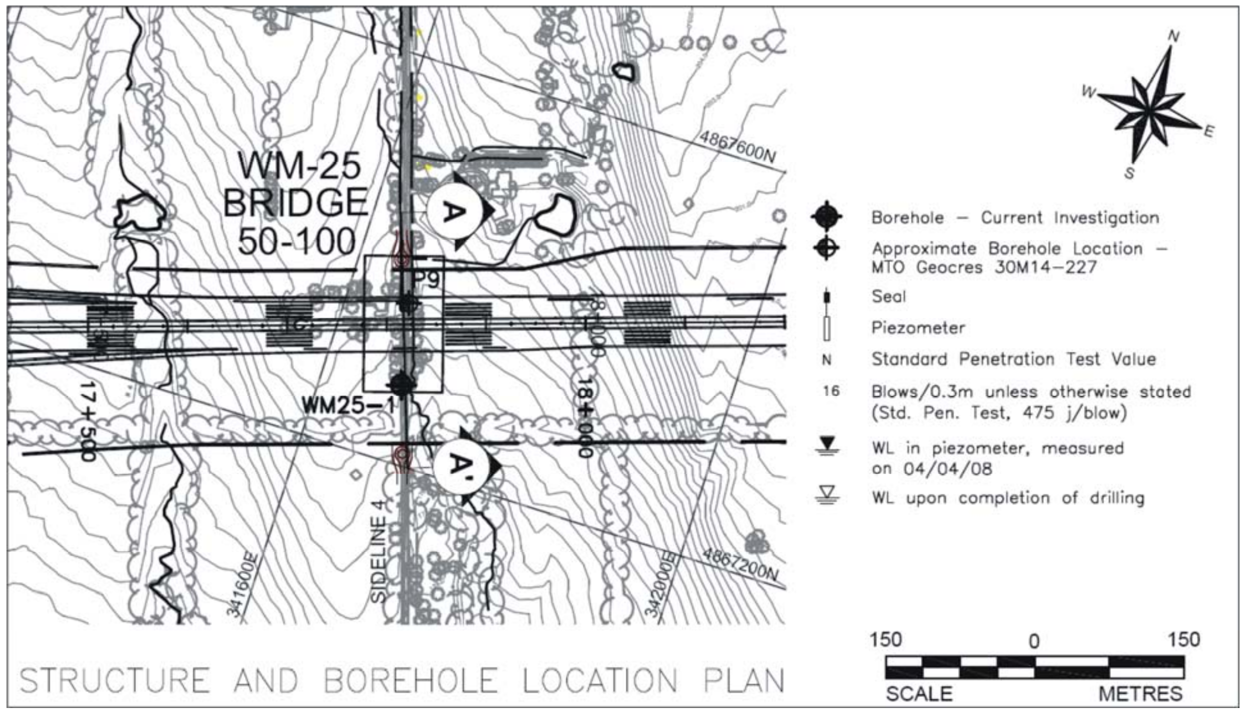
- **RECOMMENDATIONS FOR ADDITIONAL WORK**

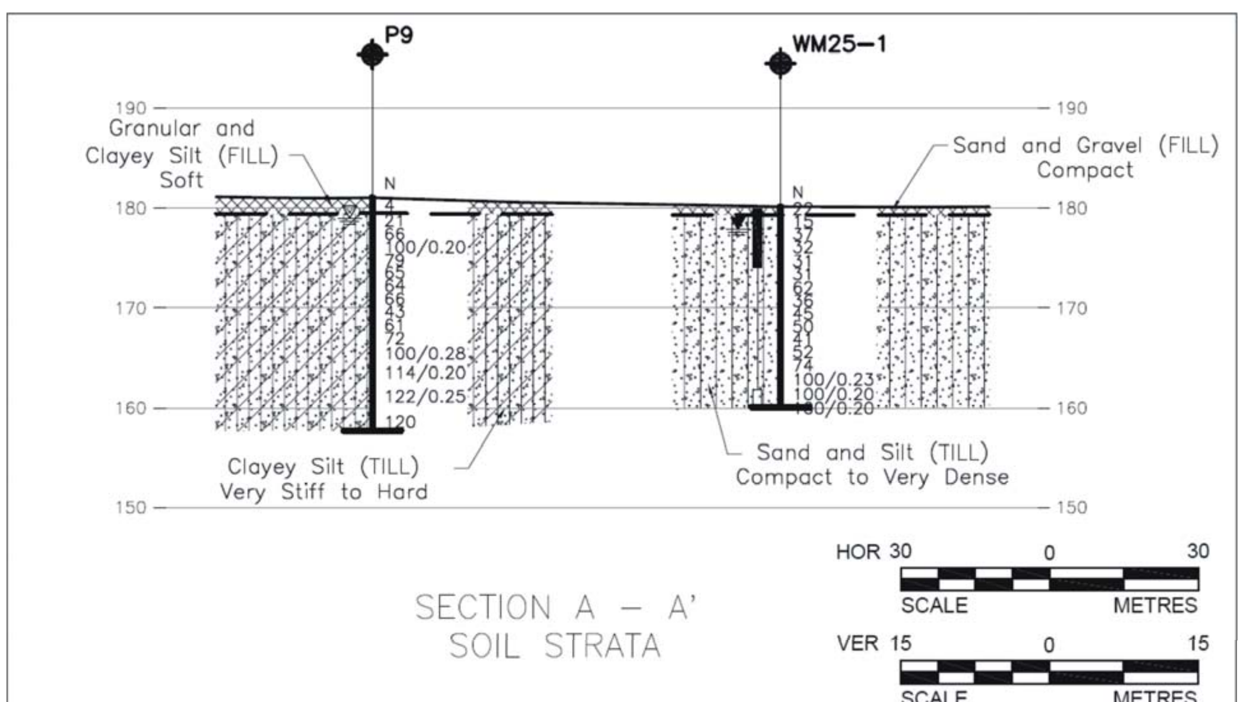
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass Highway 407 / Sideline 4 – Deleted from Project
Hwy 407 Proposed Grade: 184.2 m
Site Ranking: Medium

Location No: WM-25 (Deleted)
Existing Ground Elevation: 180 m – 181.5 m
Station: 17+820





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-25 bridge structure is located on Sideline 4, approximately 1 km north of Highway 7 in the City of Pickering, Ontario. Sideline 14 in the vicinity of the site consists of an approximately 6 m wide gravel surfaced road with relatively flat to gently sloping surface topography. The surrounding vegetation consists of grasses, shrubs and trees.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM25-1	South Abutment	4 867 278.2	341 679.9	180.1	20.0
P9*	North Abutment	4 867 359.2	341 661.9	181.1	23.3

*GEOCRES 30M14-227. Coordinates on Borehole log originally referenced to MTM-NAD27.

Subsurface Conditions:

- **Fill:** sand and gravel fill encountered in Borehole WM25-1 to a depth of 0.8 m (elev. 179.3 m); 500 mm of granular fill overlying a 1 m think layer of soft clayey silt fill containing trace gravel and organics encountered in Borehole P9 to a depth of 1.5 m (Elev. 179.6 m). SPT 'N' values measured within the sand and gravel fill and the clayey silt fill were 22 and 4 blows per 0.3 m of penetration respectively, indicating compact relative density or soft consistency. Measured water content on one sample of the sand and gravel fill was about 8 percent.

- **Till:** clayey silt to sand and silt, some clay, containing trace to some gravel, occasional cobbles and boulders encountered immediately below the fill materials and extending to the termination depths of the boreholes. SPT 'N' values measured within the till deposit varied from 15 blows per 0.3 m to 114 blows per 0.2 m, indicating a very stiff to hard consistency /compact to very dense relative density. The results of grain size distribution and Atterberg limits tests are presented on Figures WM25-A and WM25-B (Appendix B), respectively. Measured water contents on samples of the sand and silt till range between about 5 and 9 percent.

Groundwater Conditions:

- **BH WM25-1:** Depth of 6.1 m below ground surface (Elev. 174.0 m) in open borehole upon completion of drilling.; depth of 2.2 m (Elev. 177.9 m) in piezometer on April 4, 2008.

- **BH P9:** Depth of 2.3 m below ground surface (Elev. 178.8 m) in open borehole upon completion of drilling.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-25 (Deleted)

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 typical General Arrangement drawing for a side road overpass is not yet available. Based on the profile of Sideline 4, dated April 10, 2008 and provided by URS, Highway 407 will cross over Sideline 4 at about Elevation 184.2 m. Sideline 4 in the vicinity of the bridge structure will be re-constructed in cut up to 4 m deep, and will be between Elevation 177.5 m and Elevation 176.5 m at the location of the bridge crossing. For the purpose of preliminary foundation design, it is assumed that the bridge structure will be one span long (given the limited width of Sideline 4). Based on the existing ground surface elevation profile along Highway 407 centerline, fills up to about 4 m thick will be required to construct the approaches. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on dense to very dense sand and silt till / hard clayey silt till or on compacted Granular ‘A’ pad, where applicable for abutment footings “perched” within the bridge approaches	• Lower costs than deep foundations • Conventional construction	• Requires subexcavation of up to 1.5 m of surficial fill materials.
Steel H-Piles driven into “100-blow” sand and silt till or clayey silt till with “perched” pile caps within the bridge approaches	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, containing cobbles.
Caissons bored to found within “100-blow” sand and silt till or clayey silt till	• Higher bearing resistances than steel H piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: The proposed Sideline 4 grade is at an average Elevation 177 m. Footings would be founded within the dense to very dense sand and silt till at or below Elevation 175.8 m at a minimum depth of 1.2 m below the lowest surrounding grade. Alternatively, spread footings for the abutments could be founded on a Granular ‘A’ pad constructed within the bridge approaches, where applicable.

Founding Stratum	***Geotechnical Resistance***	
	Factored ULS	**SLS**
Dense to very dense Sand and Silt Till / Hard Clayey Silt Till	500 kPa	350 kPa
Compacted Granular ‘A’ (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles with pile caps “perched” within the approaches for the bridge abutments, driven to found within the “100-blow” sand and silt till or clayey silt till between Elevation 164.5 m (north side of the bridge) and Elevation 161.5 m (south side of the bridge), are feasible for support of the bridge abutments. Piles lengths would vary between about 16 m and 20 m.

Pile (abutments)	***Axial Geotechnical Resistance***	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	1,400 kN

C – Caissons: Abutments on caissons, founded within the “100-blow” till between Elevation 164.5 m and Elevation 161.5 m.

Caisson Diameter	***Axial Geotechnical Resistance***	
	Factored ULS	**SLS**
1.2 m	4,500 kN	3,500 kN
1.5 m	6,500 kN	5,500 kN

Recommended Foundation Alternative: Shallow Foundations; pile foundations with “perched” pile caps are also appropriate for supporting the bridge abutments.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, semi-integral abutments or integral abutments consistent with the foundation alternatives noted above.

• APPROACHES

Approach Height: Approximately 7.5 m high. According to the available plans, cuts of about 4 m to lower Sideline 4, and fills of about 3.5 m to raise the Highway 407 grade would be required to construct the bridge approaches.

Stability: Approaches (cuts and fills) up to 8 m high with overall side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability. All surficial fills (up to about 1.5 m thick) should be removed and replaced with approved fill materials.

Settlement: Assuming the use of conventional earth or granular embankment fills,, where applicable, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and native till deposit are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils, and sloped to within 1.2 m of the bottom of the excavation at a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for shallow foundations can be adequately controlled by pumping from properly filtered sumps. However, dewatering ahead of the excavation operations may be required to lower the groundwater level within the sand and silt ill to prevent possible “boiling” of the base of the excavation as a result of unbalanced hydrostatic as the shallow foundations may be excavated about 2 m below the groundwater level measured on April 2, 2008.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles, if selected, should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles/boulders in the sand and silt till and clayey silt till layers.

• RECOMMENDATIONS FOR ADDITIOANL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

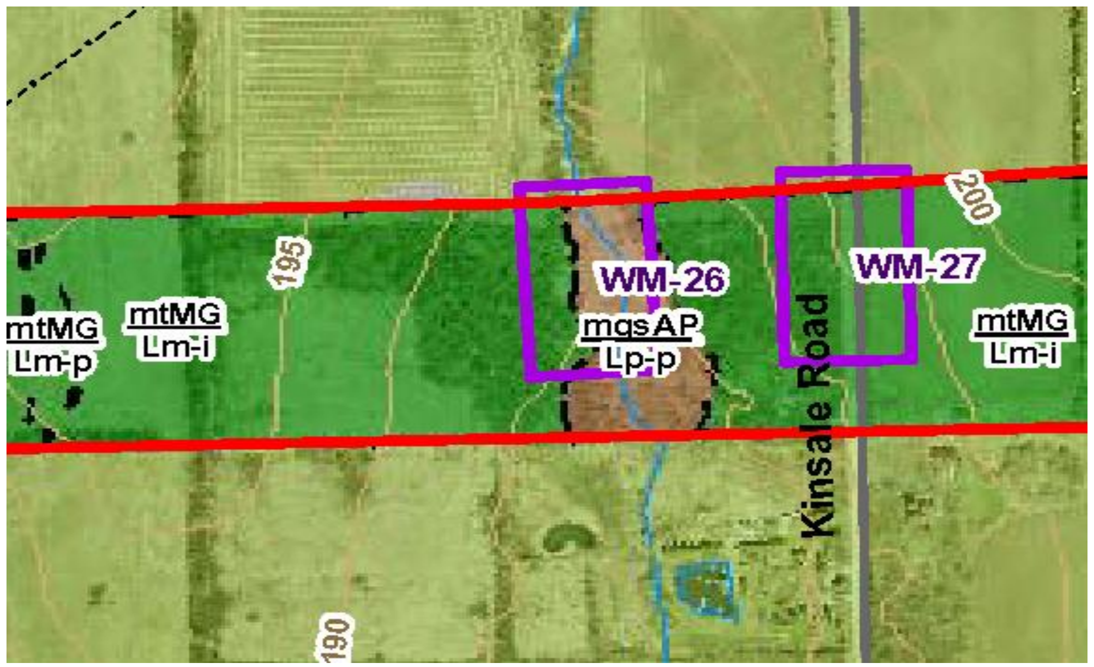
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-26

W.O: 07-20015 **Section:** Western **Location:** Culvert 150 m west of Kinsale Road **Sta.** 18+490

Original Grade: **Proposed Grade:** **Description:** Mainline crosses creek on culvert.



Site Plan and Terrain Analysis

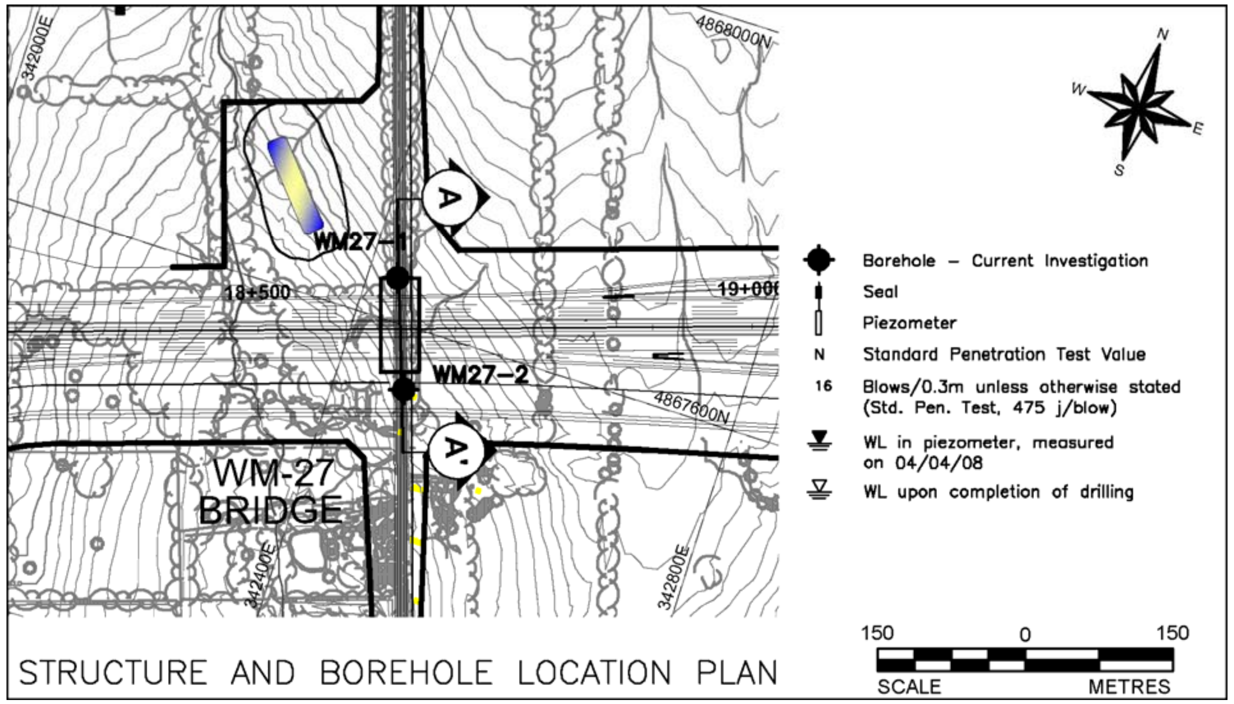
Site Photograph – Looking from Kinsale Road towards culvert

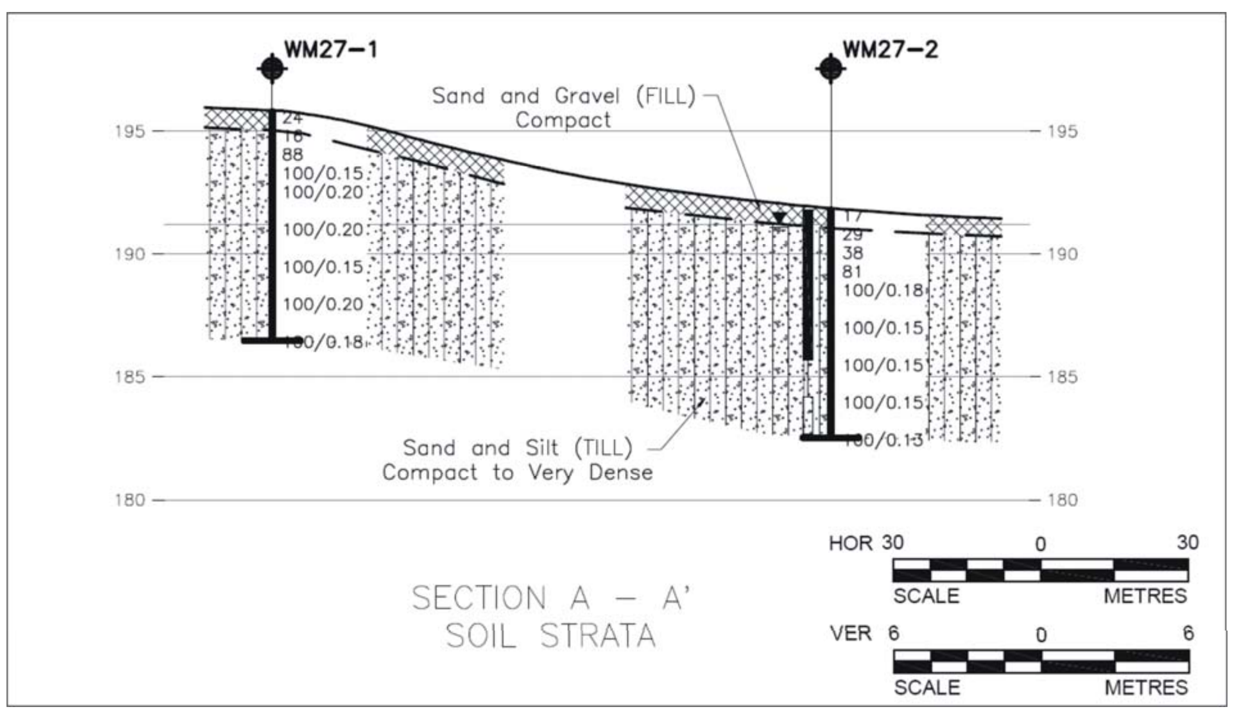
Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks
Boreholes: No existing boreholes at this site. Mapping shows that the site lies in the silt till ground moraine. The relief is low, rolling, imperfectly drained. Although no borehole information is available at the site, BHs P-9 and P-10, approximately 700 m west and east of the site, respectively, show hard clayey silt glacial till, consistent with the mapping. **Groundwater** High GWL assumed based on mapping and Bhs P-9 and P-10, which encountered water, upon completion of drilling at about 2 m depth and at the ground surface, respectively. **Estimated overburden thickness – 65m**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Comparatively low approaches across a shallow valley in a till sheet. No stability or settlement issues are anticipated provided all organics, loose and soft soils are subexcavated and replaced by compacted granular fill.	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys Depending on the final design and time of year construction is carried out, unwatering and temporary stream diversion may be required.
		Site Ranking **Foundations:** **Low** **Hydrogeology:** **Low**	

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass Highway 407 / Kinsale Road
Hwy 407 Proposed Grade: 196 m
Site Ranking: Medium

Location No: WM-27
Existing Ground Elevation: 192 m – 196 m
Station: 18+645





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-27 bridge structure is located along Kinsale Road, approximately 1.1 km north of Highway 7 in the City of Pickering, Ontario. Kinsale Road at this location consists of an approximately 6 m wide gravel surfaced road, surrounded by a heavily treed area to the west and farmland to the east. The overall topography of the terrain is gently sloping downward to the south and west.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM27-1	North Abutment	4 867 644.3	342 430.1	195.8	9.3
WM27-2	South Abutment	4 867 538.3	342 470.7	191.8	9.3

Subsurface Conditions:

- **Fill:** compact sand and gravel fill extending to a depth of 0.8 m below the existing ground surface in both boreholes. SPT 'N' values within the fill materials measured were 17 and 24 blows per 0.3 m of penetration. Measured water contents on samples of the fill ranged from about 6 to 13 percent.

- **Till:** sand and silt till containing trace to some clay and gravel with occasional cobbles noted in Borehole WM27-2. The till deposit was encountered at Elevation 195 m and Elevation 191 m in Boreholes WM27-1 and WM27-2, respectively and extends to the termination depths of the boreholes at a depth of 9.3 m. SPT 'N' values measured within the sand and silt till ranged from 16 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a compact to very dense relative density. The results of grain size distribution and Atterberg limits tests are presented on Figures WM27-A and WM27-B, respectively (Appendix B). Measured water contents within the till deposit ranged from about 4 to 10 percent.

Groundwater Conditions:

- **BH WM27-1:** Open borehole dry upon completion of drilling, however, wet soil samples noted at about Elevation 189.4 m.

- **BH WM27-2:** Depth of 0.6 m below ground surface (Elev. 191.2 m) in piezometer on February 26, 2008; depth of 0.3 m below ground surface (Elev. 191.5 m) in piezometer on April 4, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-27

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 General Arrangement drawing for Structure WM-27 is not yet available. Based on the preliminary Highway 407 crossing road profiles, dated April 10, 2008, provided by URS, Highway 407 will cross over Kinsale Road at about Elevation 196 m. Kinsale Road in the vicinity of the bridge structure will be re-constructed in cut, and will be at about Elevation 188 m at the location of the bridge crossing. For the purpose of preliminary foundation design, it is assumed that the bridge structure will be one span long (given the limited width of Kinsale Road). Based on the existing ground surface elevation profile along Highway 407 centerline, fills up to about 8 m thick will be required to construct the west approach and up to about 3 m will be required to construct the east approach. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very dense sand and silt till or on compacted Granular ‘A’ pad, where applicable for abutment footings “perched” within the bridge approaches	• Lower costs than deep foundations • Conventional construction	• Requires some sub-excavation of about 0.8 m of surficial fill
Caissons bored to found within “100-blow” sand and silt till	• Higher bearing resistances than spread footings	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: The currently proposed Kinsale Road Elevation is 188 m. Footings would be founded within the very dense sand and silt till at or below Elevation 186.5 m and at a minimum depth of 1.2 m below the lowest surrounding grade. Alternatively, spread footings for the abutments could be founded on a Granular ‘A’ pad constructed within the bridge approaches, where applicable.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Very dense Sand and Silt Till	750 kPa	500 kPa
Compacted Granular ‘A’ (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel H- Piles are considered to be not practical at this site due to the presence of very dense (i.e. “100-blow”) materials at shallow depths (2 m to 3 m below the ground surface), resulting in very short piles. However, if pile foundations are desired, consideration may be given to pre-augering and driving to provide sufficient embedment of piles; further assessment of this alternative may be carried out during detail design.

C – Caissons: Abutments on caissons, founded within the “100-blow” sand and silt till below Elevation 187.5 m. Caissons lengths should be at least 6 m, extending up to their full length (i.e. 6 m) within the “100-blow” materials.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,800 kN	3,000 kN
1.5 m	5,900 kN	4,800 kN

Recommended Foundation Alternative: Shallow Foundations.

- ### ABUTMENT TYPE

The site soils are not suitable for construction of integral abutments, unless pile foundations are constructed using pre-augering and driving methods.

- ### APPROACHES

Approach Height: according to the available plans, cuts and fills up to 8 m in height would be required to construct the approaches.

Stability: Approach cuts and fills up to 8 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fills, where applicable, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- ### CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and sand and silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 2 soils, and sloped to within 1.2 m of the bottom of the excavation at a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: dewatering measures will likely be required for excavation below the groundwater level to prevent possible “boiling” of the base of the excavation in silty materials as a result of unbalanced hydrostatic heads as the excavation for shallow foundations may extend up to about 5 m below the groundwater level measured on April 4, 2008.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles, if selected, should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles within the sand and silt till layer.

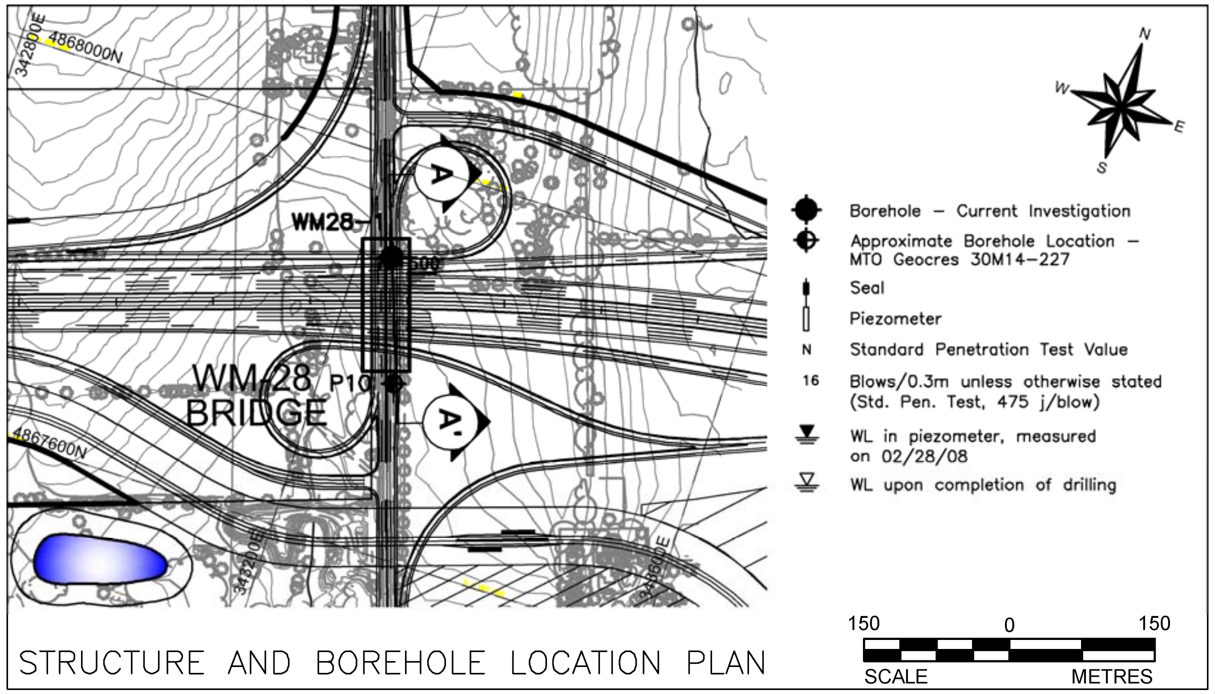
- ### CONSTRUCTION CONSIDERATIONS

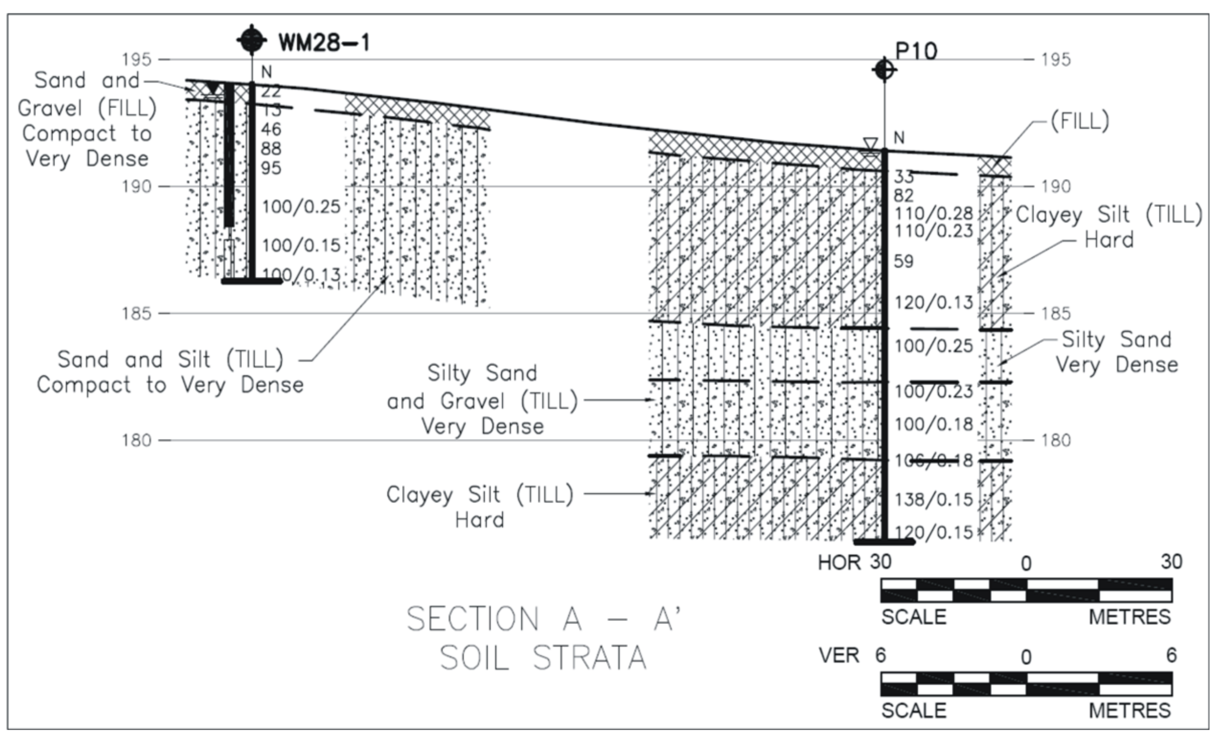
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Lakeridge Road **Hwy 407 Proposed Grade:** 195.4 m **Site Ranking:** Medium

Location No: WM-28 **Existing Ground Elevation:** 191 m – 194 m **Station:** 19+480





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-28 bridge structure is situated along Lakeridge Road, approximately 1.1 km north of Hwy 7 in the City of Pickering, Ontario. Lakeridge Road is approximately 7.5 m wide, consisting of a two-lane asphalt road with 3 m wide gravel surfaced shoulders. Vegetation in the vicinity of the site includes grasses, shrubs and scattered heavily treed areas. The overall topography is gently sloping downward to the east and south.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM28-1	North Abutment	4 867 900.8	343 233.6	194.0	7.8
P10*	South Abutment	4 867 777.2	343 275.0	191.4	15.4

*GEOCRES 30M14-227. Coordinates on the original borehole log referenced to MTM-NAD 27.

Subsurface Conditions:

- **Fill:** granular / sand and gravel fill encountered to a depth of approximately 0.8 m in both boreholes. One SPT 'N' value measured within the sand and gravel fill was 22 blows per 0.3 m of penetration, indicating a compact relative density. Water content measured on one sample of the sand and gravel fill is 6 percent.

- **Till:** sand and silt till containing trace to some clay and gravel encountered in Borehole WM28-1 immediately below the fill materials at about Elevation 193.2 m. SPT N values within the sand and silt till ranged from 13 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration indicating compact to very dense relative density. The till deposit in Borehole P10 was encountered at about Elevation 190.6 m and is described as a clayey silt to silt, sand, and gravel till containing occasional sand layers and occasional cobbles and boulders at depth. The clayey silt till in Borehole P10 was interlayered with a 2.1 m thick deposit of silty sand with gravel between Elevation 184.4 m and Elevation 182.3 m and a 3.1 m thick deposit of silty sand and gravel till between Elevation 182.3 m and Elevation 179.2 m; an SPT 'N' value in the silty sand with gravel layer was 100 blows per 0.25 m of penetration while within the silty sand and gravel till the N values ranged from 100 blows per 0.23 m of penetration to 138 blows per 0.15 m of penetration indicating a very dense relative density. Both boreholes were terminated within the till deposit at Elevation 186.3 m and 176 m, respectively. Grain size distribution test results on samples of the sand and silt till are presented on Figure WM28-A (Appendix B). Measured water contents on samples of the sand and silt/silty sand till deposit typically varied from 6 to 8 percent with one value of 14 percent in a sample collected immediately below the fill.

Groundwater Conditions:

- **BH WM28-1:** Depth of 0.4 m below ground surface (Elev. 193.6 m) in open borehole upon completion of drilling; 3.4 m below ground surface (Elev. 190.6) in piezometer on April 4, 2008.
- **BH P10:** Water level at ground surface (Elev. 191.4 m) in open borehole upon completion of drilling.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-28

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a prototype General Arrangement drawing for a typical side road underpass (Drawing No. 1), dated February 2008, and on the preliminary Highway 407 Mainline centerline and Lakeridge Road at Highway 407 profiles, dated April 2008, the proposed underpass is a two span structure with a total structure length of approximately 142 m; Highway 407 is proposed to be constructed on a fill section at about Elevation 195.4 m. The proposed Lakeridge Road grade varies between Elevation 204 m and Elevation 205 m with approach embankments up to 10 m high. Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on dense to very dense sand and silt till or "perched" within the bridge approach fills for abutments	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of about 0.8 m of surficial fill materials
Steel H-Piles driven into "100-blow" sand and silt till for abutments with "perched" pile caps.	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, containing cobbles /boulders
Caissons bored to found within "100-blow" sand and silt till.	• Higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through till potentially containing cobbles/boulders • May require temporary or permanent liner

A - Spread Footings: Based on the proposed Highway 407 grade at Elevation 195.4 m, spread footings placed at a minimum depth of 1.2 m below the lowest surrounding grade, at or below Elevation 192.5 m north of the proposed Highway 407 centerline and at or below Elevation 190.5 m south of proposed highway centerline, will be founded on dense to very dense/hard till. Abutment footings can alternatively be founded on a compacted Granular 'A' pad constructed within the bridge approach fills.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Dense to very dense Sand and Silt Till	600 kPa	400 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt / clayey silt till deposit below Elevation 187.5 m, are feasible for support of abutments with perched pile caps; piles would be approximately 14 m long.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	1,400 kN

C – Caissons: Abutments and central pier on caissons founded within the "100-blow" sand and silt till at or below Elevation 187.5 m. Caissons lengths would be at least 6 m, extending a minimum of 2 m into the "100-blow" materials.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,800 kN	3,000 kN
1.5 m	5,900 kN	4,800 kN

Recommended Foundation Alternative: Shallow Foundations.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional and semi-integral abutments; for integral abutments, deep foundations would need to be adopted.

• APPROACHES

Height: up to 10 m.

Stability: Approach embankments up to 10 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fills, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the sand and silt till and clayey silt till are classified as Type 2 soils, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be sloped to within 1.2 m of the bottom of the excavation at a slope not steeper than 1H : 1V.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for shallow foundations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

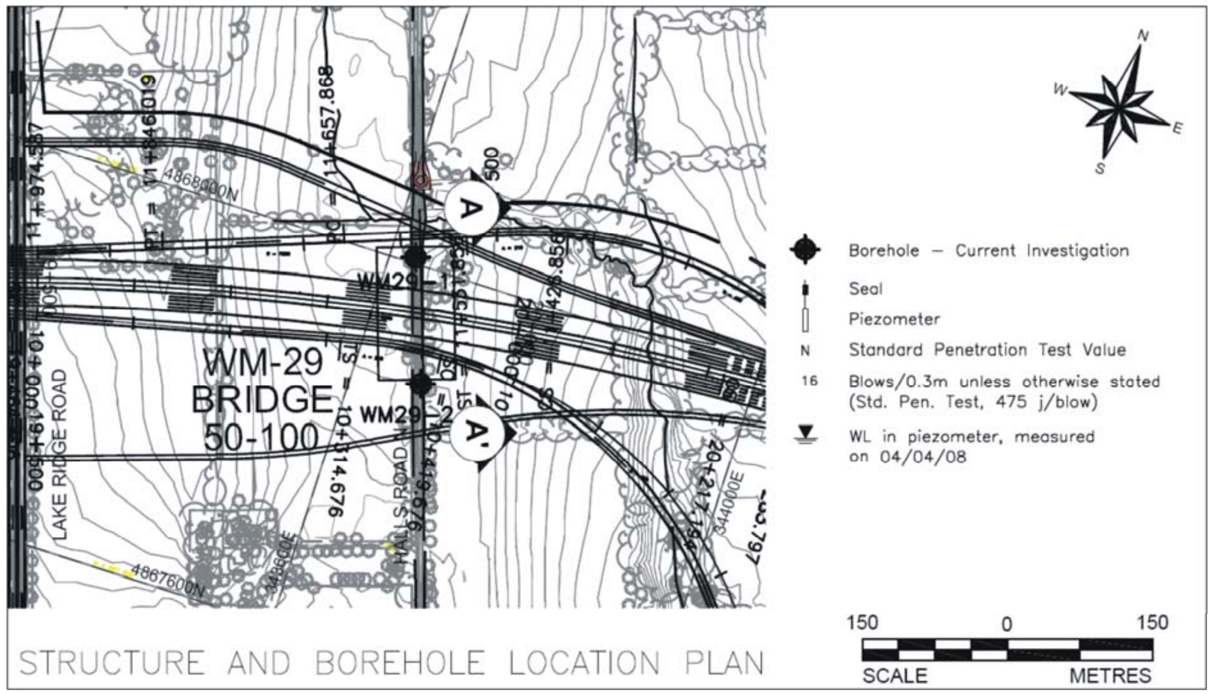
Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles/boulders within the clayey silt till layer.

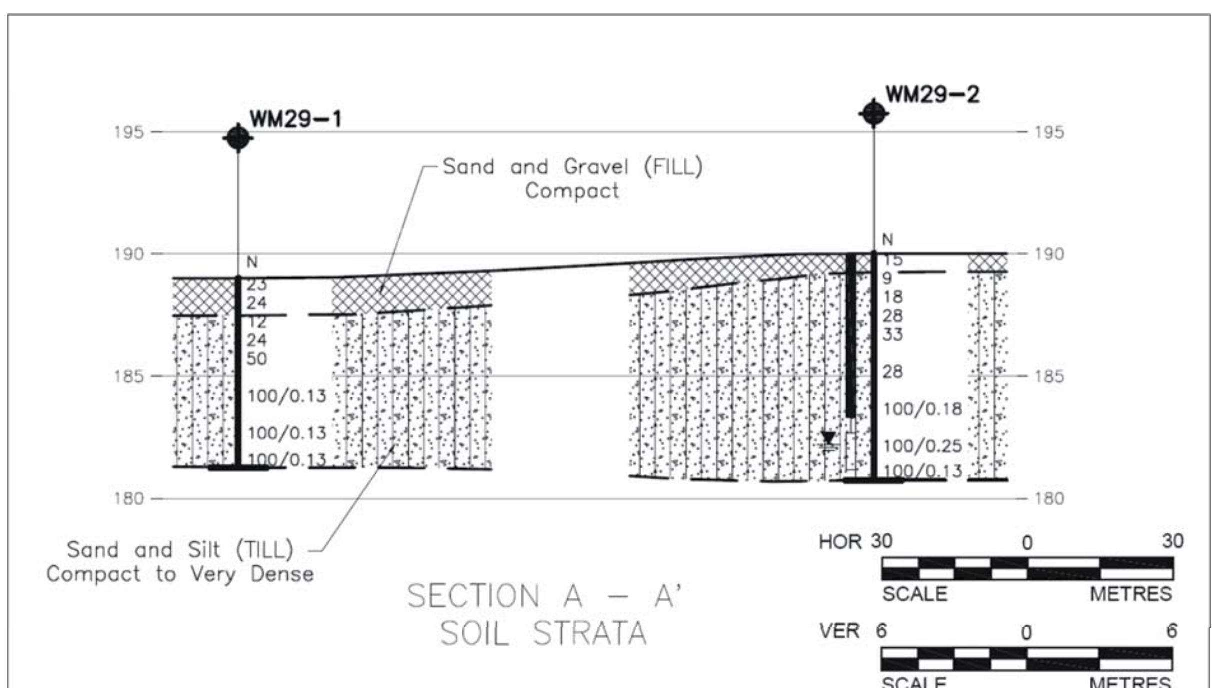
• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Halls Road North
Location No: WM-29 (Deleted)
Hwy 407 Proposed Grade: 190.3 m
Existing Ground Elevation: 189 m – 190 m
Site Ranking: Medium
Station: 19+895





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-29 bridge structure is located on Halls Road North, approximately 1.1 km m north of Highway 7. Hall's Road is constructed on embankment fill (sand and gravel) approximately 0.8 m to 1.5 m in height. The site is surrounded by gently rolling farmland and includes vegetation consisting of grasses, shrubs and trees. West Lynde Creek flows across Halls Road North, just north of the proposed bridge structure.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM29-1	North Abutment	4 868 006.6	343 626.2	189.0	7.8
WM29-2	South Abutment	4 867 883.6	343 671.2	190.0	9.3

Subsurface Conditions:

- **Fill:** sand and gravel fill encountered to depths of 1.5 m and 0.8 m in Boreholes WM29-1 and WM29-2, respectively. SPT 'N' values measured within the fill range from 15 to 24 blows per 0.3 m of penetration, indicating a compact relative density. Measured water contents on samples of the fill materials vary from 3 to 4 percent.
- **Till:** sand and silt till, some clay, trace to some gravel, containing occasional cobbles, encountered immediately beneath the fill materials; the till deposit extends to the termination depths of the boreholes at 7.8 m (Elev. 181.3 m) and 9.3 m (Elev. 180.7 m) in Boreholes WM29-1 and WM29-2, respectively. SPT 'N' values measured in the upper 1.5 m of the till range from 9 to 24 blows per 0.3 m of penetration, increasing with depth to values ranging between 28 blows per 0.3 m of penetration and 100 blows per 0.13 m of penetration, indicating a typically compact to very dense relative density. Grain size distribution and Atterberg limits test results are presented on Figures WM29-A and WM29-B, respectively (Appendix B); the results of one Atterberg limits test carried out on a clayey silt seam encountered near the bottom of Borehole WM29-1 is presented on Figure WM29-C. Measured water contents within this deposit range between about 5 and 22 percent.

Groundwater Conditions:

- **BH WM29-1:** Open borehole dry upon completion of drilling.
- **BH WM29-2:** Open borehole dry upon completion of drilling; depth of 8.7 m below ground surface (Elev. 181.3 m) in the piezometer on February 28, 2008; depth of 7.8 m below ground surface (Elev. 182.2 m) in the piezometer on April 4, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-29

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a prototype General Arrangement drawing for a typical side road underpass (Drawing No. 1), dated February 2008, and on the preliminary Highway 407 Mainline centerline, dated April 2008, the proposed underpass will carry the east and west bound lanes of highway 407 in addition to the S-W Ramp from the West Durham Link to Highway 407 westbound and the W-S Ramp from Highway 407 east bound to the West Durham Link. It is therefore assumed that this structure will consist of three spans with north and south abutments and piers. Highway 407 is proposed to be constructed at about Elevation 190.3 m and the proposed Halls Road North grade is at Elevation 199.8 m. The bridge approach embankments will be up to about 10 m high. Feasible foundation options for the proposed bridge abutments and piers are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on dense to very sand and silt till or "perched" within the bridge approach fills for abutments	• Lower costs than deep foundations • Conventional construction	• May require sub-excavation of about 1.5 m of surficial fill materials and loose sand and silt till
Steel H-Piles driven into "100-blow" sand and silt till for abutments with "perched" pile caps	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, containing cobbles
Caissons bored to found within "100-blow" sand and silt till	• Higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the proposed Highway 407 grade at Elevation 190.3 m, spread footings placed at or below Elevation 187 m, and at a minimum depth of 1.2 m below the lowest surrounding grade will be founded on compact to very dense sand and silt till. Abutment footings can alternatively be founded on a compacted Granular 'A' pad constructed within the bridge approach fills.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Compact to very dense Sand and Silt Till	450 kPa	300 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt till deposit at or below Elevation 182 m, are feasible for support of abutments with perched pile caps. Piles would be approximately 15 m long.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	1,400 kN

C – Caissons: Abutments and piers on caissons founded within the "100-blow" sand and silt till at or below Elevation 182 m. Caissons lengths would be at least 6 m, extending a minimum of 2 m into the "100-blow" materials.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,800 kN	3,000 kN
1.5 m	5,900 kN	4,800 kN

Recommended Foundation Alternative: Shallow foundations; steel H-Piles with "perched" pile caps are also appropriate for support of the abutments.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- **APPROACHES**

Height: up to about 10 m.

Stability: Approach embankments up to about 10 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fills, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the existing fill materials and sand and silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: Based on the groundwater conditions encountered in the boreholes, foundation excavations will be above the existing groundwater table. Surface water/groundwater infiltration into the excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles within the sand and silt till layer.

- **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.

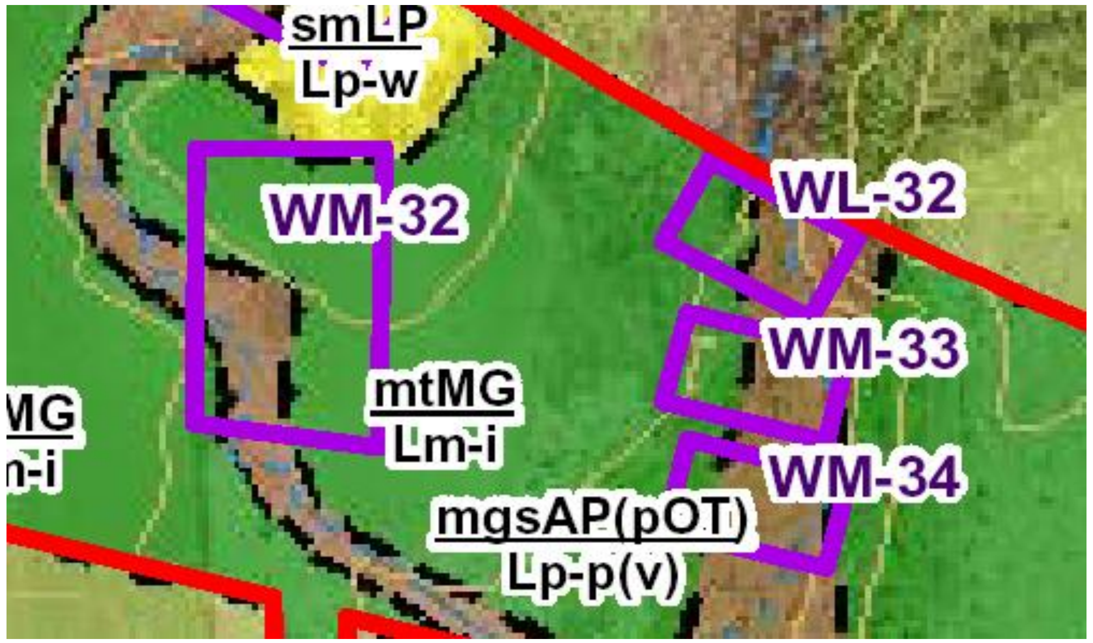
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-32

W.O: 07-20015 **Section:** Western **Location:** Mainline at realigned Coronation Road **Sta.** 20+977

Original Grade: **Proposed Grade:** **Description:** Underpass under realigned Coronation Road



Site Plan and Terrain Analysis

Site Photograph – Looking east towards site from Coronation Road

Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks

Boreholes: No BH at the site. BH P11 drilled on Coronation Road lies ~230m west.
 	
Mapping (West 4) shows the site lying in an area of silt till ground moraine. The relief is low, rolling, imperfectly drained. At the northeast of the site, there is a small area of silty lacustrine plain, well-drained.
 	
The mapping shows a small watercourse meandering across the site.
 	
BH P11 encountered;
 	
0.0 – 1.5 Fill, loose
1.5 – 3.0 Clayey silt till, stiff to very stiff
3.0– 21.8 EOH Clayey silt till, hard
 	
Groundwater
 	
No groundwater was recorded in the borehole.
 	
Estimated overburden thickness – 50m.
	The following recommendations are subject to the results of site specific investigation.
	
	1. Abutments
	
	a. Footings may be founded on Granular A cores at 1.5m below ground surface
	
	b. For closed abutments, footings may be founded on native soil at 3m below ground surface
	  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.160.0.
	  a. ULS resistance – 1,600 kN
	  b. SLS resistance – 1,400 kN
	
	d. Integral abutments are feasible. Assume 15m piles.
	
	e. Designer may select foundation based on structure configuration and costs.
	
	2. Piers
	
	Piers may be supported using the same foundation options as for abutments.
	
	Spread footings on hard native soil considered to be a feasible option.
		Approach fills up to 10 m high may be constructed at side slopes no steeper than 2H:1V using SSM or granular.
		
		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.
			No specific groundwater controll requirements are foreseen. Unwatering of excavations will be required.

Site Ranking

Foundations: **High**

Hydrogeology: **Medium**

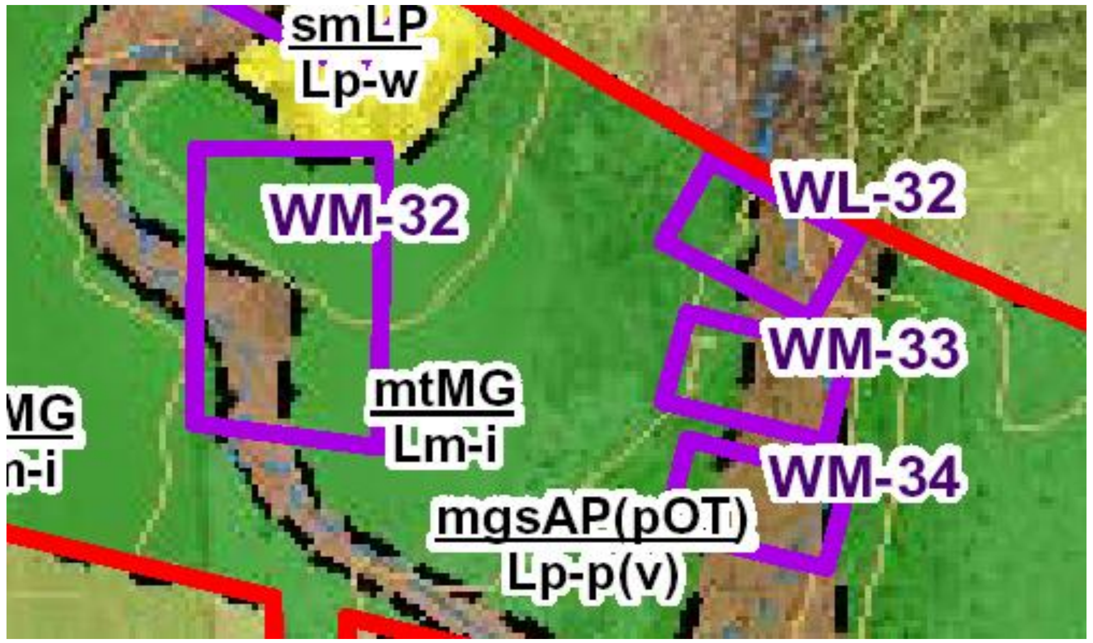
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WM-33 WM-34

W.O: 07-20015 **Section:** Western **Location:** Mainline at West Lynde Creek **Sta.** 21+171

Original Grade: **Proposed Grade:** **Description:** Twin structures to carry the Mainline over West Lynde Creek



Site Plan and Terrain Analysis

Site Photograph looking east to site from Coronation Road.

Summarized Subsurface Conditions	Recommendations: Structure	Recommendations: Approaches	Remarks
Boreholes: No BH at the site. BH P11 drilled on Coronation Road lies ~400m west. Mapping (West 4) shows the site underlain by a 50 – 70m wide alluvial deposit within an area of silt till ground moraine. The relief is low, rolling, imperfectly drained. The mapping shows a small watercourse meandering across the site. BH P11 encountered: 0.0 – 1.5 Fill, loose 1.5 – 3.0 Clayey silt till, stiff to very stiff 3.0– 21.8 EOH Clayey silt till, hard **Groundwater** Groundwater should be expected at the surface at the creek. No groundwater was recorded in the borehole. **Estimated overburden thickness – 45m.**	The following recommendations are subject to the results of site specific investigation. **1. Abutments** a. Footings may be founded on compacted Granular A cores per current MTO standard practices at 1.5m below ground surface b. For closed abutments, footings may be founded on hard native soil at 2m below ground surface 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.160.0. a. ULS resistance – 1,600 kN b. SLS resistance – 1,400 kN d. Integral abutments are feasible. Assume 15m piles. e. Designer may select foundation based on structure configuration and costs. **2. Piers** Piers may be supported using the same foundation options as for abutments. Spread footings on hard native soil are considered a suitable foundation option.	Approach fills up to 10 m high may be constructed at side slopes up to 2H:1V using SSM or better. No global stability or settlement issues are anticipated based on available information. Stripping of topsoil, peaty alluvium or other unsuitable soils will be required prior to construction.	Unwatering of excavations will be required. Possible creek diversion requirement. Depending on the results of future investigation and the depth of excavation, positive groundwater control may be required. Narrow, moderately deep valley with comparatively steep east valleyside, but no geomorphic evidence of significant valleyside instability

Site Ranking

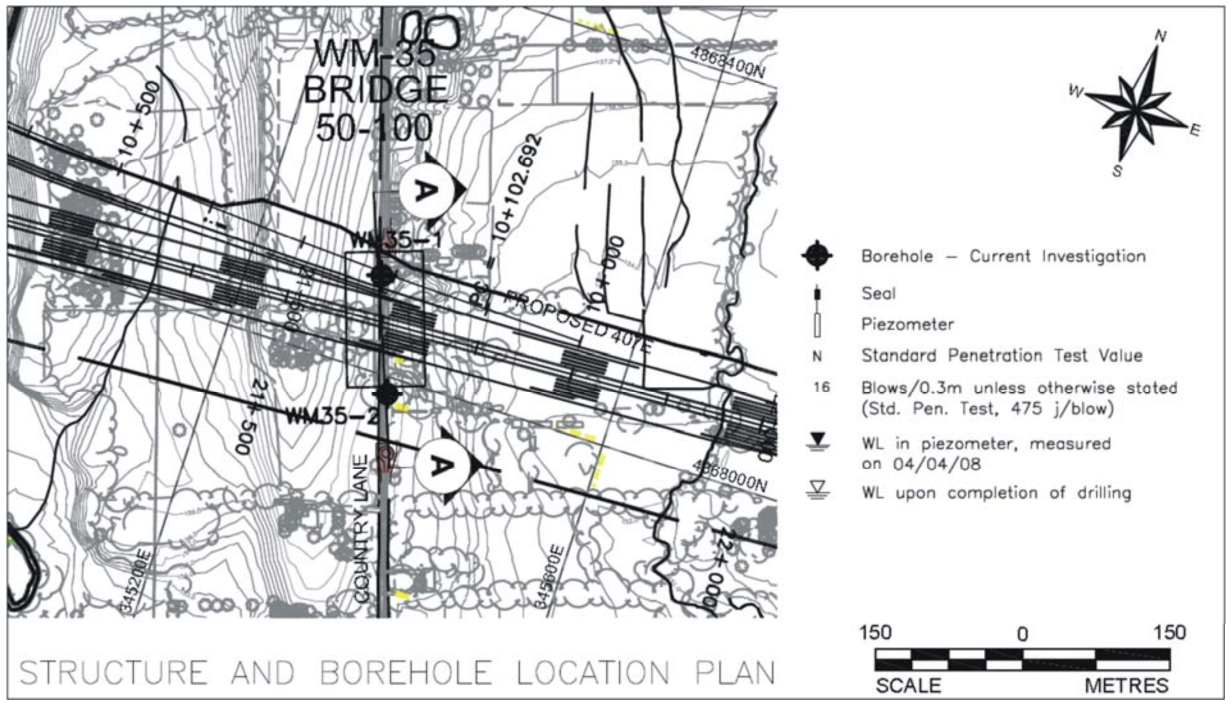
Foundations: **High**

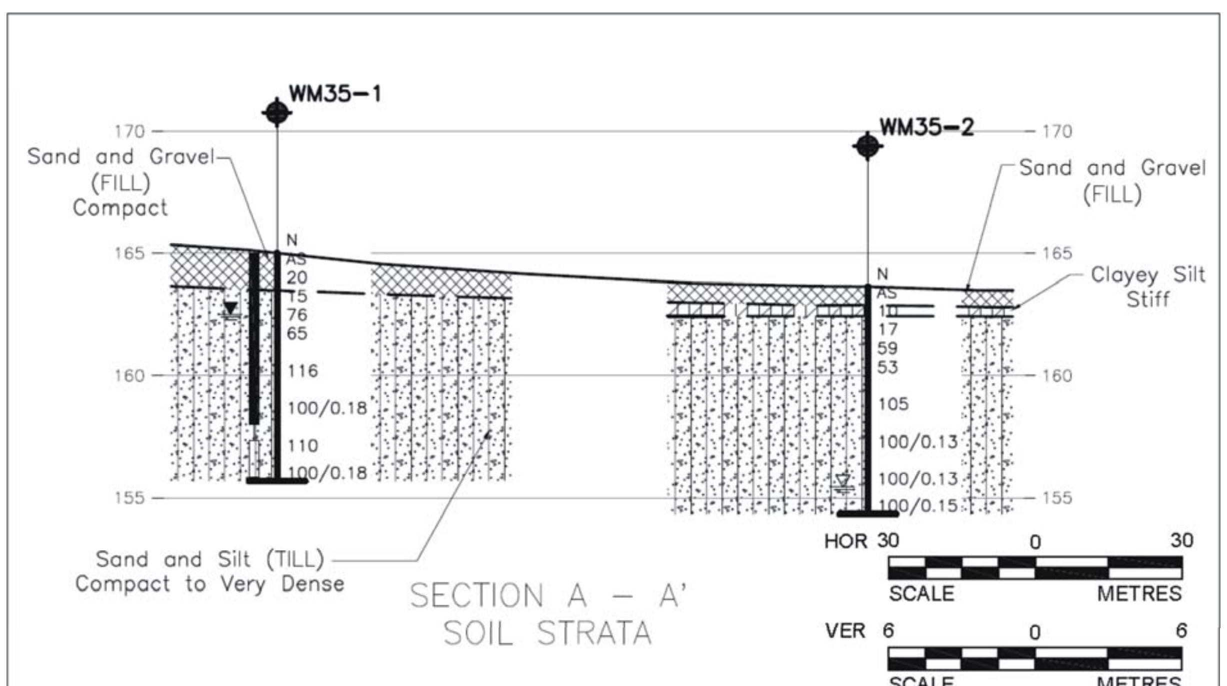
Hydrogeology: **Medium**

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Country Lane
Hwy 407 Proposed Grade: 157.2 m
Site Ranking: Medium

Location No: WM-35 – Original Location (Deleted)
Existing Ground Elevation: 163.5 m – 165.0 m
Station: 21+600





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed Structure WM-35 is situated along Country Lane, approximately 600 m north of Hwy 7. Country Lane at this location is approximately 7 m wide on a 0.5 m to 1.5 m high embankment and consists of gravel surfaced road, surrounded by farmland. The overall terrain topography is gently sloping downward to the east and south.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM35-1	North Abutment	4 868 095.8	345 333.7	165.0	9.3
WM35-2	South Abutment	4 867 982.7	345 375.8	163.6	9.3

Subsurface Conditions:

- **Fill:** sand and gravel fill extending to depths of approximately 1.5 m and 0.8 m in Boreholes WM25-1 and WM25-2, respectively. One SPT 'N' value of 20 blows per 0.3 m of penetration was measured within the fill materials, indicating a compact relative density. Measured water contents on samples of the fill range between 4 and 5 percent.

- **Clayey Silt:** A 400 mm thick layer of clayey silt was encountered below the fill materials in Borehole WM35-2. One SPT 'N' value of 10 blows per 0.3 m of penetration was measured within this deposit indicating a stiff consistency. A water content measured on a sample of this deposit was 19 percent.

- **Till:** sand and silt till containing trace to some clay and gravel encountered at depths of 1.5 m (Elev. 163.5 m) and 1.2 m (Elev. 162.4 m) in Boreholes WM35-1 and WM35-2, respectively. Both boreholes were terminated within the sand and silt till deposit at a depth of 9.3 m (Elevation 155.7 m and 154.3 m in Boreholes WM35-1 and WM35-2 respectively). SPT 'N' values measured within the till deposit ranged typically from 59 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a very dense relative density, except within the upper 1 m of this deposit where 'N' values of 15 and 17 blows per 0.3 m of penetration were recorded. The results of grain size distribution and Atterberg limits tests are presented on Figures WM35-A and WM35-B, respectively (Appendix B). Measured water contents on selected samples of the till deposit range between 6 and 14 percent.

Groundwater Conditions:

- **BH WM35-1:** Depth of 3.9 m (Elev. 161.1 m) in piezometer on January 7, 2008; depth of2.5 m (Elev. 162.5 m) in piezometer on April 4, 2008.

- **BH WM35-2:** Depth of 8.2 m (Elev. 155.4 m) in open borehole upon completion of drilling.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 5**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-35 – Original (Deleted)

FOUNDATION RECOMMENDATION

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: A newly proposed Structure WM-35 will now be located just east of Halls Road along the Highway 407 and West Durham Link interchange, as such, the following foundation recommendations do not apply to the new structure.

Based on a prototype General Arrangement drawing for a typical side road underpass (Drawing No. 1), dated February 2008, the preliminary Highway 407 Mainline centerline profile, dated April 1, 2008, and Country Lane profile, dated April 10, 2008, provided by URS, the proposed underpass is planned to be a two span structure with a total structure length of about 142 m. Highway 407 is proposed to be constructed in cut at about Elevation 157.2 m and Country Lane will be constructed on an approximately 2 m thick fill section between Elevation 166 m and Elevation 167 m. Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on compact to very dense sand and silt till	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of up to 1.5 m of surficial fill
Caissons bored to found within “100-blow” sand and silt till	• Larger caissons have higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through till, possibly containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the proposed Highway 407 grade at about Elevation 157.2 m, spread footings placed at a minimum depth of 1.2 m below the lowest surrounding grade at the central pier will be founded on the very dense sand and silt till deposit at about Elevation 156 m. Alternatively, abutment footings may be ‘perched’ within the bridge approaches and would be founded on the very dense sand and silt till at or below Elevation 161 m at the south abutment and at or below Elevation 162 m at the north abutment.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Very dense sand and silt till	600 kPa	400 kPa

B - Steel H-Piles: Steel H-piles are considered to be not practical at this site due to the presence of very dense (i.e. “100-blow”) materials at shallow depths below the existing ground surface and at the level of the proposed Highway 407 grade. However, if pile foundations are desired, consideration may be given to pre-augering and driving to provide sufficient embedment of piles. Further assessment of this alternative may be carried out during detail design.

C – Caissons: Abutments and central pier on caissons, founded within the “100-blow” sand and silt till at or below Elevation 157.5 m. Caissons lengths would be at least 6 m and would extend to their full length into “100-blow’ materials (i.e. at the pier location).

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,800 kN	3,000 kN
1.5 m	5,900 kN	4,800 kN

Recommended Foundation Alternative: Shallow Foundations.

• ABUTMENT TYPE

The site soils are not suitable for construction of integral abutments, unless pile foundations are constructed using pre-augering and driving methods.

• APPROACHES

Approach Height: approximately 8 m. Based on the available plans, cuts up to about 7 m to construct Highway 407 at the proposed elevation and fills of up to 2 m to raise Country Lane would be required to construct the bridge approaches.

Stability: Approaches (cuts and fills) up 8 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability. Measures to stabilize the embankment slope face due to potential groundwater seepage at the slope surface subsequent to the embankment slope cut, will need to be implemented. Embankments (fills and/or cuts) greater than 8 m high will require a mid-height berm in accordance with MTO design requirements.

Settlement: Minor fills would be required (up to 2 m) to construct the bridge approaches and thus settlement within the underlying subsoils is expected to be minimal and immediate (i.e. during and immediately after completion of the approach embankment construction).

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and sand and silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps. Potential groundwater seepage at the surface of the approach cut slopes should be controlled to prevent slope erosion.

Protection Systems: Refer to Section 6.7.2 of the Report.

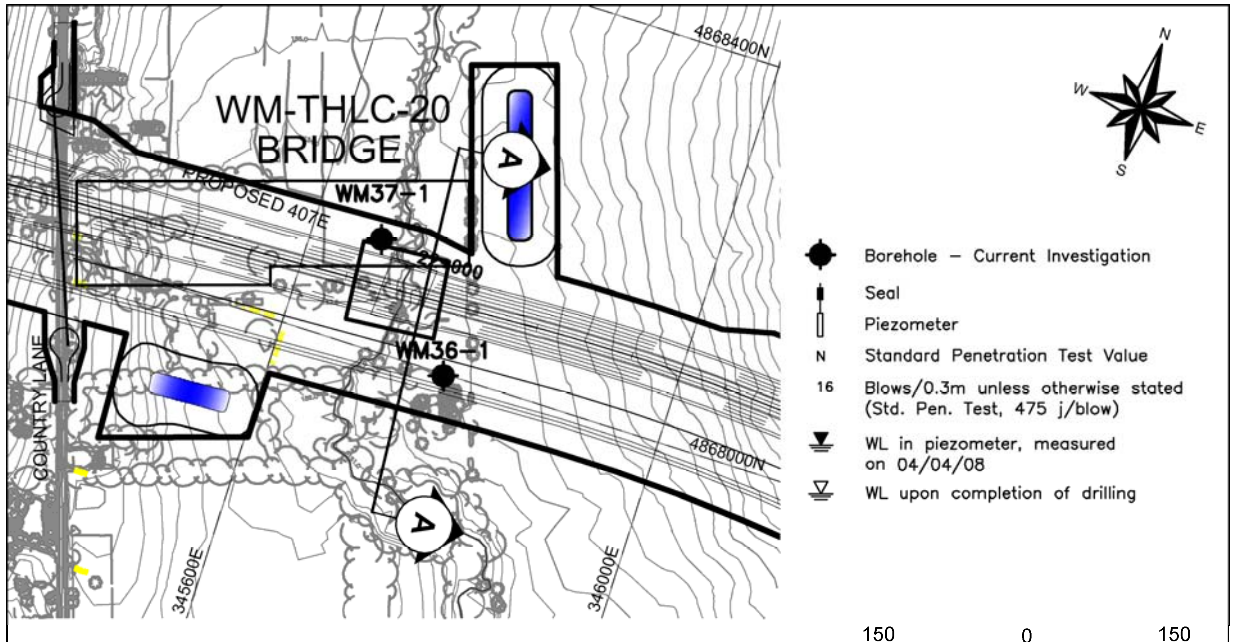
Obstructions During Caisson Drilling: flange plate reinforcement for steel H-Piles, if selected, may be required. Caisson drilling equipment must be capable of penetrating through very dense sand and silt till layers.

• RECOMMENDATIONS FOR ADDITIONAL WORK

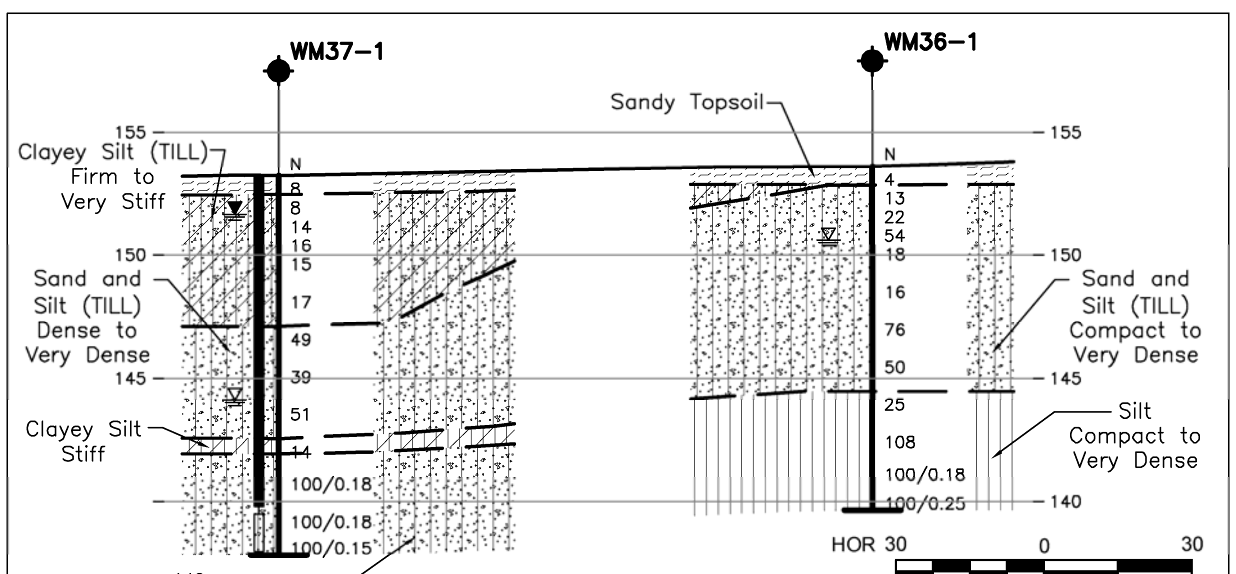
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	Overpass Highway 407 / Lynde Creek	**Hwy 407 Proposed Grade:**	159.5 m	**Site Ranking:**	Medium
Location No:	WM-36, WM-37 (WM-THLC-20)	**Existing Ground Elevation:**	153 m to 154 m	**Station:**	21+957



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The proposed Lynde Creek twinned single span structures are located approximately 525 m north of Highway 7 and 380 m east of Country Lane. Lynde Creek at this location is approximately 1.5 m wide and flows from north to south. The surrounding area consists of farmland on a gently sloping terrain from the east and south.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM36-1	East Abutment	4 867 998.0	345 772.3	153.6	14.0
WM37-1	West Abutment	4 868 110.8	345 670.5	153.2	15.4

Subsurface Conditions:

- **Topsoil:** sandy topsoil encountered at ground surface to a depth of 0.8 m in both WM36-1 and WM37-1. SPT ‘N’ values within this material ranged from 4 blows to 8 blows per 0.3 m of penetration, indicating a loose relative density.

- **Till:** Underlying the sandy topsoil in Borehole WM37-1, the borehole penetrated a 5.3 m thick layer of clayey silt till between Elev. 152.4 m and Elev. 147.1 m. SPT ‘N’ values measured within the clayey silt till ranged from 8 to 17 blows per 0.3 m of penetration indicating a firm to stiff consistency. The results of grain size distribution and Atterberg Limits are presented on Figures WM37-A and WM37-B respectively (Appendix B).

  Underlying the sandy topsoil in Borehole WM36-1 and the clayey silt till in Borehole WM37-1, the boreholes encountered sand and silt till with trace to some clay and gravel to a depth of 9.1 m (Elev. 144.5 m) in WM36-1, and to a depth of 15.4 m (Elev. 137.8 m) in WM37-1. SPT ‘N values measured within the sand and silt till generally increases with depth, ranged from 13 to 100 blows per 0.18 m of penetration, indicating a compact to very dense relative density. The results of grain size distribution are presented on Figures WM36-A, and WM37-C, and the results of Atterberg limits tests are shown on Figures WM36-B, WM37-C and WM37-D (Appendix B). Measured water contents on selected samples of the till deposit range between 8 and 14 percent.

- **Clayey Silt:** A 600 mm thick layer of clayey silt with trace to some sand was encountered within the sand and silt till deposit at approximately Elev. 142.5 m in Borehole WM37-1. One SPT ‘N’ value of 14 blows per 0.3 m of penetration was measured within this deposit indicating stiff consistency. A water content measured on a sample of this deposit was 26 percent.

- **Silt:** A 4.9 m thick layer of silt, some clay and trace to some sand, was encountered below the sand and silt till deposit in WM36-1 at approximately Elevation 144.5 m. WM36-1 was terminated within the silt deposit. SPT ‘N’ values ranged from 25 blows per 0.3 m of penetration to more than 100 blows per 0.25 m of penetration, indicating compact to very dense relative density. The result of one grain size distribution test is presented on Figure WM36-C (Appendix B). Measured water content on selected samples range between 11 and 18 percent.

Groundwater Conditions:

- **BH WM36-1:** Depth of 3 m (Elev. 150.6 m) in open borehole upon completion of drilling.
- **BH WM37-1:** Depth of 9.1 m (Elev. 144.1 m) in open borehole upon completion of drilling; 1.6 m below ground surface (Elev. 151.6 m) in piezometer on April 4, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 5**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-36, WM-37 (WM-THLC-20)

FOUNDATION RECOMMENDATION

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a General Arrangement drawing of the creek crossing as provided by URS in January 2009, Highway 407 will cross over the Lynde Creek tributary at about Elevation 159.5 m and the bridge structure will be a single span and closed-end type structure. Fill embankments up to about 6 m high will be required to construct the approaches. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very dense/very stiff sand and silt till and clayey silt till deposits	• Lower costs than deep foundations • Conventional construction	• May require sub-excavation of any surficial organic soils
Steel H-Piles driven into “100-blow” silt or sand and silt till for abutments with ‘perched’ pile caps	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till containing cobbles
Caissons bored to found within “100-blow” silt or sand and silt till	• Higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the proposed Highway 407 grade at about Elevation 159.5 m, spread footings placed at or below Elevation 151 m, and at a minimum depth of 1.2 m below the lowest surrounding grade, will be founded on very dense sand and silt till at the south abutment and very stiff clayey silt till at the north abutment.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Very dense sand and silt till / very stiff clayey silt till	450 kPa	300 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the “100-blow” silt and sand and silt till deposits, at or below Elevation 140 m, are suitable for support of abutments with perched pile caps; piles would be approximately 13.5 m long.

Pile (Abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,400 kN	1,200 kN

C – Caissons: Abutments on caissons, founded within the “100-blow” silt and sand and silt till deposits, at or below Elevation 140 m. Caissons lengths would be at least 13 m and extend up to 2 m into “100-blow’ materials.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,000 kN	2,500 kN
1.5 m	4,500 kN	3,700 kN

Recommended Foundation Alternative: Shallow Foundations, steel H-Piles.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Approach Height: up to 6 m.

Stability: Approach embankments up to 6 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fill, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankment. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the sand and silt/clayey silt till are classified as Type 2 soils according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H: 1V to within 1.2 m of the bottom of the excavation.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps. However, other dewatering measures may be required for excavation, especially during periods of spring flow below the groundwater level to prevent possible ‘boiling’ of the base of the excavation in silty materials as a result of unbalanced hydrostatic heads.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles, if selected, may be required. Caisson drilling equipment must be capable of penetrating obstructions such as cobbles within the sand and silt till layers.

Other: It is noted that basal heave could occur in the more pervious silty materials near the caisson base during installation. Refer to Section 6.7.3 of the Report for preliminary recommendations regarding use of caisson liners, drilling fluid, and tremie concrete methods.

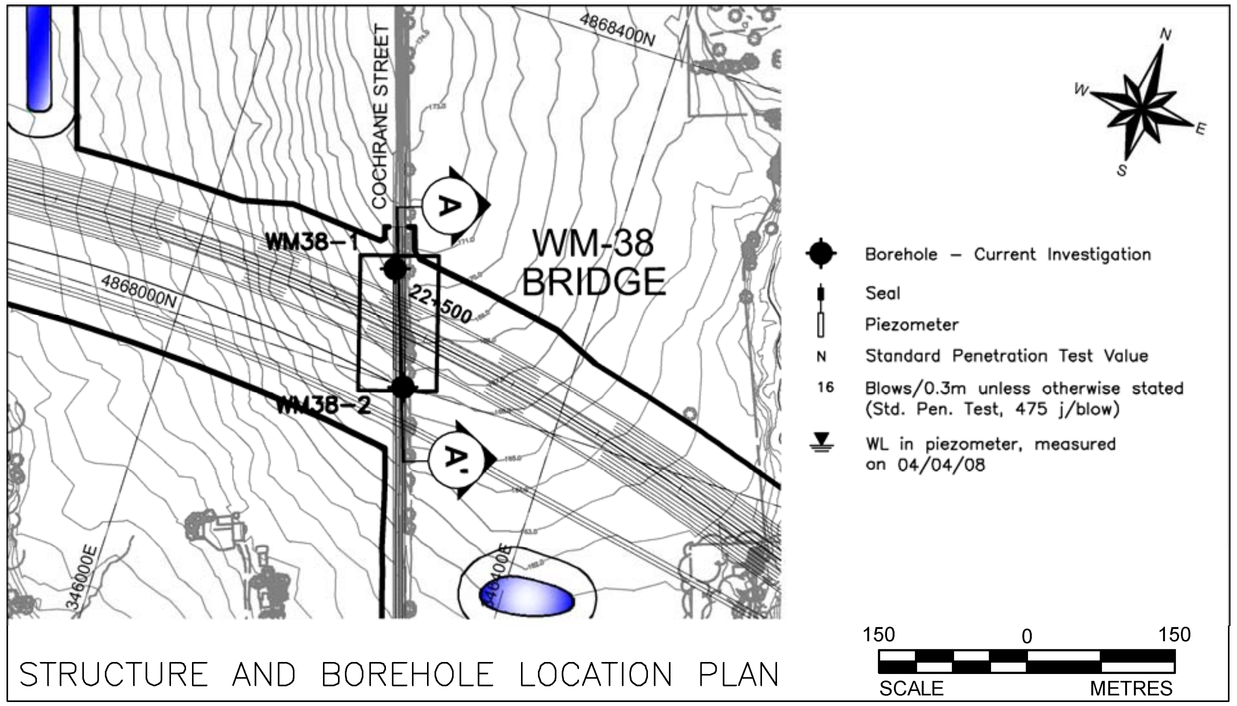
• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

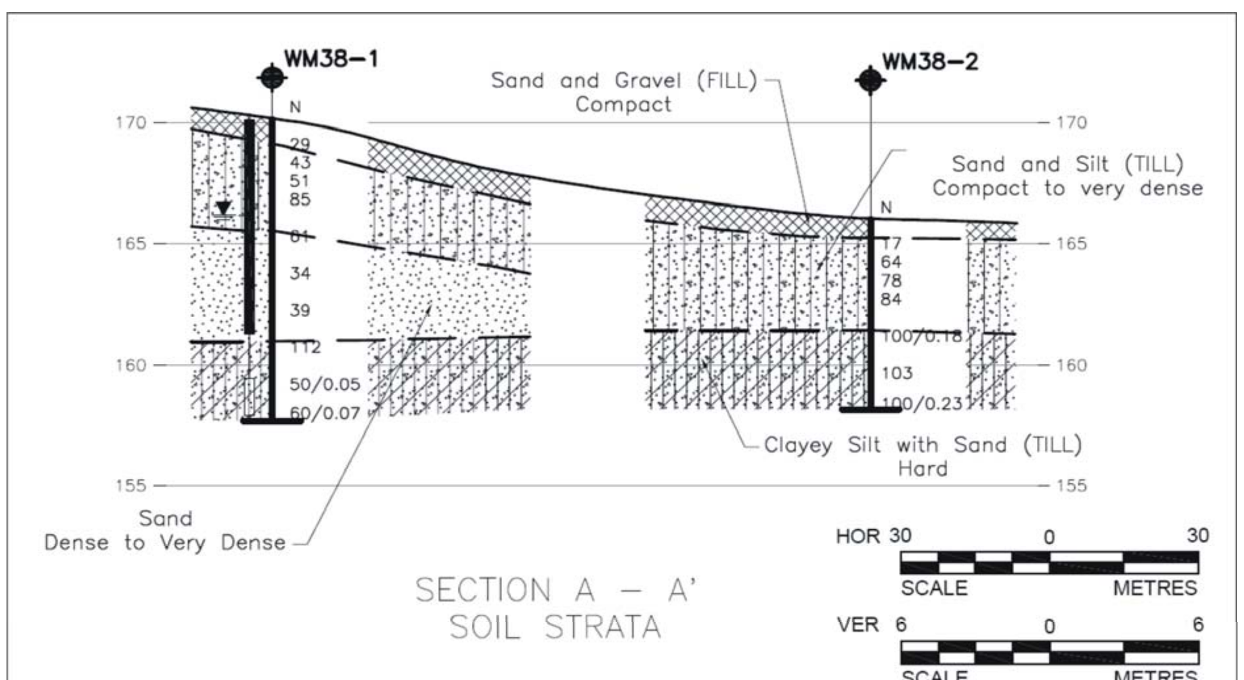
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Cochrane Street
Hwy 407 Proposed Grade: 161 m
Site Ranking: Medium

Location No: WM-38
Existing Ground Elevation: 166 m – 171 m
Station: 22+471



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-38 bridge structure is located on Cochrane Street, approximately 350 m north of Winchester Road West (Highway 7) in the Town of Whitby, Ontario. Cochrane Street in this area consists of a two-lane asphalt road, approximately 6 m wide, surrounded by farmland with occasional trees along the east shoulder. The overall topography of the terrain is gently sloping to the east and south.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM38-1	North Abutment	4 868 111.0	346 196.0	170.1	12.4
WM38-2	South Abutment	4 867 998.9	346 240.4	166.0	7.9

Subsurface Conditions:

- **Fill:** compact sand and gravel fill encountered in both boreholes, extending to depths of 1.1m and 0.8 m in Boreholes WM38-1 and WM38-2, respectively. Water contents measured on samples of the fill range from about 7 to 12 percent.

- **Sand and Silt Till:** sand and silt till, containing trace to some clay and gravel encountered immediately below the fill material in both boreholes. SPT 'N' values measured within the till deposit vary from 17 to 85 blows per 0.3 m of penetration but typically range from 43 to 85 blows per 0.3 m of penetration, indicating a generally dense to very dense relative density. The results of grain size distribution and Atterberg limits tests are presented on Figures WM38-A and WM38-B, respectively (Appendix B). Measured water contents on samples of the sand and silt till range between about 6 and 11 percent.

- **Sand:** sand, containing some silt and trace gravel encountered in Borehole WM38-1, advanced in the vicinity of the north abutment at a depth of 4.6 m below ground surface (Elev. 165.5 m), extending to a depth of 9.1 m (Elev. 161.0 m). SPT 'N' values measured within the sand deposit range from 34 to 61 blows per 0.3 m of penetration, indicating a dense to very dense relative density. The results of a grain size distribution test are presented on Figure WM38-C (Appendix B). Measured water contents on samples of this deposit range between about 13 and 15 percent.

- **Clayey Silt Till:** clayey silt with sand till, containing some gravel, encountered at depths of 9.1 m (Elev. 161.0 m) and 4.6 m (Elev. 161.4 m) in Boreholes WM38-1 and WM38-2, respectively; both boreholes were terminated within this deposit. SPT 'N' values measured within the till deposit vary from 103 blows per 0.3 m of penetration to 50 blows per 0.05 m of penetration, indicating a hard consistency. The results of grain size distribution and Atterberg limits test are presented on Figures WM38-D and WM38-E, respectively (Appendix B). Measured water contents on samples of this deposit vary between about 6 and 8 percent.

Groundwater Conditions:

- **BH WM38-1:** Depth of 3.9 m below ground surface (Elev. 166.2 m) in piezometer on April 4, 2008
- **BH WM38-2:** Wet soil samples noted during drilling at a depth of 7.6 m below the ground surface (Elev. 158.4 m).

Record of Borehole Sheets – Appendix A | **Laboratory Test Results – Appendix B** | **Key Location Plan – Drawing 5**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-38

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing of Structure WM-38, dated January 2009, the proposed underpass is a two span structure with a total structure length of approximately 88 m. Highway 407 is proposed to be constructed in cut at the crossing of Cochrane Street at about Elevation 161 m. The proposed Cochrane Street grade varies between Elevation 171 m (at the north abutment) and Elevation 168.5 m (at the south abutment). Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on hard clayey silt till or "perched" within the bridge approach cuts for abutments	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of about 1 m of surficial fill materials
Steel H-Piles driven into "100-blow" clayey silt till for abutments with "perched" pile caps.	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, potentially containing cobbles
Caissons bored to found within "100-blow" clayey silt till deposit.	• Higher bearing resistances than steel H piles	• More expensive than shallow foundations • Drilling must be advanced through till potentially containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the proposed Highway 407 grade at Elevation 161 m, spread footings placed at a minimum depth of 1.2 m below the lowest surrounding grade at the centre pier will be founded on the hard clayey silt till deposit at about Elevation 158.8 m. Alternatively, abutment footings can be "perched" within the bridge approaches, about 3 m to 4 m below the existing ground surface; i.e. at about Elevation 166 m for the north abutment and at about Elevation 163 m for the south abutment. These 'perched' footings will be founded on the very dense sand and silt till or dense sand at the north abutment and on dense to very dense sand and silt till at the south abutment.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Hard Clayey Silt Till	750 kPa	500 kPa
Dense to very dense Sand and Silt till/ Dense Sand (abutments)	500 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" clayey silt till deposit below Elevation 158 m, are feasible for support of abutments with perched pile caps. Pile lengths would vary between about 6 m (at the south abutment) and 8 m (at the north abutment).

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,400 kN	1,200 kN

C – Caissons: Abutments and central pier on caissons founded within the "100-blow" clayey silt till below Elevation 158 m. Caissons lengths would be at least 6 m below grade, penetrating up to their full depth into the "100-blow" material (i.e. at the pier location).

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,800 kN	3,000 kN
1.5 m	5,900 kN	4,800 kN

Recommended Foundation Alternative: Shallow Foundations.

- ### ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- ### APPROACHES

Height: up to 10 m.

Stability: Approach embankment cut slopes up to 10 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height bench per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability. Measures to stabilize the embankment slope face due to potential groundwater seepage at the slope surface will have to be implemented.

Settlement: The approaches for this bridge structure will be constructed in cut and thus settlement issues are not anticipated.

- ### CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill material is classified as a Type 3 soil and the native sand and silt till and sand deposits are classified as Type 2 soils according to the OSHA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps. Potential groundwater seepage at the surface of the approach cut slopes should be controlled to prevent slope erosion.

Protection Systems: Refer to Section 6.7.2 of the Report.

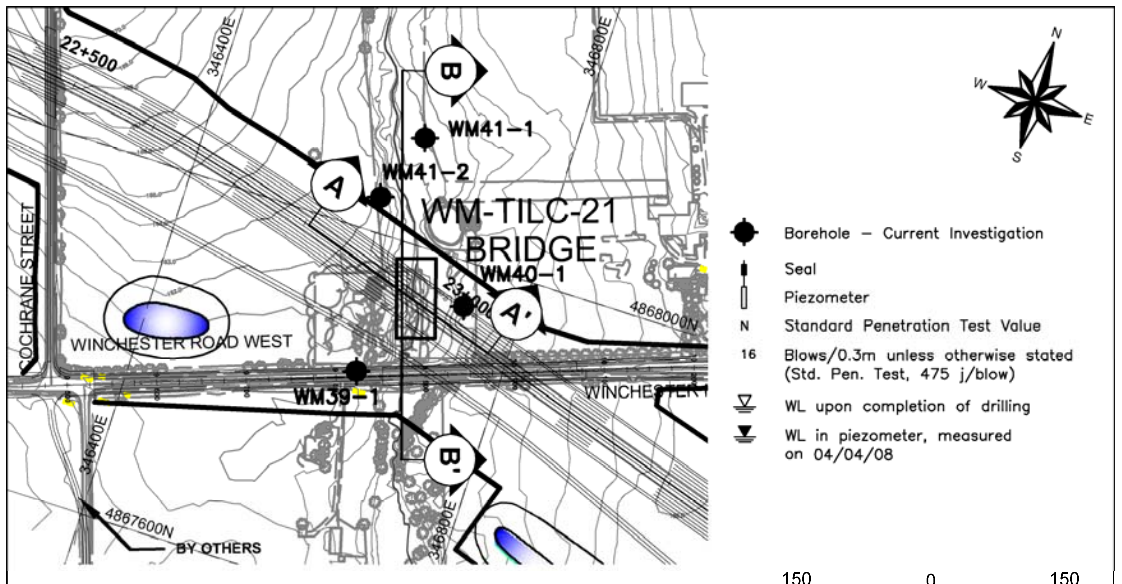
Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. No major obstructions (e.g. cobbles or boulders) are anticipated at the site based on the borehole data at this site.

- ### RECOMMENDATIONS FOR ADDITIONAL WORK

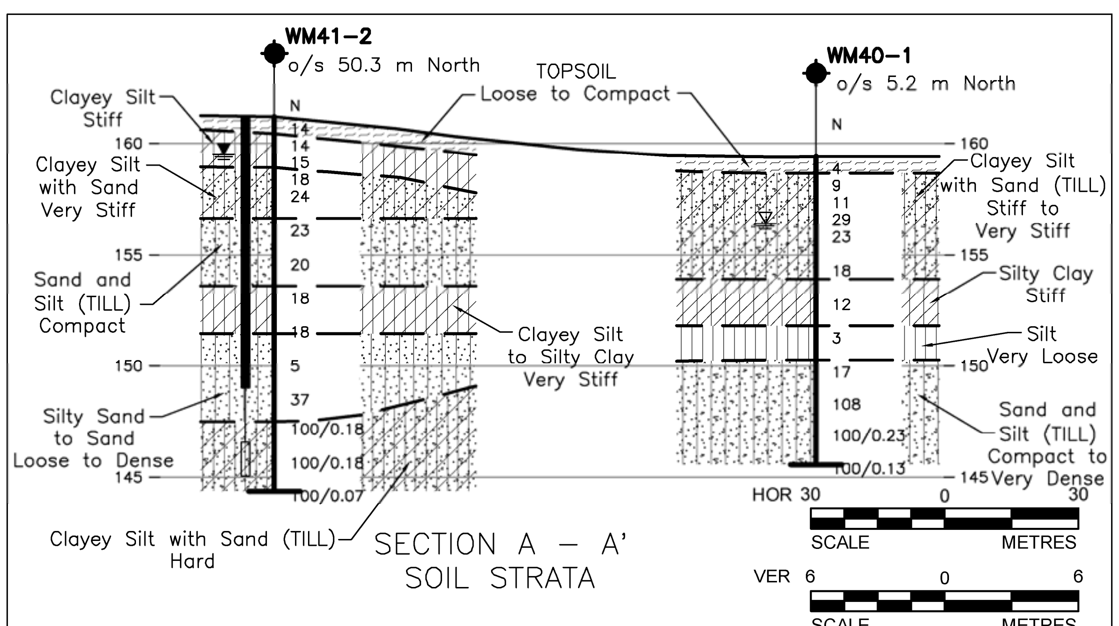
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	East Lynde Creek Tributary and Cochrane Street N/S-E Ramp (WM-39 – Deleted from Project) East Lynde Creek Tributary (WM-40 – WM-TILC-21) E-N/S Cochrane Street Ramp over East Lynde Creek Tributary (WM-41– Deleted from Project)	**Hwy 407 Proposed Grade:**	162.0 m	**Site Ranking:**	Medium
Location No:	WM-39, WM-40 (WM-TILC-21) WM-41 (Deleted)	**Existing Ground Elevation:**	156.0 m – 162.0 m	**Station:**	22+951



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed bridge structures WM-39, WM-40 and WM-41 is located just north of Winchester Road West (Highway 7), between Cochrane Street and Ashburn Road in the Town of Whitby, Ontario. The site is primarily occupied by farmland with the East Lynde Creek Tributary flowing southerly across Highway 7. A residential unit is located just north of Highway 7 near the proposed bridge structures, while a residential subdivision is located north-east of Ashburn Road. Highway 7 in this vicinity is approximately a 7 m wide, two lane asphalt road and vegetation in this area consists of scattered trees and shrubs. Overall, the topography is relatively flat.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM39-1*	West Abutment (WM-39)	4 867 846.2	346 644.0	159.0	17.0
WM40-1	East Abutment (WM-40)/ East Abutment (WM-39)	4 867 951.9	346 735.8	159.4	13.8
WM41-1*	North Abutment (WM-41)	4 868 117.0	346 637.4	158.9	16.9
WM41-2	South Abutment (WM-41)/ West Abutment (WM-40)	4 868 039.3	346 610.4	161.2	16.8

* Boreholes WM39-1 and WM41-1 have been excluded from design recommendations as Structures WM-39 and WM-41 have been omitted based on recent alignments and are located too far from Structure WM-40.

Subsurface Conditions:

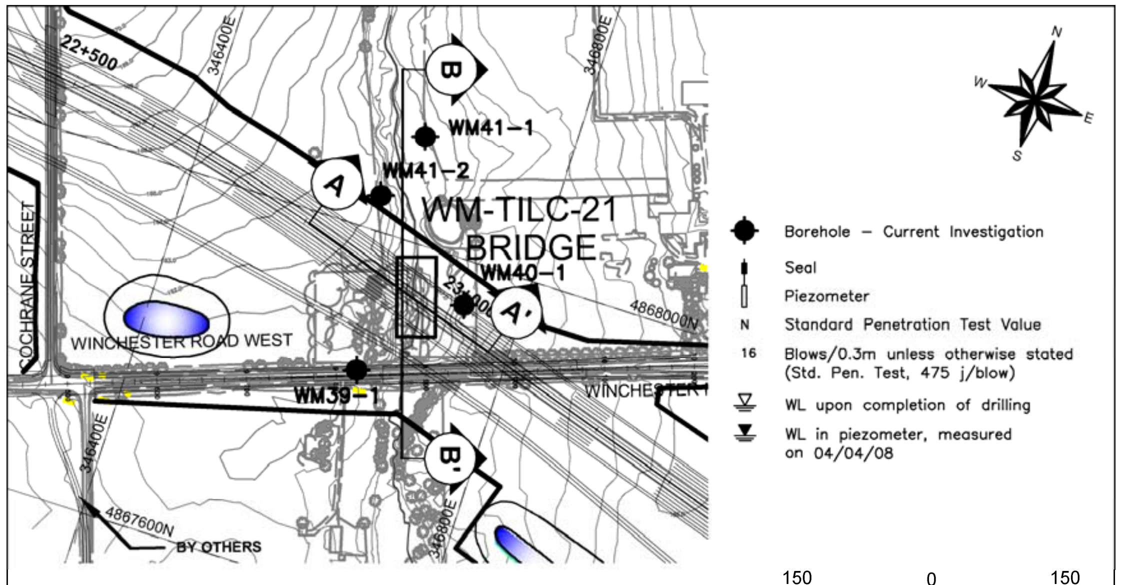
- **Topsoil/Fill:** very loose to compact topsoil, 0.5 m to 0.8 m thick, encountered in all boreholes except in Borehole WM39-1. SPT 'N' values measured within the topsoil vary from 3 to 14 blows per 0.3 m of penetration. A layer of sand and gravel fill, 0.8 m thick, was encountered only in Borehole WM39-1. One SPT 'N' value measured within the fill is 15 blows per 0.3 m of penetration, indicating a compact relative density. Measured water content within the sand and gravel layer is 8 percent.

- **Clayey Silt to Silty Clay:** an upper layer of clayey silt.to clayey silt with sand was encountered immediately below the topsoil in all boreholes except in Borehole WM39-1. Clayey silt to silty clay layers, 2 m to 3.3 m in thickness, are also encountered in all four boreholes between Elevation 154.7 m and Elevation 153.6 m The SPT 'N' values measured within these layers vary from 5 to 29 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. The results of a grain size distribution test are presented on Figure WM40-A (Appendix B); Atterberg limits test results are presented on Figures WM39-C, WM40-B and WM41-E. Measured water contents on samples of the clayey silt to silty clay layers range between approximately 12 and 24 percent.

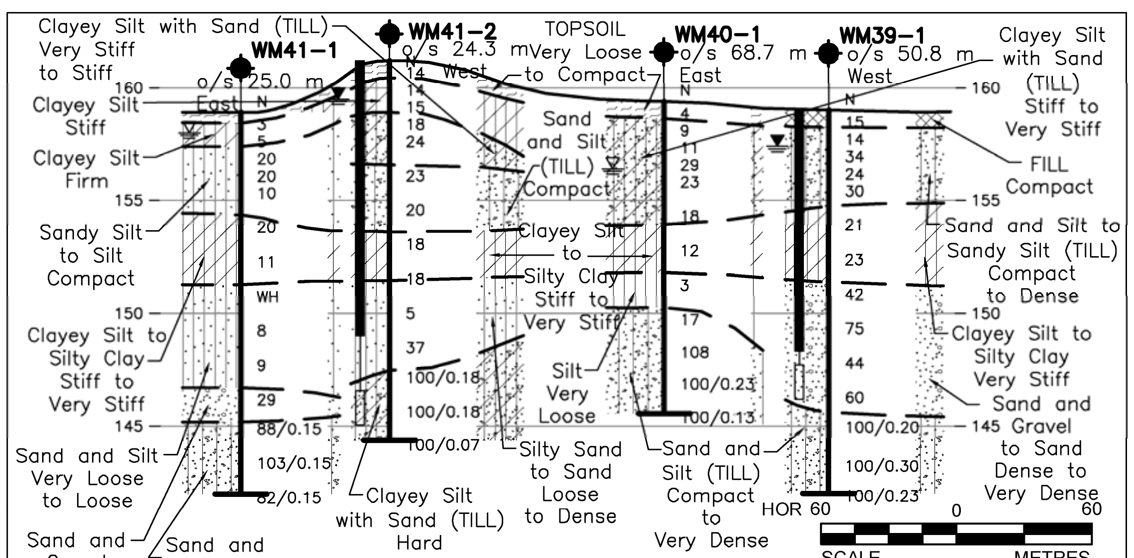
Record of Borehole Sheets – Appendix A | **Laboratory Test Results – Appendix B** | **Key Location Plan – Drawing 5**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-39, WM-40 (WM-TILC-21), WM-41 (Deleted)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION B – B'
SOIL STRATA

- **Sand to Sand and Gravel:** sand and gravel to sand, containing some gravel, trace to some silt and trace clay, encountered in Boreholes WM39-1 and WM41-1, extending from a depth of 7.6 m (Elev. 151.4 m) to 13.4 m below the ground surface and from a depth of 12.2 m (Elev. 146.7 m) to 13.7 m. SPT 'N' values measured within the sand to sand and gravel layers vary from 29 to 75 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The results of two grain size distribution tests are presented on Figure WM39-D (Appendix B). Measured water contents varied from about 6 to 14 percent.

- **Sandy Silt to Silty Sand to Sand and Silt:** silty sand to sand and sand and a silt layer encountered in Boreholes WM41-1 and WM41-2, respectively, extending between Elevation 151.5 m and 146.7 m. SPT 'N' values measured within these layers vary from the weight of the hammer (inferred loosening due to groundwater pressures) to 37 blows per 0.3 m of penetration, indicating a very loose to dense relative density. The results of two grain size distribution tests are presented on Figure WM41-H. Measured water contents vary from about 11 to 29 percent.

  Compact sandy silt to silt layers were encountered in Boreholes WM41-1 and WM40-1. In Borehole WM41-1 the silty sand to silt layer was underlying the upper clayey silt layer and extended to a depth of 4.6 m (Elev. 154.3 m). In Borehole WM40-1, 1.5 m thick layer of silt, extended from a depth of 7.6 m (Elev. 151.8 m). SPT 'N' values range between 10 and 20 blows per 0.3 m of penetration. Grain size distribution and Atterberg limits test results are presented on Figure WM41-A and WM41-B (Appendix B), respectively. Measured water contents varied from about 18 to 20 percent.

- **Till:** sandy silt to sand and silt till deposit, 0.9 m to 3.5 m thick, was encountered in Boreholes WM39-1, WM40-1and WM41-2 between Elevation 154.8 m and Elevation 158.2 m, and in Boreholes WM39-1, WM40-1 and WM41-1 at Elevations ranging from 150.3 m and 145.2 m and extended to the termination depth of the boreholes. SPT 'N' values measured within the till deposit vary from 14 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a compact to very dense relative density. Grain size distribution test results are presented on Figures WM39-A, WM40-C and WM41-F (Appendix B); Atterberg limits test results are shown on Figure WM39-B, WM40-D and WM41-F. Measured water contents varied from approximately 6 to 14 percent.

  Clayey silt with sand till was encountered in Borehole WM41-2; an upper till deposit, 2.3 m in thickness, extended from a depth of 2.3 m to 4.6 m (Elev. 156.6 m); and a bottom till deposit extended from a depth of 13.7 m to the termination depth of 16.8 m (Elev. 144.4 m). Two SPT 'N' values measured in the upper till layer are 18 and 24 blows per 0.3 m of penetration, indicating a very stiff consistency; while SPT 'N' values measured within the lower layer of the till vary from 100 blows per 0.18 m of penetration to 100 blows per 0.08 m of penetration, indicating a hard consistency. Grain size distribution and Atterberg limits test results are presented on Figure WM41-C and WM41-D (Appendix B), respectively. Measured water contents varied from about 7 to 15 percent.

Groundwater Conditions:

- **BH WM39-1:** Depth of 1.6 m below the ground surface (Elev. 157.4 m) in piezometer on April 4, 2008.
- **BH WM40-1:** Depth of 3.0 m below the ground surface (Elev. 156.4) in open borehole upon completion of drilling.
- **BH WM41-1:** Artesian conditions encountered at depth of 12.2 m below ground surface (Elev. 146.7 m);
  depth of 0.9 m below ground surface (Elev. 158.0 m) in open borehole upon completion of drilling.
- **BH WM41-2:** Depth of 1.7 m below the ground surface (Elev. 159.5 m) in piezometer on April 4, 2008.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-39, WM-40 (WM-TILC-21), WM-41 (Deleted)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing of Structure WM-39 and WM-40, as provided by URS on October 3, 2008, this structure will carry the proposed Highway 407 over East Lynde Creek Tributary. Structures WM-39 and WM-41 will no longer be required as the originally proposed ramps connecting Highway 407 and Cochrane Street have been eliminated as shown on the Highway 407 Mainline Plan received from URS on June 17, 2008. The proposed overpass is a single span structure with closed-end type abutments, and a total length of 21 m. The proposed Highway 407 grade at this location is approximately at Elevation 162 m, with approach embankment about 6 m high. Based on the existing subsurface information, feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option. It is noted that caissons are not considered to be a practical option given the artesian conditions encountered within the deeper granular deposits.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles founded into "100-blow" clayey silt till or sand and silt till deposits	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through the hard/very dense layers in the till deposits

A - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt till or clayey silt with sand till at or below Elevation 146 m and at or below Elevation 147.5 m, are feasible for support of east and west abutments, respectively; pile lengths would vary between 9 m at the east abutment and 7.5 m at the west abutment. The structural design of the abutment piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to significantly reduce post-construction settlements under the new embankment loading; in this case downdrag loads can be eliminated.

Pile	*Axial Geotechnical Resistance (East and West Abutments)*		*Downdrag Load (Unfactored)*
	Factored ULS	**SLS**	
HP 310 x 110	1,400 kN	1,200 kN	250 kN

Recommended Foundation Alternative: Steel H-Piles.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- **APPROACHES**

Height: Based on the subsoil conditions encountered at the site, the proposed approach embankment fills of 6 m high can be constructed. However, subexcavation of approximately 1.5 m of topsoil and/or clayey silt would be required.

Stability: Approach embankments 6 m high, with side slopes no steeper than 2 horizontal to 1 vertical (2H: 1V), will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth (i.e. select subgrade materials) or granular materials for embankment construction, and based on consolidation parameters and elastic deformation moduli of the approach foundation soils (estimated based on the results of oedometer testing on samples from adjacent boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlement within the foundation soils is on the order of 75 mm. About 30 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement). The majority of remaining consolidation settlement (i.e. about 70 percent) is anticipated to occur in less than three months and measures to reduce post-construction settlement to acceptable values should be undertaken. These measures may include preloading with a surcharge and construction staging, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and the use of lightweight fill materials.

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the surficial topsoil and clayey silt are classified as Type 3 soils, while the clayey silt with sand and the upper till materials are classified as Type 2 soils, respectively, according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that the groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps. Refer to Section 6.7.3 for options to control groundwater and migration of fines when driving piles at sites with possible artesian conditions.

Protection Systems: Refer to Section 6.7.2 of the Report.

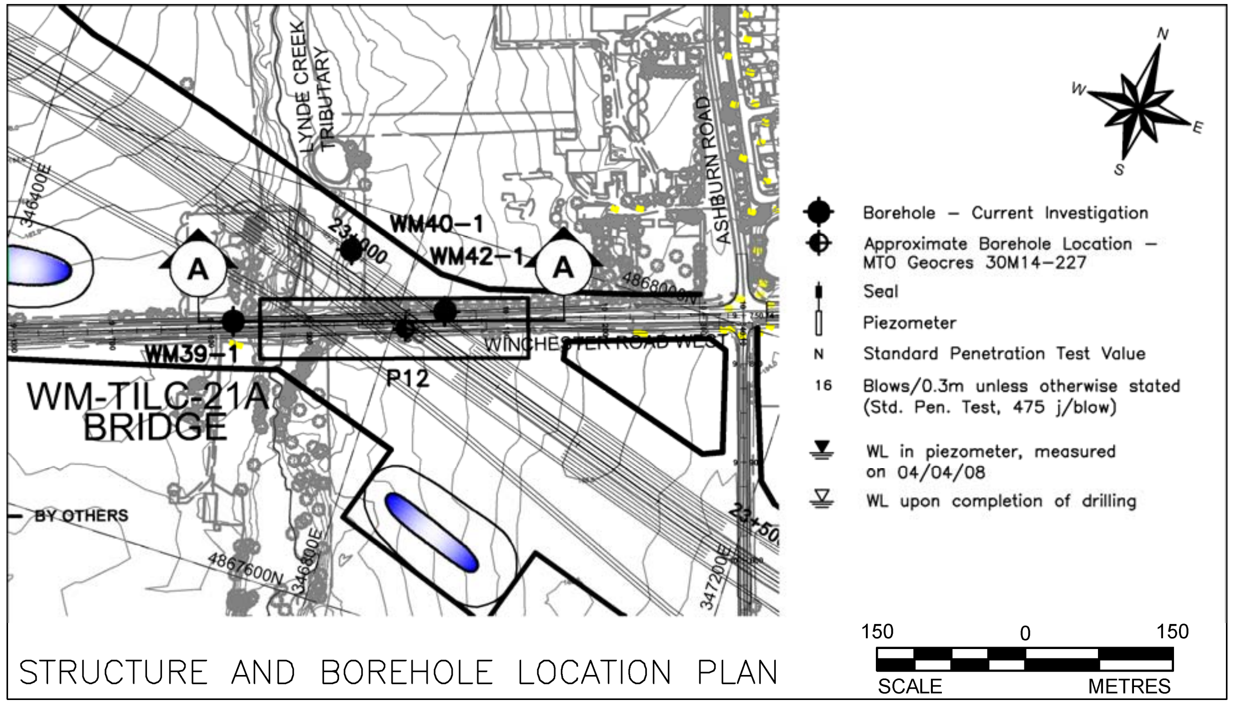
Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving into or through the very dense till layers.

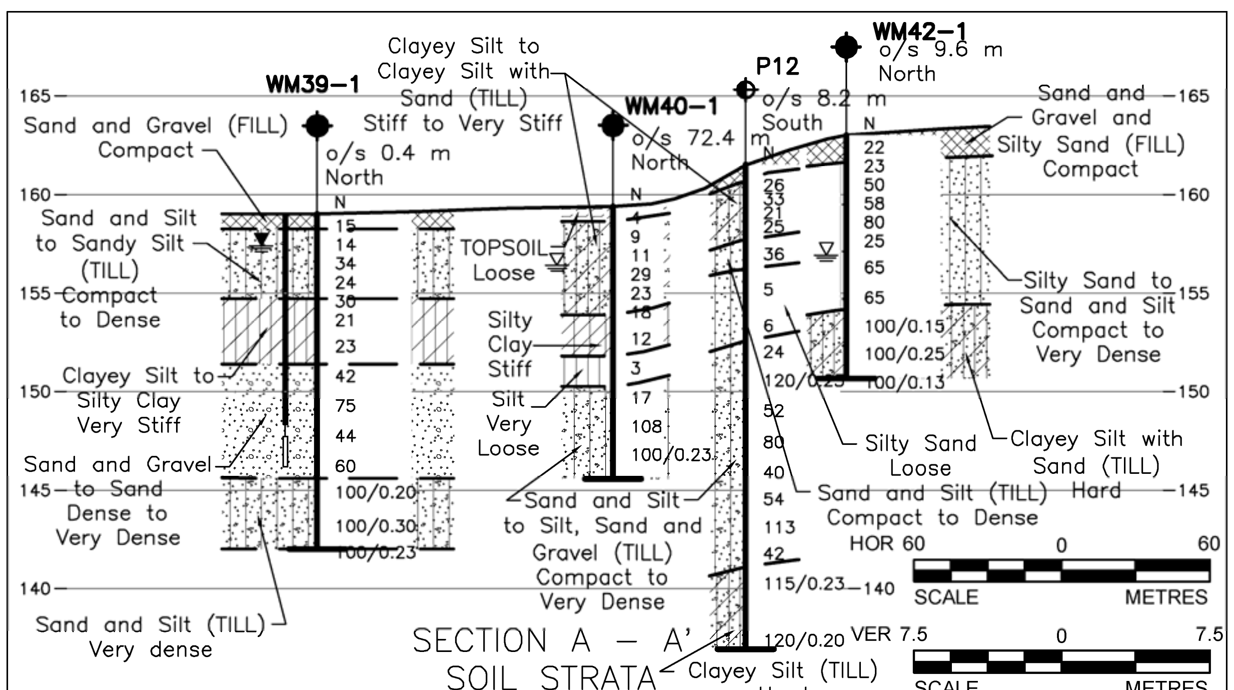
- **RECOMMENDATIONS FOR ADDITIONAL WORK**

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions and artesian conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	Underpass – Hwy 407 under Winchester Road West (Highway 7) and Hwy 7 over Lynde Creek Tributary	**Hwy 407 Proposed Grade:**	162 m	**Site Ranking:**	Medium
Location No:	WM-42 (WM-TILC-21A)	**Existing Ground Elevation:**	156 m – 164 m	**Station:**	9+963 (Hwy 7)





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WM-42 bridge structure is located along Winchester Road West (Highway 7), approximately 400 m west of Ashburn Road in the Town of Whitby, Ontario. Winchester Road West in this area consists of a two-lane asphalt road, approximately 8 m wide, surrounded by farmland with occasional trees and a residential subdivision located north east of the proposed bridge structure. A tributary watercourse to Lynde Creek flows north to south through the site. The overall topography of the terrain is relatively flat.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM39-1	West Abutment	4 867 846.2	346 644.0	159.0	17.0
WM42-1	East Abutment and Central Piers	4 867 921.5	346 845.3	163.0	12.3
WM40-1	Piers	4 867 951.9	46 735.8	159.4	13.8
P12*	-	4 867 892.3	346 812.3	161.5	24.6

* GEOCRES 30M14-227. Coordinates on original Borehole log referenced to MTM-NAD27

Subsurface Conditions:

- **Fill/Topsoil:** a 0.8 m thick layer of topsoil was encountered in Borehole WM40-1. One SPT 'N' value measured within the topsoil was 4 blows per 0.3 m of penetration, indicating a loose relative density. Granular fill layers consisting of sand and gravel to silty sand, ranging in thickness from 0.6 m to 0.8 m, were encountered in Boreholes P12, WM39-1, and WM42-1. SPT 'N' values measured within the sand and gravel to silty sand fill ranged from 15 to 23 blows per 0.3 m of penetration, indicating a compact relative density. Measured water contents within the sand and gravel and silty sand fill ranged from 4 to 8 percent.

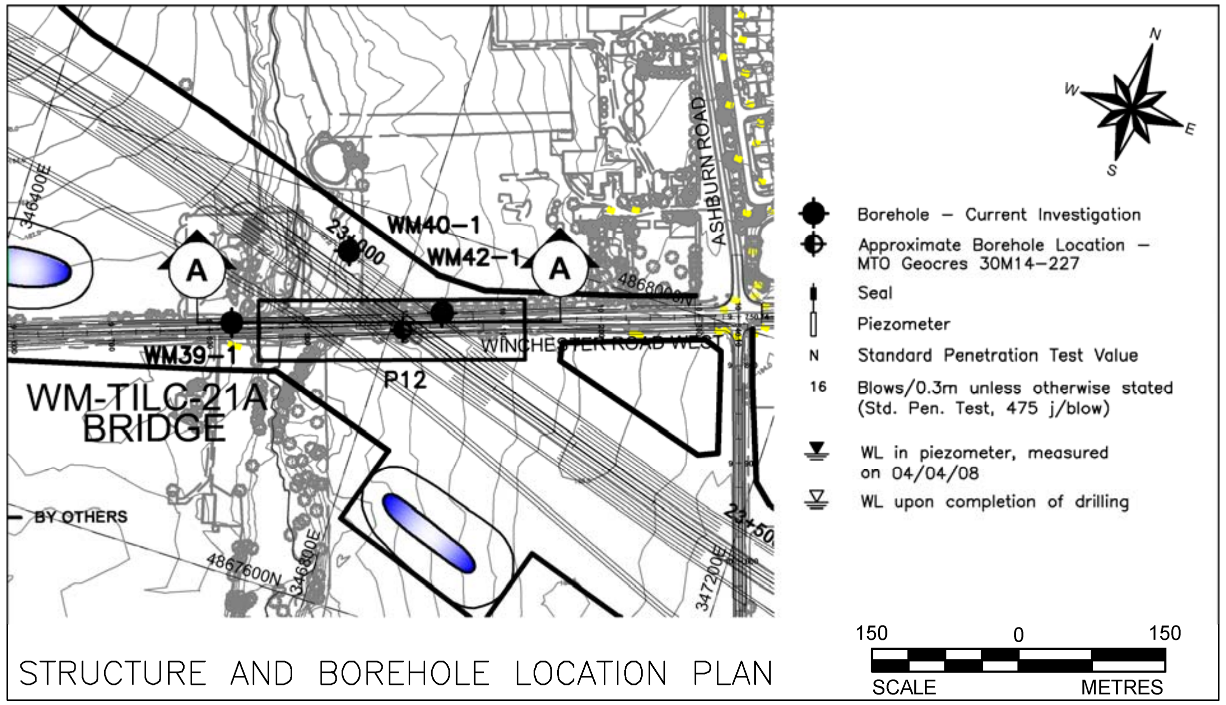
- **Silty Sand to Sand and Silt:** silty sand, containing organics in the upper 1.6 m of the deposit, to sand and silt, containing trace clay, encountered in Borehole WM42-1 immediately below the fill and extended to a depth of 8.8 m (Elev. 154.2 m). Measured SPT 'N' values varied from 25 to 80 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The results of grain size distribution and Atterberg limits tests are presented on Figures WM42-A and WM42-B (Appendix B), respectively. Measured water contents on samples of this deposit range between 7.5 and 19 percent. A layer of silty sand encountered in Borehole P12 interlayered with a silty sand and gravel till deposit had measured 'N' values of 5 and 6 blows per 0.3 m of penetration, indicating a loose relative density.

- **Upper Clayey Silt / Sandy Silt Till:** an upper deposit of till comprised of clayey silt with sand, containing trace to some gravel, to sandy silt, some clay, trace gravel was encountered in Borehole WM40-1, P12 and WM39-1 below the topsoil and fill. Measured SPT 'N' values within this deposit ranged between 9 and 34 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency/compact to dense relative density. The results of grain size distribution and Atterberg limits tests performed on the cohesive till are presented on Figures WM40-A and WM40-B (Appendix B), respectively, and indicate this material to be of low plasticity. The results of a grain size distribution and an Atterberg Limits test performed on the sandy silt till are presented on Figures WM39-A and WM-39B (Appendix B), respectively. Measured water contents within the till deposits vary from approximately 8 to 23 percent.

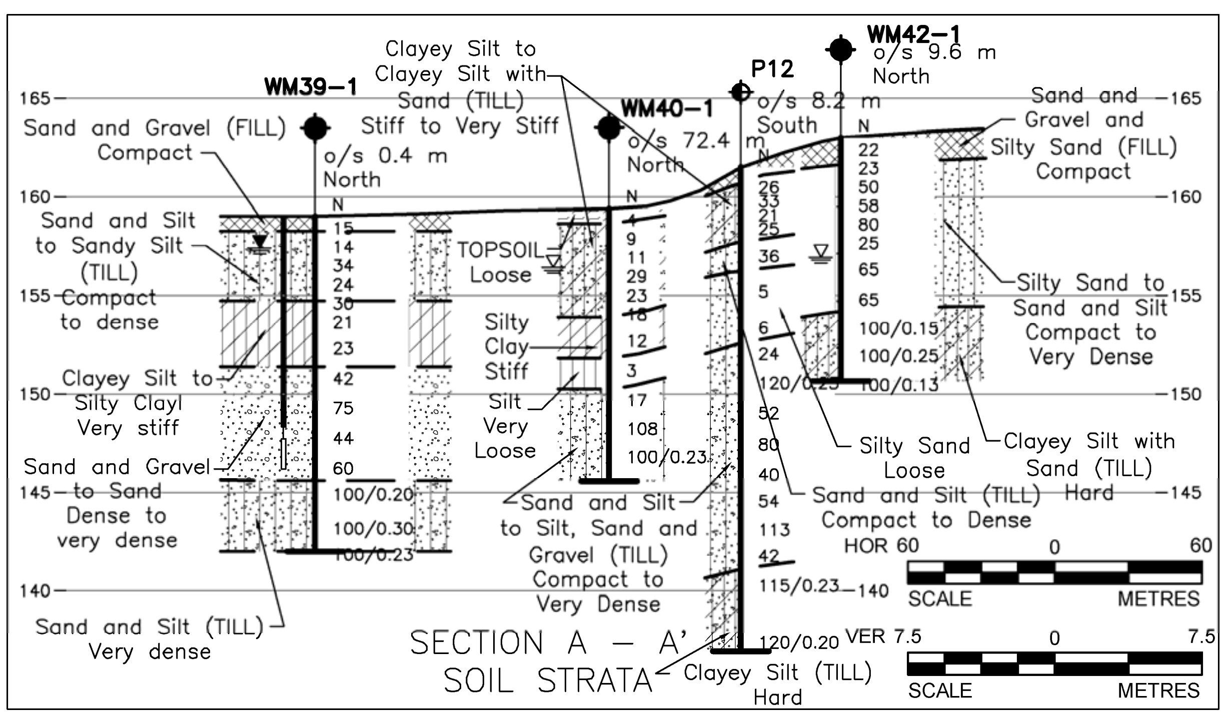
- **Silty Clay to Clayey Silt:** a 2.1 m and 3.3 m thick deposit of silty clay encountered in Borehole WM40-1 and WM39-1 below the upper deposit of clayey silt and sandy silt till, at depths of 5.5 m and 4.3 m below ground surface corresponding to Elevation 153.9 m and 154.7 m,

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-42 (WM-TILC-21A)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A' SOIL STRATA

respectively. SPT 'N' values measured in the silty clay ranged from 12 blows to 23 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency. The results of two Atterberg limits tests are presented on Figures WM40-E and WM39-C and indicate this material to be of low to medium plasticity. Water contents measured on samples of silty clay ranged from 20 to 22 percent.

- **Silt:** a 1.5 m thick layer of silt was encountered in Borehole WM40-1 below the silty clay, at a depth of 7.6 m below ground surface (Elev. 151.8 m). One SPT 'N' value measured in this layer is 3 blows per 0.3 m of penetration, indicating a very loose relative density. A water content measured on a sample of the silt is about 20 percent.

- **Sand to Sand and Gravel:** A 5.8 m thick layer of sand to sand and gravel, trace to some silt, trace clay was encountered below the silty clay layer in Borehole WM39-1 at a depth of 7.6 m (Elev. 151.4 m). SPT 'N' values measured in this layer ranged between 42 and 75 blows per 0.3 m of penetration indicating a dense to very dense relative density. Two grain size distribution test results are presented on Figure WM39-D (Appendix B). Measured water contents ranged between 6 and 15 percent.

- **Silt, Sand and Gravel to Sand and Silt Till:** silt, sand and gravel till, and sand and silt till, containing trace to some clay, including clayey silt seams was encountered in Borehole P12 at Elevation 157.7 m, in Borehole WM40-1 at Elevation 150.3 m, and in Borehole WM39-1 at Elevation 145.6 m. In Borehole P12, the till deposit encountered cobbles and boulders and extended to a depth of 20.4 m (Elev.141.1 m) and included a loose silty sand layer between a depth of approximately 5.3 m and 8.4 m. In Boreholes WM40-1 and WM39-1, the till deposit extended to the termination depths of 13.8 m (Elev. 145.6 m) and 17.0 m (Elev. 142.0 m), respectively. SPT 'N' values measured within the silty sand and gravel till and sand and silt till varied from 17 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a compact to very dense relative density. Grain size distribution test results are presented on Figure WM40-C (Appendix B). Atterberg limits test results are shown on Figure WM40-D. Measured water contents vary from 6 to 14 percent.

- **Lower Clayey Silt Till:** clayey silt till was encountered in Borehole P12 between Elevation 141.1 m and 136.9 m, while clayey silt with sand till was encountered in Borehole WM42-1 at Elevation 154.2 m and extended to the termination depth of the borehole at Elevation 150.7 m. SPT 'N' values measured in the lower clayey silt till varied from 100 blows per 0.25 m to 100 blows per 0.13 m of penetration, indicating a hard consistency. A grain size distribution test on one sample of the clayey silt till from Borehole WM42-1 is presented on Figure WM42-C. Water contents measured on samples of the clayey silt with sand till vary from 7 to 10 percent.

Groundwater Conditions:

- **WM39-1:** Depth of 1.6 m below ground surface (Elev. 157.4 m) in piezometer when checked on April 4, 2008.
- **WM40-1:** Depth of 3.0 m below the ground surface (Elev. 156.4 m) in open borehole upon completion of drilling.
- **BH WM42-1:** Depth of 6.1 m below the ground surface (Elev. 156.9 m) in open borehole upon completion of drilling.
- **BH P12:** Depth of 1.7 m below ground surface (Approximately Elev. 159.8 m) in open borehole upon completion of drilling.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-42 (WM-TILC-21A)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, bridge structure WM-42 is proposed to carry Winchester Road West (Hwy 7) over Hwy 407 and the Lynde Creek Tributary. An allowance has also been made to carry Hwy 7 over the future transit way. The structure is a six span bridge with a total length of 230 m and approach embankments up to 6.5 m and 10.5 m high at the east and west abutments, respectively. Based on the existing subsurface information, the feasible foundation options for the proposed bridge abutments and piers are listed below with advantages and disadvantages associated with each option. Shallow foundations are on considered to be a practical option given the subsoil conditions present at the site.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into "100-blow" clayey silt till or sand and silt till deposits for abutments with "perched" pile caps.	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through the hard/very dense layers in till deposits containing cobbles and boulders.
Caissons bored to found within "100-blow" clayey silt till or sand and silt till deposits.	• Higher bearing resistances than steel H-Piles	• Drilling must be advanced through hard/very dense layers in till deposits containing cobbles and boulders. • May require temporary or permanent liner to prevent seepage inflow and softening of the caisson base

A - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the '100-blow' sand and silt till or clayey silt with sand till at or below Elevation 143 m and at or below Elevation 152 m, at the west and east abutments, respectively, with "perched" pile caps. Pile lengths would vary between 20 m at the west abutment and 14 m at the east abutment. Steel HP 310 x 110 piles driven to found within sand and silt till at or below Elevation 143 m, are also feasible for support of the western piers. The piles would be approximately 15 m long. Central and eastern piers with piles driven to found within clayey silt till at or below Elevation 152 m would have lengths of about 5 m to 8 m.

Location	*Pile*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
West Abutment	HP 310 x 110	1,600 kN	1,400 kN
West Piers	HP 310 x 110	1,600 kN	1,400 kN
Central and East Piers	HP 310 x 110	1,400 kN	1,200 kN
East Abutment	HP 310 x 110	1,600 kN	1,400 kN

B - Caissons: West and east abutments on caissons founded a minimum of 1.5 m within the '100-blow' sand and silt till or clayey silt with sand till below Elevation 143 m and below Elevation 152 m, respectively. Western piers as well as the central and eastern piers also founded a minimum of 1.5 m within the '100-blow' till at or below Elevation 143 m and 152 m, respectively.

Location	*Caisson Diameter*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
West Abutment	1.2 m	4,500 kN	3,500 kN
	1.5 m	6,500 kN	5,500 kN
West Pier	1.2 m	4,500 kN	3,500 kN
	1.5 m	6,500 kN	5,500 kN
Central and East Piers	1.2 m	3,800 kN	3,000 kN
	1.5 m	5,900 kN	4,800 kN
East Abutment	1.2 m	4,500 kN	3,500 kN
	1.5 m	6,500 kN	5,500 kN

Recommended Foundation Alternative: Steel H-Piles or caissons.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Height: Up to 6.5 m along the east abutment and up to 10.5 m along the west abutment. Sub-excavation of up to 1 m of topsoil or surficial fill would be required.

Stability: Approach embankments up to 10.5 m high, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height bench (minimum 2 m wide) for approaches higher than 8 m, should have an adequate factor of safety against deep-seated slope instability.

Settlement: Assuming the use of conventional earth (i.e. select subgrade materials) or granular materials for embankment construction, and based on consolidation parameters and elastic deformation moduli of the approach foundation soils (estimated based on the results of Oedometer testing on samples from adjacent boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlement within the foundation soils is on the order of 160 mm. About 50 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement). The majority of the remaining consolidation settlement (i.e. about 70 percent) is anticipated to occur over a period of three months. Measures to reduce post-construction settlement to acceptable values may include preloading with a surcharge and construction staging. Consideration could also be given to the use of wick-drains to increase the rate of consolidation settlement. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation.

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill is classified as a Type 3 soil, while the clayey silt to silty clay / sand and gravel to sand /silty sand to sand and silt are classified as Type 2 soils according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils, and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils. Excavations for long term front face slopes should be made no steeper than 2H : 1V.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving into or through the hard or very dense till layers. Caisson drilling equipment must be capable of penetrating obstructions in event cobbles/boulders are present within the sand and silt till and clayey silt till.

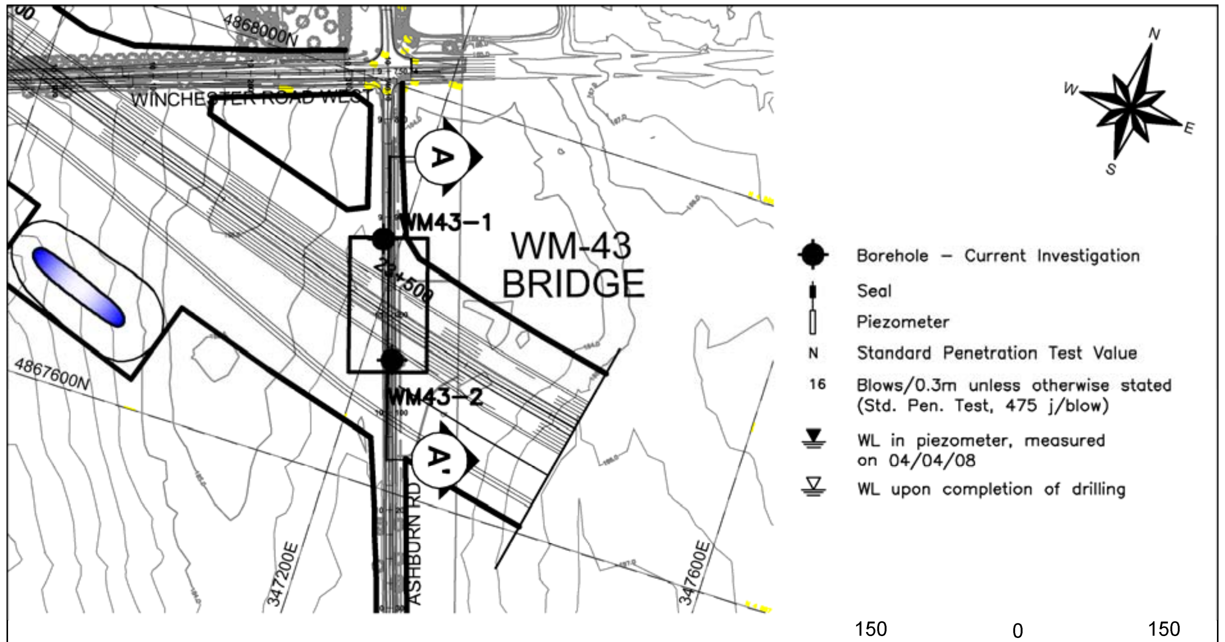
• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

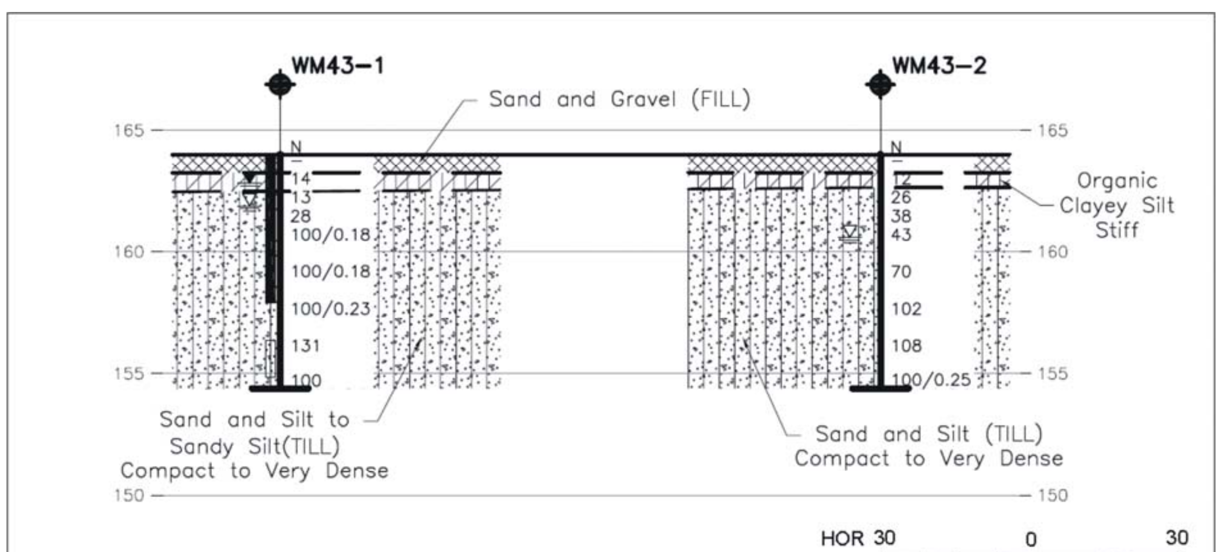
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass Highway 407 / Ashburn Road
Hwy 407 Proposed Grade: 165.5 m
Site Ranking: Medium

Location No: WM-43
Existing Ground Elevation: 164 m
Station: 23+500



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of structure WM-43 is located along Ashburn Road, approximately 165 m south of Highway 7 in the Town of Whitby, Ontario. Ashburn Road in this area is approximately 7.5 m wide on a 0.8 m embankment and consists of two lanes. The site in the vicinity of the proposed structure is surrounded by farmland and contains some shrubs and trees towards the far south of Highway 7. The terrain at the site is relatively flat to gently sloping

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM43-1	North Abutment	4 867 845.2	347 182.7	164.0	9.6
WM43-2	South Abutment	4 867 730.5	347 228.7	164.0	9.6

Subsurface Conditions:

- **Fill:** sand and gravel fill encountered at the ground surface in both boreholes and extending to a depth of 0.8 m (Elev. 163.2 m).

- **Organic Clayey Silt:** stiff organic clayey silt containing some sand and trace gravel underlying the fill material in both boreholes and extending to depth of approximately 1.5 m (Elev. 162.5 m). SPT 'N' values were 12 and 14 blows per 0.3 m of penetration within the organic clayey silt indicating a stiff consistency. Measured water contents within the organic clayey silt were 18 and 22 percent.

- **Till:** sand and silt till containing trace to some clay and gravel encountered in both boreholes immediately below the organic clayey silt; both boreholes were terminated within the sand and silt till deposit at a depth of 9.6 m (Elev. 154.4 m). SPT 'N' values within the sand and silt till ranged from 13 blows per 0.3 m of penetration to 100 blows per 0.18 m of penetration, indicating a compact to very dense relative density. Grain size distribution test results are presented on Figure WM43-A (Appendix B); Atterberg limits test results are presented on Figure WM43-B. Measured water contents within the till material ranged from 6 to 18 percent.

Groundwater Conditions:

- **BH WM43-1:** Depth of 2.1 m below ground surface (Elev. 161.9 m) in open borehole on completion of drilling; 2.3 m below ground surface (Elev. 161.7 m) in piezometer on January 7, 2008 and at 1.2 m below ground surface (Elev. 162.8 m) in piezometer on April 4, 2008.

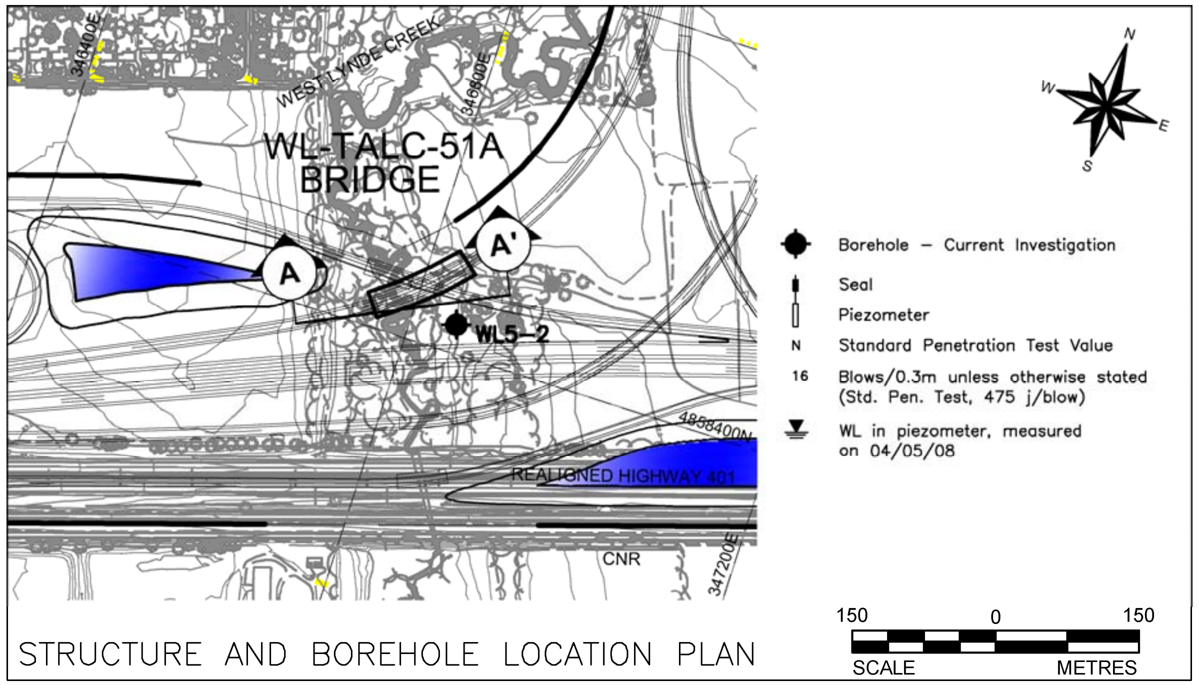
- **BH WM43-2:** Depth of 3.4 m below ground surface (Elev. 160.6 m) in open borehole upon completion of drilling.

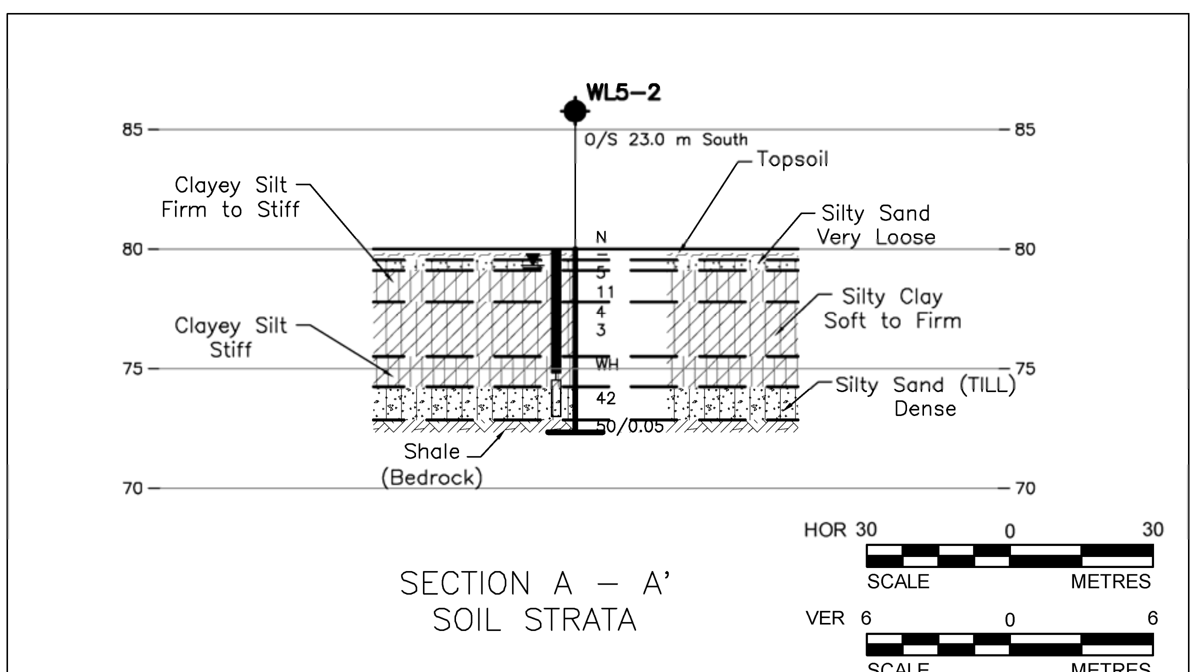
Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 5**

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: WDL/Hwy 401 IC, N-W Ramp over Hwy 401 WB Off-Ramp to Lakeridge Road
N-W Ramp Proposed Grade: 91.5 m – 93.0 m
Site Ranking: Medium

Location No: WL-5 (WL-TALC-51A)
Existing Ground Elevation: 80.0 m
Station: 9+437





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed bridge structure WL-5 for the West Durham Link/Highway 401 Interchange is located just north of the existing Highway 401, approximately 440 m east of Lakeridge Road and just east of the approximately 1 m to 2 m wide West Lynde Creek, in the Town of Whitby, Ontario. The site topography is generally flat, tree covered locally and surrounded by farmland.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL5-2	East Abutment	4 858 430.0	346 847.3	80.0	7.7

Subsurface Conditions:

- **Topsoil:** 500 mm thick layer of clayey silt topsoil, containing organics, encountered at the ground surface.
- **Silty Sand:** 400 mm thick layer of silty sand underlying the topsoil; one SPT 'N' value measured within the silty sand layer was 5 blows per 0.3 m of penetration, indicating a very loose relative density.
- **Clayey Silt to Silty Clay:** clayey silt with sand encountered immediately below the silty sand, extending to Elevation 74.2 m, interlayered with distinct deposit of silty clay approximately 2.2 m thick, between Elevation 77.8 m and Elevation 75.5 m. In-situ undrained shear strength measured within the silty clay ranged from about 30 kPa to 40 kPa, indicating a firm consistency. SPT 'N' values measured within the upper clayey silt deposit varied from 3 to 11 blows per 0.3 m of penetration, indicating a firm to stiff consistency, while within the lower clayey silt deposit, the in-situ undrained shear strength was about 70 kPa, indicating a stiff consistency. The results of a grain size distribution test and two Atterberg limits tests are presented on Figures WL5-A and WL5-B, respectively (Appendix A). Measured water contents within the cohesive deposit were between 17 and 48 percent.
- **Till:** silty sand, containing some gravel and trace to some clay, about 1.4 m thick, was encountered below the lower clayey silt deposit and extends to Elevation 72.8 m. One SPT 'N' value measured within this deposit was 42 blows per 0.3 m of penetration, indicating a dense relative density. The results of a grain size distribution test are presented on Figure WL5-C (Appendix B). Measured water content within the cohesionless till material was about 7 percent.
- **Bedrock:** shale bedrock encountered at Elevation 72.8 m; borehole terminated within bedrock at Elevation 72.3 m. One SPT 'N' value within the lower portion of the shale was 50 blows per 0.05 m of penetration.

Groundwater Conditions:

- **BH WL5-2:** Depth of 0.7 m below ground surface (Elev. 79.3 m) measured in piezometer on April 5, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 8**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-5 (WL-TALC-51A)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, the bridge structure will carry the WDL/Realigned Hwy 401 N-W Ramp over the Hwy 401 WB Off-Ramp to Lakeridge Rd. The proposed N-W Ramp bridge is a single span closed end type structure with a total length of 43.5 m and approach embankments approximately 12 m and 13 m high at the west and east abutment, respectively. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option. Shallow foundations are not considered to be a practical option given the near surface subsoils at the site.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven to found on shale bedrock for abutments with "perched" / closed-end type pile caps.	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through possible presence of cobbles within the till deposit
Caissons bored to found within shale bedrock.	• Larger caissons have higher bearing resistances than steel H-Piles	• Drilling must be advanced through possible presence of cobbles • May require temporary or permanent liner

A - Steel H-Piles: Steel HP 310 x 110 piles driven to refusal into the shale bedrock at or below Elevation 72.8 m are feasible for support of abutments with "perched" / closed-end type pile caps. The structural design of the abutment piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to minimize post-construction settlements under the new embankment loading, in which case downdrag loads can be eliminated.

Pile	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored) abutments only*
	Factored ULS	**SLS**	
HP 310 x 110 (abutments, 'perched' / closed-end type pile caps)	1,600 kN	Does not govern	250 kN

B - Caissons: Abutments on caissons founded within shale bedrock at or below Elevation 71.3 m. Caissons should be socketed a minimum of 1.5 m into the shale bedrock. Full downdrag loads as provided below should be accounted for unless long-term settlement mitigation measures as discussed above for pile foundations are undertaken.

Caisson Diameter	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored) abutments only*
	Factored ULS	**SLS**	
1.2 m	6,500 kN	Does not govern	550 kN
1.5 m	9,500 kN	Does not govern	700 kN

Recommended Foundation Alternative: Steel H-Piles or caisson foundations.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Embankment Height: Based on the GA drawings, embankment heights up to 13 m are anticipated. Based on the subsoil conditions encountered at the site, it is recommended that approach embankment fills be constructed with a maximum height of 10 m, provided that preloading with surcharge and construction staging be carried out prior to construction (refer to Settlement section below). Embankments higher than 10 m will require mitigation measures such as lightweight fills. It is further noted that sub-excavation of up to about 1 m of very loose silty soils would be required.

Stability: Approach embankments up to 10 m high, constructed with select subgrade materials or granular fill, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep seated failure provided that the embankments are constructed in stages as discussed above. For embankments up to 13 m high, mitigation measures will be required such as the use of lightweight fills and/or toe berms to achieve an adequate factor of safety. Construction of a mid-height bench will be required for embankments in excess of 8 m to control erosion and improve stability.

Settlement: Assuming the use of conventional earth or granular embankment fill materials and based on consolidation parameters and elastic deformation moduli of the foundation soils (estimated based on the results of oedometer testing on samples from adjacent boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlement within the embankment foundation soils (based on a 13 m high embankment constructed of conventional granlular fill) is on the order of 450 mm. Less than 5 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement); the majority (about 95%) of the remaining consolidation settlement is anticipated to occur over a period of three to six months. Measures to reduce post-construction settlement to acceptable values may include preloading with a surcharge and construction staging, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Additionally, depending on the results of detailed geotechnical analyses, the use of wick drains may be warranted to promote dissipation of pore pressures and promote settlement at a faster rate. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and use of lightweight fill materials.

• CONSTRUCTION CONSIDERATIONS

Excavation: the firm to stiff clayey silt to silty clay soils are classified as Type 3 soils, according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. No major obstructions (e.g.boulders) are anticipated at the site based on the borehole data at this site; although cobbles should be expected to be present within the till soils.

• 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 and retaining wall structures.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WM-43

• FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a prototype General Arrangement drawing for a typical side road underpass (Drawing No. 1), dated February 2008, and Ashburn Road at Highway 407 profiles, dated April 2008, the proposed underpass is a two span structure with a total structure length of approximately 142 m; Highway 407 is proposed to be constructed on a 1.5 m fill section at about Elevation 165.5 m. The proposed Ashburn Road grade varies between Elevation 176 m on the north side and Elevation 174 m on the south side, with approach embankments up to 10 m high. Feasible foundation options for the proposed bridge abutments and central pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on compact to dense sand and silt till or on a compacted Granular 'A' pad for abutment footings "perched" within the bridge approaches	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of about 1.5 m of surficial fill materials and organic clayey silt
Steel H-Piles driven into "100-blow" sand and silt till for abutments with "perched" pile caps	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, possibly containing cobbles
Caissons bored to found within "100-blow" sand and silt till	• Higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the proposed Highway 407 grade at Elevation 165.5 m, spread footings placed at or below Elevation 161.5 m on the north side and Elevation 162 m on the south side and at a minimum depth of 1.2 m below the lowest surrounding grade will be founded on compact to dense sand and silt till. Alternatively, spread footings for the abutments could be founded on a Granular 'A' pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Compact to dense Sand and Silt Till	500 kPa	350 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt till deposit at or below Elevation 159.0 m on the north side and at or below Elevation 156 m on the south side, are feasible for support of abutments with perched pile caps; piles would be approximately 15 m long.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,400 kN	1,200 kN

C – Caissons: Abutments and central pier on caissons founded within the "100-blow" sand and silt till below Elevation 156.0 m. Caissons lengths would be at least 6.5 m, extending 3 m to 4 m into the "100-blow" materials.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,800 kN	3,000 kN
1.5 m	5,900 kN	4,800 kN

Recommended Foundation Alternative: Shallow foundations; steel H-Piles with "perched" pile caps are also appropriate for support of the abutments.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Height: up to 10 m.

Stability: Approach embankments up to 10 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fills, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials/organic clayey silt and sand and silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps. However, other dewatering measures may be required for excavation below the groundwater level to prevent possible 'boiling' of the base of the excavation in silty materials as a result of unbalanced hydrostatic heads.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. No major obstructions (e.g. cobbles or boulders) are anticipated at the site based on the borehole data at this site.

• 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.

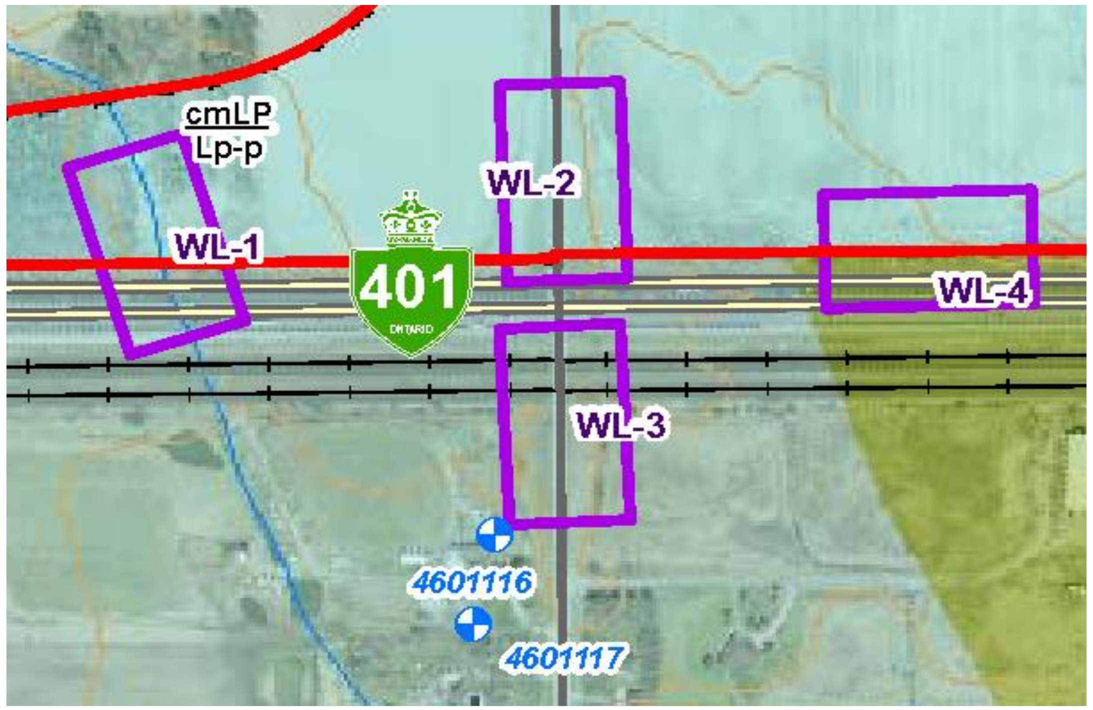
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WL-1

W.O: 07-20015 **Section:** Western **Location:** Creek west of Lakeridge Road at Hwy 401 **Sta.** Hwy 401 11+650

Original Grade: **Proposed Grade:** **Description:** New construction passes over the creek on culvert.



Site Plan and Terrain Analysis

Site Photograph – facing west from Lakeridge Road towards culvert site.

Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks
Boreholes: No BH at the site. BH 9-2, GEOCRES 30M15-80, lies ~125m north. Mapping (West (9) shows the site is underlain by a clayey silt lacustrine plain. The relief is low plain, poorly drained. This area is typically underlain by clay and silt deposits laid down by Lake Iroquois. Borehole 9-2 encountered: 0.0 – 2.1 Clayey silt topsoil 2.1 – 6.1 Clayey silt till with sand and gravel, stiff to hard 6.1 – 7.7 (EOH) Shale bedrock **Groundwater** GWL measured in BH 9-2 was at a depth of about 1.3m (Elev 84.2) **Bedrock encountered at ~8m.**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Settlement and stability not expected to be problematic unless high fills are requires, e.g. greater than 8m. However, this must be analyzed during detail design.	Narrow, shallow, channelized valley with no geomorphic evidence of significant valleyside instability Likely no appreciable alluvial deposits, based on field checks of similar valleys Depending on the final design and time of year construction is carried out, unwatering and temporary stream diversion may be required.

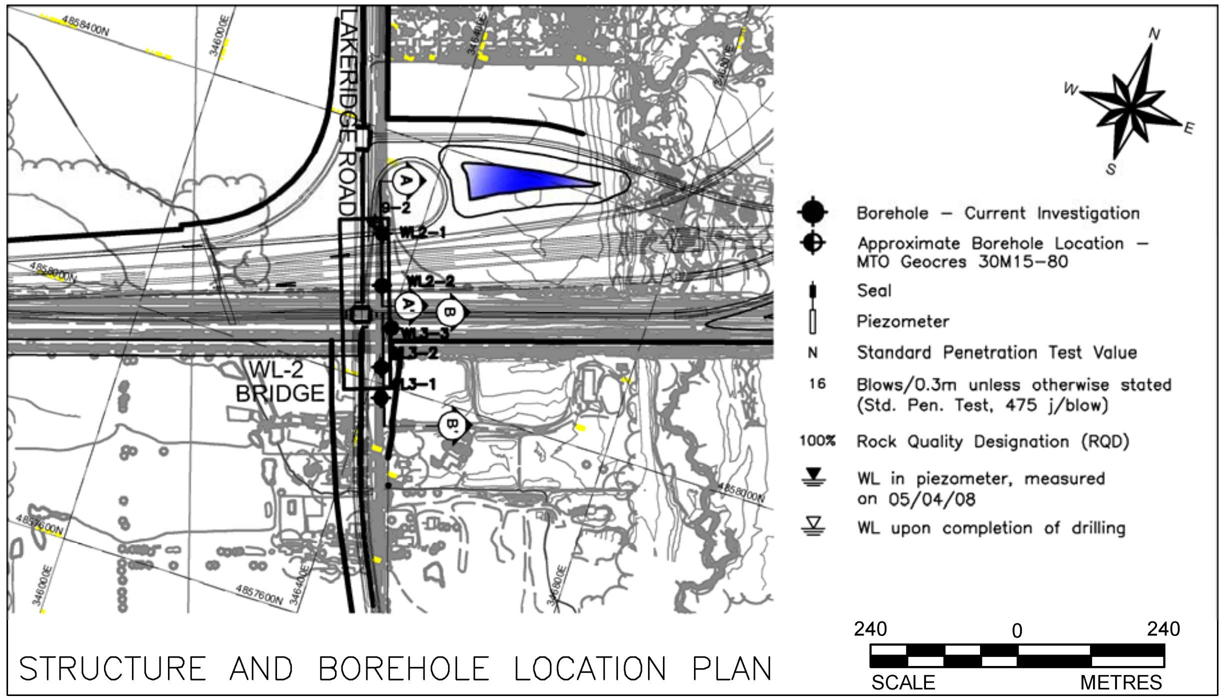
Site Ranking

Foundations: **Low**

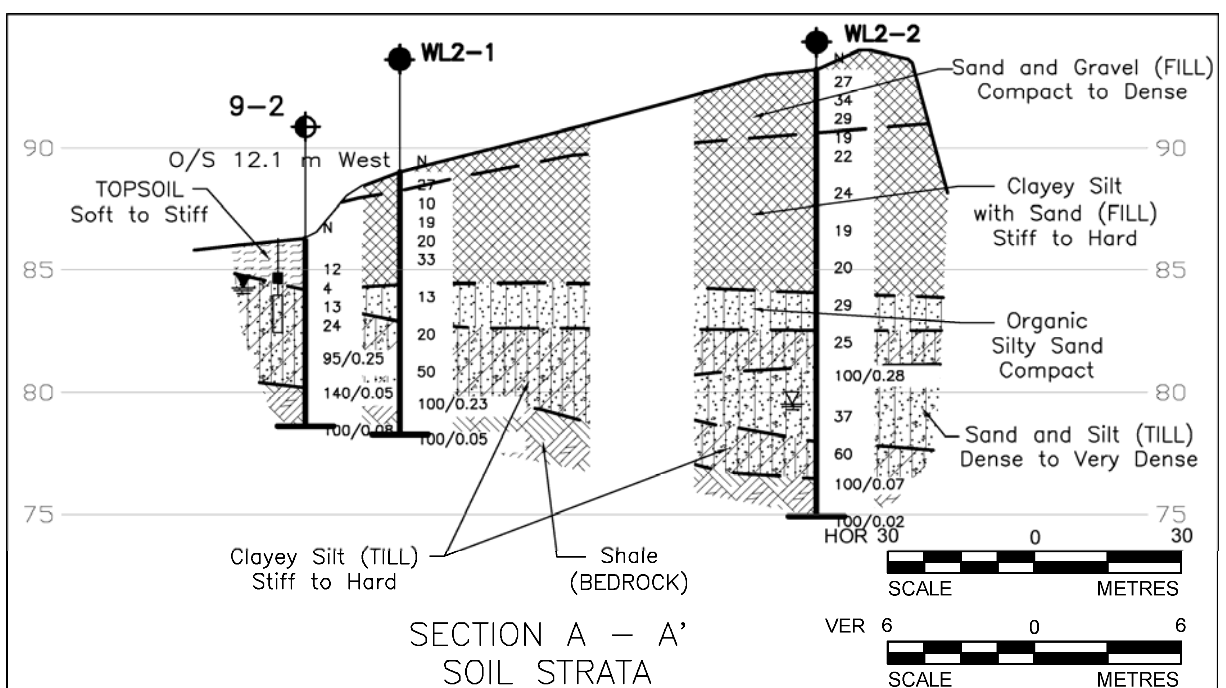
Hydrogeology: **Low**

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	WDL/Hwy 401 IC - Realigned Lakeridge Road over Realigned Hwy 401 and N-W Ramp (WL-2) and over CNR and GO Transit Tracks (WL-3)	**Proposed Grade:**	95 m – 98 m	**Site Ranking:**	High
Location No:	WL-2, WL-3 (WL-2)	**Existing Ground Elevation:**	84 m – 94 m	**Station:**	9+928 to 10+173 (Lakeridge Rd.)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WL-2 and WL-3 structures are located just north and south of the existing Highway 401 along Lakeridge Road in the Town of Whitby, Ontario. The new N-W Ramp linking West Durham Link with Highway 401 and the proposed realigned Hwy 401 will be crossed by the proposed realigned Lakeridge Road as the proposed WL-2 bridge structure and the existing CNR tracks and GO Transit tracks are crossed by the proposed realigned Lakeridge Road as the proposed WL-3 bridge structure. The surrounding area consists of farmland with a few residential units located just south of the proposed WL-3 structure. The topography in the vicinity of the proposed bridges is generally flat.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL2-1	North Abutment	4 858 235.2	346 342.8	89.0	10.7
WL2-2	South Abutment/Pier	4 858 153.9	346 368.2	93.2	18.3
WL3-1	South Approach	4 857 980.3	346 420.5	91.3	14.2
WL3-2	South Abutment	4 858 023.6	346 406.4	94.0	19.9
WL3-3	North Abutment/Pier	4 858 095.1	346 393.7	88.0	14.6
9-2*	North Abutment (WL-2)	4 858 250.0	346 325.5	85.5	7.7

*GEOCRES 30M15-80. Coordinates on original Borehole log referenced to MTM-NAD27

Subsurface Conditions:

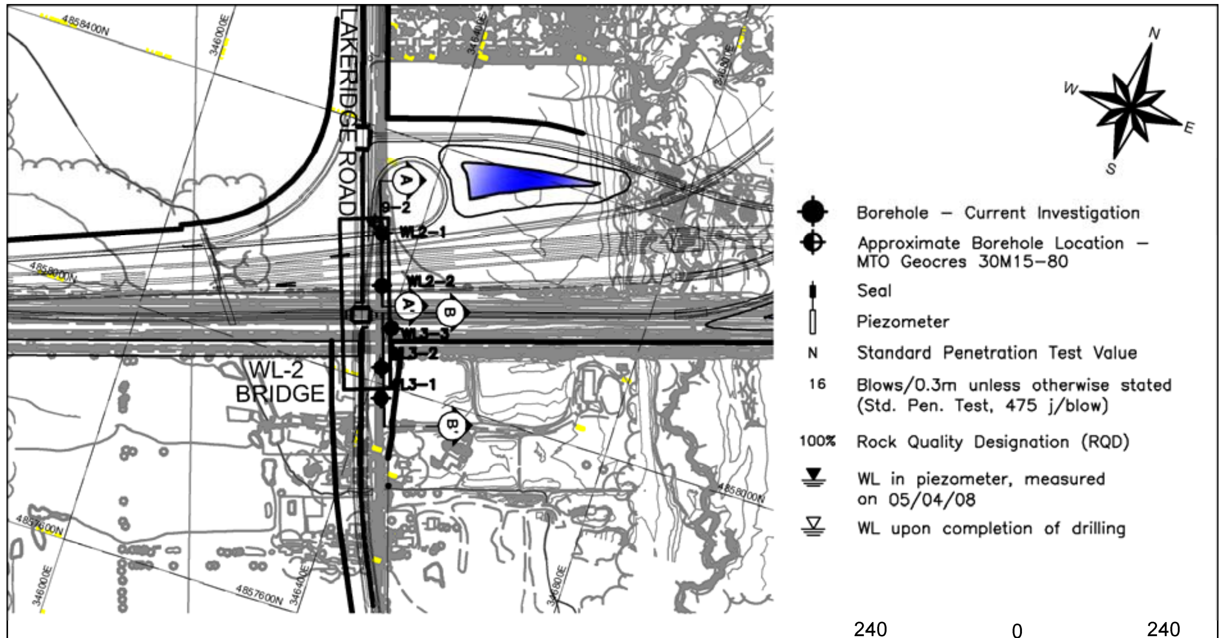
- **Topsoil/Asphalt/Fill:** soft to stiff topsoil, 2.1 m in thickness, was encountered only in Borehole 9-2. Measured SPT 'N' values were 12 and 4 blows per 0.3 m of penetration. A 200 mm thick layer of asphalt was encountered in all boreholes put down along the existing Lakeridge Road shoulder, except in Borehole 9-2. The asphalt is underlain by a layer of sand and gravel fill extending to depths ranging from 0.8 m to 4.6 m below the ground surface. Measured SPT 'N' values range from 18 to 34 blows per 0.3 m of penetration, indicating a compact to dense relative density. The results of a grain size distribution test are presented on Figure WL3-A (Appendix B). Measured water contents range between 3 and 10 percent. The sand and gravel fill is in turn underlain by a fill layer comprised of clayey silt with sand to silty clay and ranging in thickness from approximately 1.5 m to 7 m. Measured SPT 'N' values varied from 10 to 33 blows per 0.3 m of penetration, indicating a stiff to hard consistency. The results of grain size distribution tests are presented on Figures WL2-A and WL3-B (Appendix B); the results of Atterberg limits test are presented on Figures WL2-B and WL3-C. Measured water contents range from 10 to 28 percent.

- **Organic Silty Sand:** approximately 1.5 m thick organic silty sand, containing trace clay, encountered in Boreholes WL2-1, WL2-2 and WL3-1 immediately below the cohesive fill material. SPT 'N' values measured within the organic layers varied from 13 to 29 blows per 0.3 m of penetration, indicating a compact relative density. Measured organic contents on two samples are 6.6 and 4.8 percent; measured water contents vary between 22 and 31 percent.

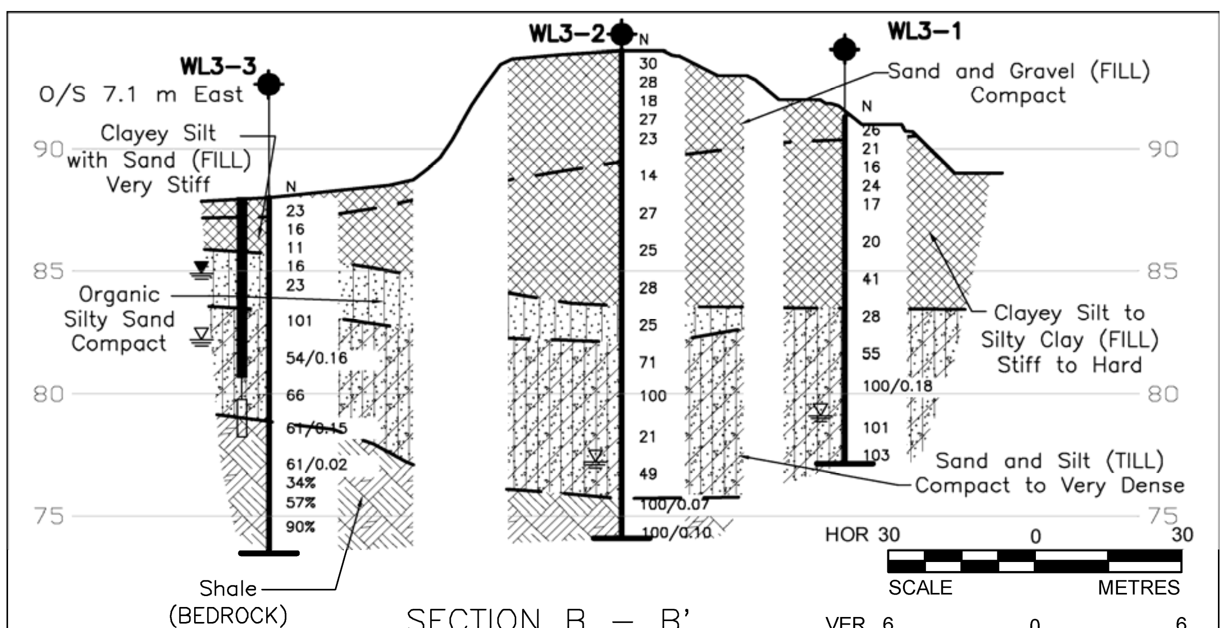
- **Till:** clayey silt with sand to clayey silt, containing some sand and trace to some gravel, encountered in Boreholes WL2-1, WL2-2, WL3-3 and 9-2. In Boreholes WL2-1 and WL2-2 the clayey silt till was encountered below the organic silty sand layer and below a sand

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-2, WL-3 (WL-2)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION B – B'
SOIL STRATA

and silt till layer in Borehole WL2-2. In Borehole WL3-3, a 2.3 m thick layer of clayey silt with sand till was encountered immediately below the silty clay fill at Elevation 85.7 m. In Borehole 9-2 the clayey silt till underlies the topsoil and extends to shale bedrock at Elevation 79.4 m. Measured SPT 'N' values vary from 12 to 60 blows per 0.3 m of penetration, indicating a very stiff to hard consistency. The results of grain size distribution tests are presented on Figures WL2-C and WL3-D (Appendix B); the results of Atterberg limits test are presented on Figures WL2-D and WL3-E. Measured water contents within the cohesive till varied from 9 to 17 percent.

Sand and silt till, containing trace to some gravel and clay, was encountered in Boreholes WL2-2, WL3-1, WL3-2 and WL3-3 at Elevations varying from 81.0 m to 83.5 m and ranged in thickness from 2 m to 6.4 m. Measured SPT 'N' values vary from 21 blows per 0.3 m of penetration to 100 blows per 0.18 m of penetration, indicating a compact to very dense relative density. The results of grain size distribution tests are presented on Figures WL2-E and WL3-F (Appendix B); the results of Atterberg limits test are presented on Figures WL2-F and WL3-G. Measured water contents within the cohesive till vary from 6 to 13 percent.

- **Bedrock:** shale bedrock was encounterd in all boreholes, except in Borehole WL3-1, at elevations varying from 75.7 m to 79.9 m. Rock coring was carried out in Borehole WL3-3 for a length of 3.8 m between Elevation 77.3 m and Elevation 73.5 m. The bedrock core samples consist of moderately to slightly weathered, thinly bedded, grey shale. Diametrical point load tests carried out on selected samples of the shale bedrock from Borehole WL3-3 yield correlated uniaxial compressive strength[1] (UCS) values ranging generally from 5 MPa to 8 MPa, with UCS values as high as 15 MPa and 31 MPa at Elevation 77.2 m and Elevation 74.4 m, respectively. These results indicate that the shale samples tested are generally weak to medium based on the rock strength classification presented in the Canadian Foundation Engineering Manual[2]. The Rock Quality Designation (RQD) measured on the upper rock core sample between Elevation 77.3 m and Elevation 76.5 m is 34 percent, indicating a poor upper rock mass quality. The RQD measured on the core samples collected from Elevation 76.5 m to Elevation 75.0 m and from Elevation 75.0 m to Elevation 73.5 m are 57 and 90 percent, respectively, indicating a fair to good rock mass quality.

Groundwater Conditions:

- **BH 9-2:** Depth of 1.2 m below ground surface (approximately Elev. 84.3 m) in piezometer on August 1988.
- **BH WL2-2:** Depth of 13.7 m below ground surface (Elev. 79.5 m) in open borehole upon completion of drilling.
- **BH WL 3-1:** Depth of 12.2 m below ground surface (Elev. 79.1 m) in open borehole upon completion of drilling.
- **BH WL3-3:** Depth of 3.1 m below ground surface (Elev. 84.9 m) in piezometer on April 5, 2008.

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[1] Approximate unconfined compressive strength determined using ISRM correlation ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech., Vol. 22, No. 2, 1985, pp. 51-60).

[2] Canadian Foundation Engineering Manual, 4th Edition.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-2, WL-3 (WL-2)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, the proposed structure(s) will carry the realigned Lakeridge Road over the realigned Highway 401, N-W Ramp, W-N Ramp, S-W Ramp and the existing CNR and GO Railway tracks. The structure will be a seven span bridge with a total length of about 258 m, and includes 9 m and 12.5 m high approach embankments at the north and south abutments, respectively. The W-N/S and N/S-E Ramps also intersect the structure at about Station 10+082 and result in approach embankments up to 11 m high east and west of the structure. An associated retaining wall structure is also proposed along the south side of the W-N/S and N/S-E embankments to provide minimum clearance requirments for the adjacent railway tracks. It is noted that foundation design for all structures crossing or adjacent to railway tracks must be carried out in conformance with the local railway authority requirements and AREMA manual. Based on the existing subsurface information, the feasible foundation options for the proposed bridge abutments and piers are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very stiff to hard clayey silt till or very dense sand and silt till for closed-end abutment footings. Alternatively, spread footings founded on a compacted Granular 'A' pad for "perched" abutments	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of up to 2.1 m of surficial organic silty sand
Steel H-Piles driven into shale bedrock for abutments and piers, except at the south abutment of WL-3, where steel H-Piles may be founded within the "100-blow" till	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through the hard/very dense layers in the till deposits, and in places containing shale pieces
Caissons bored to found within shale bedrock, except for the south abutment of WL-3, where caissons may have to be bored to found within the "100-blow" till	• Larger caissons have higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through hard/very dense layers in the till deposits, possibly containing shale pieces • May require temporary or permanent liner to prevent seepage inflow and softening of the caisson base

A - Spread Footings: Spread footings placed at or below Elevation 81.5 m and at a minimum depth of 1.2 m below the lowest surrounding grade for frost protection, will be founded on very stiff to hard clayey silt till or very dense sand and silt till. Alternatively, spread footings for "perched" abutments could be founded on a Granular 'A' pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Hard Clayey Silt Till / Very Dense Sand and Silt Till	450 kPa	300 kPa
Compacted Granular 'A' (abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to refusal into the shale bedrock at or below Elevation 75 m to 80 m are feasible for support of piers and abutments with "perched" pile caps. However, steel HP 310 x 110 piles for the south abutment may have to be driven 1.5 m within the "100-blow" sand and silt till deposit to or below Elevation 79 m.

Location	*Pile*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
Piers and abutments with "perched" pile caps driven into shale bedrock	HP 310 x 110	1,600 kN	Does not govern
South abutment with "perched" pile caps driven into very dense sand and silt till	HP 310 x 110	1,600 kN	1,400 kN

C - Caissons; Piers and abutments founded within shale bedrock at or below Elevation 74 m to 77 m. Caissons should be socketed a minimum of 2 m into the shale bedrock. Caisson lengths would be at least 7 m long, except near the north abutment, where the length is expected to be around 6 m. Caissons for the south abutment may have to be founded within the very dense sand and silt till at Elevation 78.5 m. Caisson length would be approximately 12.5 m long.

Caisson Diameter	*Axial Geotechnical Resistance (Shale Bedrock)*		*Axial Geotechnical Resistance (Very Dense Sand and Silt Till)*	
	Factored ULS	**SLS**	**Factored ULS**	**SLS**
1.2 m	6,500 kN	Does not govern	3,800 kN	3,000 kN
1.5 m	9,500 kN	Does not govern	5,900 kN	4,800 kN

Recommended Foundation Alternative: Shallow Foundations; alternatively steel H-Piles driven to bedrock/till are also appropriate.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Embankment Height: Based on the subsoil conditions encountered at the site, it is recommended that approach embankment fills be constructed with a maximum height of 12.5 m. However, sub-excavation of up to about 2.1 m of organic silty sand and any surficial topsoil would be required.

Stability: Approach embankments up to 12.5 m high, constructed of select subgrade materials or granular fill and with side slopes no steeper than 2 horizontal to 1 vertical (2H:1V) will be safe against deep-seated slope instability. Construction of a mid-height bench (2 m wide) will be required for embankments exceeding 8 m in height to control surficial erosion and improve stability. Measures to stabilize the embankment slope face due to potential surface water flow/seepage at the slope surface will have to be implemented.

Settlement: Assuming the use of conventional earth or granular embankment fills, where applicable, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments placed on native till soils. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement). It is noted that the characteristics of any existing fill soils present within the embankment footprints will need to be assessed during detail design if considerations is being given to leaving fill soils in place.

• CONSTRUCTION CONSIDERATIONS

Excavation: the organic silty sand / fills and the tills are classified as Type 3 and Type 2 soils, respectively, according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

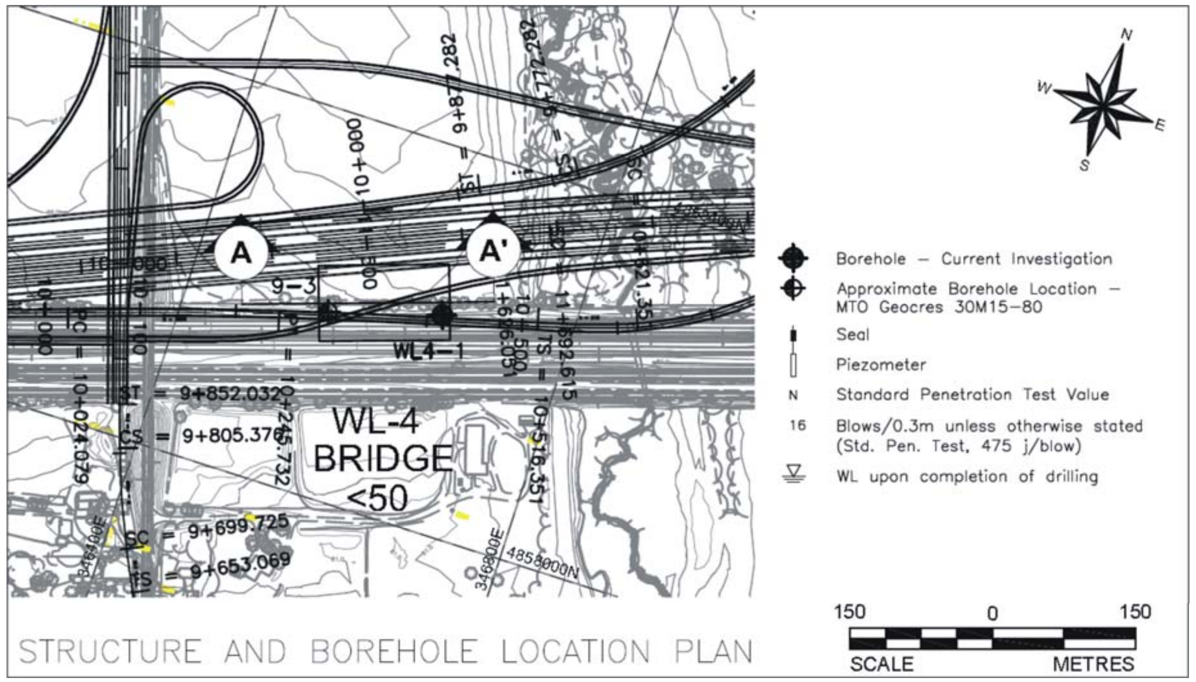
Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving into or through the hard or very dense till layers or in places containing shale fragments; caisson drilling equipment must be capable of penetrating obstructions such as shale pieces.

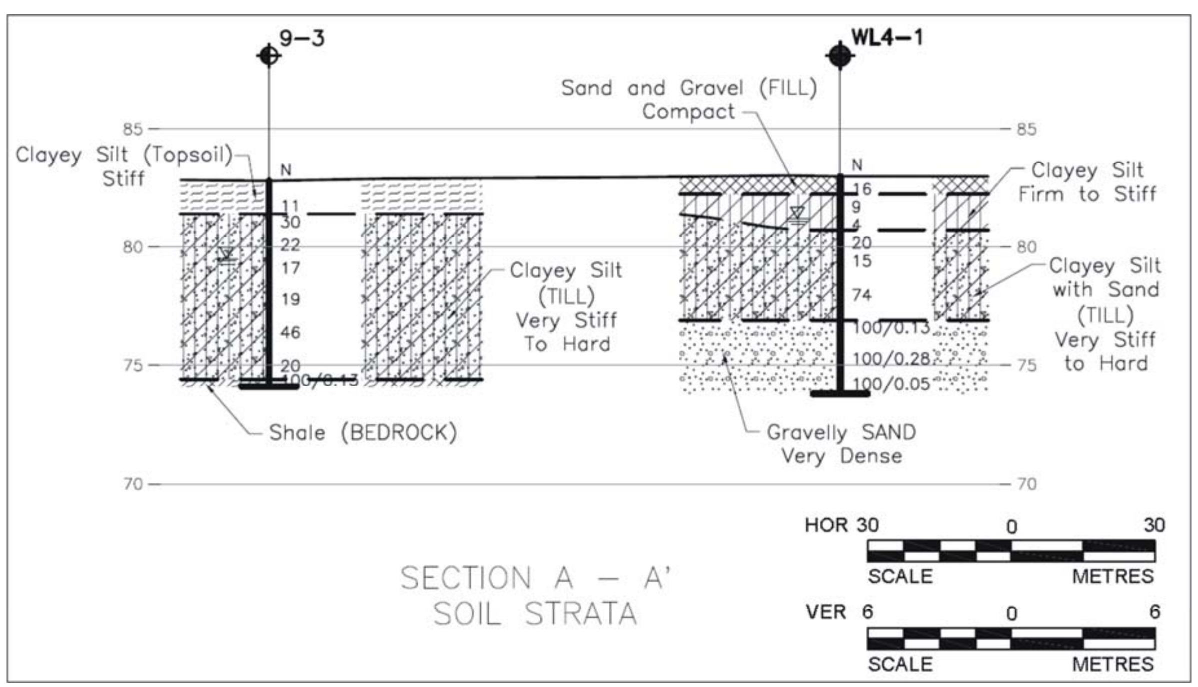
• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements and retaining wall structures.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	WDL/Hwy 401 IC, Hwy 401 EB On-Ramp over W-N Ramp	**Hwy 401 EB On-Ramp Proposed Grade:**	92.0 m – 96.5 m	**Site Ranking:**	Medium
Location No:	WL-4 (Deleted)	**Existing Ground Elevation:**	82.0 m – 85.0 m	**Station:**	9 + 579





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed bridge structure WL-4 is located just north of Highway 401, approximately 250 m east of Lakeridge Road in the Town of Whitby, Ontario. The surrounding area consists of farmlands and scattered trees and shrubs north of Highway 401. The overall topography of the terrain is relatively flat.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL4-1	East Abutment	4 858 226.4	346 664.1	83.0	9.2
9-3*	West Abutment	4 858 193.6	346 549.3	82.8	8.7

*GEOCRES 30M15-80. Coordinates on original Borehole log referenced to MTM-NAD27.

Subsurface Conditions:

- **Fill/Topsoil:** compact sand and gravel fill extending to a depth of 0.8 m below the ground surface encountered in Borehole WL4-1. One SPT 'N' value within the fill was 16 blows per 0.3 m of penetration. Clayey silt topsoil, containing some sand was encountered in Borehole 9-3 and extended to a depth of 1.4 m. One SPT 'N' value within the topsoil layer was 11 blows per 0.3 m of penetration, indicating a stiff consistency.
- **Clayey Silt:** Firm to stiff clayey silt, containing some sand and trace gravel, encountered below the surficial fill in Borehole WL4-1 to a depth of 2.3 m. SPT 'N' values measured within the cohesive layer were 9 and 4 blows per 0.3 m of penetration. The result of an Atterberg limits test is presented on Figure WL4-A (Appendix B). Two water contents measured within the clayey silt were about 12 and 16 percent.
- **Till:** clayey silt with sand, some gravel, including shale fragments, encountered immediately below the clayey silt layer in Borehole WL4-1 and topsoil in Borehole 9-3, extending to depths between 6.1 m (Elev. 76.9 m) and 8.4 m (Elev. 74.4 m). SPT 'N' values measured within the till deposit varied from 15 to 74 blows per 0.3 m of penetration, indicating a stiff to hard consistency. Grain size distribution and Atterberg limits test results are presented on Figures WL4-B and WL4-C (Appendix B). Measured water contents within the till material range between 6 and 16 percent.
- **Gravelly Sand:** gravelly sand containing some silt, trace clay and shale fragments, encountered below the clayey silt till deposit in Borehole WL4-1, extending to the borehole termination depth of 9.2 m (Elev. 73.8 m). SPT 'N' values measured within this deposit ranged from 100 blows per 0.28 m of penetration to 100 blows per 0.05 m of penetration, indicating a very dense relative density. The results of a grain size distribution test are presented on Figure WL4-D (Appendix B). Measured water contents varied between 7 and 8 percent.
- **Bedrock:** shale bedrock encountered underlying the clayey silt till in Borehole 9-3 at Elevation 74.4 m; borehole terminated at Elevation 74.1 m.

Groundwater Conditions:

- **BH WL4-1:** Depth of 1.8 m below ground surface (Elev. 81.2 m) in open borehole upon completion of drilling.
- **BH 9-3:** Depth of 3.3 m below ground surface (Approximately Elev. 79.5 m) in open borehole upon completion of drilling.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-4 (Deleted)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on preliminary drawings of Structure WL-4, provided by URS on February 22, 2008, two options are considered for the proposed site of Highway 401 Eastbound On-Ramp over Highway 401-West to West Durham Link-North Ramp (W-N Ramp). Option A shows a three span bridge structure with a total length of about 119 m, which includes embankments up to 11 m high and retaining walls along the south side of the proposed Highway 401 Eastbound On-Ramp behind the abutments. Option B envisages a one span, closed-end type bridge structure with embankments up to 10 m high and associated retaining walls along the north-east and south-west sections of the embankment. Feasible foundation options for the proposed bridge abutments and piers, where applicable, are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very stiff to hard clayey silt with sand till and very stiff clayey silt till	• Lower costs than deep foundations • Conventional construction	• Requires subexcavation of up to 4 m of surficial fill, topsoil, clayey silt and upper layer of clayey silt with sand till
Steel H-Piles driven into shale bedrock for abutments and piers	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through possible presence of cobbles in the till and gravelly sand deposit
Caissons bored to found within shale bedrock	• Larger caissons have higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through possible presence of cobbles in the till and gravelly sand deposit • May require temporary or permanent liner

A - Spread Footings: Option A indicates the proposed grade of Highway 401 EB On-Ramp at about Elevation 96.8 m on the west abutment and Elevation 92.4 m on the east abutment; top of pavement of realigned W–N Ramp at about Elevation 85.0 m. Option B shows the proposed grade of Highway 401 EB On-Ramp at about Elevation 94.0 m on both abutments and the top of pavement of W-N Ramp at about Elevation 84.0 m. For both options, spread footings placed at or below Elevation 79.0 m (east abutment) and at or below Elevation 78.5 m (west abutment), and at a minimum depth of 1.2 m below the lowest surrounding ground, will be founded on the very stiff clayey silt with sand till deposit and very stiff clayey silt till, respectively. This requires excavations for shallow footing construction of about 4 m.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Very stiff to hard clayey silt with sand till (East Abutment)	600 kPa	400 kPa
Very stiff clayey silt till (West Abutment)	350 kPa	200 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the shale bedrock, at or below Elevation 73 m are feasible for support of abutments and piers with pile caps; length of piles would be approximately 8 m to 9 m.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	does not govern

C - Caissons: Abutments and piers on caissons founded within shale bedrock below Elevation 73 m. Caissons lengths would be about 9 m and 11 m near the west and east abutments, respectively, socketed a minimum of 1 m into the shale bedrock.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	6,500 kN	does not govern
1.5 m	9,500 kN	does not govern

Recommended Foundation Alternative: Steel H-Pile foundations.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Embankment Height: Based on the subsoil conditions encountered at the site, it is recommended that approach embankment fills be constructed with a maximum height of 11 m. It is further noted that subexcavation of up to about 2.5 m of surficial fill, topsoil and clayey silt would be required.

Stability: Approach embankments up to 11 m high, constructed of select subgrade materials or granular fill and with side slopes no steeper than 2 horizontal to 1 vertical (2H:1V) will be safe against deep-seated slope instability. Construction of a mid-height berm will be required in accordance with MTO standards. Measures to stabilize the embankment slope face due to potential groundwater seepage at the slope surface will have to be implemented.

Settlement: Assuming the use of conventional earth or granular embankment fills, where applicable, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

• CONSTRUCTION CONSIDERATIONS

Excavation: the clayey silt till is classified as Type 2 soil, according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1 H: 1V to within 1.2 m of the bottom of the excavation.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps. Potential groundwater seepage at the surface of the embankment cut slopes should be controlled to prevent slope erosion.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. Caisson drilling equipment must be capable of penetrating obstructions such as shale fragments within the clayey silt till and gravelly sand layers.

• 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 and retaining wall structures.

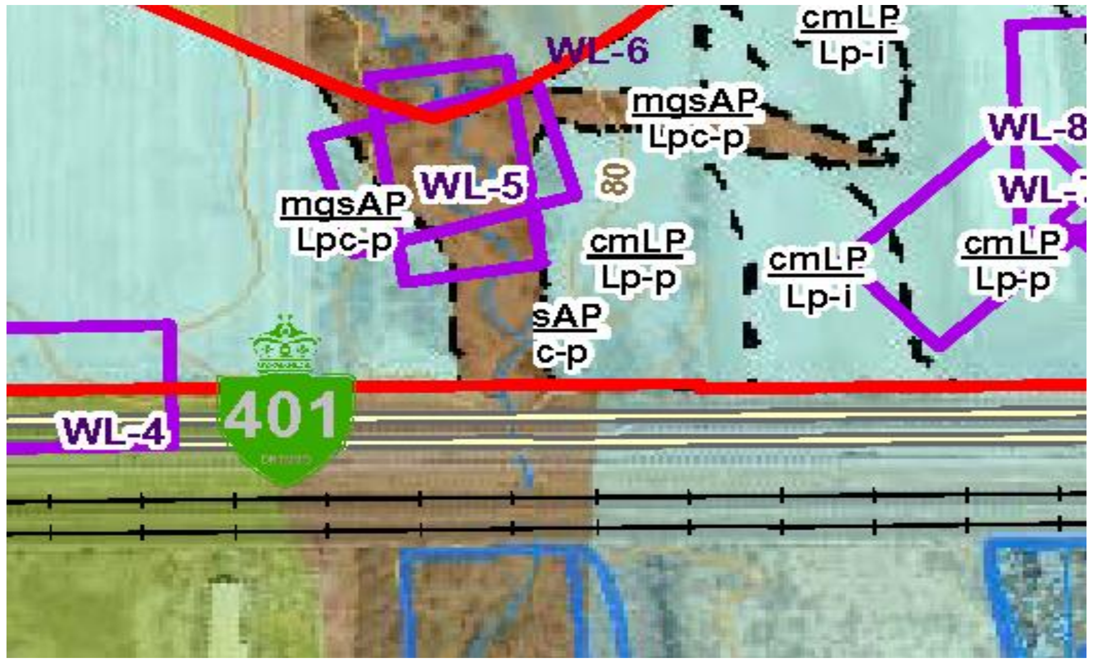
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WL-6

W.O: 07-20015 **Section:** Western **Location:** Culvert east of Lake Ridge Road at Hwy 401 **Sta.** Hwy 401 12+400

Original Grade: **Proposed Grade:** **Description:** New construction passes over creek on culvert.



Site Plan and Terrain Analysis

Site Photograph – facing south from Almond Avenue towards culvert site. Avenue towards

Summarized Subsurface Conditions	**Recommendations – Structure**	**Recommendations – Approaches**	**Remarks**
Boreholes: BH 9-3, GEOCRES 30M15-80 lies ~350m west. Mapping (West 9) shows the site is underlain by a clayey silt lacustrine plain. The relief is low plain, poorly drained. This area is typically underlain by clay and silt deposits laid down by Lake Iroquois. Borehole 9-3 encountered: 0.0 – 1.4 Clayey silt topsoil 1.4 – 8.4 Clayey silt till with sand and gravel, very stiff to hard 8.4 - 8.7 (EOH) Shale bedrock **Groundwater** GWL measured in BH 9-3 was at a depth of about 3.3m (Elev 79.5) below ground surface. **Bedrock encountered at ~8m**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Settlement and stability not expected to be problematic unless high fills are requires, e.g. greater than 8m. However, this must be analyzed during detail design. **Site Ranking** **Foundations:** Low **Hydrogeology:** Low	Moderately wide, shallow valley with no geomorphic evidence of significant valleyside instability Valley bottom sediments may be >2 m deep and likely dominantly gravelly silty sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys Depending on the final design and time of year construction is carried out, unwatering and temporary stream diversion may be required.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Realigned Hwy 401/WDL IC, W-N Ramp over Realigned Hwy 401, West Lynde Creek and Realigned Hwy 401/Lakeridge Rd. E-N/S Ramp and under N-E Ramp

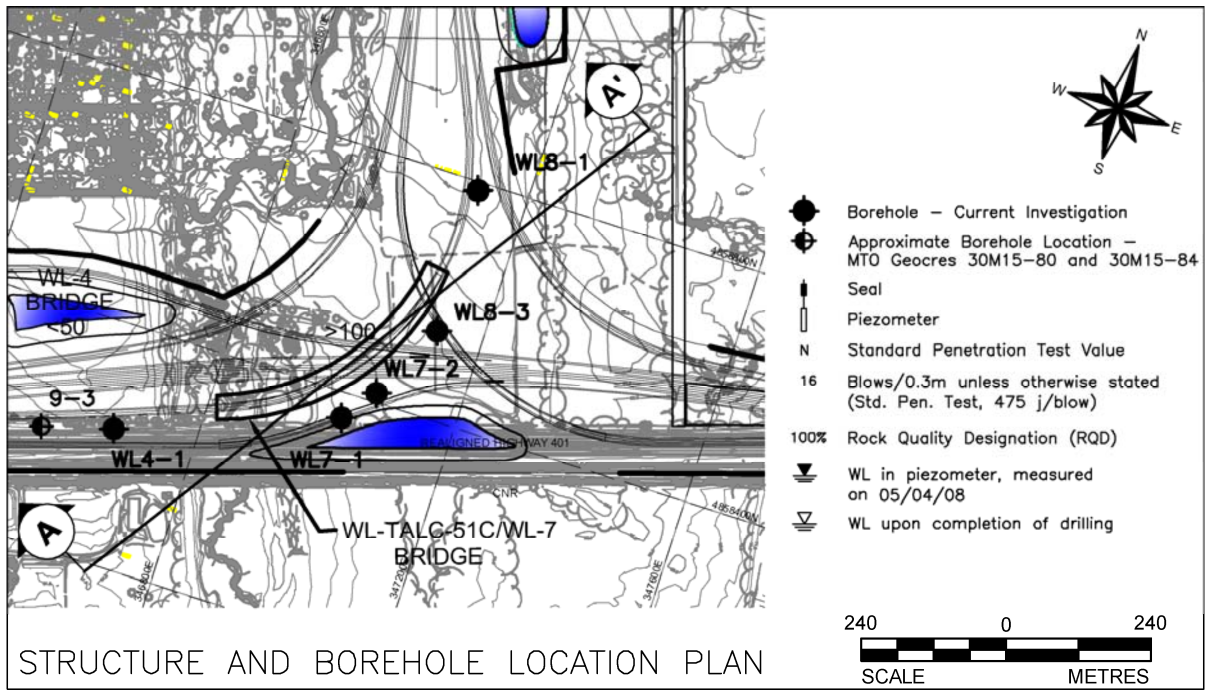
W-N Ramp Proposed Grade: 88.5 m – 92 m

Site Ranking: High

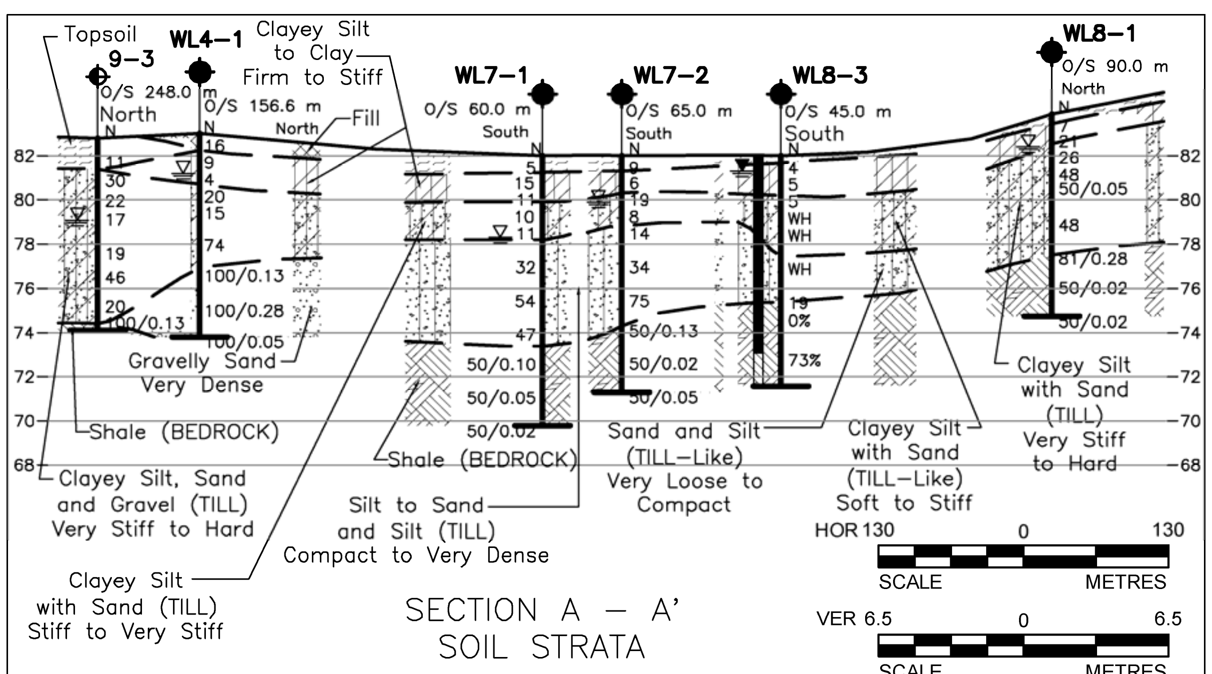
Location No: WL-7 (WL-TALC-51C/WL-7)

Existing Ground Elevation: 79 m – 83 m

Station: 10+887 (W-N Ramp)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A' SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of structure WL-TALC-51C/WL-7 is located immediately to the north of existing Highway 401, approximately 700 m east of Lakeridge Road in the Town of Whitby, Ontario. The site is occupied by farmland with vegetation consisting primarily of grasses, shrubs and scattered trees. The overall terrain is relatively flat to gently sloping.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL7-1	Piers	4 858 358.5	347 017.2	82.0	12.2
WL7-2	Piers	4 858 415.1	347 060.1	82.0	10.7
WL8-1	East Approach	4 858 786.2	347 117.0	83.9	9.2
WL8-3	Piers and East Abutment	4 858 468.3	347 124.0	82.0	10.4
WL4-1	West Approach and Abutment	4 858 226.4	346 664.1	83.0	9.2
9-3[1]	West Approach	4 858 193.6	346 549.3	82.8	8.7

[1] GEOCRES 30M15-80. Coordinates on original Borehole log referenced to MTM-NAD27.

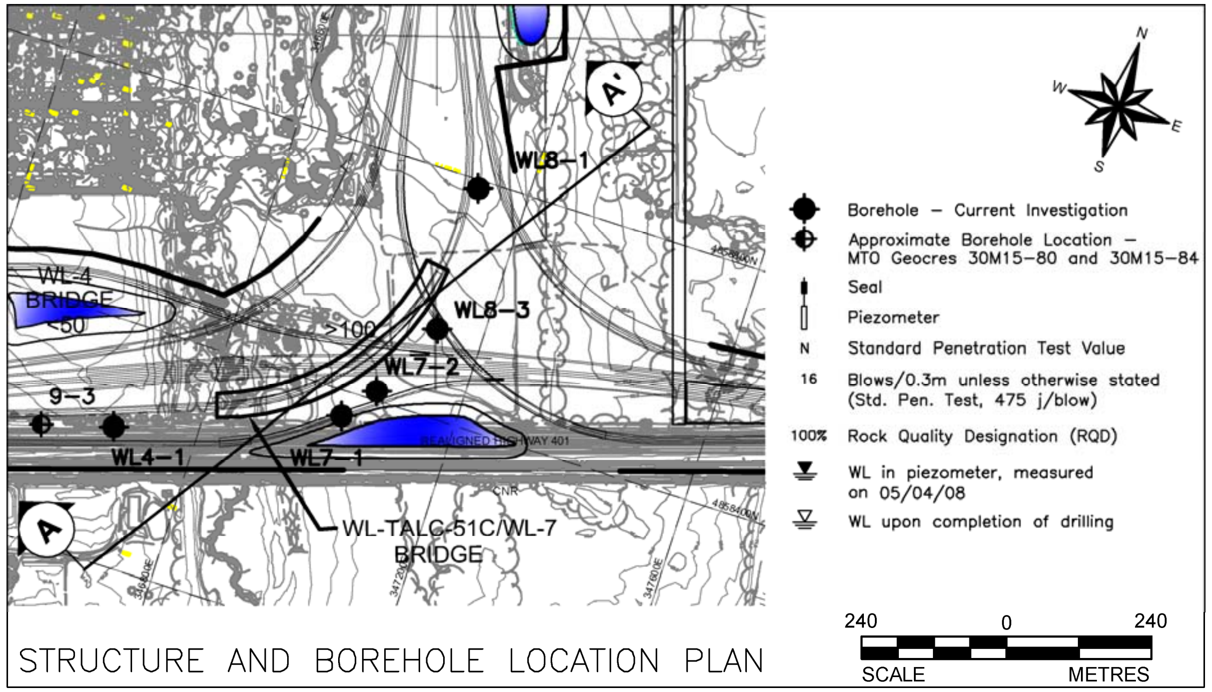
Subsurface Conditions:

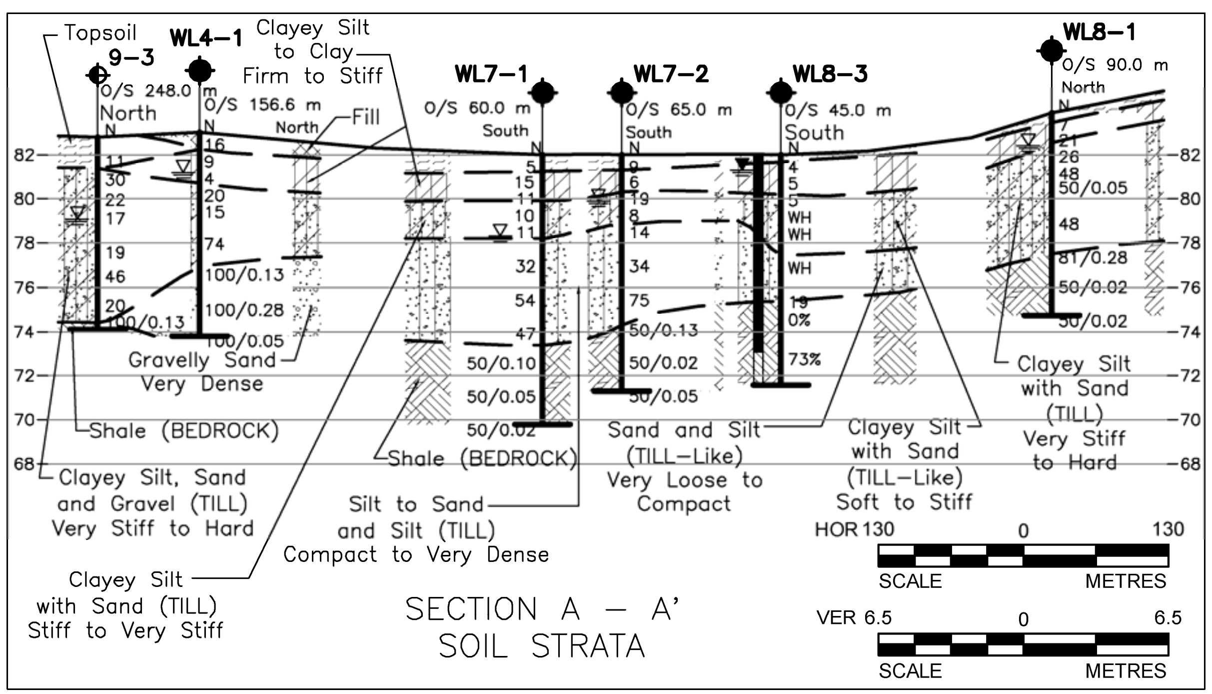
- **Topsoil/Fill:** dark brown clayey silt to silty clay, containing organic matter, encountered in all boreholes except in Borehole WL4-1. The thickness of the topsoil layer typically ranges from 300 mm to 800 mm, with a thickness of 1.4 m recorded in Borehole 9-3. SPT 'N' values measured within the topsoil ranged from 4 to 11 blows per 0.3 m of penetration, indicating a firm to stiff consistency. Compact sand and gravel fill extending to a depth of 0.8 m below the ground surface was encountered in Borehole WL4-1. One SPT 'N' value within the fill was 16 blows per 0.3 m of penetration.

- **Clayey Silt / Silty Clay to Clay:** encountered immediately below the topsoil or fill in all boreholes, except in Borehole 9-3. Clayey silt was encountered only in Borehole WL4-1 and extended to a depth of 2.3 m below the ground surface (Elev. 80.7 m). The clay to silty clay layer was present in the remaining boreholes and contained trace to some sand, trace gravel with occasional sand seams and extended to depths ranging from 1.4 m (Elev. 82.5 m) to 2.1 m (Elev. 79.9 m) below the existing ground surface. Measured SPT 'N' values within this deposit ranged from 4 to 21 blows per 0.3 m of penetration, indicating a soft to very stiff consistency. The result of one grain size distribution test is shown on Figure WLTALC51C/WL7-A (Appendix B); the results of four Atterberg limits tests carried out on samples of the cohesive deposits are presented on Figure WLTALC51C/WL7-B. Two water contents measured within the clayey silt were about 12 and 16 percent; the measured water contents on selected samples of the silty clay to clay deposit ranged between about 24 percent and 38 percent.

- **Till-Like Deposits:** consisting of clayey silt with sand, trace to some gravel, to sand and silt, trace to some gravel and clay; these deposits were encountered below the clayey silt / clay to silty clay layer. The till-like deposits were encountered in Borehole WL8-3 between about Elevation 80.2 m and Elevation 75.4 m. Typical SPT 'N' values measured within this deposit were equal to the weight of the hammer and field measured undrained shear strength typically ranged from 25 kPa to 50 kPa, indicating a soft to firm consistency/very loose to compact relative density. Measured water contents on selected samples of the till-like deposits ranged between about 9 percent and 28 percent. The results of grain size distribution and Atterberg limits tests carried out on samples of the clayey silt with sand and sand and silt till-like deposits are shown on Figures WLTALC51C/WL7-C to WLTALC51C/WL7-E (Appendix B).

LOCATION No:	WL-7 (WL-TALC-51C/WL-7)





The results of one Oedometer test carried out on a sample of the soft to firm clayey silt till-like deposit from Borehole WL8-3 are shown Figures WLTALC51C/WL7-F1 to WLTALC51C/WL7-F3 (Appendix B); the consolidation parameters as interpreted from the Oedometer test results are summarized below:

BH/Sample No.	*Sample Depth /Elev.*	γ *(kN/m³)*	σ_{vo}'*(kPa)*	σ_p'*(kPa)*	$\sigma_p' - \sigma_{vo}'$ *(kPa)*	C_c	C_r	e_o	*OCR*
WL8-3 / 4A	2.2 m / 79.8 m	18.2	27	180	153	0.47	0.0996	1.1	6.6

Notes: σ_P': Apparent pre-consolidation pressure; σ_{VO}': Computed existing vertical effective stress; Cc: Compression index; Cr: Recompression index; e_o: Initial void ratio; OCR: overconsolidation ratio.

Based on the Oedometer test results and the measured SPT "N" values and undrained shear strengths, it is considered that the soft to firm clayey silt till-like deposit is a relatively over-consolidated deposit that appears to have been subjected to some degree of softening.

- **Till:** consisting of clayey silt with sand to sand and silt or silt; the till deposits were encountered below the topsoil and clayey silt / silty clay to clay layers in all boreholes, except in Borehole WL8-3. SPT 'N' values measured within the clayey silt with sand to silt to sand and silt till, typically ranged from 11 blows per 0.3 of penetration to 50 blows per 0.05 m of penetration, indicating a generally stiff to hard consistency/compact to very dense relative density. The results of grain size distribution and Atterberg limits tests carried our on samples of the till deposits are shown on Figures WLTALC51C/WL7-G to WLTALC51C/WL7-K (Appendix B). Measured water contents on selected samples of the till deposits ranged between about 5 percent and 17 percent.

- **Gravelly Sand:** gravelly sand, containing some silt, trace clay and shale fragments, was encountered below the clayey silt till deposit in Borehole WL4-1 and extended to the borehole termination depth of 9.2 m (Elev. 73.8 m). SPT 'N' values measured within this deposit ranged from 100 blows per 0.28 m of penetration to 100 blows per 0.05 m of penetration, indicating a very dense relative density. The results of a grain size distribution test are presented on Figure WLTALC51C/WL7-L (Appendix B). Measured water contents varied between 7 and 8 percent.

- **Bedrock:** Shale bedrock was encountered in all boreholes, except in Borehole WL4-1, between Elevation 73.4 m and Elevation 77.5 m. Rock coring was carried out in Borehole WL8-3 between Elevation 74.8 m and Elevation 71.6 m. The bedrock core samples consist of highly to moderately weathered, thinly bedded, grey shale. Diametrical point load tests carried out on selected samples of the shale bedrock between Elevation 73 m and Elevation 71.6 m yield correlated uniaxial compressive strength[1] (UCS) values ranging from 2 MPa to 5.5 MPa. These results indicate that the shale samples tested are generally weak to moderately weak based on the rock strength classification presented in the Canadian Foundation Engineering Manual[2]. The Rock Quality Designation (RQD) measured on the upper rock core sample between Elevation 74.4 m and Elevation 73 m (depth of 7.2 m to 8.4 m below ground surface) is zero, indicating a very poor upper rock mass quality. The RQD measured on the core sample collected from Elevation 73 m to Elevation 71.6 m (from a depth of 9 m to 10.4 m below ground surface) is 73 percent, indicating a fair to good rock mass quality.

Groundwater Conditions:

- **BH WL7-1:** Depth of 3.7 m below ground surface (Elev.78.3 m) in open borehole upon completion of drilling.
- **BH WL7-2:** Depth of 2.1 m below ground surface (Elev. 79.9 m) in open borehole upon completion of drilling.
- **BH WL8-1:** Depth of 1.5 m below ground surface (Elev. 82.4 m) in open borehole upon completion of drilling.
- **BH WL8-3:** Depth of 1.4 m below ground surface (Elev. 80.6 m) in open borehole upon completion of drilling; depth of 0.7 m (Elev. 81.3 m) in piezometer on April 5, 2008.
- **BH WL4-1:** Depth of 1.8 m below ground surface (Elev. 81.2 m) in open borehole upon completion of drilling.
- **BH 9-3:** Depth of 3.3 m below ground surface (Elev. 79.5 m) in open borehole**.**

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[1] Approximate unconfined compressive strength determined using ISRM correlation ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech., Vol. 22, No. 2, 1985, pp. 51-60).

[2] Canadian Foundation Engineering Manual, 4th Edition.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-7 (WL-TALC-51C/WL-7)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, the proposed bridge structure will carry the realigned Hwy 401/WDL W-N Ramp over the realigned Hwy 401, West Lynde Creek and realigned Hwy 401 / Lakeridge Rd. E-N/S Ramp and under the realigned Hwy 401/WDL N-E Ramp. The W-N Ramp structure is a ten span bridge with a total length of approximately 450 m and 9.5 m and 8 m high approach embankments along the west and east abutments, respectively. The feasible foundation options for the proposed bridge abutments and piers are listed below with advantages and disadvantages associated with each option. It is noted that the existing subsoil conditions are not suitable for support of shallow foundations.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into shale bedrock for piers and abutments, possibly with "perched" pile caps	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through till (possibly containing cobbles) and highly weathered shale bedrock; • Pre-augering may be required in order to achieve minimum pile embedment (approximately 6 m): alternatively perched pile caps could be considered; • Need to be driven through about 1.8 m of highly weathered shale
Caissons bored to found within shale bedrock	• Higher bearing resistances than steel H-Piles, although partially offset by higher downdrag loads than those for steel H-Piles	• Drilling must be advanced through till (possibly containing cobbles) and and shale bedrock • May require temporary or permanent liner

A - Steel H-Piles: Steel HP 310 x 110 piles driven to refusal into the shale bedrock are feasible for support of the bridge abutments and piers. The piles would have to penetrate an approximately 1.8 m thick zone of highly weathered shale based on the rock coring carried out in Borehole WL8-3. The structural design of the abutment piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to significantly reduce post-construction settlements under the new embankment loading; in this case downdrag loads can be eliminated.

Pile	*Axial Geotechnical Resistance*		*Downdrag Load(Unfactored) Abutments only*
	Factored ULS	**SLS**	
HP 310 x 110	1,600 kN	Does not govern	250 kN

B – Caissons: Abutments and piers on caissons founded at least 1.5 m within the shale bedrock and below the highly weathered zone (e.g. below Elev. 72 m in BH WL8-3). Full downdrag loads, as provided below, should be accounted for unless long-term settlement mitigation measures are undertaken as discussed above for pile foundations.

Caisson Diameter	*Axial Geotechnical Resistance*		*Downdrag Load(Unfactored) Abutments only*
	Factored ULS	**SLS**	
1.2 m	6,500 kN	Does not govern	500 kN
1.5 m	9,500 kN	Does not govern	650 kN

Recommended Foundation Alternative: Caissons or steel H-Pile foundations.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, semi-integral or integral abutments.

• APPROACHES

Height: up to 9.5 m high along the west abutment and up to 8 m along the east abutment as indicated on the General Arrangement drawing. It is noted that embankments up to 12 m high and 8 m high at the west and east abutments, respectively, could be considered for design.

Stability: East approach embankment up to 8 m high (i.e. north of the proposed realigned Hwy 401) and west approach embankment up to 9.5 m high (i.e. south of the realigned Hwy 401), constructed with select subgrade materials or granular fill, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height bench (min. 2 m wide) for approaches higher than 8 m, will have adequate factor of safety against deep-seated instability, provided that preloading, possibly with surcharge, be carried out prior to construction. Construction staging may also be required (refer to the settlement section below). It is further noted that sub-excavation of up to 1.4 m of topsoil would be required.

Settlement: Assuming the use of conventional earth (i.e. select subgrade materials) or granular materials for embankment construction, and based on consolidation parameters and elastic deformation moduli of the approach foundation soils (estimated based on the results of Oedometer testing on samples from boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlement within the foundation soils is about 200 mm at the west abutment and 450 mm at the east abutment. The difference in total settlement between the west and east sides is primarily due to the soft to firm till-like soils present in Borehole WL8-3 near the east abutment and not at the west abutment. About 10 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement). The remaining settlement (i.e. 95 percent of total consolidation settlement) is anticipated to occur over a period of three to six months. Measures to reduce post-construction settlement to acceptable values should be undertaken; these may include preloading with a surcharge and construction staging, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Additionally, depending on the results of detailed geotechnical analyses, the use of wick drains may be warranted to promote dissipation of pore pressures and promote settlement at a faster rate. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and use of lightweight fill materials.

• CONSTRUCTION CONSIDERATIONS

Excavation: the upper firm to stiff clay to silty clay soils and till-like deposits are classified as Type 3 according to the OHSA. The upper clayey silt with sand or sand and silt till deposits are classified as Type 2 soil. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope of 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for pile/caisson caps construction can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving through the till soils and into shale bedrock. Caisson drilling equipment must be capable of penetrating shale in order to socket the caisson into the shale bedrock.

• 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.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Realigned Hwy 401/WDL IC, N-E Ramp over Realigned 401 and W-N Ramp

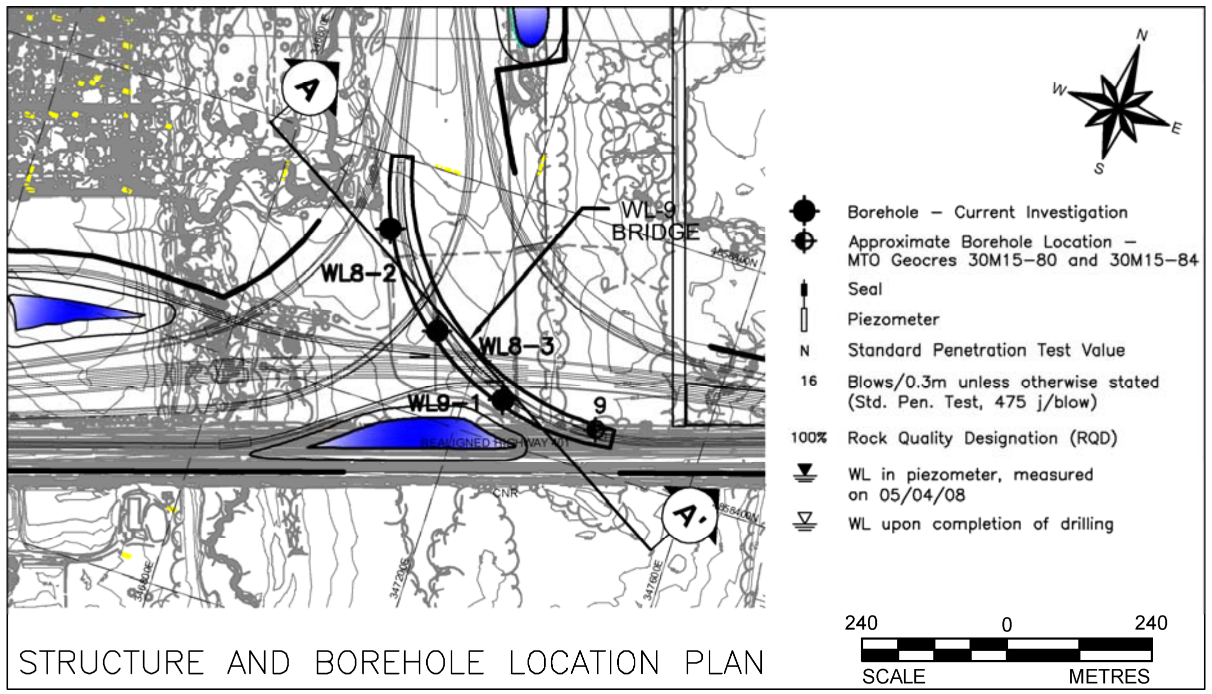
N-E Ramp Proposed Grade: 90 m – 99.5 m

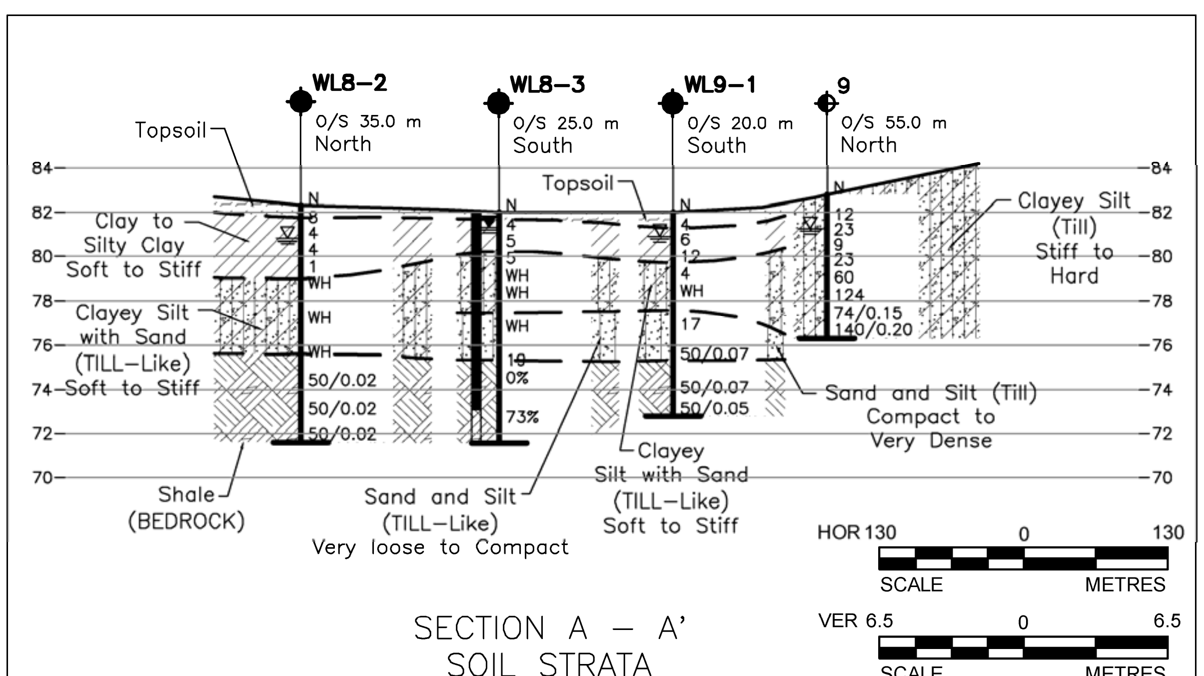
Site Ranking: High

Location No: WL-8/9 (WL-9)

Existing Ground Elevation: 82 m – 84 m

Station: 9+093 (N-E Ramp)





FOUNDATION INVESTIGATIONS

Site Description:

The site of structure WL-9 is located immediately to the north of existing Highway 401, approximately 900 m east of Lakeridge Road in the Town of Whitby, Ontario. The site is occupied by farmland with vegetation consisting primarily of grasses, shrubs and scattered trees. The overall terrain is relatively flat to gently sloping.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL8-2	North Abutment and Piers	4 858 681.3	346 998.0	82.3	10.7
WL8-3	Piers	4 858 468.3	347 124.0	82.0	10.4
WL9-1	Piers	4 858 468.3	347 261.8	82.0	9.2
9[1]	East Abutment and Piers	4 858 468.6	347 422.9	82.6	6.5

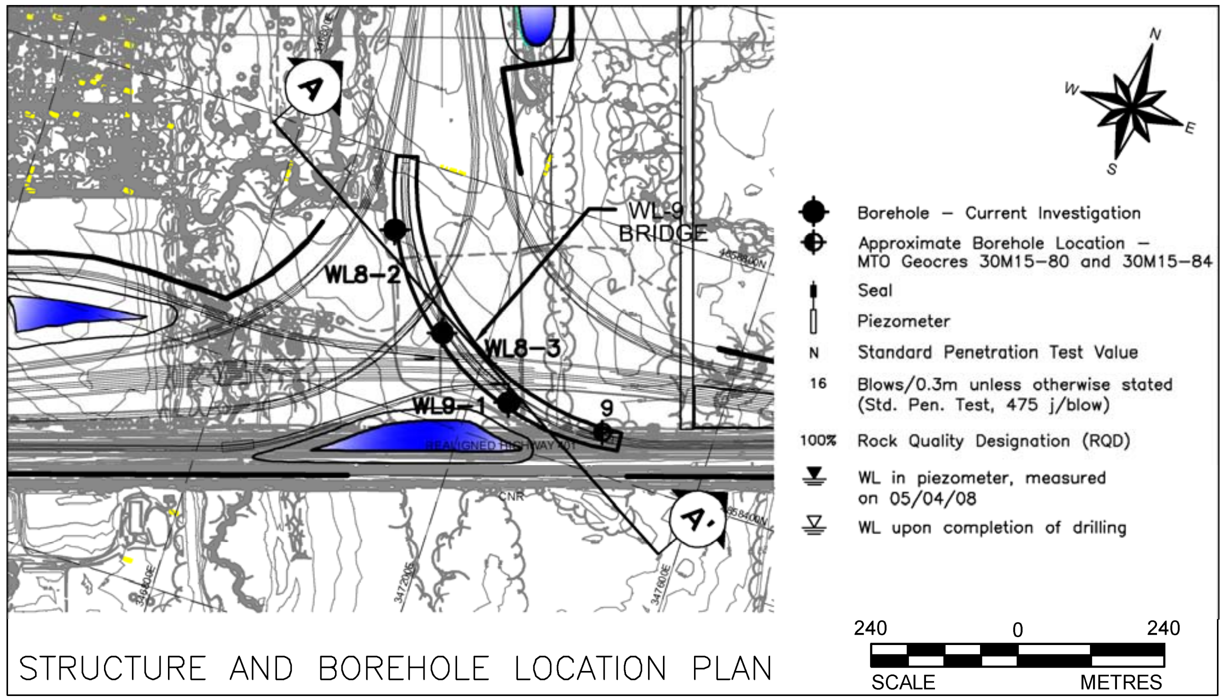
[1] GEOCRES 30M15-84. Coordinates on original Borehole log referenced to MTM-NAD27.

Subsurface Conditions:

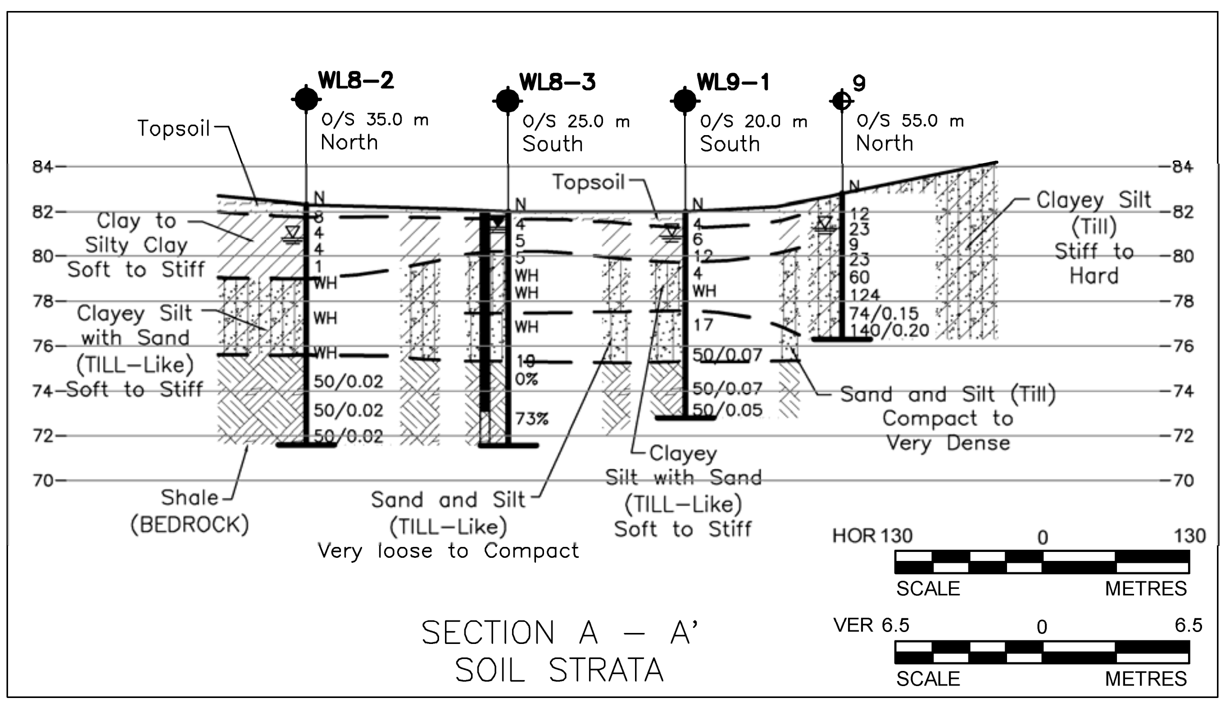
- **Topsoil:** dark brown clayey silt to silty clay, containing organic matter, encountered in all boreholes, except in Borehole 9. The thickness of the topsoil layer typically ranges from 300 mm to 800 mm. SPT 'N' values measured within the topsoil ranged from 4 to 8 blows per 0.3 m of penetration, indicating a firm consistency.
- **Silty Clay to Clay:** encountered immediately below the topsoil in all boreholes, except in Borehole 9. The silty clay to clay layer contained trace to some sand, trace gravel with occasional sand seams and extended to depths ranging from 1.8 m (Elev. 80.2 m) to 3.3 m (Elev. 79 m) below the existing ground surface. Measured SPT 'N' values within this deposit typically ranged from 4 to 12 blows per 0.3 m of penetration and field measured undrained shear strengths typically ranged from 80 kPa to greater than 100 kPa, indicating a soft to stiff consistency. The result of one grain size distribution test is shown on Figure WL9-A (Appendix B); the results of three Atterberg limits tests carried out on samples of silty clay to clay deposits are presented on Figure WL9-B. Measured water contents on selected samples of the silty clay to clay deposits ranged between about 34 percent and 47 percent.
- **Till-Like Deposits:** consisting of clayey silt with sand, trace to some gravel, to sand and silt, trace to some gravel and clay; these deposits were encountered below the silty clay to clay layer. The clayey silt with sand till-like deposit was encountered in Boreholes WL8-2, WL8-3 and WL9-1 between about Elevation 80.2 m and Elevation 79 m. Typical SPT 'N' values measured within this deposit were equal to the weight of the hammer and field measured undrained shear strength typically ranged from 25 kPa to 65 kPa, indicating a soft to stiff consistency. The sand and silt till-like deposit was encountered in Borehole WL8-3 and extended from Elevation 77.4 m to the surface of the shale bedrock at Elevation 75.4 m. Two SPT 'N' values within the granular till-like deposit were equal to the weight of hammer and 19 blows per 0.3 m of penetration, indicating a very loose to compact relative density. Measured water contents on selected samples of the till-like deposits ranged between about 9 percent and 28 percent.
  The results of grain size distribution and Atterberg limits tests carried out on samples of the clayey silt with sand and sand and silt till-like deposits are shown on Figures WL9-C, WL9-D, WL9-F and WL9-G (Appendix B).

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-8/9 (WL-9)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

The results of one Oedometer test carried out on a sample of the soft to firm clayey silt till-like deposit from Borehole WL8-3 are shown Figures WL9-E1 to WL9-E3 (Appendix B).The consolidation parameters as interpreted from the Oedometer test results are summarized below:

BH/Sample No.	*Sample Depth /Elev.*	γ *(kN/m³)*	σ_{vo}'*(kPa)*	σ_p'*(kPa)*	$\sigma_p' - \sigma_{vo}'$ *(kPa)*	C_c	C_r	e_o	*OCR*
WL8-3 / 4A	2.2 m / 79.8 m	18.2	27	180	153	0.47	0.0996	1.1	6.6

Notes: σ_P': Apparent pre-consolidation pressure; σ_{VO}': Computed existing vertical effective stress; Cc: Compression index; Cr: Recompression index; e_o: Initial void ratio; OCR: overconsolidation ratio.

Based on the Oedometer test results and the measured SPT "N" values and undrained shear strengths, it is considered that the soft to firm clayey silt till-like deposit is a relatively over-consolidated deposit that appears to have been subjected to some degree of softening.

- **Till:** sand and silt, containing some gravel and trace to some clay, encountered in Borehole WL9-1 below the till-like deposit at a depth of 4.4 m (Elev. 77.6 m). The till deposit extended to the surface of shale bedrock at Elevation 75.3 m. Two SPT 'N' values were 17 blows per 0.3 m of penetration and 50 blows per 0.07 m of penetration, indicating a compact to very dense relative density. The results of one grain size distribution test are presented on Figure WL9-G (Appendix B). Two measured water contents within the sand and silt till were about 5 and 8 percent. In Borehole 9, a clayey silt till deposit containing trace sand and gravel, was encountered immediately at the ground surface. The cohesive till deposit extended to the termination depth of the borehole at Elevation 76.1 m. SPT 'N' values measured within the clayey silt till ranged from 9 blows per 0.3 m of penetration to 140 blows per 0.2 m of penetration, indicating a stiff to hard consistency.

- **Bedrock:** Shale bedrock was encountered in all boreholes, except in Borehole 9, between Elevation 75.6 m and Elevation 75.3 m. Rock coring was carried out in Borehole WL8-3 between Elevation 74.8 m and Elevation 71.6 m. The bedrock core samples consist of highly to moderately weathered, thinly bedded, grey shale. Diametral point load tests carried out on selected samples of the shale bedrock between Elevation 73 m and Elevation 71.6 m yield correlated uniaxial compressive strength[1] (UCS) values ranging from 2 MPa to 5.5 MPa. These results indicate that the shale samples tested are generally weak to moderately weak based on the rock strength classification presented in the Canadian Foundation Engineering Manual[2]. The Rock Quality Designation (RQD) measured on the upper rock core sample between Elevation 74.4 m and Elevation 73 m (depth of 7.2 m to 8.4 m below ground surface) is zero, indicating a very poor upper rock mass quality. The RQD measured on the core sample collected from Elevation 73 m to Elevation 71.6 m (from a depth of 9 m to 10.4 m below ground surface) is 73 percent, indicating a fair to good rock mass quality.

Groundwater Conditions:

- **BH WL8-2:** Depth of 1.5 m below ground surface (Elev. 80.8 m) in open borehole upon completion of drilling.
- **BH WL8-3:** Depth of 1.4 m below ground surface (Elev. 80.6 m) in open borehole upon completion of drilling; depth of 0.7 m (Elev. 81.3 m) in piezometer on April 5, 2008.
- **BH WL9-1:** Depth of 1.1 m below ground surface (Elev. 80.9 m) in open borehole upon completion of drilling.
- **BH 9:** Depth of 1.4 m below ground surface (Approximately Elev. 81.2 m) in open borehole.

[1] Approximate unconfined compressive strength determined using ISRM correlation ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech., Vol. 22, No. 2, 1985, pp. 51-60).

[2] Canadian Foundation Engineering Manual, 4th Edition.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-8/9 (WL-9)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, the proposed bridge structure will carry the realigned Hwy 401/WDL N-E Ramp over the realigned Hwy 401and W-N Ramp. The proposed N-E Ramp structure is a fourteen (14) span bridge with a total length of approximately 620 m and 11.5 m and 7 m high approach embankments along the north and east abutments, respectively. The feasible foundation options for the proposed bridge abutments and piers are listed below with advantages and disadvantages associated with each option. It is noted that the existing subsoil conditions are not suitable for support of shallow foundations.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into shale bedrock for piers and abutments with "perched" pile caps	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through till (possibly containing cobbles) and highly weathered shale bedrock; • Pre-augering may be required at some locations in order to provide minimum embedment of piles to achieve axial resistance; perched pile caps could also be considered; • Need to be driven through about 1.8 m of highly weathered shale
Caissons bored to found within shale bedrock	• Higher bearing resistances than steel H-Piles, although partially offset by higher downdrag loads than those for steel H-Piles	• Drilling must be advanced through till (possibly containing cobbles) and weathered shale bedrock; • May require temporary or permanent liner

A - Steel H-Piles: Steel HP 310 x 110 piles driven to refusal into the shale bedrock are feasible for support of the bridge abutments and piers. The piles would have to penetrate an approximately 1.8 m thick zone of highly weathered shale based on the rock coring carried out in Borehole WL8-3. The structural design of the abutment piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to significantly reduce post-construction settlements under the new embankment loading; in this case downdrag loads can be eliminated.

Pile	*Axial Geotechnical Resistance*		*Downdrag Load(Unfactored) Abutments only*
	Factored ULS	**SLS**	
HP 310 x 110	1,600 kN	Does not govern	250 kN

B – Caissons: Abutments and piers on caissons founded at least 1.5 m within the shale bedrock and below the highly weathered zone (e.g. below Elev. 72 m in BH WL8-3). Full downdrag loads, as provided below, should be accounted for unless long-term settlement mitigation measures are undertaken as discussed above for pile foundations.

Caisson Diameter	*Axial Geotechnical Resistance*		*Downdrag Load(Unfactored) Abutments only*
	Factored ULS	**SLS**	
1.2 m	6,500 kN	Does not govern	500 kN
1.5 m	9,500 kN	Does not govern	650 kN

Recommended Foundation Alternative: Caissons or steel H-Pile foundations.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, semi-integral or integral abutments.

• APPROACHES

Height: According to the GA drawing, up to 11.5 m high along the north abutment and up to 7 m along the east abutment. It is noted that embankments up to 12 m high and 8 m high at the north and east abutment locations could be considered.

Stability: North approach embankment up to 11.5 m high (i.e. north of the proposed realigned Hwy 401) and south approach embankment up to 7 m high (i.e. south of the realigned Hwy 401), constructed with select subgrade materials or granular fill, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a minimum 2 m wide mid-height berm for approaches higher than 8 m, should have adequate factor of safety against deep-seated instability, provided that preloading, possibly with surcharge, be carried out prior to construction. Construction staging would also be required (refer to the settlement section below). It is further noted that sub-excavation of up to 0.8 m of topsoil would be required.

Settlement: Assuming the use of conventional earth (i.e. select subgrade materials) or granular materials for embankment construction, and based on consolidation parameters and elastic deformation moduli of the approach foundation soils (estimated based on the results of Oedometer testing on samples from boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlement within the foundation soils is on the order of 500 mm at the north abutment and 200 mm at the east abutment. The difference in settlement at the abutment locations is mainly due to the higher embankment and presence of soft to firm till-like soils at the north abutment and not at the east abutment. About 10 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement). The remaining settlement (i.e. 95 percent of total consolidation settlement) is anticipated to occur over a period of three to six months. Measures to reduce post-construction settlement to acceptable values should be undertaken; these may include preloading with a surcharge and construction staging, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Additionally, depending on the results of detailed geotechnical analyses, the use of wick drains may be warranted to promote dissipation of pore pressures and promote settlement at a faster rate. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and use of lightweight fill materials.

• CONSTRUCTION CONSIDERATIONS

Excavation: the firm to stiff clay to silty clay soils and till-like deposits are classified as Type 3 soils according to the OHSA. The clayey silt till and sand and silt till deposits are classified as Type 2 soil. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in the Type 3 soils, and sloped at 1H:1V to within 1.2 m of the bottom of the excavation in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for pile/caisson cap construction can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

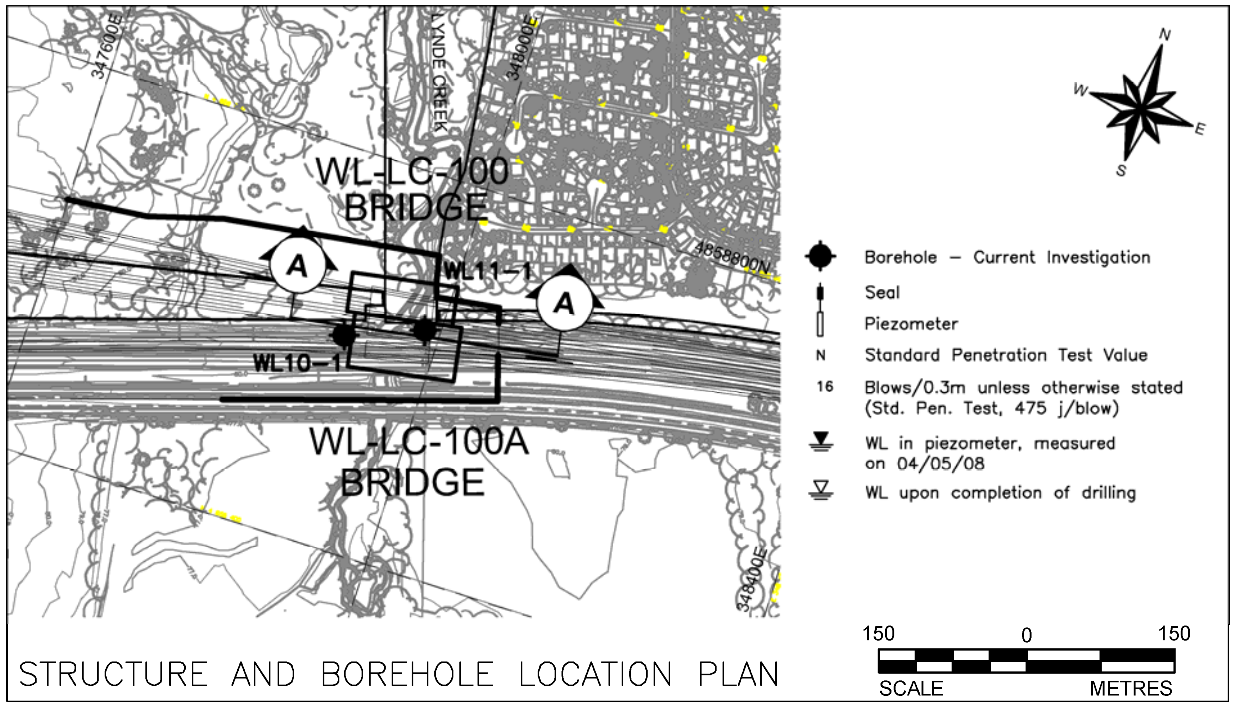
Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving through the till soils and into the shale bedrock; caisson drilling equipment must be capable of penetrating shale in order to socket the caisson into the shale bedrock.

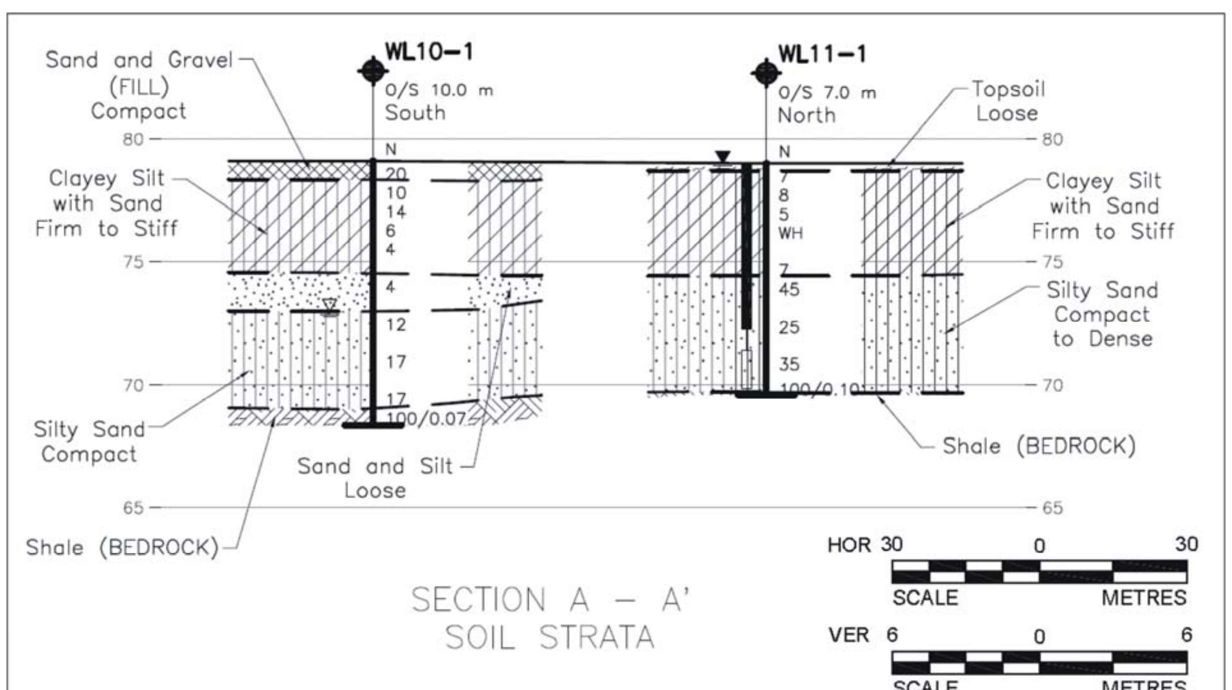
• RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	Realigned Hwy 401 and Hwy 401/WDL IC N-E Ramp over Lynde Creek	**Hwy 401 E to WDL N Proposed Grade:**	80.8 m	**Site Ranking:**	Medium
Location No:	WL-10 (WL-LC-100A), WL-11 (WL-LC-100)	**Existing Ground Elevation:**	77.0 m – 79.0 m	**Station:**	11+680





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WL-10 and WL-11 twinned, Lynde creek crossing structures is located just north of the existing Highway 401, approximately 1,600 m east of Lake Ridge Road in the Town of Whitby, Ontario. The bridge structures will carry the realigned Highway 401 eastbound and westbound lanes as well as the ramp from Highway 401 East to West Durham Link North. The 7 m to 9 m wide Lynde Creek channel flows southerly across Highway 401 and into Lake Ontario. The surrounding area consists of a low plain with poor drainage. A residential area is located north-east of the proposed structures.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL10-1	North Abutment	4 858 615.2	347 908.1	79.1	10.7
WL11-1	South Abutment	4 858 644.9	347 984.2	79.0	9.4

Subsurface Conditions:

- **Fill/Topsoil:** a 0.2 m thick layer of asphalt overlying a 0.6 m thick layer of sand and gravel fill, was encountered in Borehole WL10-1. One SPT 'N' value measured within the fill material was 20 blows per 0.3 m of penetration indicating a compact relative density. A 0.3 m thick layer of loose, sandy topsoil was encountered at ground surface of Borehole WL11-1.

- **Clayey Silt with Sand:** clayey silt with sand, containing trace gravel and occasional layers of silty sand was encountered immediately underlying the layers of fill and topsoil, extending to depths of 4.6 m (Elev. 74.5 m and 74.4 m) in Boreholes WL10-1 and WL11-1, respectively. SPT 'N' values measured within this deposit ranged from 4 to 14 blows per 0.3 m of penetration, indicating a soft to stiff consistency. The results of grain size distribution tests are presented on Figures WL10-A and WL11-A (Appendix B); Atterberg limits test results are on Figure WL11-B (Appendix B). One organic test result on a sample of the upper 1.5 m of the deposit indicated about 6 percent organic content. Measured water contents within the clayey silt with sand deposit range between 15 percent and 41 percent.

- **Sand and Silt to Silty Sand:** sand and silt, trace gravel, containing clayey silt seams to silty sand containing some gravel and trace clay, were encountered underlying the cohesive deposit. This deposit extends to the shale bedrock in both boreholes, at depths between 10.1 m (Elev. 69 m) and 9.3 m (Elev. 69.7 m) in Boreholes WL10-1 and WL11-1, respectively. SPT 'N' values measured within the sand and silt to silty sand materials range between 12 and 45 blows per 0.30 m of penetration, indicating a compact to dense relative density; a SPT 'N' value of 4 blows per 0.3 m of penetration was measured in the sand and silt layer in Borehole WL10-1. The results of grain size distribution tests are presented on Figures WL10-B and WL11-C (Appendix B), and the Atterberg limits test results are presented on Figure WL10-C (Appendix B). Measured water content on one sample of the sand and silt till material ranged from 8 to 27 percent.

- **Bedrock:** shale bedrock encountered at depths of 10.1 m (Elev. 67.3 m) and 9.3 m (Elev. 69.7 m) in Boreholes WL10-1 and WL11-1, respectively; both boreholes were terminated within the shale bedrock. SPT 'N' values at the surface of the shale indicated 100 blows per 0.07 m to 0.10 m of penetration.

Groundwater Conditions:

- **BH WL10-1:** Depth of 6.1 m below ground surface (Elev. 73 m) in open borehole upon completion of drilling.

- **BH WL11-1:** Measured water level in piezometer at ground surface (Elev. 79 m) on April 5, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 8**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-10 (WL-LC-100A), WL-11 (WL-LC-100)

• FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a drawing of Lynde Creek Bridges WL-10 and WL-11, received from URS on February 22 2008, and on the Realigned 401 Profile, received on July 15 2008, the water crossing structures will carry the realigned Highway 401 eastbound and westbound lanes as well as the Highway 401-East to West Durham Link-North Ramp (E-N Ramp) over Lynde Creek. Both WL-10 and WL-11 overpasses are proposed to be single span, closed end type structures with a total span of 17 m, and approximately 3.5 m high embankments. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option. It is noted that shallow foundations are not considered practical at this site given the subsoil conditions encountered in the preliminary boreholes.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into shale bedrock	• Allows for integral abutment design	• Pile lengths near 6 m are essentially at the limit normally used for integral abutments
Caissons bored to found within shale bedrock.	• Higher bearing resistances than steel H-Piles	• May require temporary or permanent liner

A - Steel H-Piles: Steel HP 310 x 110 piles driven to refusal into the shale bedrock at or below Elevation 69.7 m are feasible for support of abutments with pile caps. The structural design of the abutment piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to minimize post-construction settlements under the new embankment loading, in this case downdrag loads can be eliminated.

Pile	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored) abutments only*
	Factored ULS	**SLS**	
HP 310 x 110 (Abutments)	1,600 kN	does not govern	250 kN

B – Caissons: Abutments on caissons founded within shale bedrock below Elevation 69.0 m. Caissons lengths would be about 7.5 m, extending a minimum of 1.5 m into the shale bedrock. Full downdrag loads as provided below should be accounted for unless long-term settlement mitigation measures as discussed above for pile foundations are undertaken.

Caisson Diameter	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored) abutments only*
	Factored ULS	**SLS**	
1.2 m	6,500 kN	does not govern	400 kN
1.5 m	9,500 kN	does not govern	600 kN

Recommended Foundation Alternative: Steel H-Piles.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Height: Based on the subsoil conditions encountered at the site, the proposed approach embankment fills of 3.5 m in height can be constructed, provided that preloading, possibly with surcharge, be carried out prior to construction (refer to Settlement section below). In addition, subexcavation of up to about 0.8 m of surficial fill would be required.

Stability: Approach embankments up to 8 m in height with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fill materials and based on consolidation parameters and elastic deformation moduli of the foundation soils (estimated based on the results of oedometer testing on samples from adjacent boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlements, based on approach embankment heights of 3.5 m and 8 m, within the embankment foundation soils are on the order of 200 mm and 375 mm, respectively. About 10 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement); the majority (about 90%) of the remaining consolidation settlement is anticipated to occur over a period of three to six months. Measures to reduce post-construction settlement to acceptable values may include preloading with a surcharge, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. In addition, construction staging may be required for higher embankments. Additionally, depending on the results of detailed geotechnical analysis, the use of wick drains may be warranted to promote dissipation of pore pressures and promote settlement at a faster rate. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and use of lightweight fill materials.

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill material and clayey silt soils are classified as Type 3 soils according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V.

Groundwater/Surface Water Control: it is anticipated that any groundwater within the foundation excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: no major obstructions (e.g. cobbles or boulders) are anticipated at the site based on the borehole data at this site.

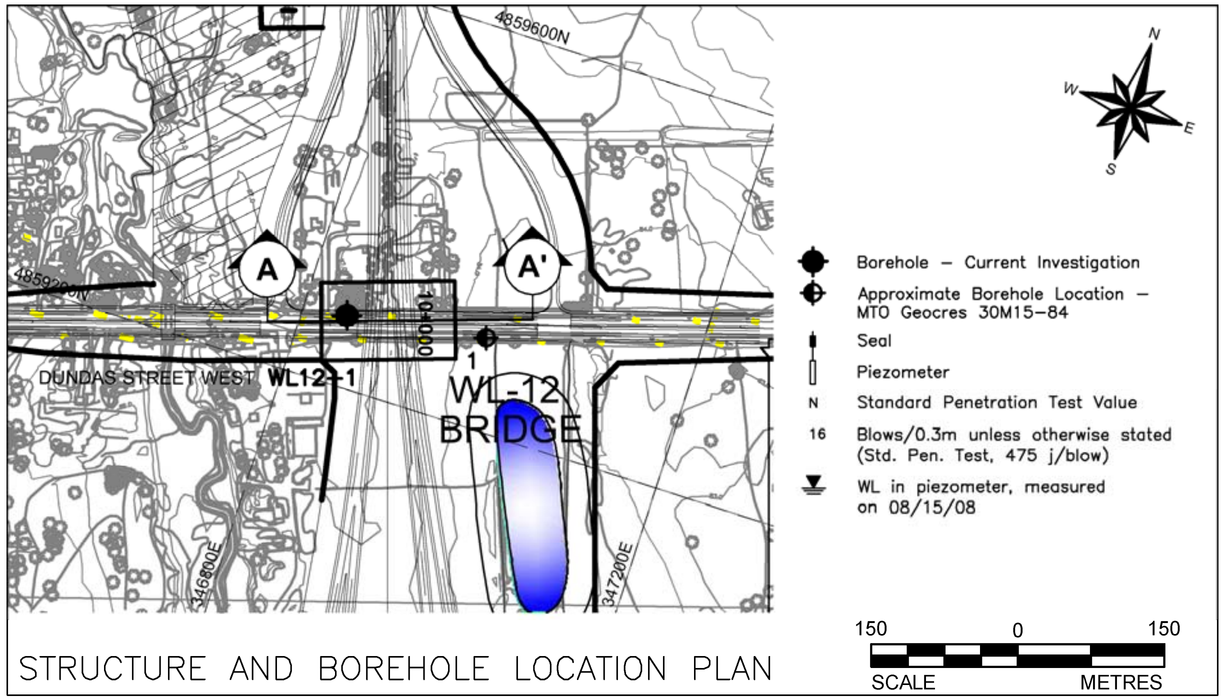
• RECOMMENDATIONS FOR ADDITIONAL WORK

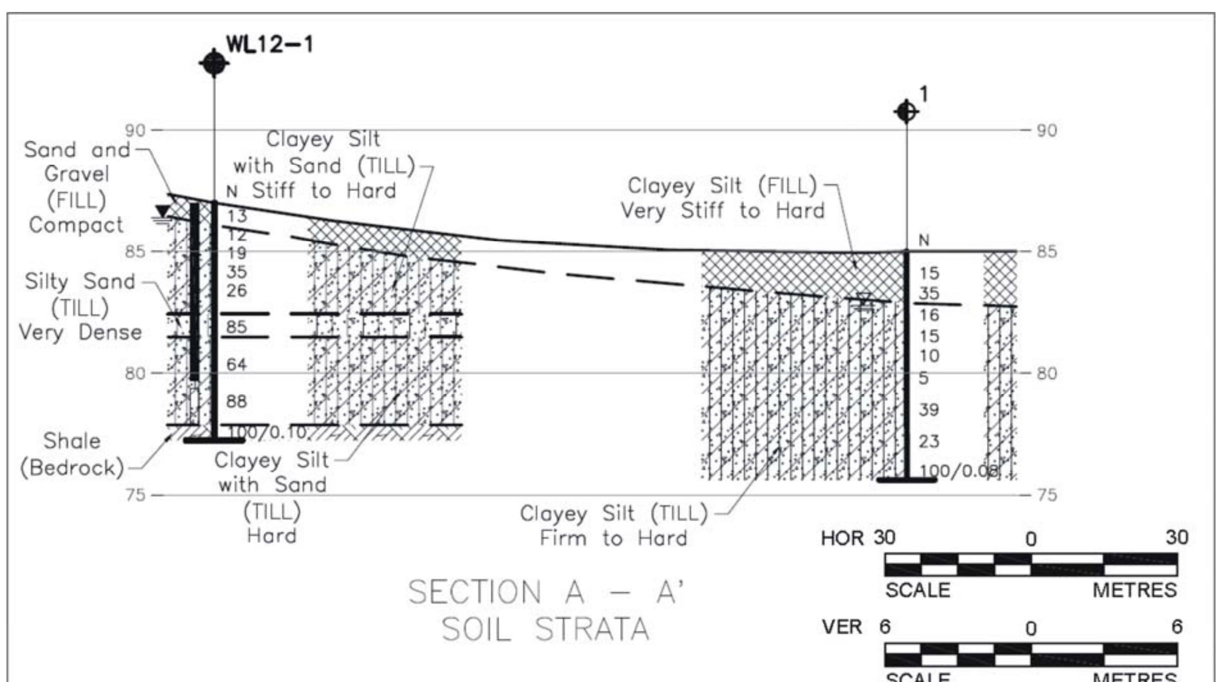
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass West Durham Link (WDL) / Dundas Street West **WDL Proposed Grade:** 87.4 m **Site Ranking:** Medium

Location No: WL-12 **Existing Ground Elevation:** 85 m to 87 m **Station:** 10+000 (Dundas St.)





FOUNDATION INVESTIGATIONS

Site Description:

The site of bridge structure WL-12 is situated on Dundas Street West, approximately 840 m east of Lake Ridge Road, in the Town of Whitby, Ontario. Dundas Street West at the site is approximately 12.5 m wide, multi-lane and is surrounded by farmlands and a few residential units along the north side of the proposed bridge structure.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL12-1	West Abutment	4 859 272.4	346 845.2	87.0	9.8
1*	East Abutment	4 859 293.8	346 987.7	85.0	9.4

*GEOCRES 30M15-84. Coordinates on original Borehole log referenced to MTM-NAD27.

Subsurface Conditions:

- **Asphalt:** 200 mm thick encountered at ground surface in Borehole WL12-1.

- **Fill:** Layers 2.1 m thick of clayey silt with sand, and 0.7 m thick of sand and gravel, encountered in Boreholes 1 and WL12-1, respectively. SPT 'N' values measured within the cohesive fill were 15 and 35 blows per 0.3 m of penetration, indicating very stiff to hard consistency; one SPT 'N' value measured within the granular fill was 13 blows per 0.3 m of penetration, indicating compact relative density.

- **Till:** silty clay to clayey silt, containing trace sand and gravel, and clayey silt with sand, containing trace to some gravel, encountered immediately below the fill material in Boreholes 1 and WL12-1, respectively. Borehole 1 was terminated within the cohesive till material at a depth of 9.4 m (Elev. 75.6 m). Borehole WL12-1 encountered the clayey silt till to a depth of 9.1 m (Elev. 77.9 m), and penetrated a 0.9 m thick interlayer of silty sand till at a depth of 4.6 m (Elev. 82.4 m). SPT 'N' values measured within the silty clay to clayey silt till deposit ranged from 5 blows per 0.3 m of penetration to 100 blows per 0.08 m of penetration, indicating a firm to hard consistency. The results of two grain size distribution tests and two Atterberg limits tests are presented on Figures WL12-A and WL12-B (Appendix B), respectively. Measured water contents within the cohesive till material ranged from approximately 6 to 13 percent, and 6 percent measured within the silty sand till layer.

- **Bedrock:** weathered shale bedrock encountered in Borehole WL12-1 at a depth of 9.1 m (Elev. 77.9 m); borehole was terminated within the bedrock at Elev. 77.2 m.

Groundwater Conditions:

- **BH WL12-1:** Depth of 0.6 m below ground surface (Elev. 86.4 m) in piezometer on August 15, 2008.

- **BH 1:** Depth of approximately 2.2 m below ground surface (Elev. 82.8 m) in open borehole upon completion of drilling.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-12

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing of Structure WL-12, as provided by URS in January 2009, the proposed underpass is a two span structure with a total length of approximately 72 m and approach embankments about 8 m in height. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on stiff to very stiff clayey silt till or on a compacted Granular 'A' pad for abutment footings "perched" within the bridge approaches	• Lower costs than deep foundations • Conventional construction	• Requires partial subexcavation of surficial fill material up to a depth of 1 m
Steel H-Piles driven into shale bedrock for abutments with "perched" pile caps	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, potentially containing cobbles
Caissons bored to found within shale bedrock	• Higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through till, potentially containing cobbles • May require temporary or permanent liner

A - Spread Footings: Based on the proposed West Durham Link grade at Elevation 87.4 m, spread footings placed at or below Elevation 82.5 m on the east side and at or below Elevation 85.5 m on the west side, and at a minimum depth of 1.2 m below the lowest surrounding grade, will be founded on stiff to very stiff silty clay to clayey silt till (east abutment) and clayey silt with sand till (west abutment). Alternatively, spread footings for the abutments could be founded on a Granular 'A' pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Stiff to very stiff Silty Clay to Clayey Silt Till / Clayey Silt with Sand Till	450 kPa	300 kPa
Compacted Granular 'A' (Abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven into shale bedrock at about Elevation 77.0 m on the west abutment and to approximately Elevation 74.0 m on the east abutment, are feasible for support of abutments with perched pile caps. Piles would be at least 10 m long.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	does not govern

C – Caissons: Abutments on caissons founded within and socketed a minimum of 1.5 m into shale bedrock, at or below Elevation 75.5 m at the west abutment and at or below Elevation 72.5 m at the east abutment.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	6,500 kN	does not govern
1.5 m	9,500 kN	does not govern

Recommended Foundation Alternative: Steel H-Piles driven into shale bedrock

- ## ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- ## APPROACHES

Height: up to 8 m.

Stability: Approach embankments up to 8 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V), will be safe against deep-seated slope instability. Subexcavation of up to 1 m of surficial fill would be required.

Settlement: Assuming the use of conventional earth or granular embankment fills, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- ## CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and the silty clay to clayey silt till/clayey silt with sand till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in Type 3 soils, and sloped to within 1.2 m of the bottom of the excavation with a slope 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the foundation excavations can be adequately controlled by pumping from filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. Caisson drilling equipment must be capable of penetrating obstructions such as shale fragments.

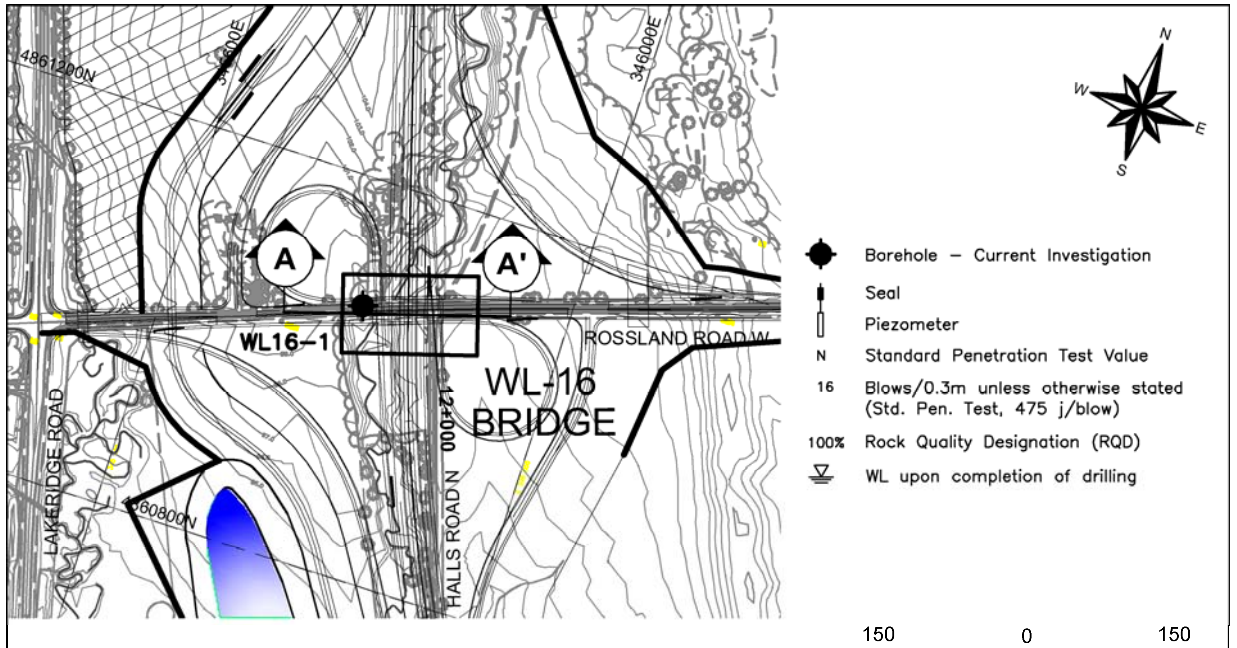
- ## RECOMMENDATIONS FOR ADDITIONAL WORK

Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements, and define the depth to bedrock at the east abutment.

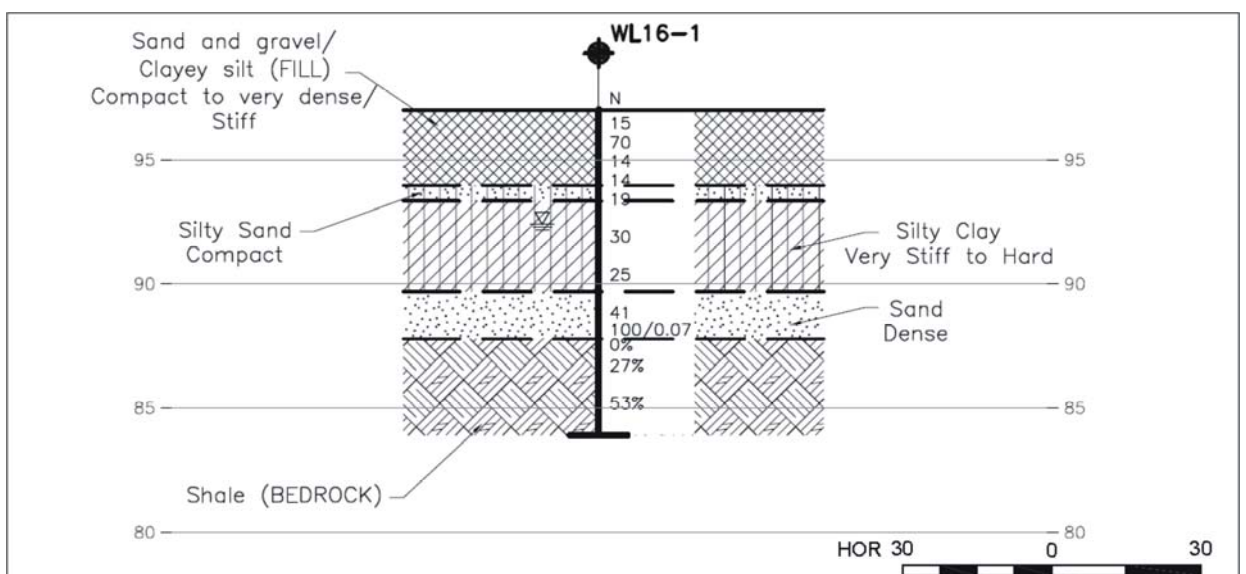
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass – West Durham Link / Rossland Road West **Hwy 407 Proposed Grade:** 98.5 m **Site Ranking:** Medium

Location No: WL-16 **Existing Ground Elevation:** 97.0 m – 100.0 m **Station:** 12+850



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The proposed bridge structure WL-16 is located along Rossland Road West approximately 400 m east of Lake Ridge Road, at the intersection of the present Halls Road North and Rossland Road West in the Town of Whitby, Ontario. Rossland Road West in this area is an approximately 5 m wide, two-lane asphalt road. The site is surrounded by farmland and a densely treed area in the vicinity of Lynde Creek tributary which flows from north to south at the proposed west abutment location. Overall, the terrain is relatively flat lying to gently sloping.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL16-1	West Abutment	4 861 073.2	345 796.6	97.0	13.1

Subsurface Conditions:

- **Fill:** sand and gravel fill encountered to a depth of 1.4 m below ground surface (Elevation 95.6 m), underlain by clayey silt fill with some sand and trace gravel extending to 3.1 m below ground surface (Elevation 94.0 m). Measured SPT 'N' values within the sand and gravel fill ranged from 15 blows to 70 blows per 0.3 m of penetration, indicating a compact to very dense relative density; SPT 'N' values measured within the clayey silt fill were 14 blows per 0.3 m of penetration, indicating a stiff consistency. Water content measured in the fill materials varies from 3 to 28 percent.

- **Silty Sand:** 0.6 m thick layer of silty sand, trace to some gravel and organics, encountered immediately below the fill. One SPT 'N' value measured within this layer was 19 blows per 0.3 m of penetration, indicating a compact relative density. One set of water content measured on a sample of the silty sand layer was about 15 percent.

- **Silty Clay:** 3.6 m thick deposit of silty clay, trace sand, encountered at a depth of 3.7 m (Elev. 93.3 m) and extending to Elevation 89.7 m. SPT 'N' values measured within the cohesive material were 25 and 30 blows per 0.3 m of penetration, indicating a very stiff to hard consistency. Water content measured in the material were 17 and 30 percent. The results of an Atterberg limits test are presented on Figure WL16-A (Appendix B) indicate the material is a silty clay of intermediate plasticity.

- **Sand:** 1.9 m thick stratum of sand, some silt and trace to some clay and gravel, encountered between Elevation 89.7 m and 87.8m. One SPT 'N' value measured within the sand material was 41 blows per 0.3 m of penetration indicating a dense relative density. The results of a grain size distribution test are presented on Figure WL16-B (Appendix B). One water content measured in the sand deposit was about 14 percent.

- **Bedrock:** rock coring was carried out in the borehole for a length of 3.9 m between Elevation 87.8 m and Elevation 83.9 m. The bedrock core samples consist of completely to highly weathered, very thinly to thinly bedded, grey shale. Diametrical point load tests carried out on selected samples of the shale bedrock between Elevation 86.5 m and Elevation 83.9 m yield correlated uniaxial compressive strength[1] (UCS) values ranging from 1 MPa to 6 MPa. These results indicate that the shale samples tested are generally very weak to weak based on the rock strength classification presented in the Canadian Foundation Engineering Manual[2]. The Rock Quality Designation (RQD) measured on the upper rock core sample between Elevation 87.8 m and Elevation 86.9 m is zero, indicating a very poor upper rock mass quality. The RQD measured on the core samples collected from Elevation 86.9 m to Elevation 85.4 m and from Elevation 85.4 m to Elevation 83.9 m are 27 and 53 percent, respectively, indicating a poor to fair rock mass quality.

Groundwater Conditions:

- **BH WL16-1:** Depth of 4.6 m below ground surface (Elev. 92.4 m) in open borehole upon completion of drilling.

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[1] Approximate unconfined compressive strength determined using ISRM correlation ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech., Vol. 22, No. 2, 1985, pp. 51-60).

[2] Canadian Foundation Engineering Manual, 4th Edition.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 7**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-16

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a prototype General Arrangement drawing for a typical side road underpass (Drawing No. 1), dated February 2008, and on the Rossland Road profile, dated June 2008, provided by URS, the proposed underpass will carry Rossland Road West traffic over the north and south bound lanes of the West Durham Link (WDL) in a two span structure with a total structure length of approximately 142 m. The proposed WDL grade is at about Elevation 98.5 m, with Rossland Road West approach embankments up to 10.5 m high. Feasible foundation options for the proposed bridge abutments and pier are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into shale bedrock for abutments and pier.	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through possible presence of cobbles, and into shale bedrock
Caissons bored to found within shale bedrock.	• Higher bearing resistances than steel H-Piles	• May require temporary or permanent liner • Drilling equipment must be capable of socketting caisson into bedrock

A - Steel H-Piles: Steel HP 310 x 110 piles driven to found within shale bedrock at or below Elevation 87.5 m, are feasible for support of abutments with perched pile caps and for central pier; piles would be approximately 16 m and 8 m long, respectively.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	Does not govern

B – Caissons: Abutments and pier on caissons founded within shale bedrock below Elevation 87.5 m. Caissons lengths would be about 17 m and 9 m long near the west abutment and central pier, respectively, socketed a minimum of 1 m into shale bedrock.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	6,500 kN	Does not govern
1.5 m	9,500 kN	Does not govern

Recommended Foundation Alternative: Steel H-Pile or caisson foundations.

- ## ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- ## APPROACHES

Height: Based on the subsoil conditions encountered as the site, it is recommended that approach embankments fills be constructed with a maximum height of 10.5 m. However, it is noted that if the existing fill material and silty sand layer are not sub-excavated, preloading with surcharge will be required (refer to Settlement section below).

Stability: Approach embankments up to 10.5 m high, constructed with select subgrade materials or granular fill, with side slopes no steeper than 2 horizontal to 1 vertical (2H:1V) will be safe against deep seated failure. Construction of a 2 m wide mid-height bench will be required for embankments in excess of 8 m high to control surficial erosion and improve stability. Measures to stabilize the embankment slope face due to potential groundwater seepage at the slope surface should be implemented.

Settlement: Assuming the use of conventional earth or granular embankment fill materials and based on consolidation parameters and elastic deformation moduli of the foundation soils (estimated based on the results of oedometer testing on samples from adjacent boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT ‘N’ values), the maximum predicted total settlement within the embankment foundation soils is on the order of 80 mm, assuming the fill and silty sand is removed. About 20 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement). The majority (about 60 percent) of the remaining consolidation settlement is anticipated to occur over a period of three to six months. Additional settlements (including long-term creep due to the presence of organics) are anticipated if the clayey silt fill material is left in place. Therefore, measures to reduce post-construction settlement to acceptable values should be undertaken; these may include sub-excavation of clayey silt fill, preloading with a surcharge, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and use of lightweight fill materials.

- ## CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and silty sand are classified as Type 3 soils, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V.

Groundwater/Surface Water Control: Based on the groundwater conditions encountered in the borehole, foundation excavations will be above the groundwater table; surface water/groundwater infiltration into the excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. No major obstructions (e.g. cobbles or boulders) are anticipated at the site based on the borehole data at the site.

- ## 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.

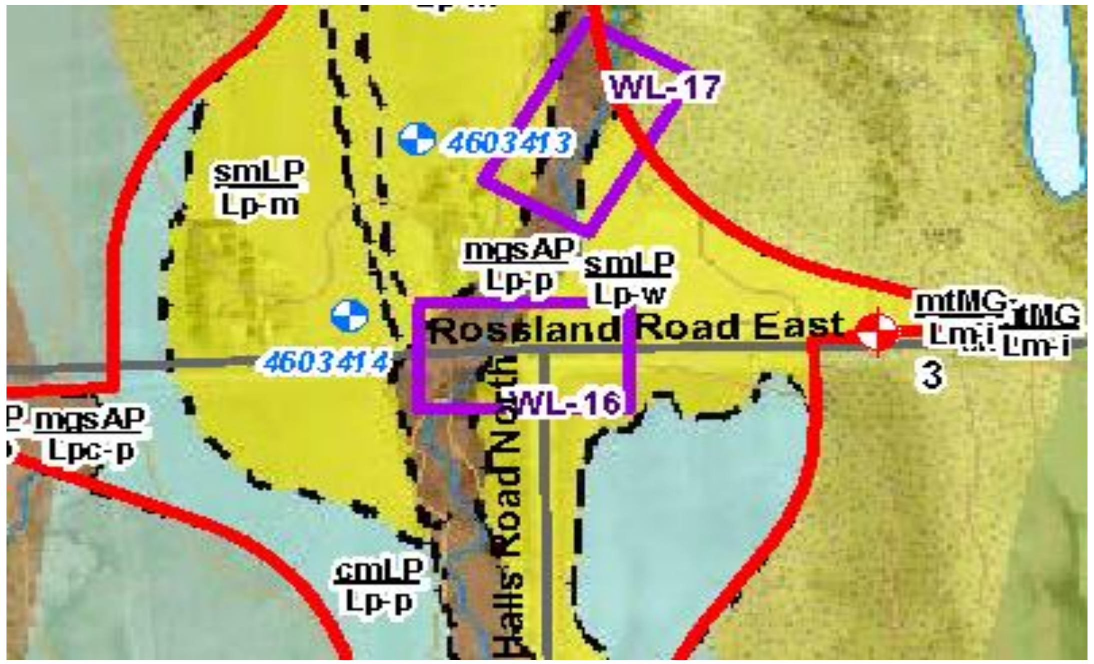
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WL-17

W.O: 07-20015 **Section:** Western **Location:** WDL north of Rossland Road East **Sta.** ~WDL 13+800

Original Grade: **Proposed Grade:** **Description:** E –N Ramp crosses creek on culvert



Site Plan and Terrain Analysis

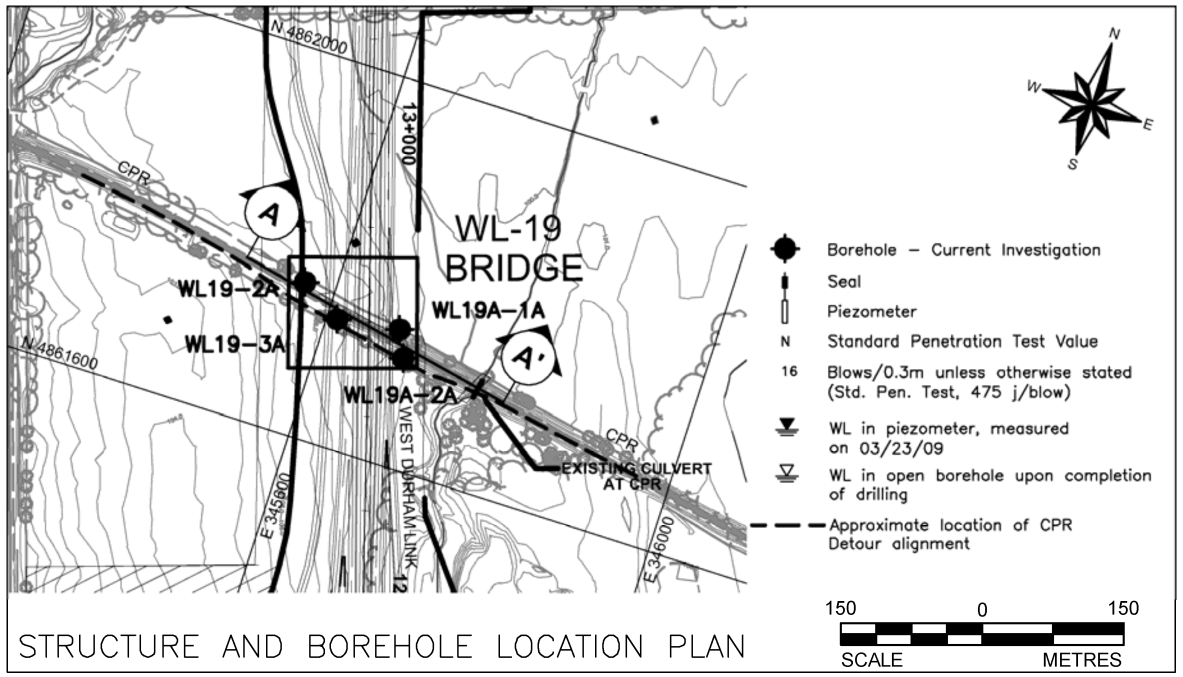
Site Photograph – facing north from Rossland Road to culvert site.

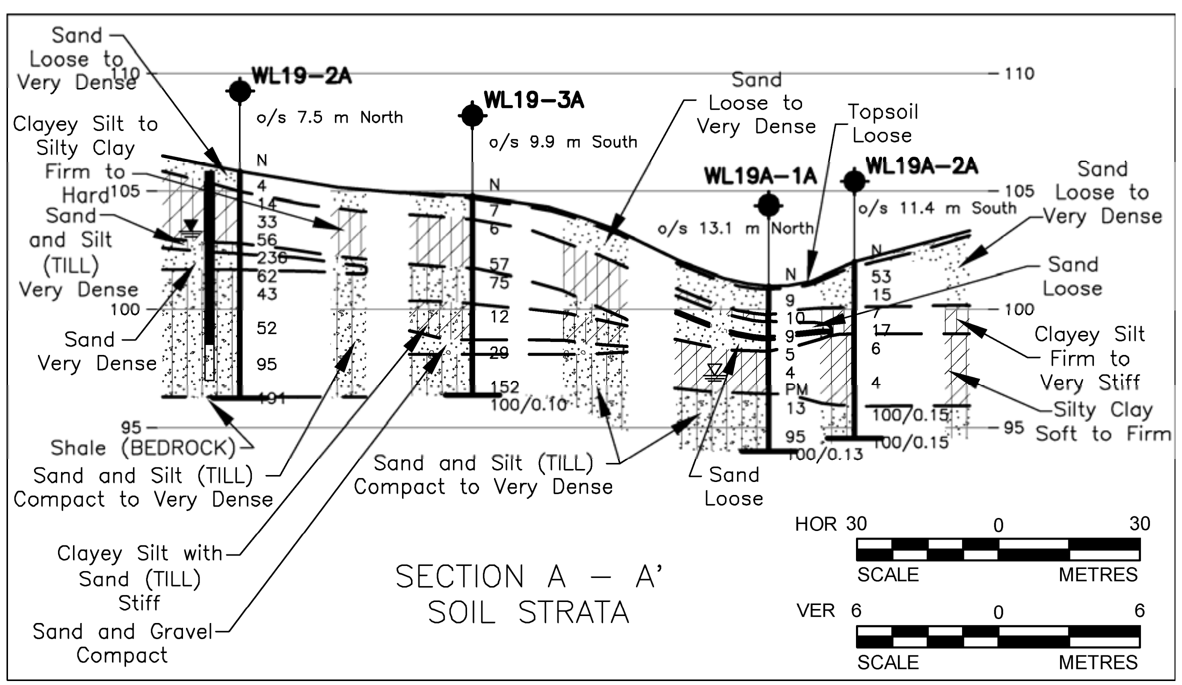
Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks
Boreholes: No BH at the site. BH 3, GEOCRES 30M15-84, lies approximately 300m to the southeast.	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Settlement and stability not expected to be problematic unless high fills are requires, e.g. greater than 8m. However, this must be analyzed during detail design.	Moderately wide, well defined valley with old meander scars and 20-35 degree steep valleysides; meandering channel has undercut valleysides, which has led to localized slumps Valley bottom sediments >1 m deep and dominantly gravelly silty sand alluvium with some clay, locally interbedded with buried organic material Depending on the final design and time of year construction is carried out, unwatering and temporary stream diversion may be required.
Mapping (West 8) shows the site is underlain by a sandy silt lacustrine plain, bordered to the south by clayey silt lacustrine plain. The relief is low plain, moderately to well drained. The creek lies in a narrow band of recent alluvium. BH 3 encountered: 0.0 – 4.4 Clayey silt till, very stiff to hard 4.4 – 5.9 Silty clay, stiff to very stiff 5.9 – 10.4 Clayey silt till, very stiff 10.4 – 11.4 Silty sand, shale fragments, very dense 11.4 – 12.3 EOH Weathered shale bedrock **Groundwater** GWL noted at 5.2m depth. **Estimated overburden thickness – 8m.**		**Site Ranking** **Foundations:** **Low** **Hydrogeology:** **Medium**	

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass West Durham Link, CPR **WDL Proposed Grade:** 96.8 m – 97.2 m **Site Ranking:** High

Location No: WL-19, WL-19A (WL-19) **Existing Ground Elevation:** 100.0 m – 106.0 m **Station:** 12+795





FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed WL-19 and WL-19A bridge structures (underpass at the CPR tracks) is located along the proposed West Durham Link and CPR intersection, approximately 370 m east of Lakeridge Road and 690 m north of Rossland Road West in the Town of Whitby, Ontario. The site is surrounded mainly by farmland and a densely treed area south-east of the proposed structures. Overall, the terrain slopes down southerly towards Lake Ontario.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL19-2A	West Abutment	4 861 761.3	345 567.1	105.8	9.6
WL19-3A	West Pier	4 861 734.3	345 611.8	104.8	8.4
WL19A-1A	East Pier	4 861 744.1	345 677.9	101.0	7.0
WL19A-2A	East Abutment	4 861 716.4	345 690.7	102.0	7.5

Subsurface Conditions:

- **Topsoil:** topsoil, up to 0.2 m thick, was encountered in all four boreholes at the ground surface. Measured SPT 'N' values generally varied from 4 to 9 blows per 0.3 m of penetration, indicating a loose relative density.

- **Sand:** layer of sand, containing some silt and trace clay, encountered in all four boreholes immediately below the topsoil, ranging in thickness from 0.8 m to 1.7 m. Layers of sand, 0.7 m and 0.5 m thick, were also encountered in Borehole WM19-2A at a depth of 3.5 m and in Borehole WM19A-1A at a depth of 1.5 m and 2.3 m. Measured SPT 'N' values generally ranged from 4 to 15 blows per 0.3 m of penetration, indicating a loose to compact relative density; although one SPT 'N' value measured on a sample of sand in Borehole WL19-2A was blows per 0.3 m of penetration and in Borehole WL19A-2A was 53, indicating a very dense relative density. Results of one grain size distribution test are presented on Figure WL19A-A (Appendix B). Measured water contents vary from about 19.5 to 26 percent.

- **Clayey Silt to Silty Clay:** clayey silt to silty clay deposits were encountered in all of the boreholes between about Elevation 103.8 m and 98.2 m. The deposits varied in thickness from 0.1 m to 3 m. Measured SPT 'N' values generally varied from 4 to 57 blows per 0.3 m of penetration, indicating a soft to hard consistency. The field measured undrained shear strength of the upper clayey silt to silty clay layer in Borehole WL19-3A was greater than 120 kPa, indicating a very stiff to hard consistency; field measured undrained shear strength of silty clay in Borehole WL19A-2A ranged from 19 kPa to 50 kPa, indicating a soft to firm consistency. The results of grain size distribution tests are presented on Figures WL19-A and WL19A-B (Appendix B); Atterberg limits test results are presented on Figures WL19-B and WL19A-C. Measured water contents generally vary from 20 to 37 percent; one water content on a sample of the lower portion of clayey silt deposit in Borehole WL19-2A was 10 percent. The results of one Oedometer test carried out on a sample of soft to firm silty clay deposit from Borehole WL19A-1A are shown on Figures WL19A-D1 to WL19A-D3 (Appendix B); the consolidation parameters as interpreted from the Oedometer test results are summarized below.

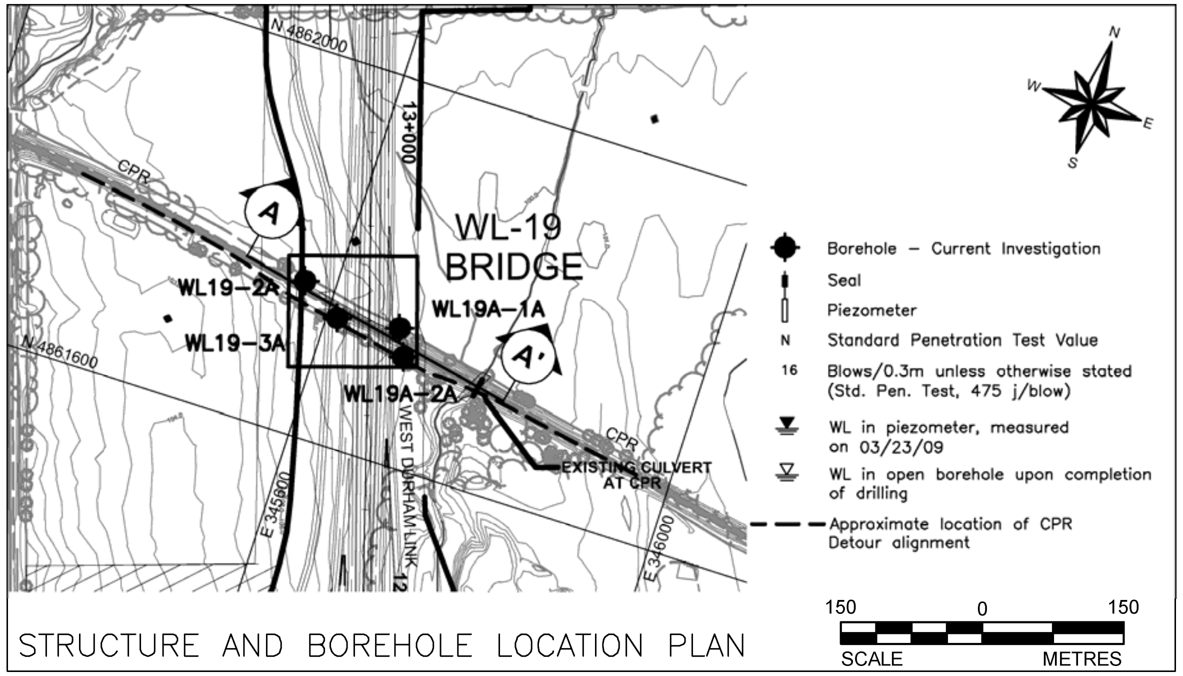
BH/Sample No.	*Sample Depth / Elev.*	γ *(kN/m³)*	σ_{vo}' *(kPa)*	σ_p' *(kPa)*	$\sigma_p' - \sigma_{vo}'$ *(kPa)*	C_c	C_r	e_o	*OCR*
WL19A-1A / 6	4.3 m / 99.7 m	17.9	67	130	63	0.37	0.13	1.1	1.9

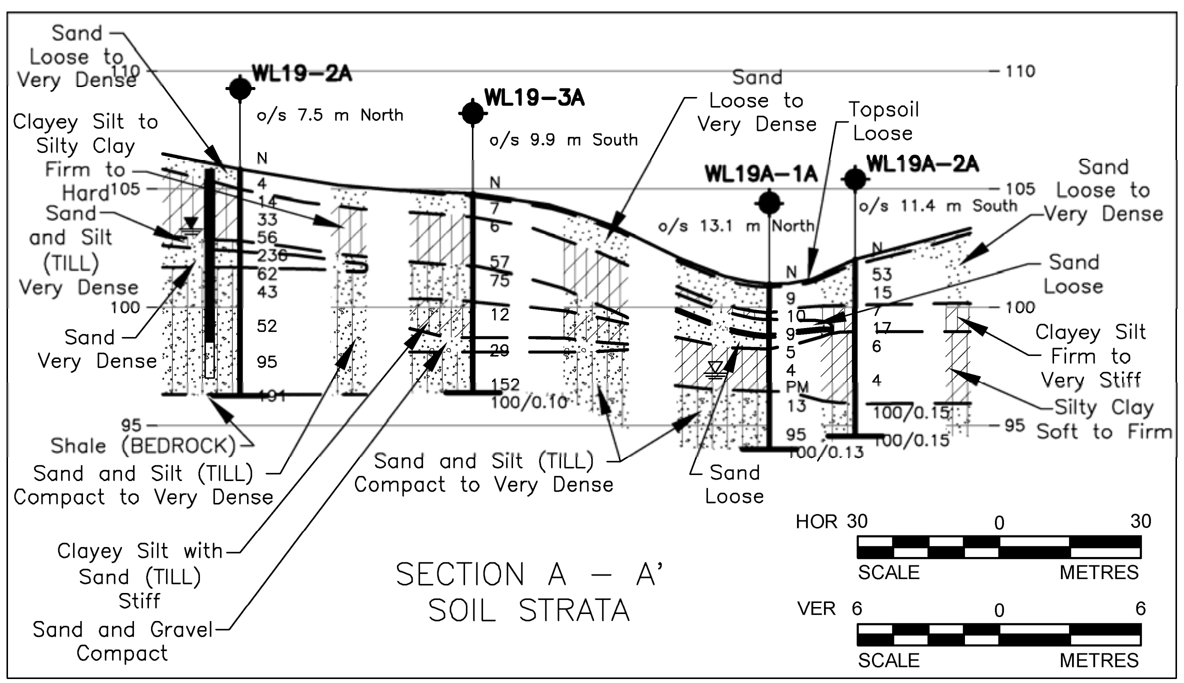
Notes: σ_P': Apparent pre-consolidation pressure; σ_{VO}': Computed existing vertical effective stress; Cc: Compression index; Cr: Recompression index; e_o: Initial void ratio; OCR: overconsolidation ratio.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 7**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-19, WL-19A (WL-19)





Based on the oedometer test results, measured SPT 'N' values and undrained shear strengths, it is considered that the soft to firm silty clay deposit is an over-consolidated deposit that appears to have been subjected to some degree of softening.

- **Till:** sand and silt, containing trace to some gravel and clay, encountered in all four boreholes. In Boreholes WL19A-1A and WL19A-2A, the till was encountered below the lower silty clay layers at depths of 4.6 m (Elev. 96.4 m) and 6.1 m (Elev. 95.9 m), respectively; both boreholes were terminated within the till deposit. In Boreholes WL19-2A and WL19-3A, the sand and silt till was encountered below the clayey silt layers at a depth of 3.1 m corresponding to Elevation 102.8 m and 101.8 m, respectively, and extended to Elevations 96.3 m and 96.4 m, respectively. Interlayered within the till deposit was a 0.7 m thick layer of sand and a 0.6 m thick layer of sand and gravel in Borehole WL19-3A. A sand layer, containing trace to some silt and gravel was encountered in Borehole WL19-2A at a depth of 3.5 m. Within the sand and sand and gravel interlayers, SPT 'N' values are 62 and 29 blows per 0.3 m of penetration, indicating a very dense and compact relative density. Measured water contents are about 12 percent and 2 percent, respectively.
  Measured SPT 'N' values within the sand and silt till deposit varied from 43 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a dense to very dense relative density; one SPT 'N' value within the upper portion of till in Borehole WL19A-1A was 13 blows per 0.3 m of penetration, indicating a compact relative density. The results of grain size distribution tests are presented on Figures WL19A-E and WL19-C (Appendix B); Atterberg limits test results are presented on Figures WL19A-F and WL19-D. Measured water contents ranged from approximately 8 to 14 percent.

  Clayey silt with sand till, containing trace to some gravel, was encountered in Borehole WL19-3A at a depth of 4.6 m below ground surface (Elevation 100.2 m) underlying the upper sand and silt till deposit. The clayey silt till layer extended to a depth of 6.1 m (Elev. 98.7 m). One SPT 'N' value was 12 blows per 0.3 m of penetration, indicating a stiff consistency. Results of a grain size distribution test are presented on Figure WL19-E.

- **Bedrock:** Inferred shale bedrock encountered only in Borehole WL19A-2A at a depth of 9.5 m (Elev. 96.3 m); no coring was performed

<u>Groundwater Conditions:</u>

- **WL19-2A:** Depth of 1.1 m below ground surface (Elev. 104.7 m) in open borehole upon completion of drilling; depth of 2.5 m below ground surface (Elev. 103.3 m) in piezometer on March 23, 2009.
- **WL19-3A:** Borehole was advanced with wash boring method; water level was not measured as it was not considered to be representative.
- **WL19A-1A:** Depth of 3.8 m below ground surface (Elev. 97.2 m) in open borehole during drilling before wash boring method was used.
- **WL19A-2A:** Borehole was advanced using wash boring method; water level was not measured as it was not considered to be representative.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-19, WL-19A (WL-19)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on a drawing of CPR – WDL Underpass provided by URS on November 11, 2008, Structures WL-19 and WL-19A (WL-19) will carry the Canadian Pacific Railway (CPR) tracks over the West Durham Link northbound and southbound lanes. The proposed underpass is a three span bridge structure with a total length of about 110 m. The west and east approach embankments have effective heights of 9.3 m and 8.6 m, respectively. The proposed WDL grade will be at about Elevation 97 m and will be constructed in a cut section which varies from approximately 8.3 m along the west abutment (with a fill height of 1 m) and 4.7 m along the east abutment (with a fill height of 3.9 m).

It is our understanding that a CPR detour has been proposed to divert trains at the bridge site during construction. The profile drawings received from URS on February 3, 2009 indicate a 740 m long detour which will extend to the south of the existing tracks from Sta. 9+615 to 10+355 with a maximum offset of about 6.9 m. Based on the existing subsurface information, the feasible foundation options for the proposed bridge abutments and piers are listed below with advantages and disadvantages associated with each option. It is noted that foundation design for all structures crossing or adjacent to the railway tacks must be carried out in conformance with the local railway authority requiremetns and AREMA manual. It should be noted that most of the recommended founding elevations are founded below the termination depths of the boreholes, as such further subsurface investigation should be carried out to confirm the subsoil conditions at the founding elevations.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very dense sand and silt till or shale bedrock at the abutments and pier locations	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of 2 m of soft to firm silty clay
Steel H-Piles driven to “100-blow” sand and silt till or shale bedrock	• Allows for integral abutment design	• Pre-augering along the west abutment will extend into shale bedrock in order to provide minimum embedment of piles for integral design and to achieve axial resistance
Caissons bored to found within “100-blow” sand and silt till or shale bedrock	• Higher bearing resistance than steel H-Piles	• Drilling must be advanced into shale bedrock and very dense layers in till deposits • May require temporary or permanent liner to prevent seepage inflow and softening of the caisson base

A – Spread Footings: East abutment and east pier footings would be founded on very dense sand and silt till at or below Elevation 95.5 m and at or below Elevation 95 m, respectively, as well as at a minimum depth of 1.2 m below the lowest surrounding grade. The west abutment and west pier footings would be founded on very dense sand and silt till or shale bedrock at approximately Elevation 96.8 m.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Very dense Sand and Silt Till	600 kPa	400 kPa
Shale Bedrock	800 kPa	Does not govern

The SLS values provided above are consistent with the allowable settlement pressures calculated in accordance with the design methods outlined in the AREMA Manual.

B - Steel H-Piles: Steel HP 310 x 110 piles driven to or below Elevation 92 m within the shale bedrock and inferred “100-blow” sand and silt till at the west and east abutments and piers respectively, and a minimum depth of 1.2 m below the lowest surrounding ground surface. Pre-augering about 5 m into the shale bedrock at the west abutment or inferred “100-blow” sand and silt till at the east abutment will be required to obtain pile lengths of approximately 5 m to 7 m, to allow for integral abutment design.

Location	*Pile*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
West Abutment and West Pier	HP 310 x 110	1,600 kN	Does not govern
East Abutment and East Pier	HP 310 x 110	1,400 kN	1,200 kN

C - Caissons: East abutment and east pier on caissons founded a minimum of 2 m within the inferred “100-blow” sand and silt till below Elevation 92 m. West abutment and west pier founded at least 2 m within shale bedrock below Elevation 92 m. Caisson lengths would be approximately 5 m.

Location	*Caisson Diameter*	*Axial Geotechnical Resistance*	
		Factored ULS	**SLS**
West Abutment and West Pier	1.2 m	6,500 kN	Does not govern
	1.5 m	9,500 kN	Does not govern
East Abutment and East Pier	1.2 m	2,000 kN	1,700 kN
	1.5 m	3,500 kN	2,800 kN

Recommended Foundation Alternative: Shallow foundations; caissons are also feasible.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional or semi-integral abutments.

- **APPROACHES**

Height: Up to 9.3 m high cut/fill combination along the side slopes and up to 9.3 m high cut along the front slope.

Stability: Approaches up to 9.3 m high, constructed in a cut section along the front slope and constructed in a combination of cut and fill consisting of select subgrade materials or granular fill along the side slopes and all with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) will be safe against deep-seated slope instability. Construction of a mid-height berm will be required for side slopes in the immediate vicinity of the abutments which exceed 8 m in height in accordance with MTO standards. Measures to stabilize the embankment slope face due to potential surface water flow/seepage at the slope surface will have to be implemented.

Settlement: The approaches for this bridge structure will be mainly constructed in cut and thus settlements are not a concern.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-19, WL-19A (WL-19)

- **DETOUR EMBANKMENTS**

Height: up to 4 m.

Stability; CPR detour embankments up to 4 m with side slopes no steeper than 2 horizontal to 1 vertical (2H: 1V) will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankment fill materials and based on consolidation parameters and elastic deformation moduli of the temporary detour embankments foundation soils (estimated based on the results of Oedometer testing and correlations with the undrained shear strength, Atterberg limits, and SPT ‘N’ values), the maximum predicted total settlement within the embankment foundation soils is in the order of 100 mm. Less than 10 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement); the remainder settlement (i.e. consolidation settlement) is anticipated to occur over a period of four months. Therefore, measures to reduce post-construction settlement to acceptable values should be undertaken. These may include preloading with a surcharge and construction staging, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the temporary embankments, including appropriate settlement monitoring instrumentation and to assess the use of lightweight fill materials.

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the sand and clayey silt to silty clay soils are classified as Type 3 soils, while the sand and silt till is classified as Type 2 soil according to OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H: 1V in Type 3 soils, and sloped to within 1.2 m of the bottom of the excavation with a side slope 1H : 1V in Type 2 soils. Front face slopes for long term excavations should be made no steeper than 2H: 1V.

Groundwater/Surface Water Control: the WDL will be constructed within a cut section where the groundwater level is close to the original ground surface, hence dewatering and drainage systems will have to be implemented. It would be advantageous to carry out grading works prior to construction of structure foundations and allow gravity drainage so as to minimize dewatering requirements. Dewatering of excavations for shallow foundations will be required. Permanent groundwater measures are likely required.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to facilitate driving into shale bedrock. Caisson drilling equipment must also be capable of penetrating shale bedrock.

- **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. An assessment of groundwater level impact should be undertaken and estimates for pumping rate made for Permit to Take Water application, at the time of detail design.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Underpass WDL / Taunton Road

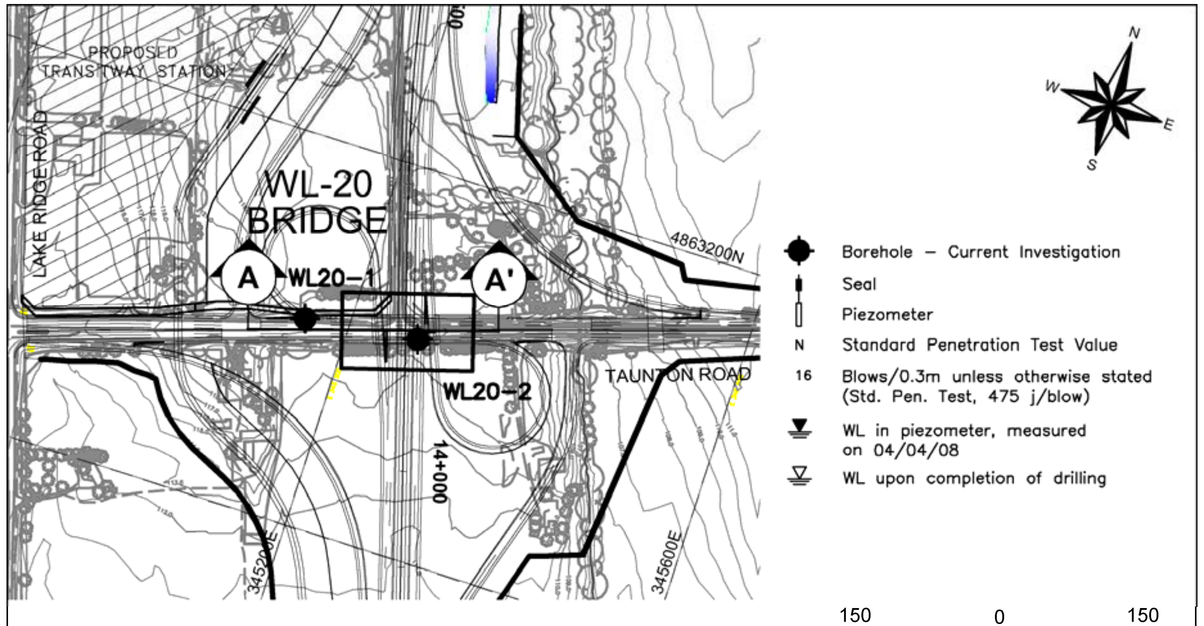
Location No: WL-20

WDL Proposed Grade: 116.3 m

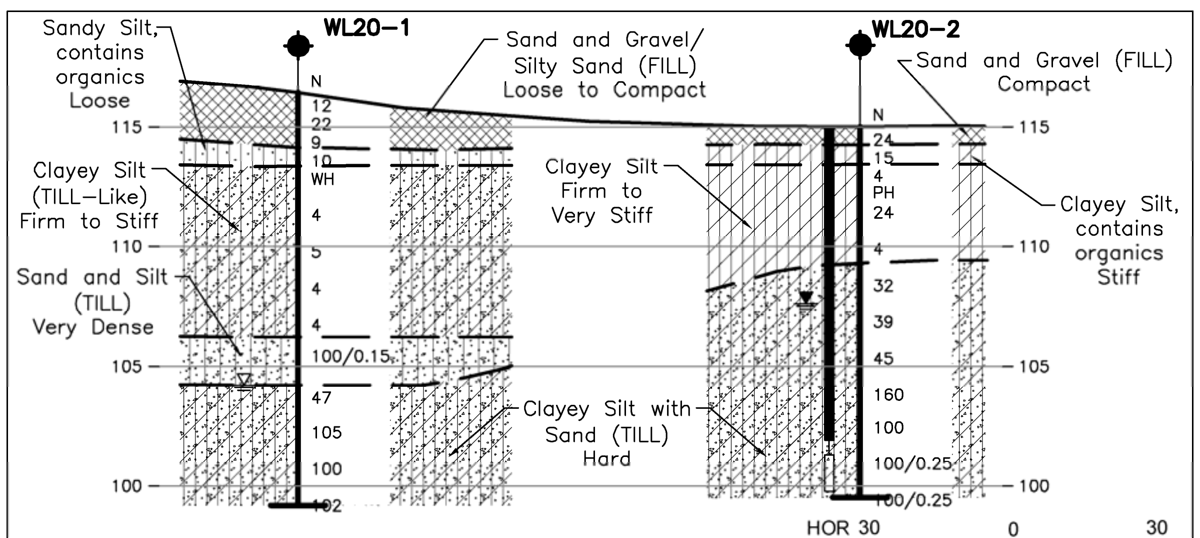
Existing Ground Elevation: 115 m – 116 m

Site Ranking: Medium

Station: 14+150



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The proposed underpass structure WL-20 is located along Taunton Road West, approximately 370 m east of Lake Ridge Road in the Town of Whitby, Ontario. Taunton Road West in this area is up to four lanes wide (with turning lanes) and approximately 14 m wide. The proposed bridge site is surrounded by farmland and low vegetation. The overall topography is gently sloping from west to east.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL20-1	North Abutment	4 863 012.2	345 154.0	116.4	17.2
WL20-2	South Abutment	4 863 027.8	345 272.1	115.0	15.5

Subsurface Conditions:

- **Fill:** sand and gravel to silty sand containing trace gravel, extended to depths between 0.8 m and 2.3 m. SPT 'N' values within the fill were between 9 and 24 blows per 0.3 m of penetration, indicating a loose to compact relative density. Water contents measured ranged from 6 to 12 percent.
- **Sandy Silt /Clayey Silt containing Organics:** Immediately below the fill materials in Boreholes WL20-1 and WL20-2, a 0.8 m thick layer of brown to black sandy silt to clayey silt containing organics, trace gravel was encountered and extended to a depth of 3.1 m and 1.6 m (corresponding to Elev. 113.4 m), respectively. Measured SPT 'N' values were 10 and 15 blows per 0.3 m of penetration, indicating a loose / stiff relative density. Measured water contents on two samples were 17 and 25 percent. The measured organic content of one sample taken in WL20-1 was 6 percent.
- **Clayey Silt:** A clayey silt deposit was encountered below the sandy/clayey silt with organics, in both boreholes. In Borehole WL20-1, the clayey silt layer was 7.1 m thick and contained some sand and gravel, and in structure appears to be till-like. In Borehole WL20-2, the clayey silt layer was 4.1 m thick and contained trace sand. The clayey silt deposit extended to a depth of 10.2 m (Elev. 106.2 m) and 5.7 m (Elev. 109.3 m) in Boreholes WL20-1 and WL20-2, respectively. SPT 'N' values measured within the clayey deposit ranged between the weight of hammer and 24 blows per 0.3 m of penetration, but typically measured 4 blows per 0.3 m of penetration; field vane measured undrained shear strength values ranged between 27 kPa and greater than 96 kPa, indicating a generally firm to stiff consistency. The results of grain size distribution and Atterberg limit tests carried out on selected samples are shown on Figures WL20-A, WL20-B and WL20-D (Appendix B). Measured water contents on selected samples ranged between 8 and 33 percent. The results of a consolidation test carried out on a selected sample of the clayey silt deposit from WL20-2 is shown on Figures WL20-C1 to WL20-C3 (Appendix B) and summarized below:

BH/Sample No.	*Sample Depth /Elev.*	*γ (kN/m^3)*	*σ_{vo}' (kPa)*	*σ_p' (kPa)*	*σ_p' - σ_{vo}' (kPa)*	*C_c*	*C_r*	*e_o*	*OCR*
WL20-2 / 4	2.7 m / 112.3 m	21.4	58	550	492	0.186	0.022	0.607	9.5

Notes: σ_p'**:** Apparent pre-consolidation pressure; σ_{VO}'**:** Computed existing vertical effective stress; Cc: Compression index; Cr: Recompression index; e_o: Initial void ratio; OCR: overconsolidation ratio.

Based on the consolidation test results, the measured SPT 'N' values and undrained shear strengths, the clayey silt deposit is considered to be over-consolidated.

- **Till**: consisting of predominantly clayey silt with sand, trace gravel was encountered below the clayey silt and till-like deposit. In Borehole WL20-1, a 2 m thick interlayer of sand and silt till was present at a depth of 10.2 m (Elev. 106.2 m) between the till-like clayey silt and clayey silt till deposit. An SPT 'N' value of 100 blows per 0.15 m of penetration indicates this deposit to be of very dense relative density. In Boreholes WL20-1 and WL20-2, the clayey silt till was encountered at a depth of 12.2 m (Elev. 104.2 m) and 5.7 m (Elev. 109.3 m), respectively and the boreholes were terminated within the clayey silt till deposit at depths of 17.2 m (Elev. 99.2 m) and 15.5 m (99.5 m) with a till thickness of 5 m and 9.8 m, respectively. Measured SPT 'N' values within the clayey silt till deposit ranged from 32 blows per 0.3 m of penetration to 100 blows per 0.25 m of penetration, indicating a hard consistency. The results of grain size distribution and Atterberg limits tests are presented on Figures WL20-E and WL20-F, respectively (Appendix B). Measured water contents ranged between 6 percent and 23 percent but were generally less than 10 percent.

Groundwater Conditions:

- **BH WL20-1:** Depth of 12.2 m below ground surface (Elev. 104.2 m) in open borehole upon completion of drilling.
- **BH WL20-2:** Depth of 7.4 m below ground surface (Elev. 107.6 m) measured in piezometer on April 5, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 6**

Golder Associates Ltd.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-20

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the Taunton Road profile at the proposed West Durham Link (WDL) drawing dated April 2008, the proposed underpass will carry Taunton Road over the north and south bound lanes of the WDL and is approximately 40 m in length. Hence a single span, closed type structure is assumed for discussion. The proposed grade of the WDL at this location is about 116.3 m, resulting in an approximate 1.5 m grade raise. The proposed Taunton Road grade will be about Elevation 124.5 m with approach embankments up to about 8 m high. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option. Based on the preliminary subsoil conditions at the site, shallow foundations are not considered suitable for support of the proposed structure.

Foundation Option	*Advantages*	*Disadvantages*
Steel H-Piles driven into “100-blow” clayey silt till for abutments with “perched” pile caps.	• Allows for integral abutment design	• Requires flange plate reinforcement to facilitate driving through till, possibly containing cobbles
Caissons bored to found within “100-blow” clayey silt till.	• Higher bearing resistances than steel H-Piles	• Drilling must be advanced through till, possibly containing cobbles • May require temporary or permanent liner

A - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the “100-blow” clayey silt till deposit at or below Elevation 102 m, are feasible for support of abutments with perched pile caps; piles would be approximately 18.5 m long. The structural design of the abutment piles should be based on the full downdrag load acting on the piles as provided below, unless preloading and surcharging are undertaken to minimize post-construction settlements under the new embankment loading; in this case downdrag loads can be eliminated.

Pile	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored)*
	Factored ULS	**SLS**	
HP 310 x 110	1,600 kN	1,400 kN	200 kN

B – Caissons: Abutments on caissons founded within the “100-blow” clayey silt till below Elevation 100.5 m. Caissons lengths would be at least 14 m, extending 2 m into the “100-blow” materials. Full downdrag loads as provided below should be accounted for unless long-term settlement mitigation measures as discussed above for steel pile foundations are undertaken.

Caisson Diameter	*Axial Geotechnical Resistance*		*Downdrag Load (Unfactored)*
	Factored ULS	**SLS**	
1.2 m	4,500 kN	3,500 kN	600 kN
1.5 m	6,500 kN	5,500 kN	700 kN

Recommended Foundation Alternative: Steel H-Piles.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

• APPROACHES

Embankments Height: up to 8 m.

Stability: Approach embankments up to 8 m high, constructed with select subgrade materials or granular fill, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) should have an adequate factor of safety against deep-seated slope instability. All fill and underlying soils containing excessive organics to its full depth should be removed prior to constructing embankments.

Settlement: Assuming the fill and underlying soils containing excessive organics are removed, embankments can be constructed using select subgrade materials or granular earth fills. Based on consolidation parameters and elastic deformation moduli of the approach embankments foundation soils (estimated based on the results of consolidation testing and correlations with the undrained shear strength, Atterberg limits, and SPT ‘N’ values), the predicted total settlement due to the embankment loading is up to 100 mm. About 30 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement); the remainder of the settlement (i.e. consolidation settlement) is anticipated to occur over a period of up to six months. Therefore, measures to reduce post-construction settlement to acceptable values should be undertaken; these may include preloading with surcharge and construction staging, use of lightweight fills or a combination of both lightweight fill and conventional earth fills. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation, and use of lightweight fill materials.

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and underlying sandy silt to clayey silt containing organics are classified as Type 3 soils according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V.

Groundwater/Surface Water Control: Based on the groundwater conditions encountered in the boreholes, excavations for foundations will be above the groundwater table; surface water/groundwater infiltration into the excavations can be adequately controlled by pumping from properly filtered sumps.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used. No major obstructions (e.g. cobbles or boulders) are anticipated at the site based on borehole data at this site.

• 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.

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:	WL-21

W.O: 07-20015 **Section:** Western **Location:** WDL and Realigned Hall's Road (north) **Sta.** WDL 17+196

Original Grade: **Proposed Grade:** **Description:** WDL crosses creek on culvert.

Site Plan and Terrain Analysis

No Photo

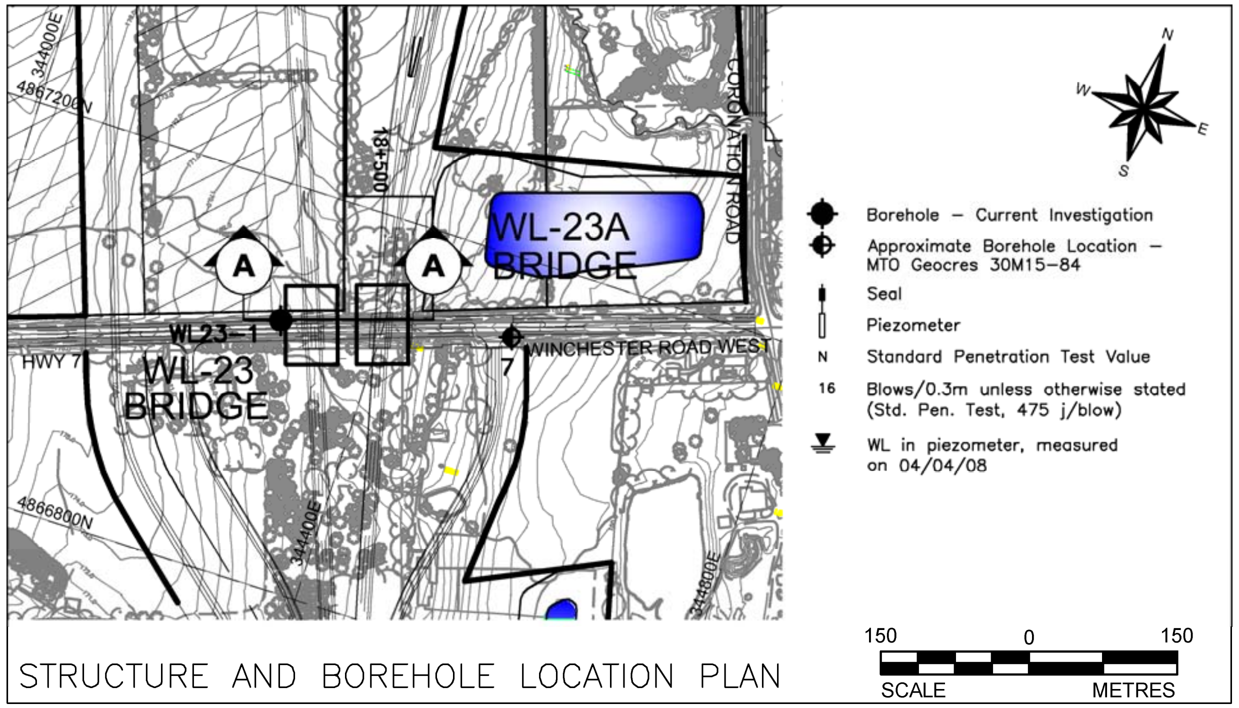
Site Photograph

Summarized Subsurface Conditions	**Recommendations – Structure**	**Recommendations – Approaches**	**Remarks**
Boreholes: No Borehole at the site. Mapping (West 7) shows that the Hall Road alignment crosses a ~70m wide silty sand alluvial plain overlain by peat. The relief is low plain with poor to very poor drainage. To the south lies a well drained sandy silt plain and to the north a rolling, poorly drained silt till ground moraine. **Groundwater** **GWL is assumed to be at or close to the surface.** **Estimated overburden thickness – 20m.**	For planning purposes, it may be assumed that an open footing culvert may be supported on the native soil at depths in the order to 2 to 3 m below existing ground surface. Footings must bear below organics or recent alluvium. Footings may be designed on the basis of a. Factored resistance at ULS –300 kPa b. Resistance at SLS – 200 kPa A closed box culvert may also be used at this site. Assume the culvert will be bedded on Granular A. The required thickness of bedding must be determined during detail design.	Settlement and stability not expected to be problematic unless high fills are requires, e.g. greater than 8m. However, this must be analyzed during detail design.	Moderately wide, well defined valley with old meander scars and 25-40 degree steep valleysides; meandering channel has undercut valleysides, which has led to localized slumps Valley bottom sediments >1 m deep and dominantly gravelly silty sand alluvium with some clay, locally interbedded with buried organic material; presence of boulders in channel suggests till locally at or close to streambed elevation Unwatering and temporary stream diversion may be required.
		Site Ranking **Foundations:** **Low** **Hydrogeology:** **Medium**	

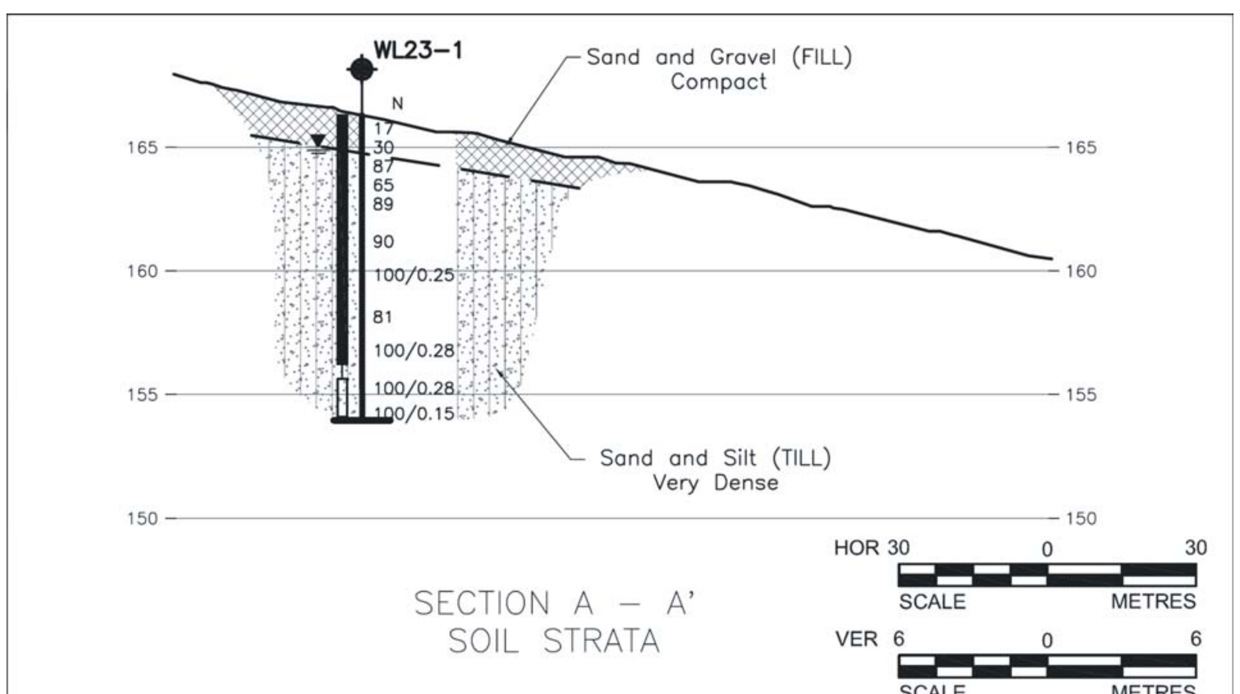
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass West Durham Link / Winchester Road West (Hwy 7)
WDL Proposed Grade: 173.9 m
Site Ranking: Medium

Location No: WL-23, WL23-A
Existing Ground Elevation: 161 m - 168 m
Station: 18+330



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The proposed bridge structure WL-23 is located along Highway 7 (Winchester Road West), approximately 400 m west of Coronation Road, in the Town of Whitby, Ontario. Highway 7 at this site is an approximate 11 m wide asphalt roadway consisting of one lane in the eastbound direction and two lanes in the westbound direction. The area beyond existing Highway 7 consists mainly of farmland, and the terrain in the vicinity of the proposed structure generally slopes down from west to east. The current borehole WL23-1 was drilled on the north shoulder of Highway 7.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL23-1	North Abutment	4 867 065.4	344 299.7	166.3	12.3
7[1,2]	Greater than 100 m from proposed structure footprint	4 867 120.4	344 526.8	156.4	6.4

Notes:
1. GEOCRES 30M15-84. Coordinates on original Borehole log referenced to MTM-NAD27.
2. This previously drilled borehole has been excluded from the subsurface description and design recommendations for this structure, given that it is located far from the structure site. A copy of the original borehole log has been provided for additional information purposes only.

Subsurface Conditions:

- **Fill:** sand and gravel fill was encountered in Borehole WL23-1, and extends to a depth of 1.5 m (Elevation 164.8 m). Two SPT 'N' values measured within the fill material were 17 and 30, indicating a compact relative density. Measured water contents on two samples were 2 and 9 percent.

- **Till:** consisting predominantly of sand and silt, containing trace to some gravel and clay was encountered in Borehole WL23-1 underlying the fill layer. The borehole was terminated within the till deposit at a depth of 12.3 m below ground surface (Elev. 154.0 m). The SPT 'N' values measured within the sand and silt till deposit ranged from 65 blows per 0.3 m of penetration to 100 blows per 0.15 m of penetration, indicating the till deposit is very dense. Grain size distribution and Atterberg limits test results are presented on Figure WL23-A and WL23-B (Appendix B), respectively. Measured water contents on samples of the sand and silt till deposit ranged between 6 and 9 percent.

Groundwater Conditions:

- **BH WL23-1:** Depth of 1.3 m below ground surface (Elevation 165.0 m) measured in piezometer on April 4, 2008.

Record of Borehole Sheets – Appendix A | **Laboratory Test Results – Appendix B** | **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-23, WL-23A

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the West Durham Link profile drawing (dated July 2008) provided by URS, the proposed overpass will carry the WDL SB and NB lanes over Winchester Road West (Hwy 7) and is approximately 40 m in length. Hence, a single-span closed type structure is assumed for discussion. A grade raise of about 1.5 m is proposed for Highway 7 at the structure location, resulting in a proposed grade at about Elevation 165.6 m. The proposed grade of the WDL at this location is about Elevation 173.9 m, with approach embankments up to 8.5 m high. Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very dense sand and silt till or on compacted Granular 'A' pad, where applicable for abutment footings 'perched' within the bridge approaches	• Lower costs than deep foundations • Conventional construction • Allows for semi-integral design	• Will require sub-excavation of about 1.5 m of surficial fill materials
Steel H-Piles driven into "100-blow" sand and silt till	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, possibly containing cobbles
Caissons bored to found within "100-blow" sand and silt till	• Higher bearing resistances than steel H-Piles	• More expensive than pile foundations • Drilling must be advanced through till, possibly containing cobbles • May require temporary or permanent liner to prevent seepage inflow and softening of caisson base

A - Spread Footings: Spread footings founded on the very dense sand and silt till and at least 1.2 m below the lowest surrounding grade (for frost protection) can be assumed for preliminary design. Based on Borehole WL-23-1, footings founded at or below about Elevation 164.5 can be considered. Abutment footings can alternatively be founded on a compacted Granular 'A' pad constructed within the bridge approach fills.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Very dense Sand and Silt Till	600 kPa	400 kPa
Compacted Granular 'A' ("perched" abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt till deposit at or below Elevation 157 m, are feasible for support of abutments with perched pile caps; piles would be approximately 13 m long.

Pile	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110 (abutments, "perched" pile caps)	1,600 kN	1,400 kN

C – Caissons: Abutment foundations supported on caissons founded within the "100-blow" sand and silt till at or below Elevation 155 m can be considered. Caissons lengths would be about 10 m, extending a minimum of 2 m into the "100-blow" till deposit.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	4,500 kN	3,500 kN
1.5 m	6,500 kN	5,500 kN

Recommended Foundation Alternative: Shallow foundations; Steel H-Piles with "perched" pile caps are also appropriate for support of the abutments.

- ## ABUTMENT TYPE

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- ## APPROACHES

Height: up to about 8.5 m.

Stability: Approach embankments consisting of select subgrade material or granular fill up to about 8.5 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) should have an adequate factor of safety against deep-seated slope instability. As per MTO requirements, a mid-height berm (2 m wide) is required for all granular fill embankments exceeding a height of 8 m. Subexcavation of the 1.5 m thick layer of surficial fill would not be required.

Settlement: Assuming that any localized soft/loose soils containing excessive organics are removed, the total settlement of the foundations soils below the embankments is expected to be less than 25 mm. Settlements of less than 25 mm can also be expected to occur within the properly compacted granular fill embankment itself. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- ## CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill materials and sand and silt till are classified as Type 3 and Type 2 soils, respectively, according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H : 1V in the Type 3 soils, and sloped to within 1.2 m of the bottom of the excavation with a slope of 1H : 1V in Type 2 soils.

Groundwater/Surface Water Control: Based on the groundwater conditions encountered in the boreholes, excavations for shallow foundations at about Elevation 164.5 m will be at or slightly below the groundwater table (measured at about Elevation 165 m on April 4, 2008). Surface water/groundwater infiltration into the excavations can be adequately controlled by pumping from properly filtered sumps and diverted by temporary ditches.

Protection Systems: Refer to Section 6.7.2 of the Report.

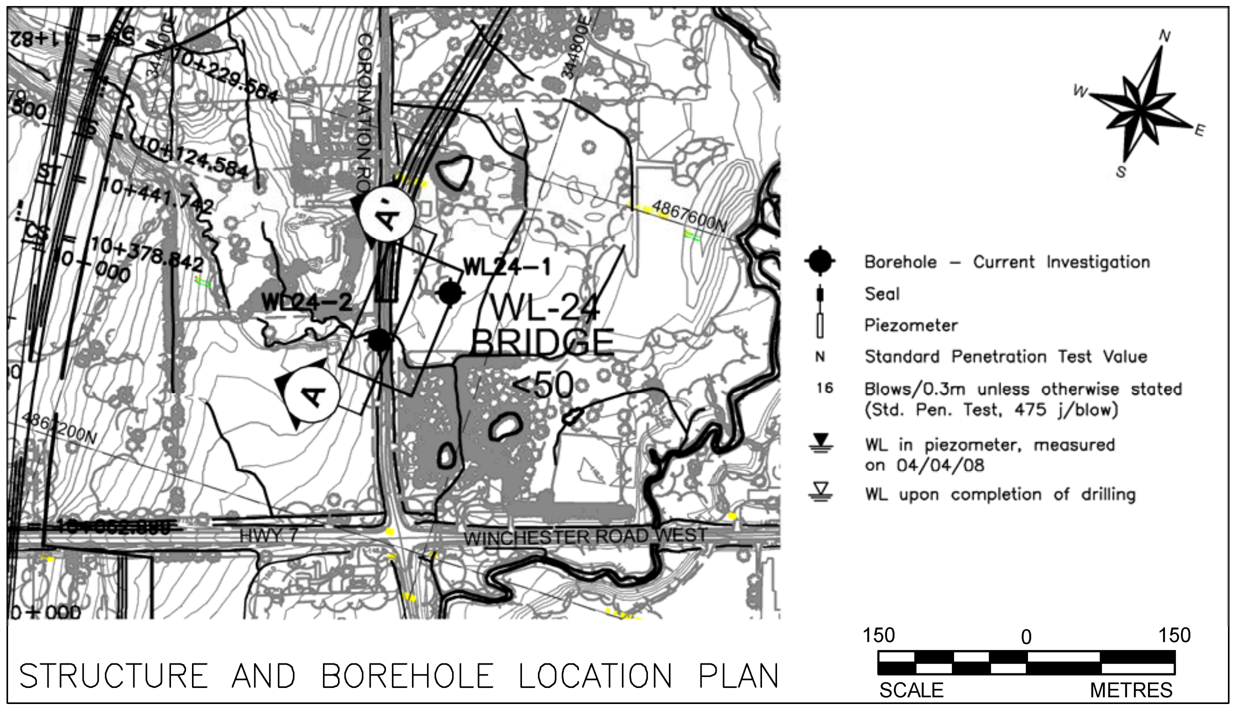
Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to assist in driving into the "100-blow" material. No major obstructions (e.g. cobbles or boulders) are anticipated at this site based on borehole data at this site.

- ## RECOMMENDATIONS FOR ADDITIONAL WORK

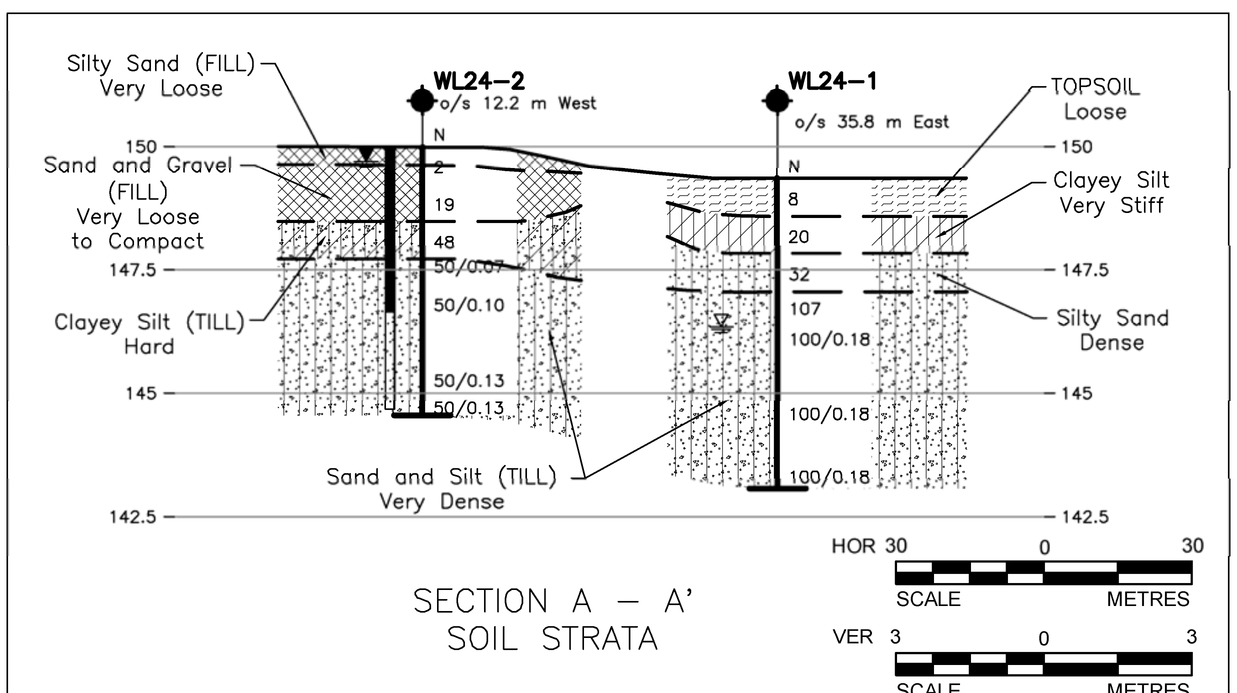
Further subsurface investigation should be carried out during detail design to confirm the subsoil conditions at the location of the bridge foundation elements.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	Overpass Highway 407 / Proposed Realigned Coronation Road over Lynde Creek Tributary – Deleted from Project	**Hwy 407 Proposed Grade:**	Not Available	**Site Ranking:**	Medium
Location No:	WL-24 (Part A Only – Deleted)	**Existing Ground Elevation:**	149.0 m – 150.0 m	**Station:**	-



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of the proposed structure WL-24 was to be located just east of Coronation Road, approximately 220 m north of Highway 7 in the Town of Whitby, Ontario. Coronation Road in this area is approximately 5.5 m wide and consists of two lanes. The site in the vicinity of the proposed structure is surrounded by farmland and contains a densely treed area immediately east of the proposed structure. Lynde Creek Tributary also flows easterly across Coronation Road. The terrain at the site is relatively flat to gently sloping.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL24-1	North Abutment	4 867 462.1	344 744.7	149.3	6.3
WL24-2	South Abutment	4 867 394.5	344 690.9	150.0	5.5

Subsurface Conditions:

- **Topsoil/Fill:** loose topsoil, 0.8 m thick layer encountered in Borehole WL24-1. One SPT 'N' value measured within the topsoil was 8 blows per 0.3 m of penetration. In Borehole WL24-2, granular fill comprised of silty sand containing organics to sand and gravel with trace to some silt was encountered at the ground surface, and extended to a depth of 1.5 m (Elevation 148.5 m) below ground surface. Two SPT 'N' values were 2 and 19 blows per 0.3 m of penetration, indicating a very loose to compact relative density. Measured water contents within the fill layer were about 28 and 12 percent.

- **Clayey Silt:** clayey silt, containing some sand and trace gravel, was encountered in Borehole WL24-1 immediately below the topsoil, and extended to a depth of 1.5 m (Elev. 147.8 m). One SPT 'N' value measured within the clayey silt layer was 20 blows per 0.3 m of penetration, indicating a very stiff consistency. Measured water content was about 15 percent.

- **Silty Sand:** silty sand, containing trace clay and gravel, was encountered in Borehole WL24-1 underlying the clayey silt. The 0.8 m thick silty sand layer extended to Elevation 147.0 m. One SPT 'N' value measured within this layer was 32 blows per 0.3 m of penetration, indicating a dense relative density. Measured water content was about 8 percent.

- **Till:** clayey silt, containing some sand and trace gravel, was encountered in Borehole WL24-2 underlying the fill layer. The till layer extended to a depth of 2.3 m (Elev. 147.1 m). One SPT 'N' value measured within the till layer was 48 blows per 0.3 m of penetration, indicating a hard consistency. Atterberg limit test results are presented on Figure WL24-A (Appendix B). Measured water content within the clayey silt till was approximately 11 percent.
  Sand and silt, containing trace to some gravel and clay, was encountered at Elevation 147.1 m and Elevation 147.7 m in Boreholes WL24-1 and WL24-2, respectively. Both boreholes were terminated within the sand and silt till deposit at a depth of 6.3 m (Elev. 143.1 m) and 5.5 m (Elev. 144.5 m), respectively. SPT 'N' values measured within the till deposit varied from 107 blows per 0.3 m of penetration to 50 blows per 0.07 m of penetration, indicating a very dense relative density. Grain size distribution and Atterberg limits test results are presented on Figures WL24-B and WL24-C (Appendix B), respectively. Measured water contents vary between 5 and 8 percent.

Groundwater Conditions:

- **BH WL24-1:** Depth of 3.0 m below ground surface (Elev. 146.3 m) in open borehole upon completion of drilling.

- **BH WL24-2:** Depth of 0.7 m below ground surface (Elev. 149.3 m) in piezometer on February 28, 2008; depth of 0.3 m below ground surface (Elev. 149.7 m) in piezometer on April 14, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 5**

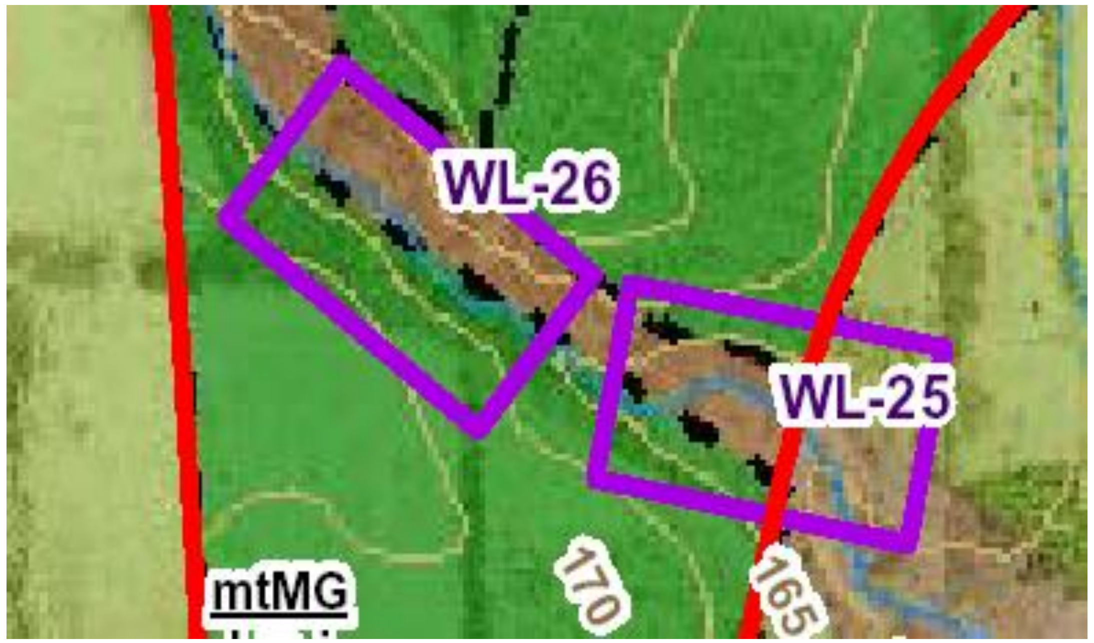
HIGHWAY 407 EAST EXTENSION – ANTICIPATED FOUNDATION CONDITIONS

(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:	WL-25

W.O: 07-20015 **Section:** Western **Location:** West Link S – Hwy 407 E/W Ramp **Sta.** 19+600

Original Grade: **Proposed Grade:** **Description:** Structure to carry ramp over far west Lynde Creek Tributary



Site Plan and Terrain Analysis

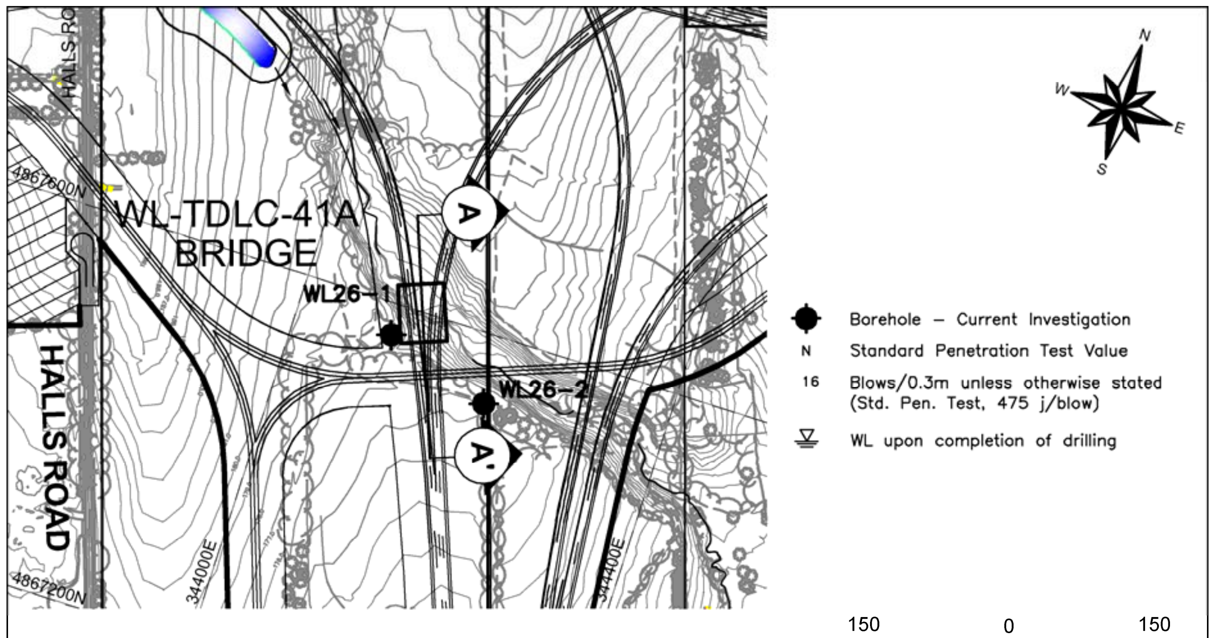
No Photo

Site Photograph

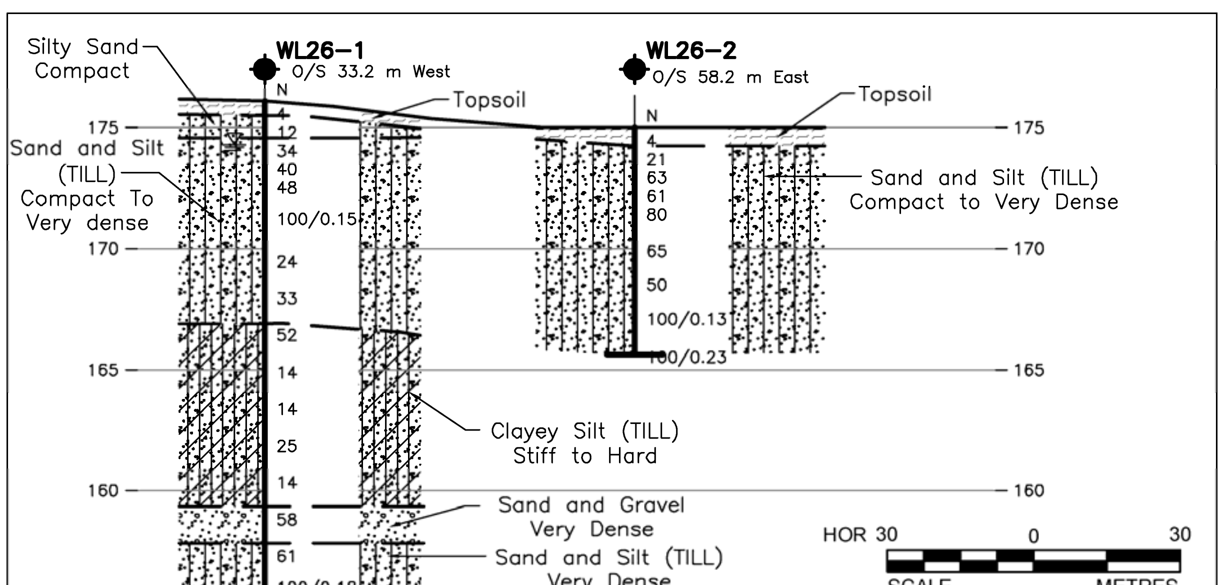
Summarized Subsurface Conditions	**Recommendations – Structure**	**Recommendations – Approaches**	**Remarks**
Boreholes: No BH at the site. Mapping (West 4) shows that the site is underlain by a 40m wide, silty sand alluvial plain within a wider area of silt till ground moraine. The Lynde creek tributary flows within the alluvial plain. The relief in the alluvial plain is low plain, poorly drained. The surrounding relief is low, rolling, imperfectly drained. **Groundwater** At the creek, the GWL should be assumed to be at the ground surface.	**1. Abutments** In the absence of specific soil information, assume the abutments will be supported on H-piles driven to refusal. a. ULS resistance – 1,600 kN b. SLS resistance – 1,400 kN Integral abutments are feasible. Assume 20m long piles. Spread footings may be feasible if the abutments are kept outside the alluvial plain of the creek. **2. Piers** If piers are required, assume piles as described above.	Approach fills up to 10 m high may be constructed at side slopes up to 2H:1V using SSM or better. No global stability or settlement issues are anticipated based on the general interpretation of the local stratigraphy. Stripping of topsoil or other unsuitable soils will be required prior to construction.	Unwatering of excavations will be required. Depending on final grades, specific groundwater control measures may be required. Narrow, well defined valley (once a glacial meltwater spillway) with moderately steep valleysides and no geomorphic evidence of significant valleyside instability
		Site Ranking **Foundations:** **Medium** **Hydrogeology:** **Low**	

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description:	Hwy 407/WDL IC, E-S & W-S Ramps over Lynde Creek Tributary	**E-S Ramp/W-S Ramp Proposed Grade:**	173 m – 175 m	**Site Ranking:**	Medium
Location No:	WL-26 (WL-TDLC-41A)	**Existing Ground Elevation:**	167 m – 172 m	**Station:**	10+985 (W-S Ramp) 11+461 (E-S Ramp)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The proposed bridge structure WL-TDLC-41A is located approximately 570 m north of Highway 7 (Winchester Road West), and approximately 360 m east of Halls Road, in the Town of Whitby, Ontario. The bridge structure crosses the Lynde Creek Tributary which flows from north to south-east, and is surrounded mainly by gently sloping farmland, except immediately to the east of the site, where a tree-covered ridge is located that runs parallel to the creek. Overall, the terrain slopes downward from north-west to the south-east.

Borehole Information:

Borehole No.	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL26-1	South Abutment	4 867 568.0	344 100.9	176.1	23.0
WL26-2[1]	Approximately 75 m away from proposed structure	4 867 529.7	344 213.2	175.0	9.4

Notes: 1. Borehole WL26-2 has been excluded from the design recommendations for this structure, given that it is located far from the structure site.

Subsurface Conditions:

- **Topsoil/Silty Sand:** topsoil, up to 0.8 m thick, was encountered in both boreholes. Two measured SPT 'N' values were 4 blows per 0.3 m of penetration, indicating a soft to firm consistency or very loose to loose relative density. A 0.9 m thick layer of silty sand, containing trace clay, was also encountered in Borehole WL26-1 immediately below the topsoil. One measured SPT 'N' value was 12 blows per 0.3 m of penetration, indicating a compact relative density. Measured water content was 14 percent on a sample of silty sand.

- **Till:** sand and silt, containing some gravel, trace to some clay was encountered below the silty sand and topsoil in Boreholes WL26-1 and WL26-2, respectively. The sand and silt till extended to the termination depth of 9.4 m (El. 165.6) and 23.0 m (El. 153.1 m) for Boreholes WL26-2 and WL26-1, respectively. An interlayer of clayey silt till, some sand was encountered within the sand and silt till deposit in Borehole WL26-1 at a depth of 9.2 m (Elev. 166.9 m) and was 7.6 m thick. Measured SPT 'N' values within the sand and silt till ranged from 21 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a compact to very dense relative density. The results of six grain size distribution tests and four Atterberg limits tests are presented on Figures WLTDLC41A-A and WLTDLC41A-B (Appendix B), respectively. Measured water contents within the sand and silt till ranged from 3 to 12 percent. Measured SPT 'N' values within the clayey till interlayer ranged from 14 to 52 blows per 0.3 m of penetration, indicating a stiff to hard consistency. The results of one grain size distribution test and one Atterberg limits test performed on a sample of the clayey till are presented on Figures WLTDLC41A-C and WLTDLC41A-D (Appendix B). Measured water contents within the clayey till ranged from 11 to 15 percent.

- **Sand and Gravel**: A 1.5 m thick layer of sand and gravel was also encountered immediately below the clayey silt till in Borehole WL26-1. One measured SPT 'N' value within the granular layer was 58 blows per 0.3 m of penetration, indicating a very dense relative density. One measured water content was 5 percent.

Groundwater Conditions:

- **BH WL26-1:** Depth of 1.8 m below ground surface (Elev. 174.3 m) upon completion of drilling.
- **BH WL26-2:** Borehole dry upon completion of drilling.

Record of Borehole Sheets – Appendix A | **Laboratory Test Results – Appendix B** | **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-26 (WL-TDLC-41A)

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, two bridge structures (possibly with the same foundation) are proposed; one to carry the Hwy 407/WDL W-S Ramp and the other to carry the E-S Ramp over the realigned Lynde Creek tributary. The W-S Ramp structure is a single span bridge with a span length of 23 m and approach embankments from approximately 2.5 m to 3.5 m high along the south and north abutments, respectively. The E-S Ramp is also a single span bridge with a span length of 21 m and approach embankments from approximately 4 m to 5.5 m high along the south and north abutments, respectively. It is noted that Borehole WL26-2 was not considered in the design recommendations as it is located too far from the proposed bridge site(s). Feasible foundation options for the proposed bridge abutments are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on compact to dense sand and silt till or on stiff clayey silt till	• Possible lower costs than deep foundations • Allows for semi-integral design	• Close proximity to creek; dewatering with possible cofferdam construction may be required.
Steel H-Piles driven into “100-blow” sand and silt till	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through very dense till
Caissons bored to found within “100-blow” sand and silt till	• Higher bearing resistances than steel H-Piles	• More expensive than pile foundations • Drilling must be advanced through very dense till • May require temporary or permanent liner to prevent seepage inflow and softening of caisson base

A - Spread Footings: Founded within the compact to dense sand and silt till or stiff to very stiff clayey silt till at or below Elevation 168 m at the south abutment and Elevation 167 m at the north abutment location; all footings should be placed at a minimum depth of 1.2 m below the lowest surrounding grade.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Compact to Dense Sand and Silt Till / Stiff to Very Stiff Clayey Silt Till	450 kPa	300 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the “100-blow” sand and silt till deposit at or below Elevation 155 m, are feasible for support of the W-S Ramp and E-S Ramp abutments; piles would be approximately 11 m to 13 m long.

Pile	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,600 kN	1,400 kN

C – Caissons: Abutment foundations supported on caissons founded within the “100-blow” sand and silt till at or below Elevation 155 m can be considered. Caissons lengths would be about 11 m to 13 m, extending a minimum of 2 m into the “100-blow” till deposit.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	4,500 kN	3,500 kN
1.5 m	6,500 kN	5,500 kN

Recommended Foundation Alternative: Steel H-Piles.

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional, integral or semi-integral abutments.

- **APPROACHES**

Height: up 3.5 m along the W-S Ramp and up to 5.5 m along the E-S Ramp.

Stability: Approach embankments consisting of select subgrade material or granular fill up to about 5.5 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) should have an adequate factor of safety against deep-seated slope instability.

Settlement: Assuming the use of conventional earth or granular embankments fills, it is expected that less than 50 mm of settlement will occur under the footprint of the new embankments. The majority of the settlement is expected to occur during and immediately after construction (i.e. elastic settlement).

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the silty sand and sand and silt till / clayey silt till are classified as Types 3 and 2 soils according to the OHSA. Temporary excavations (i.e. open for a relatively short time period) should be sloped no steeper than 1H: 1V extending to the base of the excavation. For Type 2 soils, temporary excavations can be sloped at 1H : 1V to within 1.2 m of the bottom of the excavation.

Groundwater/Surface Water Control: Based on the groundwater conditions encountered in the borehole, excavations for shallow foundations or pile caps are expected to extend to Elevation 165 m and can be adequately controlled by pumping from filtered sumps. However, dewatering ahead of the excavation operations may be required for excavations below about Elev. 174 m in silty / sandy materials to prevent possible “boiling” of the base of the excavation as a result of unbalanced hydrostatic heads.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used to assist in driving into the “100-blow” material. No major obstructions (e.g. cobbles or boulders) are anticipated at this site based on borehole data at this site.

- **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 and to determine whether artesian conditions may exist within the sand and gravel layer encountered at depth.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Overpass Highway 407/WDL IC, W-S Ramp over Lynde Creek Tributary – Deleted from Project

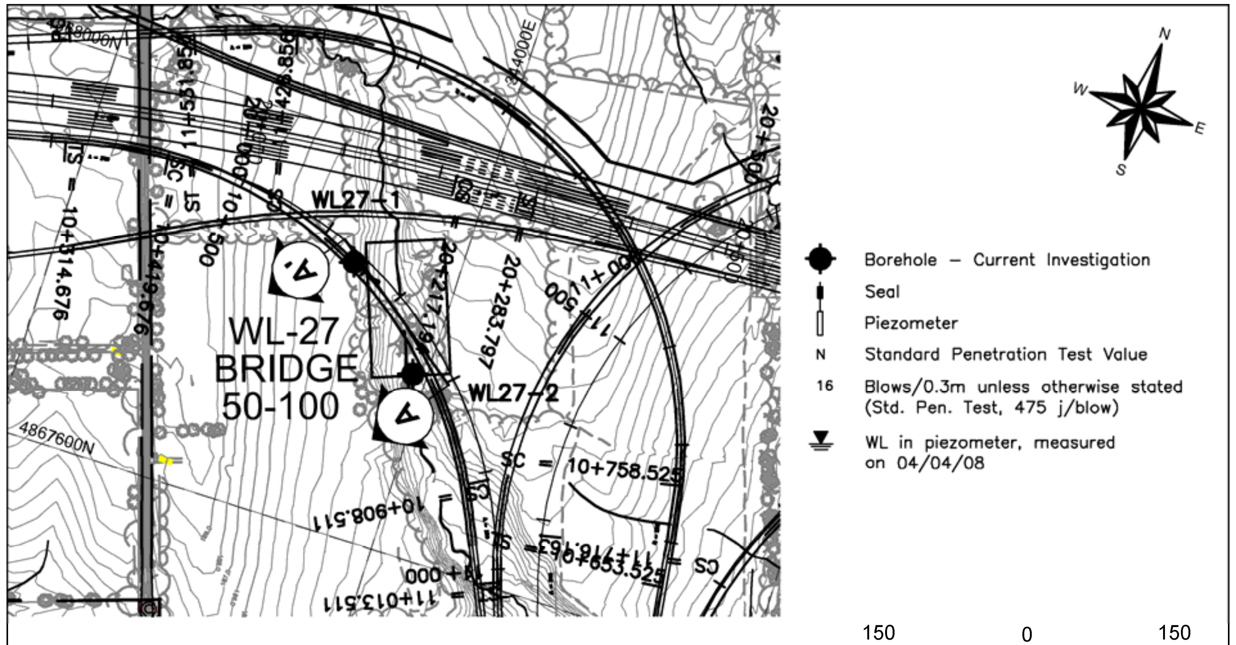
Hwy 407 Proposed Grade: Not Available

Site Ranking: Medium

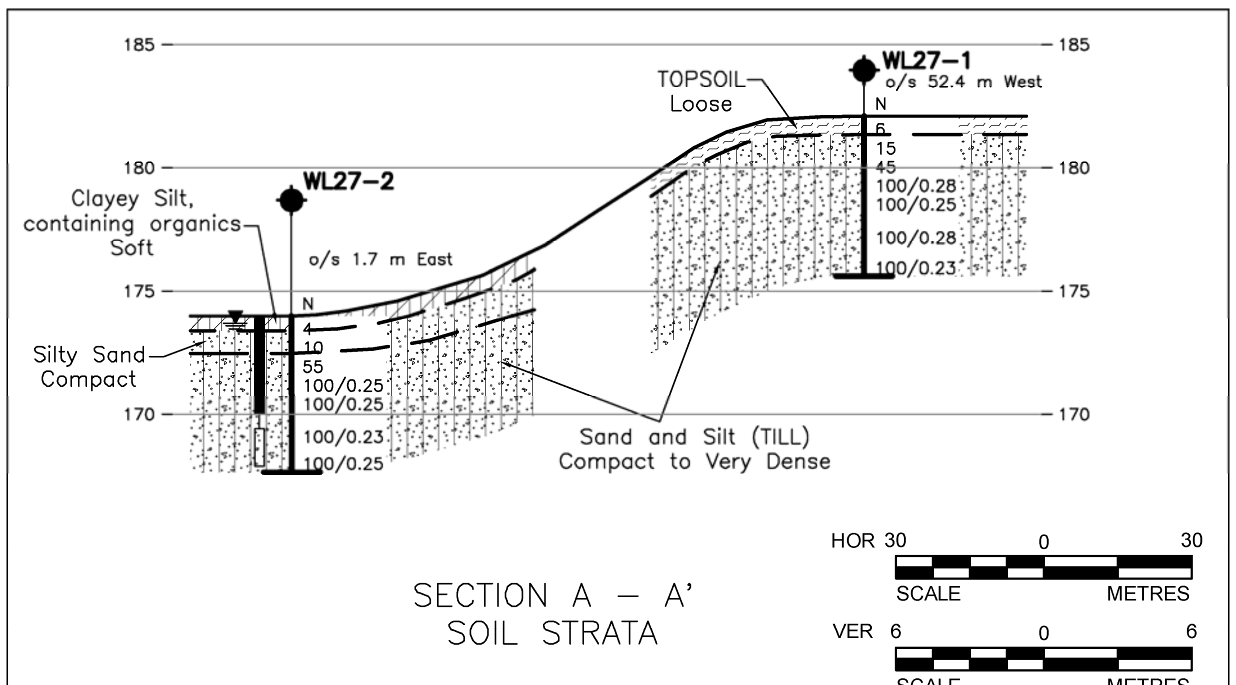
Location No: WL-27 (Part A Only – Deleted)

Existing Ground Elevation: 174.0 m – 182.5 m

Station: 20+140



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of the originally proposed WL-27 structure is situated approximately 260 m east of Halls Road North and 850 m north of Highway 7 in the Town of Whitby, Ontario. The site is surrounded by farmland with a creek tributary flowing south-east across the proposed structure. Vegetation in the vicinity of the site is comprised of trees and shrubs to the east and west of the proposed bridge structure. Topographically, the structure is situated on top of a ridge which runs north-south across the site.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL27-1	North Abutment	4 867 872.5	343 894.5	182.1	6.5
WL27-2	South Abutment	4 867 782.7	343 985.7	174.0	6.4

Subsurface Conditions:

- **Topsoil/Clayey Silt:** 0.8 m thick layer of loose topsoil was encountered at the ground surface in Borehole WL27-1. One SPT 'N' value measured within the topsoil is 6 blows per 0.3 m of penetration. Measured water content is approximately 42 percent.
  Clayey silt, containing some sand and organics, was encountered at the ground surface in Borehole WL27-2. One SPT 'N' value measured within the clayey silt layer is 4 blows per 0.3 m of penetration, indicating a soft consistency. Measured water content is about 33 percent.

- **Silty Sand:** silty sand, containing trace clay and gravel, encountered in Borehole WL27-2, immediately below the surficial clayey silt. The silty sand layer, 0.8 m thick, extended to Elevation 172.5 m. One SPT 'N' value measured within this layer was 10 blows per 0.3 m of penetration indicating a compact relative density. Measured water content is about 30 percent.

- **Till:** sand and silt, containing trace to some gravel and clay, was encountered in Borehole WL27-1 immediately below the topsoil and extended to a depth of 6.5 m (Elev. 175.6 m); in Borehole WL27-2, the sand and silt till was encountered below the silty sand layer and extended to a depth of 6.4 m (Elev. 167.7 m). Both boreholes were terminated within the till deposit. Measured SPT 'N' values generally ranged from 45 blows per 0.3 m of penetration to 100 blows per 0.23 m of penetration, indicating a dense to very dense relative density; one SPT 'N' in the upper portion of the till deposit in Borehole WL27-1 was 15 blows per 0.3 m of penetration, indicating a compact relative density. The results of grain size distribution and Atterberg limits tests are presented on Figures WL27-A and WL27-B (Appendix B), respectively. Measured water contents range between 5 percent and 10 percent.

Groundwater Conditions:

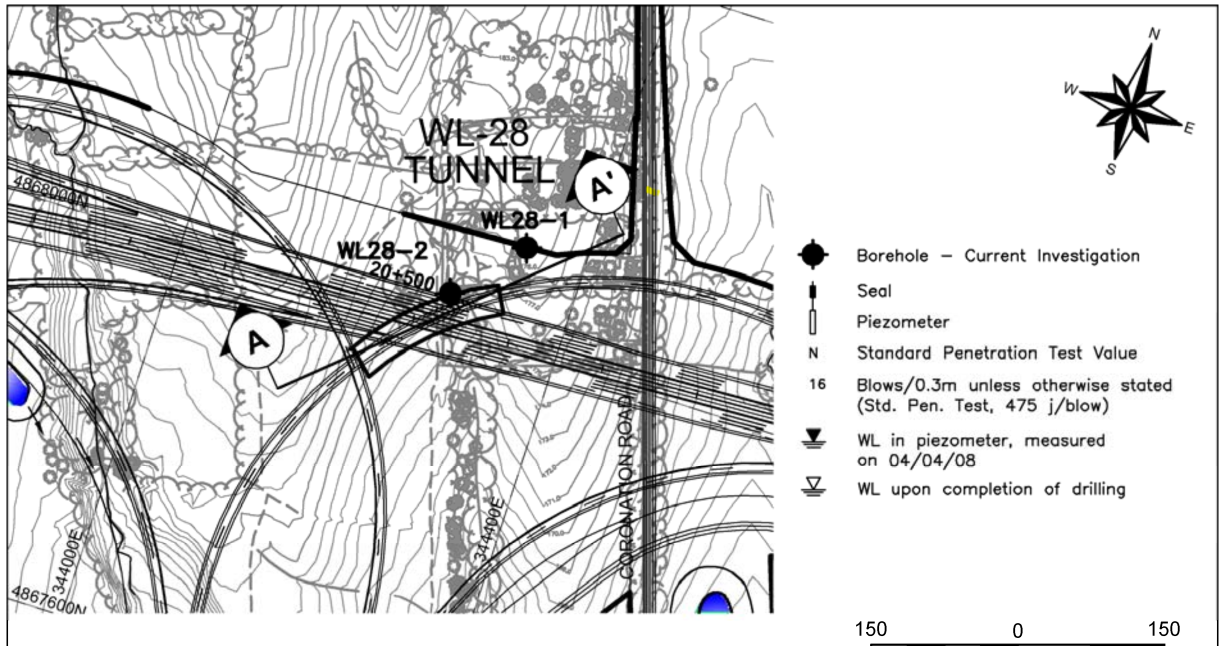
- **BH WL27-1:** Borehole dry upon completion of drilling.

- **BH WL27-2:** Depth of 1.5 m below ground surface (Elev. 172.5 m) in open borehole upon completion of drilling; depth of 0.3 m below ground surface (Elev. 173.7 m) in piezometer on April 4, 2008.

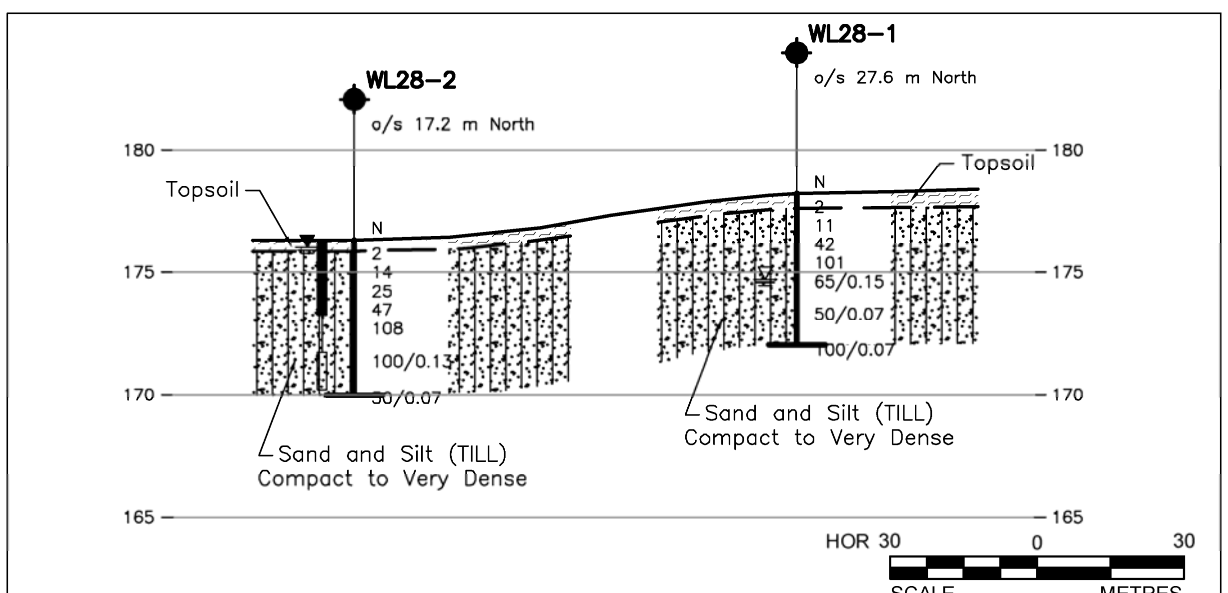
PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Tunnel - Hwy 407/WDL IC, Hwy 407 over E-S Ramp
Hwy 407 Proposed Grade: 174.5 m – 175 m
Site Ranking: High

Location No: WL-28
Existing Ground Elevation: 176 m – 181 m
Station: 20+510



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of structure WL-28 is located approximately 200 m west of Coronation Road, and approximately 950 m north of Highway 7 (Winchester Road West). The site is mainly surrounded by gentley sloping farmland except to the west of the site, where the terrain consists of a ridge covered with vegetation and trees. The overall terrain slopes downward from the north-west to the south-east.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WL28-1	North Approach	4 868 104.2	344 337.6	178.2	6.2
WL28-2	North Abutment	4 868 036.2	344 277.3	176.3	6.3

Subsurface Conditions:

- **Topsoil:** topsoil, 0.6 m and 0.5 m thick, was encountered in Boreholes WL28-1 and WL28-2, respectively. Two measured SPT 'N' values were 2 blows per 0.3 m of penetration, indicating a very loose relative density. The measured water content on one sample of topsoil from Borehole WL28-1 was 26 percent.

- **Till:** sand and silt, containing some gravel and clay, was encountered immediately below the topsoil in both boreholes. Boreholes WL28-1 and WL28-2 were terminated within the till deposit at a depth of 6.2 m (Elev. 172 m) and 6.3 m (Elev. 170 m), respectively. SPT 'N' values measured within the till generally ranged from 42 blows per 0.3 m of penetration to 100 blows per 0.07 m of penetration, indicating a dense to very dense relative density; one SPT 'N' value in the upper portion of the sand and silt till in Borehole WL28-1 and two SPT 'N' values in the upper portion of till in Borehole WL28-2 ranged from 11 to 25 blows per 0.3 m of penetration, indicating a compact relative density. Grain size distribution test results are presented on Figure WL28-A (Appendix B); Atterberg limits test results are presented on Figure WL28-B. Measured water contents within the till deposit ranged from 6 to 11 percent. Measured water contents generally varied from approximately 5 to 7 percent; two measured water contents in the upper portion of the till in Borehole WL28-1 were 9 and 11 percent.

Groundwater Conditions:

- **BH WL28-1:** Depth of 3.5 m below ground surface (Elev. 174.7 m) in open borehole upon completion of drilling.

- **BH WL28-2:** Depth of 5.2 m below ground surface (Elev. 171.1 m) in open borehole upon completion of drilling; depth of 0.3 m below ground surface (Elev. 176 m) in piezometer on April 4, 2008.

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-28

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, the proposed bridge structure will carry the Hwy 407 EB and WB lanes over the Hwy 407/WDL E-S Ramp. The E-S Ramp alignment is also located below the Hwy 407/WDL S-W Ramp, located directly south-west of the proposed structure. The bridge will be constructed entirely below existing ground surface and is categorized as a tunnel. The bridge/tunnel will be a single span structure with a span of about 13 m and a total tunnel length of 128 m. The E-S Ramp pavement grade within the tunnel is at about 163 m and is up to about 16 m below the existing ground surface.

Feasible foundation options are provided below with the advantages and disadvantages for each option. It is noted that the boreholes drilled at this site were terminated 3 m into "100-blow" material; however, they did not extend to the proposed base of tunnel / foundation level at this preliminary design stage.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on inferred "100-blow" sand and silt till	• Most practical • Conventional construction	• Requires sub-excavation of up to about 18 m below existing ground surface - although this typically would apply to all options for the tunnel.
Steel H-Piles driven into inferred "100-blow" sand and silt till deposit	• Allows for integral abutment design	• Pre-augering may be required if "100-blow" till deposit (possibly containing cobbles) is located at proposed ground surface after cut.
Caissons bored to found within the inferred "100-blow" sand and silt till deposit	• Higher bearing resistance than steel H-piles	• More expensive than shallow foundations

A - Spread Footings: Spread footings placed at or below Elevation 173 m, and at a minimum depth of 1.2 m below the lowest surrounding grade will be founded on sand and silt till. It is noted that the boreholes did not extend lower than Elevation 170 m, however the proposed founding elevation is at or below about Elevation 162 m and actual subsoils at foundation level will need to be confirmed during detail design.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
"100-blow" Sand and Silt Till	600 kPa	400 kPa

B - Steel H-Piles: Steel H- Piles are considered to be not practical at this site assuming the very dense (i.e. "100-blow") sand and silt till deposit is present at the proposed cut depth (i.e. after subexcavation for the tunnel). Pre-augering would likely be required in order to achieve minimum pile lengths (approximately 5 to 6 m). However, if pile foundations are desired, consideration may be given to pre-augering and driving to provide sufficient embedment of piles. Further assessment of this alternative may be carried out during detail design.

C – Caissons: Abutments on caissons, founded within the "100-blow" sand and silt till at or below Elevation 173 m. Caissons lengths should be at least 5 m and extend a minimum 2 m into the "100-blow" materials below the cap. The presence of the "100-blow" sand and silt till at and below the founding level must be confirmed at the detail design stage.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	3,500 kN	2,800 kN
1.5 m	5,500 kN	4,400 kN

Recommended Foundation Alternative: Shallow foundations

- **ABUTMENT TYPE**

The site soils are suitable for construction of conventional shallow foundations.

- **APPROACHES**

Height: up to 16 m cut section.

Stability: Slopes up to 16 m high, constructed in a cut section to the north-east and south-west of the tunnel, with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height bench (minimum 2 m wide) for slopes higher than 8 m, are anticipated to be safe against deep-seated slope instability.

Settlement: The approaches associated with the tunnel will be constructed in cut sections and thus settlement issues are not anticipated. Rebound (uplift) of the native till soils after the cut is not considered to be a concern.

- **CONSTRUCTION CONSIDERATIONS**

Excavation: the sand and silt till is classified as a Type 2 soil according to OHSA. Generally, temporary excavations (i.e. open for a relatively short time period) should be no steeper than 1H : 1V in Type 2 soils. At the tunnel site, temporary excavations are anticipated to be up to 18 m deep and up to 13 m below the current groundwater level. For temporary cut slopes greater than 8 m in height, side-slopes should made no steeper than 2H:1V with a mid-slope bench (2 m wide) to control temporary surficial erosion. Staged construction may be required to allow for groundwater levels to stabilize in order to achieve safe slopes and avoid sloughing of the surficial soils.

Groundwater/Surface Water Control: Based on the groundwater conditions encountered in the boreholes and assuming the "100-blow" sand and silt till extends to the foundation elevation, temporary excavations for shallow foundations at Elevation 162 m can be adequately controlled by ditching and pumping from properly filtered sumps. Localized areas of water seepage within the cut slope may be expected and controlled with temporary gravel sheeting or alternative methods. Permanent dewatering controls will likely be required as the base of the tunnel (i.e. pavement grade) will be about 13 m below the stabilized water level which was measured at the existing ground surface.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: piles and caissons are not recommended as the preferred and practical foundation options at this site. Cobbles should be expected to be present within the till soils.

- **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. Boreholes should extend to an adequate depth below the proposed excavation level / foundation level of the proposed tunnel / bridge.

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:	WL-28 WL-29

W.O: 07-20015 **Section:** Western **Location:** West Link at Mainline **Sta.** N/A

Original Grade: 183.4 **Proposed Grade:** **Description:** Structures to carry Ramp E –S and Ramp S – W over the Mainline

Site Plan and Terrain Analysis

No Photo

Site Photograph

Summarized Subsurface Conditions	**Recommendations – Structure**	**Recommendations – Approaches**	**Remarks**
Boreholes: No BH at the site. BH 8, GEOCRES 30M15-84, lies ~225m northwest Mapping (West 4) shows that the site is underlain by a silt till ground moraine. The relief is low plain, poorly drained. The surrounding relief is low, rolling, poorly to moderately drained. BH 8 encountered: 0.0 – 1.4 Silty sand, some organics, very dense 1.4 – 5.8 EOH Silty clay to clayey silt till, hard **Groundwater** The GWL should be assumed to be near the surface. **Estimated overburden thickness – 70m.**	The following recommendations are subject to the results of site specific investigation. **1. Abutments** a. Footings may be founded on Granular A cores per current MTO standard practices. b. For closed abutments, footings may be founded on hard native soil, assume 2m below ground surface 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.181.0. a. ULS resistance – 1,600 kN b. SLS resistance – 1,400 kN d. Integral abutments are feasible. Assume 10m long piles. Pre-drilling may be required. e. Designer may select foundation based on structure configuration and costs. **2. Piers** Piers may be supported using the same foundation options as for abutments. Spread footings on hard native soil are recommended.	Approach fills up to 10 m high may be constructed at side slopes up to 2H:1V using SSM or better. No global stability or settlement issues are anticipated based on the local stratigraphy. Stripping of topsoil or other unsuitable soils will be required prior to construction. **Site Ranking** **Foundations: High** **Hydrogeology: Low**	Unwatering of excavations will be required. Depending on final grades, specific groundwater control measures may be required.

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Structure Description: Hwy 407/WDL IC, S-W Ramp over Hwy 407/Lakeridge Rd. E-N/S Ramp

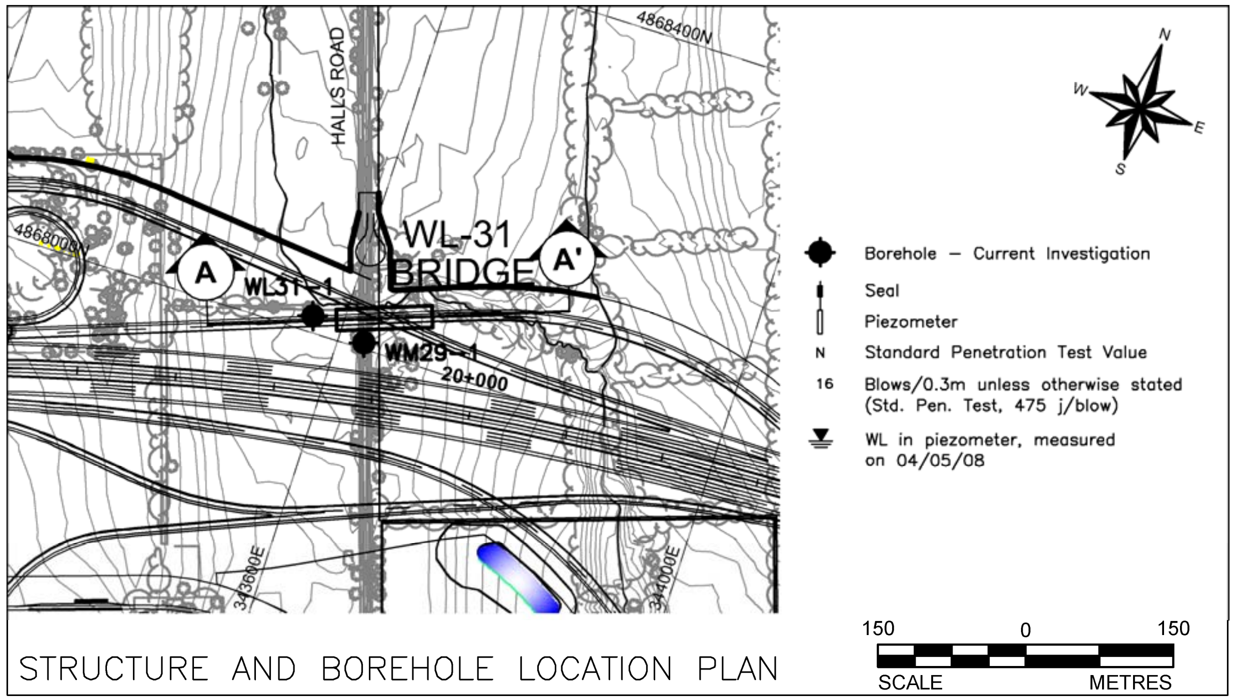
Location No: WL-31

W-S Ramp Proposed Grade: 198 m – 200 m

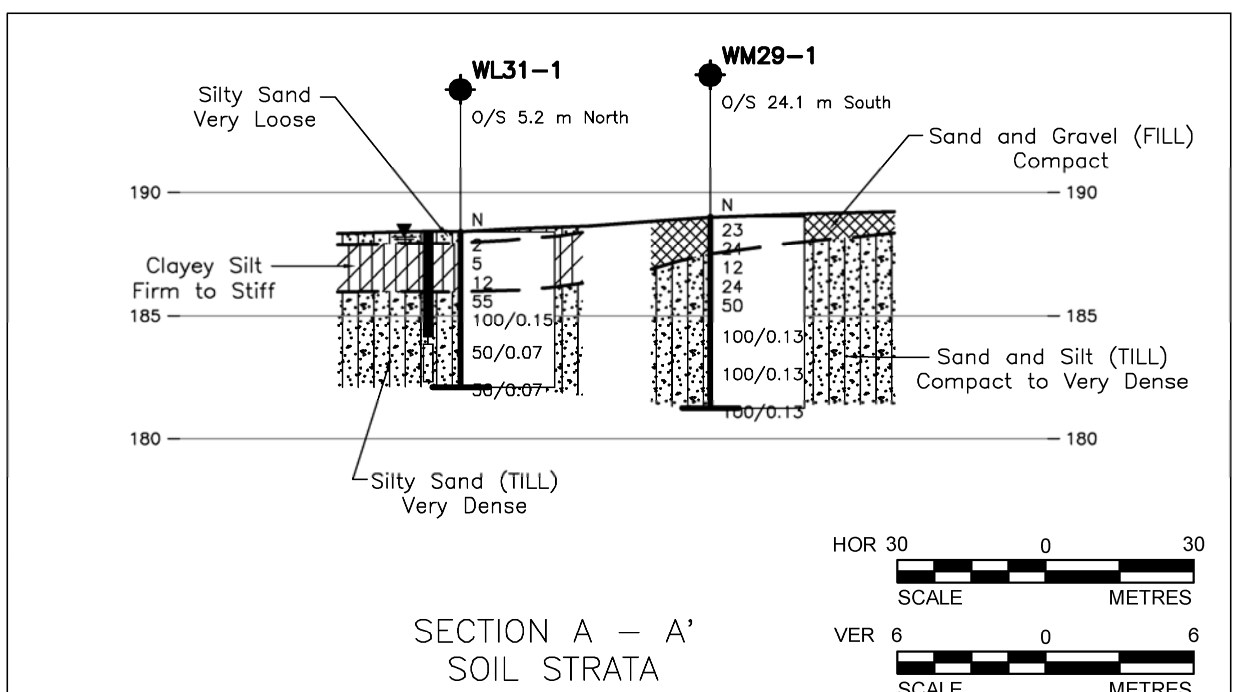
Existing Ground Elevation: 187.5 m – 190 m

Site Ranking: Medium

Station: 9+586 (S-W Ramp)



STRUCTURE AND BOREHOLE LOCATION PLAN



SECTION A – A'
SOIL STRATA

FOUNDATION INVESTIGATIONS

Site Description:

The site of structure WL-31 stretches east-west over the existing Halls Road, approximately 1.1 km north of Highway 7 in the Town of Whitby, Ontario. The site of the proposed structure is surrounded by farmlands, and just north of the proposed bridge structure, Lynde Creek is flowing from north to south-east. The terrain at this site slopes downwards to the south-east.

Borehole Information:

Borehole No	Borehole Location	MTM NAD 83 – Northing	MTM NAD 83 – Easting	Borehole Elevation (m)	Borehole Depth (m)
WM29-1	West Abutment/West Pier	4 868 006.6	343 626.2	189.0	7.8
WL31-1	West Abutment	4 868 016.8	343 568.7	188.4	6.3

Note: No boreholes were advanced near the proposed East Abutment and Pier; this should be addressed during Detail Design.

Subsurface Conditions:

- **Fill:** sand and gravel fill was encountered at the ground surface in Borehole WM29-1 and extending to a depth of 1.5 m (Elev. 163.2 m). Two SPT 'N' values measured within the fill were 23 and 24 blows per 0.3 m of penetration, indicating a compact relative density. Two measured water contents were approximately 3 and 4 percent.

- **Silty Sand:** A layer of 500 mm thick silty sand containing organics was encountered at the ground surface in Borehole WL31-1. One SPT 'N' value measured within the silty sand was 2 blows per 0.3 m of penetration, indicating a very loose relative density.

- **Clayey Silt:** brown clayey silt, containing trace sand, was encountered underlying the silty sand material in Borehole WL31-1 and extended to a depth of approximately 2.4 m (Elev. 186 m). Two SPT 'N' values were 5 and 12 blows per 0.3 m of penetration, indicating a firm to stiff consistency. A clayey silt seam was also encountered in Borehole WM29-1 at a depth 7.6 m (Elev. 181.5 m). The results of one grain size distribution and two Atterberg limits tests are presented on Figures WL31-A and WL31-B (Appendix B), respectively. Measured water contents within the clayey silt were about 19 and 22 percent.

- **Till:** sand and silt containing some clay, trace to some gravel and occasional cobbles, to silty sand containing some gravel and trace to some clay, was encountered immediately below the fill and clayey silt in Boreholes WM29-1 and WL31-1, respectively. Boreholes WM29-1 and WL31-1 were terminated within the till deposit at a depth of 7.8 m (Elev. 181.3 m) and 6.3 m (Elev. 182.1 m), respectively. SPT 'N' values measured within the till generally ranged from 50 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a very dense relative density, with the exception of the upper portion of the sand and silt till in Borehole WM29-1 where two SPT 'N' values were 12 and 24 blows per 0.3 m of penetration, indicating a compact relative density. Grain size distribution test results are presented on Figure WL31-C (Appendix B); Atterberg limits test results are presented on Figure WL31-D. Measured water contents within the till material ranged from 6 to 18 percent, and measured water contents varied between 5 and 11 percent.

Groundwater Conditions:

- **BH WM29-1:** Open borehole dry upon completion of drilling.
- **BH WL31-1:** Depth of 2.1 m below ground surface (Elev. 186.3 m) in open borehole upon completion of drilling; depth of 0.2 m below ground surface (Elev. 188.2 m) in piezometer on April 5, 2008.

Record of Borehole Sheets – Appendix A **Laboratory Test Results – Appendix B** **Key Location Plan – Drawing 4**

PART B - PRELIMINARY FOUNDATION DESIGN REPORT
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

LOCATION No:	WL-31

FOUNDATION RECOMMENDATIONS

Note: The site-specific foundation recommendations are for planning purposes only. Refer to Section 6.0 of the Foundation Design Report for the project-wide foundation recommendations, design assumptions and limitations.

General: Based on the General Arrangement drawing provided by URS in January 2009, the proposed bridge structure will carry the WDL Ramp South to Hwy 407 Ramp West (S-W Ramp) over the Hwy 407 Ramp East to Lakeridge Road Ramp N/S (E-N/S Ramp). The S-W Ramp structure is a three span bridge with a total length of 154 m and 10 m high approach embankments. It can be seen that RSS walls are proposed for both traffic directions on the E-N/S Ramp in order to retain part of the 2H: 1V side slope embankments of the S-W Ramp, with an approximately 5.5 m high RSS wall on the south side of the east abutment as shown on the drawing. Feasible foundation options for the proposed bridge abutments and piers are listed below with advantages and disadvantages associated with each option.

Foundation Option	*Advantages*	*Disadvantages*
Spread Footings founded on very dense sand and silt till or silty sand till or on a compacted Granular 'A' pad for abutment footings "perched" within the bridge approaches	• Lower costs than deep foundations • Conventional construction	• Requires sub-excavation of about 3 m of surficial fill material, silty sand, clayey silt and sand and silt till
Steel H-Piles driven into "100-blow" sand and silt till to silty sand till for piers and abutments with "perched" pile caps	• Allows for integral abutment design	• More expensive than shallow foundations • Requires flange plate reinforcement to facilitate driving through till, possibly containing cobbles/boulders • Pre-augering will be required to provide minimum embedment of piles for semi-integral design and to achieve axial resistance
Caissons bored to found within "100-blow" sand and silt till to silty sand till	• Higher bearing resistances than steel H-Piles	• More expensive than shallow foundations • Drilling must be advanced through till containing cobbles/boulders • May require temporary or permanent liner

A - Spread Footings: Spread footings placed at or below Elevation 186 m, and at a minimum depth of 1.2 m below the lowest surrounding grade will be founded on very dense sand and silt till or silty sand till. Alternatively, spread footings for the abutments could be founded on a Granular 'A' pad constructed within the bridge approaches.

Founding Stratum	*Geotechnical Resistance*	
	Factored ULS	**SLS**
Very dense Sand and Silt Till/Silty Sand Till	600 kPa	400 kPa
Compacted Granular 'A' ("perched" abutments)	700 kPa	350 kPa

B - Steel H-Piles: Steel HP 310 x 110 piles driven to found within the "100-blow" sand and silt till or silty sand deposit at or below Elevation 183 m, are feasible for support of piers and abutments with "perched pile" caps; piles would be approximately 5 m and 9 m long, respectively.

Pile (abutments)	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
HP 310 x 110	1,400 kN	1,200 kN

C – Caissons: Abutments "perched" within the bridge approaches and piers on caissons founded within the "100-blow" sand and silt till or silty sand till at or below Elevation 183 m. Caissons lengths along the abutments and piers would be approximately 5 m and 9 m, respectively, extending at least 2 m into the "100-blow" till material.

Caisson Diameter	*Axial Geotechnical Resistance*	
	Factored ULS	**SLS**
1.2 m	2,000 kN	1,700 kN
1.5 m	3,500 kN	3,000 kN

Recommended Foundation Alternative: Shallow foundations; steel H-Piles with "perched" pile caps are also appropriate for support of the abutments.

• ABUTMENT TYPE

The site soils are suitable for construction of conventional or semi-integral abutments.

• APPROACHES

Height: up to 10 m.

Stability: Approach embankments up to 10 m high with side slopes no steeper than 2 horizontal to 1 vertical (2H : 1V) and a mid-height berm per MTO requirements for approaches higher than 8 m, will be safe against deep-seated slope instability.

Settlement: Assuming the use of conventional earth (i.e. select subgrade materials) or granular materials for embankment construction, and based on consolidation parameters and elastic deformation moduli of the approach foundation soils (estimated based on the results of oedometer testing on samples from boreholes with similar soil characteristics and correlations with the undrained shear strength, Atterberg limits, and SPT 'N' values), the maximum predicted total settlement within the foundation soils is on the order of 75 mm. About 15 percent of the total settlement is expected to take place during and immediately after completion of construction (i.e. elastic settlement). The remaining settlement (i.e. 60 percent of total consolidation settlement) is anticipated to occur over a period of one to two months and measures to reduce post-construction settlement to acceptable values should be undertaken. These measures may include preloading with a surcharge, construction staging or full sub-excavation of the clayey silt deposit. Detailed geotechnical analyses need to be carried out during the detail design to assess the construction requirements of the new embankment fills, including appropriate settlement monitoring instrumentation.

• CONSTRUCTION CONSIDERATIONS

Excavation: the existing fill material, silty sand and clayey silt soils are classified as Type 3 soils according to OHSA; the sand and silt till and silty sand till are classified as Type 2 soils. Temporary excavations (i.e. open for a relatively short time period) should be made with side slopes no steeper than 1H: 1V in Type 3 soils and sloped to within 1.2 m of the bottom of the excavation with a slope 1H: 1V in Type 2 soils.

Groundwater/Surface Water Control: it is anticipated that groundwater within the excavations for shallow foundations at Elevation 186 m can be adequately controlled by pumping from filtered sumps. However, dewatering ahead of the excavation operations may be required for excavations below the groundwater table at about Elev. 188 m in the silty materials to prevent possible "boiling" of the base of the excavation as a result of unbalanced hydrostatic heads.

Protection Systems: Refer to Section 6.7.2 of the Report.

Obstructions During Pile Driving: flange plate reinforcement for steel H-Piles should be used; caisson drilling equipment must be capable of penetrating obstructions such as cobbles and boulders encountered within the sand and silt till and silty sand till.

• 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.

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:	WL-32

W.O: 07-20015 **Section:** Western **Location:** Ramp at West Lynde Creek **Sta.** 21+171

Original Grade: **Proposed Grade:** **Description:** Structure Hwy 407 E – S West Link Ramp over Lynde Creek

Site Plan and Terrain Analysis

Site Photograph looking east to site from Coronation Road.

Summarized Subsurface Conditions	Recommendations – Structure	Recommendations – Approaches	Remarks

Boreholes: No BH at the site. BH P11 drilled on Coronation Road lies ~400m west.
 	
Mapping (West 4) shows the site underlain by a 50 – 70m wide alluvial deposit within an area of silt till ground moraine. The relief is low, rolling, imperfectly drained.
 	
The mapping shows a small watercourse meandering across the site.
 	
BH P11 encountered:
 	
0.0 – 1.5 Fill, loose
1.5 – 3.0 Clayey silt till, stiff to very stiff
3.0– 21.8 EOH Clayey silt till, hard
 	
Groundwater
 	
Groundwater should be expected at the surface at the creek.
 	
No groundwater was recoded in the borehole.
 	
Estimated overburden thickness – 45m.
	The following recommendations are subject to the results of site specific investigation.
	
	1. Abutments
	
	a. Footings may be founded on Granular A cores per current MTO standard practices.
	
	b. For closed abutments, footings may be founded on hard native soil at 4m below ground surface
	  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.160.0.
	  a. ULS resistance – 1,600 kN
	  b. SLS resistance – 1,400 kN
	
	d. Integral abutments are feasible. Assume 15m long piles.
	
	e. Designer may select foundation based on structure configuration and costs.
	
	2. Piers
	
	Piers may be supported using the same foundation options as for abutments.
	
	Spread footings on hard native soil are recommended.
		Approach fills up to 10 m high may be constructed at side slopes up to 2H:1V using SSM or better.
		
		No global stability or settlement issues are anticipated based on available information.
		
		Stripping of topsoil, peaty alluvium or other unsuitable soils will be required prior to construction.
		
		Site Ranking
		
		Foundations: Medium
		
		Hydrogeology: Medium
			Unwatering of excavations will be required. Possible creek diversion requirement. Depending on the results of investigation and the depth of excavation, positive groundwater control may be required.
			
			Narrow, moderately deep valley with comparatively steep east valleyside, but no geomorphic evidence of significant valleyside instability

PRELIMIINARY FOUNDATION INVESTIGATION REPORT – HIGH FILLS AND DEEP CUTS

PRELIMINARY FOUNDATION INVESTIGATION REPORT – HIGH FILLS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

High Fill No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Fill Height (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
HF-W1	11+725 to 11+800 (Highway 407)	189 to 190	5.5	WM1-1, WM2-1	**Stratigraphy:** Surficial very loose to compact fill (2.2 m to 4.1 m thick) underlain by alternating layers of compact to very dense sand and silt till and dense to very dense sand and gravel containing cobbles/boulders extending to the termination depths of the boreholes at 14 m (Elev. 171.4 m) and 10.8 m (Elev. 176.8 m). **Groundwater:** BH WM2-1 – depth of 4.5 m below ground surface (Elev. 183.1 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Fill embankments up to 5.5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. Embankment construction will require removal of the existing topsoil and fills containing organics (up to 4 m thick). The exposed surface of the remaining fill deposit should be proof-rolled/compacted prior to placement of embankment fill. **Settlement:** No settlement issues are anticipated along this fill section. **Recommendations for Further Investigation:** Additional subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W2	11+925 to 11+975 (Highway 407)	187	5	Hydrogeology Report	**Stratigraphy:** Clayey silt till/silty sand to sandy silt till; possibly with interlayers of sand and gravel. **Groundwater:** Estimated at a depth of approximately 4 m below ground surface (Elev. 179 m).	**Design Slope Inclination**: Fill embankments up to 5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section, but must be assessed during detail design when more borehole information is available. **Settlement:** No settlement issues are anticipated along the fill section. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W3	12+475 to 12+930 (Highway 407)	179 to 181	17	WM7-1A, WM7-2, Hydrogeology Report	**Stratigraphy:** Surficial silty sand to sand and gravel fill, up to 3.4 m thick, underlain by cohesionless interlayers of dense to very dense silty sand to sand, sand and silt, and sand and gravel. The boreholes were terminated within the cohesionless deposits at depths of 14 m (Elev. 163.2 m) and 12.3 m (Elev. 154.1 m). **Groundwater:** BH WM7-2 – depth of 2.2 m below ground surface (Elev. 164.2 m) in piezometer on February 28, 2008. BH WM7-2 – depth of 2.1 m below ground surface (Elev. 164.3 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Fill embankments up to 17 m high may be constructed with slopes no steeper than 2H:1V and with a minimum 2 m wide bench for the sections of the slope up to 16 m high, and two 2 m wide benches equally spaced on slopes exceeding 16 m in height. **Stability**: No stability issues are anticipated along this fill section however this needs to be confirmed when more subsurface information is made available. Embankment construction will require removal of fill soils or soils containing excessive organics. The exposed surface of the remaining fill deposit should be proof-rolled/compacted prior to placement of embankment fill. **Settlement:** No settlement issues are anticipated at this stage; however, this will need to be confirmed when more detailed subsurface information is obtained. This will need to be re-assessed during detail design. **Other/Mitigation Options:** Embankment fill material should be permeable to maintain groundwater discharge to Brougham Creek and to limit obstructing the natural water drainage path as may be required by hydraulic considerations. **Recommendations for Further Investigation:** Additional subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section. Boreholes must be drilled to depths at least equal to the height of the proposed fill (i.e. 17 m).

PRELIMINARY FOUNDATION INVESTIGATION REPORT – HIGH FILLS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

High Fill No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Fill Height (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
HF-W4	13+625 to 13+900 (Highway 407)	158 to 166	10	Hydrogeology Report	**Stratigraphy:** Glaciolacustrine deposit of silty sand (up to 10 m thick) underlain by silty sand to sandy silt till. **Groundwater:** Estimated at or near the ground surface.	**Design Slope Inclination**: Fill embankments up to 10 m high may be constructed with slopes no steeper than 2H:1V and with a minimum 2 m wide mid-height bench for the sections of the slope higher than 8 m. **Stability**: No stability issues are anticipated along this fill section, but will need to be re-assessed when subsurface information is obtained. **Settlement:** No settlement issues are anticipated along this fill section, but will need to be re-assessed when subsurface information is obtained. **Other/Mitigation Options:** Embankment fill material should be permeable to maintain groundwater discharge to Spring Creek (from seeps evident on west valley slope) and to limit obstructing the natural water drainage path, as may be required by hydraulic considerations. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W5	14+400 to 14+975 (Highway 407)	153 to 156	12[1]	WM12-1, WM13-1, P7, WM11A-1, WM11-2	**Stratigraphy:** Surficial topsoil/organics/fill (up to 2.9 m thick) underlain by layer of soft to hard clayey silt to silty clay (10 m thick to 23 m thick) which in turn is underlain by layers of typically compact to very dense silty sand to sandy silt to sand and gravel. The cohesive layer was typically soft to firm in the upper zone and transitioned to firm to hard with depth. **Groundwater:** BH WM12-1 – artesian conditions encountered in open borehole at a depth of 16.8 m below ground surface (Elev. 124.5 m) during drilling on April 17, 2008. BH WM13-1 – artesian conditions encountered in open borehole at a depth of 15.2 m below ground surface (Elev. 124.9 m) during drilling on April 30, 2009. BH WM11-2 – artesian conditions measured at 2.4 m above ground surface (Elev. 154.8 m) on March 24, 2008.	**Design Slope Inclination**: Fill embankments up to 12 m high may be constructed with lightweight fill with side slopes no steeper than 2H:1V and with a minimum 2 m wide mid-height bench. Structure WM-EDC-9 is proposed to span across the East Duffins Creek valley, such that the extent of fill placed between the approach embankments within the valley is minimized. **Stability**: From a stability perspective, embankments up to 8 m high using convention fill or up to 12 m using lightweight fill can be constructed. For embankment higher than 8 m, mitigation measures will be required. **Settlement:** Settlements in the order of 500 mm are anticipated due to consolidation of the clayey foundation soils under a maximum 8 m high granular or 12 m high lightweight fill embankment. Embankment construction will require removal of surficial topsoil/organics and possibly fill soils. **Mitigation Options:** Measures to reduce post-construction settlement to acceptable values should be undertaken. These may include preloading with a surcharge and construction staging. Depending on the results of detailed geotechnical analyses, the use of wick drains may be warranted to promote dissipation of pore pressures and promote settlement at a faster rate. Fill material should be permeable to maintain groundwater discharge to East Duffins Creek from the valley, and to prevent blocking the natural valley drainage path, as may be required by hydraulic considerations. **Recommendations for Further Investigation:** Additional subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions, evaluate the total post-construction settlement and assess the preferred mitigation options.

PRELIMINARY FOUNDATION INVESTIGATION REPORT – HIGH FILLS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

High Fill No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Fill Height (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
HF-W6	16+150 to 16+275 (Highway 407)	162 to 163	6.5	Hydrogeology Report	**Stratigraphy:** Surficial, glaciolacustrine clayey silt underlain by sandy silt to silty sand till. **Groundwater:** Estimated to be at or near ground surface.	**Design Slope Inclination**: Fill embankments up to 6.5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. **Settlement:** No settlement issues are anticipated along this fill section. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W7	16+525 to 16+735 (Highway 407)	164 to 167	6.5	Hydrogeology Report	**Stratigraphy:** Surficial, glaciolacustrine clayey silt underlain by sandy silt to silty sand till. **Groundwater:** Estimated to be at or near ground surface.	**Design Slope Inclination**: Fill embankments up to 6.5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. **Settlement:** No settlement issues are anticipated along this fill section. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W8	17+240 to 17+625 (Highway 407)	177 to 182	6.5	Hydrogeology Report	**Stratigraphy:** Surficial silty sand to sandy silt till. Shallow alluvial deposits are expected near Carruthers Creek Tributary. **Groundwater:** Estimated to be at or near ground surface.	**Design Slope Inclination**: Fill embankments up to 6.5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. **Settlement:** No settlement issues are anticipated along this fill section. Embankment construction will require removal of surficial topsoil/organics. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W9	18+450 to 18+550 (Highway 407)	191 to 192	5.5	WM27-1, WM27-2	**Stratigraphy:** 0.8 m of surficial fill underlain by a deposit of compact to very dense sand and silt till extending to the termination depth of the boreholes at 9.3 m (Elev. 186.5 m to Elev. 182.5 m). **Groundwater:** BH WM27-2 – depth of 0.3 m below ground surface (Elev. 191.5 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Fill embankments up to 5.5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. **Settlement:** No settlement issues are anticipated along this fill section. Embankment construction will require removal of surficial fill containing organics. The exposed surface of the remaining fill deposit should be proof-rolled/compacted prior to placement of embankment fill. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.

PRELIMINARY FOUNDATION INVESTIGATION REPORT – HIGH FILLS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

High Fill No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Fill Height (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
HF-W10	20+885 to 21+225 (Highway 407)	163 to 165	11.5	Hydrogeology Report	**Stratigraphy:** Surficial, glaciolacustrine silt and sand underlain by sand and silt till deposit. Alluvial deposits of sand and gravel are also present within the Lynde Creek valley. **Groundwater:** Estimated at a depth of less than 1 m below ground surface.	**Design Slope Inclination**: Fill embankments up to 11.5m high may be constructed with slopes no steeper than 2H:1V and with a minimum 2 m wide mid-height bench. **Stability**: No stability issues are anticipated along this fill section, however, this will need to be re-assessed when subsurface information is obtained. **Settlement:** No settlement issues are anticipated along this fill section, however, this will need to be re-assessed when subsurface information is obtained. Embankment construction will require removal of surficial topsoil/organics. **Mitigation Options:** Fill material should be permeable to maintain groundwater discharge to Lynde Creek (from valley slopes) and to prevent blocking to natural drainage path as may be required by hydraulic considerations. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section. Settlement and stability will need to be re-assessed during detail design.
HF-W11	21+675 to 22+075 (Highway 407)	159 to 161	7	WM36-1, WM37-1	**Stratigraphy:** 0.8 m thick topsoil, underlain by compact to very dense sand and silt till and firm to very stiff clayey silt till, some sand, generally extending to the termination depths of the boreholes at 14 m (Elev. 139.6 m) and 15.4 m (Elev. 137.8 m). **Groundwater:** BH WM37-1 – depth of 1.6 m below ground surface (Elev. 151.6 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Fill embankments up to 7 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. **Settlement:** No settlement issues are anticipated along this fill section. Embankment construction will require removal of surficial topsoil. **Recommendations for Further Investigation:** Additional subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W12	22+930 to 23+000 (Highway 407)	163	6.5	WM40-1, Hydrogeology Report	**Stratigraphy:** 0.8 m thick topsoil underlain by stiff to very stiff clayey silt with sand till (5 m thick), underlain by compact to very dense sand and silt till was present and extended to the 2 m thick stiff silty clay at 5.5 m depth (Elev. 153.9 m), underlain by very loose silt between Elevation 151.8 m and Elevation 150.3 m (1.5 m thick). Below the silt layer, interlayers of sand to sandy gravel may also be expected. **Groundwater:** Estimated at a depth of less than 1 m below ground surface.	**Design Slope Inclination**: Fill embankments up to 6.5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. **Settlement:** It is expected that up to 75 mm of settlement will occur under the footprint of the fill embankment. About 40 percent of the total settlement is expected to occur during and immediately after construction (i.e. elastic settlement), while the remaining 35 mm is estimated to be comprised of post-construction consolidation settlement. Up to 0.8 m of topsoil will need to be removed prior to fill placement. **Mitigation Options:** Measures to reduce post-construction settlement could include preloading with a surcharge and staged construction. **Recommendations for Further Investigation:** Additional subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions, evaluate the total post-construction settlement and assess the preferred mitigation options.

PRELIMINARY FOUNDATION INVESTIGATION REPORT – HIGH FILLS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

High Fill No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Fill Height (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
HF-W13	18+050 to 18+490 (West Durham Link)	167 to 176	10	WL23-1, 7	**Stratigraphy:** 1.5 m of sand and gravel fill/organic silt underlain by a deposit of very dense sand and silt till to very stiff to hard clayey silt till extending to the termination of the boreholes at depths of 12.3 m (Elev. 154 m) and 6.4 m (Elev. 150 m). **Groundwater:** BH WL23-1 - depth of 1.3 m below ground surface (Elev. 165 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Fill embankments up to 10 m high may be constructed with slopes no steeper than 2H:1V and with a minimum 2 m wide mid-height bench for sections of the slope higher than 8 m. **Stability**: No stability issues are anticipated along this fill section, however, this will need to be re-assessed during detail design. **Settlement:** No settlement issues are anticipated along this fill section, however, this will need to be re-assessed during detail design. Embankment construction will require removal of fill/organic silt prior to placement of embankment fill. Consideration may be given to leaving the sand and gravel fill in-place or re-using the material elsewhere and should be assessed during detail design. The exposed surface of the remaining fill deposit should be proof-rolled/compacted prior to placement of embankment fill. **Recommendations for Further Investigation:** Additional subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W14	17+325 to 17+700 (West Durham Link)	148 to 157	7.5	Hydrogeology Report	**Stratigraphy:** Surficial sediments of sand and gravel underlain by silty sand to sand and silt till. **Groundwater:** Estimated at a depth of less than 1 m below ground surface.	**Design Slope Inclination**: Fill embankments up to 7.5 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. However, localized seepage may be present along the existing slope and measures to stabilize/control seepage conditions may be required due to high groundwater table and permeable soils. **Settlement:** No settlement issues are anticipated along this fill section. **Recommendations for Further Investigation:** Additional subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section.
HF-W15	14+350 to 15+075 (Highway 407)	118 to 124	8	Hydrogeology Report	**Stratigraphy:** Surficial silty sand, and sand and gravel units underlain by silty sand to sandy silt till. Glaciolacustrine deposits of silt or clay may also be present. **Groundwater:** Estimated at a depth of less than 1 m below ground surface.	**Design Slope Inclination**: Fill embankments up to 8 m high may be constructed with slopes no steeper than 2H:1V. **Stability**: No stability issues are anticipated along this fill section. **Settlement:** No settlement issues are anticipated along this fill section if granular deposits are present. Settlement greater than 25 mm can be expected in localized areas where clays are present. **Recommendations for Further Investigation:** Subsurface investigation with laboratory testing should be carried out to confirm the subsoil and groundwater conditions along the fill section. Settlement/stability will need to be assessed during detail design.

n:\active\2007\1111\07-1111-0053-urs-highway 407 extension\9 - reporting\5 final foundation report_mar 2009\high fill table-western section.doc

Note: Deep Cut Sections have been identified based on the profile drawings provided by URS on November 6, 2008. It is noted that profiles were provided for the Hwy 407 Mainline and WDL for the Western Section except for the section along the WDL south of Dundas Street. High Fill Sections may be present along the WDL, south of Dundas Street, and these areas should be identified and assessed during detail design.

[1] Based on the profile drawings this high fill section is up to 14.5 m high, however the proposed structure WM-EDC-9 (WM-12/13) is expected to span across the east Duffins Creek valley resulting in approach embankments with maximum heights of up to 12 m to be constructed from lightweight fill.

PRELIMINARY FOUNDATION INVESTIGATION REPORT – DEEP CUTS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Deep Cut No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Cut Depth (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
DC-W1	13+225 to 13+500 (Highway 407)	168 to 178	18	WM8-1, P6 Hydrogeology Report	**Stratigraphy:** Predominantly very stiff to hard clayey silt till (up to 25 m thick and containing cobbles and silty sand seams) overlying compact to very dense silty sand to sand. **Groundwater:** Estimated to range from near ground surface to approximately 5 m below ground surface. BH WM8-1 – depth of 0.7 m below ground surface (Elev. 167.4 m) in piezometer on April 4, 2008. P6 – depth of 2.7 m below ground surface (Elev. 164.4 m) in open borehole during drilling on January 7, 1994.	**Design Slope Inclination**: Drained cut slopes up to 18 m deep may be constructed at an inclination no steeper than 2H:1V and with a minimum 2 m wide mid-height bench for slopes from 8 m to 16 m deep, and two 2 m wide benches equally spaced on slopes exceeding 16 m to 18 m deep. **Drainage**: Excavation will extend into clayey silt till deposit containing silty/sandy seams below the groundwater table. Depending on actual subsoil conditions and groundwater conditions, dewatering measures such as gravity drained 'pilot trenches' may be required prior to subexcavation to control groundwater and improve stability. Permanent groundwater control measures, such as subdrains outletting to drainage ditches, are likely required. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Further subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.
DC-W2	15+500 to 15+885 (Highway 407)	159 to 161	6.5	Hydrogeology Report	**Stratigraphy:** Silty sand to sandy silt till. **Groundwater:** Estimated near 2.5 m below ground surface (Elev. 162.5 m).	**Design Slope Inclination**: Cut slopes up to 6.5 m deep may be constructed at an inclination no steeper than 2H:1V. **Drainage:** Groundwater seepage should be anticipated in the granular soils below the groundwater table. Side ditches should be adequate for surface drainage. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.
DC-W3	18+060 to 18+300 (Highway 407)	187 to 189	12	Hydrogeology Report	**Stratigraphy:** Silty sand to sandy silt till. **Groundwater:** Estimated near 5 m below ground surface (Elev. 190 m).	**Design Slope Inclination**: Drained cut slopes up to 12 m deep may be constructed at an inclination no steeper than 2H:1V and with a minimum 2 m wide mid-height bench. **Drainage**: Groundwater seepage should be anticipated in the granular soils below the groundwater table. Depending on actual subsoil conditions and groundwater conditions, dewatering measures such as gravity drained 'pilot trenches' may be required prior to subexcavation to control groundwater and improve stability. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.

PRELIMINARY FOUNDATION INVESTIGATION REPORT – DEEP CUTS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Deep Cut No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Cut Depth (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
DC-W4	18+700 to 19+200 (Highway 407)	193 to 195	7	Hydrogeology Report	**Stratigraphy:** Silty sand to sandy silt till. **Groundwater:** Estimated near 5 m below ground surface (Elev. 195 m).	**Design Slope Inclination**: Cut slopes up to 7 m deep may be constructed at an inclination no steeper than 2H:1V. **Drainage**: No major groundwater issues are anticipated. Excavation may extend below the groundwater table in some areas and groundwater seepage should be expected. Side ditches should be adequate for surface drainage. **Recommendations for Further Investigation:** Subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.
DC-W5	19+560 to 19+700 (Highway 407)	190 to 191	8	WM28-1, P10	**Stratigraphy:** Compact to very dense sand and silt till or hard clayey silt till with interlayers of very dense silty sand and gravel at a depth of 7 m (Elev. 184 m). The till deposits extended to borehole termination depths of 7.8 m (Elev. 186.3 m) and 15.4 m (Elev. 176 m). **Groundwater:** BH WM28-1 - depth of 0.4 m below ground surface (Elev. 193.6 m) in piezometer on February 28, 2008. BH WM28-1 - depth of 3.4 m below ground surface (Elev. 190.6 m) in piezometer on April 4, 2008. BH P10 – water level at ground surface (Elev. 191.4 m) in piezometer on December 20, 1993.	**Design Slope Inclination**: Cut slopes up to 8 m deep may be constructed at an inclination no steeper than 2H:1V. **Drainage**: No major groundwater issues are anticipated. Side ditches should be adequate for surface drainage. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage, especially if silty sand and gravel interlayers are present below the groundwater table. **Recommendations for Further Investigation:** Further subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.
DC-W6	20+275 to 20+450 (Highway 407)	176 to 180	8	WL28-2, Hydrogeology Report	**Stratigraphy:** Silty sand to sandy silt till. **Groundwater:** Estimated at a depth of less than 2 m below ground surface (Elev. 178 m to Elev. 183 m). BHWL28-2 – depth of 0.3 m below ground surface (Elev. 176 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Cut slopes up to 8 m deep may be constructed at an inclination no steeper than 2H:1V. **Drainage**: Groundwater seepage is anticipated for excavations in the sandy till soils below the groundwater table. Side ditches should be adequate for surface drainage. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.
DC-W7	20+615 to 20+700 (Highway 407)	169 to 171	5.5	WL28-1, WL28-2, P11	**Stratigraphy:** Compact to very dense sand and silt till, some gravel and clay, to stiff to hard clayey silt till with sand seams, extending to borehole termination depths ranging between 6.2 m (Elev. 172 m) to 21.8 m (Elev. 145.4 m). **Groundwater:** Estimated at a depth of less than 2 m below ground surface (Elev. 170 m to Elev. 173 m). BH WL28-2 – depth of 0.3 m below ground surface (Elev. 176 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Cut slopes up to 5.5 m deep may be constructed at an inclination no steeper than 2H:1V. **Drainage**: Groundwater seepage may be encountered from more permeable zones in the till soils. Side ditches should be adequate for surface drainage. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Further subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.

PRELIMINARY FOUNDATION INVESTIGATION REPORT – DEEP CUTS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Deep Cut No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Cut Depth (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
DC-W8	21+450 to 21+590 (Highway 407)	162	11.5	WM35-1, WM35-2	**Stratigraphy:** Compact to very dense sand and silt till extending to the termination of the boreholes at a depth of 9.3 m (Elev. 154.3 m and Elev. 155.7 m). **Groundwater:** Estimated at a depth of 2.5 m below ground surface (Elev. 163 m to 168 m). BH WM35-1 – depth of 3.9 m below ground surface (Elev. 161.1 m) in piezometer on January 7, 2008. BH WM35-1 – depth of 2.5 m below ground surface (Elev. 162.6 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Drained cut slopes up to 11.5 m deep may be constructed at an inclination no steeper than 2H:1V and with a minimum 2 m wide mid-height bench for the sections of cut slopes deeper than 8 m. **Drainage**: Groundwater seepage is anticipated from more permeable zones in the till soils. Depending on actual subsoil conditions and groundwater conditions, dewatering measures such as gravity drained 'pilot trenches' may be required prior to subexcavation to control groundwater and improve stability. Side ditches should be adequate for surface drainage. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Further subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.
DC-W9	22+325 to 22+625 (Highway 407)	160 – 162	7.5	WM38-1, WM38-2	**Stratigraphy:** Compact to very dense sand and silt till, some clay and gravel, overlying hard clayey silt with sand till, some gravel. A layer of sand, some silt, was encountered at WM38-1 between Elevation 165.5 m and Elevation 161 m. The top of the clayey silt with sand till deposit was encountered at about Elev. 161 m and extended to the bottom of the boreholes that were terminated at depths of 7.9 m (Elev. 158.1 m) and 12.4 m (Elev. 157.7 m). **Groundwater:** BH WM38-1 – depth of 3.9 m below ground surface (Elev. 166.2 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Cut slopes up to 7.5 m deep may be constructed at an inclination no steeper than 2H:1V. **Drainage**: Groundwater seepage should be anticipated from the sand deposit above the less permeable underlying clayey silt till. Permanent or long-term temporary groundwater control measures, such as subdrains or ditches, may be required. Side ditches should be adequate for surface drainage. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Further subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.
DC-W10	23+275 to 23+725 (Highway 407)	158 to 161	7	WM43-1, WM43-2	**Stratigraphy:** Surficial organic clayey silt and fills (up to 1.5 m thick) underlain by a deposit of compact to very dense sand and silt till extending to the termination depth of the borehole at 9.6 m (Elev. 154.4 m). **Groundwater:** BH WM43-1 – depth of 2.3 m below ground surface (Elev. 161.7 m) in piezometer on January 7, 2008. BH WM43-1 – depth of 1.2 m below ground surface (Elev. 162.8 m) in piezometer on April 4, 2008.	**Design Slope Inclination**: Cut slopes up to 7 m deep may be constructed at an inclination no steeper than 2H:1V. Localized slope flattening may be required within the near surface organic / fill soils. **Drainage**: No major groundwater issues are anticipated. Side ditches should be adequate for surface drainage. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Further subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.

PRELIMINARY FOUNDATION INVESTIGATION REPORT – DEEP CUTS
HWY 407 EAST EXTENSION – WESTERN SECTION
W.O. 07 – 20015

Deep Cut No.	Station (From – To)	Proposed Hwy 407/WDL Grade (m)	Maximum Cut Depth (m)	Reference Information/ Borehole Nos.	General Subsurface Conditions	Preliminary Recommendations
DC-W11	12+400 to 12+890 (West Durham Link)	97 to 99	6.5	WL19A-1A, WL19A-2A, WL19-2A, WL19-3A	**Stratigraphy:** Generally consists of surficial layers (1 m to 2 m thick) of loose to compact sand, underlain by a layer of (1 m to 2 m thick) soft to stiff clayey silt to silty clay, which in turn is underlain by compact to very dense sand and silt till and stiff clayey silt with sand till. Thin layers (0.6 m to 0.7 m thick) of sand to sand and gravel were encountered within the till at depths of 3.5 m (Elev. 102.3 m) and 6.1 m (Elev. 98.7 m). The till deposits extended to the termination of the boreholes at depths varying from 7 m to 9.6 m (Elev. 94 m and Elev. 96.3 m, respectively). Inferred shale bedrock was encountered (but not cored) in one borehole at a depth of 9.6 m (Elev. 96.3 m). **Groundwater:** BH WL19-2A – depth of 2.5 m below ground surface (Elev. 103.3 m) in piezometer on March 23, 2009.	**Design Slope Inclination**: Cut slopes up to 6.5 m deep may be constructed at an inclination no steeper than 2H:1V. **Drainage**: Permanent groundwater control measures will be required due to seepage from the sandy layers along the cut slopes. A passive gravity drain system could be considered to convey groundwater into ditches/a storm water collection system. **Surficial Instability:** Gravel sheeting or alternative methods may be required to control surficial erosion and instability at areas of localized seepage. **Recommendations for Further Investigation:** Further subsurface investigation should be carried out to confirm the subsoil conditions and groundwater levels at the location of the cut section.

n:\active\2007\1111\07-1111-0053-urs-highway 407 extension\9 - reporting\5 final foundation report_mar 2009\deep cut table-western section.doc

Note: Deep Cut Sections have been identified based on the profile drawings provided by URS on November 6, 2008. It is noted that profiles were provided for the Hwy 407 Mainline and WDL for the Western Section except for the section along the WDL south of Dundas Street. High Fill Sections may be present along the WDL, south of Dundas Street, and these areas should be identified and assessed during detail design.

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

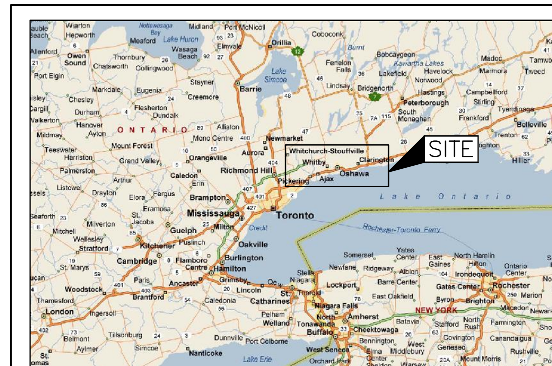
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

W.O. No.07–20015

HIGHWAY 407 EAST EXTENSION
WESTERN SECTION
PROJECT LOCATION

SHEET

Golder Associates
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
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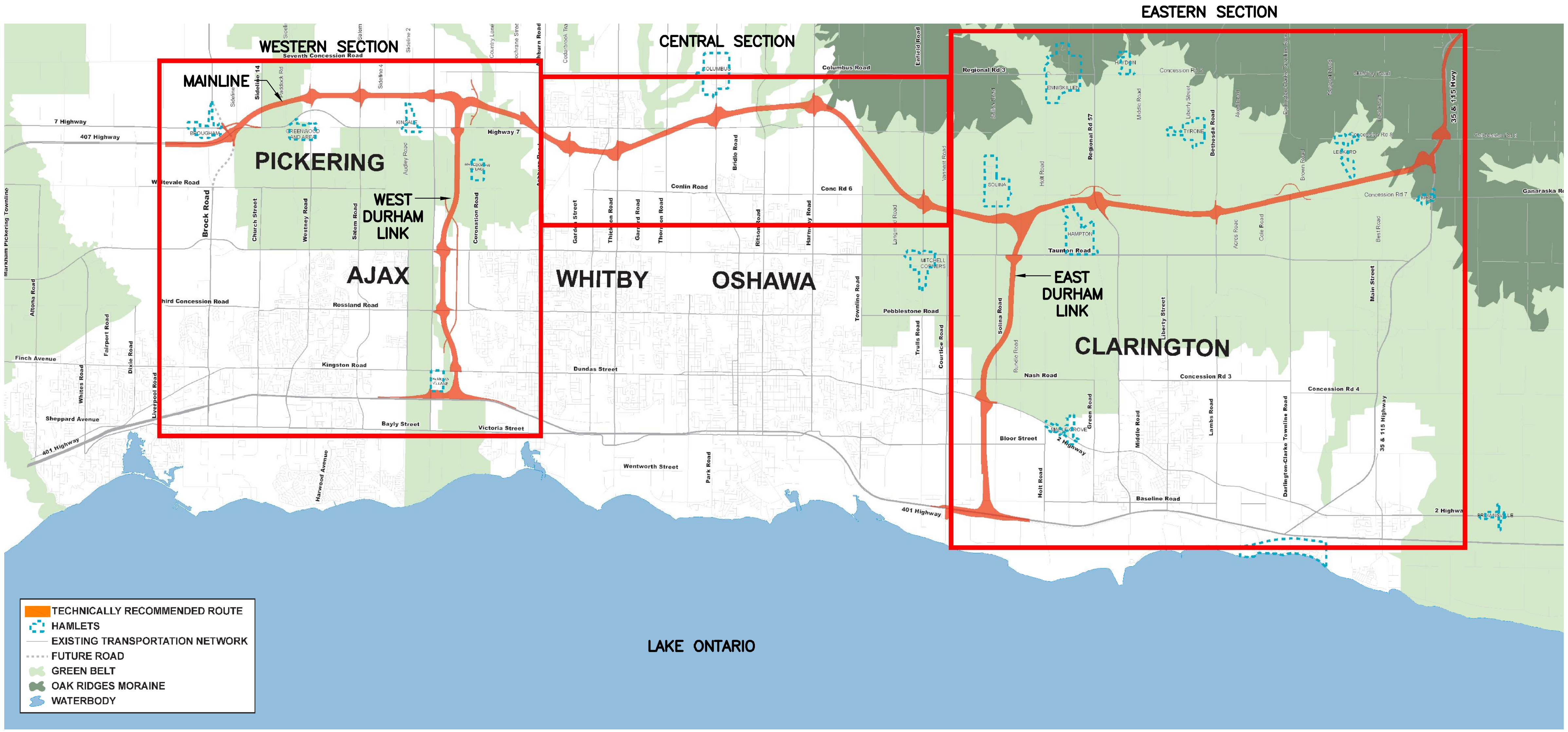

PLAN

SCALE APPROX.
0 1,600 3,200 4,800 m

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

REFERENCE

Base provided by AECOM (2008).

NO.	DATE	BY	REVISION

Geocres No. 30M14–316

HWY. 407		PROJECT NO. 07–1111–0053	DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 23–Mar–2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 1

PLOT DATE: April 3, 2009

MINISTRY OF TRANSPORTATION, ONTARIO

PLAN

SCALE
120 0 120 240 m

W.O. No. 07–20015

SHEET

HIGHWAY 407 EAST EXTENSION
WESTERN SECTION
BOREHOLE LOCATION – MAINLINE
West of Brock Rd To East of Sideline 16

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN
SCALE APPROX.
0 1,600 3,200 4,800 m

LEGEND

Borehole – Current Investigation
Borehole – MTO Geocres
DC-W3 Deep Cut Section
HF-W1 High Fill Section

No.	ELEVATION	CO–ORDINATES	
		NORTHING	EASTING
WMA–1	196.3	4863719.6	336079.0
WMA–2	196.0	4863738.8	336142.1
WM1–1	185.4	4864055.5	336810.0
WM2–1	187.6	4864046.9	336863.8
WM3–1	181.0	4864430.5	337084.4
WM3–2	181.0	4864424.0	337183.0
WM7–1A	177.2	4864799.5	337267.5
WM7–2	166.4	4864765.1	337459.7
P5	192.4	4863930.9	336544.2

NOTES

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REFERENCE

Base plans and profiles provided in digital format by URS, drawing file nos. "407E Western Section Plan+Profile (Ver4.5).dwg", received Nov. 06, 2008, "x–design_2009_01_23.dwg", received Feb. 5, 2009 and "Structure Locations Feb 3 09.dwg", received Feb. 9, 2009.

NO.	DATE	BY	REVISION

Geocres No. 30M14–316

HWY. 407		PROJECT NO. 07–1111–0053	DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 02–Apr–2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 2

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

W.O. No. 07–20015

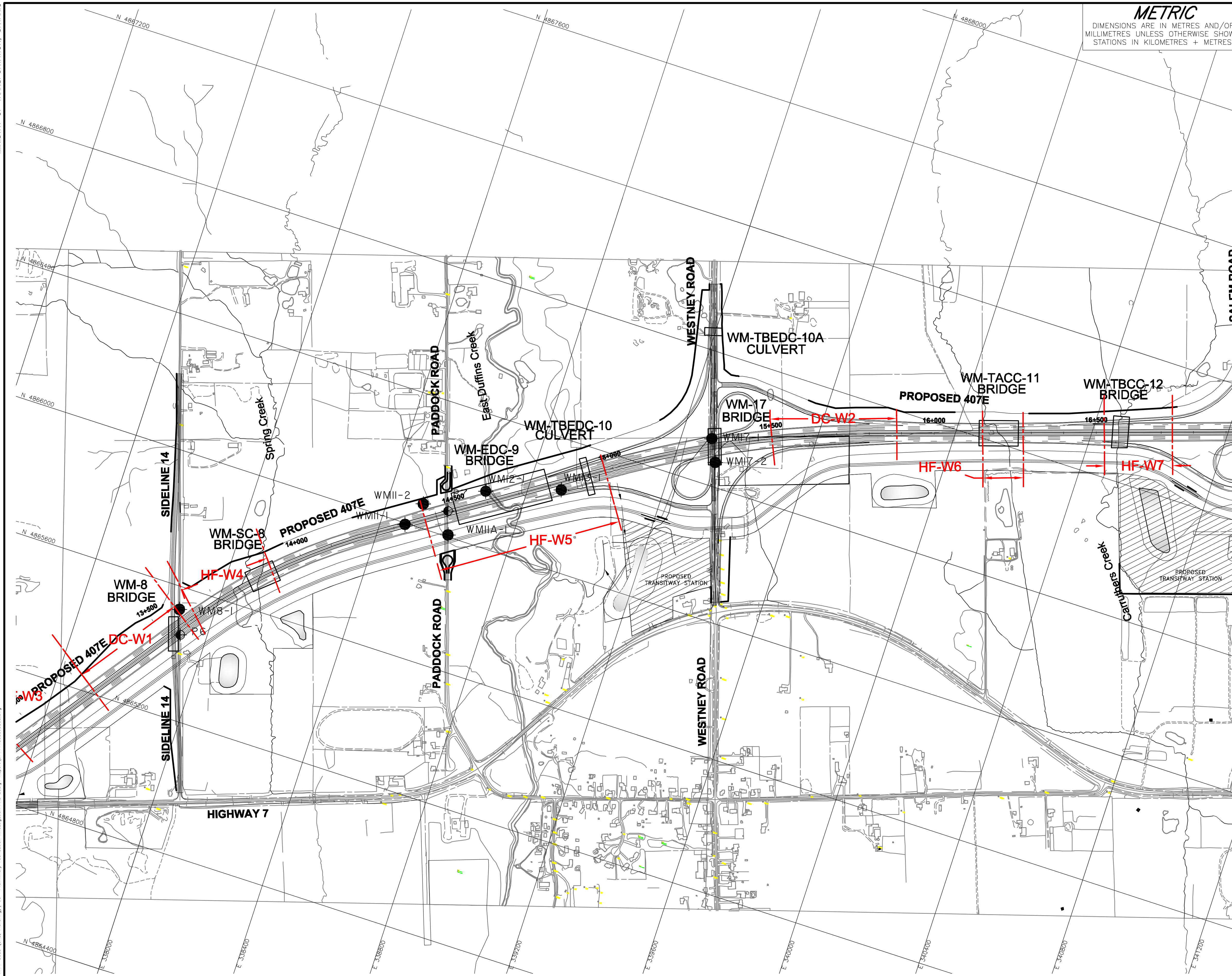
SHEET

HIGHWAY 407 EAST EXTENSION

WESTERN SECTION

BOREHOLE LOCATION – MAINLINE
East of Sideline 16 to Salem Road

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN

SCALE
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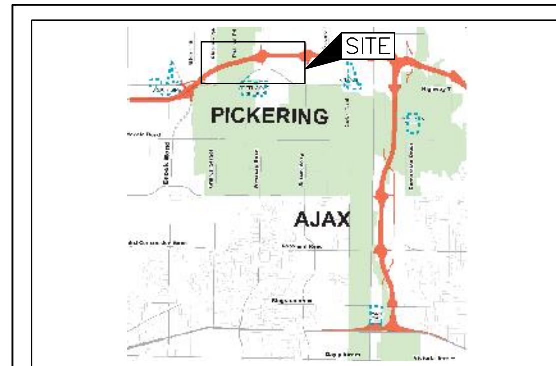

KEY PLAN
SCALE APPROX.
0 1,600 3,200 4,800 m

LEGEND

Borehole – Current Investigation
Borehole – MTO Geocres
DC-W3 Deep Cut Section
HF-W1 High Fill Section

No.	ELEVATION	CO–ORDINATES	
		NORTHING	EASTING
WM8–1	168.1	4865531.0	337893.6
WM11–1	153.5	4865995.6	338473.7
WM11A–1	143.9	4866005.9	338609.9
WM11–2	152.4	4866073.0	338507.6
WM12–1	141.3	4866170.2	338678.7
WM13–1	140.1	4866246.2	338899.0
WM17–1	155.0	4866540.5	339291.5
WM17–2	156.4	4866473.4	339324.1
P6	167.1	4865457.1	337920.0
P7	145.4	4866076.3	338586.8

NOTES

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REFERENCE

Base plans and profiles provided in digital format by URS, drawing file nos. "407E Western Section Plan+Profile (Ver4.5).dwg", received Nov. 06, 2008, "x-design_2009_01_23.dwg", received Feb. 5, 2009 and "Structure Locations Feb 3 09.dwg", received Feb. 9, 2009.

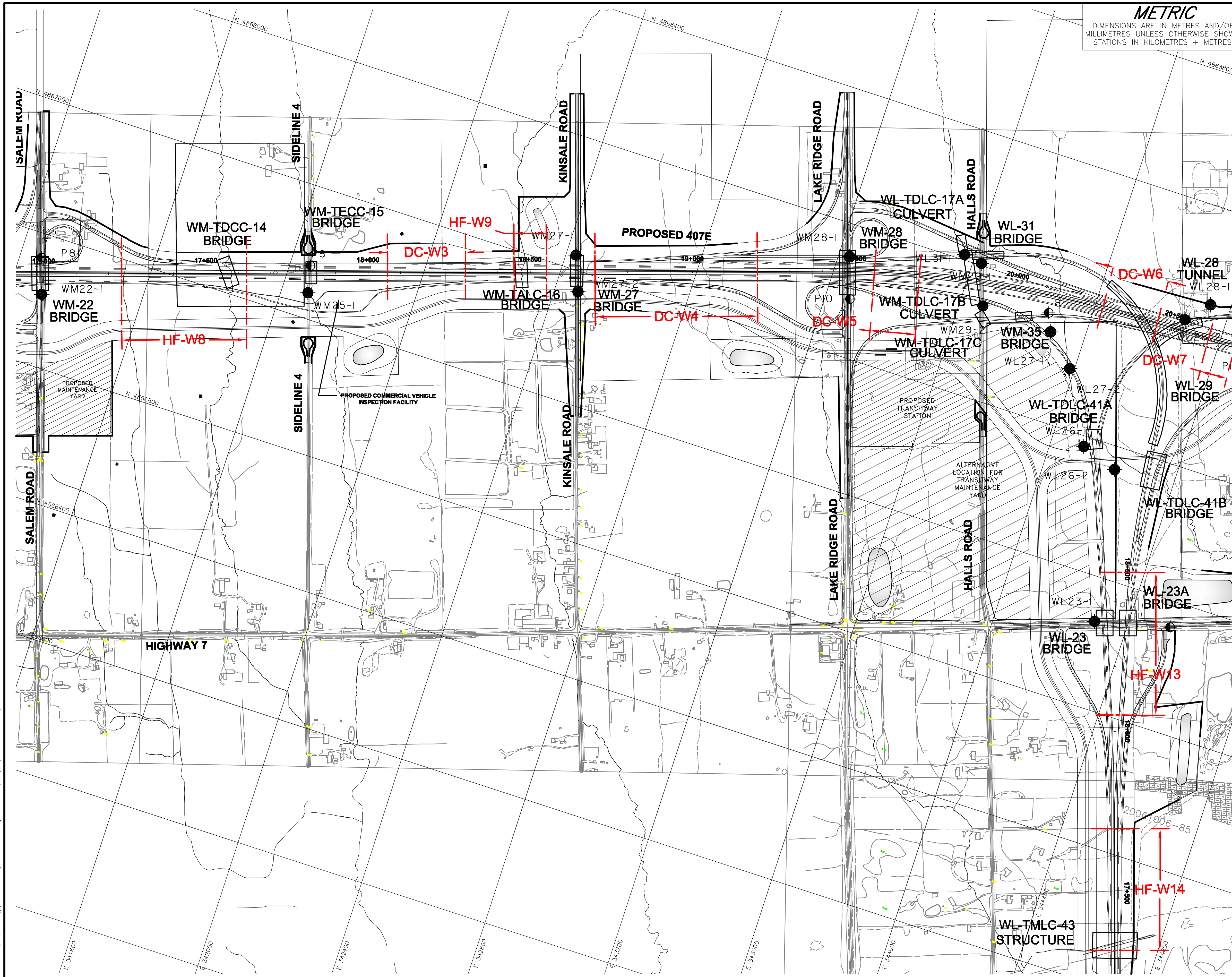
NO.	DATE	BY	REVISION

Geocres No. 30M14–316

HWY. 407		PROJECT NO. 07–1111–0053	DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 2–Apr–2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 3

PLOT DATE: April 3, 2009
FILENAME: T:\Projects\2007\07-1111-0053 (URS, Pickering)\--JC-- Preliminary Foundation Investigation And Design Report\07111100530003.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE

120 0 120 240 m

METRIC

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

W.O. No. 07–20015

SHEET

HIGHWAY 407 EAST EXTENSION

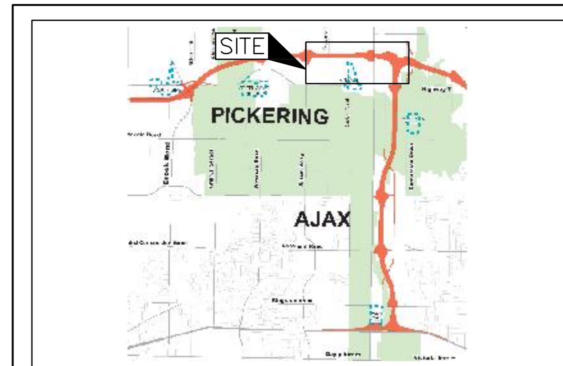
WESTERN SECTION

BOREHOLE LOCATION – MAINLINE

Salem Road to East of Coronation Rd

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE APPROX.

0 1,600 3,200 4,800 m

LEGEND

Borehole – Current Investigation

Borehole – MTO Geocres

DC-W3 Deep Cut Section

HF-W1 High Fill Section

No.	ELEVATION	CO-ORDINATES NORTHING	CO-ORDINATES EASTING
WM22–1	169.0	4867019.3	340901.0
WM25–1	180.1	4867278.2	341679.9
WM27–1	195.8	4867644.3	342430.1
WM27–2	191.8	4867538.3	342470.7
WM28–1	194.0	4867900.8	343233.6
WM29–1	189.0	4868006.6	343626.2
WM29–2	190.0	4867883.6	343671.2
WL31–1	188.4	4868016.8	343568.7
WL23–1	166.3	4867065.4	344299.7
WL26–1	176.1	4867568.0	344100.9
WL26–2	175.0	4867529.7	344213.2
WL27–1	182.1	4867872.5	343894.5
WL27–2	174.0	4867782.7	343985.7
WL28–1	178.2	4868104.2	344337.6
WL28–2	176.3	4868036.2	344277.3
P8	170.7	4867127.0	340865.8
P9	181.1	4867359.2	341661.9
P10	191.4	4867777.2	343275.0
7	156.4	4867120.4	344526.8
8	183.4	4867926.3	343870.8

NOTES

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REFERENCE

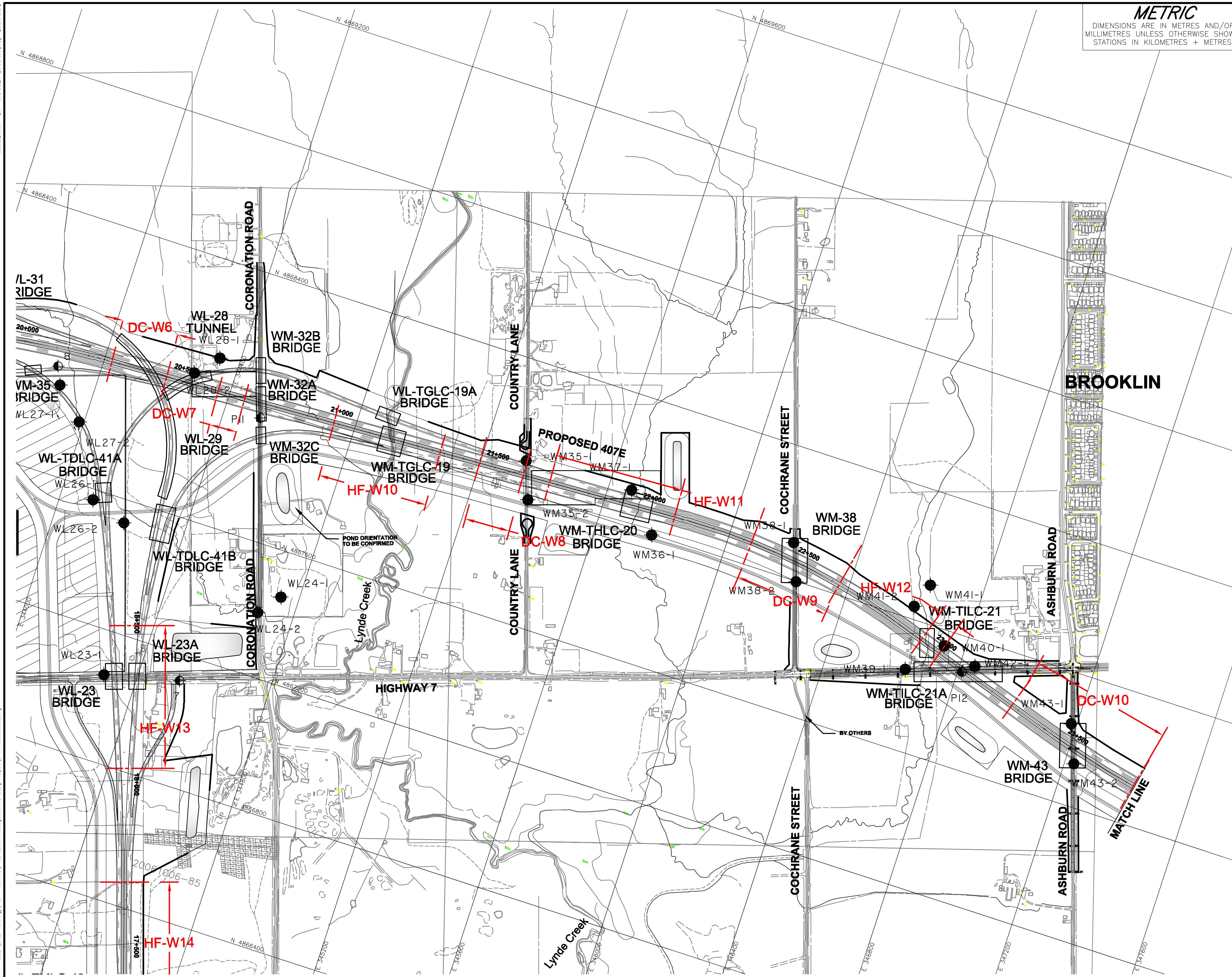
Base plans and profiles provided in digital format by URS, drawing file nos. "407E Western Section Plan+Profile (Ver4.5).dwg", received Nov. 06, 2008, "x–design_2009_01_23.dwg", received Feb. 5, 2009 and "Structure Locations Feb 3 09.dwg", received Feb. 9, 2009.

NO.	DATE	BY	REVISION

Geocres No. 30M14–316

HWY. 407		PROJECT NO. 07–1111–0053	DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 2–Apr–2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 4

PLOT DATE: April 3, 2009



PLAN

SCALE

120 0 120 240 m

METRIC

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

W.O. No. 07–20015

SHEET

HIGHWAY 407 EAST EXTENSION

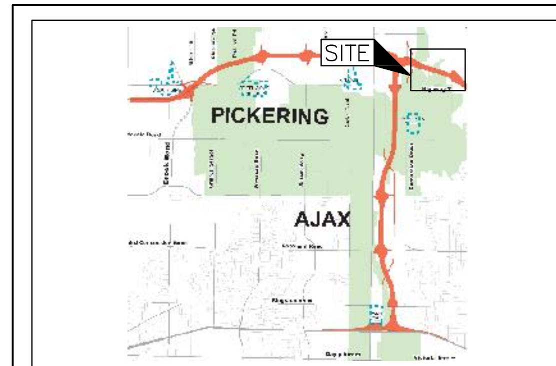
WESTERN SECTION

BOREHOLE LOCATION – MAINLINE

East of Coronation Rd to Ashburn Rd

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE APPROX.

0 1,600 3,200 4,800 m

LEGEND

Borehole – Current Investigation

Borehole – MTO Geocres

DC-W3 Deep Cut Section

HF-W1 High Fill Section

No.	ELEVATION	CO–ORDINATES	
		NORTHING	EASTING
WL24–1	149.3	4867462.1	344744.7
WL24–2	150.0	4867394.5	344690.9
WM35–1	165.0	4868095.8	345333.7
WM35–2	163.6	4867982.7	345375.8
WM36–1	153.6	4867998.0	345772.3
WM37–1	153.2	4868110.8	345670.5
WM38–1	170.1	4868111.0	346196.0
WM38–2	166.0	4867998.9	346240.4
WM39–1	159.0	4867846.2	346644.0
WM40–1	159.4	4867951.9	346735.8
WM41–1	158.9	4868117.0	346637.4
WM41–2	161.2	4868039.3	346610.4
WM42–1	163.0	4867921.5	346845.3
WM43–1	164.0	4867845.2	347182.7
WM43–2	164.0	4867730.5	347228.7
P11	162.2	4867967.5	344513.6
P12	161.5	4867892.3	346812.3

NOTES

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REFERENCE

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NO.	DATE	BY	REVISION

Geocres No. 30M14–316

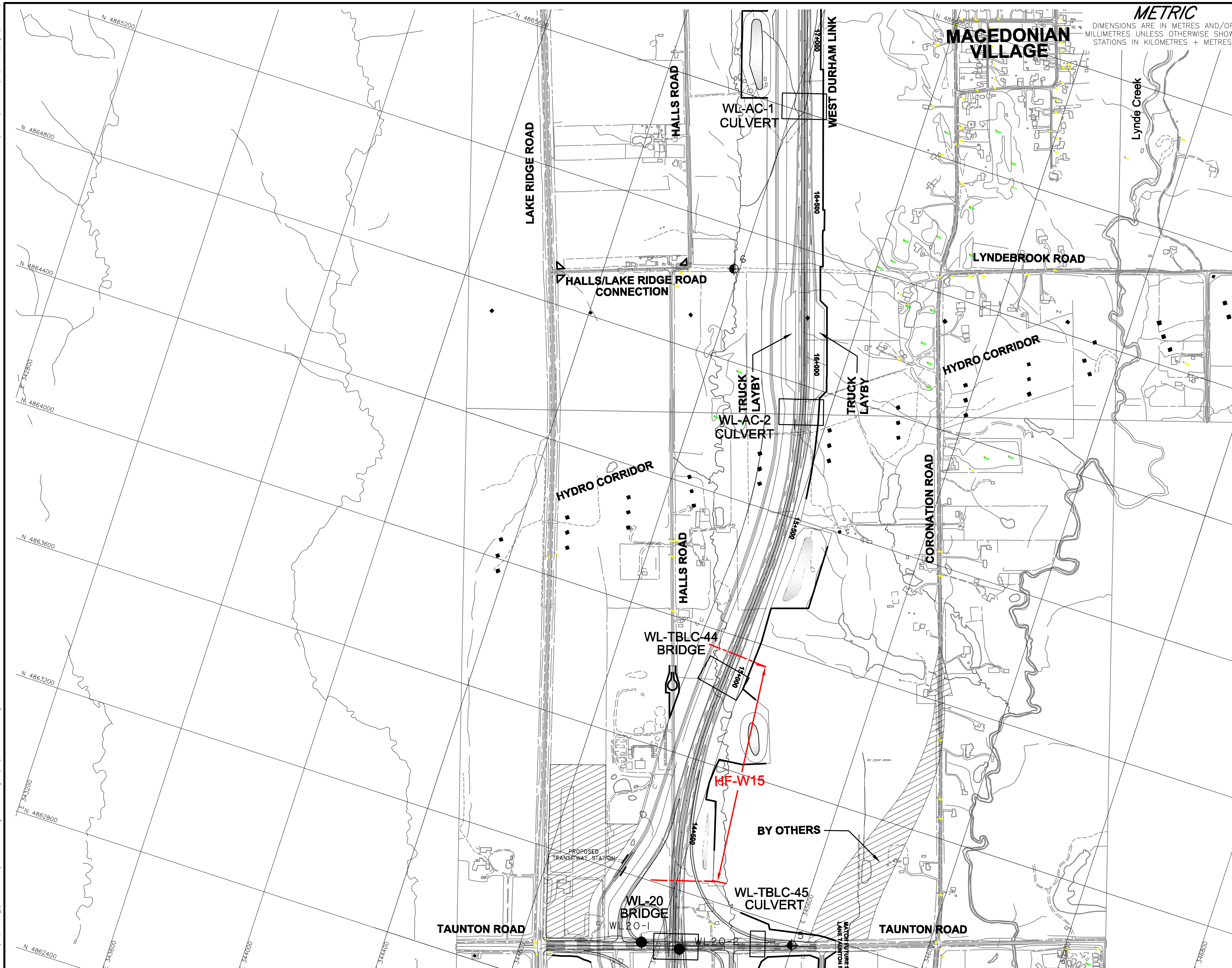
HWY. 407		PROJECT NO. 07–1111–0053	DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 2–Apr–2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 5

MINISTRY OF TRANSPORTATION, ONTARIO

PLOT DATE: April 3, 2009

METRIC

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



PLAN

SCALE

120 0 120 240 m

W.O. No. 07-20015

HIGHWAY 407 EAST EXTENSION

WESTERN SECTION

BOREHOLE LOCATION – WDL

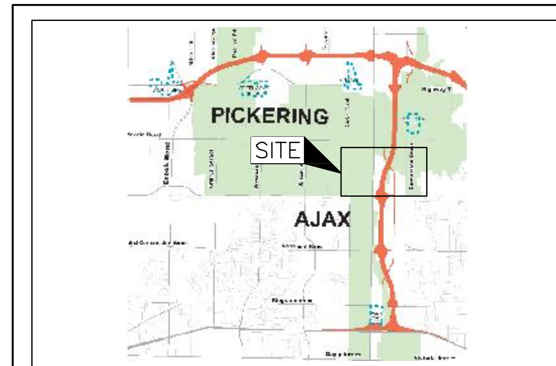
Winchester Rd West to Taunton Rd

SHEET

Golder Associates

Golder Associates Ltd.

MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE APPROX.

0 1,600 3,200 4,800 m

LEGEND

Borehole – Current Investigation

Borehole – MTO Geocres

DC-W3 Deep Cut Section

HF-W1 High Fill Section

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
WL20-1	116.4	4863012.2	345154.0
WL20-2	115.0	4863027.8	345272.1
5	111.6	4863146.3	345597.9
6	131.4	4865074.5	344782.8

NOTES

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REFERENCE

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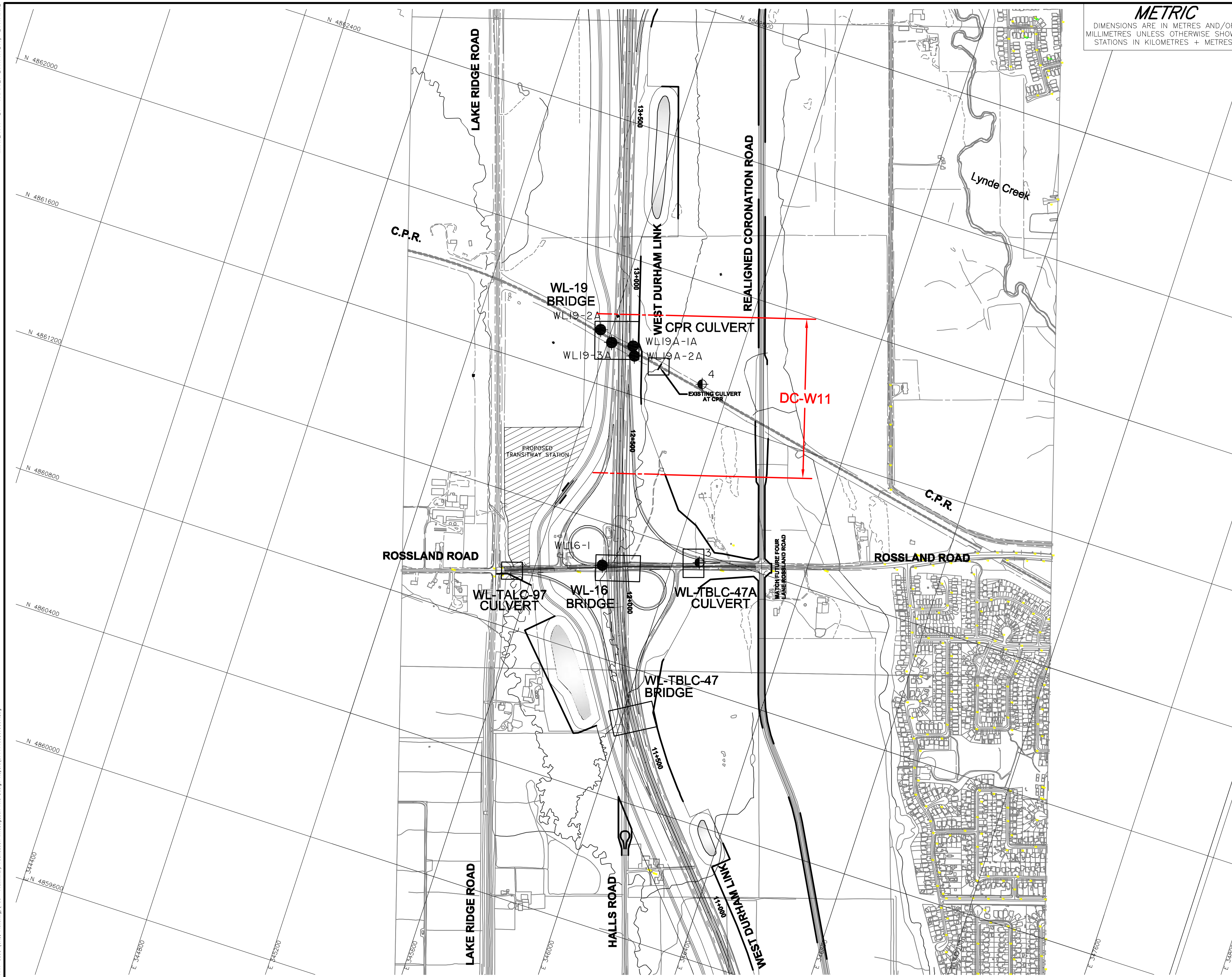
NO.	DATE	BY	REVISION

Geocres No. 30M14-316

HWY. 407		PROJECT NO. 07-1111-0053	DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 2-Apr-2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 6



PLAN

SCALE

120 0 120 240 m

METRIC

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

W.O. No. 07–20015

SHEET

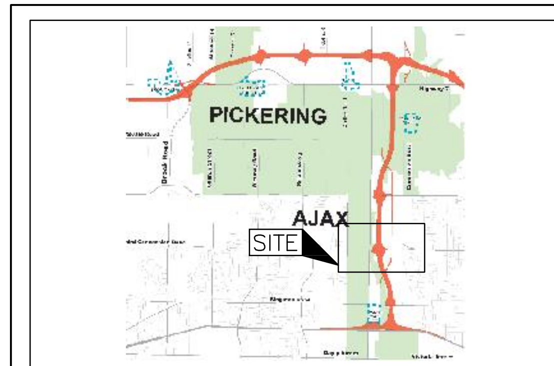
HIGHWAY 407 EAST EXTENSION

WESTERN SECTION

BOREHOLE LOCATION – WDL

Taunton Rd to South of Rossland Rd

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE APPROX.

LEGEND

- Borehole – Current Investigation
- Borehole – MTO Geocres
- DC-W3 Deep Cut Section
- HF-W1 High Fill Section

No.	ELEVATION	CO–ORDINATES	
		NORTHING	EASTING
WL16–1	97.0	4861073.2	345796.6
WL19A–1A	101.0	4861744.1	345677.9
WL19A–2A	102.0	4861716.4	345690.7
WL19–2A	105.8	4861761.3	345567.1
WL19–3A	104.8	4861734.3	345611.8
3	102.0	4861173.3	346078.4
4	102.3	4861698.5	345916.4

NOTES

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REFERENCE

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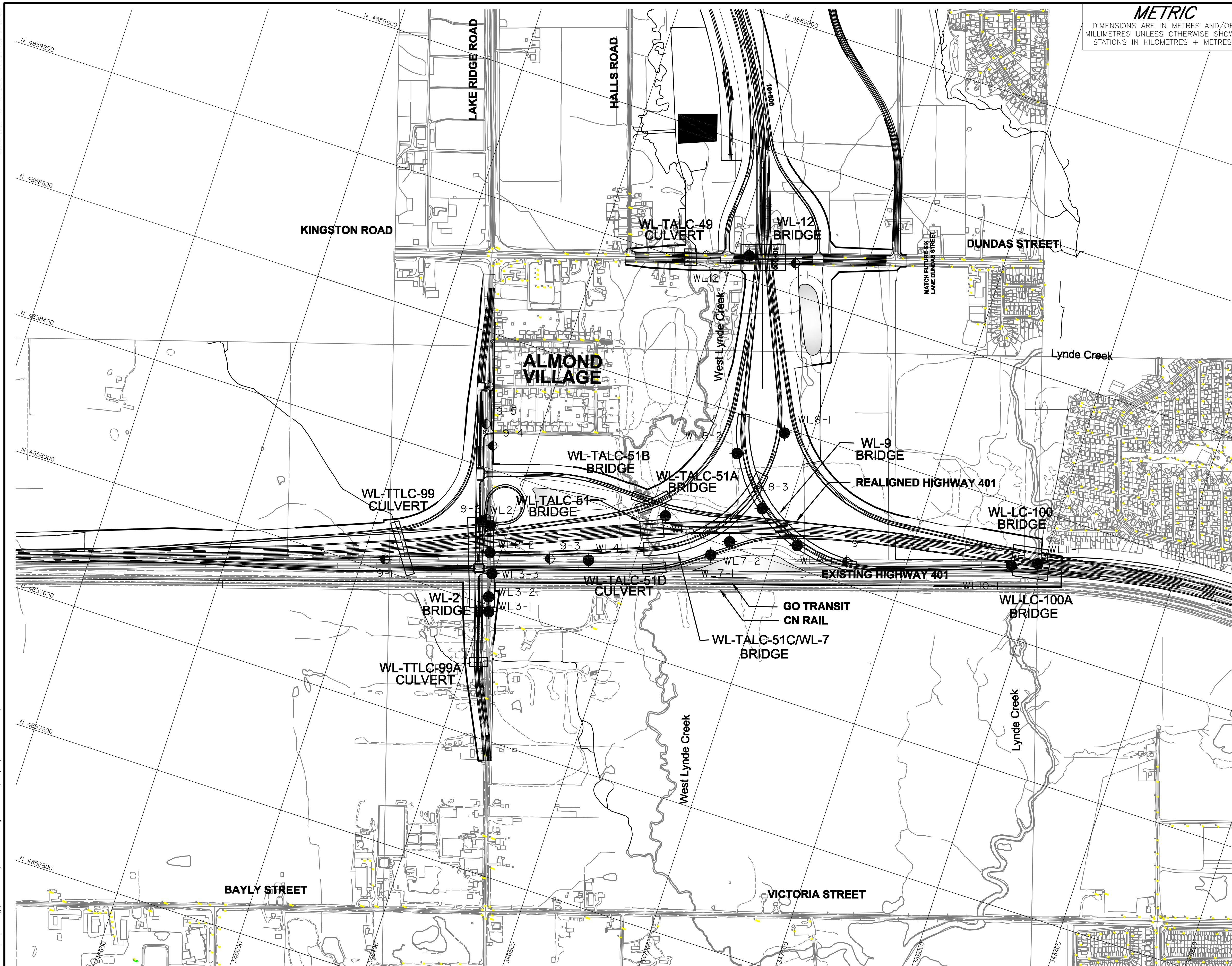
NO.	DATE	BY	REVISION

Geocres No. 30M14–316

HWY. 407		PROJECT NO. 07–1111–0053	DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 1–Apr–2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 7



PLAN

SCALE

120 0 120 240 m

METRIC

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

W.O. No. 07-20015

SHEET

HIGHWAY 407 EAST EXTENSION

WESTERN SECTION

BOREHOLE LOCATION – WDL

South of Rossland Rd to Highway 401

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN

SCALE APPROX.

0 1,600 3,200 4,800 m

LEGEND

Borehole – Current Investigation

Borehole – MTO Geocres

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
WL2-1	89.0	4858235.2	346342.8
WL2-2	93.2	4858153.9	346368.2
WL3-1	91.3	4857980.3	346420.5
WL3-2	94.0	4858023.6	346406.4
WL3-3	88.0	4858095.1	346393.7
WL4-1	83.0	4858226.4	346664.3
WL5-2	80.0	4858430.0	346847.1
WL7-1	82.0	4858358.5	347017.2
WL7-2	82.0	4858415.1	347060.1
WL7-3	82.0	4858543.9	347124.0
WL8-1	83.9	4858786.2	347117.0
WL8-2	82.3	4858681.3	346998.0
WL9-1	82.0	4858468.3	347261.8
WL10-1	79.1	4858615.2	347908.1
WL11-1	79.0	4858644.9	347984.2
WL12-1	87.0	4859272.4	346845.2
9-1	86.9	4858034.5	346066.9
9-2	85.5	4858250.0	346325.5
9-3	82.8	4858193.6	346549.3
9-4	88.4	4858470.0	346273.9
9-5	89.3	4858528.1	346234.1
1	85.0	4859293.8	346987.7
9	82.6	4858468.6	347422.9

NOTES

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REFERENCE

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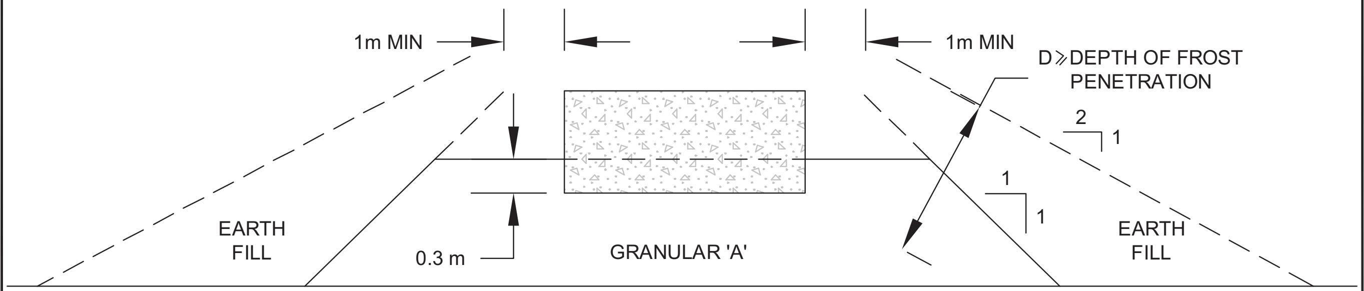
NO.	DATE	BY	REVISION

Geocres No. 30M14-316

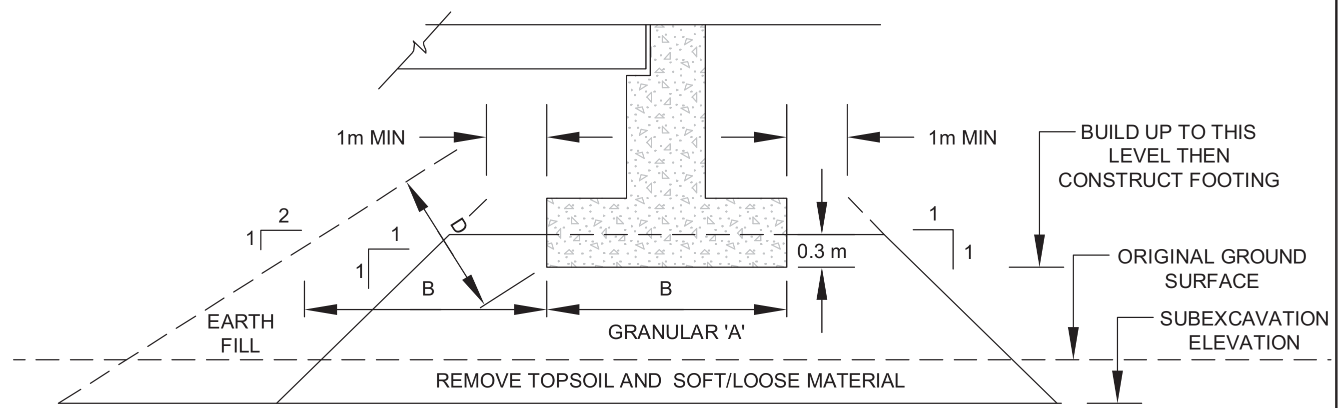
HWY. 407	PROJECT NO. 07-1111-0053		DIST.
SUBM'D. BLT	CHKD. BLT	DATE: 23-Mar-2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD. JMAC	DWG. 8

PLOT DATE: April 3, 2009

FIGURES



CROSS-SECTION



LONGITUDINAL SECTION

NOTES:

1. REMOVE TOPSOIL AND SOFT/LOOSE SUBSOIL UNDER FOOTPRINT OF COMPACTED GRANULAR 'A'.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO SP 105 510.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

NOT TO SCALE

PROJECT
W.O. No. 07-20015
HIGHWAY 407 EAST EXTENSION WESTERN SECTION
REGION OF DURHAM, ONTARIO

TITLE
TYPICAL ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE

Golder Associates
Mississauga, Ontario, Canada

PROJECT No.		07-1111-0053	FILE No.	0711110053FJC001.dwg
DESIGN			SCALE	AS SHOWN REV.
CAD	DD	Apr. 3, 2009	FIGURE No.	
CHECK	KJB	Apr. 3, 2009		1
REVIEW	JMAC	Apr. 3, 2009		

PLOT DATE: April 3, 2009
FILENAME: T:\Projects\2007\07-1111-0053 (URS, Pickering)\-JC- Preliminary Foundation Investigation And Design Report\0711110053FJC001.dwg

APPENDIX A

RECORD OF BOREHOLE SHEETS

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WMA-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4863719.6 ;E 336079.0		ORIGINATED BY GD/JZ
DIST Central	HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY DD
DATUM Geodetic	DATE January 31 and February 4, 2008		CHECKED BY TZ/HJ

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
196.3	GROUND SURFACE
196.0 / 0.0	Sandy silt, trace clay, containing organics (FILL) Loose Dark brown Moist
0.3	Sand and gravel (FILL) Loose Brown Moist
194.8 / 1.5	Silty sand, trace to some clay, trace gravel (FILL) Compact to loose Brown Moist
193.3 / 3.1	SAND, trace to some silt, occasional cobbles Dense Brown Moist
191.7 / 4.6	SAND and GRAVEL, some silt, trace clay, occasional cobbles Very dense Brown Moist. Boulder at 5.5 m depth
188.7 / 7.6	SAND, trace to some silt Very dense Brown Moist
187.5 / 8.8	SAND and SILT, trace to some clay and gravel (TILL) Very dense Brown to grey Moist
184.1 / 12.3	SAND and GRAVEL Very dense Brown Moist to wet
	END OF BOREHOLE

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.4 m below ground surface (Elevation 189.9 m).

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	9	
2	SS	4	
3	SS	20	3 68 22 7
4	SS	8	
5	SS	34	
6	SS	61/0.15	
7	SS	61/0.07	44 37 16 3
8	SS	87	
9	SS	75/0.15	10 45 39 6
10	SS	50/0.13	8 43 43 6
11	SS	50/0.25	

GROUND WATER CONDITIONS; ELEVATION SCALE 196–184; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WMA-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4863738.8 ;E 336142.1		ORIGINATED BY JZ/HM
DIST Central	HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY DD
DATUM Geodetic	DATE February 8 and 11, 2008		CHECKED BY TZ/HJ

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
196.0	GROUND SURFACE
0.0	Sandy silt, trace clay and gravel, containing organics (FILL) Loose to compact Brown Moist
194.5 / 1.5	SAND and SILT, trace to some clay, trace gravel (TILL) Compact Brown Moist to wet
192.5 / 3.5	SAND, some silt, trace clay Dense Brown Moist. Wet below 6.1 m depth
189.3 / 6.7	SAND and SILT, some gravel, trace clay, containing cobbles and boulders (TILL) Very dense Grey Wet to moist. Sand seams at a depth of 10.7 m
185.3 / 10.7	END OF BOREHOLE

NOTES:

1. Water level measured in piezometer at a depth of 5.4 m below ground surface (Elevation 190.6 m) on April 4, 2008.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	5	
2	SS	12	
3	SS	20	
4	SS	17	6 42 40 12
5	SS	34	
6	SS	42	0 80 17 3
7	SS	47	
8	SS	50/0.13	
9	SS	50/0.13	22 39 32 7
10	SS	50/0.07	

GROUND WATER CONDITIONS; ELEVATION SCALE 195–186; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM1-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4864055.5 ;E 336810.0 | ORIGINATED BY GD

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE January 25, 2008 | CHECKED BY VO/HJ

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
185.4	GROUND SURFACE								
0.0	Topsoil (FILL)								
0.2	Sandy silt to silty sand, some clay, some gravel, containing cobbles, rootlets and wood fragments (FILL) Very loose to compact Brown Moist	1	SS	3					
		2	SS	13					
		3	SS	8					
183.2 / 2.2	SAND and SILT, some gravel, trace to some clay, containing cobbles/boulders (TILL) Compact Brown Moist to wet	4	SS	21	∇	19	40	34	7
182.4 / 3.0	SAND and GRAVEL, trace silt, containing cobbles/boulders Dense Brown Wet	5	SS	38					
181.3 / 4.1	SAND and SILT, trace to some clay and gravel, containing cobbles/boulders (TILL) Very dense Grey Moist to wet	6	SS	50/0.13		10	45	35	8
		7	SS	50/0.08					
178.4 / 7.0	SAND and GRAVEL, some silt, containing cobbles/boulders Very dense Grey Wet	8	SS	51		45	43	11	1
		9	SS	50/0.08					
		10	SS	50/0.08					
173.7 / 11.7	SAND and SILT, trace to some gravel and clay, containing cobbles (TILL) Very dense Grey Wet	11	SS	50/0.08					
172.0 / 13.4	SAND, trace to some silt Very dense Grey Wet	12	SS	50/0.15					
171.4 / 14.0	END OF BOREHOLE								

ELEVATION SCALE: 185, 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No WM1-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4864055.5 ;E 336810.0 | ORIGINATED BY GD

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE January 25, 2008 | CHECKED BY VO/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.9 m below ground surface (Elevation 182.5 m).

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

Golder Associates

RECORD OF BOREHOLE No WM2-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864046.9 ;E 336863.8 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 24, 2008 CHECKED BY VO/HJ

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.6	GROUND SURFACE				
0.0	Topsoil (FILL)	1	SS	2	
0.3	Sandy silt to silty sand, trace clay, trace to some gravel, containing rootlets and organic matter (FILL) Very loose to compact Brown Moist	2	SS	14	
		3	SS	10	
185.4 / 2.2	Silty sand, some gravel, trace to some clay, trace organic matter and wood fragments, containing clayey silt interlayers (FILL) Loose Brown Moist	4	SS	4	23 38 28 11
		5	SS	4	
183.5 / 4.1	SAND and SILT, trace to some clay and gravel, containing cobbles/boulders (TILL) Compact to very dense Brown to grey Moist	6	SS	26	
		7	SS	50/0.28	11 39 37 13
180.4 / 7.2	Silty SAND and GRAVEL, containing silty sand layer and cobbles/boulders Very dense Gey Wet	8	SS	50/0.25	
		9	SS	50/0.25	41 32 24 3
		10	SS	50/0.10	
176.8 / 10.8	END OF BOREHOLE				

Elevation scale: 187, 186, 185, 184, 183, 182, 181, 180, 179, 178, 177

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

NOTES:

1. Water level measured in piezometer at depth of 9.7m below ground surface (Elevation 177.9 m) upon completion of installation.

2. Water level measured in piezometer at depth of 5.0 m below ground surface (Elevation 182.6 m) on February 28, 2008.

3. Water level measured in piezometer at depth of 4.5 m below ground surface (Elevation 183.1 m) on April 4, 2008.

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM3-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864430.5 ;E 337084.4 ORIGINATED BY VO
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE May 15, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.0	GROUND SURFACE				
0.0	Silty sand, trace gravel, containing organics (FILL) Loose Brown Moist	1	SS	8	
180.2 / 0.8	Clayey silt layer at 0.46 m depth. SAND and GRAVEL, trace to some silt, trace clay, containing rootlets, cobbles and occasional boulders Very dense Brownish grey Moist to wet	2	SS	90	
		3	SS	93	49 35 11 5
		4	SS	51/0.15	
178.0 / 3.1	SAND, trace gravel and silt Very dense Brown Wet	5	SS	51/0.08	
176.4 / 4.6	SAND and SILT, some clay, trace gravel (TILL) Very dense Grey Moist	6	SS	110/0.23	
		7	SS	129	1 48 34 17
		8	SS	100/0.13	
172.9 / 8.1	END OF BOREHOLE				

Elevation scale: 180, 179, 178, 177, 176, 175, 174, 173

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.2 m below ground surface (Elevation 179.8 m).

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

RECORD OF BOREHOLE No WM3-2

 METRIC

PROJECT 07-1111-0053 | W.O. 07-20015 | DIST Central HWY 407 | DATUM Geodetic

LOCATION N 4864424.0 ;E 337183.0

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers

DATE January 30, 2008

ORIGINATED BY GD | COMPILED BY DD | CHECKED BY TZ/BLT

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION
181.0	GROUND SURFACE
0.0	Silty sand, containing organics (FILL) Compact Dark brown to brown Moist
180.2 / 0.8	SAND and SILT, some gravel, trace to some clay, containing sand seams and occasional boulders (TILL) Dense to very dense Brown Moist Boulder encountered at 5.5 m depth
174.9 / 6.1	SAND and GRAVEL, some silt, trace clay Very dense Brown Wet to moist
172.3 / 8.7	SAND, some silt, trace gravel, containing cobbles Very dense Brown Moist
169.4 / 11.6	SAND and SILT, some gravel, trace to some clay (TILL) Very dense Grey Moist
168.7 / 12.3	END OF BOREHOLE

SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	11	
2	SS	29	
3	SS	54	
4	SS	36	
5	SS	53	17 46 29 8
6	SS	44	
7	SS	58	32 51 14 3
8	SS	69	
9	SS	65/0.13	
10	SS	50/0.02	
11	SS	100/0.10	23 33 32 12

ELEVATION SCALE: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100

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

UNIT WEIGHT γ kN/m³

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 4.9 m below ground surface (Elevation 176.1 m).
2. Water level measured in piezometer at a depth of 4.1 m and 3.9 m below ground surface (Elev. 176.9 m and Elev. 177.1 m) on February 28 and April 4, 2008, respectively.

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

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RECORD OF BOREHOLE No WM7-1A

 METRIC

PROJECT 07-1111-0053 | W.O. 07-20015 | DIST Central HWY 407 | DATUM Geodetic

LOCATION N 4864799.5 ;E 337267.5

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers

DATE September 8, 2008

ORIGINATED BY VO | COMPILED BY DD | CHECKED BY TZ/BLT

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION
177.2	GROUND SURFACE
0.0	Sand and gravel (FILL) Compact Brown and grey Moist
176.6 / 0.6	Silty sand, some gravel (FILL) Dense Brown Moist Wet below 2.7 m depth
173.9 / 3.4	SAND, trace to some silt, trace gravel Very dense brown Moist
170.7 / 6.6	SILT, trace to some sand, trace clay Very dense Brown Moist
169.1 / 8.1	Silty SAND to SAND, some silt, trace gravel and clay Very dense Brown Wet
163.2 / 14.0	END OF BOREHOLE

SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	23	
2	SS	33	
3	SS	46	
4	SS	49	
5	SS	55	
6	SS	59	
7	SS	57	
8	SS	52	0 8 90 2
9	SS	88	
10	SS	115	2 78 17 3
11	SS	113	
12	SS	140	

ELEVATION SCALE: 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165, 164

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100

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

UNIT WEIGHT γ kN/m³

Continued Next Page

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

RECORD OF BOREHOLE No WM7-1A

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864799.5 ;E 337267.5 ORIGINATED BY VO
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE September 8, 2008 CHECKED BY TZ/BLT

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

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
	--- CONTINUED FROM PREVIOUS PAGE ---				
	NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 1.8 m below ground surface (Elevation 175.4 m).				

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

RECORD OF BOREHOLE No WM7-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864765.1 ;E 337459.7 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 28 and 29, 2008 CHECKED BY TZ/HJ

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

ELEV DEPTH	DESCRIPTION
166.4	GROUND SURFACE
0.0	Silty sand, trace gravel, containing organics (FILL) Loose Dark brown Moist
165.9 0.5	SAND and SILT, some clay, trace to some gravel (TILL) Compact Brown Moist
164.1 2.3	SAND and GRAVEL, trace to some silt, trace clay Dense to very dense Brown Wet
154.5	SAND, trace to some silt and gravel Very dense Grey Moist
154.1 12.3	END OF BOREHOLE NOTES: 1. Water level measured in open borehole upon completion of drilling at a depth of 0.9 m below ground surface (Elevation 165.5 m).

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	4				
2	SS	18				
3	SS	12	8	38	40	14
4	SS	38				
5	SS	56	52	39	7	2
6	SS	59				
7	SS	77				
8	SS	48	50	39	9	2
9	SS	141				
10	SS	100/0.15				
11	SS	100/0.10				

Elevation scale: 166, 165, 164, 163, 162, 161, 160, 159, 158, 157, 156, 155

Continued Next Page

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

RECORD OF BOREHOLE No WM7-2

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4864765.1 ;E 337459.7 | ORIGINATED BY GD

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE January 28 and 29, 2008 | CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100) | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
	--- CONTINUED FROM PREVIOUS PAGE ---				
	2. Water level measured in piezometer at a depth of 2.2 m below ground surface (Elevation 164.2 m) on February 28, 2008.				
	3. Water level measured in piezometer at a depth of 2.1 m below ground surface (Elevation 164.3 m) on April 4, 2008.				

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

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RECORD OF BOREHOLE No WM8-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4865531.0 ;E 337893.6 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE December 10 and 11, 2007 | CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR SA SI CL
168.1	GROUND SURFACE					
0.0	Crushed sand and gravel (FILL)				168	
0.1	Silty sand, containing organics (FILL) Compact Brown Moist	1	SS	20		
167.3 / 0.8	Clayey silt with sand pockets, trace gravel (FILL) Firm Brown Moist	2	SS	9	167	
166.6 / 1.5	CLAYEY SILT with sand, trace gravel, occasional cobbles and silty sand seams (TILL) Hard Brown to grey Moist	3	SS	35	166	
		4	SS	45	165	1 41 41 17
		5	SS	46		
		6	SS	55	164	
	Wet below 4.6 m depth	7	SS	70	163	
		8	SS	55	162 / 161	
160.5 / 7.6	Silty SAND to SAND, some silt, trace clay Compact to very dense Grey Wet	9	SS	23	160	
		10	SS	48	159	0 74 22 4
		11	SS	13	158 / 157	
		12	SS	68	156	0 82 17 1
		13	SS	100/0.13	155 / 154	

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MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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

RECORD OF BOREHOLE No WM8-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4865531.0 ;E 337893.6 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 10 and 11, 2007 CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---								
	Silty SAND to SAND, some silt, trace clay Compact to very dense Grey Wet	14	SS	100/0.08	153				
					152				
151.2 16.9		15	SS	100/0.13		1	81	14	4
	END OF BOREHOLE								

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.4 m below ground surface (Elevation 165.7 m).

2. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 167.4 m) on April 4, 2008.

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

RECORD OF BOREHOLE No WM11-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4865995.6 ;E 338473.7 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 6.1 m to 17.4 m depth COMPILED BY DD
DATUM Geodetic DATE March 20, 2008 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
153.5	GROUND SURFACE								
0.0	TOPSOIL Compact Brown Moist	1	SS	14	153				
152.7 0.8	SAND and SILT, trace clay to SILT, some sand, trace clay Loose to compact Brown Moist	2	SS	9	152				
		3	SS	20	151				
		4	SS	20		0 NP	40	58	2
	Wet below 3.1 m depth	5	SS	21	150				
					149				
		6	SS	15	148				
		7	SS	22	147				
					146				
		8	SS	30	145	0	18	79	3
143.8 9.8		9	SS	9	144				
	CLAYEY SILT, trace to some sand, trace gravel (TILL-Like) Stiff to very stiff Grey Wet				143				
		10	SS	9		0	2	51	47
		11	TO	PH	142				
					2.3				
		12	SS	8	141				
					>96				
					140				
		13	SS	11	139	2	21	49	28

Continued Next Page

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

RECORD OF BOREHOLE No WM11-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4865995.6 ;E 338473.7
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 6.1 m to 17.4 m depth
DATE March 20, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
		14	SS	23	138	
137.7 / 15.9	Silty SAND Compact Grey Wet				137	
		15	SS	29		
136.1 / 17.4	END OF BOREHOLE					

NOTES:

1. "Blowing" sand was encountered during drilling at about a depth of 9.7 m below ground surface (Elev. 143.8 m).

2. Water level measured in open borehole upon completion of drilling at a depth of 4.0 m below ground surface (Elevation 149.5).

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

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RECORD OF BOREHOLE No WM11-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4866073.0 ;E 338507.6
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 9.1 m to 38.4 m depth
DATE March 12 to 18, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
152.4	GROUND SURFACE					
0.0	TOPSOIL Loose Brown Moist	1	SS	7	152	
151.6 / 0.8	Silty SAND, trace gravel Compact to very dense Brown Moist	2	SS	25	151	
		3	SS	70	150	
		4	SS	28		
149.5 / 2.9	SAND and SILT, trace clay Loose to dense Brown Moist	5	SS	33	149	0 50 48 2
					148	
	Wet below 4.6 m depth	6	SS	10	147	
		7	SS	7	146	
					145	
		8	SS	19	144	0 60 39 1
143.3 / 9.1	CLAYEY SILT with sand to trace sand, trace to some gravel (TILL-Like) Firm to hard Grey Wet	9	SS	5	143	
					142	
		10	SS	9	141	0 3 63 34
		11	SS	9	140	
					139	
		12	SS	10	138	

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Shear strength (field vane, +) near elev. 141: 2.6

Continued Next Page

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

RECORD OF BOREHOLE No WM11-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4866073.0 ;E 338507.6
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 9.1 m to 38.4 m depth
DATE March 12 to 18, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE DESCRIPTION
	CLAYEY SILT with sand to trace sand, trace to some gravel (TILL-Like) Firm to hard Grey Wet Cobbles encountered at 15.6 m depth
132.6 / 19.8	Silty SAND Loose Grey Wet
131.1 / 21.3	CLAYEY SILT, containing sand seams Hard Grey Wet
130.5 / 22.0	Silty SAND to SILT and SAND, containing clayey silt seams Dense to very dense Grey Wet

SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
13	SS	60/0.18	
14	SS	16	10 28 45 17
15	SS	32	
16	SS	6	
17	SS	58	
18	SS	100/0.27	0 3 83 14
19	SS	61	
20	SS	76	
21	SS	74	
22	SS	52	

Elevation scale: 137 to 123

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF BOREHOLE No WM11-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4866073.0 ;E 338507.6
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 9.1 m to 38.4 m depth
DATE March 12 to 18, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE DESCRIPTION
	Silty SAND to SILT and SAND, containing clayey silt seams Dense to very dense Grey Wet
115.0 / 37.4	Grey SHALE (BEDROCK) Wet
114.0 / 38.4	END OF BOREHOLE AUGER REFUSAL

SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
23	SS	57	1 79 17 3
24	SS	100/0.23	
25	SS	100/0.25	7 31 45 17
26	SS	38	
27	SS	64	
28	SS	100/0.13	
29	SS	100/0.08	

Elevation scale: 122 to 114

NOTES:

1. "Blowing" sand was encountered during drilling at a depth of 9.1 m below ground surface (Elev. 143.3 m).

2. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 150.9 m).

3. Water level measured in piezometer at 2.4 m above ground surface (Elev. 154.8 m) on March 24, 2008.

4. Piezometer was decommissioned in accordance with O. Reg. 903 on March 24, 2008.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM11A-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 LOCATION N 4866005.9 ;E 338609.9 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 12.2 m to 28.0 m depth COMPILED BY DD

DATUM Geodetic DATE December 13, 2007 CHECKED BY TZ/HJ

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
143.9	GROUND SURFACE							
0.0	Sand and gravel (FILL) Compact to dense Brown Moist	1	SS	22				
		2	SS	35				
142.5 1.4	Organic SILT to PEAT, occasional sand seams Very soft to soft Brown Moist	3	SS	4				
		4	SS	WH			55.2 OC = 30.7%	
141.0 2.9	Silty SAND and GRAVEL Dense Brown Wet	5	SS	32	▽			
139.8 4.1	CLAYEY SILT with SAND, trace gravel, containing sand seams Firm Grey Wet	6	SS	13		1.7		1 42 42 15
		7	SS	WH		3.2		
136.3 7.6	SILTY CLAY, trace to some sand, trace gravel Soft to firm Grey Wet	8	SS	WH		1.4		
		9	SS	WH		2		
	Silty sand seam from 11.2 m to 11.3 m depth	10	SS	8				
131.7 12.2	CLAYEY SILT, trace to some sand, containing sand and silt seams Soft to hard Grey Wet	11	SS	9				0 24 54 22
		12	SS	5				

Continued Next Page

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

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RECORD OF BOREHOLE No WM11A-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 LOCATION N 4866005.9 ;E 338609.9 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 12.2 m to 28.0 m depth COMPILED BY DD

DATUM Geodetic DATE December 13, 2007 CHECKED BY TZ/HJ

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---				
	CLAYEY SILT, trace to some sand, containing sand and silt seams Soft to hard Grey Wet	13	SS	63	0 2 76 22
		14	SS	37	0 11 49 40
		15	SS	30	
	Silt seam encountered at 20.0 m depth	16	SS	2	
		17	SS	16	
	Silt seam encountered at 23.2 m depth	18	SS	22	0 11 75 14 NP (Silt Seam)
		19	SS	15	
		20	SS	10	
116.5 27.4	SAND and SILT, trace to some clay, trace gravel Compact Wet Grey	21	SS	13	2 49 43 6
115.9 28.0	Dynamic Cone Penetration Test (DCPT)				

Continued Next Page

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

RECORD OF BOREHOLE No WM11A-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4866005.9 ;E 338609.9 — ORIGINATED BY PKS
DIST Central — HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 12.2 m to 28.0 m depth — COMPILED BY DD
DATUM Geodetic — DATE December 13, 2007 — CHECKED BY TZ/HJ

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

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	Dynamic Cone Penetration Test (DCPT)					113
112.4 31.6	END OF DCPT UPON REFUSAL END OF BOREHOLE					

NOTES:

1. "Blowing" sand was encountered during drilling at approximately a depth of 12.2 m below ground surface (Elev. 131.7 m).

2. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below ground surface (Elevation 140.9 m).

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

RECORD OF BOREHOLE No WM12-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4866170.2 ;E 338678.7 — ORIGINATED BY PKS
DIST Central — HWY 407 — BOREHOLE TYPE Portable (Tripod), wash boring from 0 m to 22 m depth — COMPILED BY DD/TZ
DATUM Geodetic — DATE April 15 to 18 and April 21 to 23, 2008 — CHECKED BY BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS GR SA SI CL
141.3	GROUND SURFACE				
0.0 0.1	TOPSOIL Compact Brown Moist	1	SS	11	
	Silty SAND, some gravel Compact to very dense Brown Moist to wet Wet below 1.2 m depth	2	SS	50	
139.8 1.5	CLAYEY SILT, trace to some sand, trace gravel Firm to very stiff Grey Wet	3	SS	11	
		4	SS	11	
		5	SS	9	1 14 56 29
		6	SS	7	
		7	SS	10	
		8	SS	12	
		9	SS	16	0 3 50 47
		10	SS	6	
129.1 12.2	SAND and SILT, trace gravel and clay, containing clayey silt seams Loose to very dense Grey Wet	11	SS	7	4 38 53 5
		12	SS	60	

Elevation scale: 141, 140, 139, 138, 137, 136, 135, 134, 133, 132, 131, 130, 129, 128, 127

Field vane sensitivity values: 3.8, 5.3

Continued Next Page

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

Foundation Design

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RECORD OF BOREHOLE No WM12-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866170.2 ;E 338678.7 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE Portable (Tripod), wash boring from 0 m to 22 m depth COMPILED BY DD/TZ
DATUM Geodetic DATE April 15 to 18 and April 21 to 23, 2008 CHECKED BY BLT

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	SAND and SILT, trace gravel and clay, containing clayey silt seams; Loose to very dense; Grey; Wet	13	SS	31				
		14	SS	80	0	55	43	2
		15	SS	160				
121.5 / 19.8	Sandy SILT, trace to some gravel and clay; Compact; Grey; Wet	16	SS	17	6	23	61	10
		17	SS	16				
119.4 / 22.0	END OF BOREHOLE							

Elevation scale: 126, 125, 124, 123, 122, 121, 120

NOTES:

1. Artesian conditions encountered at a depth of 16.8 m below ground surface (Elevation 124.5 m) on April 17, 2008.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Foundation Design

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RECORD OF BOREHOLE No WM13-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866246.2 ;E 338899.0 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers, Wash Boring from 12.2 m to 36.6 m depth COMPILED BY DD/TZ
DATUM Geodetic DATE April 30, May 4 to 7, 2008 CHECKED BY BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
140.1	GROUND SURFACE							
0.0	TOPSOIL; Loose; Brown; Moist	1	SS	8				
139.3 / 0.8	CLAYEY SILT, trace to some sand, trace gravel, containing sandy silt to silty sand seams; Firm to hard; Brown to grey; Moist to wet	2	SS	8				
		3	SS	12				
		4	SS	14				
		5	SS	8				
		6	SS	15	0	0	60	40
		7	SS	14				
	Wet below 7.9 m depth	8	SS	7				
		9	SS	9				
		10	SS	14				
		11	SS	17	3	8	49	40
126.4 / 13.7	SAND and SILT, containing clayey silt seams; Loose to dense; Grey; Wet	12	SS	41				

Elevation scale: 140, 139, 138, 137, 136, 135, 134, 133, 132, 131, 130, 129, 128, 127, 126

Field vane: + 3.8

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM13-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4866246.2 ;E 338899.0
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers, Wash Boring from 12.2 m to 36.6 m depth
COMPILED BY DD/TZ
DATUM Geodetic
DATE April 30, May 4 to 7, 2008
CHECKED BY BLT

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

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
	SAND and SILT, containing clayey silt seams Loose to dense Grey Wet	13	SS	27	
		14	SS	9	
		15	SS	4	0 49 51 0 NP
		16	SS	7	
118.8 21.3	SAND, trace to some gravel, trace silt Loose to compact Grey Wet	17	SS	17	
		18	SS	7	10 86 4 0
115.7 24.4	SAND and SILT, trace gravel and clay Loose to very dense Grey Wet	19	SS	18	
		20	SS	60	0 52 47 1 NP
		21	SS	28	
		22	SS	27	

Elevation scale: 125, 124, 123, 122, 121, 120, 119, 118, 117, 116, 115, 114, 113, 112, 111

Continued Next Page

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

Foundation Design

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RECORD OF BOREHOLE No WM13-1

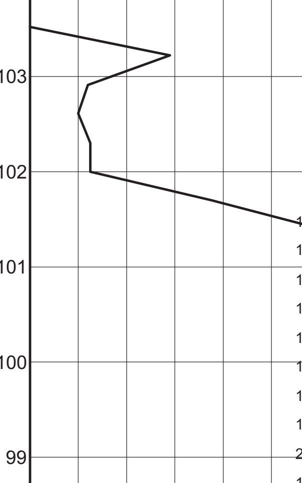
 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4866246.2 ;E 338899.0
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers, Wash Boring from 12.2 m to 36.6 m depth
COMPILED BY DD/TZ
DATUM Geodetic
DATE April 30, May 4 to 7, 2008
CHECKED BY BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
	SAND and SILT, trace gravel and clay Loose to very dense Grey Wet	23	SS	25	1 67 30 2 NP
		24	SS	8	
		25	SS	46	
105.1 35.1	SAND and GRAVEL Grey Wet	26	AS	-	
103.6 36.5	Dynamic Cone Penetration Test (DCPT)				
98.7 41.5	END OF BOREHOLE END OF DCPT NOTES: 1. Artesian conditions encountered at a depth of 15.2 m below ground surface (Elevation 124.9 m) on April 30, 2008.				

Elevation scale: 110, 109, 108, 107, 106, 105, 104, 103, 102, 101, 100, 99



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

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RECORD OF BOREHOLE No WM17-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4866540.5 ;E 339291.5 — ORIGINATED BY SB
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE December 17, 2007 — CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION
155.0	GROUND SURFACE
0.0	Sand and gravel, trace silt (FILL) Dense Brown Moist
154.2 / 0.8	Organic CLAYEY SILT, trace sand and gravel Firm Black Moist
153.5 / 1.5	CLAYEY SILT, some sand, trace gravel Very stiff to firm Brown Moist; Becoming grey at 3.1 m depth
150.4 / 4.6	SILT, some sand, trace clay Very loose to compact Grey Wet
143.4 / 11.6	CLAYEY SILT, trace sand and gravel Firm to very stiff Grey Moist

NUMBER	TYPE	"N" VALUES	GR SA SI CL
1	SS	50/0.15	
2	SS	8	
3	SS	29	3 23 37 37
4	SS	20	
5	SS	5	
6	SS	8	
7	SS	15	0 15 74 11
8	SS	4	
9	SS	9	
10	SS	19	
11	SS	12	0 1 78 21
12	SS	8	

Elevation scale: 154, 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 143, 142, 141

Field vane: 2.0, 2.2

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM17-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4866540.5 ;E 339291.5 — ORIGINATED BY SB
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE December 17, 2007 — CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION
	CLAYEY SILT, trace sand and gravel Firm to very stiff Grey Moist
138.5 / 16.5	Sandy SILT, trace to some gravel, trace clay Very loose to loose Grey Wet
132.4 / 22.6	SAND and SILT, trace to some clay, containing clayey silt lenses Compact to very dense Grey Moist to wet

NUMBER	TYPE	"N" VALUES	GR SA SI CL
13	SS	16	
14	SS	WH	
15	SS	9	
16	SS	9	8 24 63 5
17	SS	8	
18	SS	53	3 56 36 5
19	SS	44	0 50 46 4
20	SS	34	
21	SS	12	0 27 59 14
22	SS	24	

Elevation scale: 139, 138, 137, 136, 135, 134, 133, 132, 131, 130, 129, 128, 127, 126

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM17-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866540.5 ;E 339291.5 ORIGINATED BY SB
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 17, 2007 CHECKED BY TZ/HJ

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

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	SAND and SILT, trace to some clay, containing clayey silt lenses Compact to very dense Grey Moist to wet	23	SS	41	4	65	29	2
		24	SS	101				
		25	SS	100/0.25				
		26	SS	35				
118.4 36.6	SILT, trace to some sand and clay, trace gravel, containing occasional silty sand seams Very dense Grey Wet	27	SS	154	3	10	78	9
		28	SS	100/0.25				
114.9 40.1	END OF BOREHOLE	29	SS	100/0.28				

Elevation scale: 124, 123, 122, 121, 120, 119, 118, 117, 116, 115

NOTES:

1. Water level measured in piezometer at a depth of 4.3 m below ground surface (Elevation 150.7 m) on January 7, 2008.

1. Water level measured in piezometer at a depth of 2.5 m below ground surface (Elevation 152.5 m) on April 4, 2008.

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

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RECORD OF BOREHOLE No WM17-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866473.4 ;E 339324.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 10, 16 and 17, 2008 CHECKED BY TZ/HJ

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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
156.4	GROUND SURFACE							
0.0	Sand and gravel (FILL) Loose to compact Brown Moist	1	SS	14				
		2	SS	6				
155.2 1.2	Organic CLAYEY SILT, some sand Stiff Black Moist	3	SS	9				
154.1 2.3	Silty SAND with clayey silt seams Compact Brown Moist	4	SS	10				
153.3 3.1	CLAYEY SILT, trace to some sand, trace gravel Soft to stiff Grey Wet	5	SS	WH				
		6	SS	4				
		7	SS	6	1	10	43	46
		8	SS	14				
		9	SS	2				
145.7 10.7	SILT, some sand, trace clay Loose to compact Grey Wet	10	SS	2				
		11	SS	5	0	12	78	10
		12	SS	15				

Elevation scale: 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 143, 142

Field vane sensitivity labels: 2.0, 2.7, 2.2, 2.9; >96

Continued Next Page

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

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RECORD OF BOREHOLE No WM17-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866473.4 ;E 339324.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 10, 16 and 17, 2008 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
141.1								
15.2	CLAYEY SILT, some sand Very stiff Grey Wet	13	SS	20				
		14	SS	26	0	16	44	40
		15	SS	15				
136.6 19.8	SILT to Sandy SILT, trace gravel, containing clayey silt seams Compact Grey Wet	16	SS	14	0	8	83	9
		17	SS	14				
		18	SS	16				
		19	SS	13	3	33	58	6
		20	SS	22				
128.9 27.4	CLAYEY SILT, some sand, trace gravel Stiff to very stiff Grey Wet	21	SS	17				
		22	SS	14				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (141 to 127); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM17-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866473.4 ;E 339324.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 10, 16 and 17, 2008 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	CLAYEY SILT, some sand, trace gravel Stiff to very stiff Grey Wet	23	SS	14				
124.4 32.0	Sandy SILT to SILT, some sand, trace to some clay and gravel Compact to very dense Grey Wet	24	SS	48				
		25	SS	29	0	26	66	8
		26	SS	28				
		27	SS	36	4	16	63	17
		28	SS	100/0.18				
116.8 39.6	Silty SAND, trace to some gravel, trace clay Very dense Grey Wet	29	SS	100/0.25				
		30	SS	100/0.20	10	70	17	3
115.0 41.4	END OF BOREHOLE							

NOTES:

1. Shelby tube sample (SA 6A) obtained between a depth of 4.6 m and 5.2 m below ground surface (Elevation 151.8 m and Elevation 151.2 m) in an adjacent borehole for laboratory consolidation testing.

2. Wet samples noted at a depth of 4.6 m below ground surface (Elevation 151.8 m).

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (126 to 116); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM22-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867019.3 ;E 340901.0 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 14, 18, 2007 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION
169.0	GROUND SURFACE
0.0	Sand and gravel (FILL) Compact Brown Moist
168.2 / 0.8	CLAYEY SILT, with sand, trace gravel (TILL) Stiff to very stiff Brown Moist to wet
162.6 / 6.4	Silty SAND to SAND some silt, trace to some gravel, trace clay, occasional cobbles Compact to very dense Grey Wet
157.4 / 11.6	SILT, trace to some sand and clay, trace gravel Very dense Grey Wet

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	17	
2	SS	11	
3	SS	25	
4	SS	21	4 30 47 19
5	SS	23	
6	SS	13	
7	SS	66	6 56 33 5
8	SS	16	
9	SS	44	
10	SS	57	0 87 11 2
11	SS	93	
12	SS	138	1 6 85 8

ELEVATION SCALE: 168, 167, 166, 165, 164, 163, 162, 161, 160, 159, 158, 157, 156, 155

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM22-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867019.3 ;E 340901.0 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 14, 18, 2007 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION
	SILT, trace to some sand and clay, trace gravel Very dense Grey Wet
152.0 / 17.0	CLAYEY SILT, containing sand seams Hard Grey Wet
149.0 / 20.0	END OF BOREHOLE

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
13	SS	52	
14	SS	100/0.1	
15	SS	100/0.2	
16	SS	100/0.2	0 0 65 35

ELEVATION SCALE: 153, 152, 151, 150, 149

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 4.0 m below ground surface (Elevation 165.0 m).

2. Water level measured in piezometer at a depth of 5.6 m (Elevation 163.4 m) on January 7, 2008.

3. Water level measured in piezometer at a depth of 4.8 m (Elevation 164.2 m) on April 4, 2008.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM25-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4867278.2 ;E 341679.9 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE December 19, 2007 | CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
180.1	GROUND SURFACE									
0.0	Sand and gravel (FILL) Compact Brown Moist		1	SS	22	180				
179.3 / 0.8	SAND and SILT, some clay, trace gravel, occasional cobbles (TILL) Compact to very dense Brown to gey Moist to wet		2	SS	15	179				
			3	SS	37	178				
			4	SS	32		10	39	37	14
			5	SS	31	177				
	Wet below 3.7 m depth					176				
			6	SS	31	175	12	43	32	13
			7	SS	62	174				
			8	SS	36	173, 172				
			9	SS	45	171, 170				
			10	SS	50	169	2	39	43	16
			11	SS	41	168, 167				
			12	SS	52	166				

Continued Next Page

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM25-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4867278.2 ;E 341679.9 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE December 19, 2007 | CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	SAND and SILT, some clay, trace gravel, occasional cobbles (TILL) Compact to very dense Brown to gey Moist to wet		13	SS	74	165	1	50	37	12
			14	SS	100/0.23	164, 163				
			15	SS	100/0.20	162				
			16	SS	100/0.20	161				
160.1 / 20.0	END OF BOREHOLE									

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.1 m below ground surface (Elevation 174.0 m).

2. Water level measured in piezometer at a depth of 9.1 m below ground surface (Elevation 171.0 m) on January 7, 2008.

2. Water level measured in piezometer at a depth of 2.2 m below ground surface (Elevation 177.9 m) on April 4, 2008.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM27-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867644.3 ;E 342430.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 20, 2007 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.8	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	24	
195.0 0.8	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Brown to grey Moist to wet	2	SS	16	
		3	SS	88	16 49 30 5 NP
		4	SS	100/0.15	
		5	SS	100/0.20	
		6	SS	100/0.20	
		7	SS	100/0.15	
		8	SS	100/0.20	
186.5		9	SS	100/0.18	4 37 44 15
9.3	END OF BOREHOLE				

NOTE:

1. Borehole dry upon completion of drilling, however wet soil samples were noted at a depth of 6.4 m below ground surface (Elevation 189.4 m).

Elevation scale: 195, 194, 193, 192, 191, 190, 189, 188, 187

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

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

Golder Associates

RECORD OF BOREHOLE No WM27-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867538.3 ;E 342470.7 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 20, 2007 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.8	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	17	
191.0 0.8	SAND and SILT, trace to some clay and gravel, occasional cobbles (TILL) Compact to very dense Brown to grey Moist to wet	2	SS	29	
		3	SS	38	
		4	SS	81	
		5	SS	100/0.18	7 46 37 10
		6	SS	100/0.15	
		7	SS	100/0.15	
		8	SS	100/0.15	
182.5		9	SS	100/0.13	8 41 36 15
9.3	END OF BOREHOLE				

NOTES:

1. Water level measured in piezometer at a depth of 0.6 m below ground surface (Elevation 191.2 m) on February 26, 2008.

2. Water level measured in piezometer at depth of 0.3 m below ground surface (Elevation 191.5 m) on April 4, 2008.

Elevation scale: 191, 190, 189, 188, 187, 186, 185, 184, 183

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF BOREHOLE No WM28-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4867900.8 ;E 343233.6	ORIGINATED BY PKS	
DIST Central	HWY 407	BOREHOLE TYPE 114 mm O.D. Hollow Stem Augers	COMPILED BY DD
DATUM Geodetic	DATE January 29, 2008	CHECKED BY TZ/HJ	

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	22	
193.2 / 0.8	SAND and SILT, trace to some gravel and clay (TILL) Compact to very dense Brown to grey Moist	2	SS	13	
		3	SS	46	
		4	SS	88	23 43 28 6
		5	SS	95	
	Wet below 4.6 m depth	6	SS	100/0.25	
		7	SS	100/0.15	3 47 41 9
186.3		8	SS	100/0.13	
7.8	END OF BOREHOLE				

NOTES:

1. Water level in open borehole upon completion of drilling at a depth of 0.4 m below ground surface (Elevation 193.6 m).

2. Water level measured in piezometer at a depth of 0.4 m below ground surface (Elevation 193.6 m) on February 28, 2008.

3. Water level measured in piezometer at a depth of 3.4 m below ground surface (Elevation 190.6 m) on April 4, 2008.

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

RECORD OF BOREHOLE No WM29-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4868006.6 ;E 343626.2	ORIGINATED BY PKS	
DIST Central	HWY 407	BOREHOLE TYPE 108 mm O.D. Solid Stem Augers	COMPILED BY DD
DATUM Geodetic	DATE December 21, 2007	CHECKED BY TZ/HJ	

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
189.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	23	
		2	SS	24	
187.5 / 1.5	SAND and SILT, some clay, trace to some gravel, occasional cobbles (TILL) Compact to to very dense Brown Moist	3	SS	12	
		4	SS	24	
		5	SS	50	17 36 36 11
		6	SS	100/0.13	
		7	SS	100/0.13	8 40 36 16
181.3	Clayey silt seam at 7.6 m depth	8	SS	100/0.13	
7.8	END OF BOREHOLE				

NOTE:

1. Open borehole dry upon completion of drilling.

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

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RECORD OF BOREHOLE No WM29-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4867883.6 ;E 343671.2
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE December 21, 2007
CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
190.0	GROUND SURFACE							
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	15				
189.2 0.8	SAND and SILT, some clay, trace to some gravel, occasional cobbles (TILL) Loose to very dense Brown to grey Moist to wet	2	SS	9				
		3	SS	18	3	41	45	11
		4	SS	28				
		5	SS	33				
		6	SS	28	4	42	42	12
		7	SS	100/0.18				
		8	SS	100/0.25	7	43	38	12
180.7		9	SS	100/0.13				
9.3	END OF BOREHOLE							

Elevation scale: 189, 188, 187, 186, 185, 184, 183, 182, 181

NOTES:

1. Open borehole dry upon completion of drilling.

2. Water level measured in piezometer at a depth of 8.7 m below ground surface (Elevation 181.3 m) on January 7, 2008.

3. Water level measured in piezometer at a depth 7.8 m below ground surface (Elevation 182.2 m) on April 4, 2008.

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

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RECORD OF BOREHOLE No WM35-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4868095.8 ;E 345333.7
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE January 2, 2008
CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
165.0	GROUND SURFACE							
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	AS				
		2	SS	20				
163.5 1.5	SAND and SILT, trace to some clay, trace gravel (TILL) Compact to very dense Brown to grey Moist	3	SS	15				
		4	SS	76				
		5	SS	65	3	44	46	7
		6	SS	116				
	Wet below 6.1 m depth	7	SS	100/0.18				
		8	SS	110	1	37	44	18
155.7		9	SS	100/0.18				
9.3	END OF BOREHOLE							

Elevation scale: 164, 163, 162, 161, 160, 159, 158, 157, 156

NOTES:

1. Water level measured in piezometer at a depth of 3.9 m below ground surface (Elevation 161.1 m) on January 7, 2008.

2. Water level measured in piezometer at a depth of 2.5 m below ground surface (Elevation 162.6 m) on April 4, 2008.

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

RECORD OF BOREHOLE No WM35-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867982.7 ;E 345375.8 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 2, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
163.6	GROUND SURFACE					
0.0	Sand and gravel (FILL) Brown Moist	1	SS	AS		
162.9 / 0.8	CLAYEY SILT, some sand, trace gravel, containing rootlets, topsoil and wood pieces Stiff Brown Moist	2	SS	10		
162.4 / 1.2	SAND and SILT, trace to some clay, trace to some gravel (TILL) Compact to very dense Brown Moist	3	SS	17		
		4	SS	59		
		5	SS	53		
		6	SS	105		6 42 39 13
	Becoming gravelly at 6.1 m depth	7	SS	100/0.13		
		8	SS	100/0.13	▽	23 36 32 9
154.3		9	SS	100/0.15		
9.3	END OF BOREHOLE NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 8.2 m below ground surface (Elevation 155.4 m).					

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

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

UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 163 162 161 160 159 158 157 156 155

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

RECORD OF BOREHOLE No WM36-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867998.0 ;E 345772.3 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 4 and 6, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
153.6	GROUND SURFACE					
0.0	Sandy TOPSOIL Loose Brown Moist	1	SS	4		
152.8 / 0.8	SAND and SILT, trace to some clay, trace to some gravel, containing sand seams and cobbles (TILL) Compact to very dense Brown to grey Moist	2	SS	13		
		3	SS	22		
	Wet below 2.3 m depth	4	SS	54	▽	
		5	SS	18		
		6	SS	16		1 32 56 11
		7	SS	76		
		8	SS	50		13 46 33 8
144.5 / 9.1	SILT, some clay, trace to some sand Compact to very dense Grey Wet	9	SS	25		
		10	SS	108		
		11	SS	100/0.18		0 7 80 13
139.6		12	SS	100/0.25		
14.0						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

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

UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 153 152 151 150 149 148 147 146 145 144 143 142 141 140

Continued Next Page

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

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RECORD OF BOREHOLE No WM36-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867998.0 ;E 345772.3 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 4 and 6, 2008 CHECKED BY TZ/BLT

SOIL PROFILE

--- CONTINUED FROM PREVIOUS PAGE ---

END OF BOREHOLE

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below the ground surface (Elevation 150.6 m).

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM37-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868110.8 ;E 345670.5 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 6, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
153.2	GROUND SURFACE				
0.0	Sandy TOPSOIL Loose Brown Moist	1	SS	8	
152.4 / 0.8	CLAYEY SILT, some sand, trace to some gravel (TILL) Firm to very stiff Brown to grey Moist	2	SS	8	
		3	SS	14	8 15 54 23
	Wet below 2.3 m depth	4	SS	16	
		5	SS	15	
		6	SS	17	
147.1 / 6.1	SAND and SILT, trace to some clay, trace to some gravel (TILL) Dense to very dense Grey Wet	7	SS	49	5 36 47 12
		8	SS	39	
		9	SS	51	
142.5 / 10.7	CLAYEY SILT, trace to some sand Stiff Grey Wet	10	SS	14	
141.9 / 11.3	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Wet	11	SS	100/0.18	
		12	SS	100/0.18	8 35 42 15

ELEVATION SCALE: 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 143, 142, 141, 140, 139

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF BOREHOLE No WM37-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868110.8 ;E 345670.5 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 6, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
		13	SS	100/0.15	138	
137.8 15.4	END OF BOREHOLE					

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 9.1 m below ground surface (Elevation 144.1 m).

2. Water level measured in piezometer at a depth of 1.6 m below ground surface (Elevation 151.6 m) on April 4, 2008.

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; STRAT PLOT.

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

RECORD OF BOREHOLE No WM38-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868111.0 ;E 346196.0 ORIGINATED BY PLS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 3 and 7, 2008 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
170.1	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	AS		
169.0 1.1	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Brown Moist to wet	2	SS	29	
		3	SS	43	
		4	SS	51	8 39 48 5
		5	SS	85	
165.5 4.6	SAND, some silt, trace gravel Dense to very dense Brown Wet	6	SS	61	
		7	SS	34	
		8	SS	39	0 86 13 1
161.0 9.1	CLAYEY SILT with SAND, some gravel (TILL) Hard Brown to grey Wet	9	SS	112	
		10	SS	50/0.05	12 39 37 12
		11	SS	60/0.07	
157.7 12.4	END OF BOREHOLE				

Elevation scale: 170, 169, 168, 167, 166, 165, 164, 163, 162, 161, 160, 159, 158

NOTE:

1. Water level measured in piezometer at depth of 3.9 m below ground surface (Elevation 166.2 m) on April 4, 2008.

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; STRAT PLOT.

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

Foundation Design

RECORD OF BOREHOLE No WM38-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867998.9 ;E 346240.4 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 3, 2008 CHECKED BY TZ/HJ

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	AS		
165.2 / 0.8	SAND and SILT, some clay and gravel (TILL) Compact to very dense Brown Moist	2	SS	17	
		3	SS	64	
		4	SS	78	14 37 36 13
		5	SS	84	
161.4 / 4.6	CLAYEY SILT with SAND, some gravel (TILL) Hard Grey Moist to wet	6	SS	100/0.18	
		7	SS	103	13 27 37 23
		8	SS	100/0.23	
158.1 / 7.9	END OF BOREHOLE				

NOTE:

1. Wet soil samples noted at a depth of 7.6 m below ground surface (Elevation 158.4 m).

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (165, 164, 163, 162, 161, 160, 159); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM39-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867846.2 ;E 346644.0 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 9, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
159.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	15	
158.2 / 0.8	SAND and SILT to Sandy SILT, some clay, trace gravel (TILL) Compact to dense Brown to grey Moist to wet	2	SS	14	
		3	SS	34	
	Wet below 2.3 m depth	4	SS	24	5 26 57 12
		5	SS	30	
154.7 / 4.3	CLAYEY SILT to SILTY CLAY, trace sand and gravel Very stiff Grey Wet	6	SS	21	
		7	SS	23	
151.4 / 7.6	SAND and GRAVEL to SAND, some gravel, trace to some silt, trace clay Dense to very dense Grey Wet	8	SS	42	
		9	SS	75	
		10	SS	44	18 70 11 1
		11	SS	60	54 38 7 1
145.6 / 13.4	SAND and SILT, trace to some gravel (TILL) Very dense Grey Wet	12	SS	100/0.2	

Continued Next Page

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146, 145); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF BOREHOLE No WM39-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867846.2 ;E 346644.0 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 9, 2008 CHECKED BY TZ/BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	SAND and SILT, trace to some gravel (TILL) Very dense Grey Wet	13	SS	100/0.30	143
142.0 17.0		14	SS	100/0.23	
	END OF BOREHOLE NOTE: 1. Water level measured in piezometer at a depth of 1.6 m below ground surface (Elevation 157.4 m) on April 4, 2008.				

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

RECORD OF BOREHOLE No WM40-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867951.9 ;E 346735.8 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 7.3 m to 13.8 m depth COMPILED BY DD
DATUM Geodetic DATE February 27 and 29, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
159.4	GROUND SURFACE				
0.0	TOPSOIL Loose Brown Moist	1	SS	4	
158.6 0.8	CLAYEY SILT with SAND, trace to some gravel (TILL) Stiff to very stiff Brown to grey Moist	2	SS	9	
		3	SS	11	9 36 42 13
		4	SS	29	
		5	SS	23	
		6	SS	18	4 35 45 16
153.9 5.5	SILTY CLAY Stiff Grey Wet	7	SS	12	
151.8 7.6	SILT Very loose Grey Wet	8	SS	3	
150.3 9.1	SAND and SILT, some clay and gravel, containing clayey silt seams (TILL) Compact to very dense Grey Wet	9	SS	17	4 32 55 9
		10	SS	108	
		11	SS	100/0.23	
145.6 13.8	END OF BOREHOLE	12	SS	100/0.13	10 37 39 14

ELEVATION SCALE: 159, 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No WM40-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867951.9 ;E 346735.8 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 7.3 m to 13.8 m depth COMPILED BY DD
DATUM Geodetic DATE February 27 and 29, 2008 CHECKED BY TZ/BLT

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

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
	--- CONTINUED FROM PREVIOUS PAGE ---				
	NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below ground surface (Elevation 156.4 m).				

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

RECORD OF BOREHOLE No WM41-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868117.0 ;E 346637.4 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 26, 2008 CHECKED BY TZ/BLT

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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS GR SA SI CL
158.9	GROUND SURFACE				
0.0	TOPSOIL Very loose Brown Moist	1	SS	3	
158.4 0.5	CLAYEY SILT, some sand, trace gravel Firm Brown Moist	2	SS	5	
157.4 1.5	Sandy SILT to SILT, trace to some clay, trace sand, occasional sand seams Compact Brown to grey Wet	3	SS	20	
		4	SS	20	0 4 88 8
		5	SS	10	
154.3 4.6	CLAYEY SILT to SILTY CLAY, trace sand and gravel Very stiff to stiff Grey Wet	6	SS	20	
		7	SS	11	
151.3 7.6	SAND and SILT, some gravel, trace to some clay Very loose to loose Grey Wet	8	SS	WH*	
		9	SS	8*	18 30 45 7
		10	SS	9*	
146.7 12.2	SAND and GRAVEL Compact Brown Wet	11	SS	29	
145.2 13.7	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Moist	12	SS	88/0.15	

Elevation scale: 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146, 145, 144

Continued Next Page

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

RECORD OF BOREHOLE No WM41-1 — 2 OF 2 — METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4868117.0 ;E 346637.4 — ORIGINATED BY GD
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE February 26, 2008 — CHECKED BY TZ/BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Moist	13	SS	103/0.15	9	40	37	14
142.0		14	SS	82/0.15				
16.9	END OF BOREHOLE							

NOTES:

1. Artesian conditions encountered at a depth of 12.2 m below ground surface (Elevation 146.7).

2. Water level measured in open borehole upon completion of drilling at a depth of 0.9 m below ground surface (Elevation 158.0 m).

* "N' Values are lower than expected as a result of loosening due to groundwater pressures.

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Elevation scale: 143, 142

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

RECORD OF BOREHOLE No WM41-2 — 1 OF 2 — METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4868039.3 ;E 346610.4 — ORIGINATED BY PKS
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 10.7 m to 16.8 m — COMPILED BY DD
DATUM Geodetic — DATE March 3, 2008 — CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
161.2	GROUND SURFACE							
0.0	TOPSOIL Compact Brown Moist	1	SS	14				
160.4 / 0.8	CLAYEY SILT, some sand, trace gravel Stiff Brown Moist	2	SS	14				
		3	SS	15				
158.9 / 2.3	CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff Brown Moist	4	SS	18	11	28	35	26
		5	SS	24				
	Wet below 3.7 m depth							
156.6 / 4.6	SAND and SILT, trace to some clay, trace gravel (TILL) Compact Grey Wet	6	SS	23				
		7	SS	20	3	41	47	9
153.6 / 7.6	CLAYEY SILT to SILTY CLAY Very stiff Grey Wet	8	SS	18				
		9	SS	18				
151.5 / 9.8	Silty SAND to SAND, some silt, trace clay and gravel Loose to dense Grey Wet	10	SS	5	1	80	17	2
		11	SS	37				
147.5 / 13.7	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Grey Wet	12	SS	100/0.18				

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Elevation scale: 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No WM41-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868039.3 ;E 346610.4 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 10.7 m to 16.8 m COMPILED BY DD
DATUM Geodetic DATE March 3, 2008 CHECKED BY TZ/BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Grey Wet	13	SS	100/0.18	146	9	34	40	17
					145				
144.4		14	SS	100/0.07					
16.8	END OF BOREHOLE								

NOTE:

1. Water level measured in piezometer at a depth of 1.7 m below ground surface (Elevation 159.5 m) on April 4, 2008.

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

Golder Associates

RECORD OF BOREHOLE No WM42-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867921.5 ;E 346845.3 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 9, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
163.0	GROUND SURFACE							
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	22				
162.4 / 0.6	Silty sand, some gravel (FILL) Compact Brown Moist	2	SS	23				
161.6 / 1.4	Silty SAND, trace gravel and clay, containing organics Very dense Brown Moist	3	SS	50				
		4	SS	58				
160.0 / 3.0	Silty SAND to SAND and SILT, trace clay Compact to very dense Brown to grey Moist to wet	5	SS	80				
	Wet below 4.6 m depth	6	SS	25	0	62	37	1
		7	SS	65				
		8	SS	65				
154.2 / 8.8	CLAYEY SILT with sand, trace gravel (TILL) Hard Grey Wet	9	SS	100/0.15	4	32	44	20
		10	SS	100/0.25				
150.7		11	SS	100/0.13				
12.3	END OF BOREHOLE							

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.1 m below ground surface (Elevation 156.9 m).

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

RECORD OF BOREHOLE No WM43-1

1 OF 1 **METRIC**

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4867845.2 ;E 347182.7
DIST	Central HWY 407	BOREHOLE TYPE	108 mm O.D. Solid Stem Augers
DATUM	Geodetic	DATE	January 4, 2008
ORIGINATED BY	PKS	COMPILED BY	DD
CHECKED BY	TZ/HJ		

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
164.0	GROUND SURFACE
0.0	Sand and gravel (FILL) Brown Moist
163.2 / 0.8	Organic CLAYEY SILT, some sand, trace gravel Stiff Black/grey Moist
162.5 / 1.5	SAND and SILT to Sandy SILT, some clay, trace gravel (TILL) Compact to very dense Brown to grey Moist
154.4 / 9.6	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS	-	
2	SS	14	
3	SS	13	
4	SS	28	1 46 40 13
5	SS	100/0.15	
6	SS	100/0.15	
7	SS	100/0.25	
8	SS	131	0 27 61 12
9	SS	100	

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 163, 162, 161, 160, 159, 158, 157, 156, 155

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.1 m below ground surface (Elevation 161.9 m).

2. Water level measured in piezometer at at a depth of 2.3 m below ground surface (Elevation 161.7 m) on January 7, 2008.

3. Water level measured in piezometer at at a depth of 1.2 m below ground surface (Elevation 162.8 m) on April 4, 2008.

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

RECORD OF BOREHOLE No WM43-2

1 OF 1 **METRIC**

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4867730.5 ;E 347228.7
DIST	Central HWY 407	BOREHOLE TYPE	108 mm O.D. Solid Stem Augers
DATUM	Geodetic	DATE	January 4, 2008
ORIGINATED BY	PKS	COMPILED BY	DD
CHECKED BY	TZ/HJ		

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
164.0	GROUND SURFACE
0.0	Sand and gravel (FILL) Brown Moist
163.2 / 0.8	Organic CLAYEY SILT, some sand, trace gravel Stiff Black/brown Moist
162.6 / 1.4	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Grey Wet
	Wet below 6.6 m depth
154.4 / 9.6	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS	-	
2	SS	12	
3	SS	26	
4	SS	38	
5	SS	43	
6	SS	70	9 42 38 11
7	SS	102	11 49 32 8
8	SS	108	
9	SS	100/0.25	

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 163, 162, 161, 160, 159, 158, 157, 156, 155

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 3.4 m below ground surface (Elevation 160.6 m).

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

RECORD OF BOREHOLE No WL2-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858235.2 ;E 346342.8 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 4, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
89.0	GROUND SURFACE					
0.0	ASPHALT					
0.2	Sand and gravel (FILL) Compact Brown Moist	1	SS	27		
88.2 / 0.8	Clayey silt with sand, trace gravel (FILL) Stiff to hard Brown/grey Moist	2	SS	10		
		3	SS	19		
		4	SS	20		
		5	SS	33		5 26 41 28
84.4 / 4.6	Organic silty SAND, trace clay Compact Black Moist	6	SS	13	OC = 6.6%	
82.9 / 6.1	CLAYEY SILT, some sand, trace to some gravel (TILL) Very stiff to hard Brown to grey Moist to wet	7	SS	20		
	Wet below 7.6 m depth	8	SS	50		11 19 43 27
79.9 / 9.1	Grey/black, weathered SHALE (BEDROCK)	9	SS	100/0.23		
		10	SS	100/0.05		
78.3 / 10.7	END OF BOREHOLE AUGER REFUSAL					

NOTE:

1. Samples were noted to be wet at a depth of 7.6 m below ground surface (Elevation 81.4 m).

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; ELEVATION SCALE 88 87 86 85 84 83 82 81 80 79.

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL2-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858153.9 ;E 346368.2 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 4, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.2	GROUND SURFACE					
0.0	ASPHALT					
0.2	Sand and gravel (FILL) Compact to dense Brown Moist	1	SS	27		
		2	SS	34		
		3	SS	29		
90.6 / 2.6	Clayey silt with sand, trace gravel (FILL) Very stiff Brown/grey Moist	4	SS	19		
		5	SS	22		
		6	SS	24		
		7	SS	19		0 33 45 22
		8	SS	20		
84.1 / 9.1	Organic silty SAND, trace clay Compact Black Moist	9	SS	29	OC = 4.8%	
82.6 / 10.7	CLAYEY SILT with sand, trace to some gravel (TILL) Very stiff Brown Moist	10	SS	25		
81.0 / 12.2	SAND and SILT, trace to some clay, trace gravel, containing shale pieces (TILL) Dense to very dense Grey Wet	11	SS	100/0.28		
		12	SS	37		3 39 51 7

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; ELEVATION SCALE 93 92 91 90 89 88 87 86 85 84 83 82 81 80 79.

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF BOREHOLE No WL2-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858153.9 ;E 346368.2 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 4, 2008 CHECKED BY TZ/BLT

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ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.0 / 15.2	CLAYEY SILT with sand, trace to some gravel (TILL) Hard Grey Wet	13	SS	60	78	17 33 38 12
					77	
76.5 / 16.8	Grey/black SHALE (BEDROCK)	14	SS	100/0.07	76	
74.9 / 18.3	END OF BOREHOLE	15	SS	100/0.02	75	

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 13.7 m below ground surface (Elevation 79.5 m).

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

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

RECORD OF BOREHOLE No WL3-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4857980.3 ;E 346420.5 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 30, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
91.3	GROUND SURFACE					
0.0	ASPHALT					
0.2	Sand and gravel (FILL) Compact Brown Moist	1	SS	26	91	
90.4 / 0.9	Clayey silt to silty clay, some sand, trace gravel, containing shale pieces (FILL) Very stiff to hard Brown/grey Moist	2	SS	21	90	
		3	SS	16	89	
		4	SS	24		
		5	SS	17	88	
					87	
		6	SS	20	86	4 19 43 34
		7	SS	41	85	
					84	
83.5 / 7.8	SAND and SILT, some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist	8	SS	28	83	
		9	SS	55	82	16 40 34 10
					81	
	Wet below 10.7 m depth	10	SS	100/0.18	80	
		11	SS	101	79	25 32 34 9
					78	
		12	SS	103		
77.1 / 14.2	END OF BOREHOLE					

Continued Next Page

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

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RECORD OF BOREHOLE No WL3-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4857980.3 ;E 346420.5 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE January 30, 2008 | CHECKED BY TZ/BLT

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 12.2 m below ground surface (Elevation 79.1 m) .										

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

Golder Associates

RECORD OF BOREHOLE No WL3-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4858023.6 ;E 346406.4 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE January 31, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.0	GROUND SURFACE					
0.0	ASPHALT					
0.2	Sand and gravel, trace to some silt, trace clay (FILL) Compact Brown Moist	1	SS	30		
		2	SS	28	93	
		3	SS	18	92	50 41 8 1
		4	SS	27	91	
		5	SS	23	90	
89.4 4.6	Clayey silt with sand, trace gravel, containing shale pieces (FILL) Stiff to very stiff Brown Moist	6	SS	14	89	
		7	SS	27	88 87	
		8	SS	25	86	3 29 41 27
		9	SS	28	85 84	
83.6 10.4	Organic silty SAND, trace clay Compact Black Moist	10	SS	25	83	
82.1 11.9	SAND and SILT, trace to some clay and gravel (TILL) Very dense to compact Brown to grey Moist to wet	11	SS	71	82 81	18 40 34 8
	Wet below 13.7 m depth	12	SS	100	80	

Continued Next Page

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

RECORD OF BOREHOLE No WL3-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4858023.6 ;E 346406.4 — ORIGINATED BY PKS
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE January 31, 2008 — CHECKED BY TZ/BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and SILT, trace to some clay and gravel (TILL) Very dense to compact Brown to grey Moist to wet	13	SS	21		10 40 38 12
		14	SS	49	∇	
75.7 / 18.3	Grey/black, weathered SHALE (BEDROCK)	15	SS	100/0.07		
74.1 / 19.9	END OF BOREHOLE	16	SS	100/0.10		

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 16.8 m below ground surface (Elevation 77.2 m) .

Elevation scale: 78, 77, 76, 75

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

RECORD OF BOREHOLE No WL3-3

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4858095.1 ;E 346393.7 — ORIGINATED BY GD
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE March 26, 2008 — CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.0	GROUND SURFACE				
0.0	ASPHALT				
0.2	Sand and gravel, trace silt (FILL) Compact Brown Moist	1	SS	23	
87.2 / 0.8	Silty clay, some sand, trace gravel (FILL) Stiff to very stiff Grey / black Moist	2	SS	16	
		3	SS	11	
85.7 / 2.3	CLAYEY SILT with sand, trace gravel (TILL) Very stiff Brown Moist	4	SS	16	
		5	SS	23	3 30 44 23
83.4 / 4.6	SAND and SILT, some gravel, trace clay (TILL) Very dense Brown to grey Moist	6	SS	101	
		7	SS	54/0.16	16 42 37 5
		8	SS	66	
78.9 / 9.1	Dark grey, weathered, SHALE (BEDROCK)	9	SS	61/0.15	
77.3 / 10.7	Grey, SHALE (BEDROCK) Bedrock cored from 10.7 m to 14.6 m depth. For bedrock coring detail see Record of Drillhole WL3-3	10	SS	61/0.02	
		1	RC	REC 78%	RQD = 34%
		2	RC	REC 100%	RQD = 57%
		3	RC	REC 100%	RQD = 90%
73.5 / 14.6					

Elevation scale: 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76, 75, 74

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL3-3

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858095.1 ;E 346393.7 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 26, 2008 CHECKED BY TZ/BLT

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

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 5.8 m below ground surface (Elevation 82.2 m).

2. Water level measured in piezometer at a depth of 3.1 m below ground surface (Elevation 84.9 m) on April 5, 2008.

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

RECORD OF DRILLHOLE: WL3-3

PROJECT: 07-1111-0053
LOCATION: N 4858095.1 ;E 346393.7 DRILLING DATE: March 26, 2008 DATUM: Geodetic
INCLINATION: -90° AZIMUTH: ---
DRILL RIG:
DRILLING CONTRACTOR:

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate, BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage, PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular, PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN / FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		GROUND SURFACE		77.31																	
11	HQ Coring Uncased	SHALE (BEDROCK) Moderately to slightly weathered Grey Thinly bedded		10.69	1															15	
12					2																
13					3															21	
14				73.45 14.55																	
		END OF DRILLHOLE																			
15																					
16																					
17																					
18																					
19																					
20																					

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: GD
CHECKED: TZ/BLT

RECORD OF BOREHOLE No WL4-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858226.4 ;E 346664.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 25, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
83.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	16	
82.2 / 0.8	CLAYEY SILT, some sand, trace gravel Firm to stiff Brown to grey Moist	2	SS	9	
		3	SS	4	
80.7 / 2.3	CLAYEY SILT with sand, some gravel, containing shale fragments (TILL) Very stiff to hard Brown to grey Moist	4	SS	20	
		5	SS	15	17 41 31 11
	Wet below 4.6 m depth	6	SS	74	
76.9 / 6.1	Gravelly SAND, some silt, trace clay, containing shale fragments Very dense Grey Wet	7	SS	100/0.13	
		8	SS	100/0.28	27 56 13 4
73.8 / 9.2	END OF BOREHOLE	9	SS	100/0.05	

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.8 m below ground surface (Elevation 81.2 m).

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

Foundation Design

RECORD OF BOREHOLE No WL5-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858430.0 ;E 346847.3 ORIGINATED BY HM
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 15, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
80.0	GROUND SURFACE				
0.0	TOPSOIL Brown Moist	1	AS	-	
79.5 / 0.5	Silty SAND Very loose Brown Moist				
79.1 / 0.9	CLAYEY SILT, trace sand Firm to stiff Brown Moist to wet	2	SS	5	
		3	SS	11	
77.8 / 2.2	SILTY CLAY, trace sand Soft to firm Brown to grey Wet	4	SS	4	
		5	SS	3	
75.5 / 4.5	CLAYEY SILT with sand, trace to some gravel Stiff Grey Wet	6	SS	WH	7 34 37 22
74.2 / 5.8	Silty SAND, some gravel, trace to some clay (TILL) Dense Grey Wet	7	SS	42	12 49 32 7
72.8 / 7.2	Dark grey SHALE				
72.3 / 7.7	END OF BOREHOLE	8	SS	50/0.05	

NOTES:

1. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 79.3 m) on April 5, 2008.

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

Foundation Design

RECORD OF BOREHOLE No WL7-1

1 OF 1 **METRIC**

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4858358.5 ;E 347017.2
DIST	Central HWY 407	BOREHOLE TYPE	108 mm I.D. Solid Stem Augers
DATUM	Geodetic	DATE	February 12, 2008
ORIGINATED BY	HM	COMPILED BY	DD
CHECKED BY	TZ/HJ		

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

ELEV / DEPTH	DESCRIPTION
82.0	GROUND SURFACE
0.0	CLAYEY SILT, trace sand (TOPSOIL) Firm Dark brown Moist
81.2 / 0.8	SILTY CLAY, trace sand, containing sand seams Stiff Brown Moist
79.9 / 2.1	CLAYEY SILT with sand, trace to some gravel, occasional sand seams (TILL) Stiff Brown to grey Wet
78.2 / 3.8	SILT, trace to some sand, trace clay (TILL) Dense to very dense Grey Wet
73.4 / 8.6	Dark grey SHALE (BEDROCK)
69.8 / 12.2	END OF BOREHOLE

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 3.7 m below ground surface (Elevation 78.3 m).

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	5				
2	SS	15				
3	SS	11				
4	SS	10				
5	SS	11				
6	SS	32	1	16	78	5
7	SS	54	0	3	92	5
8	SS	47				
9	SS	50/0.10				
10	SS	50/0.05				
11	SS	50/0.02				

Elevation scale: 81, 80, 79, 78, 77, 76, 75, 74, 73, 72, 71, 70

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

Foundation Design

RECORD OF BOREHOLE No WL7-2

1 OF 1 **METRIC**

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4858415.1 ;E 347060.1
DIST	Central HWY 407	BOREHOLE TYPE	108 mm I.D. Solid Stem Augers
DATUM	Geodetic	DATE	February 12, 2008
ORIGINATED BY	HM	COMPILED BY	DD
CHECKED BY	TZ/HJ		

ELEV / DEPTH	DESCRIPTION
82.0	GROUND SURFACE
0.0	CLAYEY SILT, trace sand, organics (TOPSOIL) Stiff Dark brown Moist
81.3 / 0.7	CLAY to SILTY CLAY, trace sand and gravel, containing sand seams Firm Brown Moist
80.3 / 1.7	CLAYEY SILT with sand, trace to some gravel (TILL) Stiff to very stiff Brown to grey Wet Occasional sandy silt interlayers
78.8 / 3.2	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Grey Wet
74.3 / 7.7	Dark grey SHALE (BEDROCK) Moist to dry
71.3 / 10.7	END OF BOREHOLE

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.1 m below ground surface (Elevation 79.9 m).

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	9				
2	SS	6				
3	SS	19				
4	SS	8				
5	SS	14	9	44	39	8
6	SS	34				
7	SS	75	10	43	39	8
8	SS	50/0.13				
9	SS	50/0.02				
10	SS	50/0.05				

Water content plot value at sample 2: 56

Elevation scale: 81, 80, 79, 78, 77, 76, 75, 74, 73, 72

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

Golder Associates

RECORD OF BOREHOLE No WL8-1

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4858786.2 ;E 347117.0
DIST	Central HWY 407	BOREHOLE TYPE	108 mm I.D. Solid Stem Augers
DATUM	Geodetic	DATE	February 13, 2008
ORIGINATED BY	HM	COMPILED BY	DD
CHECKED BY	TZ/HJ		

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
83.9	GROUND SURFACE				
0.0	SILTY CLAY, trace sand, containing organics (TOPSOIL)	1	SS	7	
83.4 / 0.5	SILTY CLAY, trace to some sand, trace gravel. Firm to very stiff. Brown. Moist	2	SS	21	
82.5 / 1.4	CLAYEY SILT with sand, some gravel (TILL). Very stiff to hard. Brown to grey. Moist	3	SS	26	
		4	SS	48	15 40 32 13
		5	SS	50/0.05	
		6	SS	48	10 42 36 12
		7	SS	81/0.28	
77.5 / 6.4	Dark grey SHALE (BEDROCK). Moist to dry	8	SS	50/0.02	
		9	SS	50/0.02	
74.7 / 9.2	END OF BOREHOLE				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

Elevation scale: 83, 82, 81, 80, 79, 78, 77, 76, 75

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 82.4 m).

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL8-2

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4858681.3 ;E 346998.0
DIST	Central HWY 407	BOREHOLE TYPE	108 mm I.D. Solid Stem Augers
DATUM	Geodetic	DATE	February 12, 2008
ORIGINATED BY	HM	COMPILED BY	DD
CHECKED BY	TZ/HJ		

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.3	GROUND SURFACE				
0.0	SILTY CLAY, trace sand, containing organics and rootlets (TOPSOIL). Firm to stiff. Dark brown. Moist	1	SS	8	
81.7 / 0.6	CLAY to SILTY CLAY, trace to some sand, trace gravel, occasional sand seams. Very soft to firm. Brown to grey. Moist to wet	2	SS	4	
		3	SS	4	
		4	SS	1	
		5	SS	WH	
79.0 / 3.3	CLAYEY SILT with sand, trace to some gravel (TILL-Like). Firm to stiff. Grey. Wet	6	SS	WH	11 33 44 12
		7	SS	WH	
75.6 / 6.7	Dark grey SHALE (BEDROCK). Wet	8	SS	50/0.02	
		9	SS	50/0.02	
		10	SS	50/0.02	
71.6 / 10.7	END OF BOREHOLE				

Elevation scale: 82, 81, 80, 79, 78, 77, 76, 75, 74, 73, 72

Field vane: 2.4; water content: 54/46

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 80.8 m).

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL8-3

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858543.9 ;E 347124.0 ORIGINATED BY HM
DIST Central HWY 407 BOREHOLE TYPE 108 mm I.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 14, 2008 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.0	GROUND SURFACE					
0.0 / 81.7 / 0.3	CLAYEY SILT, trace sand (TOPSOIL) Soft Dark brown Wet	1	SS	4		
	CLAY to SILTY CLAY, trace sand, containing occasional sand seams Stiff to very stiff Brown Moist to wet	2	SS	5	81	
80.2 / 1.8	CLAYEY SILT with sand, trace to some gravel (TILL-Like) Soft to stiff Brown to grey Wet	3	SS	5	80	0 2 50 48
		4	SS	WH	79	
		5	SS	WH	78	
77.4 / 4.6	SAND and SILT, trace to some gravel and clay (TILL-Like) Very loose to compact Grey Wet	6	SS	WH	77	10 47 36 7
		7	SS	19	76	
75.4 / 6.6	SHALE (BEDROCK) Bedrock cored from 7.2 m to 10.4 m depth. For bedrock coring detail see Record of Drillhole WL8-3	1	RC	REC 43%	75, 74	RQD = 0%
		-	AS	-	73	
		2	RC	REC 93%	72	RQD = 73%
71.6 / 10.4	END OF BOREHOLE					

Plot annotations: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; >100, >100, >100; field vane 3.1, 3.4. WATER CONTENT (%) 10 20 30 (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L); 53. UNIT WEIGHT γ kN/m³.

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.4 m below ground surface (Elevation 80.6 m).

2. Shelby tube sample (SA 4A) obtained between a depth of 1.8 m and 2.4 m in an adjacent borehole for laboratory consolidation testing.

3. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 81.3 m) on April 5, 2008.

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

RECORD OF DRILLHOLE: WL8-3

SHEET 1 OF 1

PROJECT: 07-1111-0053
LOCATION: N 4858543.9 ;E 347124.0 DRILLING DATE: February 14, 2008 DATUM: Geodetic
INCLINATION: -90° AZIMUTH: --- DRILL RIG:
DRILLING CONTRACTOR:

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate; BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage; PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular; PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break; BR - Broken Rock. NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.
		Continued from soil log	74.79	
8, 9, 10	HQ Coring Uncased	Highly to moderately weathered, thinly bedded, grey, SHALE (BEDROCK)	7.21	1, 2
			71.56 / 10.44	
		END OF DRILLHOLE		
11		NOTE: 1. Corehole augered from Elevation 74.79 m to 71.56 m.		

Column headings: PENETRATION RATE min/(m); FLUSH; COLOUR % RETURN; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER 0.3 m; DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr Ja Jn); HYDRAULIC CONDUCTIVITY K, cm/sec; Diametral Point Load Index (MPa); RMC -Q' AVG.; NOTES WATER LEVELS INSTRUMENTATION.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: HM
CHECKED: TZ/HJ

Golder Associates

RECORD OF BOREHOLE No WL9-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858468.3 ;E 347261.8 ORIGINATED BY HM
DIST Central HWY 407 BOREHOLE TYPE 108 mm I.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 13, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
82.0	GROUND SURFACE								
0.0	CLAYEY SILT to SILTY CLAY (TOPSOIL) Firm Dark brown Moist	1	SS	4					
81.2 / 0.8	CLAY to SILTY CLAY, trace sand Stiff to very stiff Brown Moist	2	SS	6	▽				
		3	SS	12					
79.7 / 2.3	CLAYEY SILT with sand, trace to some gravel (TILL-Like) Soft to firm Brown to grey Wet	4	SS	4		4	31	42	23
		5	SS	WH					
77.6 / 4.4	SAND and SILT, some gravel, trace to some clay (TILL) Compact to very dense Grey Wet	6	SS	17		16	45	34	5
		7	SS	50/0.07					
75.3 / 6.7	Dark grey SHALE (BEDROCK) Wet	8	SS	50/0.07					
		9	SS	50/0.05					
72.8 / 9.2	END OF BOREHOLE								

Shear strength plot annotations: 4.6; >100. Water content plot: 51.

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.1 m below ground surface (Elevation 80.9 m).

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Foundation Design

Golder Associates

RECORD OF BOREHOLE No WL10-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858615.2 ;E 347908.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 27, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT / REMARKS	GR	SA	SI	CL
79.1	GROUND SURFACE									
0.0	ASPHALT									
0.2	Sand and gravel (FILL) Compact Brown Moist	1	SS	20						
78.3 / 0.8	CLAYEY SILT with sand, trace gravel, containing seams of organics Stiff Grey/black Moist	2	SS	10						
		3	SS	14		OC=5.6%	2	48	32	18
76.8 / 2.3	CLAYEY SILT with sand, trace gravel Firm Grey Wet	4	SS	6						
		5	SS	4						
	Occasional silty sand and organic seams									
74.5 / 4.6	SAND and SILT, trace gravel, containing clayey silt seams Loose Grey Wet	6	SS	4			0	48	45	7
73.0 / 6.1	Silty SAND, some gravel, trace clay Compact Grey Wet	7	SS	12	▽					
		8	SS	17						
	Containing shale pieces below 9.1 m depth	9	SS	17			29	45	21	5
69.0 / 10.1	Black SHALE (BEDROCK)	10	SS	100/0.07						
68.4 / 10.7	END OF BOREHOLE									

Shear strength plot annotations: 3.0; 2.9.

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.1 m below ground surface (Elevation 73.0 m).

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL11-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4858644.9 ;E 347984.2
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE March 26, 2008
CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION
79.0	GROUND SURFACE
78.7 / 0.0	Sandy TOPSOIL, Loose, Brown, Moist
0.3	CLAYEY SILT with sand, trace gravel, Firm to stiff, Brown to grey. Occasional layers of silty sand, trace gravel
74.4 / 4.6	Silty SAND, some gravel, trace clay, Compact to dense, Grey, Wet
69.9 / 9.1	Black, weathered SHALE (BEDROCK)
69.6 / 9.4	END OF BOREHOLE

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	7	
2	SS	8	
3	SS	5	
4	SS	WH	4 38 36 22
5	SS	7	
6	SS	45	
7	SS	25	
8	SS	35	16 59 23 2
9	SS	100/0.10	

Shear strength (field vane) 2.6 near elevation 76. Water content 41 at sample 2.

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 5.5 m below ground surface (Elevation 73.5 m).

2. Water level measured in piezometer at ground surface (Elevation 79.0 m) on April 5, 2008.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

Golder Associates

RECORD OF BOREHOLE No WL12-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4859272.4 ;E 346845.2
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE February 8, 2008
CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION
87.0	GROUND SURFACE
0.0	ASPHALT
0.2	Sand and gravel (FILL), Compact, Brown, Moist
86.1 / 0.9	CLAYEY SILT with sand, trace to some gravel, containing shale fragments (TILL), Stiff to hard, Brown, Moist
82.4 / 4.6	Silty SAND, trace gravel, containing shale fragments (TILL), Very dense, Grey, Wet
81.5 / 5.5	CLAYEY SILT with sand, trace to some gravel, containing shale fragments (TILL), Hard, Grey, Wet
77.9 / 9.1	Grey, weathered, SHALE (BEDROCK)
77.2 / 9.8	END OF BOREHOLE

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	13	
2	SS	12	
3	SS	19	
4	SS	35	
5	SS	26	15 38 37 10
6	SS	85	
7	SS	64	
8	SS	88	10 41 37 12
9	SS	100/0.10	

NOTES:

1. Water level measured in open borehole upon completion of drilling at 8.8 m depth below ground surface (Elevation 78.2 m).

2. Water level measured in piezometer at a depth of 0.6 m below ground surface (Elevation 86.4 m) on August 15, 2008.

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

Golder Associates

Foundation Design

PROJECT 07-1111-0053

RECORD OF BOREHOLE No WL16-1

1 OF 1 **METRIC**

W.O. 07-20015 LOCATION N 4861073.2 ;E 345796.6 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD

DATUM Geodetic DATE January 23, 2008 CHECKED BY TZ/HJ/SH

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact to very dense Brown Moist	1	SS	15	
		2	SS	70	
95.6 / 1.4	Clayey silt, some sand, trace gravel, containing organics (FILL) Stiff Brown to grey Moist	3	SS	14	
		4	SS	14	
94.0 / 3.1	Silty SAND, trace to some gravel, containing organics Compact Grey Wet	5	SS	19	OC = 4.9%
93.3 / 3.7	SILTY CLAY, trace sand Very stiff to hard Grey Wet	6	SS	30	
		7	SS	25	
89.7 / 7.3	SAND, some silt, trace to some clay and gravel Dense Grey Wet	8	SS	41	6 73 16 7 NP
87.8 / 9.2	Grey to black SHALE (BEDROCK) Bedrock cored from 9.2 m to 13.1 m depth For bedrock coring detail see Record of Drillhole WL16-1	9	SS	100/0.07	
		1	RC	REC 100%	RQD = 0%
		2	RC	REC 100%	RQD = 27%
		3	RC	REC 100%	RQD = 53%
83.9 / 13.1	END OF BOREHOLE NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 4.6 m below ground surface (Elevation 92.4 m).				

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; 40; UNIT WEIGHT γ kN/m³.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

PROJECT: 07-1111-0053

RECORD OF DRILLHOLE: WL16-1

SHEET 1 OF 1

LOCATION: N 4861073.2 ;E 345796.6 DRILLING DATE: January 23, 2008 DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG:

DRILLING CONTRACTOR:

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate; BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage; PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular; PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break; BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

Column headings: DEPTH SCALE METRES; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. / DEPTH (m); RUN No.; PENETRATION RATE min/(m); COLOUR / % RETURN; FLUSH; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER 0.3 m; DISCONTINUITY DATA (B Angle; DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION; Jr; Ja; Jn); HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}; Diametral Point Load Index (MPa) 2 4 6; RMC -Q' AVG.; NOTES WATER LEVELS INSTRUMENTATION

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.
		GROUND SURFACE	87.78	
10, 11, 12, 13	HQ Coring Uncased	SHALE, containing limestone seams (BEDROCK) Completely to highly weathered Grey Very thinly to thinly bedded	9.22	1, 2, 3
		END OF DRILLHOLE	83.89 / 13.11	
14, 15, 16, 17, 18, 19				

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PKS

CHECKED: TZ/HJ/SH

MIS-RCK 004 07-1111-0053.GPJ GAL-MISS.GDT 3/27/09 DD/SAC

RECORD OF BOREHOLE No WL19-2A

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4861761.3 ;E 345567.1
ORIGINATED BY TZ
DIST Central HWY 407
BOREHOLE TYPE Portable (Tripod); Wash boring from 3.5 m to 9.6 m depth
COMPILED BY DD
DATUM Geodetic
DATE September 5 and 8, 2008
CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
105.8	GROUND SURFACE				
0.0	TOPSOIL, Loose, Black, Moist	1	SS	4	
104.9 / 0.9	SAND, some silt, trace clay, Loose, Brown, Moist	2	SS	14	
	CLAYEY SILT, trace to some gravel and clay, Stiff to hard, Brown, Wet	3	SS	33	
		4	SS	56	10 42 36 12
102.8 / 3.1	SAND and SILT, some gravel, trace to some clay (TILL), Very dense, Brown to grey, Wet	5	SS	236	
102.3 / 3.5	SAND, trace to some silt and gravel, Very dense, Grey, Wet	6	SS	62	
101.6 / 4.2	SAND and SILT, some gravel, trace to some clay (TILL), Dense to very dense, Brown to grey, Wet	7	SS	43	
		8	SS	52	30 32 29 9
		9	SS	95	
		10	SS	191	
96.3 / 9.6	SHALE (BEDROCK)				
	END OF BOREHOLE				

NOTE:

1. Water level measured in open borehole before wash boring at a depth of 1.1 m below ground surface. (Elevation 104.7 m).
2. Water level measured in piezometer at a depth of 2.5 m below ground surface (Elevation 103.3 m) on March 23, 2009.

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (105, 104, 103, 102, 101, 100, 99, 98, 97); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

RECORD OF BOREHOLE No WL19-3A

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4861734.3 ;E 345611.8
ORIGINATED BY TZ
DIST Central HWY 407
BOREHOLE TYPE Portable (Tripod); Wash boring from 3.8 m to 8.4 m depth
COMPILED BY DD
DATUM Geodetic
DATE September 9, 2008
CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
104.8	GROUND SURFACE				
0.0 / 0.1	TOPSOIL, Loose, Black, Moist	1	SS	7	
	SAND, some silt, containing organics, Loose, Brown, Moist	2	SS	6	
103.8 / 1.0	CLAYEY SILT to SILTY CLAY, trace sand, Firm to hard, Brown, Moist				Field vane >120, >120
		3	SS	57	0 2 61 37
101.8 / 3.1	SAND and SILT, trace to some gravel, trace clay (TILL), Very dense, Brown, Wet	4	SS	75	
100.2 / 4.6	CLAYEY SILT with sand, trace to some gravel (TILL), Stiff, Grey, Wet	5	SS	12	11 25 33 31
98.7 / 6.1	SAND and GRAVEL, containing shale pieces, Compact, Grey/black, Wet	6	SS	29	
98.1 / 6.7	SAND and SILT, trace to some gravel, trace clay (TILL), Very dense, Brown to grey, Wet	7	SS	152	
96.4		8	SS	100/0.10	10 52 33 5
8.4	END OF BOREHOLE				

NOTE:

1. Wet soil samples noted at a depth of 3.1 m below ground surface (Elev. 101.8 m) during drilling.

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (104, 103, 102, 101, 100, 99, 98, 97); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

RECORD OF BOREHOLE No WL19A-1A

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4861744.1 ;E 345677.9
DIST	Central	HWY	407
BOREHOLE TYPE	Portable (Tripod); Wash boring from 3.8 m to 7.0 m depth		
DATUM	Geodetic	DATE	September 4 and 5, 2008
ORIGINATED BY	TZ	COMPILED BY	DD
CHECKED BY	TZ/BLT		

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.0	GROUND SURFACE				
0.0	TOPSOIL				
0.1	Loose, Black, Moist	1	SS	9	
	SAND, some silt, trace clay, Loose to compact, Brown, Wet	2	SS	10	0 6 62 32
99.8					
99.5 / 1.5	CLAYEY SILT, trace to some sand, Stiff, Grey, Wet	3	SS	9	
98.8					
2.3	SAND, some silt, trace clay, Loose, Brown, Wet	4	SS	5	0 78 19 3
98.2 / 2.8	CLAYEY SILT, trace to some sand, Stiff, Grey, Wet	5	SS	4	0 15 36 49
	SAND, trace clay, Loose, Brown, Wet	6	TO	PM	Unit weight 17.9 kN/m³
96.4 / 4.6	SILTY CLAY, some sand, Soft to firm, Grey, Wet	7	SS	13	
	SAND and SILT, trace to some gravel and clay (TILL), Compact to very dense, Grey, Wet. Clayey silt with gravel seam from 5.8 m to 6.0 m depth	8	SS	95	
		9	SS	100/0.13	
94.0 / 7.0	END OF BOREHOLE				

Elevation scale: 100, 99, 98, 97, 96, 95, 94. Ground water level symbol (∇) at approx. elevation 97.2. Water content value 40.8 plotted at sample 6.

NOTE:

1. Water level measured in open borehole before wash boring at a depth of 3.8 m below ground surface (Elevation 97.2 m).

RECORD OF BOREHOLE No WL19A-2A

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4861716.4 ;E 345690.7
DIST	Central	HWY	407
BOREHOLE TYPE	Portable (Tripod); Wash boring from 3.0 m to 7.5 m depth		
DATUM	Geodetic	DATE	September 10, 2008
ORIGINATED BY	TZ	COMPILED BY	DD
CHECKED BY	TZ/BLT		

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
102.0	GROUND SURFACE				
0.0	TOPSOIL				
0.2	Loose, Black, Moist	1	SS	53	
	SAND, some silt, trace clay, Compact to very dense, Brown, Wet	2	SS	15	
		3	SS	7	
100.1 / 1.9	CLAYEY SILT, some sand, Firm to very stiff, Brown, Wet	4	SS	17	
99.0 / 3.1	SILTY CLAY, trace to some sand, Soft to firm, Grey, Wet	5	SS	6	
		6	SS	4	0 9 39 52
95.9 / 6.1	SAND and SILT, trace to some gravel and clay (TILL), Very dense, Grey, Wet	7	SS	100/0.15	9 41 39 11
		8	SS	100/0.15	
94.5 / 7.5	END OF BOREHOLE				

Elevation scale: 101, 100, 99, 98, 97, 96, 95. Field vane sensitivity values plotted: 1.9, 2.1, 1.7, 2.6.

NOTE:

1. Wet soil samples noted at a depth of 0.5 m below ground surface (Elev. 101.5 m) during drilling.

Column headings (both logs): SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL20-1

1 OF 2 **METRIC**

PROJECT 07-1111-0053

W.O. 07-20015 LOCATION N 4863012.2 ;E 345154.0 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers below 12.2 m COMPILED BY DD

DATUM Geodetic DATE January 11, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
116.4	GROUND SURFACE									
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	12		116				
115.6 / 0.8	Silty sand, trace gravel (FILL) Loose to compact Brown Moist	2	SS	22		115				
		3	SS	9						
114.1 / 2.3	Sandy SILT, containing organics Loose Brown to black Moist	4	SS	10		114			OC=5.7%	
113.4 / 3.1	CLAYEY SILT, some sand and gravel (TILL-Like) Firm to stiff Brown to grey Wet	5	SS	WH		113	+ 7.5			
		6	SS	4		112, 111	>96			
		7	SS	5		110	+ 2.0			
		8	SS	4		109, 108	>96			15 23 35 27
		9	SS	4		107				
106.2 / 10.2	SAND and SILT, some gravel, trace to some clay (TILL) Very dense Grey Wet	10	SS	100/0.15		106, 105				19 44 31 6
104.2 / 12.2	CLAYEY SILT with SAND, trace gravel (TILL) Hard Grey Wet	11	SS	47	▽	104				
		12	SS	105		103, 102				

Continued Next Page

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL20-1

2 OF 2 **METRIC**

PROJECT 07-1111-0053

W.O. 07-20015 LOCATION N 4863012.2 ;E 345154.0 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers below 12.2 m COMPILED BY DD

DATUM Geodetic DATE January 11, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---									
	CLAYEY SILT with SAND, trace gravel (TILL) Hard Grey Wet	13	SS	100		101				0 37 42 21
		14	SS	102		100				
99.2 / 17.2	END OF BOREHOLE									

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 12.2 m below ground surface (Elevation 104.2 m).

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL20-2

 METRIC

PROJECT	07-1111-0053
W.O.	07-20015
DIST	Central
HWY	407
DATUM	Geodetic
LOCATION	N 4863027.8 ;E 345272.1
BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers
DATE	January 25, 2008
ORIGINATED BY	PKS
COMPILED BY	DD
CHECKED BY	TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
115.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	24	
114.2 / 0.8	CLAYEY SILT, some sand, trace gravel, contains organics Stiff Brown to black Moist	2	SS	15	
113.4 / 1.6	CLAYEY SILT, trace sand Firm to very stiff Brown Moist	3	SS	4	
		4	TO	PH	
	Wet below 3.1 m depth	5	SS	24	0 1 79 20
		6	SS	4	
109.3 / 5.7	CLAYEY SILT with sand, trace gravel (TILL) Hard Grey Wet	7	SS	32	
		8	SS	39	5 44 38 13
		9	SS	45	
		10	SS	160	
		11	SS	100	
		12	SS	100/0.25	5 26 55 14

Elevation scale: 114, 113, 112, 111, 110, 109, 108, 107, 106, 105, 104, 103, 102, 101

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100 (field vane values: 6.0, 2.9)

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

UNIT WEIGHT γ kN/m³

Continued Next Page

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

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RECORD OF BOREHOLE No WL20-2

 METRIC

PROJECT	07-1111-0053
W.O.	07-20015
DIST	Central
HWY	407
DATUM	Geodetic
LOCATION	N 4863027.8 ;E 345272.1
BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers
DATE	January 25, 2008
ORIGINATED BY	PKS
COMPILED BY	DD
CHECKED BY	TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES
		13	SS	100/0.25
99.5 / 15.5	END OF BOREHOLE			

NOTE:

1. Water level measured in piezometer at a depth of 7.4 m below ground surface (Elevation 107.6 m) on April 5, 2008.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL23-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4867065.4 ;E 344299.7
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
DATE January 28, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.3	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	17	
		2	SS	30	
164.8 / 1.5	SAND and SILT, trace to some gravel and clay (TILL) Very dense Brown to grey Moist	3	SS	87	
		4	SS	65	
		5	SS	89	
	Wet below 4.6 m depth	6	SS	90	6 43 42 9
		7	SS	100/0.25	
		8	SS	81	
		9	SS	100/0.28	
		10	SS	100/0.28	20 40 31 9
		11	SS	100/0.15	
154.0 / 12.3	END OF BOREHOLE				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (166 to 154); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE:

1. Water level measured in piezometer at a depth of 1.3 m below ground surface (Elevation 165.0 m) on April 4, 2008.

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

Golder Associates

RECORD OF BOREHOLE No WL24-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4867462.1 ;E 344744.7
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
DATE March 11, 2008
ORIGINATED BY PKS/JB
COMPILED BY DD
CHECKED BY TZ/BLT

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
149.3	GROUND SURFACE				
0.0	TOPSOIL Loose Brown Moist	1	SS	8	
148.6 / 0.8	CLAYEY SILT, some sand, trace gravel Very stiff Brown Moist	2	SS	20	
147.8 / 1.5	Silty SAND, trace clay and gravel Dense Brown Wet	3	SS	32	
147.1 / 2.3	SAND and SILT, trace to some clay and gravel (TILL) Very dense Brown to grey Wet	4	SS	107	7 38 43 12
		5	SS	100/0.18	
		6	SS	100/0.18	8 45 38 9
		7	SS	100/0.18	
143.1 / 6.3	END OF BOREHOLE				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (149 to 144); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below ground surface (Elevation 146.3 m).

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

Golder Associates

RECORD OF BOREHOLE No WL24-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867394.5 ;E 344690.9 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 28, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
150.0	GROUND SURFACE					
0.0	Silty sand, containing organics (FILL) Very loose Dark brown Moist	1	SS	2		
149.6 / 0.4	Sand and gravel, trace to some silt (FILL) Compact Brown Moist	2	SS	19	149	
148.5 / 1.5	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown Moist	3	SS	48	148	
147.7 / 2.3	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Brown to grey Moist	4	SS	50/0.07		
		5	SS	50/0.10	147	
					146	
		6	SS	50/0.13		9 40 36 15
					145	
144.5		7	SS	50/0.13		
5.5	END OF BOREHOLE					

NOTE:

1. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 149.3 m) on February 28, 2008.

2. Water level measured in piezometer at a depth of 0.3 m below ground surface (Elevation 149.7 m) on April 14, 2008.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL26-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867568.0 ;E 344100.9 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE Power Auger, 114 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 20, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
176.1	GROUND SURFACE						
0.0	TOPSOIL Soft Brown Moist	1	SS	4		176	
175.5 / 0.6	Silty SAND, trace clay Compact Brown Wet	2	SS	12		175	
174.6 / 1.5	SAND and SILT, some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Wet	3	SS	34	∇	174	
		4	SS	40			19 38 43 0
		5	SS	48		173	
						172	
		6	SS	100/0.15		171	
	Grey below 6.1 m depth					170	
		7	SS	24		169	
		8	SS	33		168	2 47 40 11
166.9 / 9.2	CLAYEY SILT, some sand (TILL) Stiff to hard Grey Wet					167	
		9	SS	52		166	
		10	SS	14		165	
						164	
		11	SS	14		163	0 19 48 33
		12	SS	25		162	

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

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

Golder Associates

RECORD OF BOREHOLE No WL26-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867568.0 ;E 344100.9 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE Power Auger, 114 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 20, 2008 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---				
	CLAYEY SILT, some sand (TILL) Stiff to hard Grey Wet	13	SS	14	
159.3 16.8	SAND and GRAVEL Very dense Grey Moist	14	SS	58	
157.8 18.3	SAND and SILT, some gravel, trace to some clay (TILL) Very dense Grey Wet	15	SS	61	15 36 41 8
		16	SS	100/0.18	
		17	SS	100/0.13	12 36 43 9
153.1 23.0	END OF BOREHOLE	18	SS	100/0.13	

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.8 m below ground surface (Elevation 174.3 m).

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

Golder Associates

RECORD OF BOREHOLE No WL26-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867529.7 ;E 344213.2 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE Power Auger, 114 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 21, 2008 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.0	GROUND SURFACE				
0.0	TOPSOIL Loose Brown Moist	1	SS	4	
174.2 0.8	SAND and SILT, some clay, trace to some gravel (TILL) Compact to very dense Brown to grey Moist to wet	2	SS	21	
		3	SS	63	
		4	SS	61	
		5	SS	80	
		6	SS	65	3 38 46 13
	Wet below 6.1 m depth	7	SS	50	
		8	SS	100/0.13	10 41 38 11
165.6		9	SS	100/0.23	
9.4	END OF BOREHOLE				

NOTE:

1. Borehole dry upon completion of drilling.

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

RECORD OF BOREHOLE No WL27-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4867872.5 ;E 343894.5 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE February 19, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.1	GROUND SURFACE					182	
0.0	TOPSOIL Loose Black/brown Moist	1	SS	6			
181.3 / 0.8	SAND and SILT, some gravel and clay (TILL) Compact to very dense Brown to grey Moist	2	SS	15		181	
		3	SS	45		180	
		4	SS	100/0.28			9 42 40 9
		5	SS	100/0.25		179	
						178	
		6	SS	100/0.28		177	
		7	SS	100/0.23		176	10 44 34 12
175.6 / 6.5	END OF BOREHOLE						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; 42.1

UNIT WEIGHT γ kN/m^3

NOTE:

1. Open borehole dry upon completion of drilling.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL27-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4867782.7 ;E 343985.7 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE February 20, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.0	GROUND SURFACE						
0.0	CLAYEY SILT, some sand, containing organics Soft Brown Moist	1	SS	4			
173.4 / 0.6	Silty SAND, trace gravel and clay Compact Brown Wet	2	SS	10		173	
172.5 / 1.5	SAND and SILT, trace to some clay and gravel (TILL) Very dense Brown to grey Wet	3	SS	55		172	19 36 34 11
		4	SS	100/0.2		171	
		5	SS	100/0.2		170	
		6	SS	100/0.2		169	17 33 34 16
		7	SS	100/0.2		168	
167.7 / 6.4	END OF BOREHOLE						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m^3

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 172.5 m).

2. Water level measured in piezometer at a depth of 0.3 m below ground surface (Elevation 173.7 m) on April 4, 2008.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL28-1

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4868104.2 ;E 344337.6
ORIGINATED BY	GD	COMPILED BY	DD
DIST	Central	HWY	407
BOREHOLE TYPE	114 mm O.D. Hollow Stem Augers	CHECKED BY	TZ/HJ
DATUM	Geodetic	DATE	February 25, 2008

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.2	GROUND SURFACE					
0.0	TOPSOIL Very loose Brown Moist	1	SS	2		
177.6 0.6	SAND and SILT, some gravel and clay (TILL) Compact to very dense Brown Moist	2	SS	11		
		3	SS	42		19 38 31 12
		4	SS	101		
		5	SS	65/0.15	∇	
		6	SS	50/0.07		11 38 37 14
172.0 6.2	END OF BOREHOLE	7	SS	100/0.07		

NOTE:

Water level measured in open borehole upon completion of drilling ata depth of 3.5 m below ground surface (Elevation 174.7 m).

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

Golder Associates

RECORD OF BOREHOLE No WL28-2

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4868036.2 ;E 344277.3
ORIGINATED BY	GD	COMPILED BY	DD
DIST	Central	HWY	407
BOREHOLE TYPE	114 mm O.D. Hollow Stem Augers	CHECKED BY	TZ/HJ
DATUM	Geodetic	DATE	February 25, 2008

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
176.3	GROUND SURFACE				
0.0	TOPSOIL Very loose Brown Moist	1	SS	2	
175.8 0.5	SAND and SILT, some gravel and clay (TILL) Compact to very dense Brown to grey Moist	2	SS	14	
		3	SS	25	
		4	SS	47	8 38 41 13
		5	SS	108	
	Grey below 4.6 m depth	6	SS	100/0.13	16 36 35 13
170.0 6.3	END OF BOREHOLE	7	SS	50/0.07	

NOTE:

1. Water level measured in open borehole upon completion of drilling ata depth of 5.2 m below ground surface (Elevation 171.1 m).

2. Water level measured in piezometer at a depth of 0.3 m below ground surface (Elevation 176.0 m) on April 4, 2008.

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

Golder Associates

RECORD OF BOREHOLE No WL31-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868016.8 ;E 343568.7 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 22, 2008 CHECKED BY TZ/HJ

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
188.4	GROUND SURFACE							
0.0	Silty SAND, containing organics Very loose Dark brown Moist	1	SS	2				
187.9 0.5	CLAYEY SILT, trace sand Firm to stiff Brown Wet to moist	2	SS	5				
		3	SS	12	0	3	65	32
186.0 2.4	Silty SAND, some gravel, trace to some clay (TILL) Very dense Brown to grey Moist	4	SS	55				
		5	SS	100/0.15				
	Boulder at 3.7 m depth							
	Grey below 4.6 m depth	6	SS	50/0.07	21	39	29	11
182.1		7	SS	50/0.07				
6.3	END OF BOREHOLE							

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (188, 187, 186, 185, 184, 183); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10 20 30); UNIT WEIGHT γ kN/m³

NOTE:

1. Water level measured in open borehole upon completion of drilling ata depth of 2.1 m below ground surface (Elevation 186.3 m).

2. Water level measured in piezometer at a depth of 0.2 m below ground surface (Elevation 188.2 m) on April 5, 2008.

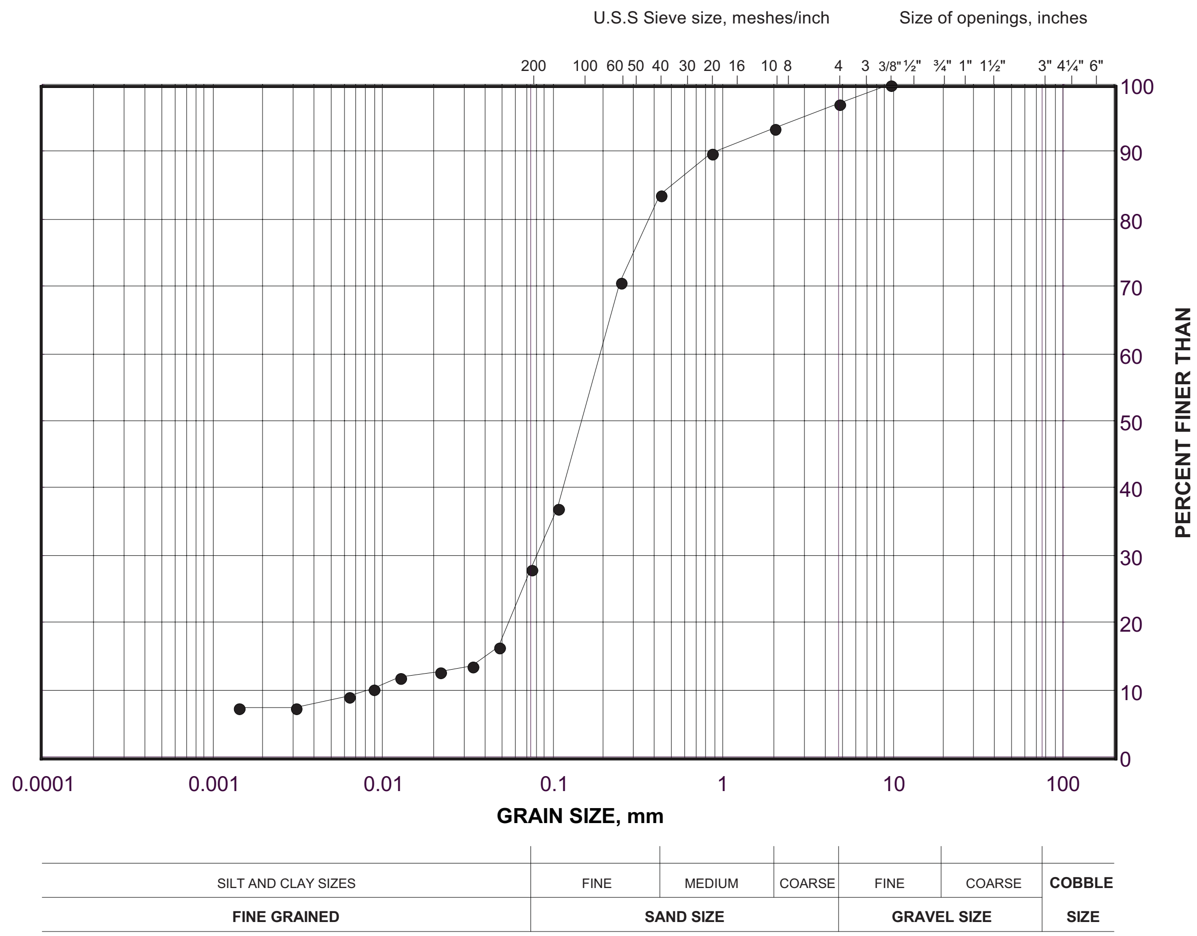
$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

APPENDIX B

LABORATORY TEST RESULTS

GRAIN SIZE DISTRIBUTION
Silty Sand, trace clay (Fill)

FIGURE WMA-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WMA-1	3	194.5

Project Number: 07-1111-0053

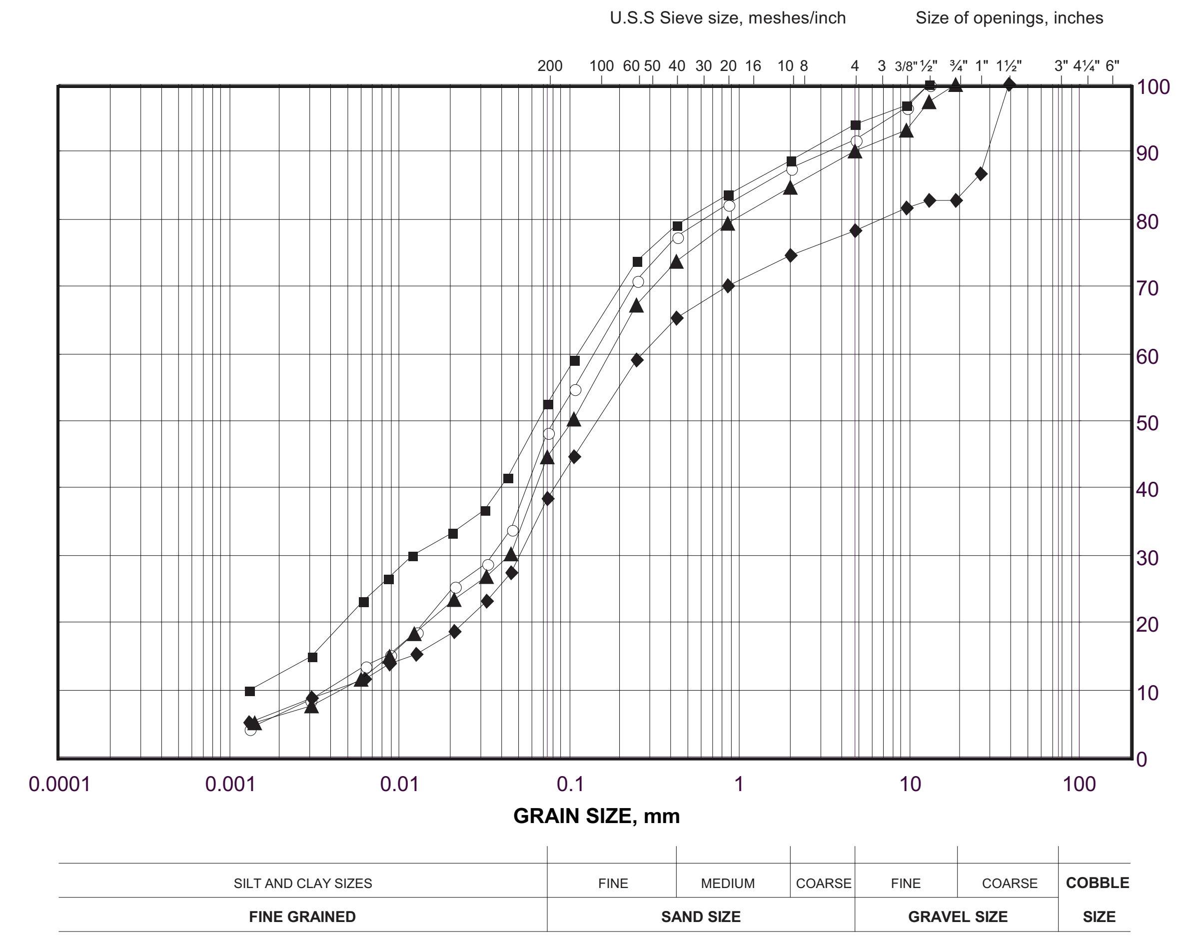
Checked By: KJB

Golder Associates

Date: 05-Jun-08

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WMA-B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WMA-1	10	185.3
■	WMA-2	4	193.4
◆	WMA-2	9	186.8
▲	WMA-1	9	187.1

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 05-Jun-08

Oct 75, FF-S-21

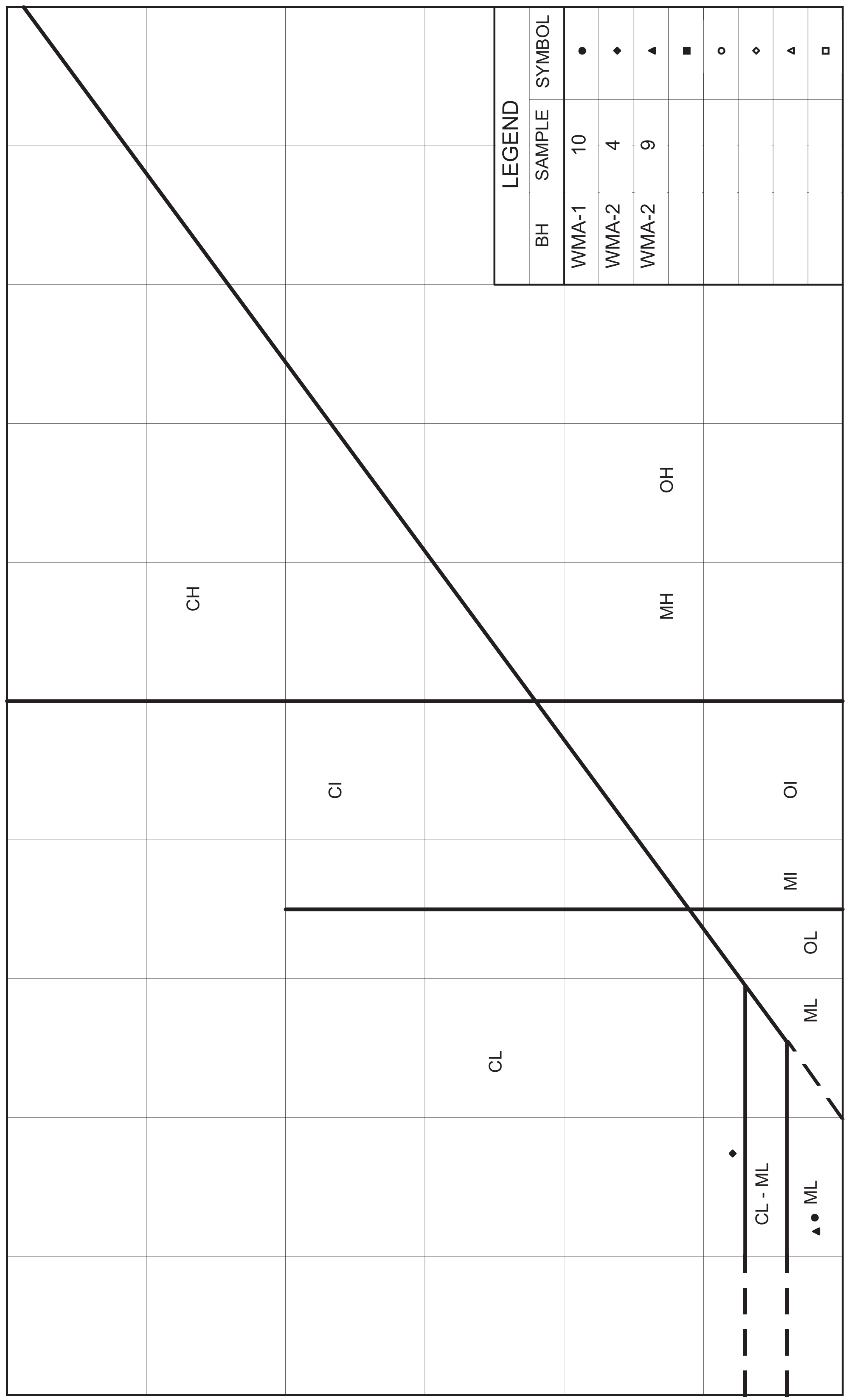


Figure No. WMA-C

Project No. 07-1111-0053

Checked By: KJB

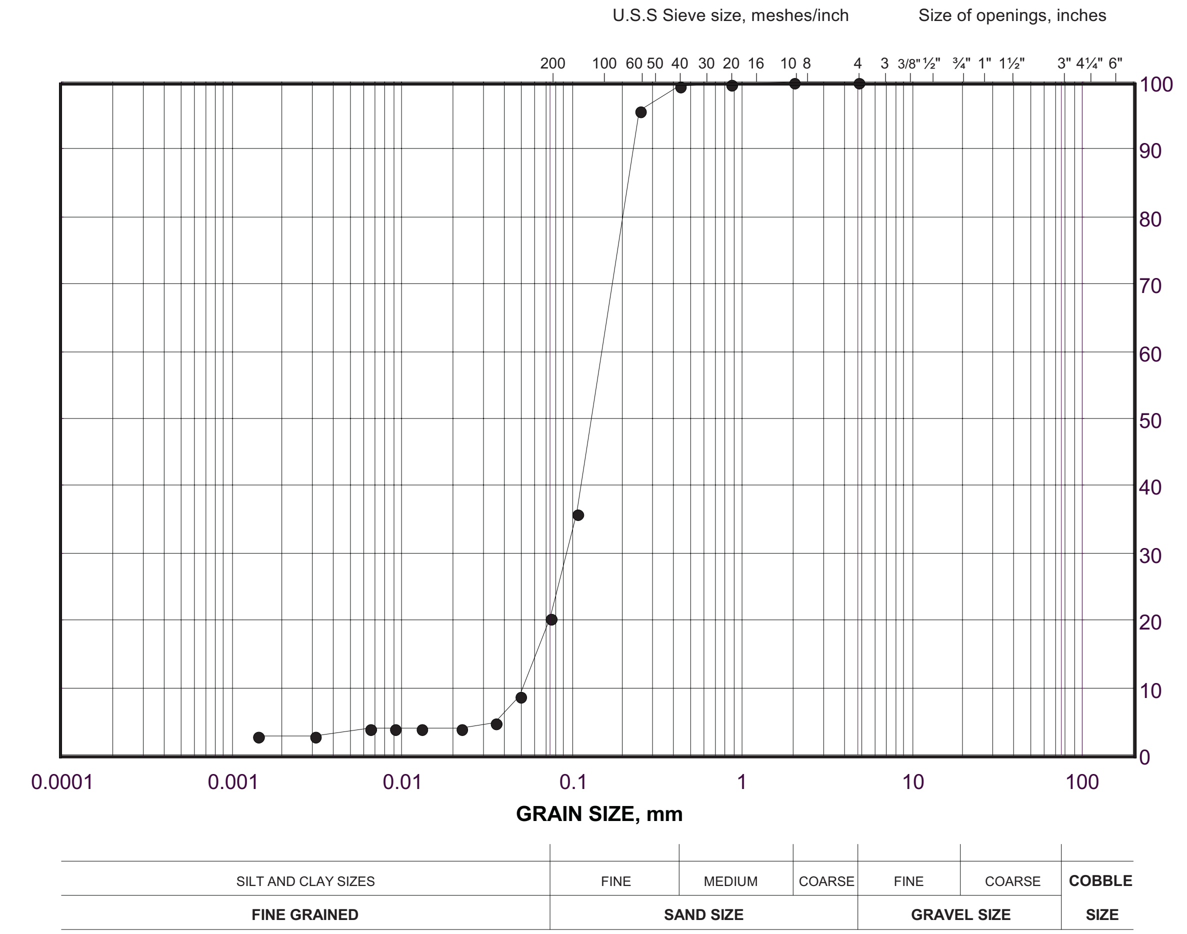
PLASTICITY CHART
Sand and Silt (Till)

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
Sand, some silt

FIGURE WMA-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WMA-2	6	191.1

Project Number: 07-1111-0053

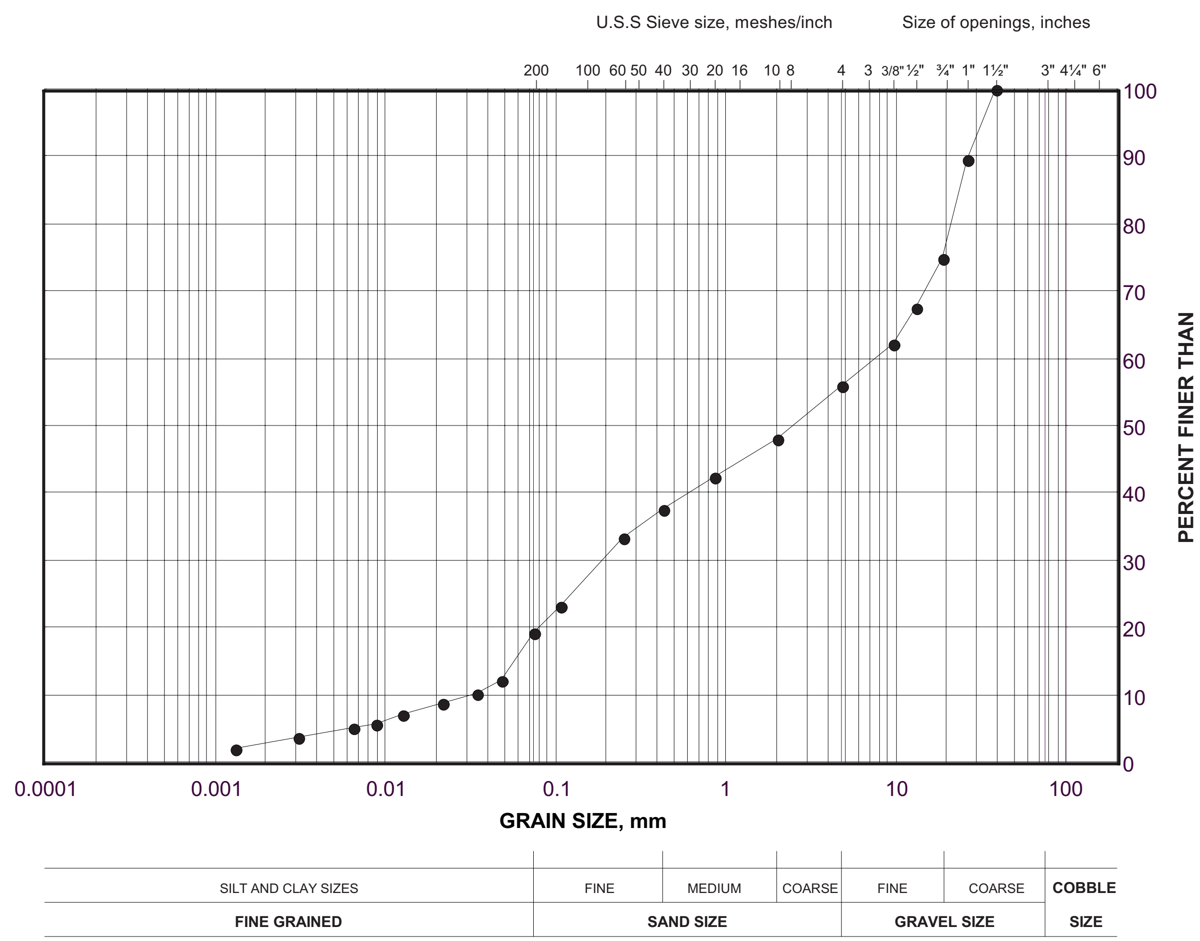
Checked By: KJB

Golder Associates

Date: 05-Jun-08

GRAIN SIZE DISTRIBUTION
Sand and Gravel, some silt

FIGURE WMA-E



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WMA-1	7	190.2

Project Number: 07-1111-0053

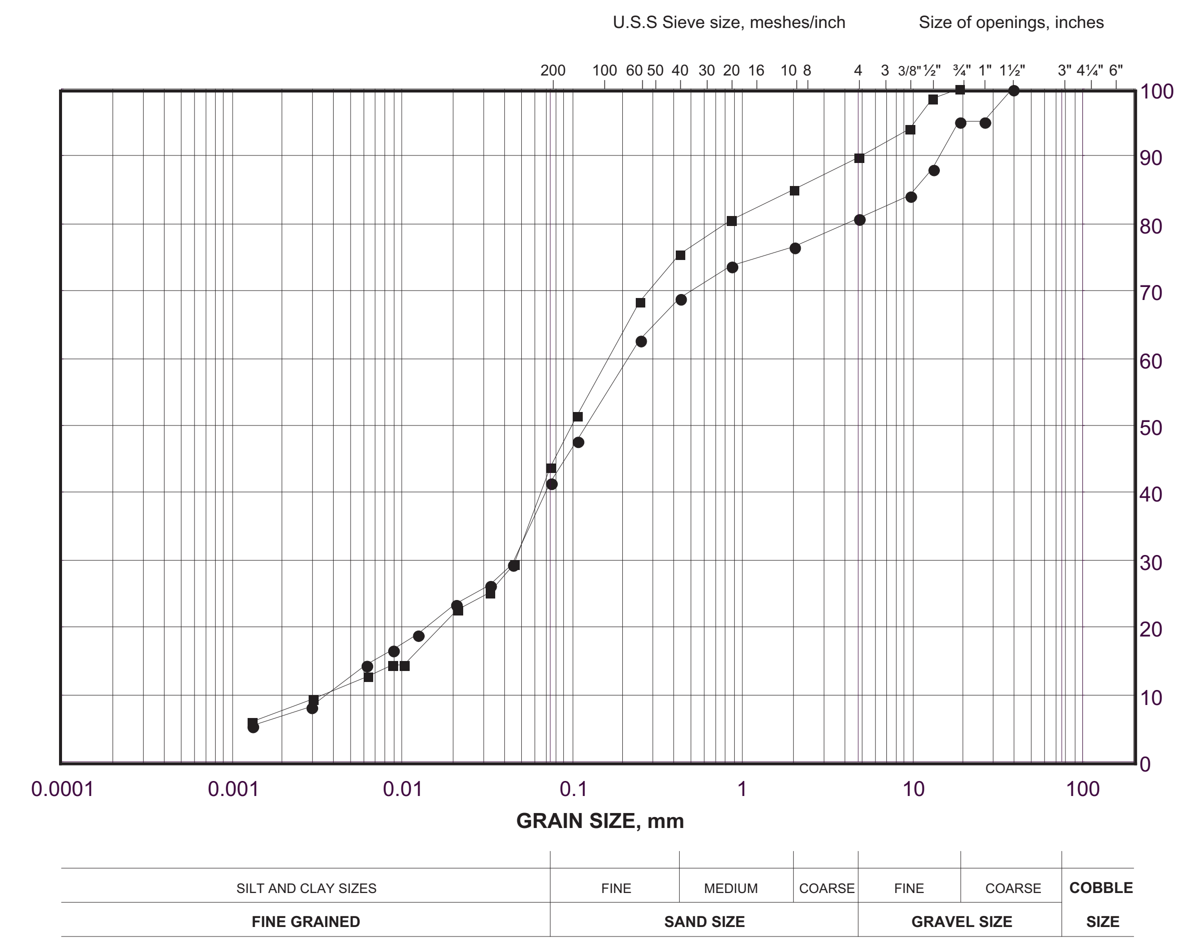
Checked By: KJB

Golder Associates

Date: 05-Jun-08

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM1-A



LEGEND

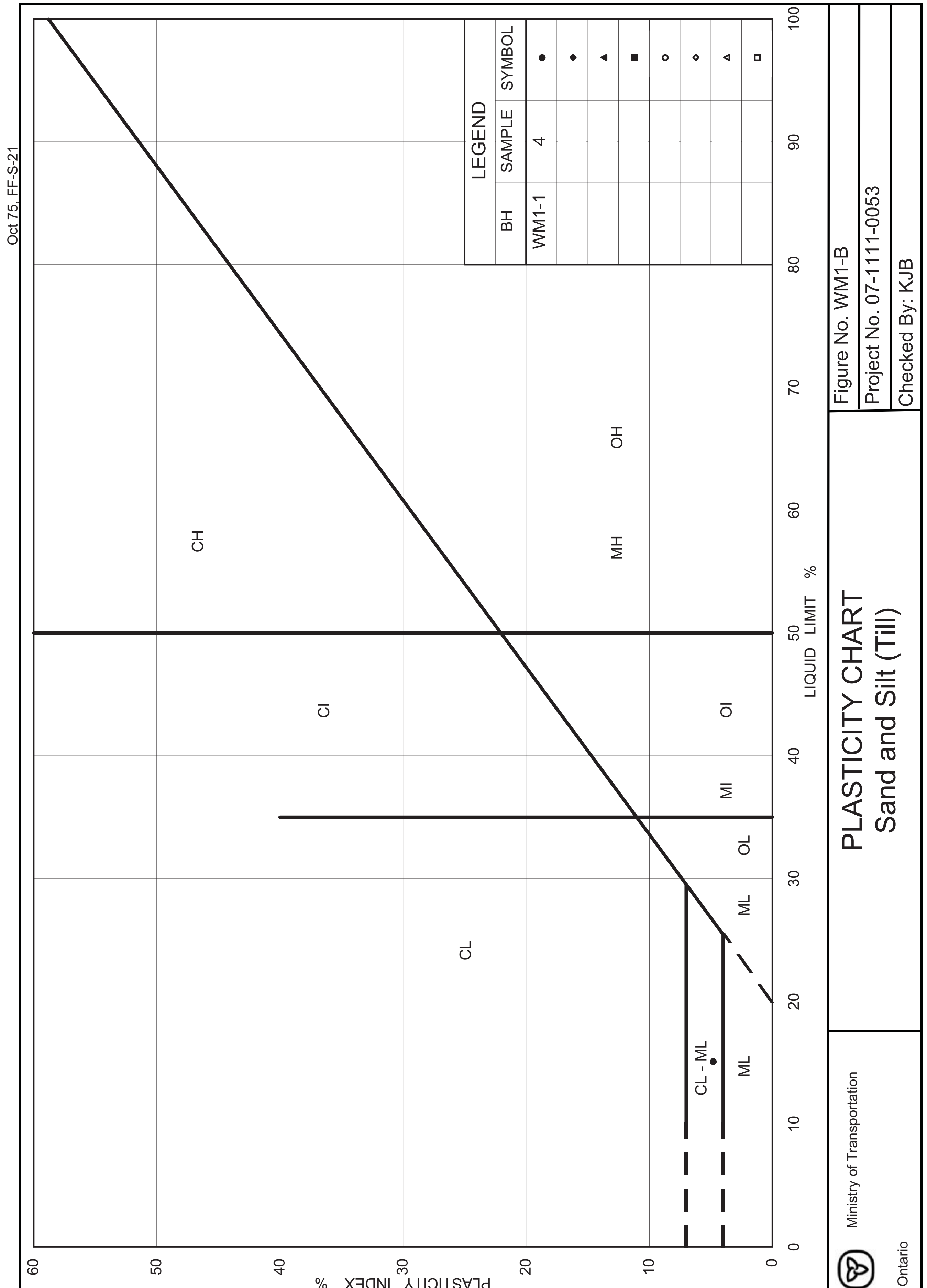
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM1-1	4	182.9
■	WM1-1	6	180.6

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

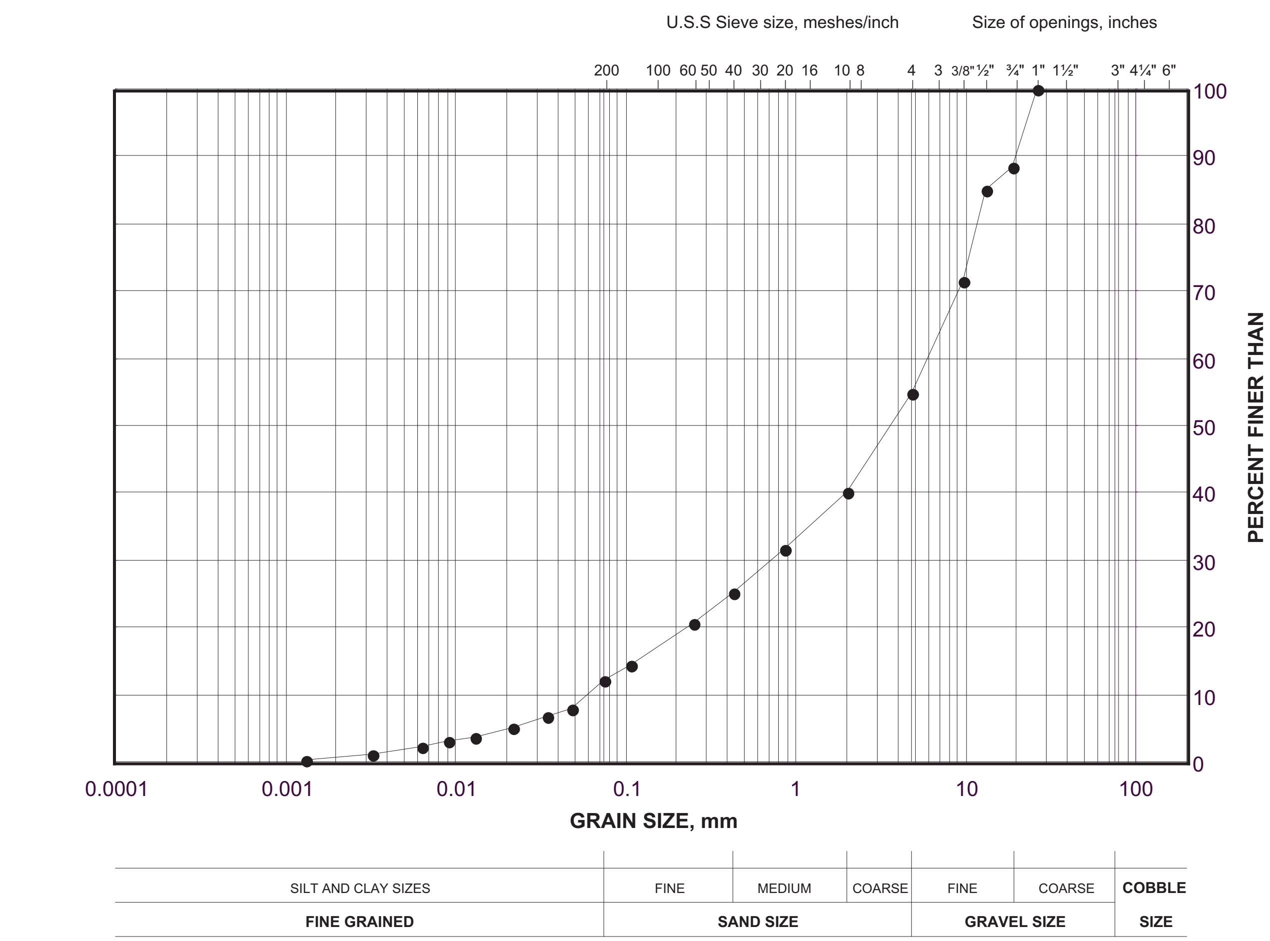
Date: 25-Mar-08



GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE WM1-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WM1-1	8	177.5

Project Number: 07-1111-0053

Checked By: KJB

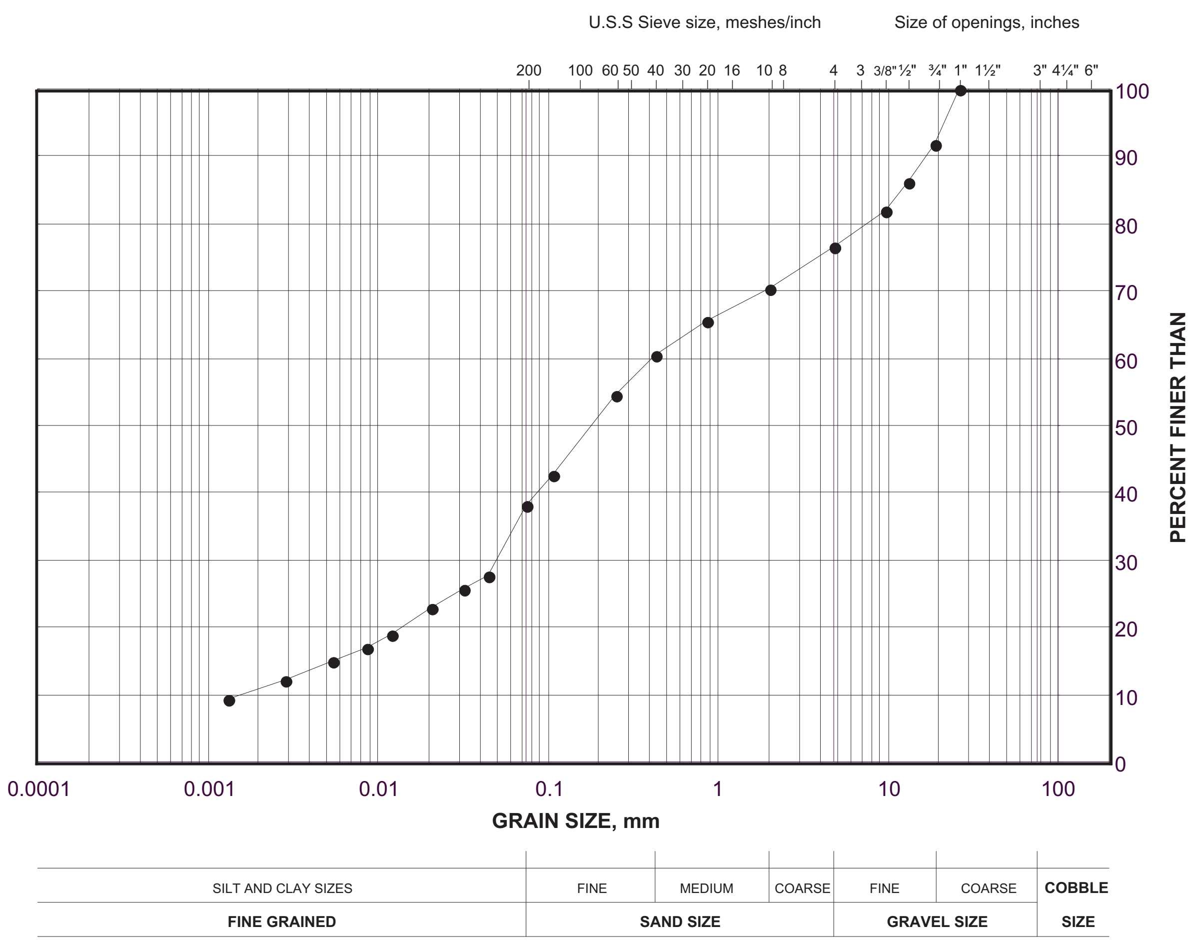
Golder Associates

Date: 25-Mar-08

GRAIN SIZE DISTRIBUTION

Silty Sand, some gravel / Clayey Silt Interlayer (Fill)

FIGURE WM2-A



LEGEND

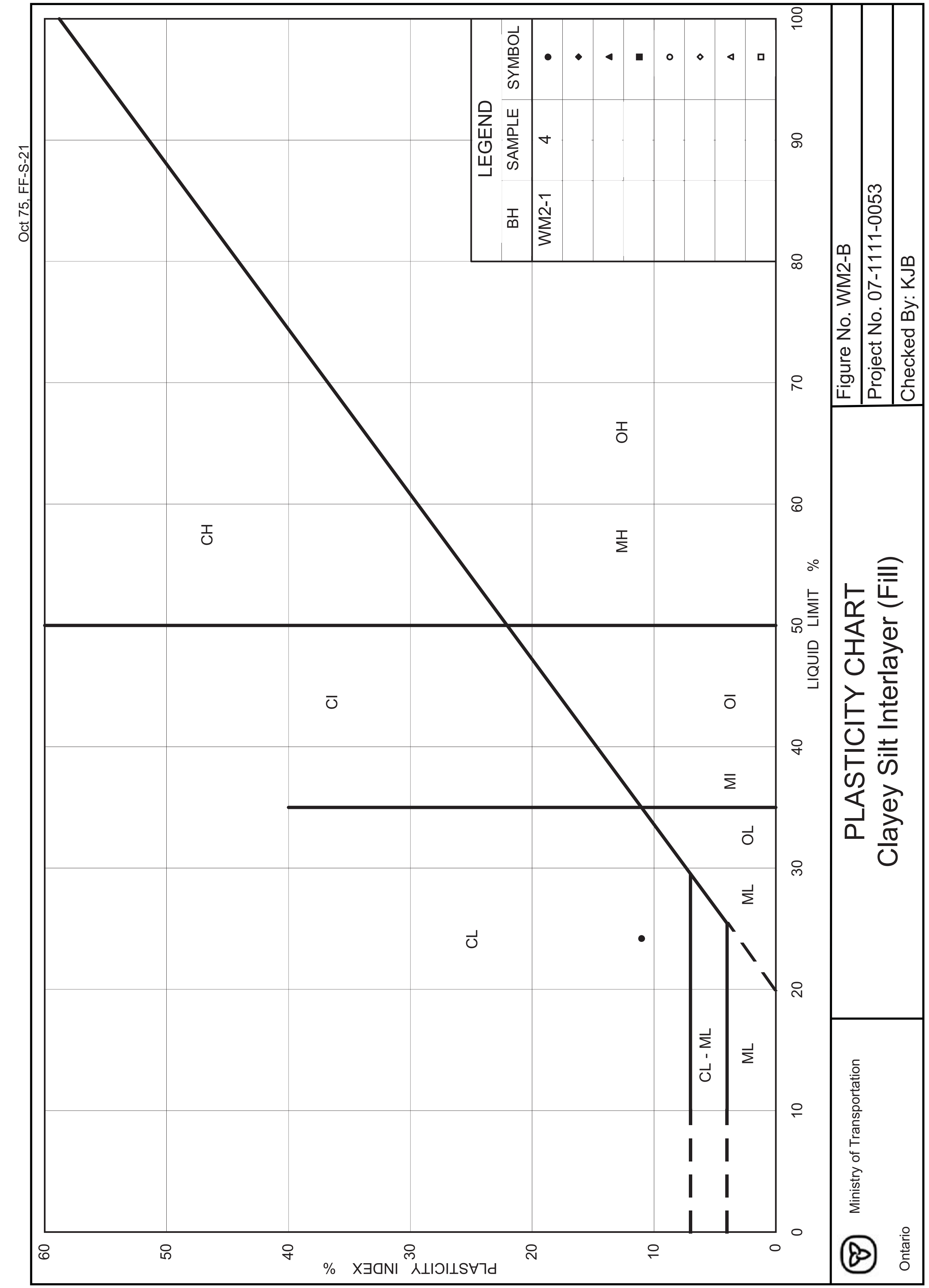
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM2-1	4	185.0

Project Number: 07-1111-0053

Checked By: KJB

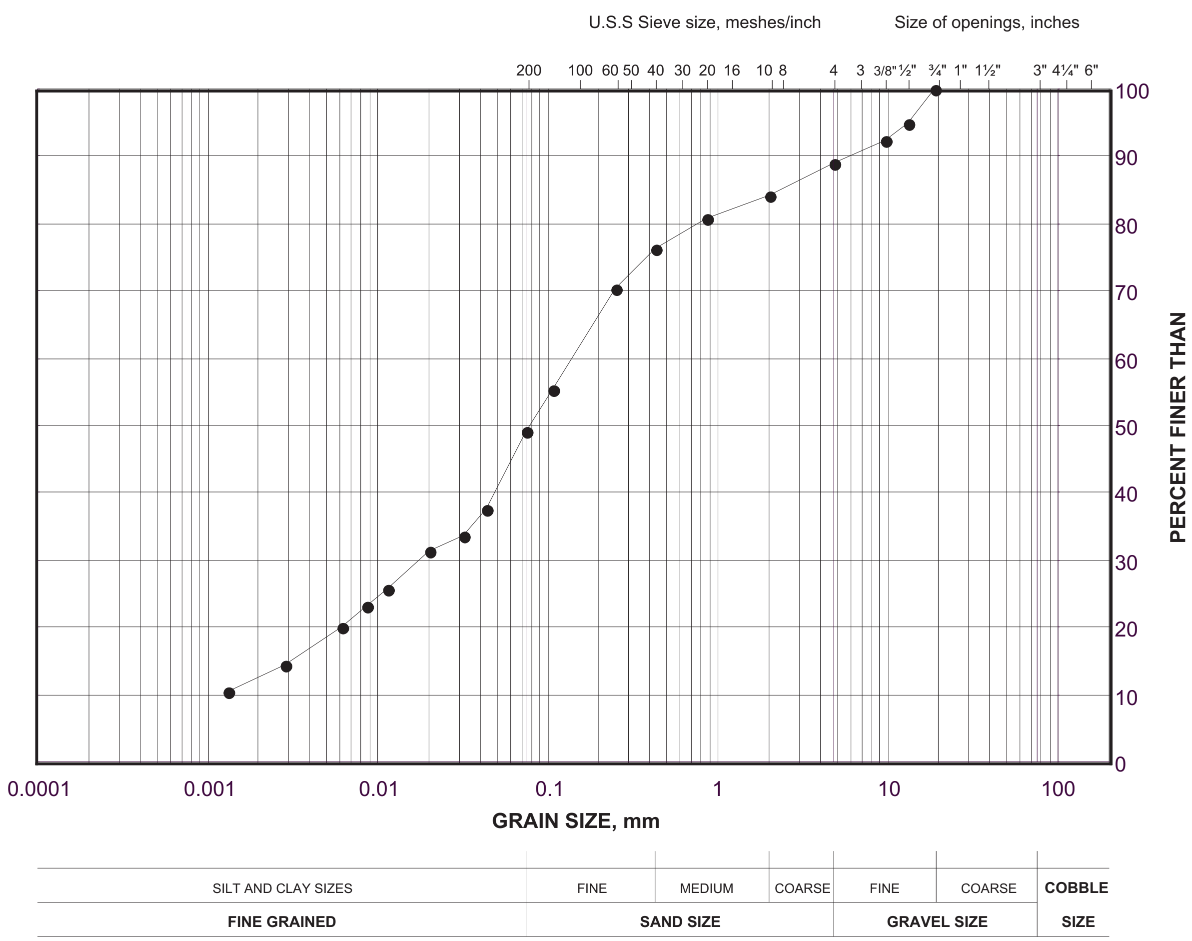
Golder Associates

Date: 25-Mar-08



GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM2-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM2-1	7	181.3

Project Number: 07-1111-0053

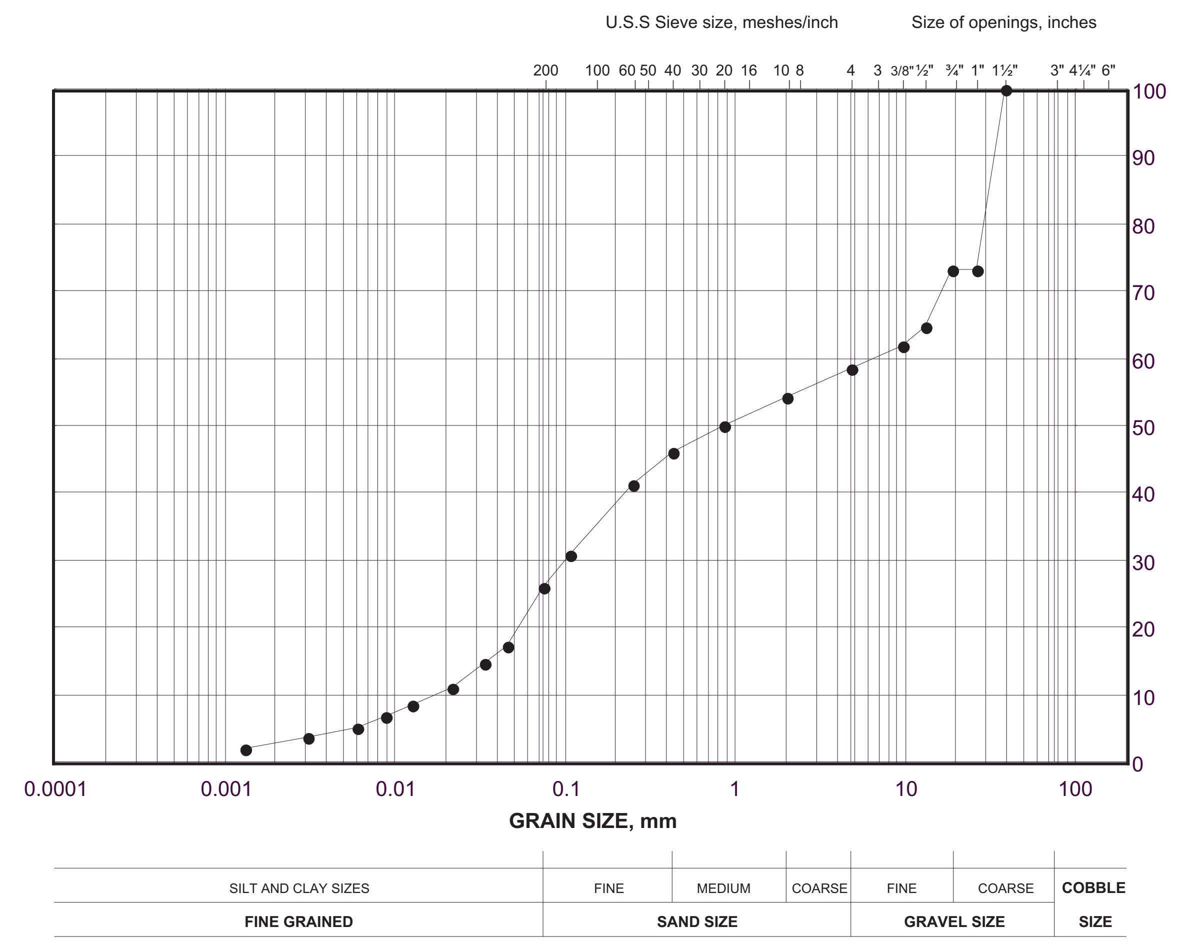
Checked By: KJB

Golder Associates

Date: 25-Mar-08

GRAIN SIZE DISTRIBUTION
Silty Sand and Gravel

FIGURE WM2-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM2-1	9	178.3

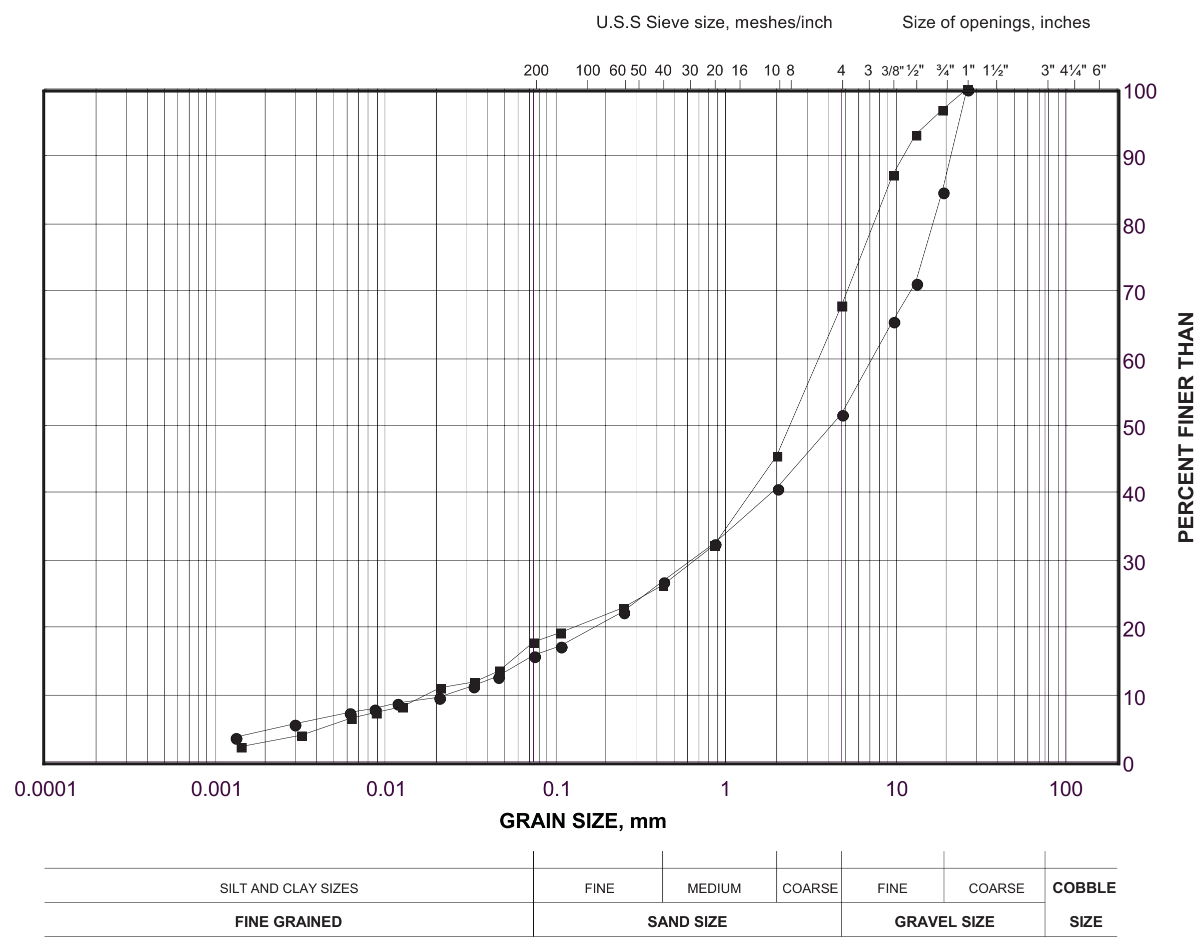
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 25-Mar-08

GRAIN SIZE DISTRIBUTION Sand and Gravel	FIGURE WM3-A



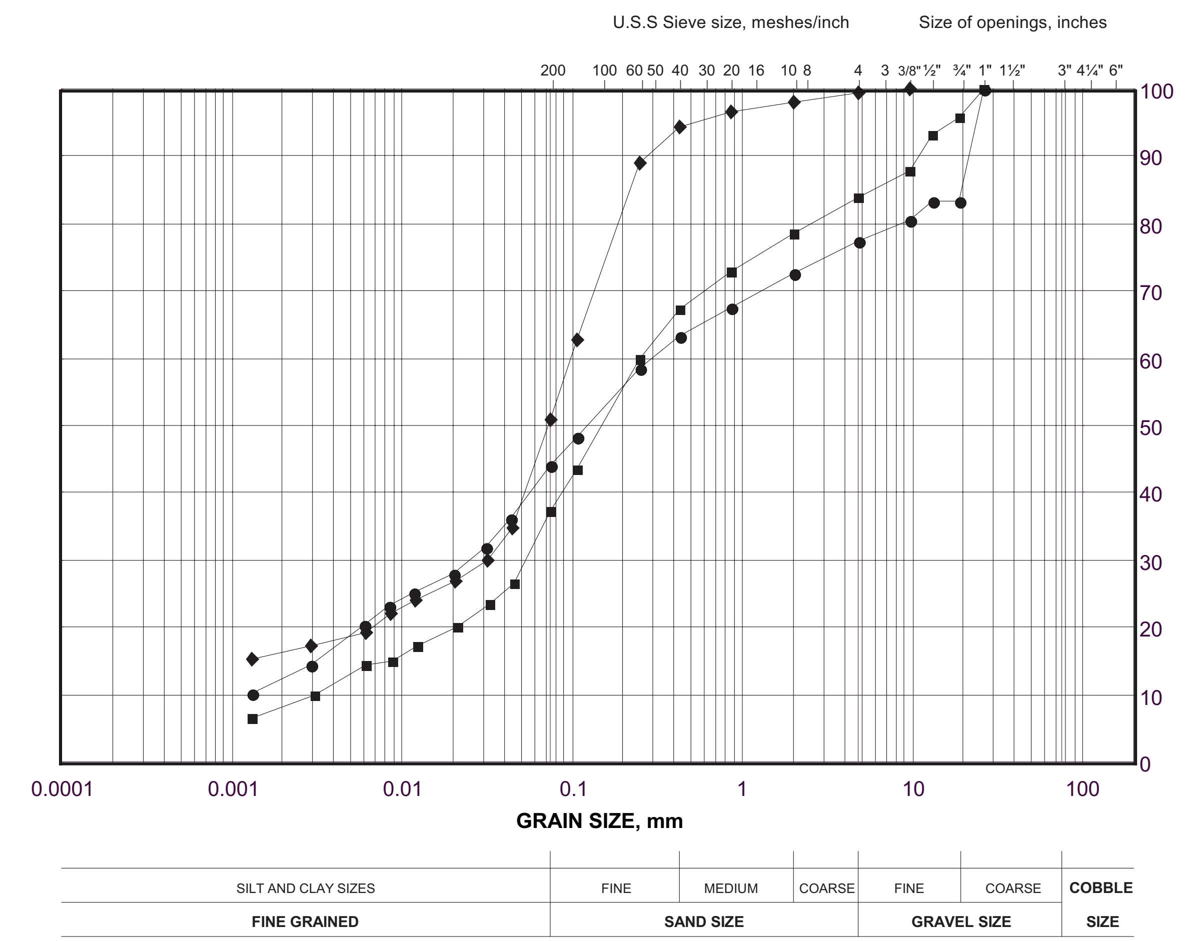
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM3-1	3	179.2
■	WM3-2	7	174.6

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 04-Jul-08

GRAIN SIZE DISTRIBUTION Sand and Silt (Till)	FIGURE WM3-B

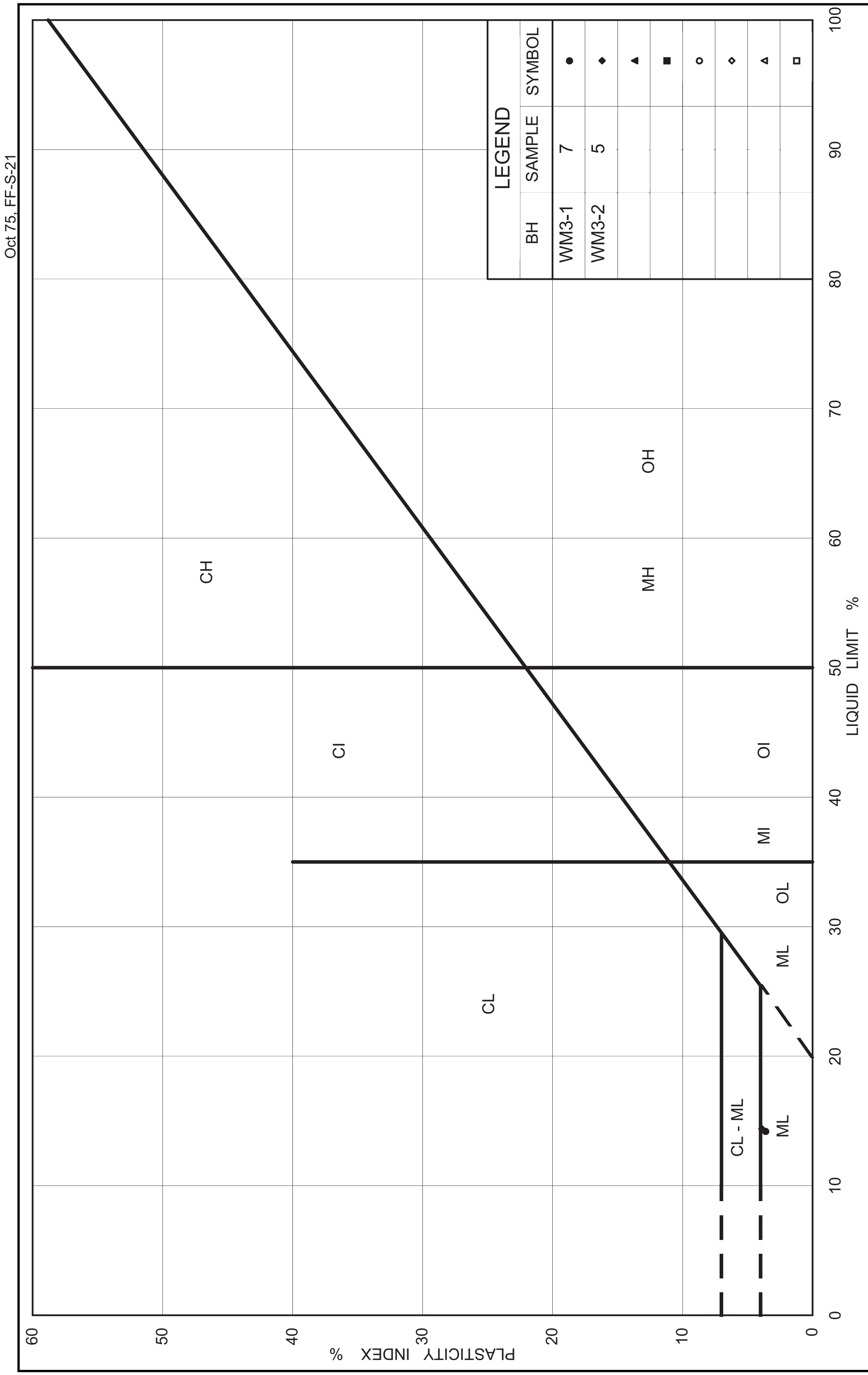


LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM3-2	11	168.8
■	WM3-2	5	177.6
◆	WM3-1	7	174.6

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 04-Jul-08



Oct 75, FF-S-21

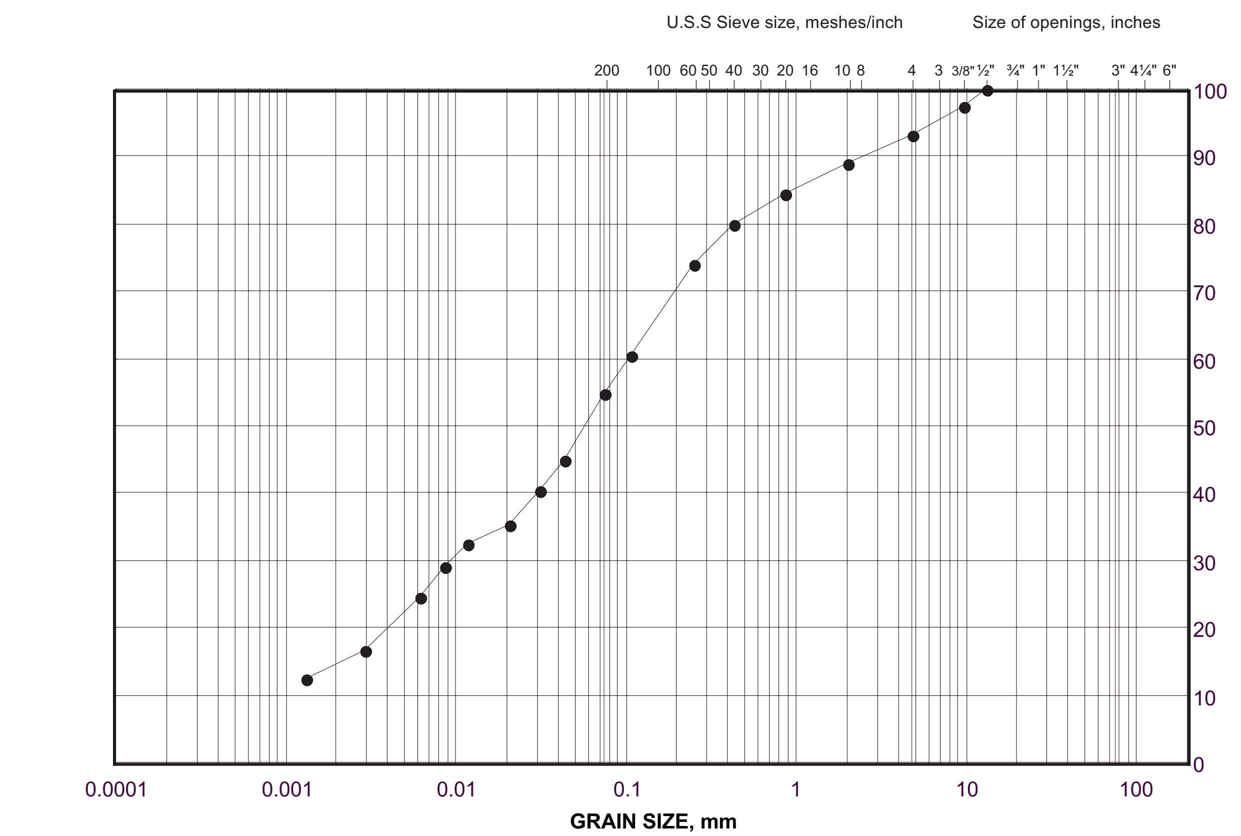
Figure No. WM3-C
Project No. 07-1111-0053
Checked By: KJB

PLASTICITY CHART
Sand and Silt (Till)

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM7-A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM7-2	3	164.6

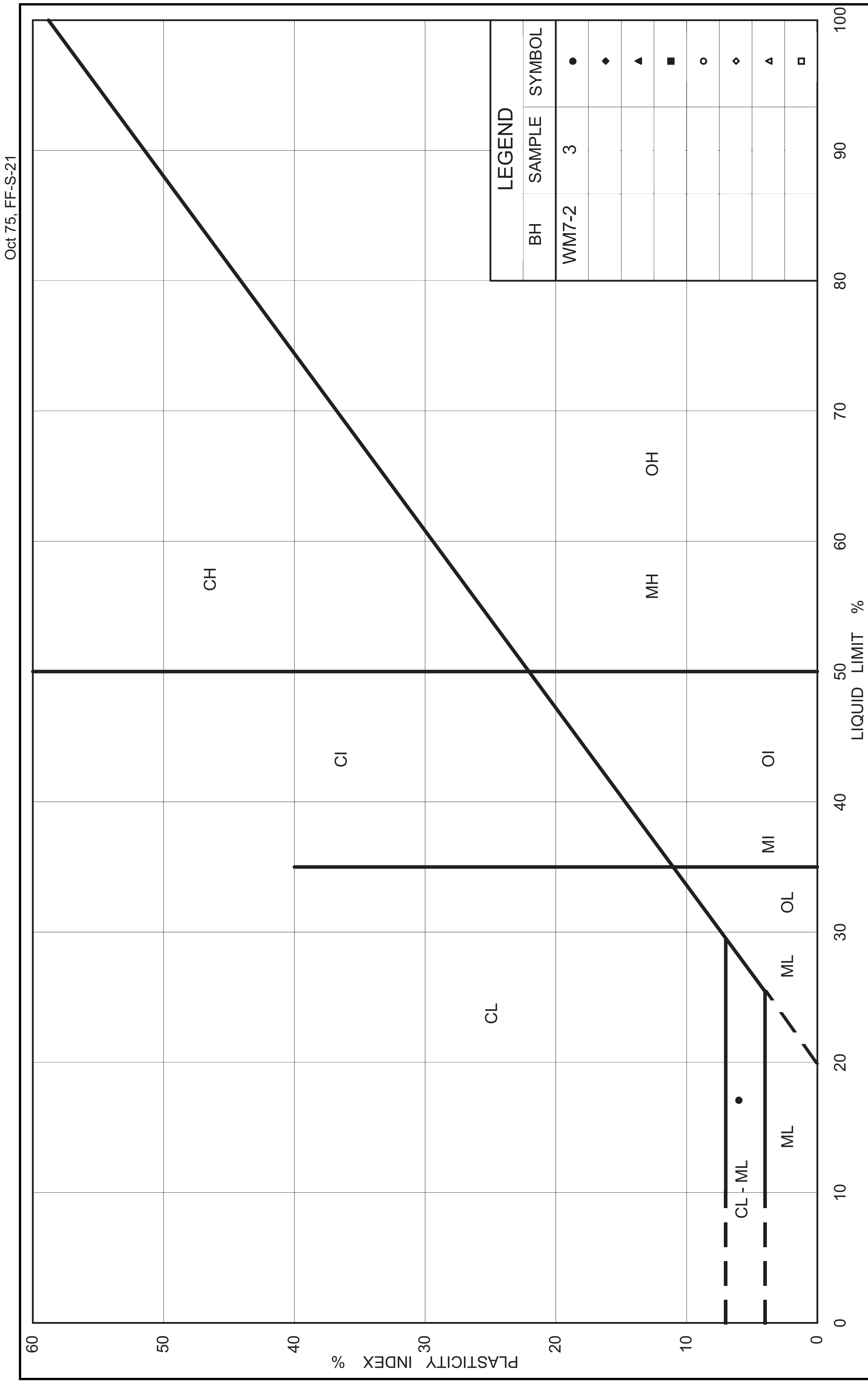
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 03-Dec-08

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
WM7-2	3	•

LEGEND

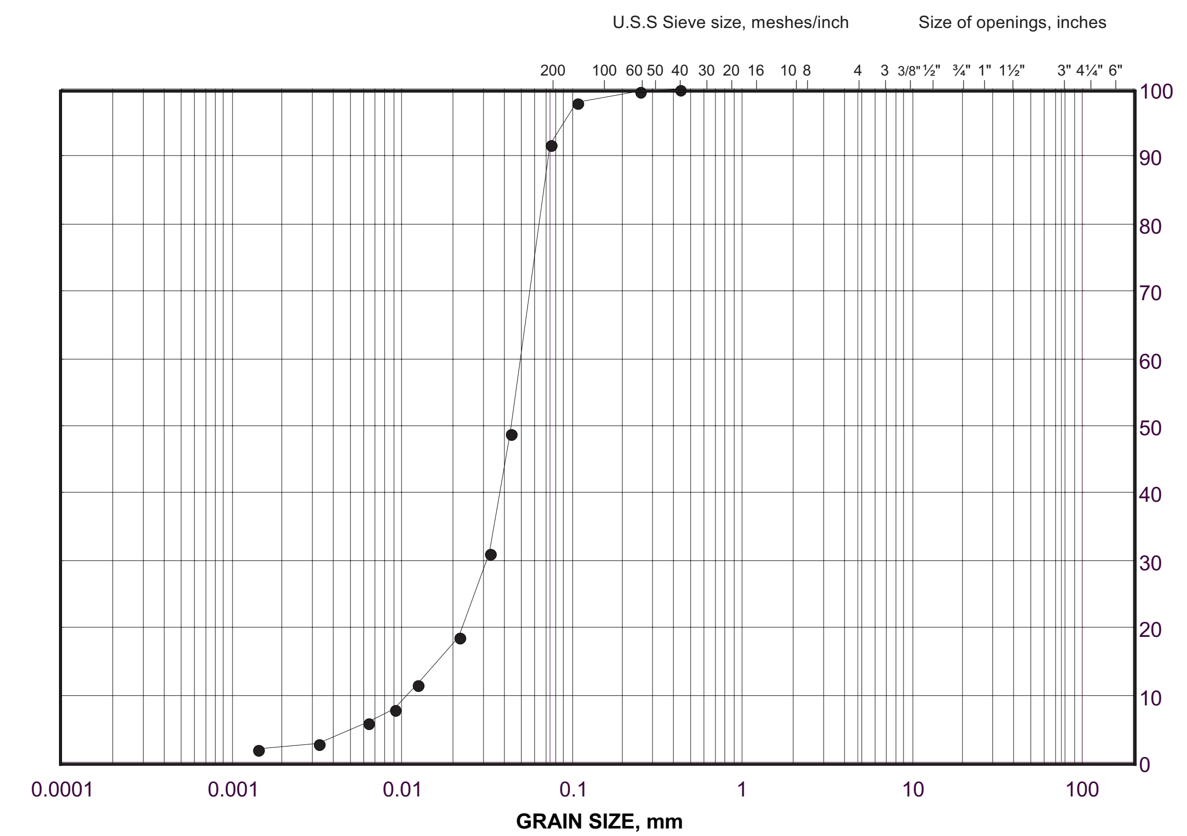
PLASTICITY CHART
Sand and Silt (Till)

Figure No. WM7-B
Project No. 07-1111-0053
Checked By: KJB

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Silt

FIGURE WM7-C



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WM7-1A	8A	169.4

Project Number: 07-1111-0053

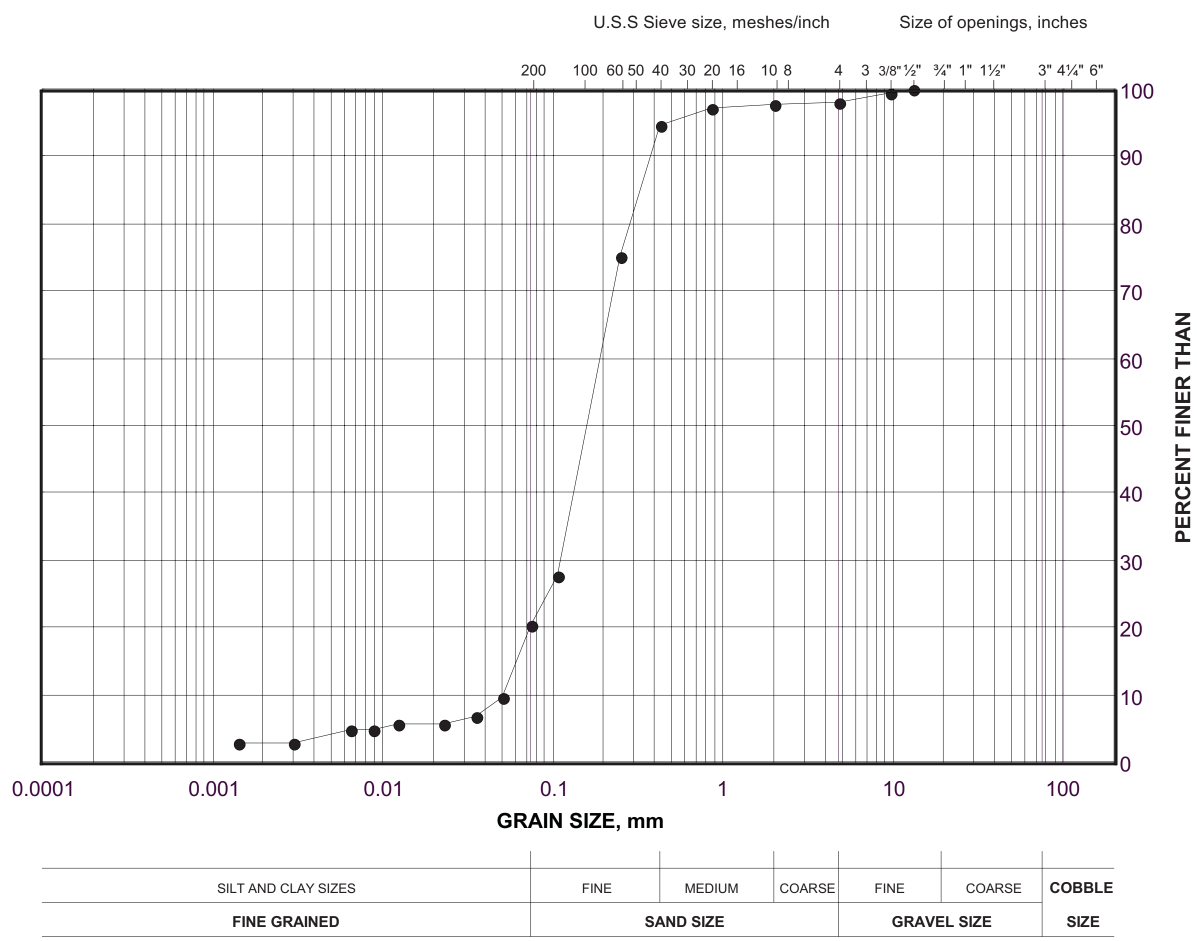
Checked By: KJB

Golder Associates

Date: 03-Dec-08

GRAIN SIZE DISTRIBUTION
Sand

FIGURE WM7-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM7-1A	10	166.2

Project Number: 07-1111-0053

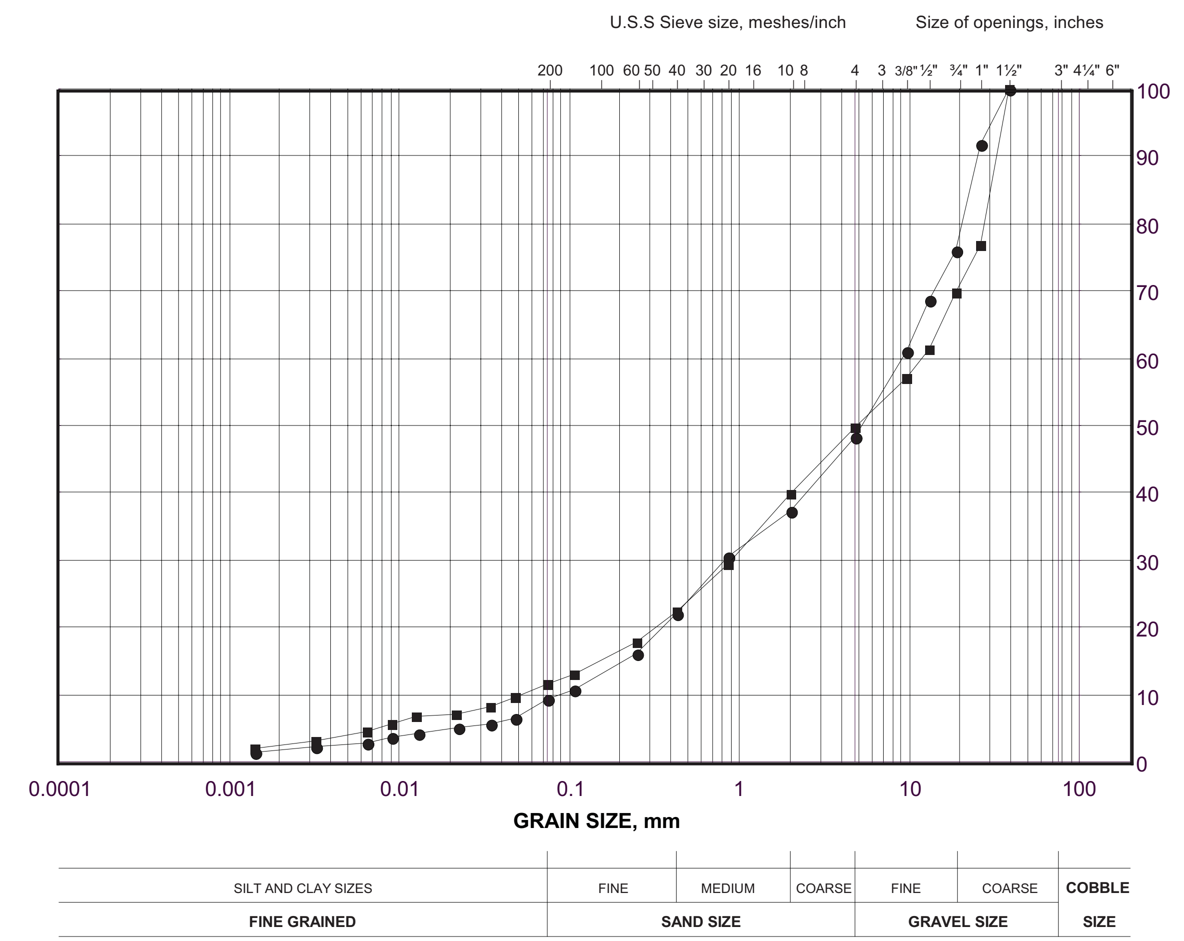
Checked By: KJB

Golder Associates

Date: 03-Dec-08

GRAIN SIZE DISTRIBUTION
Sand and Gravel

FIGURE WM7-E



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM7-2	5	163.1
■	WM7-2	8	158.5

Project Number: 07-1111-0053

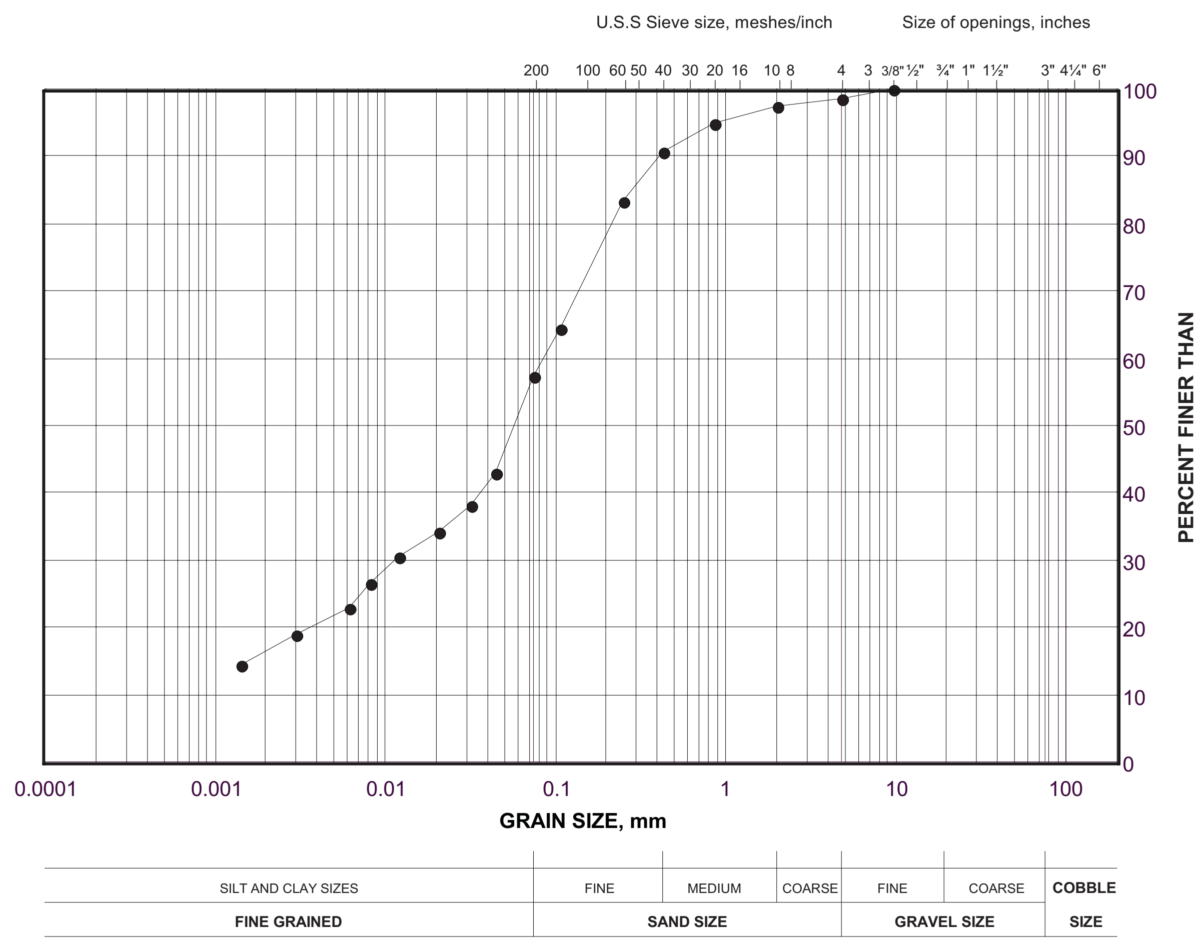
Checked By: KJB

Golder Associates

Date: 29-Oct-08

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand (Till)

FIGURE WM8-A



LEGEND

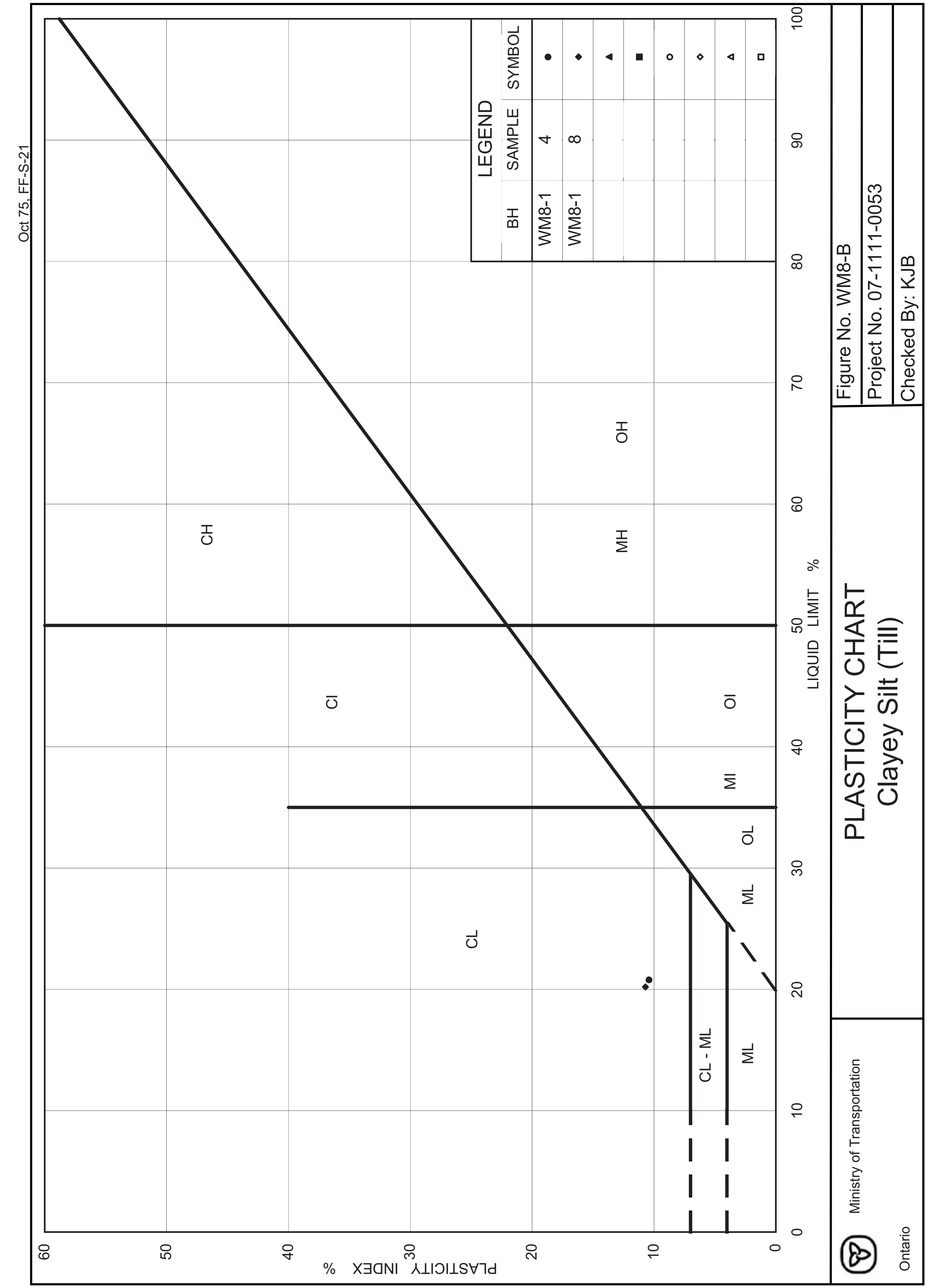
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM8-1	4	165.5

Project Number: 07-1111-0053

Checked By: KJB

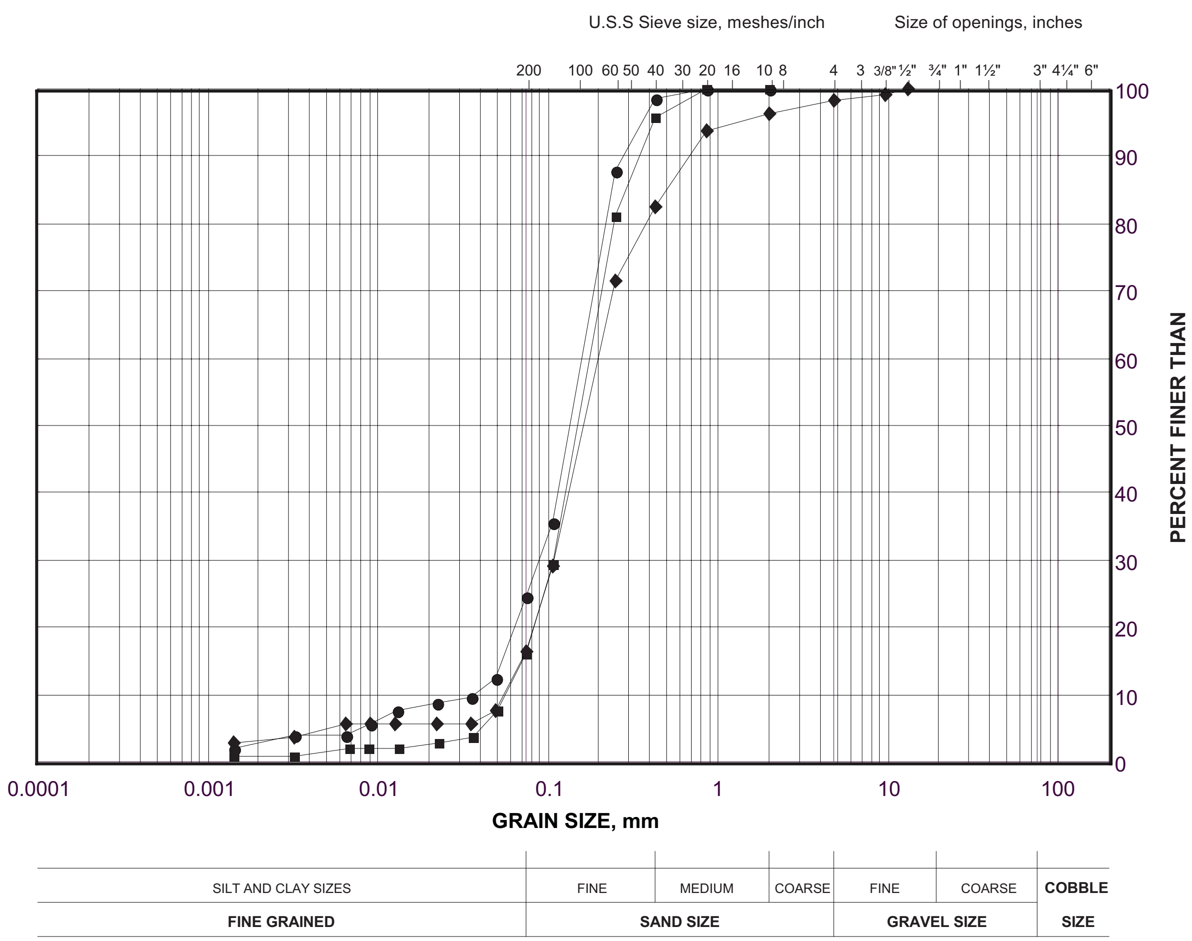
Golder Associates

Date: 01-May-08



GRAIN SIZE DISTRIBUTION
Silty Sand to Sand

FIGURE WM8-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM8-1	10	158.6
■	WM8-1	12	155.6
◆	WM8-1	15	151.2

Project Number: 07-1111-0053

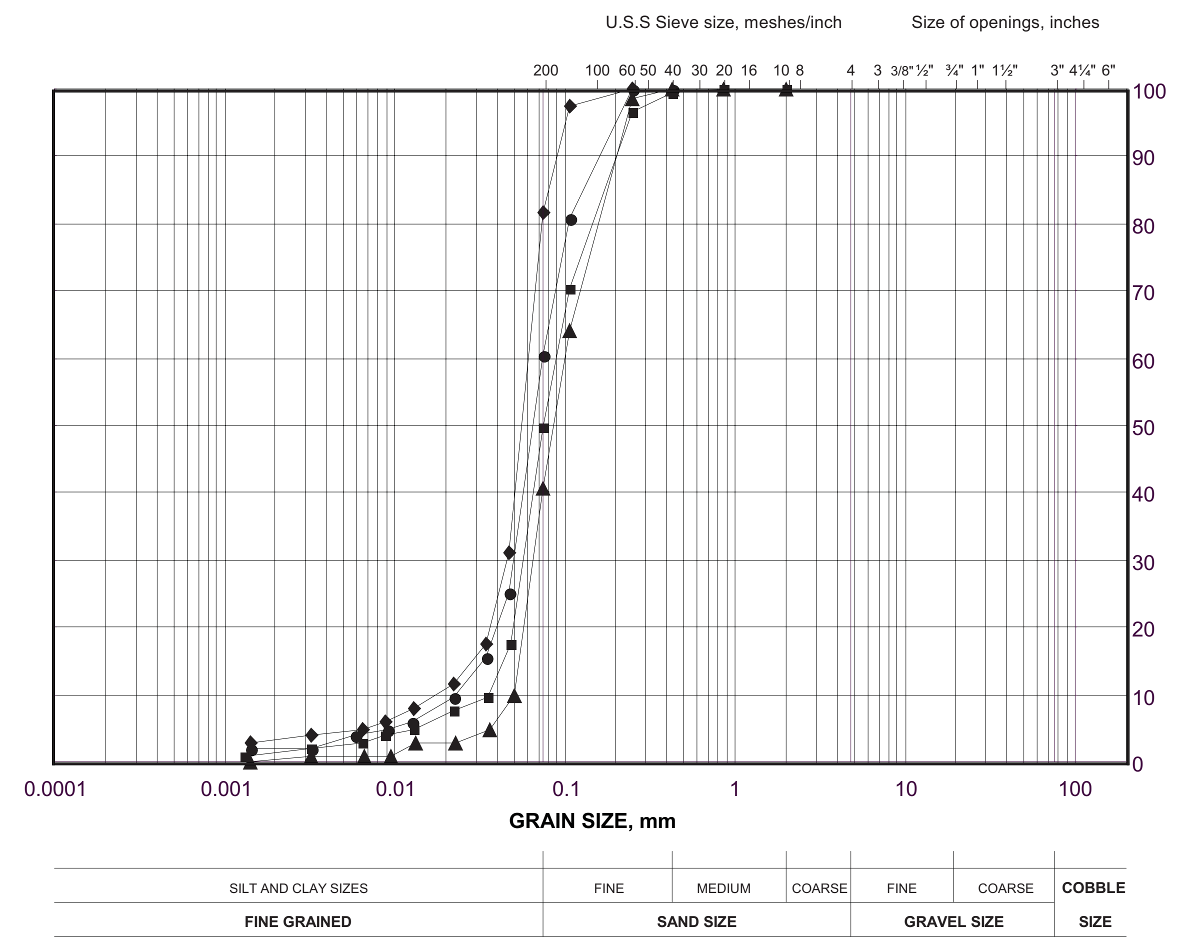
Checked By: KJB

Golder Associates

Date: 01-May-08

GRAIN SIZE DISTRIBUTION
Upper Silty Sand to Sand and Silt

FIGURE WM11-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM11-1	4	150.9
■	WM11-2	5	149.0
◆	WM11-1	8	145.6
▲	WM11-2	8	144.5

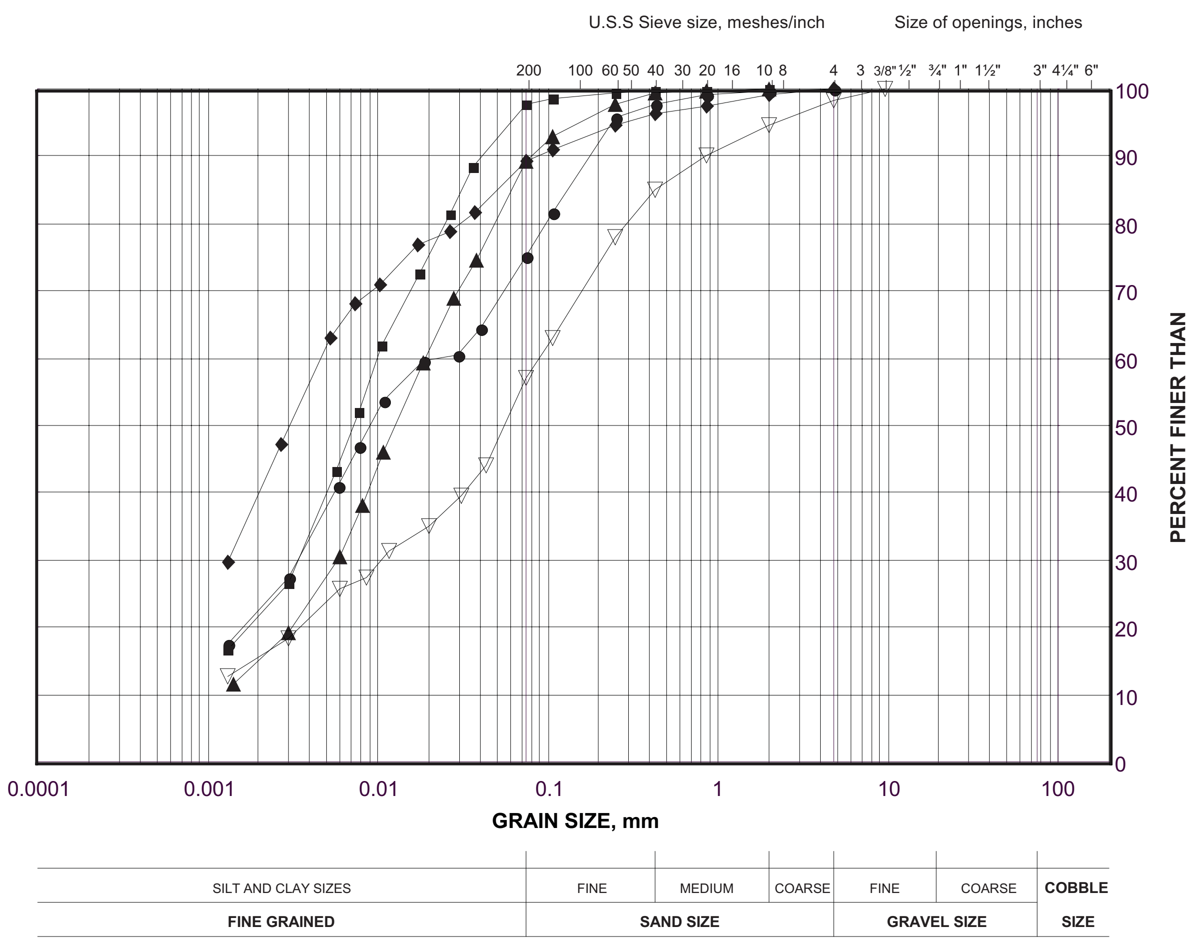
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Dec-08

GRAIN SIZE DISTRIBUTION Clayey Silt to Silty Clay, contains Sand and Silt seams	FIGURE WM11A-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM11A-1	11	131.4
■	WM11A-1	13	128.4
◆	WM11A-1	14	126.8
▲	WM11A-1	18	120.7
▽	WM11A-1	6	139.0

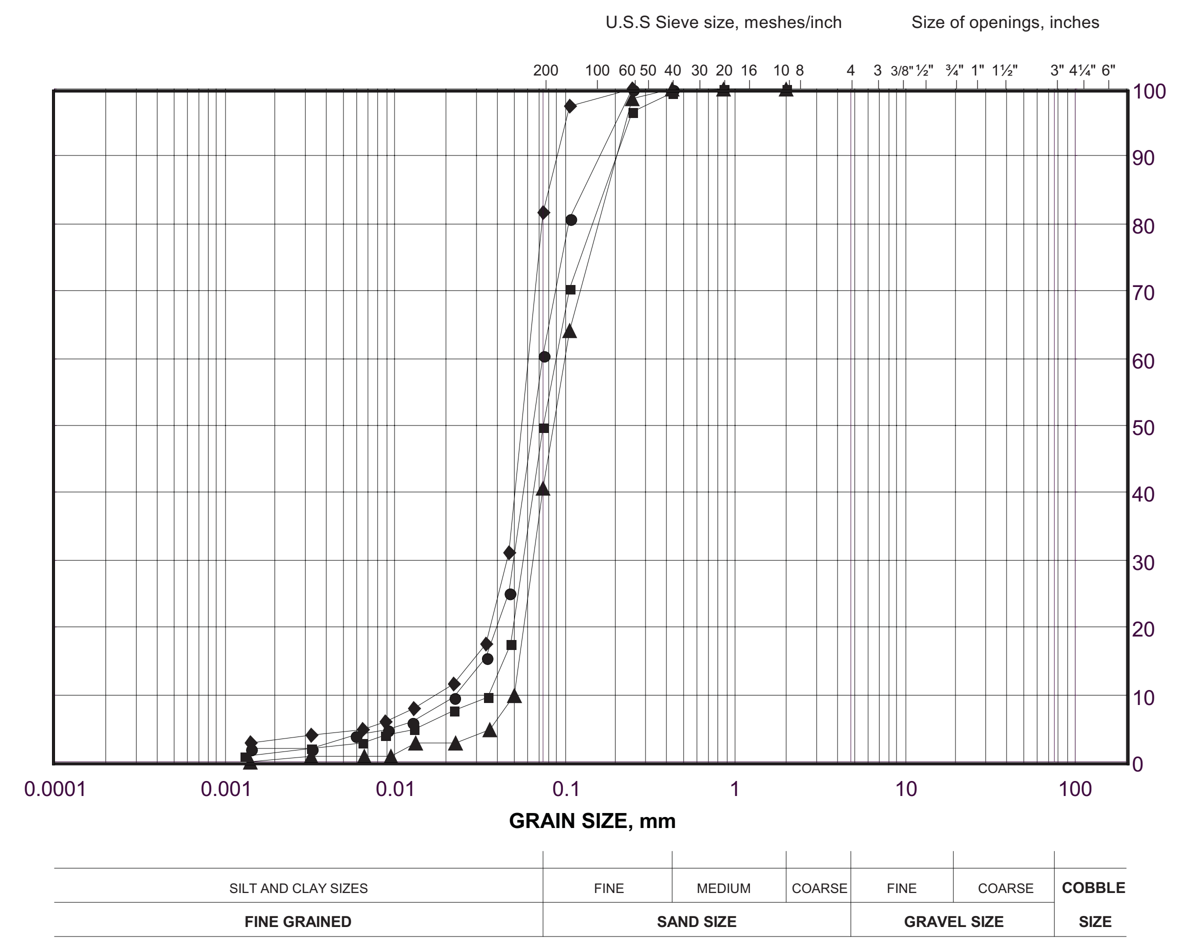
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Dec-08

GRAIN SIZE DISTRIBUTION Upper Silty Sand to Sand and Silt	FIGURE WM11-A



LEGEND

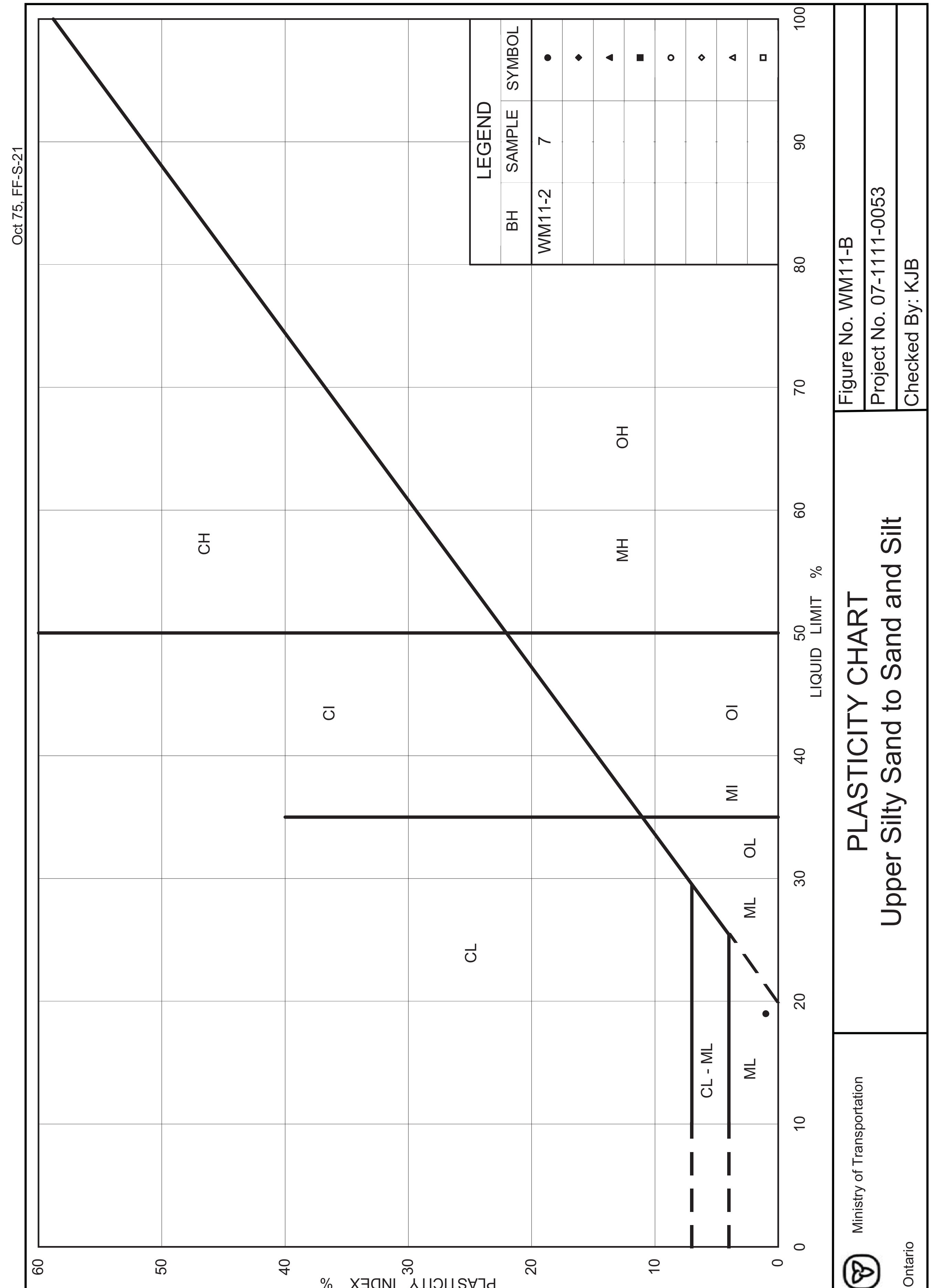
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM11-1	4	150.9
■	WM11-2	5	149.0
◆	WM11-1	8	145.6
▲	WM11-2	8	144.5

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

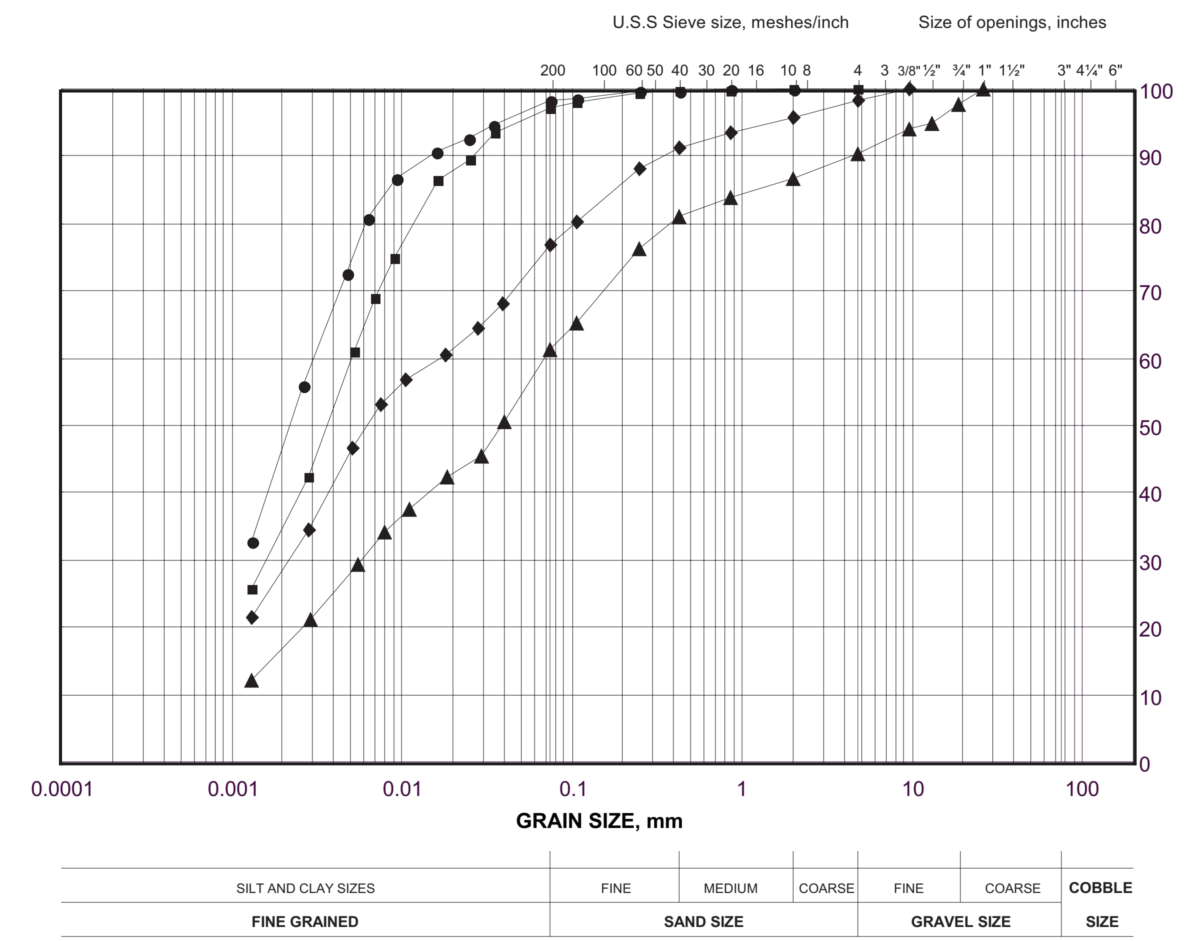
Date: 04-Dec-08



GRAIN SIZE DISTRIBUTION

Clayey Silt (Till-Like)

FIGURE WM11-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM11-1	10	142.5
■	WM11-2	10	141.4
◆	WM11-1	13	139.5
▲	WM11-2	14	135.3

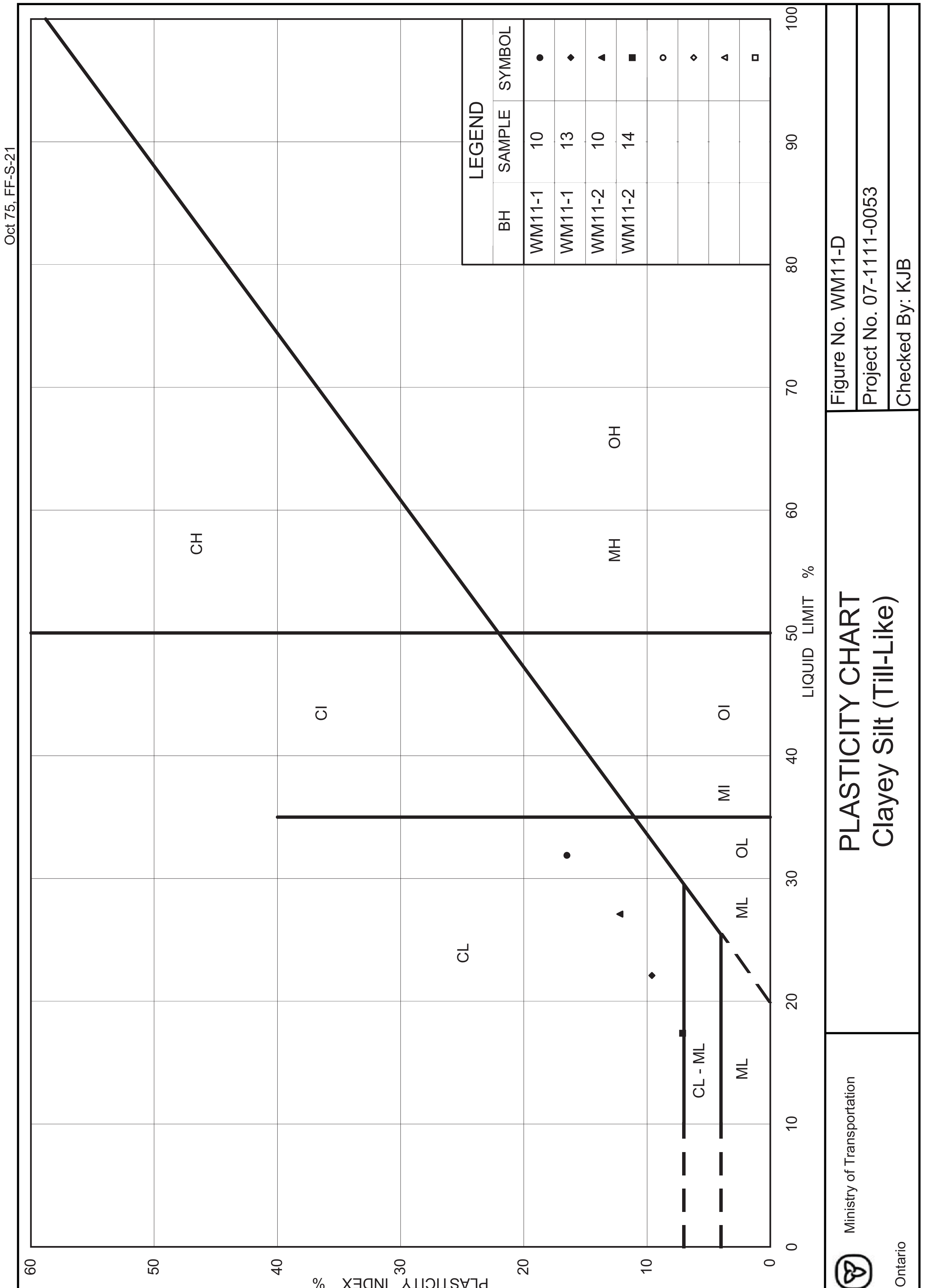
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 10-Nov-08

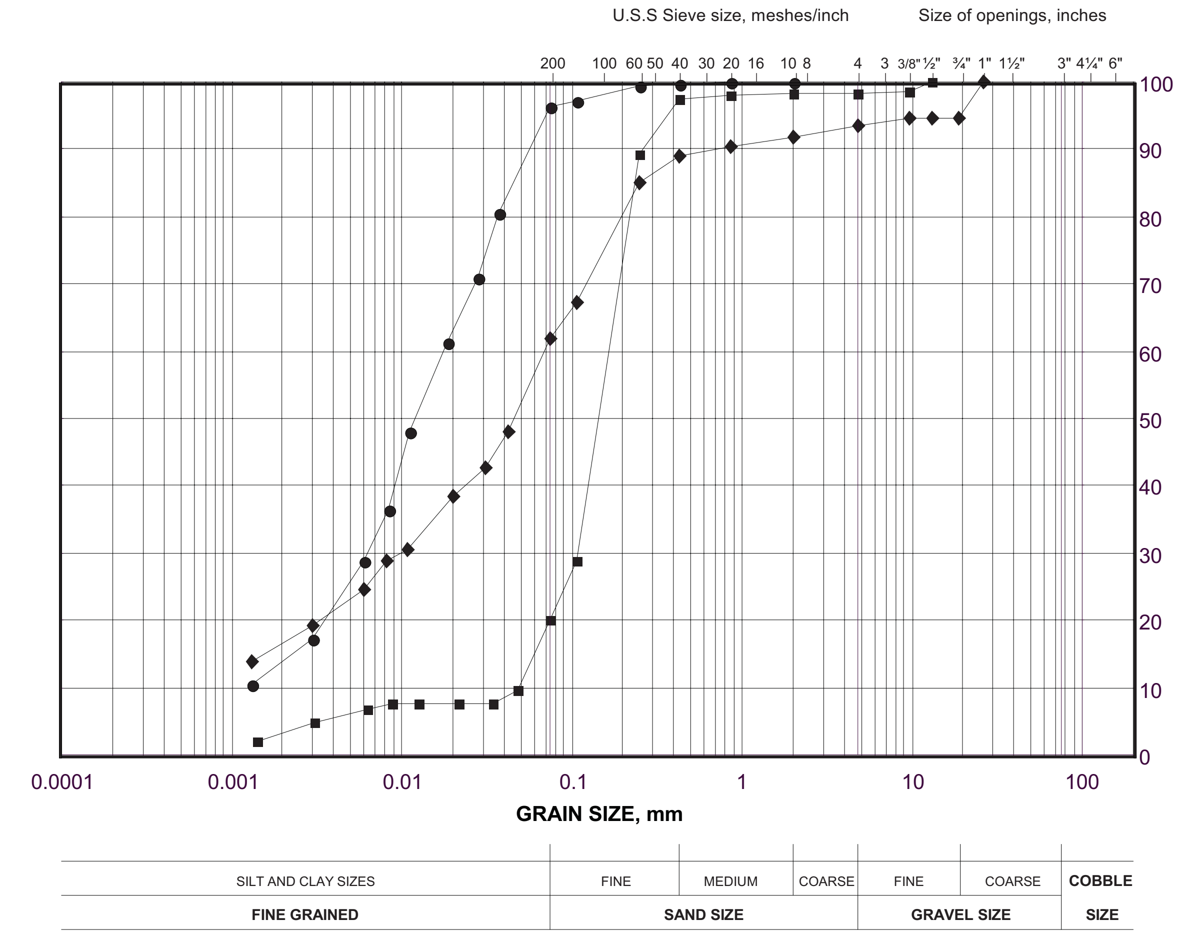
Oct 75, FF-S-21



GRAIN SIZE DISTRIBUTION

Lower Sand to Sand and Silt, contains Clayey Silt seams

FIGURE WM11-E



LEGEND

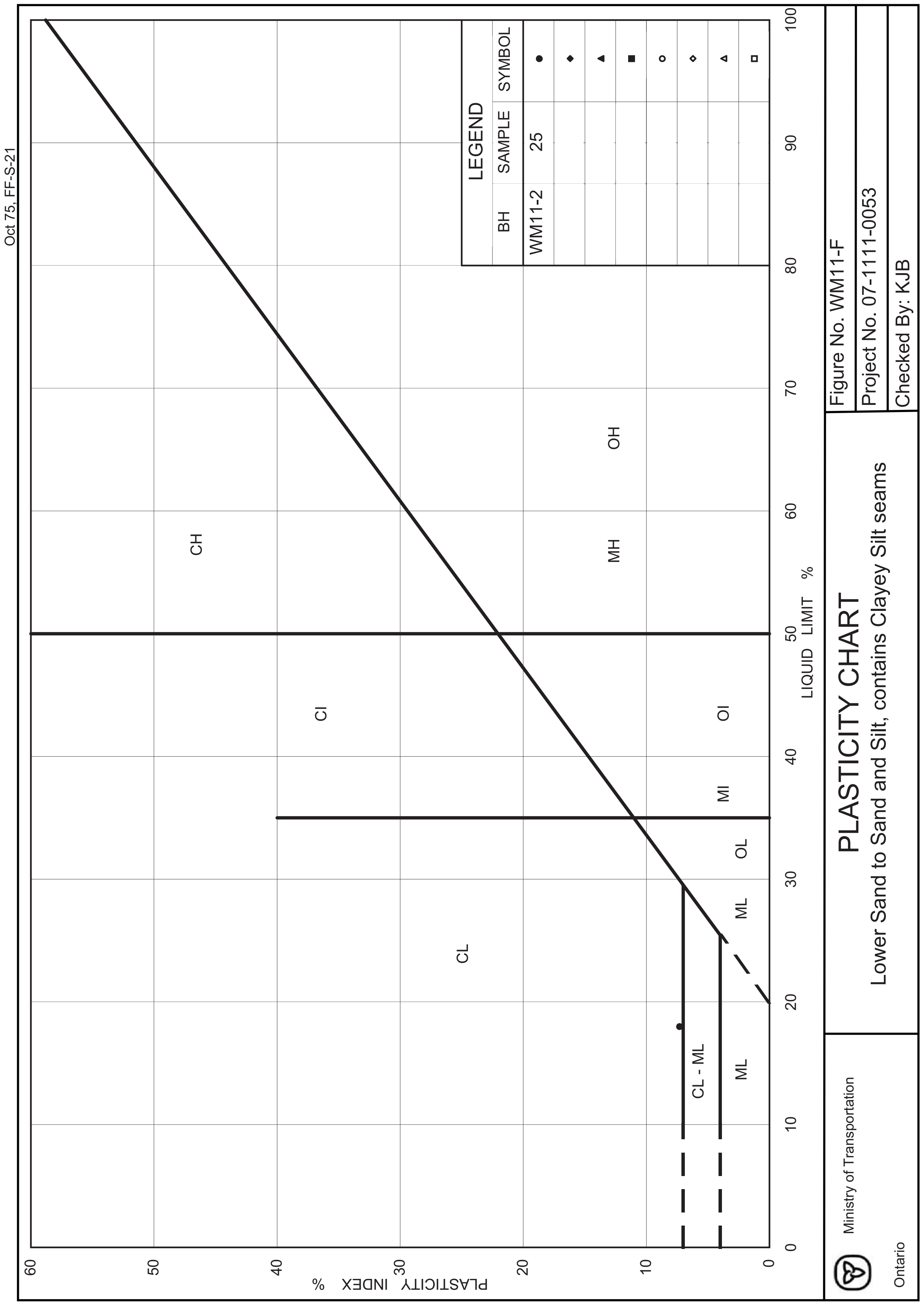
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM11-2	18	129.3
■	WM11-2	23	121.6
◆	WM11-2	25	118.7

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

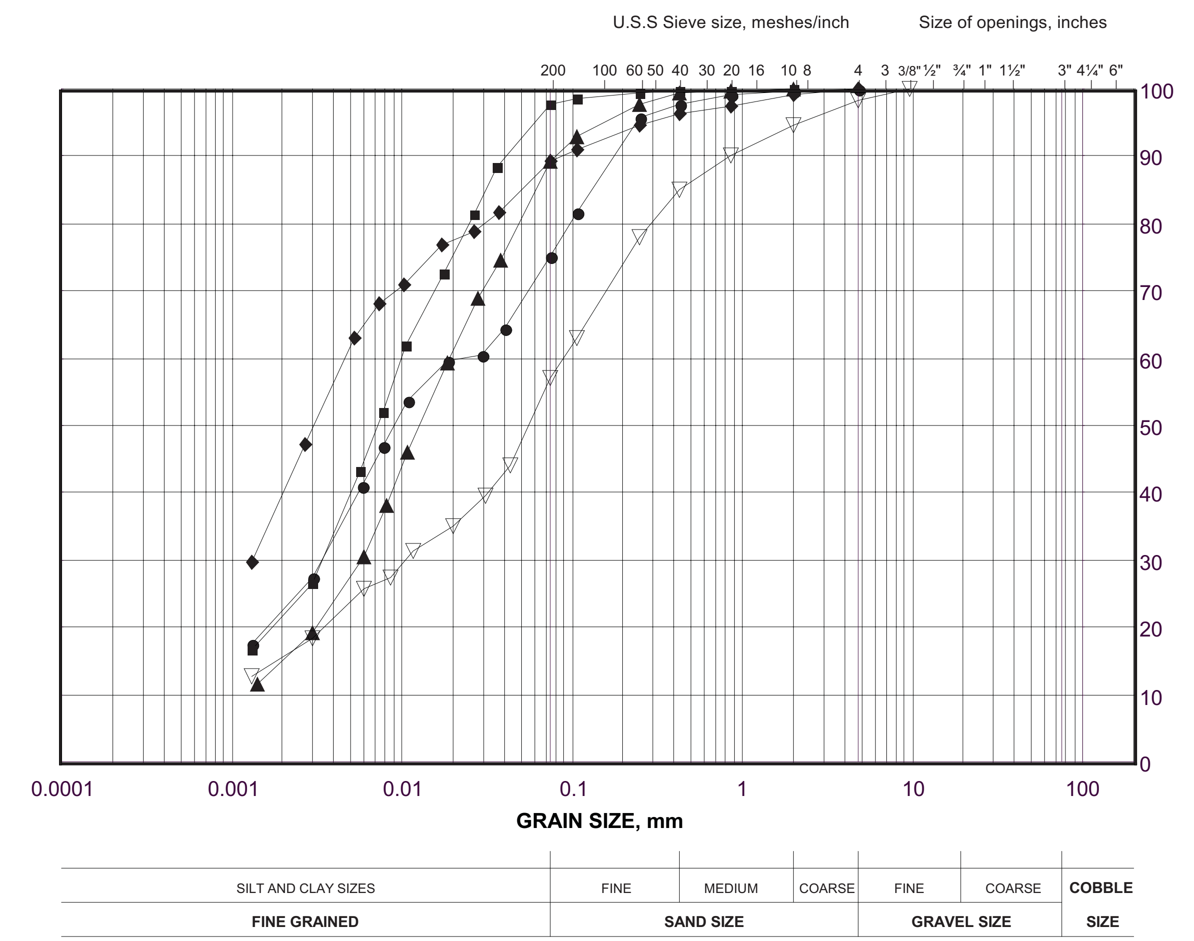
Date: 04-Dec-08



GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay, contains Sand and Silt seams

FIGURE WM11A-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM11A-1	11	131.4
■	WM11A-1	13	128.4
◆	WM11A-1	14	126.8
▲	WM11A-1	18	120.7
▽	WM11A-1	6	139.0

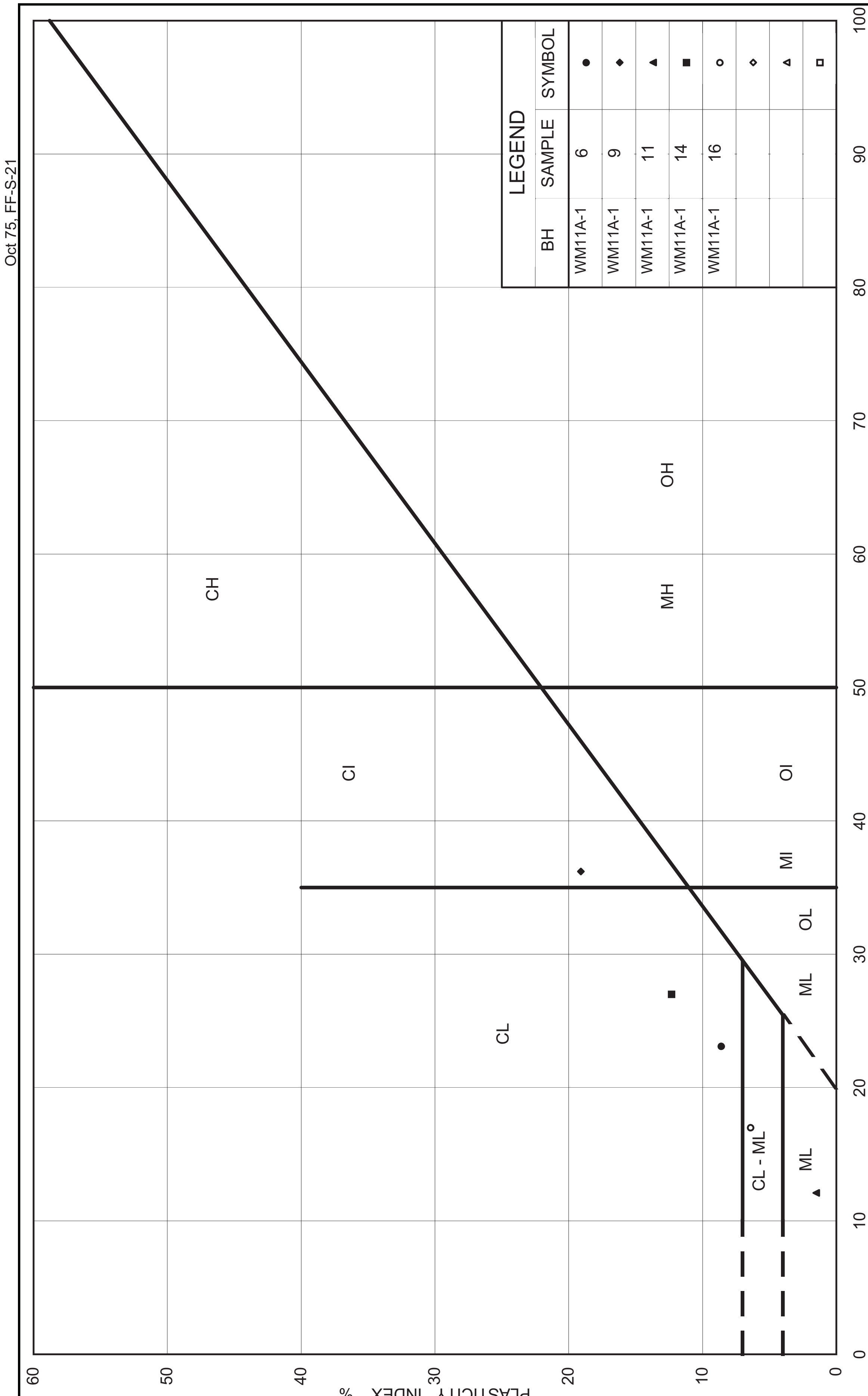
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Dec-08

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
WM11A-1	6	●
WM11A-1	9	◆
WM11A-1	11	▲
WM11A-1	14	■
WM11A-1	16	○

Figure No. WM11A-B

Project No. 07-1111-0053

Checked By: KJB

PLASTICITY CHART

Clayey Silt to Silty Clay, contains Sand and Silt seams

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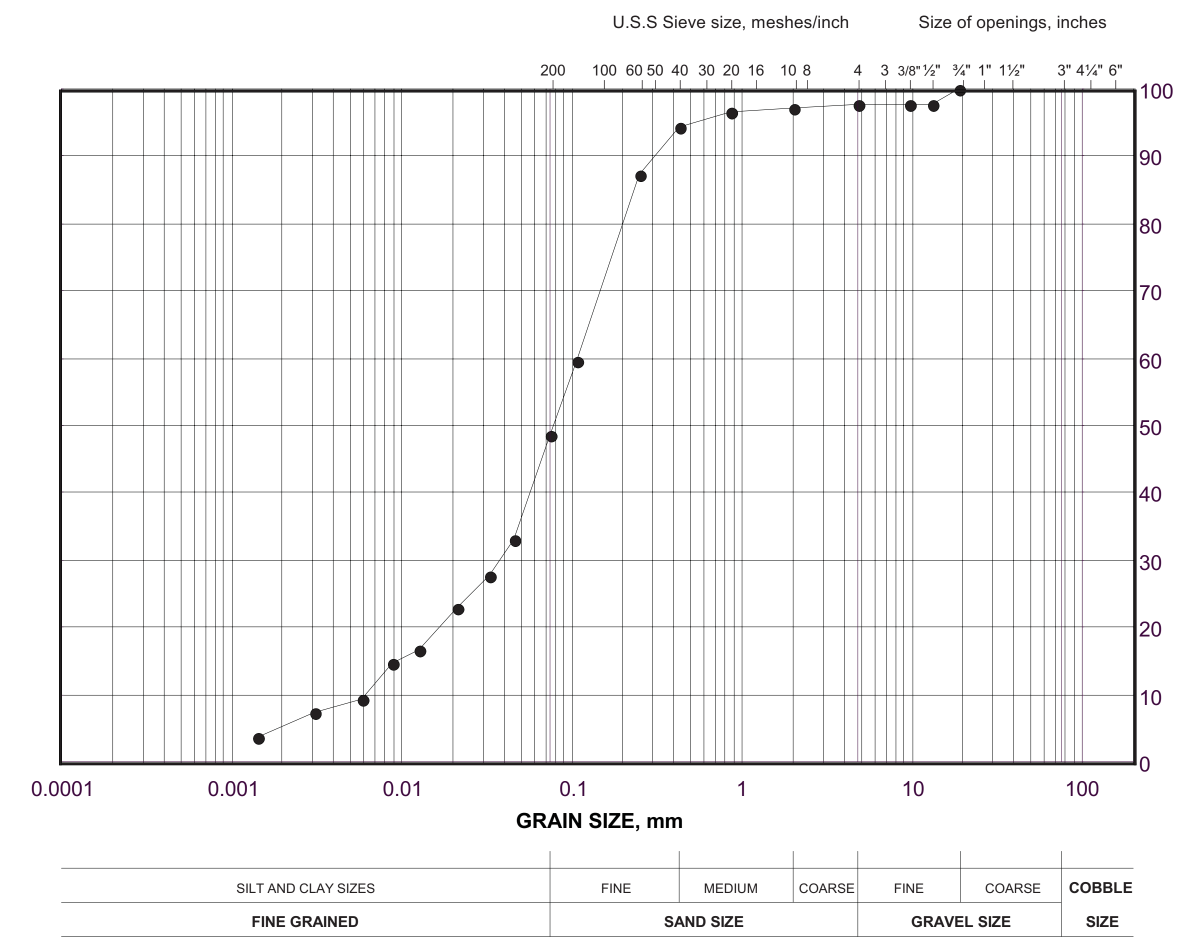
GRAIN SIZE DISTRIBUTION

Lower Sand to Sand and Silt

FIGURE WM11A-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM11A-1	21	116.2

Project Number: 07-1111-0053

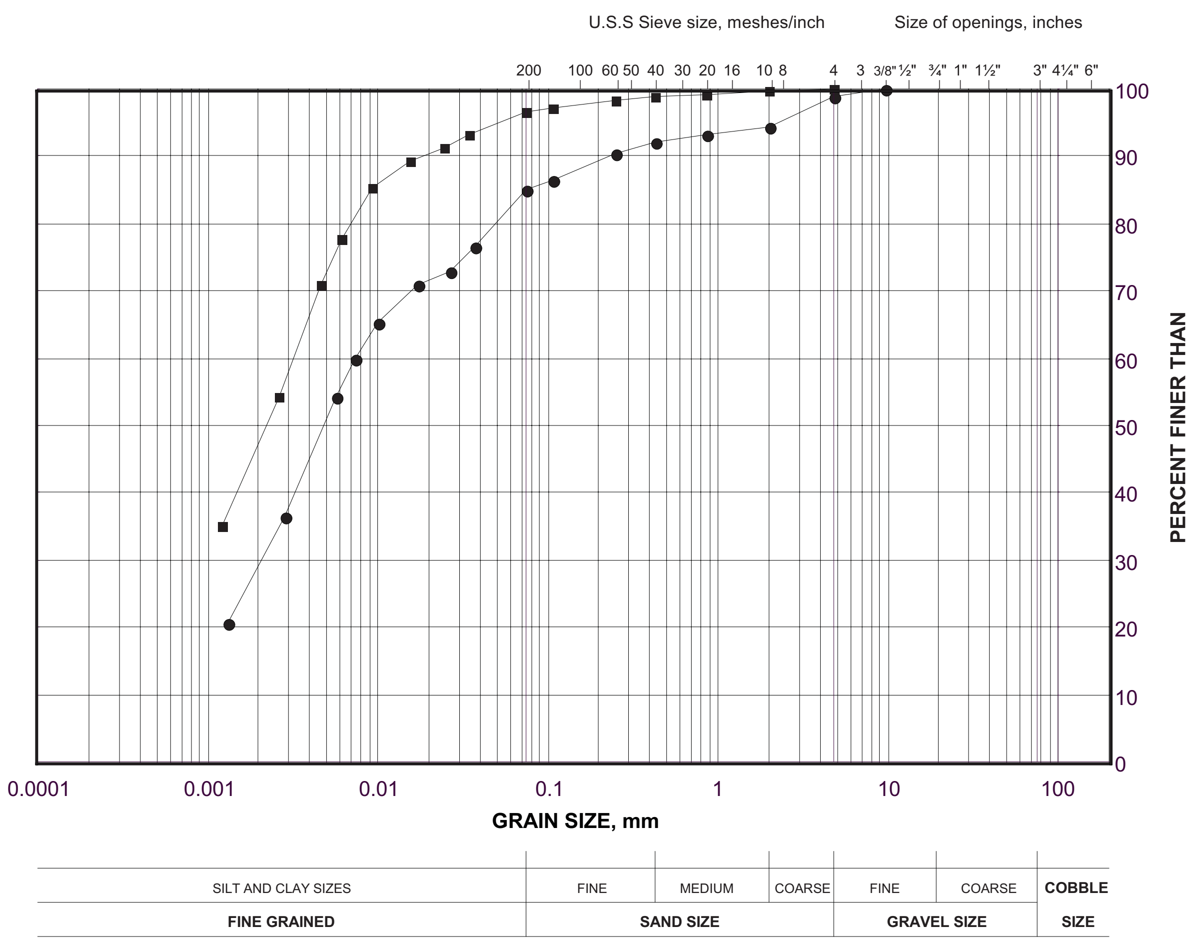
Checked By: KJB

Golder Associates

Date: 24-Sep-08

GRAIN SIZE DISTRIBUTION
Clayey Silt

FIGURE WM12-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM12-1	5	137.9
■	WM12-1	9	131.9

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 14-Oct-08

Oct 75, FF-S-21

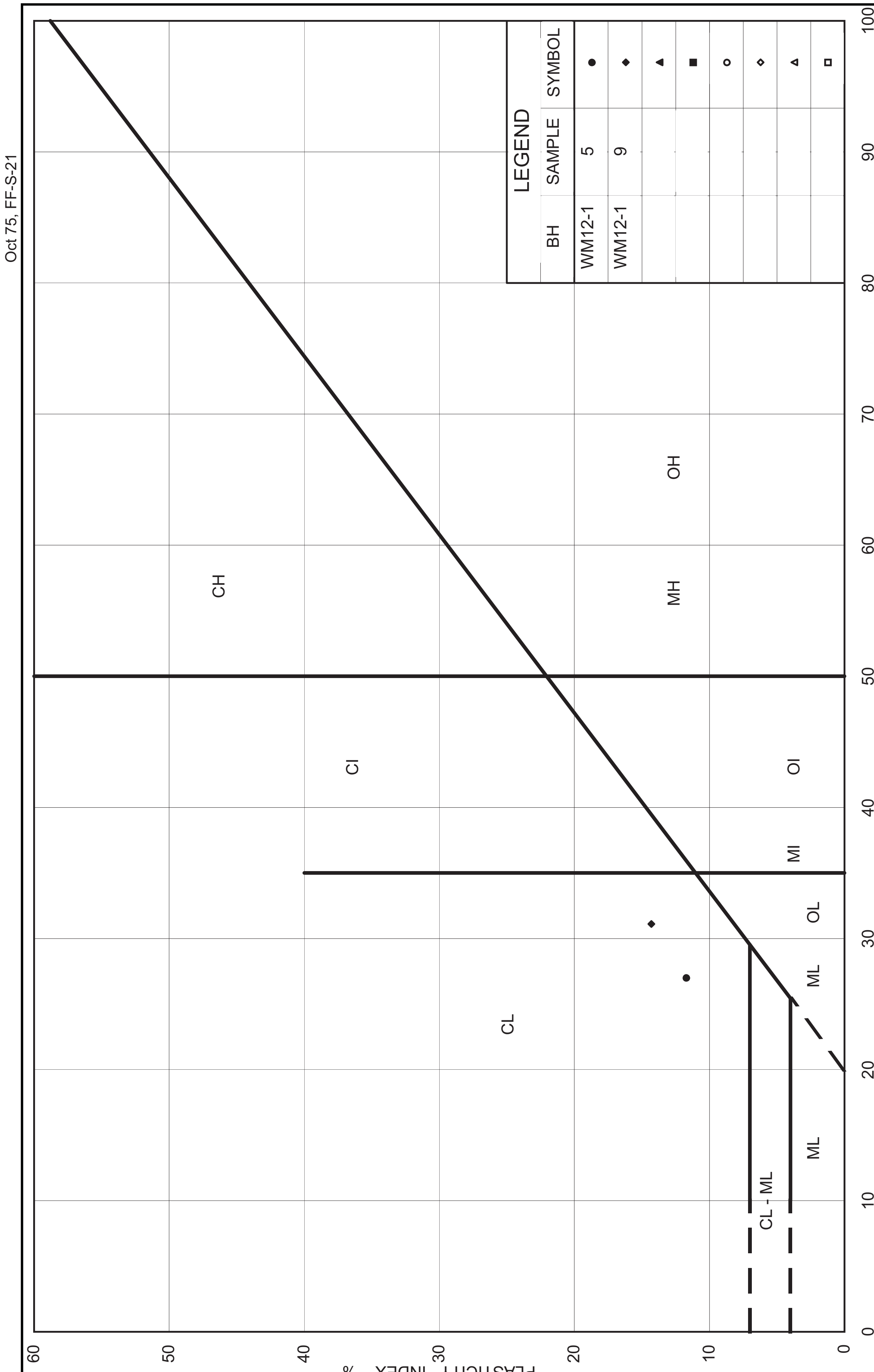


Figure No. WM12-B

Project No. 07-1111-0053

Checked By: KJB

PLASTICITY CHART
Clayey Silt

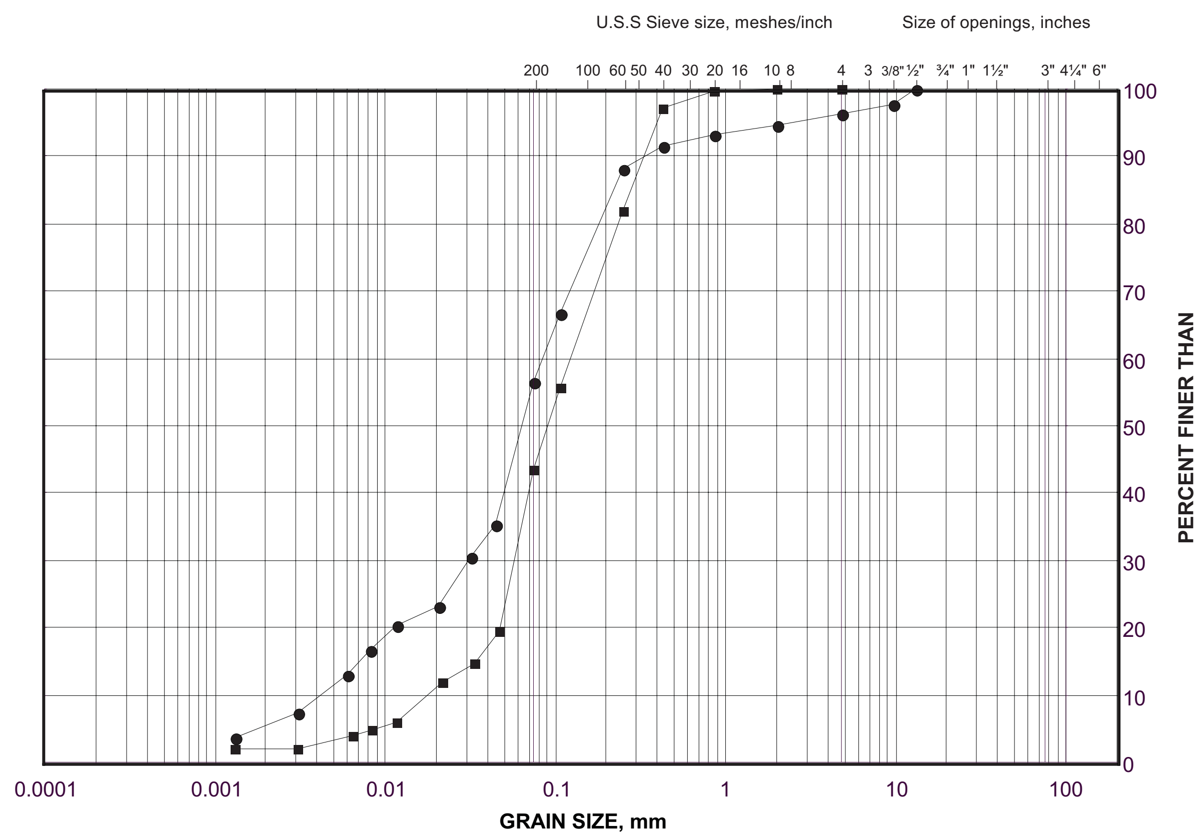
Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION

Sand and Silt

FIGURE WM12-C



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

LEGEND

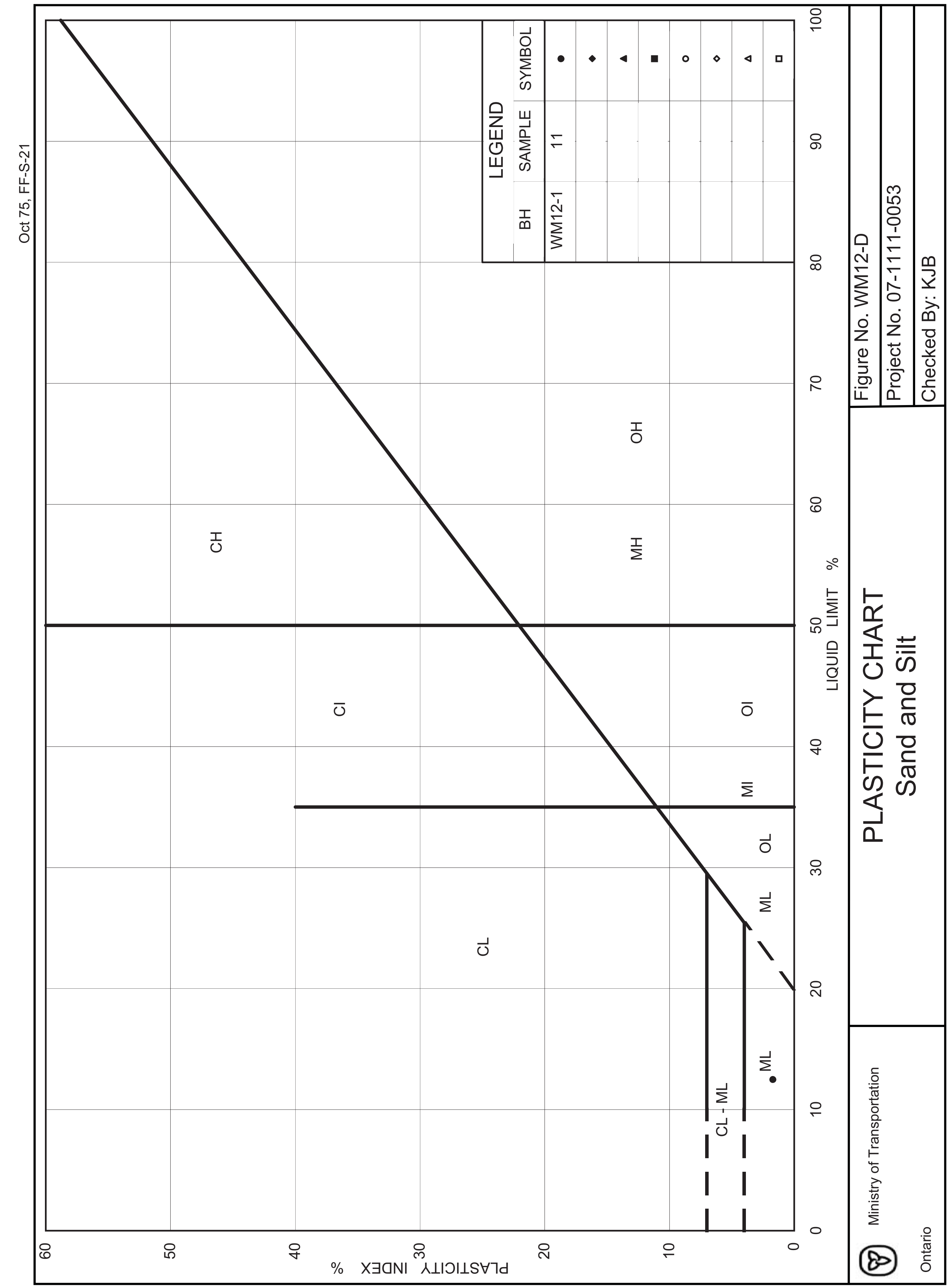
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM12-1	11	128.8
■	WM12-1	14	124.2

Project Number: 07-1111-0053

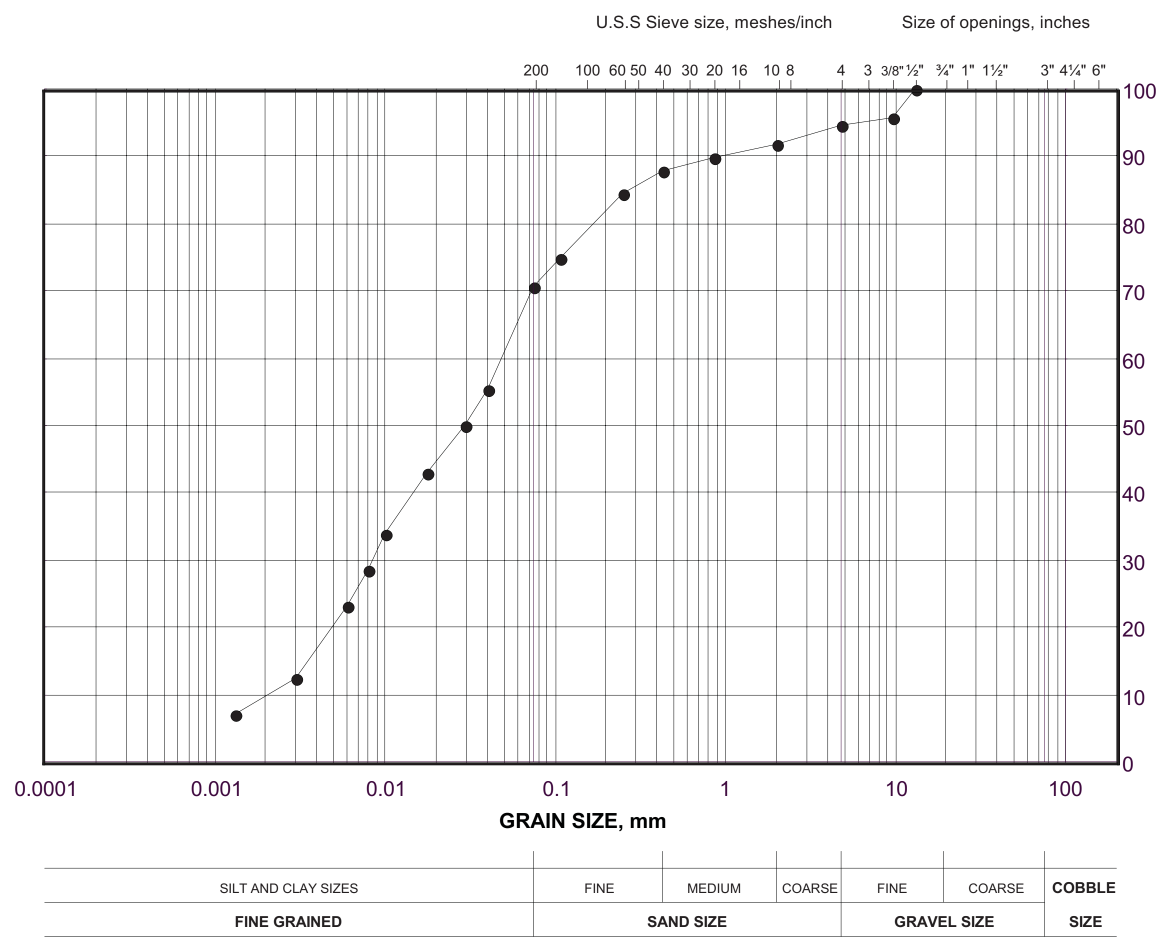
Checked By: KJB

Golder Associates

Date: 14-Oct-08



GRAIN SIZE DISTRIBUTION Sandy Silt	FIGURE WM12-E



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM12-1	16	121.2

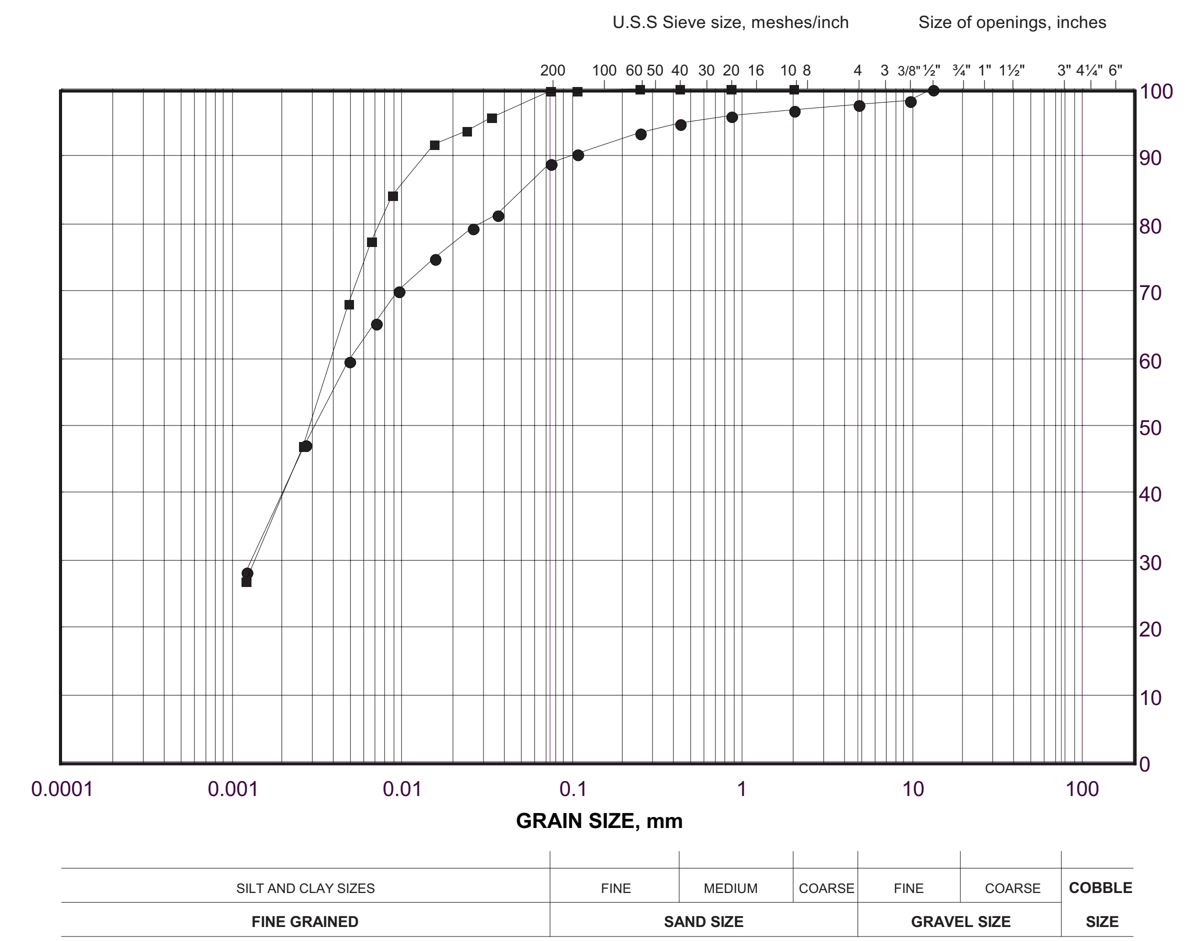
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 14-Oct-08

GRAIN SIZE DISTRIBUTION Clayey Silt	FIGURE WM13-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM13-1	11	136.4
■	WM13-1	6	144.0

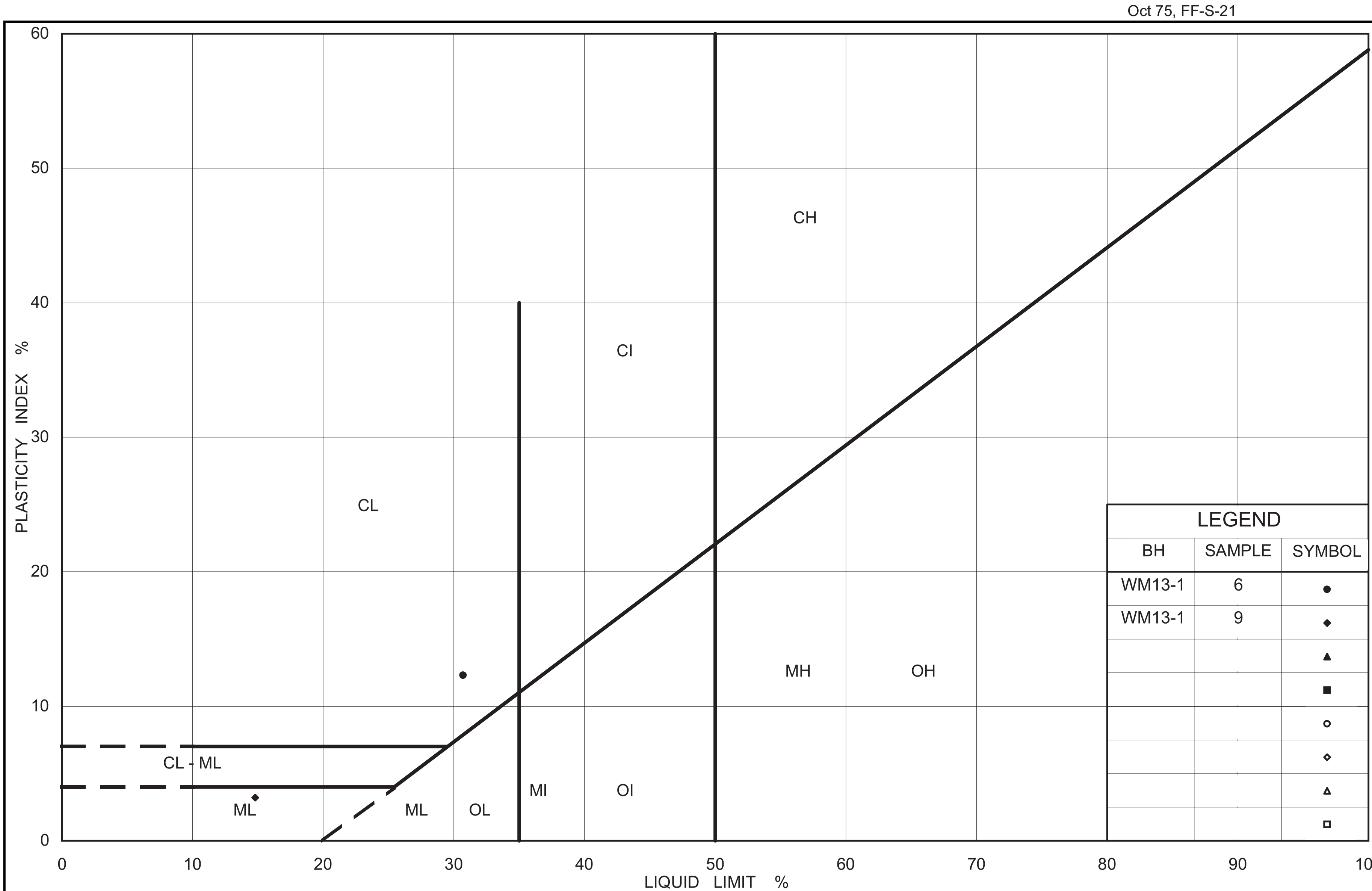
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 14-Oct-08

Oct 75, FF-S-21



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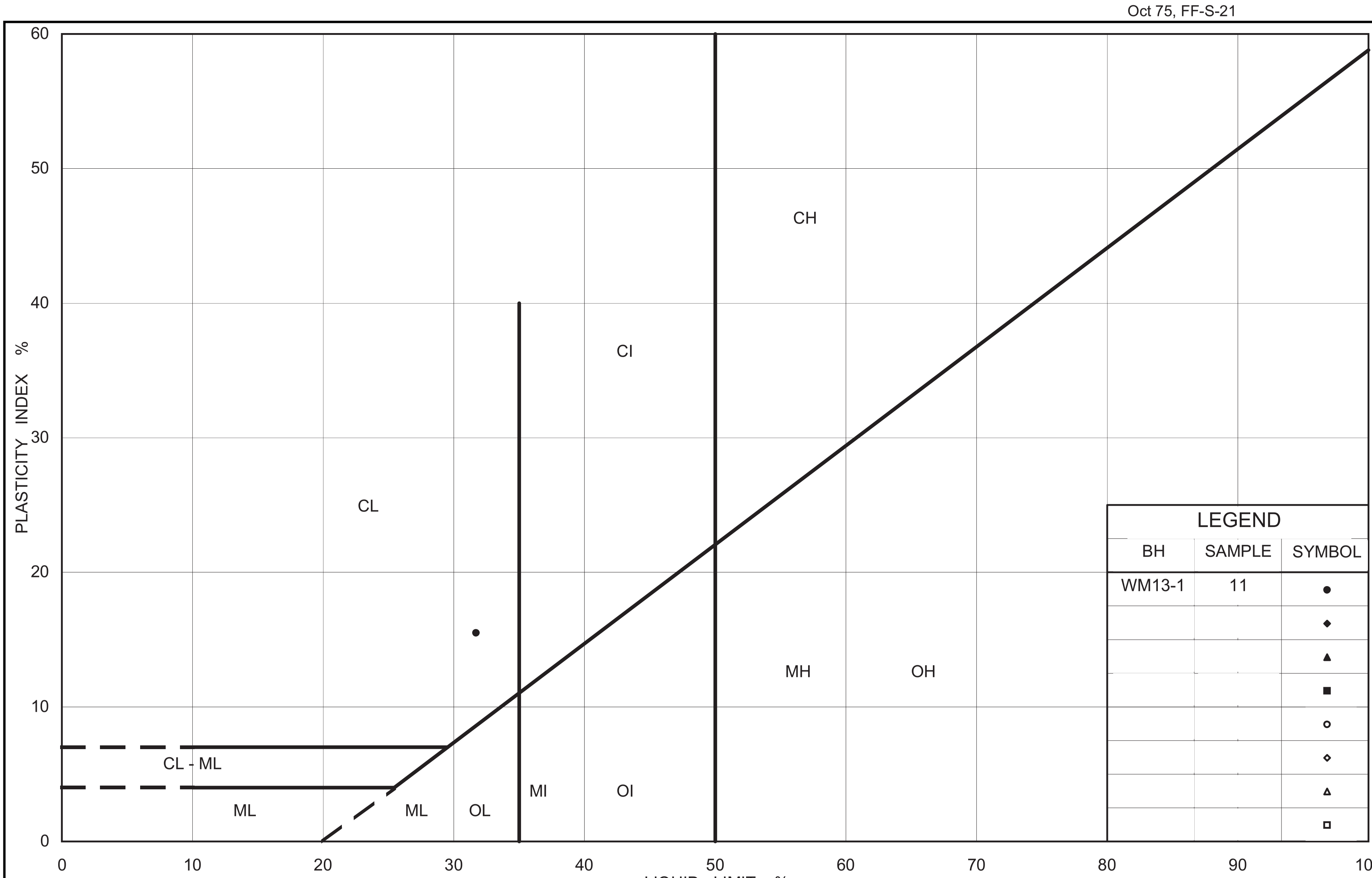
PLASTICITY CHART
Clayey Silt

Figure No. WM13-B

Project No. 07-1111-0053

Checked By: KJB

Oct 75, FF-S-21



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PLASTICITY CHART
Sandy Silt

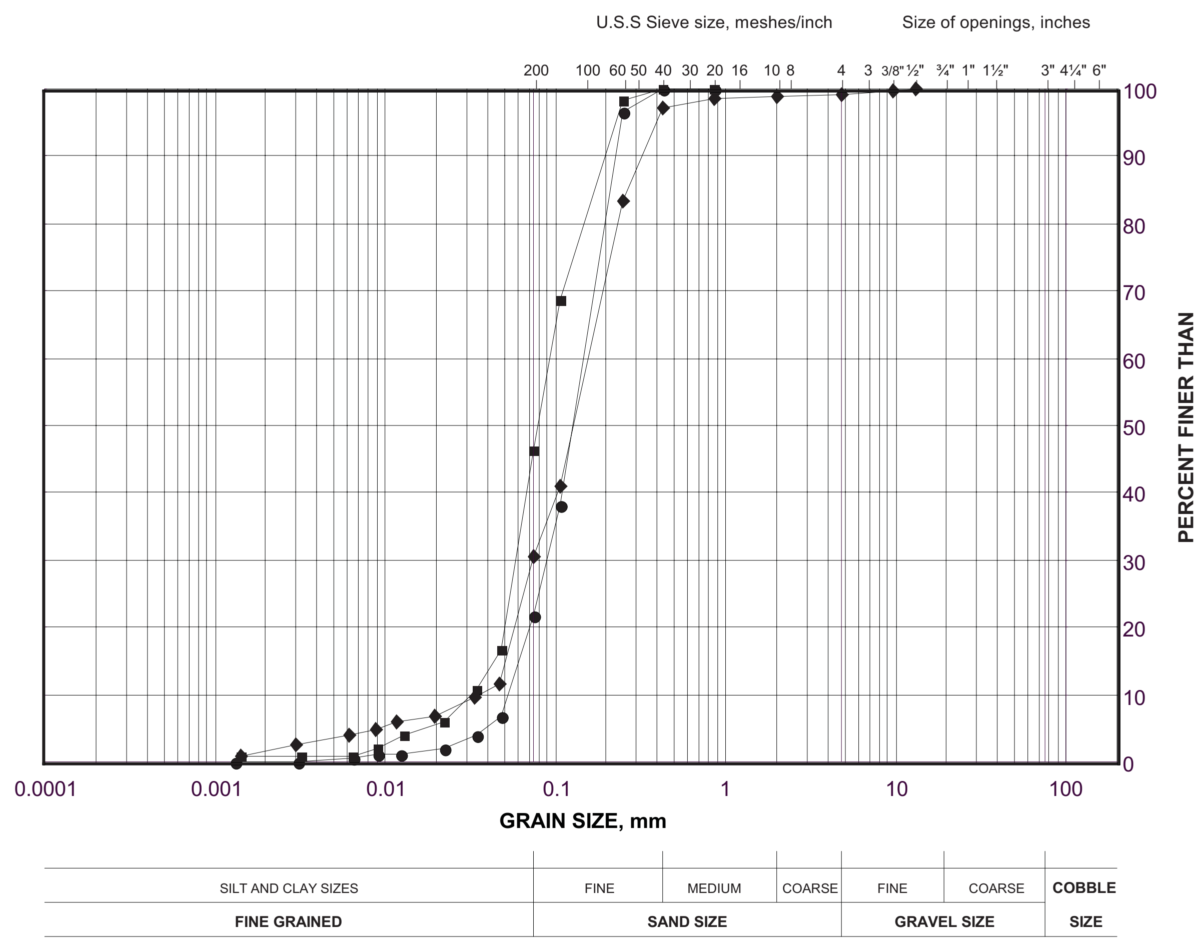
Figure No. WM13-C

Project No. 07-1111-0053

Checked By: KJB

GRAIN SIZE DISTRIBUTION
Sand and Silt

FIGURE WM13-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM13-1	15	130.3
■	WM13-1	20	122.7
◆	WM13-1	23	118.1

Project Number: 07-1111-0053

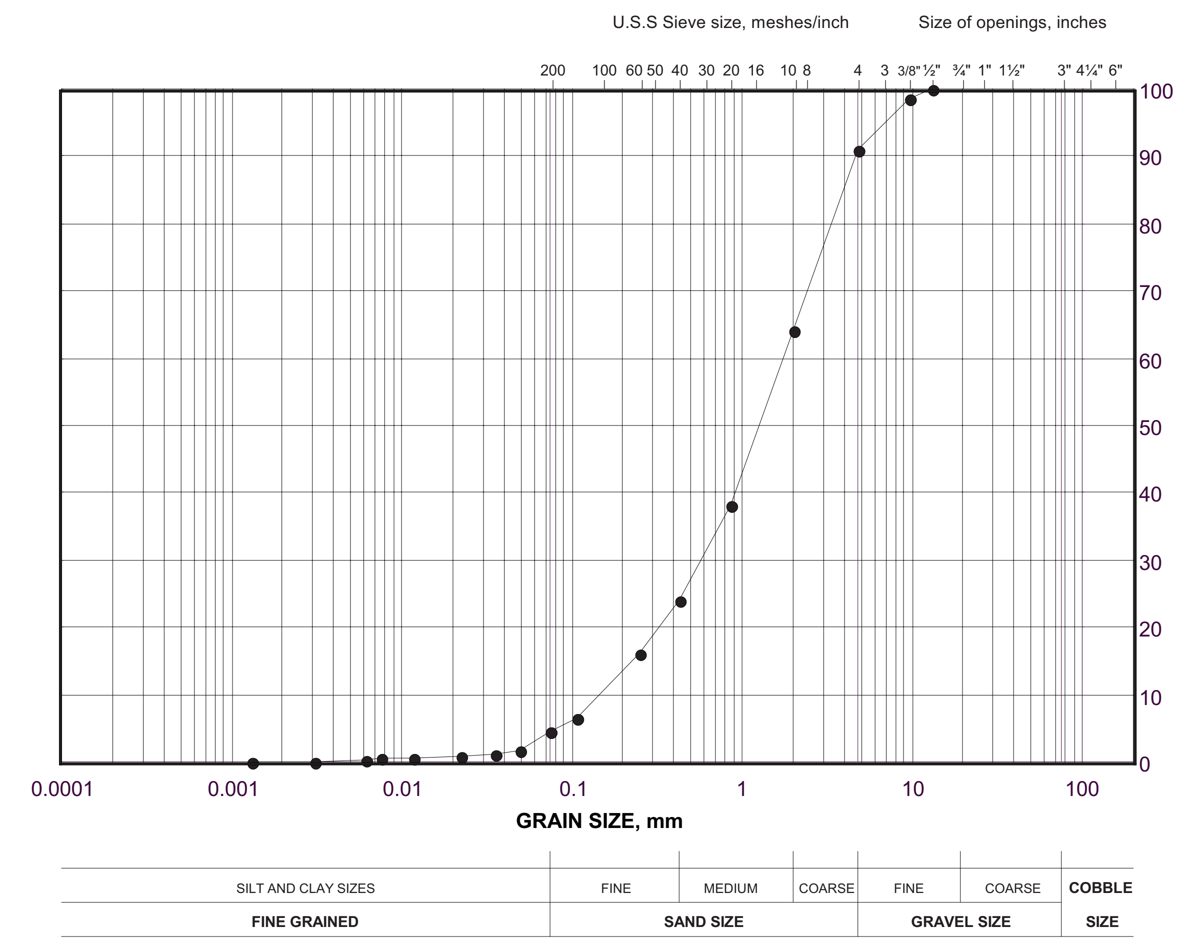
Checked By: KJB

Golder Associates

Date: 14-Oct-08

GRAIN SIZE DISTRIBUTION
Sand

FIGURE WM13-E



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM13-1	18	125.7

Project Number: 07-1111-0053

Checked By: KJB

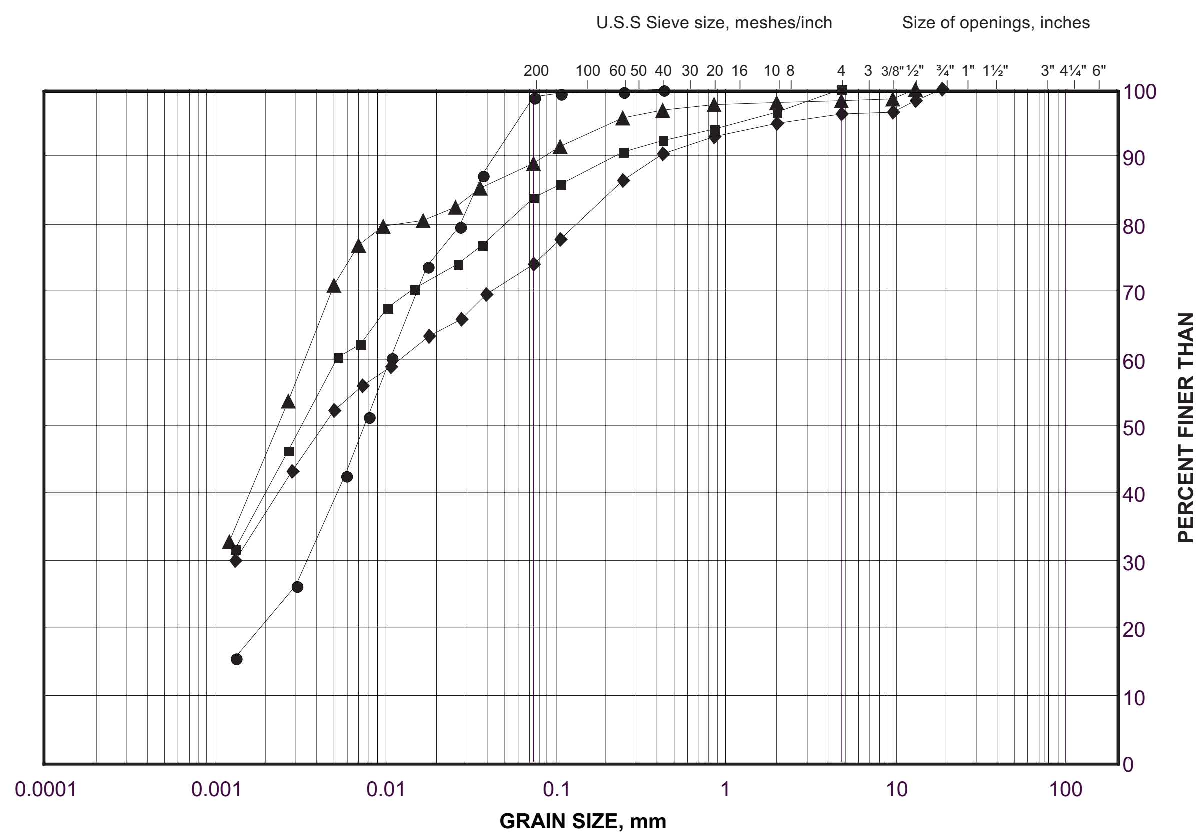
Golder Associates

Date: 14-Oct-08

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE WM17-A



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

LEGEND

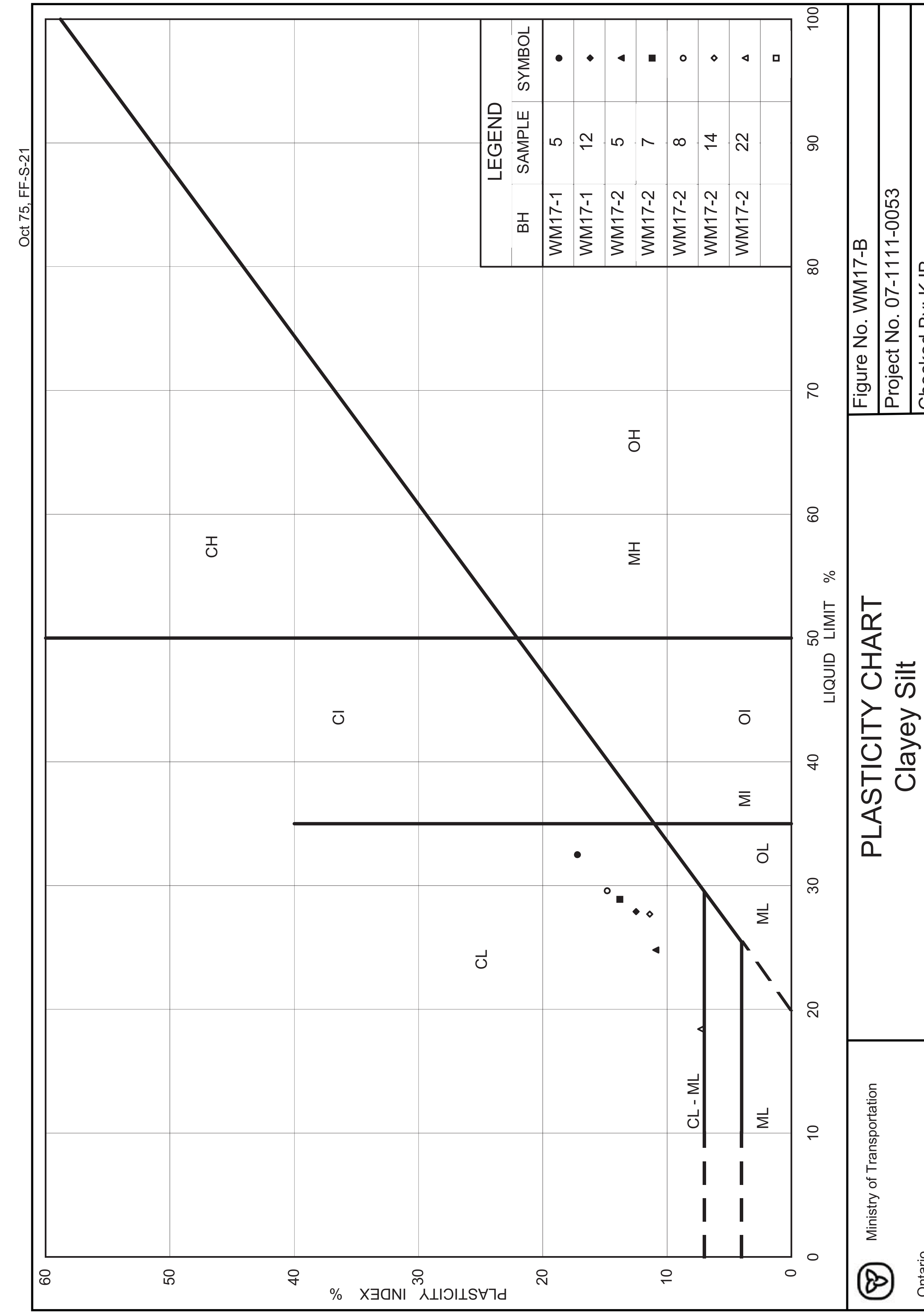
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM17-1	11	142.5
■	WM17-2	14	139.3
◆	WM17-1	3	153.2
▲	WM17-2	7	150.0

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 20-May-08



CONSOLIDATION TEST SUMMARY
Upper Clayey Silt

FIGURE WM17-C1

SAMPLE IDENTIFICATION

Project Number	07-1111-0053	Sample Number	6A
Borehole Number	WM17-2	Sample Depth, m	4.56-5.18

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	5		
Date Started	08/02/2008		
Date Completed	16/02/2008		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m^3	20.92
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m^3	17.33
Area, cm^2	31.40	Specific Gravity, measured	2.74
Volume, cm^3	59.50	Solids Height, cm	1.222
Water Content, %	20.69	Volume of Solids, cm^3	38.38
Wet Mass, g	126.91	Volume of Voids, cm^3	21.13
Dry Mass, g	105.15	Degree of Saturation, %	103.0

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.895	0.551	1.895				
4.79	1.876	0.535	1.886	185	4.07E-03	2.09E-03	8.36E-07
9.61	1.870	0.530	1.873	240	3.10E-03	6.57E-04	1.99E-07
19.44	1.862	0.524	1.866	10	7.38E-02	4.29E-04	3.11E-06
39.02	1.850	0.514	1.856	14	5.22E-02	3.23E-04	1.65E-06
78.18	1.832	0.499	1.841	37	1.94E-02	2.43E-04	4.62E-07
155.89	1.809	0.480	1.821	28	2.51E-02	1.56E-04	3.84E-07
311.90	1.779	0.456	1.794	27	2.53E-02	1.01E-04	2.51E-07
624.99	1.744	0.427	1.762	12	5.48E-02	5.90E-05	3.17E-07
1248.55	1.703	0.393	1.724	32	1.97E-02	3.47E-05	6.69E-08
2496.10	1.659	0.357	1.681	36	1.66E-02	1.86E-05	3.04E-08
1248.55	1.667	0.364	1.663				
311.90	1.685	0.379	1.676				
78.18	1.702	0.393	1.694				
19.44	1.724	0.411	1.713				
4.79	1.740	0.424	1.732				

Note:
k calculated using cv based on t_{90} values.

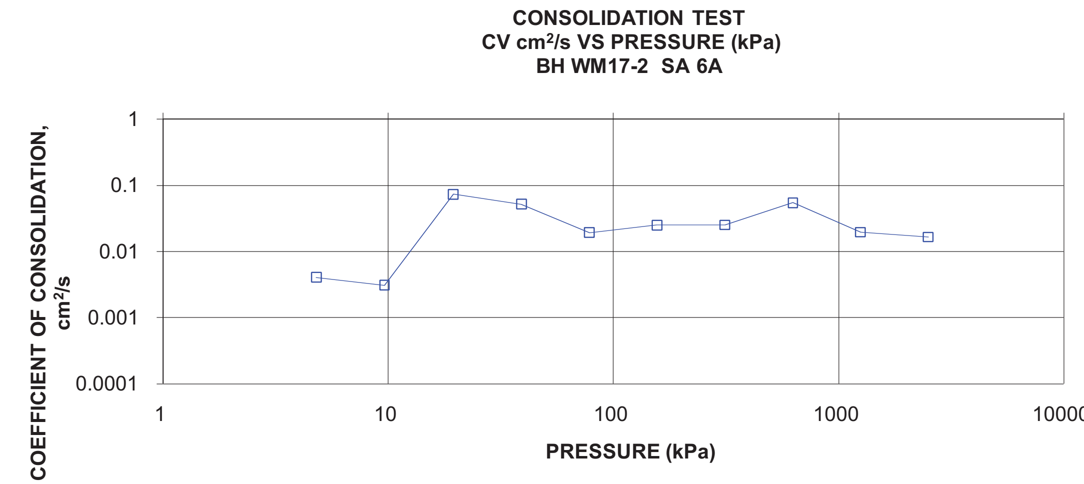
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

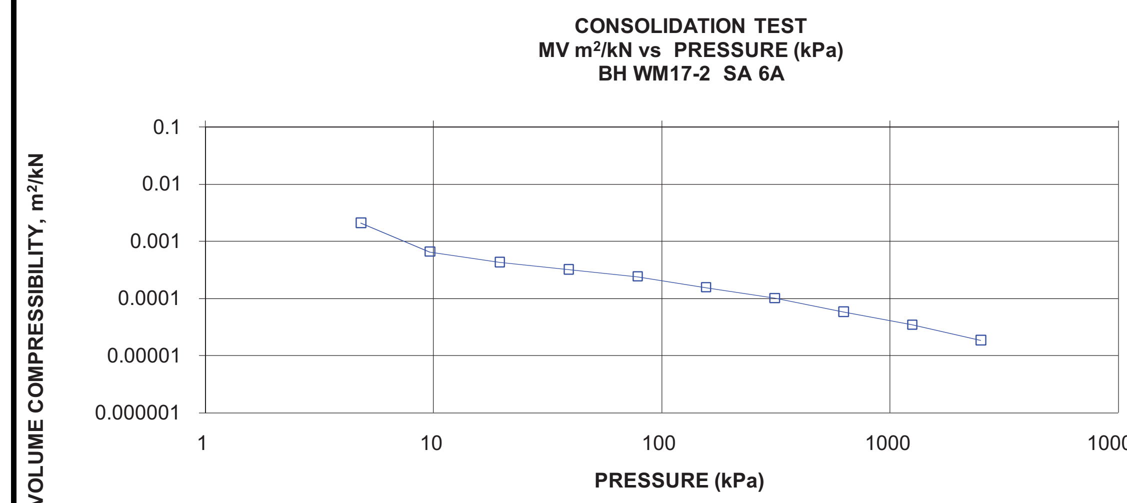
Sample Height, cm	1.74	Unit Weight, kN/m^3	22.08
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m^3	18.87
Area, cm^2	31.40	Specific Gravity, measured	2.74
Volume, cm^3	54.64	Solids Height, cm	1.222
Water Content, %	17.00	Volume of Solids, cm^3	38.38
Wet Mass, g	123.03	Volume of Voids, cm^3	16.26
Dry Mass, g	105.15		

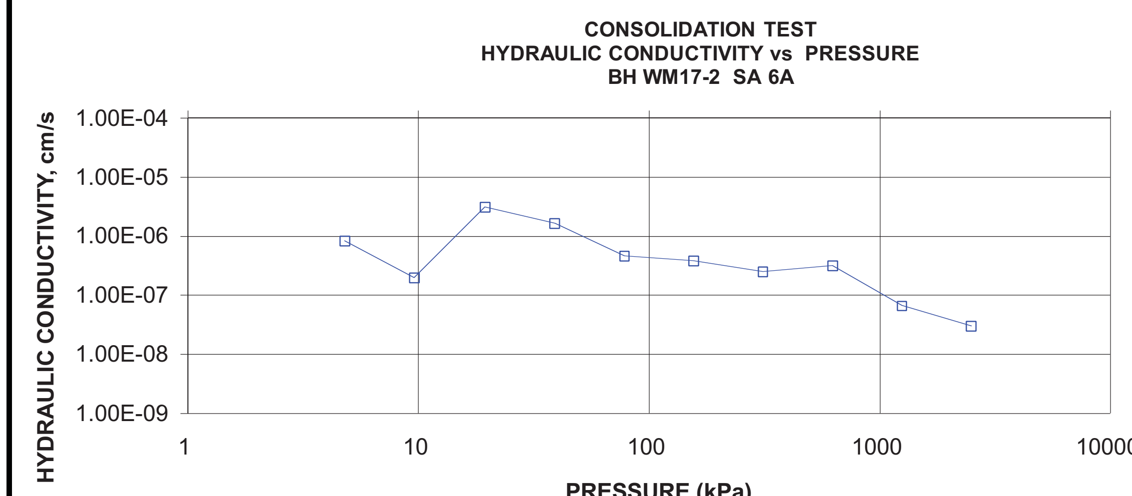
Prepared By: LFG **Golder Associates** Checked By: KJB

CONSOLIDATION TEST SUMMARY
Upper Clayey Silt

FIGURE WM17-C2



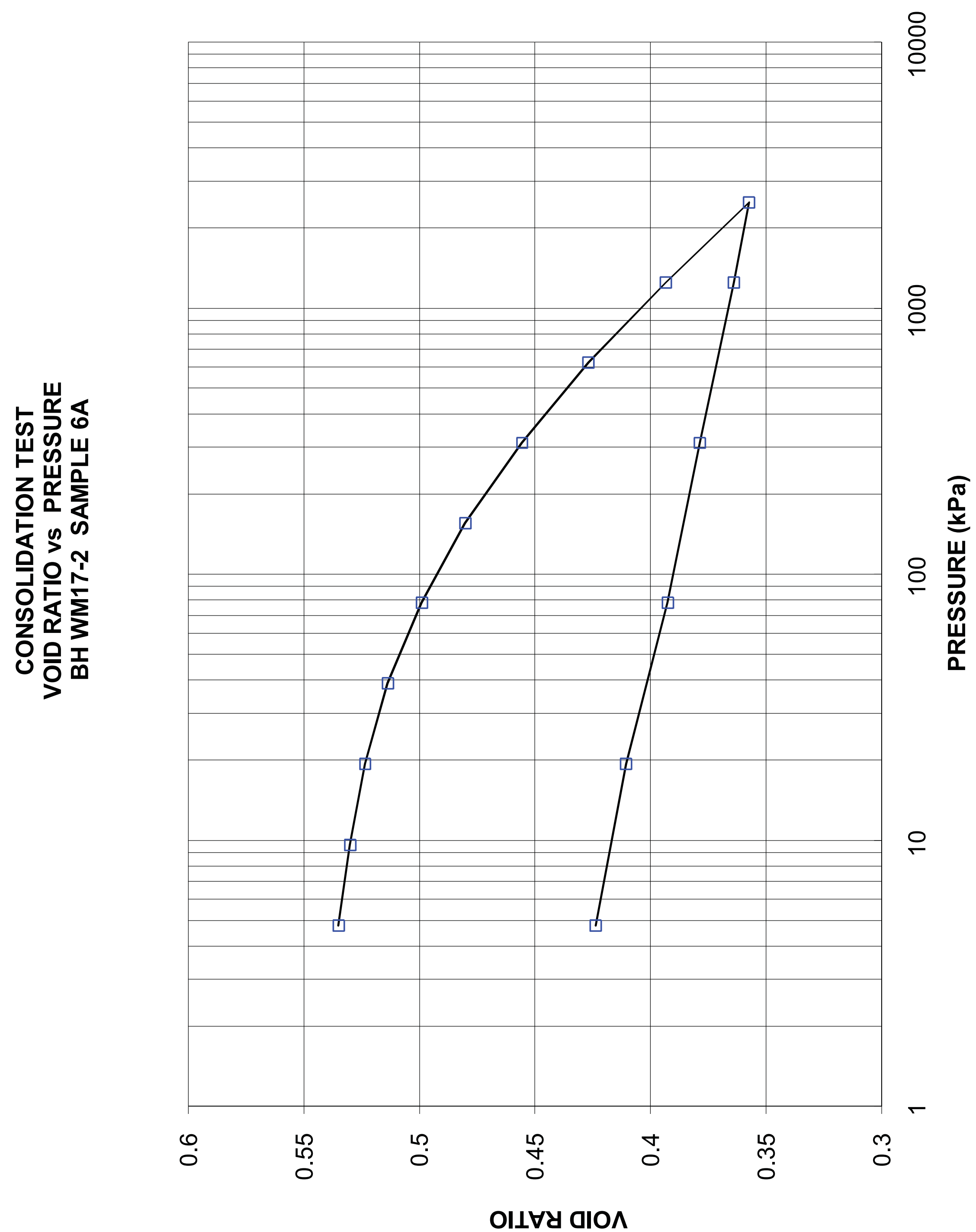




Project No. 07-1111-0053
Prepared By: LFG **Golder Associates** Checkey By: KJB

CONSOLIDATION TEST RESULTS
Upper Clayey Silt

FIGURE WM17-C3



Project No.07-1111-0053

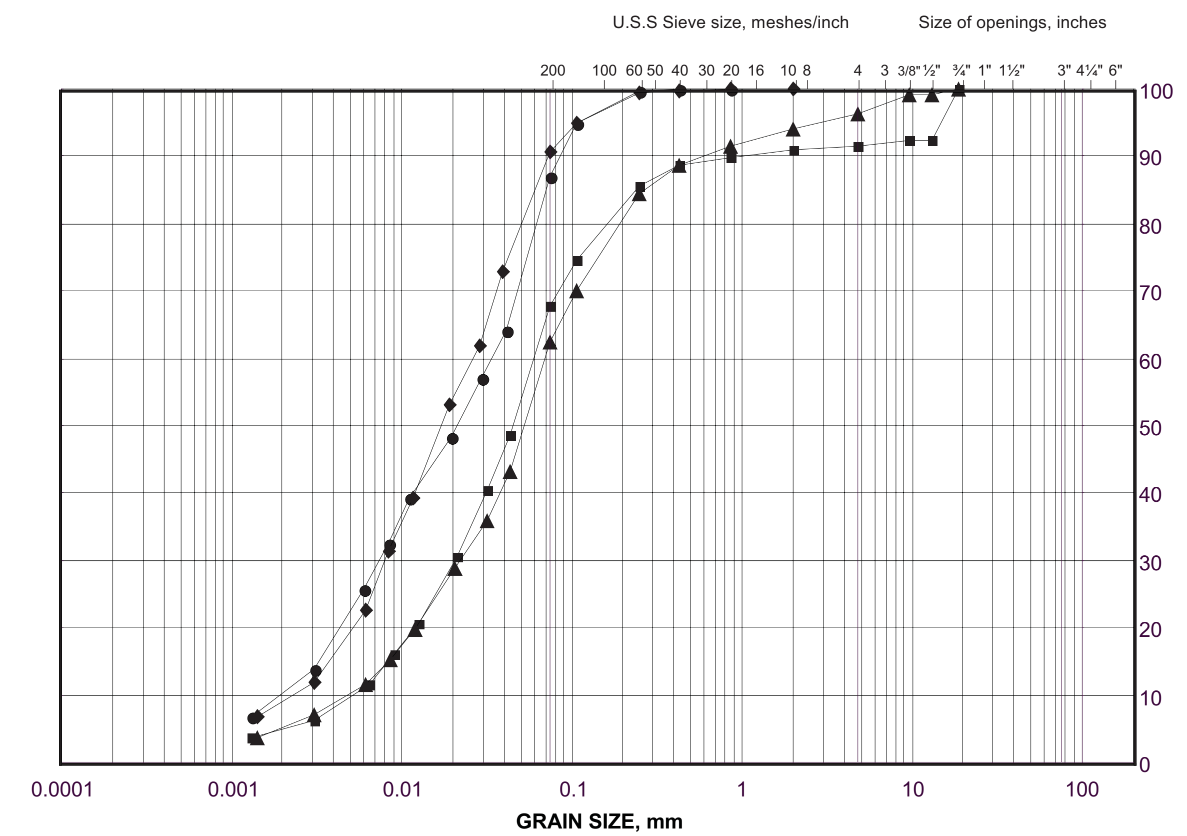
Prepared By: LFG

Golder Associates

Checked By: KJB

GRAIN SIZE DISTRIBUTION
Silt to Sandy Silt

FIGURE WM17-D



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM17-2	11	143.9
■	WM17-1	16	134.9
◆	WM17-2	16	136.3
▲	WM17-2	19	131.7

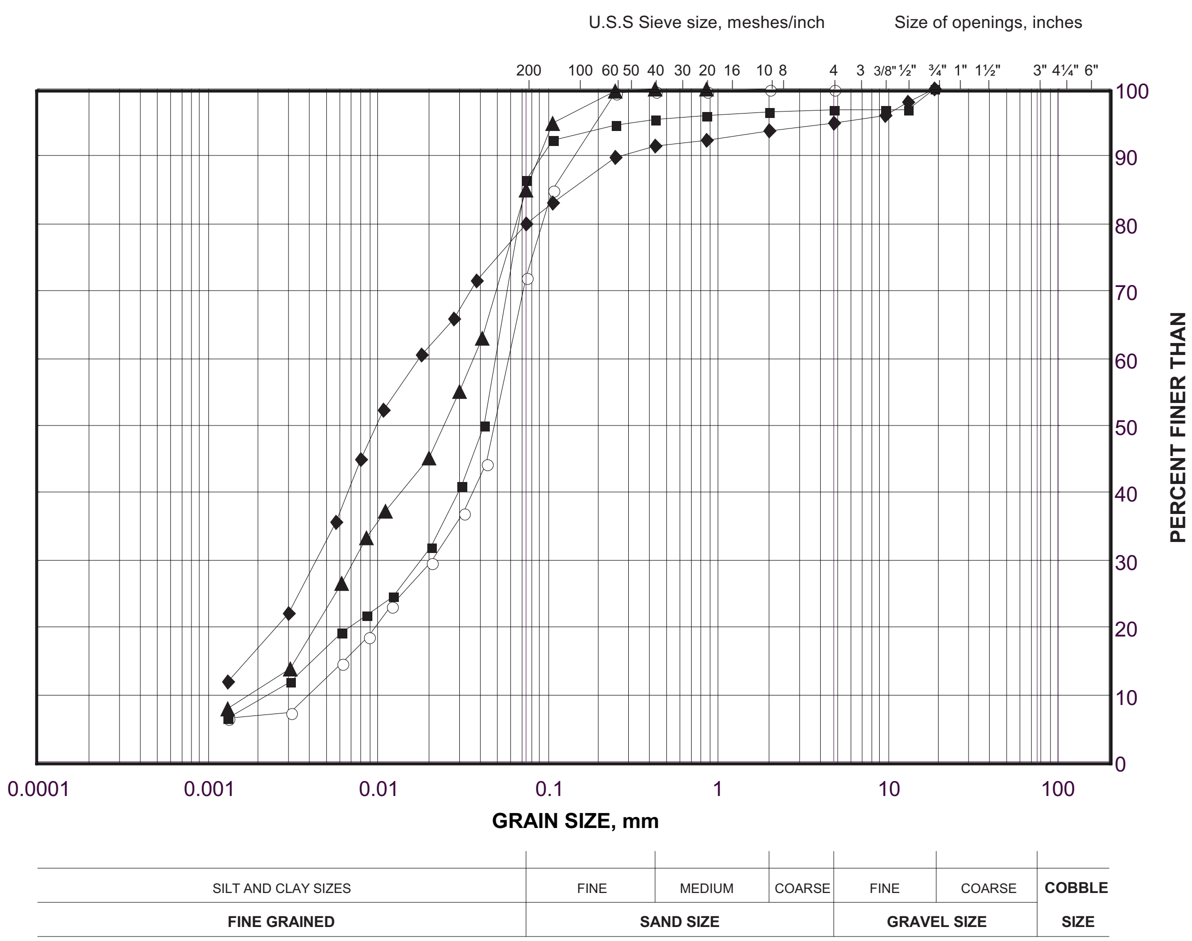
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 06-Jun-08

GRAIN SIZE DISTRIBUTION Silt to Sandy Silt	FIGURE WM17-E



LEGEND

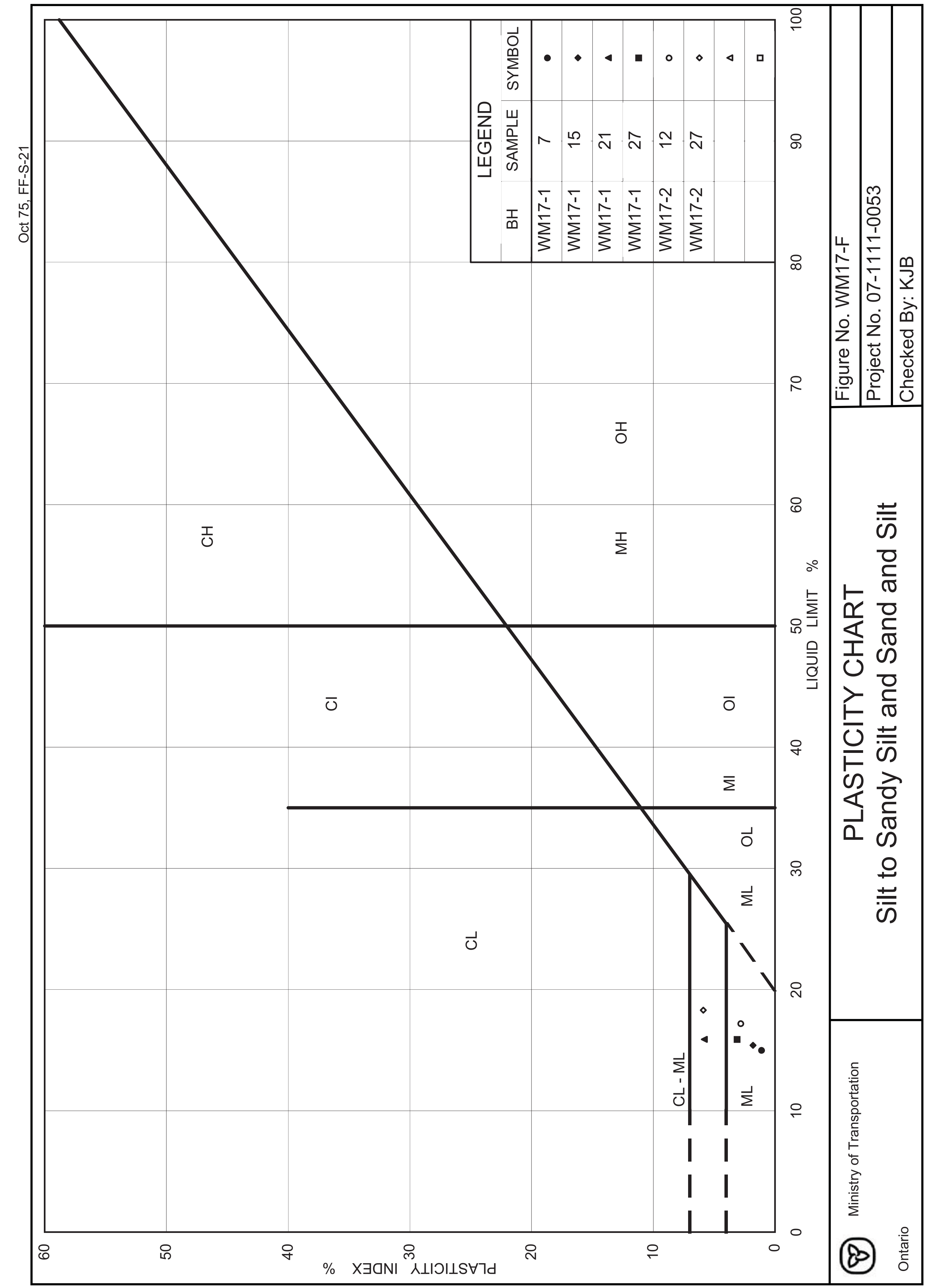
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM17-2	25	122.6
■	WM17-1	27	118.2
◆	WM17-2	27	119.5
▲	WM17-1	7	148.6

Project Number: 07-1111-0053

Checked By: KJB

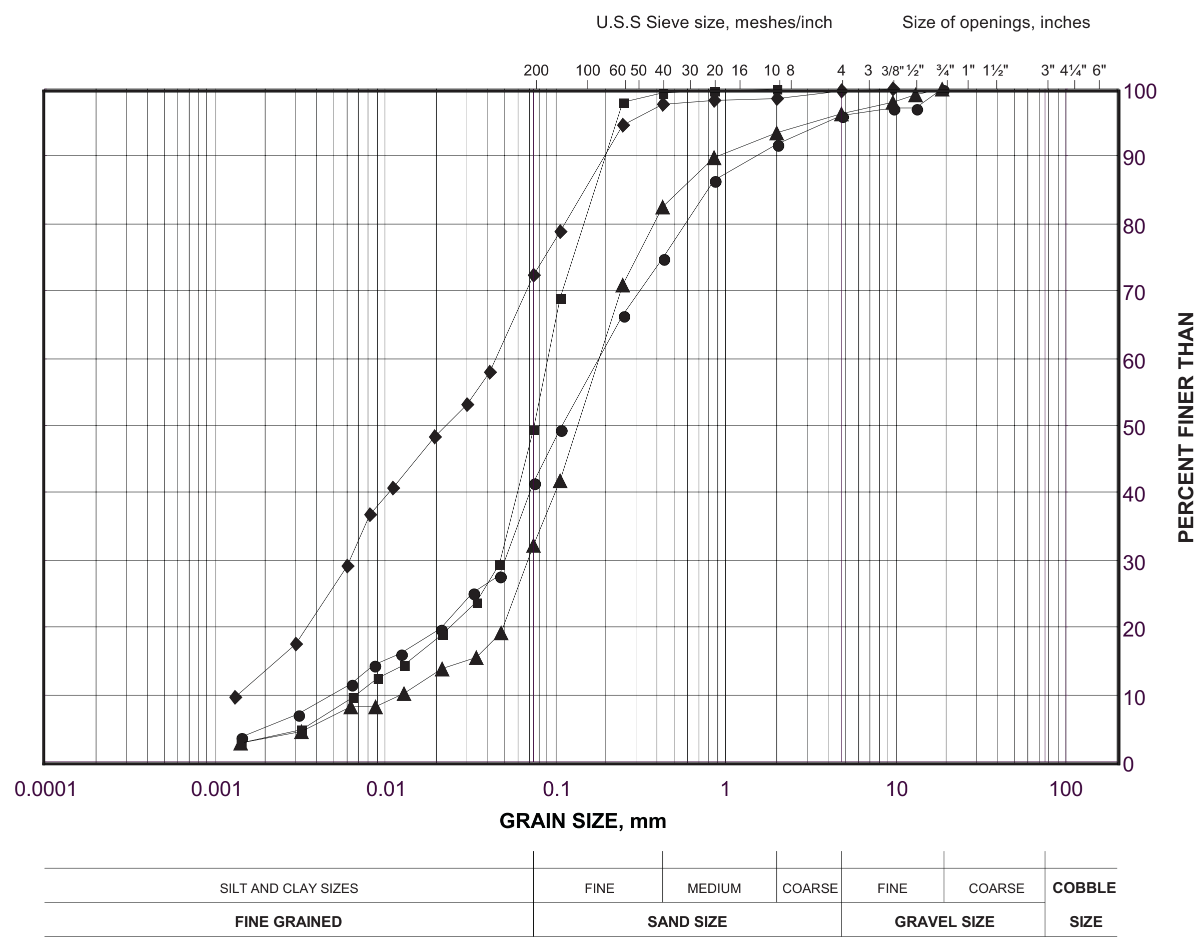
Golder Associates

Date: 06-Jun-08



GRAIN SIZE DISTRIBUTION
Sand and Silt

FIGURE WM17-G



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM17-1	18	131.8
■	WM17-1	19	130.3
◆	WM17-1	21	127.3
▲	WM17-1	23	124.2

Project Number: 07-1111-0053

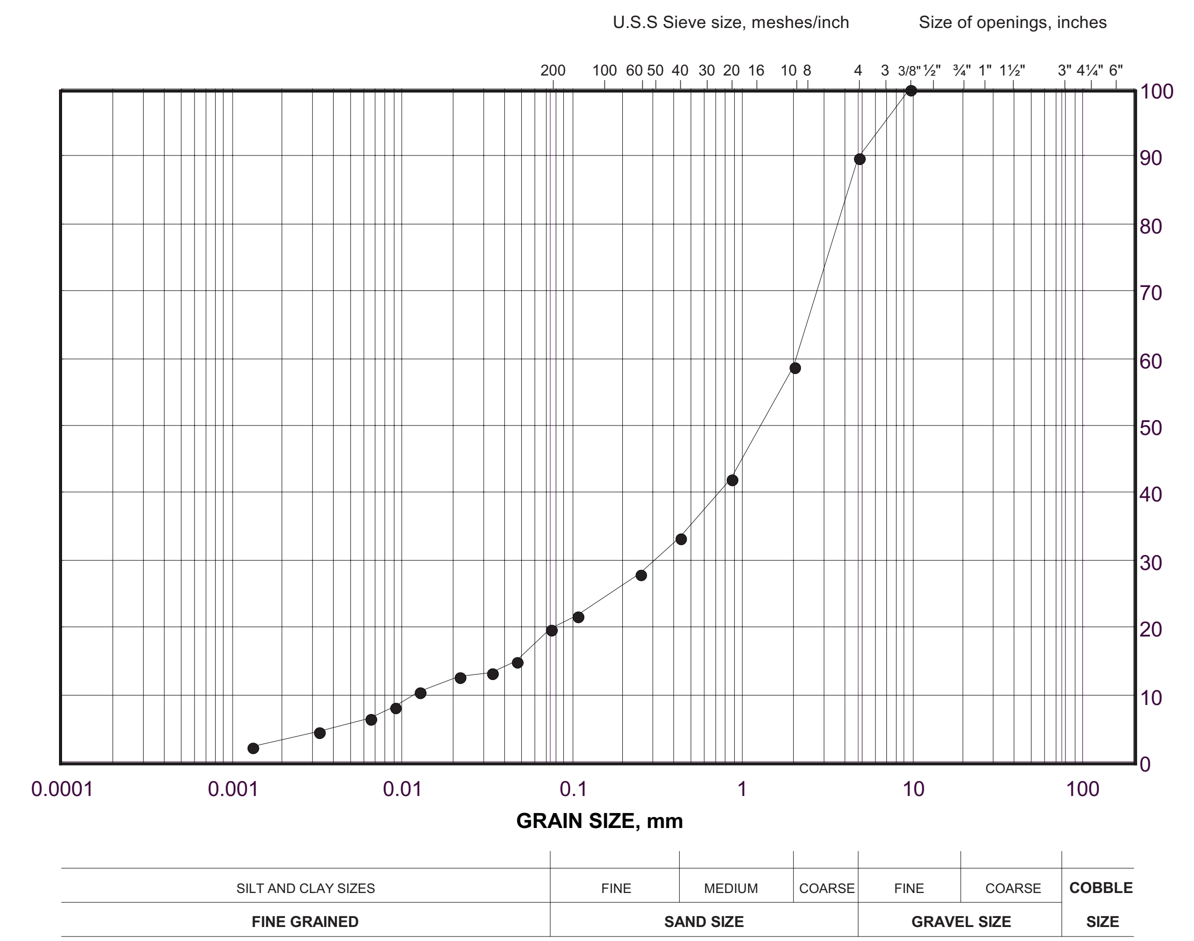
Checked By: KJB

Golder Associates

Date: 06-Jun-08

GRAIN SIZE DISTRIBUTION
Silty Sand

FIGURE WM17-H



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM17-2	30	115.15

Project Number: 07-1111-0053

Checked By: KJB

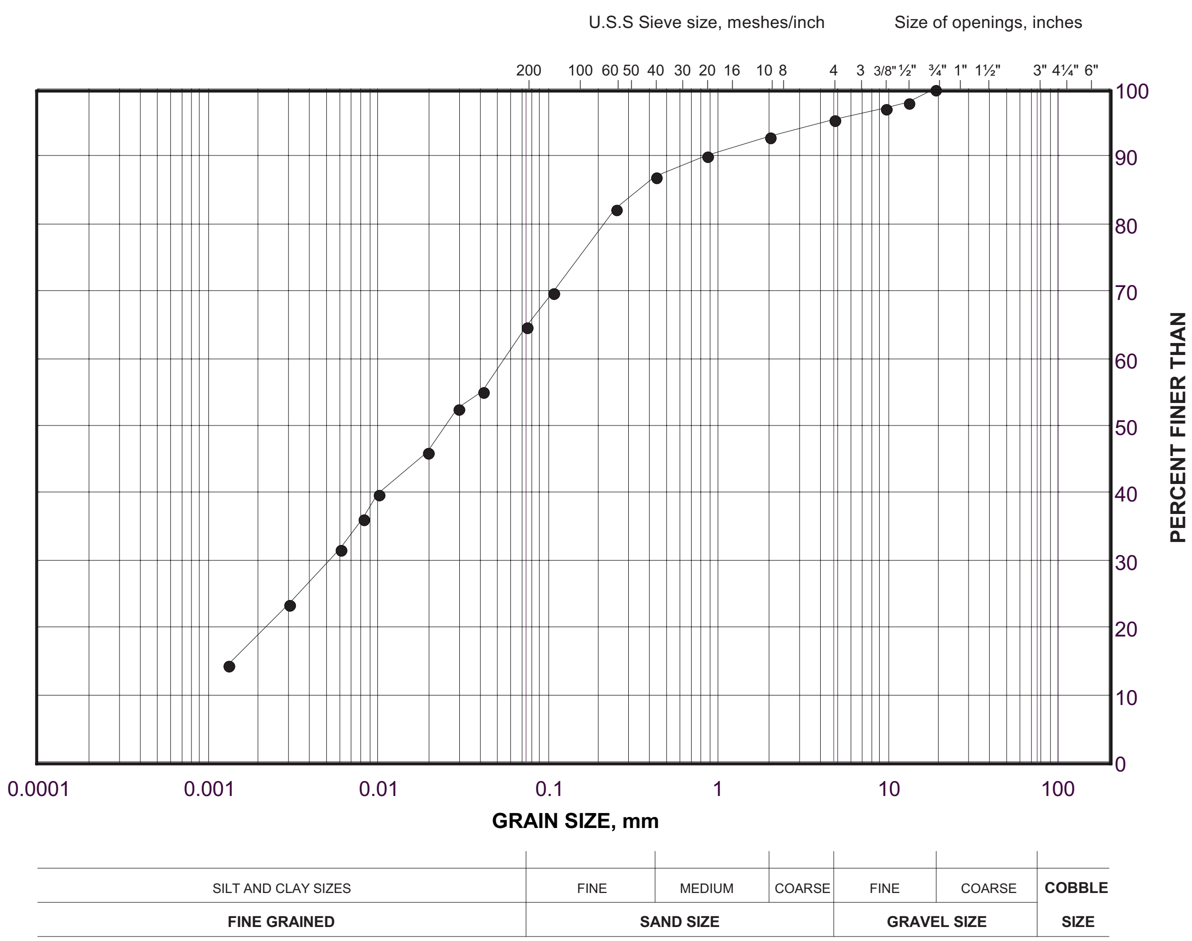
Golder Associates

Date: 06-Jun-08

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE WM22-A



LEGEND

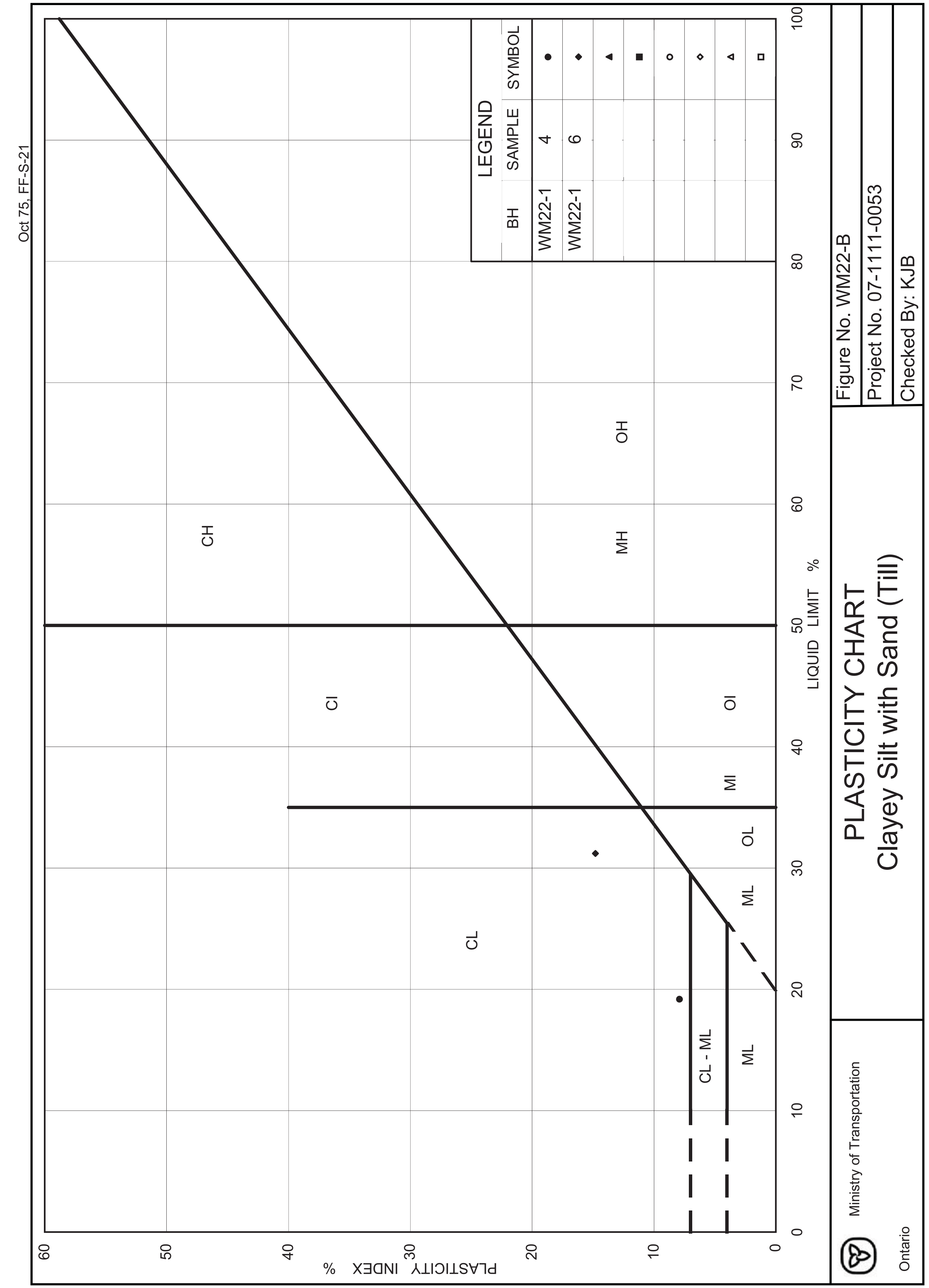
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM22-1	4	166.4

Project Number: 07-1111-0053

Checked By: KJB

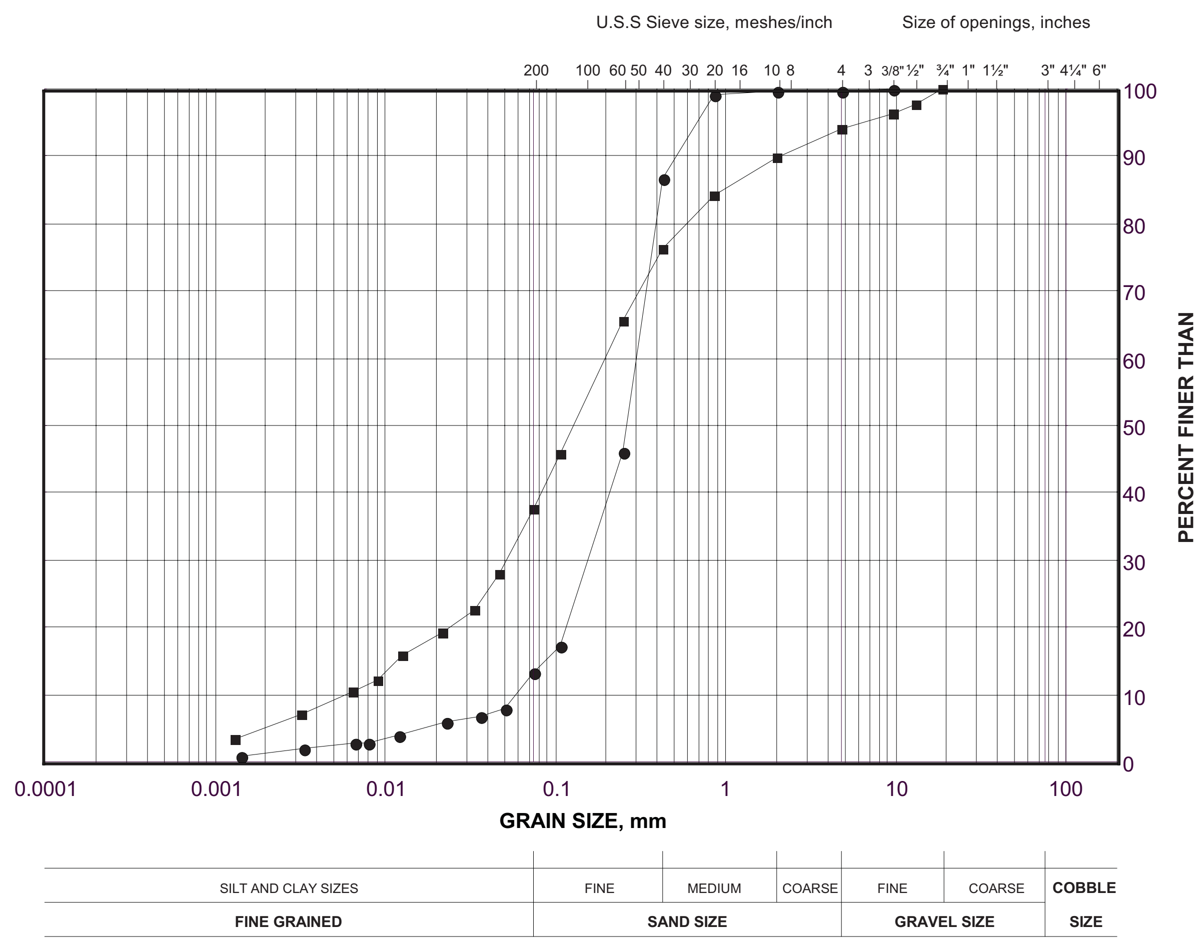
Golder Associates

Date: 13-Jun-08



GRAIN SIZE DISTRIBUTION
Silty Sand to Sand, some silt

FIGURE WM22-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM22-1	10	158.0
■	WM22-1	7	162.6

Project Number: 07-1111-0053

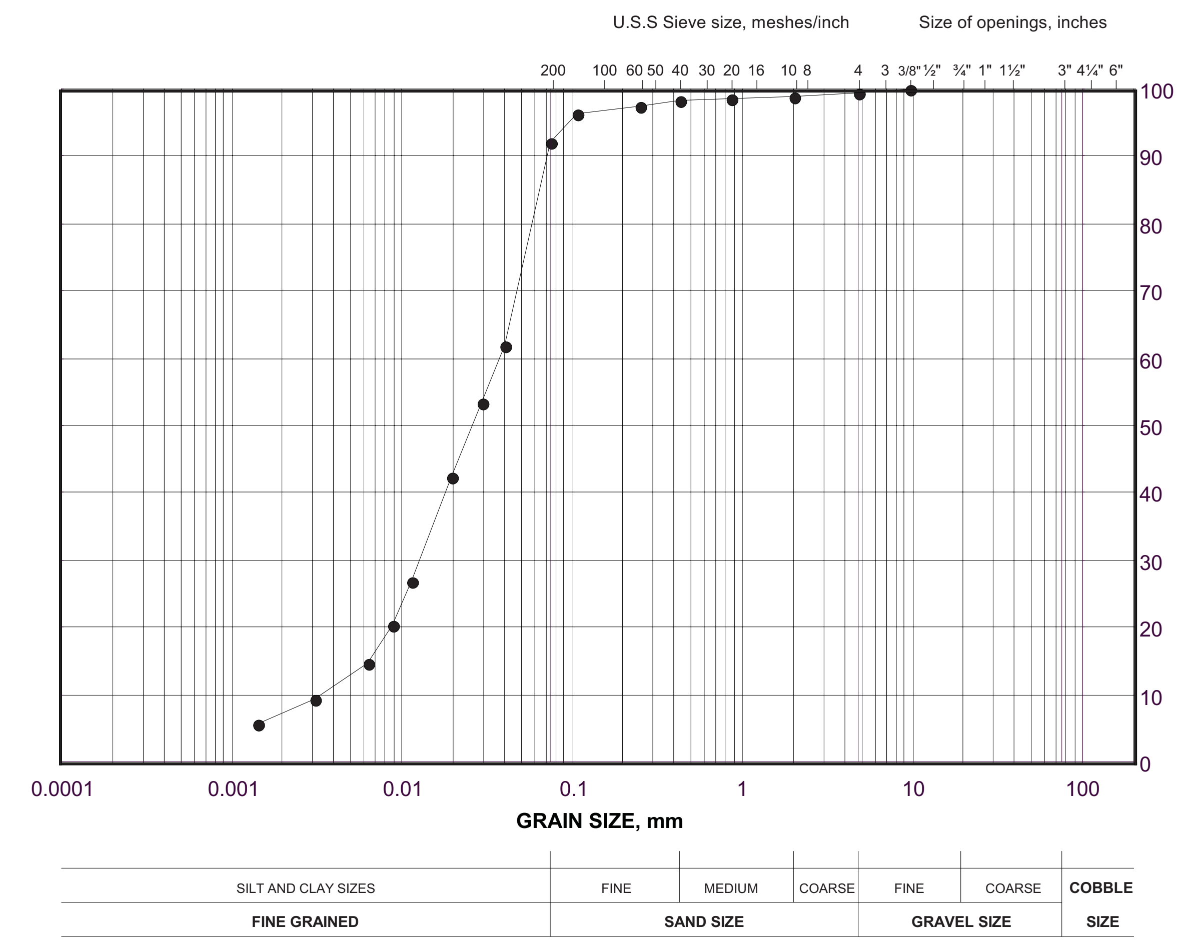
Checked By: KJB

Golder Associates

Date: 13-Jun-08

GRAIN SIZE DISTRIBUTION
Silt

FIGURE WM22-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM22-1	12	155.1

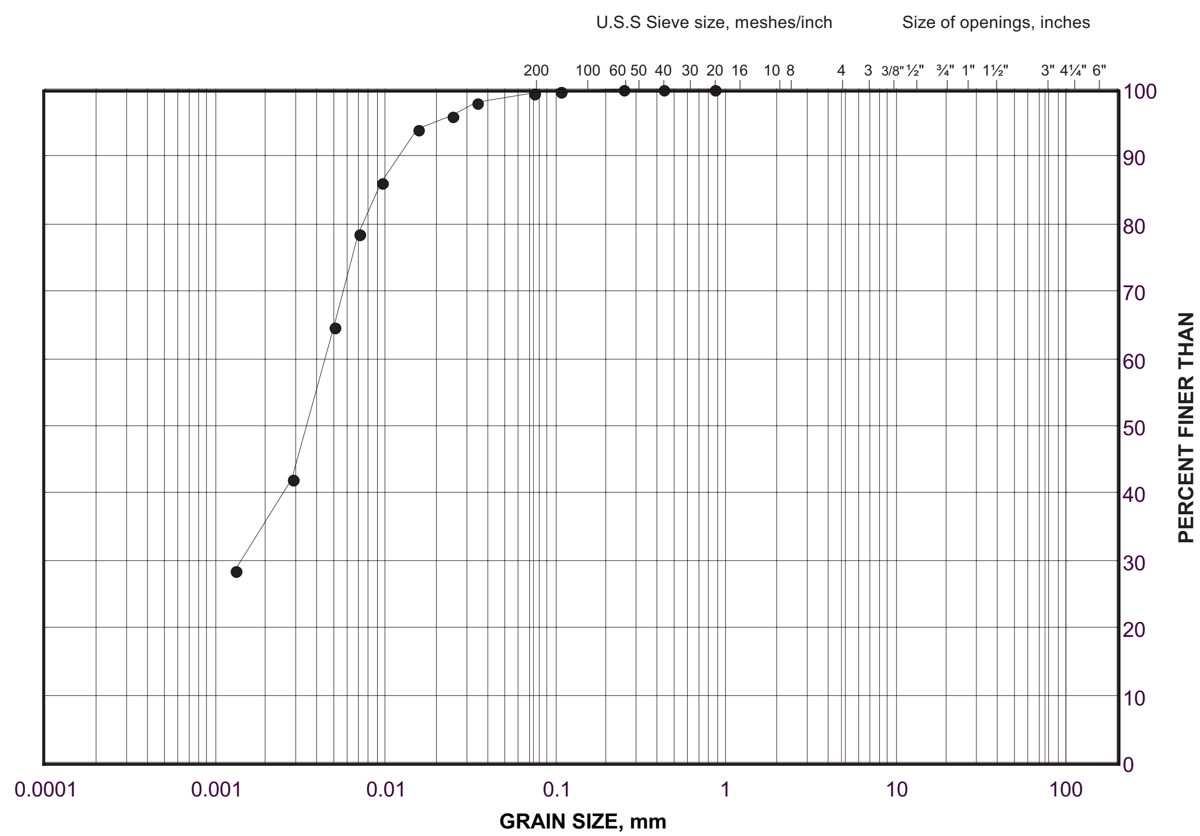
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 13-Jun-08

GRAIN SIZE DISTRIBUTION Clayey Silt	FIGURE WM22-E



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

LEGEND

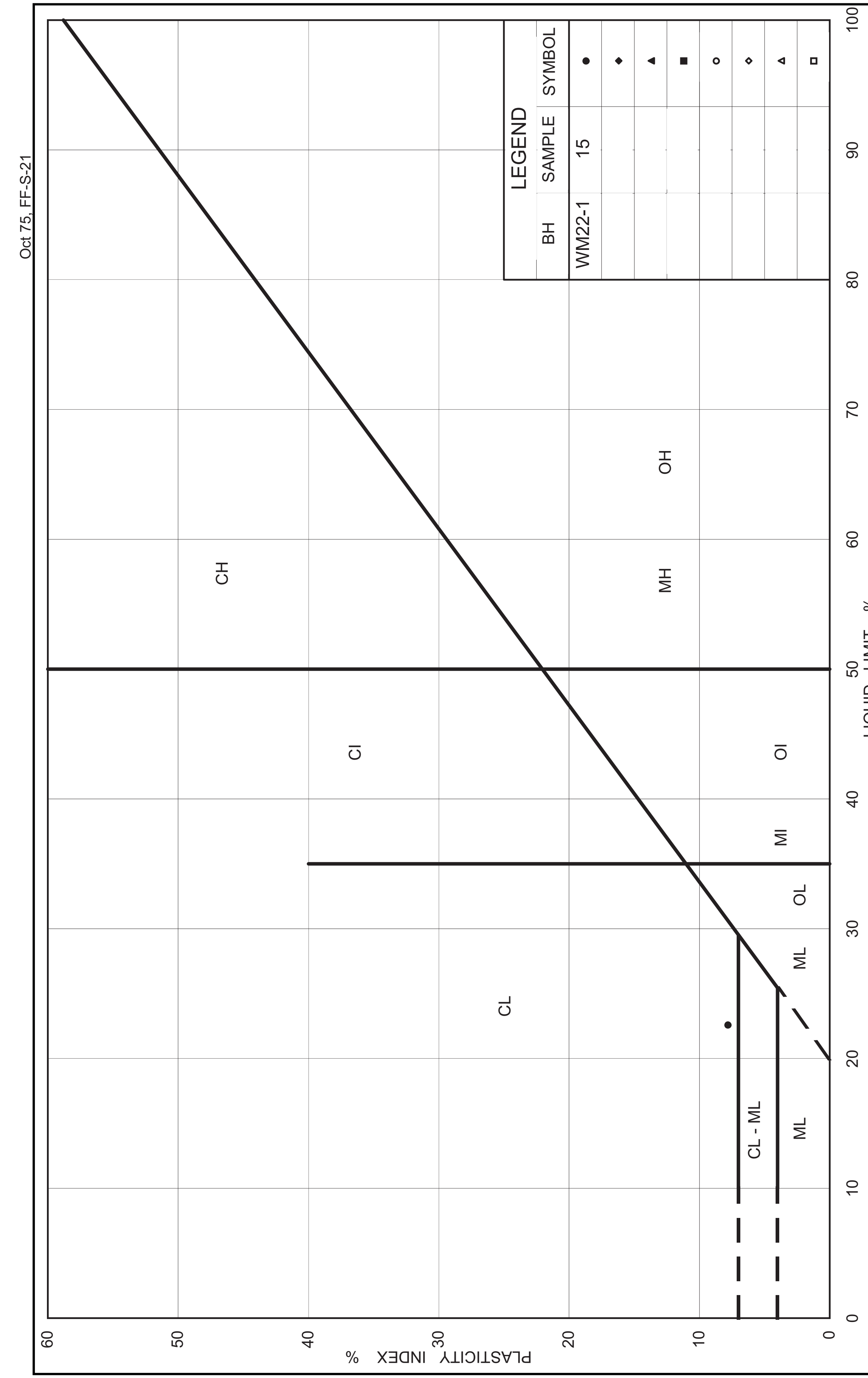
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM22-1	16	149.1

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 13-Jun-08



PLASTICITY CHART
Clayey Silt

Figure No. WM22-F

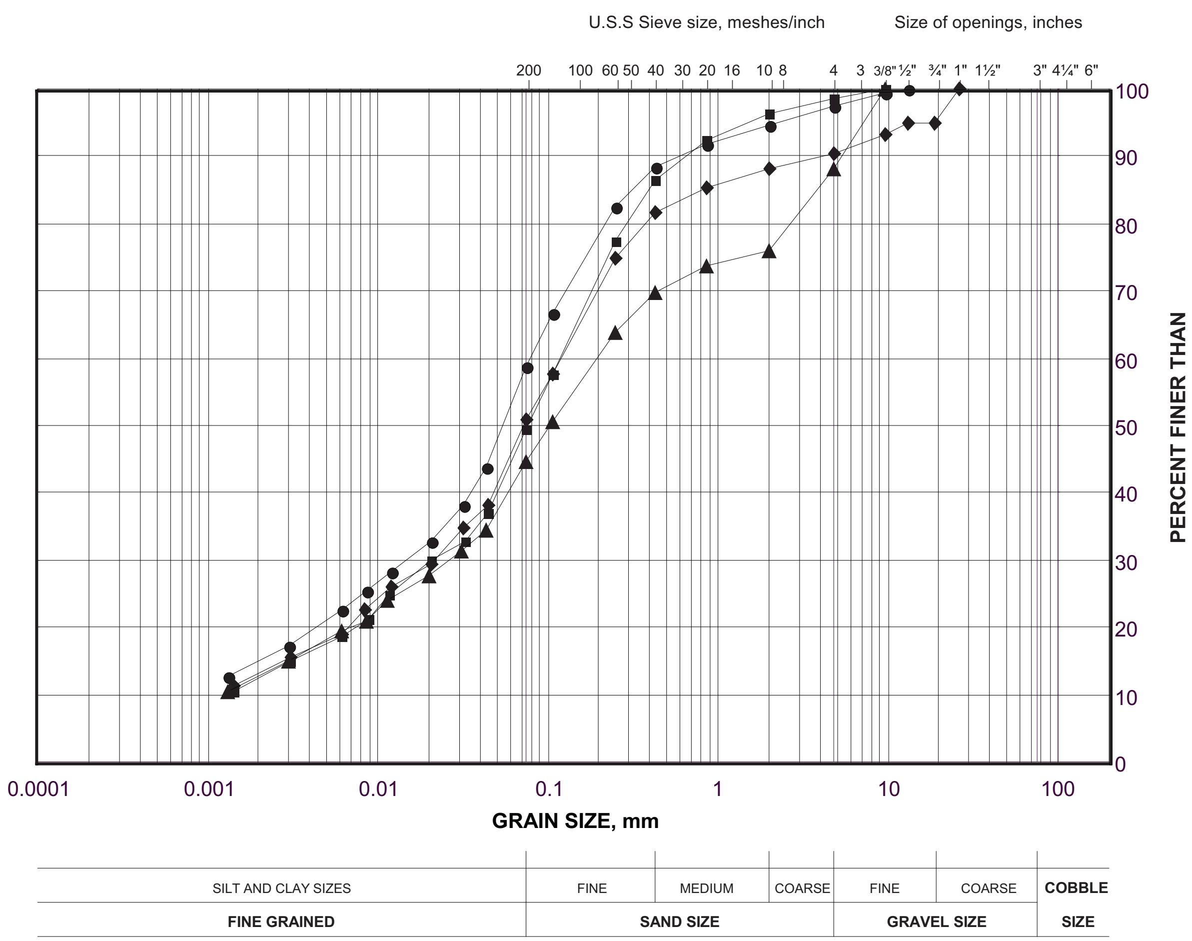
Project No. 07-1111-0053

Checked By: KJB

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION Sand and Silt (Till)	FIGURE WMTECC15-A



LEGEND

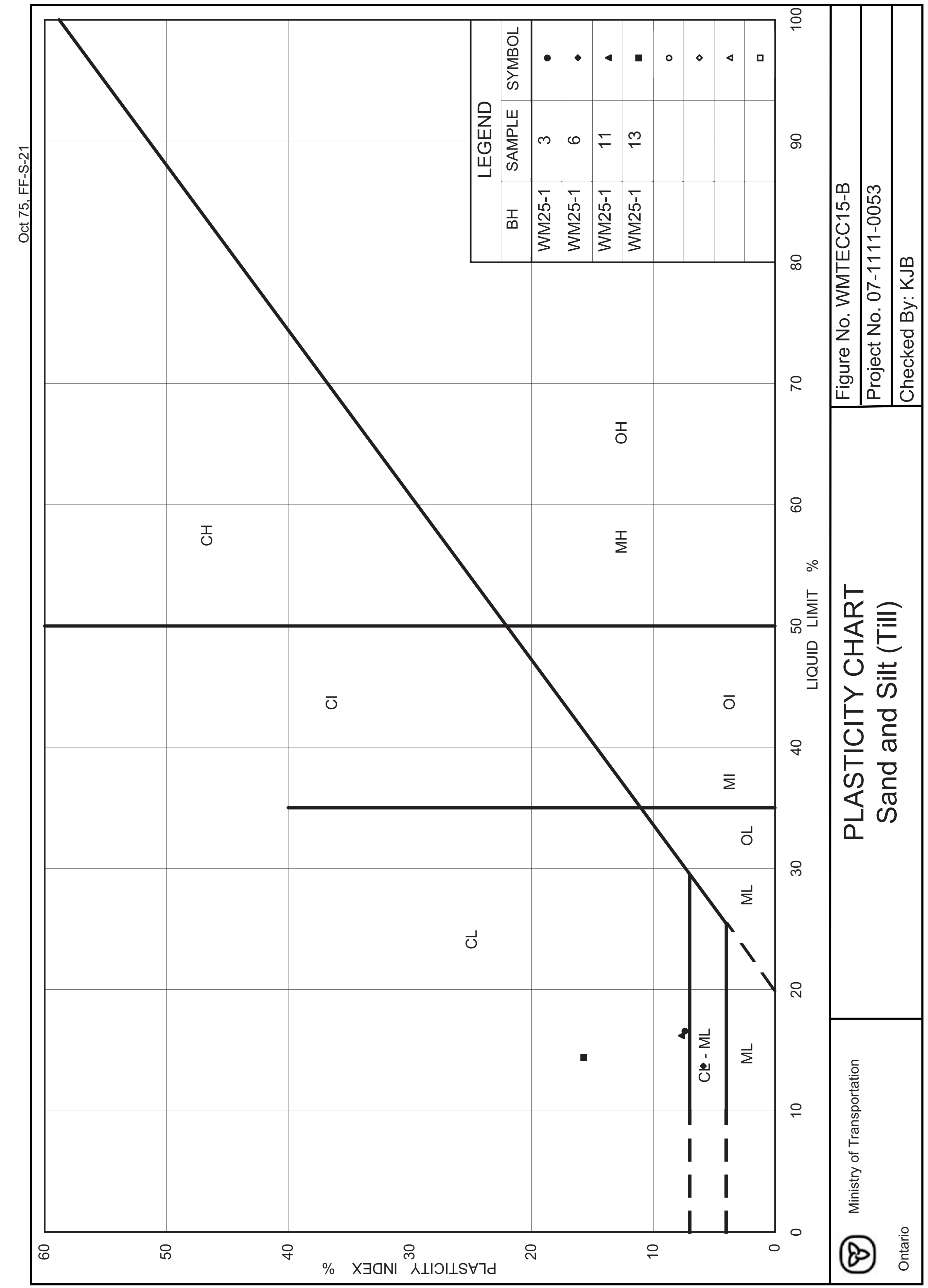
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM25-1	10	169.1
■	WM25-1	13	164.6
◆	WM25-1	4	177.5
▲	WM25-1	6	175.2

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

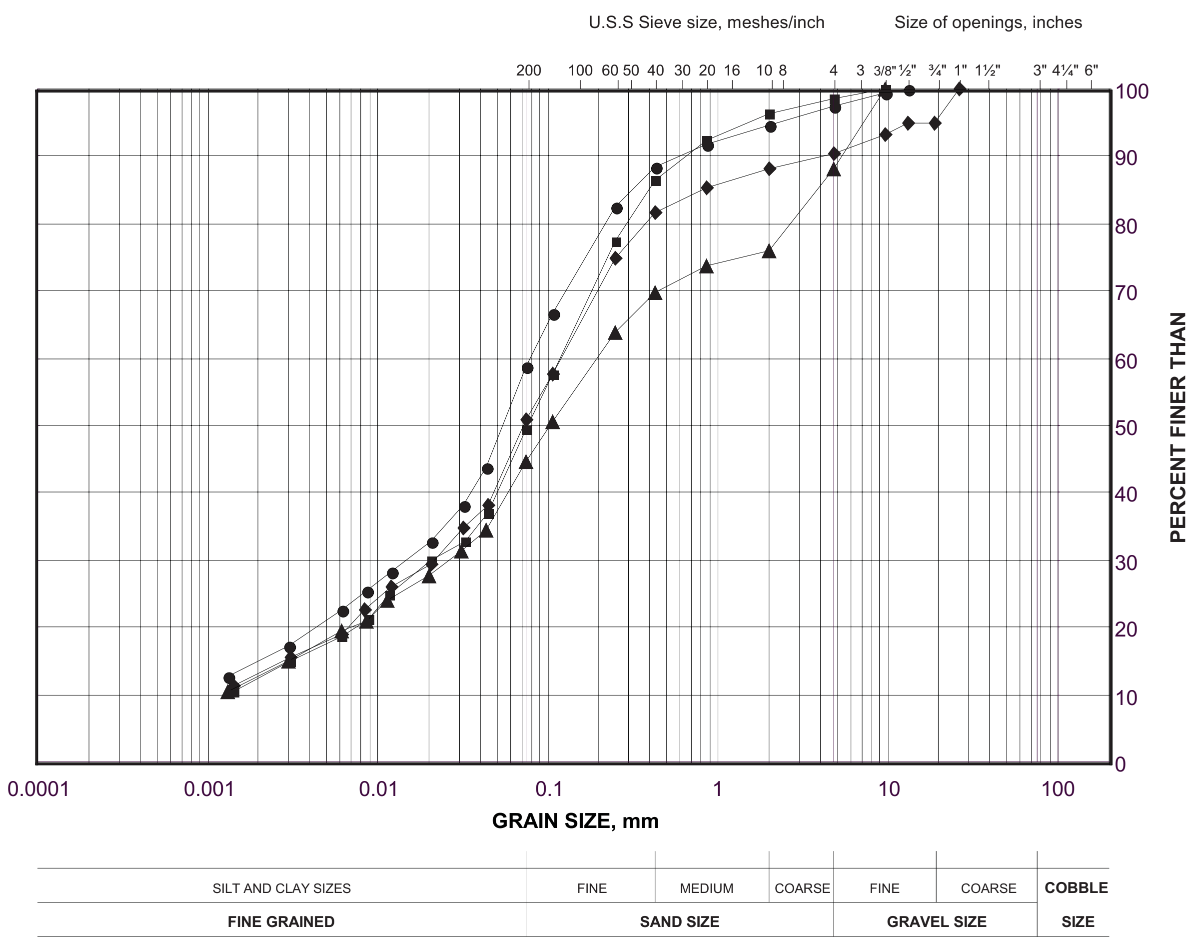
Date: 13-Jun-08



GRAIN SIZE DISTRIBUTION

Sand and Silt (Till)

FIGURE WM25-A



LEGEND

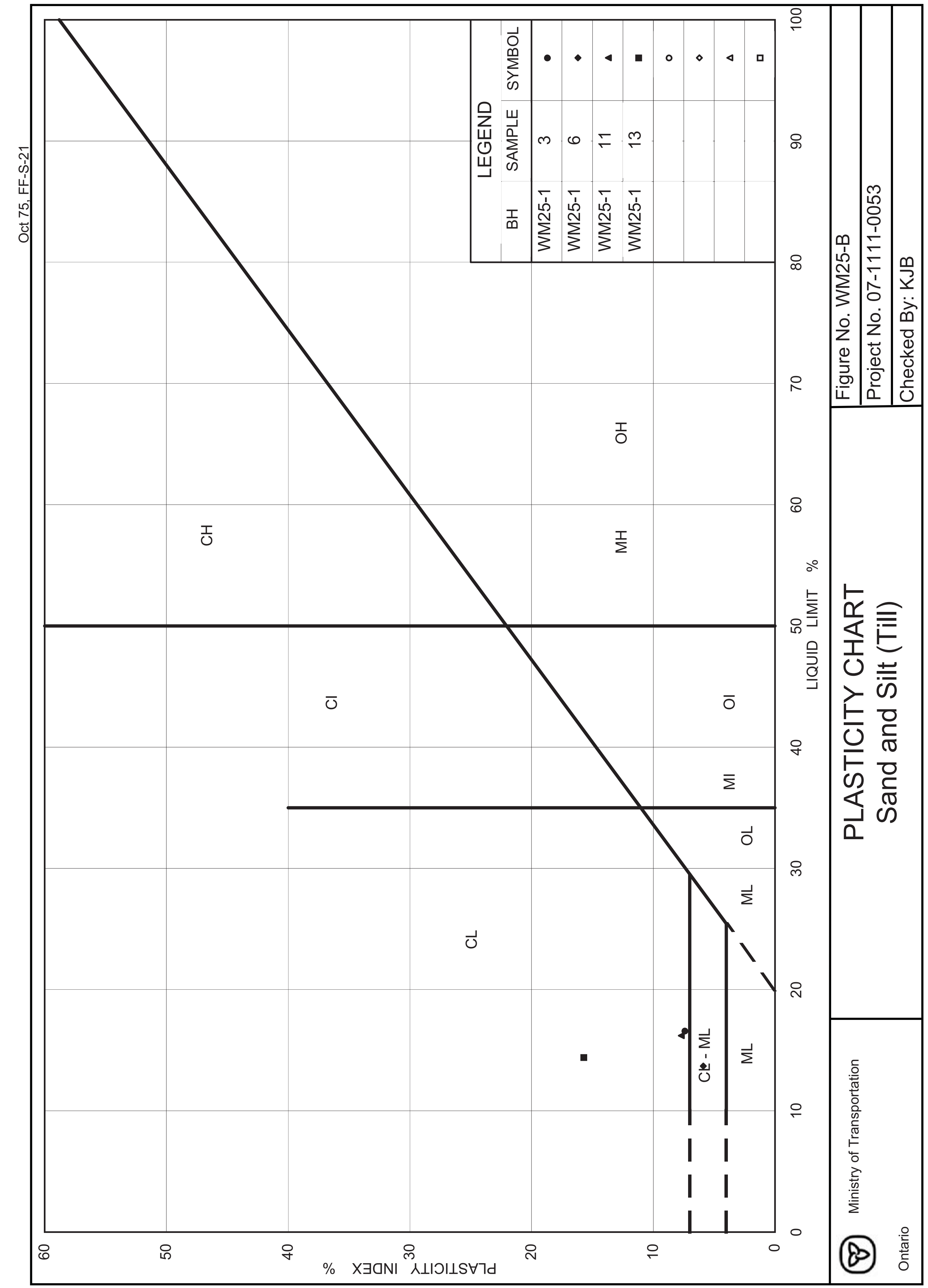
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM25-1	10	169.1
■	WM25-1	13	164.6
◆	WM25-1	4	177.5
▲	WM25-1	6	175.2

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

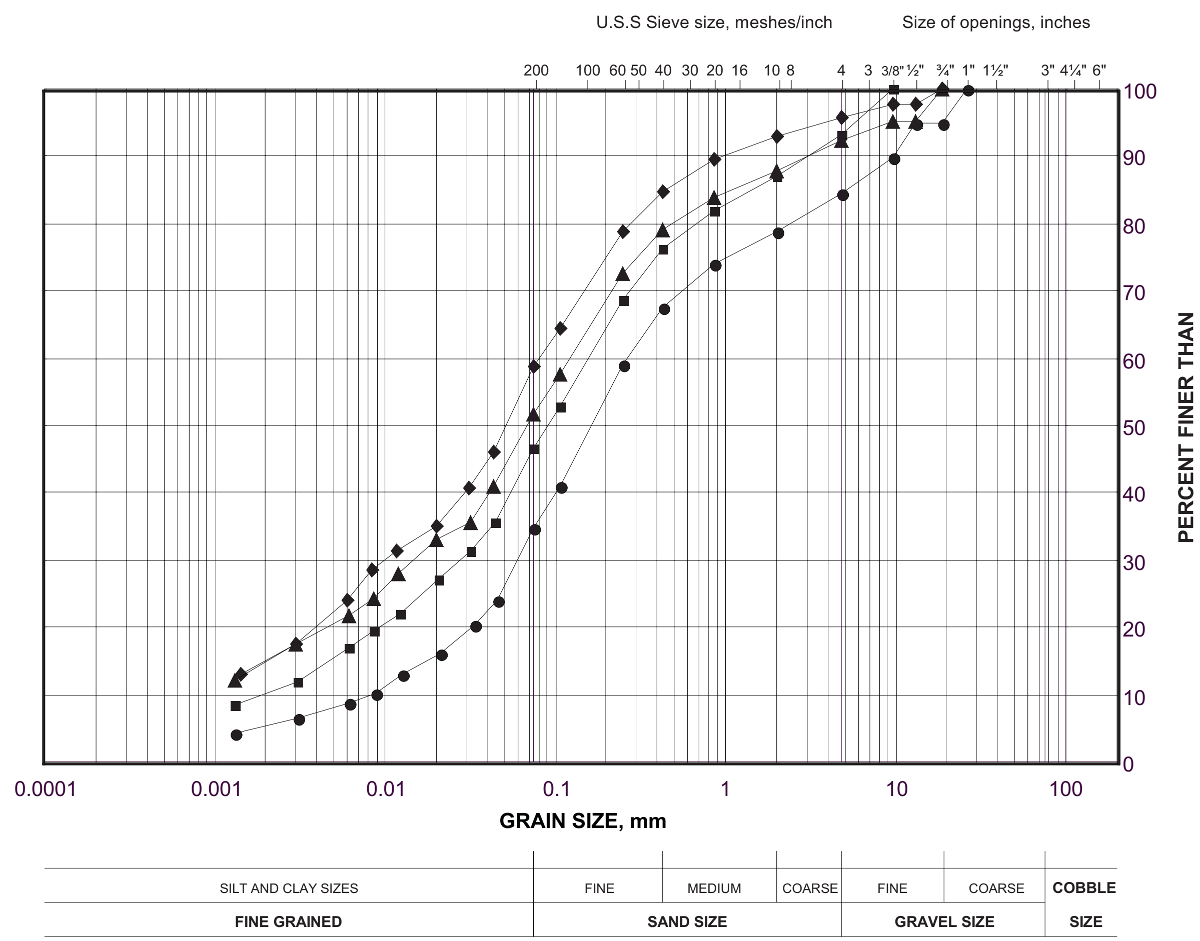
Date: 13-Jun-08



GRAIN SIZE DISTRIBUTION

Sand and Silt (Till)

FIGURE WM27-A



LEGEND

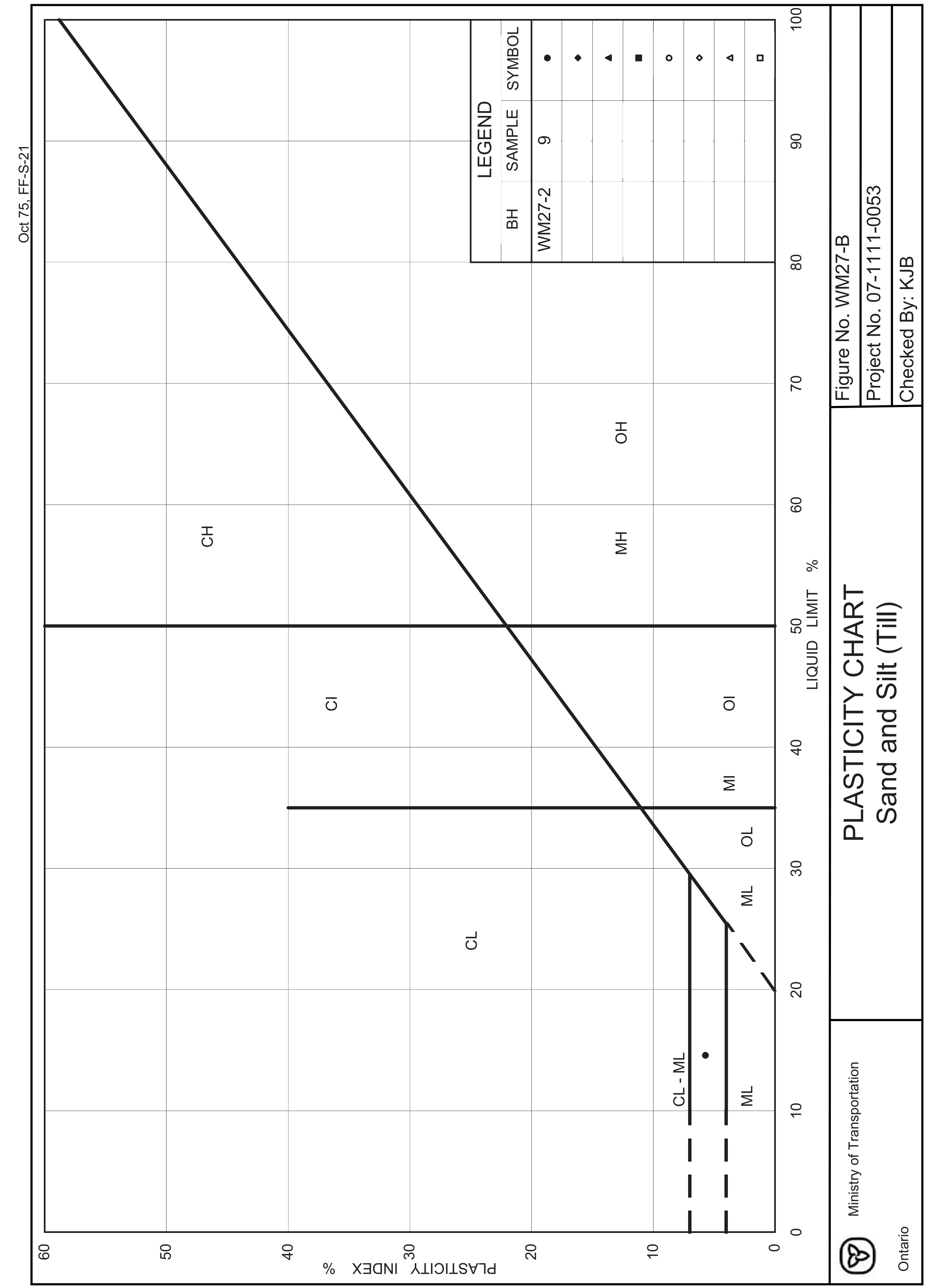
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM27-1	3	194.0
■	WM27-2	5	192.6
◆	WM27-1	9	186.6
▲	WM27-2	9	186.6

Project Number: 07-1111-0053

Checked By: KJB

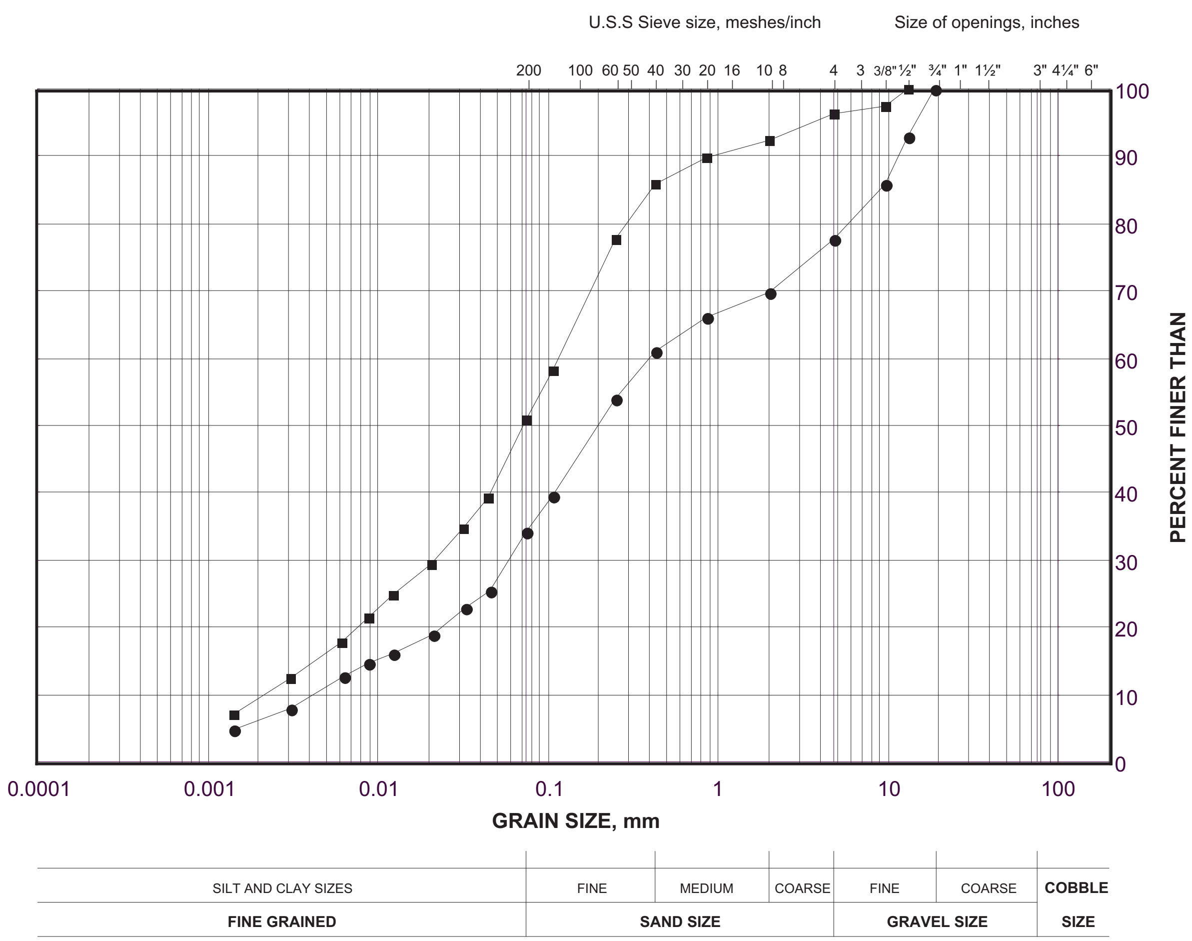
Golder Associates

Date: 05-Jun-08



GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM28-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM28-1	4	191.4
■	WM28-1	7	187.8

Project Number: 07-1111-0053

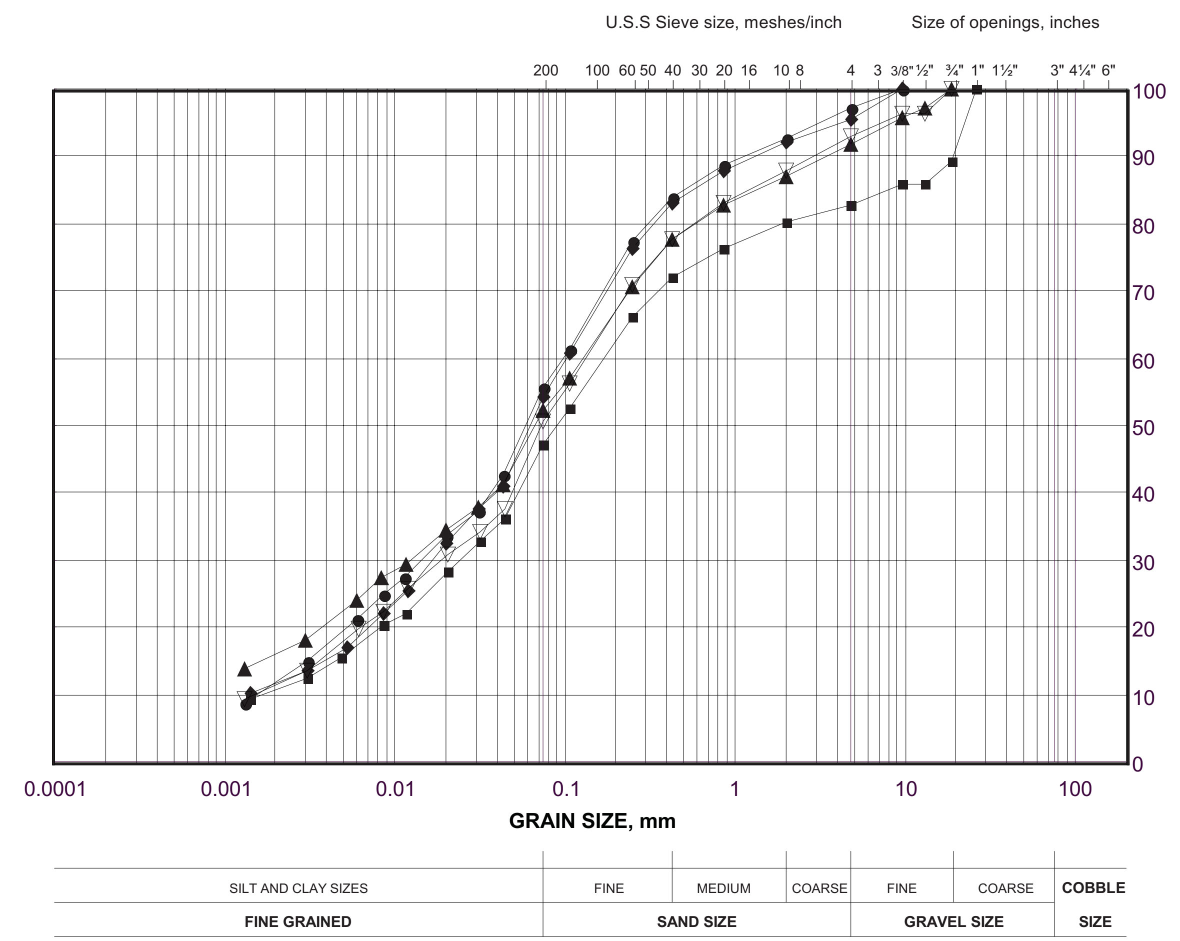
Checked By: KJB

Golder Associates

Date: 20-Jun-08

GRAIN SIZE DISTRIBUTION
Sand and Silt Till

FIGURE WM29-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM29-2	3	188.2
■	WM29-1	5	185.6
◆	WM29-2	6	185.1
▲	WM29-1	7	182.6
▽	WM29-2	8	182.1

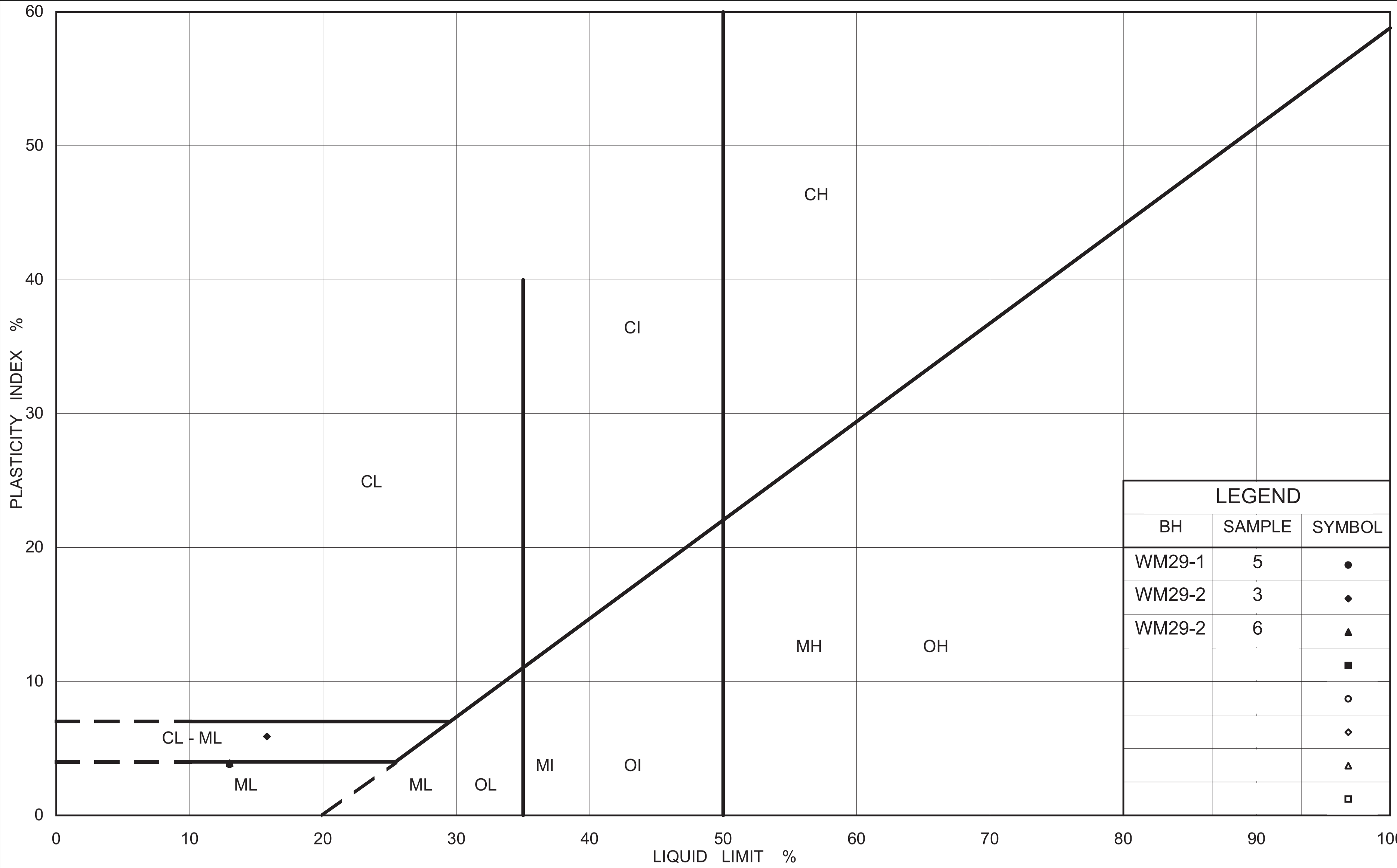
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

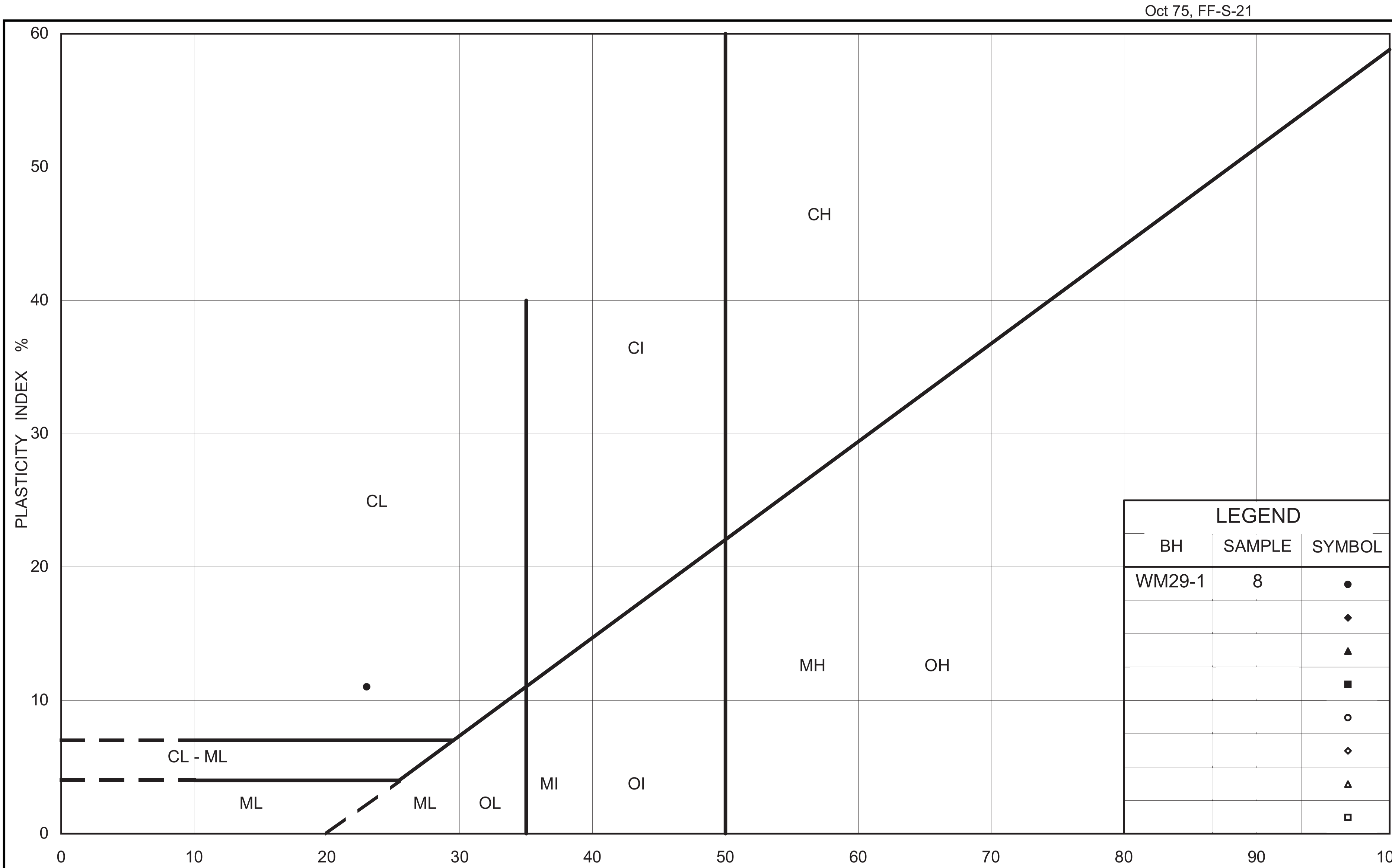
Date: 23-Jun-08

Oct 75, FF-S-21



Ministry of Transportation Ontario	PLASTICITY CHART Sand and Silt (Till)	Figure No. WM29-B Project No. 07-1111-0053 Checked By: KJB

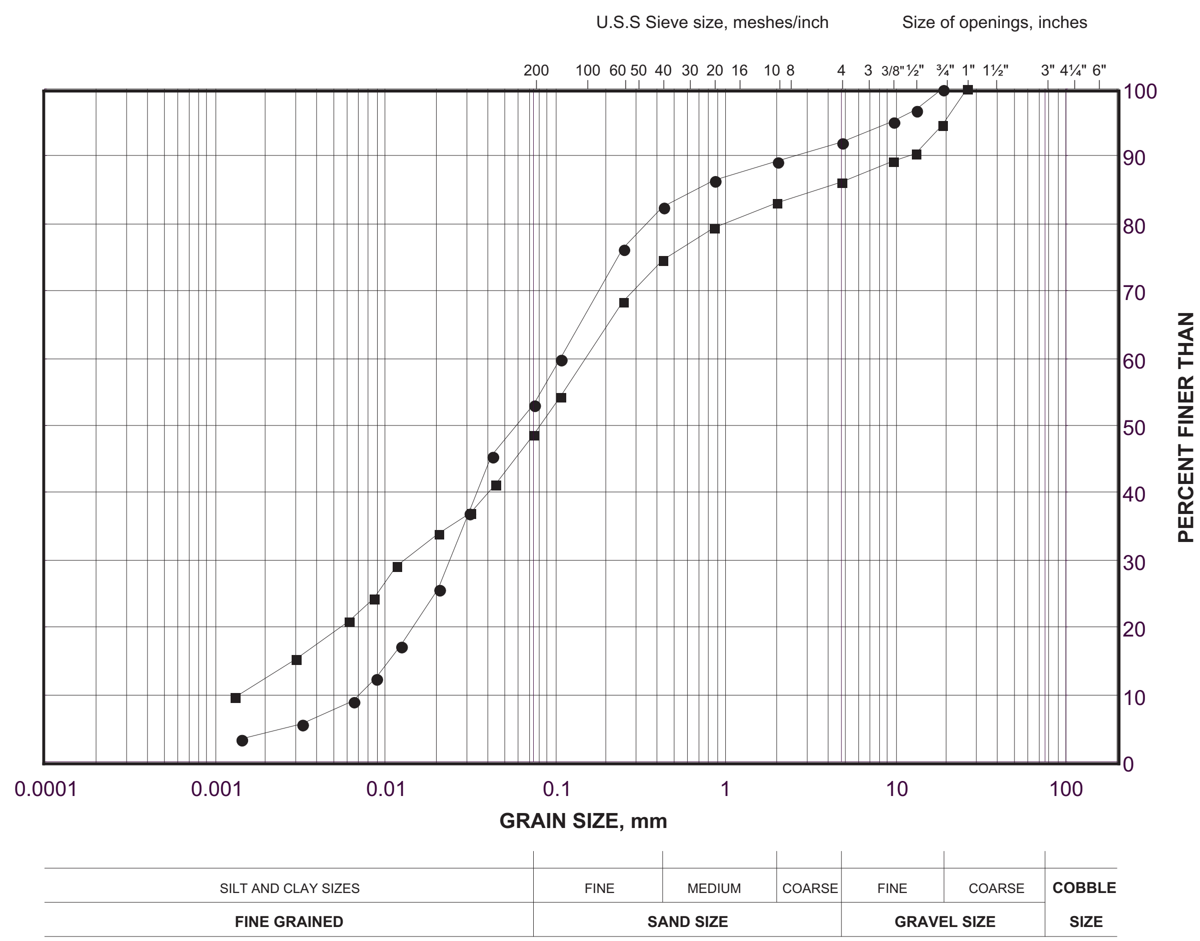
Oct 75, FF-S-21



Ministry of Transportation Ontario	PLASTICITY CHART Clayey Silt Seam	Figure No. WM29-C Project No. 07-1111-0053 Checked By: KJB

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM38-A



LEGEND

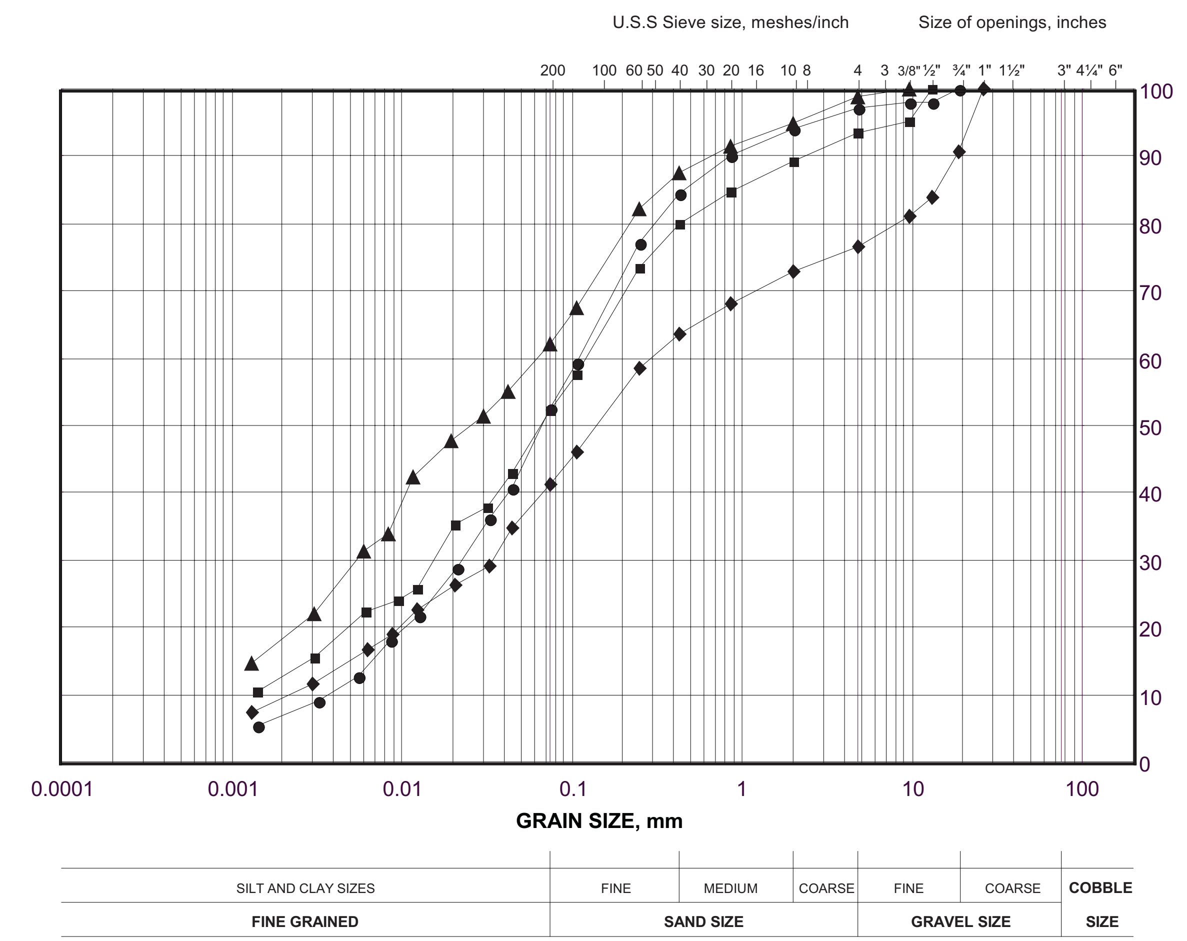
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM38-1	4	167.5
■	WM38-2	4	163.4

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 07-Apr-08

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM35-A

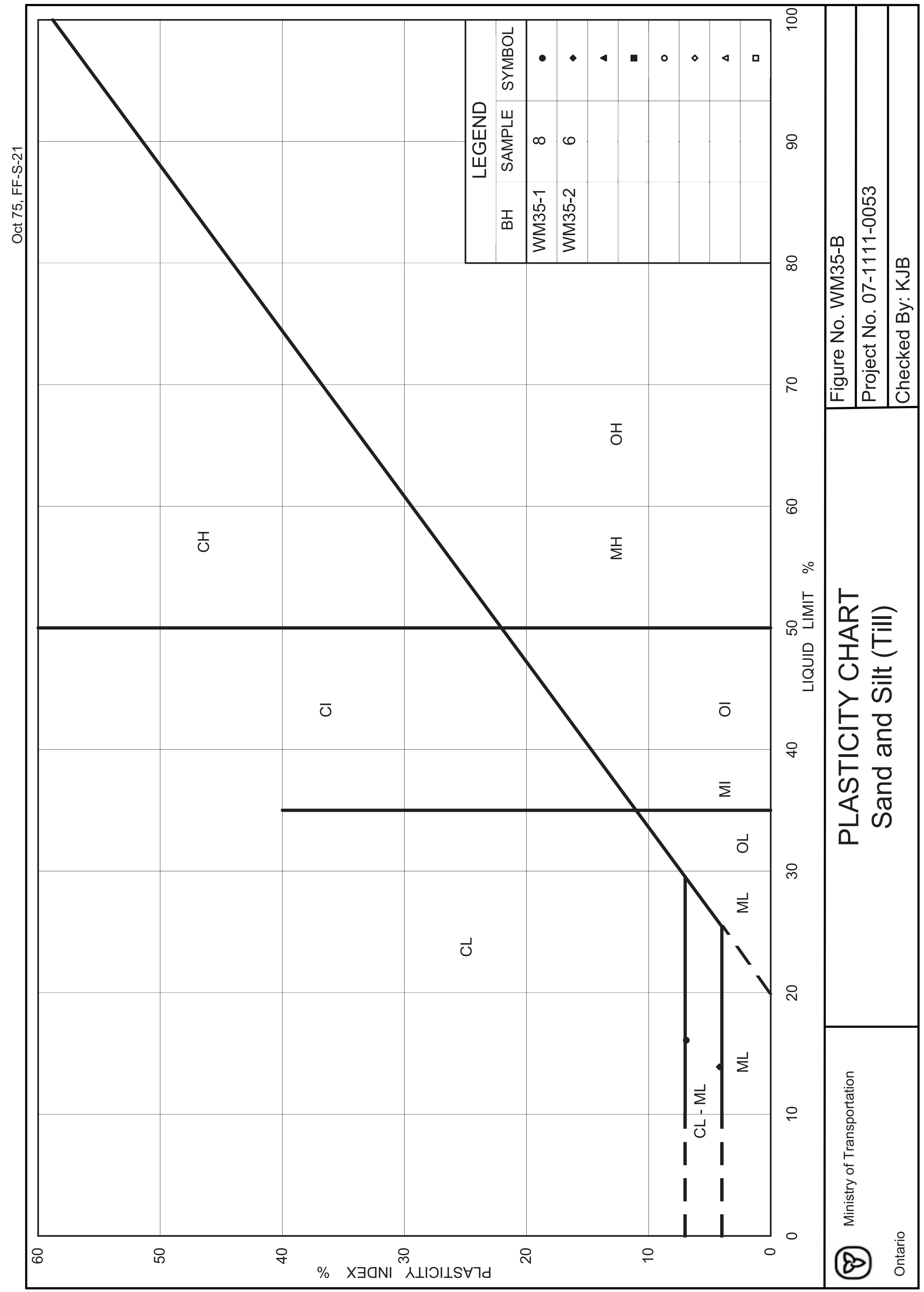


LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM35-1	5	161.7
■	WM35-2	6	158.8
◆	WM35-2	8	155.9
▲	WM35-1	8	157.2

Project Number: 07-1111-0053

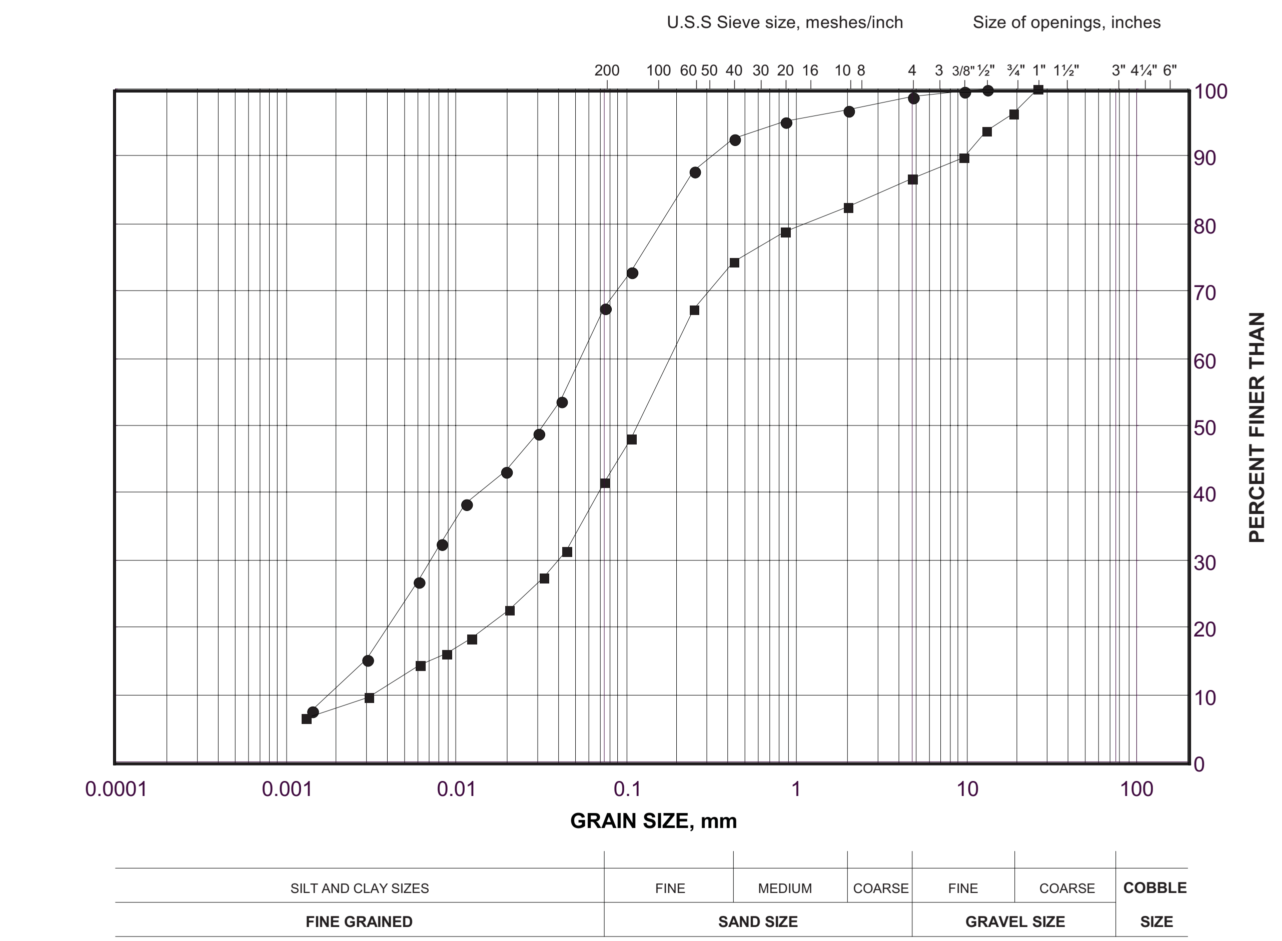
Checked By: KJB **Golder Associates** Date: 23-Jun-08



GRAIN SIZE DISTRIBUTION

Sand and Silt (Till)

FIGURE WM36-A



LEGEND

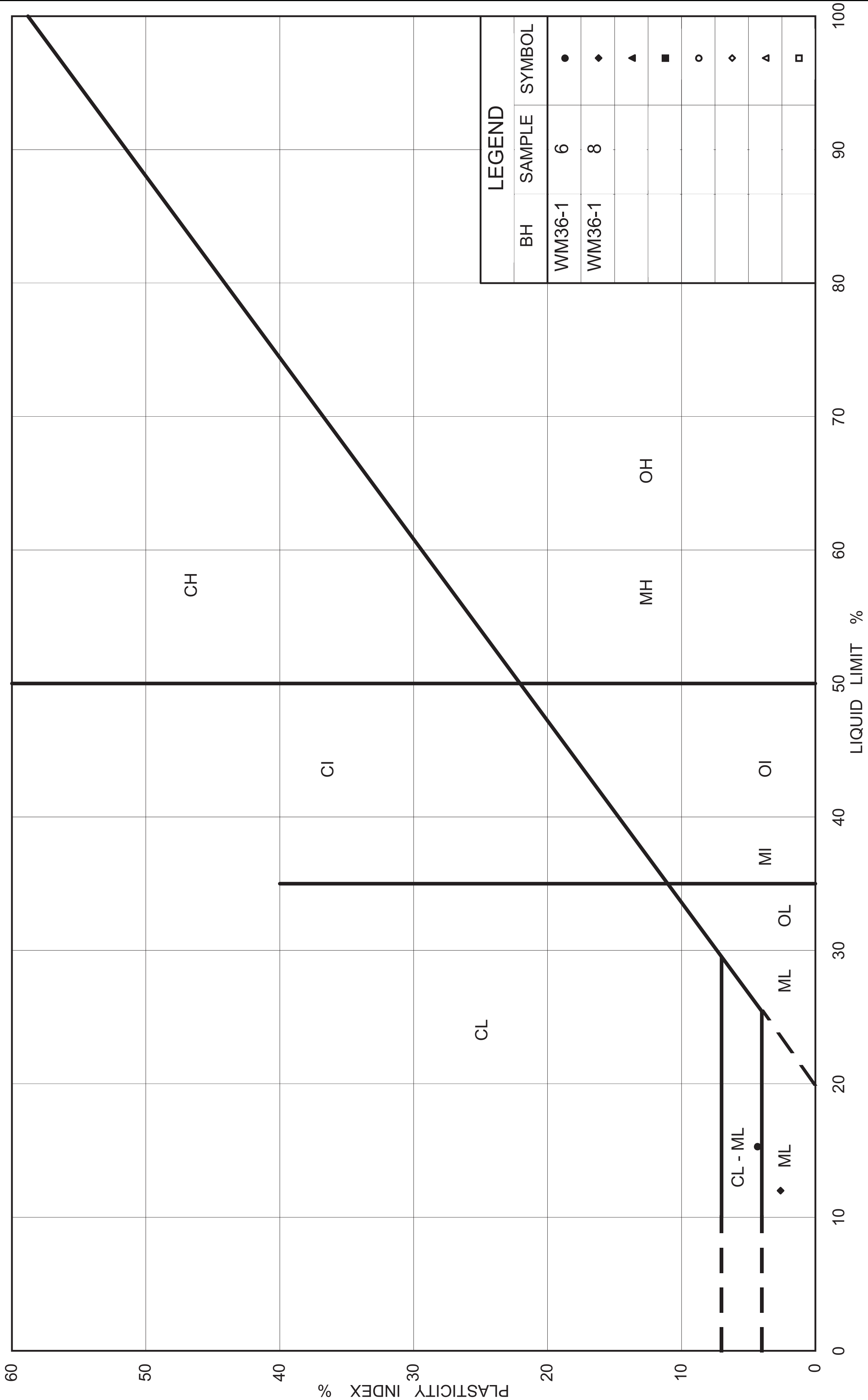
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM36-1	6	148.7
■	WM36-1	8	145.7

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Jul-08



LEGEND

BH	SAMPLE	SYMBOL
WM36-1	6	●
WM36-1	8	◆

PLASTICITY CHART
Sand and Silt (Till)

Figure No. WM36-B

Project No. 07-1111-0053

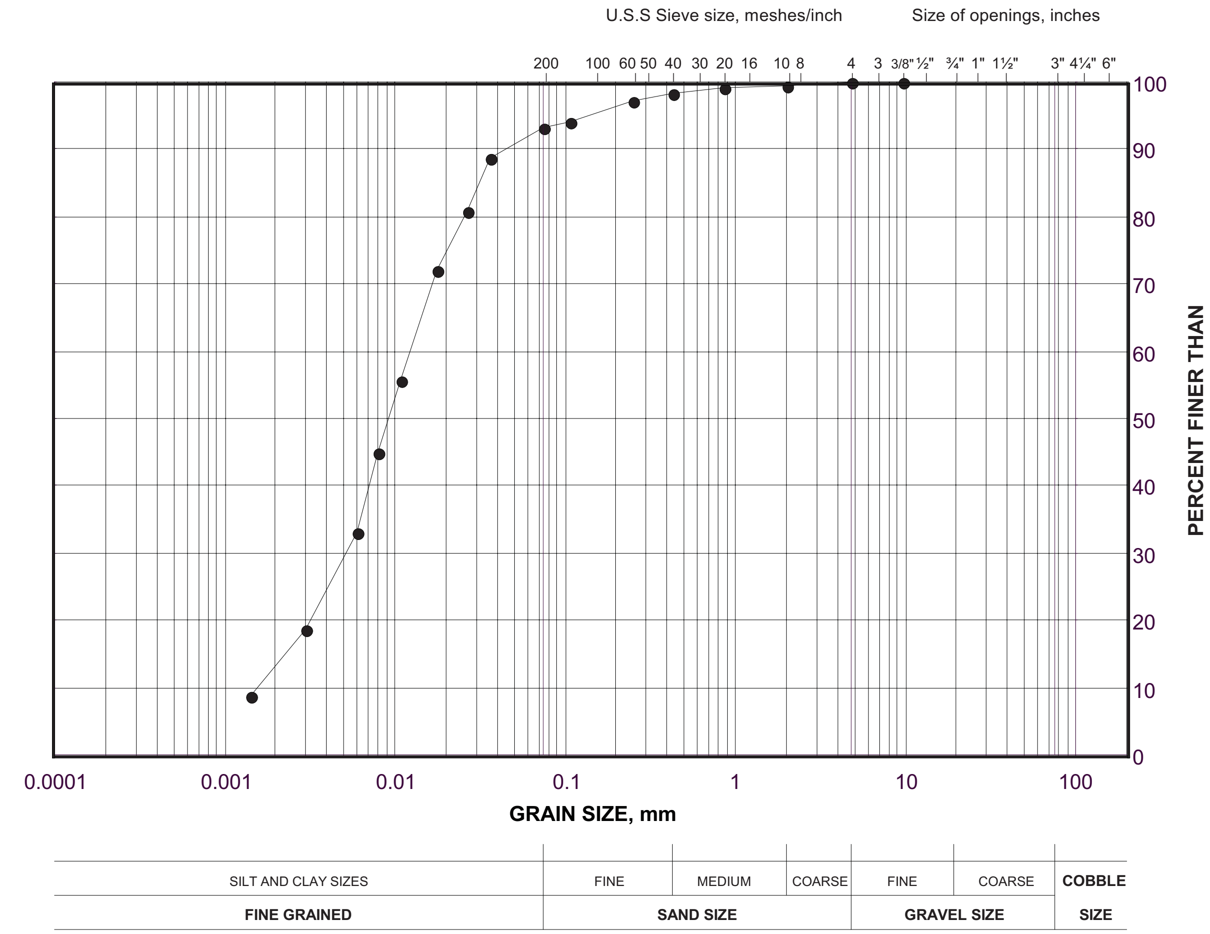
Checked By: KJB

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
Silt

FIGURE WM36-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM36-1	11	141.3

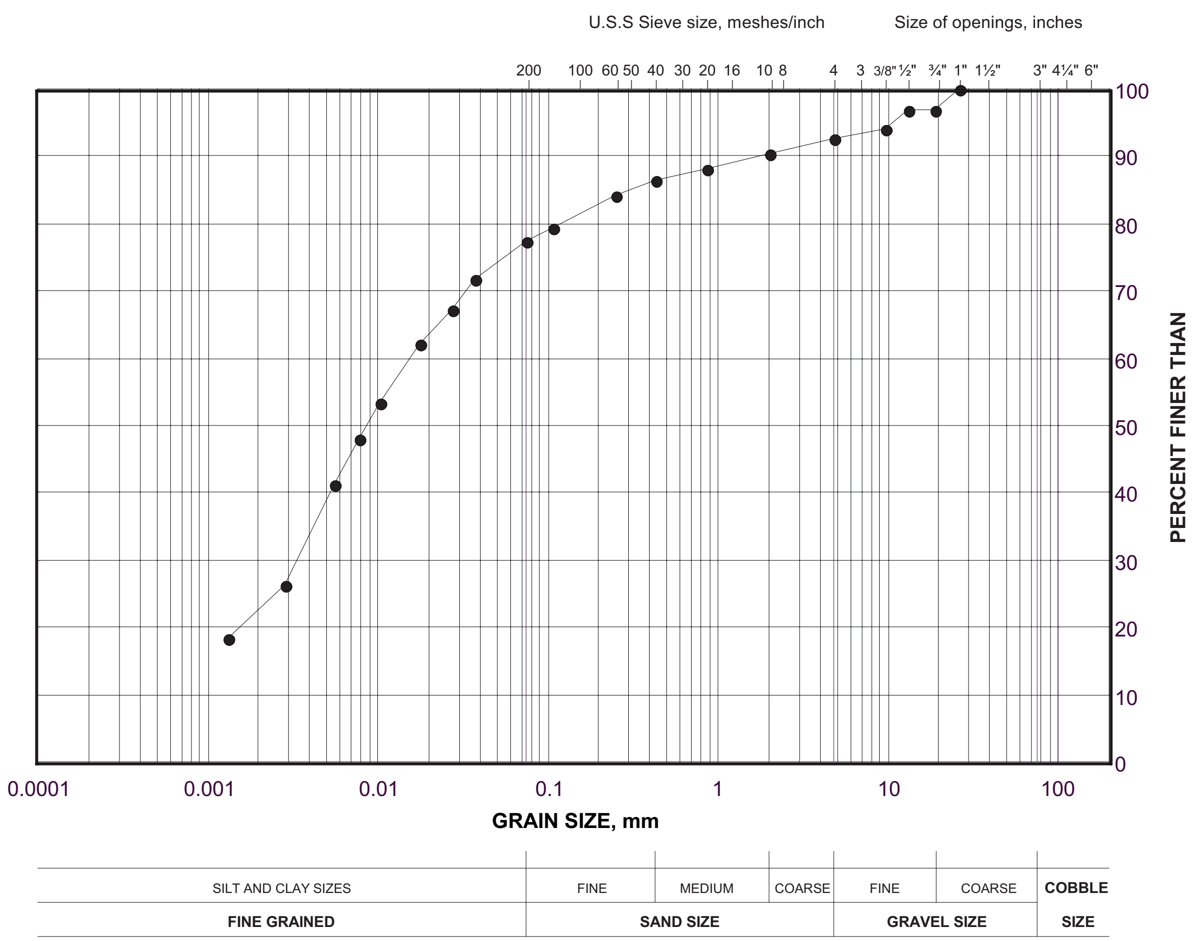
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Jul-08

GRAIN SIZE DISTRIBUTION Clayey Silt (Till)	FIGURE WM37-A

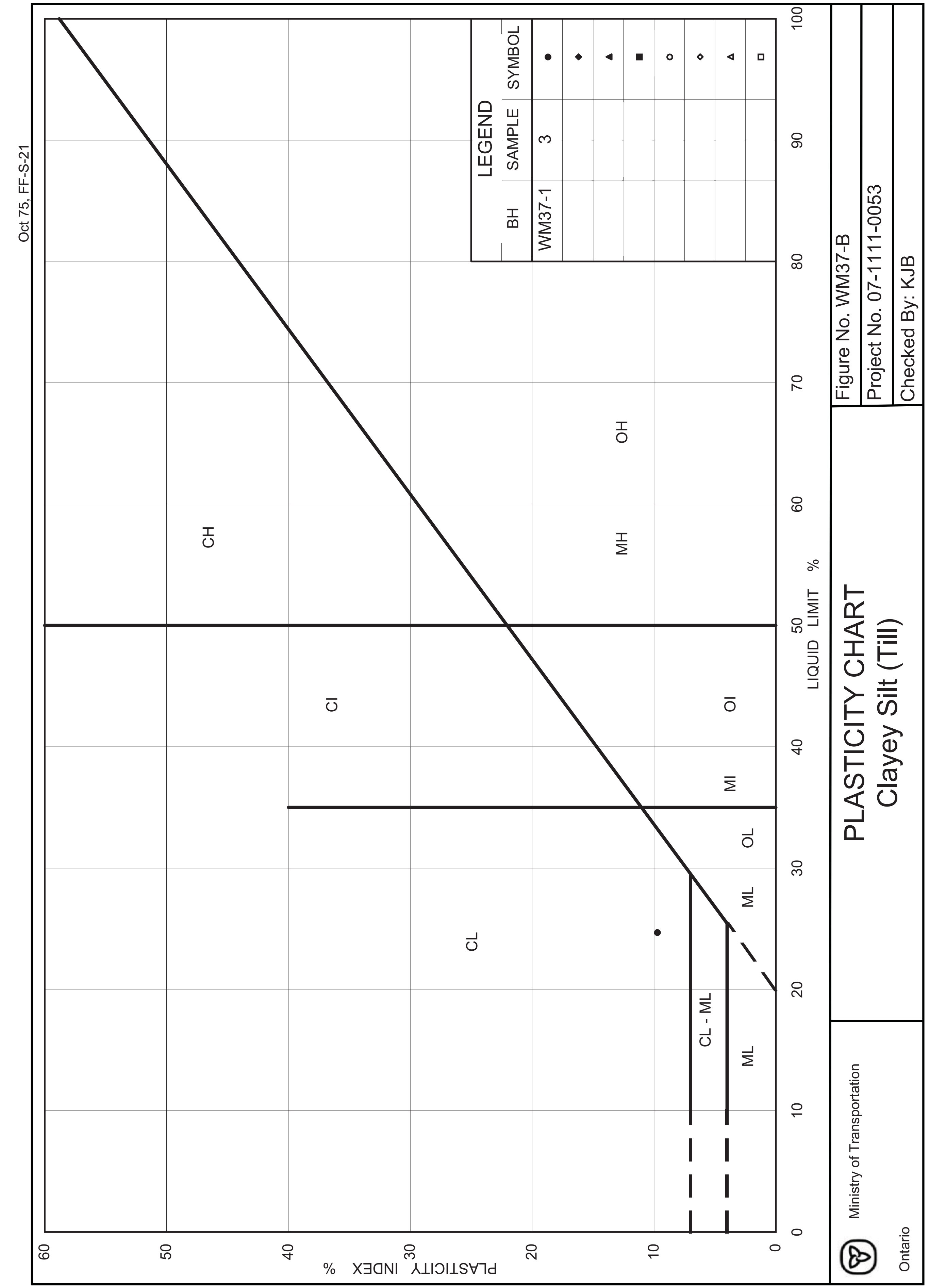


LEGEND

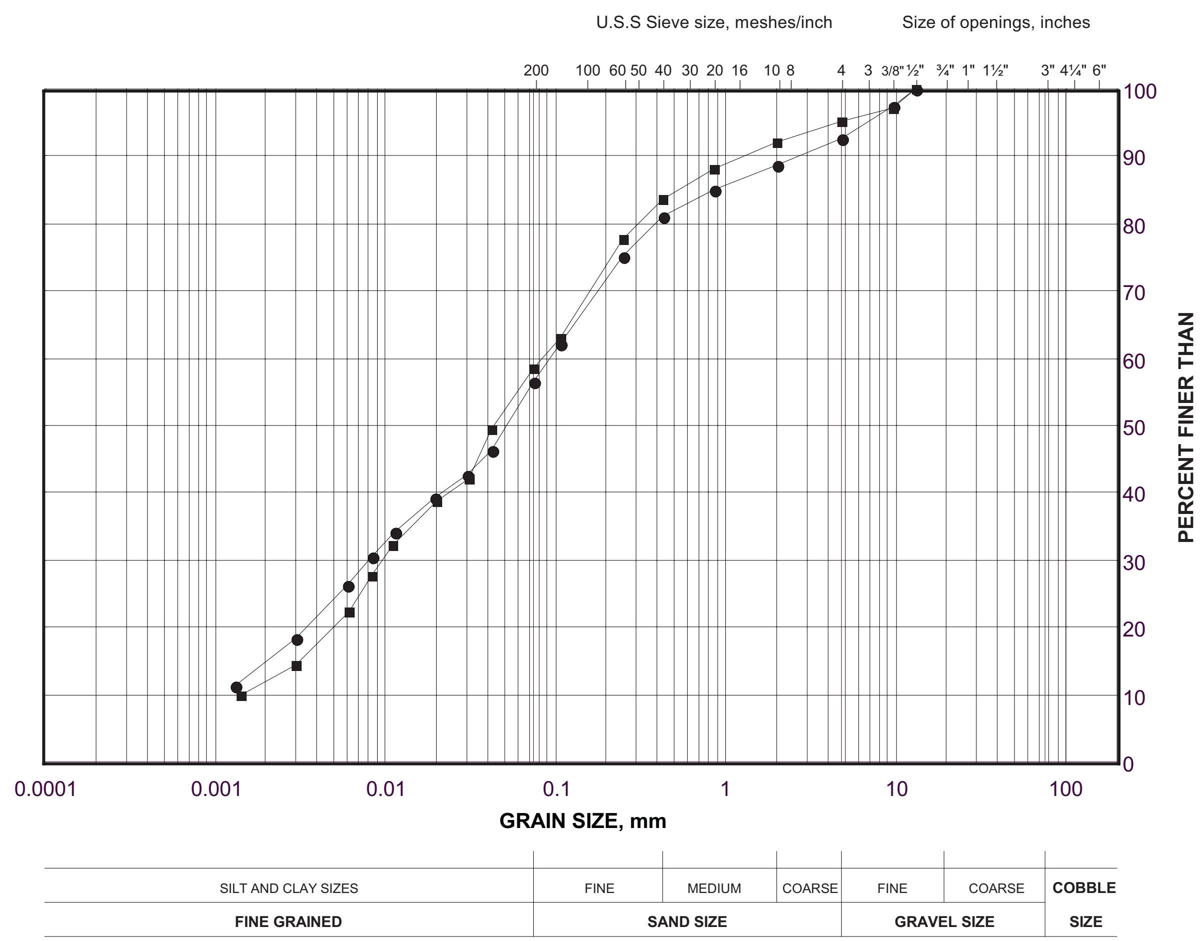
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM37-1	3	151.4

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 04-Jul-08



GRAIN SIZE DISTRIBUTION Sand and Silt (Till)	FIGURE WM37-C



LEGEND

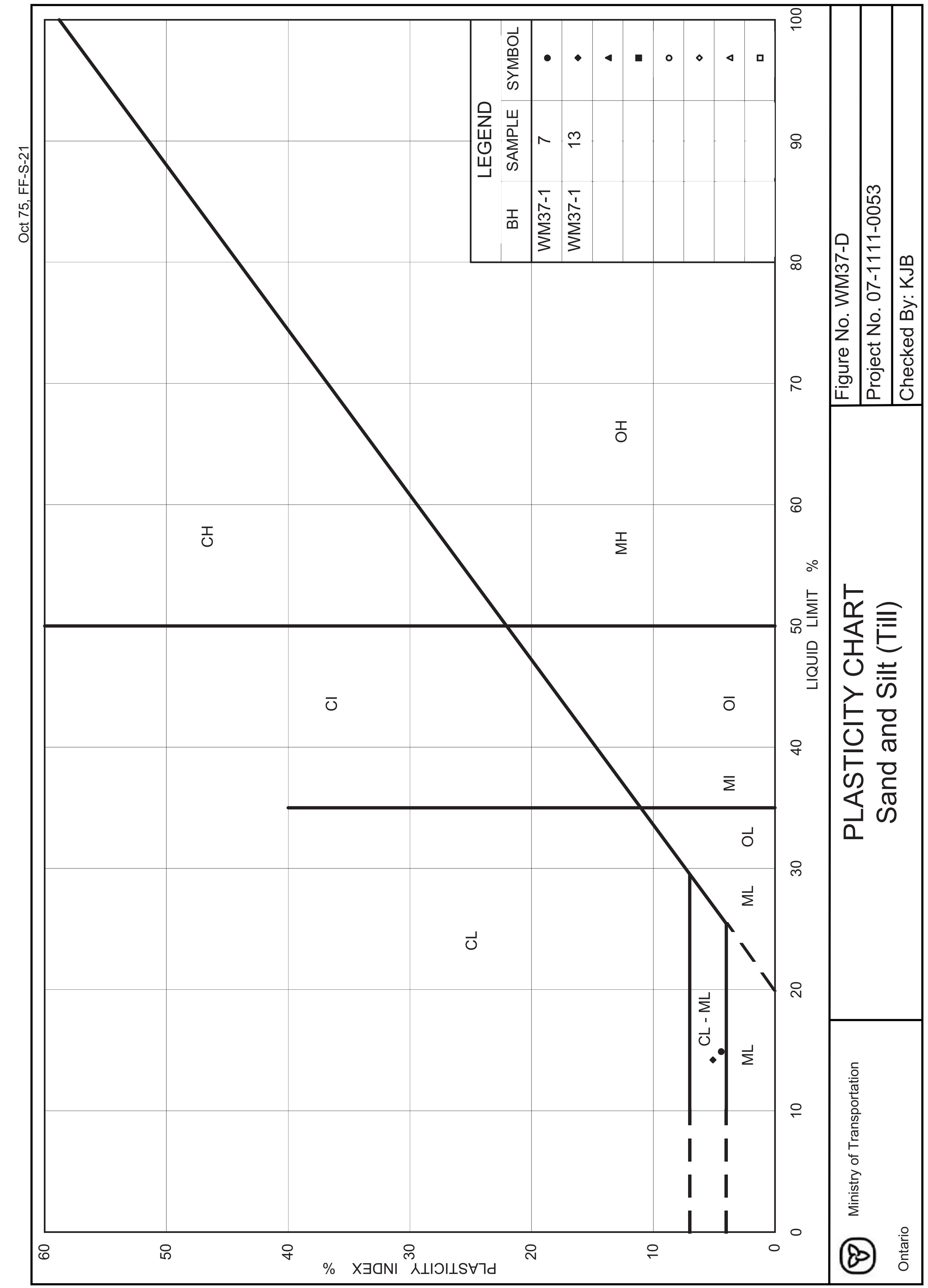
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM37-1	12	139.4
■	WM37-1	7	146.8

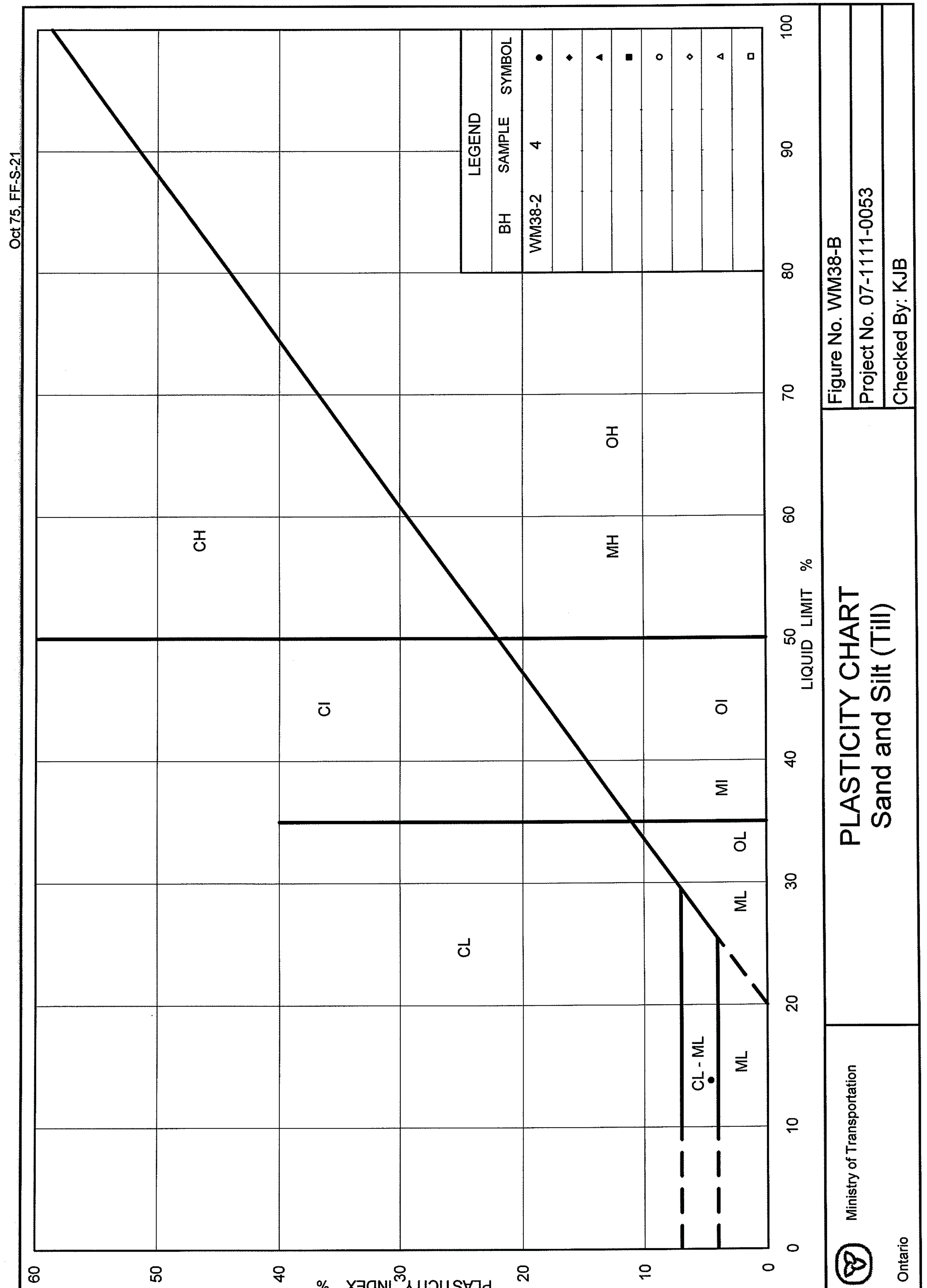
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Jul-08

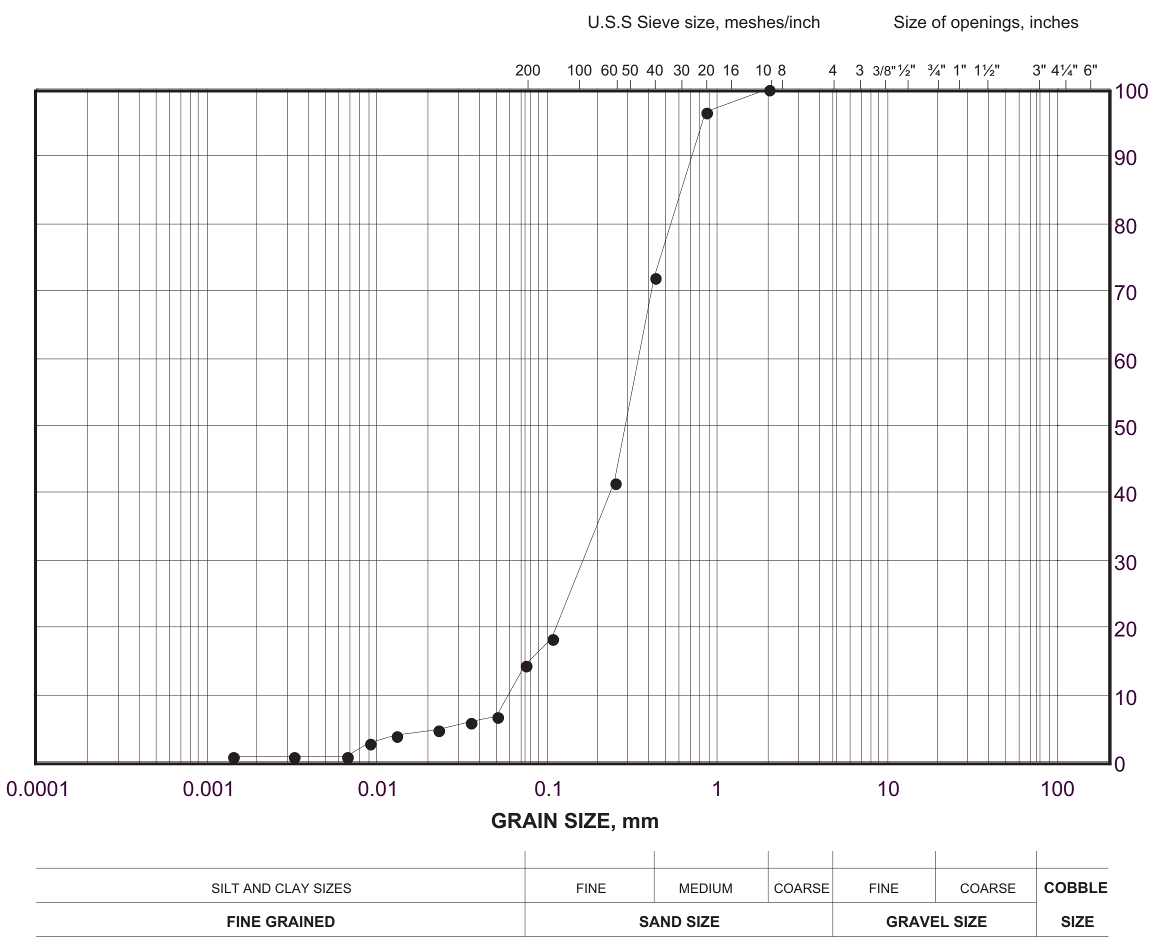




GRAIN SIZE DISTRIBUTION

Sand, some silt

FIGURE WM38-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WM38-1	8	162.2

Project Number: 07-1111-0053

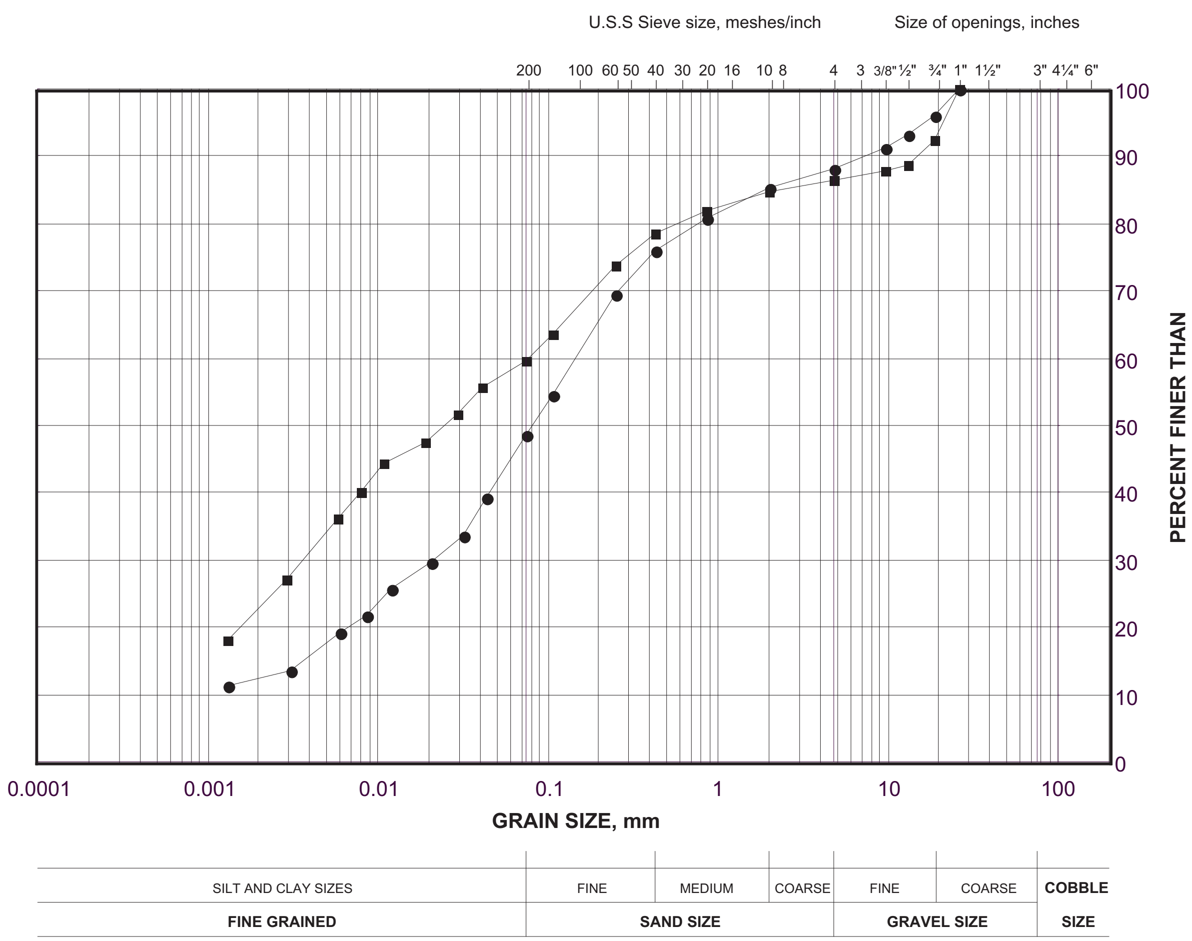
Checked By: KJB

Golder Associates

Date: 07-Apr-08

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand, some gravel (Till)

FIGURE WM38-D



LEGEND

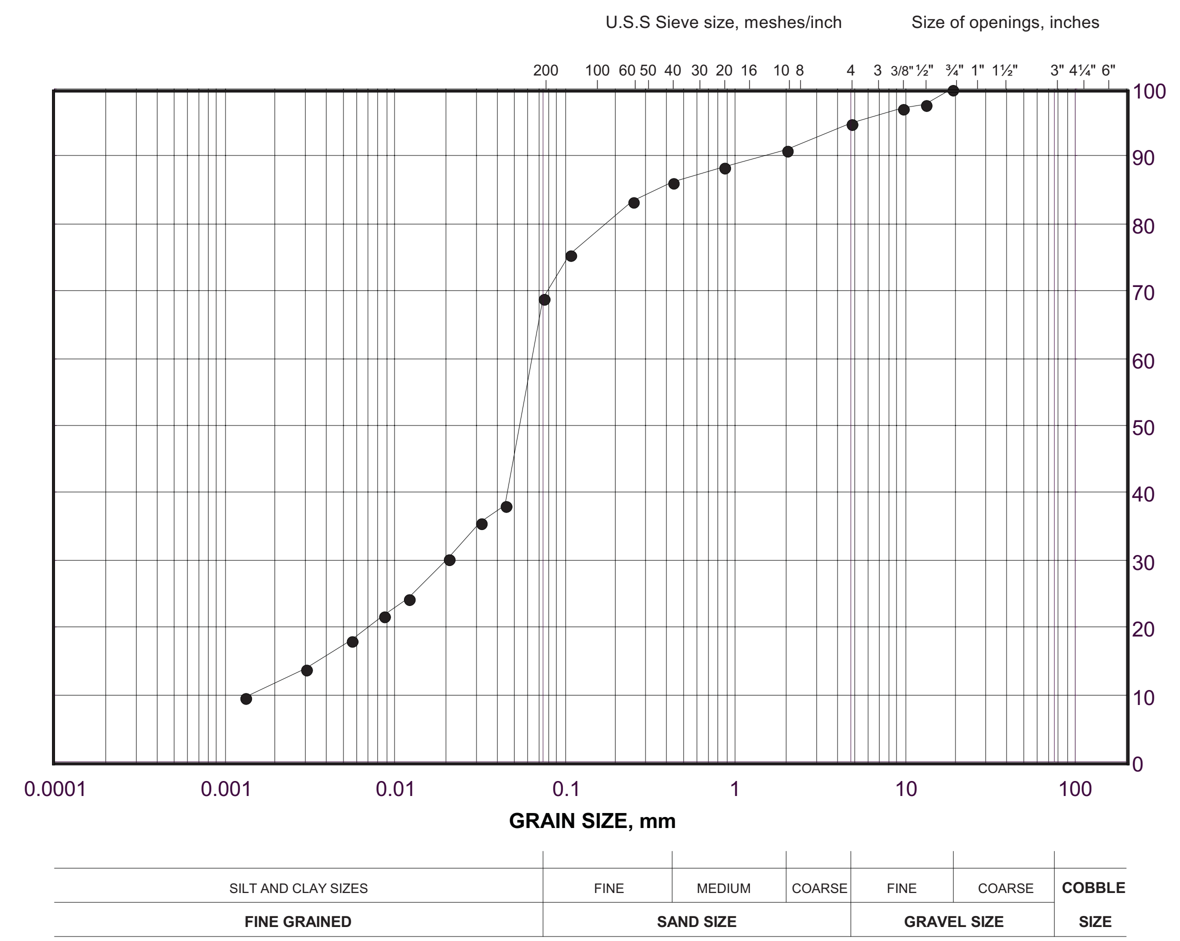
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM38-1	10	159.30
■	WM38-2	7	159.60

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 07-Apr-08

GRAIN SIZE DISTRIBUTION
Sandy Silt (Till)

FIGURE WM39-A



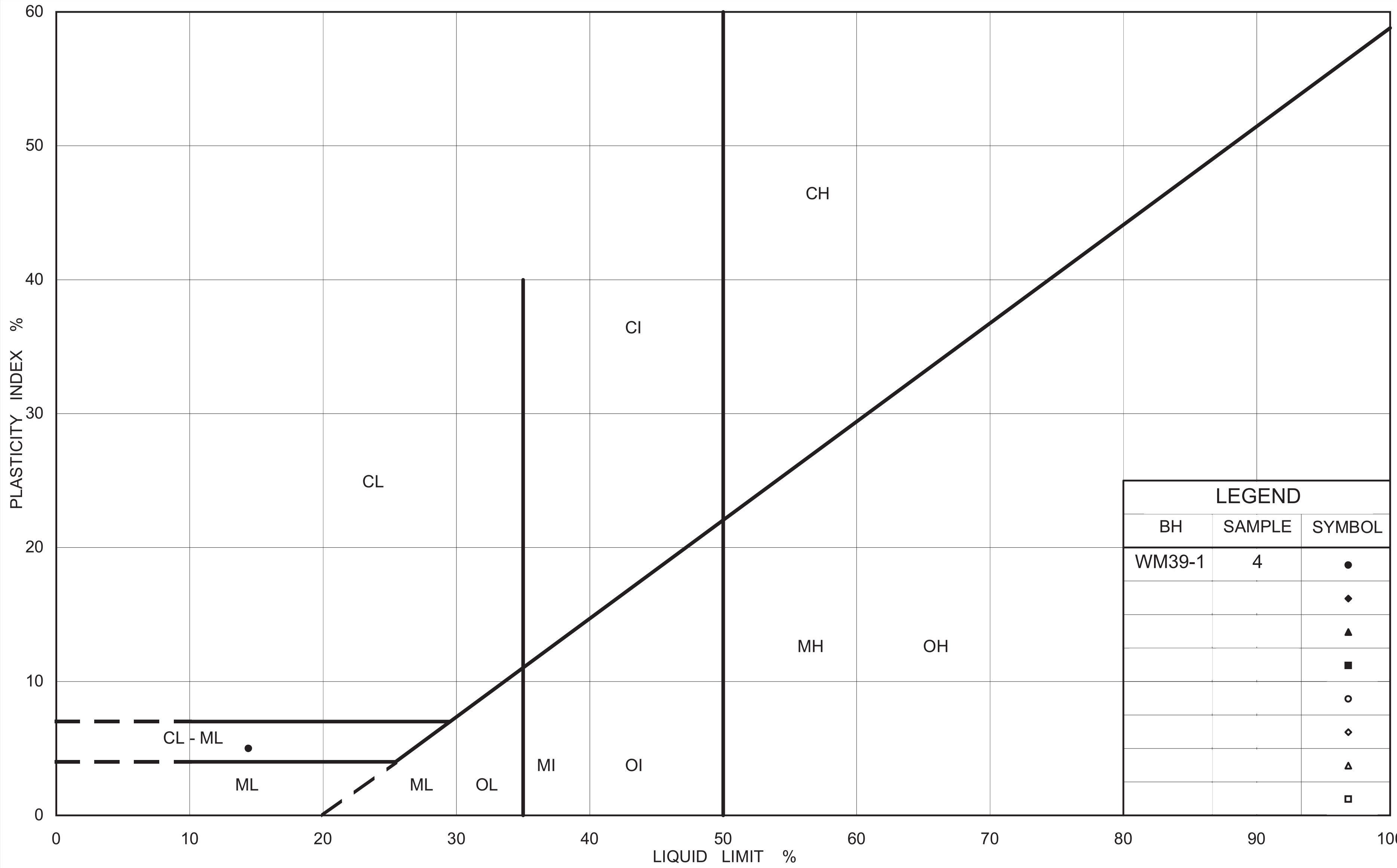
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM39-1	4	156.4

Project Number: 07-1111-0053

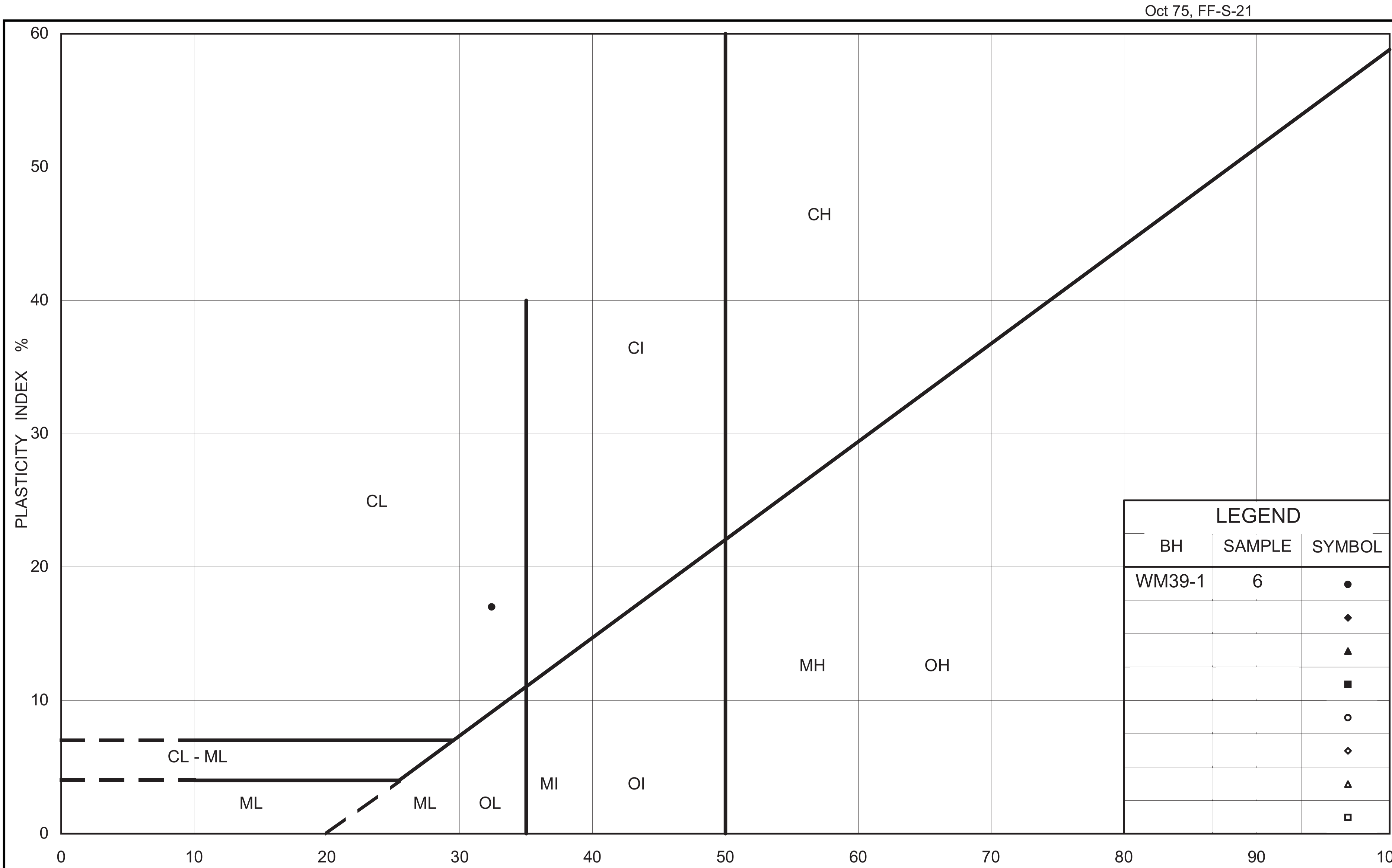
Checked By: KJB **Golder Associates** Date: 06-Oct-08

Oct 75, FF-S-21



Ministry of Transportation Ontario	PLASTICITY CHART Sandy Silt (Till)	Figure No. WM39-B Project No. 07-1111-0053 Checked By: KJB

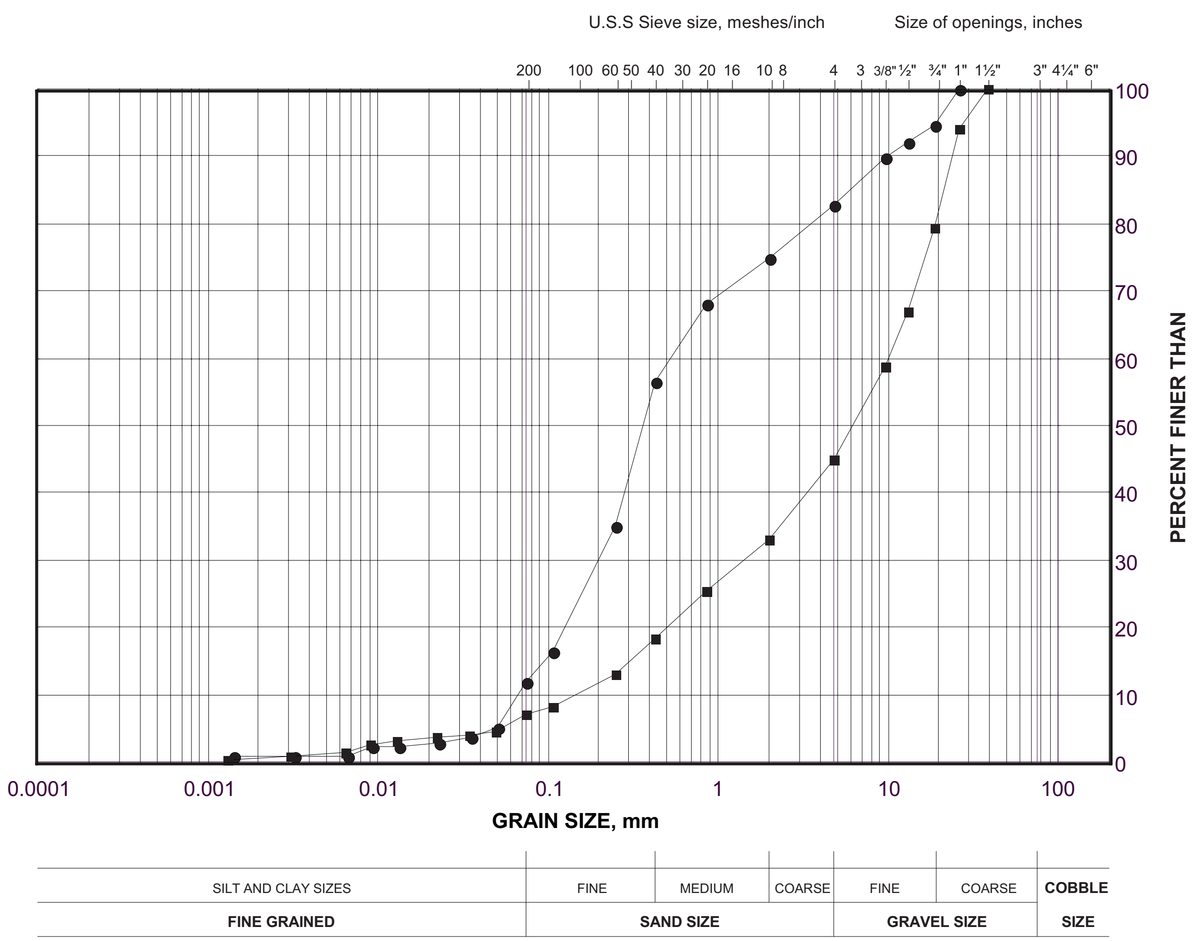
Oct 75, FF-S-21



Ministry of Transportation Ontario	PLASTICITY CHART Clayey Silt	Figure No. WM39-C Project No. 07-1111-0053 Checked By: KJB

GRAIN SIZE DISTRIBUTION
Sand to Sand and Gravel

FIGURE WM39-D



LEGEND

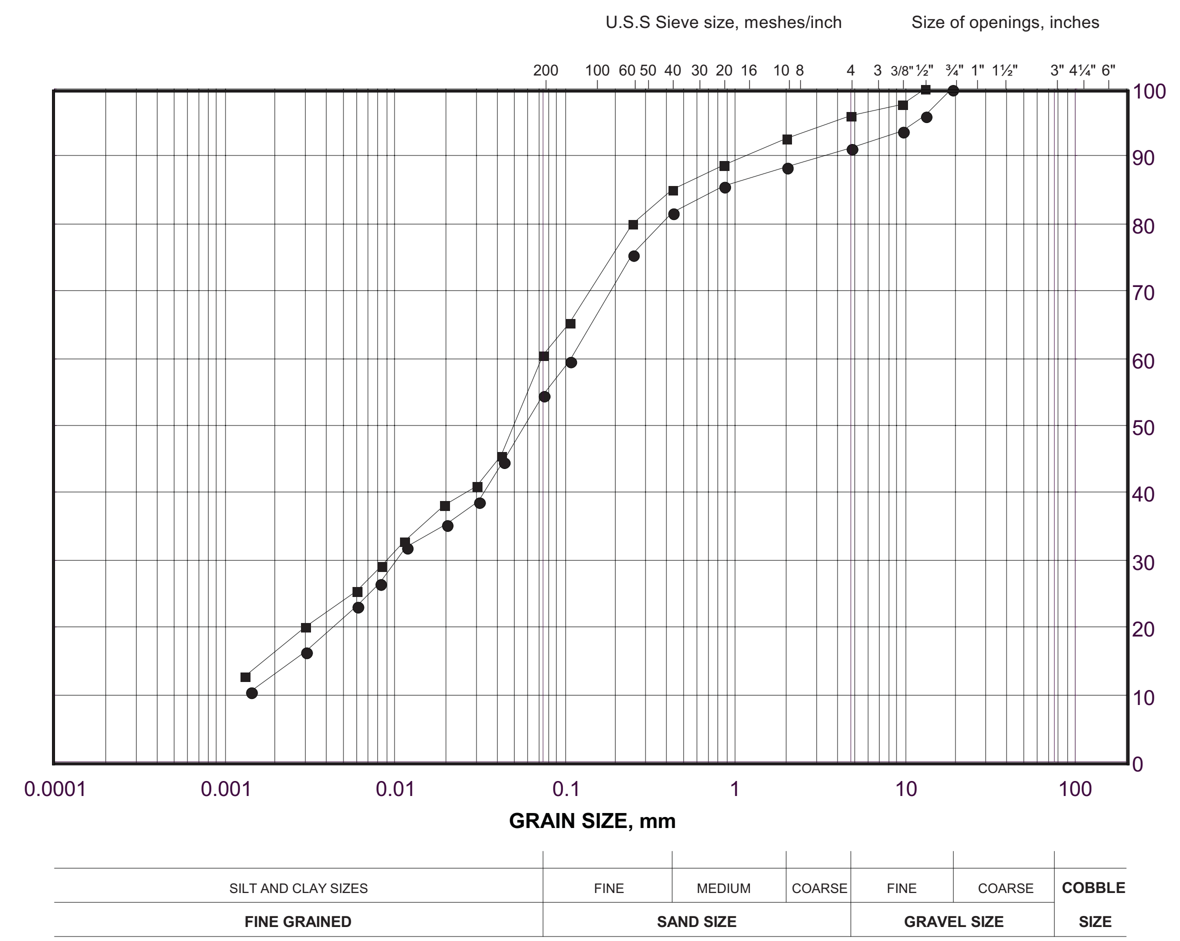
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM39-1	10	148.0
■	WM39-1	11	146.5

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 06-Oct-08

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand (Till)

FIGURE WM40-A



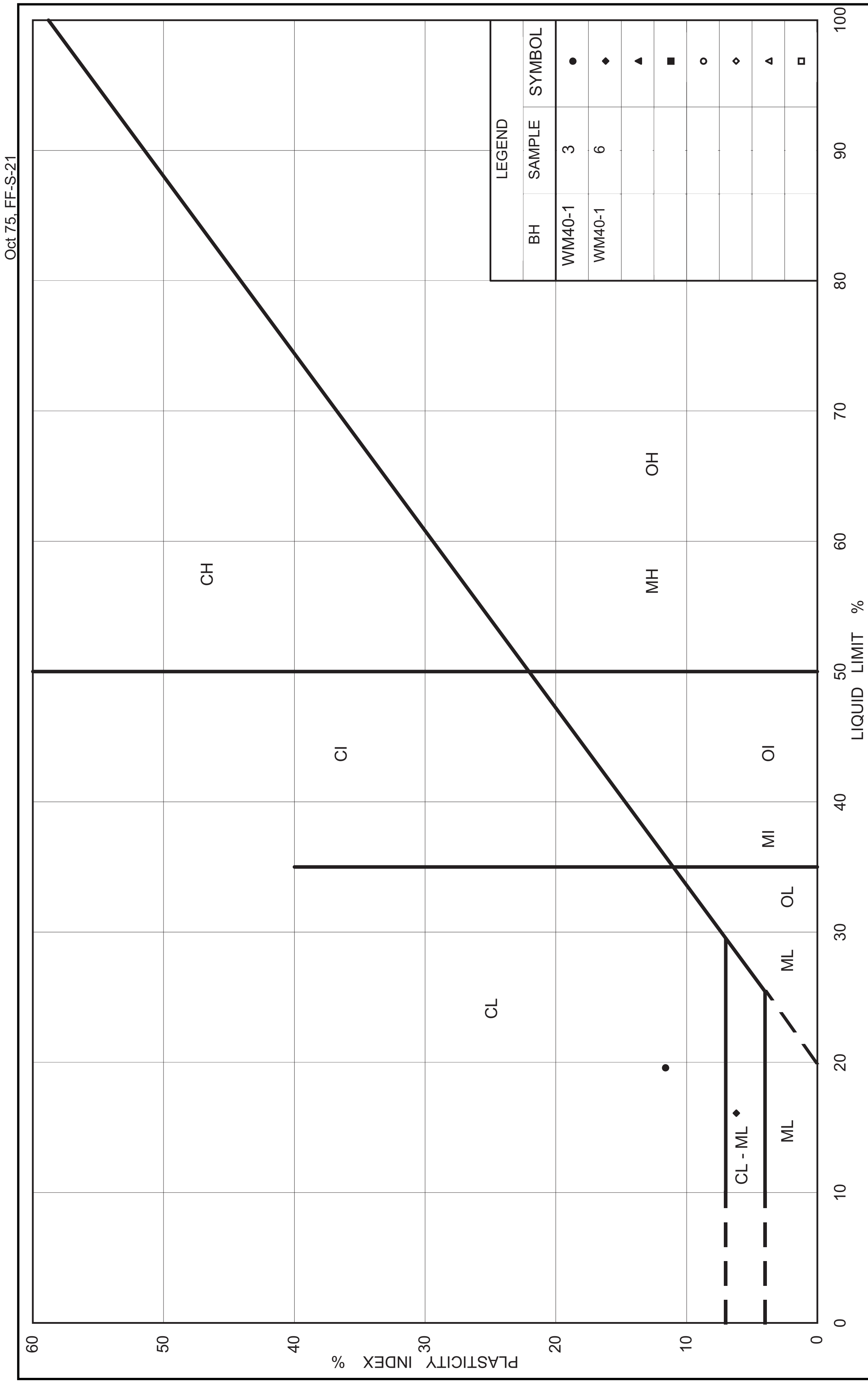
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM40-1	3	157.6
■	WM40-1	6	154.5

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 24-Nov-08

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
WM40-1	3	•
WM40-1	6	◆

Figure No. WM40-B

Project No. 07-1111-0053

Checked By: KJB

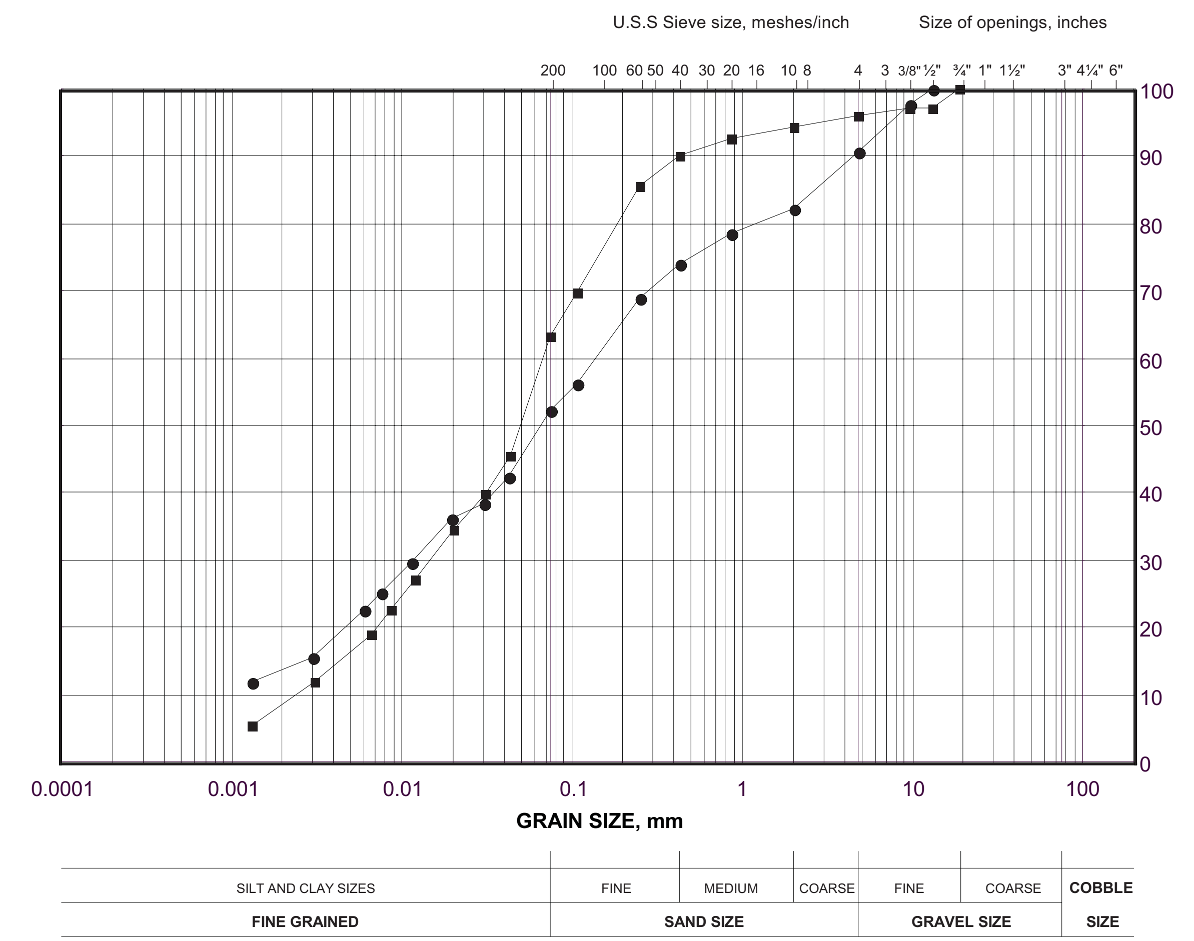
PLASTICITY CHART
Clayey Silt with Sand (Till)

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM40-C



LEGEND

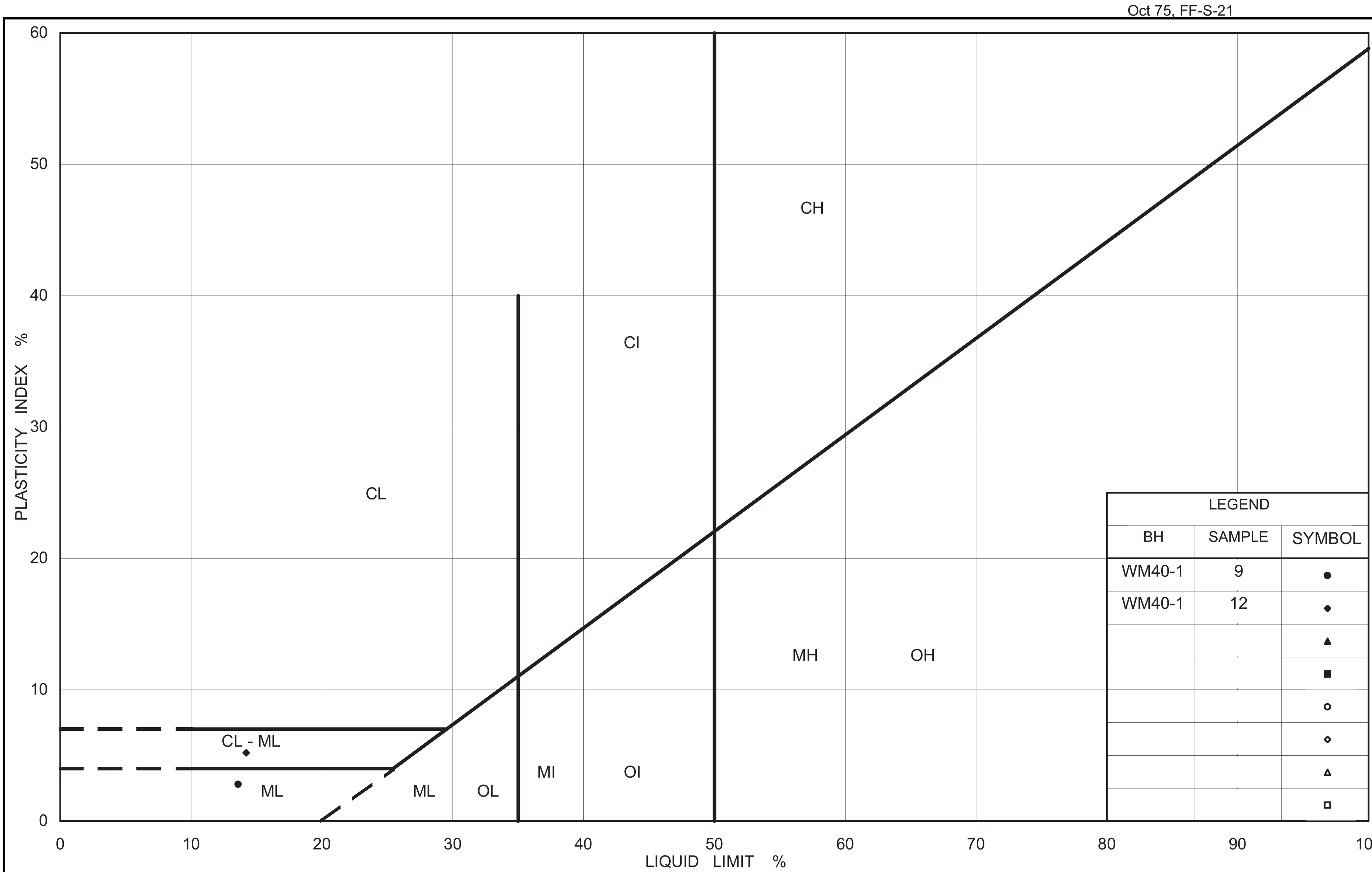
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WM40-1	12	145.7
■	WM40-1	9	150.0

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 24-Nov-08

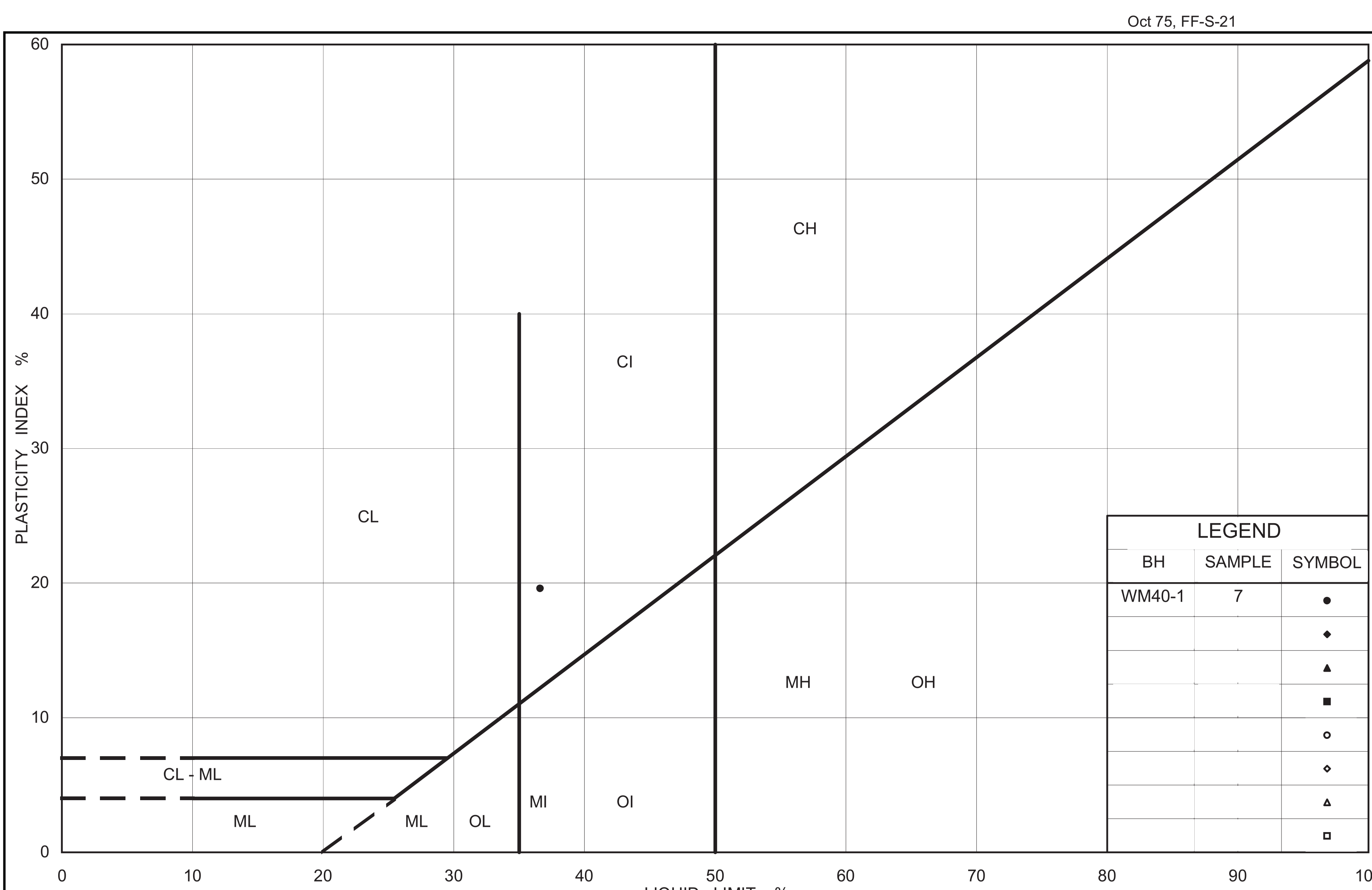


Ministry of Transportation

Ontario

PLASTICITY CHART
Sand and Silt (Till)

Figure No. WM40-D
Project No. 07-1111-0053
Checked By: KJB



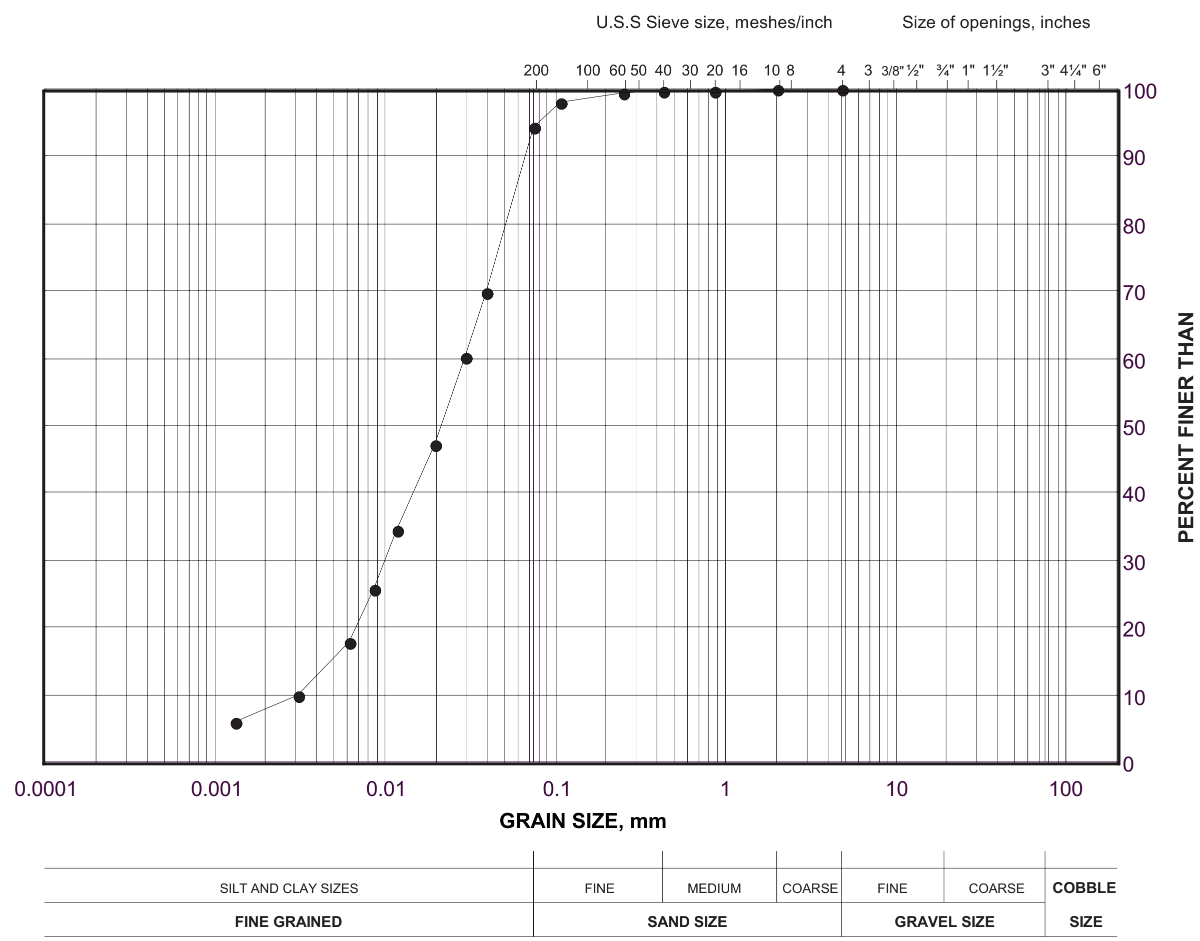
Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay

Figure No. WM40-E
Project No. 07-1111-0053
Checked By: KJB

GRAIN SIZE DISTRIBUTION Silt	FIGURE WM41-A



LEGEND

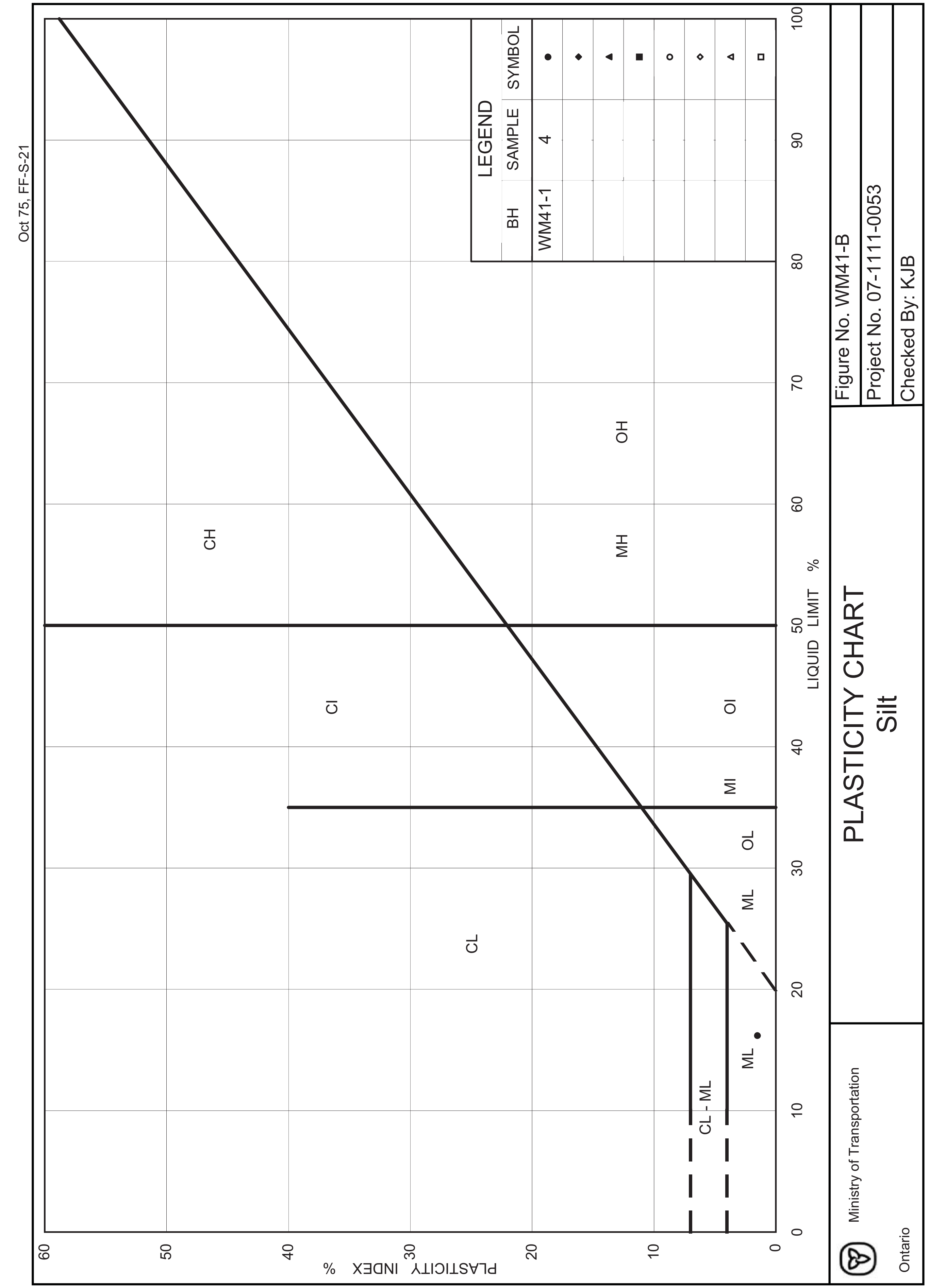
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM41-1	4	156.3

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 06-Oct-08



Oct 75, FF-S-21

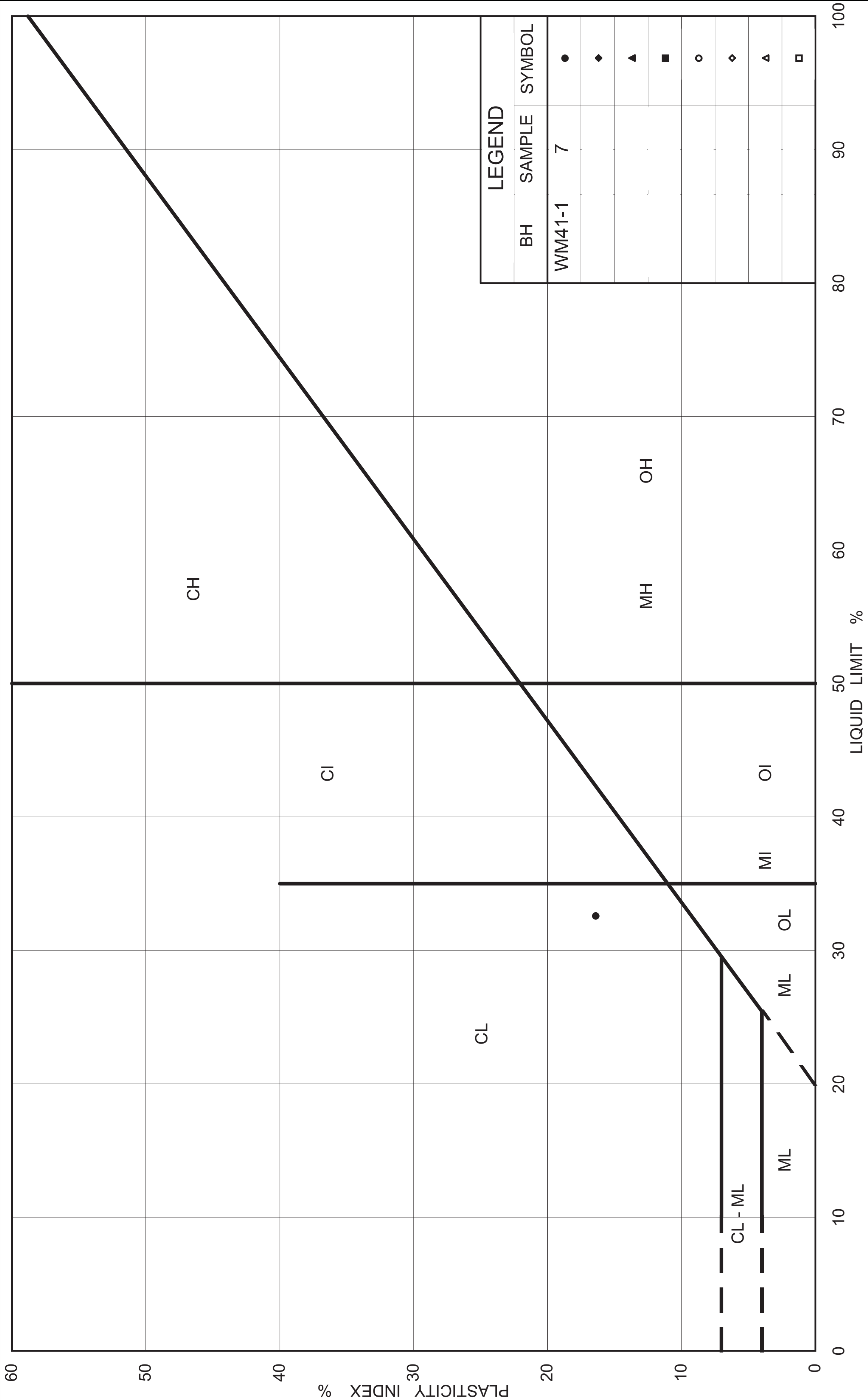


Figure No. WM41-C

Project No. 07-1111-0053

Checked By: KJB

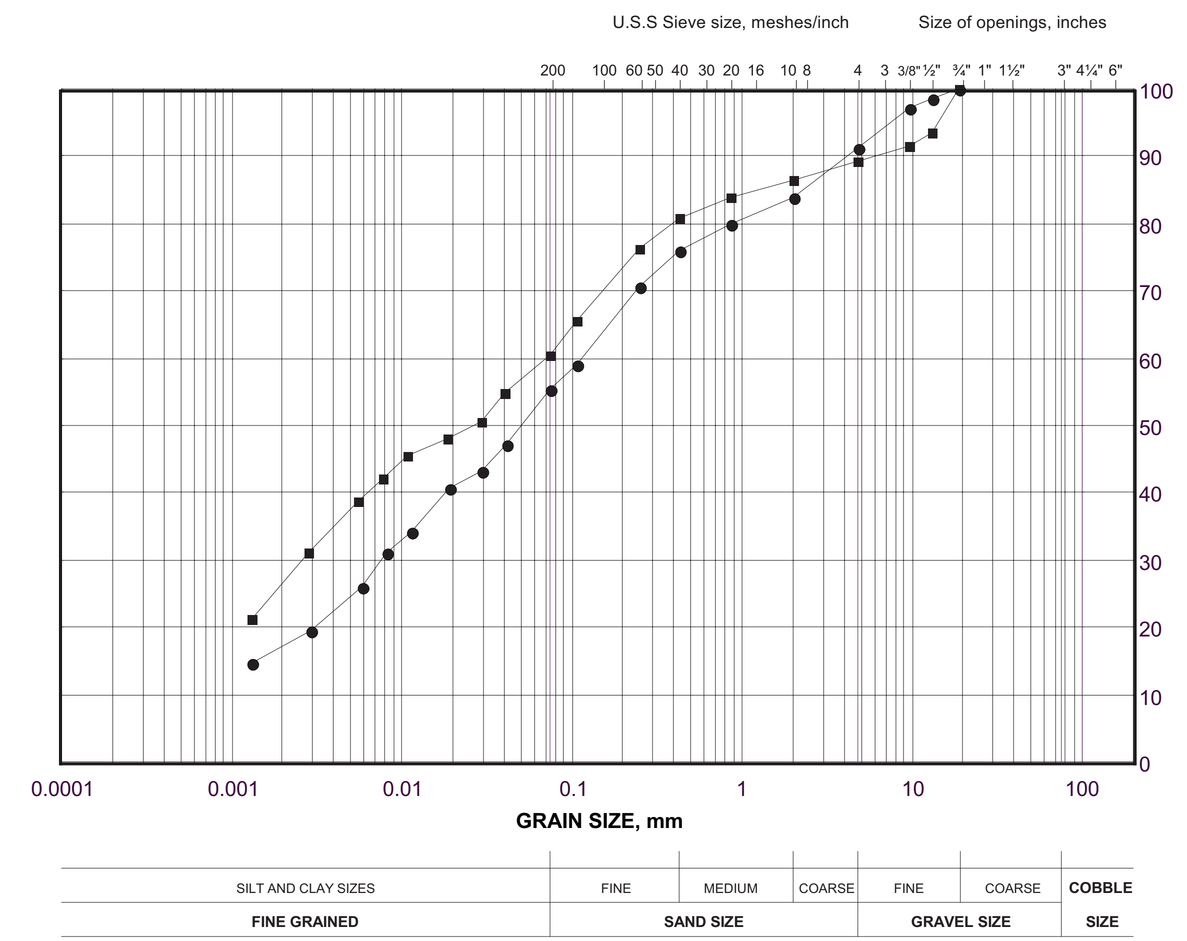
PLASTICITY CHART
Clayey Silt to Silty Clay

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand (Till)

FIGURE WM41-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM41-2	13	145.9
■	WM41-2	4	158.6

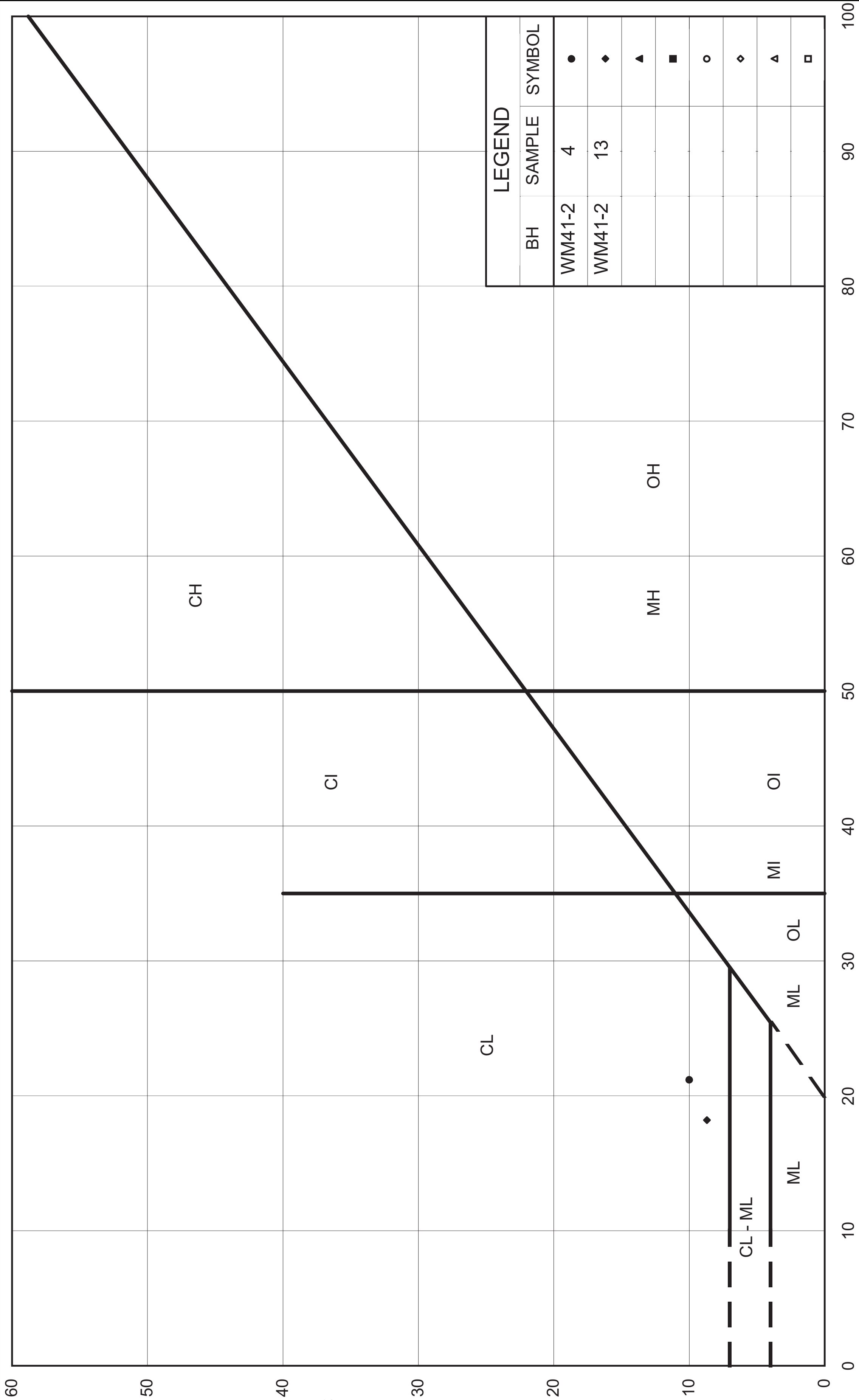
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 28-Oct-08

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
WM41-2	4	●
WM41-2	13	◆

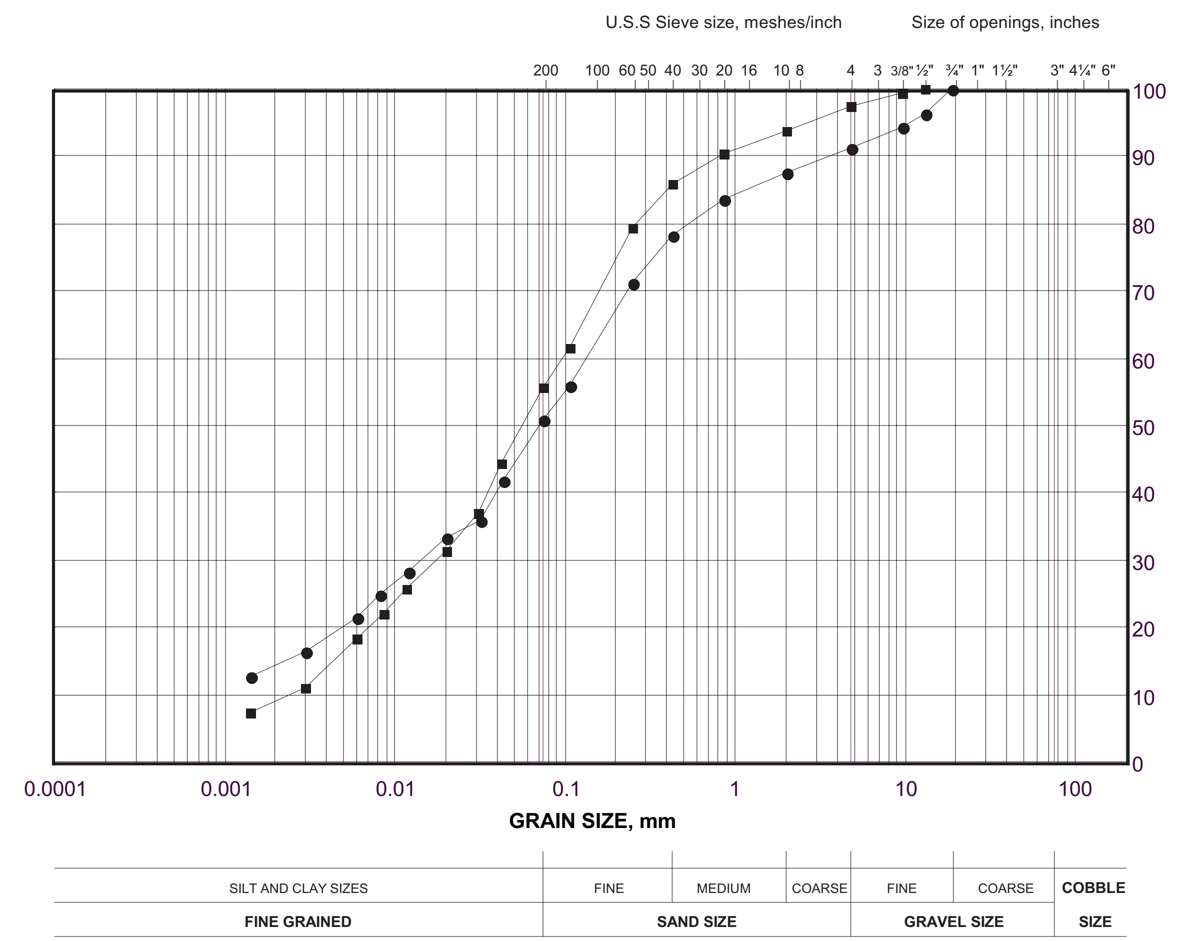
Figure No. WM41-E
Project No. 07-1111-0053
Checked By: KJB

PLASTICITY CHART
Clayey Silt with Sand (Till)

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM41-F



LEGEND

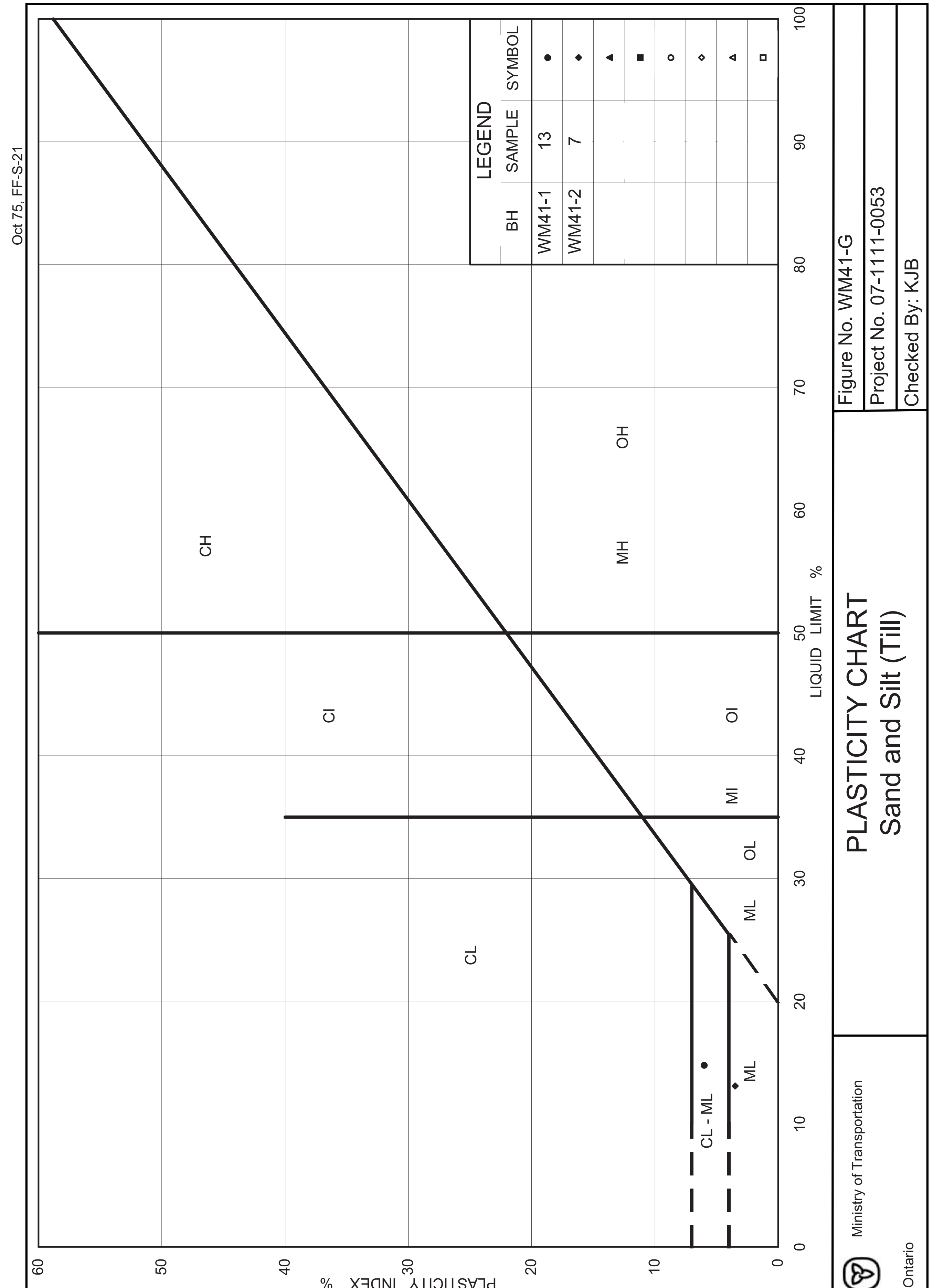
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM41-1	13	143.6
■	WM41-2	7	154.8

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

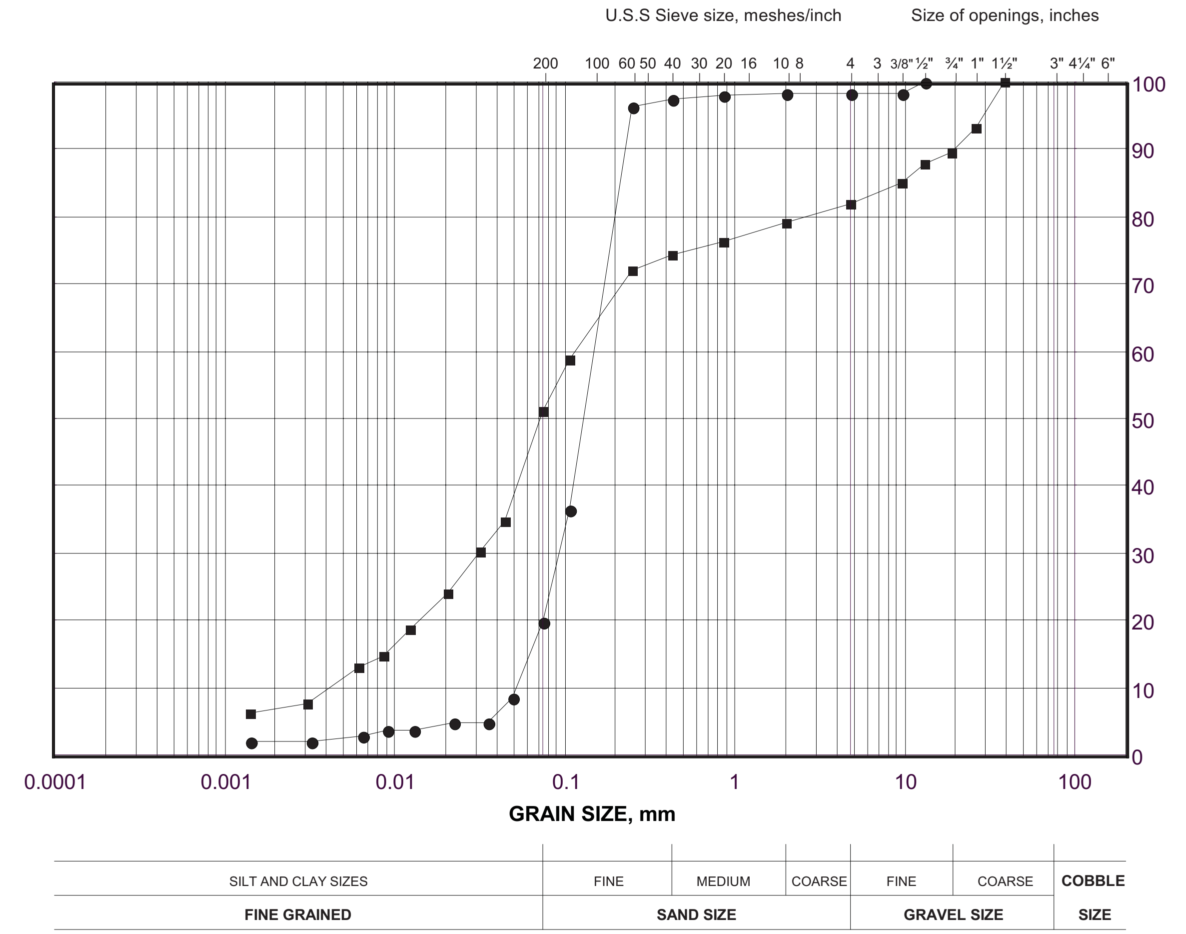
Date: 28-Oct-08



GRAIN SIZE DISTRIBUTION

Silty Sand to Sand and Silt

FIGURE WM41-H



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM41-2	10	150.2
■	WM41-1	9	149.5

Project Number: 07-1111-0053

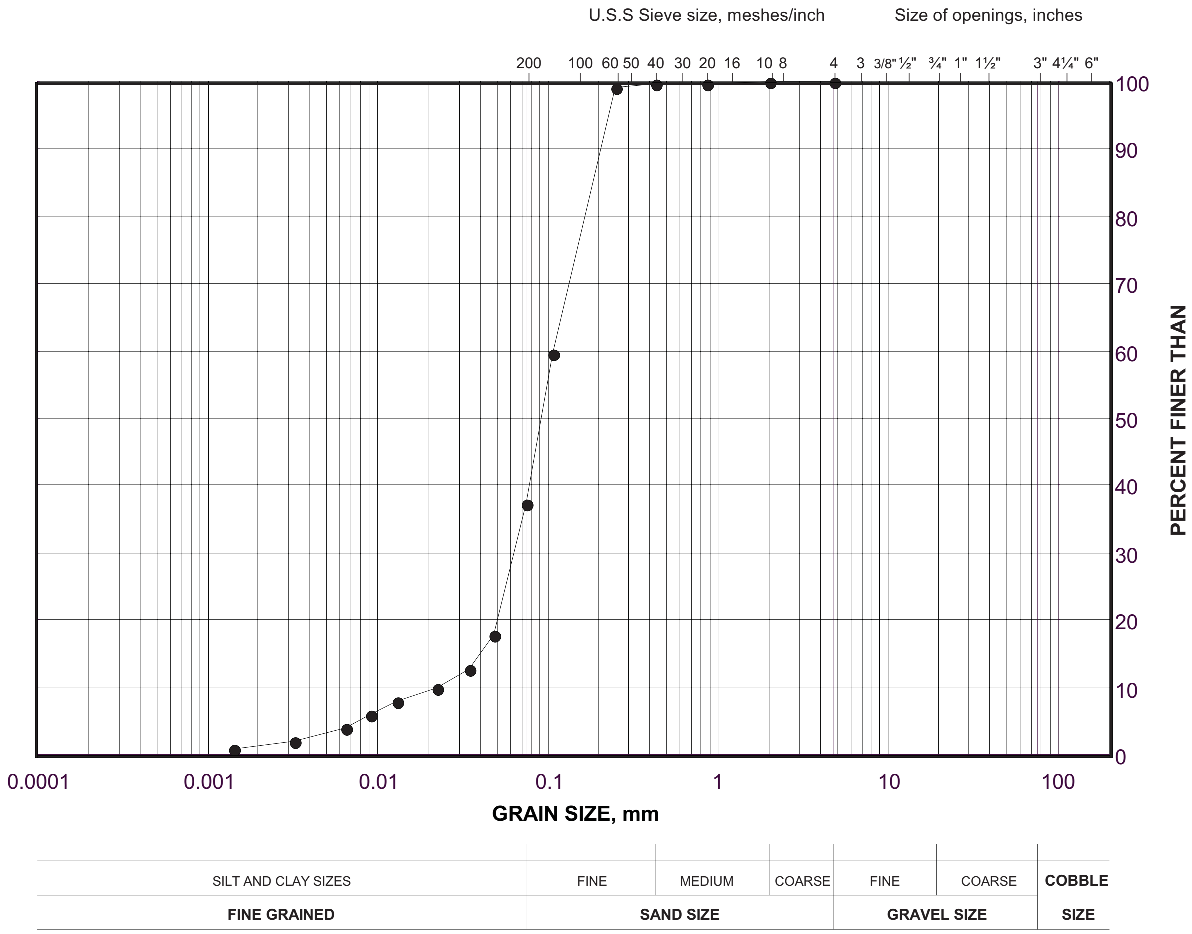
Checked By: KJB

Golder Associates

Date: 28-Oct-08

GRAIN SIZE DISTRIBUTION
Silty Sand to Sand and Silt

FIGURE WM42-A



LEGEND

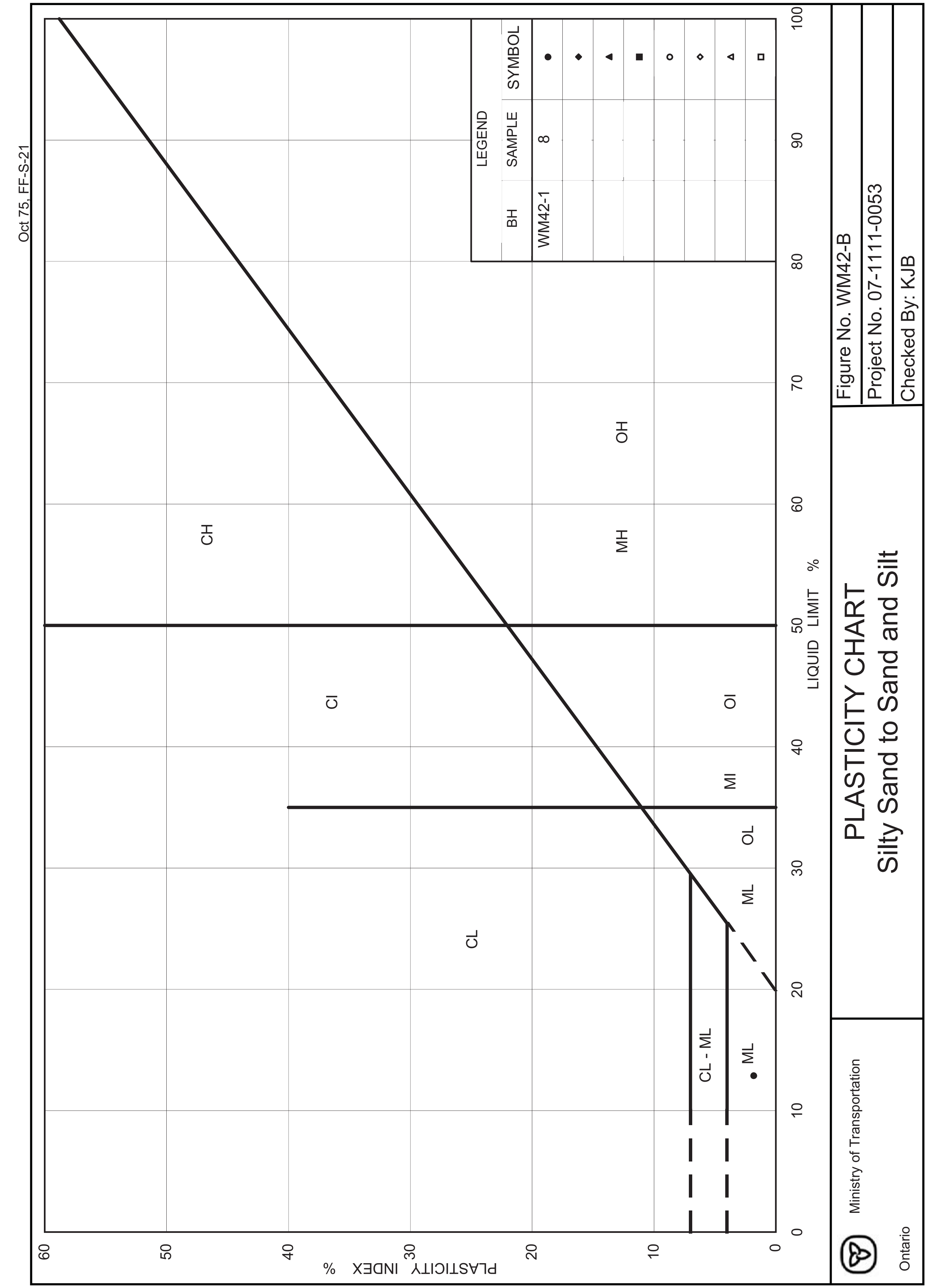
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM42-1	6	158.1

Project Number: 07-1111-0053

Checked By: KJB

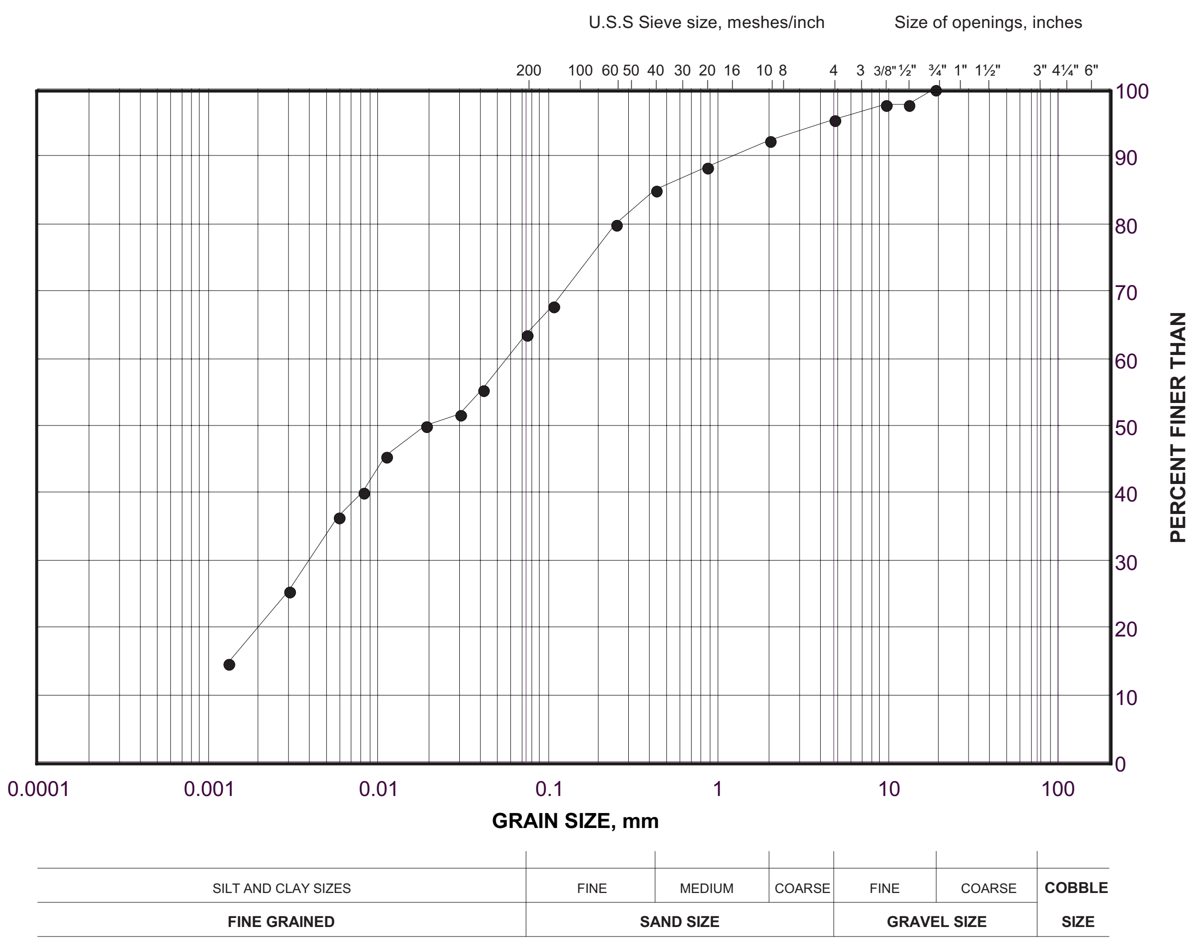
Golder Associates

Date: 22-Sep-08



GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand (Till)

FIGURE WM42-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM42-1	9	153.7

Project Number: 07-1111-0053

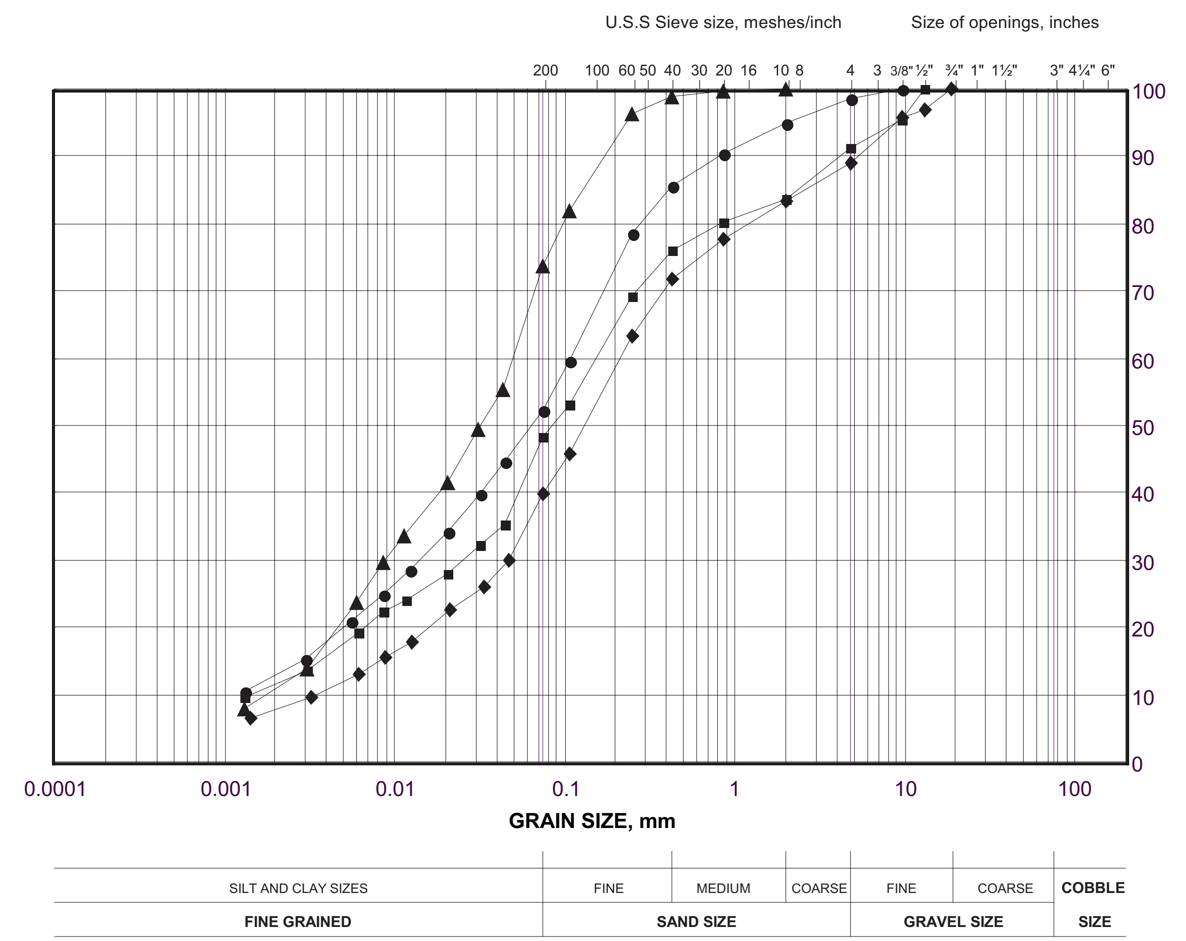
Checked By: KJB

Golder Associates

Date: 27-Oct-08

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WM43-A



LEGEND

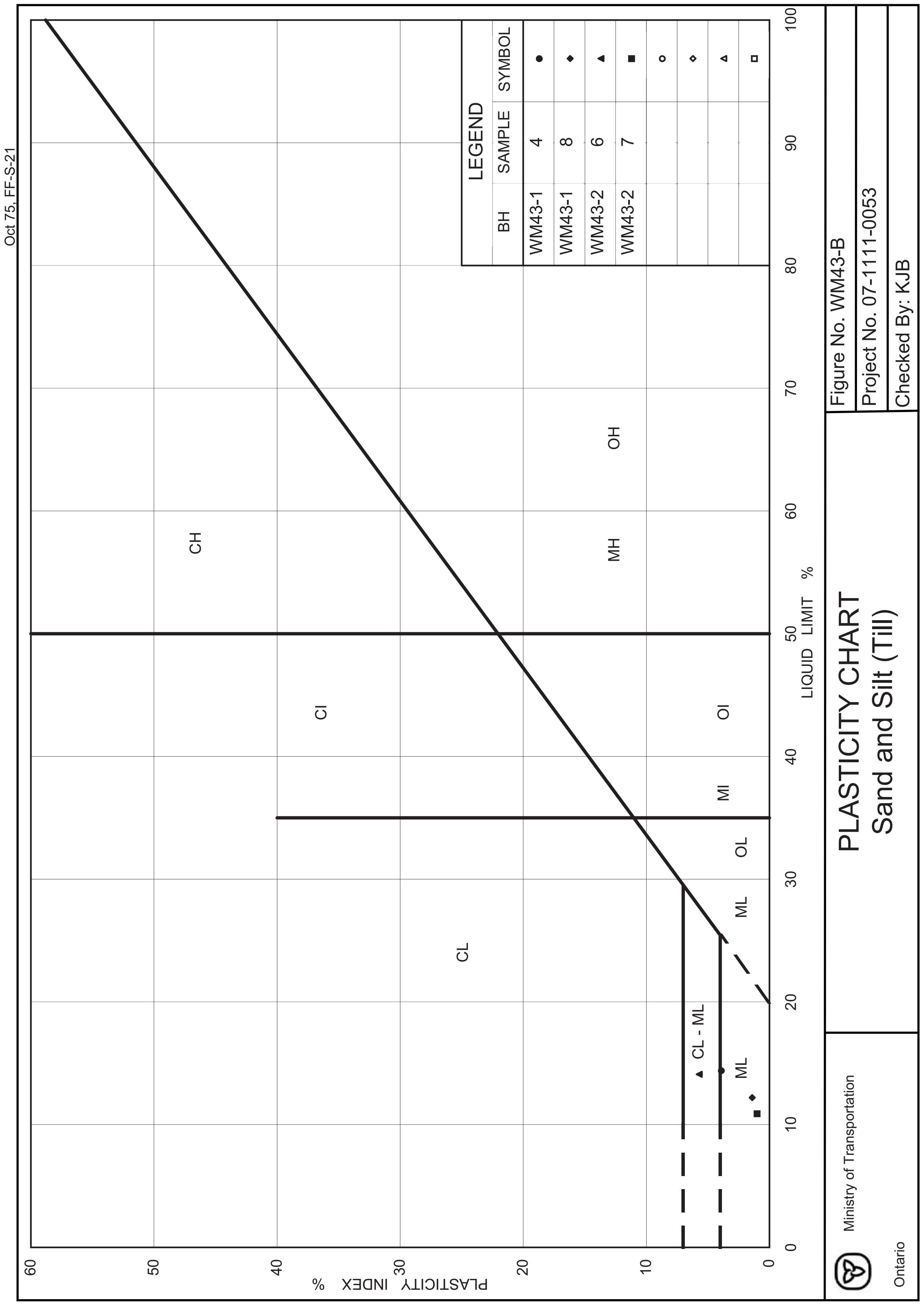
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM43-1	4	161.4
■	WM43-2	6	159.1
◆	WM43-2	7	157.6
▲	WM43-1	8	156.2

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

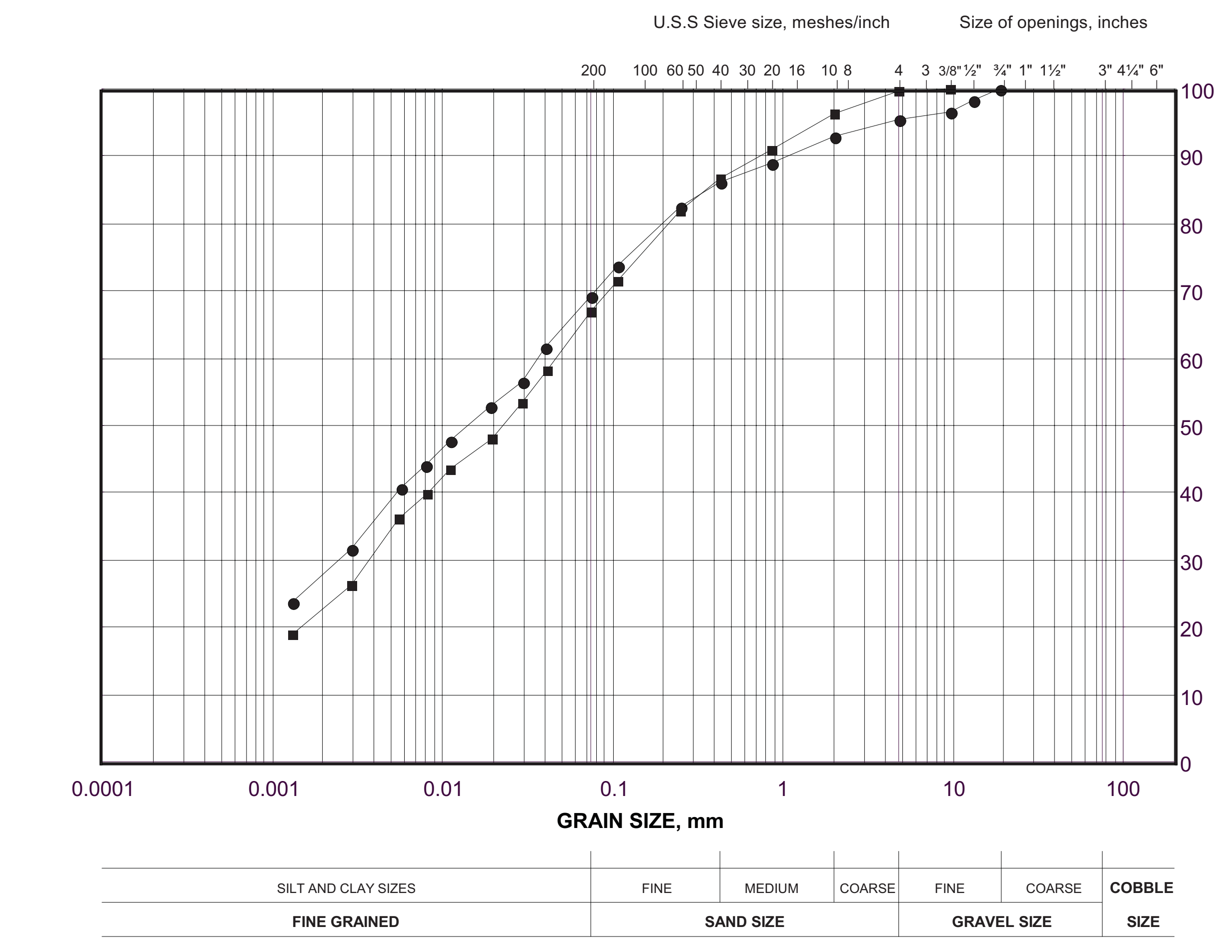
Date: 04-Jul-08



GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Fill)

FIGURE WL2-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL2-1	5	85.7
■	WL2-2	7	86.8

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Sep-08

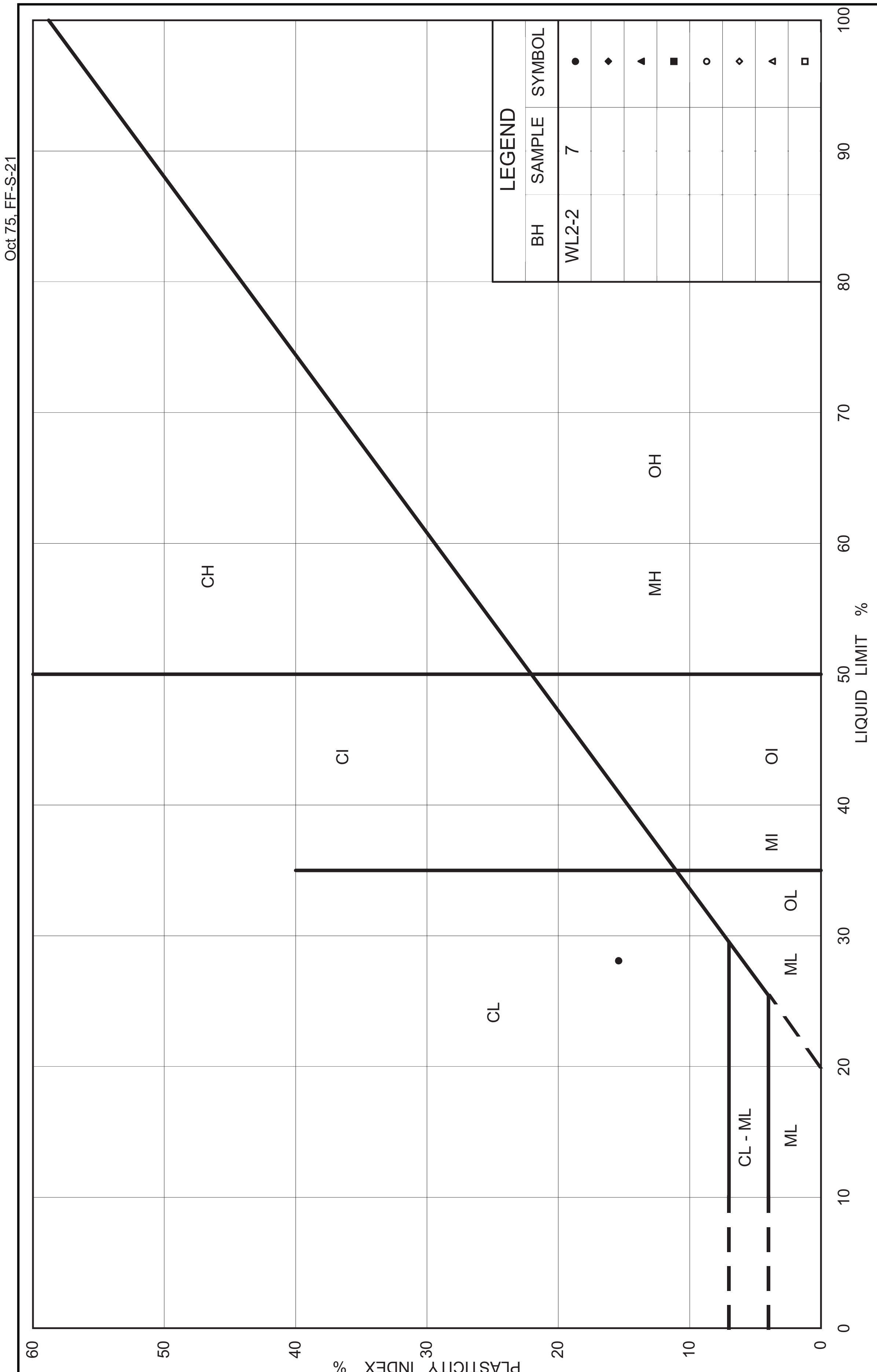


Figure No. WL2-B
Project No. 07-1111-0053
Checked By: KJB

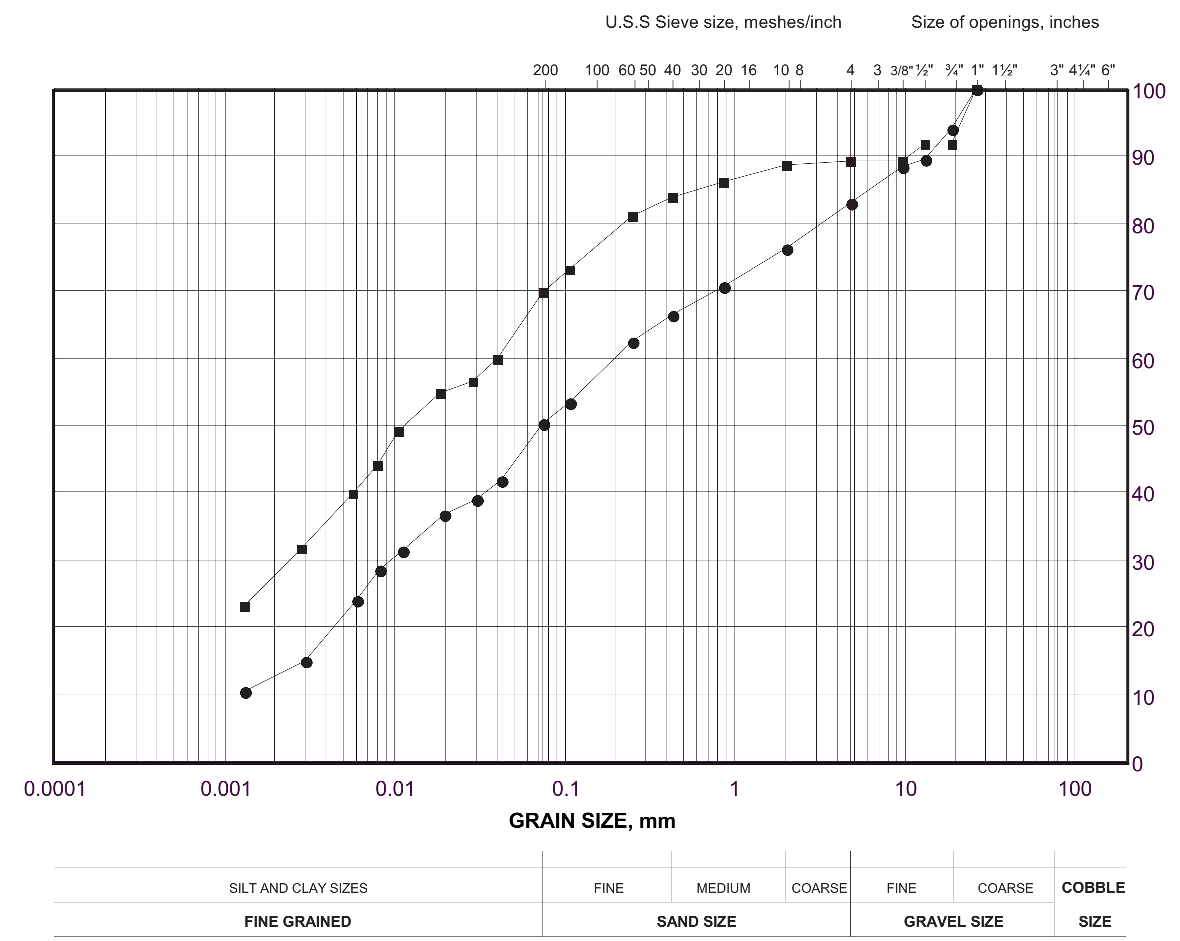
PLASTICITY CHART
Clayey Silt with Sand (Fill)

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE WL2-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL2-2	13	77.7
■	WL2-1	8	81.1

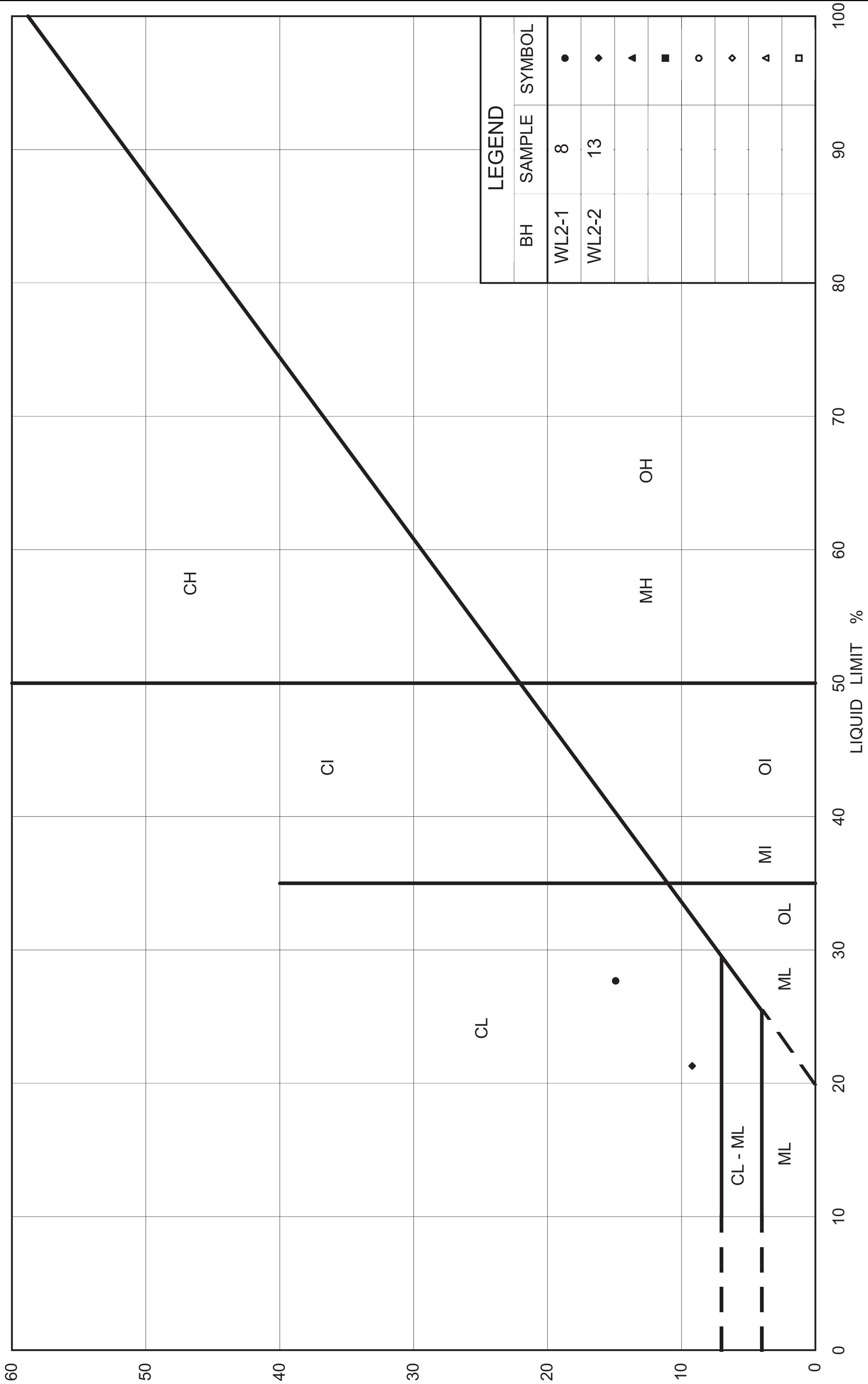
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Sep-08

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
WL2-1	8	●
WL2-2	13	◆

PLASTICITY CHART
Clayey Silt with Sand (Till)

Figure No. WL2-D
Project No. 07-1111-0053
Checked By: KJB

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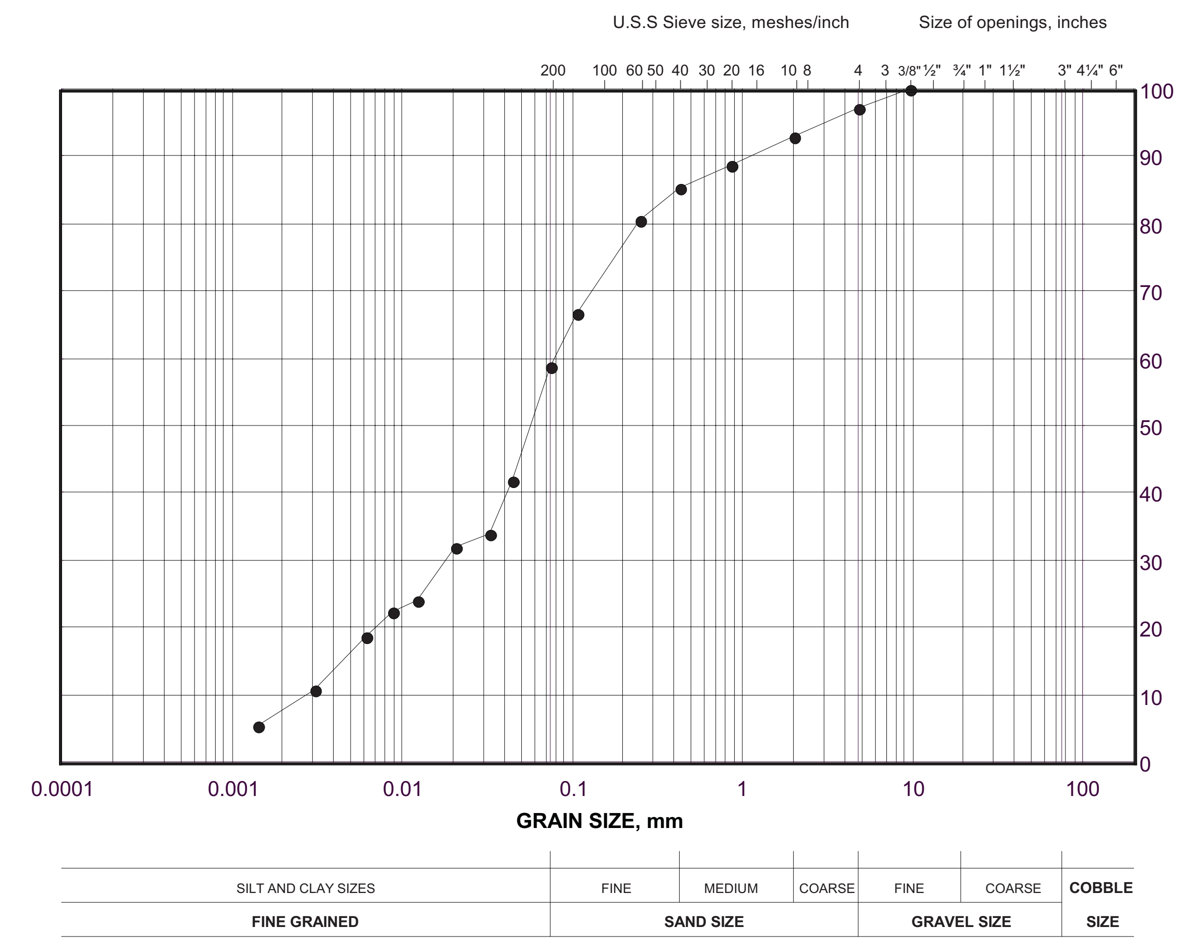
GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WL2-E



LEGEND

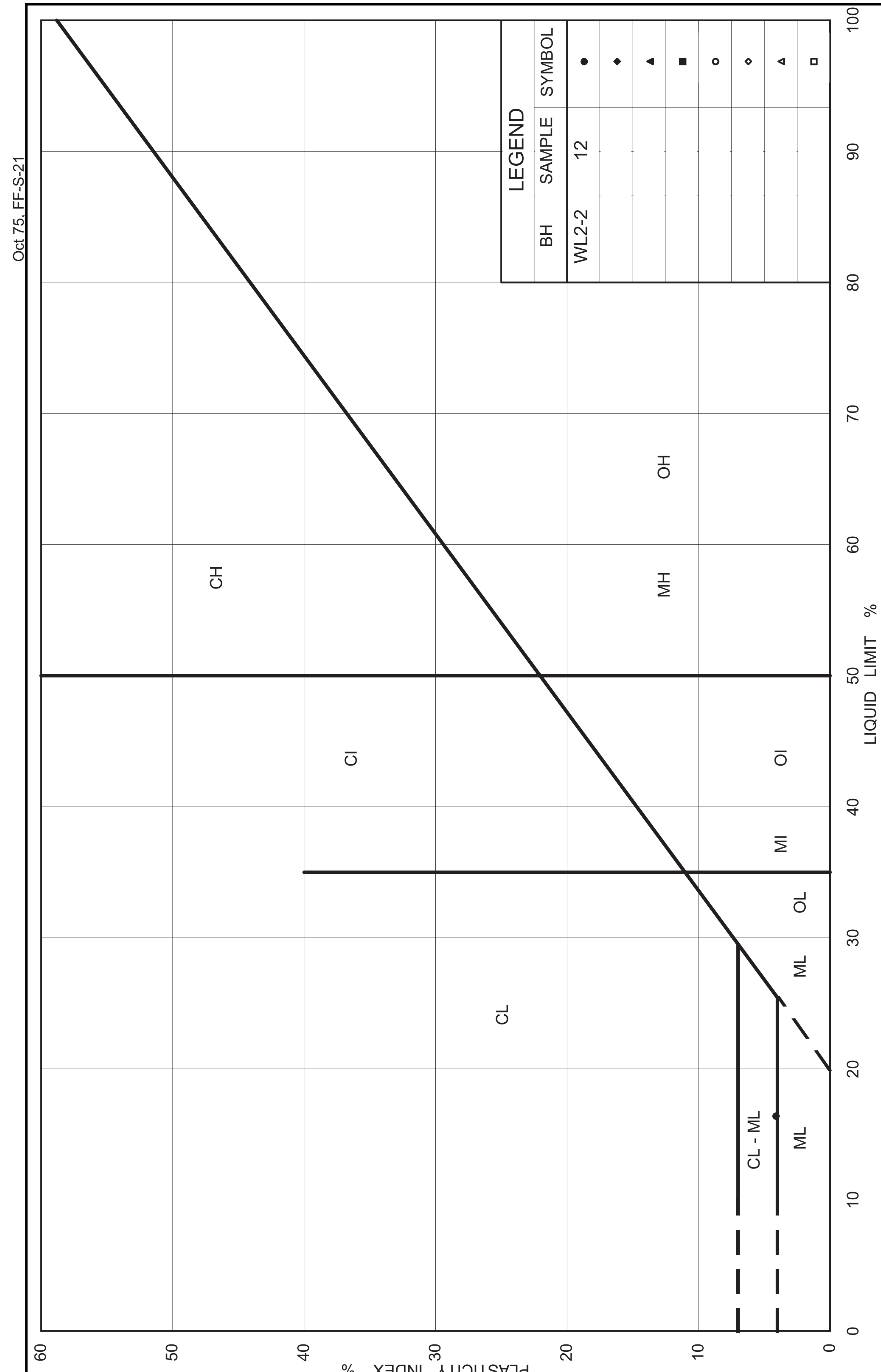
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL2-2	12	79.2

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 04-Sep-08



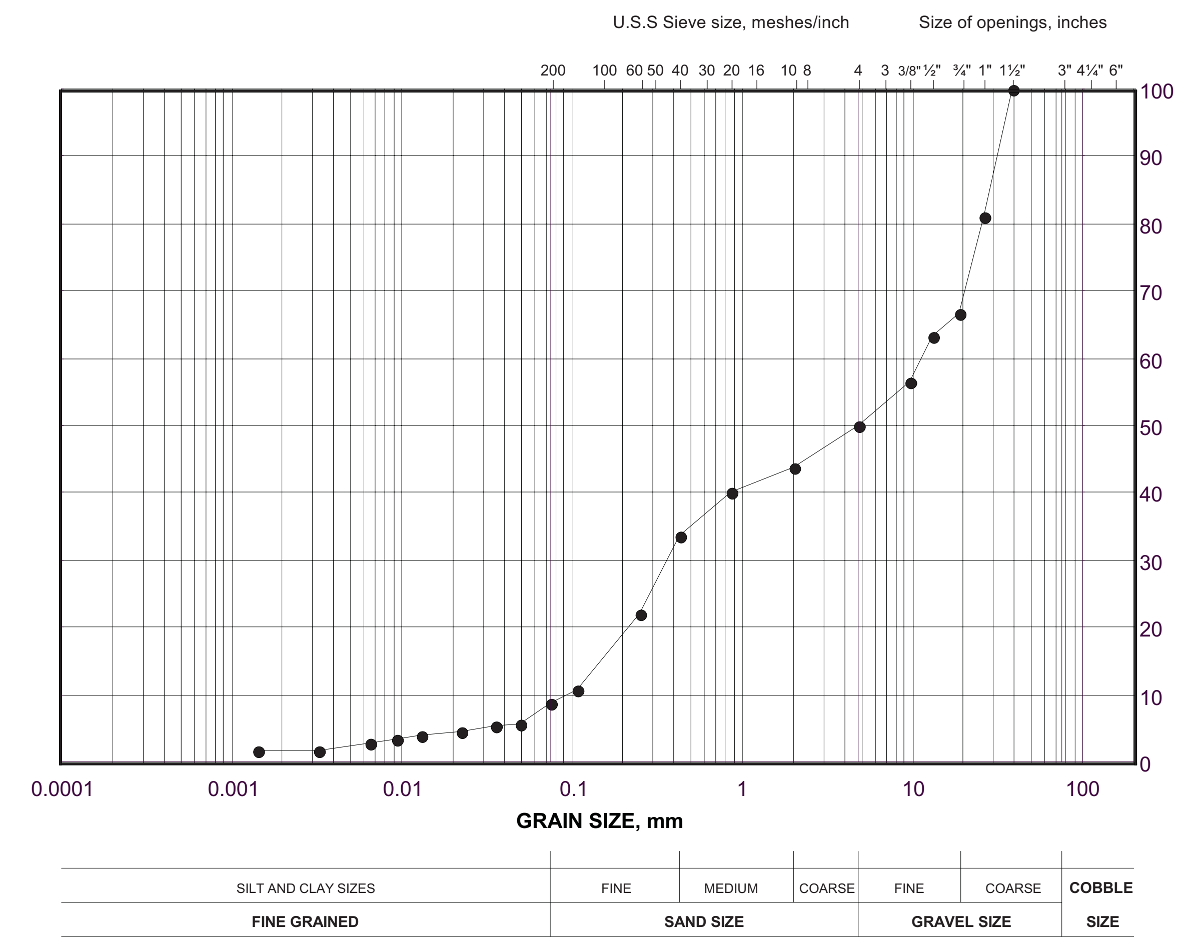
PLASTICITY CHART
Sand and Silt (Till)

Figure No. WL2-F
Project No. 07-1111-0053
Checked By: KJB

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Sand and Gravel (Fill)

FIGURE WL3-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL3-2	3	92.2

Project Number: 07-1111-0053

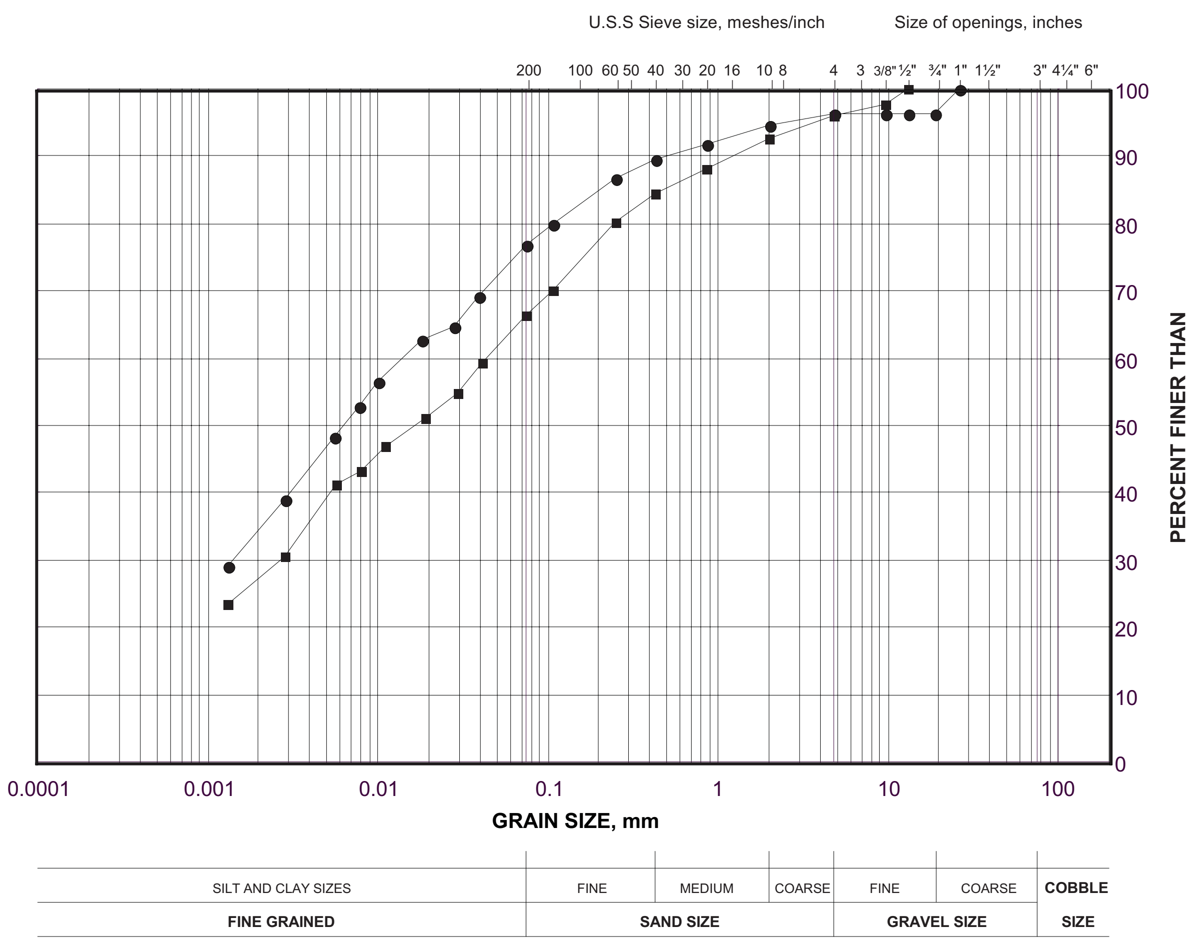
Checked By: KJB

Golder Associates

Date: 12-Sep-08

GRAIN SIZE DISTRIBUTION
Clayey Silt to Silty Clay (Fill)

FIGURE WL3-B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL3-1	6	86.4
■	WL3-2	8	86.1

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 12-Sep-08

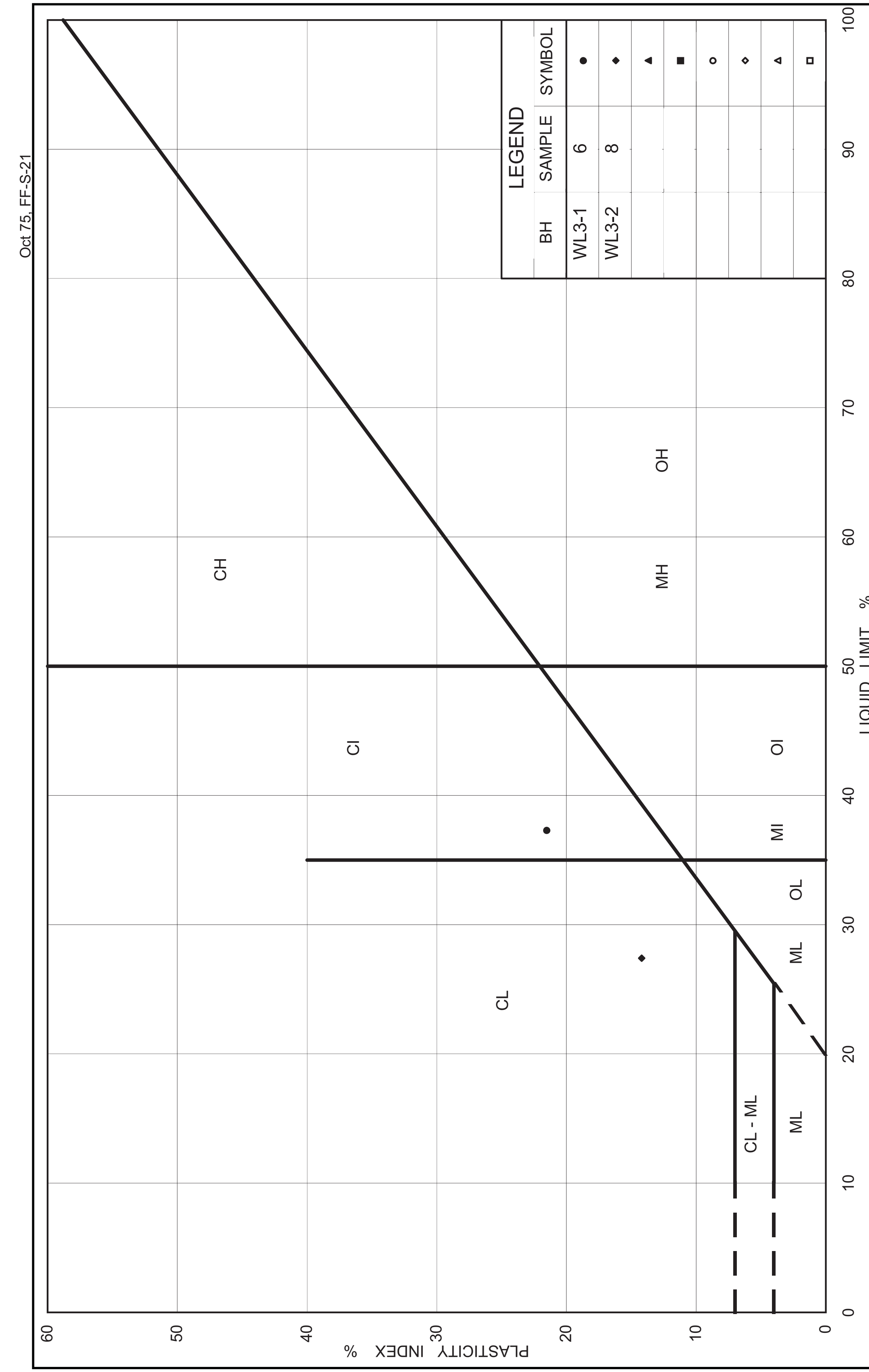


Figure No. WL3-C

Project No. 07-1111-0053

Checked By: KJB

PLASTICITY CHART
Clayey Silt to Silty Clay (Fill)

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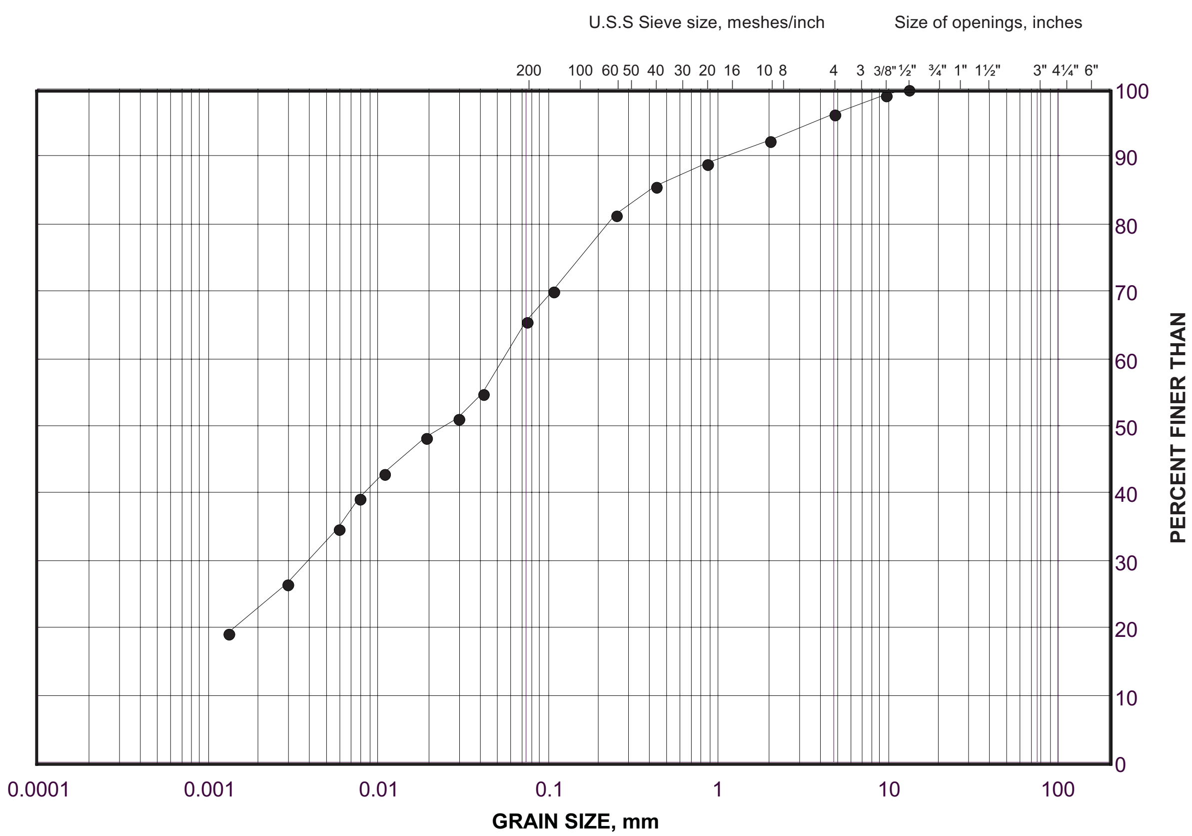
GRAIN SIZE DISTRIBUTION Clayey Silt with Sand (Till)	FIGURE WL3-D



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL3-3	5	84.6

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 12-Sep-08

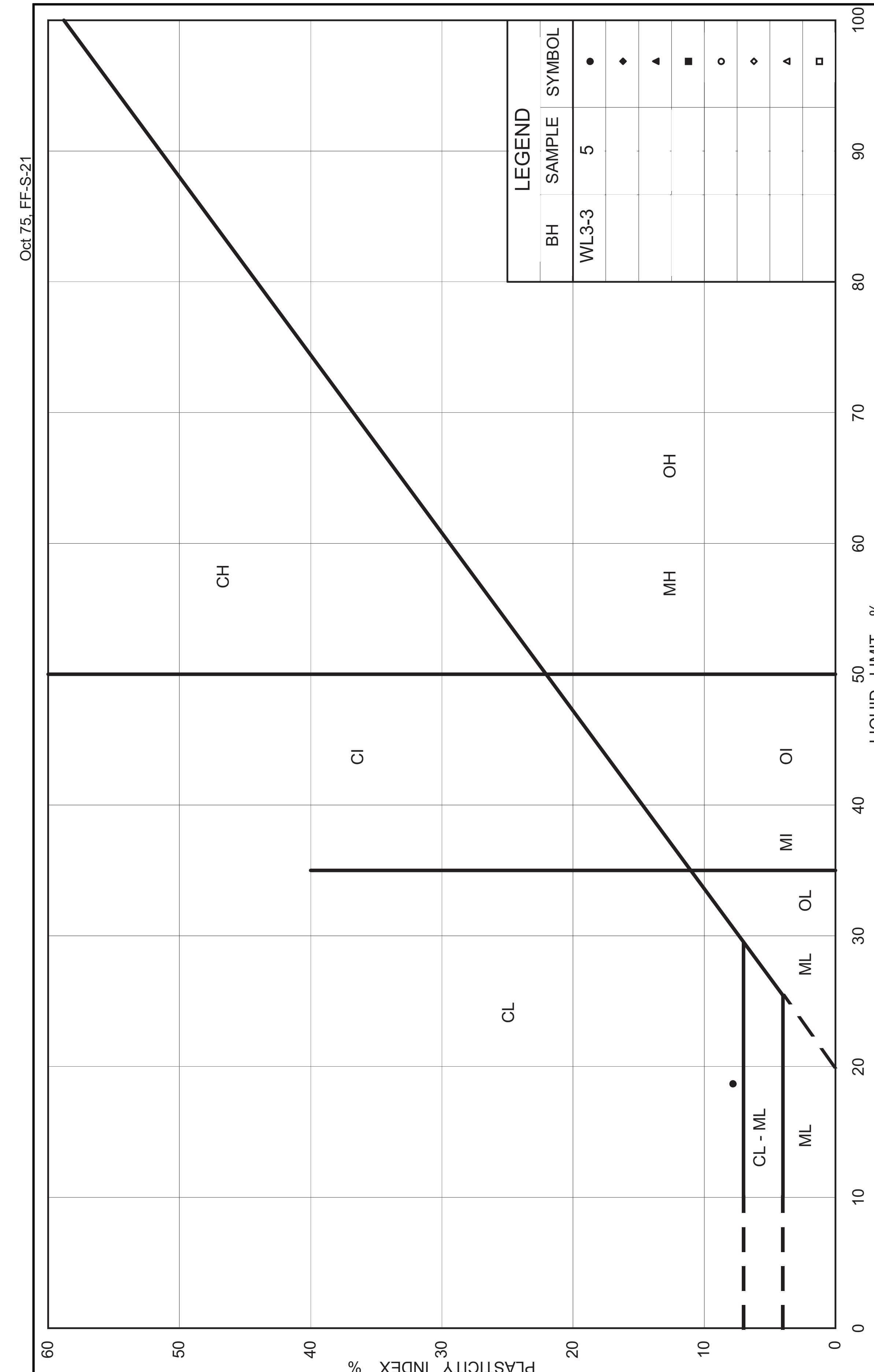


Figure No. WL3-E

Project No. 07-1111-0053

Checked By: KJB

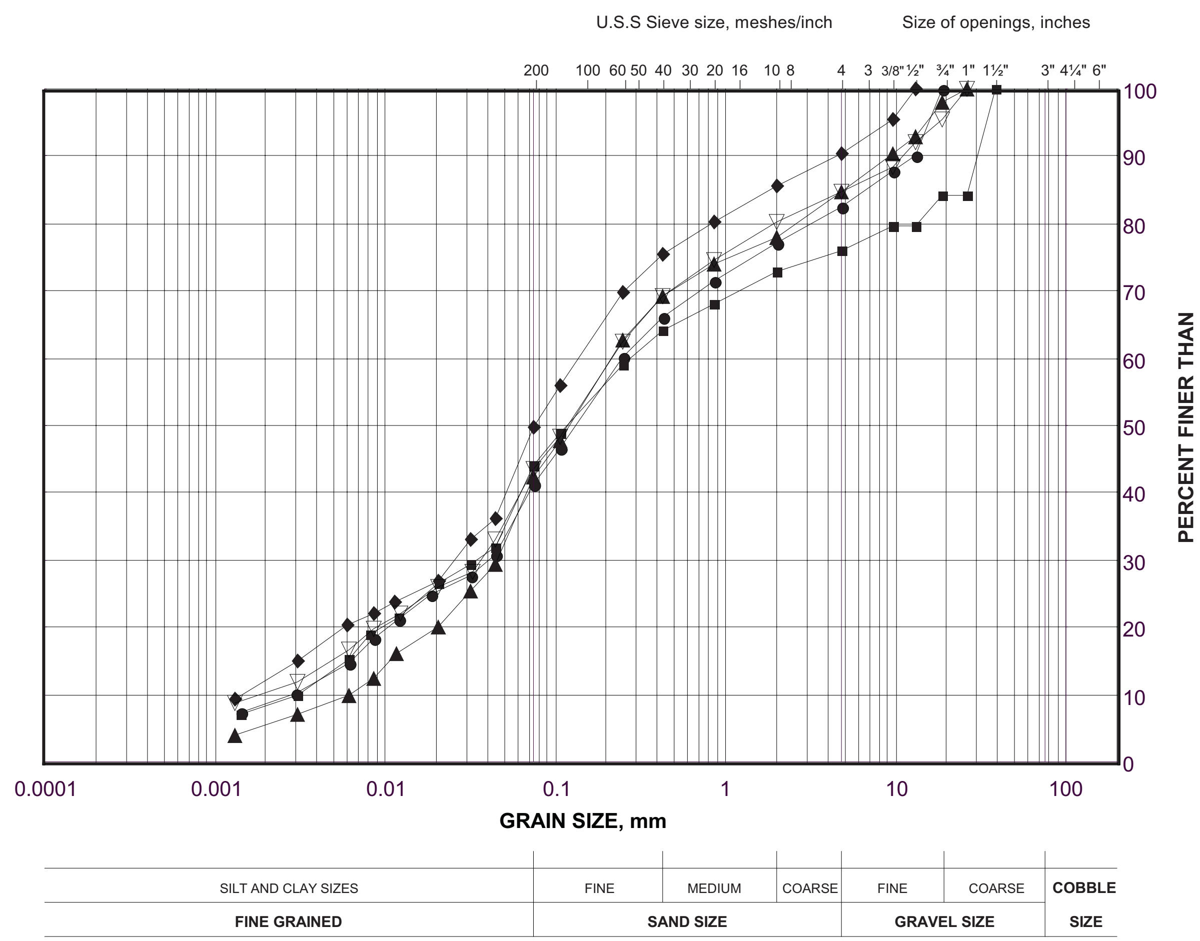
PLASTICITY CHART

Clayey Silt with Sand (Till)

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION Sand and Silt (Till)	FIGURE WL3-F



LEGEND

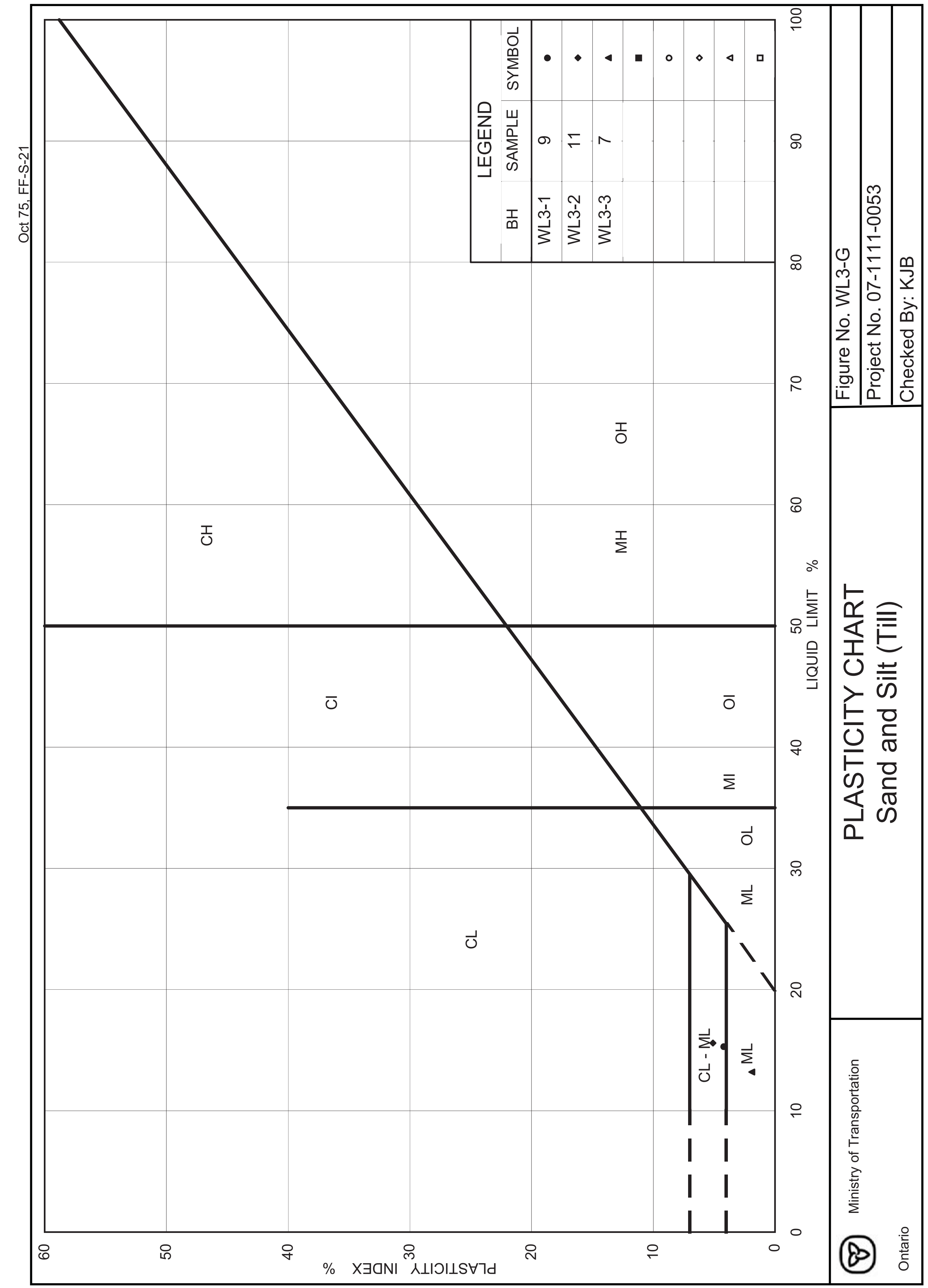
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL3-2	11	81.5
■	WL3-1	11	78.8
◆	WL3-2	13	78.5
▲	WL3-3	7	81.8
▽	WL3-1	9	81.9

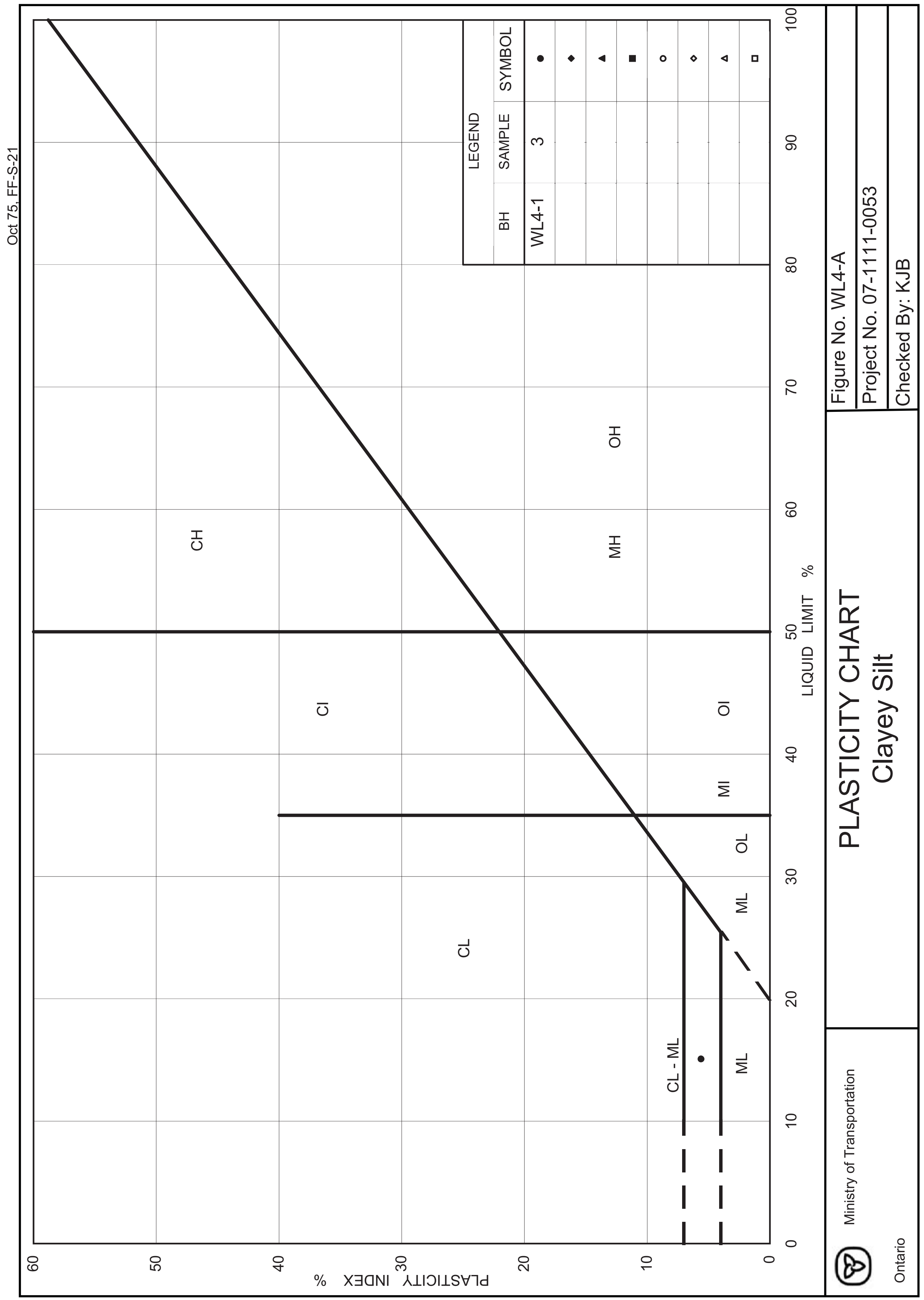
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 12-Sep-08

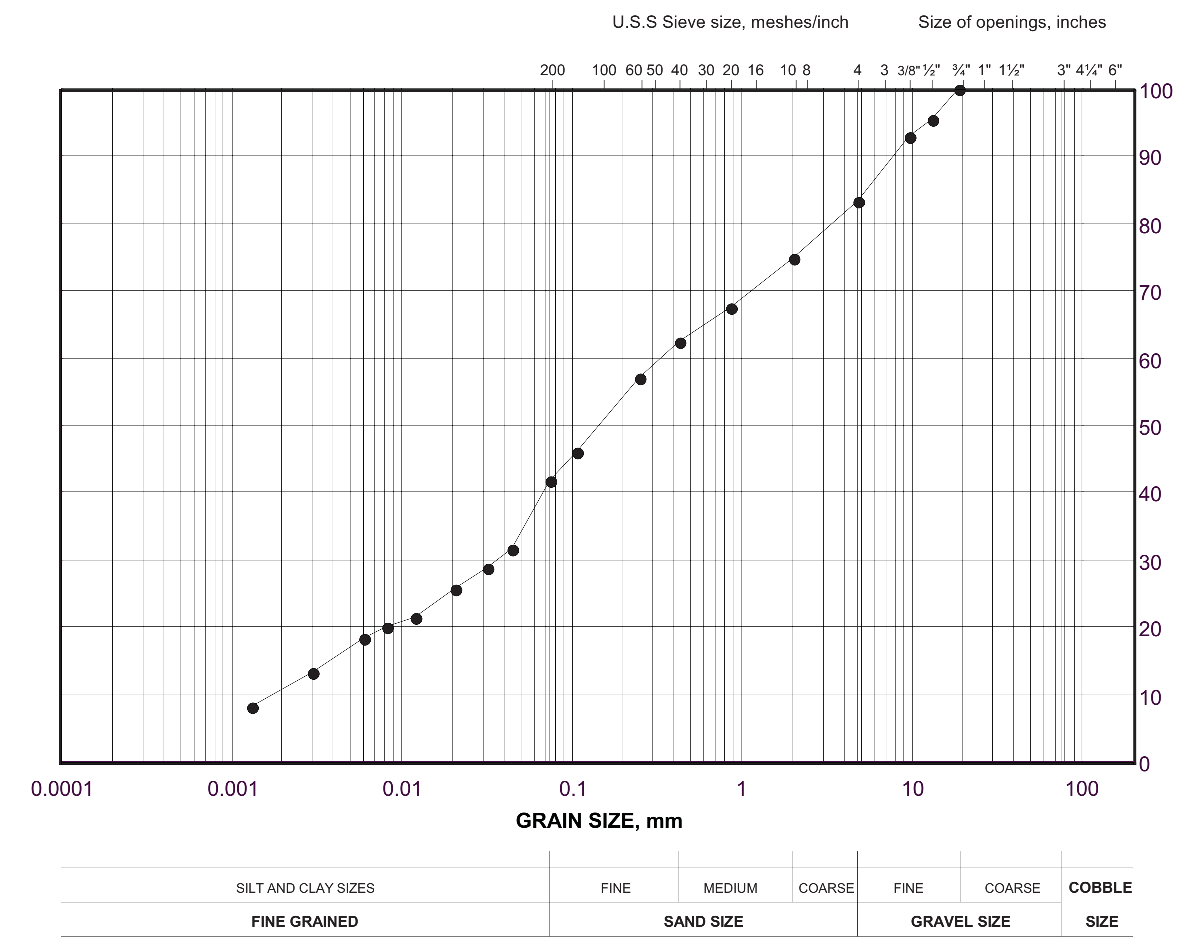




GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE WL4-B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL4-1	5	79.7

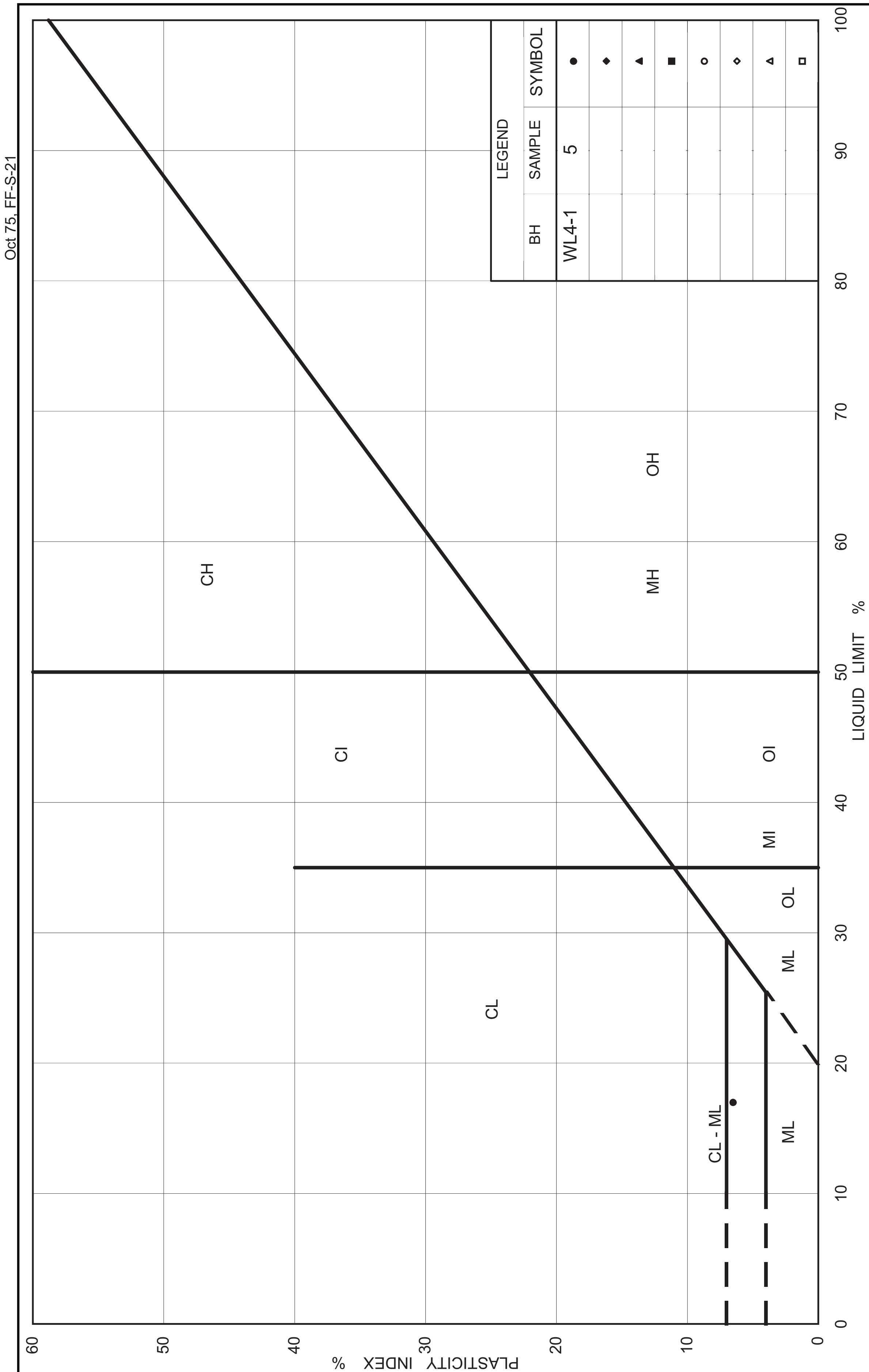
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 06-Aug-08

Oct 75, FF-S-21



PLASTICITY CHART
Clayey Silt with Sand (Till)

Figure No. WL4-C
Project No. 07-1111-0053
Checked By: KJB

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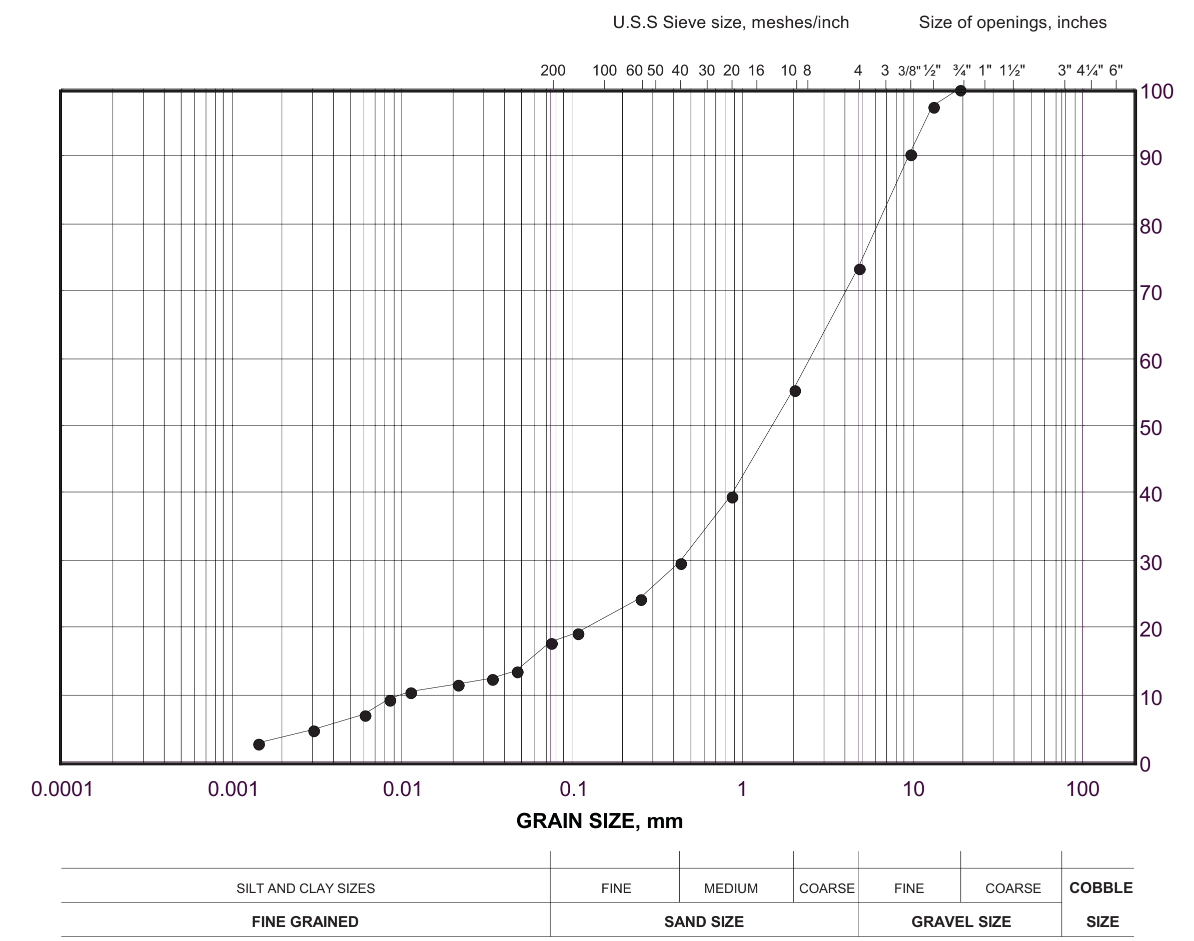
GRAIN SIZE DISTRIBUTION
Gravelly Sand

FIGURE WL4-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL4-1	8	75.2

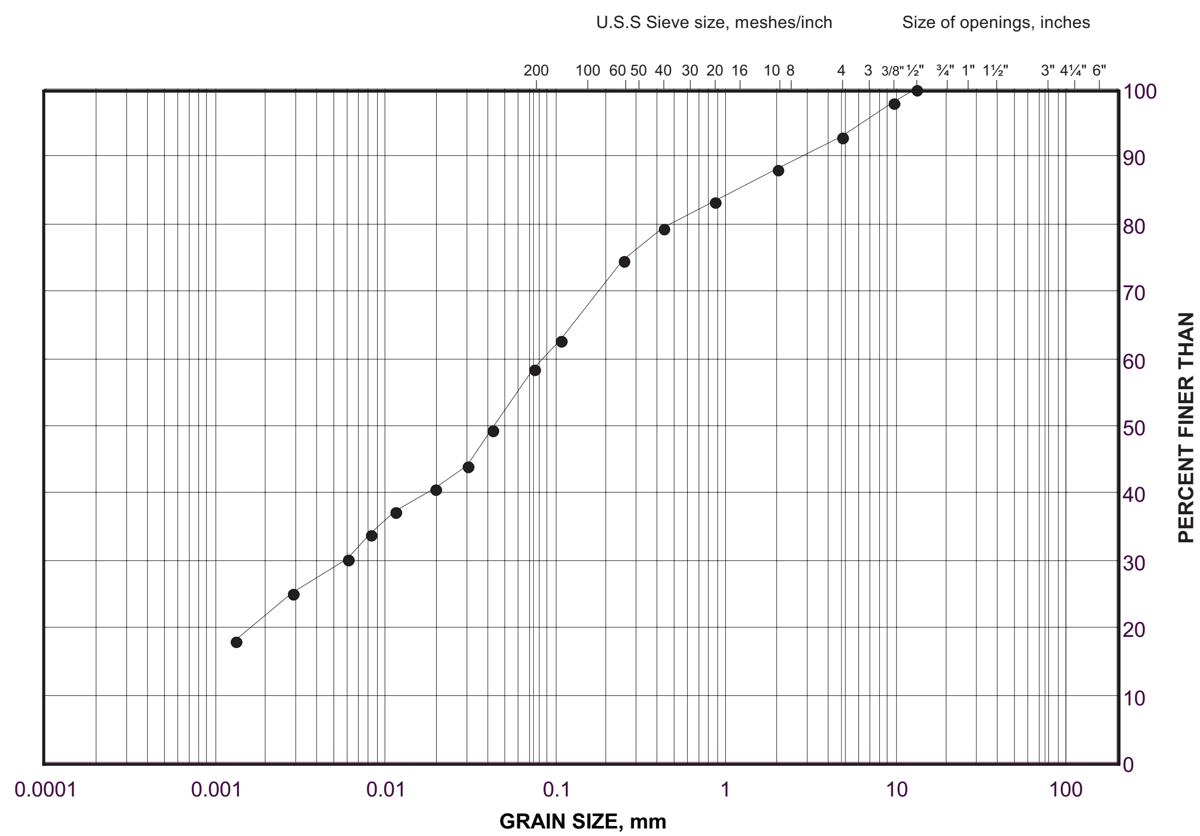
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 06-Aug-08

GRAIN SIZE DISTRIBUTION Clayey Silt to Silty Clay	FIGURE WL5-A



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

LEGEND

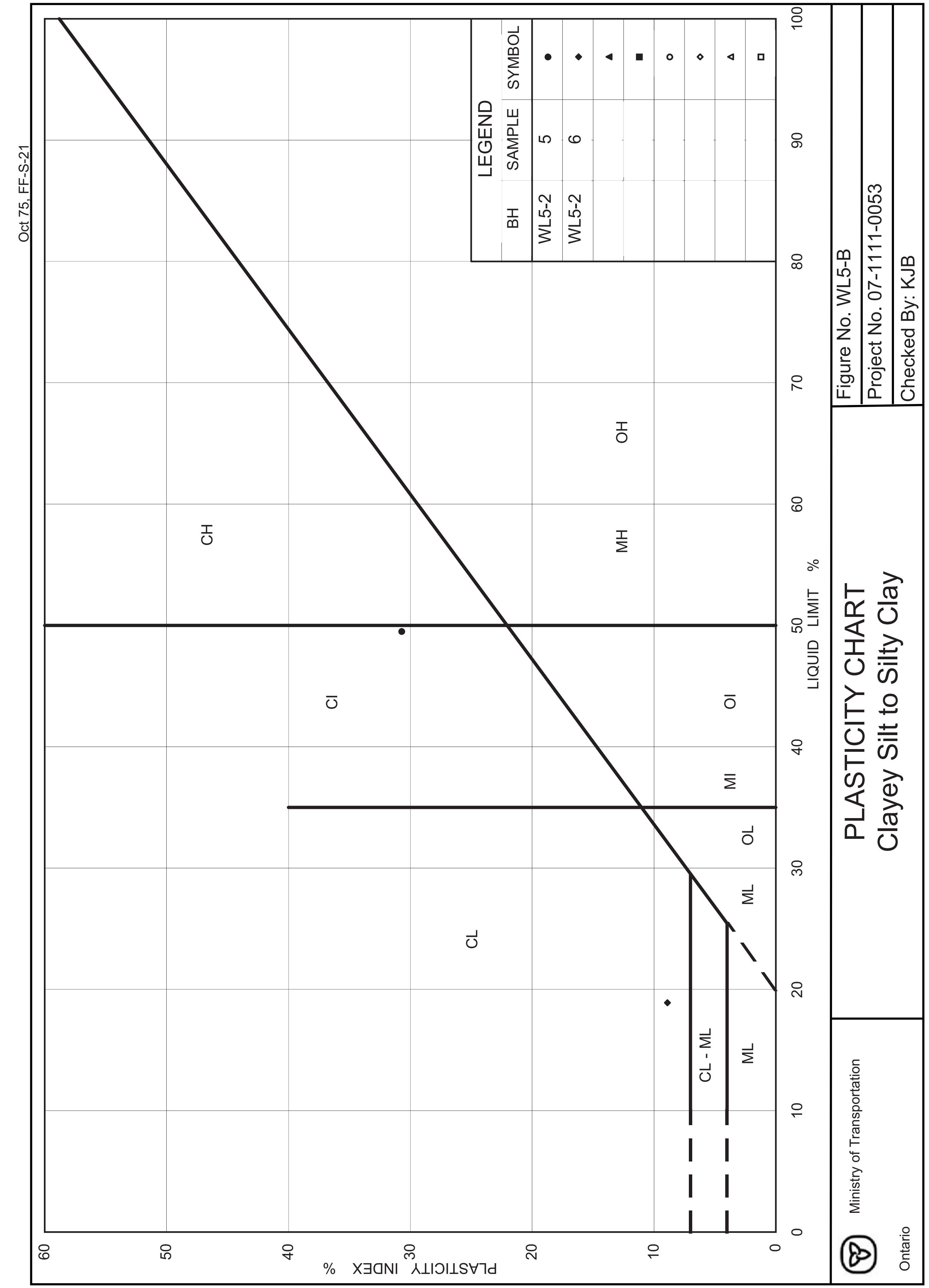
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL5-2	6	75.1

Project Number: 07-1111-0053

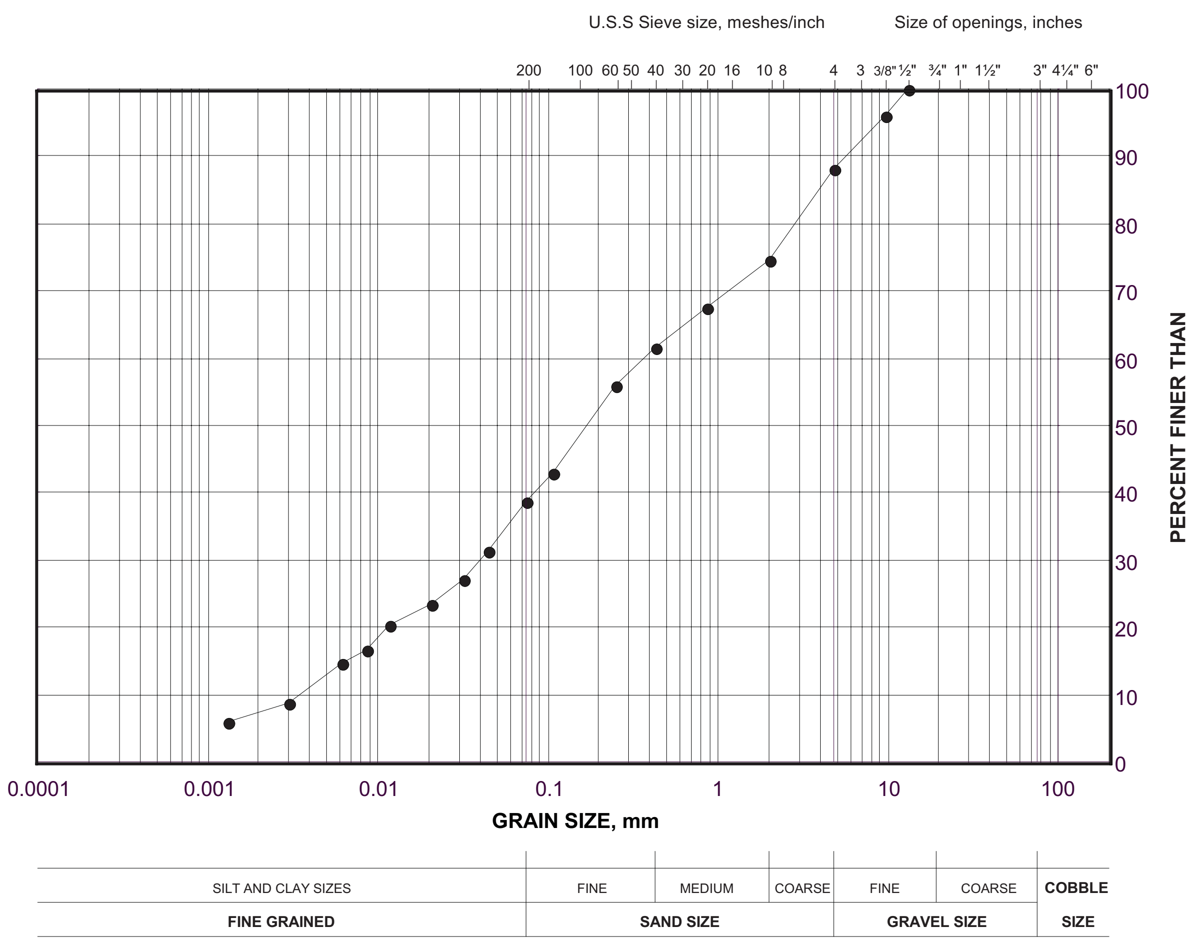
Checked By: KJB

Golder Associates

Date: 12-Aug-08



GRAIN SIZE DISTRIBUTION Silty Sand (Till)	FIGURE WL5-C



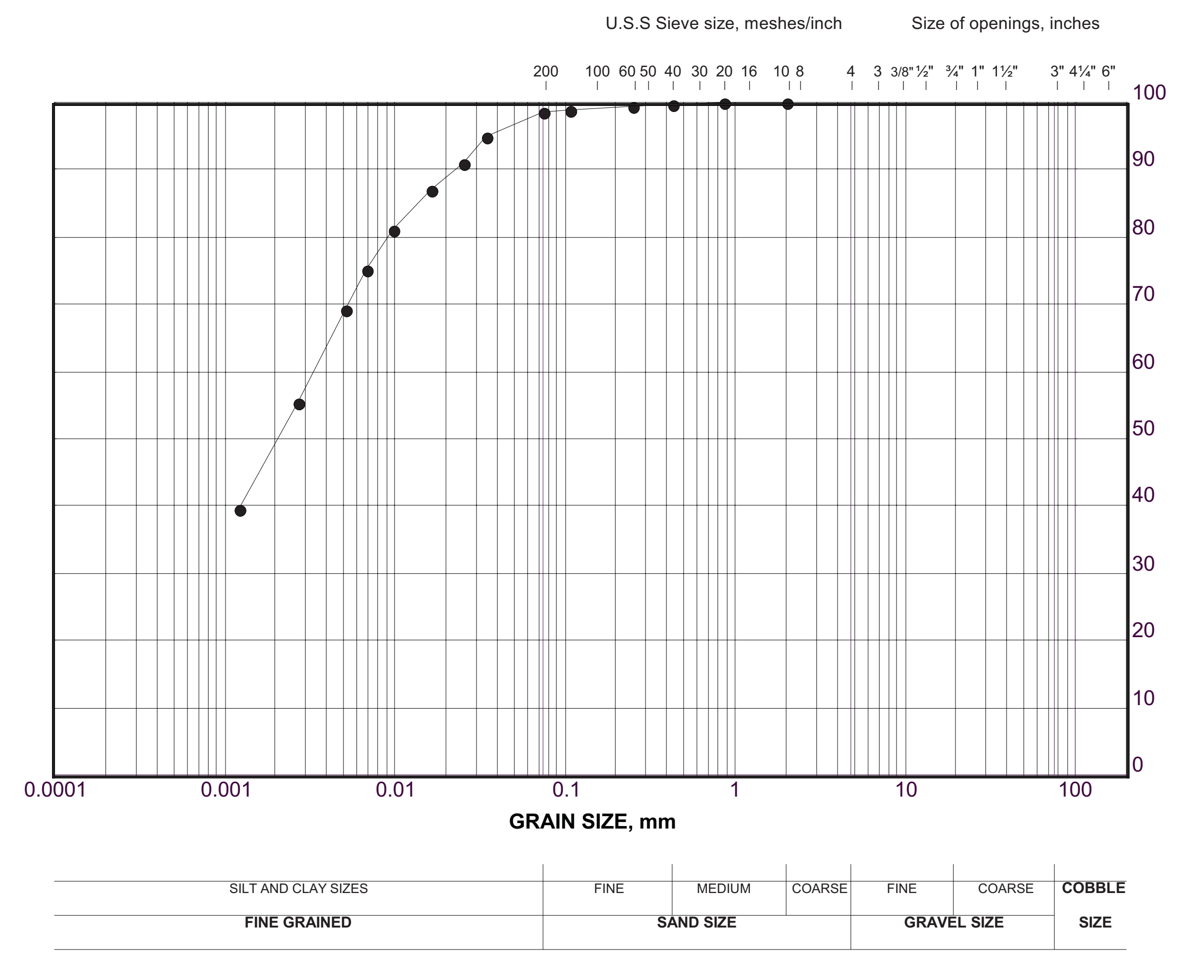
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL5-2	7	73.6

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 12-Aug-08

GRAIN SIZE DISTRIBUTION Silty Clay	FIGURE WLTALC51C/WL7-A

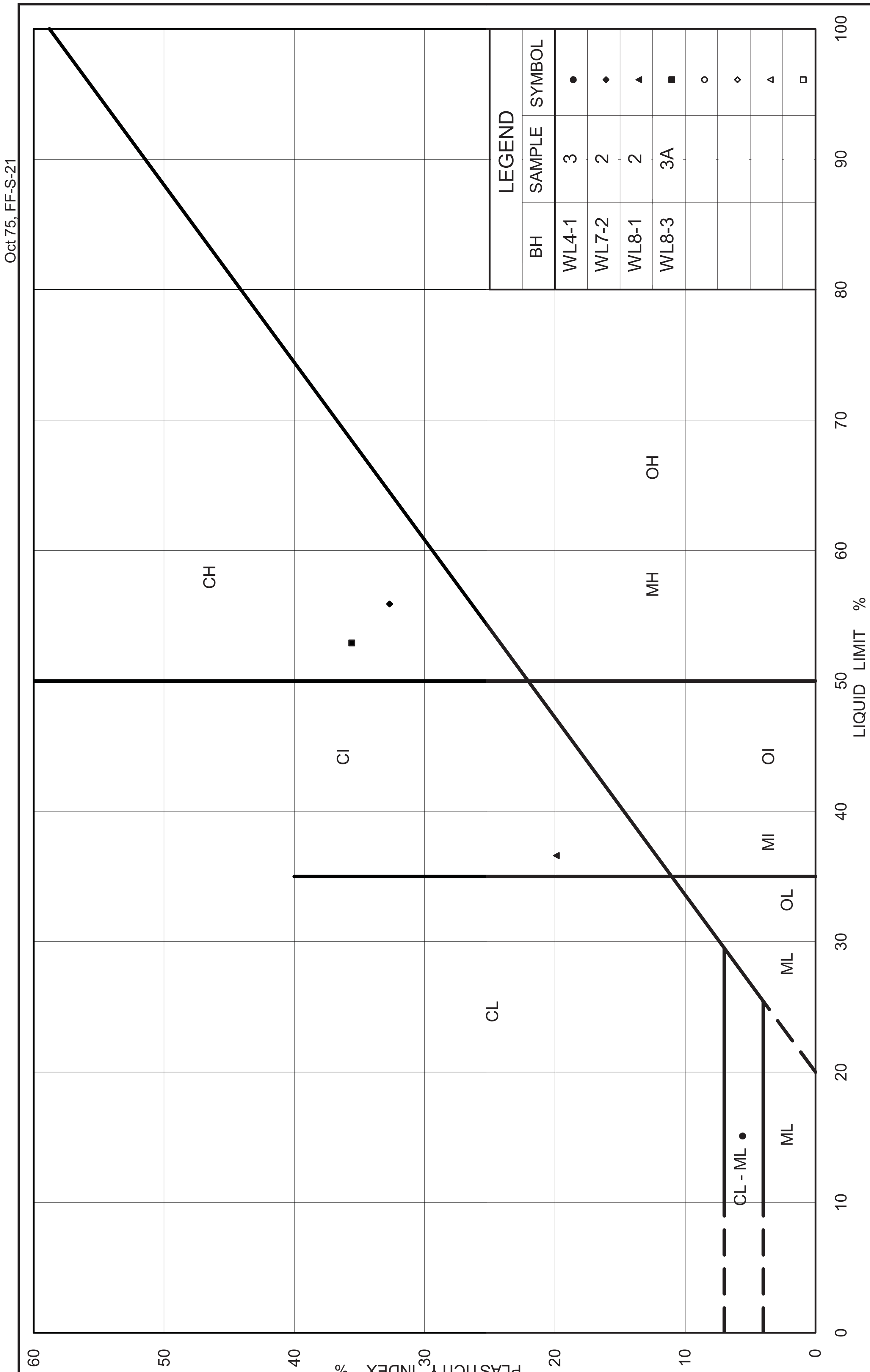


LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL8-3	3A	80.4

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 25-Jul-08



PLASTICITY CHART
Clayey Silt to Clay

Figure No. WLTALC51C/WL7-B
Project No. 07-1111-0053
Checked By: KJB

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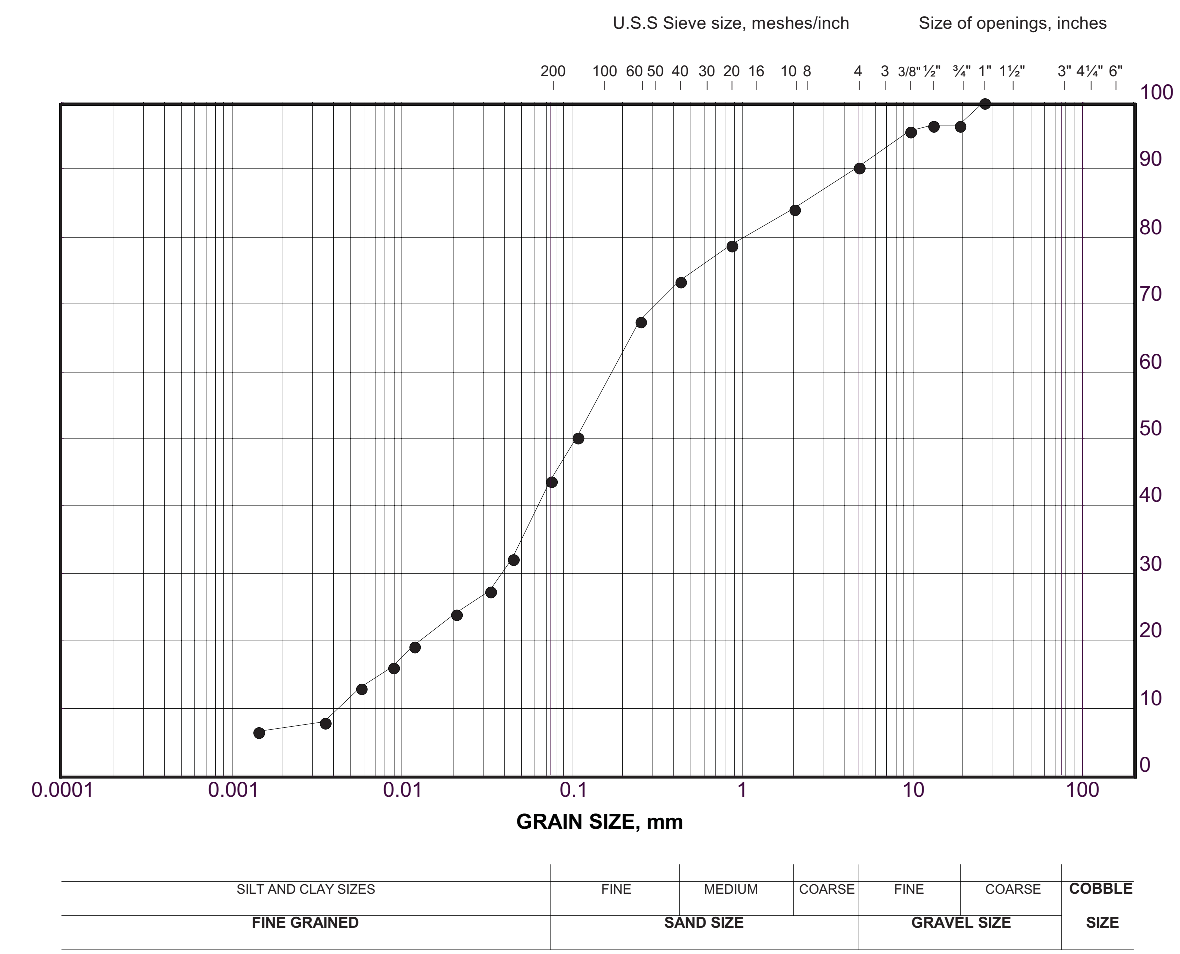
GRAIN SIZE DISTRIBUTION
Sand and Silt (Till-Like)

FIGURE
WLTALC51C/WL7-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL8-3	6	77.1

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 25-Jul-08

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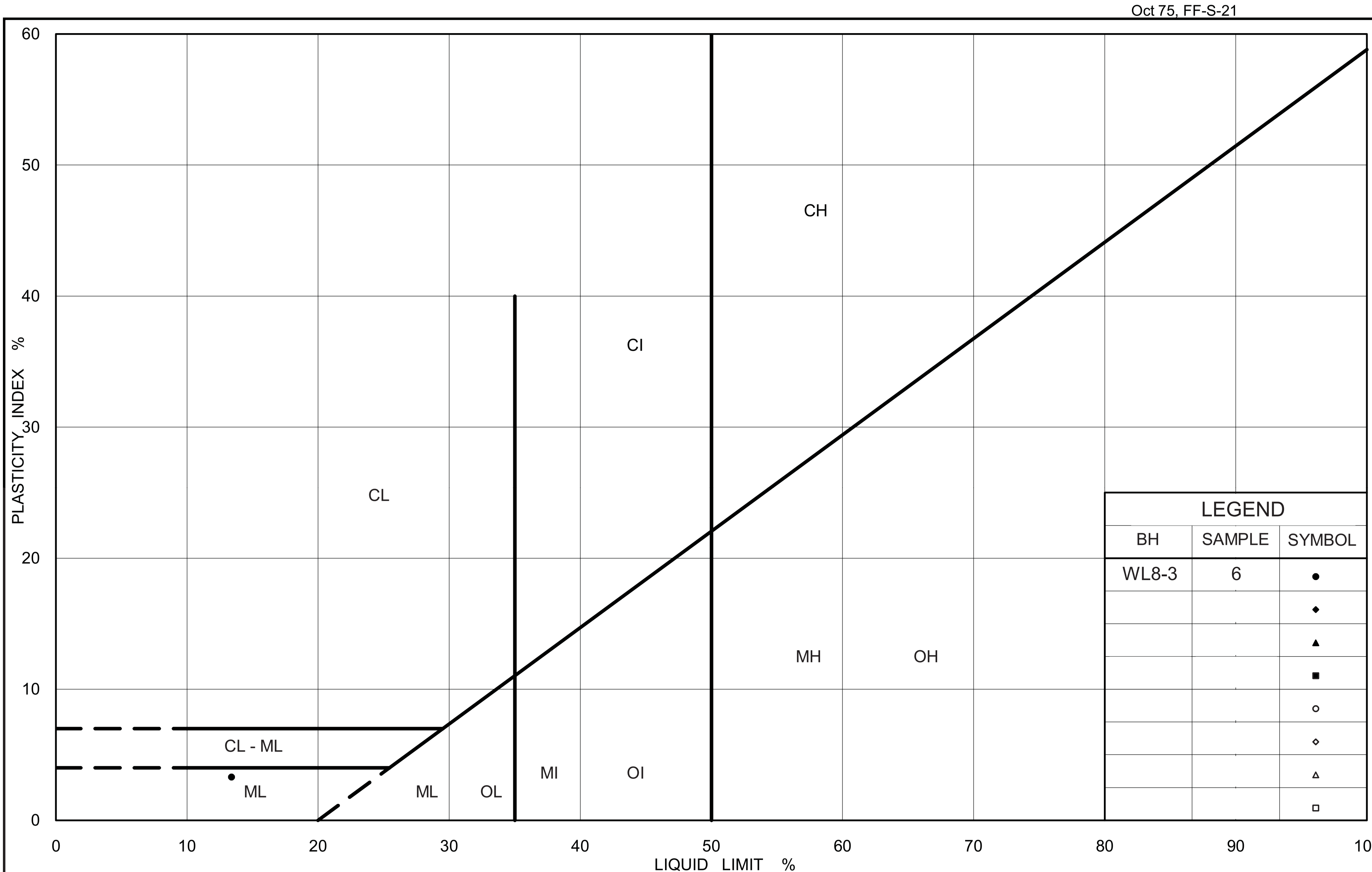

Ministry of Transportation

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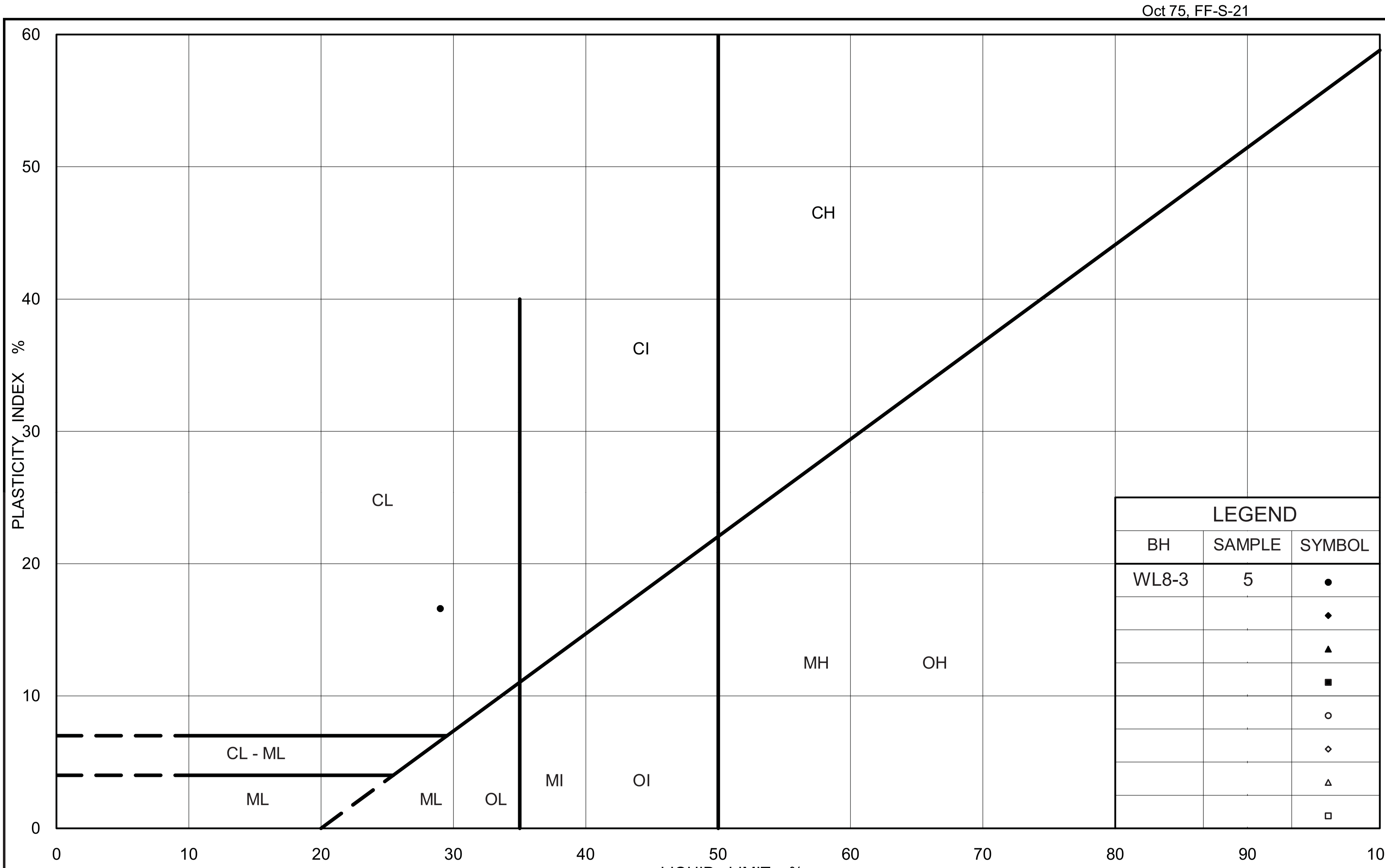
PLASTICITY CHART
Sand and Silt (Till-Like)

Figure No. WLTALC51C/WL7-D

Project No. 07-1111-0053

Checked By: KJB

Oct 75, FF-S-21



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PLASTICITY CHART
Clayey Silt with Sand (Till-Like)

Figure No. WLTALC51C/WL7-E

Project No. 07-1111-0053

Checked By: KJB

CONSOLIDATION TEST SUMMARY

Clayey Silt with Sand (Till-Like)

FIGURE WLTALC51C/WL7-F1

SAMPLE IDENTIFICATION

Project Number	07-1111-0053	Sample Number	4A
Borehole Number	WL8-3	Sample Depth, m	1.8-2.4

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	7		
Date Started	02/28/2008		
Date Completed	03/15/2008		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.26	Unit Weight, kN/m^3	18.16
Sample Diameter, cm	4.96	Dry Unit Weight, kN/m^3	12.99
Area, cm^2	19.33	Specific Gravity, measured	2.79
Volume, cm^3	24.37	Solids Height, cm	0.599
Water Content, %	39.79	Volume of Solids, cm^3	11.58
Wet Mass, g	45.15	Volume of Voids, cm^3	12.80
Dry Mass, g	32.30	Degree of Saturation, %	100.4

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.261	1.106	1.261				
4.98	1.258	1.101	1.260	7	4.80E-02	4.78E-04	2.25E-06
10.00	1.255	1.096	1.257	15	2.23E-02	4.74E-04	1.04E-06
20.00	1.250	1.087	1.253	46	7.23E-03	3.97E-04	2.81E-07
40.00	1.240	1.071	1.245	24	1.37E-02	3.97E-04	5.32E-07
80.00	1.224	1.044	1.232	51	6.31E-03	3.17E-04	1.96E-07
160.00	1.198	1.000	1.211	34	9.14E-03	2.58E-04	2.31E-07
320.00	1.150	0.920	1.174	120	2.43E-03	2.38E-04	5.68E-08
640.00	1.062	0.773	1.106	104	2.49E-03	2.18E-04	5.33E-08
1280.00	0.971	0.621	1.017	183	1.20E-03	1.13E-04	1.32E-08
2560.00	0.894	0.493	0.933	82	2.25E-03	4.77E-05	1.05E-08
1280.00	0.903	0.508	0.899				
320.00	0.935	0.561	0.919				
80.00	0.972	0.623	0.954				
20.00	1.007	0.681	0.990				
4.98	1.031	0.722	1.019				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

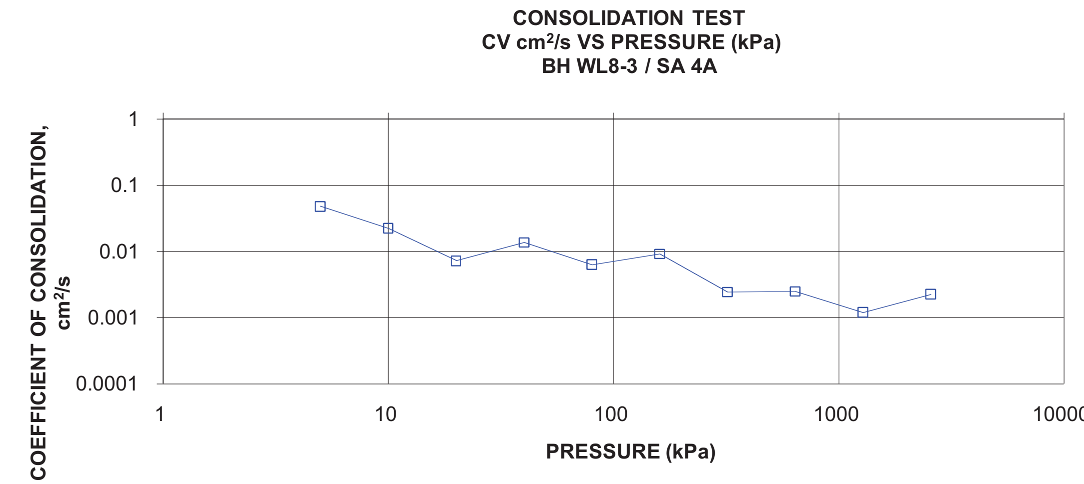
Sample Height, cm	1.03	Unit Weight, kN/m^3	20.41
Sample Diameter, cm	4.96	Dry Unit Weight, kN/m^3	15.89
Area, cm^2	19.33	Specific Gravity, measured	2.79
Volume, cm^3	19.93	Solids Height, cm	0.599
Water Content, %	28.43	Volume of Solids, cm^3	11.58
Wet Mass, g	41.48	Volume of Voids, cm^3	8.35
Dry Mass, g	32.30		

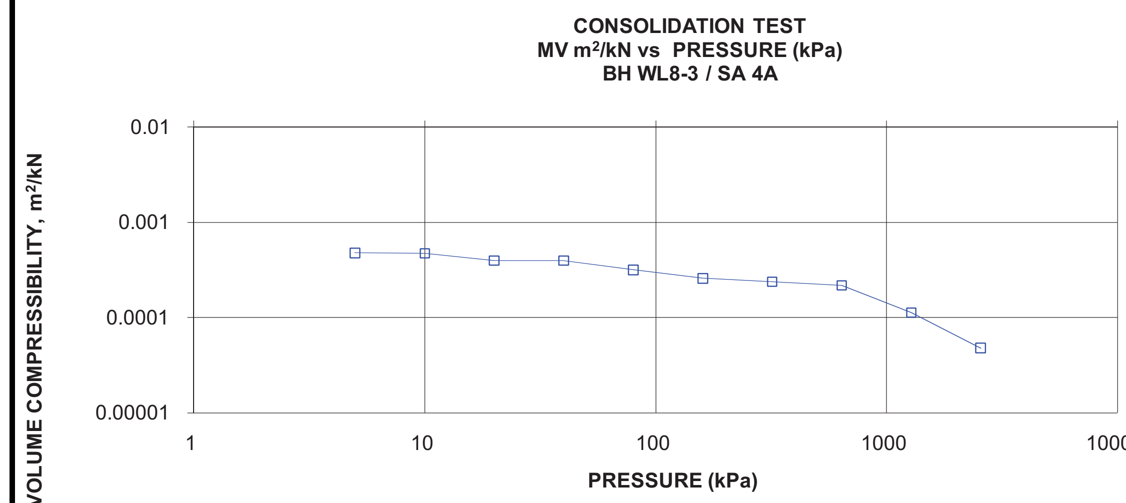
Prepared By: LFG **Golder Associates** Checked By: MM

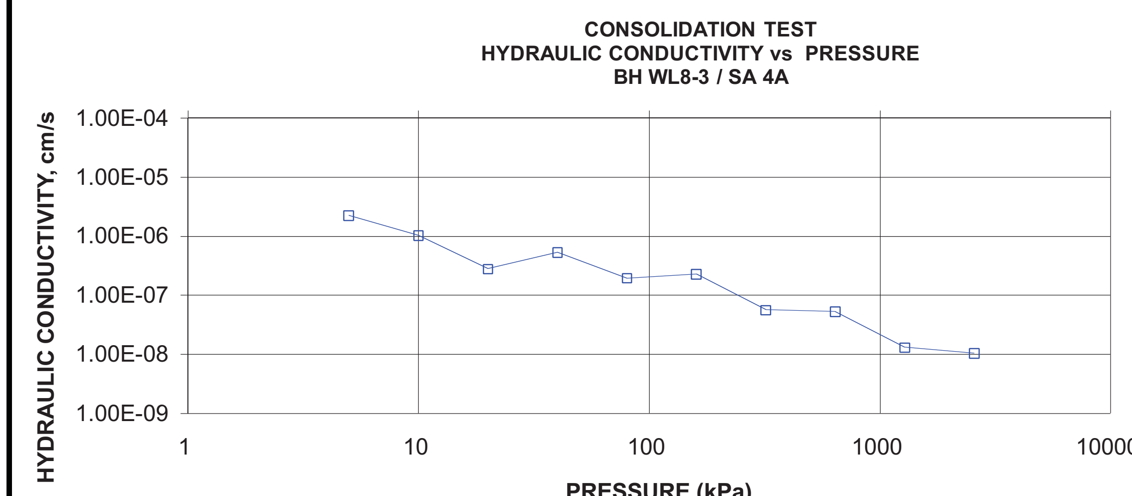
CONSOLIDATION TEST SUMMARY

Clayey Silt with Sand (Till-Like)

FIGURE WLTALC51C/WL7-F2





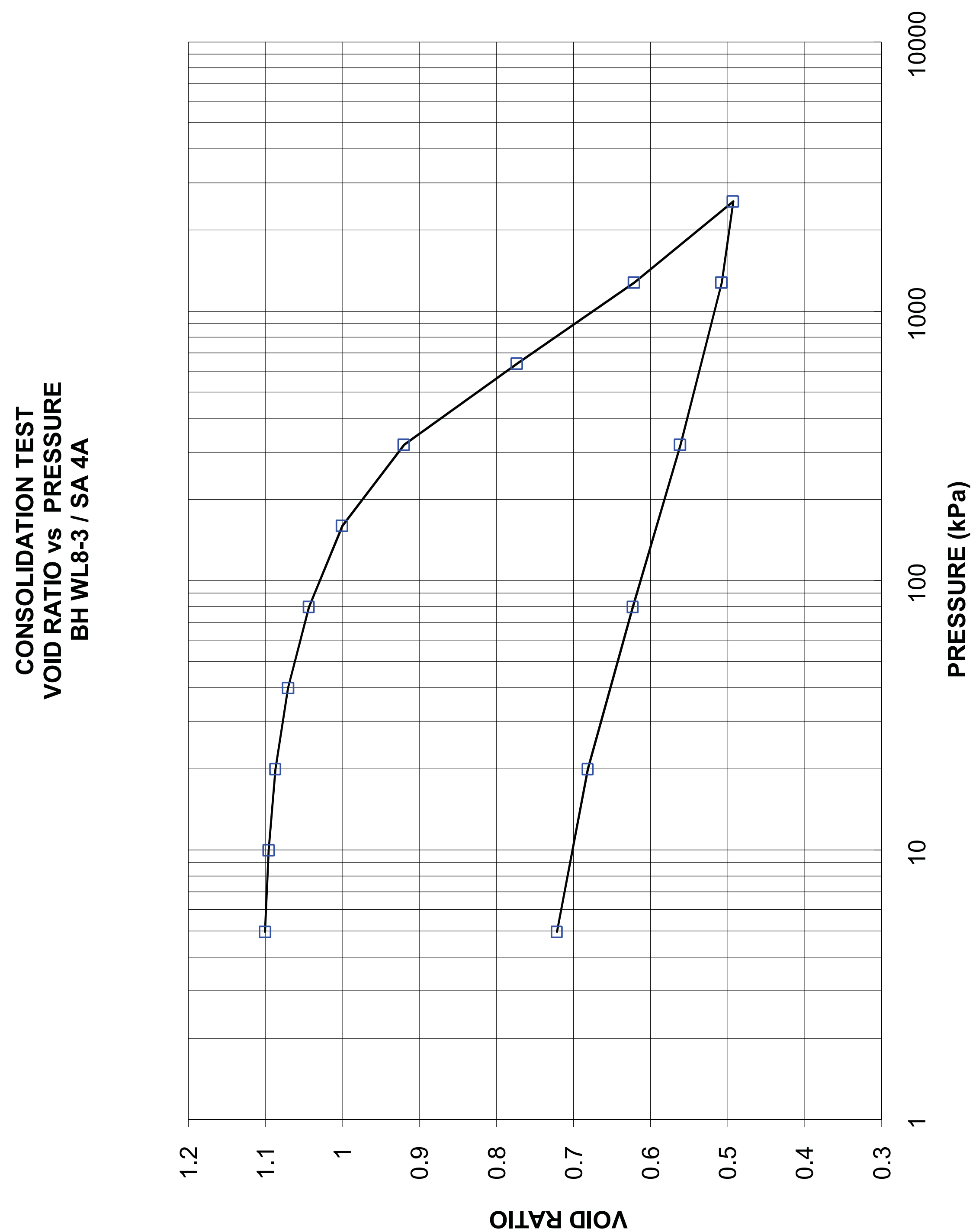


Project No. 07-1111-0053

Prepared By: LFG **Golder Associates** Checkey By: MM

CONSOLIDATION TEST RESULTS
Clayey Silt with Sand (Till-Like)

FIGURE WLTALC51C/WL7-F3



Project No.07-1111-0053

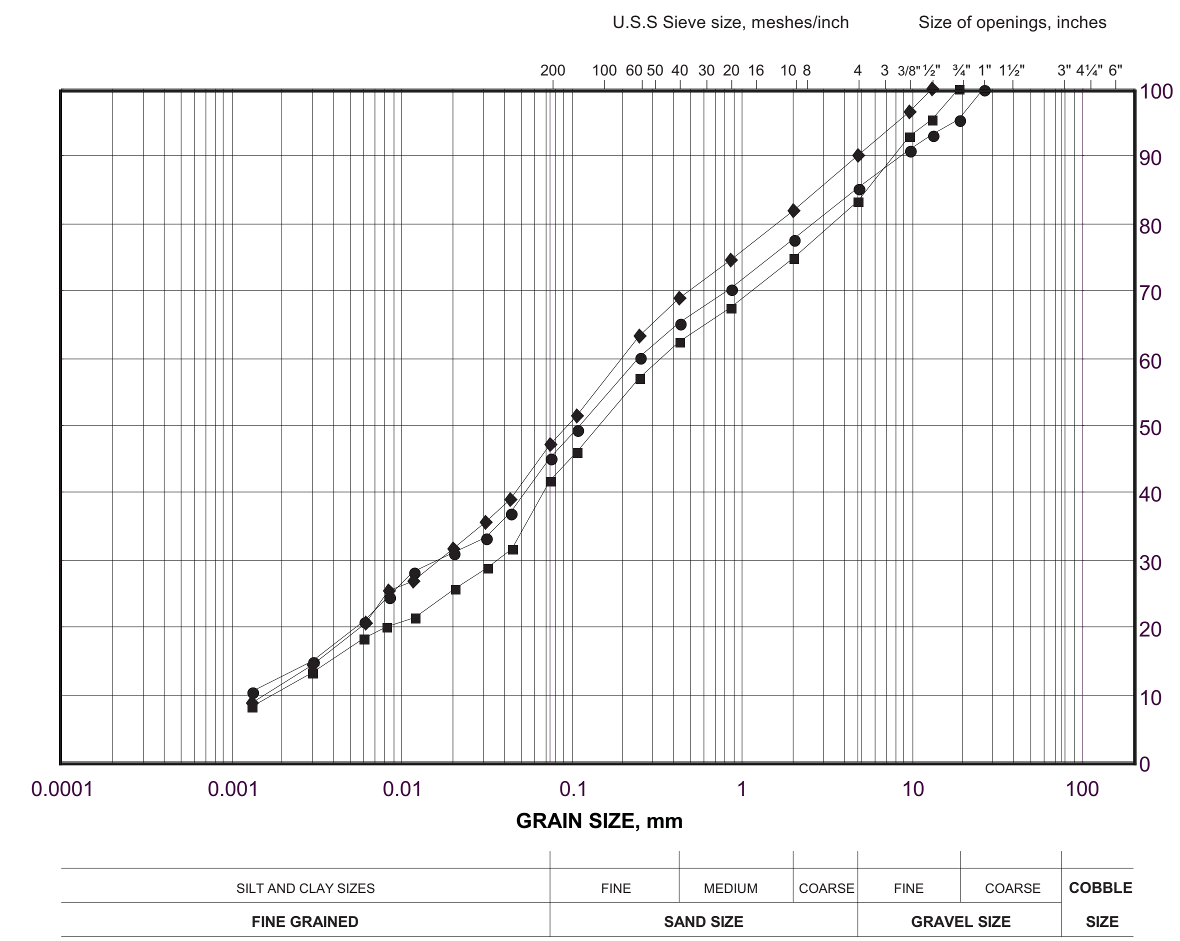
Prepared By: LFG

Golder Associates

Checked By: MM

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand (Till)

FIGURE WLTALC51C/WL7-G



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL8-1	4	81.4
■	WL4-1	5	79.7
◆	WL8-1	6	78.8

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 17-Mar-09

Oct 75, FF-S-21

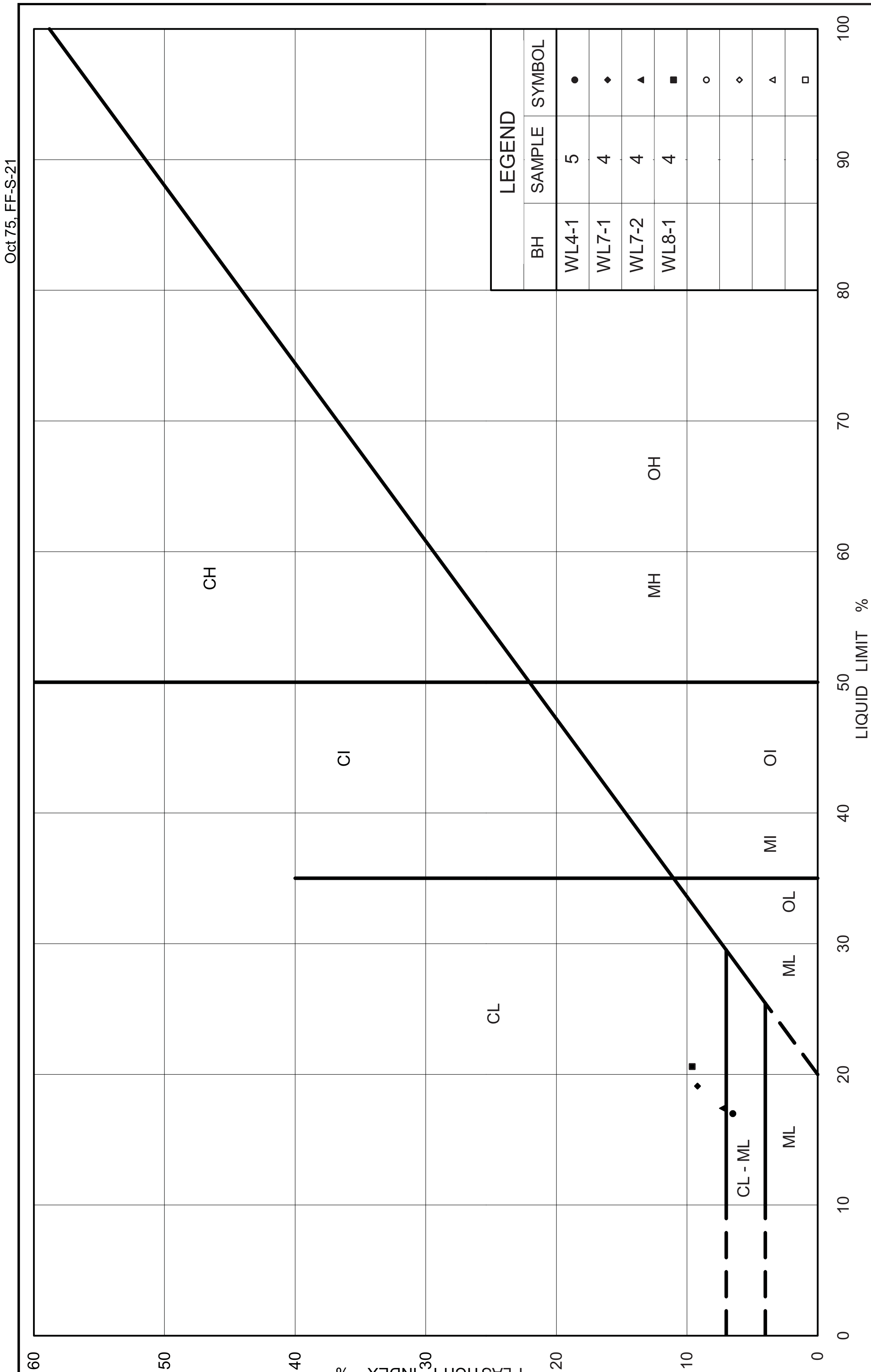


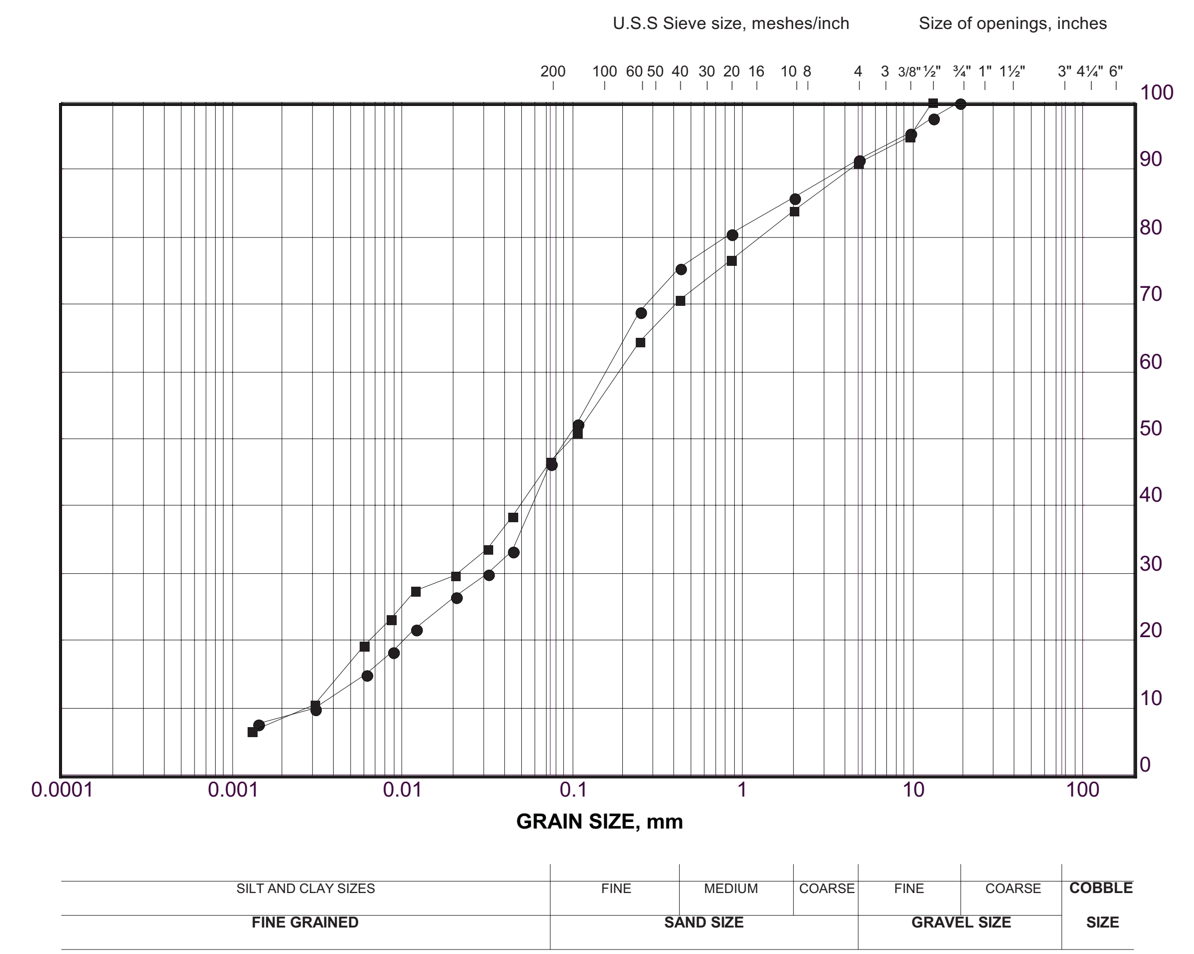
Figure No. WLTALC51C/WL7-H
Project No. 07-1111-0053
Checked By: KJB

PLASTICITY CHART
Clayey Silt with Sand (Till)

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE
WLTALC51C/WL7-I



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL7-2	5B	78.7
■	WL7-2	7	75.7

Project Number: 07-1111-0053

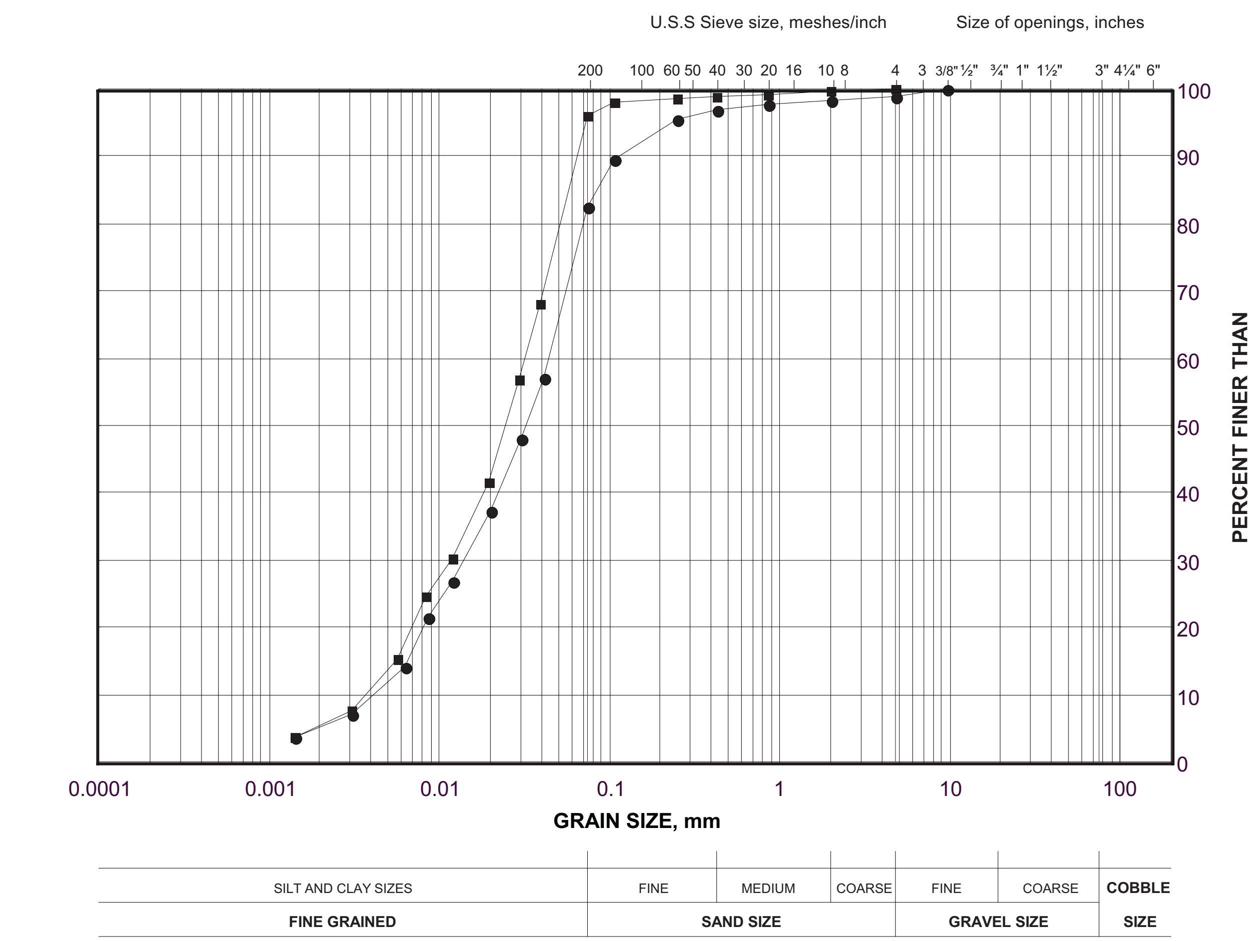
Checked By: KJB

Golder Associates

Date: 25-Jul-08

GRAIN SIZE DISTRIBUTION
Silt (Till)

FIGURE
WLTALC51C/WL7-J



LEGEND

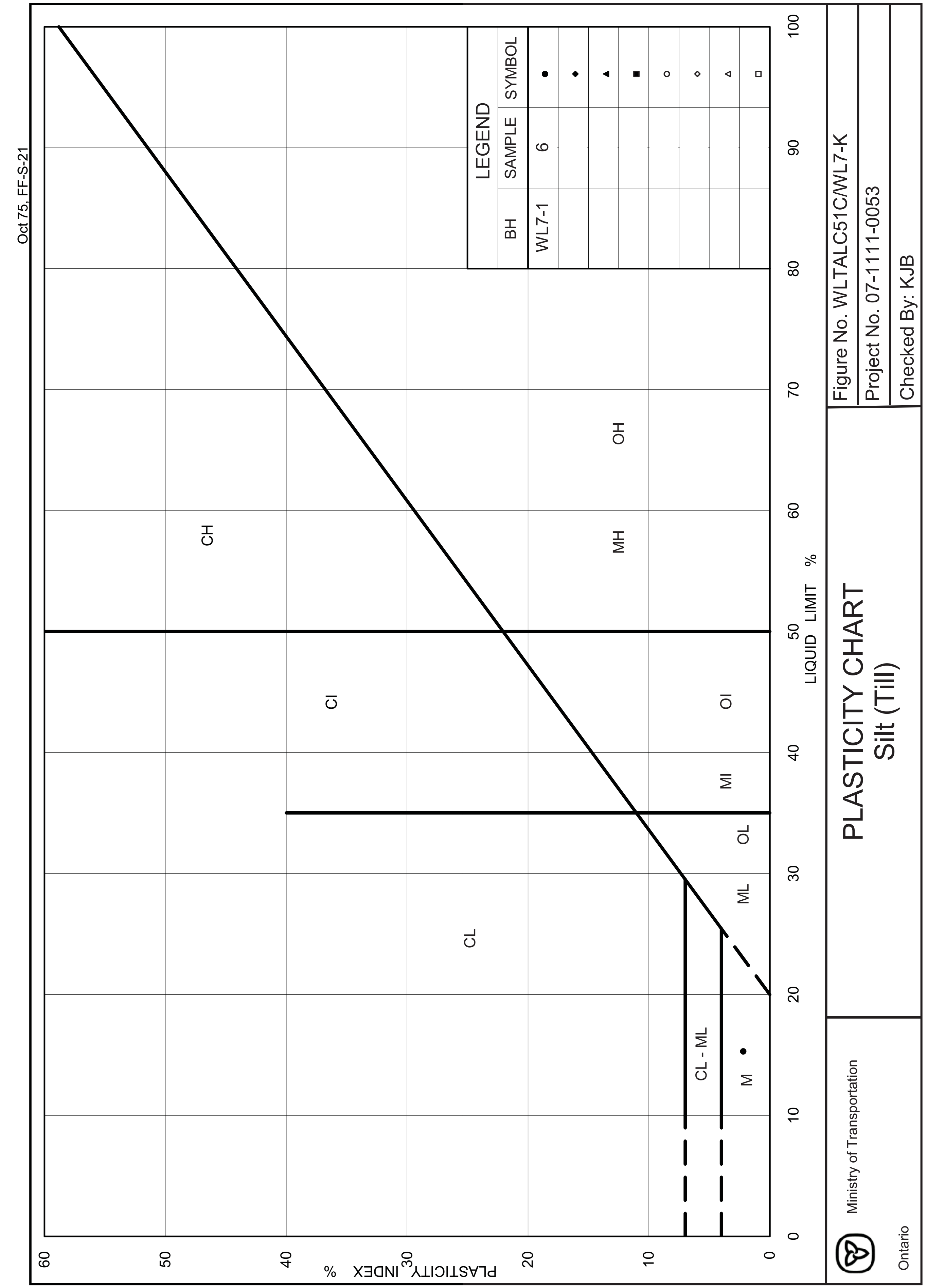
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL7-1	6	77.1
■	WL7-1	7	75.6

Project Number: 07-1111-0053

Checked By: KJB

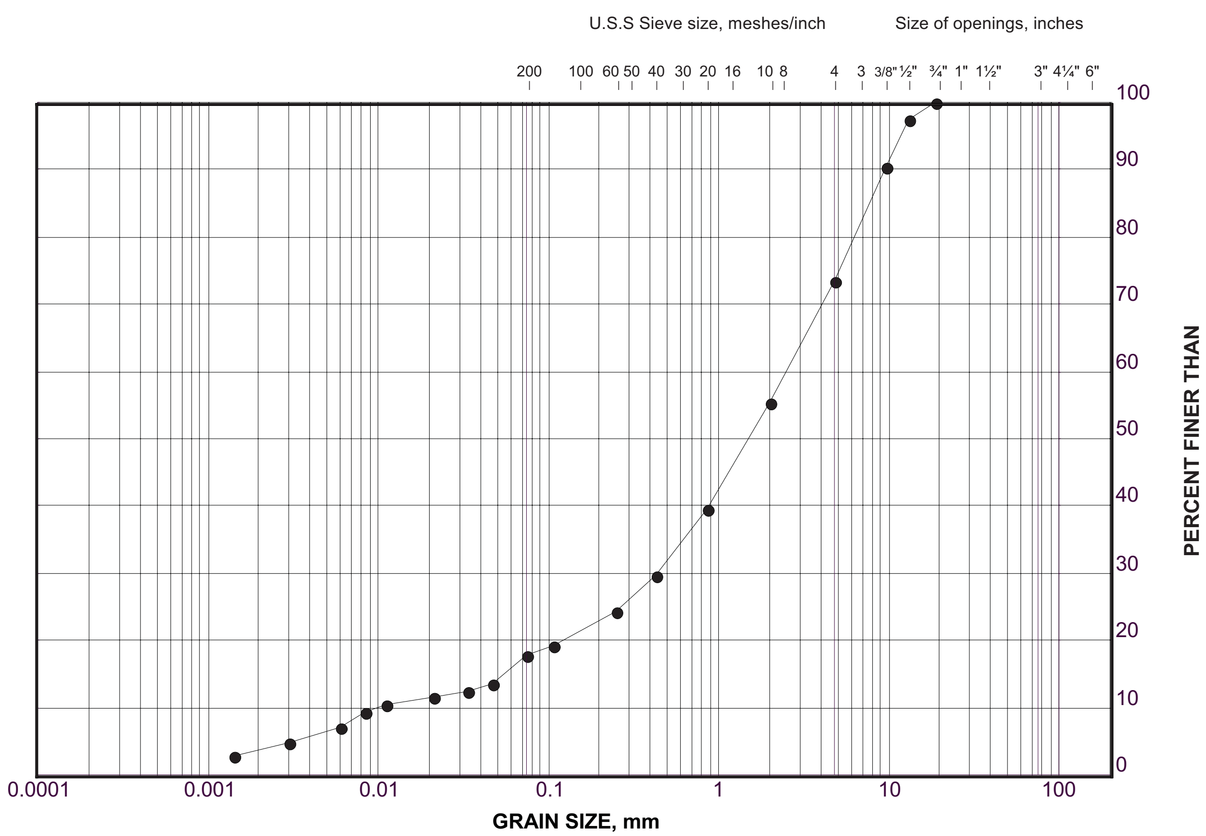
Golder Associates

Date: 09-Jul-08



GRAIN SIZE DISTRIBUTION
Gravelly Sand

FIGURE WLTALC51C/WL7-L



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL4-1	8	75.2

Project Number: 07-1111-0053

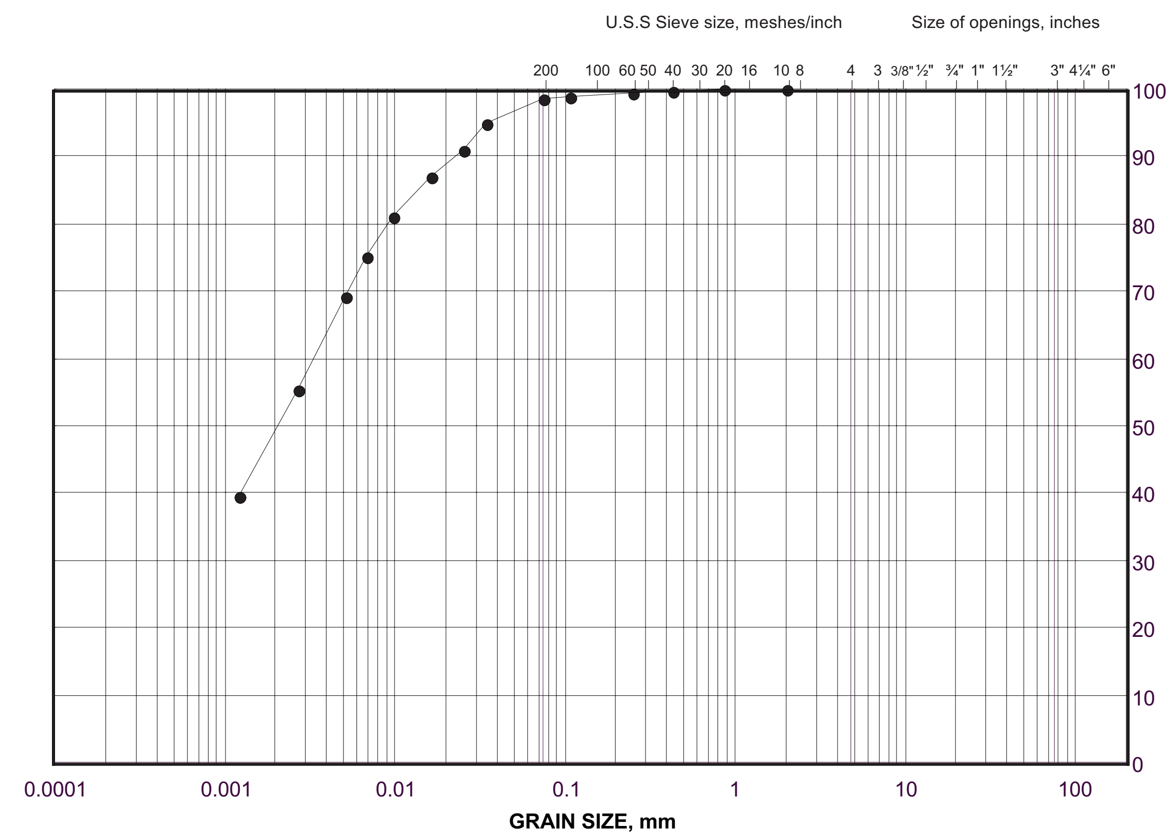
Checked By: KJB

Golder Associates

Date: 06-Aug-08

GRAIN SIZE DISTRIBUTION
Silty Clay

FIGURE WL9-A



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

LEGEND

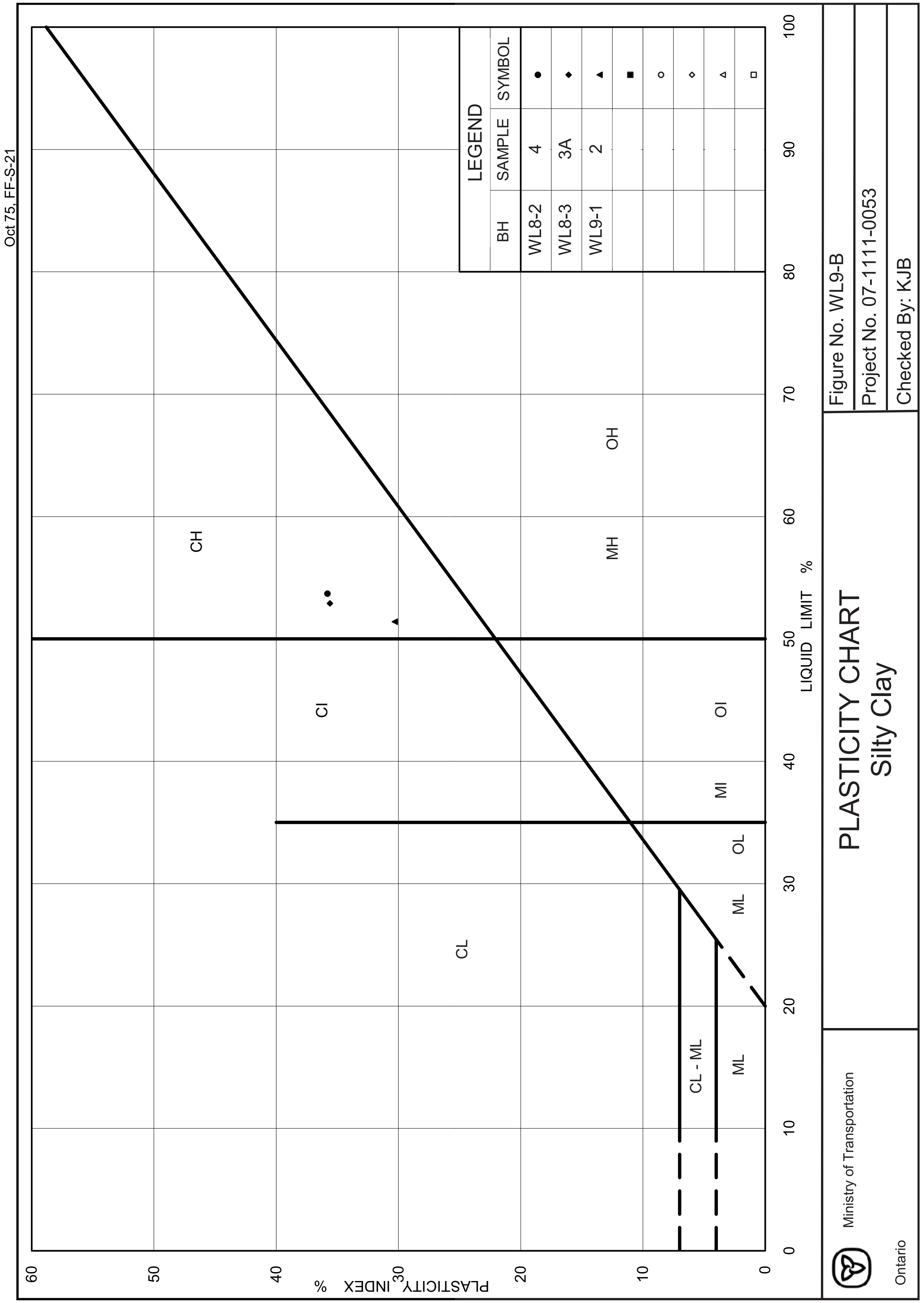
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL8-3	3A	80.4

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

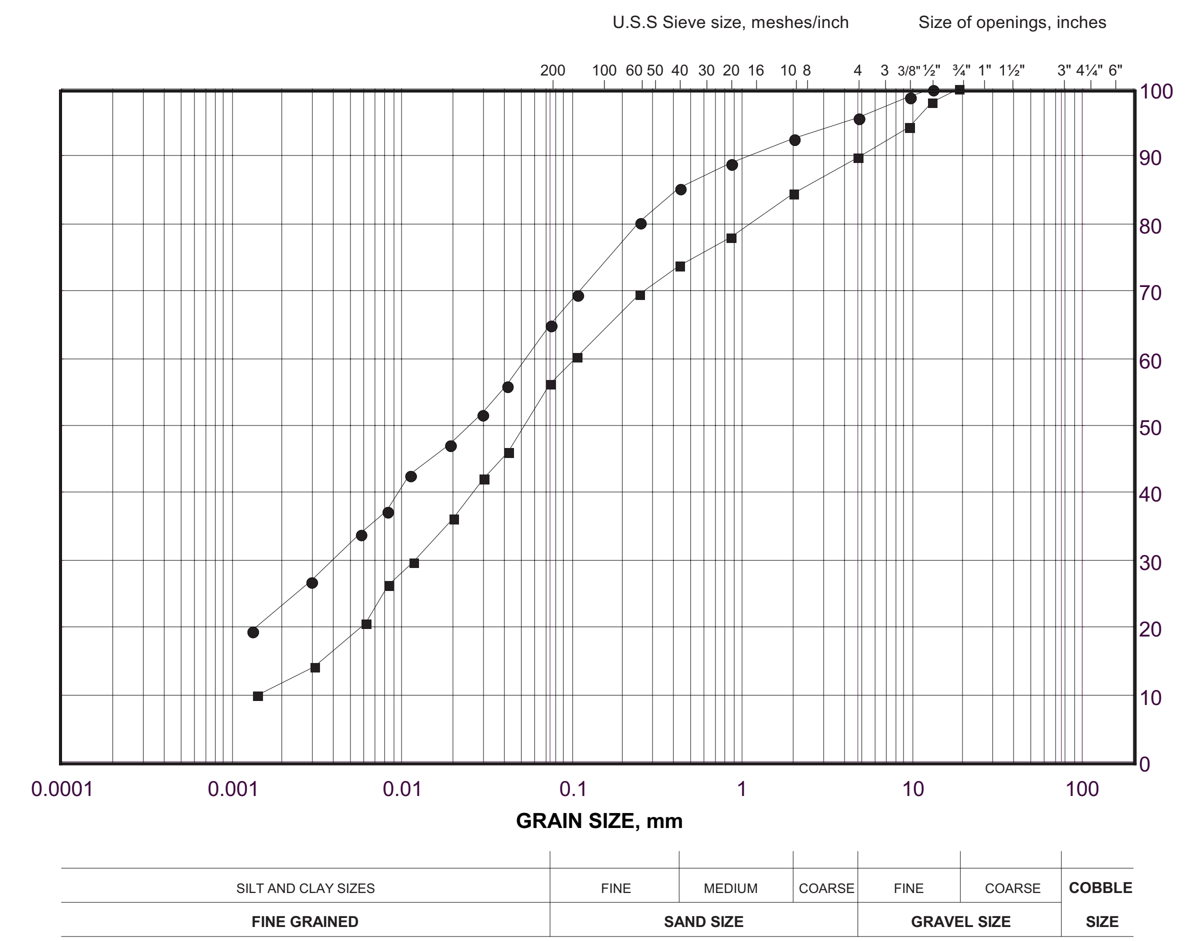
Date: 25-Jul-08



GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till-Like)

FIGURE WL9-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL9-1	4	79.5
■	WL8-2	6	77.4

Project Number: 07-1111-0053

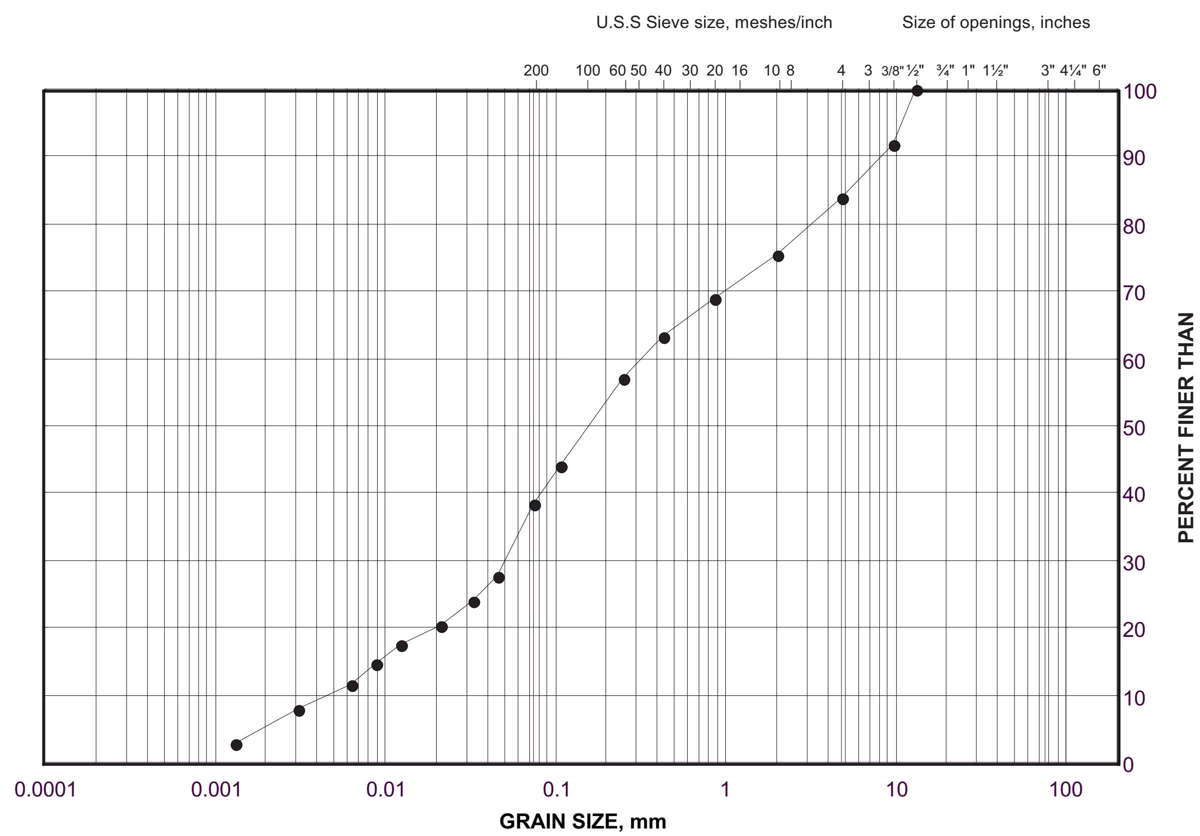
Checked By: KJB

Golder Associates

Date: 17-Mar-09

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WL9-D



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL9-1	6	77.1

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 25-Jul-08

CONSOLIDATION TEST SUMMARY
Clayey Silt with Sand (Till-Like)

FIGURE WL9-E1

SAMPLE IDENTIFICATION

Project Number	07-1111-0053	Sample Number	4A
Borehole Number	WL8-3	Sample Depth, m	1.8-2.4

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	7		
Date Started	02/28/2008		
Date Completed	03/15/2008		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.26	Unit Weight, kN/m^3	18.16
Sample Diameter, cm	4.96	Dry Unit Weight, kN/m^3	12.99
Area, cm^2	19.33	Specific Gravity, measured	2.79
Volume, cm^3	24.37	Solids Height, cm	0.599
Water Content, %	39.79	Volume of Solids, cm ^{3}	11.58
Wet Mass, g	45.15	Volume of Voids, cm ^{3}	12.80
Dry Mass, g	32.30	Degree of Saturation, %	100.4

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.261	1.106	1.261				
4.98	1.258	1.101	1.260	7	4.80E-02	4.78E-04	2.25E-06
10.00	1.255	1.096	1.257	15	2.23E-02	4.74E-04	1.04E-06
20.00	1.250	1.087	1.253	46	7.23E-03	3.97E-04	2.81E-07
40.00	1.240	1.071	1.245	24	1.37E-02	3.97E-04	5.32E-07
80.00	1.224	1.044	1.232	51	6.31E-03	3.17E-04	1.96E-07
160.00	1.198	1.000	1.211	34	9.14E-03	2.58E-04	2.31E-07
320.00	1.150	0.920	1.174	120	2.43E-03	2.38E-04	5.68E-08
640.00	1.062	0.773	1.106	104	2.49E-03	2.18E-04	5.33E-08
1280.00	0.971	0.621	1.017	183	1.20E-03	1.13E-04	1.32E-08
2560.00	0.894	0.493	0.933	82	2.25E-03	4.77E-05	1.05E-08
1280.00	0.903	0.508	0.899				
320.00	0.935	0.561	0.919				
80.00	0.972	0.623	0.954				
20.00	1.007	0.681	0.990				
4.98	1.031	0.722	1.019				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

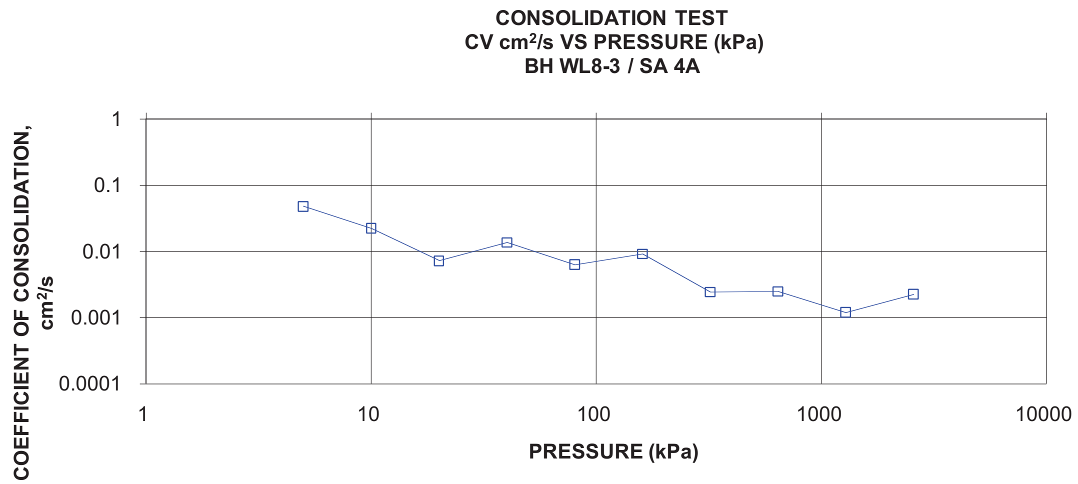
Sample Height, cm	1.03	Unit Weight, kN/m^3	20.41
Sample Diameter, cm	4.96	Dry Unit Weight, kN/m^3	15.89
Area, cm^2	19.33	Specific Gravity, measured	2.79
Volume, cm^3	19.93	Solids Height, cm	0.599
Water Content, %	28.43	Volume of Solids, cm ^{3}	11.58
Wet Mass, g	41.48	Volume of Voids, cm ^{3}	8.35
Dry Mass, g	32.30		

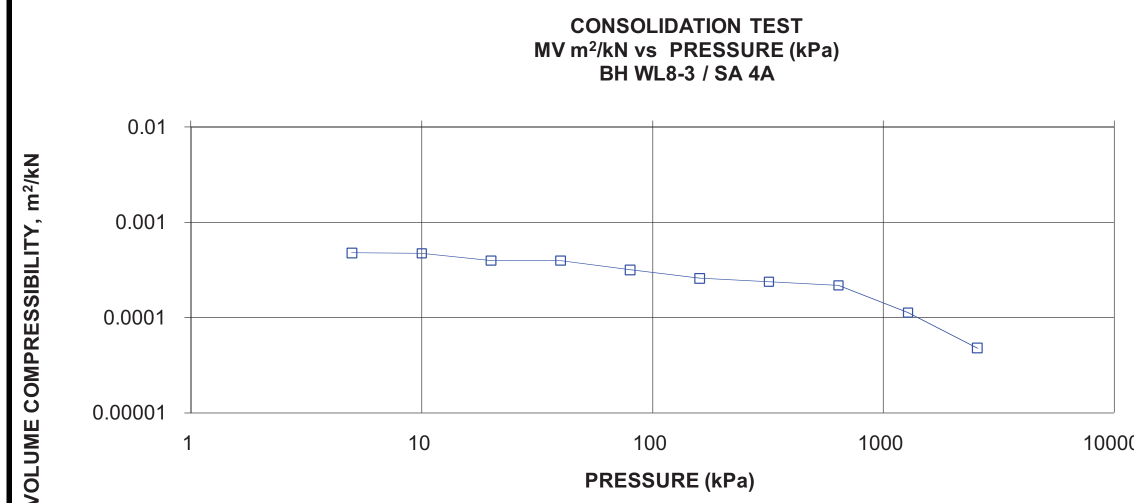
Prepared By: LFG **Golder Associates** Checked By: KJB

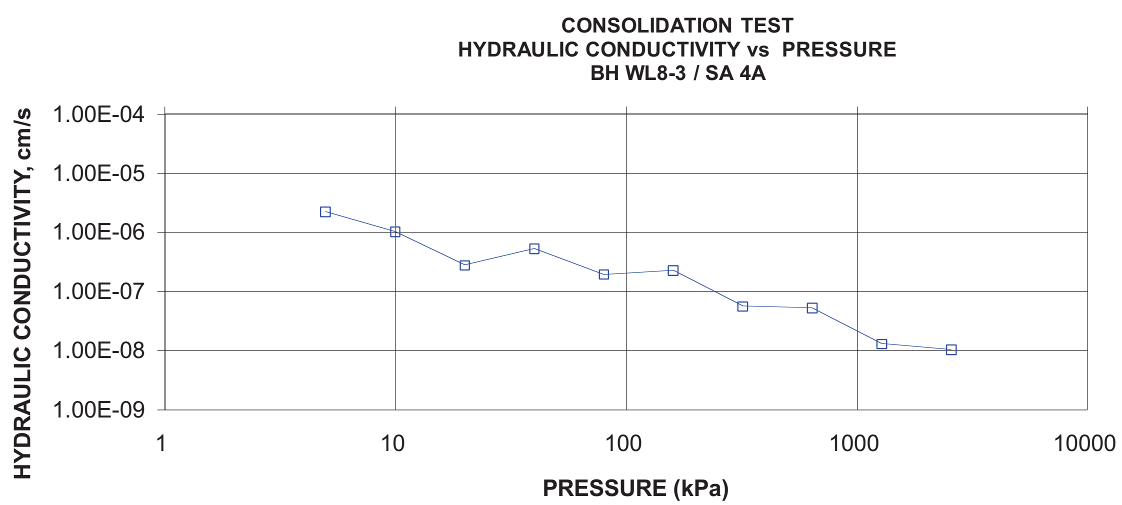
CONSOLIDATION TEST SUMMARY

Clayey Silt with Sand (Till-Like)

FIGURE WL9-E2







Project No. 07-1111-0053

Prepared By: LFG

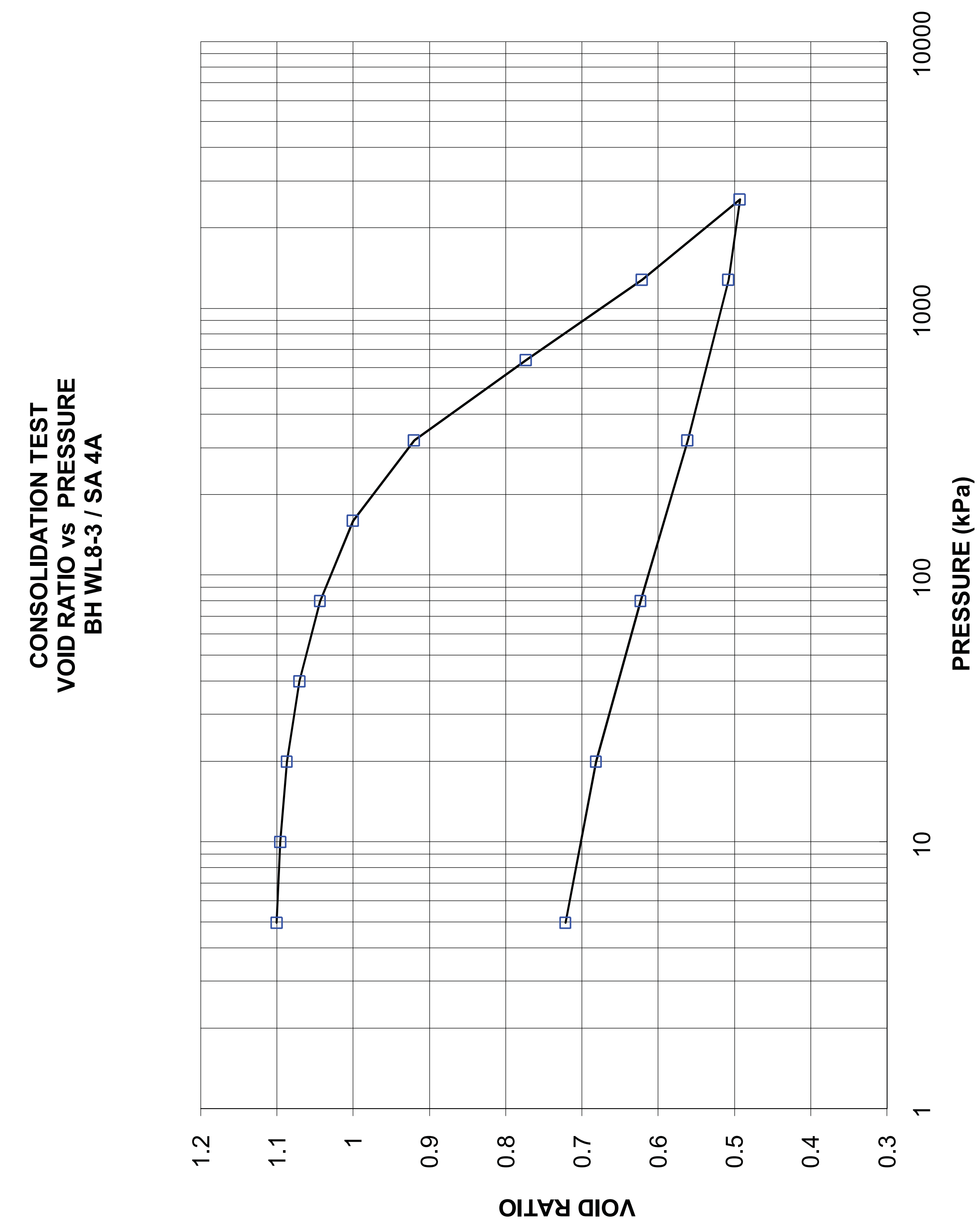
Golder Associates

Checkey By: KJB

CONSOLIDATION TEST RESULTS

Clayey Silt with Sand (Till-Like)

FIGURE WL9-E3



Project No.07-1111-0053

Prepared By: LFG

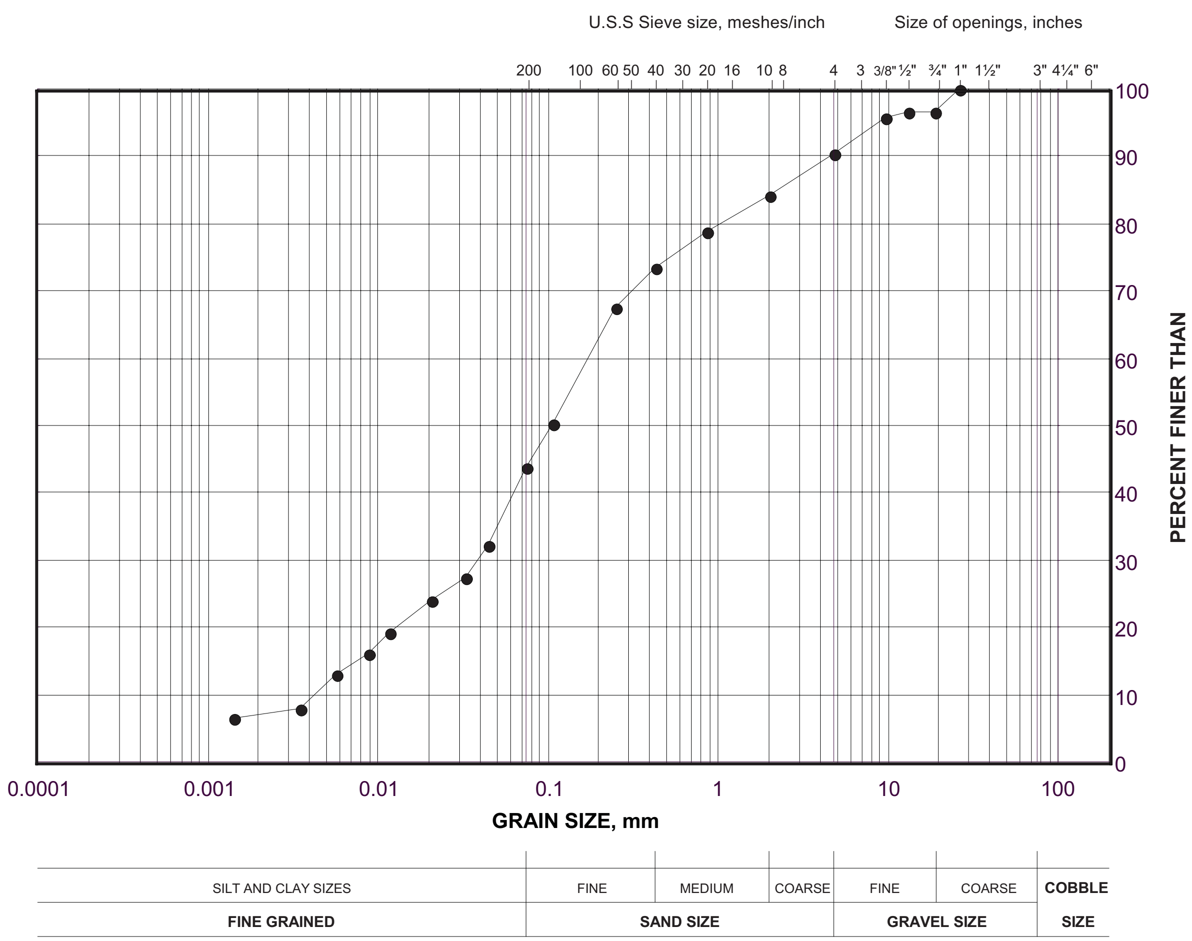
Golder Associates

Checked By: KJB

GRAIN SIZE DISTRIBUTION

Sand and Silt (Till-Like)

FIGURE WL9-F



LEGEND

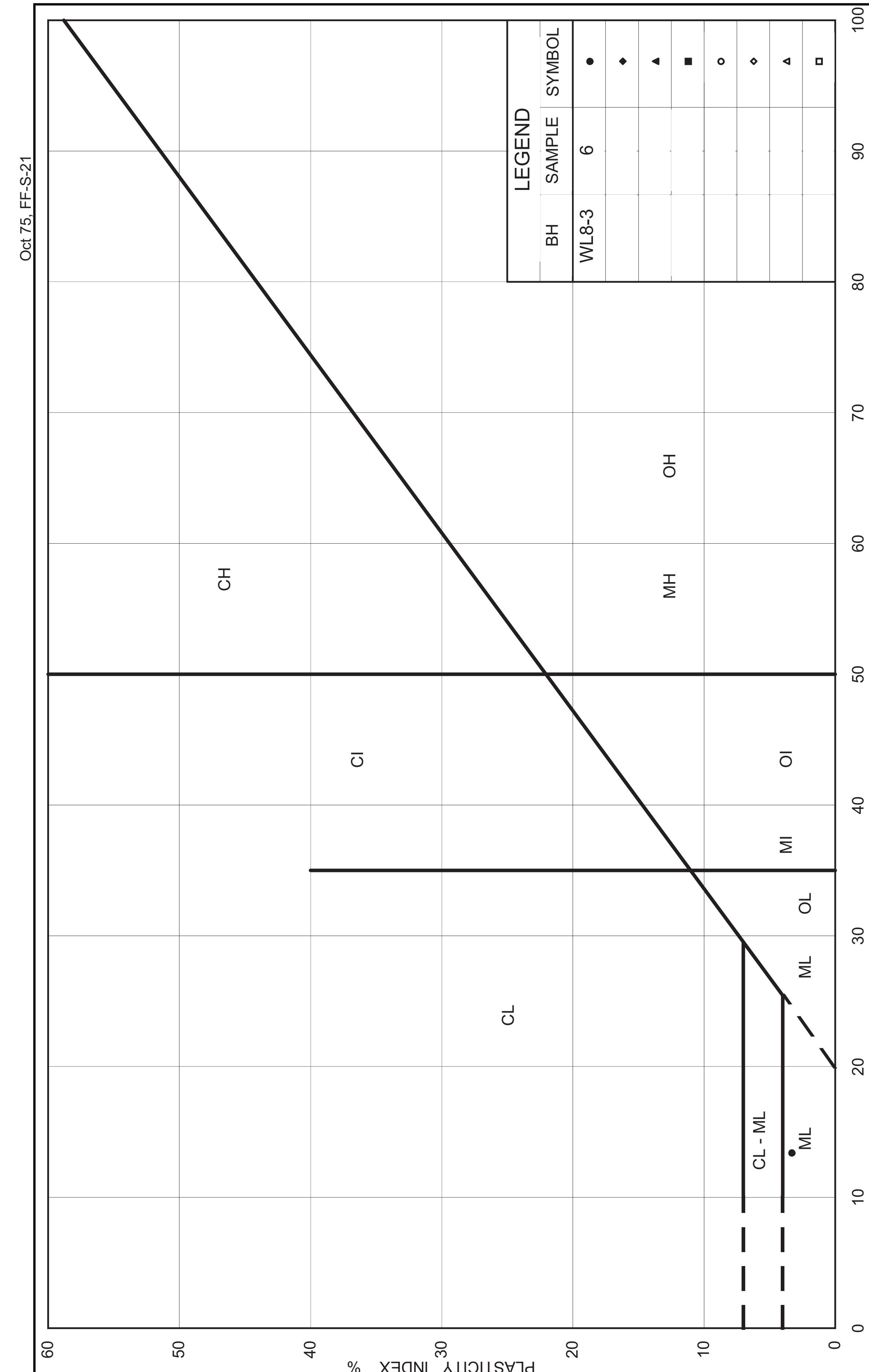
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL8-3	6	77.1

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 25-Jul-08



PLASTICITY CHART

Sand and Silt (Till-Like)

Figure No. WL9-G

Project No. 07-1111-0053

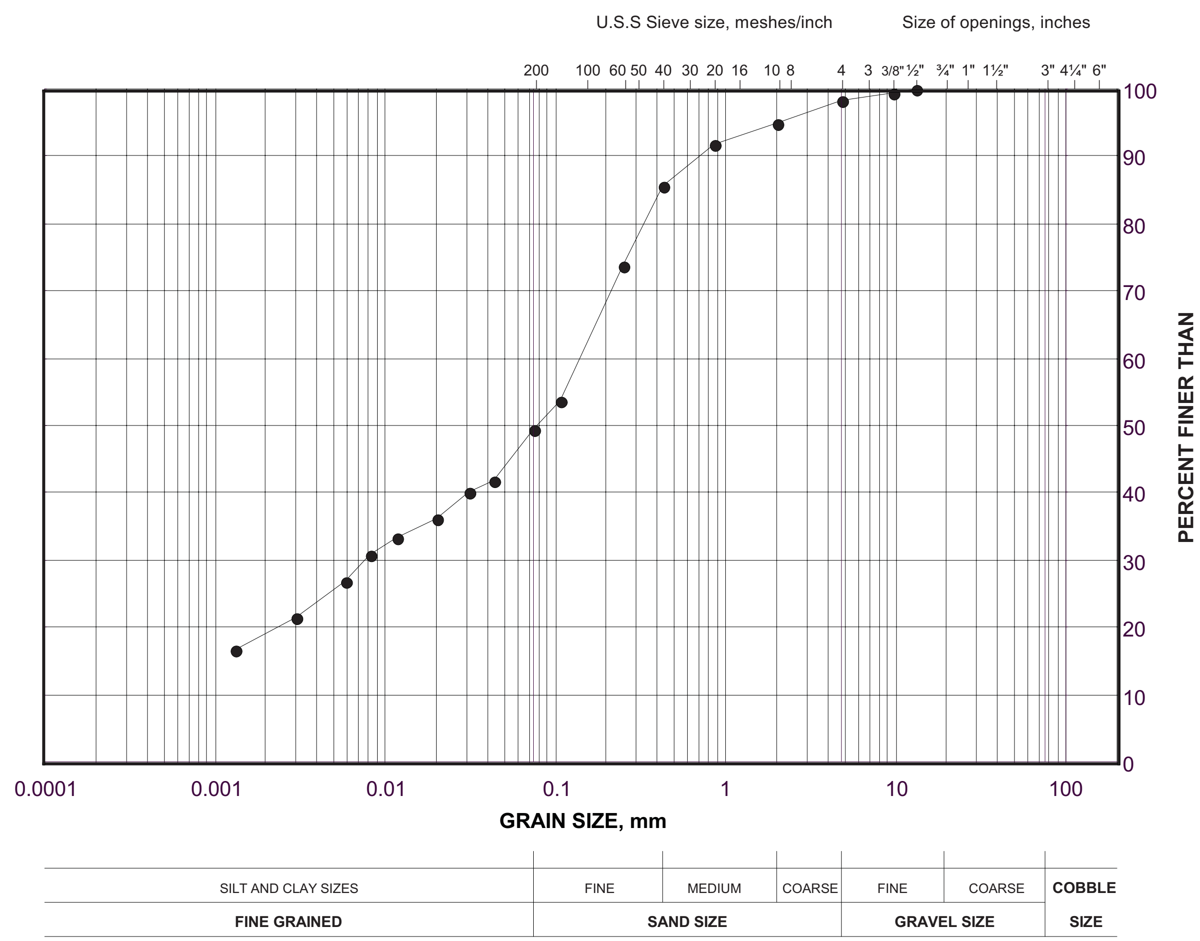
Checked By: KJB

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand

FIGURE WL10-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL10-1	3	77.3

Project Number: 07-1111-0053

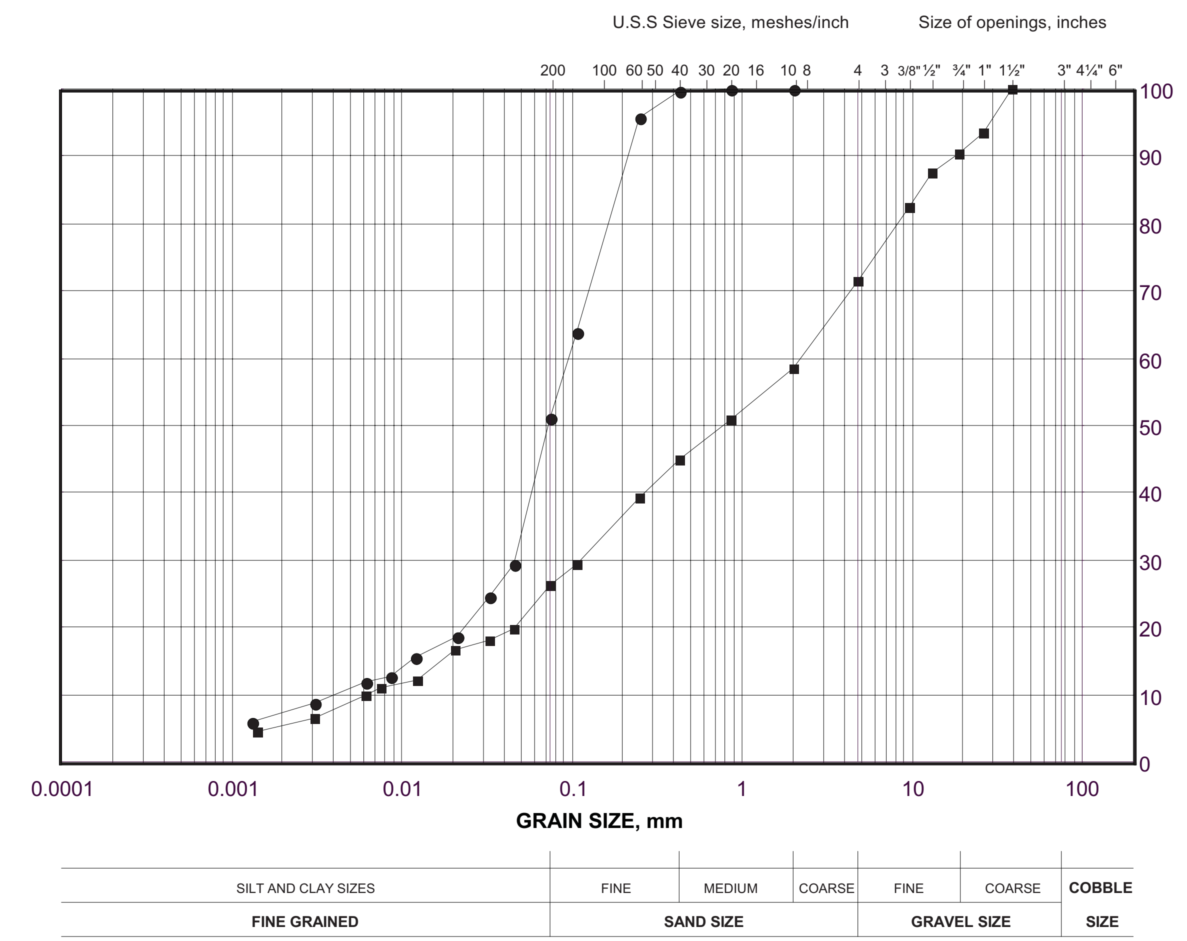
Checked By: KJB

Golder Associates

Date: 23-Jul-08

GRAIN SIZE DISTRIBUTION
Sand and Silt to Silty Sand

FIGURE WL10-B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL10-1	6	74.2
■	WL10-1	9	69.7

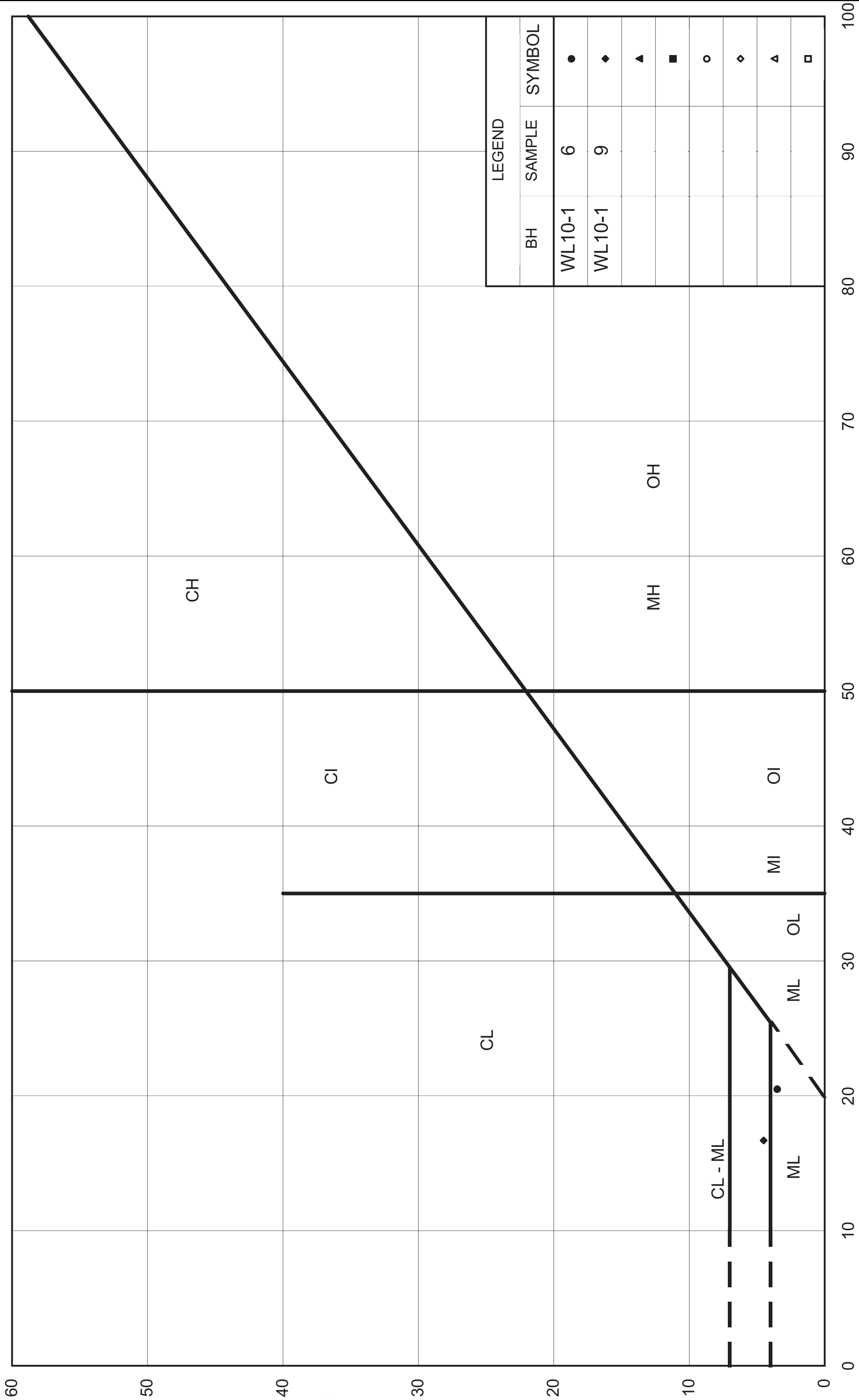
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 19-Aug-08

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
WL10-1	6	●
WL10-1	9	◆

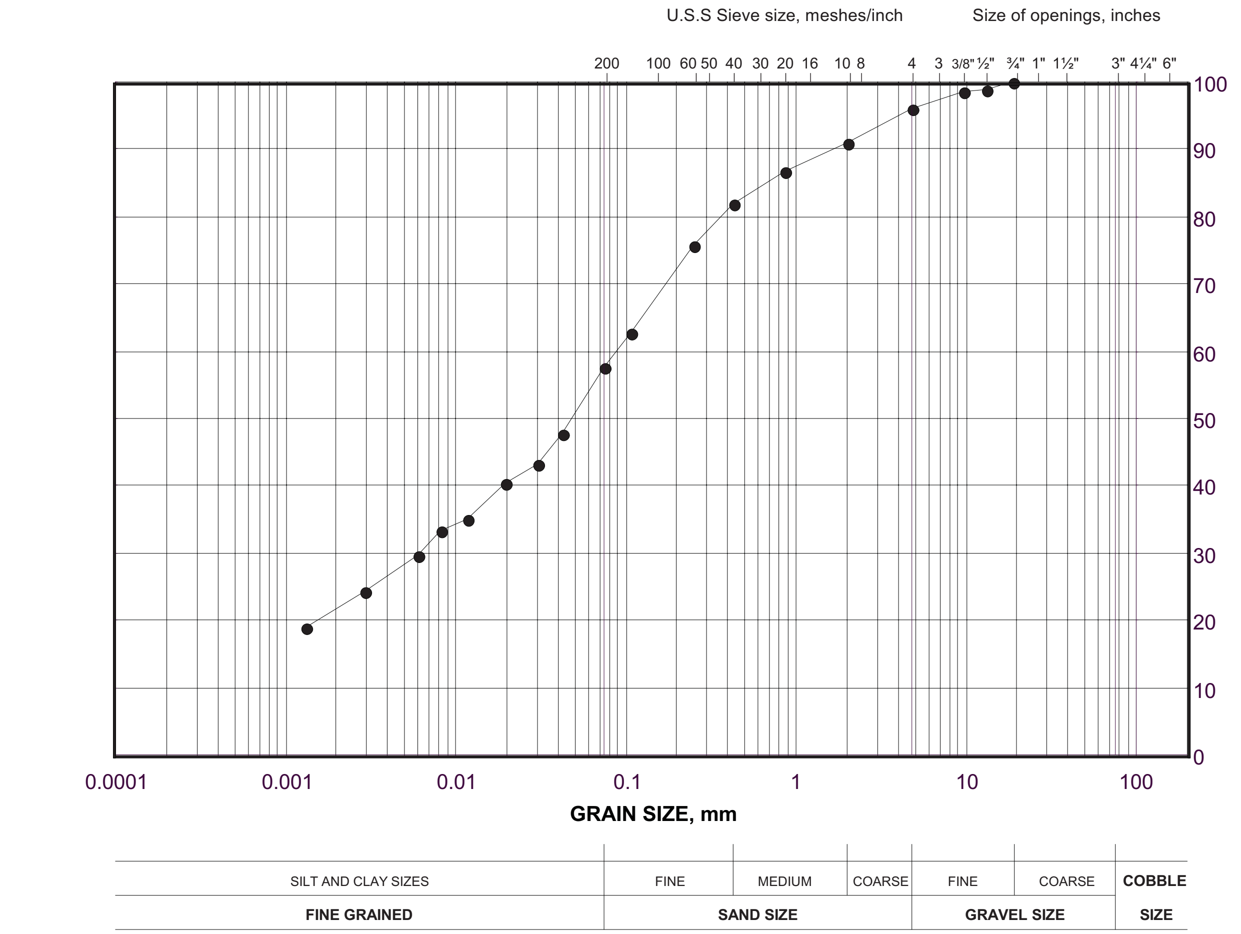
Figure No. WL10-C
Project No. 07-1111-0053
Checked By: KJB

PLASTICITY CHART
Sand and Silt to Silty Sand

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand

FIGURE WL11-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL11-1	4	76.4

Project Number: 07-1111-0053
Checked By: KJB

Golder Associates

Date: 12-Aug-08

Oct 75, FF-S-21

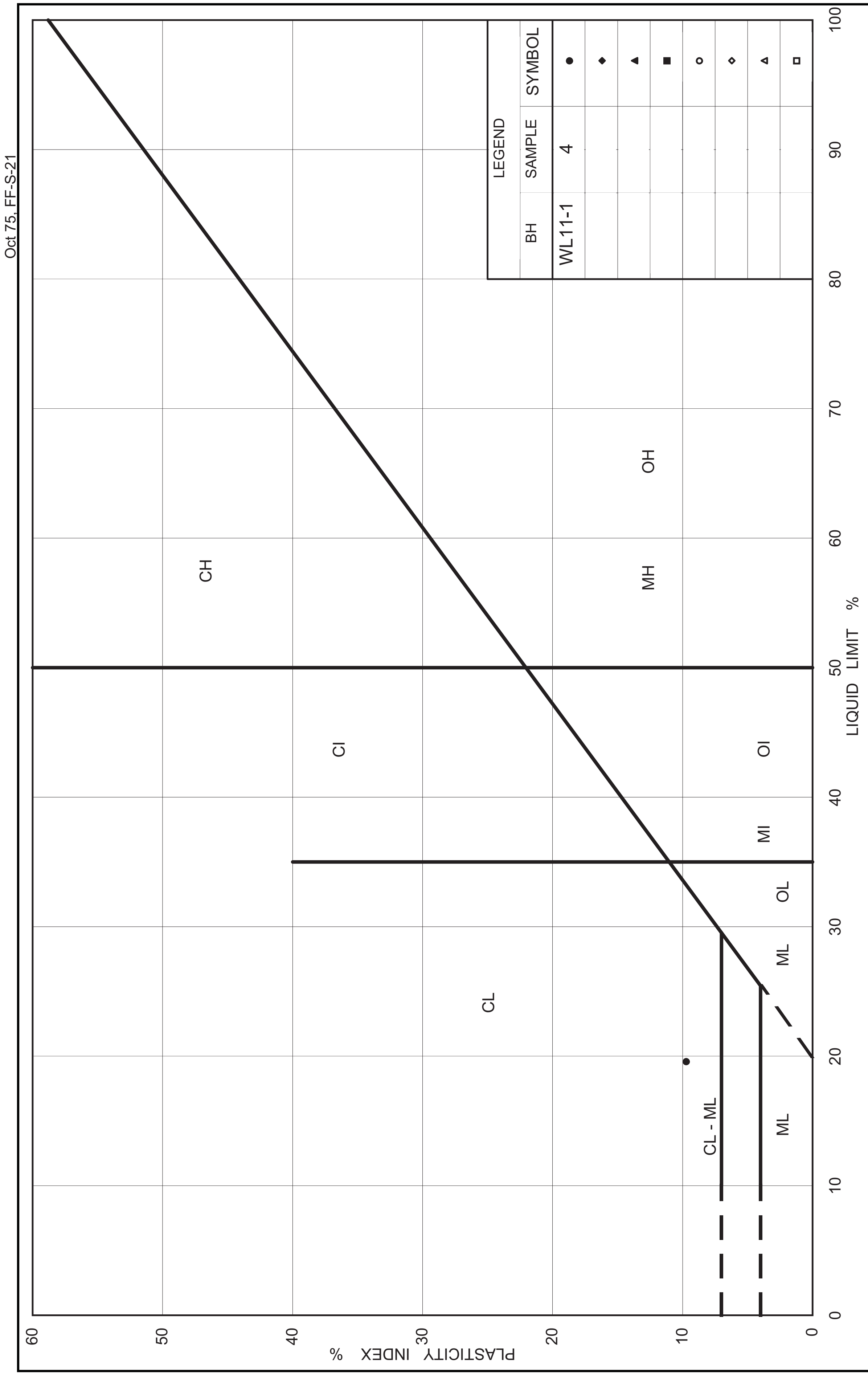


Figure No. WL11-B

Project No. 07-1111-0053

Checked By: KJB

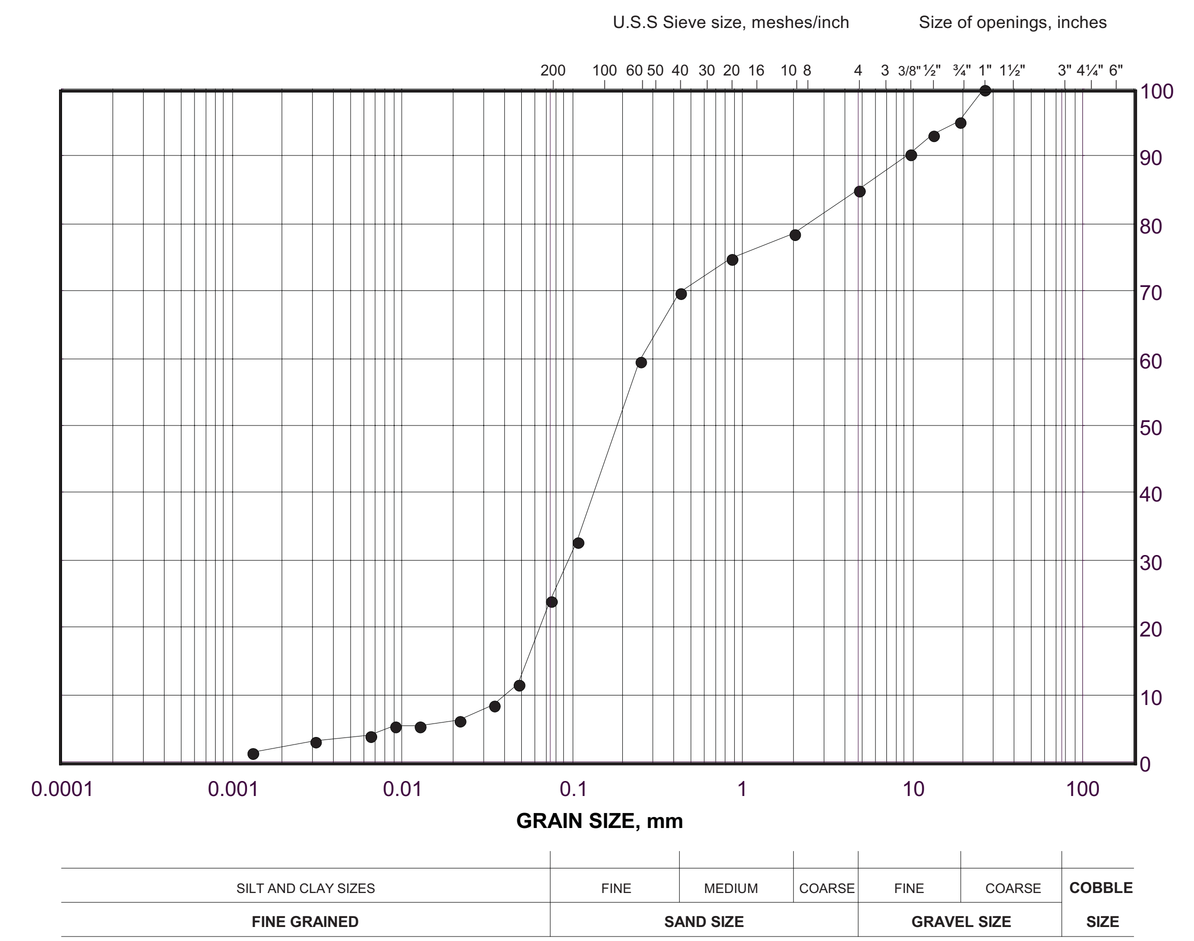
PLASTICITY CHART
Clayey Silt with Sand

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Sand

FIGURE WL11-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL11-1	8	71.1

Project Number: 07-1111-0053

Checked By: KJB

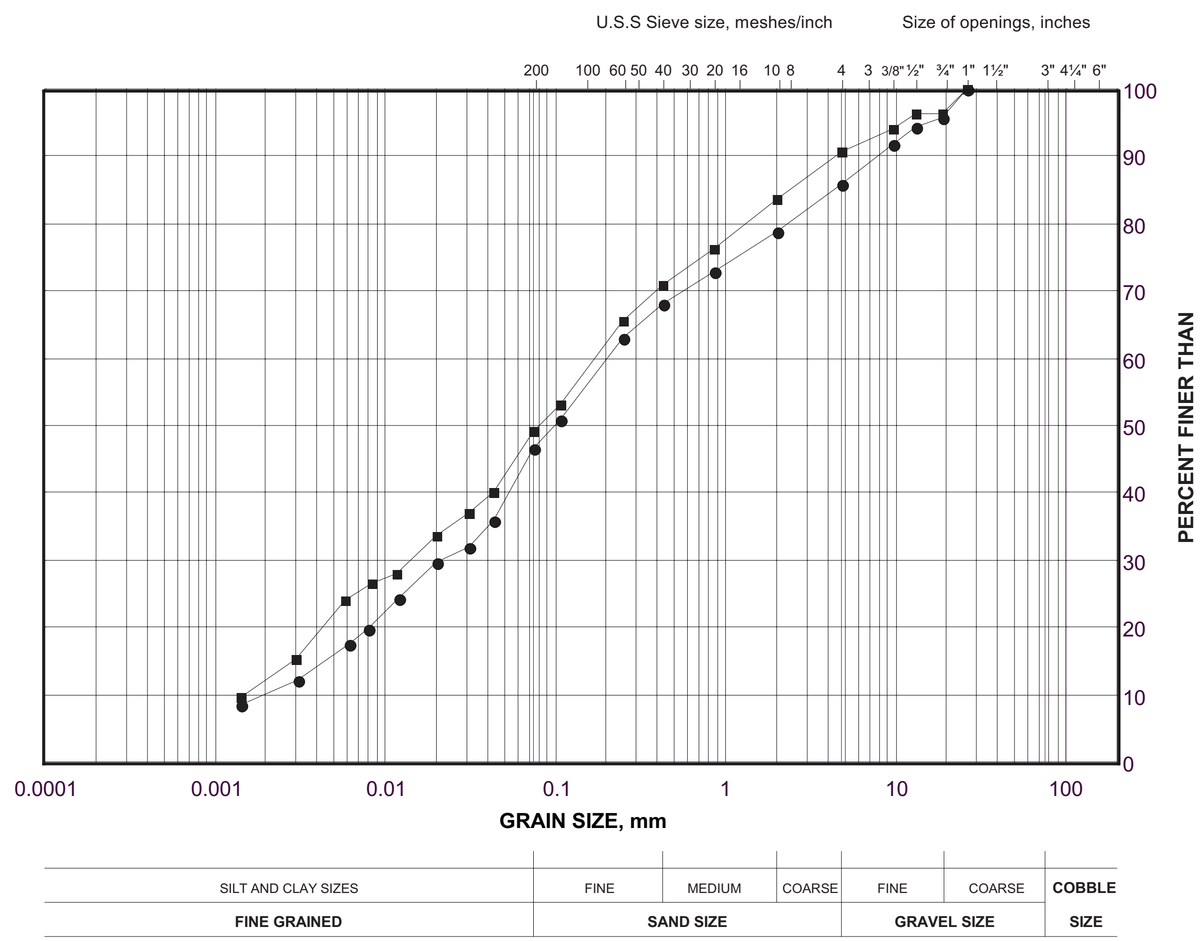
Golder Associates

Date: 23-Jul-08

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE WL12-A



LEGEND

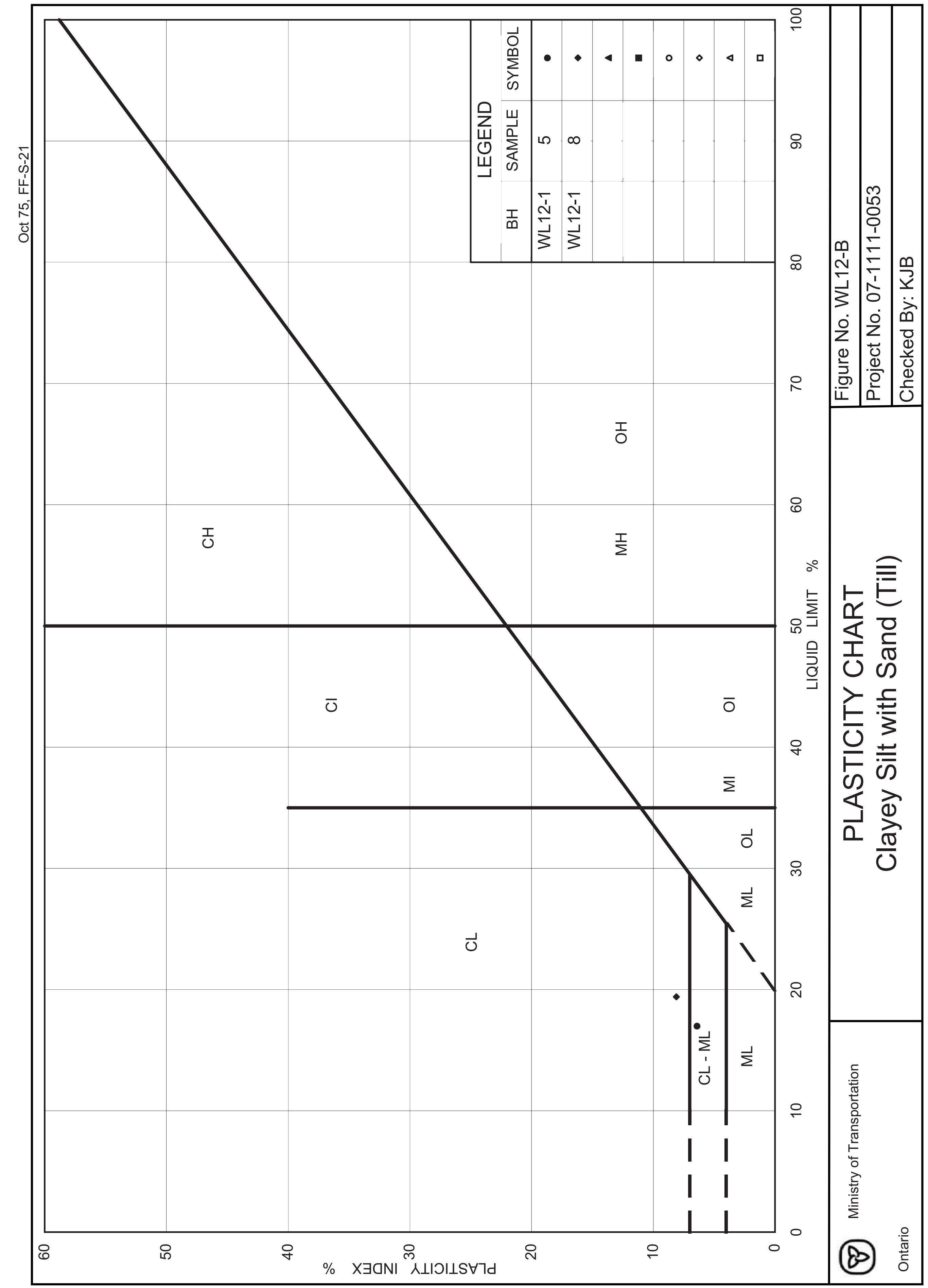
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL12-1	5	83.6
■	WL12-1	8	79.1

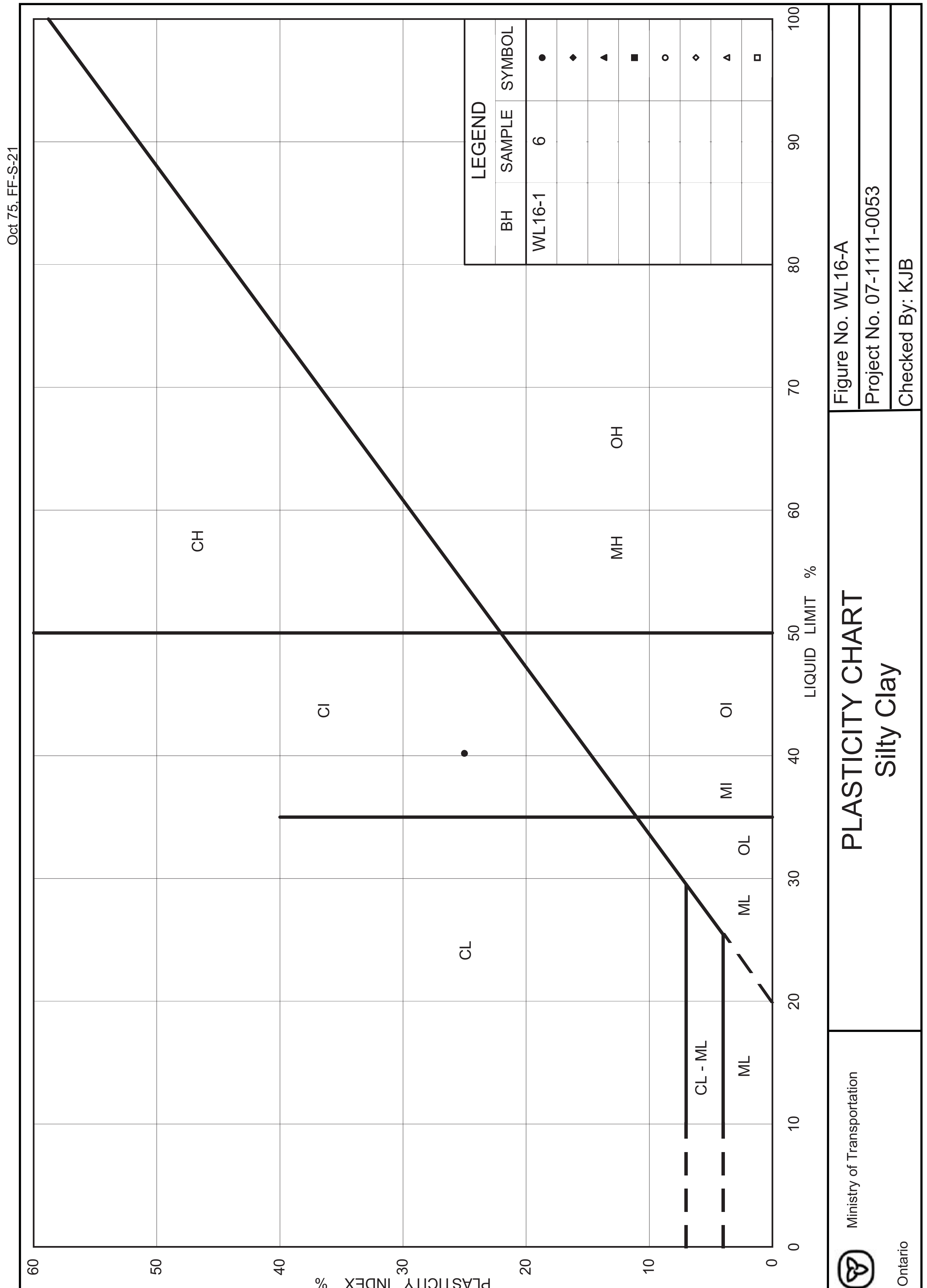
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 15-Jul-08

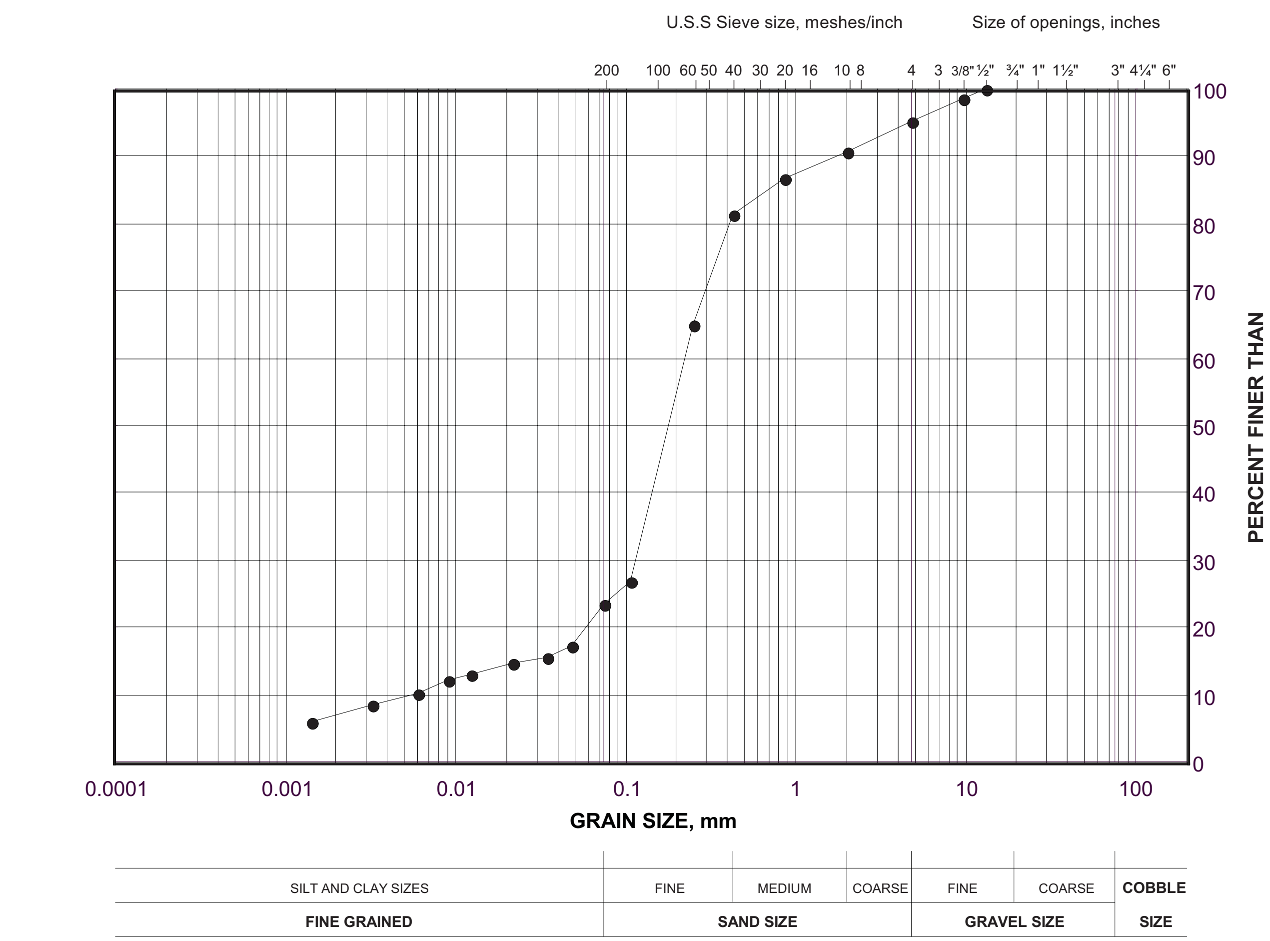




GRAIN SIZE DISTRIBUTION

Sand

FIGURE WL16-B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL16-1	8	89.1

Project Number: 07-1111-0053

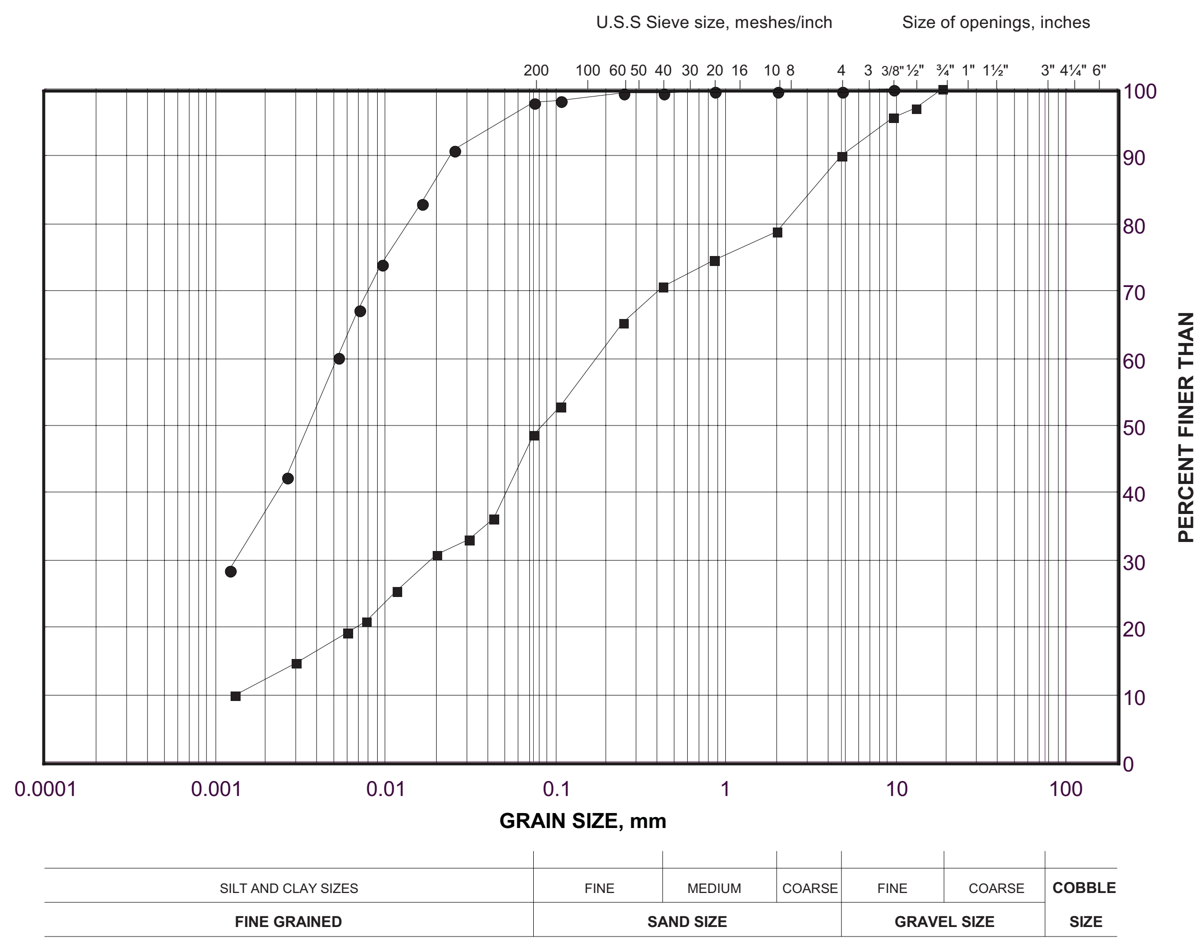
Checked By: KJB

Golder Associates

Date: 21-Jul-08

GRAIN SIZE DISTRIBUTION
Clayey Silt to Silty Clay

FIGURE WL19-A



LEGEND

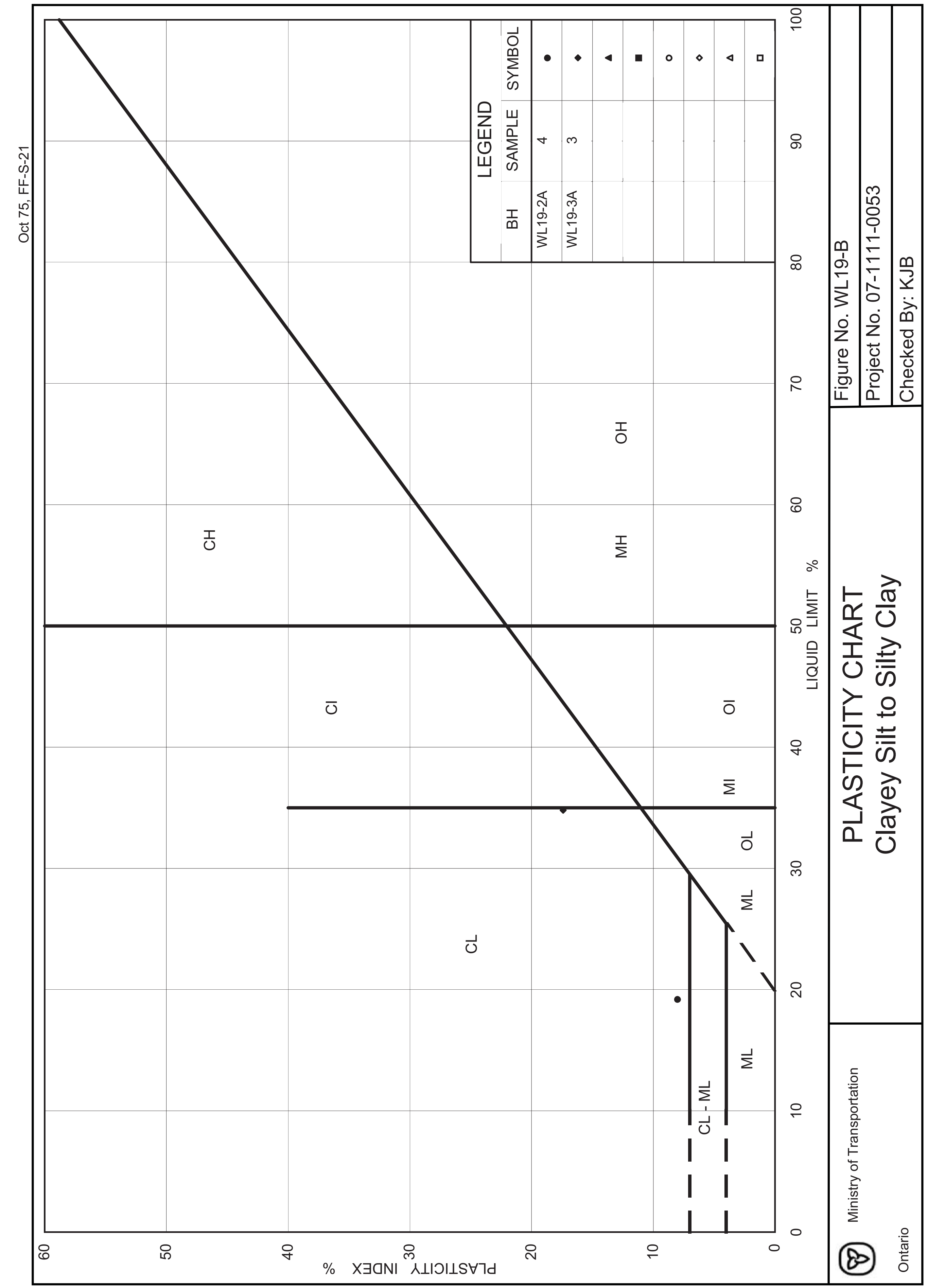
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL19-3A	3	102.2
■	WL19-2A	4	103.2

Project Number: 07-1111-0053

Checked By: KJB

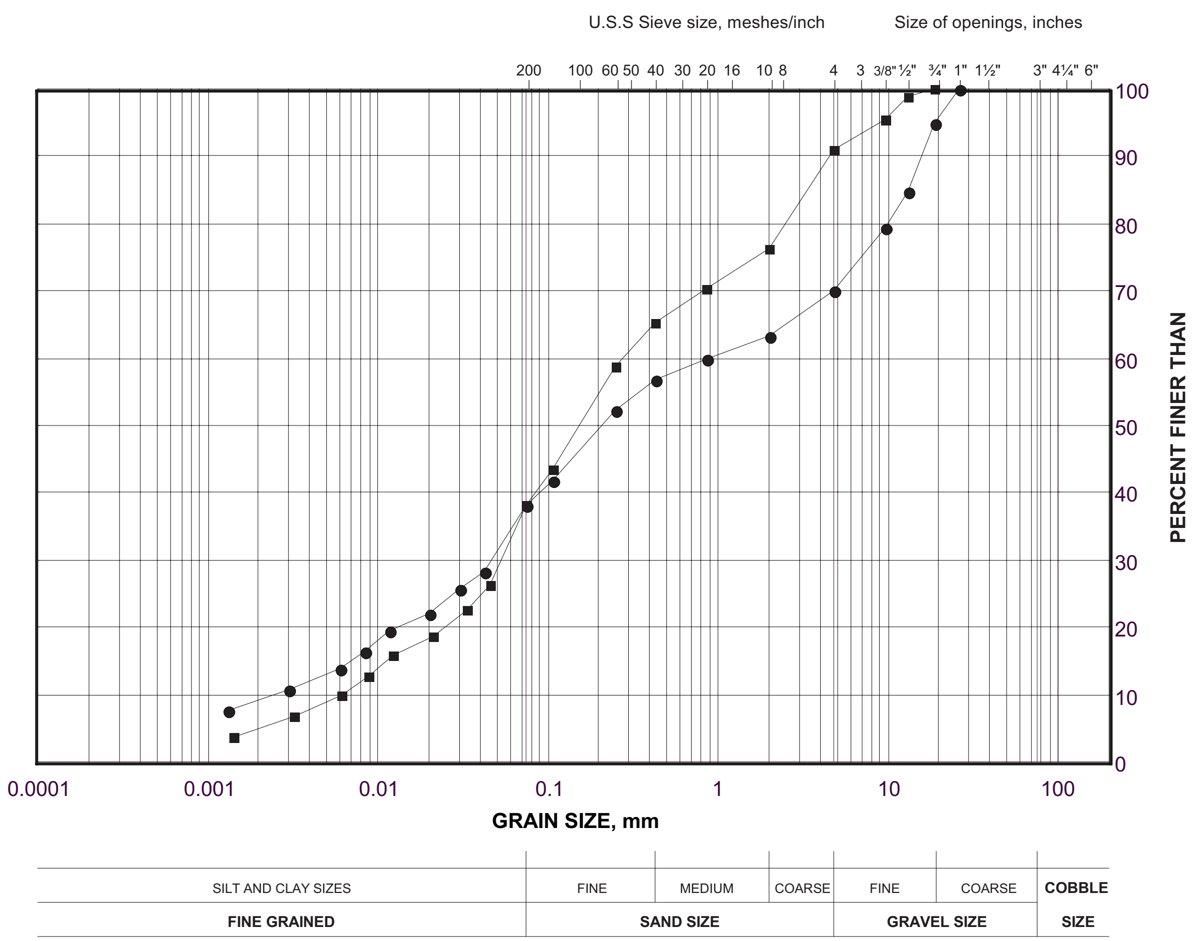
Golder Associates

Date: 09-Dec-08



GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WL19-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL19-2A	8	99.4
■	WL19-3A	8	96.5

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 09-Dec-08

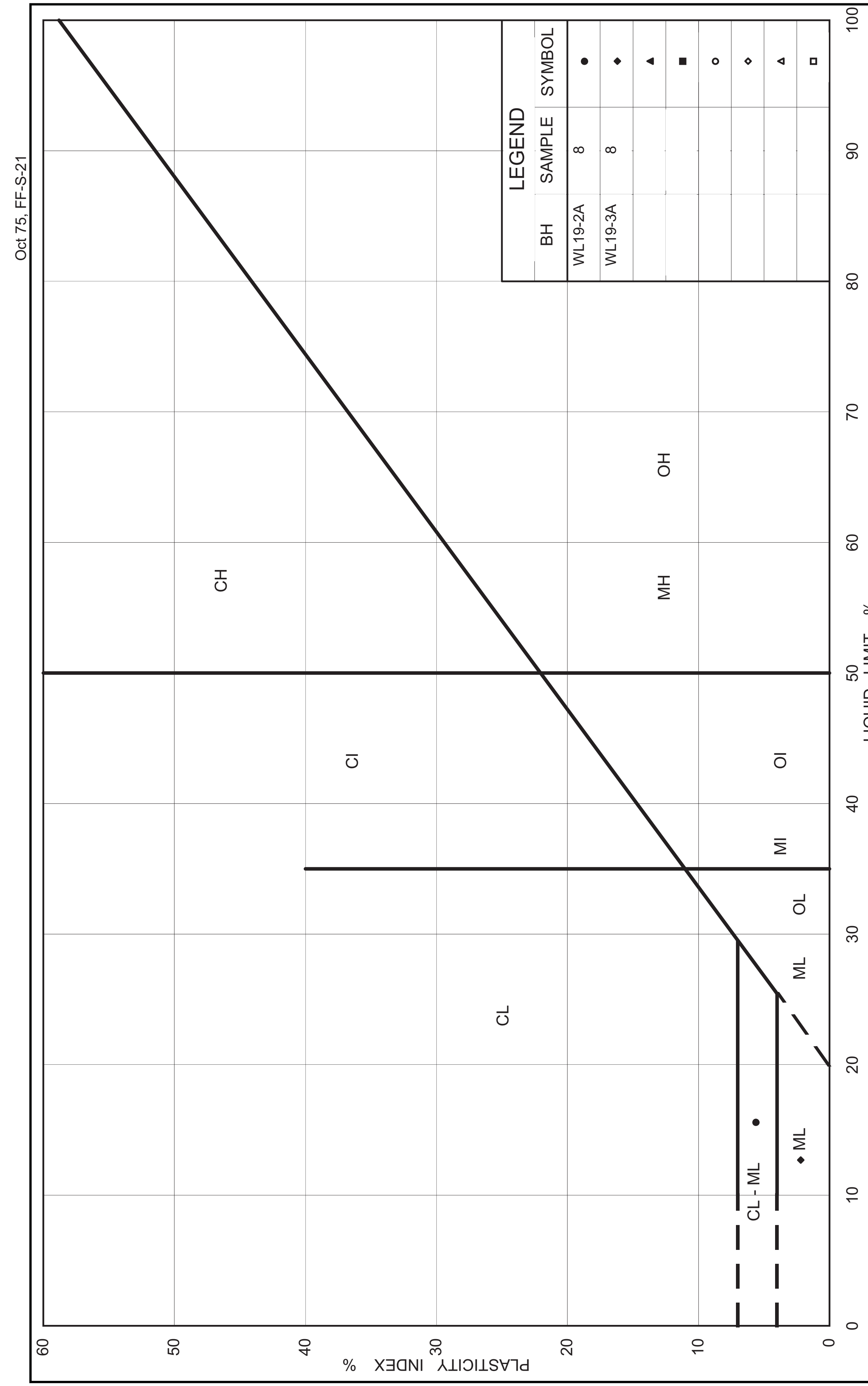


Figure No. WL19-D

Project No. 07-1111-0053

Checked By: KJB

PLASTICITY CHART
Sand and Silt (Till)

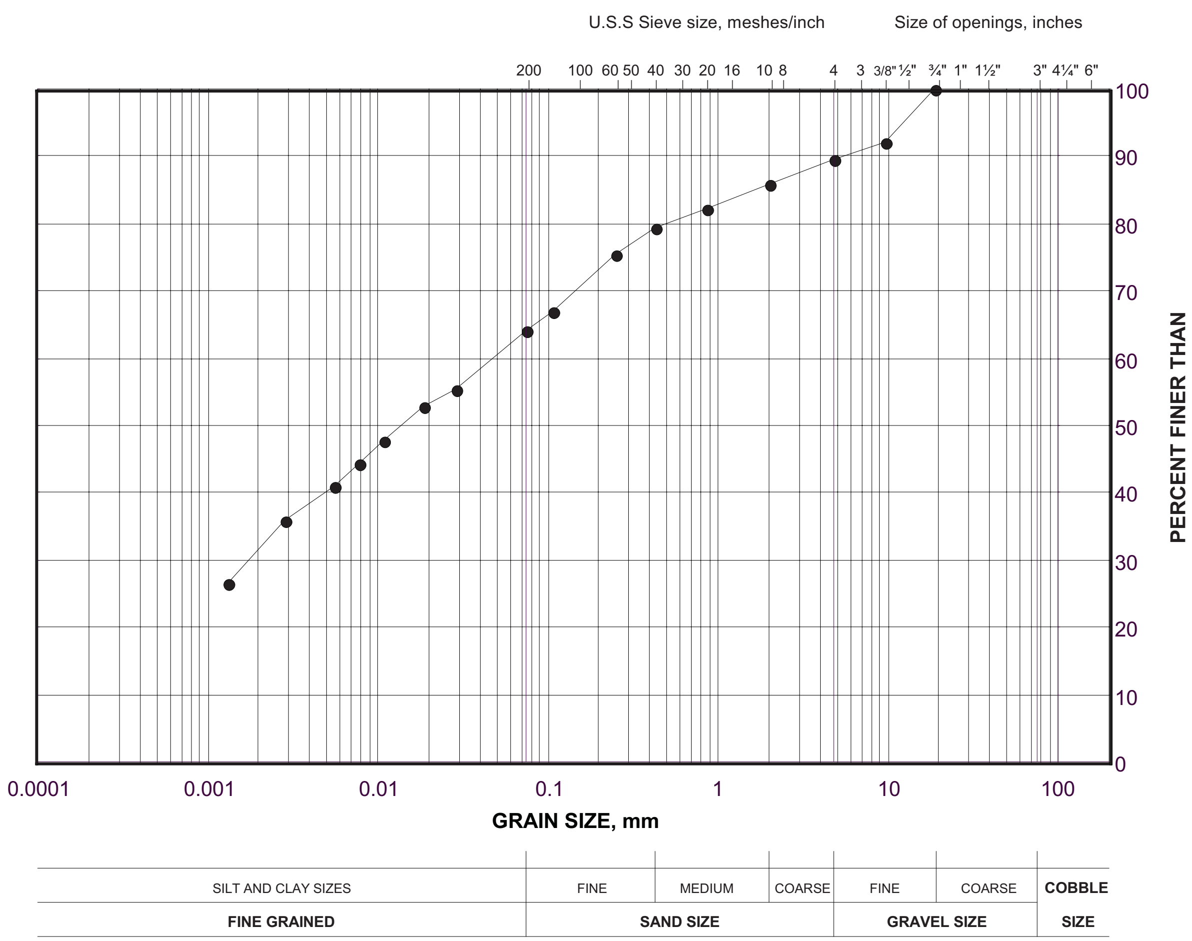
Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE WL19-E



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL19-3A	5	99.9

Project Number: 07-1111-0053

Checked By: KJB

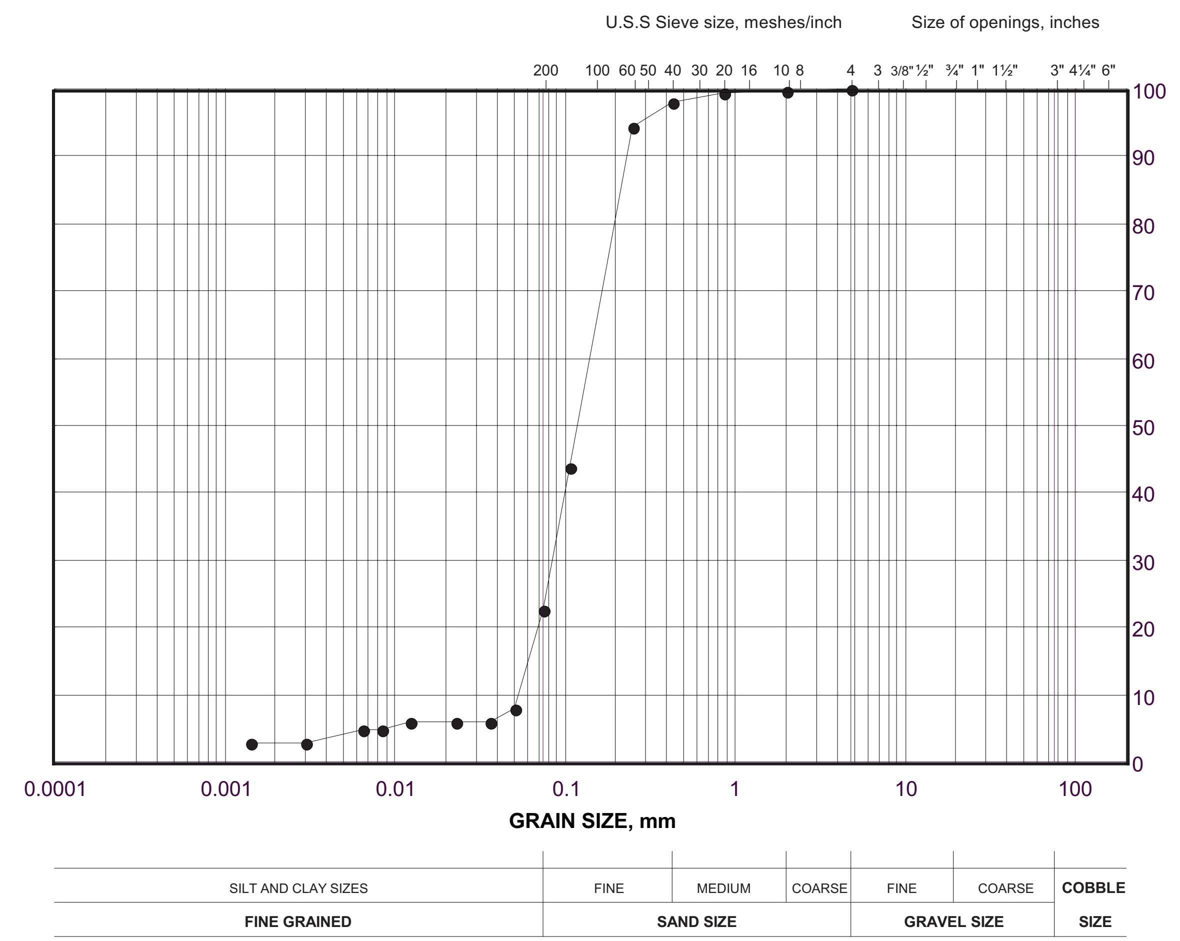
Golder Associates

Date: 05-Dec-08

GRAIN SIZE DISTRIBUTION

Sand

FIGURE WL19A-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL19A-1A	4A	98.5

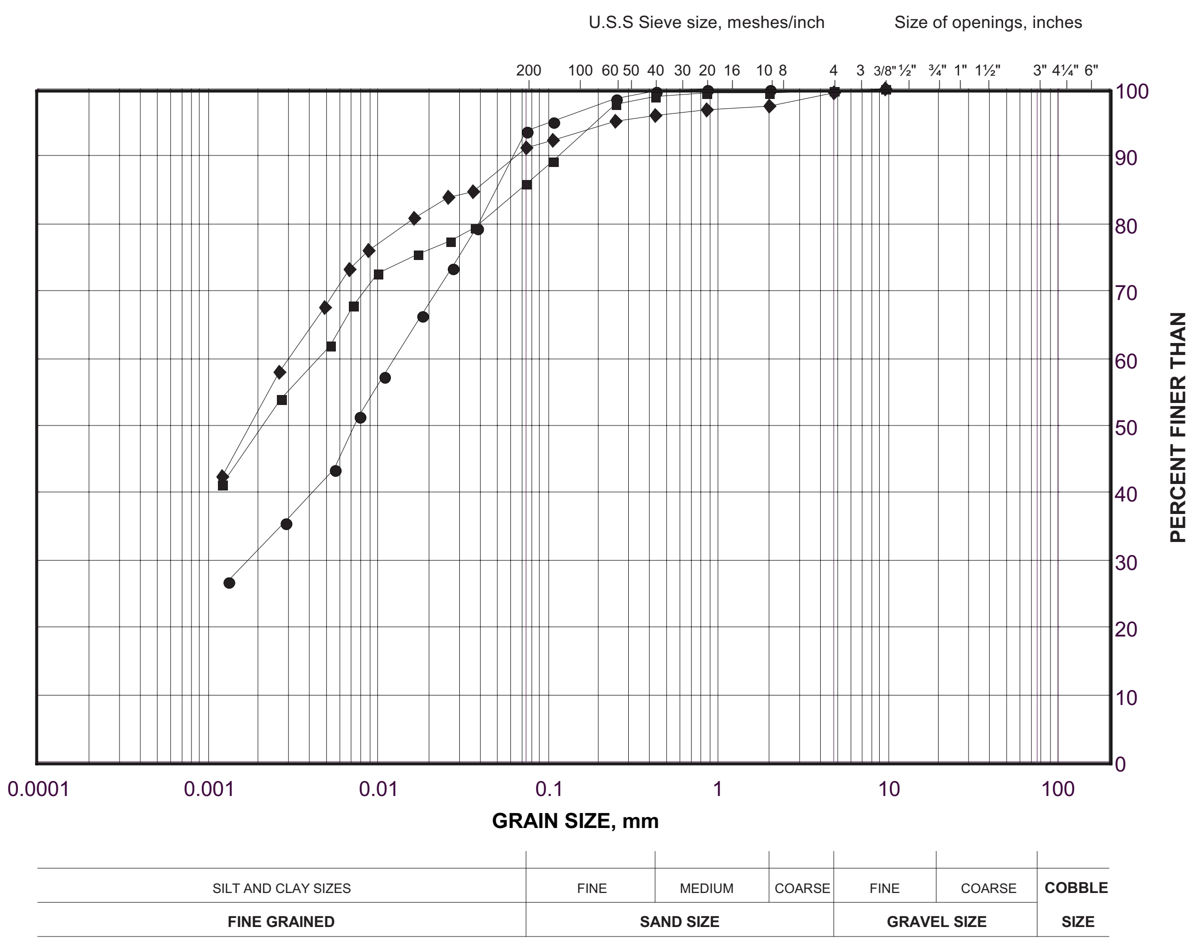
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 09-Dec-08

GRAIN SIZE DISTRIBUTION Clayey Silt to Silty Clay	FIGURE WL19A-B

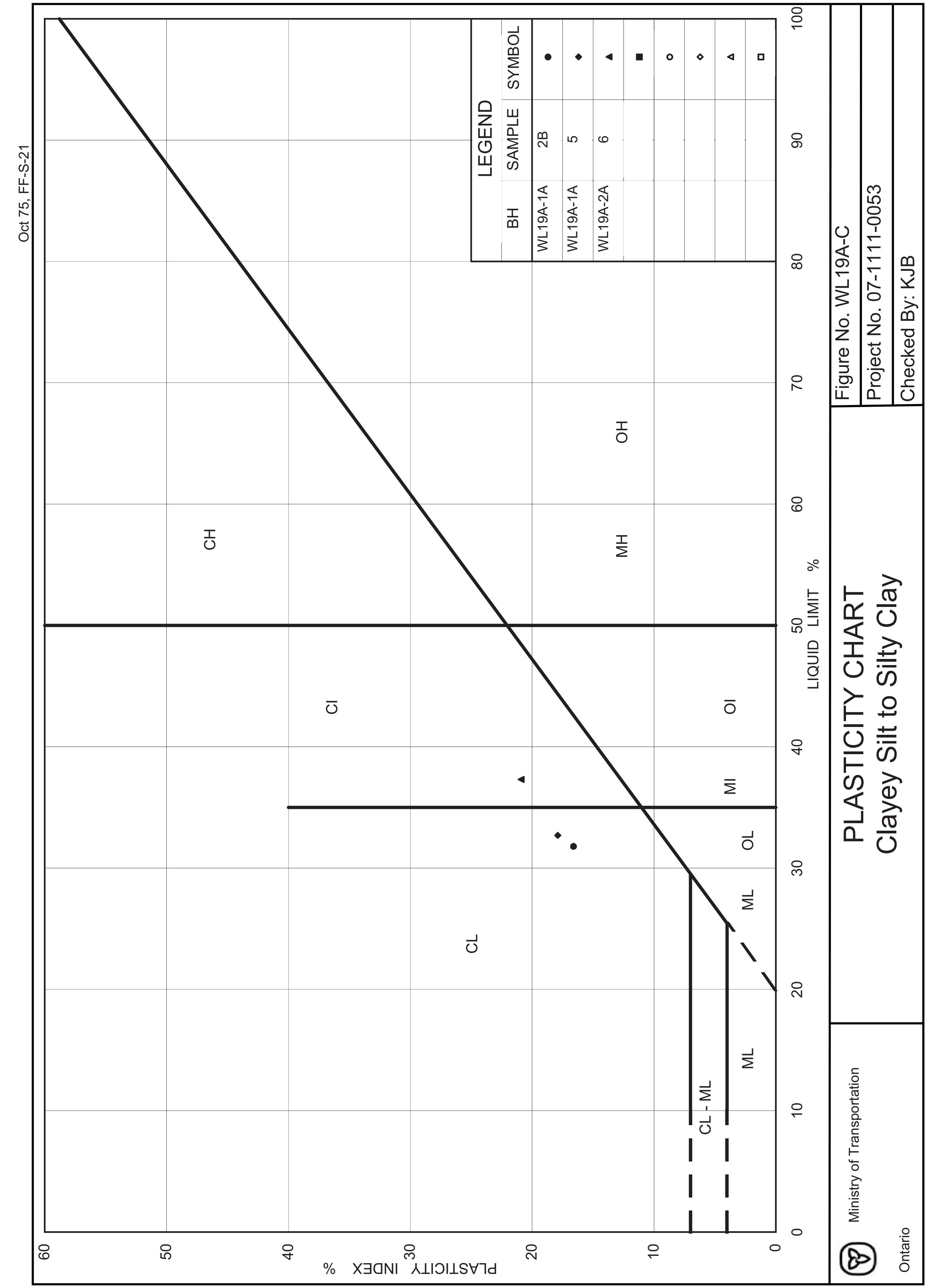


LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL19A-1A	2B	99.7
■	WL19A-1A	5	97.6
◆	WL19A-2A	6	97.1

Project Number: 07-1111-0053

Checked By: KJB **Golder Associates** Date: 09-Dec-08



CONSOLIDATION TEST SUMMARY
Clayey Silt to Silty Clay

FIGURE WL19A-D1

SAMPLE IDENTIFICATION

Project Number	07-1111-0053	Sample Number	6
Borehole Number	WL19A-1A	Sample Depth, m	4.0-4.6

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	5		
Date Started	10/20/2008		
Date Completed	11/01/2008		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.22	Unit Weight, kN/m^3	17.90
Sample Diameter, cm	5.00	Dry Unit Weight, kN/m^3	12.71
Area, cm^2	19.60	Specific Gravity, measured	2.74
Volume, cm^3	23.83	Solids Height, cm	0.575
Water Content, %	40.82	Volume of Solids, cm^3	11.27
Wet Mass, g	43.50	Volume of Voids, cm^3	12.55
Dry Mass, g	30.89	Degree of Saturation, %	100.4

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.216	1.114	1.216				
4.93	1.200	1.086	1.208	866	3.57E-04	2.69E-03	9.40E-08
9.86	1.196	1.078	1.198	155	1.96E-03	7.17E-04	1.38E-07
19.73	1.185	1.060	1.191	283	1.06E-03	8.50E-04	8.84E-08
39.46	1.166	1.026	1.176	394	7.44E-04	8.17E-04	5.95E-08
78.92	1.139	0.980	1.152	335	8.40E-04	5.59E-04	4.60E-08
157.83	1.097	0.906	1.118	228	1.16E-03	4.43E-04	5.04E-08
315.66	1.023	0.778	1.060	399	5.97E-04	3.82E-04	2.24E-08
631.32	0.950	0.651	0.986	240	8.60E-04	1.91E-04	1.61E-08
1262.64	0.889	0.546	0.920	89	2.01E-03	7.88E-05	1.56E-08
2525.27	0.837	0.454	0.863	135	1.17E-03	3.43E-05	3.93E-09
1262.64	0.845	0.469	0.841				
315.66	0.863	0.499	0.854				
78.92	0.892	0.550	0.877				
19.73	0.925	0.607	0.908				
4.93	0.938	0.630	0.931				

Note:
k calculated using cv based on t_{90} values.

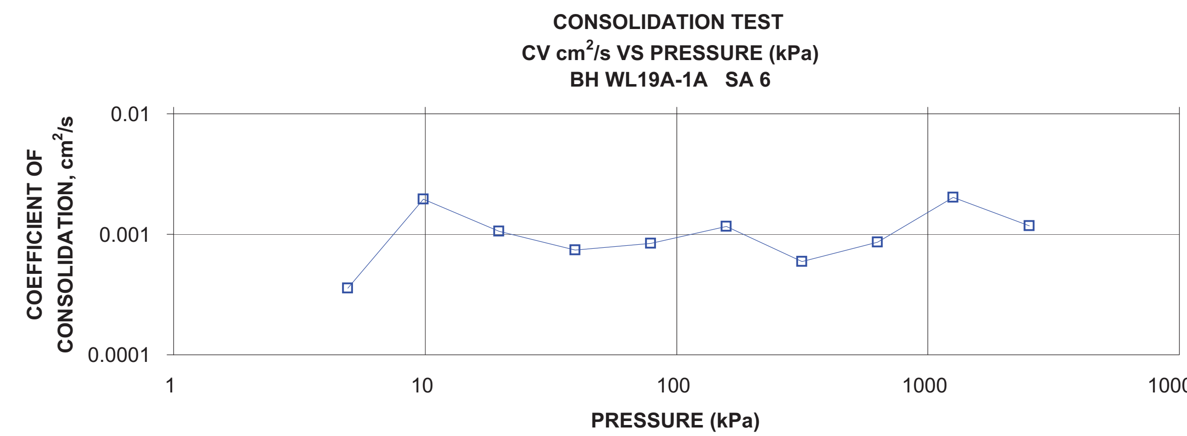
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

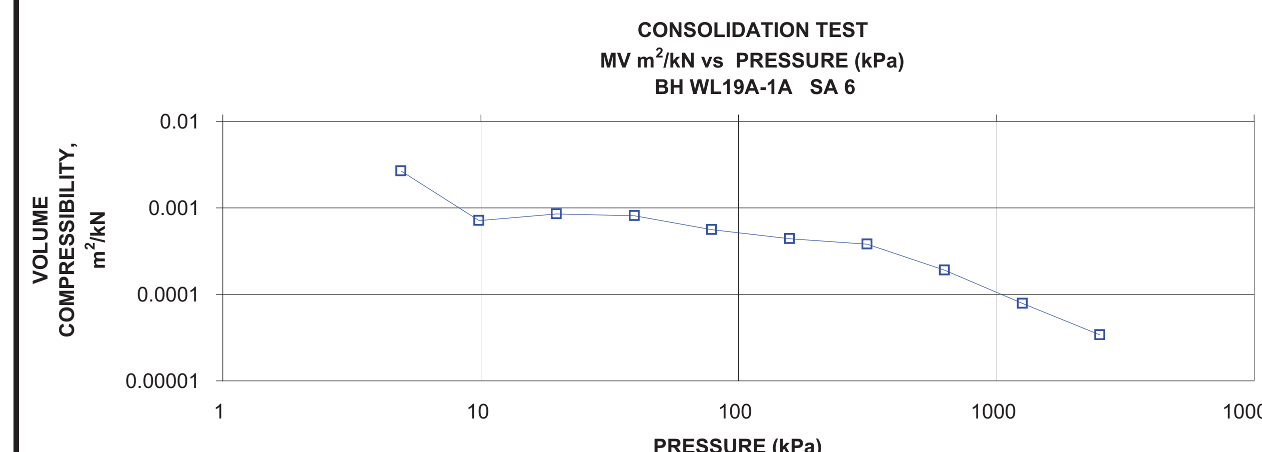
Sample Height, cm	0.94	Unit Weight, kN/m^3	21.08
Sample Diameter, cm	5.00	Dry Unit Weight, kN/m^3	16.48
Area, cm^2	19.60	Specific Gravity, measured	2.74
Volume, cm^3	18.38	Solids Height, cm	0.575
Water Content, %	27.91	Volume of Solids, cm^3	11.27
Wet Mass, g	39.51	Volume of Voids, cm^3	7.11
Dry Mass, g	30.89		

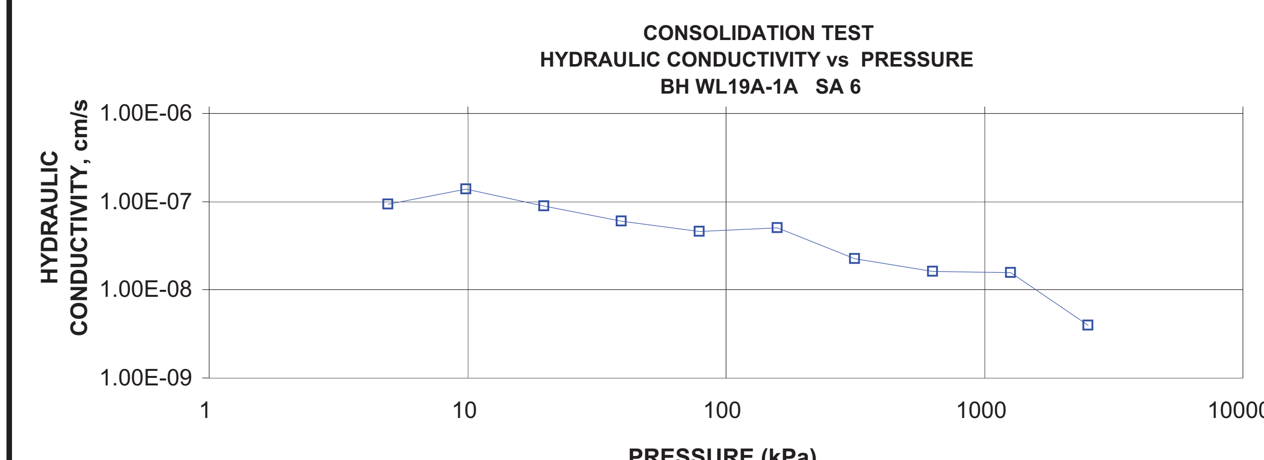
Prepared By: LFG　　Golder Associates　　Checked By: MM

CONSOLIDATION TEST SUMMARY
Clayey Silt to Silty Clay

FIGURE WL19A-D2



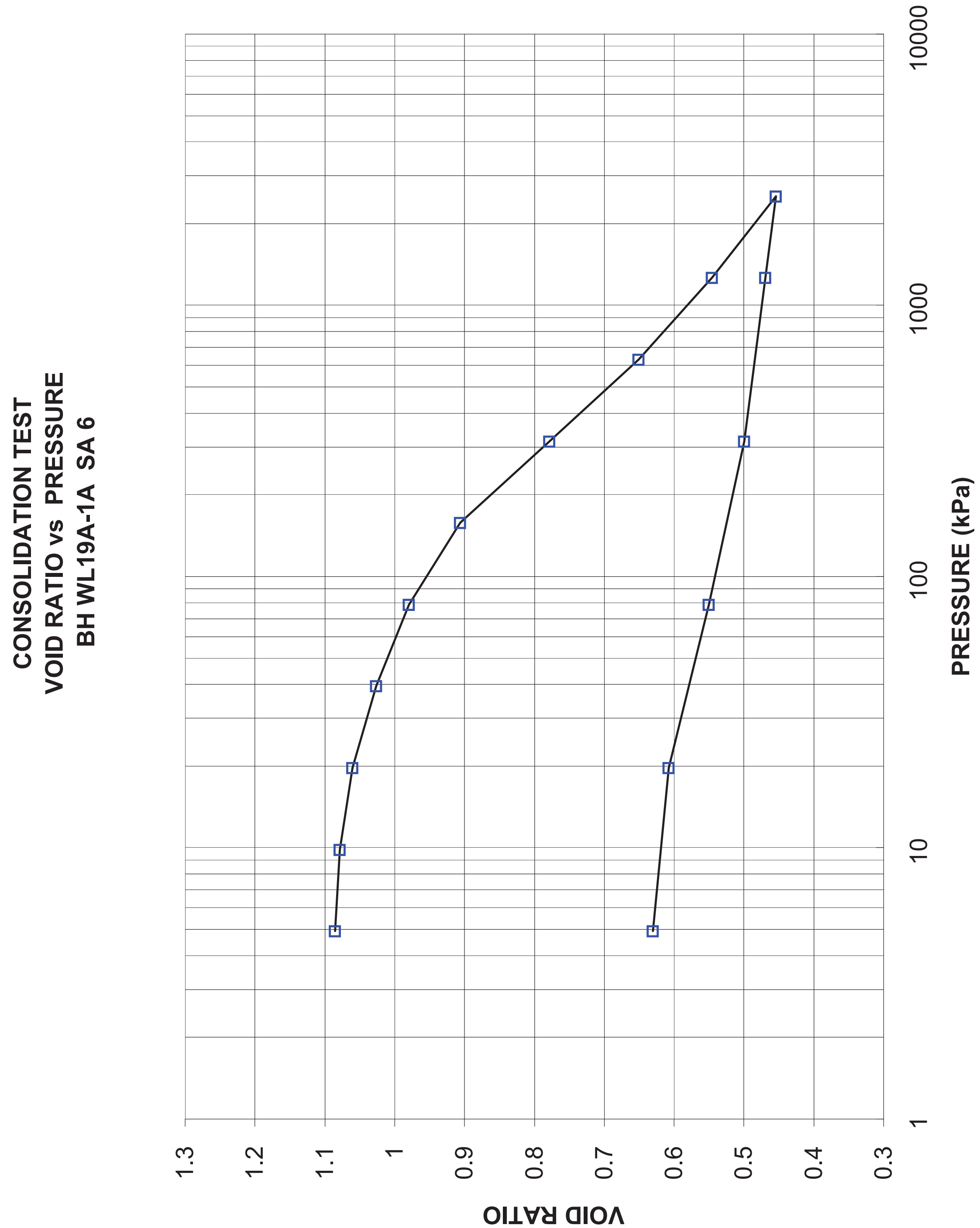




Project No. 07-1111-0053
Prepared By: LFG　　Golder Associates　　Checked By: MM

CONSOLIDATION TEST RESULTS
Clayey Silt to Silty Clay

FIGURE WL19A-D3



Project No.07-1111-0053

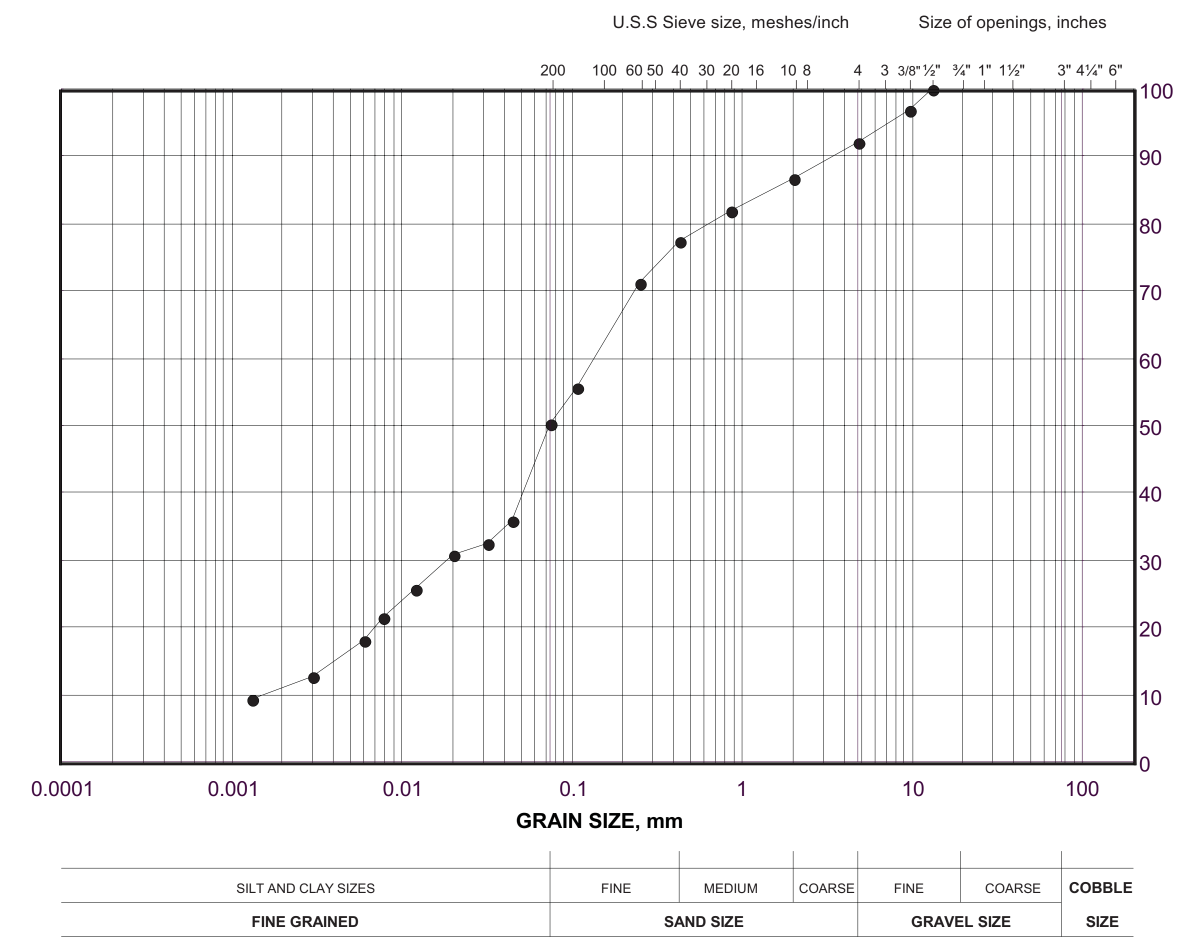
Prepared By: LFG

Golder Associates

Checked By: MM

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WL19A-E



LEGEND

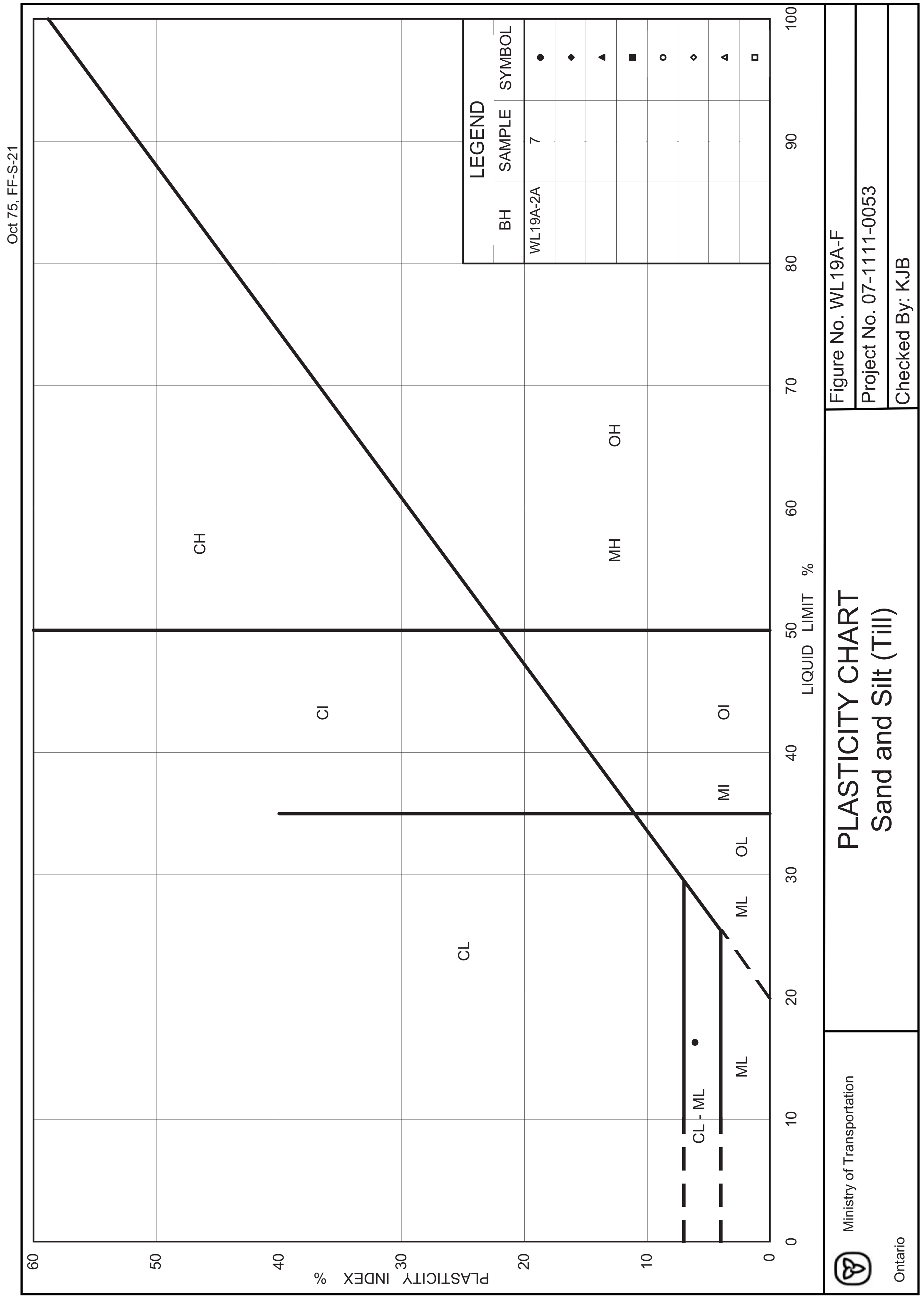
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL19A-2A	7	95.8

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

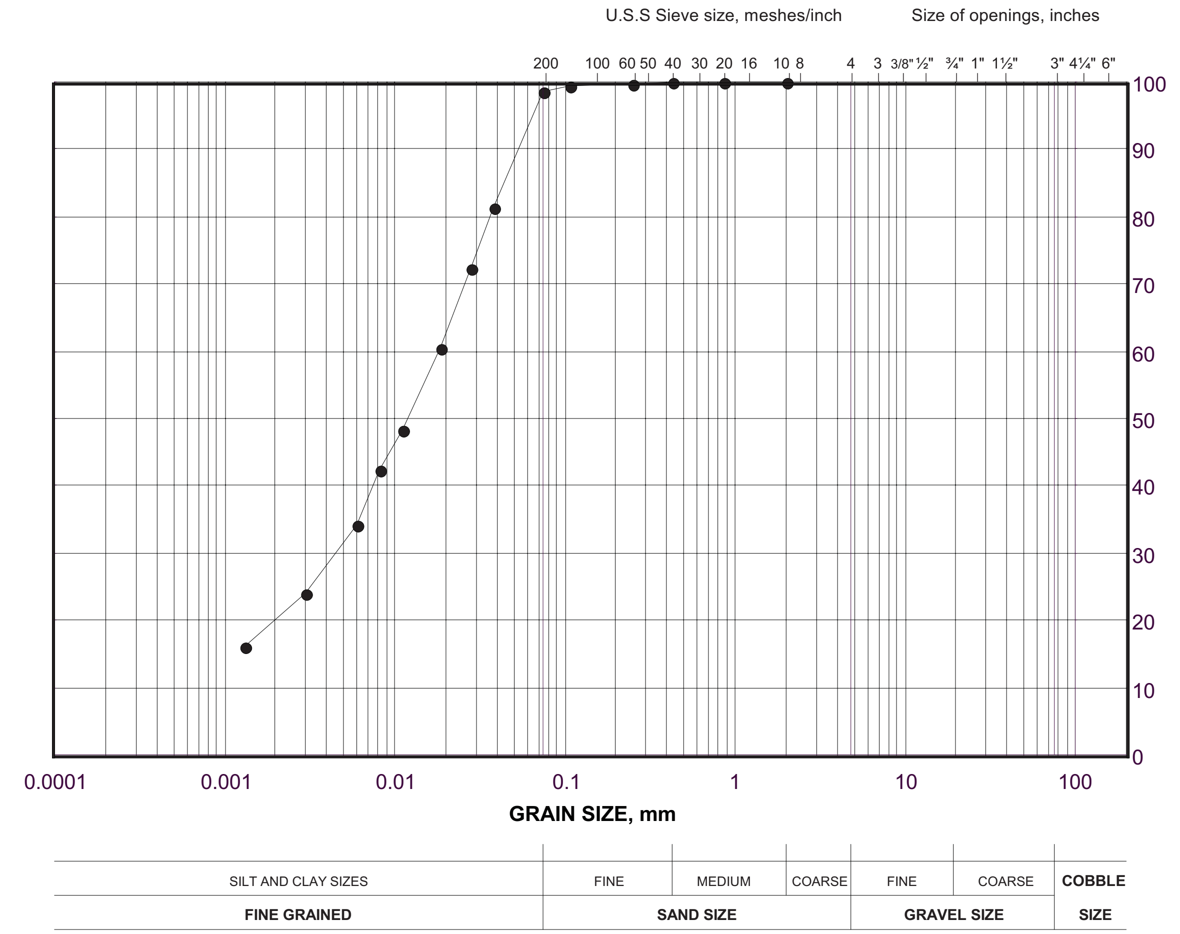
Date: 05-Dec-08



GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE WL20-A



LEGEND

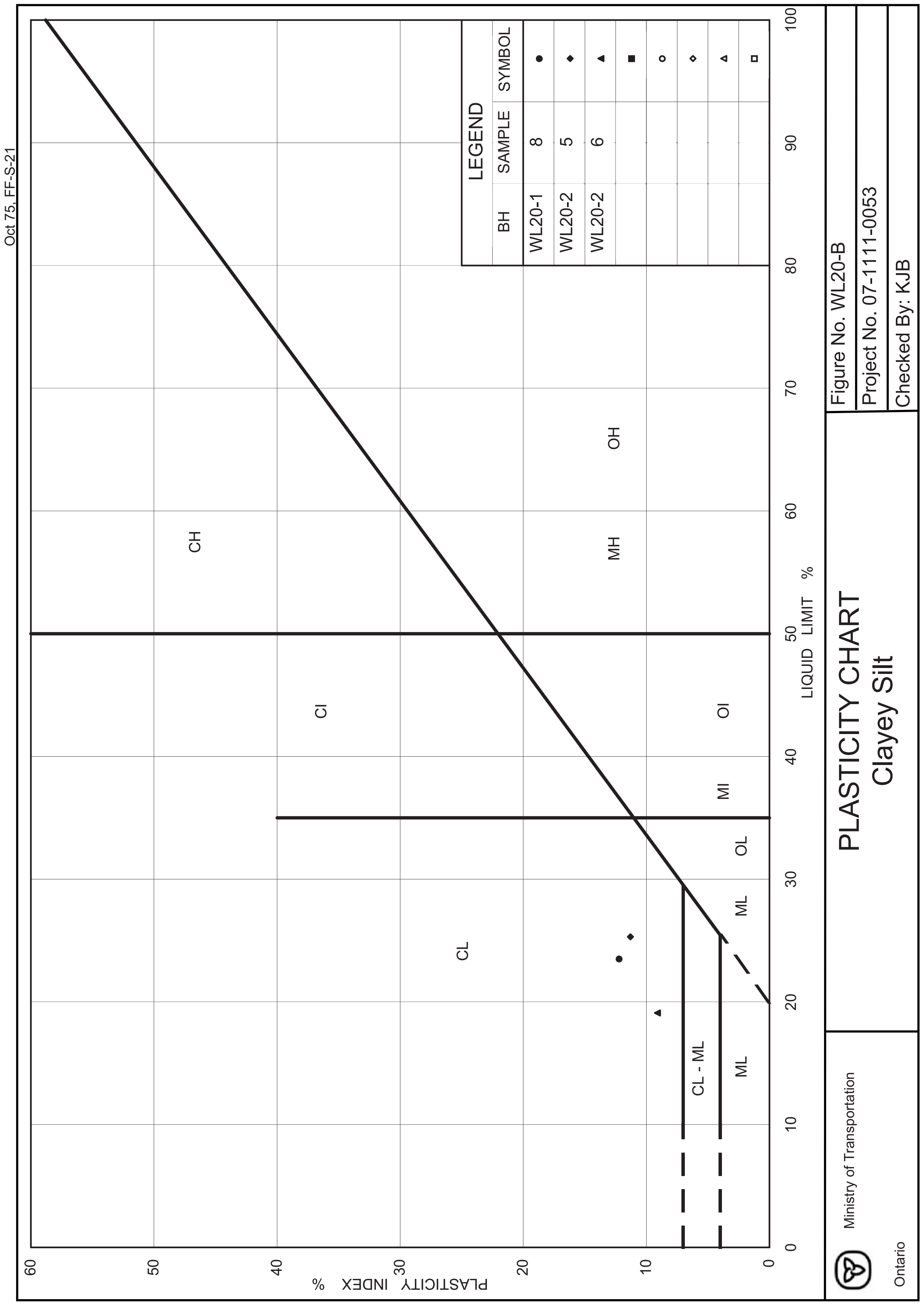
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL20-2	5	111.6

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 17-Jul-08



CONSOLIDATION TEST SUMMARY

Clayey Silt

FIGURE WL20-C1

SAMPLE IDENTIFICATION

Project Number	07-1111-0053	Sample Number	4
Borehole Number	WL20-2	Sample Depth, m	2.4-3.0

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	5		
Date Started	02/15/2008		
Date Completed	02/27/2008		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m^3	20.36
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m^3	16.77
Area, cm^2	31.39	Specific Gravity, measured	2.76
Volume, cm^3	59.64	Solids Height, cm	1.177
Water Content, %	21.41	Volume of Solids, cm^3	36.95
Wet Mass, g	123.83	Volume of Voids, cm^3	22.69
Dry Mass, g	101.99	Degree of Saturation, %	96.3

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.900	0.614	1.900				
4.89	1.899	0.613	1.900	5	1.53E-01	1.08E-04	1.61E-06
9.63	1.897	0.611	1.898	17	4.49E-02	2.22E-04	9.78E-07
19.42	1.894	0.609	1.896	15	5.08E-02	1.61E-04	8.03E-07
39.03	1.890	0.606	1.892	17	4.46E-02	1.07E-04	4.70E-07
78.08	1.885	0.601	1.888	7	1.08E-01	6.74E-05	7.13E-07
156.29	1.877	0.594	1.881	13	5.77E-02	5.38E-05	3.04E-07
312.14	1.865	0.584	1.871	7	1.06E-01	4.05E-05	4.21E-07
624.04	1.841	0.564	1.853	7	1.04E-01	4.05E-05	4.13E-07
1248.47	1.789	0.520	1.815	20	3.49E-02	4.38E-05	1.50E-07
2495.40	1.710	0.453	1.750	22	2.95E-02	3.33E-05	9.64E-08
1248.47	1.720	0.461	1.715				
312.14	1.736	0.475	1.728				
78.08	1.749	0.486	1.743				
19.42	1.756	0.492	1.753				
4.89	1.773	0.506	1.765				

Note:
k calculated using cv based on t_{90} values.

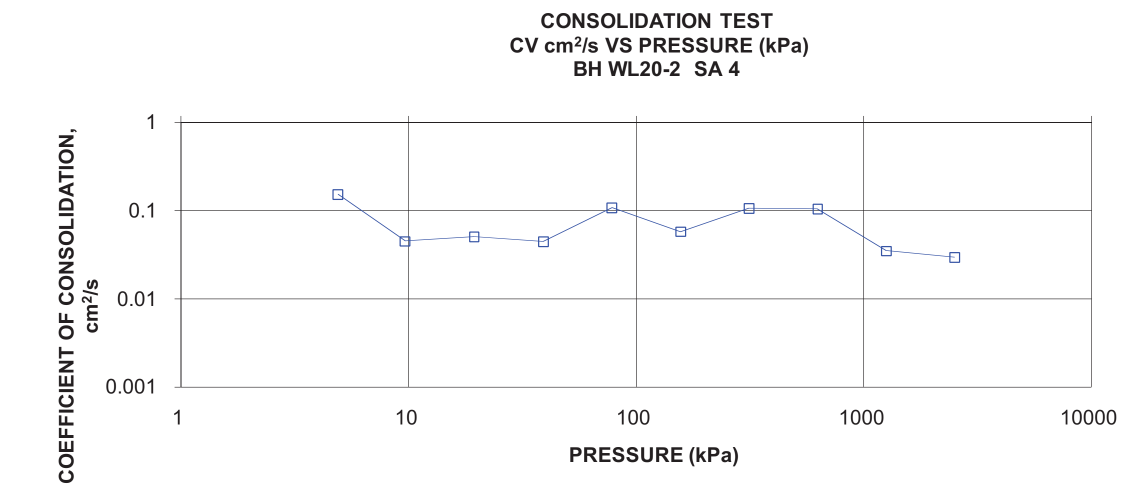
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

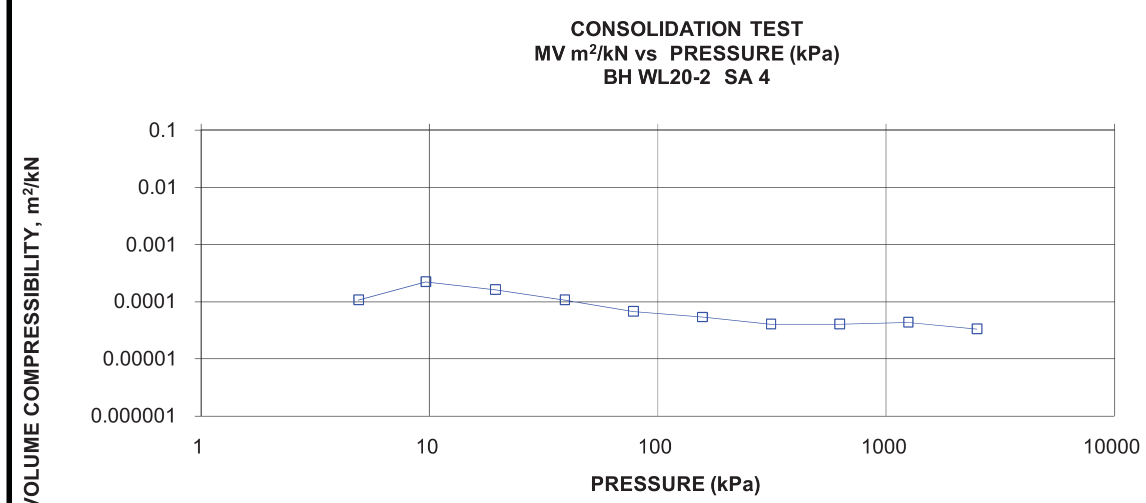
Sample Height, cm	1.77	Unit Weight, kN/m^3	21.46
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m^3	17.97
Area, cm^2	31.39	Specific Gravity, measured	2.76
Volume, cm^3	55.66	Solids Height, cm	1.177
Water Content, %	19.40	Volume of Solids, cm^3	36.95
Wet Mass, g	121.78	Volume of Voids, cm^3	18.70
Dry Mass, g	101.99		

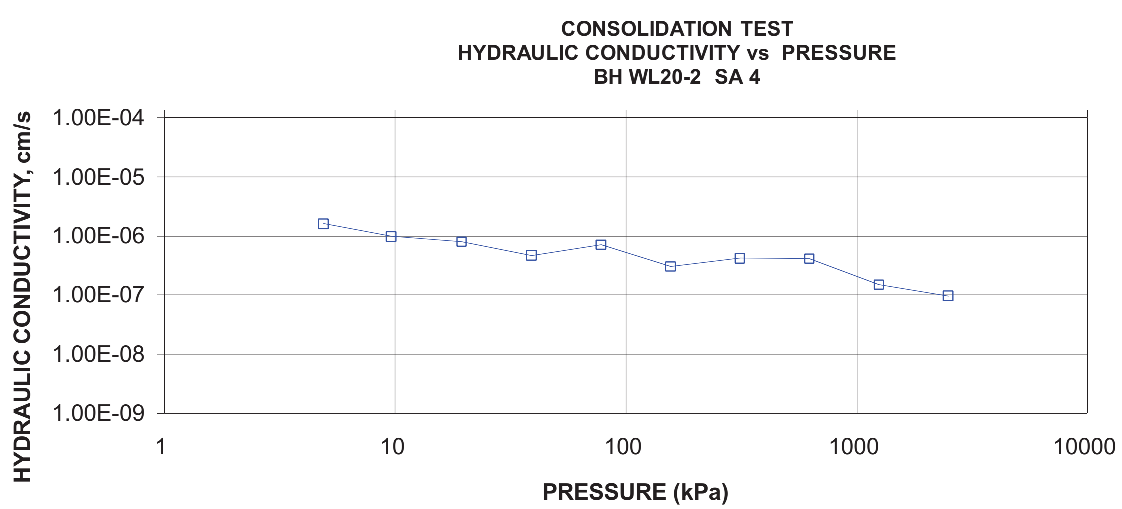
Prepared By: LFG **Golder Associates** Checked By: MM

CONSOLIDATION TEST SUMMARY
Clayey Silt

FIGURE WL20-C2







Project No. 07-1111-0053

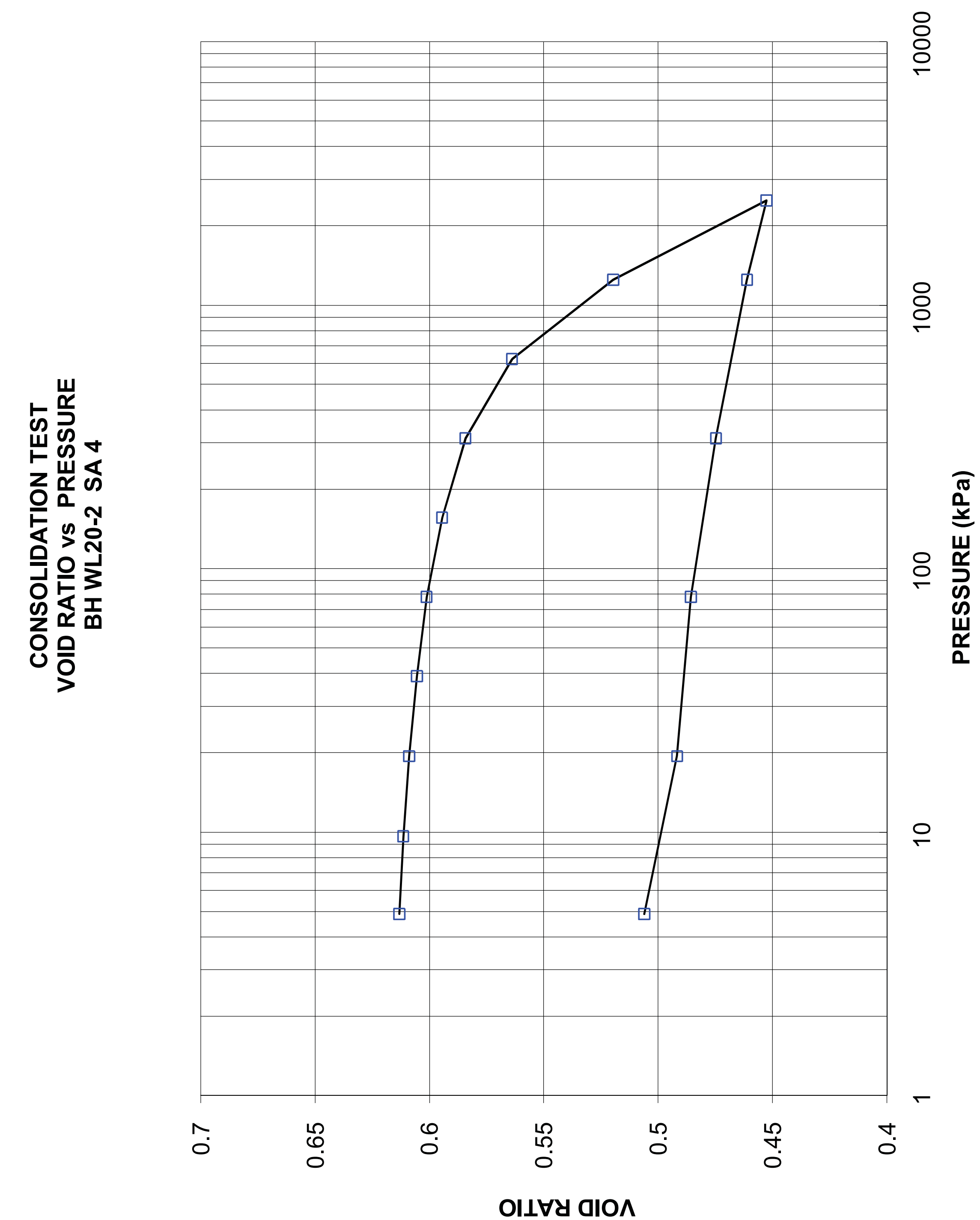
Prepared By: LFG

Golder Associates

Checked By: MM

CONSOLIDATION TEST SUMMARY
Clayey Silt

FIGURE WL20-C3



Project No.07-1111-0053

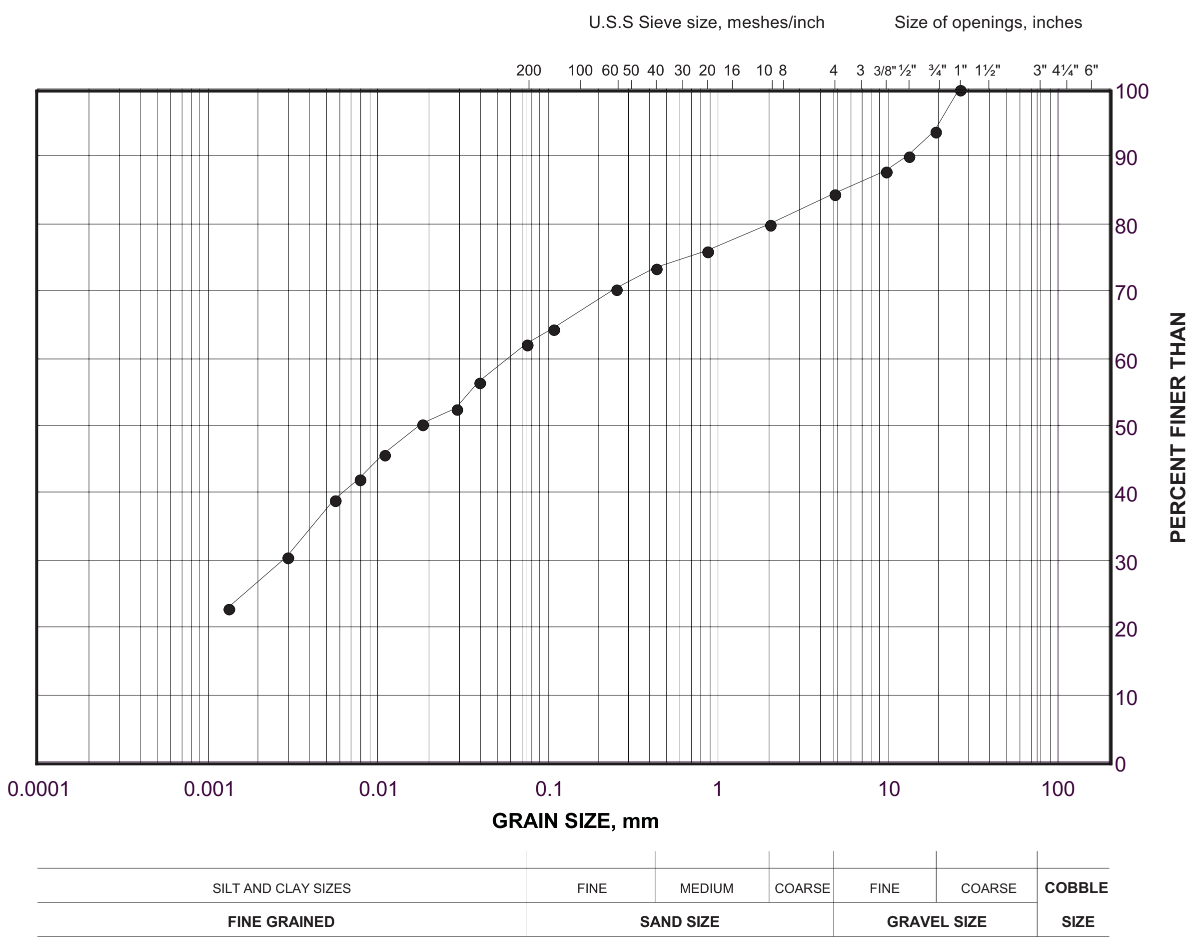
Golder Associates

Prepared By: LFG

Checked By: MM

GRAIN SIZE DISTRIBUTION
Clayey Silt (Till-Like)

FIGURE WL20-D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL20-1	8	108.5

Project Number: 07-1111-0053

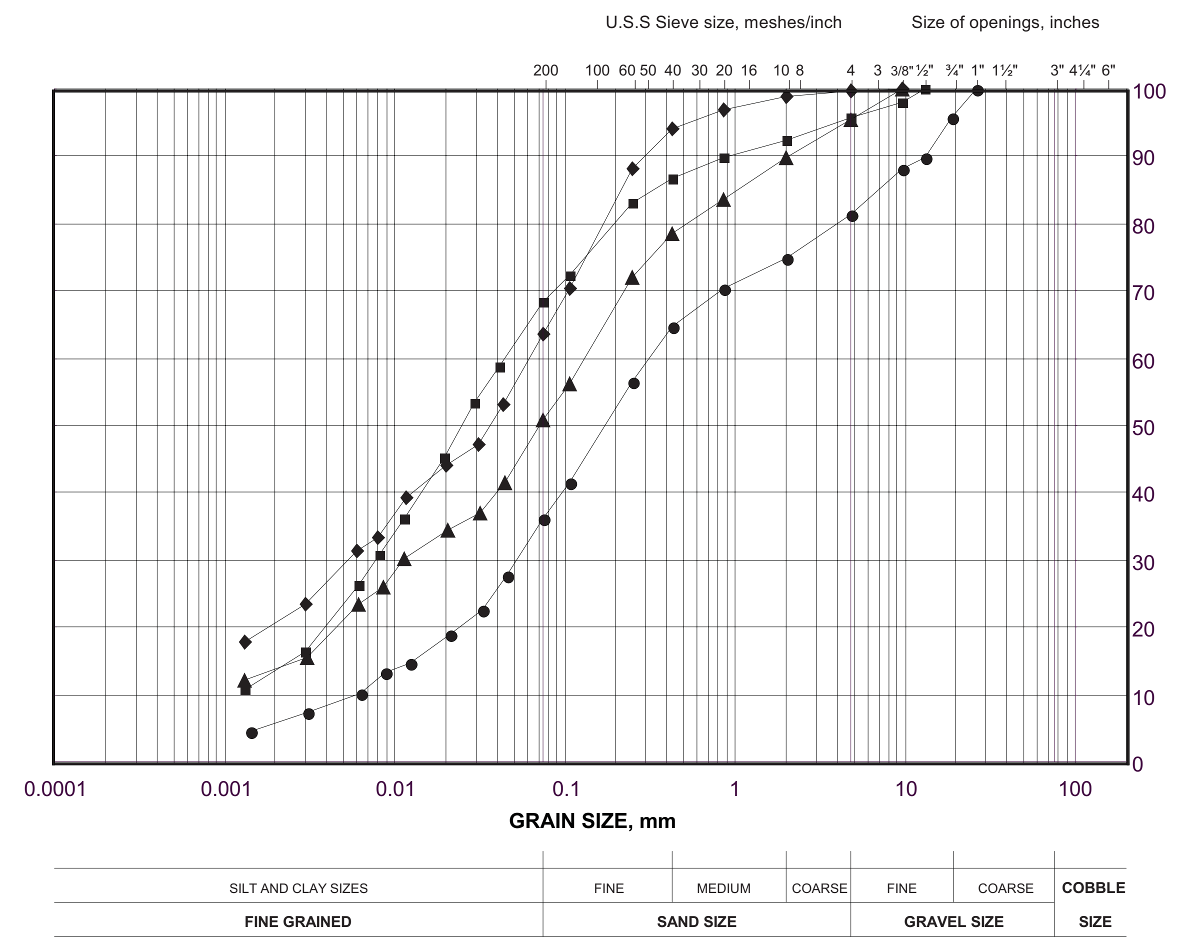
Checked By: KJB

Golder Associates

Date: 17-Jul-08

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand to Sand and Silt (Till)

FIGURE WL20-E



LEGEND

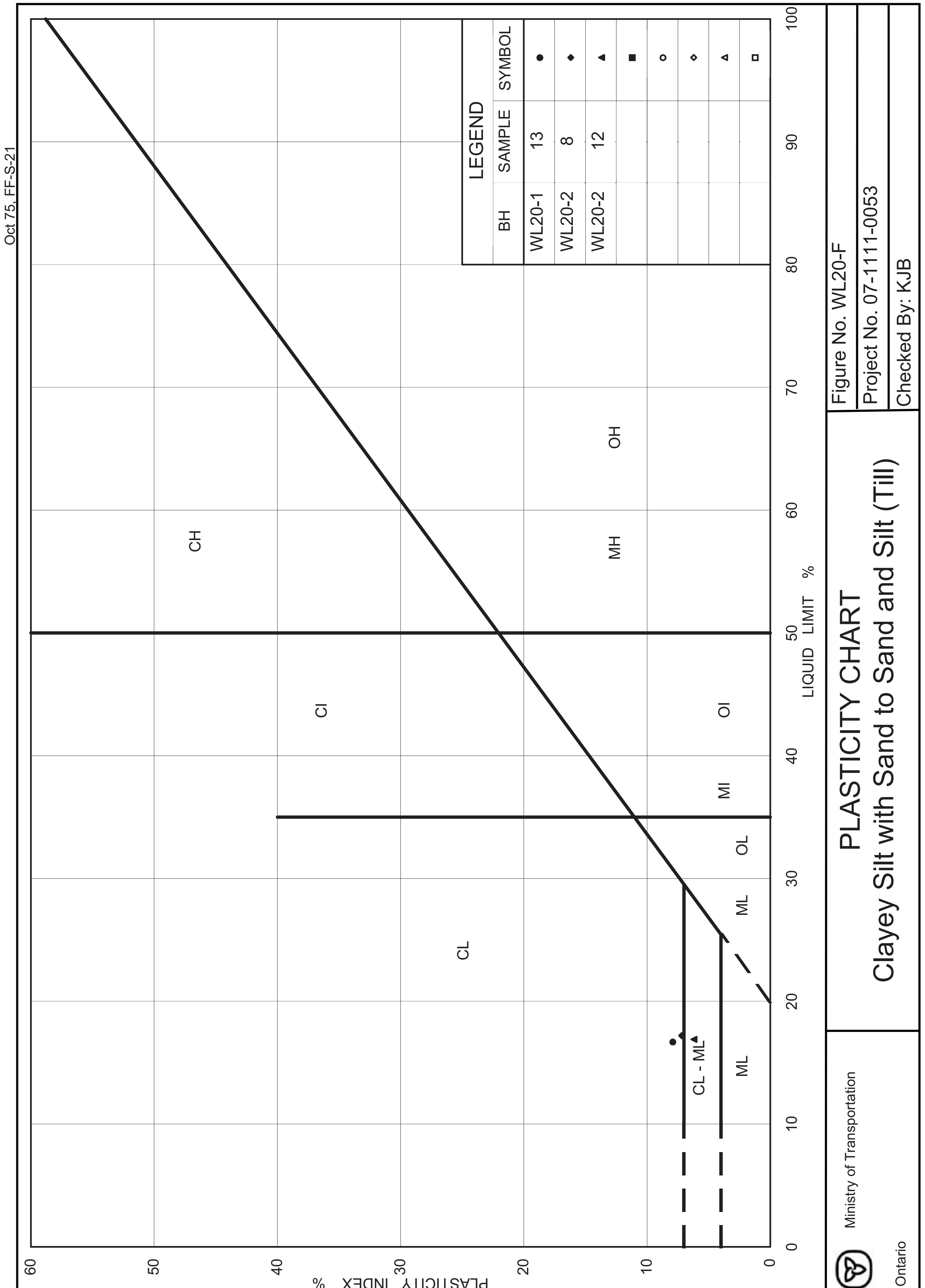
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL20-1	10	105.6
■	WL20-2	12	101.1
◆	WL20-1	13	101.0
▲	WL20-2	8	107.1

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

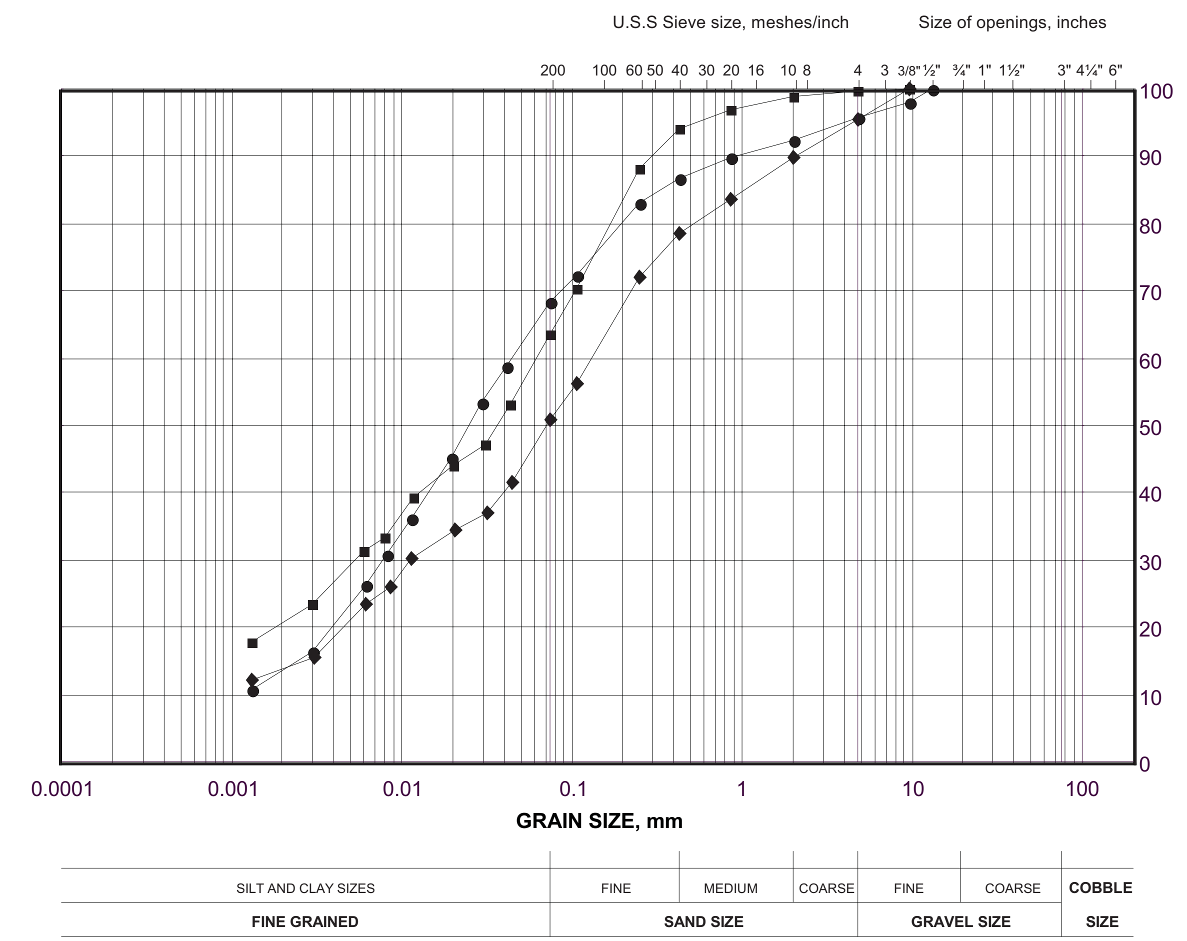
Date: 26-Aug-08



GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE WL20-G



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL20-2	12	101.1
■	WL20-1	13	101.0
◆	WL20-2	8	107.1

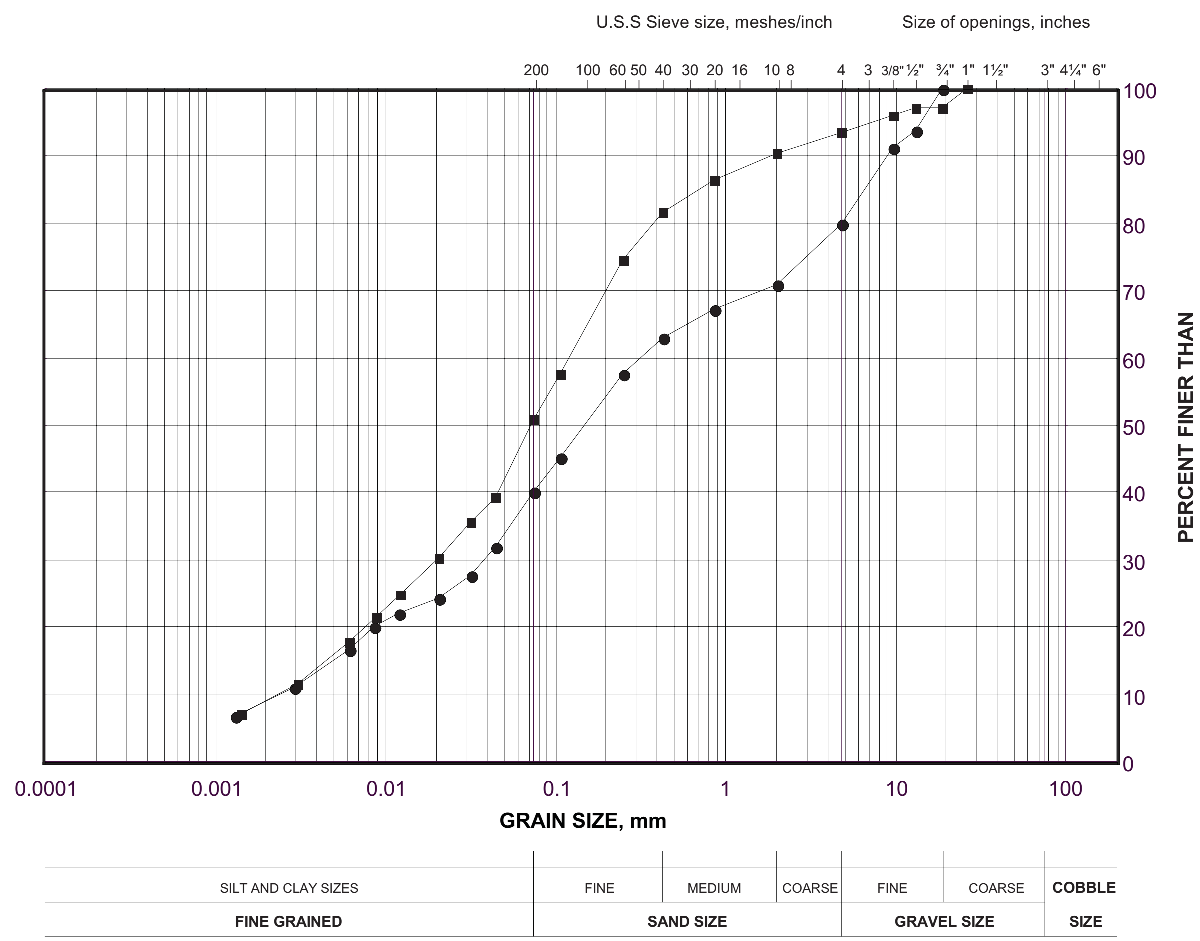
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 17-Jul-08

GRAIN SIZE DISTRIBUTION Sand and Silt (Till)	FIGURE WL23-A



LEGEND

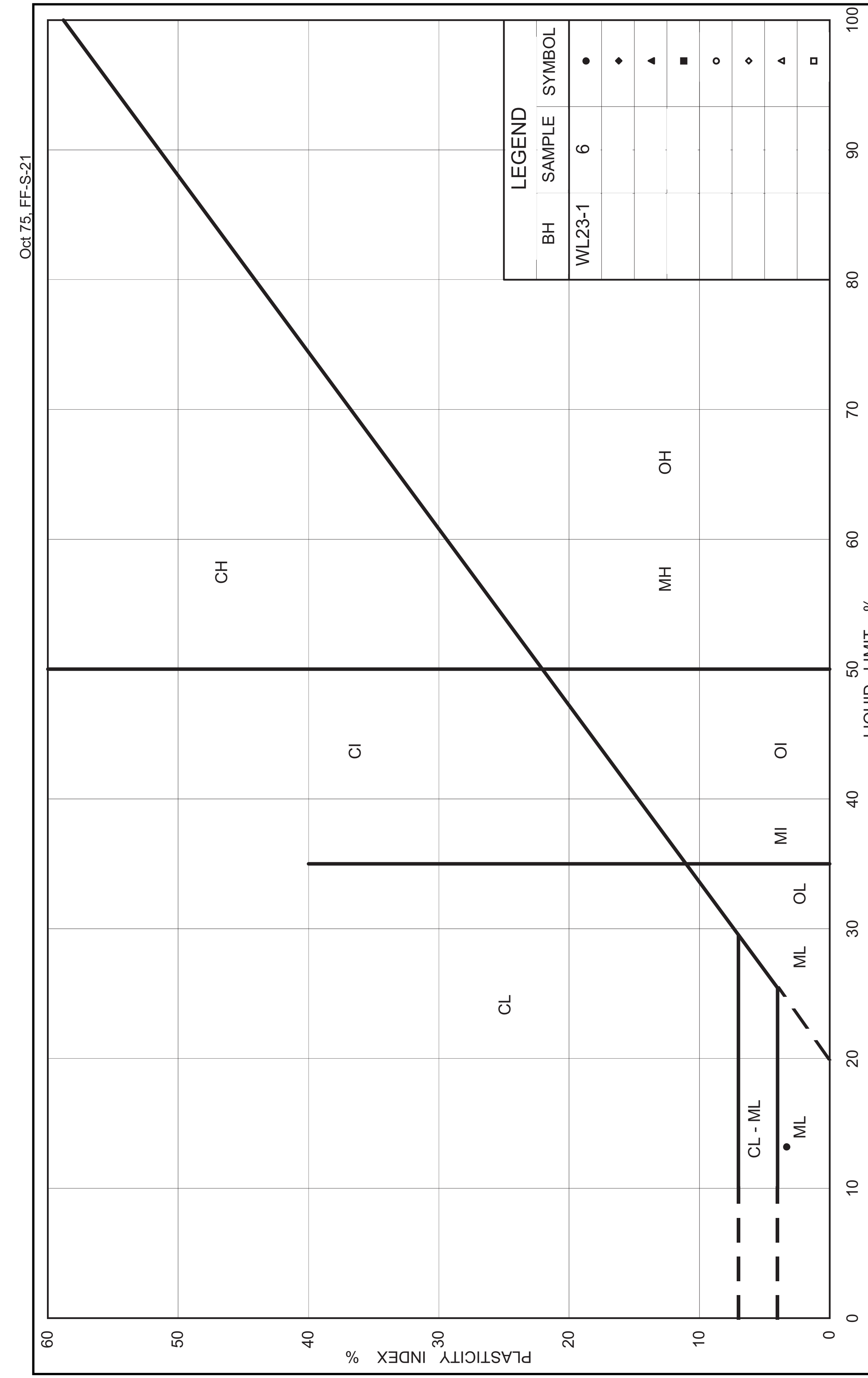
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL23-1	10	155.4
■	WL23-1	6	161.4

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

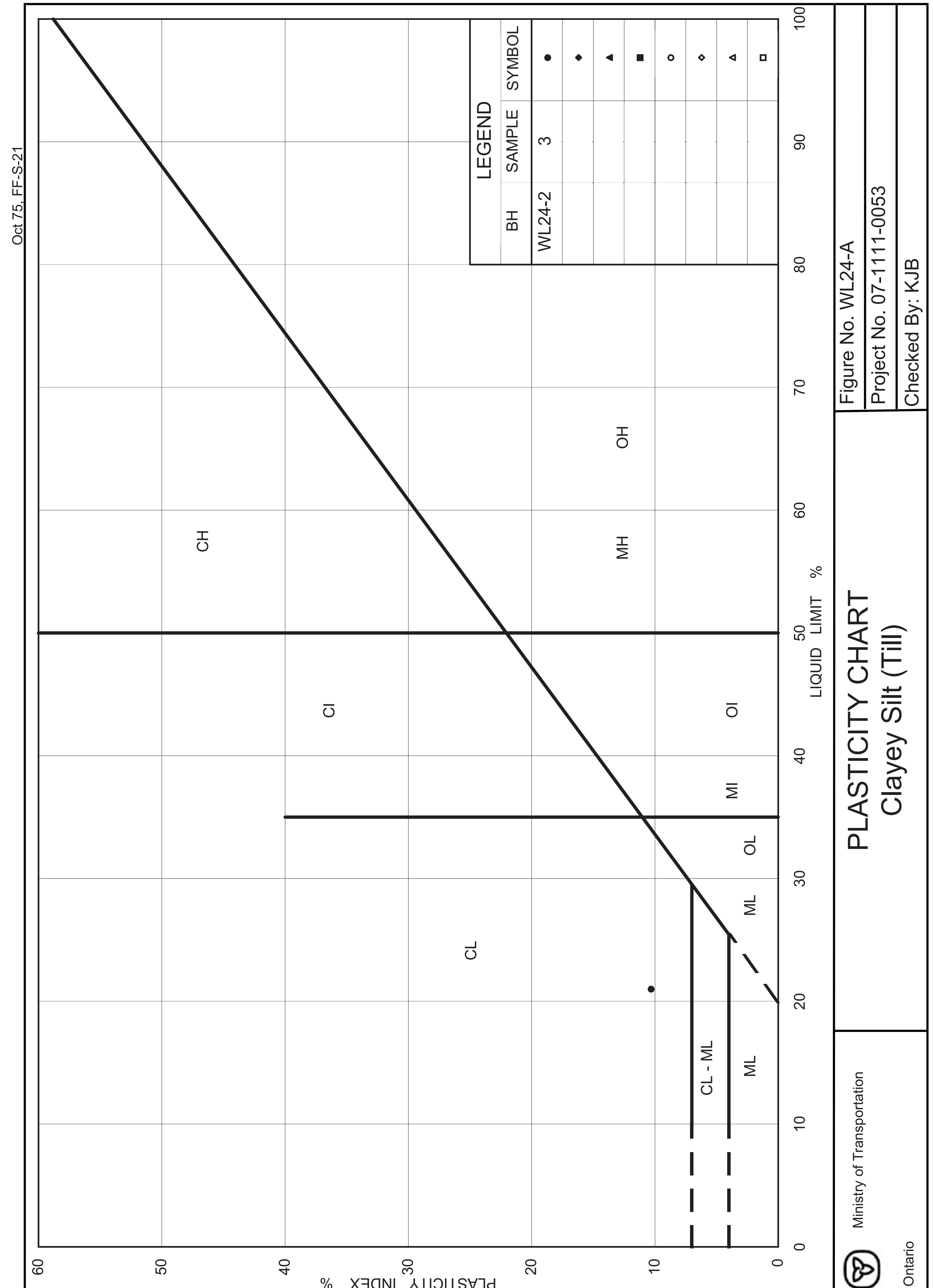
Date: 21-Jul-08



PLASTICITY CHART
Sand and Silt (Till)

Figure No. WL23-B
Project No. 07-1111-0053
Checked By: KJB

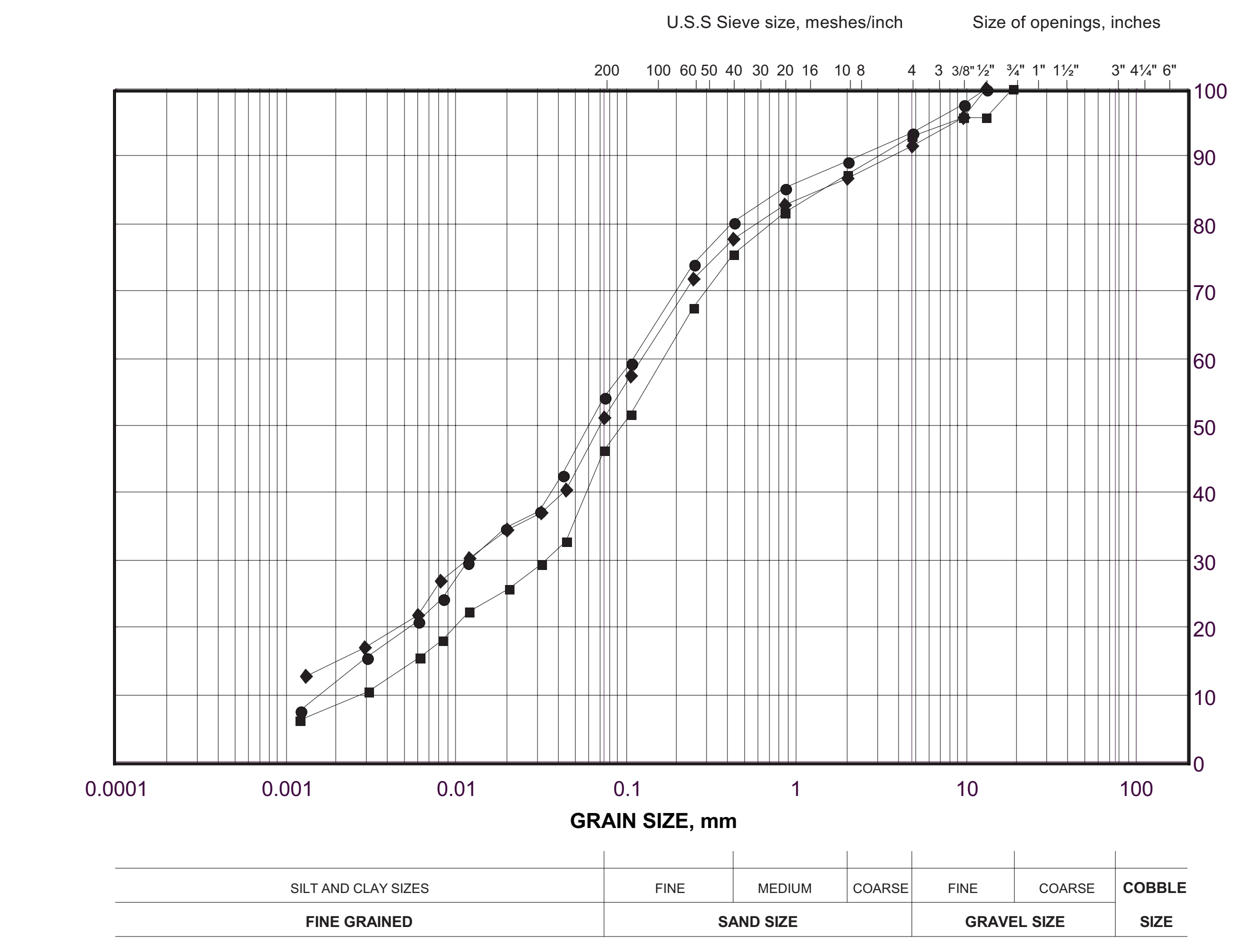
Ministry of Transportation
Ontario



GRAIN SIZE DISTRIBUTION

Sand and Silt (Till)

FIGURE WL24-B



LEGEND

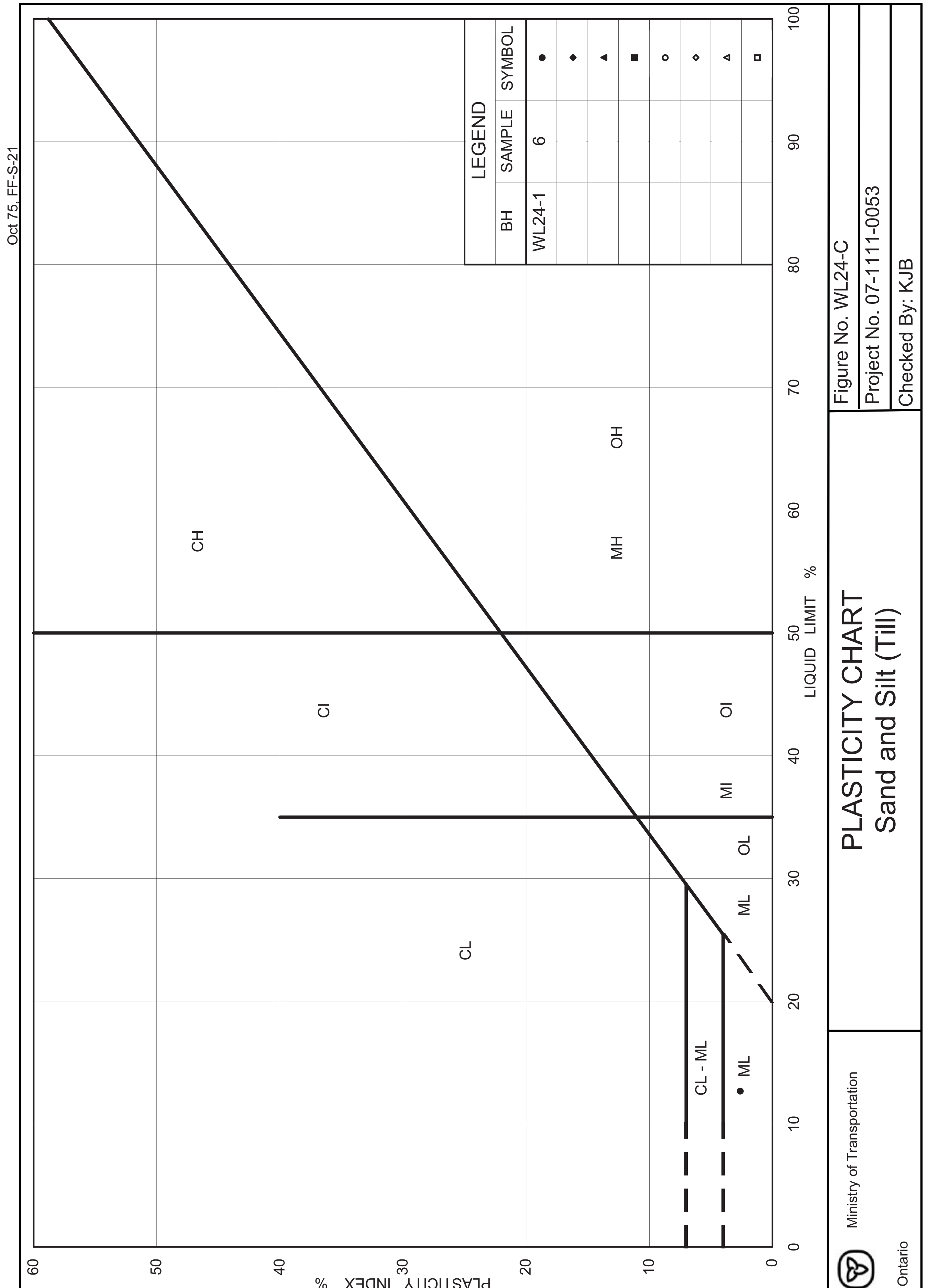
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL24-1	4	146.8
■	WL24-1	6	144.6
◆	WL24-2	6	145.4

Project Number: 07-1111-0053

Checked By: KJB

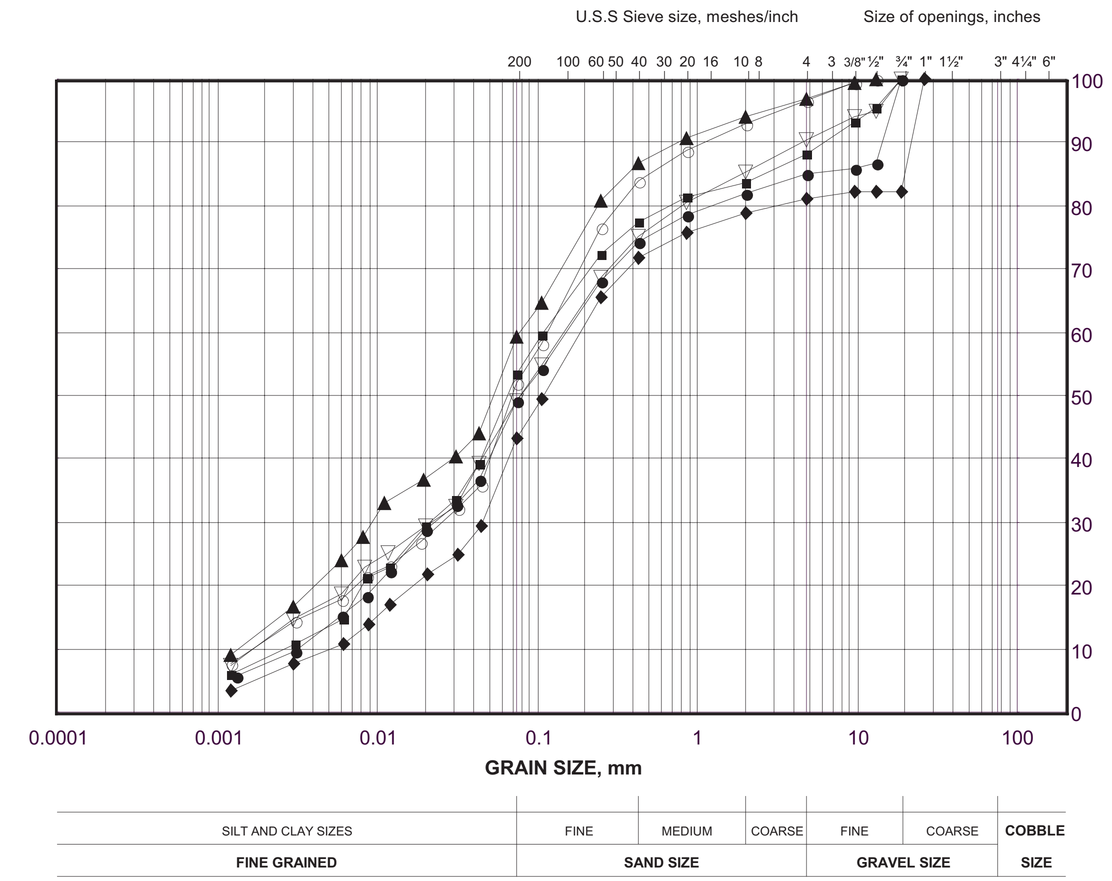
Golder Associates

Date: 04-Dec-08



GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WLTDLC41A-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL26-1	15	157.5
■	WL26-1	17	154.7
◆	WL26-1	4	173.5
▲	WL26-2	6	170.1
▽	WL26-2	8	167.4
○	WL26-1	8	168.2

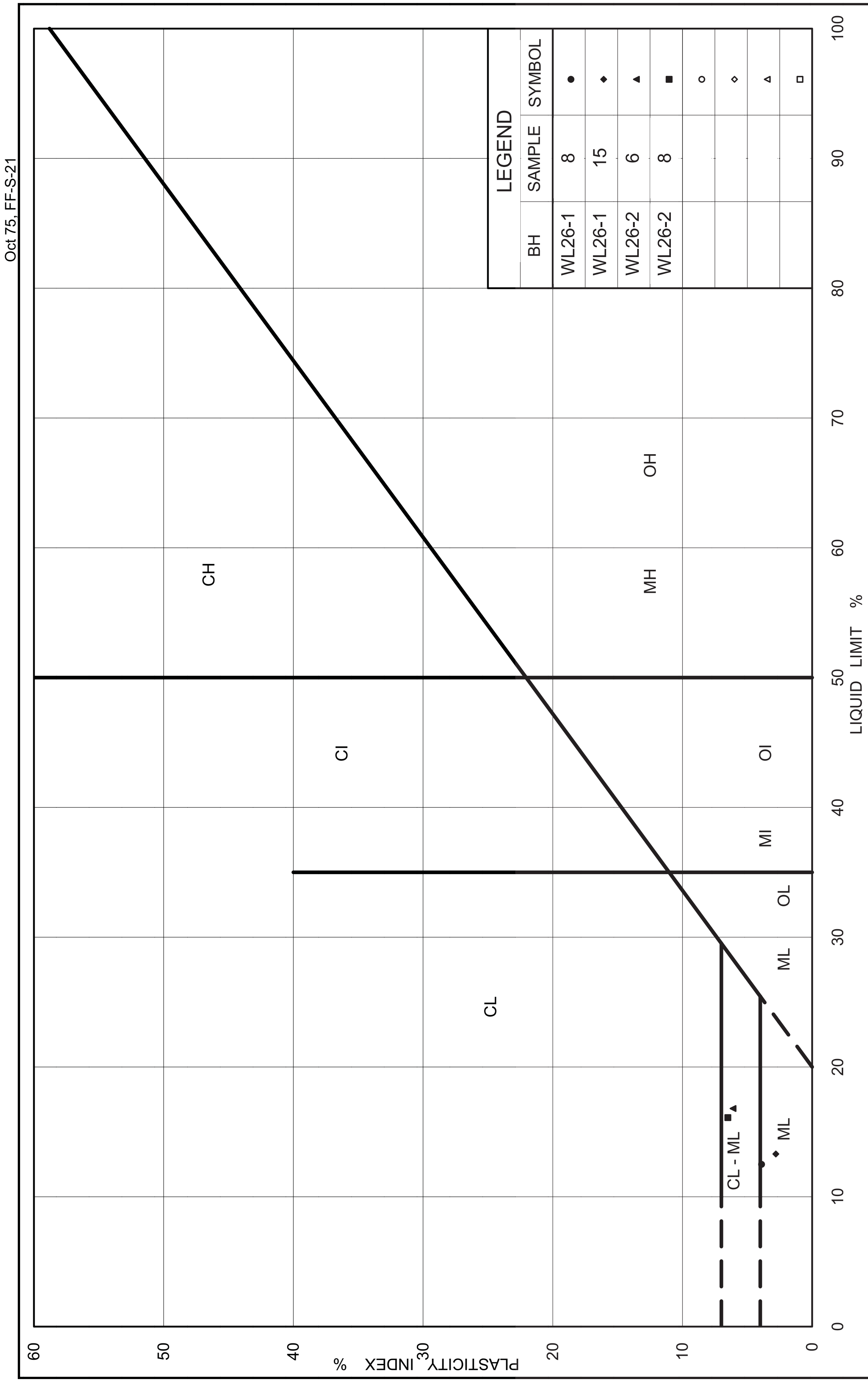
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 11-Mar-09

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
WL26-1	8	●
WL26-1	15	◆
WL26-2	6	▲
WL26-2	8	■

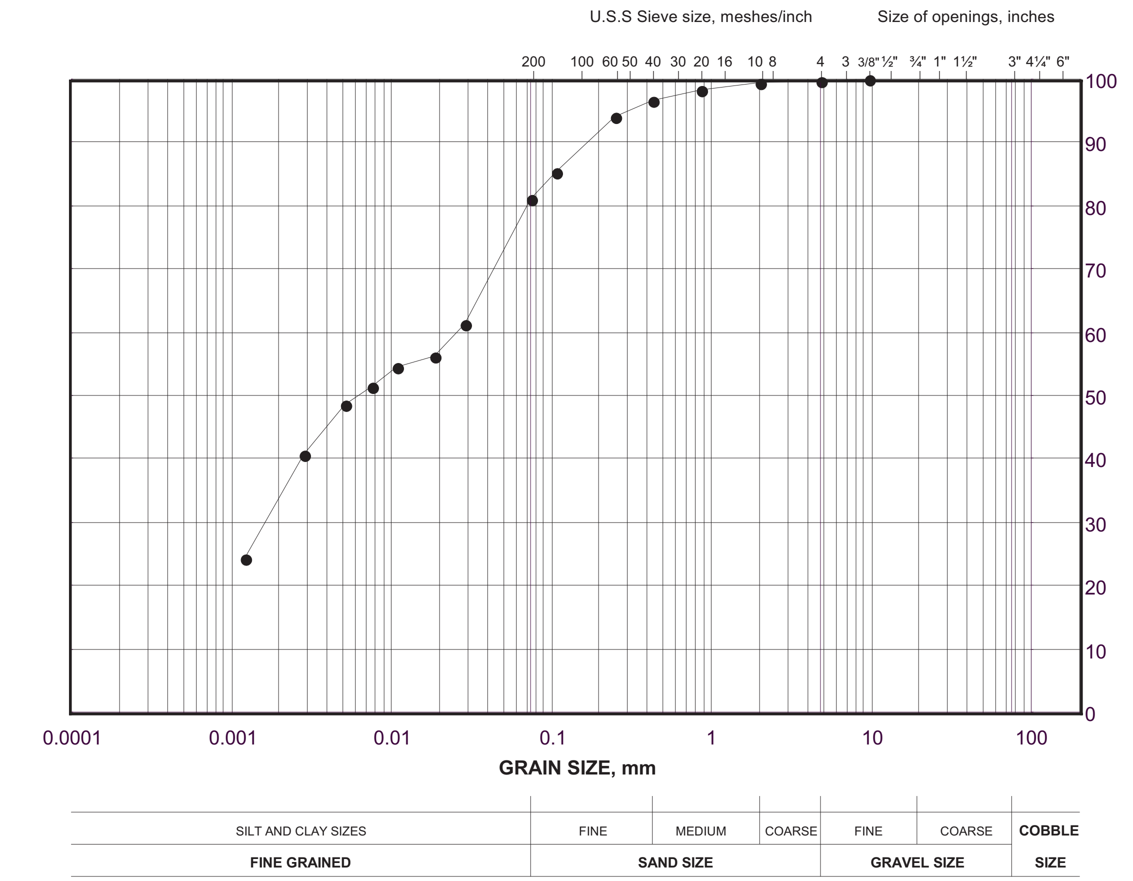
Figure No. WLTDLC41A-B
Project No. 07-1111-0053
Checked By: KJB

PLASTICITY CHART
Sand and Silt (Till)

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Clayey Silt (Till)

FIGURE WLTDLC41A-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL26-1	11	163.6

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 11-Mar-09

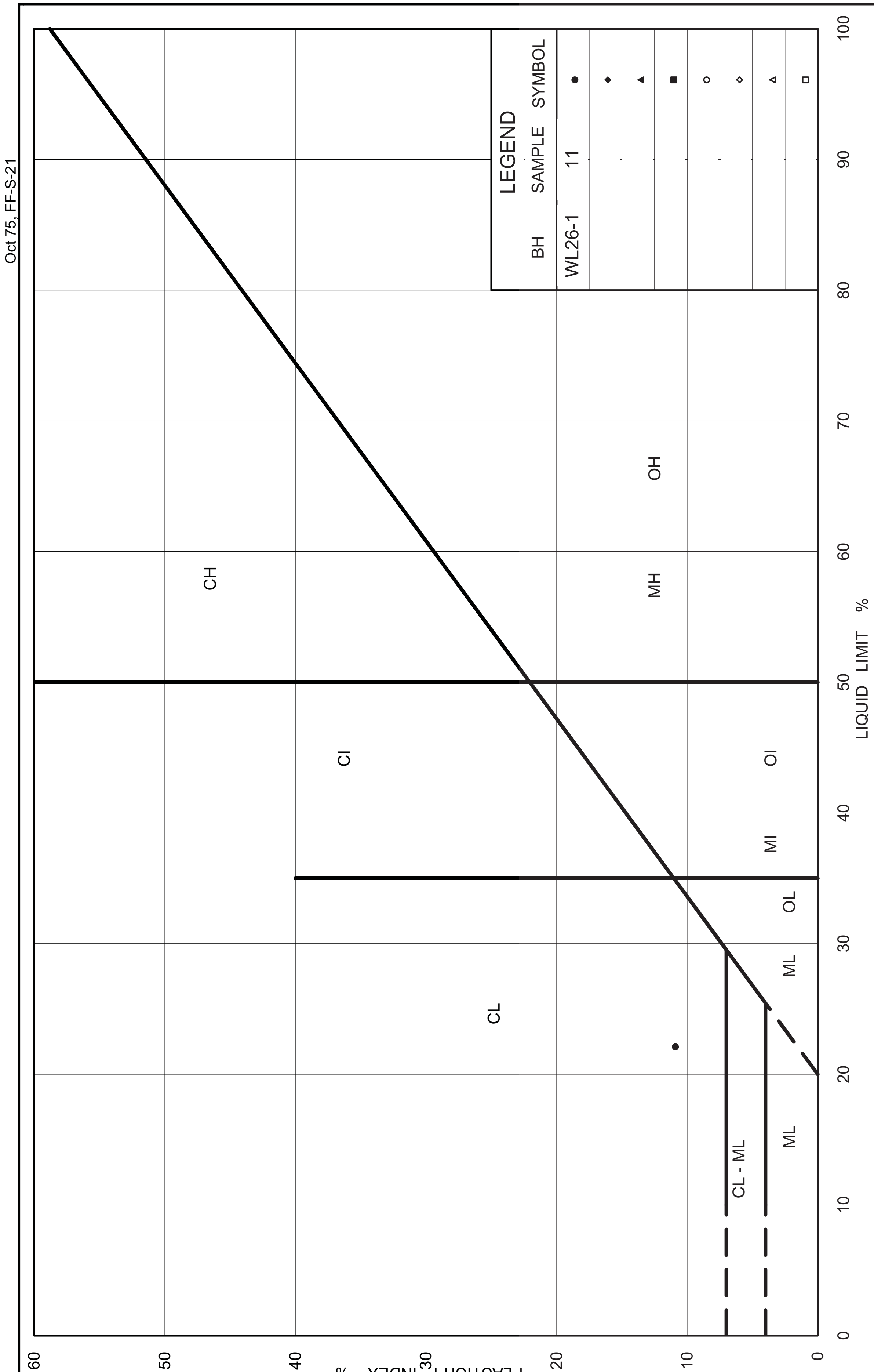


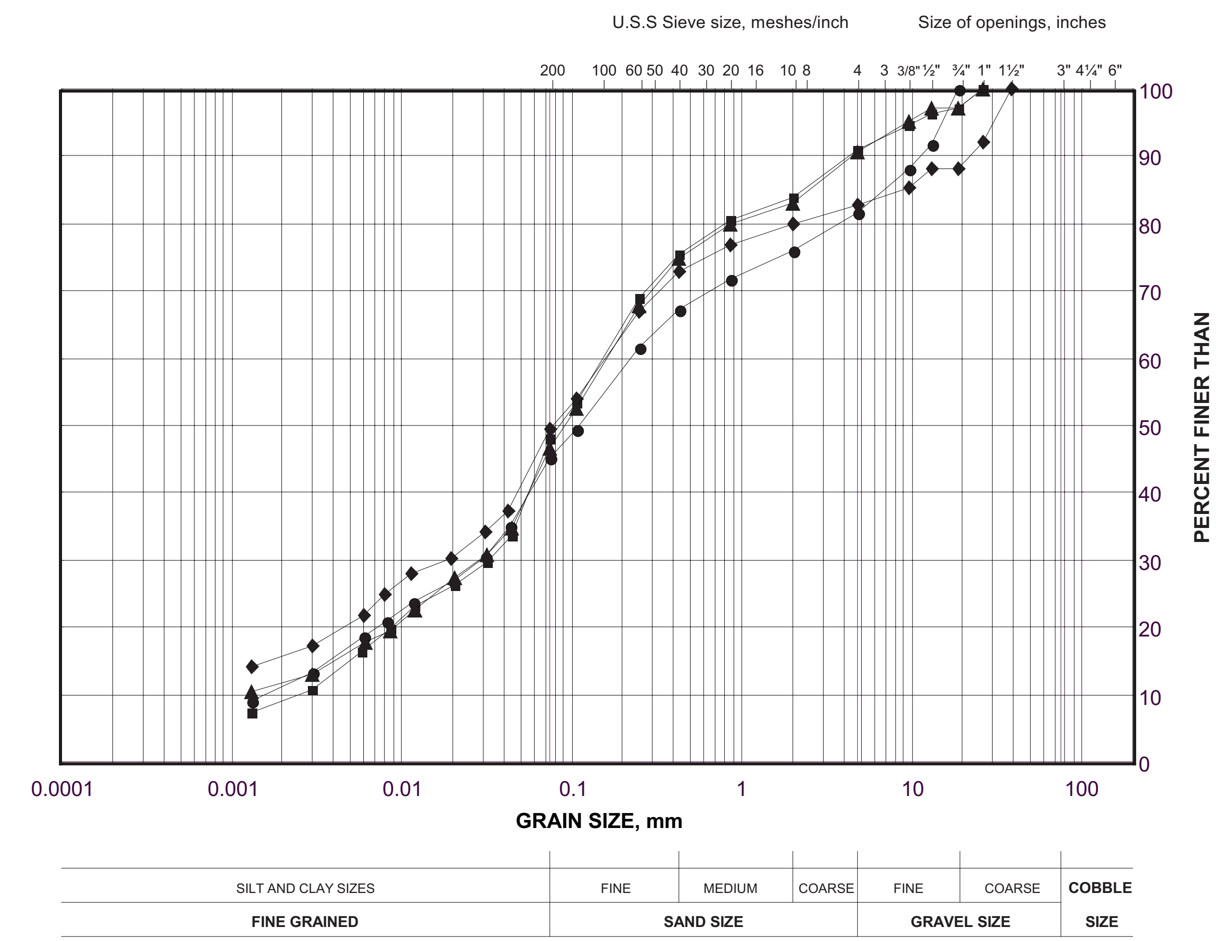
Figure No. WLTDLC41A-D
Project No. 07-1111-0053
Checked By: KJB

PLASTICITY CHART
Clayey Silt (Till)

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WL27-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL27-2	3	172.2
■	WL27-1	4	179.6
◆	WL27-2	6	169.3
▲	WL27-1	7	175.8

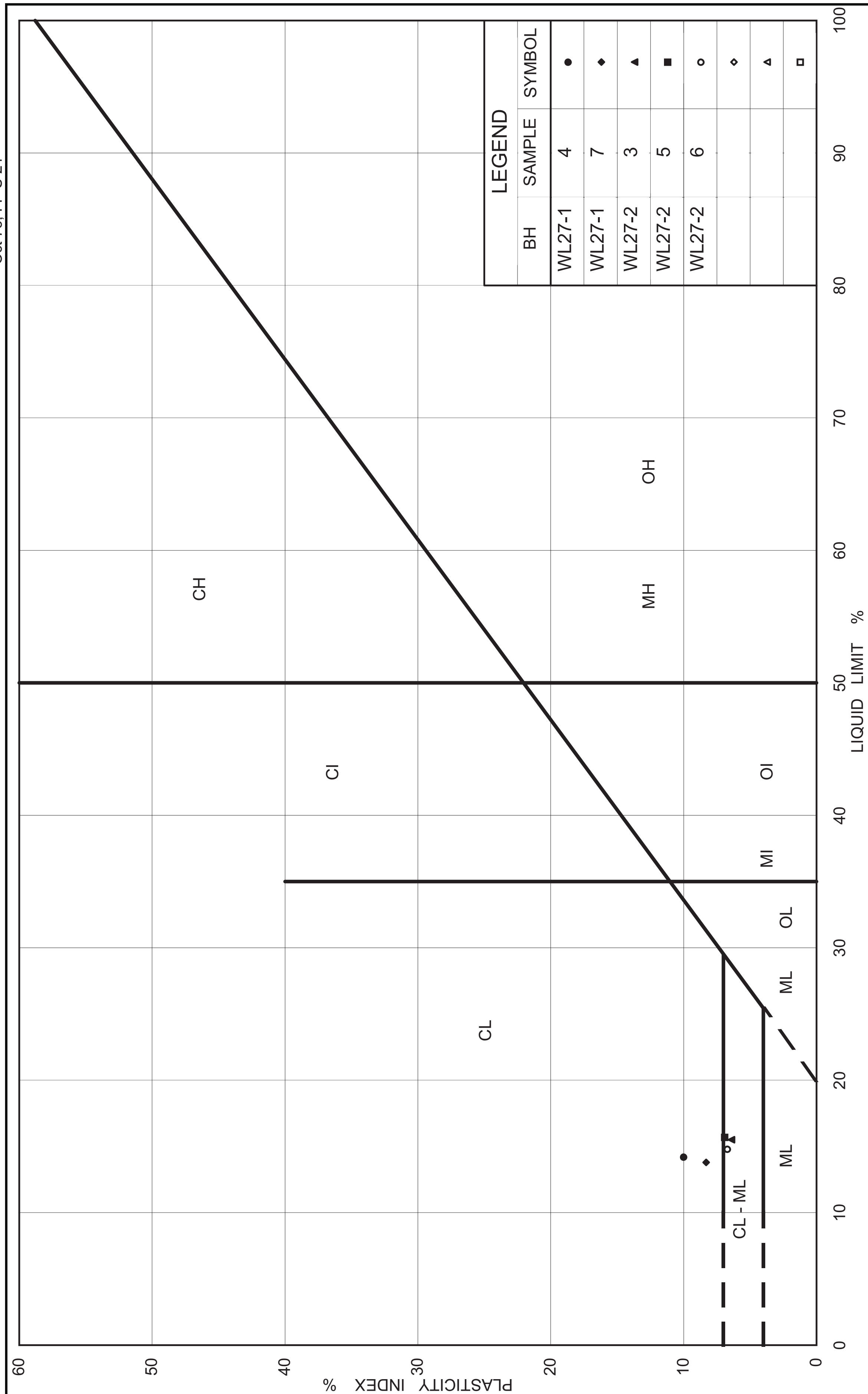
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 05-Nov-08

Oct 75, FF-S-21



PLASTICITY CHART
Sand and Silt (Till)

Figure No. WL27-B

Project No. 07-1111-0053

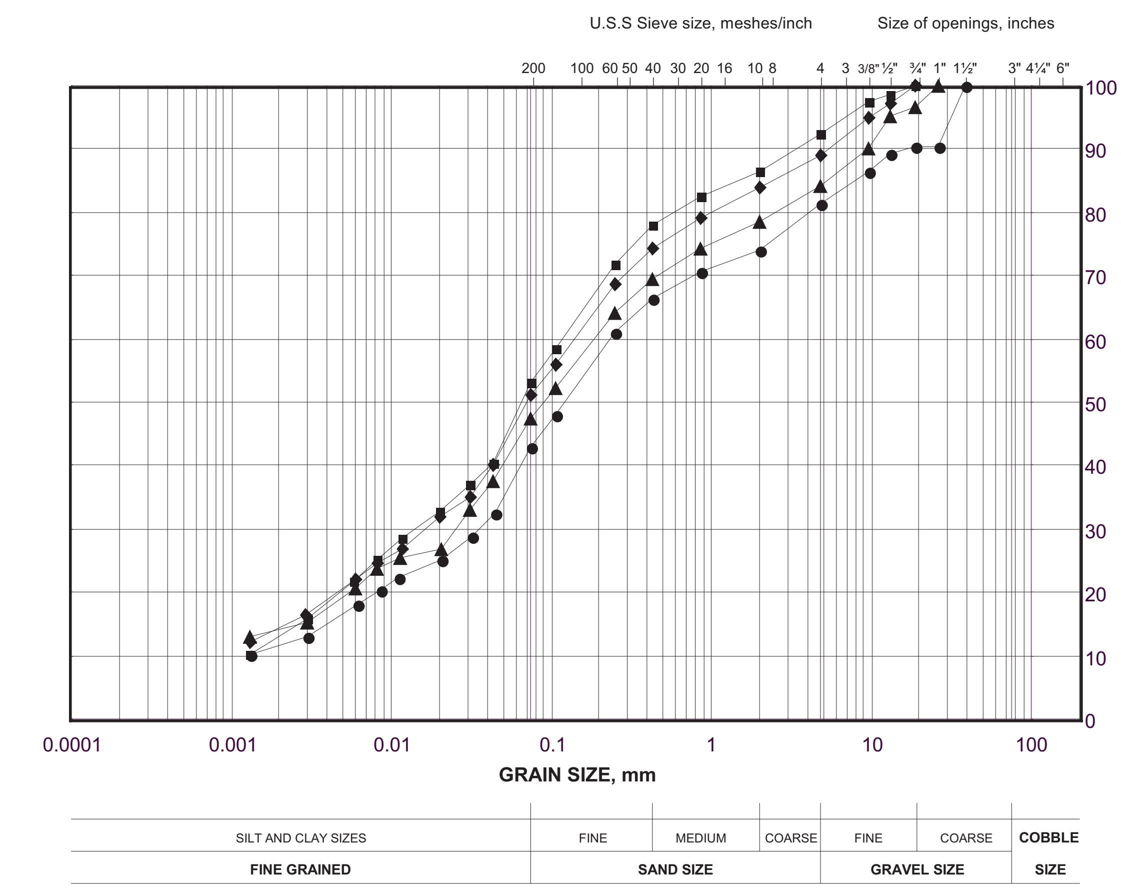
Checked By: KJB

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
Sand and Silt (Till)

FIGURE WL28-A



LEGEND

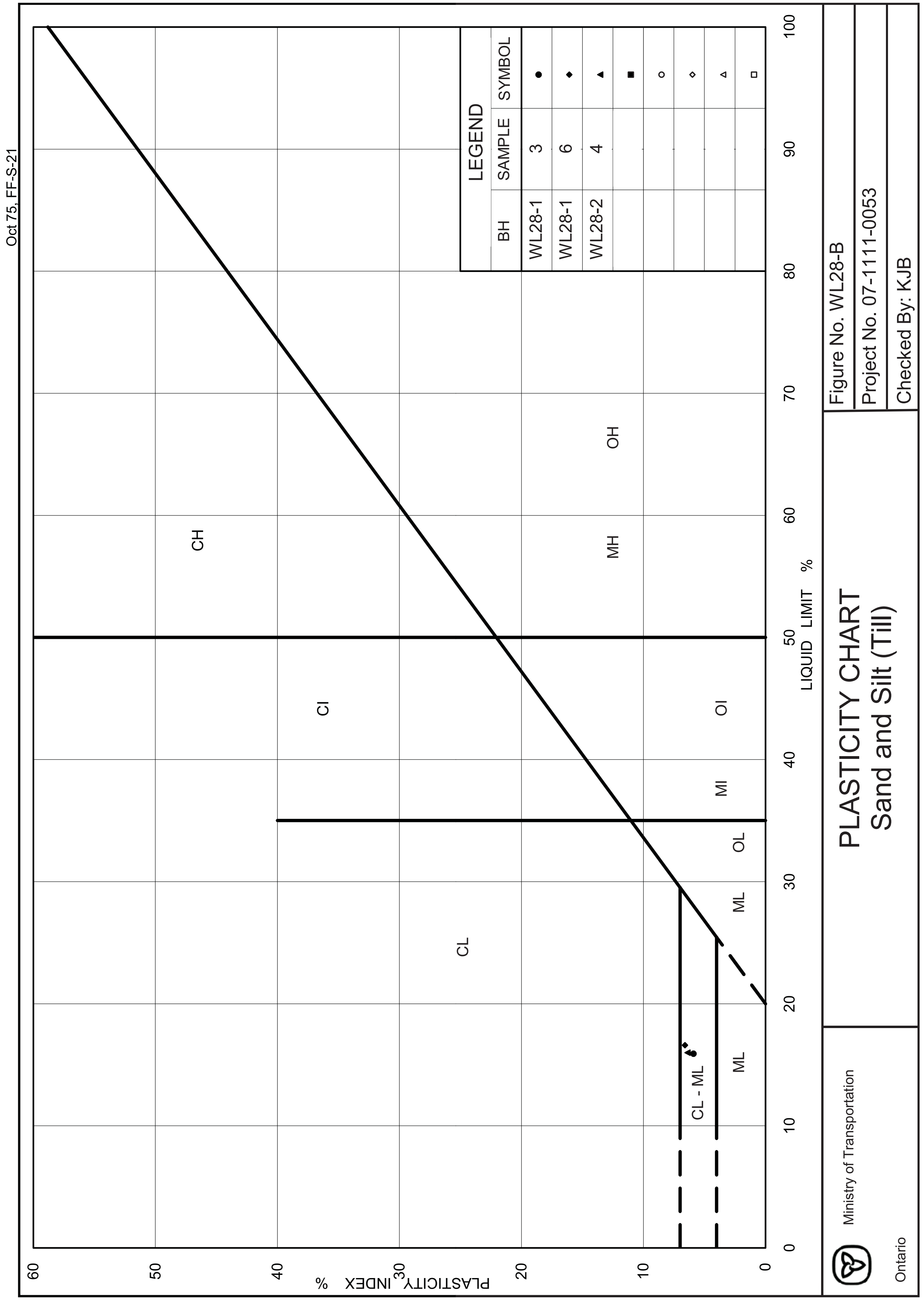
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WL28-1	3	176.4
■	WL28-2	4	173.7
◆	WL28-1	6	173.5
▲	WL28-2	6	171.4

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

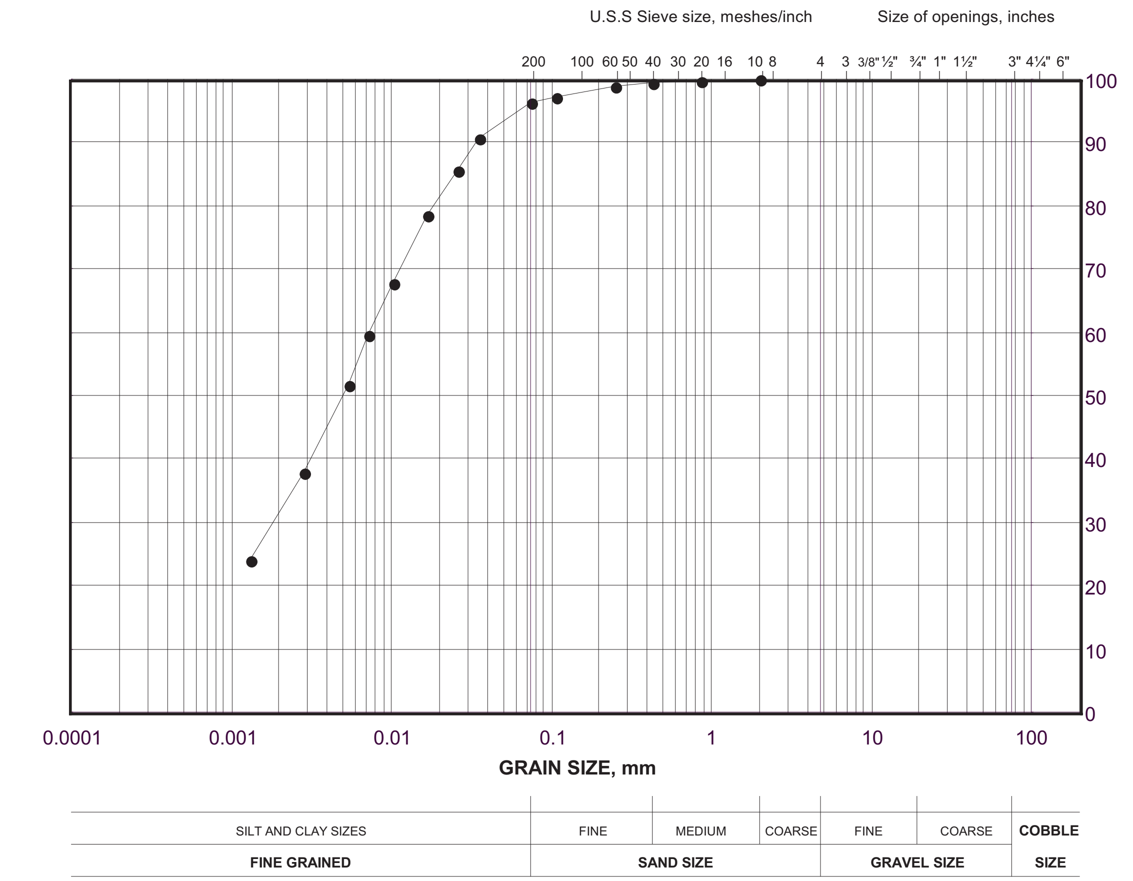
Date: 13-Mar-09



GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE WL31-A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WL31-1	3	186.6

Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 25-Mar-09

Oct 75, FF-S-21

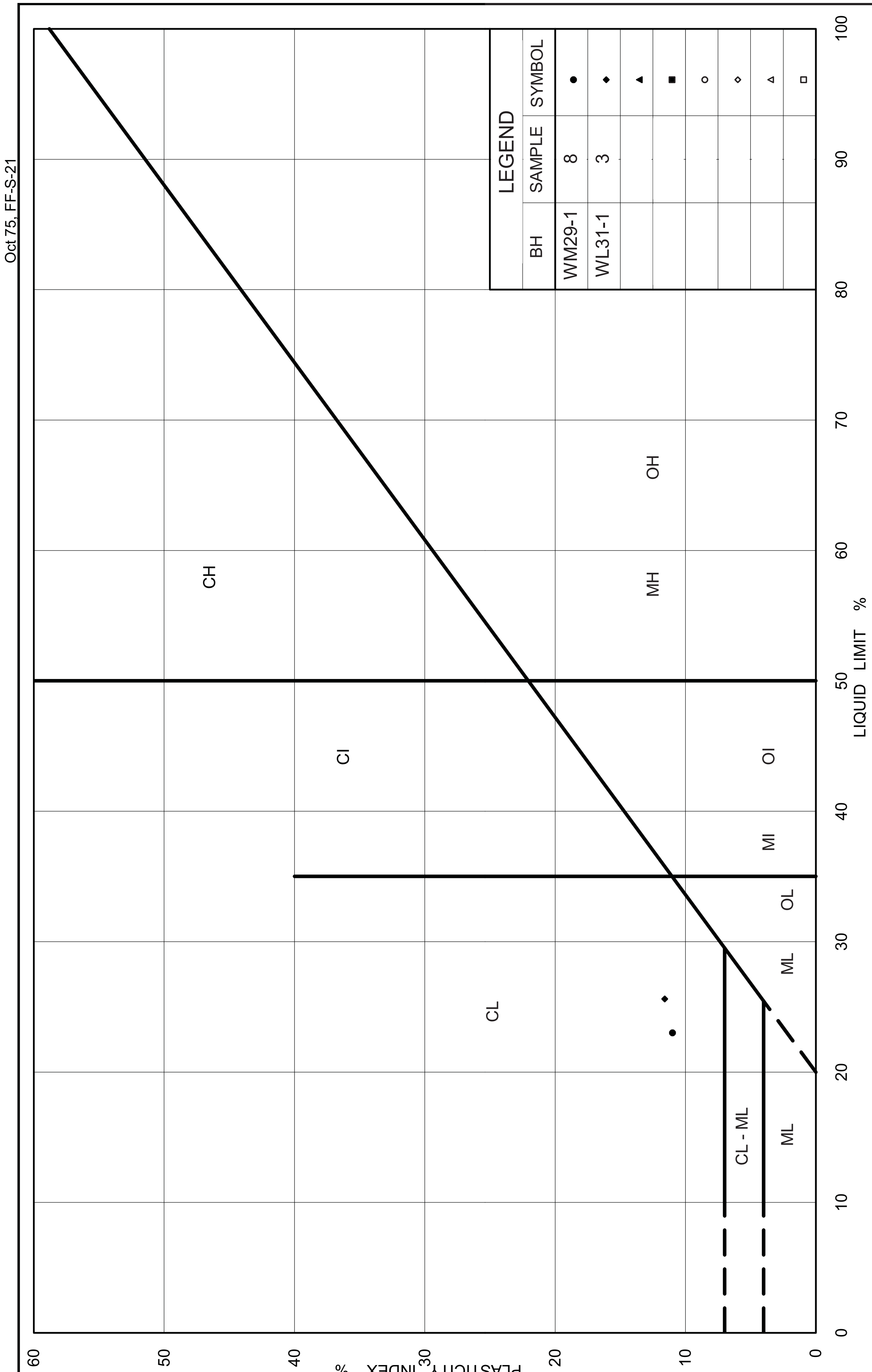


Figure No. WL31-B

Project No. 07-1111-0053

Checked By: KJB

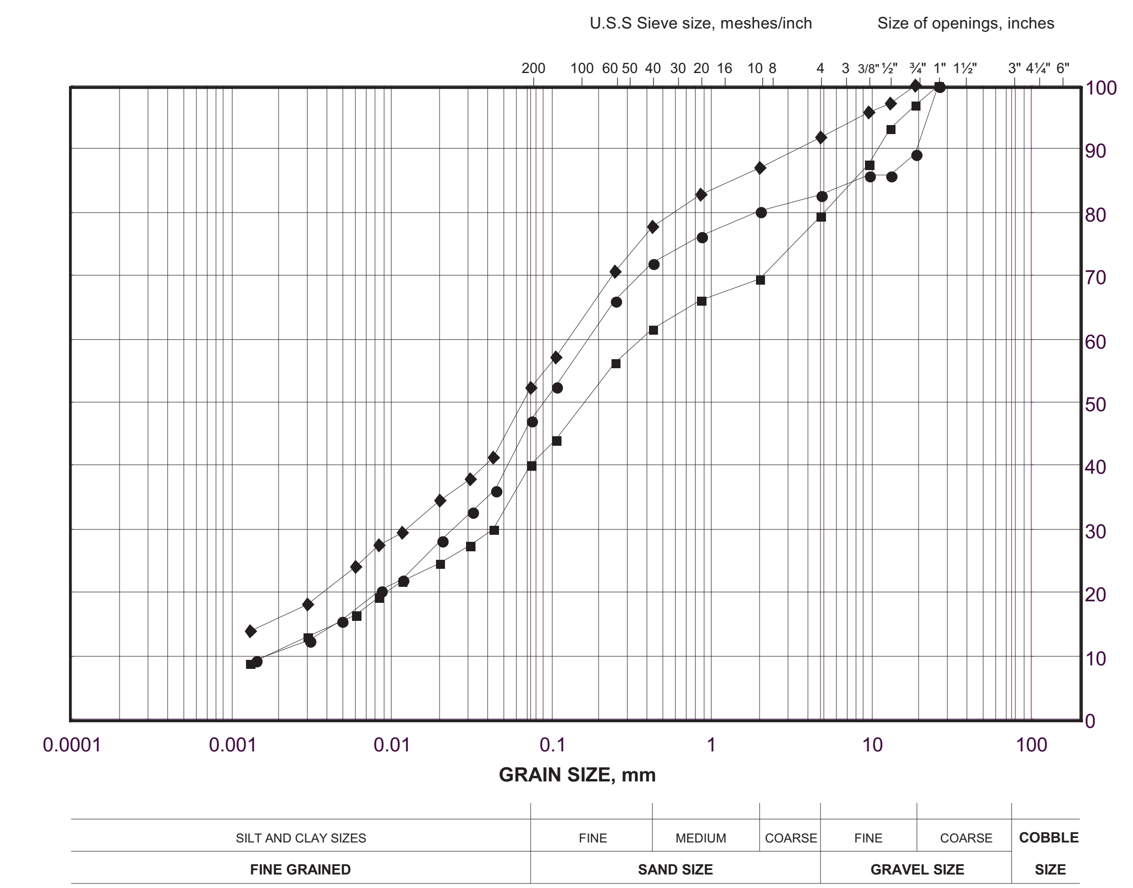
PLASTICITY CHART
Clayey Silt and Clayey Silt Seam

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
Silty Sand to Sand and Silt (Till)

FIGURE WL31-C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM29-1	5	185.7
■	WL31-1	6	183.7
◆	WM29-1	7	182.6

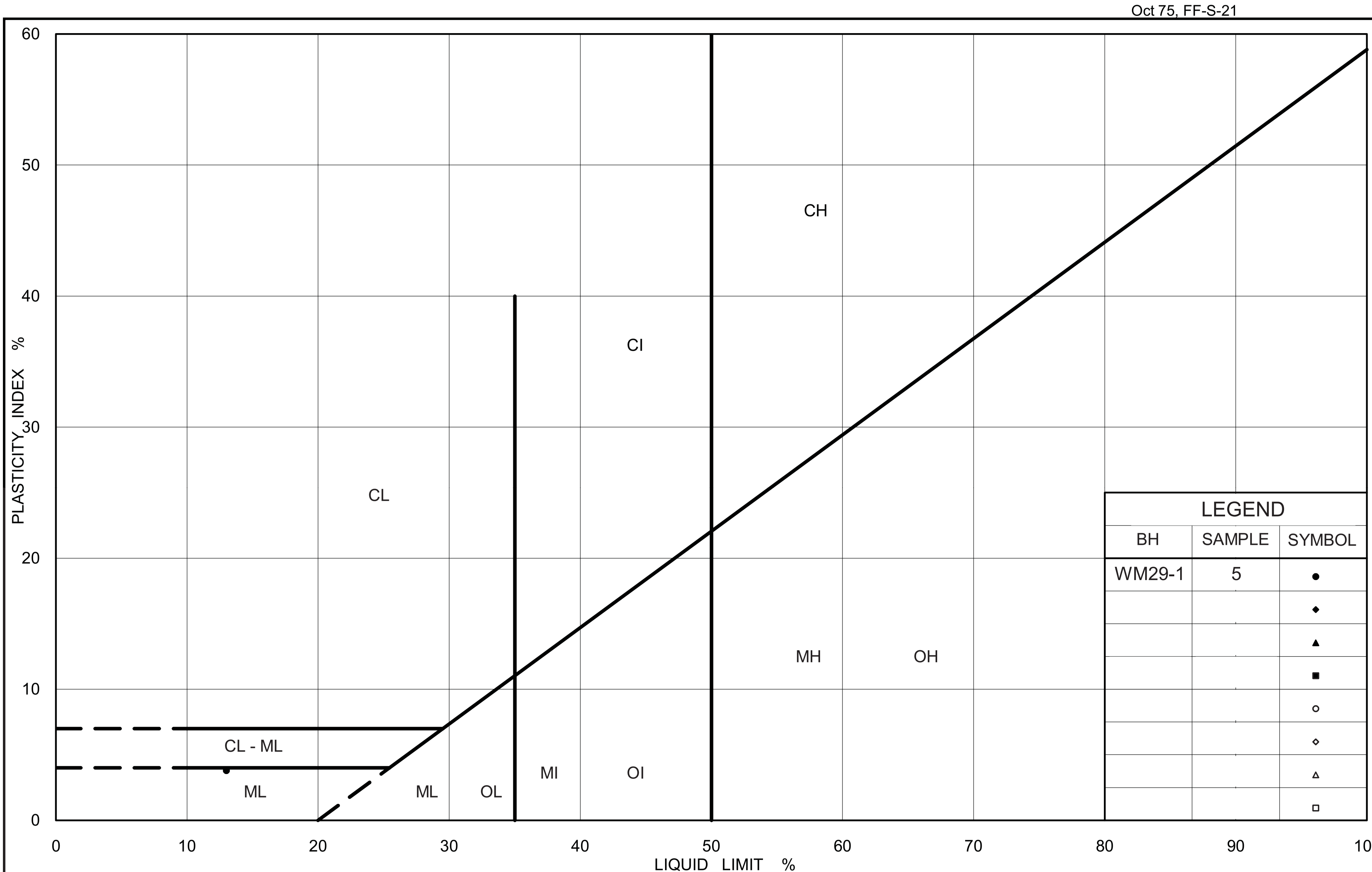
Project Number: 07-1111-0053

Checked By: KJB

Golder Associates

Date: 25-Mar-09

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
WM29-1	5	●
		◆
		▲
		■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Sand and Silt (Till)

Figure No. WL31-D

Project No. 07-1111-0053

Checked By: KJB

APPENDIX C

RECORD OF BOREHOLE SHEETS FROM PREVIOUS INVESTIGATIONS

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-1 METRIC

W P 242-86-00 LOCATION Co-ords. N 4 857 812.9; E 346 050.1 ORIGINATED BY KZ
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY KZ
DATUM Geodetic DATE 88 08 23 CHECKED BY TCK

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
86.9	Ground Level
0.0	Clayey Silt Some Sand (Fill) Brown
84.8 / 2.1	Grey Clayey Silt to Silt (Organic Topsoil)
82.9 / 4.0	Cohesive Het. Mixture of Clayey Silt, Sand and Gravel (Glacial Till)
81.3 / 5.6	Granular Het. Mixture of Silt, Sand, and Gravel Compact to Very Dense (Glacial Till)
76.8 / 10.1	Cohesive Het. Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)
74.1 / 12.8	Bedrock Shale
73.1 / 13.8	End of Borehole

SAMPLES

NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	25		
2	SS	12		1 24 47 28
3	SS	13		
4	SS	7		
5	SS	7		1 29 44 26
6	SS	18		
7	SS	76		6 51 39 4
8	SS	59		
9	SS	116/23 cm		
10	SS	200/8 cm		

ELEVATION SCALE: 86, 84, 82, 80, 78, 76, 74

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity   15 ⊕ 5 (%) STRAIN AT FAILURE (20, 10)

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-2 METRIC

W P 242-86-00 LOCATION Co-ords. N 4 858 028.4; E 346 308.7 ORIGINATED BY KZ
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger and Cone Test COMPILED BY KZ
DATUM Geodetic DATE 88 08 26 CHECKED BY TCK

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
85.5	Ground Level
0.0	Clayey Silt Trace of Sand (Organic Topsoil) Dk. Brown / Brown
83.4 / 2.1	Cohesive Het. Mixture of Clayey Silt, Sand and Gravel Stiff to Hard (Glacial Till) Brown / Grey
79.4 / 6.1	Bedrock Shale
77.8 / 7.7	End of Borehole

SAMPLES

NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	12		
2	SS	4	Seal	
3	SS	13		12 35 37 16
4	SS	24	Piezometer	2 57 26 15
5	SS	95/25 cm		41 42 13 4
6	SS	140/5 cm		
7	SS	100/8 cm		

ELEVATION SCALE: 84, 82, 80, 78

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity   15 ⊕ 5 (%) STRAIN AT FAILURE (20, 10)

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-3 — METRIC

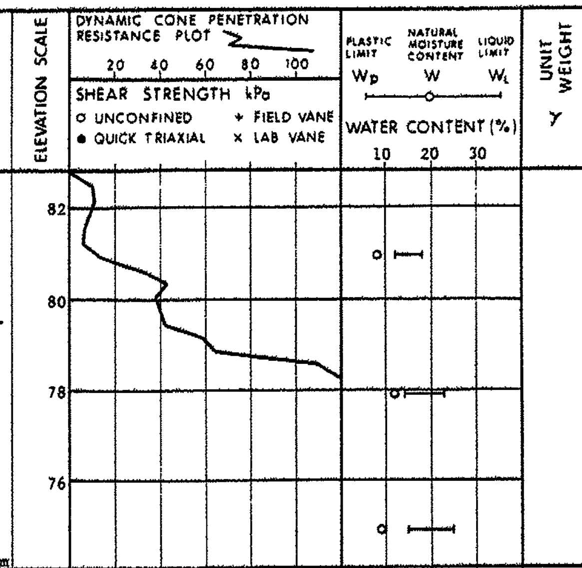
W P 242-86-00 — LOCATION Co-ords. N 4 857 972.0; E 346 532.5 — ORIGINATED BY KZ

DIST 6 HWY 401 — BOREHOLE TYPE Hollow Stem Augers and Cone Test — COMPILED BY KZ

DATUM Geodetic — DATE 88 08 23, 24 — CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION
82.8	Ground Level
0.0	Clayey Silt, Some Sand (Topsoil)
81.4 / 1.4	Brown / Grey, Cohesive Het. Mixture of Clayey Silt, Sand and Gravel, Very Stiff to Hard (Glacial Till)
74.4	Bedrock - Shale
74.1 / 8.7	End of Borehole

NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	11		
2	SS	30		19 33 35 13
3	SS	22		
4	SS	17		
5	SS	19		4 30 45 21
6	SS	46		
7	SS	20		16 53 20 11
8	SS	100/13 cm		



$+^3$, $\times^5$: Numbers refer to Sensitivity — 15 ⟡ 5 (%) STRAIN AT FAILURE (20 / 10)

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-4 — METRIC

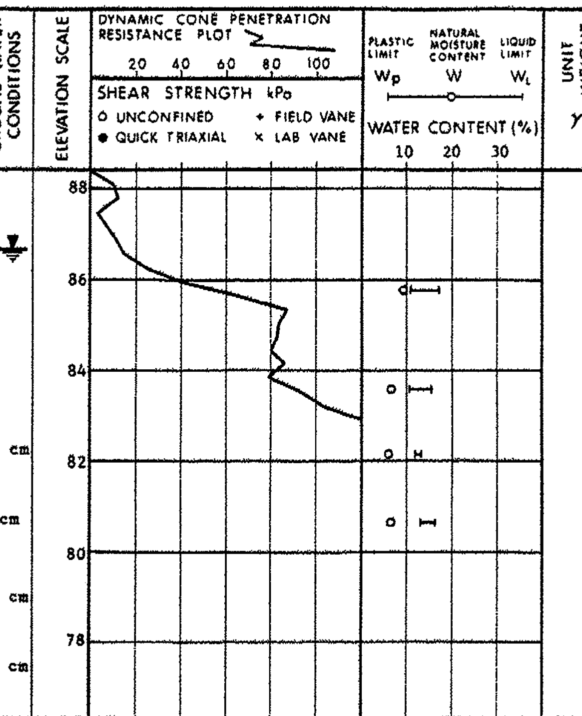
W P 242-86-00 — LOCATION Co-ords. N 4 858 248.4; E 346 257.1 — ORIGINATED BY KZ

DIST 6 HWY 401 — BOREHOLE TYPE Solid Stem Augers, Rock Coring, Cone Test — COMPILED BY KZ

DATUM Geodetic — DATE 88 08 29 — CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION
88.4	Ground Level
0.0	Clayey Silt, Some Sand (Fill)
87.0 / 1.4	Cohesive Het. Mixture of Clayey Silt Sand and Gravel, Very Stiff to Hard, Brown / Grey (Glacial Till)
82.8 / 5.6	Granular Het. Mixture of Silt, Sand and Gravel, Very Dense (Glacial Till)
81.4 / 7.0	Cohesive Het. Mixture of Clayey Silt, Sand and Gravel, Hard (Glacial Till)
77.7 / 10.7	Bedrock Shale
76.3 / 12.1	End of Borehole

NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	11		
2	SS	23		
3	SS	32		16 31 37 16
4	SS	29		
5	SS	32		17 43 32 8
6	SS	60/10 cm		13 42 38 7
7	SS	60/8 cm		12 53 27 8
8	SS	102/23 cm		
9	SS	100/10 cm		
10	RC	REC 90%		RQD = 10%



$+^3$, $\times^5$: Numbers refer to Sensitivity — 15 ⟡ 5 (%) STRAIN AT FAILURE (20 / 10)

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-5

METRIC

W P 242-86-00 LOCATION Co-ords. N 4 858 306.5; E 346 217.3 ORIGINATED BY KZ

DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Augers and Cone Test COMPILED BY KZ

DATUM Geodetic DATE 88 08 26 CHECKED BY TCK

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
89.3	Ground Level						
0.0	Clayey Silt Some Sand (Fill)	1	SS	30		88	
87.9 / 1.4	Cohesive Het. Mixture of Clayey Silt, Sand and Gravel Brown Grey Very Stiff to Hard (Glacial Till)	2	SS	40	Seal		
		3	SS	48			20 43 30 7
		4	SS	20		86	
85.3 / 4.0	Granular Het. Mixture of Silt, Sand and Gravel Compact (Glacial Till)	5	SS	23	Piezometer	84	
83.7 / 5.6	Cohesive Het. Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)	6	SS	145/20 cm			7 48 38 7
		7	SS	120/23 cm		82	
79.7		8	SS	106		80	14 48 26 12
9.6	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 859 072.2;E 346 970.9 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 09 CHECKED BY KA

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.0	Ground Surface						
0.0	Clayey Silt with Some Sand V. Stiff to Hard (Fill)	1	SS	15		84	
		2	SS	35			
82.9 / 2.1	Silty Clay to Clayey Silt With Traces of Sand and Gravel Firm to Hard (Glacial Till)					83	
		3	SS	16			
						82	
		4	SS	15			
		5	SS	10		81	
		6	SS	5		80	
						79	
		7	SS	39			
						78	
	Trace of Shale Fragments	8	SS	23		77	
						76	
75.6		9	SS	100	/8cm		
9.4	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m^3

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 3

1 OF 1 METRIC

WP 662-89-00 LOCATION Co-ords: N 4 860 951.7; E 346 061.7 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 13 CHECKED BY KA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS
102.0	Ground Surface				
0.0	Clayey Silt with Some Sand and Gravel V. Stiff to Hard (Glacial Till)	1	SS	31	
		2	SS	22	
		3	SS	32	
		4	SS	24	
		5	SS	17	
97.6 / 4.4	Silty Clay with Occ. Layers of Sand & Silt Stiff to V. Stiff	6	SS	21	▼
		7	SS	12	
96.1 / 5.9	Clayey Silt with Traces of Sand and Gravel Occ. Sand Layers V. Stiff (Glacial Till)	8	SS	20	
		9	SS	21	
		10	SS	28	
91.6 / 10.4	Silty Sand with Traces of Shale Fragments Very Dense	11	SS	71	
90.6 / 11.4	Weathered Shale Bedrock	12	SS	100 /8cm	
89.7 / 12.3	End of Borehole				

ELEVATION SCALE: 101, 100, 99, 98, 97, 96, 95, 94, 93, 92, 91, 90

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 — SHEAR STRENGTH kPa: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 — PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30 — UNIT WEIGHT γ kN/m^3 — REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity $15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 4

1 OF 1 METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 861 476.9; E 345 899.7 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 13 CHECKED BY KA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS
102.3	Ground Surface				
0.0	Clayey Silt with Traces of Sand and Gravel V. Stiff to Hard (Glacial Till)				▼
		1	SS	34	
		2	SS	35	
		3	SS	25	
99.4 / 2.9	Sandy Silt to Silt Compact to Dense	4	SS	37	
		5	SS	21	
		6	SS	27	
97.0 / 5.3	Clayey Silt to Silt with Some Sand and Gravel V. Stiff to Hard (Glacial Till)	7	SS	51	
		8	SS	30	
		9	SS	28	
92.1 / 10.2	Shale	10	SS	100 /13cm	
91.2 / 11.1	End of Borehole				

ELEVATION SCALE: 102, 101, 100, 99, 98, 97, 96, 95, 94, 93, 92

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 — SHEAR STRENGTH kPa: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 — PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30 — UNIT WEIGHT γ kN/m^3 — REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity $15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 5 — 1 OF 1 — METRIC

WP 662-89-00 LOCATION Co-ords: N 4 862 924.7; E 345 581.2 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 15 CHECKED BY KA

ELEV / DEPTH	SOIL PROFILE — DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
111.6	Ground Surface					
0.0	Clayey Silt to Silt with Traces of Gravel Hard (Glacial Till)				▼	111
		1	SS	41		
		2	SS	122		110
		3	SS	71		109
		4	SS	56		
		5	SS	32		108
		6	SS	42		107
						106
		7	SS	95		105
						104
103.2		8	SS	98		
8.4	Silt With some Sand and Traces of Gravel V. Dense (Glacial Till)					103
102.2		9	SS	80	/15cm	
9.4	End of Borehole					

Column headings also printed: STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity $15 \diamond 5$ (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 6 — 1 OF 1 — METRIC

WP 662-89-00 LOCATION Co-ords: N 4 864 852.9; E 344 766.1 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 15 CHECKED BY KA

ELEV / DEPTH	SOIL PROFILE — DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
131.4	Ground Surface					
0.0	Sand with Traces of Organics Loose					131
130.1		1	SS	4		
1.3	Clayey Silt With Traces of Sand and Gravel Hard (Glacial Till)				▼	130
		2	SS	32		
	Silty Sand With Some Gravel V. Dense	3	SS	95		129
		4	SS	100	/10cm	128
		5	SS	100	/5cm	
		6	SS	100	/10cm	127
						126
125.3		7	SS	100	/5cm	
6.1	End of Borehole					

Column headings also printed: STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity $15 \diamond 5$ (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No 7

1 OF 1 METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 866 898.8; E 344 510.2 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 16 CHECKED BY KA

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
156.4	Ground Surface					
0.0	Organic Silt With Traces of Sand and Gravel V. Stiff	1	SS	26		156
154.9 / 1.5	Silty Sand With Traces of Organics Loose	2	SS	8		155
154.3 / 2.1	Clayey Silt With Some Sand and Gravel V. Stiff to Hard (Glacial Till)	3	SS	10		154
		4	SS	28		153
		5	SS	78		152
		6	SS	100 /10cm		151
150.0 / 6.4	End of Borehole					

SOIL PROFILE · SAMPLES · DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 · SHEAR STRENGTH kPa: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 · PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L · WATER CONTENT (%) 10 20 30 · UNIT WEIGHT γ kN/m^3 · REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity $15 \overset{20}{\underset{1C}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No 8

1 OF 1 METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 867 704.8; E 343 854.2 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 16 CHECKED BY KA

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
183.4	Ground Surface					
0.0	Silty Sand With Some Gravel and Pockets of Organic Silt V. Dense	1	SS	63		183
182.0 / 1.4	Silty Clay to Clayey Silt With Some Sand and Gravel Hard (Glacial Till)	2	SS	179		182
		3	SS	100 /13cm		181
		4	SS	100 /8cm		180
		5	SS	100 /8cm		179
		6	SS	100 /3cm		178
		7	SS	100 /5cm		
177.6 / 5.8	End of Borehole					

SOIL PROFILE · SAMPLES · DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 · SHEAR STRENGTH kPa: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 · PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L · WATER CONTENT (%) 10 20 30 · UNIT WEIGHT γ kN/m^3 · REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity $15 \overset{20}{\underset{1C}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 9

1 OF 1 METRIC

W.P. 662-89-00	LOCATION Co-ords: N 4 858 247.0; E 347 406.1	ORIGINATED BY LRL
DIST 6 HWY 401/407 Link	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY LRL
DATUM Geodetic	DATE 1993 12 09	CHECKED BY KA

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION
82.6	Ground Surface
0.0	Clayey Silt With Traces of Sand and Gravel Stiff to Hard (Glacial Till)
76.1 / 6.5	End of Borehole

SAMPLE NUMBER	TYPE	'N' VALUES
1	SS	12
2	SS	23
3	SS	9
4	SS	23
5	SS	60
6	SS	124
7	SS	74 /15cm
8	SS	140 /20cm

ELEVATION SCALE: 82, 81, 80, 79, 78, 77

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100

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

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^5$: Numbers refer to Sensitivity $15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No P5

1 OF 1 METRIC

W.P. 282-86-01	LOCATION N 4 863709.4 E 336527.6	ORIGINATED BY DK
DIST 6 HWY 407	BOREHOLE TYPE S.S. Auger, Cone Test	COMPILED BY DK
DATUM Geodetic	DATE 94 01 10	CHECKED BY BI

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION
192.4	Ground Surface
0.0	Granular Fill
191.5 / 0.9	Heterogeneous Mixture of Clayey Silt, Trace Gravel Occasional Silt Zones, Brown (Glacial Till) — Stiff / Hard
187.1 / 5.3	Sandy Silt to Silty Sand Very Dense — Brown / Grey
182.5 / 9.9	Heterogeneous Mixture of Clayey Silt, Trace Gravel, Grey, Hard
181.6 / 10.8	End of Borehole

• Unstabilized water level measured upon completion of drilling on 94 01 10

SAMPLE NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	12	
2	SS	31	
3	SS	60	
4	SS	66	1 27 68 4
5	SS	85	
6	SS	53	
7	SS	110 /18cm	

ELEVATION SCALE: 192, 190, 188, 186, 184, 182

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100: Preaugered 600 mm of frozen ground; 186; 120/28cm

High blowcounts due to frozen ground

SHEAR STRENGTH kPa: o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100

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

UNIT WEIGHT γ kN/m³

$+^3, \times^5$: Numbers refer to Sensitivity $15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P6 — 1 OF 1 — METRIC

W.P. 282-86-01 LOCATION N 4 865235.6 E 337903.4 ORIGINATED BY DK
DIST 6 HWY 407 BOREHOLE TYPE H.S. Auger, Cone Test COMPILED BY DK
DATUM Geodetic DATE 94 01 05 – 94 01 07 CHECKED BY BI

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
167.1	Ground Surface				
0.0	Clayey Silt, Trace Gravel, Some Organic Inclusions, Brown and Grey, Firm (Fill)	1	SS	6	
163.7 / 3.4	Heterogeneous Mixture of Clayey Silt, Trace Gravel, Some Sand layers, Grey, Very Stiff to Hard (Glacial Till)	2	SS	17	
		3	SS	33	
		4	SS	30	
160.2 / 6.9	Silty Sand, Trace Gravel, Grey, Compact to Dense	5	SS	17	
		6	SS	23	0 42 52 6
		7	SS	34	
		8	SS	20	
		9	SS	37	0 91 5 4
151.4		10	SS	68	
15.7	End of Borehole				

Ground water: 164.4 *

High blowcount due to frozen ground

* Unstabilized water level measured upon completion of drilling on 94 01 07

$+^3, \times^5$: Numbers refer to Sensitivity; $15 \diamond 5$ (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P7 — 1 OF 1 — METRIC

W.P. 282-86-01 LOCATION N 4 865854.8 E 338570.2 ORIGINATED BY DK
DIST 6 HWY 407 BOREHOLE TYPE H.S. Auger, Cone Test COMPILED BY DK
DATUM Geodetic DATE 94 01 05 CHECKED BY BI

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
145.4	Ground Surface				
0.0	Silty Sand, Trace Gravel, Brown and Grey, Compact (Fill)	1	SS	27	
143.1 / 2.3	Organics with Wood Fibres, Black, Loose (Peat)	2	SS	8	
141.9 / 3.5	Sand with Gravel, Trace Silt, Grey, Dense (Alluvial Deposit)	3	SS	32	
140.1 / 5.3	Silty Clay, Some silt zones, Grey, Soft to Stiff	4	SS	4	
		5	SS	6	
		6	SS	11	
		7	SS	15	
134.0 / 11.4	Silty Sand, Grey, Compact	8	SS	4**	
		9	SS	3**	
130.2 / 15.2	Silty Clay, Grey, Very Stiff; more silty	10	SS	24	
127.9		11	SS	17	0 2 85 13
17.5	Silty Sand, Grey, Compact, Occasional Silt Zones				
126.7		12	SS	8**	
18.7	End of Borehole				

Preaugered 600 mm of frozen ground

120/25cm

* Unstabilized water level taken upon completion of drilling on 94 01 05

** Unrepresentative blowcounts due to possible disturbance caused by unbalanced hydrostatic heads

$+^3, \times^5$: Numbers refer to Sensitivity; $15 \diamond 5$ (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario — Foundation Design

RECORD OF BOREHOLE No P8 — 1 OF 1 — METRIC

W.P. 282-86-01 | LOCATION N 4 866905.5 E 340849.2 | ORIGINATED BY DK
DIST 6 HWY 407 | BOREHOLE TYPE H.S. Auger, Cone Test | COMPILED BY DT
DATUM Geodetic | DATE 93 12 21 – 93 12 24 | CHECKED BY BI

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
170.7	Ground Surface					
0.0	Granular Fill					
0.5	Heterogeneous Mixture of Clay Silt, Trace Sand, Trace Gravel, Occasional Cobbles and Boulders (Glacial Till) — Very Stiff	1	SS	17	▼*	
	Hard	2	SS	31		
		3	SS	51		
	Brown	4	SS	100/25cm		
	Grey, Some Sand Layers	5	SS	45		
		6	SS	100/23cm		
163.1 / 7.6	Silty Sand, Dense to Very Dense, Brown and Grey	7	SS	33		
		8	SS	74		
160.0 / 10.7	Silt, Trace Clay, Some Sand, Grey, Dense to Very Dense	9	SS	46		0 21 75 4
		10	SS	91		
		11	SS	100/18cm		
	Silty Sand layer	12	SS	40		
	Becoming more Clayey	13	SS	100/23cm		0 3 79 18
		14	SS	100		
151.6 / 19.1	Silty Clay, Grey, Hard (Lacustrine)	15	SS	76		
		16	SS	48		
		18	SS	70		
142.8		19	SS	58		
27.9	End of Borehole					
	* 93 12 24					

Dynamic Cone Penetration Resistance Plot (20 40 60 80 100); Shear Strength kPa (○ Unconfined, + Field Vane, ● Quick Triaxial, × Lab Vane; 20 40 60 80 100); Plastic Limit w_P, Natural Moisture Content w, Liquid Limit w_L; Water Content (%) 10 20 30; Unit Weight γ kN/m³

Elevation scale: 170, 168, 166, 164, 162, 160, 158, 156, 154, 152, 150, 148, 146, 144

AUGER

WASHBORING

+3, ×5: Numbers refer to Sensitivity — 15◇5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario — Foundation Design

RECORD OF BOREHOLE No P9 — 1 OF 1 — METRIC

W.P. 282-86-01 | LOCATION N 4 867137.7 E 341645.3 | ORIGINATED BY DK
DIST 6 HWY 407 | BOREHOLE TYPE H.S. Auger, Cone Test | COMPILED BY DT
DATUM Geodetic | DATE 93 12 20 – 93 12 21 | CHECKED BY BI

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.1	Ground Surface					
0.0	Granular Fill					
0.5	Clayey Silt, Trace Gravel and Organics, Greenish Grey, Soft (Fill)	1	SS	4		
179.6 / 1.5	Heterogeneous Mixture of Clayey Silt, Trace Gravel, Occasional Cobbles and Boulders, Grey (Glacial Till) — Very Stiff	2	SS	21	▼*	
	Hard	3	SS	68		
		4	SS	100/20cm		
		5	SS	79		
		6	SS	65		
		7	SS	64		
		8	SS	66		
		9	SS	43		
	Occasional Sand Layers	10	SS	61		
		11	SS	72		
		12	SS	100/28cm		
		13	SS	114/20cm		
		14	SS	122/25cm		
157.8		15	SS	120		
23.3	End of Borehole					
	* Unstabilized water table measured upon completion of drilling on 93 12 21					

Dynamic Cone Penetration Resistance Plot (20 40 60 80 100); Shear Strength kPa (○ Unconfined, + Field Vane, ● Quick Triaxial, × Lab Vane; 20 40 60 80 100); Plastic Limit w_P, Natural Moisture Content w, Liquid Limit w_L; Water Content (%) 10 20 30; Unit Weight γ kN/m³

Elevation scale: 180, 178, 176, 174, 172, 170, 168, 166, 164, 162, 160, 158

120/18cm

+3, ×5: Numbers refer to Sensitivity — 15◇5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No P10

 METRIC

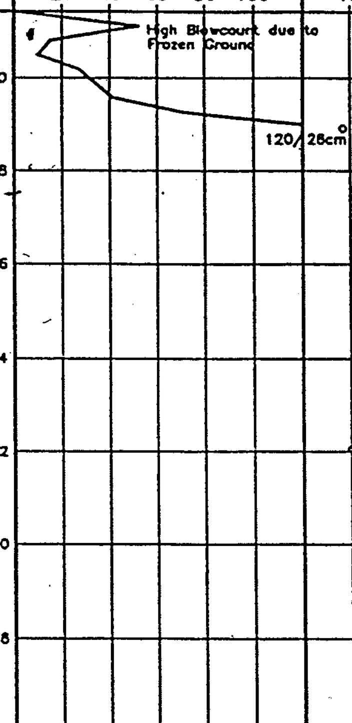
W.P. 282-86-01 LOCATION N 4 867555.7 E 343258.4 ORIGINATED BY DK

DIST 6 HWY 407 BOREHOLE TYPE H.S. Auger, Cone Test COMPILED BY DT

DATUM Geodetic DATE 93 12 17 – 93 12 20 CHECKED BY BI

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.4	Ground Surface				
190.6 / 0.0	Granular Fill				
0.8	Heterogeneous Mixture of Clayey Silt, Trace Gravel Occasional Sand Seams, Cobbles and Boulders, Hard (Glacial Till) Brown / Grey	1	SS	33	
		2	SS	82	
		3	SS	110/28cm	5 37 45 13
		4	SS	110/23cm	
		5	SS	59	
		6	SS	120/13cm	
184.4 / 7.0	Silty Sand with Gravel Grey, Very Dense	7	SS	100/25cm	
182.3 / 9.1	Heterogeneous Mixture of Silt, Sand and Gravel Occasional Sand Layers Grey, Very Dense (Glacial Till)	8	SS	100/23cm	6 56 32 6
		9	SS	100/18cm	
179.2 / 12.2	Heterogeneous Mixture of Clayey Silt, Trace Gravel Occasional Sand Layers, Cobbles and Boulders Grey, Hard (GLacial Till)	10	SS	106/18cm	
		11	SS	138/15cm	
176.0 / 15.4	End of Borehole	12	SS	120/15cm	
	* 93 12 20				

Dynamic cone penetration resistance plot (20 40 60 80 100); Shear strength kPa: o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE; Water content (%) 10 20 30; Unit weight γ kN/m³. Elevation scale: 190, 188, 186, 184, 182, 180, 178.



+3, x5: Numbers refer to Sensitivity   15 ◇ 5 (%) STRAIN AT FAILURE (20, 10)

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No P11

 METRIC

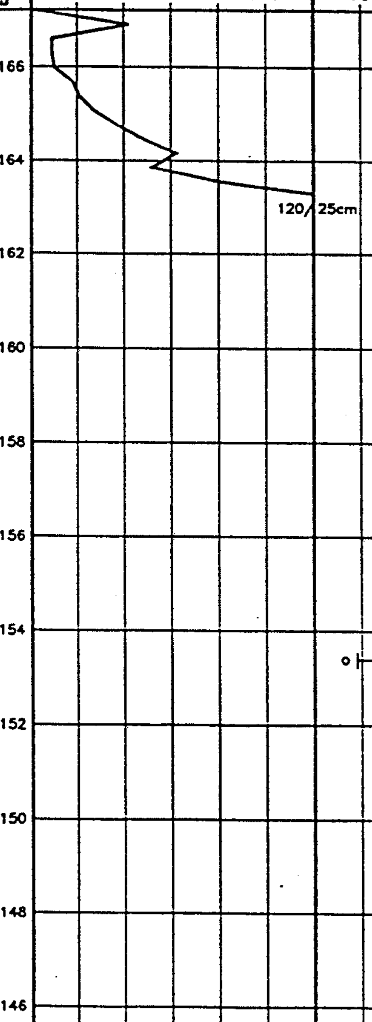
W.P. 282-86-01 LOCATION N 4 867746.0 E 344497.0 ORIGINATED BY DK

DIST 6 HWY 407 BOREHOLE TYPE H.S. Auger, Cone Test COMPILED BY DT

DATUM Geodetic DATE 93 12 15 – 93 12 16 CHECKED BY BI

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
167.2	Ground Surface				DRY	
0.0	Asphalt and Granular Fill					
0.3	Clayey Silt with Organic Inclusions, Firm, Brown (Fill)	1	SS	6		
165.7 / 1.5	Heterogeneous Mixture of Clayey Silt, Some Sand Trace Gravel Occasional Cobbles and Boulders (Glacial Till) — Stiff to Very Stiff / Hard / Some Wet Sand Seams / Brown / Grey	2	SS	14		
		3	SS	25		
		4	SS	52		
		5	SS	100/8cm		
		6	SS	100/13cm		
		7	SS	100/10cm		
		8	SS	110/20cm		
		9	SS	110/13cm		
		10	SS	115/15cm		
		11	SS	120/20cm		5 40 34 21
		12	SS	110/20cm		
		13	SS	100/15cm		
145.4		14	SS	115/28cm		
21.8	End of Borehole					
	* 93 12 16					

Dynamic cone penetration resistance plot (20 40 60 80 100); Shear strength kPa: o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE; Water content (%) 10 20 30; Unit weight γ kN/m³. Elevation scale: 166, 164, 162, 160, 158, 156, 154, 152, 150, 148, 146.



+3, x5: Numbers refer to Sensitivity   15 ◇ 5 (%) STRAIN AT FAILURE (20, 10)

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No P12   1 OF 1   METRIC

W.P. 282-86-01   LOCATION N 4 867670.7 E 346795.7   ORIGINATED BY DK

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

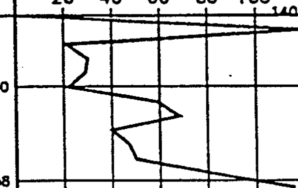
ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
161.5	Ground Surface						
160.7 / 0.0	Granular Fill						High blowcount due to frozen ground
0.8	Heterogeneous Mixture of Clayey Silt, Trace Sand and Gravel, Very Stiff to Hard (Glacial Till) — Brown / Grey	1	SS	26	▼*		
		2	SS	33		160	
		3	SS	21			
157.7		4	SS	25		158	
3.8	Heterogeneous Mixture of Silt, Sand and Gravel, Occasional Cobbles and Boulders, Grey, Compact to Very Dense (Glacial Till)	5	SS	36			6 47 36 11
	Silty Sand, Grey, Loose	6	SS	5**		156	
		7	SS	6**		154	
		8	SS	24		152	
		9	SS	120 /23cm		150	
		10	SS	52			
	Trace Clay	11	SS	80		148	29 37 26 8
		12	SS	40		146	
	Trace Clay	13	SS	54		144	
		14	SS	113			
141.1	Some Sand Layers	15	SS	42		142	
20.4	Heterogeneous Mixture of Clayey Silt, Trace Gravel, Occasional Cobbles and Boulders, Grey, Hard (Glacial Till)	16	SS	115 /23cm		140	
						138	
136.9 / 24.6	End of Borehole	17	SS	120 /20cm			

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m^3



* Unstabilized water level measured upon completion of drilling on 93 12 15

** Unrepresentative blowcounts due to possible disturbance caused by unbalanced hydrostatic heads

$+^3$, $\times^3$: Numbers refer to Sensitivity   15 ◇ 5 (20, 10) (%) STRAIN AT FAILURE